PACIFIC REGIONAL OCEANIC AND

COASTAL FISHERIES DEVELOPMENT PROGRAMME

(PROCFish/C/CoFish)

PAPUA NEW GUINEA COUNTRY REPORT:

PROFILES AND RESULTS FROM SURVEY WORK AT ANDRA, TSOILAUNUNG, SIDEIA, AND PANAPOMPOM

(June to November 2006)

by

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Kalo Pakoa, Ribanataake Awiva and Lindsay Chapman

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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.

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EXECUTIVE SUMMARY

The coastal component of the Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) conducted fieldwork in four locations around Papua New Guinea in June to November 2006. Papua New Guinea 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 Papua New Guinea 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 many local attachments from the National Fisheries Authority, the Nature Conservancy, and the Conservation International. 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 Papua New Guinea, the four sites selected for the survey were: Andra, Tsoilaunung, Sideia and Panapompom.

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,

[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.

- presenting no major logistical problems,
- having been previously investigated, and
- presenting particular interest for Papua New Guinea's National Fisheries Authority (NFA).

Results of fieldwork in Andra

Andra is a coral island located on the barrier reef on the northern part of the high island of Manus located at latitude 1°55′S and longitude 146°57′E. It is small in size (1 km x 200 m), and the outer reef is protected from the prevailing easterly winds. Travel to Andra from Lorengau (the provincial centre) takes about an hour by speed boat, the main mode of transport to these islands. The island community is a large village divided into clans. There is no principal chief on the island, but there are heads of clans and a village council. Reef ownership is by clan, and the ownership right of the people of Andra extends from the outer reef to the mainland coastline and halfway between Ahus to the east and Ponam to the west. Access to the outer reefs in front of the island is restricted to Andra inhabitants. Few Andra residents own land on mainland Manus; many are fishers rather than farmers. Their stable food crop is 'sago starch', made from sago palms, which grow wild on the mainland; sago flour is usually prepared with seafood for meals. Sago is also sold for household income. Bartering of fish and garden produce with the mainland people is common practice. The community of Andra is heavily reliant on marine resources for food and income from sale of trochus, bêche-de-mer, lime powder and fish.

Socioeconomics: Andra

Fisheries are the most important source of income for the people on Andra. All households depend on fisheries for income: half as first and the other half as secondary income. The production and selling of lime (corals) is the first source of income for more than half of the households who depend on fisheries as secondary income. Agriculture and salaries are of minor importance. Fishing provides also the most important source of protein and nutrition: all households eat fresh fish and invertebrates and, occasionally, canned fish. Fresh fish consumption is moderate (~36 kg/person/year), but invertebrate consumption is rather low (6.5 kg/person/year).

The average household expenditure level is higher than across all four PROCFish sites in Papua New Guinea, a result of the isolated location of Andra, which involves high transport cost, and the need to purchase food items other than seafood due to the lack of agricultural produce on the atoll.

Finfish fishing is done by males and females. Females fish the sheltered coastal reef and lagoon for subsistence; males target the outer reef for commercial purposes. Females dominate reeftop gleaning; however, both genders are heavily involved in the commercial bêche-de-mer fishery when the season is open. Females do not participate in trochus collection as it is done by males free-diving at the back- and outer reefs. Most fishing is done using paddling canoes, but motorised boats are also used, particularly at the outer reef.

Finfish resources: Andra

Finfish resources in Andra at the time of surveys were found to be moderately or slightly impacted, especially on the outer reefs, where most commercial fishing was conducted. The habitat was healthy, with high live-coral cover, displaying the second-highest value among the four country sites and the 15th highest in the region. However, a very low coverage of *Acropora* coral was noted.

The western side of the pass is an area of conflict between Andra fishers and fishers from the village of Ponam, resulting in limited fishing by either group of fishers. Here, biodiversity as well as sizes were much higher than on the opposite side of the pass. This area acts, in effect, as a naturally protected area. Although results from the socioeconomic study suggest that, overall, fishing pressure was moderate, specific conditions were found at different reef areas.

Finfish resources were, overall, naturally rich, with high biodiversity, and fish density the second-highest and biomass the highest in the country, both values ranking high on a regional scale. Although density and biomass were above the regional average, these values were mostly due to the resources in the outer reef, while coastal and lagoon fisheries were about the same as the regional average.

Finfish resources showed first signs of fishing impact, especially in the internal reefs. Sizes of finfish were small, suggesting impact from fishing and, although line fishing was mostly practised, spear diving was also common, even at night. The target species were Scaridae, Serranidae (*Plectropomus areolatus, P. laevis* and *P. leopardus*), Lethrinidae, Siganidae, Acanthuridae and Lutjanidae. This practice normally rapidly impacts the average size of fish. Herbivores, especially Acanthuridae and Scaridae, constantly dominated the fish assembly. Size ratios were low for selected families, large carnivores were rare and top predators (sharks) were absent.

Invertebrate resources: Andra

Reefs within the main lagoon and the barrier-reef slope were generally very suitable for giant clams (Tridacnidae).There was a complete range of giant clams present, even species that are becoming rare in other parts of the Pacific. However, only small numbers of the larger clams (*Tridacna gigas*, *T. squamosa* and *Hippopus hippopus*) were recorded. *T. derasa* was absent from records. Giant clam density was low for most species, suggesting that stocks are heavily impacted by fishing, although a full range of size classes was generally present. Despite the low abundance of the larger species (*T. squamosa* and *T. gigas*), their continued presence is promising for conservation efforts. If fishing controls can be instituted, natural recovery may still be possible.

The commercial topshell (*Trochus niloticus*) was not common. Considering the scale of habitat available, the nutrient profile of the system and presence of other grazing gastropods (e.g. *Tectus pyramis*), trochus were considered to be depleted. However, despite being recorded at very low density, the small trochus shells recorded suggested recent successful spawning of trochus and ongoing recruitment. Green snail (*Turbo marmoratus*) was absent in this survey. Both blacklip (*Pinctada margaritifera*) and goldlip pearl oysters (*P. maxima*) were recorded at Andra and habitat conditions are very suitable for oyster (pearl) culture. Densities are not sufficient to encourage commercial fishing of shell, but would provide ample broodstock for any hatchery venture.

A comprehensive range of sea cucumber species was recorded at Andra. A range of very suitable habitats and depths were present, especially the sheltered, rich lagoon benthos. The larger-than-usual scale of the white teatfish fishery in the lagoon and passages makes it a potentially excellent provider of income. However the level of fishing pressure here is among the highest ever recorded in any white teatfish fishery surveyed by PROCFish in the Pacific. High-value sandfish (*Holothuria scabra*) were recorded close to Andra, but occurrence and density measures revealed that most of the population had been harvested by fishers. Presence and density data collected suggest that most sea cucumber stocks are, or have been, under high fishing pressure. Most species are now depleted across the site and in need of an extended period of recovery and increased levels of protection from fishing.

Recommendations for Andra

- Either the NFA or the Ailan Awareness group support and assist the community's desire to draft its own fisheries management plan with the management plan extended to include additional coastal issues, e.g. waste management.

- As part of the fisheries management plan, community fisheries management measures be effectively implemented and compliance with rules be enforced. Management measures suggested are as follows:
  - Spearfishing be controlled and spearfishing at night be banned.
  - The use of large nets for fishing in the lagoon be regulated.
  - Establishment of MPAs be considered as a possible management tool. (The western side of the pass has limited fishing access due to the conflict of interest between fishers from the two villages so this area would be ideal as an MPA.)
  - A monitoring system be put in place to follow further changes in finfish and invertebrate resources.

- Strict controls be implemented on the fishing of the commercial topshell (*Trochus niloticus*) to ensure there is a future for this fishery. Stock should be 'rested' from fishing for a medium term (3–5 years, or until densities at the major fishing areas recover to at least 500 individuals per ha). However, if any ongoing fishing needs to occur, authorities should ensure that only large, 'A' grade product is caught and commercialised.

- The white teatfish fishery in the lagoon bordering Andra (and the passages) be protected to ensure it remains a potentially excellent provider of income. It is critical to ensure that some areas are protected to maintain 'patches' of broodstock at high density, and therefore secure production of the next generation of stock.

Results of fieldwork in Tsoilaunung

Tsoilaunung island group is the eastern group of islands in Lovongai District of New Hanova in New Ireland Province, located at latitude 2°26′S and longitude 150°30′E, and about 23 km long and 2 km wide. The northern group is divided into wards 4 and 5, both made up of 8 islets that are within the PROCFish/C study area. The Provincial Elected Representative, together with the Island or Area Council is the community decision-making institution. The sandy islands are separated from the mainland by a shallow, sandy lagoon. Fibreglass skiffs and outboard motors are the principle mode of transport to Kavieng (1 hour by boat) and between islands, but dugout canoes are used mainly for fishing. The inhabitants of these islands are fishers rather than farmers and depend heavily on marine products for food and income. The fishing area in Tsoilaunung is accessible to all. Invertebrate resources are fished the hardest since they are the most easily accessed species. Other sources of income are the sale of sago starch and sago thatch (for roofing), mangrove wood, fish and lobsters. Although some of the islanders own land on the mainland, farming is done only by a few people. Bartering is common between the island residents and those of the New Hanova and New Ireland mainland; islanders exchange fish for garden produce or wooden canoes.

Socioeconomics: Tsoilaunung

Fisheries are the most important source of income for the people on Tsoilaunung. Half of all households depend on fisheries for first and another quarter of all households for second income. Handicraft marketing is the second most important source of revenue. Agriculture and salaries are of minor importance. Fisheries are also the most important source of protein. All households eat fresh fish, invertebrates and canned fish. Fresh-fish consumption (~35 kg/person/year) and invertebrate consumption (11.3 kg/person/year) are moderate, about average for the region and much higher than indicated for Papua New Guinea nationwide. The low consumption of canned fish confirms that purchased foods are limited.

The average household expenditure level is lower than across all four PROCFish sites in Papua New Guinea, indicating that the people on Tsoilaunung are self-sufficient in terms of seafood and agricultural produce and that, overall, the living standard is relatively low on the island.

Finfish fishing is done by males and females with females fishing along the sheltered coastal reef for subsistence and in the lagoon for both subsistence and sale. Males target the lagoon and outer reef mainly for commercial purposes. Females dominate reeftop, soft-benthos and mangrove gleaning; however, both genders are heavily involved in the commercial bêche-de-mer fishery when the season is open. Females do not participate in trochus and lobster collection as it requires free-diving at the back- and outer reef. Most fishing is done using paddling canoes, but some motorised boats are also available.

Finfish fishing is performed using various techniques; handlining is the main method used at the sheltered coastal reef, handlining and spear diving at the lagoon and outer reef. Deep-bottom lines and gillnets are mainly used at the outer reef, rarely in the lagoon. Apparently, the use of *Derris derris* fish poison at night is still common. Invertebrate fishers collect regularly from the reeftops, soft benthos and mangroves. Catches mainly serves subsistence needs on Tsoilaunung. However, commercial catches estimated for bêche-de-mer and trochus are substantial.

Finfish resources: Tsoilaunung

The status of finfish resources in Tsoilaunung was moderate. Density and biomass of finfish were the second-highest in the country, and biodiversity was high compared to the regional average, although the lowest in the country. A lack of large-sized species was common to all habitats. Low average sizes were common for the most-caught families, especially Lethrinidae. As in Andra, a total lack of top predators was noted here, together with a high level of shark fishing. Presence of crown-of-thorns starfish was noted.

The outer reefs were healthy, with relatively high live-coral cover (although the lowest in the country). The outer reefs were the richest also in terms of finfish composition and biomass: high biodiversity, large sizes, high biomass and density, both the highest among all outer reefs in the country, characterised this habitat.

However, coral conditions at specific stations were poorer than at Andra. In the intermediate and coastal reefs, finfish resources were impoverished: fish density, biomass, biodiversity, and average size were fairly low. A consistent dominance of herbivores was noted. The low abundance of carnivores in the two soft-bottom habitats (coastal and intermediate reefs), is most probably a result of intense fishing, mainly targeting emperorfish.

Invertebrate resources: Tsoilaunung

The shallow water of the main lagoon and the barrier-reef slope was suitable for clams, although the western shores within the lagoon were mostly sandy. The range and coverage of giant clam species were relatively complete; even the largest species, *Tridacna gigas*, becoming rare in other parts of the Pacific, was present. Although *T. gigas, T. squamosa, and Hippopus hippopus* were present, their density was low. *T. derasa* was absent. The density of the more common, smaller giant clam species, such as *T. maxima*, was moderate to low. The smallest species (*T. crocea*) was found at moderate density. A full range of size classes for giant clams was recorded in Tsoilaunung but the largest size classes were not particularly common. The lower density of *T. maxima* and *T. crocea* and the rareness of the larger species support the assumption that clam stocks are moderately to heavily affected by fishing.

Habitat for *Trochus niloticus* at Tsoilaunung was suitable and sufficient to support significant numbers of this commercial topshell. However, although trochus were well distributed around reefs, they occurred at low density. Presence, and density records suggest stocks are severely over-fished and well below the level at which commercial fishing is recommended. However, there was evidence of recent successful spawning and ongoing recruitment, in that a full range of shell sizes of trochus was recorded in survey. This is a promising result for any future for the fishery. Although no green snail (*Turbo marmoratus*) was recorded during the survey, this species may still be present but at depleted or commercially extinct abundance. The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common.

The sheltered, rich lagoon benthos was very suitable for sea cucumbers, and a range of habitats and depths was present. A comprehensive range of sea cucumber species was recorded at Tsoilaunung, although some species were notable by their absence (e.g. curryfish, *Stichopus hermanni*). Presence and density data suggest that stocks have been under very high fishing pressure and are now at extreme levels of depletion. High-value sandfish (*Holothuria scabra*) were recorded, but few large individuals were recorded in the stock, and immature and newly mature individuals were being harvested by fishers.

Recommendations for Tsoilaunung

- Either the NFA or the Ailan Awareness group support and assist the Wards' desire to draft their own fisheries management plan with the plan expanded to also include any positive outcomes from the Wildlife Conservation Society study of the effect of prolonged *tabu* on reef resources, as well as the discussions already started to establish one or more MPAs.

- No commercial finfish fishing be allowed as the current state of resources appears sustainable for subsistence use only.

- Spear diving and reef-shark fishing be regulated.

- Fishing controls be established for giant clams, to enable natural recovery, which is still possible for the larger giant clam stocks and assured for the smaller species. Remnant stocks of *T. gigas* and *T. derasa* be completely protected from fishing in order that they can act as a locally adapted broodstock to regenerate the populations of the Kavieng area.

- Trochus fishing be controlled to allow the population to rebuild. If fishing controls can be established to protect remnant stocks, there is a future for this fishery. Stocks need to be 'rested' from fishing for a medium term (5–10 years, or until densities at the major fishing areas recover to 500–600 per ha).

- Strict controls on sea cucumber fishing be implemented to allow a resting period for these depleted resources. Under the present stock status, it is difficult to see a justification for continued commercial fishing at this site. A resting period is needed to allow the immature *Holothuria scabra* to reach full maturity and produce future populations of this valuable species.

Results of fieldwork in Sideia

Sideia is a high, mountainous and densely forested island. The community is scattered along the coast in small hamlets and there are no large village communities. There are no roads and people move around by foot, canoe or boat. People are farmers rather than fishers. There are a few coconut plantations in the area, and people also depend on bêche-de-mer and trochus for income. The island's rich forest resources remain largely untapped. There is a local market three times a week at the Catholic mission, where locals sell produce, but people also travel to Alotau to sell their produce. The island is bordered by fringing reefs, mangroves (with resident crocodiles), and a number of semi-lagoons with shallow pools and pseudo barrier reefs. A larger barrier reef extends out from the northwest and northeast corners of the island and is more intact on the eastern side. The reefs are generally land-influenced and on the protected side of Sideia Island, where the current is limited. Coral cover was found to be generally good throughout the system, with complex substrates. Reef faces were generally steep drop-offs, with little in the way of shoaling reef on the outside.

Socioeconomics: Sideia

Fisheries are the most important source of income for the people on Sideia. Seventy per cent of all households depend on fisheries for first and another 20% of all households for second income. Agriculture also plays an important role as complementary income source. Salaries, private business and handicrafts are of minor importance. All households eat fresh fish and invertebrates and 90% also eat canned fish. Fresh-fish consumption is relatively low (~24 kg/person/year), but higher than the country average. Invertebrate consumption is moderate (9.5 kg/person/year). The low canned fish consumption confirms that purchased foods are limited and that people in Sideia are highly self-sufficient in terms of food supply.

Finfish fishing is done by males and females. Female fishers mainly target the sheltered coastal reef for subsistence. Males target the lagoon and the outer reef mainly for commercial purposes. Females dominate the collection of invertebrates in mangroves, often combined with reeftop, soft-benthos and/or intertidal collection. However, both genders are heavily involved in fishing for bêche-de-mer when the commercial season is open. Females do not participate in trochus, lobster or other invertebrate collection, as it involves free-diving at the back- and outer reefs. Most fishing is done using paddling canoes; some sail canoes are also available. Finfish are caught using various techniques; mainly handlines, together with spear diving, handheld spearing or trolling in the lagoon and particularly at the outer reef. *Derris derris* fish poison is still used, but not to a large extent.

Finfish resources: Sideia

The status of finfish resources in this site was relatively good. The reefs were naturally rich and cover of live coral was good and diverse. Fishing at this site was mostly concentrated in the outer reefs and mostly done by handline (over grounds 60–100 m deep), therefore targeting carnivores. Some spearfishing was also practised, even at night.

The finfish community was diverse and fish were sighted in schools (mainly herbivores). Sightings of *Bolbometopon muricatum* and *Cheilinus undulatus*, although of small-to-moderate sizes, were fairly frequent. Large carnivores (e.g. groupers) and top predators (sharks) were also quite common.

These observations, along with the analysis of the collected data, suggest that Sideia is a relatively healthy site. However, some signs of fishing impacts were noticed: Lethrinidae were small in size; the finfish community was dominated by herbivores in both habitats, possibly due to the character of the reef habitat, which was mainly composed of hard bottom; and fish were wary of divers, interpreted as fear induced by spearfishing. When analysed at the reef-habitat level, resources appeared in better condition (higher density and biomass) at the back-reefs than at the outer reefs. Biodiversity was, however, higher at the outer reefs.

Invertebrate resources: Sideia

The sheltered inshore and more exposed barrier reefs at Sideia provided a range of habitats suitable for giant clams. There was a complete range of giant clam species present at Sideia. Clam density was moderately high for the more common, smaller species, e.g. *Tridacna maxima*, and relatively high for larger species, e.g. *T. squamosa* and *Hippopus hippopus*. The largest species, *T. gigas* and *T. derasa*, were noted, but at low density. This suggests that the fishery is only moderately impacted here compared to other regions of the Pacific, and recovery of the fishery should be more easily achieved through simple controls on fishing. *T. gigas*, the true giant clam, was still present at Sideia and recorded both in large and smaller sizes. This survey suggests there was still recruitment of *T. gigas* around Sideia in recent years.

Trochus (*Trochus niloticus*) at Sideia was rare and severely overfished. This statement is based on the scale of habitat available, the wide distribution but low density of trochus, the density of other grazing gastropods (e.g. *Tectus pyramis*) and evidence from meetings with trochus fishers, who continue to fish stocks for only 2–8 pieces per trip. Presence and density records suggest stocks are below the level at which commercial fishing is recommended and in need of protection to allow a recovery. No green snail was recorded during the survey. The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common at Sideia.

Considering the variety of suitable environments present at Sideia, the range of sea cucumber species recorded was not as extensive as may have been expected. Presence and density data collected in survey suggest that stocks have been under very high fishing pressure and are now at extreme levels of depletion. The condition of reef and other benthic substrates around Sideia was notably ‘dirty’ compared to other places in the Pacific.

Recommendations for Sideia

- The community seek further assistance, either from NFA or NGOs to undertake underwater stock assessment and monitoring of major resource status. Results may be useful to establish community regulations on the various fisheries, in particular commercial harvesting of bêche-de-mer, trochus and others.

- Immediate fisheries management intervention actions be taken to reduce the current exploitation level, in particular on mangrove and reeftop fisheries.

- Spear diving be regulated and night spearfishing banned.

- Use of *tabu* areas be considered as a primary management measure.

- The giant clam fishery be controlled by protecting high-density areas and larger-sized clams.

- Trochus (*Trochus niloticus*) fishing be urgently controlled to ensure there is a future for this fishery. Stock should be 'rested' from fishing for a medium term (5–10 years, or until densities at the major fishing areas recover to 500–600 per ha).

- Strict controls on sea-cucumber fishing be implemented to allow a medium- to long-term resting period to allow these important resource stocks to recover. Under the present stock status, commercial fishing needs to cease.

Results of fieldwork at Panapompom

Paneati-Panapompom is an atoll-like formation that can be reached in two hours by dinghy from Misima. Panapompom is a high island in the centre of a large lagoon system. The main settlement of Panaeati lies on the northern border of the lagoon and is another high island. The population of both islands is around 3000–3500 people and the main income sources are copra, bêche-de-mer, trochus shells, and betel nut. The islanders also trade sailing canoes with other islanders in the area and are well-known for their pigs. There are some small, low sand islands on the encircling barrier reef. Numerous shallow and deep passages link the lagoon to the open ocean. The back-reef area was mainly sand, and the reeftops were covered in rubble and boulder habitat. The reef fronts were complex, rich in coral, and dropped off steeply.

Socioeconomics: Panapompom

Fisheries are the most important source of income for the people on Panapompom. Forty-three per cent of all households depend on fisheries for first income and another 33% of all households for second income. Other sources, mainly handicrafts, also play an important role as first (27%) and second (40%) income source. Agriculture supplies 20% of all households with first income and salaries 13%. Fisheries are an important source of protein; all households eat fresh and canned fish, and most also eat invertebrates. Fresh-fish consumption (~37.4 kg/person/year) is among the highest of all PROCFish sites surveyed in the country. Invertebrate consumption is rather low (1.8 kg/person/year) and the low canned-fish consumption confirms that purchased foods are limited and that people on the high island of Panapompom are highly self-sufficient in terms of food supply.

Finfish fishing is done by males and females, although females fish far less than males. Most fishing takes place in the lagoon; males also target the outer reef. Sheltered coastal reef fishing mainly serves subsistence needs, while lagoon and outer-reef fishing is mostly commercially oriented. Most fishing is done using paddling canoes, but some sail canoes are also available.

Various techniques are used for finfish fishing, mainly handlines in the sheltered coastal reef. Handlines are complemented by trolling or deep-bottom lines in any of the other habitats targeted, including the lagoon, outer reef or a combination of both during one fishing trip. *Derris derris* fish poison is still used, but not to a large extent.

Invertebrate fishing is only for subsistence, except for the commercial bêche-de-mer fishery, which operates during the 6-month open season, accounts for ~95% of the total annual reported catch and is considered the island's major income source. The fishing pressure calculated for the bêche-de-mer fishery is alarmingly high and also high for the soft-benthos and reeftop fisheries; immediate fisheries management interventions are needed.

Finfish resources: Panapompom

The status of finfish resources in Panapompom was found to be good. Fishing in Panapompom has decreased in the past few years due to the decommissioning of the nearby goldmine, which was acting as the main trading centre. This might partially explain the rich condition of the reefs and high fish abundance. Furthermore, fishing is done exclusively from sailing outrigger canoes, imposing less pressure on the reefs compared to fishing from motorised boats.

The reefs appeared healthy and rich in live-coral cover, more so than the other country sites. Fish diversity was highest among the country sites, particularly in the intermediate and outer reefs. The trophic community was equally composed of herbivores and carnivores, further suggesting that the ecosystem is healthy. Large parrotfish and surgeonfish and large groupers were fairly abundant. Lethrinidae, Lutjanidae and Mullidae were present at all habitats in higher density than at the other sites. At the reef habitat level, resources were very variable: the coastal reefs were particularly rich in density and biomass, displaying the highest values of all the habitats in Panapompom as well as among all the coastal reefs surveyed in the country.

The intermediate reefs presented record high levels of biodiversity for this type of reef and size ratios were also quite high. The fish community composition was diverse and rich, with several families and many species contributing to the majority of the biomass. Trophic composition was well balanced among carnivores, herbivores and plankton feeders. These are signs of a rich and healthy ecosystem. Balistidae, Lethrinidae and Lutjanidae were small in size, probably indicating some fishing pressure on these selected families. Lutjanidae and Lethrinidae together composed more than half of the catches for lagoon reefs. However, the back-reefs displayed the lowest values of biomass, size and size ratio for this site and biodiversity was low, even compared to values in Andra and Sideia. First signs of fishing impact were visible in small size ratios of Lethrinidae. Other signs of fishing impact were visible in the western part of the site, where fishing was carried out also by the people of the larger island of Paneati. The unusually high density and biomass of coastal reefs might have been caused by the small area closed to fishing, which was recently established as a result of a community decision.

Invertebrate resources: Panapompom

The shallow-water lagoon and surrounding barrier reef were very suitable for clams, although the best reef habitats were not common around the shores of Panapompom Island itself. There was a complete range of giant clam species present. Giant clam density at Panapompom was reasonably high for the most common species *Tridacna maxima*. Although a 'full' range of sizes was present, the lack of clams >15 cm, especially during shallow-reef assessments, indicates an impacted stock. *Hippopus hippopus* was relatively common, although *T. crocea*, *T. squamosa* and *T. derasa* were more depleted. Despite the low abundance of the larger species (*T. squamosa*, *T. derasa* and *T. gigas*), their continued presence is promising for conservation efforts.

There was extensive habitat suitable for the commercial topshell (*Trochus niloticus*). However, the distribution and abundance of trochus reflect a severely overfished resource and suggest that stocks are below the level at which commercial fishing should proceed and are in need of urgent protection from fishing. Presently, the trochus stock is dominated by mostly large, old shells, with no strong record of ongoing recruitment. Protection of this broodstock resource will result in recruitment and stock growth over time. If suitable trochus fishing areas can be successfully protected from fishing, some aggregation of the remaining adult trochus might facilitate recovery. The giant turban shell (*Turbo marmoratus*) was absent in this survey. The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common.

The range of sea cucumber species recorded at Panapompom was not as extensive as expected for a site with diverse habitats and depths, possibly because of the oceanic influence that prevailed in most of the lagoon. Sea cucumber fishing remains an important activity at Paneati-Panapompom and other fishing grounds at Conflict Atoll and reefs north of these islands. Presence and density data collected suggest that sea cucumber stocks have been under very high fishing pressure and are now at extreme levels of depletion.

Recommendations for Panapompom

- The community seek assistance, either from NFA or NGOs to improve marketing conditions, especially prices paid by mobile buyers; and undertake underwater stock assessment and monitoring of major resources. Results may be useful to establish community regulations for finfish fisheries and, in particular, commercial harvesting of bêche-de-mer and trochus.

- Immediate fisheries management interventions are needed to reduce the alarmingly high fishing pressure on soft-benthos and reeftop fisheries.

- There be no further increase in finfish catches.

- Fishing controls on giant clams be established, especially for the larger species (*Tridacna squamosa*, *T. derasa* and *T. gigas*). Once controls are in place, natural recovery of stocks is probable.

- Stocks of the commercial topshell (*Trochus niloticus*) be immediately protected from fishing to ensure there is a future for this fishery. An extended resting period is suggested for the medium term (5–10 years), until densities at the major fishing areas recover to 500–600 per ha.

- Strict controls be implemented on the sea cucumber fishery to allow an extended resting period for these severely depleted resources. Commercial fishing needs to cease.

RÉSUMÉ

Les agents de la composante côtière du Programme régional de développement des pêches océaniques et côtières dans les PTOM français et pays ACP du Pacifique (PROCFish/C) ont conduit des travaux de terrain sur quatre sites de Papouasie-Nouvelle-Guinée, de juin à novembre 2006. La Papouasie-Nouvelle-Guinée est l'un des 17 États et Territoires insulaires océaniens qui font l'objet d'enquêtes échelonnées sur 5 à 6 ans, conduites dans le cadre de PROCFish ou de son programme associé CoFish (projet régional de développement de la pêche côtière) [3].

Le but de ces enquêtes était de recueillir des données de référence sur l'état des ressources récifales et de combler l'énorme manque d'informations qui entrave la gestion efficace de ces ressources.

Le projet visait en outre à obtenir les résultats suivants :

- Réalisation de la première évaluation comparative exhaustive des ressources récifales de plusieurs pays (poissons, invertébrés et aspects socioéconomiques) jamais entreprise en Océanie, selon des méthodes identiques sur chaque site ;
- Diffusion de rapports nationaux comprenant un ensemble de « profils des ressources halieutiques récifales » pour les sites étudiés dans chaque pays, servant de base au développement de la pêche côtière et à la planification de sa gestion ;
- Élaboration d'un ensemble d'indicateurs (ou de points de référence de l'état des stocks), pour faciliter l'établissement de plans de gestion des ressources récifales à l'échelle nationale et locale, et celui de programmes de suivi, et
- Élaboration de systèmes de gestion des données et de l'information, dont des bases de données régionales et nationales.

Les enquêtes conduites en Papouasie-Nouvelle-Guinée comprenaient trois volets (poissons, invertébrés et aspects socioéconomiques) sur chaque site. Une équipe de cinq chercheurs du projet et de nombreux stagiaires locaux détachés par le Service national des pêches, *The Nature Conservancy*, et *Conservation International* a enquêté sur deux sites par sortie. Durant les travaux de terrain, l'équipe s'est attachée à renforcer les capacités de ses homologues locaux en les formant aux méthodes d'enquête et d'inventaire utilisées dans chaque domaine étudié, notamment la collecte de données et leur saisie dans la base de données du Projet.

Les quatre sites retenus en Papouasie-Nouvelle-Guinée étaient les suivants : Andra, Tsoilaunung, Sideia et Panapompom.

Chaque site sélectionné devait répondre aux critères particuliers suivants :

- 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 ;

[3] 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.

- la taille du site devait être appropriée ;
- le site devait abriter des habitats divers ;
- 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 de Papouasie-Nouvelle-Guinée.

Résultats des travaux de terrain sur l'île d'Andra

Andra est une île corallienne située sur le récif barrière au nord de l'île haute de Manus à 1°55' S par 146° 57' E. Sa taille est petite : 1 km de long par 0,2 km de large, et son orientation par rapport aux vents dominants d'Est permet une exploitation quasi permanente du récif extérieur. Le trajet de Lorengau (le centre provincial) à Andra prend environ une heure en canot à moteur, principal moyen de transport dans ces îles. La communauté insulaire consiste en un grand village dont la population est répartie en clans. Il n'y a pas de chef suprême de l'île, mais des chefs de clan ainsi qu'un conseil de village. Ce sont les clans qui sont propriétaires des zones récifales, et leurs droits de propriété couvrent une zone délimitée par le littoral de l'île et par le récif extérieur, et qui s'étend jusqu'à mi-distance du village d'Ahus, à l'est, et du village de Ponam, à l'ouest. Seuls les habitants d'Andra ont droit d'accès aux récifs extérieurs situés en face de l'île. Peu de résidents d'Andra possèdent des terres sur l'île principale de Manus, et beaucoup sont des pêcheurs plutôt que des agriculteurs. Leur régime alimentaire est basé sur le « sagou », une fécule extraite des palmiers sagoutiers qui poussent naturellement sur l'île. La farine de sagou est habituellement utilisée dans la cuisine pour accompagner les produits de la mer. Les ménages tirent également des revenus de la vente du sagou. Les villageois troquent fréquemment le poisson et les produits de leur jardin avec les habitants de Manus. La communauté villageoise d'Andra est fortement tributaire des ressources marines pour son alimentation et pour ses revenus, qu'elle tire de la vente de trocas, de bêche-de-mer, de chaux en poudre et de poissons.

Conclusions socio-économiques : Andra

La pêche est la principale source de revenus de la population d'Andra. Pour gagner de l'argent, tous les ménages dépendent de cette activité, principale source de revenus pour la moitié d'entre eux, et source de revenus secondaire pour l'autre moitié. Pour plus de la moitié des ménages, la production et la vente de chaux (coraux) est la principale source de revenus, la pêche étant une source de revenus secondaire. L'agriculture et l'emploi rémunéré sont des sources de revenus de moindre importance. Première source de protéines, la pêche revêt une importance capitale pour la nutrition de la population : tous les ménages consomment du poisson et des invertébrés frais et, de temps à autre, du poisson en conserve. Le niveau de consommation de poisson frais est modéré (environ 36 kilos par personne et par an), mais le taux de consommation d'invertébrés est assez faible (6,5 kilos par personne et par an).

Le niveau moyen des dépenses des ménages est le plus élevé des quatre sites étudiés par les agents du projet en Papouasie-Nouvelle-Guinée. Les causes sont l'isolement géographique d'Andra, qui augmente les coûts de transport, et la nécessité d'acheter des denrées alimentaires pour compléter des produits de la mer en raison de la rareté de produits agricoles sur l'atoll.

Les poissons sont pêchés par les hommes, qui pratiquent la pêche sur l'extérieur du tombant du récif à des fins commerciales, et par les femmes, qui se concentrent sur la pêche vivrière dans les zones récifales abritées et dans le lagon. Le ramassage est une activité principalement féminine, mais hommes et femmes participent très activement à la pêche commerciale de l'holothurie lorsque la saison est ouverte. Les femmes ne prennent pas part à la collecte des trocas, pêchés en apnée par les hommes sur l'arrière-récif et sur le récif extérieur. Les sorties de pêche se font généralement en pirogue, mais les canots à moteur sont également utilisés, notamment sur le récif extérieur.

Ressources en poisson : Andra

Les enquêtes effectuées à Andra ont permis de constater que les ressources en poisson sont peu ou modérément affectées par la pêche, le principal impact se faisant sentir dans les zones récifales externes ciblées par la pêche commerciale. L'habitat est en bonne santé, avec un taux élevé de couverture corallienne vivante, en deuxième place des quatre sites du pays, et en 15e place pour la région. Force est de constater, cependant, que le taux de couverture des coraux *Acropora* est très faible.

Les pêcheurs d'Andra et ceux du village de Ponam se disputent la zone située à l'ouest de la passe, et les activités de pêche de ces deux groupes y sont limitées. La biodiversité y est beaucoup plus riche et les tailles des poissons nettement plus grandes que de l'autre côté de la passe. Cette zone constitue donc, de fait, une aire marine protégée naturelle. Les résultats de l'enquête socioéconomique laissent à penser que, dans l'ensemble, la pression de pêche est modérée, mais des conditions spécifiques à diverses zones récifales ont également été constatées.

Dans l'ensemble, les ressources en poisson sont naturellement abondantes, avec une riche biodiversité et une densité de poissons élevée (en deuxième place pour le pays), et la biomasse la plus importante du pays, ces deux valeurs étant élevées pour la région. Les valeurs de densité et de biomasse supérieures à la moyenne régionale sont plutôt représentatives des ressources présentes sur le récif extérieur, car les valeurs correspondantes pour les pêcheries côtières et lagunaires sont sensiblement égales à la moyenne régionale.

Les ressources en poisson accusent les premiers impacts de la pêche, notamment à l'intérieur du récif. La petite taille des poissons est révélatrice à cet égard et, si la plupart des pêcheurs pêchent à la ligne, la chasse au fusil harpon est également répandue, même de nuit. Les espèces ciblées sont les Scaridae (*Plectropomus areolatus, P. laevis* and *P. leopardus*), les Serranidae, les Acanthuridae et les Lutjanidae. Cette pratique entraîne normalement une diminution rapide de la taille moyenne des poissons. Les herbivores, notamment les Acanthuridae et les Scaridae, sont partout les mieux représentés. Les ratios de taille de certaines familles sont faibles, les grands carnivores sont rares et les grands prédateurs sont totalement absents.

Ressources en invertébrés : Andra

Dans l'ensemble, les récifs situés à l'intérieur du lagon principal et le tombant du récif barrière offrent des habitats très propices aux bénitiers (Tridacnidae). Les espèces de bénitiers sont toutes présentes, y compris des espèces qui se raréfient ailleurs dans le Pacifique. Cependant, les bénitiers de plus grande taille (*Tridacna gigas*, *T. squamosa* et *H. hippopus*) sont peu nombreux. Aucun spécimen de *T. derasa* n'a été observé. La faible densité de la plupart des espèces de bénitiers suggère que ces stocks sont fortement affectés par la pêche, bien que la gamme des classes de taille soit généralement complète. Quoique peu abondantes, les espèces de plus grande taille (*T. squamosa* et *T. gigas)* sont toujours présentes, ce qui augure favorablement pour les efforts de conservation. Ces espèces peuvent peut-être encore se reconstituer s'il est possible de prendre des mesures pour limiter la pêche.

Le troca commercial (*Trochus niloticus*) est peu commun. Étant donné l'étendue de l'habitat disponible, les disponibilités nutritionnelles du système et la présence d'autres gastéropodes brouteurs (par exemple *Tectus pyramis*), on peut considérer que ce stock est épuisé. Cependant, malgré la très faible densité constatée, la présence de petits trocas suggère qu'ils ont récemment réussi à se reproduire et que leur recrutement se poursuit. Le burgau (*Turbo marmoratus*) était totalement absent lors de l'enquête. L'huître perlière à lèvres noires (*Pinctada margaritifera*) et l'huître perlière à lèvres dorées (*P. maxima*) ont été observées à Andra, où les conditions d'habitat sont tout à fait propices à la perliculture. Les densités ne sont pas suffisantes pour encourager des prélèvements de ces espèces à l'échelle commerciale, mais elles le sont largement pour fournir des géniteurs à une éventuelle écloserie.

La gamme d'espèces d'holothurie observée à Andra est très complète. Les habitats et les profondeurs convenant à ces espèces sont multiples, notamment dans le benthos lagunaire, habitat à la fois riche et protégé. L'abondance inhabituelle des holothuries à mamelles blanches dans le lagon et dans les passes font de cet animal une excellente source potentielle de revenus. Cependant, le niveau de pression de pêche exercé sur ces zones est l'un des plus élevés jamais observés par les chercheurs du projet PROCFish dans les pêcheries d'holothurie à mamelles blanches d'Océanie.

Des holothuries de sable (*Holothuria scabra*) de haute valeur commerciale ont été observées près d'Andra, mais les mesures d'occurrence et de densité révèlent que la majeure partie de cette population a déjà été pêchée. Les valeurs de présence et de densité mesurées donnent à penser que la plupart des stocks d'holothuries subissent, ou ont déjà subi, une forte pression de pêche. La plupart des espèces sont maintenant épuisées sur toute la superficie du site. Toute reconstitution du stock exigera donc beaucoup de temps ainsi qu'un degré plus élevé de protection vis-à-vis des pêcheurs.

Recommandations pour Andra

- Le Service national des pêches ou l'ONG *Ailan Awareness* devraient appuyer les efforts de la communauté locale, qui souhaite élaborer son propre plan de gestion de la pêche, et la portée de ce dernier devrait être élargie afin de traiter d'autres problématiques affectant les zones côtières, comme la gestion des déchets.

- Appliquer effectivement les mesures de gestion communautaire énoncées dans le plan de gestion de la pêche et faire respecter les règlements. Les mesures suivantes sont suggérées :
    - Restreindre la pêche au fusil harpon et l'interdire de nuit.
    - Réglementer l'utilisation des grands filets dans le lagon.
    - Envisager la création d'aires marines protégées comme outil de gestion (la pêche n'est pas intensive à l'ouest de la passe en raison du conflit d'intérêt qui oppose les habitants de deux villages, et cette zone est donc une candidate idéale à la création d'une aire marine protégée).
    - Mettre en place un système de suivi permettant de surveiller l'évolution des ressources en poissons et en invertébrés.

- Imposer des contrôles stricts sur la pêche du troca commercial (*Trochus niloticus*) pour pérenniser cette pêcherie. Le stock devrait avoir le temps de « récupérer » à moyen terme, c'est-à-dire que la pêche devrait être fermée pendant 3 à 5 ans, ou jusqu'à ce que les densités reviennent aux environs de 500 individus/hectare dans les principales zones exploitées. Cependant, s'il est impossible de fermer cette pêcherie, les autorités devront prendre les mesures nécessaires pour autoriser exclusivement la prise et la vente de trocas de catégorie « A ».

- Protéger la pêcherie d'holothuries à mamelles blanches dans le lagon aux alentours d'Andra (et dans les passes) pour préserver son excellent potentiel économique. Assurer l'essentielle protection de certaines zones pour conserver des « poches » de forte densité de géniteurs, et assurer ainsi la production de la génération suivante.

Résultats des travaux de terrain à Tsoilaunung

L'archipel de Tsoilaunung est situé dans la zone orientale du district de Lovongai, dans la région de la Nouvelle-Hanovre (Province de la Nouvelle-Irlande). Long d'environ 23 km et large de 1 km, il se trouve à 2°26´S de latitude et 150°30´E de longitude. Les îles septentrionales de l'archipel sont regroupées en deux circonscriptions de huit îlots (la quatrième et la cinquième) situées dans la zone étudiée dans le cadre du projet PROCFish/C. Les décisions de la communauté sont prises par le représentant élu de la Province et par le Conseil régional (Conseil des îles). Ce sont des îles sablonneuses qui sont séparées de l'île principale par un lagon sablonneux et peu profond. La pirogue en fibre de verre équipée d'un moteur hors-bord est le moyen de transport le plus communément utilisé pour passer d'une île à l'autre ou se rendre à Kavieng (une heure de traversée), la pirogue traditionnelle étant généralement préférée pour la pêche. Pêcheurs plutôt qu'agriculteurs, les habitants de ces îles sont fortement tributaires des produits de la mer pour leur subsistance et leurs revenus. La zone de pêche de Tsoilaunung est accessible à tout le monde et les ressources en invertébrés sont les plus exploitées car ces espèces sont les plus faciles à atteindre. Les habitants tirent également des revenus de la vente de farine de sagou et de chaume de sagoutier (matériau de couverture), de bois de palétuvier, de poisson et de langoustes également des sources de revenus. Certains habitants de ces îles possèdent de la terre sur l'île principale, mais peu d'entre eux pratiquent l'agriculture. Le troc se pratique couramment avec les habitants de la Nouvelle-Hanovre et de l'île principale de Nouvelle-Irlande, le poisson s'échange alors contre des produits du jardin ou des pirogues en bois.

Conclusions socio-économiques : Tsoilaunung

La pêche est la principale source de revenus des habitants de Tsoilaunung, où elle est la première source de revenus pour la moitié des ménages, et la deuxième source pour un quart d'entre eux. La vente d'objets d'artisanat est la deuxième source de revenus, l'agriculture et l'emploi rémunéré demeurant minoritaires. La pêche est également la principale source de protéines. Tous les ménages consomment du poisson et des invertébrés frais, ainsi que du poisson en conserve. La consommation de poisson frais (environ 35 kg par personne et par an) et d'invertébrés (11,3 kg par personne et par an) est modérée. Elle correspond approximativement à la moyenne régionale, mais est beaucoup plus élevée que la moyenne nationale en Papouasie-Nouvelle-Guinée. La faible consommation de poisson en conserve confirme que les achats de denrées alimentaires sont peu fréquents.

Le niveau moyen des dépenses des ménages est le plus bas des quatre sites étudiés par les agents du projet PROCFISH en Papouasie-Nouvelle-Guinée, ce qui indique que les habitants de Tsoilaunung sont autosuffisants en produits de la mer et en produits agricoles, et que leur niveau de vie est assez bas.

La pêche des poissons est pratiquée par les hommes comme par les femmes, ces dernières pratiquant la pêche vivrière sur les récifs côtiers abrités, et la pêche à des fins commerciales sur ces mêmes récifs et dans le lagon. Les hommes pêchent dans le lagon et sur le récif extérieur, principalement aux fins de vente. Cependant hommes et femmes participent très activement à la pêche commerciale de l'holothurie lorsque la saison est ouverte. Les femmes ne prennent pas part à la pêche des trocas et des langoustes, qui nécessite des plongées en apnée sur l'arrière-récif et sur le tombant externe du récif. Les pêcheurs utilisent des pirogues la plupart du temps, mais disposent également de quelques canots à moteur.

Plusieurs techniques sont utilisées pour pêcher le poisson : sur les récifs côtiers abrités, la palangrotte est la méthode la plus courante, mais dans le lagon et sur le récif extérieur, ce sont la palangrotte et le fusil harpon. Les lignes pour la pêche profonde et les filets maillants sont surtout utilisés sur le récif extérieur mais rarement dans le lagon. Apparemment, les pêcheurs font encore fréquemment usage de poison à base de *Derris derris* la nuit. Les pêcheurs d'invertébrés exploitent régulièrement les crêtes des récifs, les fonds meubles et les mangroves, principalement pour subvenir à leurs besoins de subsistance. Selon les estimations cependant, de grandes quantités d'holothuries et de trocas sont capturées à des fins commerciales.

Ressources en poisson : Tsoilaunung

L'état des ressources en poisson est modérément bon. La densité et la biomasse de poisson s'inscrivent au deuxième rang pour le pays, et le taux de biodiversité est élevé par rapport à la moyenne régionale, mais c'est aussi le plus faible enregistré dans le pays. Les espèces de grande taille sont rares dans tous les habitats. Dans toutes les familles les plus pêchées, notamment les Lethrinidae, la moyenne des tailles est basse. Tout comme à Andra, on constate une absence totale de grands prédateurs, et la pêche des requins est intensive. La présence d'étoiles de mer *Acanthaster planci* a été constatée.

Les récifs extérieurs sont en bonne santé, avec un taux de couverture corallienne vivante relativement élevé, mais cependant le plus bas du pays. Les récifs extérieurs sont également les plus richement dotés en termes de composition par espèces et de biomasse. Cet habitat est caractérisé par une forte biodiversité et de grandes tailles, ainsi qu'une biomasse importante et une forte densité, ces deux valeurs étant les plus hautes de celles de tous les récifs extérieurs du pays.

Cependant, à certains endroits, les coraux sont en moins bon état qu'à Andra. Les ressources en poisson des récifs intermédiaires et côtiers sont appauvries : les valeurs de densité de poissons, de biomasse, de biodiversité et de taille moyenne sont assez basses. Les espèces herbivores sont prédominantes. La faible abondance des carnivores dans les deux habitats à fonds meubles (récifs côtiers et intermédiaires) résulte probablement d'opérations de pêche intensive ciblant surtout le poisson empereur.

Ressources en invertébrés : Tsoilaunung

Les eaux peu profondes du lagon principal et le tombant du récif barrière conviennent bien aux bénitiers, quoique le littoral occidental de l'intérieur du lagon soit surtout sablonneux. La gamme d'espèces de bénitiers présentes et la couverture par ces animaux sont relativement complètes. Même la plus grande espèce de bénitiers (*Tridacna gigas*) est représentée, alors qu'elle devient de plus en plus rare ailleurs dans le Pacifique. Les espèces *T. gigas*, *T. squamosa* et *Hippopus hippopus* sont présentes, mais leur densité est faible. L'espèce *T. derasa* est totalement absente. La densité des espèces plus communes comme *T. maxima*, de plus petite taille, varie de modérée à faible. La densité de la plus petite espèce (*T. crocea)*, est modérée. Une gamme complète de classes de taille de bénitiers a été observée à Tsoilaunung mais les plus grandes classes de taille ne sont pas particulièrement répandues. La densité plus faible de *T. maxima* et de *T. crocea*, ainsi que la rareté des espèces de grande taille, tendent à confirmer l'hypothèse d'un impact modéré, voire fort, de la pêche sur les stocks de bénitiers.

L'habitat de *Trochus niloticus* lui convient et il est suffisamment étendu pour accueillir des quantités considérables de cette espèce d'intérêt commercial. Cependant, bien que les trocas soient bien répartis sur les récifs, leur densité reste faible. Les observations de présence et de densité suggèrent que les stocks sont fortement surexploités et sont réduits à un niveau nettement inférieur au minimum recommandé pour la pêche commerciale. Cependant, la présence de toutes les tailles de classe de trocas lors de l'enquête indique qu'ils ont récemment réussi à pondre et que leur recrutement se poursuit. Cette constatation augure favorablement de l'avenir de cette pêcherie. Aucun burgau (*Turbo marmoratus*) n'a été observé lors de l'enquête. Il se peut que des individus de cette espèce soient encore présents, mais qu'elle soit appauvrie, ou si raréfiée qu'elle peut être considérée comme disparue au sens commercial. L'huître perlière à lèvres noires (*Pinctada margaritifera*) est assez bien représentée.

Bien abrité, le benthos lagunaire est riche et convient bien aux holothuries, offrant une bonne diversité de profondeurs et d'habitats. La gamme d'espèces d'holothuries observée à Tsoilaunung est assez complète, mais certaines espèces sont notoirement absentes, comme l'holothurie scissipare (*Stichopus hermanni*). Les données de présence et de densité sont indicatives d'une très forte pression de pêche et d'un épuisement extrême des stocks. Des holothuries à haute valeur commerciale (*Holothuria scabra*) ont été observées, mais les individus de grande taille sont rares, et les pêcheurs capturent maintenant les juvéniles et les jeunes adultes.

Recommandations pour Tsoilaunung

- Les habitants de la circonscription souhaitent élaborer leur propre plan de gestion de la pêche, et le Service national des pêches ou l'ONG *Ailan Awareness* devraient appuyer leurs efforts et les aider dans cette démarche. La portée du plan devrait également être élargie pour tenir compte d'éventuelles retombées positives de l'étude effectuée par la *Wildlife Conservation Society* sur l'efficacité d'un tabou de longue durée sur les ressources récifales, ainsi que des discussions déjà entamées en vue de la création d'une ou de plusieurs aires marines protégées.

- Totalement interdire la pêche commerciale des poissons, seule la pêche vivrière paraissant durable au vu de l'état actuel des ressources.

- Réglementer la pêche au fusil harpon et la pêche des requins de récif.

- Strictement limiter la pêche des bénitiers pour permettre la reconstitution naturelle des stocks, encore possible pour les espèces de grande taille, et assurée pour les espèces de plus petite taille. Imposer une protection absolue et interdire la pêche des derniers stocks de *T. gigas* et de *T. derasa,* qui sont adaptés aux conditions locales, et peuvent servir à fournir les géniteurs qui assureront la reconstitution des populations dans la région de Kavieng.

- Strictement limiter la pêche des trocas, pour permettre à cette population de se reconstituer. Cette pêcherie a encore un avenir à condition que les stocks restants soient protégés par des mesures de restriction de la pêche. Les stocks doivent avoir le temps de « récupérer » à moyen terme, c'est-à-dire que la pêche devrait être fermée pendant 5 à 10 ans, ou jusqu'à ce que les densités reviennent aux environs de 500 à 600 individus/hectare dans les principales zones de pêche.

- Imposer des limites strictes à la pêche de l'holothurie pour donner à ces ressources appauvries le temps de se reconstituer. Étant donné l'état actuel des stocks, il serait difficile de justifier la poursuite de la pêche commerciale sur cette zone. Il faut laisser aux juvéniles d'*Holothuria scabra* le temps de parvenir à pleine maturité et de produire les générations futures de cette espèce à haute valeur commerciale.

Résultats des travaux de terrain à Sideia

Sideia est une île haute, montagneuse, et couverte de denses forêts. Les habitants vivent dans des petits hameaux disséminés le long de la côte, et il n'y a pas de grand village sur l'île. En l'absence de route, les habitants se déplacent à pied, en pirogue ou en bateau. Ce sont des agriculteurs plutôt que des pêcheurs. On dénombre quelques plantations de cocotiers et la population tire également des revenus de la vente de bêche-de-mer et de trocas. Les riches ressources forestières de l'île demeurent largement inexploitées. Les habitants vendent leurs produits au marché de la mission catholique qui se tient trois fois par semaine, et se rendent également au marché d'Alotau. L'île est bordée par des récifs frangeants, des mangroves (avec des crocodiles en résidence), ainsi qu'un certain nombre de lagons semi-fermés avec des bassins peu profonds et des pseudo-récifs barrière. Un récif barrière plus grand se développe à partir des extrémités nord-ouest et nord-est de l'île, sa partie orientale étant plus intacte que l'autre. Dans l'ensemble, les récifs sont influencés par la terre et sont situés du côté abrité de Sideia, où les courants ne sont pas trop forts. La couverture corallienne est généralement bonne sur l'ensemble du système et bénéficie de substrats complexes. La plupart des tombants des récifs sont en pente abrupte et les pentes douces sont rares sur les tombants externes.

Conclusions socio-économiques : Sideia

La pêche est la principale source de revenus des habitants de Sideia, où elle est la première source de revenus pour 70 %, et la deuxième pour 20 % d'entre eux. L'agriculture joue également un rôle important comme source supplémentaire de revenus. En revanche, les emplois rémunérés, les entreprises privées et l'artisanat revêtent une moindre importance. Le poisson et les invertébrés frais sont consommés dans tous les ménages, dont 90 % consomment également du poisson en conserve. Le niveau de consommation de poisson frais est relativement faible (environ 24 kilos par personne et par an) mais supérieur à la moyenne nationale. Le taux de consommation d'invertébrés est modéré (9,5 kilos par personne et par an). La faible consommation de poisson en conserve confirme que les habitants achètent peu de denrées alimentaires et sont donc largement autosuffisants pour leur alimentation.

La pêche des poissons est pratiquée par les hommes comme par les femmes, ces dernières ciblant principalement les récifs côtiers abrités où elles pratiquent la pêche vivrière. Les hommes pêchent dans le lagon et sur le récif extérieur, principalement à des fins commerciales. Les femmes prédominent pour le ramassage des invertébrés dans les mangroves, s'aventurant souvent sur les crêtes de récif, les fonds meubles ou les zones intertidales. Cependant hommes et femmes participent très activement à la pêche commerciale de l'holothurie lorsque la saison est ouverte. Les femmes ne prennent pas part à la pêche des holothuries, des langoustes et d'autres invertébrés qui nécessitent des plongées en apnée sur l'arrière-récif et sur le tombant externe du récif. Dans la plupart des cas, les pêcheurs sortent en pirogue (à la pagaie) mais ils ont aussi des pirogues à voile. Diverses techniques de pêches sont utilisées : principalement la palangrotte, mais aussi le fusil harpon, la sagaie, ou la pêche à la traîne dans le lagon, notamment sur le récif extérieur. Le poison à base de *Derris derris* est encore utilisé, mais peu fréquemment.

Ressources en poisson: Sideia

L'état des ressources en poisson est relativement bon. Les récifs sont naturellement riches et la couverture corallienne aussi bonne que diversifiée. Sur ce site, les pêcheurs ciblent principalement les récifs extérieurs, pêchant généralement à la palangrotte (par des profondeurs de 60 à 100 mètres) et ciblant donc les carnivores. La pêche au fusil harpon est également pratiquée, même de nuit.

La communauté de poissons est diversifiée et la présence de bancs de poissons (surtout herbivores) a été notée. Des *Bolbome-topon muricatum* et des *Cheilinus undulatus* ont été observés mais souvent de taille petite à moyenne. Les grands carnivores (mérous) et les grands prédateurs (requins) sont également assez communs.

Ces observations, ainsi que les résultats de l'analyse des données collectées suggèrent que le site de Sideia est en relative bonne santé. Les observations réalisées révèlent cependant l'impact de la pêche : les Lethrinidae sont de petite taille, la communauté des poissons est dominée par les herbivores dans les deux habitats, ce qui résulte peut-être des caractéristiques de l'habitat récifal, au substrat principalement dur. Par ailleurs, la méfiance des poissons vis-à-vis des plongeurs traduit leur crainte de la pêche au fusil harpon. Analysées à l'échelle de l'habitat récifal, les ressources semblent être en meilleur état, avec une densité et une biomasse plus élevées, sur les arrière-récifs que sur les récifs extérieurs, sur lesquels la biodiversité est pourtant plus riche.

Ressources en invertébrés : Sideia

Les zones abritées des récifs côtiers et les récifs barrière plus exposés fournissent une gamme d'habitats propices aux bénitiers. La gamme complète des espèces de bénitiers est présente à Sideia. La densité des espèces les plus communes et de plus petite taille est moyenne (*Tridacna maxima)* et celle des plus grandes espèces relativement élevée (*T. squamosa* et *Hippopus hippopus*). La présence des espèces *T. gigas* and *T. derasa* a été notée, mais leur densité est faible. Ces indications laissent à penser que la pêcherie n'est que modérément touchée par la pêche par comparaison avec d'autres lieux du Pacifique et que des mesures de limitation de la pêche plus simples suffiront à lui permettre de se reconstituer. *T. gigas*, le véritable bénitier, est encore présent à Sideia, et des individus de grande et de petite tailles ont été observés. Les résultats de l'étude laissent à penser que le recrutement de cette espèce s'est poursuivi à Sideia au cours des dernières années.

Le trocas (*Trochus niloticus*) est rare à Sideia et victime d'une forte surexploitation. Cette conclusion est fondée sur l'étendue de l'habitat disponible, la présence très dispersée et la faible densité de cette espèce, la densité d'autres gastéropodes brouteurs, comme *Tectus pyramis*, et les témoignages des pêcheurs, qui ont déclaré, lors d'entrevues, qu'ils continuent à exploiter ces stocks, mais ne réussissent à prendre qu'un à huit trocas par sortie. Les données de présence et de densité laissent à penser que les stocks sont arrivés à un niveau nettement inférieur au minimum recommandé pour la pêche commerciale et doivent être protégés pour pouvoir se renouveler. Aucun burgau (*Turbo marmoratus*) n'a été observé lors de l'enquête. L'huître perlière à lèvres noires (*Pinctada margaritifera*) est relativement commune à Sideia.

Étant donné la variété de milieux favorables disponibles à Sideia, l'éventail des espèces d'holothuries observées à Sideia n'est pas aussi complet qu'il pourrait l'être. Les données de présence et de densité recueillies au cours de l'étude révèlent l'impact d'une très forte pression de pêche sur ces stocks, qui sont maintenant dans un état d'épuisement avancé. Les récifs et d'autres substrats benthiques des alentours de Sideia sont particulièrement « sales » par rapport à d'autres sites de l'Océanie.

Recommandations pour Sideia

- La communauté locale souhaite bénéficier d'une assistance supplémentaire, de la part du Service national des pêches ou d'une ONG, pour réaliser une évaluation des stocks en plongée et assurer le suivi de l'état des ressources les plus importantes. Les résultats pourraient servir à l'élaboration de règlements communautaires applicables aux diverses pêcheries, notamment à la pêche commerciale des holothuries, des trocas et d'autres espèces.

- Prendre des mesures d'intervention immédiatement pour réduire les niveaux actuels d'exploitation, notamment pour ce qui concerne la pêche dans les mangroves et sur les crêtes récifales.

- Restreindre la pêche au fusil harpon et l'interdire de nuit.

- Envisager l'imposition d'un tabou sur certaines zones comme principal outil de gestion.

- Limiter la pêche des bénitiers en protégeant les zones de forte densité et les plus gros individus de chaque espèce.

- Limiter d'urgence la pêche des trocas (*Trochus niloticus*) pour préserver l'avenir de cette pêcherie. Les stocks doivent avoir le temps de « récupérer » à moyen terme, c'est-à-dire que la pêche devrait être fermée pendant 5 à 10 ans, ou jusqu'à ce que les densités reviennent aux environs de 500 à 600 individus/hectare dans les principales zones de pêche.

- Imposer des limites strictes à la pêche de l'holothurie pour donner à ces importants stocks le temps de « récupérer » à moyen ou long terme. Étant donné l'état actuel des stocks, la pêche commerciale doit cesser.

Résultats des travaux de terrain à Panapompom

Paneati-Panapompom est une formation semblable à un atoll située à environ deux heures en canot à moteur de Misima. Panapompom est une île haute située au centre d'un grand système lagonaire. L'île de Paneati, où se trouve le village principal, se situe à la frontière septentrionale du lagon. C'est également une île haute. La population de ces deux îles compte entre 3 000 et 3 500 habitants, dont les principales sources de revenus sont le copra, la bêche-de-mer, les coquilles de trocas et la noix de bétel. Les insulaires vendent également des pirogues à voile aux habitants des îles avoisinantes et sont réputés pour les porcs qu'ils élèvent. Plusieurs petits îlots sablonneux émaillent le récif-barrière, et de nombreuses passes de diverses profondeurs relient le lagon à l'océan. L'arrière-récif est principalement sablonneux et les crêtes des récifs abritent un habitat constitué de roche et de blocs de corail. Les tombants externes sont complexes, richement couverts de corail et en pente abrupte.

Conclusions socio-économiques : Panapompom

La pêche est la principale source de revenus des habitants de Panapompom, où elle est la première source de revenus pour 43 % des ménages, et la deuxième pour 33 % d'entre eux. D'autres activités, en premier lieu l'artisanat, jouent également un rôle important, représentant la première source de revenus pour 27 % des ménages, et la deuxième pour 40 % d'entre eux. L'agriculture et l'emploi salarié sont la première source de revenus pour 40 % et 13 % des ménages respectivement. La pêche est une importante source de protéines. Tous les ménages consomment du poisson frais et en conserve, et la plupart d'entre eux consomment également des invertébrés. La consommation de poisson frais (environ 37,4 kg par personne et par an) est l'une des plus élevées de tous les sites étudiés par les agents du programme PROCFish en Papouasie-Nouvelle-Guinée. La consommation d'invertébrés est assez faible (1,8 kg par personne et par an) et la faible consommation de poisson en conserve confirme que les habitants de l'île haute de Panapompom achètent peu de denrées alimentaires et sont donc largement autosuffisants pour leur alimentation.

La pêche des poissons est pratiquée par les hommes et par les femmes, quoique ces dernières pêchent beaucoup moins. Les zones exploitées se situent principalement à l'intérieur du lagon, mais les hommes ciblent également le récif extérieur. La pêche sur le récif côtier abrité sert essentiellement à des fins vivrières, tandis que la pêche à l'intérieur du lagon et sur le récif extérieur est surtout de nature commerciale. Les pêcheurs sortent surtout en pirogue à pagaie, mais des pirogues à voile sont également disponibles.

Plusieurs techniques sont utilisées : la pêche à la palangrotte, dans les zones récifales abritées, et la pêche à la traîne ou avec des lignes pour la pêche profonde sur les autres habitats, dont l'intérieur du lagon ou le récif extérieur, qui peuvent être ciblés lors une même sortie. Le poison à base de *Derris derris* est encore utilisé, mais peu fréquemment.

La pêche des invertébrés est exclusivement vivrière, à l'exception de la pêche commerciale des holothuries, dont la saison de récolte dure six mois, et qui représente 95 % des captures totales annuelles d'invertébrés déclarées. Cette activité est considérée comme la principale source de revenus des habitants. La pression de pêche calculée pour la pêcherie d'holothuries a atteint un niveau alarmant, et elle est également forte pour les pêcheries des fonds meubles et des crêtes récifales. Les gestionnaires des pêches doivent prendre des mesures d'intervention immédiatement.

Ressources en poisson: Panapompom

L'étude confirme que les ressources en poisson sont en bon état. L'intensité de la pêche est en baisse depuis plusieurs années à la suite de l'arrêt de l'exploitation d'une mine d'or sur une île avoisinante, qui était devenue le principal centre commercial. Ce phénomène pourrait expliquer en partie la richesse et le bon état des récifs ainsi que la forte abondance des poissons. En outre, la pêche est pratiquée à bord de pirogues à balancier à voile, et la pression de pêche sur les récifs est moindre que lorsque des canots à moteur sont utilisés.

Les récifs semblent en bonne santé et leur couverture de corail vivant est plus riche que celle des autres sites du pays. La diversité des espèces est également la plus élevée de tous les sites du pays, notamment sur les récifs intermédiaires et extérieurs. La communauté trophique est partagée également entre herbivores et carnivores, indice supplémentaire de la bonne santé de l'écosystème. Les perroquets, les chirurgiens et les mérous de grande taille sont assez abondants. Lethrinidae, Lutjanidae et Mullidae sont présents dans tous les habitats, et dans des densités supérieures à celles des autres sites. A l'échelle de l'habitat récifal, on constate une variabilité des ressources : les récifs côtiers affichent des densités et une biomasse élevées, avec les valeurs les plus élevées de tous les habitats de Panapompom, ainsi que par rapport à tous les récifs côtiers étudiés dans le pays.

Le niveau de biodiversité des récifs intermédiaires est absolument exceptionnel pour ce type de récif et les ratios de taille sont également assez élevés. La composition de la communauté de poissons est à la fois diversifiée et riche, plusieurs familles et de nombreuses espèces contribuant à former la majeure partie de la biomasse. La composition trophique est bien équilibrée, et les carnivores, les herbivores et les poissons planctonophages sont tous représentés, autant de signes de la bonne santé de l'écosystème. La petite taille des Balistidae, des Lethrinidae et des Lutjanidae dénote probablement une certaine pression de pêche sur ces familles ciblées. A eux seuls, les Lutjanidae et les Lethrinidae représentent la moitié des prises réalisées sur les récifs lagonaires. Cependant, les valeurs de biomasse, de taille et de ratios de taille des arrière-récifs sont basses, même par comparaison avec celles d'Andra et de Sideia. Les petits ratios de taille des Lethrinidae sont l'un des premiers signes de l'impact de la pêche. D'autres signes sont également visibles dans la zone occidentale du site, où les habitants de l'île, plus grande, de Paneati viennent également pêcher. Ces densités et biomasses de poissons inhabituellement élevées dans la zone récifale côtière de Panapompom peuvent être attribuées à la récente création d'une petite zone fermée, où la pêche est interdite, en vertu d'une décision de la communauté villageoise.

Ressources en invertébrés : Panapompom

Les eaux peu profondes du lagon et le récif barrière qui les entourent conviennent particulièrement bien aux bénitiers, bien que les habitats récifaux les plus adaptés soient rares le long du littoral de l'île proprement dit. L'éventail d'espèces de bénitiers présents est pour l'instant très complet. La densité des bénitiers à Panapompom est raisonnablement élevée dans le cas de *Tridacna maxima*, l'espèce la plus commune. Bien que l'éventail des espèces soit « complet », l'absence de bénitiers mesurant plus de 15 cm, notamment lors des enquêtes en eau peu profonde, dénote un impact sur le stock. *Hippopus hippopus* est relativement commun, mais les stocks de *T. crocea*, *T. squamosa* et de *T. derasa* sont plus appauvris. Les espèces les plus grandes (*T. squamosa, T. derasa* et *T. gigas)* sont peu abondantes, mais le fait qu'elles soient toujours présentes augure favorablement pour la conservation.

L'habitat favorable au troca à valeur commerciale *Trochus niloticus* est très étendu. Cependant, l'abondance et la répartition des trocas dénotent une forte surexploitation de cette ressource et laissent à penser que les stocks sont maintenant appauvris à un niveau inférieur à celui qui permet une exploitation commerciale, et qu'il est urgent de les protéger en en interdisant la pêche. A l'heure actuelle, le stock de trocas se caractérise par une prédominance d'individus âgés et de grande taille, et rien ne suggère que le recrutement se poursuit encore. Protéger ce stock de géniteurs permettra au recrutement de se poursuivre, et au stock de se reconstituer à terme. S'il est possible d'assurer une protection effective des zones de pêche de trocas, la reconstitution du stock pourrait être facilitée par un regroupement des trocas adultes restants. Le burgau (*Turbo marmoratus*) était totalement absent lors de l'enquête. L'huître perlière à lèvres noires (*Pinctada margaritifera*) est relativement commune.

L'éventail d'espèces d'holothurie observé à Panapompom n'est pas aussi large qu'il devrait l'être sur un site offrant une telle diversité d'habitats et de profondeurs. L'influence océanique prédominante sur la plus grande partie du lagon en est peut-être la cause. La pêche de l'holothurie se pratique toujours à Paneati-Panapompom et dans d'autres zones de pêche autour de l'atoll Conflict et des récifs situés au nord de ces îles. Les données de présence et de densité donnent à penser que les stocks d'holothuries ont subi une très forte pression de pêche et sont dans un état d'épuisement très avancé.

Recommandations pour Panapompom

- La communauté locale souhaite bénéficier d'une assistance supplémentaire, de la part du Service national des pêches ou d'une ONG, pour améliorer la commercialisation de ses produits, notamment ses prix de vente aux acheteurs itinérants, pour réaliser une évaluation des stocks en plongée et assurer le suivi de l'état des ressources les plus importantes. Les résultats pourraient servir à l'élaboration de règlements communautaires applicables aux diverses pêcheries, notamment à la pêche des poissons, et, en particulier, à la pêche commerciale des holothuries et des trocas.

- Prendre immédiatement des mesures d'intervention pour réduire la pression de pêche actuellement alarmante qui pèse sur les pêcheries des fonds meubles et des crêtes récifales.

- Éviter toute augmentation des prises de poisson.

- Limiter la pêche des bénitiers, notamment des espèces de grande taille (*Tridacna squamosa*, *T. derasa* et *T. gigas*). Il est probable que les stocks se reconstitueront une fois que les mesures de gestion auront été prises.

- Protéger immédiatement les stocks de trocas commercial (*Trochus niloticus*) et en interdire la pêche pour préserver l'avenir de cette pêcherie. Les stocks doivent avoir le temps de « récupérer » à moyen terme, c'est-à-dire que la pêche devrait être fermée pendant 5 à 10 ans, ou jusqu'à ce que les densités reviennent aux environs de 500 à 600 individus/hectare dans les principales zones de pêche.

- Imposer des limites strictes à la pêche de l'holothurie pour donner à ces stocks au stade de l'épuisement avancé le temps de « récupérer » à moyen ou long terme. La pêche commerciale doit cesser.

ACRONYMS

ACP	African, Caribbean and Pacific Group of States
AIMS	Australian Institute of Marine Science
ASL	Ailan Seafoods Limited
AUD	Australian dollar(s)
AusAID	Australian Agency for International Development
BdM	bêche-de-mer (or sea cucumber)
CI	Conservation International
CMT	customary marine tenure
CoFish	Pacific Regional Coastal Fisheries Development Programme
COTS	crown of thorns starfish
CPUE	catch per unit effort
Ds	day search
D-UVC	distance-sampling underwater visual census
EDF	European Development Fund
EEZ	exclusive economic zone
EMP	Emirau Marine Products
EU/EC	European Union/European Commission
FAD	fish aggregating device
FAO	Food and Agricultural Organization (UN)
FFA	Forum Fisheries Agency
FL	fork length
GDP	gross domestic product
GPS	global positioning system
GRT	gross registered tonnage
ha	hectare
HH	household
LLG	Local Level Governments
LRFF	live reef food fish
MCRMP	Millennium Coral Reef Mapping Project
MIRAB	Migration, Remittances, Aid and Bureaucracy (model explaining the economies of small island nations)
MOP	mother-of-pearl
MOPt	mother-of-pearl transect
MPA	marine protected area
MRM	marine resource management
MSA	medium-scale approach
MSY	maximum sustainable yield
NASA	National Aeronautics and Space Administration (USA)
NCA	nongeniculate coralline algae
NFA	National Fisheries Authority

NGO	non-governmental organisation
Ns	night search
OCT	Overseas Countries and Territories
PGK	Papua New Guinea PGK (currency)
PICTs	Pacific Island countries and territories
PROCFish	Pacific Regional Oceanic and Coastal Fisheries Development project
PROCFish/C	Pacific Regional Oceanic and Coastal Fisheries Development project (coastal component)
RBt	reef-benthos transect
RFID	Reef Fisheries Integrated Database
RFs	reef-front search
RFs_w	reef-front search: walking
SBq	soft-benthos quadrat
SCUBA	self-contained underwater breathing apparatus
SE	standard error
SPC	Secretariat of the Pacific Community
TAC	total allowable catches
TNC	The Nature Conservancy
TSPZ	Torres Strait Protected Zone
UNDP	United Nations Development Programme
UPNG	University of Papua New Guinea
USD	United States dollar(s)
WCPO	western and central Pacific Ocean
WHO	World Health Organization

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).

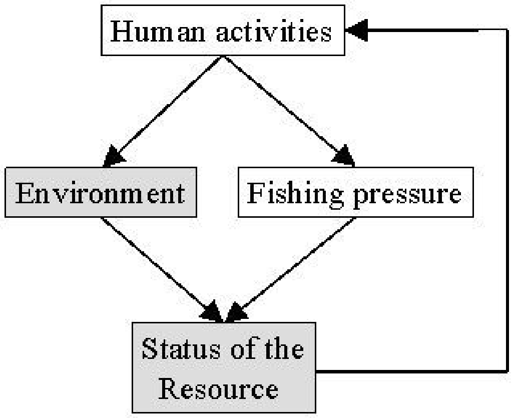

Figure 1.1: Synopsis of the PROCFish/C* multidisciplinary approach.
PROCFish/C conducts coastal fisheries assessment through simultaneous collection of data on the three major components of fishery systems: people, the environment and the resource. This multidisciplinary information should provide the 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).

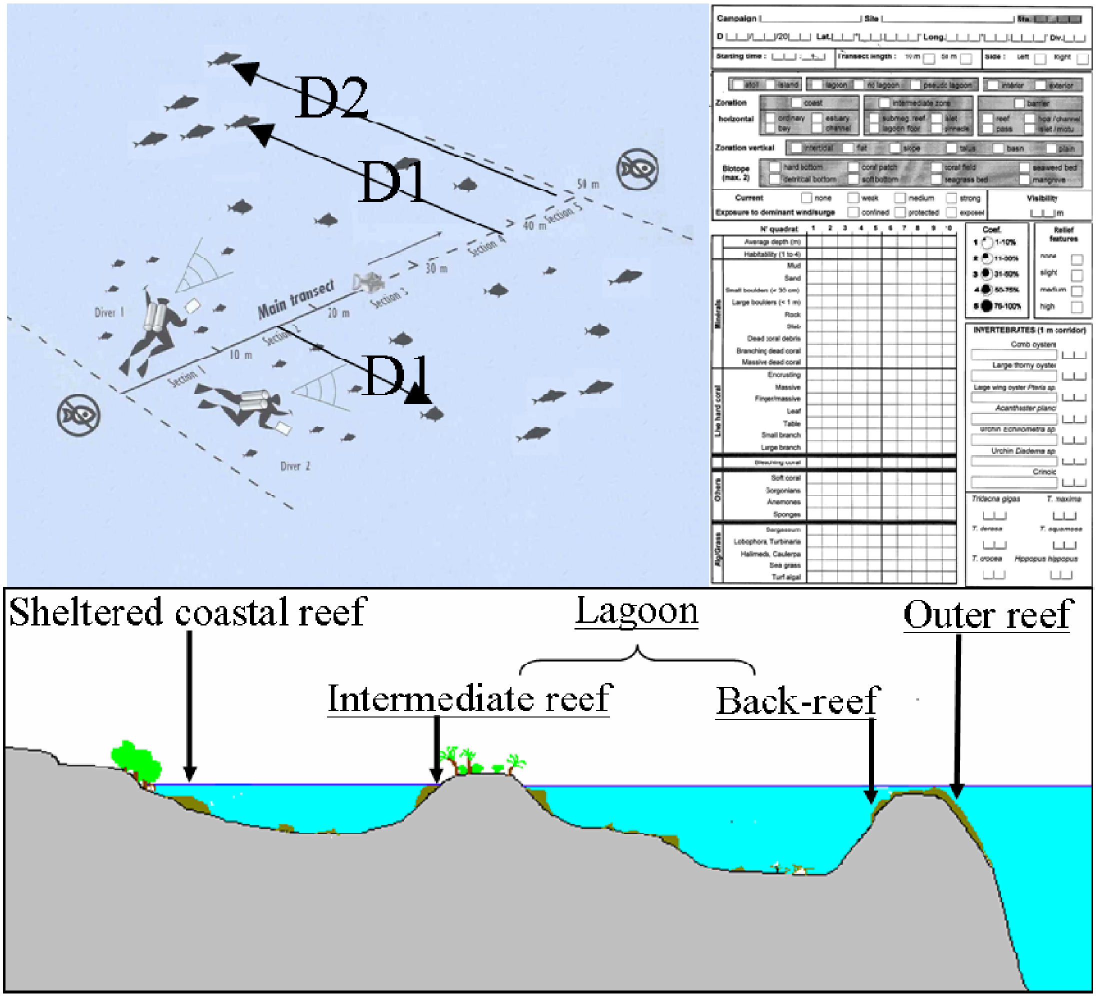

Figure 1.2: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver recorded the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys 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).).[4]

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.).

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

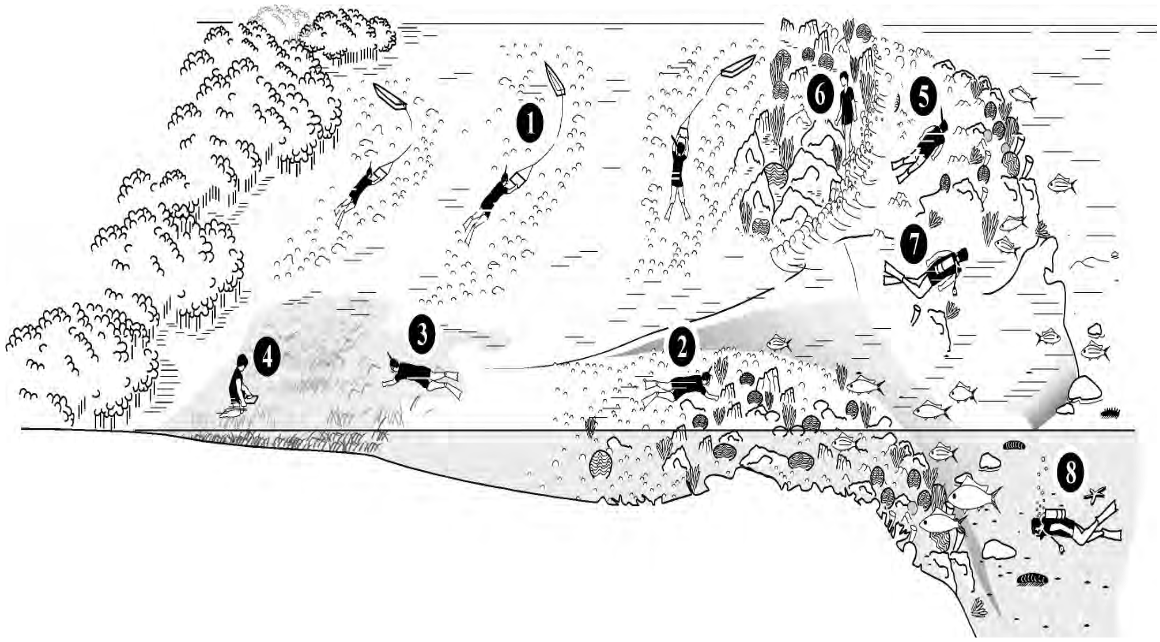

Figure 1.3: Assessment of invertebrate resources and associated environments.
Techniques used include: broad-scale assessments to record large sedentary invertebrates (1); fine-scale assessments to record epi-benthic resources and potential indicator species (2) and (3); quadrats to count targeted infaunal 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 Papua New Guinea

1.3.1 General

Papua New Guinea (PNG) comprises the eastern half of the world’s largest tropical island plus an archipelago of about 60 islands lying between approximately 1–12°S latitude and 141–157°E longitude in the western Pacific Ocean (Figure 1.4). PNG has a total land area of 462,243 km^2 and an EEZ estimated to cover 3,120,000 km^2 (Gillett 2002, Chapman 2004). The country shares a land border with Indonesia (West Irian) and sea borders with Australia, the Federated States of Micronesia (FSM) and Solomon Islands (Kailola 1995).

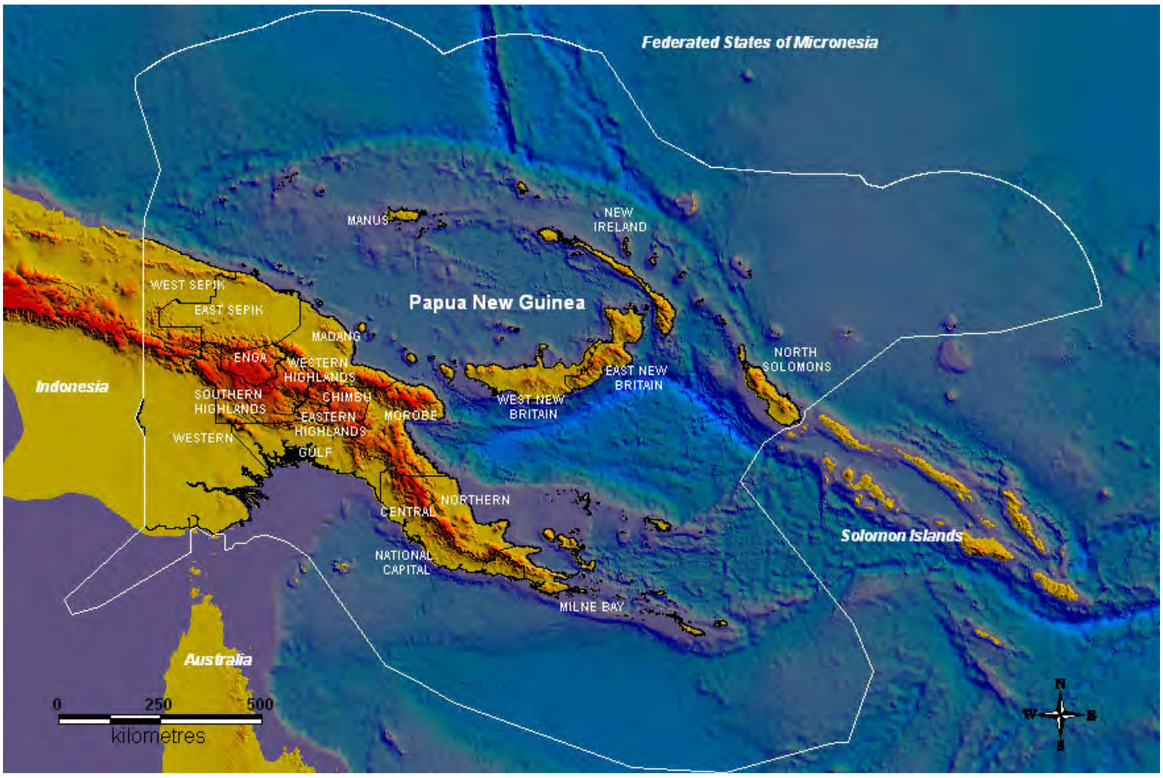

Figure 1.4: Map of Papua New Guinea.

Most of the larger islands in PNG have a rugged geography, generally with steep mountain terrains leading either to extensive flood plains and swamps or a narrow coastal fringe. PNG has over 5000 lakes and numerous rivers and streams (Anon. 1996). PNG's total coastline length of ~17,000 km includes about 4250 km (25%) of deltaic flood plain/lagoon systems, while some 4180 km (24%) of the coastline occurs around islands and atolls (FAO 2008, Gillett 2002).

PNG experiences a moderate tropical climate with high levels of seasonal rainfall. In the Highlands, temperatures can range from 4°C to 32°C. The lowland, coastal and island areas have an average daily temperature of 27°C. The annual rainfall is 1011 mm (PNG Embassy 2008, Turner 2007).

The 2000 population census figures show a population of 5,190,786 and a density of 11.2 per km^{2}. The population estimate for 2005 is 5,887,000. The annual population growth rate for 1992–2002 was 2.6% (Turner 2007). Nearly 40% of the population lives in the densely-inhabited Highlands provinces; only ~13% lives in rural coastal areas (Kailola 1995).

In 1975, PNG gained political independence. The nation is governed under a Westminster system based on a written constitution and a single legislative house known as the National Parliament, with national elections every five years. In addition to its national government, PNG has a decentralised system of semi-autonomous governments in each of its 19 provinces (PNG Embassy 2008, CIA 2008, ReefBase 2008). The provincial governments have a similar constitutional arrangement to the national government and have equal power with the latter in areas such as agriculture, business development, town planning, forestry and natural resources. National laws, however, take precedence over provincial laws if there is conflict (PNG Embassy 2008).

Primary activities, such as mining and agriculture, are the mainstays of the economy, with mining being the major export earner. In 2002, agriculture accounted for 27.2% of Gross Domestic Product (GDP), industry 39.4% and services 33.4% (Turner 2007). Subsistence agriculture sustains a large segment of the population and provides enough for exports. These include coconut and palm products, coffee, tea, cocoa, fish and timber products (SOPAC 1999). In 2001, imports were worth USD 998.8 million. The main imports were machinery and transport equipment, manufactured goods, and food and live animals. In 2001, these imports were sourced from Australia (60%), Japan (8.5%), Singapore (7.8%), and the United States of America (7.1%). In 2001, export earnings were USD 1812.9 million. The main exports from PNG in that year were crude petroleum, gold, and logs destined for Singapore (27.5%), Japan (13.2%), Australia (10.6%), and China (4.4%) (PNG Embassy 2008, Turner 2007).

1.3.2 The fisheries sector

The three main categories of fishing in PNG are subsistence, artisanal and commercial/industrial, with recreational fishing being of minor importance (Kailola 1995). Along the mainland and high-island coasts and in the smaller island communities, fishing activities include the harvesting of the reef flats, spear fishing, shallow-water handlining from dugout canoes, netting, and trapping in the freshwater reaches of the larger rivers. In the swampy lowland areas, net fisheries for barramundi, catfish, and sharks occur, while in the Gulf of Papua there is also a village-based lobster fishery. The collection of invertebrates, both commercially (bêche-de-mer, trochus and other shells) and for subsistence purposes is extensive. Commercial trawling for prawns takes place in the Papuan Gulf and other parts of southern PNG; a tuna longline fishery has been established, with vessels successfully catching sashimi-grade tuna and exporting them to overseas markets (Gillett 2002, FAO 2008); a domestic purse-seine fishery has developed with six vessels in 2007; and a locally-based foreign purse-seine fishery is well established, with 33 vessels in 2007, along with tuna canning and loining facilities in several locations around PNG, where much of the catch is landed for processing (Kumoru and Koren 2007). Whereas resources such as sea cucumber, trochus, green snail and penaeid prawns are being harvested at or near maximum sustainable yield, many other marine resources are considerably underused (ReefBase 2008).

Offshore tuna fishery

Papua New Guinea for many years allowed foreign dominance of the tuna fisheries within its EEZ; however, in 1995, the government ceased issuing licences to foreign longline vessels in an attempt to promote development of domestic longlining. However, by the late 1990s, foreign longline vessels were licensed for both tuna and shark fishing. In tandem with this was the development of domestic tuna purse-seining, locally-based foreign purse-seining, and the establishment of shore facilities to process some of the purse-seine catch.

Foreign tuna fishing operations

Papua New Guinea has very rich fishing grounds for tuna. Asian longliners have fished these waters since the 1950s, with Japan the first country, followed by Taiwan vessels commencing operations in the mid-1960s, and Korean vessels in the mid-1970s (SPC 1984). Catches by the Japanese fleet fluctuated between 1874 t and 14,104 t in 1972–1977 (Klawe 1978). Since 1978, when PNG declared its 200 nm EEZ, longline activity has been subject to access agreements (SPC 1984). Japanese distant-water pole-and-line vessels worked extensively in the waters around PNG in the 1970s under a joint-venture arrangement, with a catch of 56,595 t in 1974. As for longlining, pole-and-line fishing was subject to access agreements in 1978, with Japan redirecting some of this effort to other areas (Wankowski 1980).

The 1970s saw much research undertaken within the waters of PNG with the establishment of the joint-venture pole-and-line fishing operation increasing from one company in 1970 to four companies in 1974. SPC (1984) summarises this research undertaken in the 1970s, which included the tagging and release of 13,000 fish from 1971 to 1976. This also led to two tagging cruises being undertaken by the SPC Skipjack Survey and Assessment Project: the first in 1977, which tagged 1167 skipjack tuna and 21 yellowfin tuna (Kearney 1977), and the second in 1979, which tagged 8469 tuna (Kearney and Hallier 1979). An economic downturn in the pole-and-line tuna fishery led to a winding-back of joint-venture operations, with two companies ceasing operation in the late 1970s and the remaining two companies suspending operations in 1982 (Doulman 1982). The pole-and-line fishery reopened in 1984 with nine vessels; however, this was short-lived and operations ceased permanently in 1985 (Chapman 2004).

Purse seining commenced in the waters of PNG in the early 1970s; however, catches were insignificant until 1976, when they increased rapidly to at least 57,000 t in 1982. At this time, Japanese, Taiwanese, Korean and American vessels were fishing within the PNG EEZ under access agreements (SPC 1984). The main expansion in the tuna fishery in PNG waters came through purse seining in the 1980s and 1990s, with US vessels fishing under a multilateral agreement that commenced in 1988, and other nations fishing through access agreements. In the 1990s, the PNG Government wanted to domesticate the tuna fishery as much as possible and, in support of this, ceased all tuna longline agreements for foreign fishing access in 1995 (Buraik and Yule 1995, Gillett 2002).

In 1999 there were 78 foreign fishing vessels from Philippines, Taiwan, China, Korea Federated States of Micronesia, Kiribati and Vanuatu licensed to fish in PNG waters, as well as 50 US purse seiners (Gillett 2002). These vessels took around 85,000 t in 1999, worth an estimated USD 75 million. Most of this catch was transhipped to canneries in Thailand, Philippines and American Samoa (Gillett 2002). Catches have continued to increase during the 2000s from this foreign purse-seine fleet, with 97,379 t recorded in 2002, 213,197 t in 2004, and 276,611 t in 2006. Japan also commenced purse-seine fishing in PNG waters in 2005 (Kumoru and Koren 2007).

Domestic industrial fishing including FAD fishing and processing activities

Joint-venture pole-and-line fishing operations in the 1970s were the first attempt at developing domestic industrial fishing activities by the PNG Government. However, by 1989 there was still no large-scale domestic tuna fishing industry in PNG (Anon. 1989). The early 1990s saw several local tuna longline operations trialled, one in Port Moresby and the other in East New Britain. Both operations closed down soon after. In support of the East New Britain project, SPC was asked to provide technical assistance in 1993/1994, and the Government of East New Britain provided a 14.5 m fibreglass vessel that it had received under Japanese aid (Beverly and Chapman 1996). The fishing trials were very successful with average catch rates of 118 kg/100 hooks, which was double the regional average; however, at the conclusion of the project, there was no local uptake of tuna longlining in this area (Beverly and Chapman 1996).

In 1995 the government ceased all tuna longline agreements for foreign fishing access in support of domestication of this fishery with local longline operations (Buraik and Yule 1995, Gillett 2002). As a result of this, some longlining was conducted under charter arrangements. However, this too was stopped so that the fishery was closed to all except genuine domestic operations (Gillett 2002). In 1996 there were nine longline vessels licensed, increasing to 21 in 2001 and 40 in 2003, although not all were active (Kumoru 2004). The catch from domestic longline operations has fluctuated between 3356 t (2006) and 4810 t (2004) during the period 2002–2006 (Kumoru and Koren 2007).

In May 1992 the PNG Government concluded an agreement with the Z-fishing group of the United States of America to establish a tuna cannery in Madang, with the potential spin-off benefits including the licensing of national companies to supply the cannery and onshore cold storage and victualling facilities for domestic boats (Anon. 1994). Construction of this cannery met with many delays, due to conflicts regarding import duty tariffs imposed by government on imported materials, but recommenced in 1995 (Anon. 1996). Also at this time, the government allowed a second cannery to be constructed in Madang by the Philippine company RD Cannery (Anon. 1996).

The RD cannery was commissioned in June 1997 and this allowed the company to bring in 10 purse-seine vessels to supply fish to the cannery. The vessels were considered domestic vessels, although they remained Philippine-flagged. Coupled with this development was the expansion in numbers of FADs for these purse seiners to set on (Kumoru 2002, 2004). In 2002 it was estimated that 800 FADs were in operation; however, the actual number could have been double this amount. In response to this, a control limit of 1000 FADs was implemented through an FAD Management Policy (Kumoru 2002).

Also in 2002, some mid-water handlining trials for tuna were undertaken using two Philippine vessels (*bancas* or pump boats) as part of the longline or mid-water fishery (Kumoru 2004), with this fishing conducted mainly around FADs. Following the successful trials by these two vessels, 15 licences were issued in 2006 and 2007, with 10 of these being active.

The catch from domestic (PNG-flagged) and locally based foreign purse seiners has steadily increased along with vessel numbers over the period 2001–2006. In 2001, 22 vessels caught 54,286 t, while in 2006 39 vessels landed 134,703 t (Kumoru and Koren 2007). Around half of this catch was landed to the shore facilities in PNG for processing, with RD Cannery in Madang processing 150 t/day, the South Seas Tuna Wewak loining facility processing 200 t/day, and the Frabelle cannery in Lae processing 100 t/day. There are also plans for a second cannery to be built at Vidar, north of Madang, and this cannery will process 200 t/day (Kumoru and Koren 2007).

Shark fishing operations

The commercial harvesting of sharks in PNG started in 1976, through a gillnet fishery which ran from 1976 to 1982 (Gillett 2002). This fishery ceased operation due to a decline in catch rates and international sanctions on driftnetting being applied (Kumoru 2003). In the early 1990s, shark fishing trials were undertaken in the Gulf of Papua region by two licensed longliners targeting deep-water sharks, mainly for the liver oil (Kumoru 2003). There is little information on the species composition of this catch. In 1992 and 1993, these two vessels fished for 475 days and landed over 37,500 deep-water sharks in 1992 and 18,900 in 1993 with the average weight of the sharks being 2.6 kg (Hair and Opnai 1995).

Sharks were targeted again in the mid-1990s, when several tuna longline freezer vessels switched from tuna to shark fishing, as higher prices were being paid for shark products, especially shark fins, and there was a readily available market for shark meat (Kumoru 2003). In the late 1990s, the number of vessels targeting sharks increased, with 21 vessels fishing in 2000 with little regulation. In 2001, the National Fisheries Authority (NFA) implemented a management plan for the shark fishery and limited the number of licences to nine as well as limiting hook numbers and setting a total allowable catch limit (Kumoru 2003, 2004). The value of exports of dried and frozen shark products, mainly fins, was USD 1.2 million in 1999 (Gillett 2002) and USD 2 million in 2002 (Kumoru 2003, Infofish 2008). The shark fishery continued with nine vessels licensed; 1123 t of sharks were landed in 2006, of which 316 t of frozen shark meat was exported. This suggests that considerable and increasing quantities of shark meat are processed and consumed locally (Kumoru and Koren 2007).

Small-scale tuna fishery including fishing around FADs

There is no real history of small-scale tuna fishing by Papua New Guinean fishers, although small quantities of tuna are caught by coastal fishers throughout the country from a range of small-scale canoes and fishing vessels (Chapman 2004, Anon. 1992). The government has encouraged the development of small-scale tuna fishing activities; in support of this and developing coastal fisheries in general, several boatbuilding projects were undertaken in the late 1970s and early 1980s. Several of the coastal fisheries stations had boat-building facilities while in 1982 a UNDP project designed several outrigger canoes, one 11 m long and powered by a 15 hp outboard (Gulbrandsen and Savins 1987).

In support of developing small-scale tuna fishing activities, SPC was asked to provide technical assistance on several occasions. The first was in 1984, when SPC assisted with the construction and deployment of two FADs set off Wewak, and provided training to local fisheries officers in several fishing methods that can be used in association with FADs (Chapman 1998). In 1992/1993, two FAD projects were undertaken. The first was off Port Moresby, where a FAD was rigged and deployed some 5 nm southwest of Daugo Island (Beverly and Cusack 1993). The second was undertaken near Rabaul and in the Duke of York Islands, where three FADs were rigged and deployed and another five were donated and deployed by the Mar Fishing Company. Unfortunately, vandals cut most of these FADs free soon after deployment, even though two had proven successful with both artisanal fishers and sports fishers (Beverly and Chapman 1996).

The National Fisheries College (NFC) is located at Kavieng, New Ireland Province. This college provides training for local fishers to work on commercial vessels, primarily tuna fishing vessels. SPC was requested to assist the college in developing and implementing more appropriate practical training to meet the needs of the expanding domestic tuna fishery, as well as small-scale tuna fishing activities. The first assistance was given in 1998/1999 and included the deployment of one FAD. Students were taken to the FAD and different fishing techniques were demonstrated (Watt 1999). The second assistance was provided in 2001 and included the rigging and deployment of two FADs and some small-scale tuna longlining and exporting trials (Sokimi and Chapman 2001). In 2002 SPC provided some follow-up training with lecturers at the college on fishing methods, with one FAD deployed in order to demonstrate fishing methods (Sokimi and Chapman 2003).

There is a well established sport and game fishery in several locations around PNG. Six game fishing clubs hold regular tournaments; one major tournament is held each year around April and rotated among the clubs (Whitelaw 2001). There are a couple of charter vessels located at Madang, Port Moresby, Lae and Rabaul, which operate on a part-time basis. There is quite an array of privately-owned sportsfishing craft, many over 7.5 m in length. Whitelaw (2001) records at least 30 sports fishing vessels in Madang, 50 in Lae, 13 in Kimbe, 30 in Raubal, over 60 in Port Moresby, and 6 at Lihir.

Deep-water fisheries – deep-water snapper

Deep-water snapper fishing was introduced to fishers in several part of the country, firstly by SPC and then through a series of international aid projects. SPC's first fishing trials and training in PNG in deep-water fishing activities and the gear used was in West New Britain in 1979, when 15 fishing trips were made (Fusimalohi and Crossland 1980). This was followed in 1982 with deep-water snapper fishing undertaken around Port Moresby, Samarai Island and Manus Island (Chapman and Fusimalohi 1998). Further trials and training were undertaken by SPC in 1984 at the request of the PNG Fisheries Department. These activities were undertaken in West New Britain Province, Manus Province and East Sepik Province (Chapman 1998). SPC's final trials and specific training in these methods and gear took place in 1988; a total of 50 fishing trips were completed at Oro Bay in Northern Province and Rabaul in East New Britain Province (Wellington and Cusack 1998).

During the 1980s, PNG fisheries conducted research into deep-water snapper fishing around the country, sometimes in conjunction with the SPC activities (Kinch 2004a, Chapman 2004). In East Sepik Province, following the introduction of the methods and gear by the PNG Fisheries Division in 1982, five local canoes were fitted with the wooden handreels used for this fishing method, landing 9 t of fish in a five-month period in 1983 (Chapau 1985). This fishery expanded in 1984 and 1985, with landings of 14.3 and 20 t respectively (Chapau and Dalzell 1991). This fishery declined in 1986 due to a range of logistical factors and lack of support services for the local fishers (Chapau and Dalzell 1991). Kinch (2004a) summarises the research undertaken in Central, Milne Bay, North Solomon, New Ireland, East Sepik and West Sepik provinces.

The potential for developing a deep-water snapper fishery in PNG is still high, with Dalzell and Preston (1992) summarising some of the early estimates of maximum sustainable yield (MSY) for this fishery in PNG, with the most likely being 511–1534 t/year based on MSY being 10–30% of total biomass. Chapman (2004) reported that, in 2003, the deep-water snapper fishery was *ad hoc* due to rising costs and marketing problems, especially in remote areas, although artisanal fishing was still occurring in some locations, such as Manus Island and West New Britain, where the catches were sold locally.

Deep-water carid shrimp

Two fishing trials were undertaken in PNG waters to trap deep-water shrimps. The first was undertaken off Port Moresby in 1981, where traps were set in depths of 230–650 m (King 1982). Small numbers of six species of deep-water caridean shrimps were caught, including the nylon shrimps: Mino nylon shrimp (*Heterocarpus sibogae*), humpback nylon shrimp (*H. gibbosus*), smooth nylon shrimp (*H. laevigatus*), and Madagascar nylon shrimp (*H. dorsalis*), *Plesionika bifurca*, and *Nematocarcinus undulatipes* (Kailola 1995, King 1982). The second survey for deep-water shrimps was conducted off Kavieng, New Ireland

Province in 1983, with traps set in depths of 285–565 m. Again, the catches were low (DPI 1984).

Aquaculture and mariculture

Aquaculture has never been a traditional practice in PNG, although some island communities have been reported to maintain clam gardens in selected areas of the reef. Aquaculture was introduced in the 1950s as a means to alleviate high malnutrition levels in inland areas. A carp hatchery, which produces fingerlings for distribution to villages, exists in the Highlands area (Anon. 1989).

Until recently, freshwater aquaculture was the focus of a major national government programme that included operating carp and trout hatcheries in highland and inland areas, restocking natural water bodies with introduced species, and promoting small-scale commercial aquaculture. The programme was considerably scaled down and handed over to provincial governments in late 1996. Marine aquaculture has included farming of seaweed, giant clams, crocodiles, milkfish, mullets, mussels, oysters, and prawns. There is currently one pearl oyster farm, located in Milne Bay, and another being established in New Ireland. In the late 1990s there was cage culture of groupers at Manus Island but the viability was hampered by a nationwide moratorium on the export of live reef food fish. A barramundi farm operates outside of Madang (FAO 2008, Gillett 2002).

Although development has so far been on a relatively small scale, there is significant opportunity for aquaculture operations in both inland ponds and coastal sea cages. Pond culture of trout and carp has developed significantly in the last few years with over six thousand farms throughout inland areas. Commercial farms for barramundi and pearl culture have been established and have recently commenced for genetically modified tilapia. At the commercial level, trout, barramundi and pearl culture has been established and recently commenced for prawns. Commercial trout farming began in 1976, but has undergone turbulent times with feed and fingerling constraints (Infofish 2008).

Carp

Common carp (*Cyprinus carpio*) were introduced to PNG for subsistence farmers on account of their adaptability to harsh environments, disease resistance, omnivorous diet and fast growth rates. Carp spawn in waters >18°C and so are distributed in both the PNG highlands and lowlands (Ponia and Mobiha 2002). The Department of Primary Industry (DPI) maintains a simple facility at its Highlands Agriculture Experimental Station, Aiyura, Eastern Highlands Province. Two varieties of *Cyprinus carpio* are raised and bred. About 6000 fingerlings are produced annually and distributed to fish farmers throughout the country. It seems, however, that the promotion of carp culture has been less successful than expected (Kan 1979).

Trout

Rainbow trout (*Salmo gairdneri*) was introduced in the early 1950s. A small-scale, but rather successful farm, Kotuni Trout Farm, is located near Goroka, Eastern Highlands Province. A Department of Primary Industries (DPI) hatchery has been in existence at Mendi, Southern Highlands Province, since 1972 (Kan 1979). Many Highlanders reside at high altitudes (1300–1800 m), where the water temperatures of the streams are 13°–17°C, which is the optimum temperature for farming trout. However, for trout to reproduce, the water temperature has to be lower than 13°C. The only commercial trout hatchery is at the foot of Mt Wilhelm in Chimbu Province (2280 m), where water temperatures are 10°C. There are no edible indigenous species in the temperate streams aside from eels or shrimps, so trout meat is considered a delicacy and an important food for social occasions (Ponia and Mobiha 2002).

Tilapia

There are two species of tilapia (*Tilapia rendalli* and *T. mossambicus*) commonly found in PNG. *T. mossambicus* escaped from ponds in the Highlands and became well established in river systems, particularly the Sepik River. Nearly all fish are taken from the wild by villagers and then sold to DPI outlets for processing and distributing to the Highlands where a market is readily available. A 1979 report states that production is around 3000 t/year. Tilapia is now one of the most important food sources in this area, and it has a high fecundity. However, this species of tilapia is not good for aquaculture. There is considerable interest in a new genetic strain of the Nile tilapia (*Oreochromis niloticus*) bred during a project known as 'Genetic Improvement of Farmed Tilapias (GIFT)' project. GIFT tilapia grows up to 60% faster than the most commonly farmed species of tilapia (Kan 1979, Ponia and Mobiha 2002).

Mother-of-pearl shells

Pinctada sp. is cultured on a private farm near Samarai, Milne Bay Province. A similar type of farm operated in Port Moresby until 1976, when an oil spill occurred and subsequently wiped out the crop (Kearney 1976, Kan 1979).

The shell fishery for trochus (*Trochus niloticus*), pearl shell (3 *Pinctada* species, the most abundant of which is the blacklip pearl shell *P. margaritifera*) and green snail (*Turbo marmoratus*), PNG's third largest export fishery, is also essentially village-based. Shells are collected by coastal villagers and sold to middlemen for eventual export or local processing. Total harvests of shell products in PNG have typically been 350–550 t/year, although exports in 1994 were only 253 t and worth about USD 1.9 million (Gillett 2002). The apparent decline in landings is thought to be due to localised over-harvesting (FAO 2008).

Freshwater prawns

The development of freshwater prawn (*Macrobrachium rosenbergii*) culture in PNG has been slow due to a lack of expertise and the absence of appropriate resources and technology. One of the key constraints has been the poor quality and limited availability of supplementary feeds. Since the cost of feed represents the major expense in semi-intensive aquaculture, feeds must be cost-effective in order to maintain or increase profit. A limited range of formulated aquafeeds are available locally in PNG but these are costly. A lower-cost compound diet formulated from locally available ingredients must be developed if aquaculture is to expand (Nandlal *et al.* 2005).

Seaweed

There is interest in developing seaweed (*Euchema*) farming in the Milne Bay Province (MBP) but very little has been written since 2003. In late 2001, a New Zealand seaweed consultancy firm conducted a survey in MBP funded by the Food and Agriculture Organization (FAO). In November 2002, SPC, in conjunction with the Solomon Islands'

Department of Fisheries and Marine Resources (DFMR), conducted a seaweed farming workshop. Kinch *et al*. (2003) state that, to develop seaweed farming in MBP, there is a need to initially import seaweed from countries that are already producing it. Before there is any development in seaweed farming, alternative livelihood options need to be assessed and possible seaweed farming and mariculture projects need to be identified. In addition, a pilot seaweed farm needs to be set up as an alternative-livelihoods project. There is also a need to undertake site-selection surveys and establish growth-rate trials and a monitoring programme to introduce *Kappaphycus/Eucheuma* spp. at selected sites.

Reef and reef fisheries (finfish and invertebrates)

Together with Indonesia and Philippines, PNG lies in the Indo-West Pacific, the biogeographical centre of coral diversity, and PNG reefs are among the most diverse in the world (Kailola 1995). There are an estimated 40,000 km² of coral reefs to a depth of 30 m (Dalzell and Wright 1986). Currently, the reefs are exploited almost exclusively by small-scale artisanal and subsistence fishers who use a range of techniques such as spear guns, hook and line, hand spears, kite fishing, gill nets, hand traps, derris root, dynamite, weirs and bamboo traps to harvest reef and reef-associated fish (Dalzell and Wright 1990, Huber 1994, Quinn 2004). Despite the overall health of the PNG fishery, local overexploitation has been noted, particularly in fisheries with access to cash markets (Huber 1994). Human population density, technological efficiency and market pressure have been cited as probable causes of overfishing (Cinner *et al*. 2006).

Reef fishery

This fishery is artisanal, with most catch used for subsistence consumption; however, a small portion is exported annually. In 2002, ~132.82 t of reef fish was exported, valued at PGK ~797,176. A total of 49.94 t of reef fish was exported in 2003 valued at PGK 288,356. Most reef fish products are exported as a trunk, whole, gill-and-gutted, raw, or filleted, and either frozen or chilled. The quantity of reef fish sold and consumed locally is not accounted for in the NFA database (Infofish 2008).

Barramundi

Two species of barramundi (*Lates calcarifer* and *Panulirus ornatus*) are the most important aquatic resources in the Western and Gulf Provinces. Until the fishery collapsed in 1990, barramundi was the fourth-largest export fishery in PNG but is now artisanal. The main barramundi fisheries are in the Fly River system and adjacent coastal region, and the coastal fishery based in Daru, catching a combined total of 70–170 t/year (National Fisheries Authority 2004, Gillett 2002). The fishery is village-based and production very dependent upon the activities of freezer vessels. The fishing method used is set gillnetting, using monofilament nets of the standard length of 100 m. The fishery is managed through Daru Research Station and control is by way of mesh-size restrictions and closure of certain areas during migration season. Fishers are also prohibited from catching and marketing juveniles (Anon. 1990a).

Live reef fishery

The live reef food fish (LRFF) trade began in PNG in 1990 at Hermit Islands in Manus Province. Since then LRFF operations have occurred in Milne Bay, Bougainville, New Ireland and East New Britain Provinces. Up to 32 target species of fish were recorded in the catches and comprised fish from the families Serranidae (19 spp.), Labridae (1 sp.), Lutjanidae (8 spp.), Carangidae (1 sp.), Lethrinidae (2 spp.) and Scorpaenidae (1 sp.). The annual harvest of LRFF in PNG has been relatively low, ranging from 3 t in 1993 to just over 35 t in 1997. Concerns about over-harvesting led to a moratorium on new licences from late 1997 to 1998. Due to the strong interest in LRFF as an income opportunity for village communities, the NFA Board approved two trial LRFF operations in December 2000 (Gisawa and Lokani 2001).

Due to the nature of their operations and the fish they target, LRFF exporting companies have the potential to cause severe negative impacts on reef fish resources. DFMR monitors catches by these companies. The negative impacts can be mitigated by: banning hookah for LRFF collection, advising maritime provinces on the likely costs and benefits of this type of fishing operation, establishing an economic study on LRFF exporting from PNG, improving the monitoring of the fisheries, and using traditional knowledge of reef-fish spawning aggregations to draft management measures such as area and seasonal closures (Richards 1993). Concerns about the unsustainable targeting of grouper spawning-aggregation sites by LRFF operations and the use of cyanide (and other chemicals) to stun and capture fish has led to the formulation of the *Live Reef Food Fish Fishery Management Plan*. Catch limits, fishing method restrictions, areas of operations, and licences are included in the Plan (National Gazette No. G48 16 April 2003).

Invertebrates

The largest and most important export fishery for PNG comprises the sedentary resources (Anon 1999).

Trochus

Following World War II the islanders and coastal people harvested trochus for consumption of the meat and commercial sale of the shell. In 1951 PNG exported 1030 t, the highest annual production. From 1980 trochus exports increased from 320 t to 850 t by 1989. Since 1980, PNG has exported a total of 4200 t of trochus, valued at an estimated PGK 10 million (Department of Fisheries and Marine Resources 1997). The taking and processing of trochus shell is administered and regulated under the *Continental Shelf and Natural Living Resources (CSNLR) Act*. In June 1989 and 1990, a *Trochus Management Plan* was submitted to the Government to be regulated under the CSNLR Act. A PNG trochus potential yield of 800–1000 t/year was estimated by the 1989 UNDP Fisheries Sector Review. Although the current export figures are below the estimated potential yield, signs of localised over-harvesting are becoming apparent in the island provinces of North Solomons, Manus and New Ireland, which are major producers of trochus. Trochus shell purchase data and shipment records are currently being collected in order to verify these observations. At the same time, surveys are planned for the areas concerned to provide an assessment of the level of exploitation of trochus stocks in New Ireland, Manus and West New Britain Provinces. Papua New Guinea has no immediate plans for trochus culture. It would become necessary as a management tool only when the wild stocks are in danger of non-recovery (Lokani and Chapau 1992, Department of Fisheries and Marine Resources 1997**).**

Giant clams

Milne Bay Province in Papua New Guinea is one of the few areas in the world where wild stocks of giant clams *Tridacna* spp. remain. Stock assessment surveys from 1980 onwards show low population numbers. The low stocks are a reflection of previous unsustainable commercial fishing, poaching and subsistence harvesting. According to Kinch (2002a) there is an urgent need to develop means of conserving and ensuring the recovery of giant clam populations in the province. The prospect of culturing giant clams could be considered but exploitation pressure has to be limited to allow giant clam stocks to maintain their stability and regenerative capacity. The most appropriate management for giant clams and other marine resources would be to encourage management and control over reefs by local communities. This would form a cost-effective means of managing a resource, by which local communities enforce management regimes (Kinch 2002a, Skewes *et al*. 2003).

Bêche-de-mer

The artisanal fishery of bêche-de-mer is probably the oldest export from the marine environment in PNG. It was documented from 1878 but was probably exploited earlier than that (Lokani 1995). Bêche-de-mer is the most dominant export of all sedentary resources (Anon. 1999). In recent years, bêche-de-mer has slowly become an important income earner for the coastal and island communities, especially at a time of depressed prices for copra, which is the traditional cash-generating product for the island communities. The species currently exploited are: sandfish (*Holothuria scabra*), white teatfish (*H. fuscogilva*), black teatfish (*H. nobilis*), blackfish (*Actinopyga miliaris*), deep-water redfish (*A. echinites*) and surf redfish (*A. mauritiana)*. About 95% of the products are shifted by air within the country and exported (Lokani 1990). Production averaged only 5.5 t/year in the period 1960–1984, but began increasing in 1985 and peaked in 1991 with exports of almost 700 t dried weight (equivalent to at least 7000 t green or wet weight) (Gillett 2002). Harvests began to decline and 1994 exports were only 207 t, valued at USD 1.8 million. The decline is probably a result of localised over-exploitation, or at least removal of virgin biomass. The government is currently attempting to put in place management arrangements for some of the more heavily exploited areas and species. It has been estimated that total yields of 1000 t/year could be obtained from a properly managed, geographically distributed bêche-de-mer fishery in PNG (FAO 2008).

Stock assessment surveys have been carried out in the provinces that have a bêche-de-mer fishery. The increase in the number of species being targeted by fishers is attributed to the over-harvesting of high-value species and increasing prices of low-value species (Lokani and Chapau 1992, Hair and Aini 1996, Lokani 2001, Kinch 2002b, Skewes *et al*. 2002).

The PNG *Bêche-de-mer Management Plan* has been developed by the NFA in consultation with stakeholders. NFA acknowledges the need to include traditional management practices into the management plan. The primary objectives of the management plan are to maximise economic benefits from the fishery for both the nation and the local inhabitants, to ensure the use of the bêche-de-mer resource is sustainable, and to minimise impacts on the marine and coastal environment. The principal management mechanisms used to protect the fishery from overexploitation are: provincial-level total allowable catches (TAC), including some individual quotas for higher-value species; minimum legal sizes (live and dry); gear restrictions (no underwater breathing apparatus); and a minimum closure period (1st October – 15th December). In acknowledging that more information is needed to support the Plan, the NFA has identified research to support sustainable use of bêche-de-mer resources as an urgent priority (Anon. 2001, Skewes *et al*. 2002, Kinch 2004b).

Sea turtles

There are seven species of marine turtles in the world (Spring 1980). Six species are found in PNG, including the Torres Strait green turtle (*Chelonia mydas*), flatback (*C. depressa*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricata*), olive ridley (*Lepidochelys olivacea*), and leatherback (*Dermochelys coriacea*). The dominant species caught is the green turtle (*C. mydas*) followed by the flatback (*N. depressus*) and the hawksbill (*B. imbricata*). The green turtle contributes the highest proportion of the turtle catch by numbers/year (P. Polon pers. comm., cited in Kare 1995).

Turtle research was initiated in 1984 in Western Province as a result of growing concern over the extensive subsistence and artisanal harvesting of green turtles (*Chelonia mydas*) and, to a lesser extent, hawksbills (*Eretmochelys imbricata)*. Research concentrated on the dynamics of the fishery, which involves at least 183 part-time fishers from the Daru Island area, who appear to hunt selectively for large turtles using outboard or sail-powered craft and harpoons. Biological research concentrated on reproduction, feeding, and general condition of individual turtles (Anon. 1987). Detailed analysis of the green turtle has been documented by Kwan (1991), concentrating on the fishery, biology and implications for management of this species. Research into the monitoring of the Daru turtle fishery comes under the PNG Department of Environment and Conservation. The fisheries research staff based at Daru have began to gather information from fishers, including date of capture, species, sex, carapace length, area (reef) captured and method of capture (Kare 1995).

Dugong fishery

There is little documented information on the dugong fishery. The first indication of dugong stocks being overfished in PNG came from the data landed at Daru (Hudson 1985). Before World War II, about 25 dugongs were caught per year, according to the Papuan Kiwai fishers whom Hudson interviewed. In the 1950s and 1960s the Kiwai fishers were encouraged to kill dugongs, turtles and fish to supply the newly established hospital, schools, jail and local market. This resulted in an increase in dugong kills to 75/year (Johannes and MacFarlane 1991). In the 1970s, when the barramundi and lobster fisheries were introduced, there were unfortunate implications for the dugong population (Hudson 1985). The Government of PNG has declared this animal as a 'national animal' under the *Fauna Protection Act* (Hudson 1985, Johannes and McFarlane 1991). The restriction to allow hunting by traditional means only and on the sale of the animal at present at the Daru market has made it impossible to collect accurate catch statistics. Although a number of surveys have been carried out by scientists from Australia and PNG, the safe future of this animal is not guaranteed (Marsh *et al*. 1984, Marsh 1985).

Lobsters

Five species of lobster have been recorded in PNG: the ornate spiny lobster (*Panulirus ornatus*), painted spiny lobster (*P. versicolor*), double-spined spiny lobster (*P. penicillatus*), tropical spiny lobster (*P. longipes femoristriga)* and the scalloped spiny lobster (*P. homarus*) (Pyne 1970). Small amounts of lobster are caught throughout PNG coastal waters; the only concentrated fishery is in the Gulf of Papua and Torres Strait. Since 1985 this has essentially been a village-based dive fishery with catches being purchased, processed and exported by commercial operators. Landings are typically around 100 t/year and are dominated by the ornate spiny lobster (*P. ornatus*). 1994 exports were 136 t valued at USD 2.8 million (FAO 2008, Gillett 2002).

Lobster research in the 1970s and 1980s indicated that most *P. ornatus* lobsters migrated into the Gulf of Papua to breed and then died. Further, it suggested that trawling that was targeting the dense aggregations of this migration had the potential to effectively wipe out the population if allowed to continue for three consecutive years (Williams 1994). In 1984, to sustain the stocks, Australia and PNG agreed to ban the trawling of migrating lobsters. The stock of *P. ornatus* in PNG reef areas of the Torres Strait Protected Zone was assessed (Evans and Polon 1995). The prawn and lobster fisheries in the Torres Strait Protected Zone are being co-managed with Australia under the Torres Strait Treaty Arrangements. The management is aimed at preserving the fishery for the traditional inhabitants, with strict limited entry for non-inhabitants (Infofish 2008).

Crabs

The mud crab (*Scylla serrata*) is fished at subsistence levels throughout PNG. There are two common species of crab found in PNG: *Scylla serrata* and *S. Serrata* var *paramamosain.* Large mud crabs have been reported in the mouth of Fly River (Western Province), Kikori and Pukari areas (Gulf Province), Murik Lakes (East Sepik Province), and Balgai Bay (New Ireland Province). The species normally occur in estuaries, rivers and streams on muddy substrates, particularly mangrove areas (Lari 1995). Lari (1995) notes that a 1995 study carried out in Western Province showed that the mud crab is an underexploited resource with commercial potential. High transportation costs prevent the crabs from being transported to the market place. Women in MBP, particularly in the Trobriand Islands and the south coast of mainland Milne Bay, harvest mud crabs (Kinch 2002a). From 1994 to 2001, about 29.3 t of crabs were exported with a cumulative value of PGK 0.353 million. Most crabs were exported out of East New Britain, Milne Bay, National Capital District, New Ireland, and Western Provinces. They are exported either live, frozen or cooked (Infofish 2008).

Prawns

The commercial fishery for prawns in the Gulf of Papua began in 1969 and quickly became Papua New Guinea's largest export fishery (Evans and Opnai 1995a). Polovina and Opnai (1989) stated that almost 50% of the catch comprised banana prawns (*Penaeus merguiensis*). The prawn fishery is the most valuable commercial fishery, accounting for exports of 594 t (tail weight) worth about USD 5.6 million in 1994, and 808 t tail weight worth USD 5.9 millions in 1999 (Gillett 2002). The fishery takes place mainly in the Gulf of Papua, adjacent to Gulf Province, although there are four prawn trawl fisheries, the Gulf of Papua, Orangerie Bay, Torres Strait, and Western Province (Kailola 1995). Five prawn species are routinely taken but the catch is dominated by the banana prawn. Total PNG prawn production has in the past exceeded 1300 t tail weight (FAO 2008).

Prawn surveys were carried out between 1955 and 1971 (Opnai 1988) and continue on a regular basis. The accounts of these surveys and the development of the prawn industry have been well documented by Rapson and Macintosh (1971), and Wilson and Tatamasi (1976). More recent research and development have been described by Gwyther (1982), Branford (1982), Kolkolo (1983) and Polovina and Opnai (1989). Stock assessment of the fishery in 1982 resulted in suggestions for management of the fishery. These included restricting the number of operators, limiting vessel length to 20 m and restricting engine power to less than 500 bhp (Anon. 1987). An interim Gulf of Papua prawn fishery management plan was set up in 1988 with the full consultation of prawn operators, who agreed to reduce vessel numbers in the fishery (Evans and Opnai 1995a).

DFMR introduced an ongoing management programme in 1987 to ensure the prawn resource was exploited sustainably. As a result, ongoing assessment and monitoring of the prawn resource have become an integral part of the management programme. Among the management requirements is the closure of the three-mile zone and, depending on climate conditions, trials may be allowed in the later part of the fishing season. The DFMR may revoke licences that are not used within a period of two months and ensure that existing gear restrictions remain in force (Anon. 1990a, Evans *et al*. 1995, Evans and Opnai 1995b).

Ciguatera

Information on ciguatera poisoning compiled by the Research and Survey Branch in 1988 suggested that it is comparatively rare in PNG. However, one of the problems with ciguatera is that, except in severe cases, symptoms may not be recognised, so many cases may not have been reported. Medical records from 1971 to 1981 show that ~60 people contracted ciguatera poisoning from coral trout, barracuda, red bass, and purple headed parrot fish (Department of Fisheries and Marine Resources 1988).

1.3.3 Fisheries research activities

Fisheries research in PNG has traditionally been carried out by the NFA or its predecessor organisations, and has a long history. Major research programmes on tuna, prawns, barramundi, lobsters, various reef fish, and other key fishery species were originally initiated in the 1960s and have been instrumental in the development of current management arrangements for PNG fisheries. More recently, research has also focused on trochus, bêche-de-mer, live reef fish and freshwater fish species, as well as on applied topics, such as fishing gear technology, vessel design and operating economics, aquaculture development and post-harvest fishery technology. Much of this work is supported by international technical assistance agencies and partner research institutions overseas (National Fisheries Authority 1997, FAO 2008).

The purpose of the Research and Surveys Branch of the NFA is to provide the NFA with information on fisheries resources and produce management plans for each major fishery being exploited. A report (Anon. 1989) listed the five areas of research as being: prawn research and management (for establishing biology and population dynamics of adult and juvenile populations, and fishery dynamics through issue and collection of log sheets); Torres Strait lobster biology and management (to provide information on the biology of tropical rock lobster including reproductive biology of the Torres Strait fishery); sedentary resources assessment (use of visual census and other techniques to collect basic biological data for stock estimates on trochus, green snail and other mother-of-pearl shells, bêche-de-mer and giant clams); barramundi research and management (to conduct comprehensive net census in the coastal and inland waters, monitoring juvenile stocks in Daru coastal areas, and determining the level of fishing mortality of spawning fish by tagging and recapture); and investigation of the impact of introduced carp in the Sepik River (to assess the environmental effects of carp on the tilapia populations in the Sepik River).

Females in fisheries research and development

PNG is possibly the first country to implement a national women-in-fisheries programme. In 1990, the DFMR gave serious consideration to including females in its development programmes. Females' participation in fisheries activities was recognised as essential to the ongoing process of economic development. Surveys were carried out by DFMR to assess the role and needs of females in the sector. Based on the findings, projects were developed to promote females in fisheries, with emphasis on increasing the potential for generating income opportunities at the community level. DFMR, with the assistance of SPC, provided training in fish handling, processing and marketing. Workshops were organised in seafood processing and marketing (Anon. 1990b); bêche-de-mer processing (Anon. 1991); seafood quality, processing, marketing, and business skills (Cecily 1995). DFMR also accessed small-scale fish-processing equipment and set up a revolving fund to finance small-business ventures (Anon. 1990a, Cecily 1995).

1.3.4 Fisheries management

The responsibility for fisheries matters lies with the National Fisheries Authority (NFA, previously the DFMR) under the Minister for Fisheries and Marine Resources. The Executive Director of the NFA is responsible to a board composed of government and private sector appointed representatives and oversees the work of the Authority, which has its headquarters at Port Moresby. It is planned that the NFA will also have regional offices in Kavieng, Madang and the Highlands (Kailola 1995).

NFA programme areas are: fisheries management, fisheries databases, tuna and offshore fisheries, inshore fisheries, Torres Strait/Gulf fisheries, and aquaculture fisheries. The overall purpose of the NFA is to manage PNG fisheries resources (National Fisheries Authority 1997). The NFA produces management plans for specific fisheries of national importance. Currently the resources with management plans are tuna, bêche-de-mer, prawns in the Gulf of Papua and Orangerie Bay (Milne Bay Province), and prawns, lobsters and bêche-de-mer in Torres Strait. Management plans for the shark fishery and the live reef food fish trade have been discussed in earlier sections of this report. Future management plans for lobster and aquarium fish are envisaged (Anon. 1999, National Fisheries Authority 2004).

The NFA works under the Fisheries Management Act 1998 and related fisheries regulations, and is established as a non-commercial statutory authority. NFA also has to work under parts of the *Torres Strait Protection Zone Act* (Gillett 2002). The *Torres Strait Protected Zone* (TSPZ) *Act* came into being in February 1985, following the ratification of the Torres Strait Treaty between PNG and Australia. The aim of the zone was to protect the traditional way of life and livelihood of Torres Strait inhabitants. The zone has three categories of fishing: traditional, community, and commercial. Traditional fishers are guaranteed the right to move freely throughout the zone; community fishing is limited to commercial fishing by traditional Australian inhabitants in the zone; and commercial fishing is carefully regulated and shared under a catch-sharing arrangement (Anon. 1987).

Apart from the *Fisheries Act*, there are at least 28 other legislative instruments currently in force and relevant to the fisheries sector. Most important of these is the *Organic Law on Provincial and Local-level Governments* of July 1995, which gives provincial governments the responsibility for fisheries and other development activities and the provision of basic services. The *Organic Law* requires that national bodies devolve as many of their functions as possible to the Provincial authorities, or carry them out at Provincial level (FAO 2008).

In managing PNG's marine resources, the government works with communities, incorporating traditional marine-tenure systems into management plans (Chapau *et al*. 1991). Anon. (1996) states that in 1996 artisanal fishers for penaeid prawns in a local village, Hisiu, outside of Port Moresby, decided to work together with the NFA on a community-based management plan. In the past, plans failed because resource owners' views were never integrated in the drawing up of management plans. Local and international organisations have been instrumental in empowering communities to manage their resources. The Nature Conservancy (TNC), CI (Conservation International), and the University of Papua New Guinea (UPNG) have developed community-based coastal and marine programmes that assist local communities to manage their marine resources (Kinch 2001, 2003, 2005; Kwa 2004). According to Cinner *et al*. (2006), the underlying message is that conservation may be achieved without active enforcement patrols by having a management system that meets a number of community needs and goals and reflects the cultural context of the community.

1.4 Selection of sites in Papua New Guinea

Four PROCFish/C sites were selected in Papua New Guinea, one at Andra, part of Manus Island in Manus Province, one at Tsoilaunung (Tsoi) in New Ireland Province, and the other two in Milne Bay Province, Sideia and Panaeati/Panapompom (Figure 1.5). These sites were selected for two reasons. First, these sites shared most of the required characteristics for our study: they had active reef fisheries, were representative of the country, were relatively closed systems,[5] 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 Papua New Guinea's National Fisheries Authority and the Provincial Governments. Second, there was a mix of marketing arrangements for the non-subsistence catch from bartering, to selling at main centres within an hour's travel by boat, to export of some species, mainly commercial invertebrate species.

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

Andra Tsoilaunung Sideia Panapompom

Figure 1.5: Map of the four PROCFish/C sites selected in Papua New Guinea.

2. PROFILE AND RESULTS FOR ANDRA

2.1 Site characteristics

Andra (Figure 2.1) is a coral island located on the barrier reef on the northern part of the high island of Manus located at the latitude 1°55´S and longitude 146°57´E. Manus is the second-last island in the chain often referred to as 'Scorpions tail'. It is small in size, one kilometre long and 200 m wide, and its orientation in regard to the prevailing easterly winds makes it possible to exploit the outer reef almost all the time. Travel to Andra from Lorengau (provincial centre) takes about an hour by fibreglass speed boat, which is the principle mode of transport to these islands. The island community is a large village divided into clans. There is no principal chief on the island, but there are heads of clans and a village council. Reef ownership is by clan, and the ownership right of the people of Andra extends from the outer reef across the lagoons right to the mainland coastline and halfway between Ahus to the east and Ponam to the west.

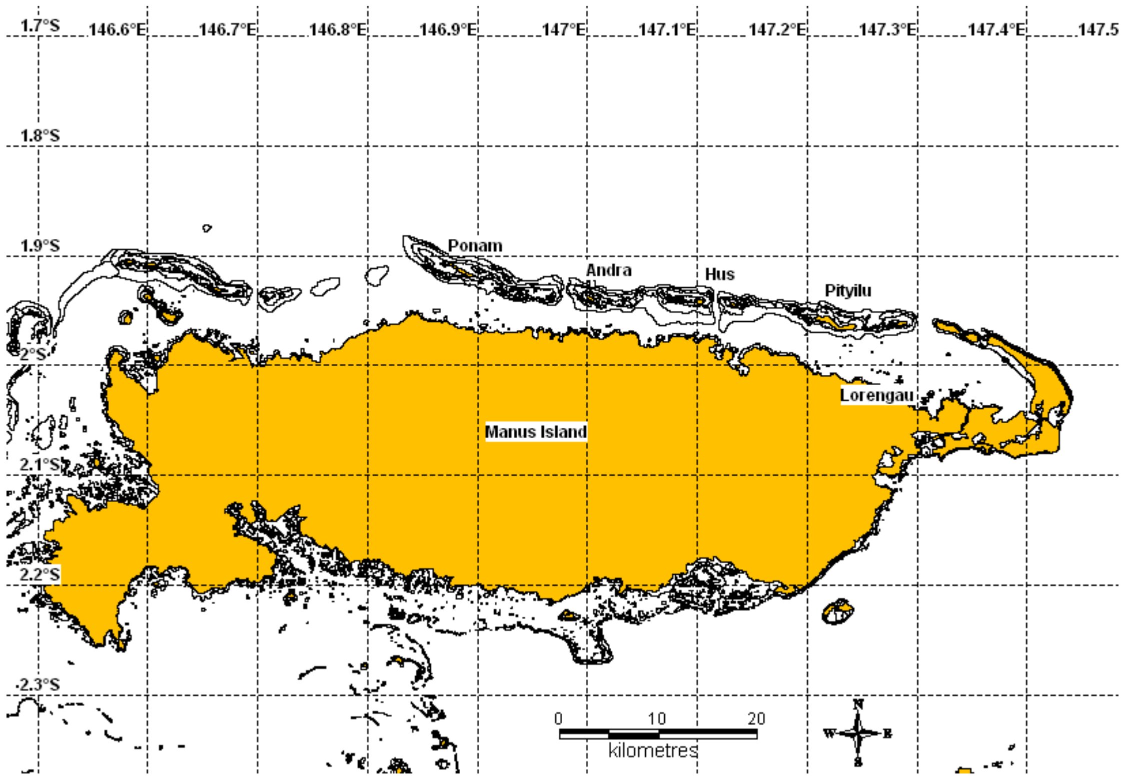

Figure 2.1: Map of Andra.

Access to the outer reefs in front of the island is restricted to Andra inhabitants. Few Andra residents own land on mainland Manus; many are fishers rather than farmers. Their stable food crop is 'sago starch', made from sago palms, which grow wild on the mainland; sago flour is usually prepared with seafood for meals. Sago is also sold for household income. Bartering of fish and garden produce with the mainland people is common practice. The community of Andra is heavily reliant on marine resources for food and income from sale of trochus, bêche-de-mer, lime powder and fish. Andra is the main producer of lime because Andra lime is considered the best in Manus for betel nut chewing.

2.2 Socioeconomic surveys: Andra

Socioeconomic fieldwork was carried out on Andra during September 2006. Andra is a small island community, which is equipped with a Catholic church, one preparatory and one elementary school (five teachers), one health post staffed with a community health worker, one community house, one soccer field and 4–5 private sellers who maintain very small shop outlets within their home space. The survey targeted the entire community, which is divided into six clans, three each occupying the northern and the southern part of the atoll. Each clan maintains one rainwater tank, and one females' toilet and one males' toilet, which are built above the water and are flushed naturally by the tides. Each clan is headed by one leader, and the six leaders form the Community Leaders Group, complemented by one female representing females' affairs. One Andra resident acts as the leader of one of the twelve Local Level Governments (LLGs), and also represents Andra, which is one of these twelve LLGs. Any matter brought forward by the LLG, the governmental administrative and political institution, is discussed by the Community Leaders Group. The Community Leaders Group may accept or reject any recommendation and has the authority to make its own rules and take decisions concerning the governance of Andra and its resources.

In total, 30 households were surveyed, which equally represented all six clans on the island. These 30 households included 148 people, representing ~35% of the total number of households (85) and population (419) on the island.

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 29 individual interviews with finfish fishers (18 males, 11 females) and 12 interviews with invertebrate fishers (1 male, 11 females) were conducted. These fishers belonged to one of the 30 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing. The survey was conducted outside the bêche-de-mer and trochus harvesting season on Andra. Both fisheries are subject to regular or irregular openings, and performed as a community fishing activity. Information and data on the characteristics and total impact of both were thus collected from key persons. Because this data is not part of the normal, questionnaire-based interviews, it was not entered into the database. The results for bêche-de-mer and trochus are, therefore, separately presented and discussed.

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

Our survey results (Table 2.1) suggest an average of about 2–3 fishers (2.4) per household. If we apply this average to the total number of households, we arrive at a total of 204 fishers on Andra. Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of 96 males and 108 females who fish for both finfish and invertebrates, although not necessarily at the same time. In short, there are no fishers on Andra who only target finfish or who only collect invertebrates.

All households on Andra have at least one boat, 8% of which are motorised; the remaining boats are paddling or sail canoes.

Ranked income sources (Figure 2.2) highlight the lack of alternatives for people on a small atoll island such as Andra. All households are dependent on fisheries for income, half as primary income, the other half as secondary. There is no income from agriculture and very few households earn money from salaries. Other sources include handicrafts and, most importantly, selling lime. In Andra, the lime used for preparing betel nut for chewing is derived from the island's hard coral resources and not from shells as elsewhere. Thus, lime production on Andra is very closely associated with fisheries. The average annual household expenditure level is moderately high, USD ~2070 /household/year, suggesting that people on Andra are burdened with the cost of purchasing food items that they cannot produce, and the costs of travelling to markets on the mainland (A return trip Andra – Loringau cost PGK 20 at the time of the survey.). Remittances are insignificant and only very few households receive small amounts of money from their relatives at times (average amount USD ~150 /year for these few households). The high dependence of the community on their reef and lagoon resources for income generation, the infrastructure on the island, and its traditional and strong leadership, indicate that the Andra community enjoys a traditional rather than urbanised lifestyle.

The importance of fisheries shows further in the fact that all households surveyed consume fresh fish, invertebrates and canned fish. All households also confirmed that, normally, fresh fish and invertebrates consumed are caught by somebody from the household. At times (~20% of all responses), fresh fish may also be bought, but invertebrates are never purchased. However, for both fresh fish and invertebrates, non-commercial distribution is common, i.e. ~87% and 63% respectively. These figures indicate the high dependency on reef and lagoon resources for nutrition on one hand, and a strong traditional and social network among community members on the other hand.

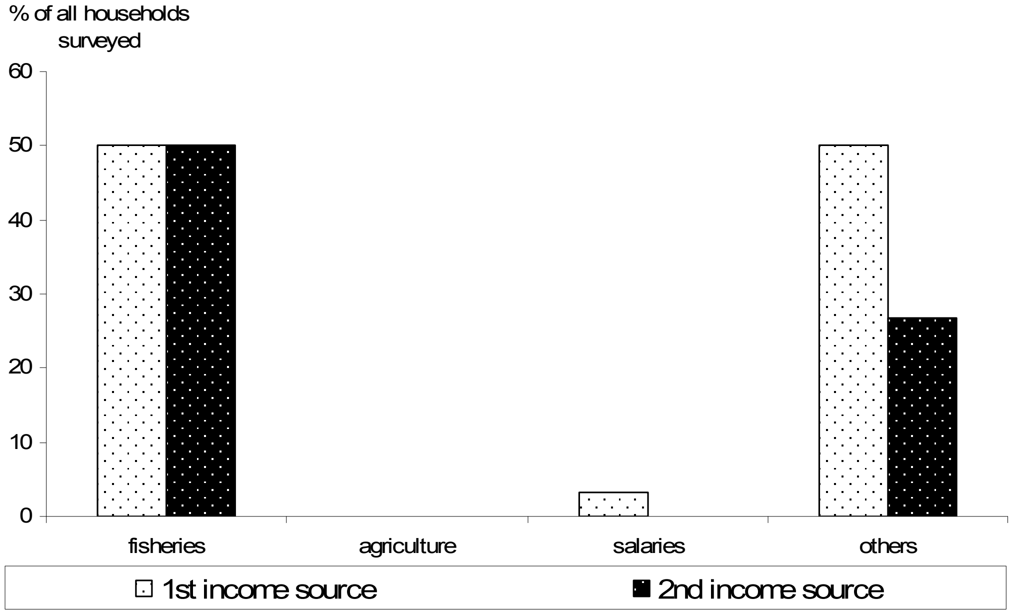

Figure 2.2: Ranked sources of income (%) in Andra.
Total number of households = 30 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.
'Others' are mostly home-based small businesses.

Fresh fish consumption on Andra (~36 kg/person/year ±5.3) is comparative to the regional average (FAO 2008) and to most of the other PROCFish sites surveyed in Papua New Guinea (Figure 2.3), but lower than the average consumption determined nationwide (DFMR 1993). Invertebrate consumption (meat only) is ~6.5 kg/person/year (Figure 2.4) and significantly lower than that of finfish but about the same as the average calculated for all PROCFish/C sites in Papua New Guinea. Although most people reported eating canned fish on average at least once a week, canned fish consumption is extremely low (>2 kg/person/year). This trend seems to apply for all sites surveyed (Table 2.1).

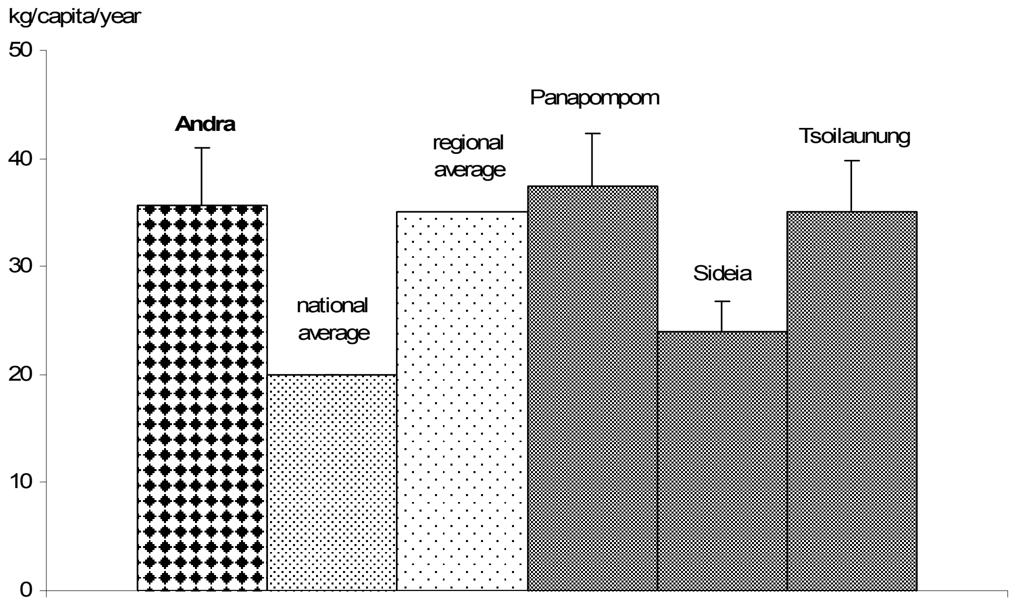

Figure 2.3: Per capita consumption (kg/year) of fresh fish in Andra (n = 30) compared to the national (DFMR 1993) and regional (FAO 2008) averages and the other three PROCFish/C sites in Papua New Guinea.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

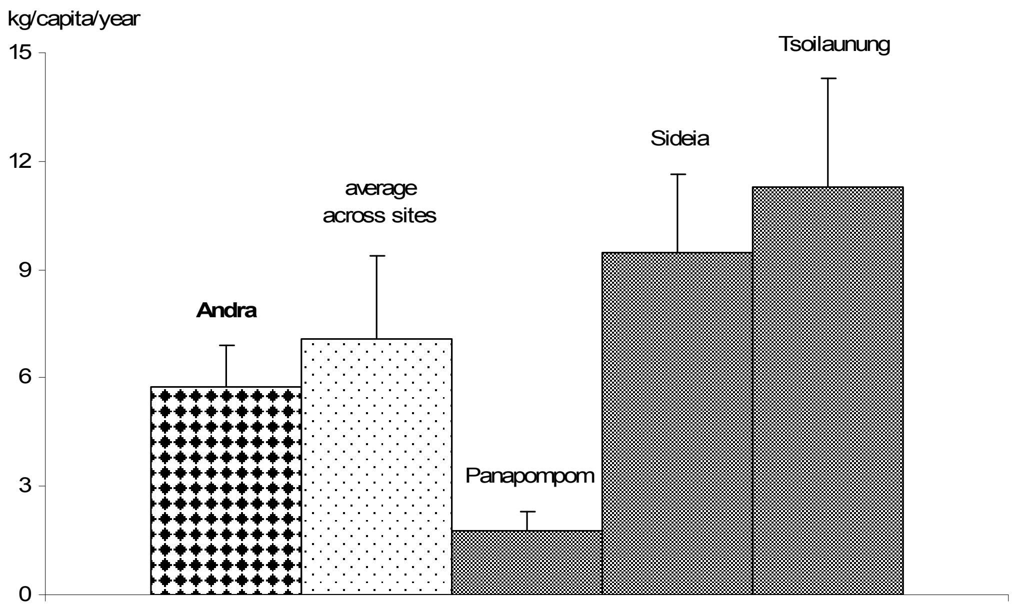

Figure 2.4: Per capita consumption (kg/year) of invertebrates (meat only) in Andra (n = 30) compared to the other three PROCFish/C sites in Papua New Guinea.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Comparison of results among all sites investigated in Papua New Guinea (Table 2.1) shows that people on Andra are about average as far as their dependency on fisheries for income generation is concerned, but they have far fewer alternative income sources than observed elsewhere. Andra's consumption of fresh fish, invertebrates or canned fish is about average and so is the frequency at which they are consumed. Nevertheless, the average household expenditure level on Andra is more than double the average across all four PROCFish sites, reflecting the high costs of transport to and from the island to the mainland markets, and the lack of agricultural potential. Remittances do not play any role on Andra, or at any other sites surveyed in Papua New Guinea.

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

Survey coverage	Site (n = 30 HH)	Average across sites (n = 120 HH)
Demography		
HH involved in reef fisheries (%)	100.0	100.0
Number of fishers per HH	2.40 (±0.22)	2.65 (±0.13)
Male finfish fishers per HH (%)	0.0	9.1
Female finfish fishers per HH (%)	0.0	1.9
Male invertebrate fishers per HH (%)	0.0	0.9
Female invertebrate fishers per HH (%)	0.0	0.6
Male finfish and invertebrate fishers per HH (%)	47.2	40.6
Female finfish and invertebrate fishers per HH (%)	52.8	46.9
Income		
HH with fisheries as 1st income (%)	50.0	53.3
HH with fisheries as 2nd income (%)	50.0	32.5
HH with agriculture as 1st income (%)	0.0	9.2
HH with agriculture as 2nd income (%)	0.0	18.3
HH with salary as 1st income (%)	3.3	13.3
HH with salary as 2nd income (%)	0.0	3.3
HH with other source as 1st income (%)	50.0	26.7
HH with other source as 2nd income (%)	26.7	25.0
Expenditure (USD/year/HH)	2071.94 (±161.99)	982.39 (±80.23)
Remittance (USD/year/HH) (1)	151.02 (±41.78)	110.91 (±16.64)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	35.66 (±5.30)	33.77 (±2.66)
Frequency fresh fish consumed (times/week)	3.79 (±0.30)	3.34 (±0.14)
Quantity fresh invertebrate consumed (kg/capita/year)	6.54 (±1.42)	7.02 (±2.66)
Frequency fresh invertebrate consumed (times/week)	1.13 (±0.14)	1.49 (±0.10)
Quantity canned fish consumed (kg/capita/year)	11.79 (±1.67)	5.13 (±0.65)
Frequency canned fish consumed (times/week)	1.73 (±0.21)	0.93 (±0.11)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	100.0	99.2
HH eat canned fish (%)	100.0	97.5
HH eat fresh fish they catch (%)	100.0	100.0
HH eat fresh fish they buy (%)	20.0	20.0
HH eat fresh fish they are given (%)	86.7	86.7
HH eat fresh invertebrates they catch (%)	100.0	100.0
HH eat fresh invertebrates they buy (%)	0.0	0.0
HH eat fresh invertebrates they are given (%)	63.3	63.3

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

2.2.2 Fishing strategies and gear: Andra

Degree of specialisation in fishing

Fishing on Andra is performed by both males and females (Figure 2.5). Male and female fishers are engaged in both finfish fisheries and invertebrate harvesting; none of the respondents specialised either in fishing only for finfish or invertebrates. According to our survey sample, slightly more females than males are engaged in fishing.

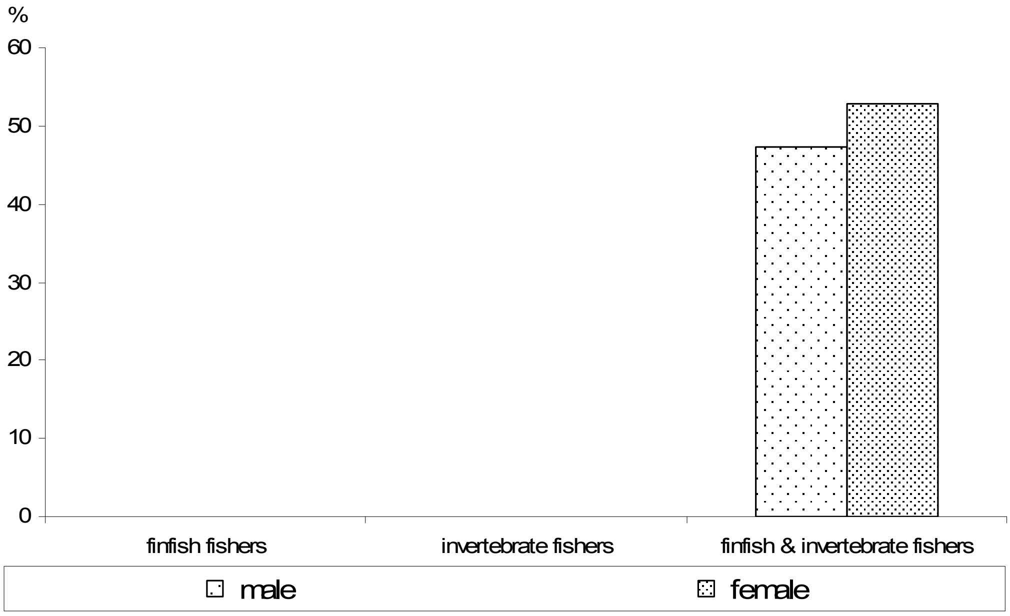

Figure 2.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Andra.
All fishers = 100%.

Targeted stocks/habitat

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	16.7	100.0
	Lagoon	22.2	0.0
	Outer reef	88.9	0.0
Invertebrates	Reeftop	100.0	100.0
	Bêche-de-mer	100.0	100.0
	Other	100.0	0.0

'Other' refers to the trochus and giant clam fisheries.
Finfish fisher interviews, males: n = 18; females: n = 11. Invertebrate fisher interviews, males: n = 1; females, n = 11.

Gender differences show in the habitats targeted. While all female fishers interviewed target the sheltered coastal reef, most male fishers fish at the outer reef. Invertebrate collection is usually associated with the reeftop, and periodically with bêche-de-mer and trochus harvesting (Table 2.2).

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 Andra on their fishing grounds (Tables 2.2 and 2.3).

Our survey sample suggests that fishers on Andra can choose among sheltered coastal reef, lagoon and outer-reef fishing. However, the reef substrate is the main habitat to support invertebrate fisheries on Andra, with the exception of bêche-de-mer, which are also collected from soft benthos within the lagoon (Figure 2.6). Gender participation analysis shows that females dominate the fishery, but only engage in reeftop gleaning and collection of bêche-de-mer in shallow water. Females do not engage in trochus or bêche-de-mer diving (Figure 2.7).

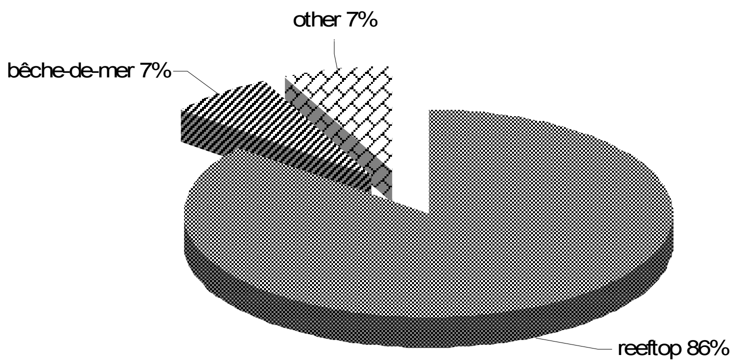

Figure 2.6: Proportion (%) of fishers targeting the three primary invertebrate habitats found in Andra.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the trochus and giant clam fisheries.

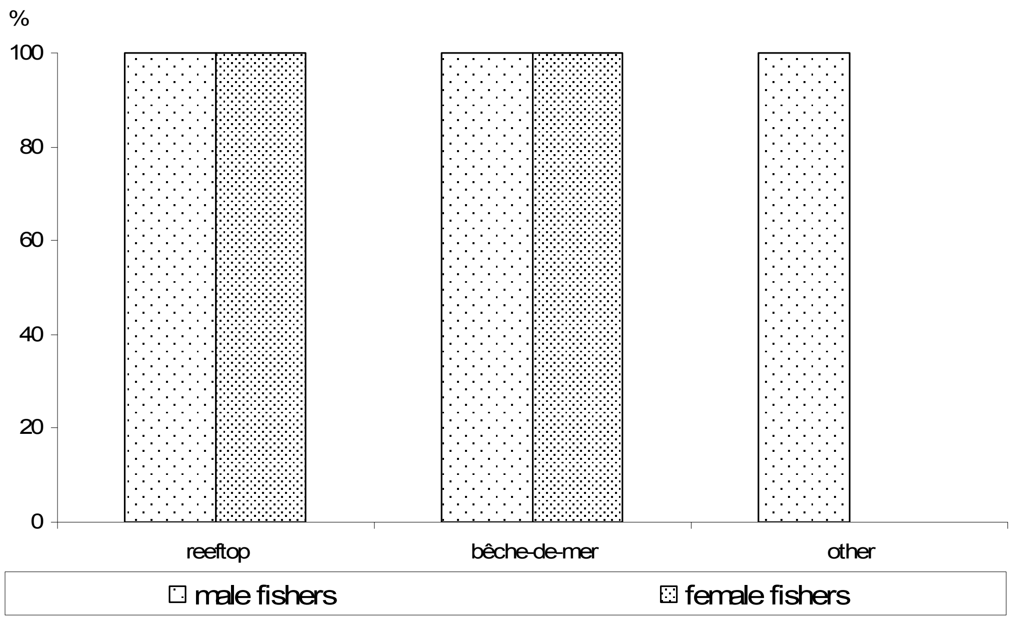

Figure 2.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Andra.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 18 for males, n = 11 for females; 'other' refers to the trochus and giant clam fisheries.

Gear

Figure 2.8 shows that fishers on Andra use mainly handlines and spears (diving or handheld) to catch fish at the sheltered costal reef. Deep-bottom lining and trolling are the main methods used at the outer reef. Here, to some extent, spear diving is also performed. In the lagoon, fishers use both handlining and deep-bottom lining. Fishing on Andra always involves the use of a boat, mostly paddling canoes but also motorised boats, especially for trolling at the outer reef.

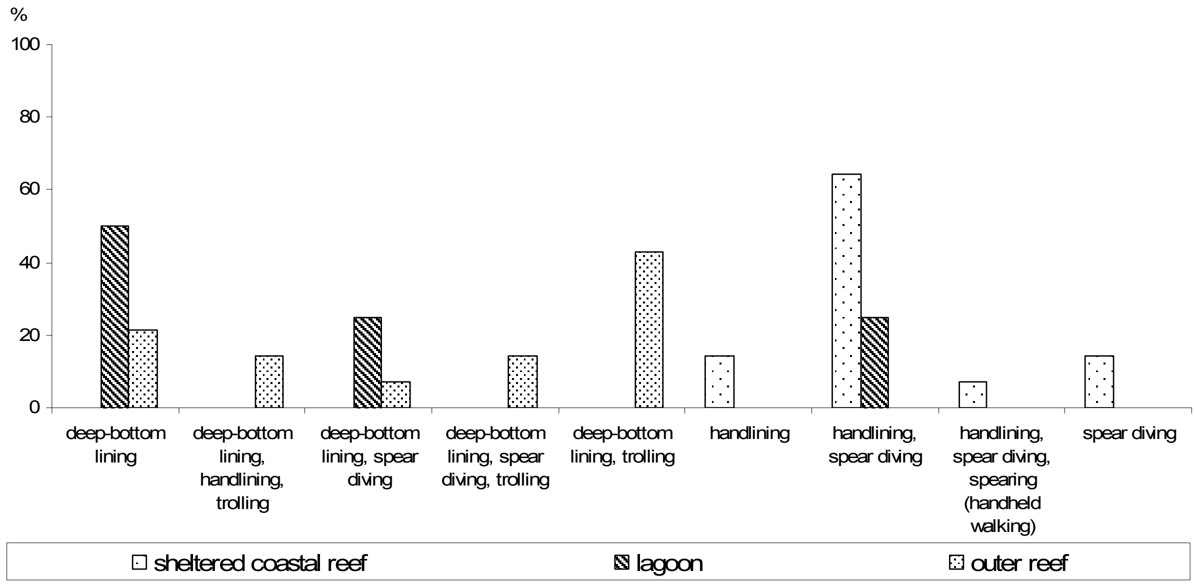

Figure 2.8: Fishing methods commonly used in different habitat types in Andra.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Figure 2.9: Hand-made torpedo line to pick-up bêche-de-mer at greater depth (15–18 m).

Gleaning and free-diving for invertebrates use very simple tools only. Reeftop gleaning is usually done by walking during low tide and mostly during the day, on the dried reef flats that have been reached by paddling canoe. Edible gastropods or other invertebrates are picked up by hand, and mask, snorkel and fins are used for free-diving. Knives or sometimes a spear gun are used to catch giant clams, octopus or lobsters. Two different approaches are used in the periodical bêche-de-mer fishery. Females and males collect sea cucumbers by hand in shallow water, using canoes to bring back their catch to shore. In addition, bêche-de-mer and trochus are collected at the outer reef. For the collection of bêche-de-mer at greater depth (15–18 m), handmade sinkers called 'torpedo lines' are used (Figure 2.9). Trochus is collected by free-diving with mask, snorkel and fins.

Frequency and duration of fishing trips

As shown in Table 2.3, male fishers in Andra make more frequent fishing trips than do females. Males target the sheltered coastal reef about 2.5 times/week, females only ~1.5 times/week. Trip duration does not differ much (~4 hours for males and >3 hours for females). Most male fishers prefer to target the outer reef and fish there more often (>3 times/week) than in the sheltered coastal reef or the lagoon. An average trip to the outer reef lasts 5 hours.

Invertebrates are much less often collected on reeftops. Males may do so once a fortnight while females make 1.5 trips/week. While males fishers spend on average ~2 hours collecting invertebrates, females spend on average >3 hours/trip.

If the bêche-de-mer season is open, all fishers go out almost every day of the week for a period of up to two months. Fishers go together to collect within the lagoon, but only owners can target their own part of the outer reef. Fishers spend ~6–8 hours collecting, transporting and drying bêche-de-mer. For trochus, the open season is very limited, usually two days. On the first day, all families are obliged to fish their own reef area only, but on the second day they may harvest wherever they want. Usually, males fish 12 hours/day on both days to catch as much as they can; night diving with torches is not practised.

Most fishers targeting finfish in the lagoon and the outer reef do so according to the tides, i.e. during the day or night. However, >85% of all respondents at the sheltered coastal reef prefer to fish during the day. This response is mainly due to the high participation of female fishers at this habitat who prefer to fish during daytime because they have other responsibilities at home. Invertebrates are exclusively collected during the day; this is true for reeftop gleaning and bêche-de-mer and trochus harvesting.

Finfish fishing and reeftop gleaning are both performed continuously during the year. Bêche-de-mer is subject to the governmental (National Fisheries Authority) open season (usually from mid-January to mid-July) and the decision of the community leaders group. Normally, Andra opens its bêche-de-mer harvesting season for a certain period every three years (e.g. in 2006 it was opened for two months). It was indicated that the next open season for bêche-de-mer collection in Andra could be expected in early 2009.

Trochus was last harvested in 2003; the following open season (two days) was expected in 2007.

The community is known for its *marahu* (community netting). However, at the time of survey, the net was not in good shape and as a result the males of the community hardly ever got together for this fishing event. When an appropriate net is available this practice is still pursued; all males (except those whose wives are pregnant) walk around the island and net for rainbow runner or any other schooling fish. The fish is chased into the net by threshing the water surface with spears.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	2.67 (±0.67)	1.49 (±0.36)	3.50 (±0.58)	3.18 (±0.38)
	Lagoon	2.63 (±0.43)	0	4.88 (±0.88)	0
	Outer reef	3.39 (±0.30)	0	5.25 (±0.41)	0
Invertebrates	Reeftop	0.58 (n/a)	1.50 (±0.35)	2.00 (n/a)	3.23 (±0.36)
	Bêche-de-mer (1)	6 (2 months)	6 (2 months)	6–8	6
	Trochus (1)	2 /season		12	

Figures in brackets denote standard error; n/a = standard error not calculated; (1) information collected from key informant.
Finfish fisher interviews, males: n = 18; females: n = 11. Invertebrate fisher interviews, males: n = 1; females: n = 11.

2.2.3 Catch composition and volume – finfish: Andra

Catches from the sheltered coastal reef include a great variety of fish species and species groups; *Scaridae* alone determine >40% of the total reported catch. Lethrinidae account for another 13–14%, followed by Haemulidae, Mullidae, Acanthuridae and Serranidae. In lagoon catches Lethrinidae are reported as dominant (~37%), while Scaridae, Mullidae and Haemulidae each represent about 8% of the total reported catch. Others, including Serranidae, Carangidae, Acanthuridae and Balistidae, determine most of the remaining catch. At the outer reef, the main families caught are: Lethrinidae (>20%), Haemulidae (>19%), Lutjanidae (~16%) and Carangidae (~10%), while Scaridae (*Bolbometopon muricatum*) and other parrotfish play a minor role (Details are provided in Appendix 2.1.1.).

Our survey sample of finfish fishers interviewed represents ~14% of the projected total number of finfish fishers on Andra. The group of fishers interviewed is representative of both commercial and subsistence fisheries. Hence survey results are extrapolated to estimate the total annual fishing pressure imposed by the people of Andra on their fishing ground. The survey showed that the Andra community is highly dependent on reef fisheries for food and income, and that a great proportion of their catch is sold on the mainland. This shows also in Figure 2.10, where the share of catch that serves the island's subsistence needs is less than the share sold. Females' contribution to the total annual catch is small, mainly because they usually catch only for food. Female invertebrate fishers interviewed also confirmed that they catch fish, but not for commercial purposes. Therefore, focus was given to data on male fishers as they better represent the potential impact on Andra fishing grounds. However, the fact that females do not fish commercially does not exclude them from very often being in charge of marketing the catch of the male fishers from their household. Although fishers reported that they prefer to fish at the outer reef and go there most often, most of the reef fish catch comes from the sheltered coastal reef and lagoon habitats combined. A large part of the impact at the outer reef may also come from trolling, a fishing strategy that targets pelagic fish. This is not the subject of our study and thus is mostly ignored in this report.

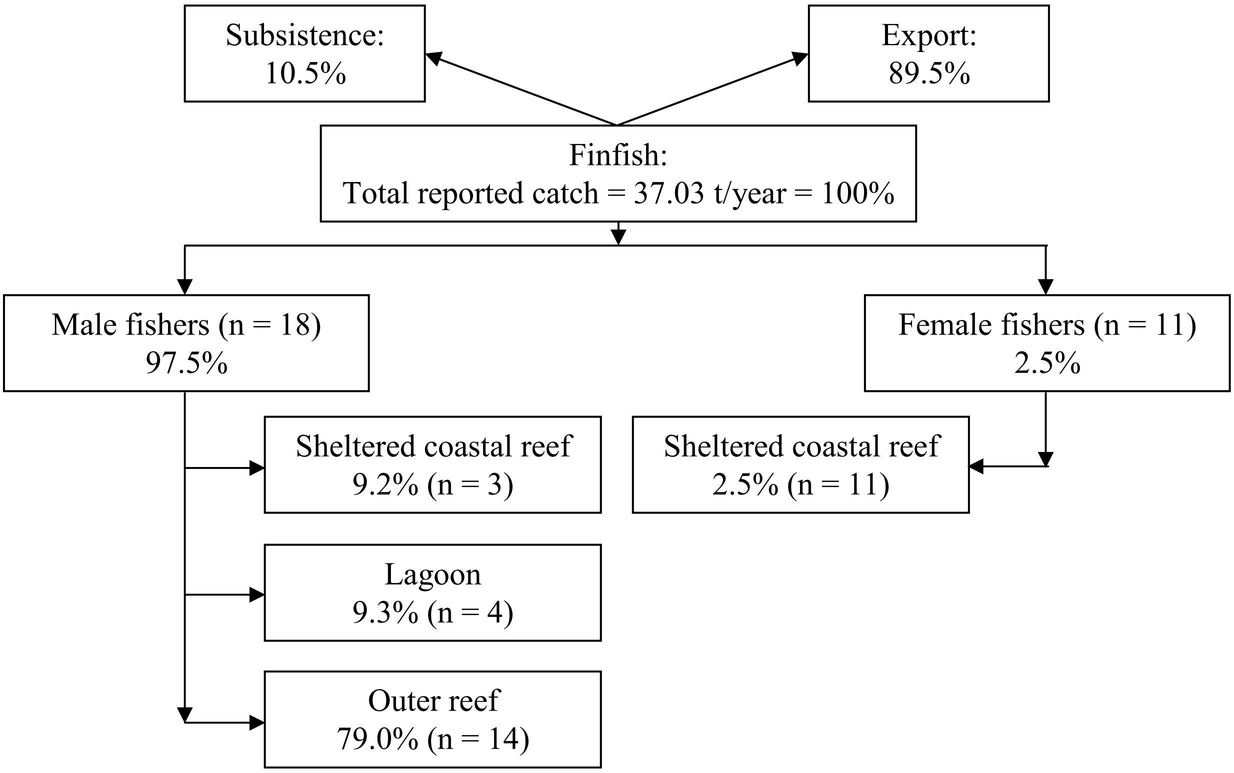

Figure 2.10: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Andra.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

As shown in Figure 2.10 the minor share (10.5%) of impact is due to the demand imposed by the population of Andra on its reef resources, while most (89.5%) of all impact is determined by external demand.

The impact on the sheltered coastal reef is a function of the number of fishers targeting this habitat rather than the catch rate. As shown in Figure 2.11, catches amount to about 1000 kg/fisher/year, which is half of what a fisher catches at the outer reef (>2000 kg/fisher/year). The outer reef is the most important habitat as it provides ~79% of the reported catch. Lagoon fishing seems to yield the lowest catch rates (~800 kg/fisher/year). Females' catches are reported to be very low and support the earlier observation that females fish mainly for subsistence rather than for sale.

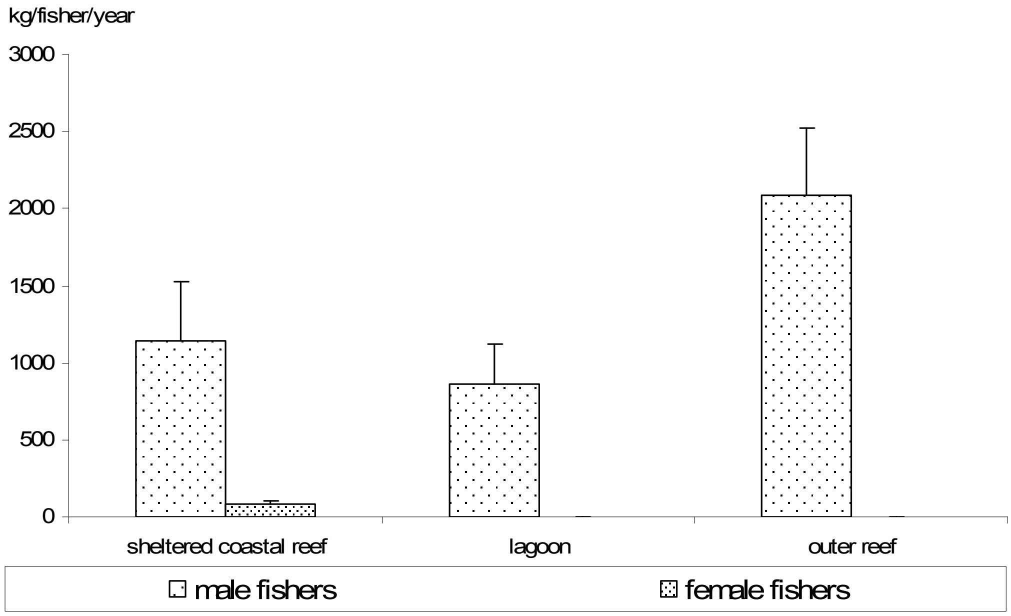

Figure 2.11: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Andra (based on reported catch only).

Differences in the CPUEs of male fishers in the sheltered coastal and the outer reef (Figure 2.12) are insignificant (both >2.5 kg/hour fished). This suggests that the reason why fishers at the sheltered coastal reef reach only half the annual productivity of fishers at the outer reef, is not the status of the resource but rather differences in fishing strategy. The CPUE of lagoon fishers is much lower than any of the others, and CPUEs of female fishers are very low compared to those of male fishers.

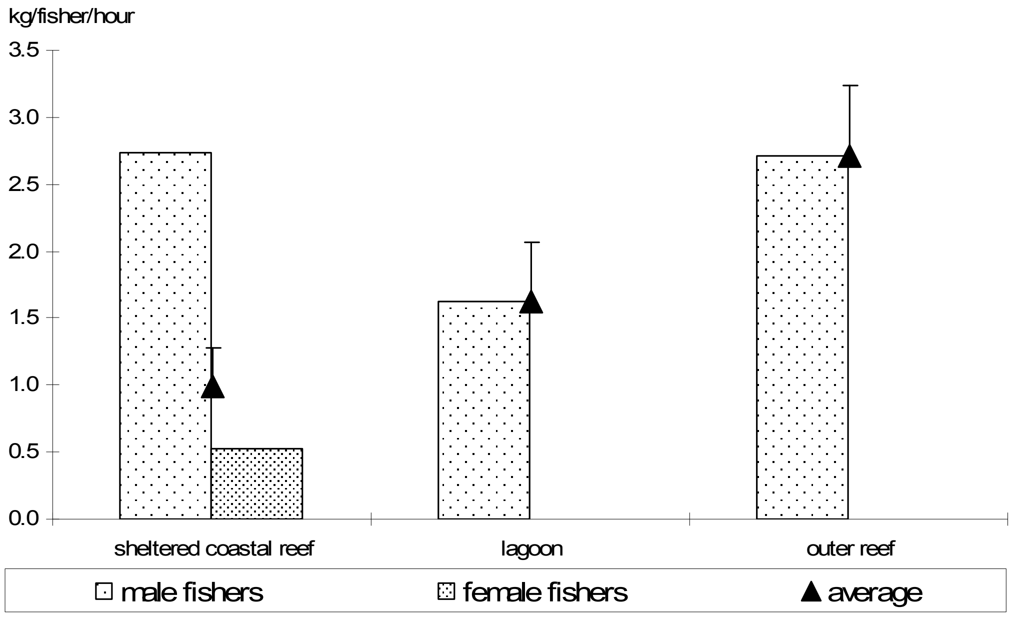

Figure 2.12: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in Andra.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

The high interest in commercial fishing also shows if comparing data on the objectives of fishing trips provided by respondents. Most fishing is done in order to earn income, and fishers targeting the outer reef are slightly more commercially interested than all others (Figure 2.13). Data presented in Figure 2.13 also show that the non-commercial distribution among community members is a part of the Andra community's lifestyle. However, the fishers themselves did not consider this kind of exchange as important as the results from the household survey showed.

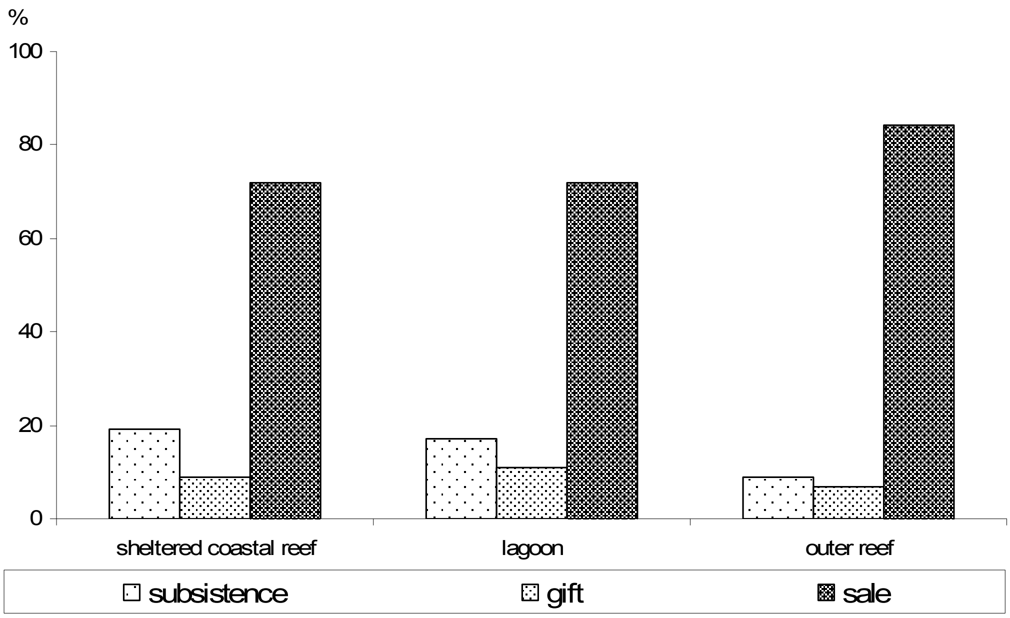

Figure 2.13: The use of finfish catches for subsistence, gift and sale, by habitat in Andra.
Proportions are expressed in % of the total number of trips per habitat.

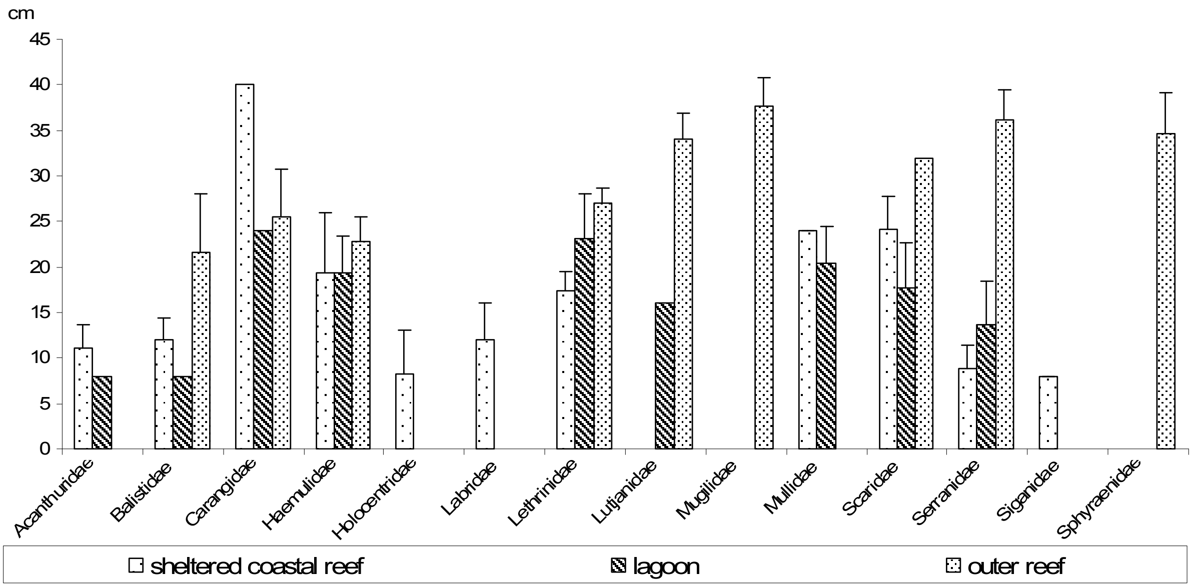

Figure 2.14: Average sizes (cm fork length) of fish caught by family and habitat in Andra.
Bars represent standard error (+SE).

Data on average reported finfish sizes by family and habitat (Figure 2.14) show great variability in the fish sizes by family. In general, sizes are largest at the outer reef, particular for Mugilidae, Lutjanidae, Scaridae, Serranidae and Sphyraenidae, which average ~25 cm fork length. There is a slight tendency for the fish size of some species to increase from the sheltered coastal reef to the lagoon and to the outer reef, e.g. Lethrinidae and Serranidae. However, the average fish size of other species, such as Acanthuridae, Balistidae, Mullidae, Scaridae and Serranidae, decreases from the sheltered coastal reef to the lagoon. Overall, the average size of fish caught at the sheltered coastal reef is 10–15 cm, with some species averaging ~20–25 cm. In the lagoon, average size is ~7.5–20 cm length, i.e. several species are caught at an average size smaller than 10 cm.

Parameters selected to assess the current fishing pressure on live reef resources in Andra are shown in Table 2.4. Fishing pressure among sheltered coastal reef, lagoon and outer reef is compared, as well as total reef area versus total fishing ground area. The latter includes reef and lagoon or soft-benthos habitats. Size varies among the three major habitats: the sheltered coastal reef is the smallest (~3 km²), the outer reef is about triple that size (~10 km²), and the lagoon is the largest area with 27 km². As shown in Table 2.4, most fishers target the smallest area, the sheltered coastal reef, but catch the least amount (~310 kg/fisher/year). Thus, while fisher density is highest in the sheltered coastal reef and lowest in the lagoon followed by the outer reef, catch is highest at the outer reef. Overall, i.e. considering the total reef and total fishing ground areas, population density is low to moderate and fisher density is low. Taking into account only the total available reef area, the fishing pressure induced by subsistence needs only is low (~0.63 t/km²/year); if considering the entire available fishing ground, fishing pressure is reduced by half (0.36 t/km²/year). When we consider that subsistence catches represent only ~10% of the total annual catch, total fishing pressure increases to 4 t/km² of total fishing ground or 6 t/km² of total reef area. However, these figures still suggest that the impact level is low to moderate.

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

Parameters	Habitat				
	Sheltered coastal reef	Lagoon	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	3.00	26.99	9.95	22.54	39.94
Total number of fishers	120	17	67	204	204
Density of fishers (number of fishers/km^2 fishing ground) [(1)]	40	1	7	9	5
Population density (people/km^2) [(2)]				19	10
Average annual finfish catch (kg/fisher/year) [(3)]	309.42 (±140.08)	864.91 (±260.03)	2088.18 (±436.05)		
Total fishing pressure of subsistence catches (t/km^2)				0.63	0.36

Figures in brackets denote standard error; [(1)] total number of fishers is extrapolated from household surveys; [(2)] total population = 419; total number of fishers = 204; total subsistence demand = 14.24 t/year; [(3)] catch figures are based on recorded data from survey respondents only.

Considering all parameters, it can be assumed that current fishing pressure on Andra reef and lagoon resources is rather low and does not give cause for concern. Although fisher density is high at the sheltered coastal reef, this habitat is mainly targeted to satisfy subsistence needs. Highest pressure is assumed to come from fishers with a strong commercial interest. However, these fishers mainly target the outer reef, a more open system, which will dilute potential impacts. This argument is supported by data presented earlier. For instance, average fish size reported in catches was found to generally increase from coastal reef to outer reef. However, impact may still apply if considering certain species. Catch reported from the outer reef has a very low abundance of Scaridae, one of the major fish families caught elsewhere. This may indicate that previous fishing pressure may have already impacted certain species groups. However, before final assessment and conclusions are drawn, the socioeconomic and resource data need to be compared.

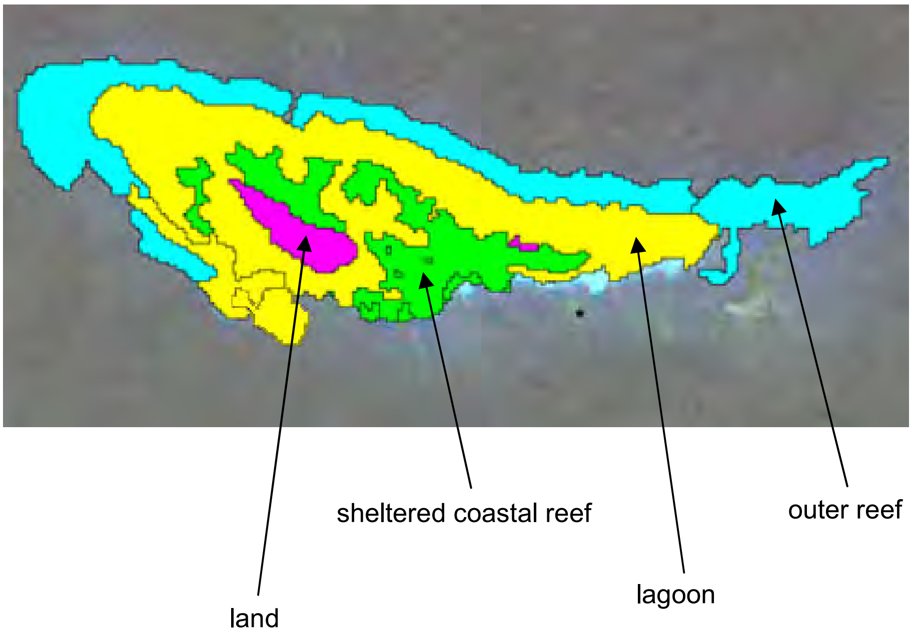

Figure 2.15: Habitats targeted by fishers in Andra.

Commercialisation

Fish and seafood are hardly ever sold on Andra. People on the island are self-sufficient and share catch among themselves on a non-commercial basis. However, some finfish and invertebrates are marketed at Loringau (Manus) or other markets on the mainland. Prices vary and depend on competition, size, processing level and also on the time available for each seller. For instance, people from Andra or other small islands have limited time to sell their produce as they depend on boat transport opportunities to get to the mainland and back to Andra.

Because of the limited cooling capacities, most fish and seafood products are sold boiled and/or smoked. At the time of survey, prices at the Loringau (Manus) market were PGK 5–8 /octopus (boiled/smoked) and on average PGK 4.20 /kg of boiled/smoked finfish, both reef and pelagic species. Marketing is done by males and females, but mostly females. Children very often help and may take charge of the stands.

Market analysis concerning retail prices of the most common canned fish products (mackerel and tuna in oil or tomato sauce) and corned beef showed that, in Loringau (Manus), canned fish costs PGK 8 /kg and canned corned beef PGK 14.4 /kg; on Andra, canned fish costs PGK 13 /kg and corned beef PGK 26.5 /kg.

If comparing market prices for boiled/smoked fish and imported canned fish and corned beef, it is obvious that local seafood is much cheaper than any of the canned produce available in local stores. Prices also show the isolation and transport costs of living in an island community such as Andra, compared with costs of living on the mainland (Details on prices and calculations made are provided in Appendix 2.1.3.).

2.2.4 Catch composition and volume – invertebrates: Andra

Calculations of the recorded annual catch rates per species groups are shown in Figure 2.16. The graph does not include bêche-de-mer and trochus catches as they are periodic and bound to open seasons in particular years only. The graph, however, shows that the major impact (wet weight) of regular fishing pressure imposed by invertebrate collectors and free-divers on Andra reefs mainly affects two species groups: giant clams (*Tridacna* spp.) and octopus (*Octopus* sp.), while *Turbo crassus*, *Tripneustes gratilla*, *Lambis lambis* and *Cypraea tigris* are of minor if not insignificant importance (Appendices 2.1.2 and 2.1.3). Overall, the total impact of gleaning mainly to satisfy subsistence needs is low compared to the total catch of bêche-de-mer and trochus during the open seasons. The average catch (dry weight) of bêche-de-mer per family on Andra is reported to be 100–150 kg, and thus totals 8.5–12.75 t (dry weight)/open season. For trochus, the average catch of shell weight is reported to range between 80 kg/family if collecting in the lagoon and up to 160 kg/family if collecting at the outer reef. For the previous two-day open season, a total harvest of 11 t of trochus shell was reported.

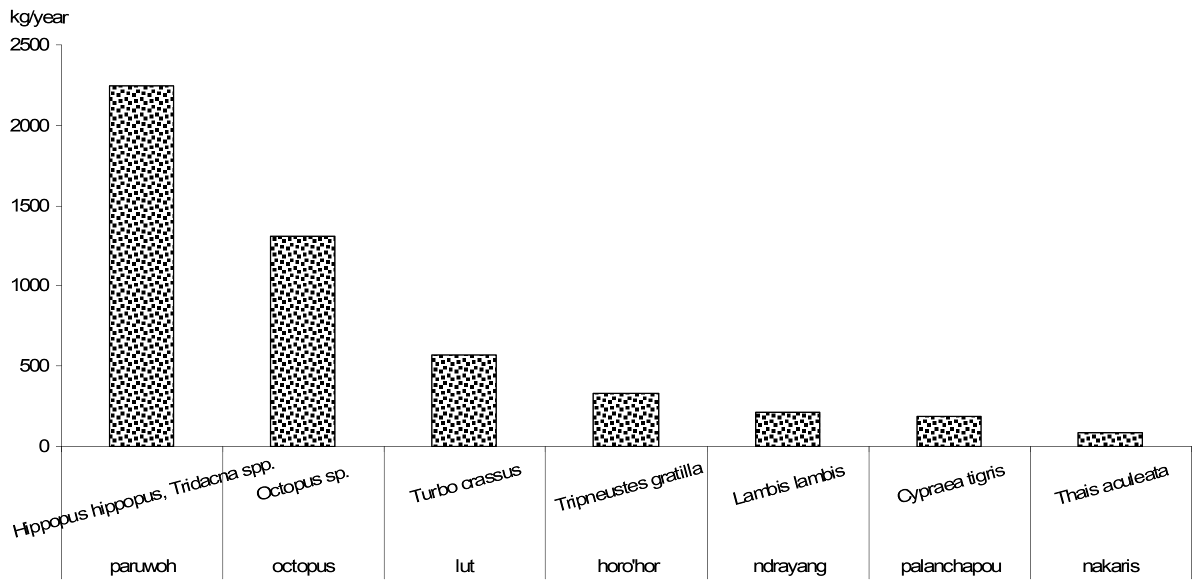

Figure 2.16: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Andra.

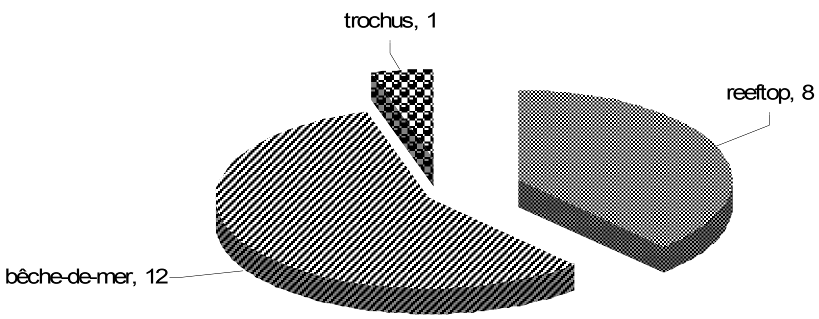

Figure 2.17: Number of vernacular names recorded for each invertebrate fishery in Andra.

As stated above, the invertebrate fishery on Andra is basically limited to reeftop gleaning, apart from bêche-de-mer and trochus collection during open seasons. For reeftop gleaning, there are eight main species groups identified by vernacular names; trochus is a single-species fishery, and a total of 12 bêche-de-mer species were listed (Figure 2.17).

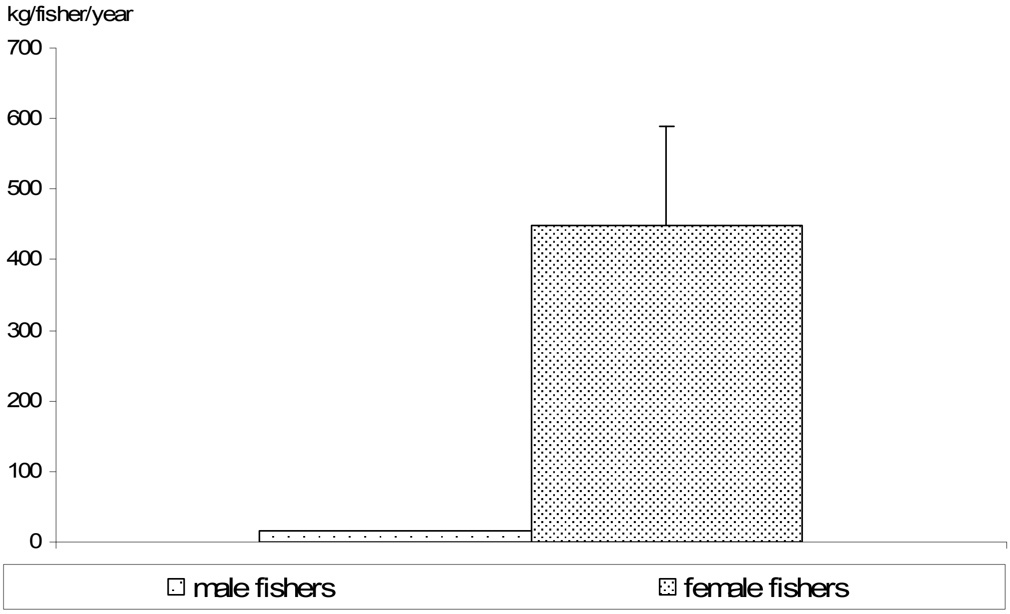

Figure 2.18: Average annual invertebrate catch (kg wet weight/year) in reeftop habitat by fisher and gender in Andra.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 1 for males, n = 11 for females).

Females are the main reeftop gleaners on Andra (Figure 2.18). However, it should be noted that the survey sample of male respondents is very limited and hence this gender difference should not be over-emphasised. Females collect on average about 450 kg of wet weight/fisher/year. This compares to an average family catch of 100–150 kg dry weight of bêche-de-mer or, if considering that dry weight represents about 10% of the fresh catch, 1000–1500 kg/family wet weight. By comparison, males collect on average 80 kg/family of trochus shells in two days if they target the lagoon and 160 kg if fishing in the outer reef.

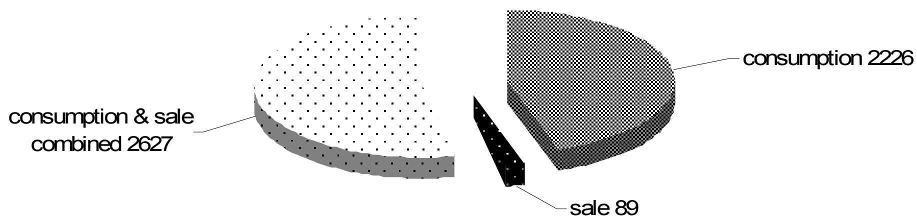

Figure 2.19: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Andra.

In contrast to finfish fisheries, the regular reeftop gleaning fishery is mainly pursued for subsistence purposes. The amount sold on the mainland market is small, at most only 28% of the total catch if assuming that half of the catch in the category ‘consumption & sale’ (2627 kg/year) is actually sold (Figure 2.19). However, if we consider the bêche-de-mer and trochus that are periodically harvested, the picture changes completely. These two fisheries are aimed at export and income earning. Trochus meat is also locally consumed or sold on the mainland market.

The total annual catch volume (expressed in wet weight based on recorded data from all respondents interviewed) amounts to 4.94 t/year (Figure 2.20). This catch is from reeftop gleaning only. By comparison, the reported total catches from the previous open seasons 2006 (bêche-de-mer) and 2003 (trochus) were 8.5–12.75 t and 11 t. The catch composition of bêche-de-mer and trochus is shown in Table 2.5.

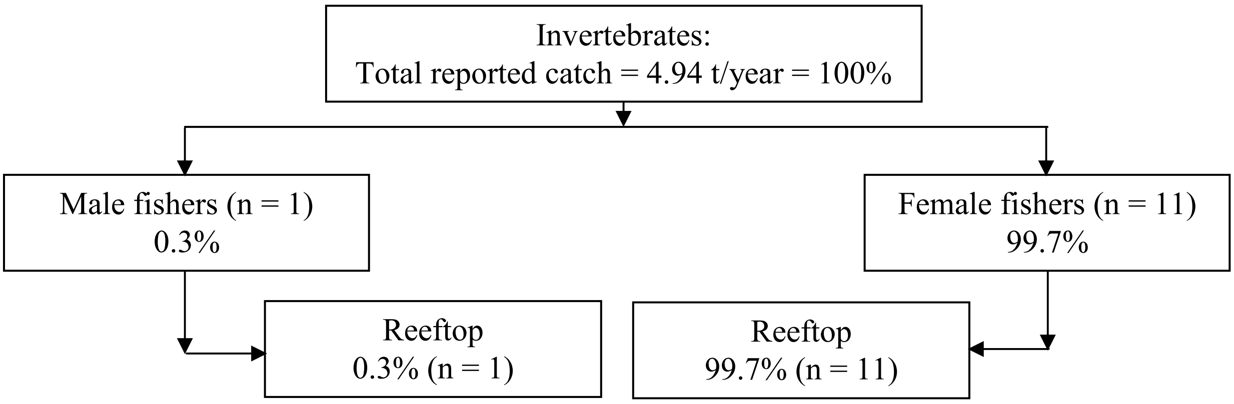

Figure 2.20: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Andra.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

Table 2.5: Reported total catch and catch composition of bêche-de-mer species and trochus collected in the 2006 season in Andra

Vernacular name	Scientific name	Size class (cm)	% of catch
Lollyfish	*Holothuria coluber, Holothuria atra*	8-10	9.5
Leopardfish	*Bohadschia argus*	14-16	5
Deep-water redfish	*Actinopyga echinites*	14-16	5
White teatfish	*Holothuria fuscogilva*	26-28	50
Surf redfish	*Actinopyga mauritiana*	16-18	5
Sandfish	*Holothuria scabra*	26-28	2
Curryfish	*Stichopus variegatus, Stichopus hermanni*	26-28	5
Elephant trunkfish	*Holothuria fuscopunctata*	26-28	5
Greenfish	*Stichopus chloronotus*	26-28	5
Prickly redfish	*Thelenota ananas*	26-28	5
Black teatfish	*Holothuria nobilis*	24-26	1
Stonefish	*Actinopyga lecanora*	16-18	2.5
Total:			**100**
Lal, lalai	*Trochus niloticus*	8-10	100

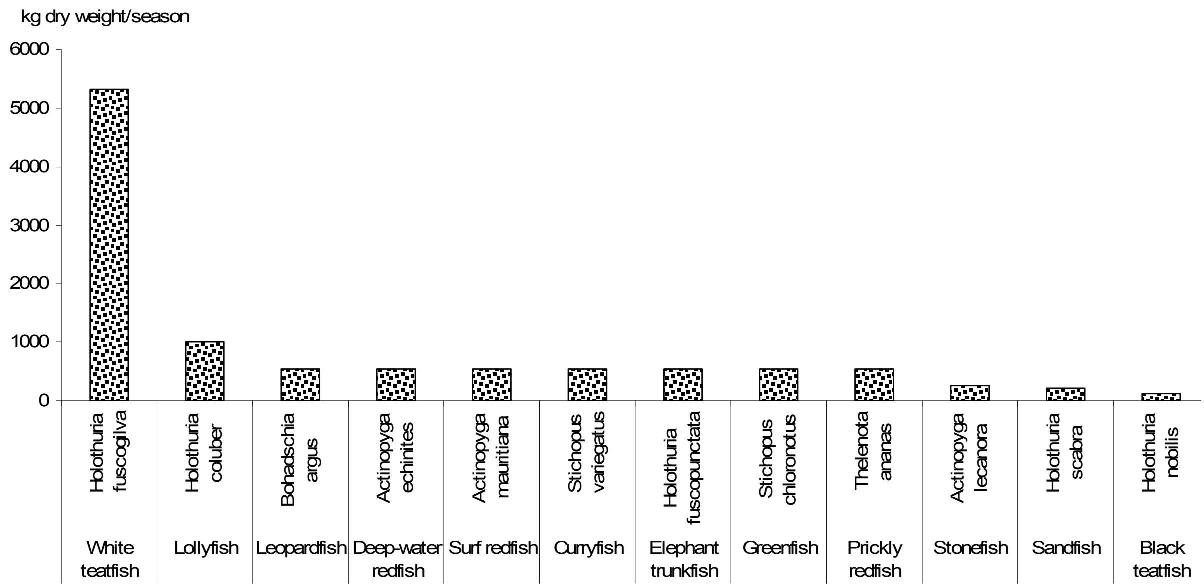

Figure 2.21: Total catch (dry weight) by species for a bêche-de-mer harvesting season in Andra.

Figure 2.21 shows the total impact expressed in dry weight for each bêche-de-mer species reported. The estimated share of each species in an average catch during an open season on Andra as included in Table 2.5 has been applied.

Table 2.6: Parameters used in assessing fishing pressure on invertebrate resources in Andra

Parameters	Fishery / Habitat		
	Reeftop	Trochus	Bêche-de-mer
Fishing ground area (km^2)	3.31	2.39	7.2
Number of fishers (per fishery) (1)	204	96	204
Density of fishers (number of fishers/km^2 fishing ground)	62	40	28
Average annual invertebrate catch (kg/fisher/year) (2)	411.88 (±133.37)	80.0-160.0 (3)	62.5-83.3 (4)

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; (3) shell weight only; (4) dry weight only.
Reeftop area = total reef area; potential trochus harvesting area = outer-reef area; potential bêche-de-mer harvesting area = total fishing ground of Andra.

Table 2.6 shows lowest fisher densities for commercial fisheries, i.e. bêche-de-mer and trochus. However, the fisher density for reeftop gleaning is also not very high, especially considering that the catch is only ~400 kg/fisher/year.

Commercialisation

The selling of any seafood is done individually although some of the fisheries may be organised as a community event. Trochus is either sold to buyers who come to the village, or on the mainland. There are ~4–5 buyers, with whom fishers bargain to get the best price. All buyers check for quality and size limits. On average, PGK 10 are paid per kg of trochus shells. With an average catch of 80–160 kg/family, in a 2-day open season a family may earn PGK 880–1600 (USD 259–518[6]). Since the Andra community includes 85 households, the total revenue from a 2-day open season may be PGK 68,000–136,000 (USD 22,005–44,011).

[6] Exchange rate PGK to USD = 0.32361.

The meat is either consumed by the household or sold at the mainland market. About 10 boiled and/or smoked pieces are sold on a stick for PGK 0.50.

No quota is provided for trochus harvesting. Philippe from Papindo at Loringau indicated that his company exports about 10 t of trochus shells each year with fluctuations between years, from a maximum of 15–20 t/year down to ~5 t/year. He exports trochus to the same client in Hong Kong to whom he sells his bêche-de-mer products.

Solai Pahun, another trochus buyer at Loringau, started in 2003. He exports about 5 t/year with no major fluctuations between years. He buys for PGK 10 /kg and sells for PGK 15 /kg to the MSB Company at Rabaul.

Seeadler Sea Products at Loringau started to market trochus and bêche-de-mer in June 2003. The company buys locally and sells to Kavieng or other local buyers. Seeadler buys trochus from fishers for PGK 10 /kg.

Between 2003 and 2006, the volume of trochus traded was:

2003	57 bags [(1)]	2850 kg
2004	96 bags	4800 kg
2005	57 bags	2850 kg
2006	87 bags	4350 kg

[(1)] 1 bag ~ 50 kg.

Manus Stationery started to purchase trochus and bêche-de-mer in 2003. The company bought ~15 t of trochus shell in 2003, none in 2004 and 2005, and only a marginal amount in 2006. Trochus was sold to a dealer based at Singapur or to MSB at Rabaul. The company pays PGK 9 /kg to the fisher and sells for PGK 12 /kg to Rabaul. The company decided to focus on bêche-de-mer as it provides opportunities to deal with larger quantities.

Bêche-de-mer are locally boiled and dried, and then sold to any of the seven buyers listed by respondents (Jack Santo, Louis, Sikai Ltd., Seeadler, a buyer at Kavieng, Manus Stationery and Manuwai-TNC) located on the mainland, but mostly at Loringau (Manus). The average prices paid for the various species, depending on quality and size are presented in Table 2.7. Assuming an average catch of 100–150 kg dried bêche-de-mer per household, and applying the percentage of catch as indicated by respondents, on average a household may earn PGK ~26,000 per season (USD ~8600). This total earning provides USD 2870 /year assuming that bêche-de-mer is harvested only once every three years. This estimated amount highlights the importance of the bêche-de-mer fishery for Andra, as these earnings cover the annual average household expenditure.

Table 2.7: Average prices at which bêche-de-mer species are bought at Loringau (Manus)

Vernacular name	Scientific name	Price (PGK /kg)			% of catch	Catch / household		
		From	To	Average		100 kg	150 kg	Average
Lollyfish	*Holothuria coluber, Holothuria atra*	8	10	14	9.5	133	200	266
Leopardfish	*Bohadschia argus*	20	25	35	5	175	263	350
Deep-water redfish	*Actinopyga echinites*	20	20	30	5	150	225	300
White teatfish	*Holothuria fuscogilva*	120	135	195	50	9750	14,625	19,500
Surf redfish	*Actinopyga mauritiana*	60	80	110	5	550	825	1100
Sandfish	*Holothuria scabra*	120	170	230	2	460	690	920
Curryfish	*Stichopus variegatus, Stichopus hermanni*	60	80	110	5	550	825	1100
Elephant trunkfish	*Holothuria fuscopunctata*	10	10	15	5	75	113	150
Greenfish	*Stichopus chloronotus*	60	80	110	5	550	825	1100
Prickly redfish	*Thelenota ananas*	60	80	110	5	550	825	1100
Black teatfish	*Holothuria nobilis*	50	60	85	1	85	128	170
Stonefish	*Actinopyga lecanora*	60	80	110	2.5	275	413	550
Total:					**100**	**13,303**	**19,955**	**26,606**

The National Fisheries Authority (NFA) provides an annual quota of 50 t of bêche-de-mer/year. In the beginning of the fisheries in 2000, this target was fulfilled within three months but, with each year thereafter, it took longer and longer to reach the maximum harvest quota. In 2006, it took about six months to collect 50 t of dried bêche-de-mer for export.

Four bêche-de-mer dealers were interviewed at Loringau. Philippe (Papindo) started to buy bêche-de-mer and trochus in the year 2000 and serves a client in Hong Kong. Only in 2006 did he buy bêche-de-mer from Andra but has never bought trochus.

Seeadler Seafood Products buys small amounts of bêche-de-mer only, only a couple of bags per season. Some of the fishers are from Andra, and some from other places, such as Harangan island, BP island (Bidullo) and Ponam. This company sells to Papindo at Loringau.

Manus Stationery deals with one dealer based in Singapur, or sells to a Rabaul-based agent. The bêche-de-mer volume has fluctuated over the past four years but generally increased from 2003 to 2006 (15 t in 2003, 12 t in 2004, 10 t in 2005 and 25 t in 2006). Market competition, i.e. prices paid by buyers, is considered the main factor that determines the company's total annual volume rather than supply from fishers. This company's main supplying fishers come from almost all surrounding villages and small islands, including Andra. Between 2003 and 2006, he observed that the high-value species such as white teatfish, black teatfish and stonefish have decreased in total volume supplied but that, at the same time, prices for these three species increased.

All buyers interviewed highlighted that the quality of dried bêche-de-mer produce sometimes does not meet the quality desired, although, in general, the quality is acceptable. Some of the buyers, for example Manus Stationery, visit fishers at times to talk about processing standards. Some buyers suggested that NFA train fishers in adequate processing techniques. All buyers confirmed that the market demand at Hong Kong or elsewhere is much higher than the supply, and much larger volumes could easily be exported and sold.

Fisheries management

Andra is a very traditional island community, which enjoys and maintains its social values and structure. As explained above, decisions on the islands that may overrule or adopt suggestions made by the local level government are made by the island's community leaders' group. This leaders' group is composed of representatives from each of the six clans, and includes a representative of the females' group.

The community of Andra complies with the NFA regulations, including size limits for trochus, i.e. only specimens with a diameter of 8.5–11 cm are collected. Also, when the bêche-de-mer season is open, sizes are monitored. There is no use of hookah or SCUBA gear, night diving, poison, or explosives allowed on Andra, and any harvest seasons determined by NFA are obeyed with.

In addition to the NFA regulations, Andra exercises its own closures for the trochus and bêche-de-mer fisheries. During the past it seems as if the community opened the bêche-de-mer fishery every third year, only for two months during the legal season (which may last as long as six months). The trochus fishery is opened usually for only two days every third year or at even longer intervals. So far the community seems to have been strong enough to withstand the pressure that is increasingly imposed by commercial buyers who are aware that Andra still has considerable trochus and bêche-de-mer resources left. The community is keen to cooperate much more with local NGOs in particular concerning knowledge of their resource status and advice on sustainable yields.

The community has also decided to ban gillnetting and night spear diving using torches. Interest has been expressed in drafting and implementing a fisheries management plan. The community has a long-term conflict over resource use with the neighbouring island's community of Ponam. The fishing ground between both islands, which is very protected by a barrier reef and includes a protected lagoon area, has been claimed by both communities. Although this conflict may not be resolved, both communities acknowledge this area as a *tabu* zone and no fishing is practised there. This zone, therefore, functions as a marine reserve.

2.2.5 Discussion and conclusions: socioeconomics in Andra

- Fisheries are the most important source of income for the people on Andra. All households depend on fisheries for income: half as first and the other half as secondary income. However, since the production and selling of lime (corals) is the first source of income for more than half of the households who depend on fisheries as secondary income, it can be argued that the sea supplies the most important income for all. Agriculture and salaries are of minor importance.

- Fishing provides also the most important source of protein and nutrition, as the atoll island has no agricultural potential. All households eat fresh fish and invertebrates, and also, occasionally, canned fish. All households consume mainly fish and seafood that is caught by a member of the household or given by somebody else from the community, but hardly ever bought.

- Fresh fish consumption is moderate (~36 kg/person/year), but invertebrate consumption is rather low (6.5 kg/person/year). Fresh fish consumption is similar to the regional average and much higher than the national figure for Papua New Guinea. The low canned fish consumption confirms that foods are rarely purchased. Price calculations made show that, on average, canned fish costs twice as much as boiled/smoked fish sold at the Loringau (Manus) market.

- The average household expenditure level is higher than across all four PROCFish sites in Papua New Guinea, a result of the isolated location of Andra, which involves high transport cost, and the need to purchase food items other than seafood due to the lack of agricultural produce on the atoll.

- Finfish fishing is done by males and females. Females fish the sheltered coastal reef and lagoon for subsistence; males target the outer reef for commercial purposes. Females dominate reeftop gleaning; however, both genders are heavily involved in the commercial bêche-de-mer fishery when the season is open. Females do not participate in trochus collection as it is done by males free-diving at the back- and outer reefs. Most fishing is done using paddling canoes, but motorised boats are also used, particularly at the outer reef.

- Various techniques are used to catch finfish: mainly handlining and spearing at the sheltered coastal reef; deep-bottom lining and spearing in the lagoon; and deep-bottom lining and trolling at the outer reef.

- Fishing pressure in terms of numbers of fishers is highest at the sheltered coastal reef, where average annual catch is lowest. Highest catch rates and most of the reported catch are from the outer reef, but the number of fishers here, and hence fisher density, are low. Overall, fishing pressure, either expressed as population density or fisher density, or in terms of subsistence catch per area of fishing ground available, is low and none of the parameters suggest any cause for concern. However, impacts from previous fishing may show in the occurrence and characteristics of certain fish species, e.g. Scaridae. However, before final conclusions are made, comparison with results from the resource surveys is needed.

- The regular invertebrate fishery is confined to reeftop gleaning, which mainly serves the subsistence needs of the Andra community. However, the major impact estimated for giant clams and octopus may also be due to the selling of boiled and smoked giant clam meat and octopus at the mainland markets. On the other hand, the total catches of bêche-de-mer and trochus, when the community leaders' group decides to open these fisheries, are substantial.

- However, considering total catch rates and number of fishers involved in each of the three major fisheries, including bêche-de-mer and trochus, in relation to the available area, no alarming levels of fishing pressure emerge.

Data collected and discussions held with people from Andra suggest that the island's reef and lagoon resources are in good shape, even though the community heavily depends on them for subsistence and income purposes. The very strong traditional community structures and high internal social coherence are important factors which support the implementation of community fisheries management measures when needed and a high level of compliance by the community members. The community watches ruefully over their reef and lagoon areas and keeps intruders at bay. Some fishers do disregard certain rules, such as spear diving at night with a torch, or the use of the poisonous root (*Derris derris*); however, as these do not occur often, they appear to be somewhat tolerated.

The community is well aware of the possible detrimental effects of over-harvesting their trochus and bêche-de-mer resources and therefore tries to keep fishing pressure low so it can be used to provide the community's financial needs.

2.3 Finfish resource surveys: Andra

This report presents a preliminary assessment of the finfish resources of the coral reefs of Andra off the island of Manus (Figure 2.22).

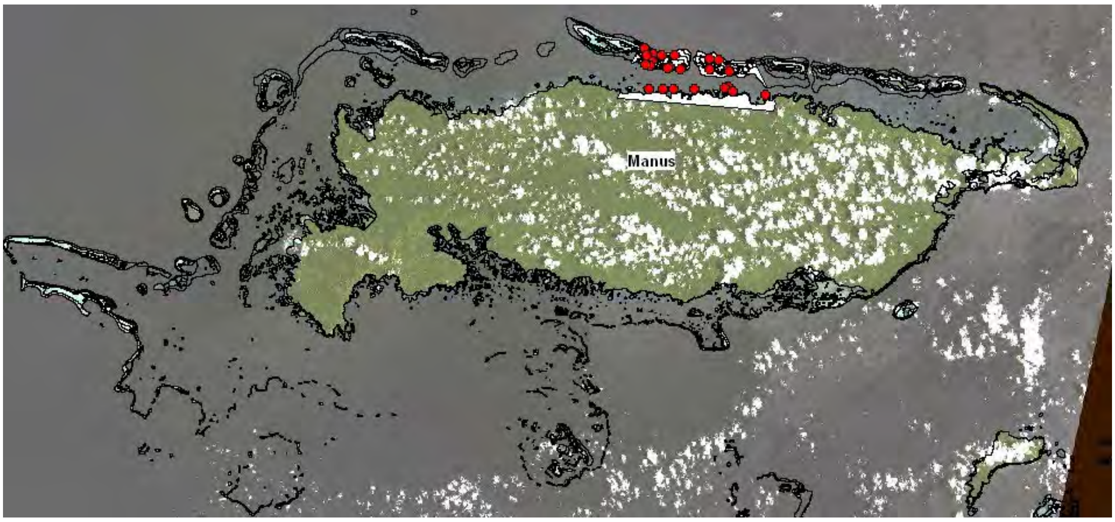

Figure 2.22: Location of the selected site of Andra on the island of Manus.

Finfish resources and associated habitats were assessed between 28 August and 4 September 2006, from a total of 24 transects (6 sheltered coastal reef, 6 intermediate-reef, 6 back-reef, and 6 outer-reef transects, see Figure 2.23 for transect locations and Appendix 3.1.1 for coordinates).

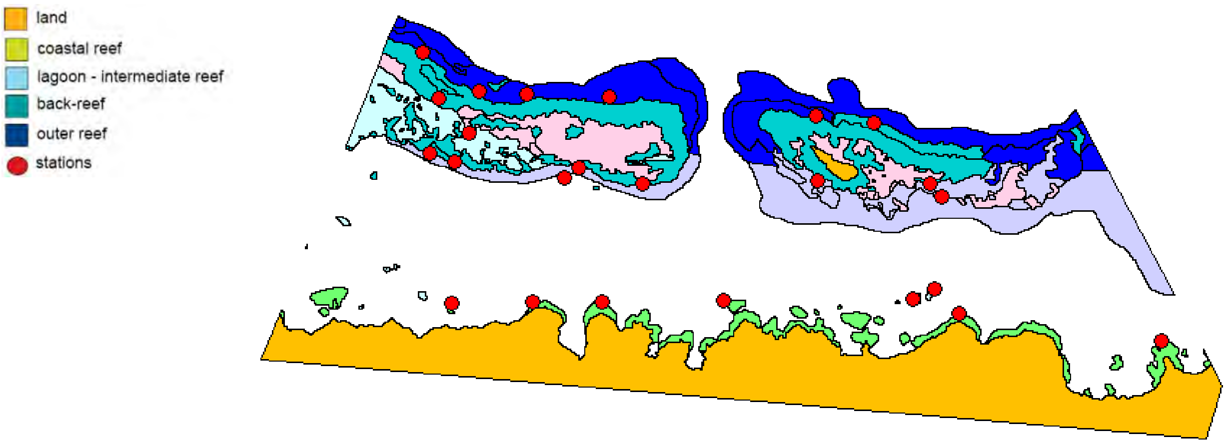

Figure 2.23: Habitat types and transect locations for finfish assessment in Andra.

2.3.1 Finfish assessment results: Andra

A total of 22 families, 56 genera, 194 species and 13,813 fish were recorded in the 24 transects (See Appendix 3.1.2 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, 173 species and 12,629 individuals.

Finfish resources varied greatly among the four reef environments found in Andra (Table 2.8.). The outer reef contained a greater number of fish (1.3 fish/m^2), larger average fish sizes (19 cm FL) and second-highest size ratio (57%), larger biomass (313 g/m^2) and higher species richness (57 species/transect) compared to the poorer coastal, intermediate and back-reefs. Lowest density was recorded in the coastal reefs (0.6 fish/m^2), while lowest biomass was found in the intermediate reefs (84 g/m^2). Back-reefs displayed the lowest average size (15 cm FL), average size ratio (49%) and biodiversity (40 species/transect) of the site.

Table 2.8: Primary finfish habitat and resource parameters recorded in Andra (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)	3.0	3.0	9.6	9.9	25.5
Depth (m)	5 (2-12) (3)	5 (1-10) (3)	4 (1-9) (3)	6 (3-10) (3)	5 (1-12) (3)
Soft bottom (% cover)	19 ±4	14 ±5	18 ±5	4 ±2	12
Rubble & boulders (% cover)	4 ±3	2 ±0	6 ±3	11 ±5	7
Hard bottom (% cover)	40 ±6	56 ±8	48 ±4	57 ±5	52
Live coral (% cover)	32 ±7	20 ±4	24 ±4	27 ±2	26
Soft coral (% cover)	3 ±1	7 ±2	3 ±1	1 ±0	3
Biodiversity (species/transect)	41 ±5	44 ±4	40 ±3	59 ±7	46±3
Density (fish/m^2)	0.6 ±0.1	0.7 ±0.1	0.7 ±0.2	1.3 ±0.3	0.9
Size (cm FL) (4)	18 ±1	16 ±1	15 ±1	19 ±1	17
Size ratio (%)	58 ±2	55 ±2	49 ±2	57 ±2	54
Biomass (g/m^2)	101.4 ±20.8	84.4 ±14.6	98.1 ±30.3	313.6 ±150.1	180.9

(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: Andra

The sheltered coastal reef environment of Andra was dominated by four major families: three herbivorous: Acanthuridae, Scaridae and Siganidae, and one carnivorous: Mullidae (Figure 2.24, Table 2.9). In addition, Chaetodontidae were high in density and present with 17 species. The four major families were represented by 42 species; particularly high biomass and abundance were recorded for *Acanthurus lineatus*, *Ctenochaetus striatus*, *Siganus lineatus*, *S. argenteus*, *Parupeneus indicus*, *Chlorurus bleekeri* and *P. barberinus* (Table 2.9). This reef environment was dominated by hard bottom (40%) and live coral (32%), with a relatively small percentage of soft bottom (19%) (Table 2.8, Figure 3).

Table 2.9: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Andra

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus lineatus*	Lined surgeonfish	0.06 ±0.05	14.1 ±11.6
	Ctenochaetus striatus	Striated surgeonfish	0.13 ±0.03	12.4 ±2.6
Siganidae	*Siganus lineatus*	Goldenlined rabbitfish	0.02 ±0.02	8.3 ±6.8
	Siganus argenteus	Forktail rabbitfish	0.06 ±0.03	6.5 ±3.5
Mullidae	*Parupeneus indicus*	Indian goatfish	0.01 ±0.01	5.7 ±3.1
	Parupeneus barberinus	Dash-and-dot goatfish	0.02 ±0.01	3.7 ±2.4
Scaridae	*Chlorurus bleekeri*	Bleeker's parrotfish	0.02 ±0.01	5.5 ±2.3

The size and biomass of finfish in the coastal reefs of Andra were the second-highest at the site. Size ratio (58%) was the highest both at this site and among all the three country sites with coastal reefs (Tsoilaunung and Panapompom being the other two). Density was the lowest in Andra and second-lowest among the three sites. Biodiversity was higher only than in the back-reefs (41 versus 40 species/transect) and much lower than in the outer reef, but the highest among the three sites. The trophic structure in Andra coastal reefs was highly dominated by herbivorous fish, which were mainly represented by Acanthuridae, Scaridae and Siganidae. Mullidae was the most abundant carnivore family, with two main species in terms of biomass. Lutjanidae were relevant only in terms of biomass, and mainly represented by *Lutjanus fulvus*. Size ratios were below 50% of average maximum values for Labridae, Lethrinidae and Lutjanidae.

The coastal reefs of Andra were mainly covered by hard bottom (40%) with a very high cover of live coral (32%). The high percentage of coral explains the relatively high abundance of Chaetodontidae and the good health of these coastal reefs. Soft bottom was rather limited (19%) but the sandy patches hosted a relatively large abundance of Mullidae. However, the very low abundance of Lethrinidae, which usually occur in habitats with sandy bottoms, cannot be simply explained by the habitat composition. Emperor fish are the second most important fish family caught in this reef habitat (13% of total catches) and their low density along with the extremely low size ratio (32%) may indicate that this group is impacted by fishing.

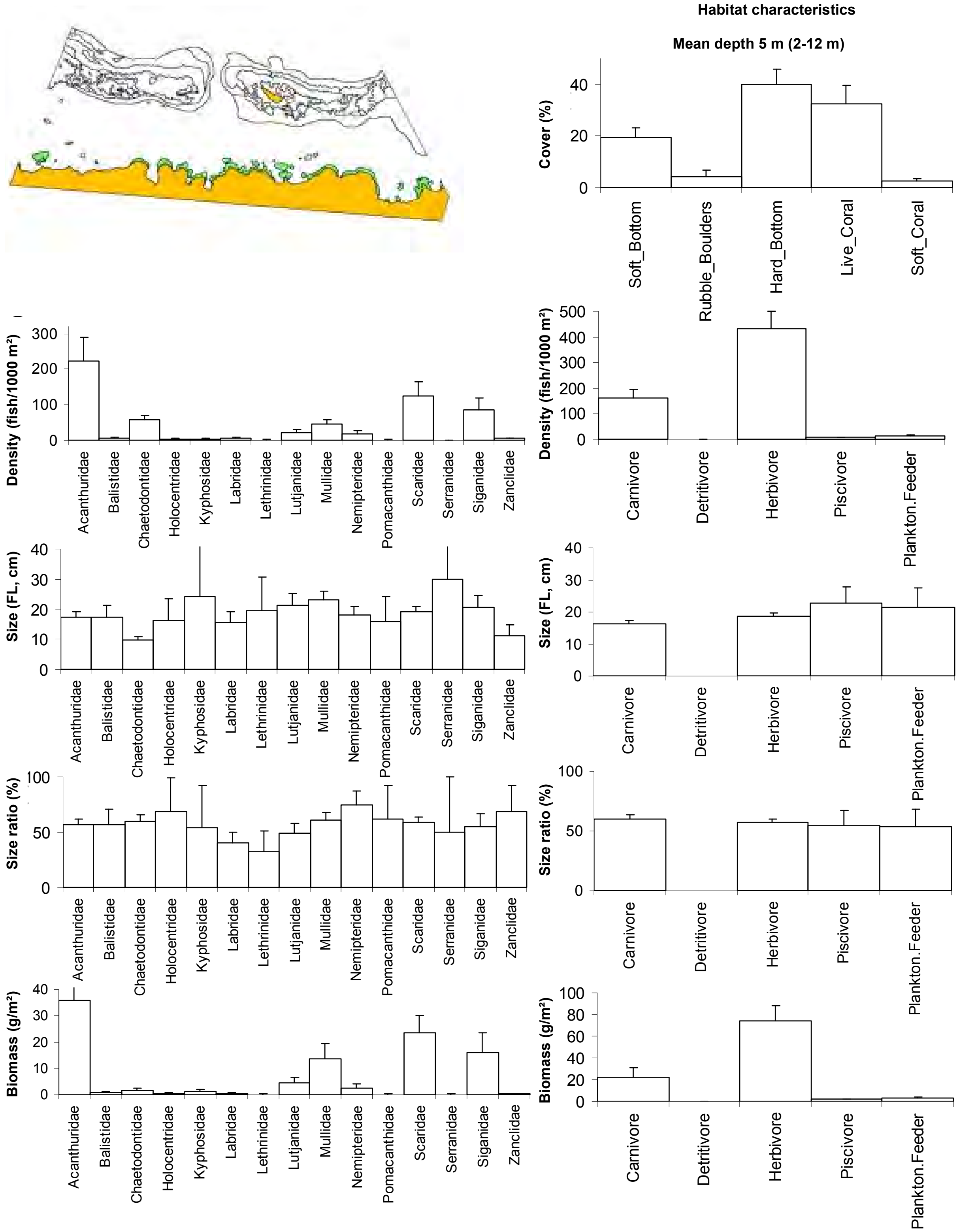

Figure 2.24: Profile of finfish resources in the sheltered coastal reef environment of Andra.
Bars represent standard error (+SE); FL = fork length.

Intermediate-reef environment: Andra

The intermediate reef of Andra was dominated, both in terms of density and biomass, by herbivorous Acanthuridae and Scaridae (Figure 2.25). These two families were present with 22 species, with the most important in terms of biomass and abundance being: *Acanthurus lineatus*, *Ctenochaetus striatus*, *Scarus rivulatus*, *S. dimidiatus* and *A. nigricans* (Table 2.10). The substrate was mainly hard bottom (56%), with a relatively large amount of live coral (20%); soft bottom was scarce (14%) (Table 2.8, Figure 2.25).

Table 2.10: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Andra

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus lineatus*	Lined surgeonfish	0.09 ±0.05	21.0 ±12.6
	Ctenochaetus striatus	Striated surgeonfish	0.22 ±0.09	20.1 ±8.0
	Acanthurus nigricans	Whitecheek surgeonfish	0.03 ±0.01	2.2 ±1.0
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.02 ±0.02	8.6 ±8.1
	Scarus dimidiatus	Yellow-barred parrotfish	0.02 ±0.01	2.3 ±0.9

The density of finfish at this reef was high but lower than at the outer reefs and equal to the back-reef values (0.7 fish/m^2). Biodiversity was also high and ranked second at this site with 44 species of fish/transect. However, size and size ratio were in the low range and, as a result, biomass was the lowest among Andra reefs. However, when compared to the intermediate reefs of Tsoilaunung and Panapompom, Andra values were relatively good: both density and biomass displayed the highest values, and size, size ratio and biodiversity were second-highest below Panapompom (Table 2.8). Size ratio was much lower than 50% of maximum for some families, especially for Lutjanidae (28%) and Lethrinidae (29%), but also for Labridae and Serranidae, a first sign of impact from fishing on these selected families. Lethrinidae and Scaridae comprised the majority of fish catches from the lagoon habitats. The trophic composition was highly dominated by herbivores, with Acanthuridae and then Scaridae making up most of the biomass, with several small-to-medium-sized species, such as *Ctenochaetus striatus*, *Acanthurus lineatus*, *A. nigricans* and *Scarus dimidiatus*. The substrate composition, strongly dominated by hard bottom and live coral (76% together), explains the high abundance of such herbivores.

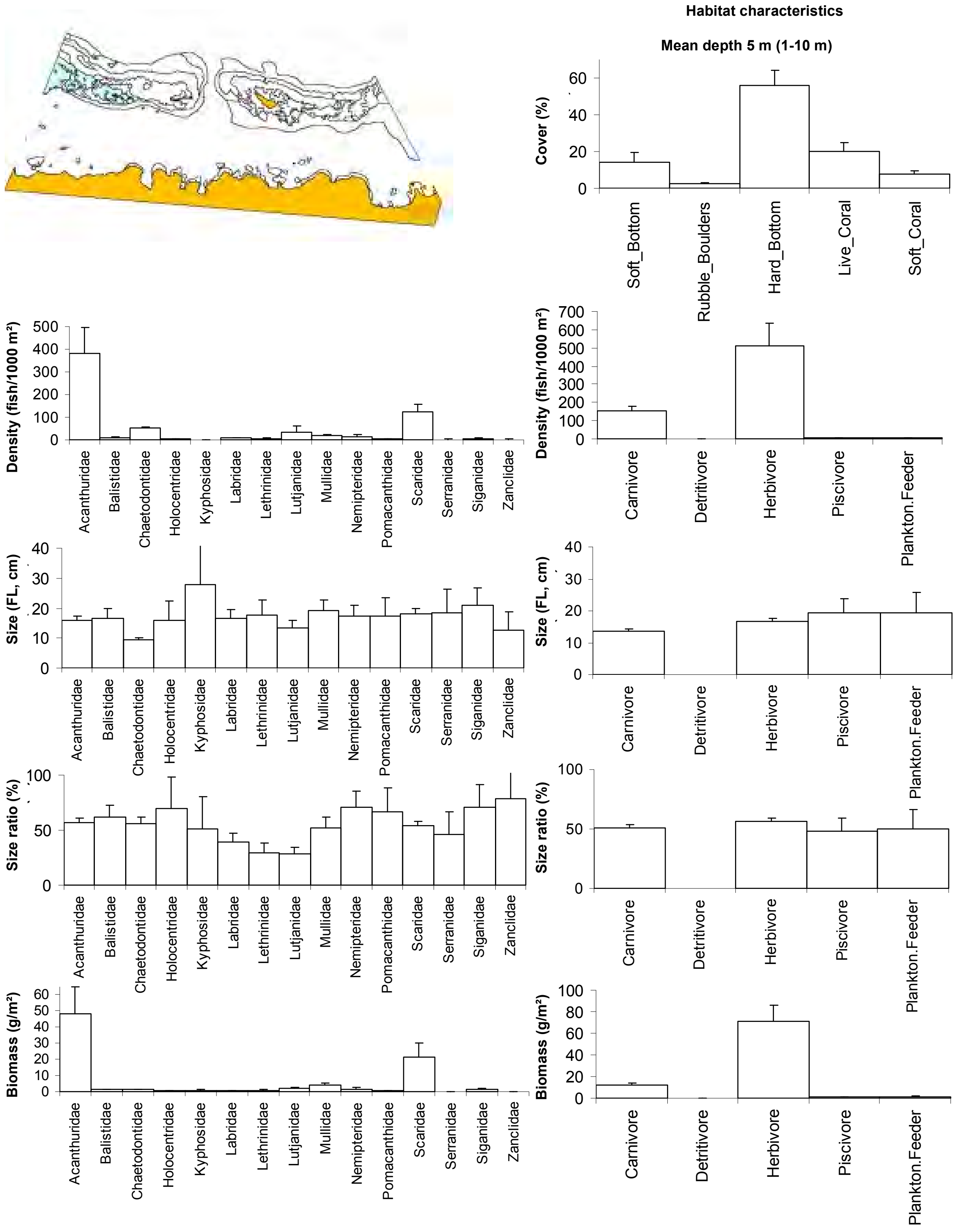

Figure 2.25: Profile of finfish resources in the intermediate-reef environment of Andra.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Andra

The back-reef of Andra was dominated by the herbivore families Acanthuridae and Scaridae in terms of density and by the carnivore family Lutjanidae in terms of biomass only (Figure 2.26). These three families were represented by a total of 36 species; the main species were: *Acanthurus lineatus*, *Ctenochaetus striatus*, *Lutjanus gibbus*, *Scarus prasiognathos*, *Lethrinus harak*, *Chlorurus sordidus*, *C. bleekeri*, *Hipposcarus longiceps* and *S. dimidiatus* (Table 2.11). Hard bottom covered most of the habitat (48%), cover of live coral was high (24%) and soft bottom occupied >20% of the total substrate (Table 2.8 and Figure 2.26).

Table 2.11: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Andra

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus lineatus*	Lined surgeonfish	0.10 ±0.06	24.1 ±16.6
	Ctenochaetus striatus	Striated surgeonfish	0.23 ±0.11	21.1 ±10.1
Lethrinidae	*Lethrinus harak*	Thumbprint emperor	0.02 ±0.02	3.3 ±3.3
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.01 ±0.01	6.9 ±6.9
Scaridae	*Scarus prasiognathos*	Singapore parrotfish	0.01 ±0.01	5.4 ±5.4
	Chlorurus sordidus	Daisy parrotfish	0.04 ±0.03	2.7 ±2.5
	Chlorurus bleekeri	Bleeker's parrotfish	0.01 ±0.01	2.7 ±1.1
	Hipposcarus longiceps	Pacific longnose parrotfish	0.01 ±0.00	2.3 ±1.0
	Scarus dimidiatus	Yellow-barred parrotfish	0.02 ±0.01	1.8 ±0.9

Fish density at this reef was similar to density in the intermediate reef and lower than in the outer reefs. However, size, size ratio and biodiversity were the lowest at the site. When compared to the other back-reefs at Sideia and Panapompom, Andra back-reefs displayed the highest density, second-highest biomass (lower than at Sideia), and second-highest size ratio but smallest average size and biodiversity. Size ratio was much below 50% for Labridae (28%) and Lethrinidae (34%), but also for Scaridae (46%), Mullidae (49%) and Acanthuridae (49%), suggesting an impact from fishing. The trophic structure was dominated by herbivores in terms of abundance and especially biomass (six times higher than carnivores). The substrate, which was mainly composed of hard bottom and live coral (72%), was the type that generally favours herbivores, such as Acanthuridae, which were dominant here but small in size, suggesting an impact from fishing.

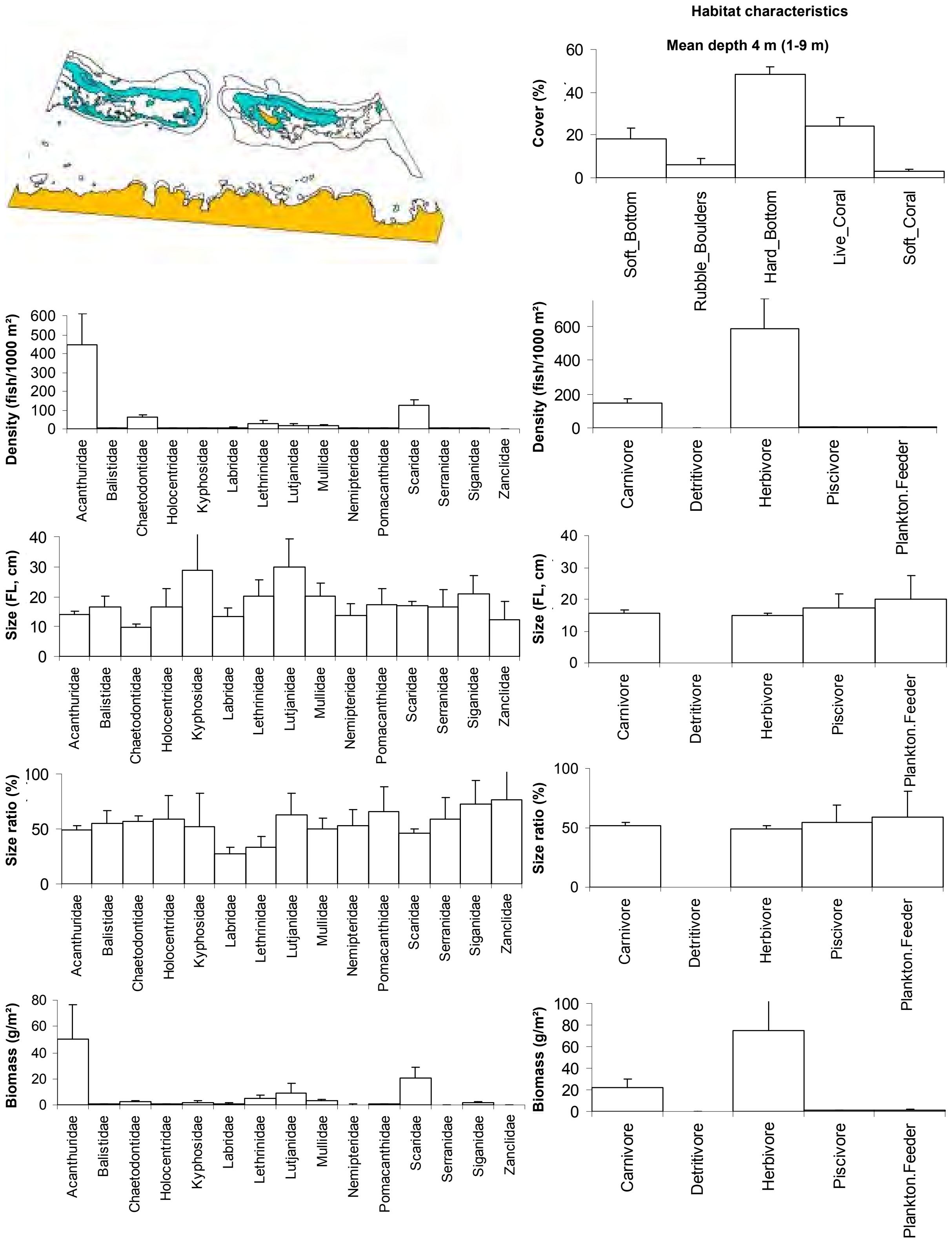

Figure 2.26: Profile of finfish resources in the back-reef environment of Andra.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Andra

The outer reef of Andra was heavily dominated, in terms of density, by herbivores Acanthuridae and Scaridae (Figure 2.27). These two families were represented by a total of 39 species; the main species were: *Acanthurus blochii*, *A. lineatus*, *Scarus prasiognathos*, *Ctenochaetus striatus*, *Bolbometopon muricatum*, *Naso brevirostris*, *Chlorurus sordidus*, *Hipposcarus longiceps*, *S. oviceps* and *A. nigricans* (Table 2.12). Hard bottom (57%) covered most of the habitat, cover of live coral was large (27%), and soft bottom, as commonly occurs in an outer reef, occupied less than 5% of total substrate (Table 2.8 and Figure 2.27).

Table 2.12: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Andra

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	Ringtail surgeonfish	0.24 ±0.24	97.3 ±93.1
	Acanthurus lineatus	Lined surgeonfish	0.25 ±0.13	50.1 ±27.9
	Ctenochaetus striatus	Striated surgeonfish	0.27 ±0.10	27.0 ±10.2
	Naso brevirostris	Spotted unicornfish	0.01 ±0.01	4.3 ±2.0
	Acanthurus nigricans	Whitecheek surgeonfish	0.04 ±0.02	3.1 ±1.4
Scaridae	*Scarus prasiognathos*	Singapore parrotfish	0.03 ±0.03	27.7 ±27.7
	Bolbometopon muricatum	Bumphead parrotfish	0.003 ±0.003	26.7 ±26.7
	Chlorurus sordidus	Daisy parrotfish	0.04 ±0.02	4.0 ±1.9
	Hipposcarus longiceps	Pacific longnose parrotfish	0.01 ±0.00	3.4 ±2.2
	Scarus oviceps	Dark-capped parrotfish	0.01 ±0.01	3.3 ±2.0

Fish density at this reef was very high compared to at the other habitats and as high as Tsoilaunung outer-reef value (1.3 fish/m^2). Biomass, size and biodiversity values were also the highest at the site. Compared to the other three sites, biomass was lower only than the Tsoilaunung value, and the high biodiversity (59 species/transect) was lower only than the extremely high value at Panapompom (75 species/transect). Average fish size (19 cm FL) ranked third, lower than at Panapompom (21 cm) and Tsoilaunung (20 cm), while average size ratio (57%) was lower only than the Panapompom value (59%). Size ratios by family were generally quite high except for Labridae and Lethrinidae. Emperorfish, along with sweetlips and snappers, were the main component of fish catches and their smaller-than-average sizes suggest a first impact from fishing. Catches and density of fishers at the outer reefs were higher than at any other reefs. The trophic structure was widely dominated by herbivores, whose biomass was 16 times higher than that of carnivores. The large species *Bolbometopon muricatum* were sighted at one location and contributed to this high herbivore biomass. Composition of habitat, dominated by hard bottom and live coral (84%), is the type that normally favours herbivores such as Acanthuridae, which were clearly dominant here.

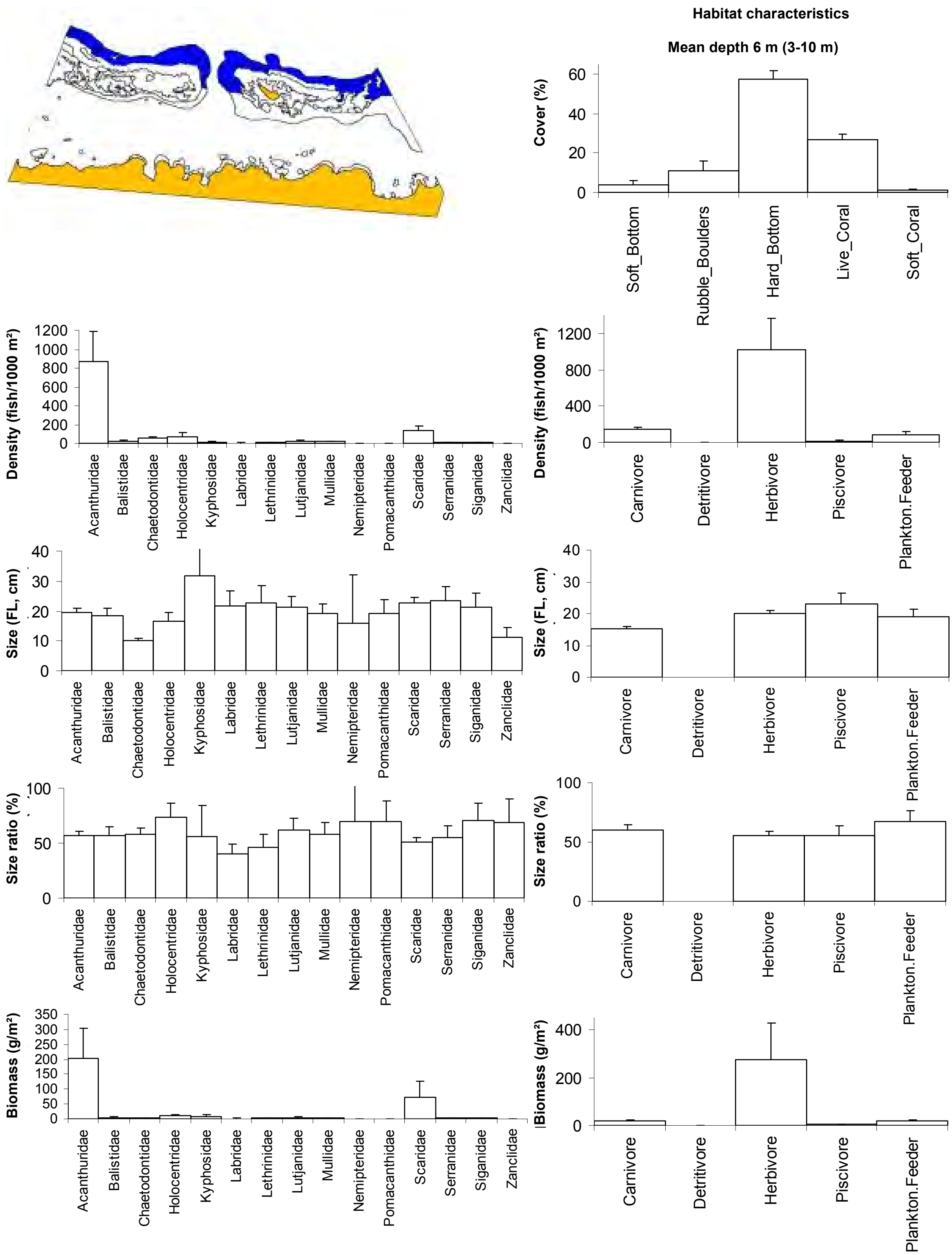

Figure 2.27: Profile of finfish resources in the outer-reef environment of Andra.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Andra

Overall, the reefs of Andra were heavily dominated by two main herbivore families, Acanthuridae and Scaridae (Figure 2.28). These two families were represented by a total of 48 species, dominated by *Acanthurus blochii*, *A. lineatus*, *Ctenochaetus striatus*, *Scarus prasiognathos*, *Bolbometopon muricatum*, *Chlorurus sordidus*, *C. bleekeri* and *A. nigricans* (Table 2.13). The habitat was mainly covered by hard bottom (57%) and a large amount of live coral (27%); soft bottom covered >5% of total substrate, as common for an outer reef (Table 2.8 and Figure 2.28).

Table 2.13: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Andra (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	Ringtail surgeonfish	0.10	38.9
	Acanthurus lineatus	Lined surgeonfish	0.15	32.7
	Ctenochaetus striatus	Striated surgeonfish	0.23	22.3
	Acanthurus nigricans	Whitecheek surgeonfish	0.02	2.0
Scaridae	*Scarus prasiognathos*	Singapore parrotfish	0.01	12.8
	Bolbometopon muricatum	Bumphead parrotfish	0.00	10.4
	Chlorurus sordidus	Daisy parrotfish	0.03	2.9
	Chlorurus bleekeri	Bleeker's parrotfish	0.01	2.1

Overall, Andra reefs appeared to support a relatively good finfish resource, with highest biomass, second-highest density and average size, second-ranked size ratio, but relatively low biodiversity compared to values recorded at the other country sites. However, detailed assessment at the habitat and family level revealed poorer biomass at coastal and back-reefs compared to the other sites, and a consistently strong dominance of herbivores over carnivores. Few families dominated the overall fish community and a general lack of carnivores was the dominant profile. The dominance of herbivores is only partially explained by the composition of the habitat, which is mainly hard rock and live coral, with a very small percentage of soft substrate. This type of habitat normally favours most invertebrate-feeding carnivores, such as Mullidae and Lethrinidae. The study of size and size ratio trends revealed that fish were smaller than average, which indicates a first impact from fishing on some selected families of carnivores and herbivores, but especially on Lethrinidae. The main fishing tools were lines, which selectively catch Lethrinidae and Lutjanidae, along with nets and spear diving, sometimes practised at night, which target both herbivores (Scaridae) and carnivores.

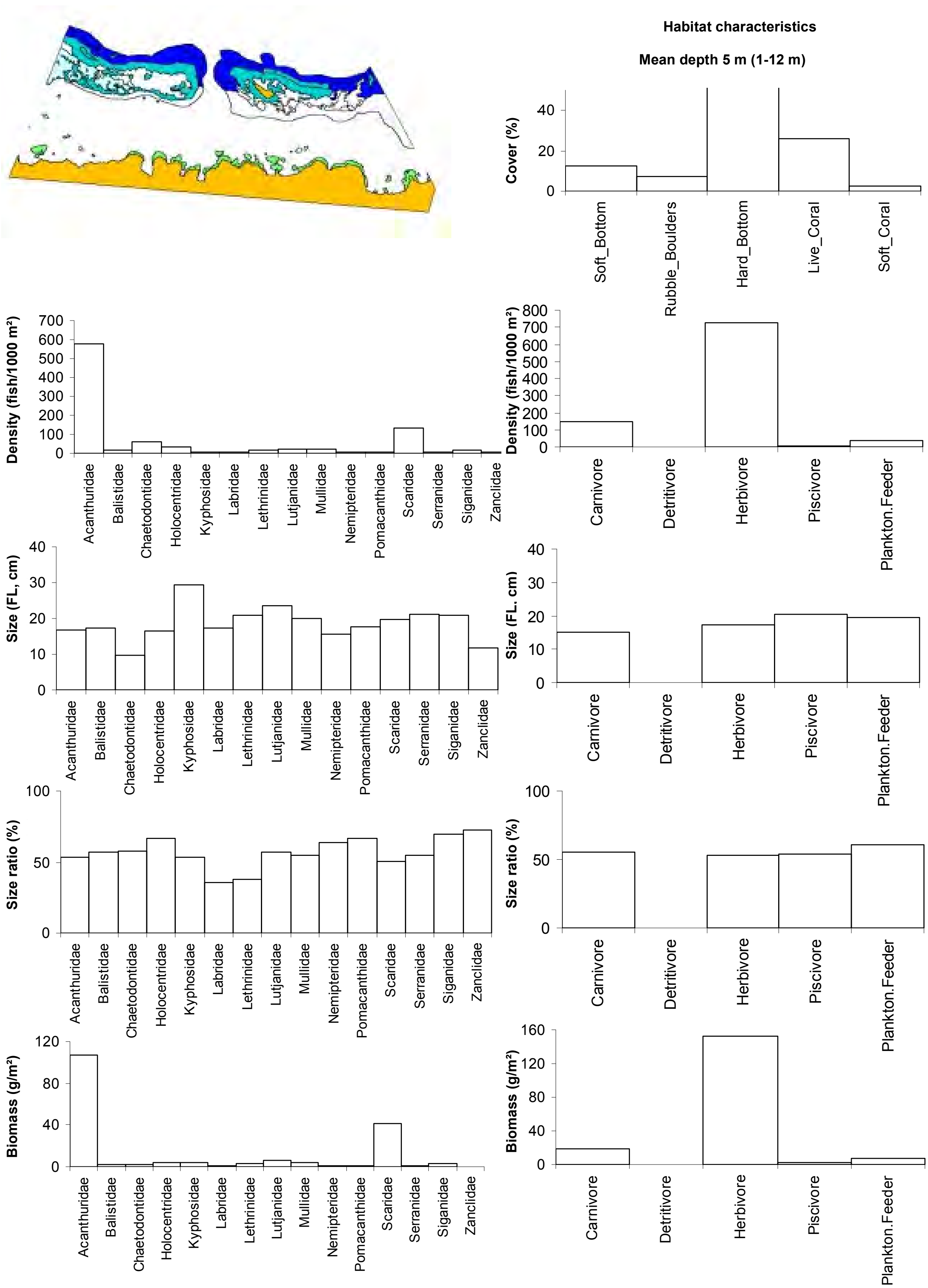

Figure 2.28: Profile of finfish resources in the combined reef habitats of Andra (weighted average).
FL = fork length.

2.3.2 Discussion and conclusions: finfish resources in Andra

The assessment indicated that the finfish resources in Andra at the time of surveys were moderately or slightly impacted. More impact appeared to be inflicted on outer reefs, where most commercial fishing was conducted.

A specific situation needs to be considered in regards to fishing access: on the eastern side of the pass, fishing is normally performed only by fishers from Andra, while the western side is an area of conflict, where both Andra fishers and fishers from the village of Ponam try to access, resulting in limited fishing by either group of fishers. Here, biodiversity as well as sizes were much higher than on the opposite side of the pass. This area acts, in effect, as a naturally protected area. In general, the people of Andra depend on fishing for income generation (50% of the population receive first income from fishing profits.) but especially for food. Although results from the socioeconomic study suggested that, overall, fishing pressure was moderate, specific conditions were found at different reef areas.

- The habitat was healthy, with a high average cover of live coral, displaying the second-highest value among the four country sites and the 15th highest in the region. However, a very low coverage of *Acropora* coral was noted.

- Finfish resources were, overall, naturally rich, with high biodiversity, and fish density the second-highest and biomass the highest in the country, both values ranking high on a regional scale. Sightings of *Cheilinus undulatus* and *Bolbometopon muricatum* were relatively frequent. Although the density and biomass values were above the regional average, these values were mostly due to the resources in the outer reef, while coastal and lagoon fisheries were about the same as the regional average.

However:

- finfish resources showed first signs of fishing impact, especially in the internal reefs. In particular we noticed:
  - Herbivores, especially Acanthuridae and Scaridae, constantly dominated the fish assembly.
  - Size ratios were low for selected families.
  - Large carnivores were rare.
  - Top predators (sharks) were absent.

- Habitat differences were noted in terms of substrate conditions.
  - In the coastal and outer reefs the cover of live coral was highest, and corals were very healthy.
  - The intermediate and back-reefs had lower coverage of live coral but still relatively high values (20–24% of total substrate cover) due to the narrow fringing reef system with several channels and passes allowing frequent water exchange, which fosters coral colonies.

- Finfish varied strongly among the four habitats:
  - Resources in coastal reefs were in better condition than in intermediate and back-reefs, with higher biomass (the second-highest in the country, three times lower than in outer reefs) as well as average species sizes (highest size ratio and second-largest size). However, density was the lowest of the four habitats. The fish community was

dominated by herbivores but carnivore species associated with soft bottom were rather abundant as well. Lethrinidae and Lutjanidae were small in size, which is probably a sign of fishing impact.

- Inside the lagoon (in the intermediate and back-reefs) the use of nets was quite common and targeted different families, both herbivores and carnivores. Finfish resources in the intermediate reefs were rather poor, with lowest biomass and second-lowest density. Biodiversity was relatively high, but size ratios suggested an impact from fishing, especially on Lutjanidae, Lethrinidae and Serranidae.
- Resources in the back-reefs were in similar condition to those in the intermediate reefs, but average sizes and size ratios of fish were smaller, especially for Labridae, Lethrinidae, Scaridae, Mullidae and Acanthuridae.
- Finfish resources in the outer reefs displayed the highest biomass and density, as well as sizes and biodiversity. The finfish community was dominated by average- and large-sized species of Acanthuridae and Scaridae, as well as by high biomass of *Bolbometopon muricatum*. This reef appeared to be the most frequently fished habitat, although the density of fishers was relatively small. Fishing was mainly done by line, targeting carnivorous species (especially Lethrinidae). Such fish represented the majority of catches from outer reefs and, as a result, this family displayed very low abundance and reduced average body size, both signs of serious impact.

2.4 Invertebrate resource surveys: Andra

The diversity and abundance of invertebrate species at Andra were independently determined using a range of survey techniques (Table 2.14): broad-scale assessment (using the 'manta tow'; locations shown in Figure 2.29) and more targeted, finer-scale assessment of specific reef and benthic habitats (Figures 2.30 and 2.31).

The main objective of the broad-scale assessment was 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, more targeted assessments were conducted in specific reef areas to describe the status of resources in those areas of naturally higher abundance and/or most suitable habitat.

Table 2.14: Number of stations and replicate measures completed at Andra

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	13	76 transects
Reef-benthos transects (RBt)	18	108 transects
Soft-benthos transects (SBt)	9	55 transects
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	7	42 transects
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	9	54 search periods
Sea cucumber day searches (Ds)	6	36 search periods
Sea cucumber night searches (Ns)	2	12 search periods

Figure 2.29: Broad-scale survey stations for invertebrates in Andra.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

Figure 2.30: Fine-scale reef-benthos transect survey stations and soft-benthos transect survey stations for invertebrates in Andra.
Black circles: reef-benthos transect stations (RBt);
black stars: soft-benthos transect stations (SBt).

Figure 2.31: Fine-scale survey stations for invertebrates in Andra.
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 diamonds: sea cucumber day search stations (Ds).

Seventy-three species or species groupings (groups of species within a genus) were recorded in the Andra invertebrate surveys: 12 bivalves, 24 gastropods, 22 sea cucumbers, 6 urchins, 5 sea stars, 1 cnidarian, 1 crab and 2 lobsters (Appendix 4.1.1). Information on key families and species is detailed below.

2.4.1 Giant clams: Andra

Shallow reef habitat that is suitable for giant clams was moderately extensive at Andra (17.3 km²: approximately 3.3 km² at the mainland shoreline, 6 km² within the lagoon and back-reef, and 7.9 km² on the reef crest and reef slope of the barrier). Although there was a large area of lagoon available (75.4 km²), most of this was approximately 20–30 m deep; the back-reef of Andra and the barrier reef often comprised expanses of soft substrates.

Within the lagoon, reef was relatively sheltered from the southerly winds and the lagoon had sufficient depth. There was noticeable 'land' influence (riverine inputs) near the coast, although the oceanic influence across the lagoon was generally strong. Flushing of the lagoon was unusually strong for such an enclosed system, with water flow parallel to the coast (generally from east to west). Numerous passages in the barrier reef linked the lagoon to the open ocean.

The reef at Andra held five species of giant clam: the elongate clam *Tridacna maxima*, boring clam *T. crocea*, fluted giant clam *T. squamosa*, the true giant clam *T. gigas*, and the horse-hoof or bear's paw clam *Hippopus hippopus*. The smooth clam *T. derasa* was the only species missing from all records. Records from this sampling method revealed that

T. maxima had the widest occurrence (found in 7 stations and 16 transects) followed by *T. squamosa* (found in 5 stations and 7 transects; see Figure 2.32). Although broad-scale sampling usually provides an overview of distribution and density, *H. hippopus*, *T. crocea* and *T. gigas* were not recorded in broad-scale assessments.

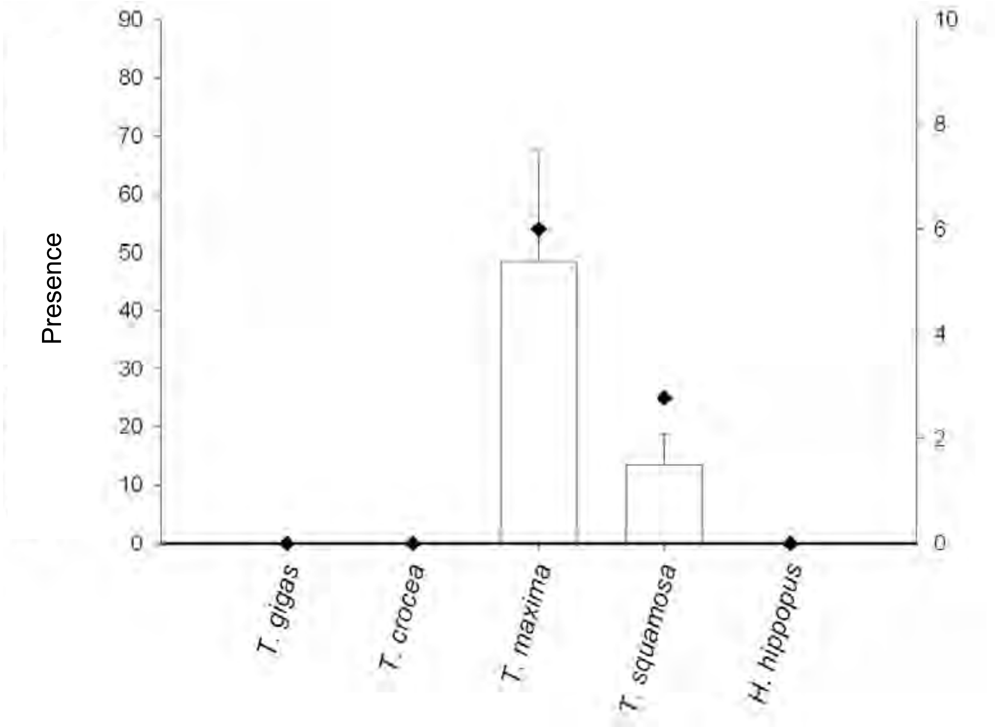

Figure 2.32: Presence and mean density of giant clam species in Andra based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 2.33). In these reef-benthos assessments (RBt), *T. maxima* and *T. crocea* were present in 83% and 44% of stations respectively. These smaller species reached maximum station densities of 375 /ha for *T. maxima* and 4168 /ha for *T. crocea*. The larger *T. squamosa*, which is normally recorded at lower density in surveys, was relatively scarce in these shallow reef surveys (recorded in 17% of RBt stations at an average density of 9.3 /ha ±5.4). The free-standing *H. hippopus* was only noted in one station, at a density of 83.3 /ha.

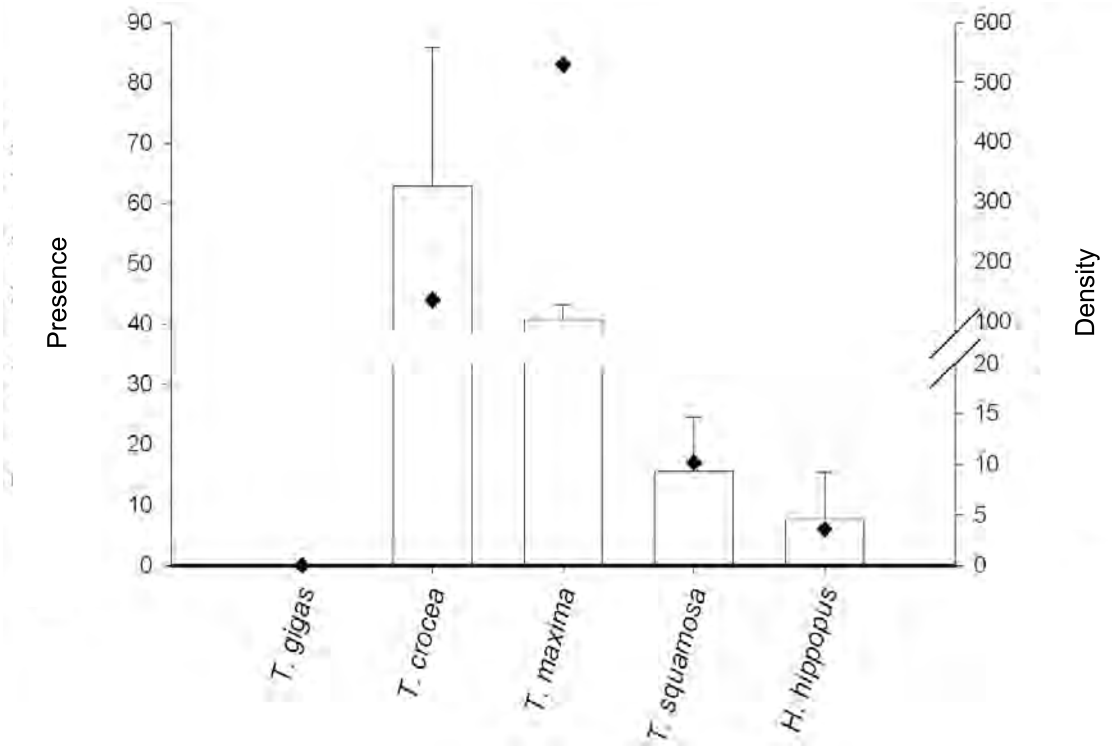

Figure 2.33: Presence and mean density of giant clam species in Andra based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

A full range of small and large individuals of *T. maxima* were recorded in surveys (mean size 16.1 cm ±0.6). *T. maxima* from reef-benthos transects alone (in shallow-water reefs) had a smaller mean length (12.3 cm ±0.7, which represents a clam of 5 years old). *T. crocea* averaged 10.3 cm ±0.3 (over 6 years old). The faster growing *T. squamosa* (which grows to an asymptotic length L∞ of 40 cm) averaged 22.7 cm ±1.5 (>6 years old), whereas *H. hippopus* averaged 15.6 cm ±0.6 (>3 years old). No *T. derasa* were recorded (Figure 2.35).

The true giant clam *T. gigas* can reach well in excess of one metre in length, but averaged 39.9 cm ±3.0 in Andra. All these clams were held at inshore areas near the village (in 'clam gardens'), having been taken from the reefs and held in short-term reserves close to the houses on Andra (Figure 2.34).

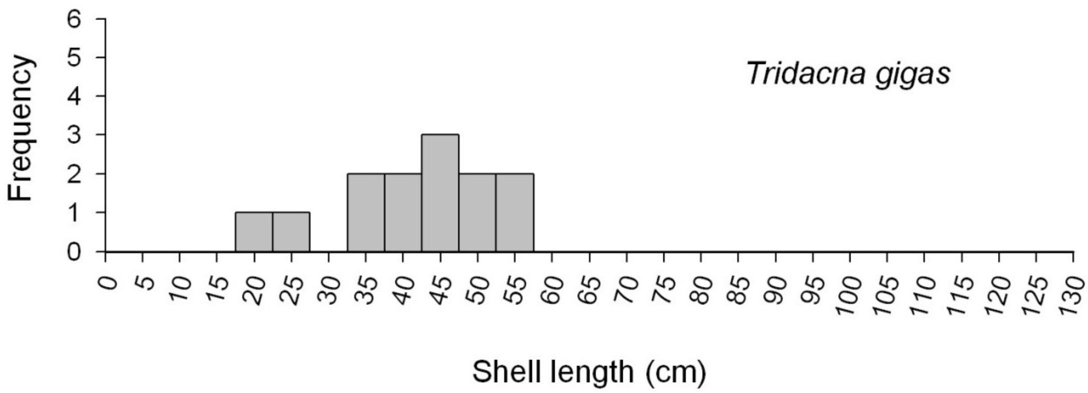

Figure 2.34: Size frequency histogram of the true giant clam *Tridacna gigas* shell length (cm) for Andra.

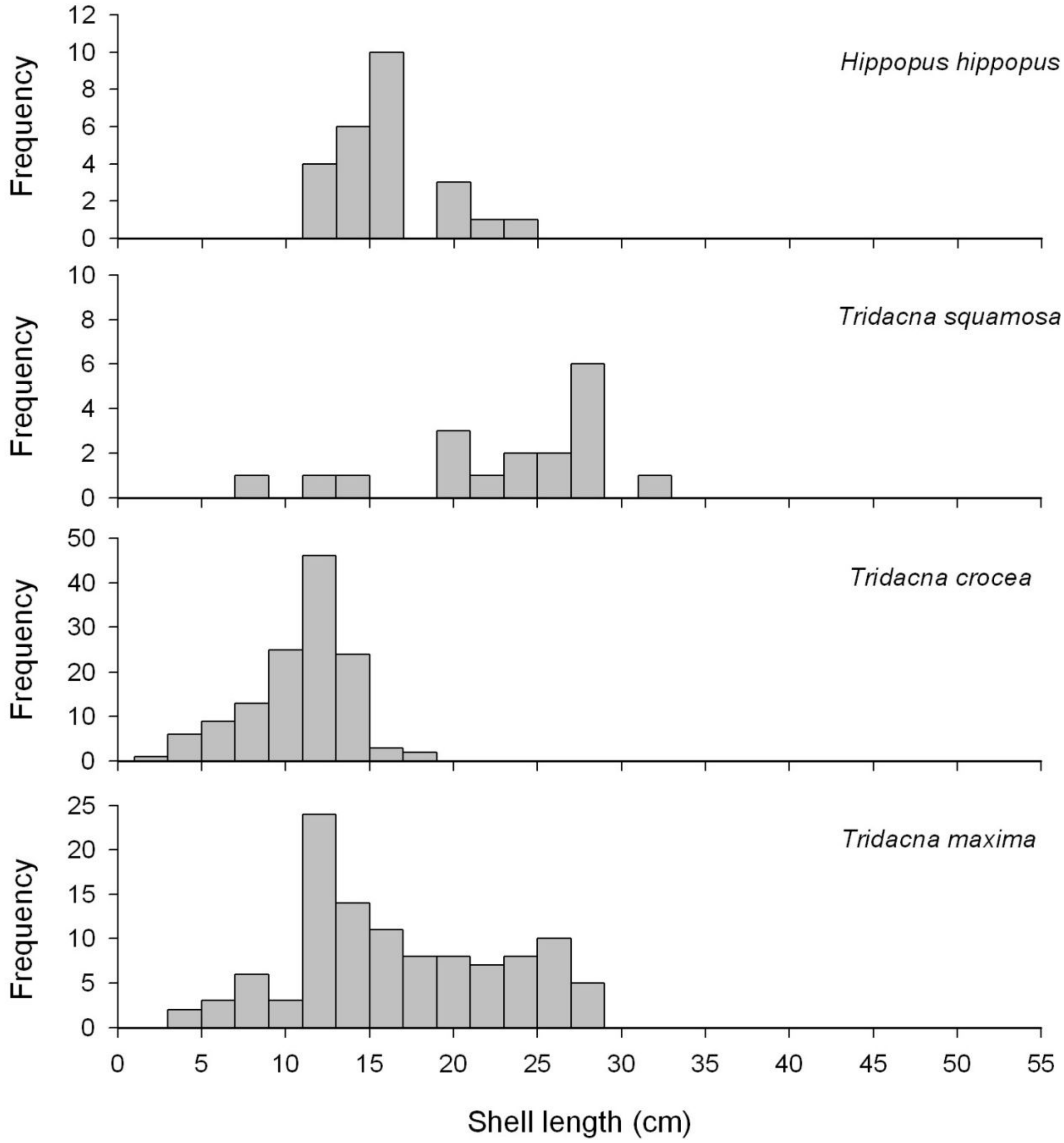

Figure 2.35: Size frequency histograms of giant clam shell length (cm) for Andra.

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

Papua New Guinea is within the natural distribution of the commercial topshell *Trochus niloticus* in the Pacific. The outer reef at Andra constitutes a moderately extensive benthos for *T. niloticus* and this area could potentially support significant numbers of this commercial species (16.5 km lineal distance of exposed reef perimeter). Although shallow reef was found outside the barrier reef in the form of a gently sloping reef-front and shoals, the back-reef was often very sandy, and reef in the main lagoon was not optimal for trochus (mostly bommies on sand).

PROCFish survey work revealed that *T. niloticus* was present, both outside the barrier reef (outer-reef slope and reeftop) and on reef within the lagoon (Table 2.14). The great green turban (*Turbo marmoratus*, more usually called 'green snail') was not found in this survey.

Table 2.14: Presence and mean density of *Trochus niloticus*, *Tectus pyramis*, *Pinctada margaritifera* and *Pinctada maxima* in Andra
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	2.2	0.8	5/13 = 38	8/76 = 11
RBt	122.7	28.3	3/16 = 19	4/96 = 4
RFs	9.2	3.1	6/9 = 67	15/54 = 28
MOPt	80.4	32.0	5/7 = 71	14/42 = 33
Tectus pyramis				
B-S	1.8	0.6	5/13 = 38	8/76 = 11
RBt	97.2	22.6	16/18 = 89	30/108 = 28
RFs	3.5	1.2	5/9 = 56	7/54 = 13
MOPt	53.6	18.7	6/7 = 86	13/42 = 31
Pinctada margaritifera				
B-S	0.9	0.4	4/13 = 31	4/76 = 5
RBt	0	0	0/18 = 0	0/108 = 0
RFs	0	0	0/9 = 0	0/54 = 0
MOPt	0	0	0/7 = 0	0/42 = 0
Pinctada maxima				
Ds	3.2	3.2	1/6 = 17	4/36 = 11

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

Aggregations of trochus were not common across the reefs at Andra, although a reasonable number of trochus were recorded in survey (total of 115 individuals). The highest-density aggregations of stock were recorded close to the main island with the barrier reef and reef slopes generally holding trochus at low density. When trochus aggregations are below a threshold of approximately 500 /ha, they are generally considered below the density suitable for commercial fishing (See Appendix 4.5.). Although trochus was found at various locations around Andra, densities in most cases were well below this threshold level, with only one shallow reef station (of a potential 18) and none of the SCUBA or reef-front search stations holding trochus above the threshold density. In fact, in most cases the densities were so low as to jeopardise successful fertilisation after spawning due to the scarcity of adults on the reef. As trochus are single-sexed broadcast spawners, males and females need to be in close proximity to generate new stock (the 'Allee' effect, i.e. markedly decreased population growth occurs at low densities).

The suitability of reefs for grazing gastropods was highlighted by results for trochus and for the false trochus or green topshell (*Tectus pyramis*). This related, but less valuable species of topshell (an algal-grazing gastropod with a similar life history to trochus) was abundant at Andra (n = 77 recorded in survey).

Trochus shell size-class frequencies indicate that there was a good range of trochus sizes present at Andra (Figure 2.36), including some small, young shells (<8 cm). First maturity of trochus occurs at 7–8 cm in Papua New Guinea, at ~3 years of age); stocks under low fishing pressure are usually dominated by larger size classes (≥ 12 cm basal size). The mean basal width of trochus at Andra was 9.5 cm ±0.2. For this cryptic species, younger shells are normally only detected in general surveys after they reach a size of ~5.5 cm, as this is the size at which small trochus begin to emerge from cryptic spaces in shallow-water back-reef areas to join the main stock.

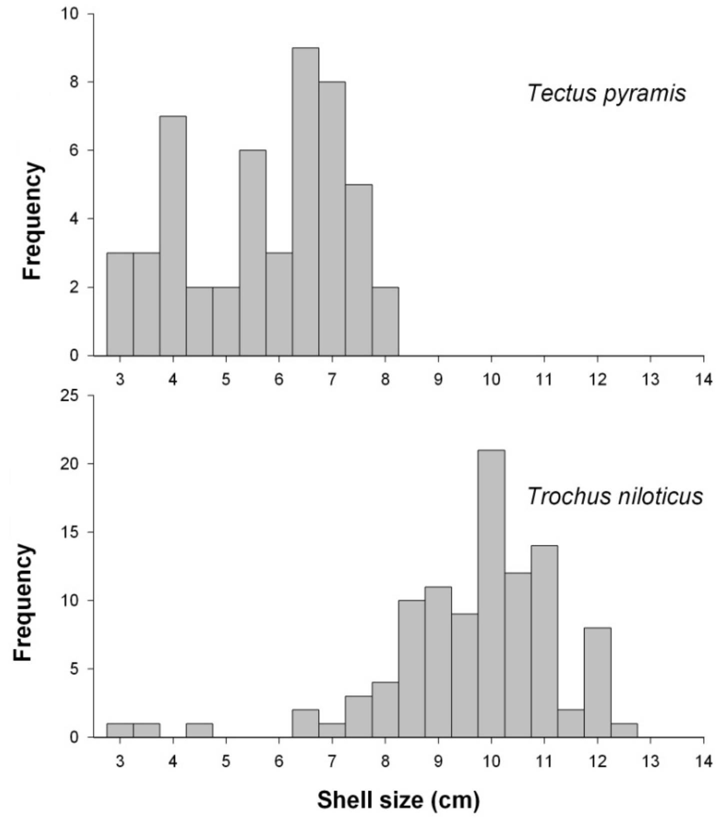

Figure 2.36: Size frequency histograms of trochus (*Trochus niloticus*) and 'false' trochus (*Tectus pyramis*) shell base diameter (cm) for Andra.

The mean size (basal width) of *T. pyramis* was 5.6 cm ±0.2. Many small *Tectus* (<5.5 cm) were also recorded in survey, which may suggest that conditions for recent spawning and/or settlement of both *Trochus* and *Tectus* species may have been favourable in recent years.

Blacklip pearl oysters *Pinctada margaritifera* are usually cryptic and normally sparsely distributed in open lagoon systems (such as found at Andra). However, the strong water-flow conditions make this a very good site for pearl oysters, although records from surveys of shallow-water reefs reveal a low density. Only six blacklip were seen during assessments, the mean shell length (anterior–posterior measure) being 13.3 cm ±0.8.

Goldlip (or 'silverlip') pearl oysters *Pinctada maxima* were also recorded in the lagoon at Andra during deep-water searches for sea cucumbers (found in one station of six at an average density of 3.2 /ha ±3.2). This species is cryptic and not generally targeted when looking for sea cucumbers; therefore this density estimate is likely to underestimate the actual resource. Goldlip prefers 'garden bottom', with good water flow and relatively oceanic conditions, which were found in the lagoon at Andra. Here, the searches for sea cucumbers were conducted at depths of ≥ 25 m and covered both sandy benthos and the 'garden bottom', which was generally found in the vicinity of coral stands. This type of benthos is difficult to describe, but includes whip corals and sponges and a generally low relief, with the pearl oysters lying flat on the bottom, not easily seen by the untrained eye.

2.4.3 Infaunal species and groups: Andra

Soft-benthos habitats at the coastal margins of Andra were generally suitable for seagrass, but meadows were sparsely populated, very sandy and quite compacted. Although some arc shells (*Anadara* spp.) were seen, no concentrations of in-ground resources (shell 'beds') were recorded and therefore no infaunal stations (quadrat surveys) were completed.

2.4.4 Other gastropods and bivalves: Andra

Seba's spider conch (*Lambis truncata*, the larger of the two common spider conchs) was not recorded in survey, but *L. lambis* was recorded at very low density in broad-scale and soft-benthos transects (<5 /ha, n = 4 individuals recorded in all surveys). Other *Lambis* spp. were also recorded (*L. chiragra*). The strawberry or red-lipped conch (*Strombus luhuanus*) was uncommon and not recorded in survey (Appendices 4.1.1 to 4.1.8).

Five species of turban shell (*Turbo argyrostomus*, *T. chrysostomus*, *T. crassus*, *T. setosus*, and *T. petholatus*) were recorded at low density. The larger, silver-mouthed turban (*T. argyrostomus*) was recorded in 89% of reef-front search stations at a mean density of 9.2 /ha ±2.4. Other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Dolabella*, *Drupella*, *Latirolagena*, *Mitra*, *Ovula*, *Pleuroploca*, *Polinices*, *Tectus*, *Thais* and *Vasum*) were also recorded during independent surveys (Appendices 4.1.1 to 4.1.8).

Data on other bivalves found in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Hyotissa*, *Modiolus*, *Pinna*, and *Spondylus* species, are also in Appendices 4.1.1 to 4.1.8. No creel survey was conducted at Andra.

2.4.5 Lobsters: Andra

There was no dedicated reef-front night assessment of lobsters (See Methods.). However, general surveys and assessments for nocturnal sea cucumber species (Ns) were conducted; these offered an opportunity to record lobster species. Lobsters (*Panulirus* spp.) were moderately common in surveys (n = 16), and one slipper lobster (*Parribacus caledonicus*) was also recorded. Prawn killers (*Lysiosquillina maculata*) were not noted along the sandy shorelines; a single large mud crab (*Scylla serrata*) was recorded near the village (14 cm carapace width).

2.4.6 Sea cucumbers[7]: Andra

The study area at Andra has extensive habitat (main lagoon: 75.4 km^2; small shallow lagoon surrounding island: 5.5 km^2). Despite Andra being an offshore island, the large system presents an archetypal high-island lagoon environment that is very suitable for sea cucumbers (which are deposit feeders that eat detritus and other organic matter in the upper few mm of bottom substrates).

[7] 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.

The sheltered lagoon supports a range of habitats, is well flushed and has a rich nutrient profile. Reef margins, seagrass and areas of shallow, mixed hard- and soft-benthos habitat were extensive and, although riverine inputs (and other inputs from land) were not notable near Andra Island, they were significant nearer the mainland.

The presence and density of sea cucumber species were determined through broad-scale and dedicated in-water survey methods (Table 2.15, Appendices 4.1.1 to 4.1.8; see also Methods). With completion of the full range of surveys, twenty-one commercial species of sea cucumber (plus one indicator species) were recorded (Table 2.15), which is a similar amount to the number recorded in another PROCFish site located in New Ireland Province, and greater than the species number recorded in Milne Bay Province.

Sea cucumber species associated with shallow reef, such as the medium-value leopardfish (*Bohadschia argus*), were found relatively commonly in the better areas, but were only noted in 14% of broad-scale transects. The high-value black teatfish (*Holothuria nobilis*) was rarely recorded (found in <10% of broad-scale surveys and reef-benthos transects). When they were recorded in these locations, they occurred at a density of <5 /ha, which is low and potentially low enough to negatively impact future recruitment. Although this is a concern, both juveniles and adults were recorded at one site near the shoreline of Andra. The fast growing and medium/high-value greenfish (*Stichopus chloronotus*) was rarely noted across the full site (recorded in 5% of broad-scale transects) but averaged 28 /ha in reef-benthos transect surveys (Appendix 4.1.3).

Surf redfish (*Actinopyga mauritiana*) was relatively common across reef-front search stations (recorded in 78% of RFs stations) but densities averaged <10 /ha in shallow water and ~20 /ha on reef slopes and in deeper-water shoals. In commercial fishery situations this species generally reaches a threshold of ≥ 300 /ha and is commonly recorded at densities of ≥ 500 /ha.

More protected areas of reef and soft benthos in the more enclosed areas of the lagoon close to Andra did record blackfish (*A. miliaris*) and stonefish (*A. lecanora*) at reasonable densities (50–70 /ha). Curryfish (*Stichopus hermanni*), a common species around these types of systems, was recorded in Andra, despite being missing from New Ireland records. Both the occurrence (recorded in 3% of broad-scale transects) and densities were very low. For the lower-value sea cucumbers, e.g. lollyfish (*Holothuria atra*), pinkfish (*H. edulis*), snakefish (*H. coluber*) and flowerfish (*Bohadschia graeffei*), there was also no exceptional coverage or density records.

High-value sandfish (*H. scabra*) were recorded close to Andra in seagrass between the island and the barrier reef. Only three individuals were found and these were all of adult size (mean length 16 cm). Although no large area of mangrove was present (This species generally prefers a 'richer' environment.), the seagrass provided unexposed habitat that potentially could support a population of sandfish. Anecdotally, there were reports of recent fishing of sea cucumbers in this area where most of the brown sandfish (*B. vitiensis*) and higher-value sandfish (*H. scabra*) were harvested. In this habitat sandfish was present in 2 of 9 SBt stations at a density of 13.9 /ha ±9.8. The lower-value false sandfish (*B. similis*) was also present but at lower rates and density.

Deep-water assessments were completed to obtain preliminary abundance estimates of white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*), and amberfish (*T. anax*). Deeper-water dives (average 22 m in depth) also recorded elephant trunkfish (*H. fuscopunctata*). In general, water movement (flushing of oceanic water) was dynamic in the lagoon and especially dynamic near the main passes on both sides of Andra. The area with sufficient depth and habitat for these species was larger at Andra (~52 km^2) than at other sites, as the lagoon was very dynamic, with suitable benthos for the high-value white teatfish (*H. fuscogilva*) almost all the way to the mainland (instead of being confined to passage areas). *H. fuscogilva* was present for all Ds stations but never at high density (recorded at a maximum station density of 42.9 /ha). Fifty per cent of replicates held white teatfish, although four out of the six Ds stations contained this species in ≤ 2 replicates. As can be seen from the variability of around these recordings, the presence of *H. fuscogilva* was patchy. Fishing pressure on these stocks around Andra was very high. While we were surveying, fishers were targeting this species seven days a week, which is highly unusual in Melanesian island fisheries. Fishers were free-diving, using 'bomb lines' (a small straightened hook below a lead weight, tethered to a line and float) to help target (over 2–3 duck dives) and lift white teatfish from depths greater than 20 m. Anecdotal reports from people in Lorengau, the main town of Manus, claim that >5 people have died through what is termed 'shallow-water blackout' during the current fishing season alone (due to hyperventilation prior to diving which closes down the body's natural breathing mechanism without sufficiently increasing the body's oxygen load http://en.wikipedia.org/wiki/Shallow_water_blackout).

Another deeper-water, high-value species, prickly redfish (*T. ananas*) and lower-value amberfish (*T. anax*) were recorded at very low presence and density in surveys.

2.4.7 Other echinoderms: Andra

Close to Andra, the edible collector urchin (*Tripneustes gratilla*) was found in seagrass (recorded in 44% of soft-benthos transect stations) but at low density (average station density 23.1 /ha ±10.1). Along the barrier reef, edible urchins, such as the slate urchin (*Heterocentrotus mammillatus*) were not recorded; however, other less sought-after edible urchins, such as *Diadema* spp. and *Echinothrix* spp. were recorded at relatively low levels. The same was true for *Echinometra mathaei* (Appendices 4.1.1 to 4.1.7).

Starfish (e.g. *Linckia laevigata*, the blue starfish) were recorded at medium levels (in 51% of broad-scale transects) but not at high density. Coralivore (coral eating) starfish were present at Andra in low-to-moderate numbers, with twenty-three recordings of a pincushion star (*Culcita novaeguineae*) and the crown-of-thorns starfish (*Acanthaster planci*, COTS) in survey. *A. planci* was recorded both inshore and at more oceanic-influenced stations in 9% of broad-scale transects, at a low average density of 2.3 /ha ±1.1. Although a single COTS can consume about 6 m^2 of coral per year, this level of infestation is well below a level which could cause concern. The horned or chocolate chip star (*Protoreaster nodosus*) was very common among the soft-benthos stations within the seagrass (89% presence, average density 870.4 /ha ±334.7) and the doughboy sea star (*Choriaster granulatus*) was also noted in the lagoon, especially in deep-water stations.

Table 2.15: Sea cucumber species records for Andra

Species	Common name	Commercial value [5]	B-S transects n = 76			Other stations RBt = 18; SBt = 9			Other stations RFs = 9; MOPt = 7			Other stations Ds = 6; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga caerulea	-	M/H												
Actinopyga echinites	Deepwater redfish	M/H				13.9	62.5	22 SBt						
Actinopyga lecanora	Stonefish	M/H				4.6	41.7	11 RBt				71.1	71.1	100 Ns
Actinopyga mauritiana	Surf redfish	M/H	0.2	16.7	1	2.3	41.7	6 RBt	7.8 20.8	10.1 48.6	78 RFs 43 MOPt			
Actinopyga miliaris	Blackfish	M/H										57.8	57.8	100 Ns
Bohadschia argus	Leopardfish	M	4.8	33.4	14	23.1 27.8	83.3 125.0	28 RBt 22 SBt				1.6 31.1	3.2 31.1	50 Ds 100 Ns
Bohadschia graeffei	Flowerfish	L	24.1	44.7	54	113.4	204.2	56 RBt	3.0	20.8	14 MOPt	2.0	6.0	33 Ds
Bohadschia similis	False sandfish	L				4.6	41.7	11 SBt						
Bohadschia vitiensis	Brown sandfish	L	1.3	20.0	7							13.3	26.7	50 Ns
Holothuria atra	Lollyfish	L	7.2	25.0	29	76.4 1227	171.9 1227	44 RBt 100 SBt	4.4 6.0	5.6 20.8	78 RFs 29 MOPt	2.4	14.3	17 Ds
Holothuria coluber	Snakefish	L	6.4	80.6	8	9.3 194	83.3 250	11 RBt 78 SBt				17.8	17.8	100 Ns
Holothuria edulis	Pinkfish	L	2.4	23.1	11	2.3	41.7	6 RBt				4.8	7.1	67 Ds
Holothuria fuscogilva [4]	White teatfish	H	0.9	33.3	3	2.3 69.4	41.7 89.3	6 RBt 78 SBt				16.7	16.7	100 Ds
Holothuria fuscopunctata	Elephant trunkfish	M										3.2	3.8	83 Ds
Holothuria leucospilota	-	L												
Holothuria nobilis [4]	Black teatfish	H	2.0	30.0	7	2.3 13.9	41.7 41.7	6 RBt 33 SBt						
Holothuria scabra	Sandfish	H				13.9	62.5	22 SBt						
Stichopus chloronotus	Greenfish	H/M	1.3	25.0	5	27.8	71.4	39 RBt						
Stichopus hermanni	Curryfish	H/M	0.4	17.0	3							0.4 4.4	2.4 8.9	17 Ds 50 Ns
Stichopus horrens	Peanutfish	M/L										13.3	13.3	100 Ns
Stichopus pseudhorrens	-	M												
Stichopus vastus	Brown curryfish	H/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; MOPt = mother-of-pearl transect; Ds = sea cucumber day search; Ns = sea cucumber night search.

Table 2.15: Sea cucumber species records for Andra (continued)

Species	Common name	Commercial value [5]	B-S transects n = 76			Other stations RBt = 18; SBt = 9			Other stations RFs = 9; MOPt = 7			Other stations Ds = 6; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Synapta spp.	-	-	0.2	16.7	1	9.3	83.3	11 SBt						
Thelenota ananas	Prickly redfish	H	1.5	19.4	8							0.4	2.4	17 Ds
Thelenota anax	Amberfish	M	4.0	61.3	7							0.4	2.4	17 Ds
Thelenota rubrolineata	Candy canefish	L												

[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; MOPt = mother-of-pearl transect; Ds = sea cucumber day search; Ns = sea cucumber night search.

2.4.8 Discussion and conclusions: invertebrate resources in Andra

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 within the body of the invertebrate chapter.

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

- Reefs within the main lagoon and the barrier-reef slope were very suitable for giant clams (Tridacnidae) although some back-reef areas were relatively sandy. There was a complete range of giant clams present, even species that are becoming rare in other parts of the Pacific. However, only small numbers of the larger clams (*Tridacna gigas*, *T. squamosa* and *H. hippopus*) were recorded. *T. derasa* was absent from records.

- Giant clam density at Andra was low for most species, although a full range of size classes was generally present. Despite the low abundance of the larger species (*T. squamosa* and *T. gigas*), their continued presence is promising for conservation efforts. These species are usually the first to decline and disappear when fishing pressure impacts giant clam stocks. If fishing controls can be instituted, natural recovery may still be possible.

- The low densities of giant clams recorded during surveys at Andra suggest that stocks are heavily impacted by fishing.

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

- Trochus at Andra were not common. Considering the scale of habitat available, the nutrient profile of the system and presence of other grazing gastropods (e.g. *Tectus pyramis*), trochus were considered to be depleted. However, despite being recorded at very low density, there was evidence of recent successful spawning of trochus and ongoing recruitment (Small trochus shells were recorded in survey.).

- The great green turban snail ('green snail', *Turbo marmoratus*) was absent in this survey.

- Both blacklip (*Pinctada margaritifera*) and goldlip pearl oysters (*P. maxima*) were recorded at Andra. The 30 m depth profile of the lagoon and the well flushed water-flow regime make the location very suitable for oyster (pearl) culture. Densities are not sufficient to encourage commercial fishing of shell, but would provide ample broodstock for any hatchery venture.

Data on sea cucumber distribution, density and size suggest that:

- A comprehensive range of sea cucumber species were recorded at Andra. A range of habitats and depths were present and the sheltered, rich lagoon benthos was very suitable for many of these commercial deposit feeders.

- The lagoon bordering Andra (and passages) has an unusual white teatfish fishery due to the high flushing rates and suitable benthos found throughout most of the system. The larger-than-usual scale of this fishery makes it a potentially excellent provider of income. However, it is critical to ensure that some areas are protected to maintain 'patches' of white teatfish (*Holothuria fuscogilva*) broodstock at high density, and therefore secure production of the next generation of stock. This is not happening at present and the level of fishing pressure is among the highest ever recorded in any white teatfish fishery visited by PROCFish in the Pacific.

- High-value sandfish (*Holothuria scabra*) were recorded close to Andra, but occurrence and density measures revealed that most of the population had been harvested by fishers.

- Presence and density data collected in survey suggest that most sea cucumber stocks are, or have been, under high fishing pressure. Most species are now depleted across the site and in need of an extended period of recovery and increased levels of protection from fishing.

- Sea cucumbers play an important role in 'cleaning' hard (limestone) substrates and processing soft (sand and mud) benthic substrates. When these species are removed, there is the potential for detritus to build up, creating conditions that can promote the development of non-palatable algal mats (blue–green algae) or anoxic conditions (areas lacking in oxygen and unsuitable for life). These conditions are less likely to impact most areas of Andra due to the high flushing rates, but were noticeable close to the mainland.

2.5 Overall recommendations for Andra

- Either the NFA or the Ailan Awareness group support and assist the community's desire to draft its own fisheries management plan with the management plan extended to include additional coastal issues, e.g. waste management.

- As part of the fisheries management plan, community fisheries management measures be effectively implemented and compliance with rules be enforced. Management measures suggested are as follows:

  - Spearfishing be controlled and spearfishing at night be banned.
  - The use of large nets for fishing in the lagoon be regulated.
  - Establishment of MPAs be considered as a possible management tool. The western side of the pass has limited fishing access due to the conflict of interest between fishers from the two villages so this area would be ideal as an MPA.
  - A monitoring system be put in place to follow further changes in finfish and invertebrate resources.

- Strict controls be implemented on the fishing of the commercial topshell (*Trochus niloticus*) to ensure there is a future for this fishery. Stock should be 'rested' from fishing for a medium term (3–5 years, or until densities at the major fishing areas recover to at least 500 individuals per ha). However, if any ongoing fishing needs to occur, authorities should ensure that only large, 'A' grade product is caught and commercialised.

- The white teatfish fishery in the lagoon bordering Andra (and the passages) be protected to ensure it remains a potentially excellent provider of income. It is critical to ensure that some areas are protected to maintain 'patches' of broodstock at high density, and therefore secure production of the next generation of stock.

3. PROFILE AND RESULTS FOR TSOILAUNUNG

3.1 Site characteristics

Tsoilaunung island group (Figure 3.1) is the eastern group of islands in Lovongai District of New Hanova in New Ireland Province located at latitude 2°26'S and longitude 150°30'E. This group of *motu* is about 23 km long and 2 km wide. The northern group is divided into Wards 4 and 5, both made up of 8 islets that are within the PROCFish study area. The Provincial Elected Representative, together with the Island or Area Council is the community decision-making institution. The sandy islands are separated from the mainland by shallow lagoon, deeper in some areas and murky towards the mainland. The lagoon has very little coral as it is mostly sand. Fibreglass skiffs and outboard motors are the principle mode of transport to Kavieng (one hour by boat) and between islands, but dugout canoes are used mainly for fishing.

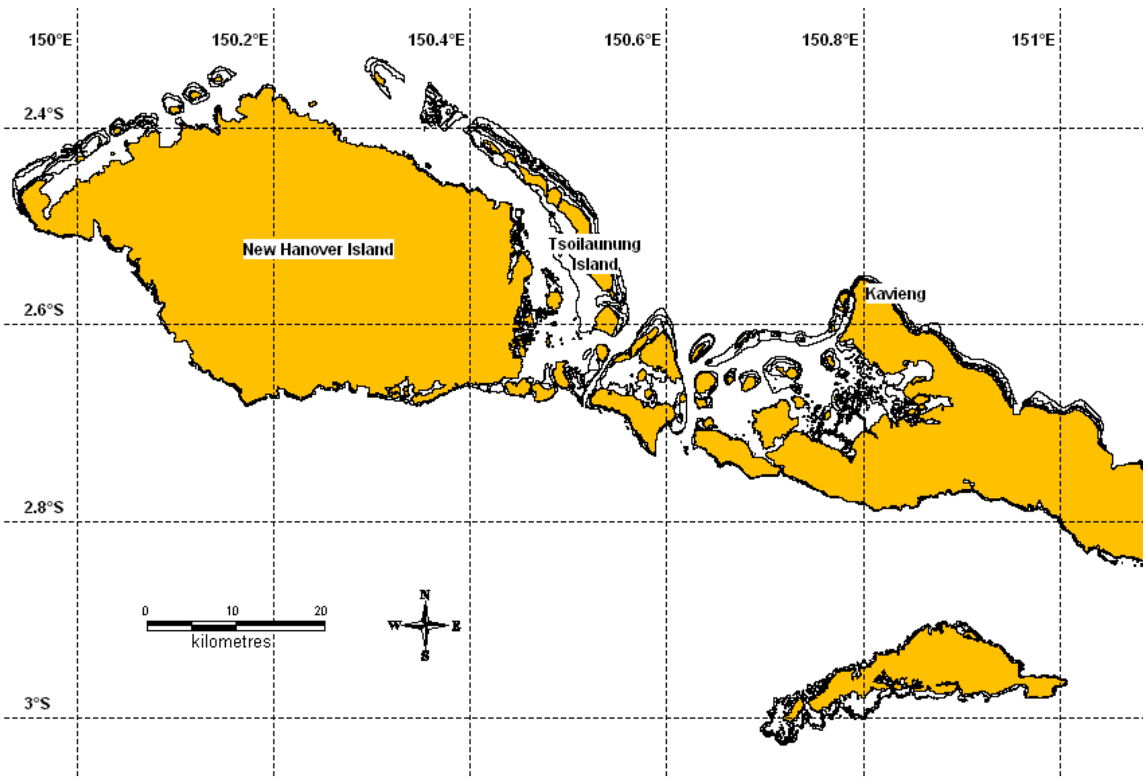

Figure 3.1: Map of Tsoilaunung.

The inhabitants of these islands are fishers rather than farmers. They depend heavily on marine products for food and income. The fishing area in Tsoilaunung is accessible to all. Invertebrate resources are fished the hardest since they are the most easily accessed species. Other sources of income are the sale of sago thatch (for roofing), mangrove wood, fish and lobsters. Although some of the islanders own land areas on the mainland, farming is done only by a few people. Bartering is common between the island residents and those of the New Hanova and New Ireland mainland; islanders exchange fish for garden produce or wooden canoes. Sago palm is also important in the area for food (sago starch) and for housing (thatch and wall).

3.2 Socioeconomic surveys: Tsoilaunung

Socioeconomic fieldwork was carried out on Tsoilaunung during September 2006. Tsoilaunung is an island off Kavieng in the New Ireland Province. Tsoilaunung island is administratively divided into two Wards. Ward V includes five communities with about 1100 people in the island's northern half: Mamion, Mansava, Kulibang, Pasik and Tsoilik. Ward IV, representing the island's southern part, has an estimated total population of 570 people in three main communities: Ungakum, Kavulikiao and Vopakang. New Ireland, unlike elsewhere, is under a traditional matrimonial system that gives ownership over the reef and marine and other resources to females. Therefore, females are very much involved in bêche-de-mer and trochus commercial fisheries. Traditionally, *Turbo cinereus* shells were used to make shell money, but this is now replaced by the local currency, Kina (PGK). However, these necklaces are still mandatory and in use for customary purposes, such as weddings, births and funerals.

There are at least four church nominations established on the island, including the United Church, Assembly of God and the Christian Rival Church. There are two elementary schools and a lower and upper primary school. Most of the supplies are sourced from the mainland; however, there are two shops where some basic items can be bought.

In total, 30 households were surveyed that represented the populations of both wards according to their total population figures. These 30 households included 138 people, representing ~8% of the total number of households (363) and population (1670) on the island.

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 32 individual interviews of finfish fishers (19 males, 13 females) and 27 invertebrate fishers (13 males, 14 females) were conducted. These fishers belonged to one of the 30 households surveyed. Sometimes, the same person was interviewed for both finfish fishing and invertebrate harvesting.

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

Our survey results (Table 3.1) suggest an average of about 2–3 fishers (2.4) per household. If we apply this average to the total number of households, we arrive at a total of 871 fishers on Tsoilaunung. Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of 218 males and 48 females who only go finfish fishing, and another 12 female fishers who exclusively collect invertebrates. However, the majority of all fishers do both finfish fishing and invertebrate collection, although not necessarily at the same time, i.e. 242 males and 351 females.

Almost all households on Tsoilaunung have a boat, but only a few are motorised; all others are paddling or, in rare cases, sail canoes. Information obtained from key informants suggests that in total there are ~18 motorised boats on the island: ~12 in Ward V and 6 in Ward IV.

Ranked income sources (Figure 3.2) highlight the fact that income alternatives for people on a small island such as Tsoilaunung are limited. Two-thirds of all households are dependent on fisheries for income, half as a primary source, a quarter as complementary secondary income. There is little first or second income from agriculture and only about 17% of all households earn first income from salaries. The production and selling of handicrafts is the second most important source of revenue, supplying more than a quarter of all households with first and 30% of households with second income. The average annual household expenditure level is low (USD ~872 /household/year) suggesting that people on Tsoilaunung are self-sufficient with primary produce. Remittances are insignificant and only very few households may receive small amounts of money from their relatives at times. On average, these small amounts total USD ~117 a year for the households that receive these payments. Traditional leadership for the effective management of the island's joint marine and terrestrial resources may suffer from the relatively high population density, its division into two administrative wards, and the fact that each ward represents various communities, as well as the fact that certain areas of the island are difficult to access.

The importance of fisheries shows further in the fact that all households reported eating fresh fish, invertebrates and also canned fish. All households also reported that normally the fresh fish and invertebrates that they eat are caught by somebody from the household. In rare cases (~20% of all responses) fresh fish may also be sometimes bought. Invertebrates were bought even less often (7%). However, for both fresh fish and invertebrates, non-commercial distribution is common (~93% and 100% respectively). These figures indicate the high dependency on reef and lagoon resources for nutrition, and a strong social network among community members and families in Tsoilaunung.

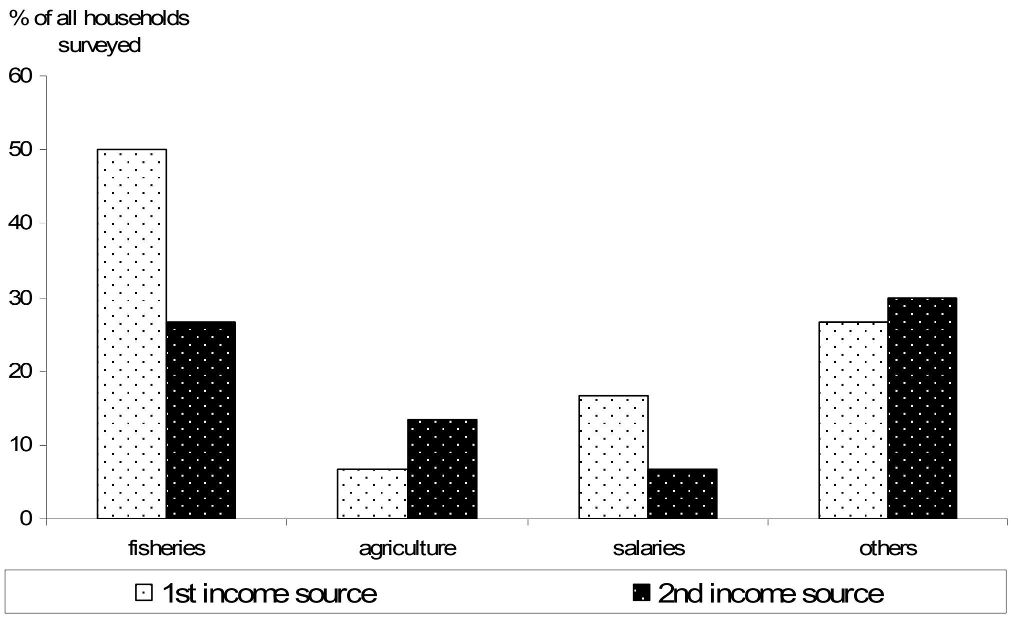

Figure 3.2: Ranked sources of income (%) in Tsoilaunung.
Total number of households = 30 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.
'Others' are mostly home-based small business.

The consumption of fresh fish (~ 35 kg/person/year ±4.7) on Tsoilaunung is similar to the regional average (FAO 2008) and to most of the other PROCFish/C sites surveyed in Papua New Guinea (Figure 3.3), but higher than the average consumption determined nationwide (DFMR 1993). The consumption of invertebrates (meat only) is ~11.3 kg/person/year ±3.01 (Figure 3.4) and, although only about one-third of the finfish consumption, is significantly higher than the average for all PROCFish/C sites in Papua New Guinea. Although most people reported eating canned fish on average at least once a week, canned fish consumption is low (<7 kg/person/year). However, compared to the average across all sites surveyed in the country, this is the highest consumption of canned fish (Table 3.1).

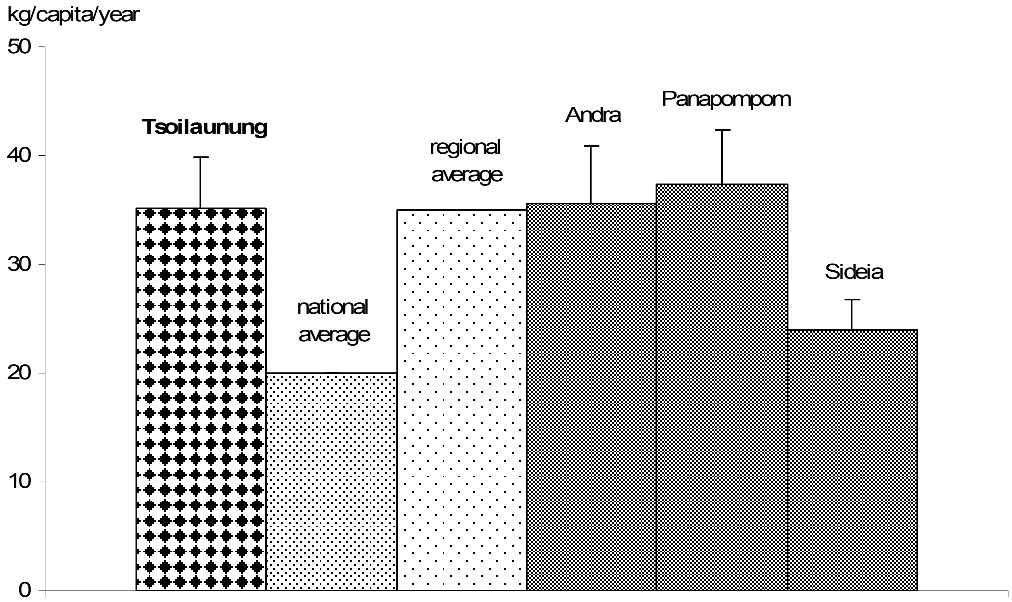

Figure 3.3: Per capita consumption (kg/year) of fresh fish in Tsoilaunung (n = 30) compared to national (DFMR 1993) and regional averages (FAO 2008) and other three PROCFish/C sites in Papua New Guinea.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

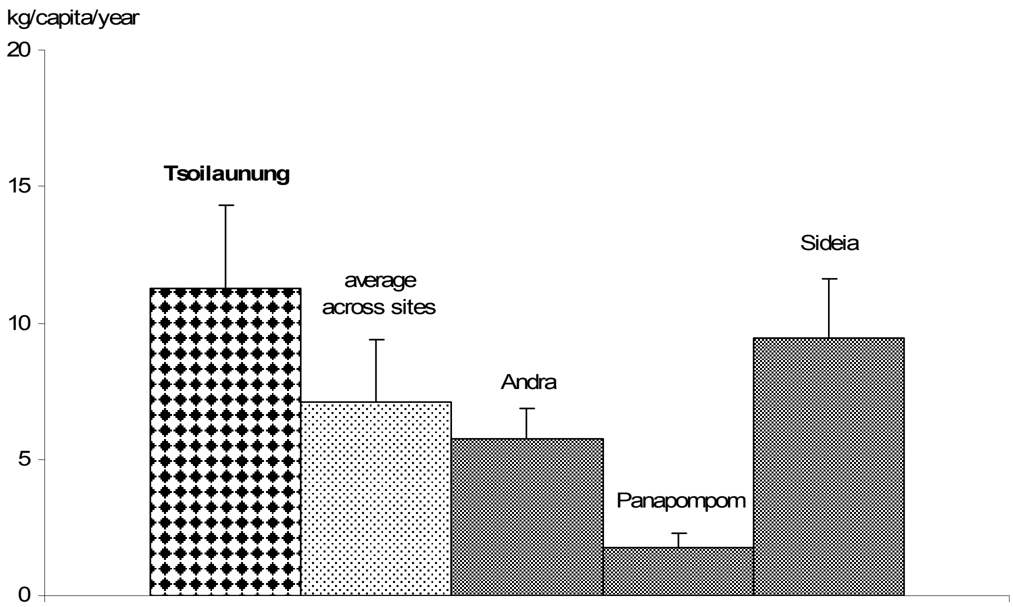

Figure 3.4: Per capita consumption (kg/year) of invertebrates (meat only) in Tsoilaunung (n = 30) compared to the other three PROCFish/C sites in Papua New Guinea.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Comparing the results among all sites investigated in Papua New Guinea (Table 3.1), people on Tsoilaunung are about average as far as their dependency on fisheries for income generation is concerned, and they are also average concerning the importance of other income sources. Tsoilaunung's consumption figures for fresh fish, invertebrates or canned fish are about average and so is the frequency at which they are consumed. Nevertheless, the average household expenditure level on Tsoilaunung is lower than the average across all four PROCFish/C sites, suggesting a relatively high self-sufficiency level of primary produce, and a certain agricultural potential. Remittances do not play any role on Tsoilaunung or at any other sites surveyed in Papua New Guinea.

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

Survey coverage	Site (n = 30 HH)	Average across sites (n = 120 HH)
Demography		
HH involved in reef fisheries (%)	100.0	100.0
Number of fishers per HH	2.40 (±0.30)	2.65 (±0.13)
Male finfish fishers per HH (%)	25.0	9.1
Female finfish fishers per HH (%)	5.6	1.9
Male invertebrate fishers per HH (%)	0.0	0.9
Female invertebrate fishers per HH (%)	1.4	0.6
Male finfish and invertebrate fishers per HH (%)	27.8	40.6
Female finfish and invertebrate fishers per HH (%)	40.3	46.9
Income		
HH with fisheries as 1st income (%)	50.0	53.3
HH with fisheries as 2nd income (%)	26.7	32.5
HH with agriculture as 1st income (%)	6.7	9.2
HH with agriculture as 2nd income (%)	13.3	18.3
HH with salary as 1st income (%)	16.7	13.3
HH with salary as 2nd income (%)	6.7	3.3
HH with other source as 1st income (%)	26.7	26.7
HH with other source as 2nd income (%)	30.0	25.0
Expenditure (USD/year/HH)	872.09 (±88.45)	982.39 (±80.23)
Remittance (USD/year/HH) (1)	117.31 (±38.11)	110.91 (±16.64)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	35.11 (±4.69)	33.03 (±2.29)
Frequency fresh fish consumed (times/week)	3.75 (±0.30)	3.34 (±0.14)
Quantity fresh invertebrate consumed (kg/capita/year)	11.28 (±3.01)	7.07 (±2.29)
Frequency fresh invertebrate consumed (times/week)	1.60 (±0.16)	1.49 (±0.10)
Quantity canned fish consumed (kg/capita/year)	6.88 (±1.05)	5.64 (±0.66)
Frequency canned fish consumed (times/week)	1.21 (±0.20)	0.93 (±0.11)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	100.0	99.2
HH eat canned fish (%)	100.0	97.5
HH eat fresh fish they catch (%)	100.0	100.0
HH eat fresh fish they buy (%)	20.0	20.0
HH eat fresh fish they are given (%)	93.3	86.7
HH eat fresh invertebrates they catch (%)	93.3	100.0
HH eat fresh invertebrates they buy (%)	6.7	0.0
HH eat fresh invertebrates they are given (%)	100.0	63.3

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

3.2.2 Fishing strategies and gear: Tsoilaunung

Degree of specialisation in fishing

Fishing on Tsoilaunung is performed by both males and females (Figure 3.5). While about half of all males exclusively target finfish, the other half of all male fishers and most female fishers fish for both finfish and invertebrates. Only a very small number of females on Tsoilaunung exclusively collect invertebrates. According to our survey sample, slightly more males than females are engaged in fishing.

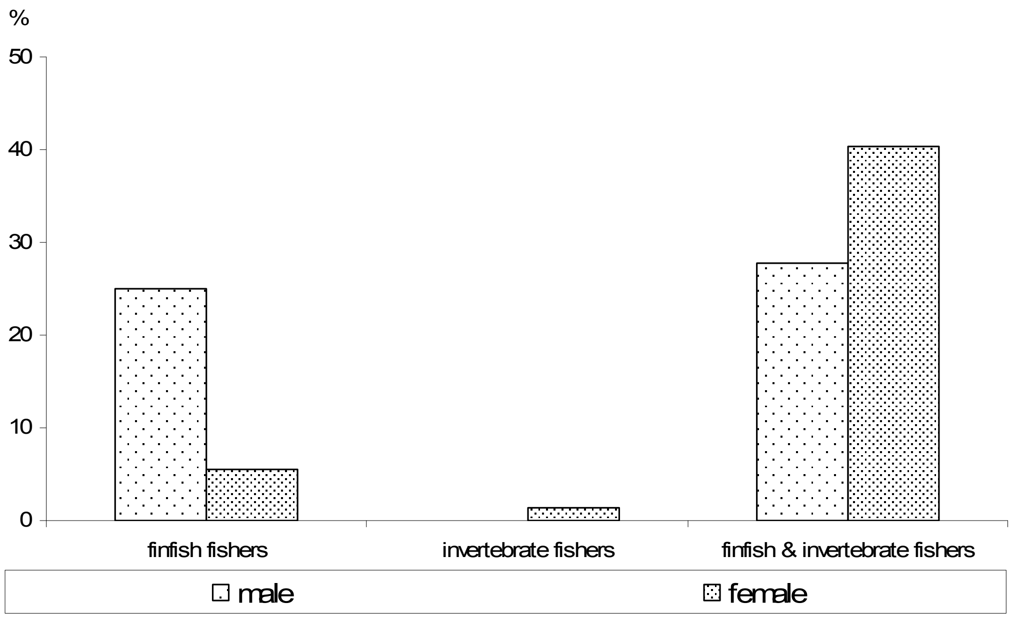

Figure 3.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Tsoilaunung.
All fishers = 100%.

Targeted stocks/habitat

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	0.0	15.4
	Lagoon	89.5	92.3
	Outer reef	47.4	0.0
Invertebrates	Reeftop	7.7	50.0
	Soft benthos	7.7	50.0
	Mangrove	7.7	35.7
	Bêche-de-mer	76.9	42.9
	Lobster	76.9	0.0
	Trochus	69.2	0.0

Finfish fisher interviews, males: n = 19; females: n = 13. Invertebrate fisher interviews, males: n = 13; females: n = 14.

Gender differences show in the habitats targeted. While female finfish fishers target the sheltered coastal reef and lagoon, males catch finfish mostly in the lagoon but also at the outer reef. Invertebrate collection is usually associated with females harvesting on reeftops, soft benthos and mangroves, while males mainly target bêche-de-mer, lobster and trochus for commercial purposes. Over 40% of all female fishers also participate in commercial bêche-de-mer collection (Table 3.2).

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 Tsoilaunung on their fishing grounds (Tables 3.2 and 3.3).

Our survey sample suggests that fishers on Tsoilaunung have the choice among sheltered coastal reef, lagoon and outer-reef fishing. However, soft-benthos and reef substrate are the main habitats to support invertebrate fisheries on Tsoilaunung (Figure 3.6). Females not only dominate the gleaning fisheries (reeftop, soft benthos, mangroves) but also engage in the collection of bêche-de-mer in shallow water. Females do not engage in trochus or lobster diving (Figure 3.7).

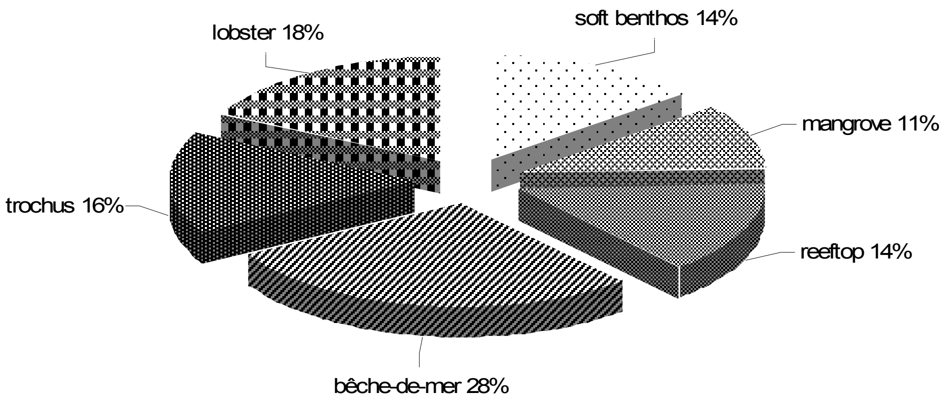

Figure 3.6: Proportion (%) of fishers targeting the six primary invertebrate habitats found in Tsoilaunung.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; ‘other’ refers to the giant clam and sea urchin fisheries.

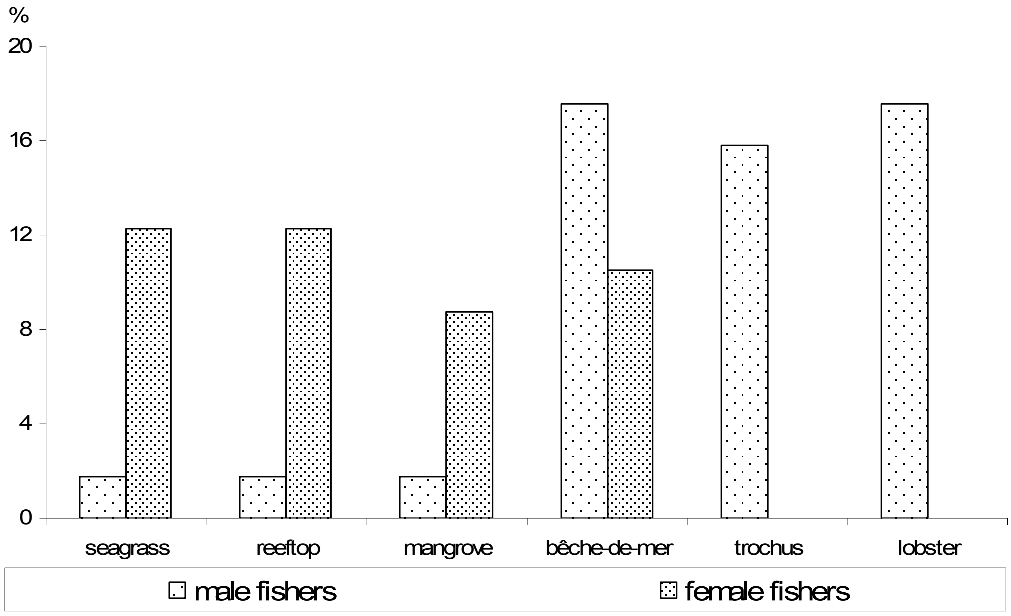

Figure 3.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Tsoilaunung.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers who target each habitat: n = 13 for males, n = 14 for females.

Gear

Figure 3.8 shows that fishers on Tsoilaunung use mainly handlines to catch fish at the sheltered coastal reef. Handlines are also often used for lagoon fishing. The combination of handlines and spear diving is the major technique used at the outer reef and in the lagoon. Deep-bottom lines and gillnets may also be used to some degree at the outer reef, but very rarely in the lagoon only. Apparently, there is also widespread use of fish poisoning with the *Derris derris* root, particularly at night. This practice was not reported by respondents, but indicated by key informants. Fishing on Tsoilaunung always involves the use of a boat, mostly paddling canoes but also motorised boats.

About once or twice a year, fish drives (*sungkai*) are undertaken by most of the males and some females. All participants hold a fishing net in a line during high tide, then move slowly towards the shore while hitting the water surface while the tide goes down. This group fishing may take all night long. Pregnant females and their husbands are not allowed to participate.

Gleaning and free-diving for invertebrates is done using very simple tools only. Reeftop gleaning is usually done by walking during low tide and mostly during the day on the dried reef flats that have been reached by paddling canoe. Edible gastropods or other invertebrates are picked up by hand; mask, snorkel and fins are used for free-diving. Knives or sometimes a speargun are used to catch giant clams, octopus or lobsters. The periodical bêche-de-mer fishery includes two different approaches. Females and males collect in shallow water by hand, using canoes to bring back their catch to shore. In addition, bêche-de-mer and trochus are collected at the outer reef. If bêche-de-mer are recovered from greater depth, home-made 'torpedos' or 'sinkers' are used to hook up specimens. Trochus is collected by free-diving with mask, snorkel and fins.

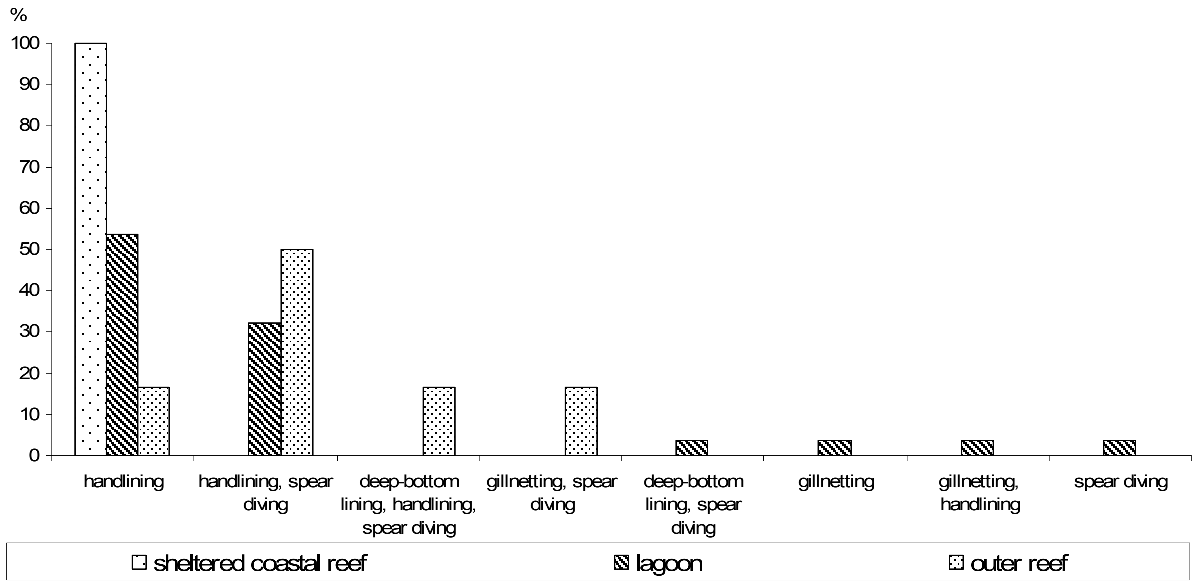

Figure 3.8: Fishing methods commonly used in different habitat types in Tsoilaunung.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Frequency and duration of fishing trips

As shown in Table 3.3, male fishers go fishing more often than female fishers. Males target the lagoon and outer reef each about twice per week, while females catch fish at the sheltered coastal reef only once a week. However, females target the lagoon more frequently, almost twice per week. There is only a small difference in the average duration of each fishing trip among habitats targeted and between genders. On average, a fishing trip to the sheltered coastal reef and lagoon takes ~4 hours. If the outer reef is targeted, male fishers spend on average 5 hours.

Fishers seem to collect invertebrates as often as fishing for finfish. Females collect on reeftops, soft benthos and mangroves at least once if not twice a week. Males target commercial fisheries, including bêche-de-mer, lobster and trochus, 1–1.5 times/week. During the harvesting time for bêche-de-mer, females venture out 4 times/week. Invertebrate collection trips are time consuming. The more subsistence-oriented collection trips take 2–4 hours on average, while commercial harvesting of bêche-de-mer, lobster and trochus was reported to take ~5–6 hours on average for each trip.

Males catch finfish according to the tide and, consequently, most fishers targeting the lagoon and the outer reef do so either at day or at night. However, females, who are the only fishers targeting the sheltered coastal reef, do so exclusively at day time. Except for lobsters, all other invertebrates are collected during the day. Ninety per cent of all lobster fishers prefer to fish at night.

Finfish fishing and most invertebrate fishing are performed continuously during the year. Bêche-de-mer is subject to the governmental (National Fisheries Authority) open season (usually during the 6-month period from mid-January to mid-July; in 2006 the season was open from January to September) and the decision of the community leaders' group. Fishers on Tsoilaunung reported that they collect bêche-de-mer 5–6 months/year. It also appears that trochus fishers may stop collecting at some stage, although on average at least 11 fishing months in a year were reported.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef		1.00 (±0.00)		4.50 (±0.00)
	Lagoon	2.28 (±0.28)	1.90 (±0.40)	3.88 (±0.33)	4.00 (±0.43)
	Outer reef	2.12 (±0.69)	0	5.17 (±0.46)	0
Invertebrates	Reeftop	2.00 (n/a)	1.57 (±0.30)	4.00 (n/a)	4.14 (±0.78)
	Soft benthos	0.46 (n/a)	1.03 (±0.19)	1.50 (n/a)	1.93 (±0.47)
	Mangrove	3.00 (n/a)	2.09 (±0.85)	4.50 (n/a)	3.30 (±1.24)
	Bêche-de-mer	1.38 (±0.27)	4.08 (±0.82)	5.65 (±0.61)	4.75 (±0.91)
	Lobster	1.59 (±0.30)	0	4.25 (±0.45)	0
	Trochus	1.29 (±0.37)	0	5.78 (±0.71)	0

Figures in brackets denote standard error; n/a = standard error not calculated.
Finfish fisher interviews, males: n = 19; females: n = 13. Invertebrate fisher interviews, males: n = 13; females: n = 14.

3.2.3 Catch composition and volume – finfish: Tsoilaunung

Catches from the sheltered coastal reef are limited to a few species and families. Most of the reported catch weight is met by two species, a scientifically non-identified *vugata* and *Lethrinus olivaceus* (*sungui*). *L. atkinsoni* (*osang*) determines most of the remaining ~10% of the reported catch.

Reported lagoon catches are diverse and include over 50 vernacular names. However, about 10 species or species groups determine most of the catch by weight. These include: *Lethrinus atkinsoni*, *L. xanthochilus*, *Lutjanus gibbus*, *Scolopsis lineatus*, *Liza* spp., *Caranx* spp. and *Scarus schlegeli*. By family, Lethrinidae alone represent >26% of the reported catch weight, followed by Siganidae (12%), Lutjanidae (10%) and Scaridae (4%). *Siganus* spp. were reported to aggregate every month at new moon. Fishers usually target them with nets.

Catches from the outer reef are less varied than those from the lagoon. Here, the most prominent fish are *Bolbometopon muricatum* (26.5%) and *Caranx* spp. (18%). Most of the remaining catch is determined by Siganidae (*Siganus argenteus*, *S. lineatus*, *S. rivulatus*) (~16%), Lethrinidae (*Lethrinus atkinsoni*, *L. nebulosus*, *L. lentjan*) (~8%) and others (Details are provided in Appendix 2.1.1.).

Our survey sample of finfish fishers interviewed represents ~4% of the projected total number of finfish fishers on Tsoilaunung. Although the group of fishers interviewed includes both commercial and subsistence fishers, the limited sample size may jeopardise any extrapolation of survey results. Accordingly, care must be taken in using the extrapolated figures given here to estimate the total annual fishing pressure imposed by the people of Tsoilaunung on their fishing ground. The survey showed that people in Tsoilaunung are highly dependent on reef fisheries for food and for income, and that a great proportion of their catch is sold on the mainland. This shows also in Figure 3.9, where the share of catch required to satisfy the island's subsistence needs is small as compared to the share sold. Females' contribution to the total annual catch is about one-quarter only. This may be due to the fact that most females mainly catch for food rather than for selling on the mainland. This does not contradict the fact that some females on Tsoilaunung buy fish that they either sell processed (smoked) or fresh, often in combination with selected invertebrates, at the mainland's market. Most of the fishing impact is sourced from the lagoon, and about one-quarter of the reported catch is taken at the outer reef only. The proportion of females' catches from the sheltered coastal reef, mostly aimed at catching fish for the family's daily meal, is insignificant by comparison.

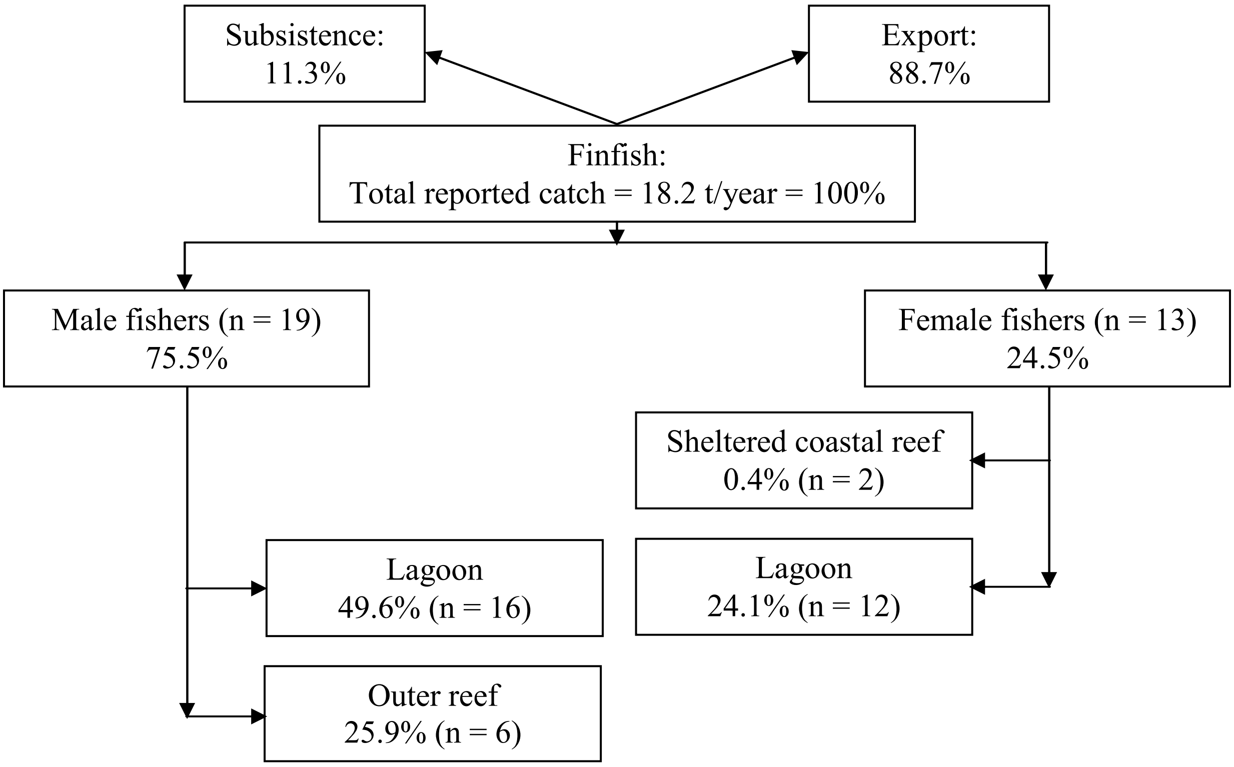

Figure 3.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Tsoilaunung.
N is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

As shown in Figure 3.9, the minor share (11.3%) of impact is due to the demand imposed by the population of Tsoilaunung on its reef resources, while most (88.7%) of all impact is determined by external demand.

The insignificant impact on the sheltered coastal reef is basically determined by the small annual catch rates for female fishers, which confirms the above observation that catches from the sheltered coastal reef serve the daily demand of the families only. While male finfish fishers seem to achieve higher catches (~600 kg/fisher/year) from the lagoon than do female finfish fishers (~400 kg/fisher/year), highest catch rates (~800 kg/fisher/year) were reported from the outer reef (only performed by males) (Figure 3.10).

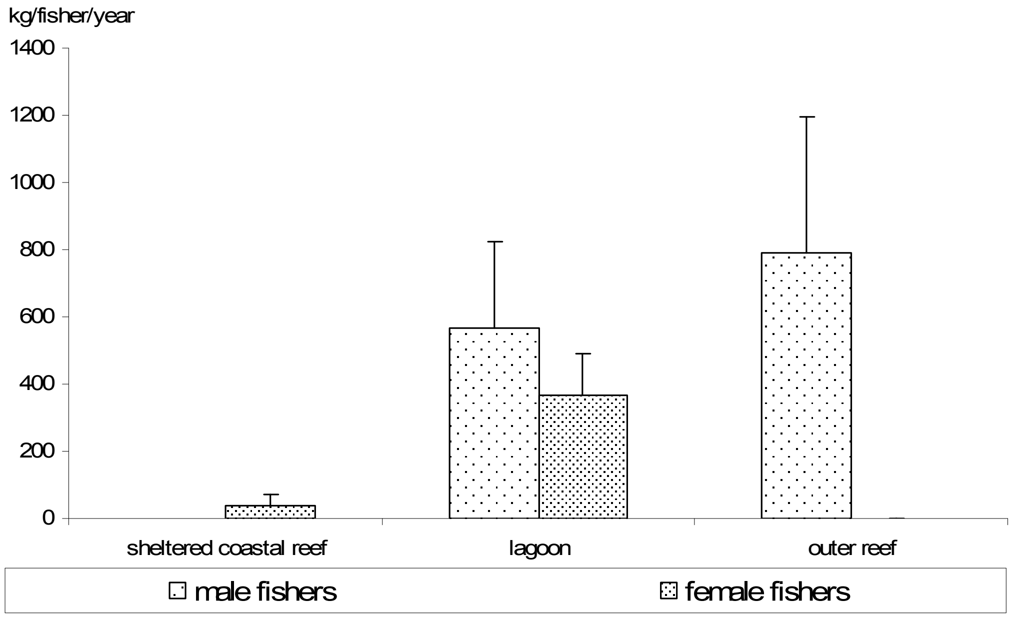

Figure 3.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Tsoilaunung (based on reported catch only).

Differences in the CPUE (Figure 3.11) are significant if comparing data among the three different habitats and between genders. As expected, CPUEs for female fishers targeting the sheltered coastal reef are very low. Male fishers are more effective than female fishers if catching fish in the lagoon. However, CPUEs reported for male fishers at the outer reef are lower than those of male fishers targeting the lagoon. This is probably due to the resource status but rather to differences in the average length of fishing trip (5 hours to the outer reef as compared to 4 hours in the lagoon) and perhaps fishing strategies.

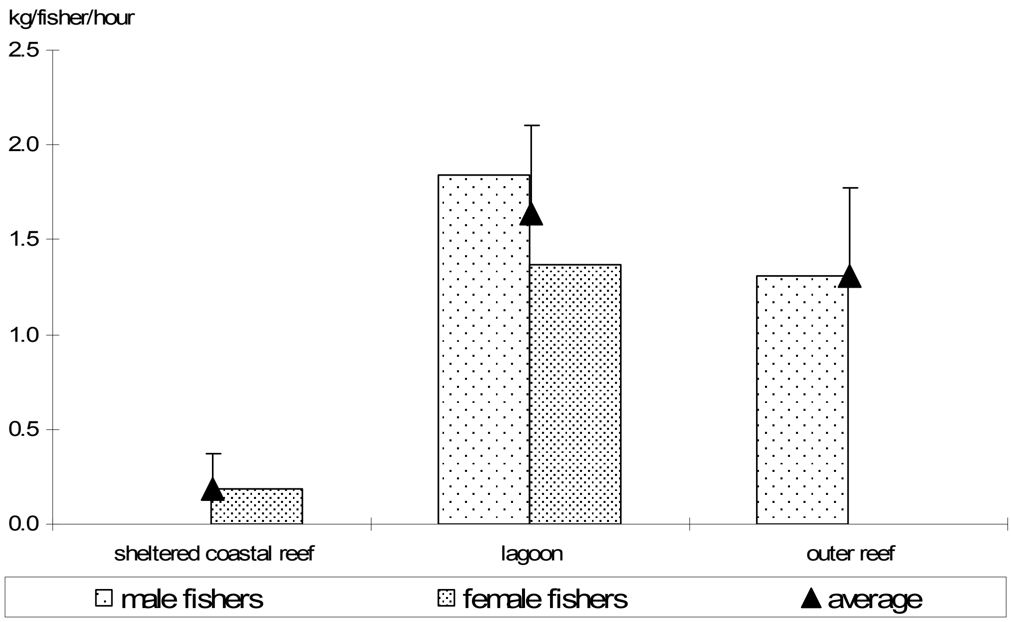

Figure 3.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Tsoilaunung.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

The high interest in commercial fishing also shows when comparing data on the objectives of fishing trips provided by respondents. Most fishing targeting the lagoon and outer reef is done in order to earn income, and fishers targeting the outer reef are slightly more commercially interested than lagoon fishers (Figure 3.12). Figure 3.12 also shows that the non-commercial distribution among community members is a part of Tsoilaunung people's lifestyle. This applies in particular to female fishers targeting the sheltered coastal reef. As suggested by earlier results, Figure 3.12 confirms that sheltered coastal reef fishing serves subsistence and social purposes only.

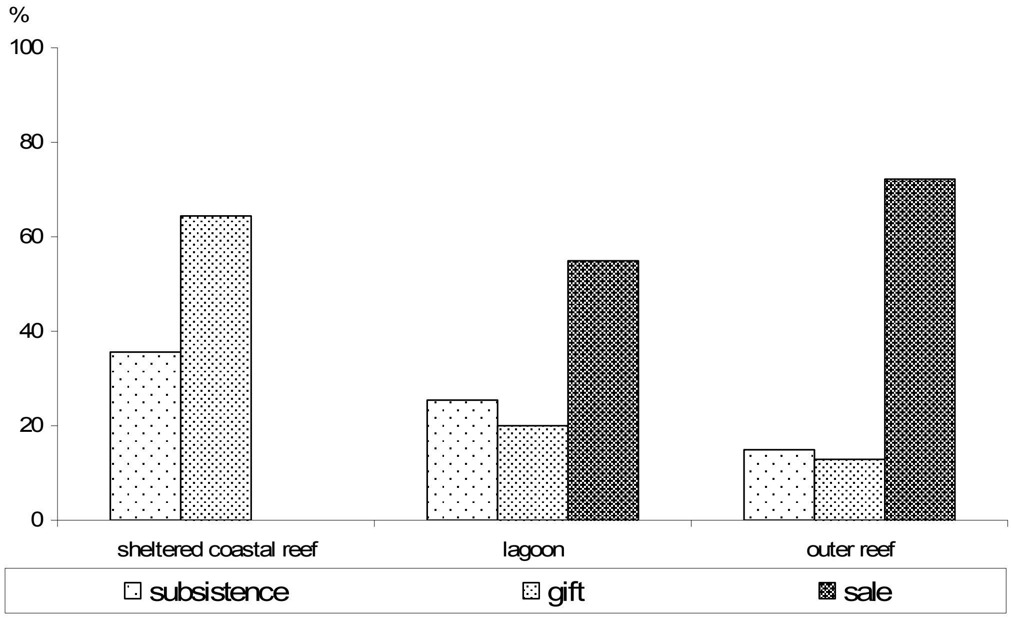

Figure 3.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Tsoilaunung.
Proportions are expressed in % of the total number of trips per habitat.

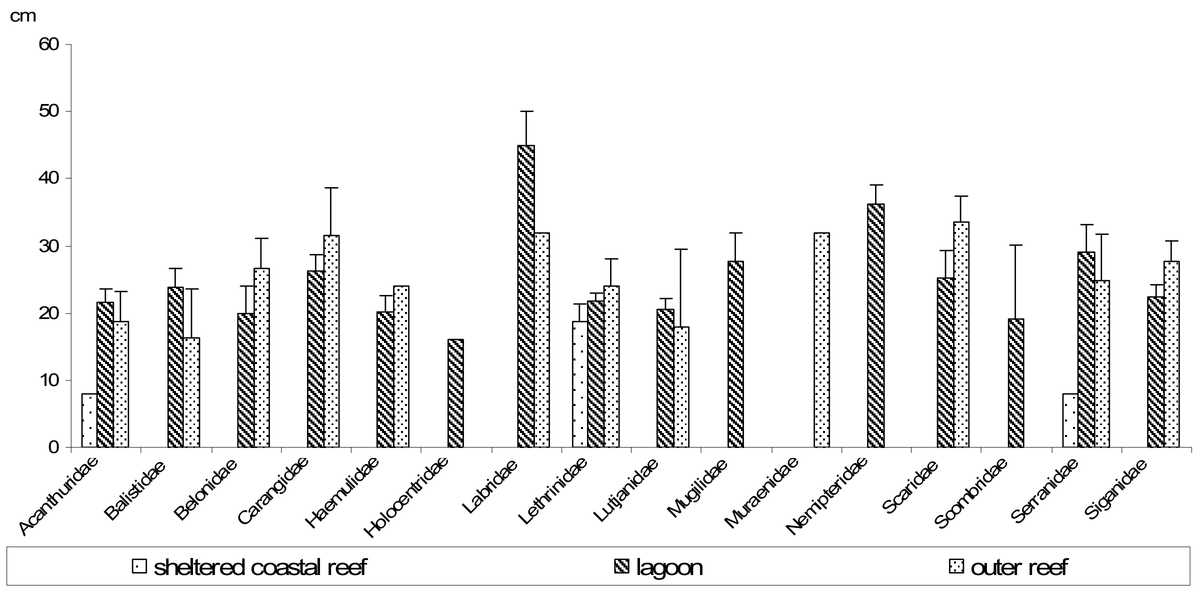

Figure 3.13: Average sizes (cm fork length) of fish caught by family and habitat in Tsoilaunung.
Bars represent standard error (+SE).

Data on the average reported finfish sizes by family and habitat as shown in Figure 3.13 show a great variability in fish sizes by family. Surprisingly, average fish sizes are not largest in catches from the outer reef, but rather in catches from the lagoon. This is particularly true for Labridae and Balistidae and, to a lesser extent, for Acanthuridae, Lutjanidae and Serranidae. However, average sizes reported for families of Belonidae, Carangidae, Scaridae and Siganidae are largest at the outer reef. Overall, average fish sizes reported for catches from the sheltered coastal reef are smallest (8–10 cm only). Average fish sizes vary between 20 and 30 cm for most families reported from both lagoon and outer-reef catches. The average fish size of Labridae caught in the lagoon (40 cm) is an outstanding exception.

Some parameters selected to assess the current fishing pressure on Tsoilaunung living reef resources are shown in Table 3.4. Fishing pressure is compared among sheltered coastal reef, lagoon and outer reef, as well as between total reef area and total fishing ground area (Figure 3.14). The latter includes reef and lagoon or soft-benthos habitats. The size of the three major habitats varies. The outer reef is the smallest with ~22 km^2, the sheltered coastal reef, however, is only 3.5 km^2 larger (~24.4 km^2), and the largest area is the lagoon with ~32 km^2. As shown in Table 3.4, most fishers target the largest area, the lagoon, but this group catches on average much less (~480 kg/fisher/year) as compared to fishers targeting the outer reef (~788 kg/fisher/year). The least number of fishers with the lowest average annual catch rate target the sheltered coastal reef. As a result of the total number of fishers and size of the habitat, lowest fisher density exists in the sheltered coastal reef, followed by the outer reef, where fisher density is also low. However, a fisher density of 20 fishers/km^2 as calculated for the lagoon is moderate. Overall, if taking into account all fishers and the total reef area only, fisher density reaches a moderate level of 19 fishers/km^2. Fisher density is rather low, however, if taking into account the total available fishing ground surface. Similarly, overall population density figures for reef and total fishing ground surfaces are low-to-moderate. Calculation of the total subsistence catch over the total reef and fishing ground areas results in very low fishing pressure (>1 t/km^2 of total reef area). However, it should be borne in mind that the proportion of subsistence catches accounts for 11% of the total annual catch only. Accordingly, the actual fishing pressure including both subsistence and commercial catches may be 10 t/km^2 of reef and 6 t/km^2 of total fishing ground area. Hence, total fishing pressure on Tsoilaunung's reef area is moderate, if not high. The reported larger average fish lengths for certain species caught in the lagoon may suggest impact, at least on these species at the outer reef. This observation may indicate that previous fishing pressure may have already impacted certain species groups. For instance, the proportion of Scaridae reported for catches from the lagoon seems to be small when we consider that *Bolbometopon muricatum* represents about one-quarter of reported catches from the outer reef. However, these results from the socioeconomic survey need to be compared with results from the resource surveys before any final conclusions can be drawn.

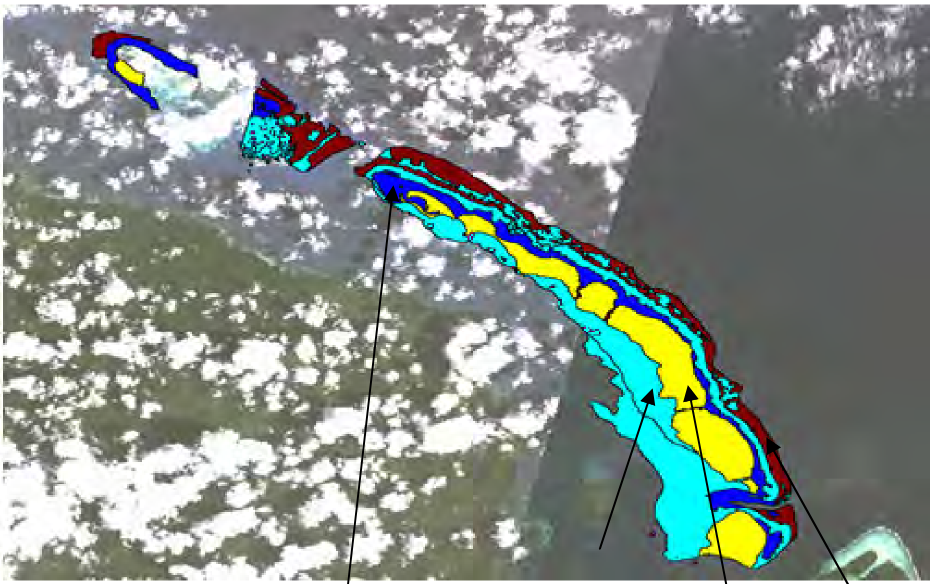

Figure 3.14: Habitats targeted by fishers in Tsoilaunung.

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

Parameters	Habitat				
	Sheltered coastal reef	Lagoon	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	24.42	42.73	21.96	46.37	89.11
Density of fishers (number of fishers/km^2 fishing ground) (1)	2	15	7	19	10
Population density (people/km^2) (2)				36	19
Average annual finfish catch (kg/fisher/year) (3)	36.94 (±36.28)	479.99 (±155.21)	788.11 (±409.15)		
Total fishing pressure of subsistence catches (t/km^2)				1.01	0.53
Total number of fishers	57	643	159	859	859

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) total population = 1670; total number of fishers = 859; total subsistence demand = 47.0 t/year; (3) catch figures are based on recorded data from survey respondents only.

Commercialisation

Fish and seafood are hardly ever sold on Tsoilaunung. People on the island are self-sufficient and will rather share on a non-commercial basis among themselves. However, finfish and invertebrates are either sold to buyers from Manus who come to Tsoilik, are marketed through 1–2 agents, or directly sold at Kavieng market on the mainland. Prices vary between these options as is shown below.

- Village fish prices on Tsoilaunung:	PGK 0.10 to 2.00 /fish (depending on size)
- Buyers from Manus on Tsoilaunung:	PGK 2.00 /kg reef fish
	PGK 3.50 /kg mackerel
	PGK 1.50 /kg tuna
	PGK 1.00 /kg shark
- Agents buying on Tsoilaunung:	PGK 1.20–1.50 /kg reef fish
- Kavieng market:	PGK 2.00 /kg reef fish.

Note that direct selling at the Kavieng market includes cost for ice (PGK ~5 /ice block) and transport cost (PGK 25.00 one way).

Because of the limited cooling capacities, much of the fish and seafood products are sold boiled and/or smoked. Marketing is done by males and females, but females seem to dominate. Children very often help and may even be in charge of the stands.

3.2.4 Catch composition and volume – invertebrates: Tsoilaunung

Calculations of the recorded annual catch rates per species groups are shown in Figure 3.15. The graph shows that the major impact by wet weight of regular fishing pressure imposed by collectors and some free divers on Tsoilaunung invertebrate resources is mainly due to four bêche-de-mer species: *Holothuria scabra*, *Thelenota ananas*, *H. nobilis* and *H. fuscogilva*. Furthermore, *Scylla serrata*, *H. fuscopunctata*, *Parribacus* spp., *Panulirus longipes* and *Bohadschia similis* catches are significant with 2–4 t/year of recorded catch each. *Trochus niloticus*, giant clam, *Stichopus* spp. and *Cardisoma* spp. account for almost 2 t/year each. Catches reported from gleaners targeting reeftops, soft-benthos and most of mangrove catches are of minor importance. Most of these species have been summarised under 'others' (detailed data provided in Appendices 2.2.2 and 2.2.3).

Overall, the total impact of subsistence gleaning is low if compared to the total catch of bêche-de-mer, lobster and trochus.

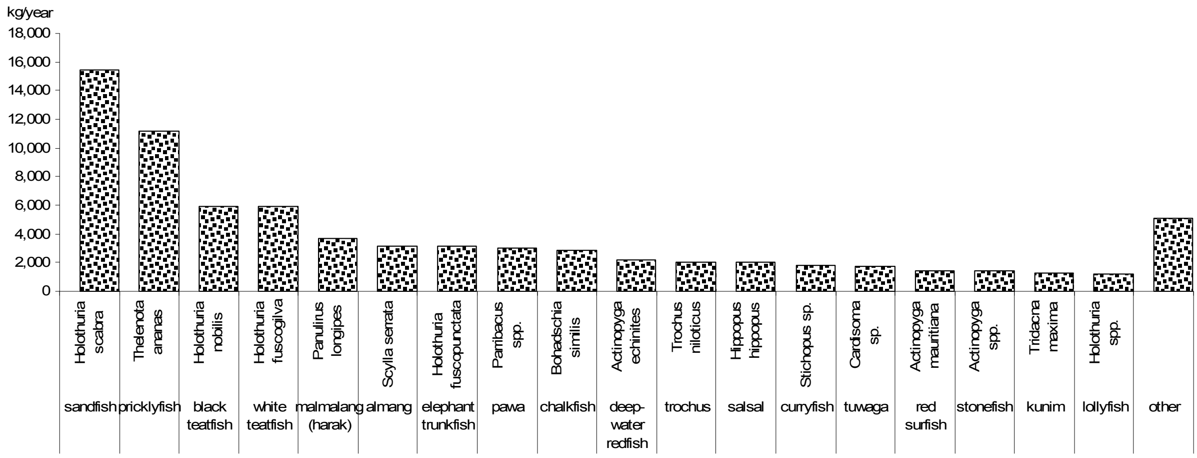

Figure 3.15: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Tsoilaunung.

As stated earlier, invertebrate fisheries on Tsoilaunung include reeftop, soft-benthos and mangrove gleaning, apart from commercial bêche-de-mer, lobster and trochus collection. The highest number of vernacular names were recorded for bêche-de-mer, soft-benthos and reeftop gleaning. However, a large number of vernacular names were also reported for the mangrove and lobster fisheries (Figure 3.16).

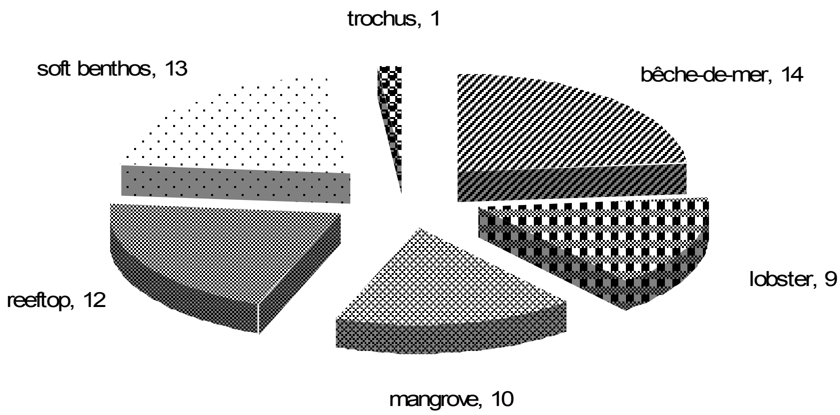

Figure 3.16: Number of vernacular names recorded for each invertebrate fishery in Tsoilaunung.

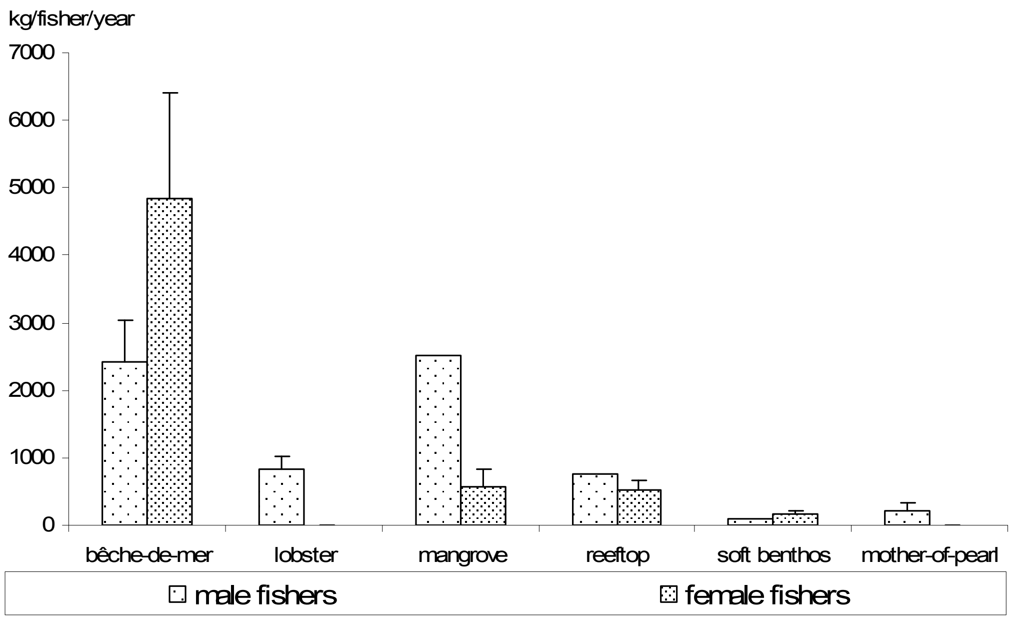

Figure 3.17: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Tsoilaunung.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 13 for males, n = 14 for females).

Females are the main bêche-de-mer collectors on Tsoilaunung. This observation shows in Figure 3.17, where the average annual catches reported by female gleaners are almost double that of males. The high variability (SE) in catches reported for female fishers, however, needs to be taken into account. Male fishers' average annual catches dominate in mangroves, although the sample size is limited. As far as reeftop and soft-benthos gleaning activities are concerned, overall average annual catches are low and there are no distinct differences between males and females.

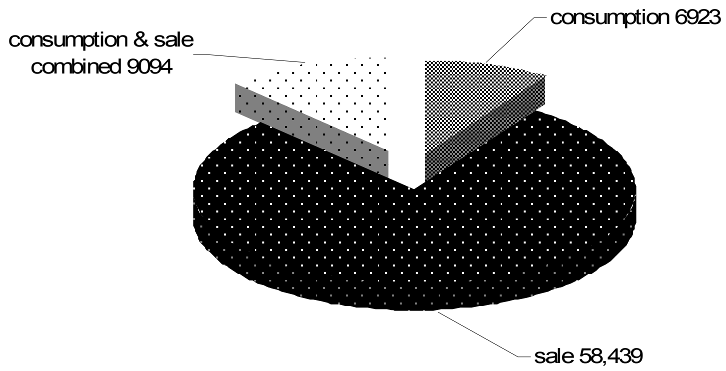

Figure 3.18: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Tsoilaunung.

In contrast to finfish fisheries, the regular reeftop, soft-benthos and mangrove gleaning fisheries are mainly pursued for subsistence purposes. The share sold on the mainland market is small. However, the impressive proportion of invertebrate catches sold (Figure 3.18) is due to commercial fisheries, including bêche-de-mer, trochus and lobster.

The total annual catch volume (expressed in wet weight based on recorded data from all respondents interviewed) amounts to 74.5 t/year (Figure 3.19). The graph supports two earlier observations. Firstly, there are no significant differences between genders, i.e. male and female fishers contribute each about half of the reported catch by wet weight. While females are more involved in subsistence gleaning activities, overall, the impact on reeftop, soft-benthos and mangrove resources is low. Highest impact is on commercial species. Bêche-de-mer fisheries, although restricted officially to a maximum of six months/year, account for 70% of all reported catches by wet weight, with females providing the largest share. Lobster fisheries yield more annual catch by wet weight than trochus catches, which are reported to be small.

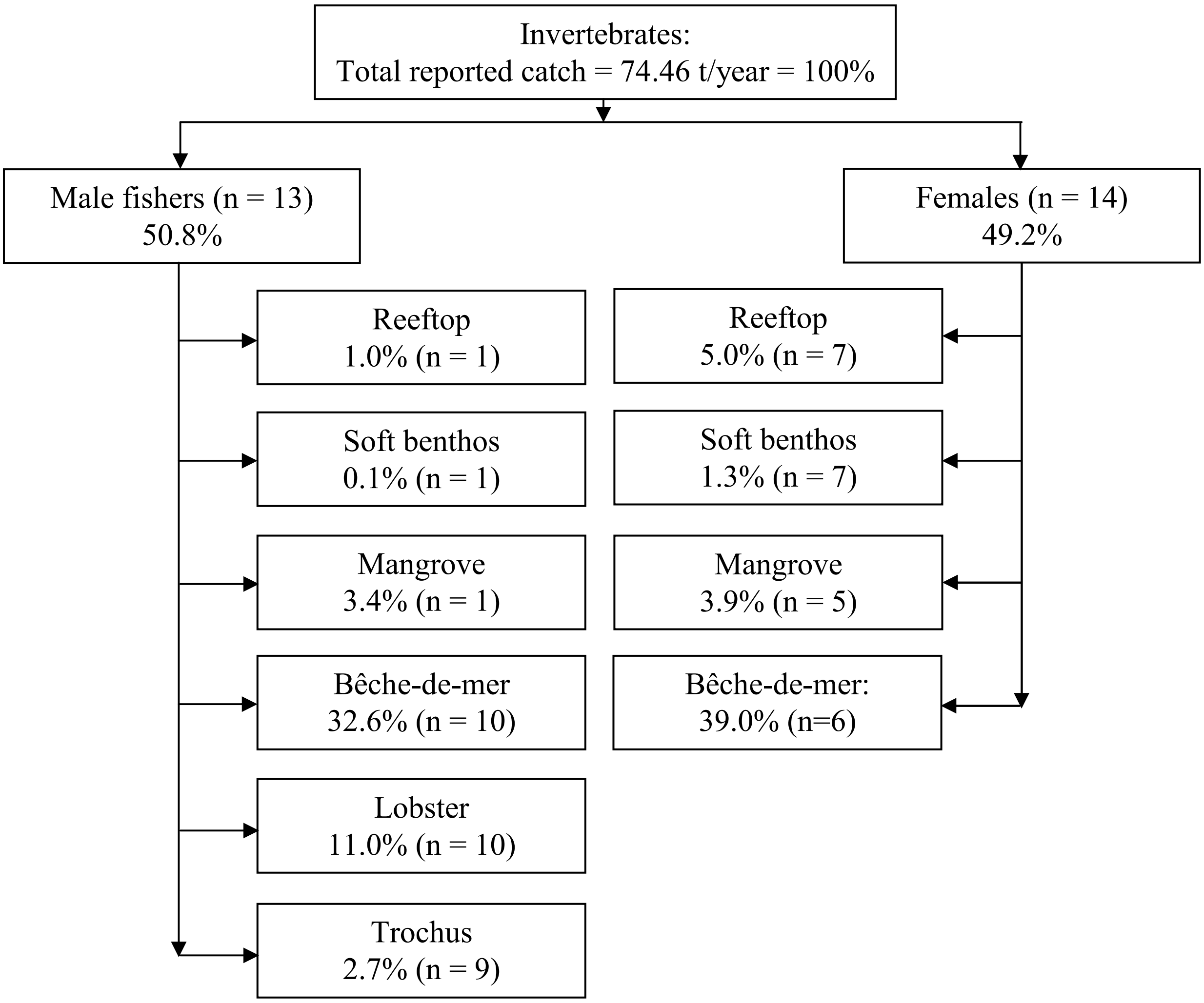

Figure 3.19: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Tsoilaunung.
N is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The parameters presented in Table 4.5 show the highest fisher density for the commercial bêche-de-mer fishery. Also, reeftop gleaning that serves both subsistence and small income generation has a high participation. Lobster and trochus fisheries have lower fisher densities due to the size of the available habitat that supports either species. Most fishers also glean soft-benthos and mangrove habitats. By comparison, the reported annual catch rates by fisher for the commercial bêche-de-mer fishery are alarmingly high. Mangrove and reeftop gleaners do collect considerably less biomass by wet weight within a year.

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

Parameters	Fishery / Habitat					
	Reeftop	Soft benthos	Mangrove	Bêche-de-mer (3)	Lobster (4)	Trochus (4)
Fishing ground area (km^2)	16.43	n/a	n/a	16.43	31.82	31.82
Number of fishers (per fishery) (1)	200	200	148	342	186	168
Density of fishers (number of fishers/km^2 fishing ground)	12	n/a	n/a	21	6	5
Average annual invertebrate catch (kg/fisher/year) (2)	560.90 (±120.16)	146.48 (±47.91)	898.18 (±382.45)	3333.04 (±734.40)	820.54 (±210.01)	224.52 (±111.73)

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) inside lagoon shallow reef area surface considered only; (4) outside reef perimeter (km).

Commercialisation

For invertebrates, as for finfish, Tsoilaunung fishers have several marketing opportunities. Fishers may sell to agents who visit the island frequently or at certain times. Also, fishers may sell their produce to a local person who again sells marine produce on the Kavieng market. This applies in particular to finfish, crabs, and a number of other invertebrates that serve local demand.

Commercial catches are usually sold to Ailan Seafoods Limited (ASL), a fish-processing company based in Kavieng, New Ireland Province. ASL was established in 2002. It was awarded a contract from the National Fisheries Authority to lease its processing facility, a part of a fishing complex that was built by the National Fisheries Authority through funding from the Asian Development Bank and AusAID. ASL is a business arm of Emirau Marine Products (EMP) of New Ireland Province. EMP owns 51% of ASL and the remaining 49% is owned by Ailan Seafood Limited of New Zealand. ASL specialises in buying reef fish, snappers, mackerel, crayfish, lobsters, bêche-de-mer, and trochus shells, which it processes and exports in frozen and chilled form. It usually buys marine products from local islanders, among whom are the fishers from Tsoilaunung.

ASL is also a private sector partner for the European Union Rural Coastal Fisheries Development Project in New Ireland. It has entered into agreement with the local villagers to buy fish from them to assist them to pay off the boats which have been acquired through funding from the EU.

The ASL company slowly moved into reef fish, crabs and then trochus shells, which were first sold to the Rabaul button factory. The market was then expanded overseas to Italy, Japan, Hong Kong and Madagascar. ASL used to export 120 t/year of shells. The company's main market for crabs is Australia, with an export of 10 t/year. In addition, 10 t/year of lobster tails are exported to Australia. Bêche-de-mer are bought at offices in Kavieng and Lorengau, Manus Province, to mainly serve the Hong Kong market with ~50 t/year.

Information obtained from one of the company's managers suggests that seasons have changed considerably in the last five years of their operation due to seismic activities. For instance, the high season for lobster in the period August to October no longer generates much supply. Since they started marketing bêche-de-mer and trochus 11 years ago, sizes of bêche-de-mer and trochus shells are getting smaller and smaller, the quantities are reduced and low-value species now dominate the catch. New Ireland has a quota of 80 t this season; however, there is no reason to believe that this quota can be obtained. The company's manager estimated that the 2006 season may achieve a total of 65 t, however, with low-value and small-sized species dominating. The marketing of lobsters and other crustaceans marketing was started some eight years ago. Catch is purchased from local fishers; however, some of the islanders belong to the Seventh Day Adventist church and, therefore, do not engage in crustacean fisheries.

The lack of ice used for transporting, in particular fish, to the market place was highlighted as a major problem.

EMA's price list for bêche-de-mer is provided in Table 3.6. These prices may vary considerably from price ranges indicated by respondents (Table 3.7). The latter, however, do not only refer to prices received from EMA but from all other fish buyers.

Table 3.6: EMA's buying prices (PGK /kg dry weight), 2006 for bêche-de-mer, Kavieng, New Ireland

Vernacular name	Quality				
	A super	A	B	C	D
Brown sandfish		12.50	11.50		
Chalkfish		8.50	6.50		
Curryfish		25.00	20.00		
Tigerfish		13.50	12.50		
Stonefish		22.00	20.00	18.00	
Yellowfish		27.00	22.00	20.00	
Sandfish		90.00	75.00	50.00	35.00
Red surffish	28.00	26.00		17.00	
Snakefish		8.00			
White teatfish		50.00	40.00	35.00	
Pinkfish		6.00			
Lollyfish		9.00	6.00	4.00	
Amberfish			10.00		
Greenfish		40.00			
Pineapplefish		37.00	36.00		
Flowerfish			4.00		
Elephant trunkfish				11.00	
Dragonfish		7.00			

Table 3.7: Prices obtained for bêche-de-mer by respondents from September 2006 PROCFish survey on Tsoilaunung

Vernacular name	PGK /kg dry weight		
	Average	Minimum	Maximum
Sandfish	54	7	90
Lollyfish	5	3	6
Deep-water redfish	9	6	10
Tigerfish	11	10	12
Stonefish	16	10	20
Pricklyfish	18	12	25
White teatfish	31	20	45
Black teatfish	22	10	40
Flowerfish	6	2	10
Elephant trunkfish	9	5	15
Red surffish	17	10	20
Curryfish	14	5	25
Pineapplefish	12	12	12
Chalkfish	6	6	6
Dragonfish	25	25	25

Fisheries management

The two wards on the island usually comprise five members including: the ward secretary, the sub-ward chairman for each community and a females' representative. The ward members make plans that are presented to the Lavangai local level government for recommendation and endorsement to the provincial government. Once a plan has been accepted and formulated by the provincial government, the recommendations it contains are given to the national government for overall approval. This system is, unfortunately, slow, and thus makes it difficult for the WDC to operate efficiently and to react legally and quickly to upcoming problems. Reef ownership is with the community and community tenure allows community-made rules and regulations to be drafted and enforced. However, individual efforts to protect the reef in front of owners' properties have proved ineffective as long as there is no legal basis to apply and enforce punishment.

Ward members reported that the marine resources in Tsoilaunung fishing ground have been deteriorating since the mid-1970s. In 1975 the reef was believed to be rich and endowed with many fish. Stocks began to decline in 1987–1989 and, nowadays, much more time is needed to catch a few fish. Also in 1975 there were many sharks, which are hardly found these days. The introduction and increased use of gillnets, which may have also affected sharks and turtles, were suggested as possible contributing factors. Also, the absence of mullets, which traditionally were available in abundance, is attributed to the use of gillnets. Ward V confirmed that the use of gillnets became popular in 2003. At present there are about 10 gillnets in use in Ward V and another six in Ward IV, most with a 2–3 inch mesh size. Income pressure is another factor considered to contribute significantly to the overexploitation of the marine resources.

Between the two wards on the island, ward- and sub-ward fishing ground limits are not enforced. Every person from the island can fish where desired. However, fishers from outside the Tsoilaunung community are chased away.

While efforts are underway to save the island's marine environment and resources, people from Tsoilaunung are not believed to obey any rules or suggestions. Community rules were made, for instance, by Ward V to stop fishers collecting bêche-de-mer and fish that were too small, and from collecting at night. However, fishers still continue to collect whatever they may find; they venture out at night and they also destroy and turn corals upside down if necessary. Fishers also still use the poisonous root (*Derris derris*) for night fishing. While the bêche-de-mer season is controlled by NFA and was opened from January to September, the trochus fishery is not controlled. The only control mechanism is the acceptance of certain sizes by buyers.

While there are no effective traditional or community fisheries rules, discussions on establishing a marine protected area began in June/September 2006 with the Wildlife Conservation Society and the Ailan Awareness Group.

The Wildlife Conservation Society included Tsoilaunung in the New Ireland project that was run from 2003 to 2005 to assess traditional management practices, such as *tabu*. From 2006 onwards, plans call for the establishment of three new project sites, one of which is Ungakum on Tsoilaunung. In each of the new project sites, socioeconomic studies will be first conducted. A household questionnaire survey was already done in Ungakum but the data has not yet been entered and analysed. Secondly, ecological surveys addressing fish, invertebrates and corals will follow. Finally, effects of *tabu* will be tested by identifying a reef area of ~600–1000 m with the village people that will be closed for about six years. The society will regularly monitor selected ecological parameters and compare results with non-closed test sites outside the *tabu* zone.

The NGO, Ailan Awareness Group, started in 1983 with awareness campaigns in the Kavieng area, focusing on marine resources. The major objective is to help people protect at least half of the coast in the Kavieng area by assisting in the drafting, implementation and follow-up of fisheries management plans. However, the NGO only provides assistance upon demand. A first visit has already been made to Tsoilik and a return visit is planned to give further assistance on that island. The NGO has been granted a small NFA project to work with seven communities in drafting their fisheries management plan. This project is well underway and the seven communities are already establishing their plans.

A representative of an environmental NGO lives on the island to talk with local people about environmental problems, in particular the marine environment, to create awareness and to conduct an educational programme on the local environment, including both land and marine resources.

3.2.5 Discussion and conclusions: socioeconomics in Tsoilaunung

- Fisheries are the most important source of income for the people on Tsoilaunung. Half of all households depend on fisheries for first and another quarter of all households for second income. Handicraft marketing is the second most important source of revenue. Agriculture and salaries are of minor importance.

- Fisheries are also the most important source of protein. All households eat fresh fish, invertebrates and canned fish. All households consume mainly fish and seafood that is caught by a member of the household or given by somebody else from the community, but hardly ever bought.

- Fresh fish consumption is moderate (~35 kg/person/year), and so is invertebrate consumption (11.3 kg/person/year). However, overall, consumption of fresh fish is about average for the region and much higher than indicated for Papua New Guinea nationwide. The low consumption of canned fish confirms that purchased foods are limited.

- The average household expenditure level is lower than across all four PROCFish sites in Papua New Guinea, indicating that the people on Tsoilaunung are self-sufficient in terms of seafood and agricultural produce and that, overall, the living standard is relatively low on the island.

- Finfish fishing is done by males and females with females fishing along the sheltered coastal reef for subsistence and in the lagoon for both subsistence and sale. Males target the lagoon and outer reef mainly for commercial purposes. Females dominate reeftop, soft-benthos and mangrove gleaning; however, both genders are heavily involved in the commercial bêche-de-mer fishery when the season is open. Females do not participate in trochus and lobster collection as it requires free-diving at the back- and outer reef. Most fishing is done using paddling canoes, but some motorised boats are also available.

- Finfish fishing is performed using various techniques; handlining is the main method used at the sheltered coastal reef, handlining and spear diving at the lagoon and outer reef. Deep-bottom lines and gillnets are mainly used at the outer reef, rarely in the lagoon. Apparently, the use of *Derris derris* fish poison at night is still common.

- Fishing pressure in terms of fisher density and population density per habitat, reef area and total fishing ground are low to moderate. Also, total subsistence catch per reef area and total fishing ground are relatively low. However, the proportion of subsistence catches is only 11% of the total annual catch. If the total annual catch is considered, fishing pressure may be as high as 6–10 t/km² for total fishing ground or reef area respectively. Larger average fish sizes were reported for certain species in catches from the lagoon, and not for catches from the outer reef, which may suggest that there is some visible impact of fishing at the outer reef. For the lagoon, impact may be suggested by the very low representation of Scaridae reported in catch composition.

- Invertebrate fishers collect regularly from the reeftops, soft benthos and mangroves. Catches mainly serve subsistence needs on Tsoilaunung. However, commercial catches estimated for bêche-de-mer and trochus are substantial.

- A relatively high fisher density and an alarmingly high annual catch rate per fisher for the commercial exploitation of bêche-de-mer raise concern for the status of Tsoilaunung bêche-de-mer resources and their future. Trochus and lobster fisheries both may also serve to earn income, have much lesser participation and reported annual catch rates per fisher. In the case of trochus, the low figures may suggest low resource status. All other gleaning activities seem to be reasonably worthwhile in terms of average annual reported catch rates.

Data collected and discussions held with people from Tsoilaunung suggest that the island's reef and lagoon resources have deteriorated considerably over the past 25 years. Population increase and the pressure to generate income are factors considered to have triggered over-exploitation, in particular of commercial species for export. Local buyers reported that the quotas set by NFA for the annual bêche-de-mer harvest can no longer be met. The fact that the open season, which usually lasts six months, was extended to nine months in 2006, and that the quota was still not met, may support this argument. Buyers also reported that most of the catch is accounted for by low-value and small-sized species. Key informants on the island confirmed that, although people are aware of minimum sizes for bêche-de-mer, fishers still collect whatever they may find and use destructive collection methods.

The trochus fishery is not regulated and fishers confirmed that catches are not as good as they used to be and that much more time is required to collect small amounts of trochus shells.

Although the communities own their reef and marine resource areas, any regulations suggested are not complied with. Ward representatives stressed the need for a legal basis from which to apply and enforce punishment in case of misconduct or disregard of rules. To establish a legal basis, the slow official process through local, regional and national government authorities needs to be followed. In parallel, Ward members expressed interest in seeking assistance from the Ailan Awareness Group to draft and establish their own fisheries management plan. The ongoing monitoring of the effect of applying a *tabu* (a 6-year closure) to one selected reef on the island (Ungakum) may demonstrate the value of traditional management measures.

3.3 Finfish resource surveys: Tsoilaunung

Tsoilaunung is a group of coralline islands located on the barrier reef west of Kavieng, at a location of 2º26'E and 150º30'E (Figure 3.20). The fishing ground is a free-access area.

Finfish resources and associated habitats were assessed in Tsoilaunung (Figure 3.20) between 17 and 22 August 2006, from a total of 18 transects (6 sheltered coastal, 6 intermediate, 6 outer-reef transects; see Figure 3.21 for transect locations and Appendix 3.2.1 for coordinates).

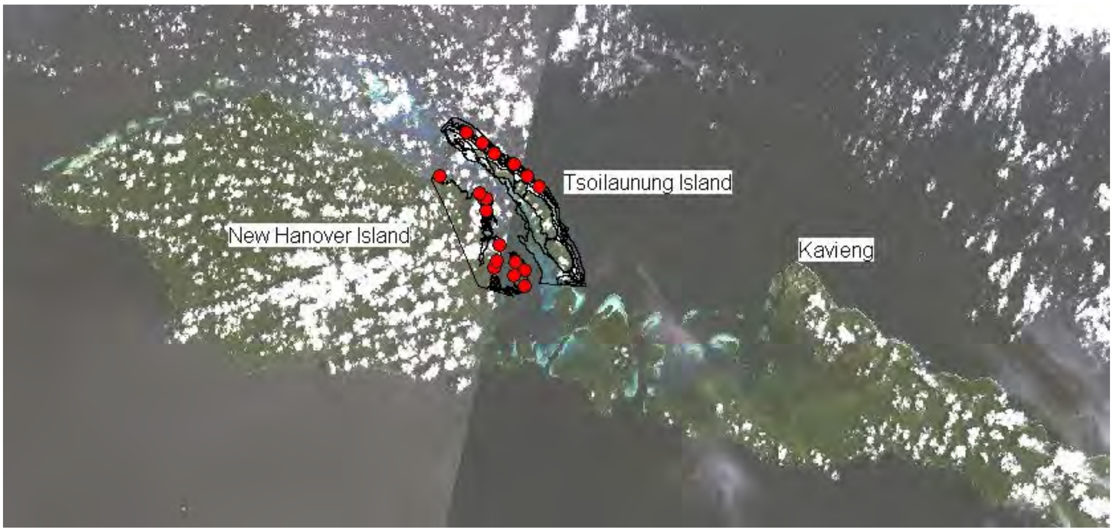

Figure 3.20: Location of the selected site of Tsoilaunung off the island of New Hanover.

3.3.1 Finfish assessment results: Tsoilaunung

A total of 21 families, 59 genera, 169 species and 7967 fish were recorded in the 18 transects (See Appendix 3.2.2 for list of species.). Only data on the 15 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 51 genera, 153 species and 7395 individuals.

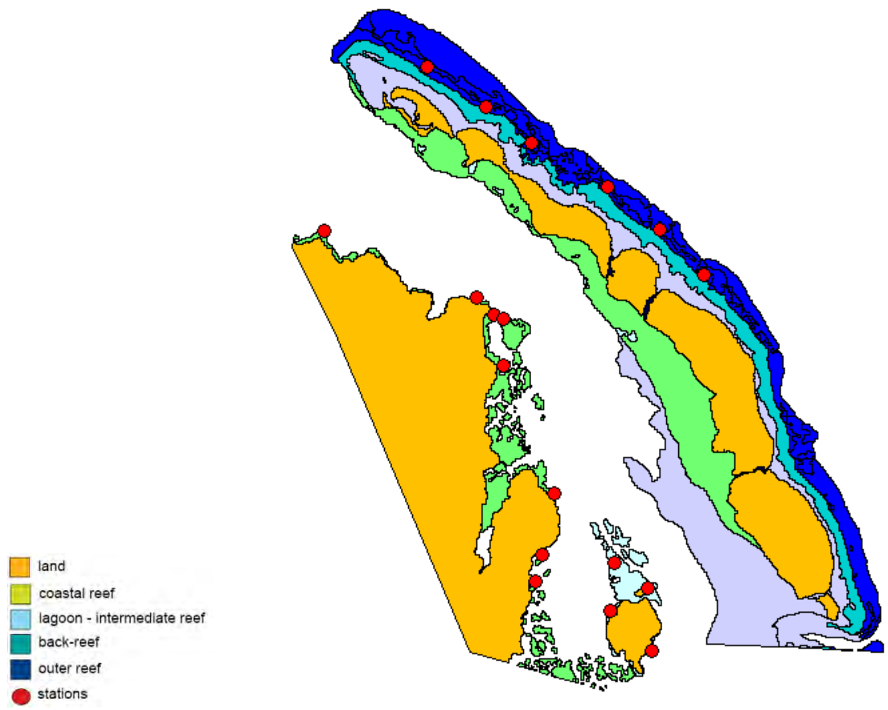

Figure 3.21: Habitat types and transect locations for finfish assessment in Tsoilaunung.

Finfish resources varied slightly among the three reef environments found in Tsoilaunung (Table 3.8). The outer reef contained the highest density (1.7 fish/m^2), size (20 cm FL), size ratio (56%), biomass (337 g/m^2) and biodiversity (51 species/transect) among the three habitats, while intermediate reefs displayed the lowest density (0.3 fish/m²) and biomass (39 g/m^2), and coastal reefs the lowest biodiversity (28 species/transect, the lowest value in the country) and size ratio (53%).

Table 3.8: Primary finfish habitat and resource parameters recorded in Tsoilaunung (average values ±SE)

Parameters	Habitat			
	Sheltered coastal reef (1)	Intermediate reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	6	6	18
Total habitat area (km^2)	24.4	2.9	21.7	49.1
Depth (m)	3 (1-6) (3)	3 (1-5) (3)	6 (3-10) (3)	4 (1-10) (3)
Soft bottom (% cover)	25 ±5	29 ±6	8 ±3	14
Rubble & boulders (% cover)	9 ±2	7 ±1	2 ±0	5
Hard bottom (% cover)	38 ±4	34 ±6	63 ±5	40
Live coral (% cover)	26 ±5	28 ±5	27 ±4	22
Soft coral (% cover)	2 ±1	2 ±1	0 ±0	1
Biodiversity (species/transect)	28 ±4	32 ±2	51 ±6	37±3
Density (fish/m^2)	0.4 ±0.2	0.3 ±0.0	1.3 ±0.3	0.7
Size (cm FL) (4)	16 ±1	16 ±1	20 ±1	18
Size ratio (%)	53 ±3	54 ±3	56 ±2	54
Biomass (g/m^2)	52.3 ±18.3	39.0 ±9.4	336.6 ±131.7	144.9

(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: Tsoilaunung

The sheltered coastal reef environment of Tsoilaunung was dominated by four major families: Scaridae, Acanthuridae and Chaetodontidae in terms of density, and Lutjanidae in terms of biomass (Figure 3.22). These four families were represented by 42 species: particularly high abundance and biomass were recorded for *Scarus psittacus*, *S. flavipectoralis*, *Lutjanus carponotatus*, *Ctenochaetus striatus*, *Acanthurus blochii*, *Chlorurus bleekeri* and *C. sordidus* (Table 3.9). This reef environment presented a moderately diverse habitat with hard bottom covering 38% of total surface, high cover of live corals (26%), and 34% of substrate composed of mobile bottom (soft and rubble together) (Table 3.8 and Figure 3.22).

Table 3.9: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Tsoilaunung

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus psittacus*	Common parrotfish	0.09 ±0.04	11.67 ±5.11
	Scarus flavipectoralis	Yellowfin parrotfish	0.06 ±0.03	6.37 ±2.67
	Chlorurus bleekeri	Bleeker's parrotfish	0.02 ±0.02	2.76 ±2.54
	Chlorurus sordidus	Daisy parrotfish	0.03 ±0.02	2.41 ±1.71
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.05 ±0.01	4.09 ±1.31
	Acanthurus blochii	Ringtail surgeonfish	0.01 ±0.01	3.23 ±3.19
Lutjanidae	*Lutjanus carponotatus*	Spanish flag snapper	0.02 ±0.02	4.91 ±4.45

The density, size and biomass of finfish in the sheltered coastal reefs of Tsoilaunung were intermediate between the low values in the intermediate reefs and the high values in the outer reefs. However, size ratio (53%) and biodiversity (28 species/transect) were the lowest recorded at the site. Compared to the other country sites presenting coastal reefs, Tsoilaunung displayed the lowest values, with biomass 1/8 and density 1/3 of the values of Panapompom coastal reefs. Holocentridae, Labridae and especially Lethrinidae and Mullidae presented very low size ratios, probably indicating heavy exploitation of these families. Lethrinidae appeared to compose the majority of catches (80%) from this reef habitat. The trophic structure in Tsoilaunung coastal reef was dominated by herbivorous fish, represented mainly by Scaridae. High abundance of Chaetodontidae reflected the relatively high live-coral cover at this habitat.

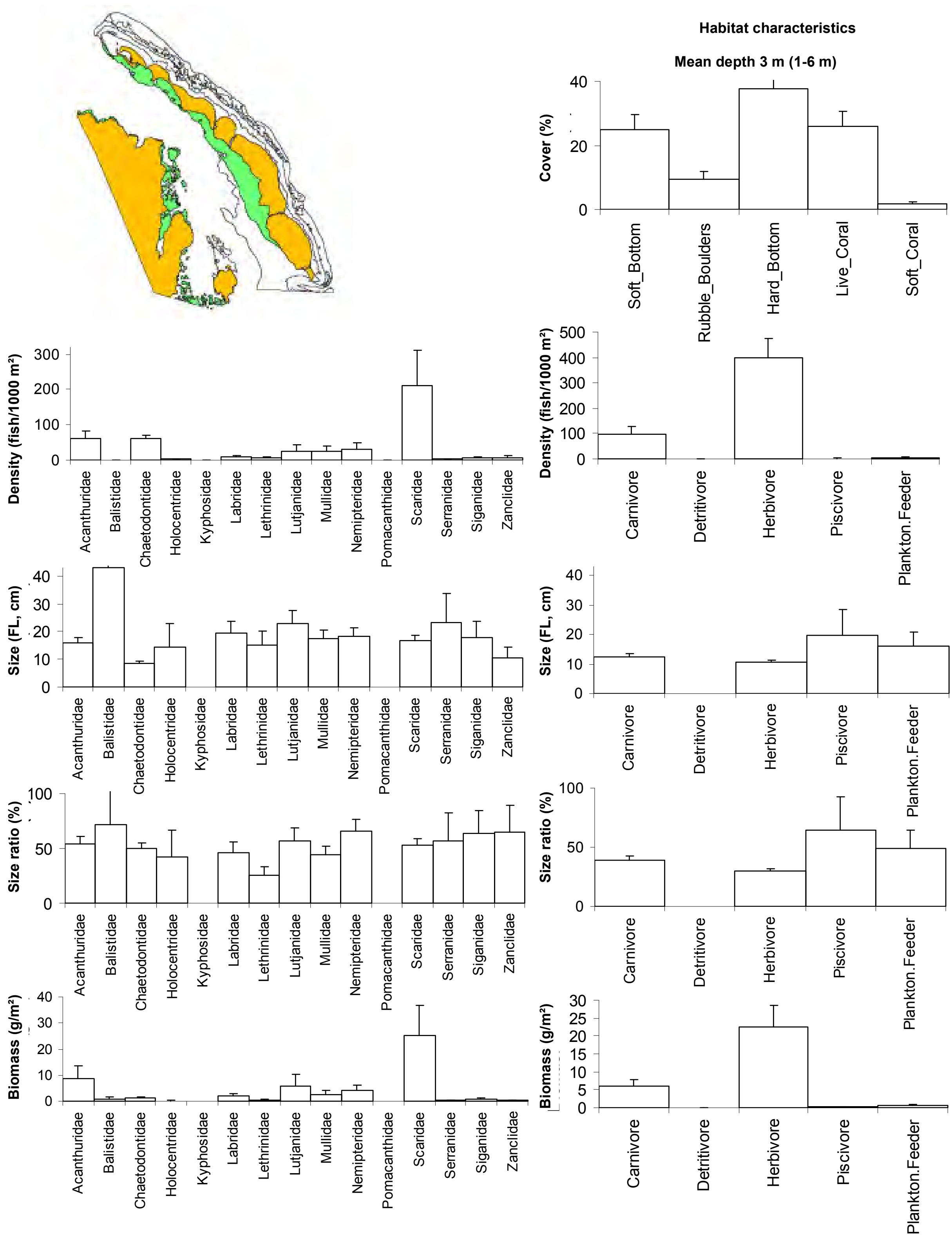

Figure 3.22: Profile of finfish resources in the sheltered coastal reef environment of Tsoilaunung.
Bars represent standard error (+SE); FL = fork length.

Intermediate-reef environment: Tsoilaunung

The intermediate-reef environment of Tsoilaunung was dominated by two herbivorous families: Scaridae and Acanthuridae for both density and biomass, and by two carnivorous families: Chaetodontidae and Nemipteridae only for density (Figure 3.23). These four families were represented by 47 species; particularly high biomass and abundance were recorded for: *Scarus psittacus*, *Ctenochaetus striatus*, *S. dimidiatus*, *S. flavipectoralis*, *Scolopsis temporalis* and *S. trilineata* (Table 3.10). This reef environment presented similar percentage cover of hard bottom (34%), live coral (28%) and soft bottom (29%), offering availability of preferred habitats to several families (Table 3.8).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus psittacus*	Common parrotfish	0.03 ±0.01	3.8 ±0.9
	Scarus dimidiatus	Yellow-barred parrotfish	0.02 ±0.01	2.9 ±0.9
	Scarus flavipectoralis	Yellowfin parrotfish	0.01 ±0.01	2.6 ±1.0
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.03 ±0.01	3.4 ±1.2
Nemipteridae	*Scolopsis temporalis*	Bald-spot monocle bream	0.01 ±0.01	0.8 ±0.7
	Scolopsis trilineata	Three-lined monocle bream	0.01 ±0.01	0.7 ±0.2

The density and biomass of finfish in the intermediate reefs of Tsoilaunung were the lowest of the site, while size, size ratio and biodiversity were higher than coastal-reef values but lower than outer-reef values (Table 3.8). When compared to the same type of habitat in Andra and Panapompom, the intermediate reefs of Tsoilaunung had the lowest values of all parameters. Herbivores and carnivores displayed similar abundance values, especially due to the relatively high abundance of butterflyfish and threadfin breams, but herbivores showed higher biomass in the trophic composition of the finfish community. Labridae, Lutjanidae, Mullidae and Nemipteridae were similarly important in the biomass composition of carnivores. Average size ratio was very low for Lethrinidae (22%), Mullidae (34%), Serranidae (37%) and Holocentridae (42%), suggesting an impact from fishing. Emperors were in fact the preferentially caught family in such habitat (26% of total catches), caught by fishers using lines over sandy bottom. The intermediate reefs of Tsoilaunung displayed a relatively diverse composition of hard and soft bottom, with also a very good cover of live corals, which hosted a high diversity and abundance of Chaetodontidae. The diversity of habitat can explain the relatively high diversity of families represented, although the community was strongly dominated by two major families: Scaridae and Acanthuridae.

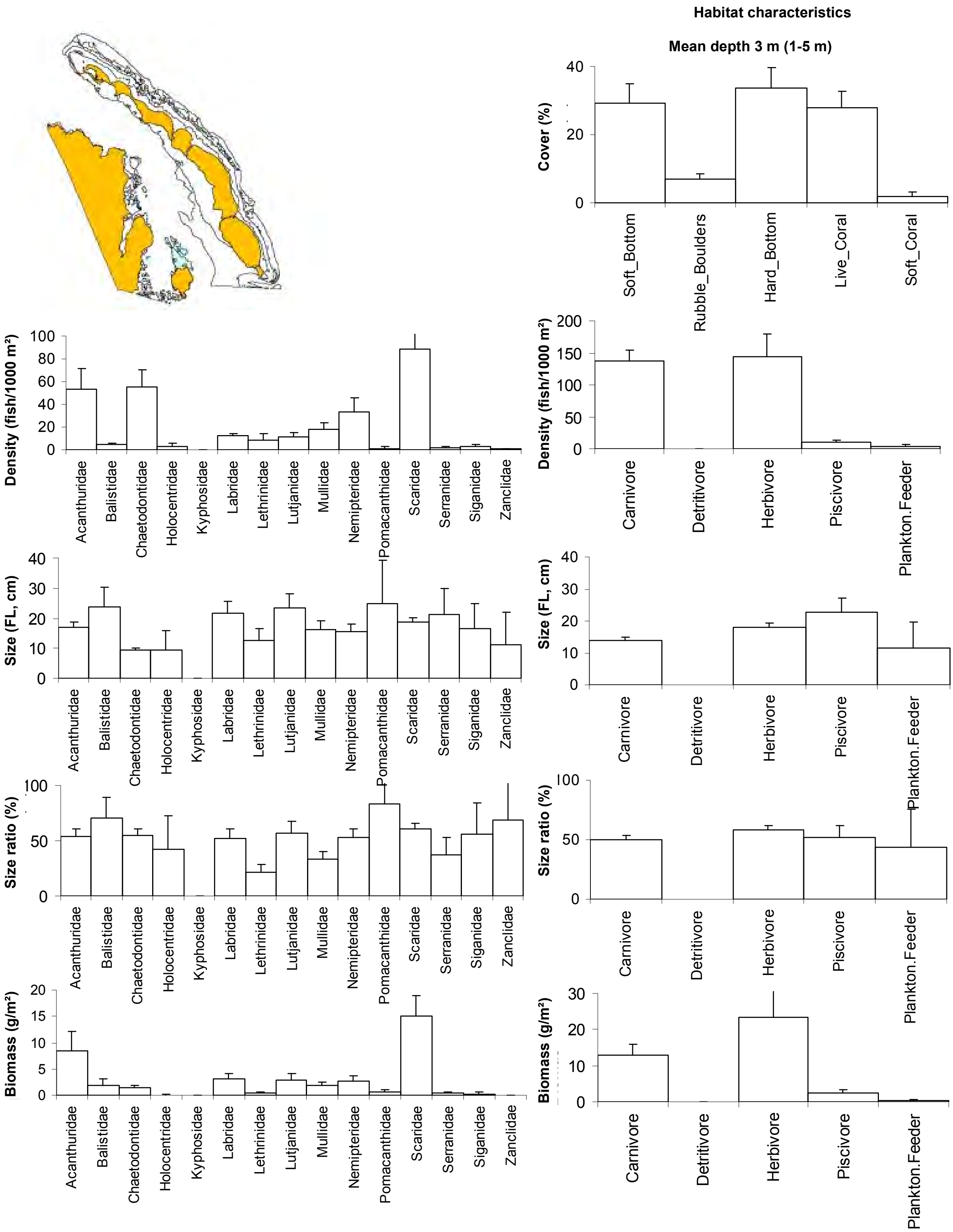

Figure 3.23: Profile of finfish resources in the intermediate-reef environment of Tsoilaunung.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Tsoilaunung

The outer-reef environment of Tsoilaunung was dominated by three major families: herbivorous Acanthuridae and Scaridae, and carnivorous Lutjanidae (Figure 3.24). These were represented by 42 species; particularly high biomass and abundance were recorded for: *Lutjanus gibbus*, *Acanthurus blochii*, *A. lineatus*, *Ctenochaetus striatus*, *Scarus ghobban*, *S. psittacus*, *A. nigricans* and *L. fulvus* (Table 3.11). This reef environment presented mostly hard bottom (63%), high coral cover (27%) and very little soft-bottom cover (8%, Table 3.8).

Table 3.11: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Tsoilaunung

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.22 ±0.17	101.6 ±67.4
	Lutjanus fulvus	Flametail snapper	0.01 ±0.01	2.1 ±1.2
Acanthuridae	*Acanthurus blochii*	Ringtail surgeonfish	0.07 ±0.07	56.7 ±55.4
	Acanthurus lineatus	Lined surgeonfish	0.19 ±0.09	27.6 ±12.7
	Ctenochaetus striatus	Striated surgeonfish	0.24 ±0.03	22.6 ±3.6
	Acanthurus nigricans	Whitecheek surgeonfish	0.07 ±0.02	6.1 ±2.1
Scaridae	*Scarus ghobban*	Bluebarred parrotfish	0.02 ±0.02	11.6 ±11.5
	Scarus psittacus	Common parrotfish	0.04 ±0.02	7.9 ±4.6

The density, size, size ratio, biomass and biodiversity of finfish in the outer reefs of Tsoilaunung were the highest of the site, and density and biomass were also the highest among all four outer reefs surveyed (Table 3.8). Size ratio (56%) and biodiversity (51 species/transect) were comparatively low when compared to the very high values recorded in Panapompom and Andra. Herbivores were more abundant than carnivores, but biomass was very similar between the two trophic groups. Lutjanidae were the most represented carnivores. Average size ratio was quite high for most families, suggesting that finfish resources were in good condition. The outer reefs of Tsoilaunung had a substrate that was mainly composed of hard bottom and live coral, advantaging herbivores over carnivores.

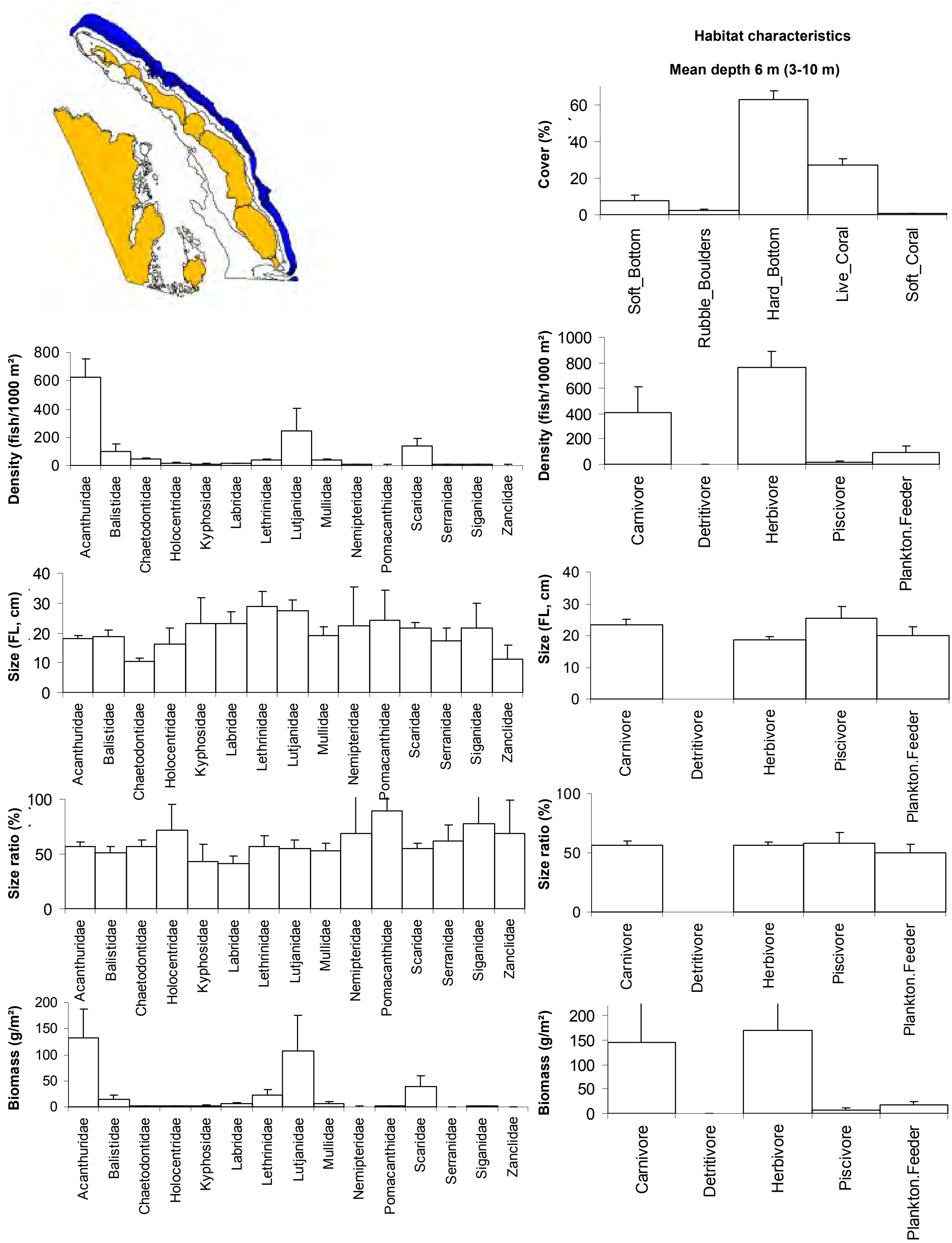

Figure 3.24: Profile of finfish resources in the outer-reef environment of Tsoilaunung.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Tsoilaunung

Overall, the fish assemblage of Tsoilaunung was dominated by the herbivorous families Acanthuridae and Scaridae, and the carnivorous family Lutjanidae (Figure 3.25). These three families were represented by a total of 49 species, dominated (in terms of biomass and density) by *Lutjanus gibbus*, *Acanthurus blochii*, *A. lineatus*, *Ctenochaetus striatus*, *Scarus psittacus*, *S. ghobban*, *S. flavipectoralis* and *A. nigricans* (Table 3.12). The average substrate was dominated by hard bottom (40%), with average cover of live coral (22%), and a relatively good proportion of mobile bottom (19%). The overall substrate composition and fish assemblage in Tsoilaunung shared characteristics of primarily coastal reefs (50% of total habitat) and outer reefs (44%) and, only to a much less extent, of intermediate reefs (6%).

Table 3.12: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Tsoilaunung (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	Ringtail surgeonfish	0.03	21.9
	Acanthurus lineatus	Lined surgeonfish	0.07	10.1
	Ctenochaetus striatus	Striated surgeonfish	0.11	10.0
	Acanthurus nigricans	Whitecheek surgeonfish	0.02	2.2
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.08	36.7
Scaridae	*Scarus psittacus*	Common parrotfish	0.05	7.8
	Scarus ghobban	Bluebarred parrotfish	0.01	4.2
	Scarus flavipectoralis	Yellowfin parrotfish	0.02	3.2

Overall, Tsoilaunung appeared to support a rather good finfish resource, with second-ranked value of biomass and density (lower than in Andra: 145 versus 181 g/m^2, and 0.7 versus 0.9 fish/m^2), similar average fish size value to those in Sideia and Panapompom (18 cm FL), but low value of biodiversity (37 versus 75 species/transect in Panapompom, Table 3.8). These results suggest that the finfish resource in Tsoilaunung was in relatively good condition, especially due to the healthy condition of finfish in the outer reefs. The more detailed assessment at the trophic and family level revealed a dominance of herbivores over carnivores, especially in terms of density. This trend could not be fully explained by the substrate of the habitat, since this was composed of 10–>25% of soft bottom, which normally favours carnivorous families, such as Lethrinidae and Mullidae. Overall, size ratios were high for most families, except for Lethrinidae and Labridae, suggesting a possible impact from fishing on these families. Lethrinidae were, in fact, the most targeted fish, caught mainly by line fishing over sandy patches.

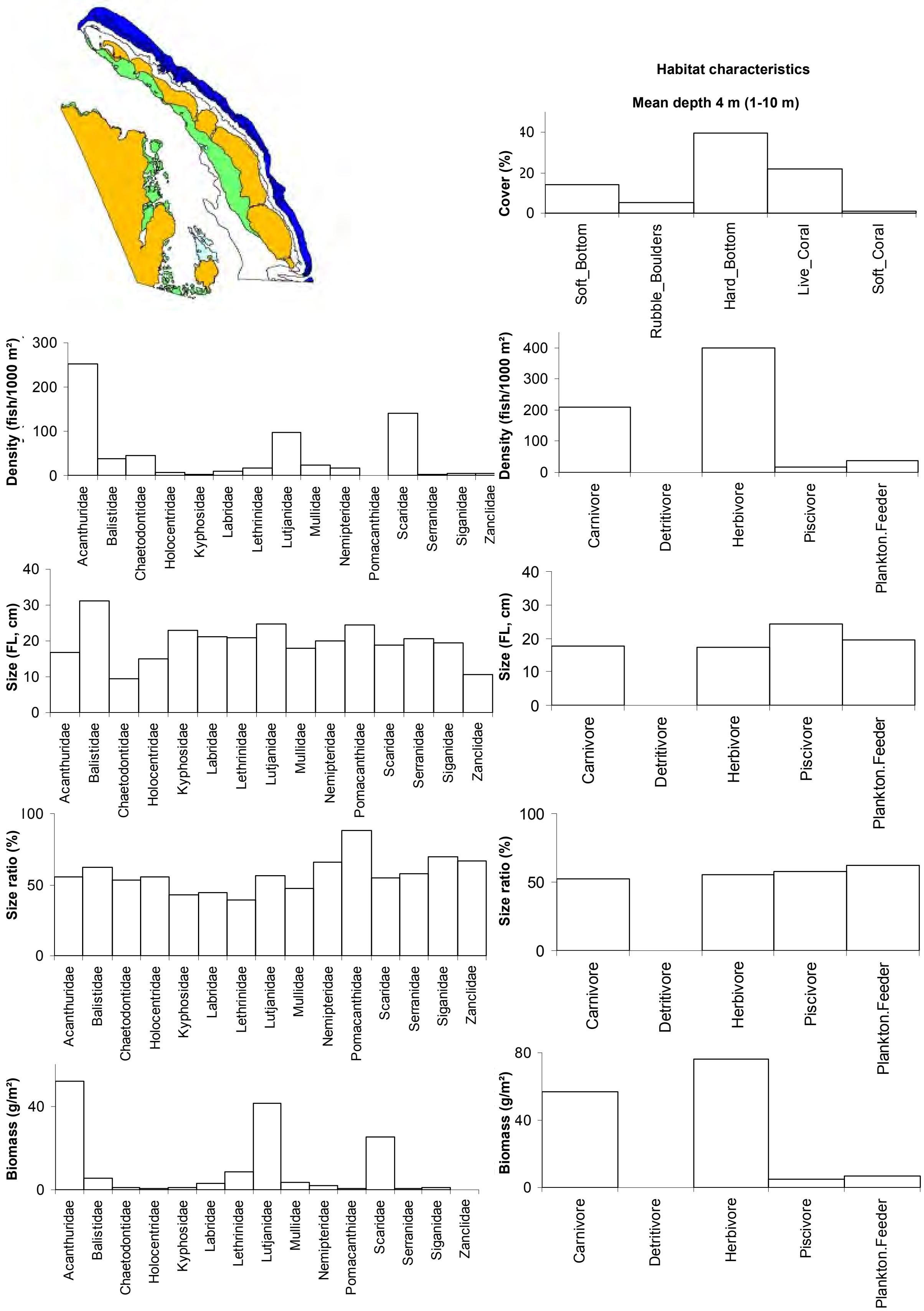

Figure 3.25: Profile of finfish resources in the combined reef habitats of Tsoilaunung (weighted average).
FL = fork length.

3.3.2 Discussion and conclusions: finfish resources in Tsoilaunung

- The assessment indicated that the status of finfish resources in Tsoilaunung was moderately good. This was due to the good condition of the reefs, with relatively high live-coral cover, as well as to the naturally high biodiversity (closeness to the centre of biodiversity). More specifically:
  - Live-coral cover was relatively high, even if the lowest in the country. Coral conditions at specific stations were poorer than at Andra. Presence of COTs was noted.
  - Density and biomass of finfish were the second-highest in the country, and biodiversity displayed high values compared to the regional average, although lowest in the country. However, the healthy status of the outer reefs was not mirrored by the condition of the intermediate and coastal reefs. In these two habitats, density, biomass, biodiversity, and average size were fairly low.

- These and more detailed observations lead us to consider the finfish resources in Tsoilaunung as impoverished, i.e.:
  - A consistent dominance of herbivores was noted.
  - The low abundance of carnivores in the two habitats mostly composed of soft bottom (coastal and intermediate reefs) is most probably a result of intense fishing, mainly targeting emperorfish.
  - A lack of large-sized species was common to all habitats.
  - Low average sizes were common for the most-caught families, especially Lethrinidae.
  - As in Andra, a total lack of top predators was noted here, together with a high level of shark fishing.

- However, analysis at the reef-habitat level was needed to better understand status and distribution of resources, due to their high spatial variability.
  The substrate was variable in the three reefs:
  - The coastal and intermediate reefs had very high coverage of live coral (second only to that in Panapompom). There was high coral cover at the back-reef in areas adjacent to the channels and fringe of lagoon pools.
  - The outer reefs appeared to be the richest environment at the level of habitat condition, with high cover of live coral.

Finfish distribution varied among the three reef types:

- The coastal and intermediate reefs displayed very low fish density and biomass, the lowest at this site as well as compared to the equivalent habitats at the other country sites. Even biodiversity and sizes were small. Moreover, fish in these habitats appeared scared of divers, a sign of frequent spearfishing.

- The outer reefs were the richest also in terms of finfish composition and biomass: high biodiversity, large sizes, high biomass and density, both the highest among all outer reefs in the country, characterised this habitat.

3.4 Invertebrate resource surveys: Tsoilaunung

The diversity and abundance of invertebrate species at Tsoilaunung were independently determined using a range of survey techniques (Table 3.13), broad-scale assessment (using the 'manta tow'; locations shown in Figure 3.26) and more targeted, finer-scale assessment of specific reef and benthic habitats (Figures 3.27 and 3.28).

The main objective of the broad-scale assessment was 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 assessments were conducted in target areas to specifically describe the status of resource in those areas of naturally higher abundance and/or most suitable habitat.

Table 3.13: Number of stations and replicate measures completed at Tsoilaunung

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)	10	80 quadrat groups
Mother-of-pearl transects (MOPt)	1	6 transects
Mother-of-pearl searches (MOPs)	5	30 search periods
Reef-front searches (RFs)	8	48 search periods
Sea cucumber day searches (Ds)	6	36 search periods
Sea cucumber night searches (Ns)	2	12 search periods

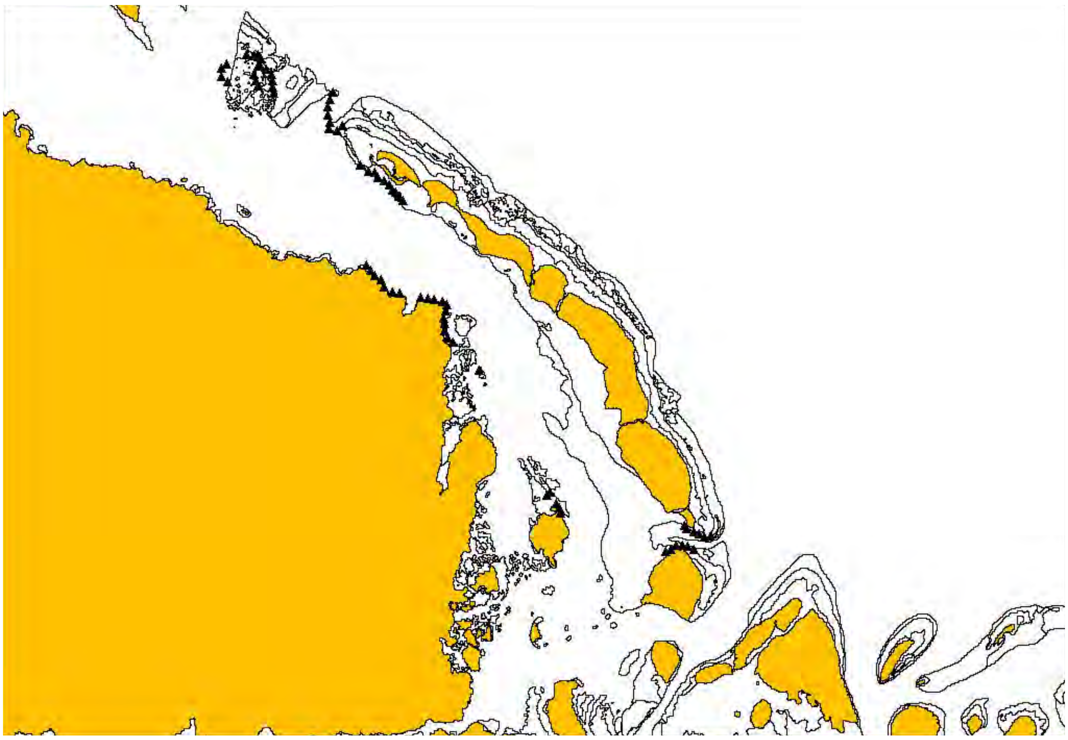

Figure 3.26: Broad-scale survey stations for invertebrates in Tsoilaunung.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

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

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

Eighty-three species or species groupings (groups of species within a genus) were recorded in the Tsoilaunung invertebrate surveys: 17 bivalves, 24 gastropods, 23 sea cucumbers, 6 urchins, 6 sea stars, 2 cnidarians, 2 crabs and 2 lobsters (Appendix 4.2.1). Information on key families and species is detailed below.

3.4.1 Giant clams: Tsoilaunung

Shallow reef habitat that is suitable for giant clams was relatively extensive at Tsoilaunung (63.9 km^2). Although there was a large area available, this was largely restricted to the more exposed reef front, which borders the shallow lagoon east of the Tsoilaunung Islands, some intermediate patch reef habitat in the lagoon, and the eastern shoreline of the mainland (approximately 16.4 km^2 within the lagoon and 47.5 km^2 on the reef front or slope). The western shorelines of the Tsoilaunung islands were very sandy and did not support a large amount of hard substrate (some rubble and areas of seagrass).

Within the lagoon, reef was sheltered as there was protection from islands in the west and east, and the main lagoon west of Tsoilaunung had sufficient depth. There was still significant ‘land’ influence (riverine inputs), although flushing was strong to the north and south of Tsoilaunung where passages linked the lagoon to the ocean.

Reefs at Tsoilaunung held five species of giant clam and broad-scale sampling provided an overview of clam distribution and density. The species recorded were: the elongate clam *Tridacna maxima*, the boring clam *T. crocea*, the fluted giant clam *T. squamosa*, the true giant clam *T. gigas*, and the horse-hoof or bear’s paw clam *Hippopus hippopus*. The smooth clam *T. derasa* was the only species missing from the records. Records from broad-scale sampling revealed that *T. crocea* (recorded in 11 stations and 54 transects) had the widest occurrence, followed by *T. maxima* (found in 9 stations and 18 transects), *T. squamosa* (3 stations and 4 transects) and *T. gigas* (3 stations and 3 transects). *H. hippopus*, which is well camouflaged and usually relatively sparsely distributed, was also recorded in three stations (3 transects in total, see Figure 3.29).

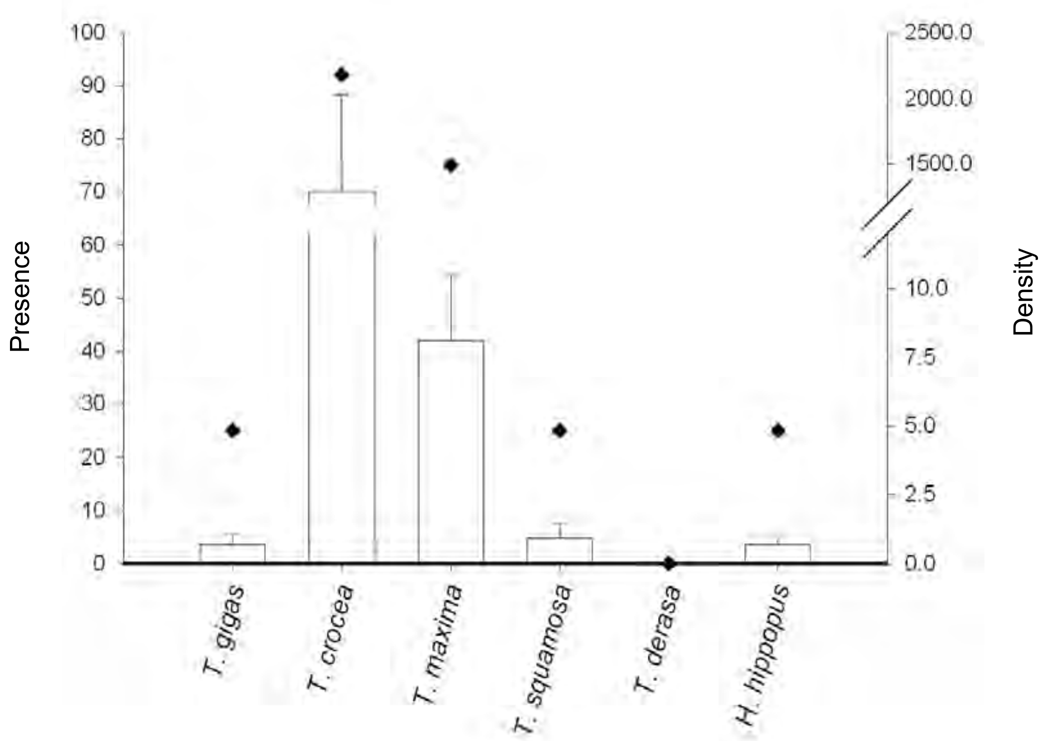

Figure 3.29: Presence and mean density of giant clam species in Tsoilaunung based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 3.30). In these reef-benthos assessments (RBt), *T. crocea* was present in 75% of stations, and *T. maxima* in 69%. These smaller species reached maximum station densities of 13,750 /ha for *T. crocea* and 250 /ha for *T. maxima*. The larger *T. squamosa*, which is normally recorded at lower density in surveys, was relatively scarce in these shallow-reef surveys (recorded in 13% of RBt stations, at an average density of 5.2 /ha ±3.6). The free-standing *H. hippopus* was noted in 25% of stations and reached a maximum station density of 83.3 per ha. A total of three *T. gigas* specimens were seen on reefs during broad-scale surveys (the rest were stockpiled on soft benthos near the village). In both broad-scale and reef-benthos transects, the larger clam species were more evident as dead shells than as live individuals.

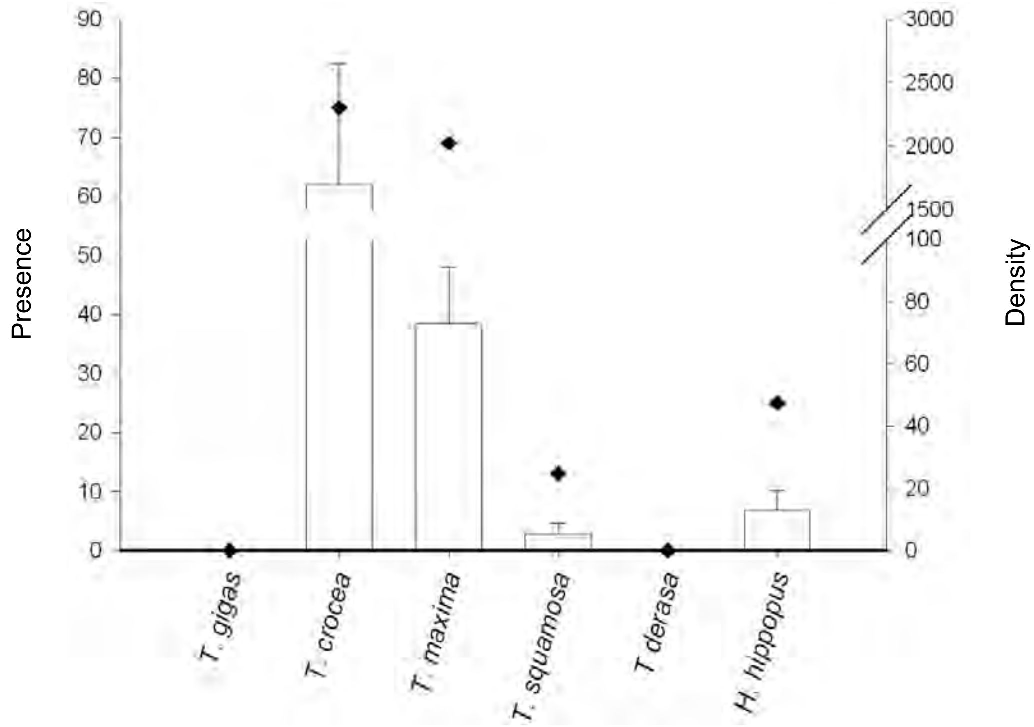

Figure 3.30: Presence and mean density of giant clam species in Tsoilaunung based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

A full range of small and large individuals of *T. maxima* were recorded in survey (mean size 14.7 cm ±0.8). *T. maxima* from reef-benthos transects alone (on shallow-water reefs) had a slightly smaller mean length (13.6 cm ±1.2, which represents a clam just under 6 years old). *T. crocea* averaged 8.3 cm ±0.2 (>5 years old) but fewer clams larger than 12 cm were recorded than might be expected. The faster growing *T. squamosa* (which grows to an asymptotic length L∞ of 40 cm) averaged 25.2 cm ±1.9 (>6 years of age), whereas *H. hippopus* averaged 16.7 cm ±2.0 (3 years of age, see Figure 3.31). The three *T. gigas* clams seen on reef averaged 52.7 cm ±1.8, whereas those stockpiled near the shore on soft benthos were larger at an average of 70.0 cm ±5.3 (Figure 3.32). No *T. derasa* were recorded.

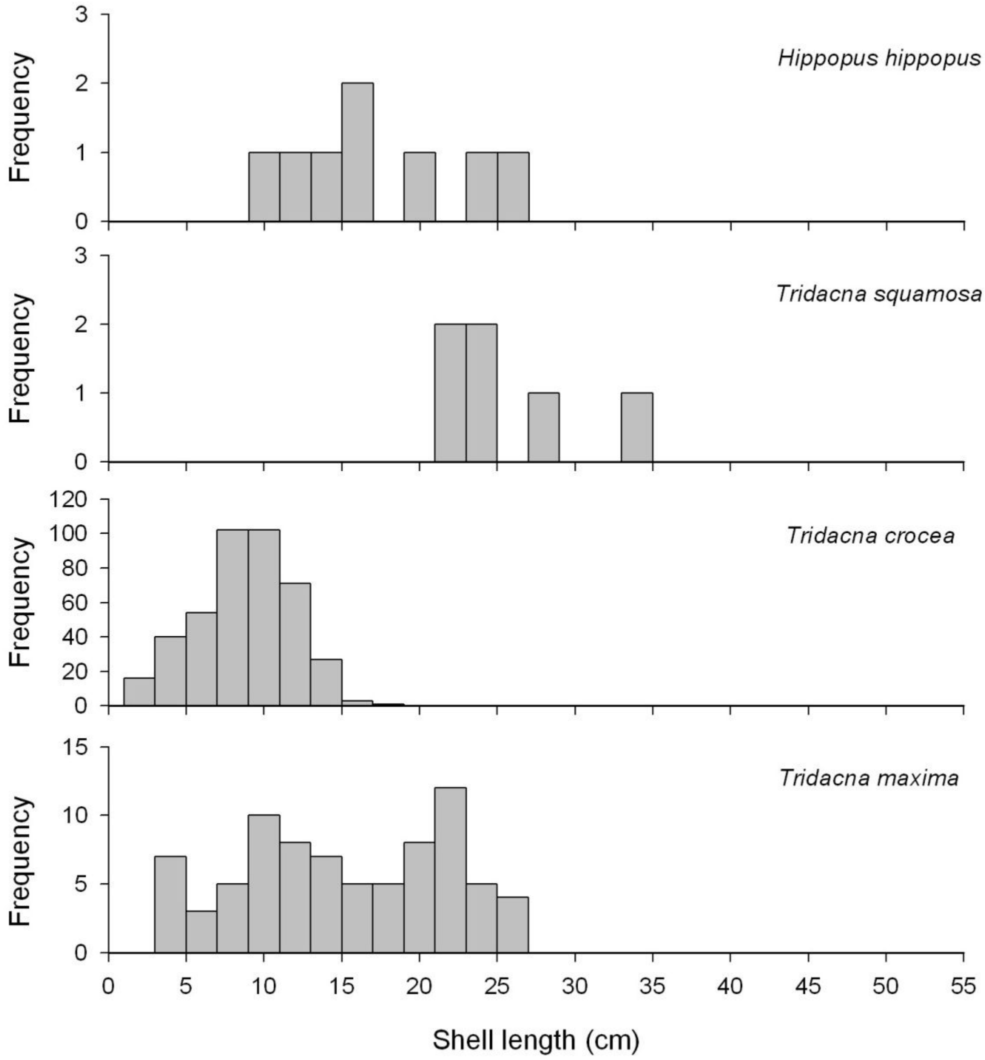

Figure 3.31: Size frequency histograms of giant clams shell length (cm) for Tsoilaunung.

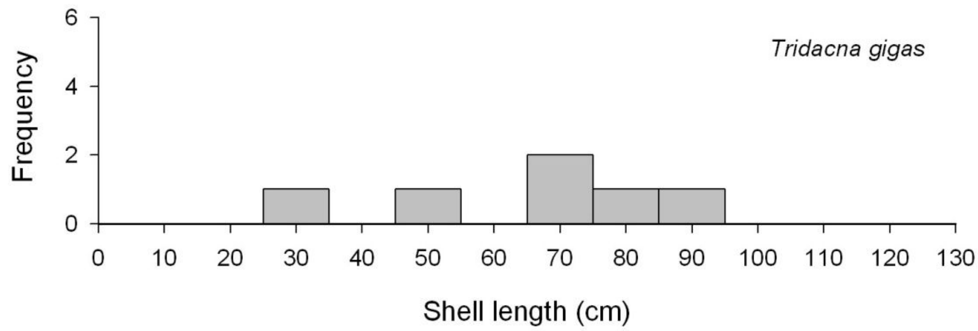

Figure 3.32: Size frequency histogram of the true giant clam *Tridacna gigas* shell length (cm) for Tsoilaunung.

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

Papua New Guinea is within the natural distribution of the commercial topshell *Trochus niloticus* and the turban snail *Turbo marmoratus* in the Pacific. The outer reef at Tsoilaunung constitutes a moderately extensive benthos for *T. niloticus* and this area could potentially support significant numbers of this commercial species (31.8 km lineal distance of barrier-reef perimeter). Although extensive shallow-water reef was found outside the barrier, reef in the main lagoon was not optimal for trochus (mostly comprising bommies on sand with too much sediment load and too little water movement to be suitable habitat for juveniles).

PROCFish survey work revealed that *T. niloticus* was present on both the barrier reef (outer-reef slope and reeftop) and on reefs within the lagoon (Table 3.14). The great green turban (more usually called 'green snail') *Turbo marmoratus* was absent in this survey, although New Ireland Province was a major producer in the past.

Table 3.14: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Tsoilaunung
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	0.5	0.3	2/12 = 17	2/72 = 3
RBt	13.0	8.3	3/16 = 19	4/96 = 4
RFs	1.5	0.7	3/8 = 38	3/48 = 6
MOPs	6.1	2.8	3/5 = 60	4/30 = 13
Tectus pyramis				
B-S	0.5	0.3	2/12 = 17	2/72 = 3
RBt	135.4	35.8	11/16 = 69	29/96 = 30
RFs	5.4	2.0	5/8 = 63	9/48 = 19
MOPs	16.7	5.6	4/5 = 80	4/30 = 13
MOPt (1)	62.5	-	1/1 = 100	2/6 = 33
Pinctada margaritifera				
B-S	0.5	0.3	2/12 = 17	2/72 = 3
RBt	15.6	6.4	5/16 = 31	5/96 = 5
RFs	0	0	0/8 = 0	0/48 = 0
MOPs	0	0	0/5 = 0	0/30 = 0

B-S = broad-scale survey; RBt = reef-benthos transect; RFs = reef-front search; MOPs = mother-of-pearl search; MOPt = mother-of-pearl transect; (1) Single MOPt station did not yield records for *T. niloticus* or *P. margaritifera*.

No large aggregations of trochus were found in surveys of Tsoilaunung (only n = 17 individuals recorded in total), and stock that was recorded was at low density and below abundances considered appropriate for commercial fishing (Appendix 4.5). Although trochus was found at various locations around Tsoilaunung, densities in most cases were so low as to jeopardise successful fertilisation after spawning and therefore regeneration of stock ('Allee effect').

Shell size-class frequencies indicate that there was a good range of trochus sizes present at Tsoilaunung (Figure 3.33), including small, young shells (First maturity of trochus is at 7–8 cm in Papua New Guinea, ~3 years of age.). The mean basal width of trochus at Tsoilaunung was 7.4 cm ±0.5. For this cryptic species, younger shells are normally only picked up in general surveys after they reach a size of about 5.5 cm, as this is the size at which small trochus begin to emerge from cryptic spaces in shallow-water back-reef areas to join the main stock.

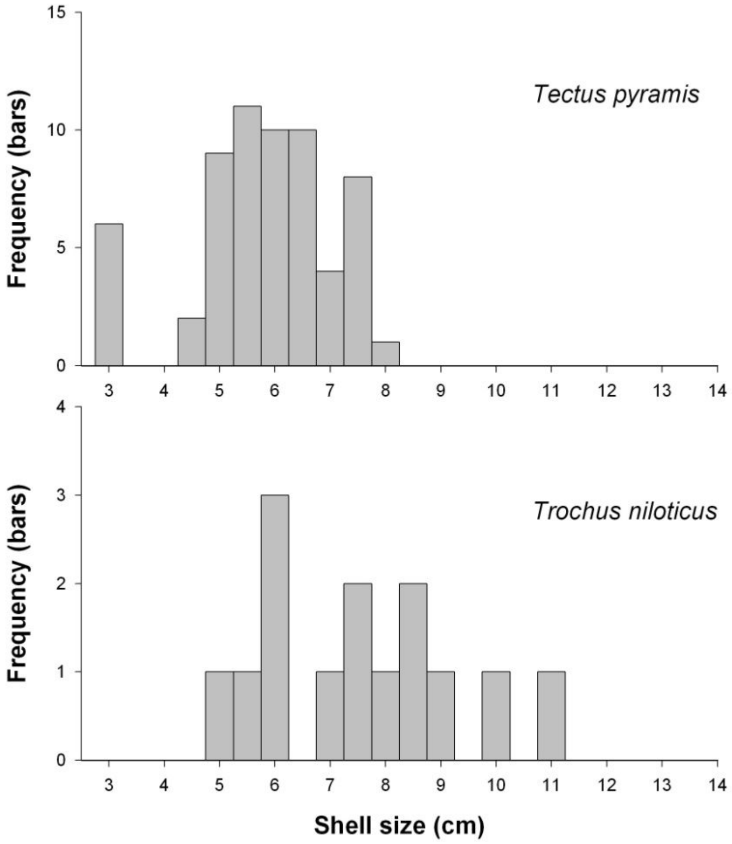

Figure 3.33: Size frequency histograms of trochus (*Trochus niloticus*) and 'false' trochus (*Tectus pyramis*) shell base diameter (cm) for Tsoilaunung.

The suitability of reefs for grazing gastropods was also highlighted by survey results for the false trochus or green topshell (*Tectus pyramis*). This related, but less valuable species of topshell (an algal-grazing gastropod with a similar life history to trochus) was abundant at Tsoilaunung (n = 61 recorded in survey). The mean size (basal width) of *T. pyramis* was 5.5 cm ±0.2. Small *Tectus* (<5.5 cm) were also recorded in survey, which may suggest that conditions for recent spawning and/or settlement of both *Trochus* and *Tectus* may have been favourable in the previous spawning seasons.

Despite blacklip pearl oysters (*Pinctada margaritifera*) being cryptic and normally sparsely distributed in open lagoon systems (such as found at Tsoilaunung), the number of blacklip seen during assessments was moderately high (n = 13). The mean shell length (anterior–posterior measure) was 12.8 cm ±0.4.

3.4.3 Infaunal species and groups: Tsoilaunung

Soft benthos at the western coastal margins of Tsoilaunung Island looked superficially suitable for shell beds. Within this area, no *Lambis lambis* was found, but other shellfish species of interest were recorded: *Atactodea*, *Chama*, *Codakia*, *Conus*, *Dolabella*, *Fragum*, *Modiolus*, *Pinna*, *Polinices*, *Spondylus*, *Strombus gibbosus* and *Tectus* (Appendix 4.2.5).

However, the seagrass meadows did not hold significant numbers of the larger subsistence type bivalves commonly targeted in the Pacific e.g. arc shells (*Anadara* spp.) or venus shells (*Gafrarium* spp.).

Distribution of arc shells was sparse, with only two of the ten stations assessed holding *Anadara* spp. (arc shells recorded in 3% of quadrat groups; see Methods). The overall density yielded by these surveys of soft benthos was low (mean density of 0.1 /m^2 ±0.07). The mean length of the arc shells sampled was 49.7 mm ±2.3.

Although seagrass meadows were present no significant in-ground shell beds were identified. Soft benthos at Tsoilaunung held a very small number of *Anadara* spp. It is not possible to determine why these soft-benthos areas held such low numbers of bivalves, which are usually targeted by subsistence fishers.

3.4.4 Other gastropods and bivalves: Tsoilaunung

Seba's spider conch (*Lambis truncata*, the larger of the two common spider conchs) was not recorded in survey, but *Lambis lambis* was recorded at moderate density in reef-benthos and soft-benthos transects (20–30 /ha, n = 26 individuals recorded in all surveys). Other *Lambis* species were also recorded (*L. chiragra* and *L. crocata*). The strawberry or red-lipped conch (*Strombus luhuanus*) was uncommon and one individual was recorded in broad-scale survey (Appendices 4.2.1–4.2.10).

Three species of turban shell (*Turbo argyrostomus*, *T. chrysostomus* and *T. petholatus*) were recorded at low density. The larger, silver-mouthed turban (*T. argyrostomus*) was recorded in 38% of reef-front search stations at a mean density of 1.5 /ha ±0.7. No *T. setosus* was seen in reef or MOP surveys. Other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Dolabella*, *Latirolagena*, *Mitra*, *Pleuroploca*, *Polinices*, *Tectus*, *Thais* and *Vasum*) were also recorded during independent survey (Appendices 4.2.1–4.2.10).

Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Anadara*, *Atactodea*, *Atrina*, *Chama*, *Codakia*, *Fragum*, *Hyotissa*, *Modiolus*, *Pinna*, *Pteria and Spondylus* are also in Appendices 4.2.1–4.2.10. No creel survey was conducted at Tsoilaunung.

3.4.5 Lobsters: Tsoilaunung

There was no dedicated reef-front assessment of lobsters at night (See Methods.). However, general surveys and night-time assessments for nocturnal sea cucumber species (Ns) were conducted, which offered an opportunity to record lobster species. Lobsters (*Panulirus versicolor* and sp.) were moderately common in survey (n = 14), as were prawn killers (*Lysiosquillina maculata*, n = 4) along the sandy shorelines. No slipper lobsters (*Parribacus caledonicus*) were recorded.

3.4.6 Sea cucumbers[8]: Tsoilaunung

The study area at Tsoilaunung has extensive lagoon habitat (main lagoon 156.5 km², small shallow lagoon to east of island group, 11.0 km²). These lagoons border a small chain of low-lying islands (Tsoilaunung 29.2 km²). Due to the predominant land influence from the mainland and sheltered nature of the lagoon, this archetypal high-island lagoon system is very suitable for these deposit-feeding resource species (that eat detritus and other organic matter in the upper few mm of bottom substrates), even along the barrier islands of Tsoilaunung.

Reef margins and areas of shallow, mixed hard- and soft-benthos habitat (suitable for sea cucumbers) were extensive in the lagoon, and a range of habitats and depths were present. The western edge of Tsoilaunung island itself was predominantly sandy, with the best coral being found north and south of the islands and within the main lagoon. In general, water movement (flushing of oceanic water) was not dynamic except through the main passes to the north and south, and riverine inputs (and other inputs from land) were more notable near the mainland.

Species presence and density were determined through broad-scale, fine-scale and dedicated in-water survey methods (Table 3.15, Appendices 4.2.1–4.2.10; also see Methods). With completion of the full range of surveys, twenty-two commercial species of sea cucumber (plus one indicator species) were recorded (Table 3.15), which is similar to the amount found at the other PROCFish site in the north of Papua New Guinea, but greater than the species number recorded in Milne Bay Province. The presence of valuable commercial species reflected the varied environment of the lagoon at Tsoilaunung.

Sea cucumber species associated with shallow reef areas, such as leopardfish (*Bohadschia argus*), were rarely recorded (found in <8% of broad-scale surveys and <20% of reef-benthos transects). This represents a low density for the medium-value *B. argus*. The fast growing and medium/high-value greenfish (*Stichopus chloronotus*) was also rare (recorded in 1% of broad-scale transects and not in reef-benthos assessments). Similarly depleted was the high-value black teatfish (*Holothuria nobilis*), which was also only noted in 1% of broad-scale transects (at a mean density of <0.5 /ha) and not recorded in shallow-water reef-benthos transect assessments (See Appendix 4.2.3).

Surf redfish (*Actinopyga mauritiana*) were noted once, and were at low density, despite the suitable environment of the barrier-reef front and platform. In reef-front searches, the average density of this species was below 1 /ha.

Protected areas of reef and soft benthos in the more enclosed areas of the lagoon did return more species data than was recorded down south in Milne Bay Province. Blackfish (*Actinopyga miliaris*) were found in one station and stonefish (*A. lecanora*) were recorded in night searches and SCUBA searches for MOP. In all cases the density was low at <10 /ha. Curryfish (*Stichopus hermanni*), a common species around these types of systems, was not recorded in Tsoilaunung. However, a few lower-value species, e.g. lollyfish (*Holothuria atra*), pinkfish (*H. edulis*), snakefish (*H. coluber*) and flowerfish (*Bohadschia graeffei*) were noted, but again they were rare (in <20% of stations) and at low density (<14 /ha).

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[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.

The high-value sandfish (*H. scabra*) was recorded close to Tsoilaunung, in seagrass on the western shores of the chain of islands. Although no mangroves were present (This species generally prefers a 'richer' environment.), the seagrass meadow was relatively thick in some areas and benthos soft and muddy in a few locations. In this more preferred habitat sandfish was present in 75% of stations at a density of 100.7 /ha ±41.5. The size of the sandfish present was medium for this species, at an average length of 17.1 cm ±0.6 (Figure 3.34).

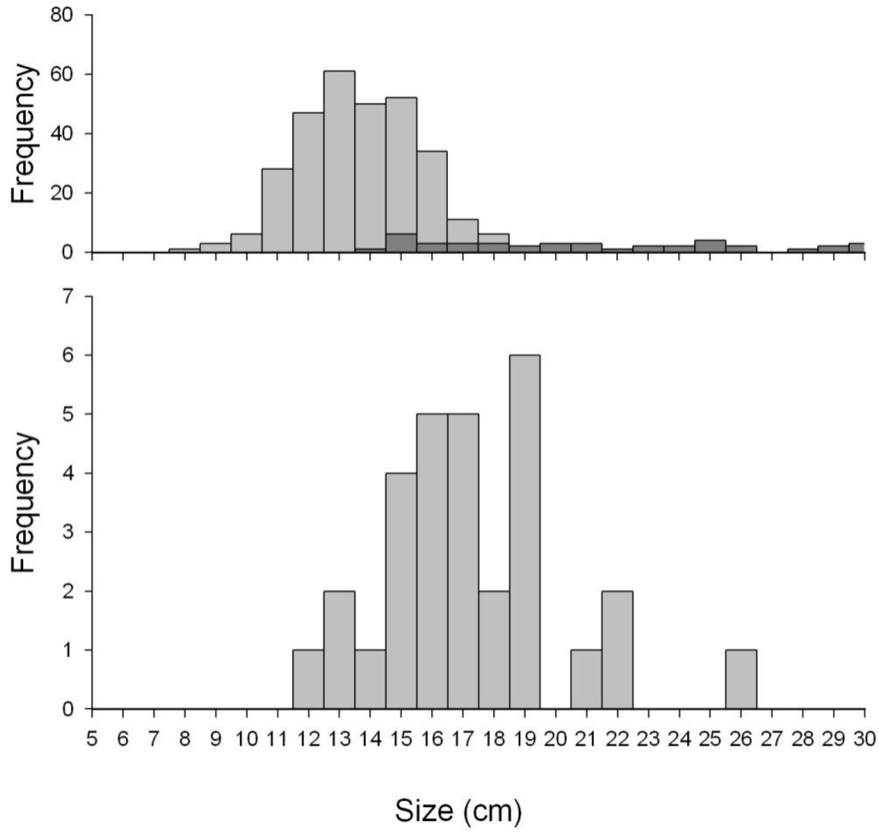

Figure 3.34: Histogram of sandfish *Holothuria scabra* length frequencies from Tsoilaunung (lower graph), and two other western Pacific samples for comparison (upper graph).

The lower-value false sandfish (*Bohadschia similis*) was present at similar rates and density. Their average length was 14.8 cm ±1.1.

Deep-water assessments were completed to obtain preliminary abundance estimates of white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*), and amberfish (*T. anax*). SCUBA surveys (average depth 22.4 m) also recorded elephant trunkfish (*H. fuscopunctata*). The available area of more oceanic-influenced lagoon with sufficient depth was not large, and dives in the lagoon proper showed the benthos to be too rich (fine-grained depositional sediments) for the high-value white teatfish (*H. fuscogilva*). *H. fuscogilva* was present, however, mainly in the passes and outside the barrier (recorded in 83% of Ds stations). *H. fuscogilva* was recorded at a maximum station density of 21.4 /ha. The presence and density of the prickly redfish (*T. ananas*) and amberfish (*T. anax*) was low.

3.4.7 Other echinoderms: Tsoilaunung

In seagrass close to Tsoilaunung island, the edible collector urchin (*Tripneustes gratilla*) was common (recorded in 58% of soft-benthos transect stations) and at relatively high density (average station density 1177.1 /ha ±677.2). Along the barrier reef, other edible urchins, such as the slate urchin (*Heterocentrotus mammillatus*) was also common (recorded in 75% of reef-front search stations) but at moderate density (mean station density of 92.6 /ha ±49.5). Other urchins that are usually a less preferred food source, such as *Diadema* sp. And *Echinothrix* spp., can be used within assessments as potential indicators of habitat condition. These species (plus *Echinometra mathaei*) were also recorded at relatively high levels on occasion (Appendices 4.2.1–4.2.7).

Starfish (e.g. *Linckia laevigata*, the blue starfish) were common (recorded in 92% of broad-scale transects) but not at high density. Coralivore (coral eating) starfish were present at Tsoilaunung in moderate numbers, with 53 recordings of a pincushion star (*Culcita novaeguineae*) and 39 recordings of the crown of thorns (*Acanthaster planci*, COTS) in survey. *A. planci* was recorded both inshore and at more oceanic-influenced stations (in 21% of broad-scale transects) at an average density of 6.5 /ha ±1.9. Although a single COTS can consume about 6 m^2 of coral per year, this level of infestation is not an outbreak or even an incipient outbreak. It is suggested that local monitoring of important reefs is needed to ensure numbers do not increase further and, if they do, that individuals are manually removed to protect sites of particular importance. The horned or chocolate chip star (*Protoreaster nodosus*) was very common among the soft-benthos stations within the seagrass (100% presence, average density 1215.3 /ha ±355.4) and the doughboy sea star (*Choriaster granulatus*) was also noted in the lagoon.

Table 3.15: Sea cucumber species records for Tsoilaunung

Species	Common name	Commercial value [5]	B-S transects n = 72			Other stations RBt = 18; SBt = 9			Other stations RFs = 8; MOPs = 5			Other stations Ds = 6; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga caerulea	-	M/H												
Actinopyga echinites	Deepwater redfish	M/H				13.9	41.7	33 SBt						
Actinopyga lecanora	Stonefish	M/H							1.5	7.6	20 MOPs	8.9	17.8	50 Ns
Actinopyga mauritiana	Surf redfish	M/H							0.5	3.9	13 RFs			
Actinopyga miliaris	Blackfish	M/H				2.6		6 RBt						
Bohadschia argus	Leopardfish	M	1.2	16.7	7	7.8 3.5	41.7	19 RBt 8 SBt	1.5	7.6	20 MOPs	1.2	3.6	33 Ds
Bohadschia graeffei	Flowerfish	L	3.0	16.7	18	7.8		6 RBt	0.5 1.5	3.9	13 RFs 20 MOPs			
Bohadschia similis	False sandfish	L				2.6 107.6	161.5	6 RBt 67 SBt						
Bohadschia vitiensis	Brown sandfish	L	0.5	16.7	3	31.3	125.0	25 SBt						
Holothuria atra	Lollyfish	L	1.9	16.7	11	13.0 10.4	62.5	19 RBt 17 SBt	8.3	22.2	38 RFs	1.6	3.2	50 Ds
Holothuria coluber	Snakefish	L	1.2	41.7	3	15.6 6.9	83.3	13 RBt 8 SBt				62.2	62.2	100 Ns
Holothuria edulis	Pinkfish	L	0.2	16.7	1									
Holothuria fuscogilva [4]	White teatfish	H				3.5	41.7	SBt				9.1 4.4	11.0 8.9	83 Ds 50 Ns
Holothuria fuscopunctata	Elephant trunkfish	M	0.2	16.7	1							0.4	2.4	17 Ds
Holothuria leucospilota	-	L										4.4	8.9	50 Ns
Holothuria nobilis [4]	Black teatfish	H	0.2	16.7	1				0.5	3.9	13 RFs			
Holothuria scabra	Sandfish	H	0.2	16.7	1	100.7	134.3	75 SBt						
Stichopus chloronotus	Greenfish	H/M	0.2	16.7	1									
Stichopus hermanni	Curryfish	H/M	0.5	16.7	3									
Stichopus horrens	Peanutfish	M/L										17.8	35.6	50 Ns
Stichopus pseudhorrens	-	M												
Stichopus vastus	Brown curryfish	H/M	1.2	20.8	6									

[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; MOPs = mother-of-pearl search; Ds = sea cucumber day search; Ns = sea cucumber night search.

Table 3.15: Sea cucumber species records for Tsoilaunung (continued)

Species	Common name	Commercial value (5)	B-S transects n = 72			Other stations RBt = 18; SBt = 9			Other stations RFs = 8; MOPs = 5			Other stations Ds = 6; Ns = 2		
			D (1)	DwP (2)	PP (3)	D	DwP	PP	D	DwP	PP	D	DwP	PP
Synapta spp.	-	-	0.2	16.7	1	52.1	156.3	33 SBt						
Thelenota ananas	Prickly redfish	H	0.9	16.7	6							0.4	2.4	17 Ds
Thelenota anax	Amberfish	M	0.2	16.7	1							1.6	3.2	50 Ds
Thelenota rubrolineata	Candy canefish	L												

(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; MOPs = mother-of-pearl search; Ds = sea cucumber day search; Ns = sea cucumber night search.

3.4.8 Discussion and conclusions: invertebrate resources in Tsoilaunung

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 within the body of the invertebrate chapter.

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

- The shallow water of the main lagoon and the barrier-reef slope was suitable for clams, although the best reef habitats were not common around the western shores of Tsoilaunung within the lagoon as they were mostly sandy.

- There was a relatively complete range and coverage of giant clam species. Even the largest species, *Tridacna gigas*, was present, which is becoming rare in other parts of the Pacific. *T. derasa* was absent. Although the larger species of clam were present (*T. gigas, T. squamosa and Hippopus hippopus*) their density was low, and *T. gigas* was rarely seen.

- The density of the more common smaller giant clam species, such as *T. maxima*, was moderate to low. The smallest species (*T. crocea*) was found at moderate density and was never recorded at the very high densities noted in other parts of the Pacific.

- A preponderance of the large, mature size classes generally gives a promising indication of stock health. A 'full' range of size classes for giant clams was recorded in Tsoilaunung but the largest size classes were not particularly common.

- The lower density of *T. maxima* and *T. crocea* and the rareness of the larger species support the assumption that clam stocks are moderately to heavily affected by fishing at Tsoilaunung, although in some areas the habitat was not very suitable.

- Although *T. gigas* was at critically low densities and *T. derasa* was absent from records, remnant stocks of this largest species offer a locally adapted broodstock to regenerate populations if they were given protection from fishing. These stocks are invaluable to the Kavieng area and awareness of their importance should be highlighted to ensure they are protected from fishing.

- If fishing controls can be instituted, natural recovery should still be possible for the larger giant clam stocks and assured for the smaller species. These natural water filters pump large amounts of water (filtering 3.5 litres per 1 gram of dried soft tissue weight per hour). Therefore this group plays a natural cleaning role, which is an environmentally important activity, in addition to acting as a food source for coastal communities.

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

- Habitat for trochus at Tsoilaunung was suitable and sufficient to support significant numbers of these commercial gastropods.

- Considering the scale and characteristics of habitat available at Tsoilaunung and the density of other grazing gastropods (e.g. *Tectus pyramis*), trochus were well distributed around reefs but at low density. Presence and density records suggest stocks are severely over-fished and well below the level at which commercial fishing is recommended.

- Despite being recorded at very low density, there was evidence of recent successful spawning and ongoing recruitment, in that a full range of shell sizes of trochus was recorded in survey. This is a promising result for any future for the fishery.

- No green snail (*Turbo marmoratus*) was recorded during the survey but a freshly dead juvenile shell (11 cm across operculum) was found near one of the villages, indicating the species may still be present but at depleted or commercially extinct abundance.

- The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common at Tsoilaunung. Densities of wild shells were sufficient to encourage interest in pearl culture operations, as the lagoon was evidently suitable for pearl oysters. Shell densities were not sufficient for any commercial fishing of wild mature shell, but may be enough to provide broodstock.

Data on sea cucumber distribution, density and size suggest that:

- The sheltered, rich lagoon benthos was very suitable for deposit feeders, and a range of habitats and depths was present.

- A comprehensive range of sea cucumber species was recorded at Tsoilaunung, although some species were notable by their absence (e.g. curryfish, *Stichopus hermanni*).

- Presence and density data collected in survey suggest that stocks have been under very high fishing pressure and are now at extreme levels of depletion.

- Sea cucumbers play an important role in 'cleaning' hard (limestone) and processing soft (sand and mud) benthic substrates. When these species are removed, there is the potential for detritus to build up, creating conditions that can promote the development of non-palatable algal mats (blue–green algae) or anoxic conditions (oxygen-poor areas unsuitable for life). These conditions were recorded at some locations around Tsoilaunung.

- High-value sandfish (*Holothuria scabra*) were recorded close to Tsoilaunung, but few large individuals were recorded in the stock, and immature and newly mature individuals were being harvested by fishers.

3.5 Overall recommendations for Tsoilaunung

- Either the NFA or the Ailan Awareness group support and assist the Wards' desire to draft their own fisheries management plan with the plan expanded to also include any positive outcomes from the Wildlife Conservation Society study of the effect of prolonged *tabu* on reef resources, as well as the discussions already started to establish one or more MPAs.

- No commercial finfish fishing be allowed as the current state of resources appears sustainable for subsistence use only.

- Spear diving and reef-shark fishing be regulated.

- Fishing controls be established for giant clams, to enable natural recovery, which is still possible for the larger giant clam stocks and assured for the smaller species. Remnant stocks of *T. gigas* and *T. derasa* be completely protected from fishing in order that they can act as a locally adapted broodstock to regenerate the populations of the Kavieng area.

- Trochus fishing be controlled to allow the population to rebuild. If fishing controls can be established to protect remnant stocks, there is a future for this fishery. Stocks need to be 'rested' from fishing for a medium term (5–10 years, or until densities at the major fishing areas recover to 500–600 per ha).

- Strict controls on sea cucumber fishing be implemented to allow a resting period for these depleted resources. Under the present stock status, it is difficult to see a justification for continued commercial fishing at this site. A resting period is needed to allow the immature *Holothuria scabra* to reach full maturity and produce future populations of this valuable species.

4. PROFILE AND RESULTS FOR SIDEIA

4.1 Site characteristics

Sideia (Figure 4.1) is a high, mountainous and densely forested island. The community is scattered along the coast in small hamlets and there are no large village-style communities. There are no roads and people move around by foot, canoe or boat. People are farmers rather than fishers. There are a few coconut plantations in the area, and people also depend on bêche-de-mer and trochus for income. The island's rich forest resources remain largely untapped. There is a local market three times a week at the Catholic mission, where locals sell produce, but people also travel to Alotau to sell their produce.

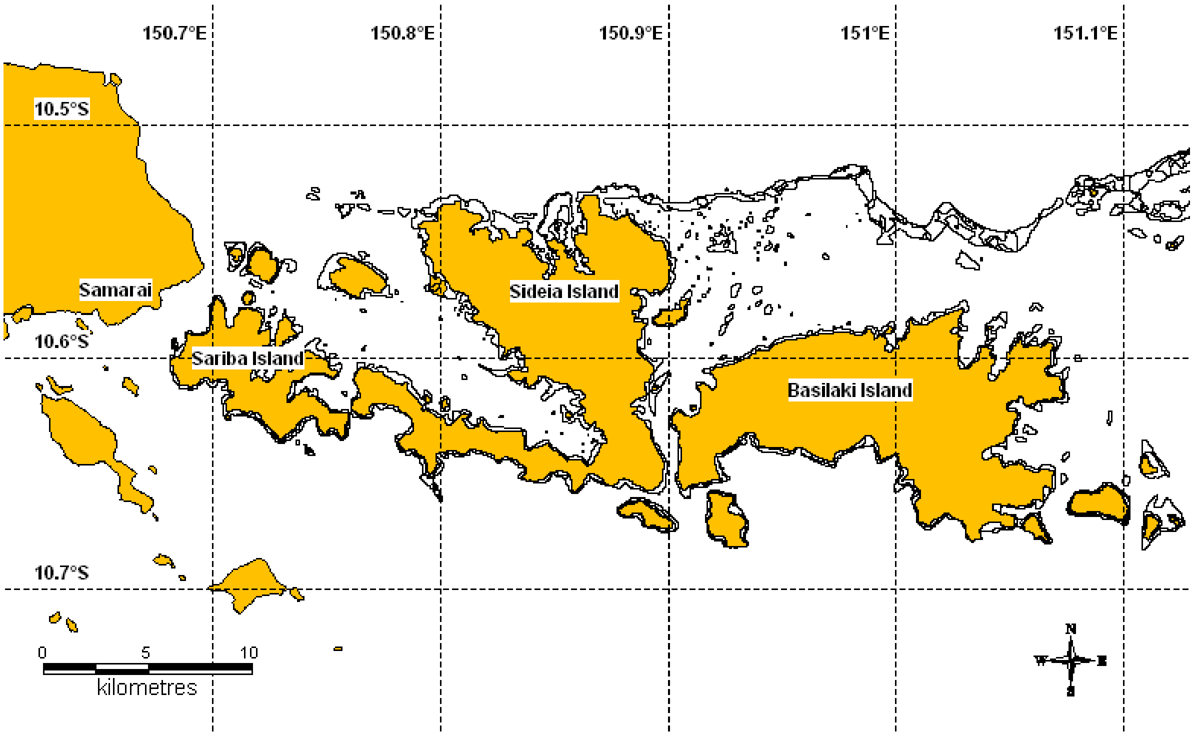

Figure 4.1: Map of Sideia.

The high island is bordered by fringing reefs, mangroves (with resident crocodiles), and a number of semi-lagoon structures with shallow-water pools and pseudo barrier reefs. A larger barrier reef extends out from the northwest and northeast corners of the island, and this is more intact on the eastern side, whereas in the west, it only came near the surface as two patch reefs. The reefs were generally land-influenced and located on the protected side of Sideia Island, where the current is limited. The two arms of the barrier reef provided some contrast and coral cover was generally good throughout the system, with complex substrates. Reef faces were generally steep drop-offs, with little in the way of shoaling reef on the outside.

4.2 Socioeconomic surveys: Sideia

Socioeconomic fieldwork was carried out on Sideia, located in Milne Bays Province at the end of October 2006. Sideia, as common to Milne Bay Province in general, is a high island with mountains up to 300 m high. The volcanic soils are rich in humus and minerals and have always been used for agricultural production. Sideia has major hamlets on the western side (including the Catholic mission station), the northern side and the eastern side, and several small, scattered hamlets. Most of the hamlets are situated along the coast, but a few were also recently established in the mountains. Hamlets may consist of a few families and the distance between each hamlet may be over an hour's walk. If calculated in distance from the Catholic mission station, the furthest hamlet may be reached in about a half-day's walk through mangrove swamps, tropical forest, mountains and hillsides following a bush track. People do not have outboard engines and either walk or paddle by canoe to get from location to location. Each of these major hamlets and the few scattered minor hamlets were included and represented in the socioeconomic survey.

In total, 30 households were surveyed that included 207 people, representing 39% of the total number of households (77) and population (531) on the island.

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 32 individual interviews with finfish fishers (17 males, 15 females) and 32 with invertebrate fishers (16 males, 16 females) were conducted. These fishers belonged to one of the 30 households surveyed. Sometimes, the same person was interviewed for both finfish fishing and invertebrate harvesting.

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

Our survey results (Table 4.1) suggest an average of 3 fishers/household. If we apply this average to the total number of households, we arrive at a total of 234 fishers on Sideia. Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of 10 males who only go finfish fishing and another 5 males who exclusively collect invertebrates. However, the majority of all fishers (103 males and 116 females) do both finfish fishing and invertebrate collection, although not necessarily at the same time.

Ninety per cent of all households on Sideia have a canoe. There are no motorised boats available. The Catholic mission was identified as the only owner of a motorised boat; however, this is mainly used for transport, not for fishing.

Ranked income sources (Figure 4.2) highlight the fact that fishing is the most important income source for people on Sideia. 70% of all households quoted that fishing provides first income, and 20% confirmed fishing as a secondary income source. Agriculture is less important for generating the households' main revenue as 10% of all households depend mainly on agriculture. However, agriculture plays an important role in complementing income, i.e. more than half of all households sell some of their agricultural produce. In addition, 20% of all households are mainly sustained by income from salaries. Any other alternative is insignificant for income generation on Sideia. The average annual household expenditure level is low at USD ~ 520 /household/year, suggesting that people on Sideia are among the most self-sufficient communities that were surveyed in Papua New Guinea. Remittances are insignificant and only very few households may occasionally receive small amounts of money from their relatives. On average, these small amounts total USD ~92 a year for those households that receive these payments.

The importance of fisheries shows further in the fact that all households eat fresh fish and invertebrates, and 90% also eat canned fish. All households also reported that, normally, the fresh fish and invertebrates consumed are caught by somebody from the household, or are received as a gift from a family or community member. Only in very rare cases (16–20% of all responses), are fresh fish and invertebrates bought. These figures highlight the high dependency on reef and lagoon resources for protein, but also the high level of self-sufficiency and strong social network among community members and families in Sideia.

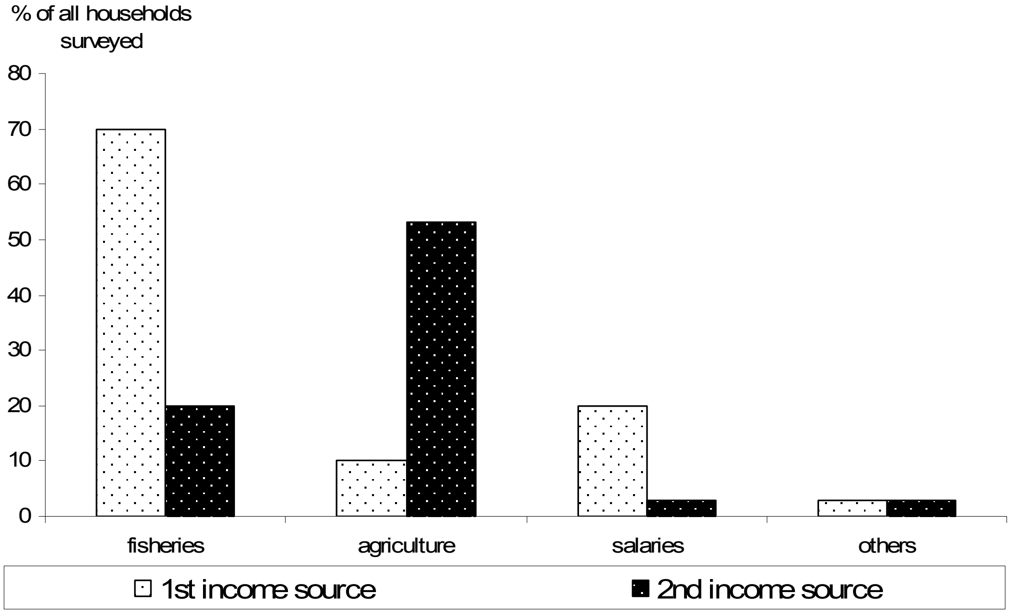

Figure 4.2: Ranked sources of income (%) in Sideia.
Total number of households = 30 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small business.

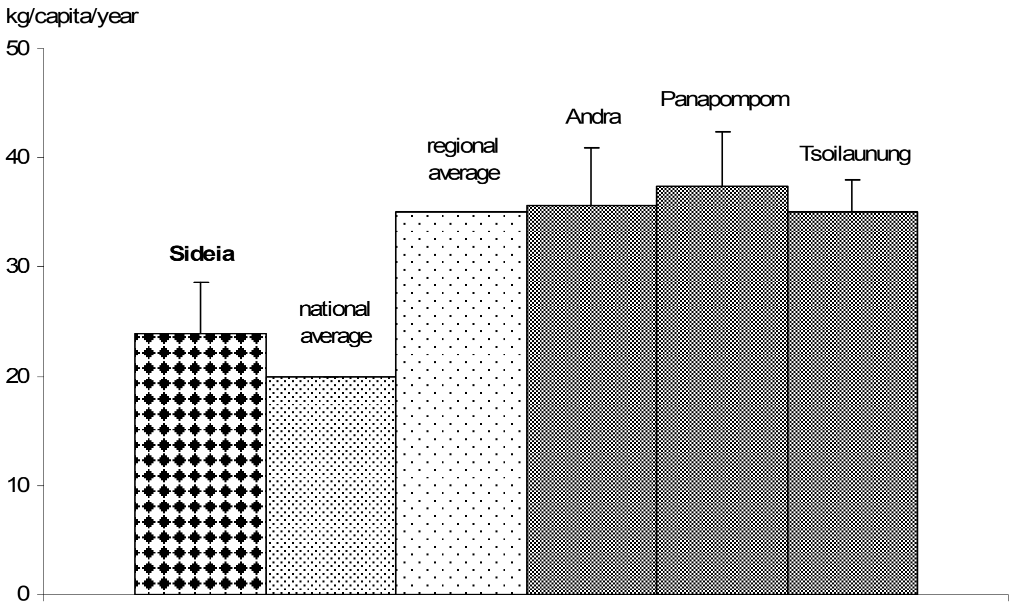

Figure 4.3: Per capita consumption (kg/year) of fresh fish in Sideia (n = 30) compared to the national (DFMR 1993) and regional (FAO 2008) averages and the other three PROCFish/C sites in Papua New Guinea.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

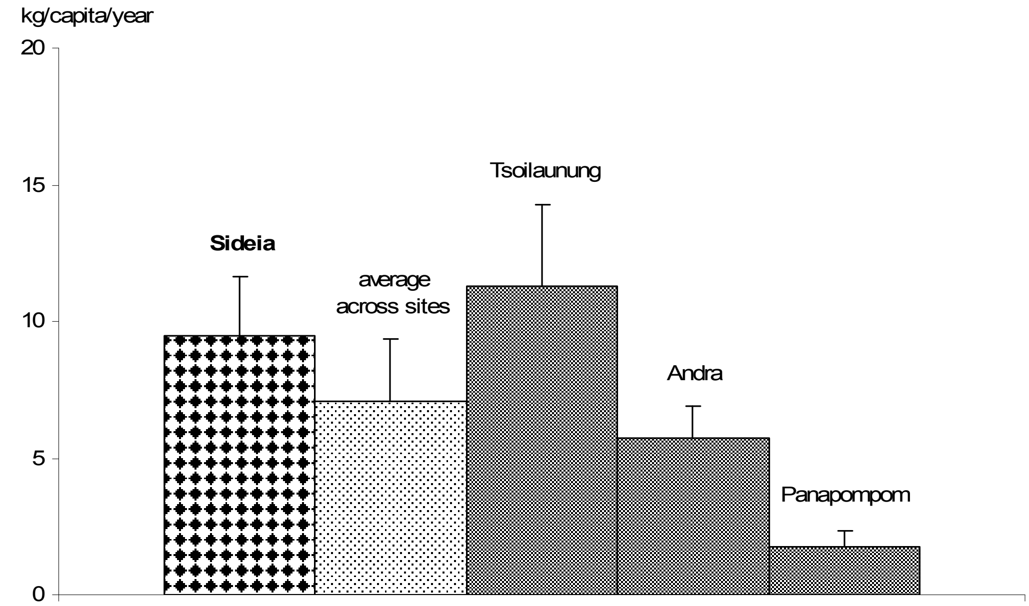

Figure 4.4: Per capita consumption (kg/year) of invertebrates (meat only) in Sideia (n = 30) compared to the other three PROCFish/C sites in Papua New Guinea.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

The consumption of fresh fish (~24 kg/person/year ±2.9) in Sideia is below the regional average (FAO 2008) and the lowest among all PROCFish sites surveyed in Papua New Guinea (Figure 4.3), but still higher than the estimated consumption nationwide (DFMR 1993). The consumption of invertebrates (meat only) is ~9.5 kg/person/year ±2.15 (Figure 4.4) and significantly higher than the average consumption figures calculated for all PROCFish sites in Papua New Guinea. Although most people eat canned fish, the frequency at which canned fish is consumed is low (about once a month) and so is the amount of canned fish eaten (l.2 kg/person/year). Compared to the other sites surveyed in the country, this is the lowest consumption of canned fish (Table 4.1).

Comparison of results among all sites investigated in Papua New Guinea (Table 4.1) shows that people in Sideia are more dependent on fisheries for income generation than average. Sideia's consumption figures, be they for fresh fish, invertebrates or canned fish, are below average and so is the frequency at which they are consumed, except for the frequency of invertebrate consumption. The average household expenditure level on Sideia is extremely low, well below the average across all four PROCFish sites, suggesting that the community is highly self-sufficient, and confirming the rich agricultural potential of this high island. Remittances do not play any role on Sideia nor at any other sites surveyed in Papua New Guinea.

Table 1: Fishery demography, income and seafood consumption patterns in Sideia

Survey coverage	Site (n = 30 HH)	Average across sites (n = 120 HH)
Demography		
HH involved in reef fisheries (%)	100.0	100.0
Number of fishers per HH	3.03 (±0.22)	2.65 (±0.13)
Male finfish fishers per HH (%)	4.4	9.1
Female finfish fishers per HH (%)	0.0	1.9
Male invertebrate fishers per HH (%)	2.2	0.9
Female invertebrate fishers per HH (%)	0.0	0.6
Male finfish and invertebrate fishers per HH (%)	44.0	40.6
Female finfish and invertebrate fishers per HH (%)	49.5	46.9
Income		
HH with fisheries as 1st income (%)	70.0	53.3
HH with fisheries as 2nd income (%)	20.0	32.5
HH with agriculture as 1st income (%)	10.0	9.2
HH with agriculture as 2nd income (%)	53.3	18.3
HH with salary as 1st income (%)	20.0	13.3
HH with salary as 2nd income (%)	3.3	3.3
HH with other source as 1st income (%)	3.3	26.7
HH with other source as 2nd income (%)	3.3	25.0
Expenditure (USD/year/HH)	513.90 (±90.77)	982.39 (±80.23)
Remittance (USD/year/HH) (1)	92.23 (±33.61)	110.91 (±16.64)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	23.95 (±2.87)	33.03 (±2.29)
Frequency fresh fish consumed (times/week)	3.04 (±0.27)	3.34 (±0.14)
Quantity fresh invertebrate consumed (kg/capita/year)	9.47 (±2.15)	7.07 (±2.29)
Frequency fresh invertebrate consumed (times/week)	2.47 (±0.24)	1.49 (±0.10)
Quantity canned fish consumed (kg/capita/year)	1.19 (±0.19)	5.64 (±0.66)
Frequency canned fish consumed (times/week)	0.24 (±0.04)	0.93 (±0.11)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	100.0	99.2
HH eat canned fish (%)	90.0	97.5
HH eat fresh fish they catch (%)	100.0	100.0
HH eat fresh fish they buy (%)	20.0	20.0
HH eat fresh fish they are given (%)	100.0	86.7
HH eat fresh invertebrates they catch (%)	100.0	100.0
HH eat fresh invertebrates they buy (%)	16.7	0.0
HH eat fresh invertebrates they are given (%)	100.0	63.3

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

4.2.2 Fishing strategies and gear: Sideia

Degree of specialisation in fishing

Fishing on Sideia is performed by both gender groups (Figure 4.5). However, few fishers specialise in one fishery, i.e. either finfish or invertebrate collection, but pursue both.

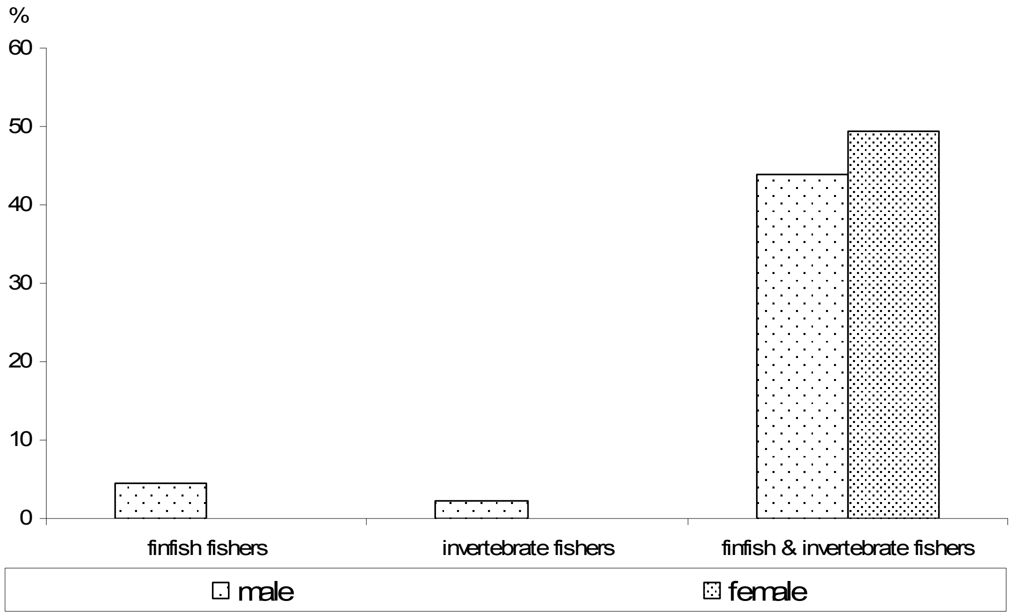

Figure 4.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Sideia.
All fishers = 100%.

Targeted stocks/habitat

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	11.8	80.0
	Sheltered coastal reef & outer reef	11.8	0.0
	Lagoon	41.2	6.7
	Outer reef	58.8	20.0
Invertebrates	Soft benthos & mangrove	0.0	25.0
	Soft benthos & mangrove & reeftop	0.0	12.5
	Mangrove	12.5	6.3
	Mangrove & reeftop	0.0	43.8
	Mangrove & intertidal	0.0	6.3
	Bêche-de-mer	87.5	25.0
	Lobster	6.3	0.0
	Trochus	25.0	0.0
	Other	6.3	0.0

'Other' refers to the giant clam and *Lambis lambis* fisheries.
Finfish fisher interviews, males: n = 17; females: n = 15. Invertebrate fisher interviews, males: n = 16; females, n = 16.

Gender differences show in the habitats targeted. While female finfish fishers interviewed on Sideia target mainly the sheltered coastal reef and only very few the outer reef, males prefer fishing the outer reef and the lagoon. Very few males fish the sheltered coastal area, or may combine both the sheltered coastal and the outer reefs during one fishing trip. Invertebrate collection is usually done by females harvesting in mangroves, and mostly in combination with reeftop or soft-benthos gleaning during the same trip. Males are mostly engaged in commercial invertebrate fisheries, particularly bêche-de-mer, but also trochus harvesting. A quarter of all female fishers also engage in bêche-de-mer fishing. Males' participation in mangrove collection, and diving for lobsters and other species, such as giant clams, is insignificant (Table 4.2).

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 Sideia on their fishing grounds (Tables 4.2 and 4.3).

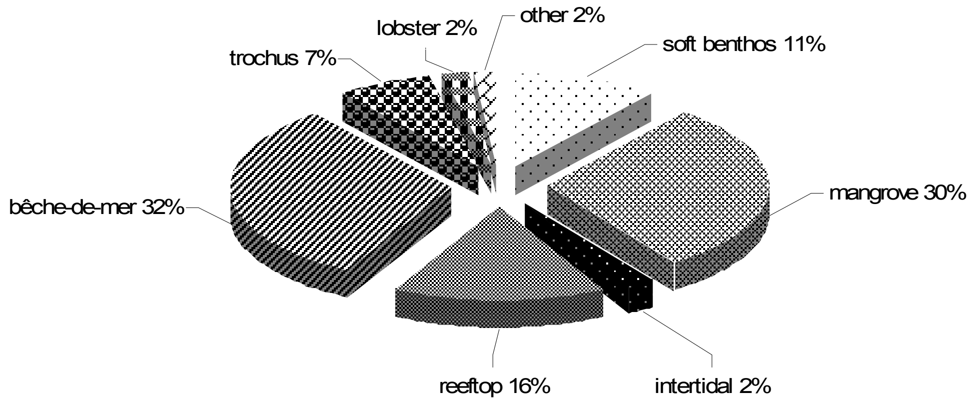

Figure 4.6: Proportion (%) of fishers targeting the eight primary invertebrate habitats found in Sideia.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; 'other' refers to the giant clam and *Lambis lambis* fisheries.

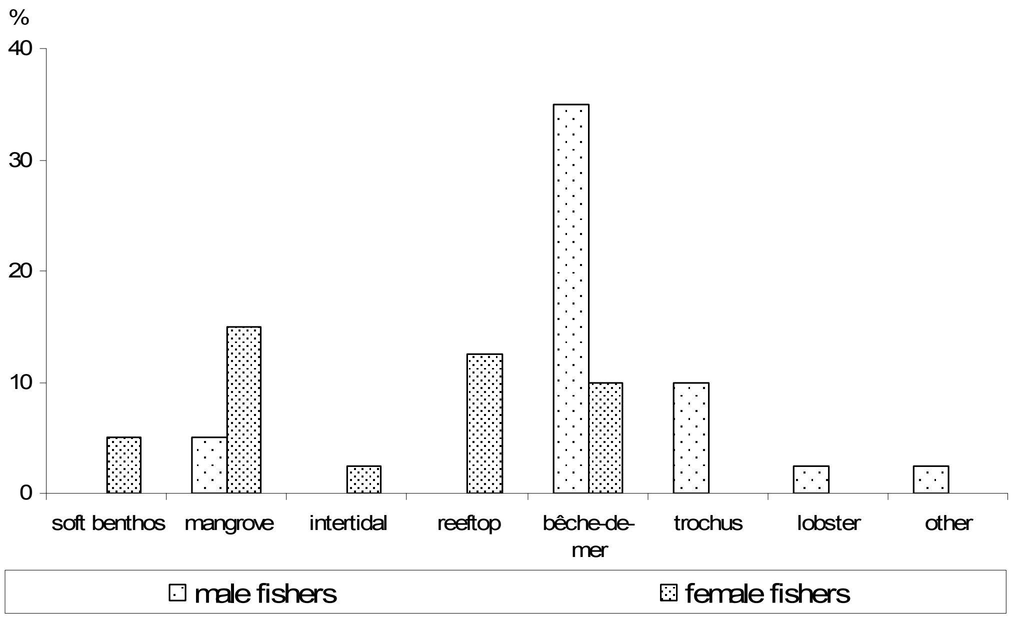

Figure 4.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Sideia.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers who target each habitat: n = 16 for males, n = 16 for females; 'other' refers to the giant clam and *Lambis lambis* fisheries.

Our survey sample suggests that fishers on Sideia have the choice among sheltered coastal reef, lagoon and outer-reef fishing. However, mangrove, soft benthos and, to a lesser extent, reef are the main habitats that support invertebrate fisheries on Sideia (Figure 4.6). Gender participation shows that females dominate the gleaning fisheries (mainly mangroves) and also collect bêche-de-mer in shallow water. Females do not engage in trochus or lobster diving (Figure 4.7).

Gear

Figure 4.8 shows that fishers on Sideia use mainly handlines to catch fish in any of the habitats targeted. Handlines may be complemented by spear diving or handheld spearing if fishing the outer reef or in the lagoon. At the outer reef, trolling is an important technique added to the use of handlines. Fishing on Sideia always involves the use of a non-motorised paddling or sailing canoe.

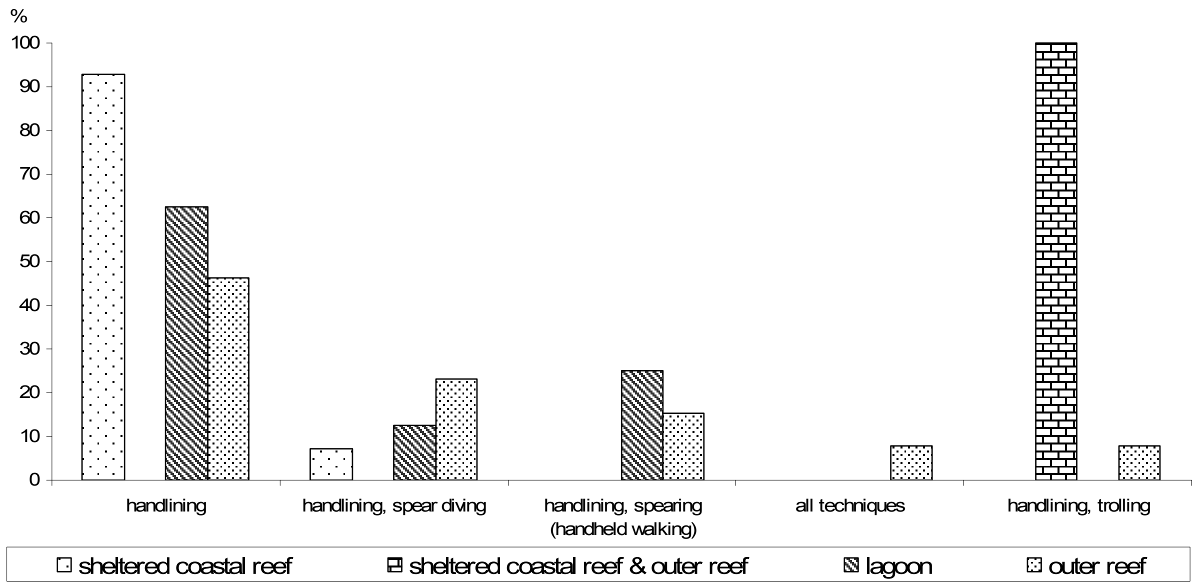

Figure 4.8: Fishing methods commonly used in different habitat types in Sideia.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Gleaning and free-diving for invertebrates is done using very simple tools only. Reeftop gleaning is usually done by walking during low tide and mostly during the day on the dried reef flats that have been reached by paddling canoe. Edible gastropods or other invertebrates are picked up by hand, and masks, snorkel and fins are used for free-diving. Knives or sometimes a spear gun are used to catch giant clams, octopus or lobsters. The periodical bêche-de-mer fishery includes two different approaches. Females and males collect in shallow water by hand, using canoes to bring back their catch to shore. In addition, bêche-de-mer and trochus are collected at the outer reef. Trochus is collected by free-diving with mask, snorkel and fins.

Frequency and duration of fishing trips

As shown in Table 4.3, male and female fishers on Sideia go fishing ~4–6 times/month regardless of which habitat they target. However, there are differences in the average duration of each fishing trip among habitats targeted and between genders. Males fishing in the lagoon and outer reef usually spend 4–5 hours/trip. Females targeting the sheltered coastal reef spend less time, 3–4 hours/trip.

Invertebrate collection trips seem to be made as often as finfish fishing trips. Females collect in mangroves, either in combination with reeftop and/or soft benthos visits, about ~1–2 times/week. Males dive for giant clams or trochus or collect in mangroves about once a week. However, bêche-de-mer harvesting is an exception for both gender groups. During the 6-month open season, fishers may go out at least 3 times/week. Others may join a fishing party that stays on a small, uninhabited atoll island reached by sailboat, for up to one month. The duration of invertebrate fishing trips is comparable to finfish fishing with female fishers spending a bit less time and males staying out for 4 or more hours per trip. Again, bêche-de-mer collection takes more time for male and female fishers with an average of 5–6.5 hours per day fished, in particular if bêche-de-mer fishing is done as a family or clan from a camp based for a couple of weeks on an uninhabited island.

Females mainly prefer fishing during the day. Males, on the other hand, mainly catch finfish according to the tide. About half of the male fishers target the lagoon either at day or night, depending on tidal conditions, while the majority of male fishers target the outer reef when the tide is right. Except for lobsters, all invertebrates are collected during the day. Ninety per cent of all lobster fishers prefer to fish at night.

All finfish fishing and most invertebrate fishing are performed continuously during the year. Bêche-de-mer is subject to the governmental (National Fisheries Authority) open season (usually from mid-January to mid-July) and the decision of the community leaders' group. Fishers on Sideia collect bêche-de-mer for 5–6 months/year.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	1.00 (±0.00)	1.79 (±0.43)	4.00 (±1.00)	3.46 (±0.27)
	Sheltered coastal reef & outer reef	1.50 (±0.50)	0	7.00 (±0.00)	0
	Lagoon	1.71 (±0.18)	1.00 (n/a)	4.86 (±0.63)	3.00 (n/a)
	Outer reef	1.50 (±0.31)	1.33 (±0.33)	4.50 (±0.48)	3.83 (±0.83)
Invertebrates	Soft benthos & mangrove	0	2.00 (±0.00)	0	3.00 (±0.00)
	Soft benthos & mangrove & reeftop	0	1.50 (±0.50)	0	3.00 (±0.00)
	Mangrove	1.00 (±0.00)	1.00 (n/a)	3.00 (±0.00)	3.00 (n/a)
	Mangrove & reeftop	0	1.43 (±0.17)	0	3.64 (±0.18)
	Mangrove & intertidal	0	2.00 (n/a)	0	3.00 (n/a)
	Bêche-de-mer	3.86 (±0.10)	3.00 (±0.41)	6.36 (±0.17)	5.25 (±0.25)
	Lobster	0.23 (n/a)	0	5.00 (n/a)	0
	Trochus	0.88 (±0.13)	0	4.00 (±0.41)	0
	Other	1.00 (n/a)	0	4.00 (n/a)	0

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam and *Lambis lambis* fisheries.
Finfish fisher interviews, males: n = 17; females: n = 16. Invertebrate fisher interviews, males: n = 16; females: n = 16.

4.2.3 Catch composition and volume – finfish: Sideia

The catch composition reported from the sheltered coastal reef is diverse. However, there are a few species that dominate, including Scaridae (*Cetoscarus bicolor*, *Scarus ghobban*, *S.* spp.) with ~17%; Serranidae (*Epinephelus* spp., *Plectropomus leopardus*) with ~11%; and *Rhinecanthus* spp., *Pentapodus emeryii*, *Naso unicornis* and *wadumu* (not scientifically identified) each accounting for ~6% of the reported catch by weight.

Reported lagoon catches are less diverse and include over 30 species by vernacular name. However, more than half of the reported catch by weight is determined by 7 species by vernacular name. These include *Carangoides orthogrammus* (~13%), *Scomberomorus commerson* (~12%), *Nemipterus* spp. (7%), *Kyphosus vaigiensis, Chaetodon fasciatus* and *Lutjanus semicinctus* each making up 5.4–6.1% of the reported catch by weight.

The outer-reef catches reported include a great number of vernacular names representing at least 40 species. Again, most of the reported catch by weight is accounted for by a few species: *Elagatis bipinnulata* (~15%), *Kyphosus vaigiensis* (~10%), *Scomberomorus commerson* (~9%), *Carangoides orthogrammus* (~6%), *Scarus* spp., *Lutjanus semicinctus* and *Nemipterus* spp. making up 4.2–6.0% of the reported catch by weight each (Details are provided in Appendix 2.3.1.).

Our survey sample of finfish fishers interviewed represents ~14% of the projected total number of finfish fishers on Sideia. Although the group of fishers interviewed includes both commercial and subsistence fishers, the limited sample size may jeopardise extrapolation of survey results. Accordingly, caution is advised in using the extrapolated figures given here to estimate the total annual fishing pressure imposed by the people of Sideia on their fishing ground. The survey showed that people in Sideia are highly dependent on reef fisheries for income, and that most of their catch is sold on the mainland. This shows also in Figure 4.9, where the share of catch required to satisfy the island's subsistence needs accounts only for 20% of the total catch. Females' contribution to the total annual catch is about one-quarter only. This may be due to the fact that most females mainly catch for food rather than for selling on the mainland. This does not contradict the fact that some females on Sideia sell processed (smoked) or fresh fish, often in combination with selected invertebrates, at the mainland's market. Most of the fishing impact is sourced from the outer reef (~45% of the total reported catch), followed by the lagoon (~25%), and least is taken from the sheltered coastal reef. The proportion of females' catches from the sheltered coastal reef, mostly aimed at providing fish for the family's daily meal, is about 16% only.

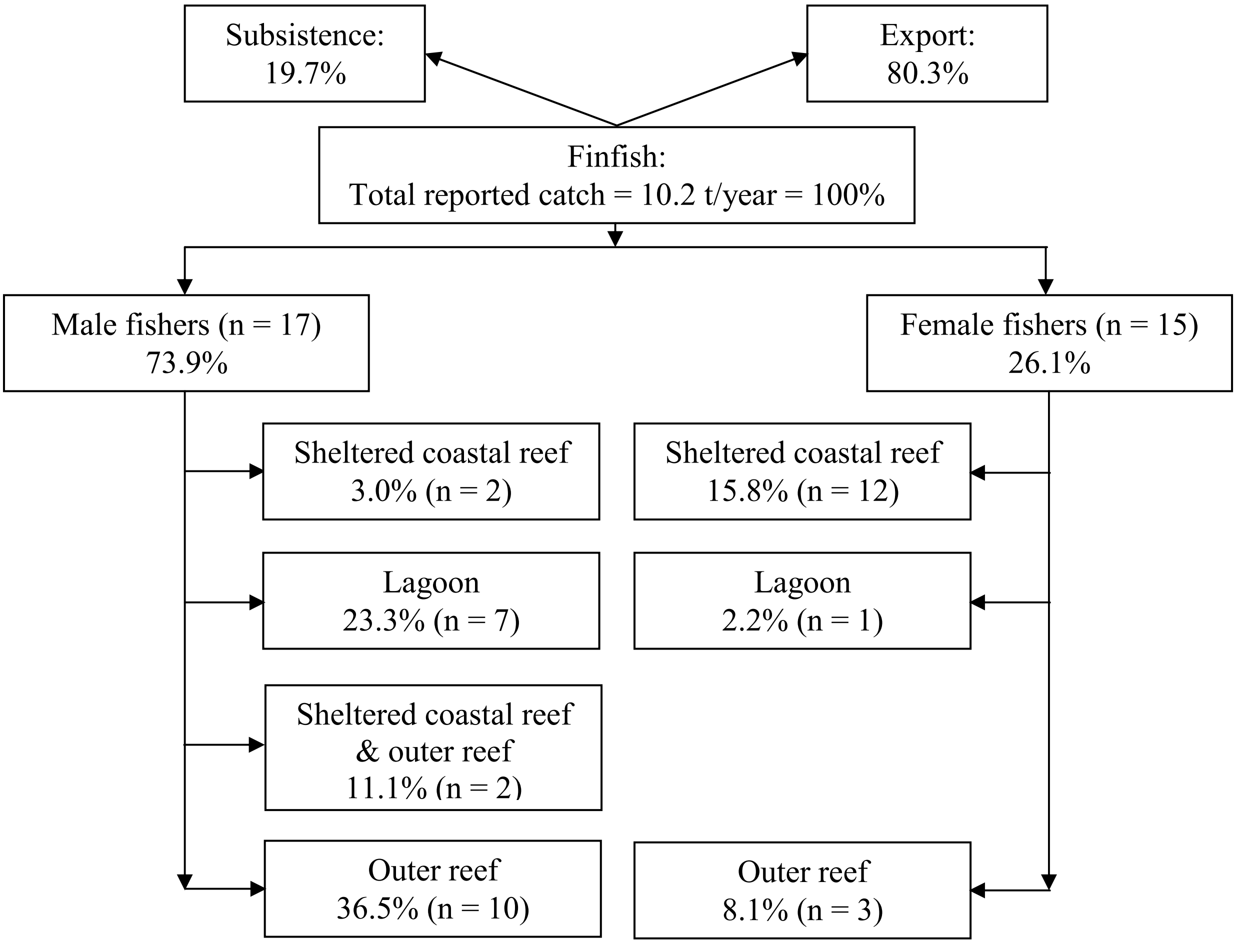

Figure 4.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Sideia.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and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

As shown in Figure 4.9, the minor share (~20%) of impact is due to the demand imposed by the population of Sideia on its reef resources, while most (~80%) of the total impact is determined by external demand.

The insignificant impact on the sheltered coastal reef is basically determined by the small annual catch rates per female and the few male fishers. This observation confirms the above explanation, i.e. catches from the sheltered coastal reef serve only subsistence needs. While male finfish fishers seem to achieve higher catches (~350 kg/fisher/year) from the lagoon than do female finfish fishers (~200 kg/fisher/year), the highest catch rates (~400 kg/fisher/year) were reported from the outer reef. Females also achieve their highest catches from the outer reef (~300 kg/fisher/year) (Figure 4.10).

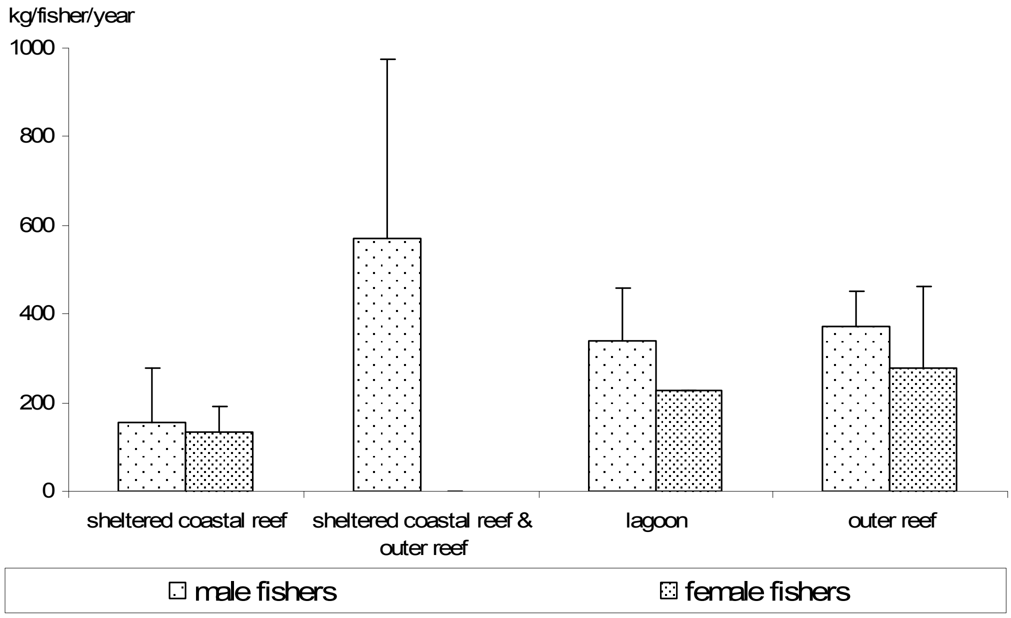

Figure 4.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Sideia (based on reported catch only).

Figure 4.11 shows that, overall, CPUEs obtained by Sideia fishers are not very high. CPUEs range between 0.5 and 1.2 kg/hour of fishing trip, with the lowest value from fishing the sheltered coastal reef and the highest value from the outer reef. While male fishers seem to have a slightly higher productivity than females, the inverse picture is true for the lagoon catches. However, female fishers' CPUE for lagoon fishing should not be over emphasised, as only one female lagoon fisher was interviewed.

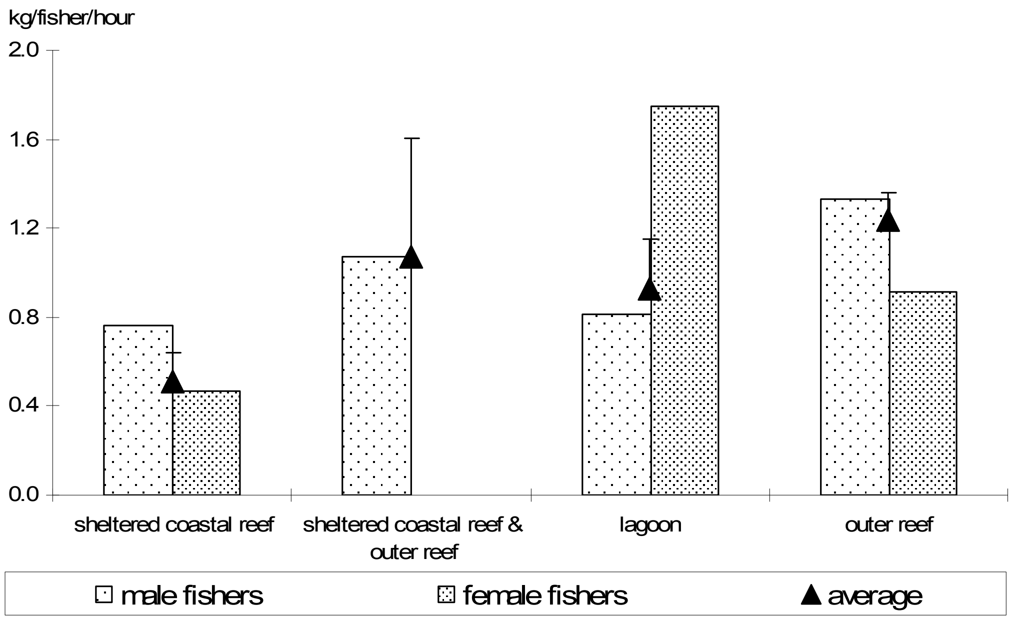

Figure 4.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Sideia.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

The high interest in commercial fishing also shows if comparing data on the objectives of fishing trips provided by respondents. Most fishing in the lagoon and outer reef is done in order to earn income (Figure 4.12). Data presented in Figure 4.12 also show that non-commercial distribution among community members is part of Sideia people's lifestyle. This applies in particular to female fishers targeting the sheltered coastal reef. As suggested by earlier results, Figure 4.12 confirms that sheltered coastal reef fishing mainly serves subsistence rather than social and income purposes.

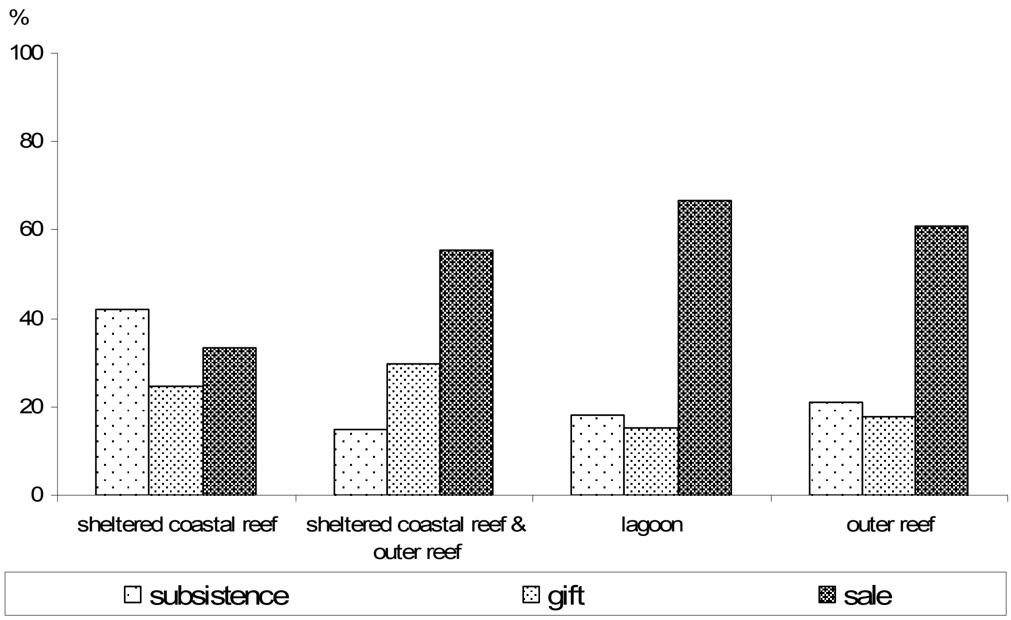

Figure 4.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Sideia. Proportions are expressed in % of the total number of trips per habitat.

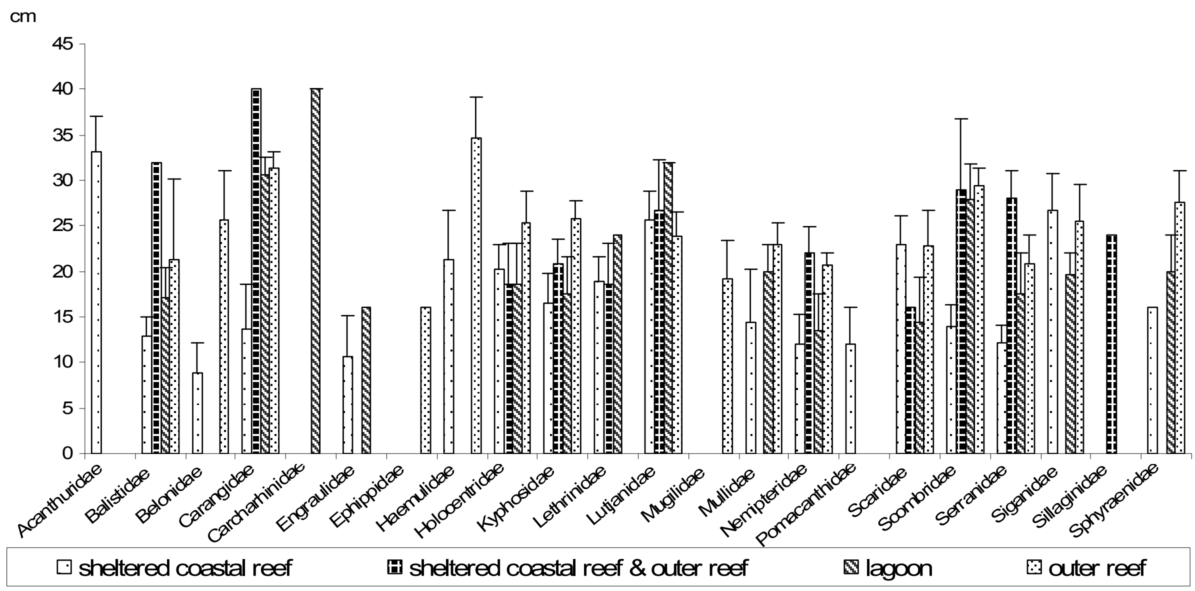

Figure 4.13: Average sizes (cm fork length) of fish caught by family and habitat in Sideia. Bars represent standard error (+SE).

Data on the average finfish sizes reported by family and habitat (Figure 4.13) show a great variability in fish sizes by family. As expected, usually the average size increases in catches from the sheltered coastal reef to the lagoon and the outer reef. Generally, fish sizes from sheltered coastal reef catches range from 15 to 20 cm; however, they can be as small as 10 cm (Belonidae, Engraulidae). The size (30–35 cm) of Acanthuridae caught at the sheltered coastal reef is surprising. Catches from the lagoon usually contain fish with an average length of 15–20 cm, and sizes reported from the outer reef are larger (25–30 cm). Fish from the families Holocentridae, Scombridae, Sphyraenidae and Carangidae are the largest in catches from the outer reef.

Some parameters selected to assess the current fishing pressure on Sideia's living reef resources are shown in Table 4.4. Fishing pressure is compared among sheltered coastal reef, lagoon and outer reef, as well as total reef area versus total fishing ground area. The latter includes reef and lagoon or soft-benthos habitats. The surface area of habitats varies considerably, i.e. from the smallest, the lagoon (~0.6 km^2) to the outer reef (~4.4 km^2) to the largest, the sheltered coastal reef (~10 km^2). As a result of the small surface areas of the lagoon, fisher density there is highest. The lowest fisher density (10 /km^2) coincides with the smallest average annual catch per fisher at the sheltered coastal reef. Taking into account the total reef and total fishing ground area, fisher density is rather low and population density is moderate. Calculating fishing pressure induced on total reef and fishing ground area by subsistence demand only, figures are low with 0.8 t/km^2 on an annual basis. Considering that subsistence catches only account for 20% of the total annual catch, total fishing pressure may account for ~4 t/km^2. This catch rate is still considered low and gives no reason for alarm.

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

Parameters	Habitat					
	Sheltered coastal reef	Sheltered coastal reef & outer reef	Lagoon	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	9.98	n/a	0.57	4.36	14.60	14.91
Density of fishers (number of fishers/km^2 fishing ground) (1)	10		79	17	16	15
Population density (people/km^2) (2)					36	36
Average annual finfish catch (kg/fisher/year) (3)	137.39 (±51.58)	569.00 (±405.97)	326.70 (±103.04)	350.99 (±69.50)		
Total fishing pressure of subsistence catches (t/km^2)					0.8	0.8
Total number of fishers	97	11	45	75	228	228

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) total population = 531; total number of fishers = 228; total subsistence demand = 11.84 t/year; (3) catch figures are based on recorded data from survey respondents only.

4.2.4 Catch composition and volume – invertebrates: Sideia

Calculations of the annual catch rates reported per species group are shown in Figure 4.14. The graph shows that the major impact by wet weight of regular fishing pressure imposed by collectors on Sideia invertebrate resources is mainly due to bêche-de-mer species, in particular *Thelenota ananas*, *Holothuria fuscopunctata*, *H. fuscogilva*, *H. nobilis*, *Stichopus* spp. and *Bohadschia argus.* Species collected from mangroves, especially *Terebralia palustris* and soft-benthos species, including *Strombus luhuanus*, *Lambis* spp. and *Scylla serrata*, also determine major impact by wet weight. Species that represent lesser impact and generally have a catch of less than 1 t/year are summarised under 'others' (Detailed data are provided in Appendices 2.3.2 and 2.3.3.).

Overall, the total impact of subsistence gleaning is low compared to the total catch of bêche-de-mer species.

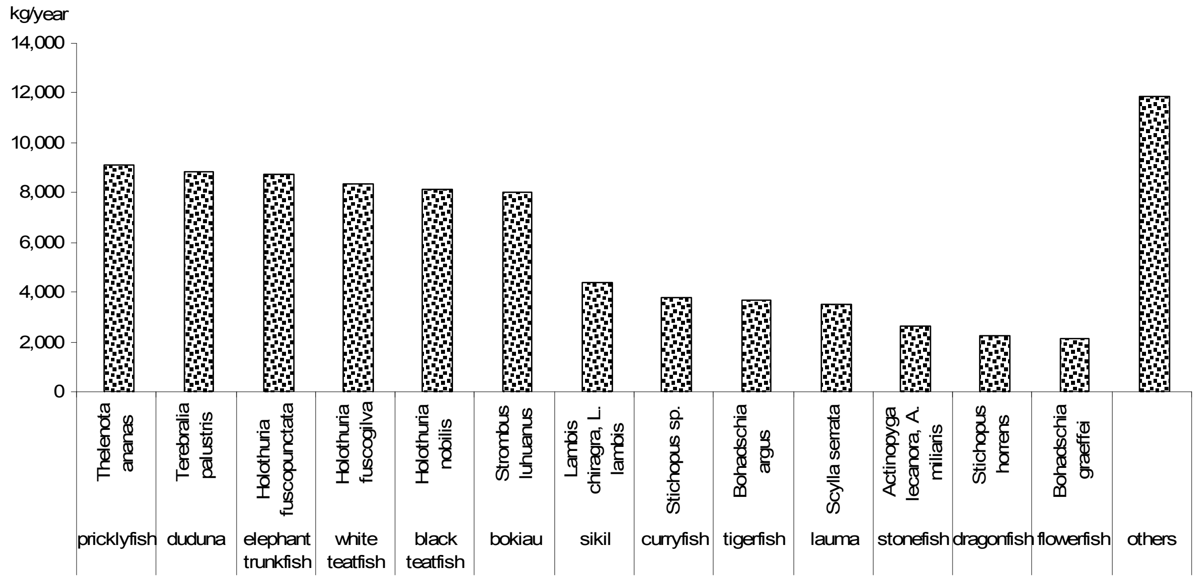

Figure 4.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Sideia.
'Others' refer to the giant clam and *Lambis lambis* fisheries.

As stated earlier, invertebrate fisheries on Sideia include mangrove and bêche-de-mer and, to a lesser extent, reeftop, soft-benthos and intertidal gleaning, and trochus, lobster and other dive fishing, such as giant clams or *Lambis lambis.* The highest number of vernacular names was recorded for the two most important fisheries: bêche-de-mer and mangrove collection (Figure 4.15).

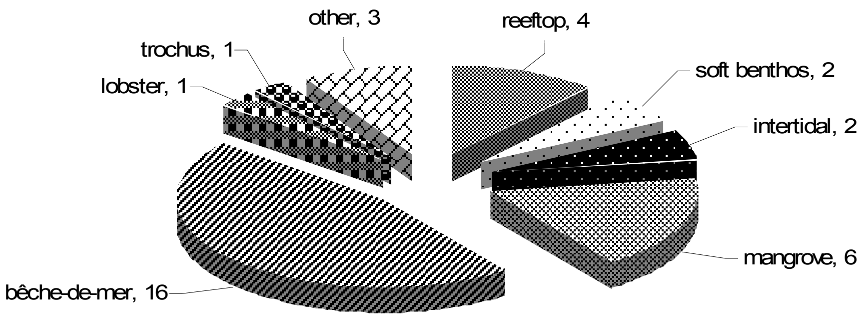

Figure 4.15: Number of vernacular names recorded for each invertebrate fishery in Sideia.
'Other' refer to the giant clam and *Lambis lambis* fisheries.

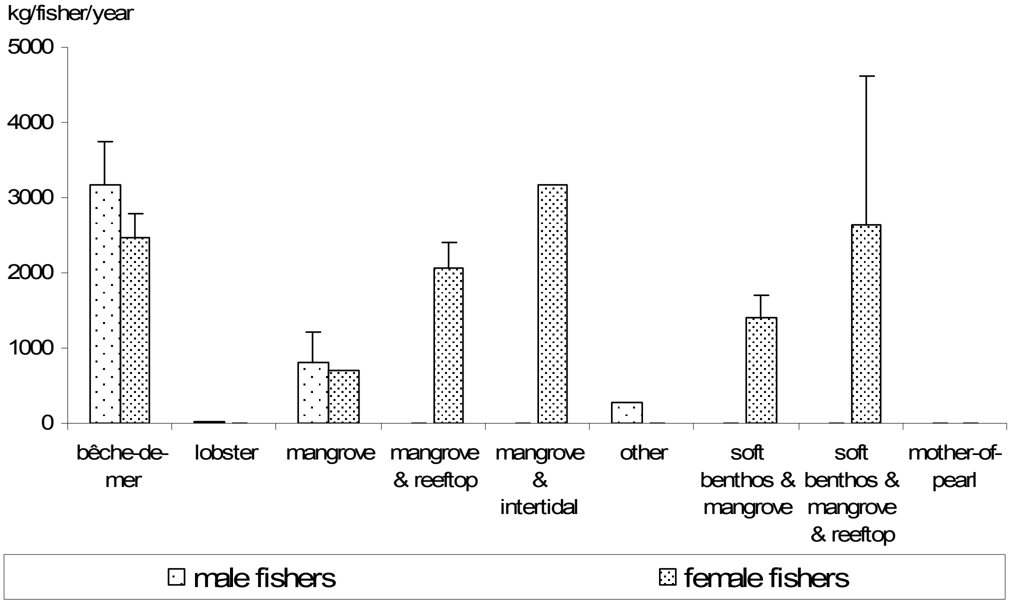

Figure 4.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Sideia.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 16 for males, n = 16 for females); 'other' refer to the giant clam and *Lambis lambis* fisheries.

Females are the main gleaners on Sideia. They also contribute substantially to the island's bêche-de-mer fishery. This observation shows in Figure 4.16, where the average annual catches reported by female gleaners targeting mangroves, particularly if in combination with reeftop and/or intertidal habitats, are high with ≥ 2000 kg/fisher/year. Comparison of the productivity of male and female bêche-de-mer fishers shows a slighter higher catch rate for males (~3000 kg/fisher/year) than for females (~2500 kg/fisher/year).

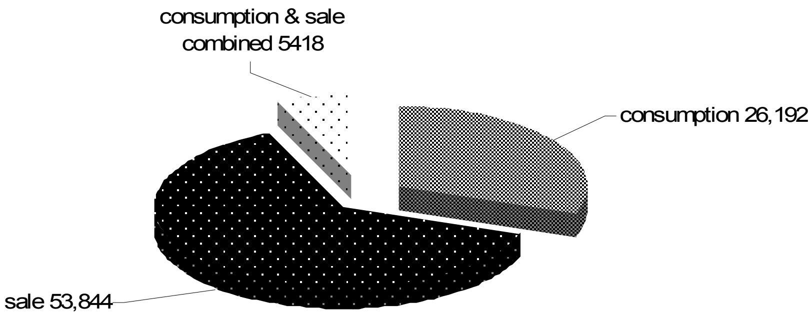

Figure 4.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Sideia.

As shown in Figure 4.17, the proportion of invertebrate catches used for subsistence purposes is significant but only half of the share intended for sale. The commercial proportion is mainly determined by the annual bêche-de-mer fishery.

The total annual catch volume (expressed in wet weight based on recorded data from all respondents interviewed) amounts to 85.45 t/year (Figure 4.18). The graph supports two earlier observations. Firstly, both gender groups substantially contribute to invertebrate fisheries; females are slightly less productive than males. Secondly, females account for the impact from gleaning activities, mainly targeting the mangrove and combined mangrove and reeftop and/or soft-benthos and intertidal habitats. Males are mainly engaged in commercial fisheries; bêche-de-mer is the most impacted commercial resource. Although a great number of females participate in the bêche-de-mer fishery and females' productivity is only 0.5 t/fisher/year lower than that of male fishers, females' overall bêche-de-mer harvest is much smaller than that of males.

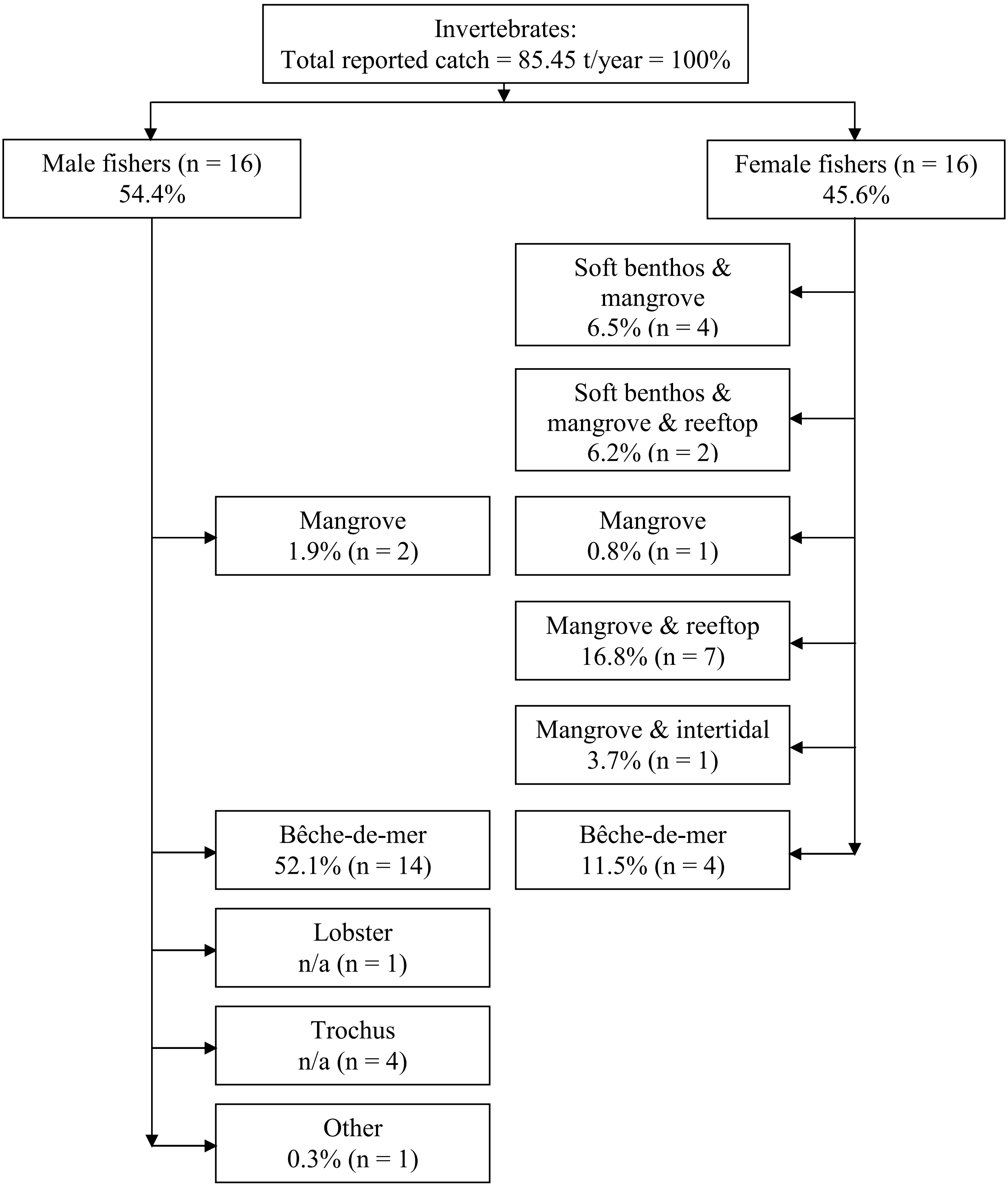

Figure 4.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Sideia.
n is the total number of interviews conducted per each fishery; n/a = no information available; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey; 'Other' refer to the giant clam and *Lambis lambis* fisheries.

The parameters presented in Table 4.5 show highest fisher densities for the commercial bêche-de-mer fishery. The combined gleaning of mangroves and reeftop is the most popular fishery for subsistence and small-income earning, and a considerable number of fishers also target the commercial trochus fishery. Although, overall, fisher density does not seem to be alarmingly high in any of the habitats targeted, the average annual catch per fisher for bêche-de-mer, the combined mangrove and reeftop gleaning, and the combined soft-benthos and mangrove gleaning are high.

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

Parameters	Fishery / Habitat						
	Mangrove & reeftop (3)	Mangrove	Soft benthos & mangrove	Bêche-de-mer (3)	Lobster	Trochus (4)	Other (4)
Fishing ground area (km^2)	8.9	n/a	n/a	8.9	n/a	4.9	4.9
Number of fishers (per fishery) (1)	51	21	29	123	7	27	7
Density of fishers (number of fishers/km^2 fishing ground)	6	n/a	n/a	14	n/a	6	1
Average annual invertebrate catch (kg/fisher/year) (2)	2053.49 (±342.16)	782.52 (±227.69)	1396.77 (±311.22)	3021.27 (±437.56)	29.98 (n/a)	2.93 (±0.60)	266.00 (n/a)

Figures in brackets denote standard error; 'other' refers to the giant clam and *Lambis lambis* fisheries; (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 surface considered only; (4) outer-reef area considered only. For the sake of clarity, the combined fisheries of soft benthos, mangrove & reeftop targeted by a total of 14 fishers (average catch = 2642 kg/fisher/year ±1965.67) and mangrove & intertidal targeted by 7 fishers (average catch = 3170.29 kg/fisher/year ±n/a) are not included in the above table.

Commercialisation

Commercial catches of fish and invertebrates mainly target the local market on Sideia, close to the Catholic mission. Invertebrates (crabs, shells and other molluscs) from the huge mangrove area around Sideia are offered up to 3 times/week at the local market. However, the Catholic mission station helps local people by providing a return trip to Alotau on the mainland for PGK 20. The regular price is 2–3 times this amount, or even higher if boats are operated by faster outboard engines. The duration of a regular trip to Alotau is 4–5 hours by any of the three mission boats (built by local workmen back in the 70s and 80s when the mission was administered by Europeans), which travel at a speed of 4–6 knots.

The bêche-de-mer fishery takes place during the 6-month period (January–June) as determined by government regulations. The collected specimens are boiled and dried and individually sold to any of the three major buyers on the mainland depending on who offers the best price. Agents have motorised boats by which they travel to the islands to buy directly from fishers. Kiwali Exporters seem to be the main company as they operate eight motorised boats; each vessel is designated to an individual island.

According to the Sideia Village Magistrate and Ward Councillor, the most important activities for the Sideia people are subsistence gardening for food and the bêche-de-mer fishery for income. During the bêche-de-mer fishing period, gardening is reduced to harvesting only.

Fisheries management

Discussions held with Elders on Sideia revealed that local people mainly obey fisheries regulations. However, some fishers still dive at night using torches to collect bêche-de-mer. Also, sometimes the use of fish poison (*Derris derris*) is reported for catching schools of fish. It seems, nevertheless, that such activities are not frequent. Neither the Magistrate nor his enforcement officers or village policemen tolerate disobedience or non-compliance. All authorities are known for their determination, monitoring and punishment of offenders or illegal activities.

Also, the community seems to be well aware of the possible detrimental effects resulting from over-harvesting trochus and bêche-de-mer. Particular measures or community regulations to keep fishing pressure low were not specified.

4.2.5 Discussion and conclusions: socioeconomics in Sideia

- Fisheries are the most important source of income for the people on Sideia. Seventy per cent of all households depend on fisheries for first and another 20% of all households for second income. Agriculture also plays an important role as complementary income source. Salaries, private business and handicrafts are of minor importance.

- Fisheries are a less important source of protein as compared to all other PROCFish sites surveyed in the country. However, fresh-fish consumption is higher than the country average. All households eat fresh fish and invertebrates and 90% also eat canned fish. All households consume fish and seafood that is mainly caught by a member of the household or given by somebody else from the community, but hardly ever bought.

- Fresh-fish consumption is relatively low (~24 kg/person/year) and invertebrate consumption is moderate (9.5 kg/person/year). The low canned fish consumption confirms that purchased foods are limited and that people in Sideia are highly self-sufficient in terms of food supply.

- Self-sufficiency in food supply, associated with a relatively low living standard, also shows in the average household expenditure level, which is significantly lower than the average of all four PROCFish sites in Papua New Guinea.

- Finfish fishing is done by males and females and hardly any males or females specialise in finfish fishing or invertebrate collection only.

- Female fishers mainly target the sheltered coastal reef for subsistence and only very few females catch fish at the outer reef. Males target the lagoon and the outer reef mainly for commercial purposes. Females dominate the collection of invertebrates in mangroves, often combined with reeftop, soft-benthos and/or intertidal collection. However both genders are heavily involved in fishing for bêche-de-mer when the commercial season is open. Females do not participate in trochus, lobster or other invertebrate collection (giant clams, *Lambis lambis*, etc.), as it involves free-diving at the back- and outer reefs. Most fishing is done using paddling canoes; some sail canoes are also available.

- Finfish are caught using various techniques: mainly handlines, together with spear diving, handheld spearing or trolling in the lagoon and particularly at the outer reef. Apparently, *Derris derris* fish poison is still used, but not to a large extent.

- Fishing pressure is relatively low, at 0.8 t/km² total reef or total fishing ground area regarding subsistence catches only, or ~4 t/km² if taking into consideration total annual catches that include a commercial proportion of 80%. Due to habitat size and the number of fishers, fisher density is high in the lagoon.

- Invertebrates are collected regularly from mangroves, reeftops, soft-benthos and intertidal areas. Catches mainly serve subsistence needs or local sales on Sideia. However, the commercial catches estimated for bêche-de-mer are substantial and considered the island's major income source. By comparison, catches of trochus and lobsters are low.

- While overall fisher densities do not give reason for any major concern, average annual catch rates reported for the commercial bêche-de-mer as well as for the combined gleaning of mangroves and reeftops, soft benthos and mangroves are high and give cause for concern. The low annual catch rates reported for the commercial trochus fishery suggest that the resource level is low, if not depleted.

The data collected and discussions held with people from Sideia suggest that the island's reef and lagoon resources are still providing a good basis for subsistence and income needs. Fishing pressure as estimated from current finfish catch data does not give any cause for alarm. There are at least three local buyers for bêche-de-mer, suggesting that catches still satisfy the demand. Fishers respect the six-month open season for bêche-de-mer. The island's authorities do not accept misconduct, such as night diving for bêche-de-mer, and imposes punishment. The community is aware that overfishing threatens their resources, in particular, bêche-de-mer and trochus. Respondents said that the community tries to keep the fishing pressure low. However, no information on specific community regulations concerning trochus, lobsters or any other fishery was available.

4.3 Finfish resource surveys: Sideia

The island of Sideia is located off the eastern point of the mainland of Papua New Guinea (Figure 4.19).

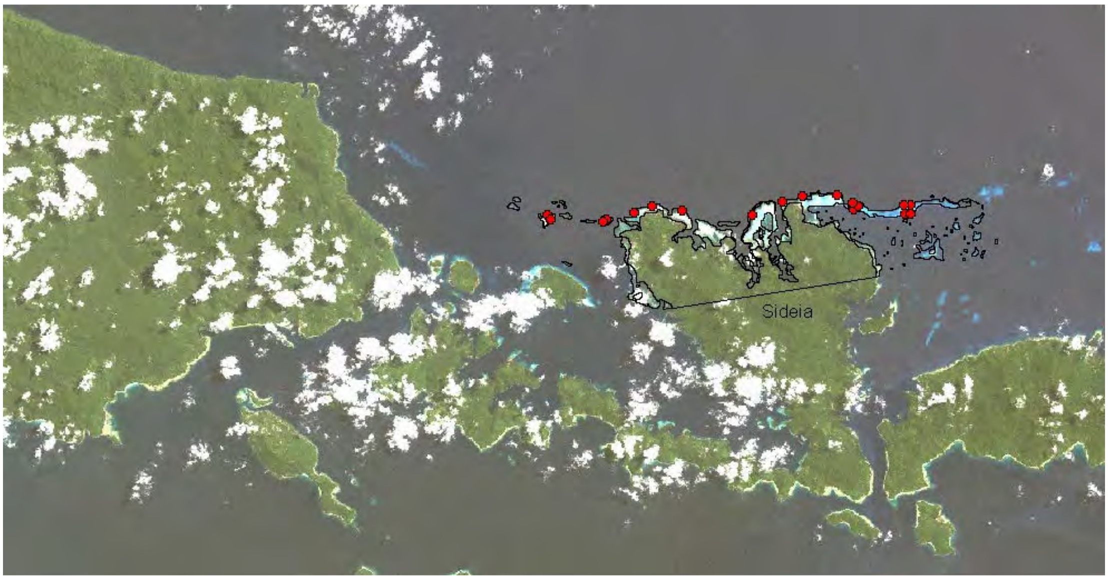

Figure 4.19: Location of the selected site of Sideia.

Finfish resources and associated habitats were assessed between 25 and 30 October 2006 from a total of 18 transects (6 back-reef and 12 outer-reef transects; see Figure 4.20 and Appendix 3.3.2 for transect locations and coordinates respectively). The habitat in the internal part of the lagoon was composed of sandy patches with no coral, and therefore no intermediate reefs were included in the sampling design. Similarly, coastal reefs were missing from the study, since the coastal habitat was particularly murky and of difficult access due to the large concentration of seawater crocodiles.

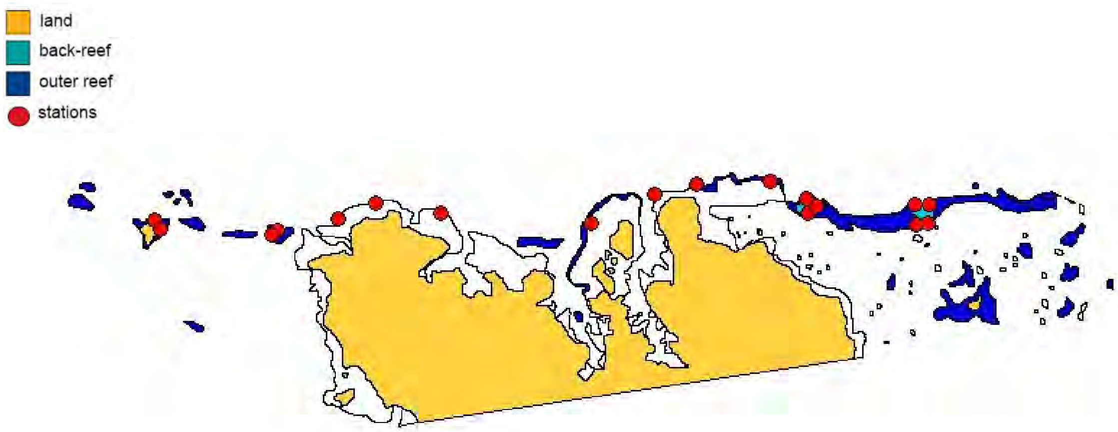

Figure 4.20: Habitat types and transect locations for finfish assessment in Sideia.

4.3.1 Finfish assessment results: Sideia

A total of 23 families, 56 genera, 180 species and 10,335 fish were recorded in the 14 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 41 genera, 151 species and 6307 individuals.

Finfish resources differed slightly between the two reef environments found in Sideia (Table 4.6). The back-reefs contained higher density (0.6 fish/m²), biomass (109 g/m²), and size ratio (60%), while the outer reefs displayed higher biodiversity (48 versus 46 species/transect).

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

Parameters	Habitat		
	Back-reef [(1)]	Outer reef [(1)]	All reefs [(2)]
Number of transects	6	12	18
Total habitat area (km^2)	0.3	4.4	4.6
Depth (m)	4 (1-10) [(3)]	5 (4-12) [(3)]	2 (1-12) [(3)]
Soft bottom (% cover)	18 ±4	8 ±3	8
Rubble & boulders (% cover)	19 ±5	15 ±5	15
Hard bottom (% cover)	42 ±8	51 ±5	50
Live coral (% cover)	17 ±2	24 ±4	23
Soft coral (% cover)	2 ±1	3 ±1	3
Biodiversity (species/transect)	46 ±5	48 ±5	47 ±4
Density (fish/m^2)	0.6 ±0.2	0.4 ±0.1	0.1
Size (cm FL) [(4)]	18 ±1	18 ±1	18
Size ratio (%)	60 ±3	57 ±2	57
Biomass (g/m^2)	109.2 ±37.9	46.2 ±11.3	24.2

[(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.

Back-reef environment: Sideia

The back-reef environment of Sideia was dominated by two herbivorous families: Acanthuridae and Scaridae (Figure 4.21). Chaetodontidae were relatively abundant and present with 14 species, but did not contribute much to the total biomass. The two major families were represented by 29 species; particularly high biomass and abundance were recorded for *Ctenochaetus striatus*, *Scarus psittacus*, *S. rivulatus*, *S. quoyi* and *S. dimidiatus* (Table 4.7). This reef environment presented a large surface covered by hard bottom (42%), relatively little live coral (17%) and a larger percentage covered in soft bottom and rubble (27%, Table 4.6).

Table 4.7: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Sideia

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.07 ±0.04	12.5 ±8.7
Scaridae	*Scarus psittacus*	Common parrotfish	0.02 ±0.02	6.3 ±5.9
	Scarus rivulatus	Rivulated parrotfish	0.04 ±0.03	5.0 ±3.3
	Scarus quoyi	Quoyi's parrotfish	0.02 ±0.02	3.6 ±3.5
	Scarus dimidiatus	Yellow-barred parrotfish	0.03 ±0.02	3.4 ±1.7

The density, size ratio and biomass of finfish in the back-reefs of Sideia were higher than values recorded at the outer reefs; however, biodiversity was smaller and average fish size was the same (18 cm FL).

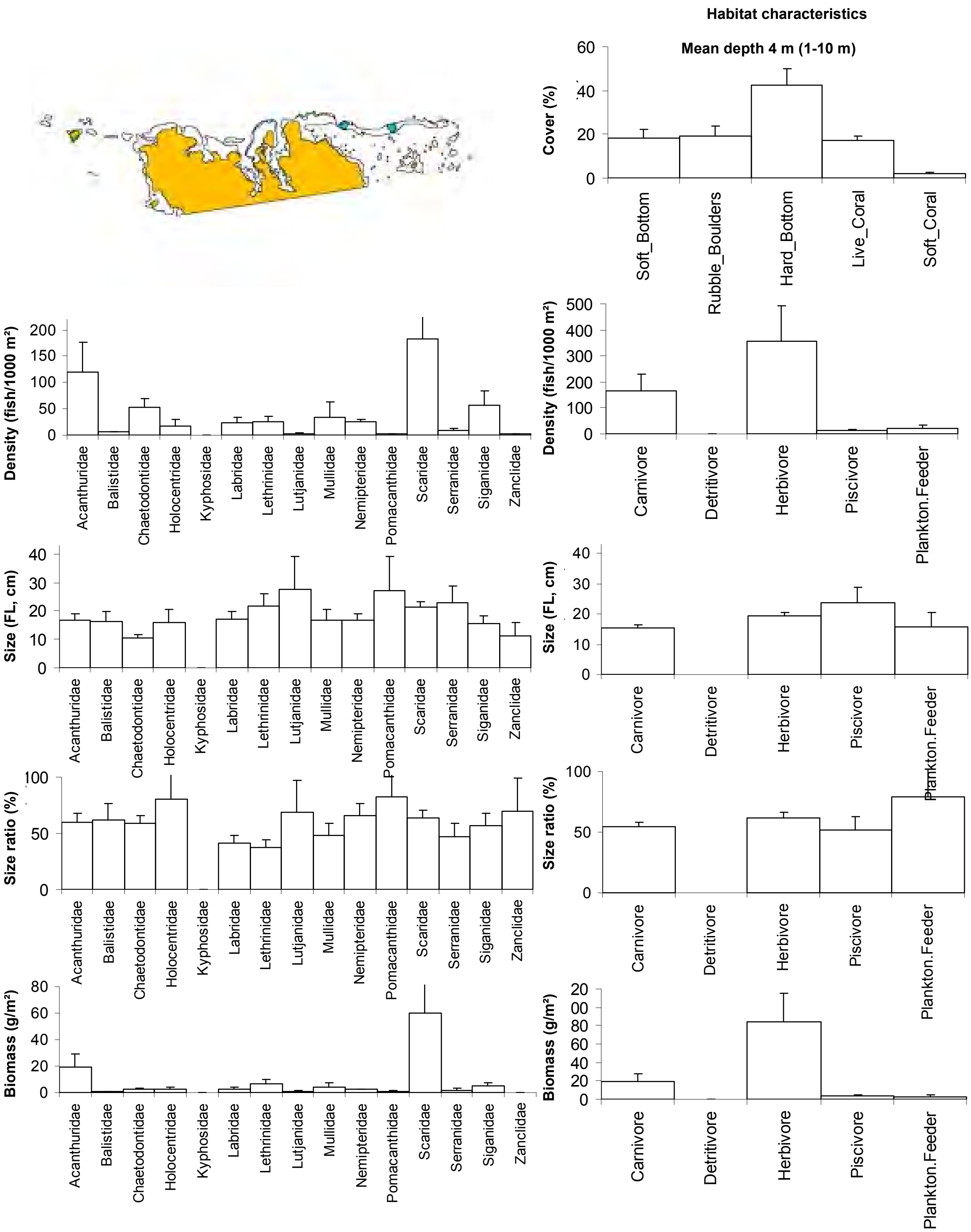

Figure 4.21: Profile of finfish resources in the back-reef environment of Sideia.
Bars represent standard error (+SE); FL = fork length.

When compared to back-reefs in Andra and Panapompom, Sideia back-reefs still showed the highest biomass but second-ranked value of density, smaller than in Andra (0.6 versus 0.7 fish/m²). However, size, size ratio and biodiversity were highest in Sideia.

Herbivores dominated the trophic structure, both in terms of density and biomass. Carnivores were present in low numbers and contributed only a little to the biomass of the fish community. Scaridae were mainly represented by mid-to-large-sized species, while Acanthuridae were mostly represented by the small-sized *Ctenochaetus striatus*. At one site, average-sized (80 cm) *Bolbometopon muricatum* were sighted. Average size ratio was low only for Lethrinidae (37%). This could indicate a first response to fishing pressure. Substrate was almost equally composed of hard bottom, coral and mobile bottom (soft and rubble) favouring different families. Beside Acanthuridae and Scaridae, Labridae, Lethrinidae, Mullidae, Nemipteridae and Siganidae were present in relatively good numbers, resulting in a good diversity of the fish community.

Outer-reef environment: Sideia

The outer-reef environment of Sideia was dominated by two herbivorous families: Acanthuridae and Scaridae and, to a lesser extent and only for biomass, by one carnivorous family: Lutjanidae (Figure 4.22). These three major families were represented by 38 species; particularly high biomass and abundance were recorded for *Ctenochaetus striatus*, *Acanthurus lineatus*, *Scarus rivulatus*, *Lutjanus gibbus*, *Chlorurus bleekeri*, *C. sordidus* and *L. carponotatus* (Table 4.8). This reef environment presented a substrate composition dominated by hard bottom (51%), with a good cover of live coral (24 %) and limited soft bottom (15%) and rubble (8%, Table 4.6 and Figure 4.22).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.10 ±0.04	11.6 ±4.7
	Acanthurus lineatus	Lined surgeonfish	0.03 ±0.01	6.2 ±3.5
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.004 ±0.004	3.5 ±3.2
	Lutjanus carponotatus	Spanish flag snapper	0.004 ±0.004	2.3 ±2.2
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.02 ±0.02	5.8 ±3.5
	Chlorurus bleekeri	Bleeker's parrotfish	0.03 ±0.01	3.0 ±0.6
	Chlorurus sordidus	Daisy parrotfish	0.03 ±0.01	2.8 ±0.9

The density, size ratio and biomass of finfish in the outer reef of Sideia were lower than at the back-reefs, and density and biomass were also the lowest among all country outer reefs. Biodiversity was higher than at back-reefs but again the lowest among the outer reefs (48 versus 51, 59 and 75 species/transect at Tsoilaunung, Andra and Panapompom respectively). Trophic composition was dominated by herbivores (mostly Acanthuridae and Scaridae); carnivores were essentially represented by Lutjanidae. Substrate was mostly composed of hard bottom, with very little soft bottom, which is normally preferred by some specific carnivore species of the families Lethrinidae and Mullidae.

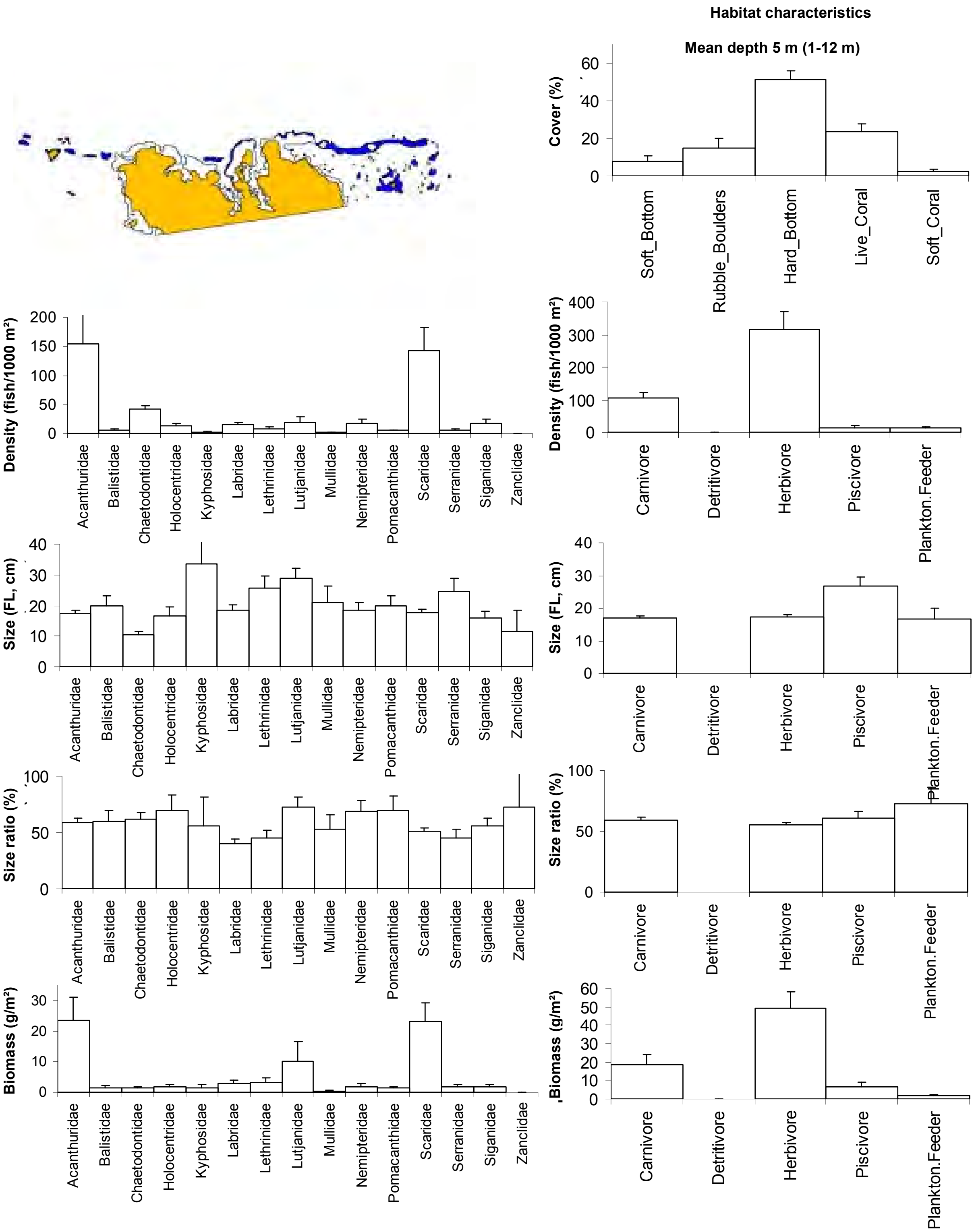

Figure 4.22: Profile of finfish resources in the outer-reef environment of Sideia.
Bars represent standard error (+SE); FL = fork length.

Overall-reef environment: Sideia

Overall, the fish assemblage of Sideia was dominated by two herbivorous families: Acanthuridae and Scaridae and, to a much lesser extent, one carnivorous family: Lutjanidae (only for biomass, Figure 4.23). Chaetodontidae, present with 19 species, displayed high abundance only. The three major families were represented by a total of 42 species, dominated (in terms of biomass and density) by *Ctenochaetus striatus*, *Acanthurus lineatus*, *Scarus rivulatus*, *Chlorurus bleekeri*, *C. sordidus*, *A. blochii*, *Lutjanus carponotatus*, *S. dimidiatus* and *L. fulvus* (Table 4.9). The average substrate was dominated by hard bottom (50%), with relatively high cover of live coral (23%), and a good proportion of mobile bottom (23%). The overall substrate and fish assemblage in Sideia shared characteristics of primarily outer reefs (94% of total habitat) and to a minimal extent of back-reefs (6%).

Table 4.9: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Sideia (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.032	3.6
	Acanthurus lineatus	Lined surgeonfish	0.007	1.8
	Acanthurus blochii	Ringtail surgeonfish	0.002	0.7
Lutjanidae	*Lutjanus carponotatus*	Spanish flag snapper	0.001	0.7
	Lutjanus fulvus	Flametail snapper	0.001	0.5
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.008	1.8
	Chlorurus bleekeri	Bleeker's parrotfish	0.008	0.9
	Chlorurus sordidus	Daisy parrotfish	0.009	0.8
	Scarus dimidiatus	Yellow-barred parrotfish	0.007	0.6

Overall, Sideia appeared to support a relatively good finfish resource with the highest density and fish size compared to the other country sites, but lowest biomass and average biodiversity (lower than Panapompom only). However, comparisons with other sites are of a limited value since reef habitats in Sideia are limited to back- and outer reefs. A detailed assessment at the family level revealed a clear dominance of herbivores over carnivores. The contribution made by carnivores to the overall biomass composition was mainly due to Lutjanidae and, to a much lesser extent, Lethrinidae. The poverty of carnivores could be partially explained by the composition of the habitat, mainly outer reef composed of hard rock and live coral, with very little soft substrate, which normally favours most invertebrate-feeding carnivores, such as Mullidae and Lethrinidae. Overall, size ratios were high for most families and only slightly below 50% for Lethrinidae, probably suggesting some impact from fishing.

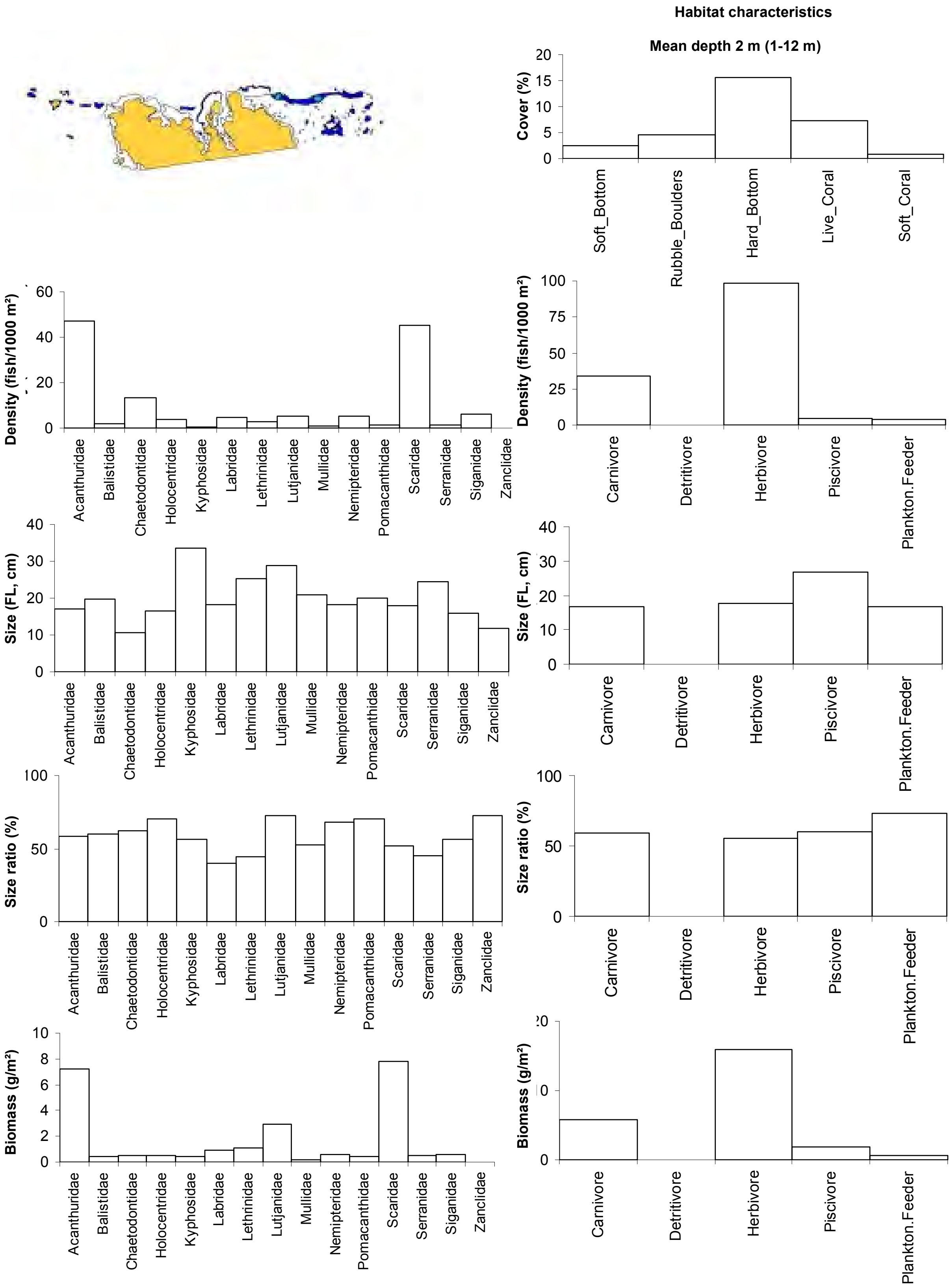

Figure 4.23: Profile of finfish resources in the combined reef habitats of Sideia (weighted average).
FL = fork length.

4.3.2 Discussion and conclusions: finfish resources in Sideia

- The assessment indicated that the status of finfish resources in this site was relatively good. Fishing at this site was mostly concentrated in the outer reefs and mostly done by handline (over grounds 60–100 m deep), therefore targeting carnivores. Some spearfishing was also practised, even at night.
  - The reefs were naturally rich and cover of live coral was good and diverse.
  - The finfish community was diverse and fish were sighted in schools (mainly herbivores). Sightings of *Bolbometopon muricatum* and *Cheilinus undulatus*, although of small to moderate sizes, were fairly frequent. Large carnivores (e.g. groupers) and top predators (sharks) were also quite common.

- These observations, along with the analysis of the collected data, suggest that Sideia is a relatively healthy site. However, some signs of fishing impacts were noticed, e.g:
  - Lethrinidae were small in size.
  - The finfish community was dominated by herbivores in both habitats, possibly due to the character of the reef habitat, which was mainly composed of hard bottom.
  - The fish were wary of divers, interpreted as fear induced by spearfishing.

- When analysed at the reef-habitat level, resources appeared in better conditions (higher density and biomass) at the back-reefs than at the outer reefs. Biodiversity was, however, higher at outer reefs.

4.4 Invertebrate resource surveys: Sideia

The diversity and abundance of invertebrate species at Sideia Island were independently determined using a range of survey techniques (Table 4.10): broad-scale assessment (using the ‘manta tow’; locations shown in Figure 4.24) and finer-scale assessment of specific reef and benthic habitats (Figures 4.25 and 4.26).

The main objective of the broad-scale assessment was 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 assessments were conducted in target areas to specifically describe the status of resource in those areas of naturally higher abundance and/or most suitable habitat.

Table 4.10: Number of stations and replicate measures completed at Sideia

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	73 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)	0	0 transect
Mother-of-pearl searches (MOPs)	4	24 search periods
Reef-front searches (RFs)	4	24 search periods
Sea cucumber day searches (Ds)	6	36 search periods
Sea cucumber night searches (Ns)	0	0 search period

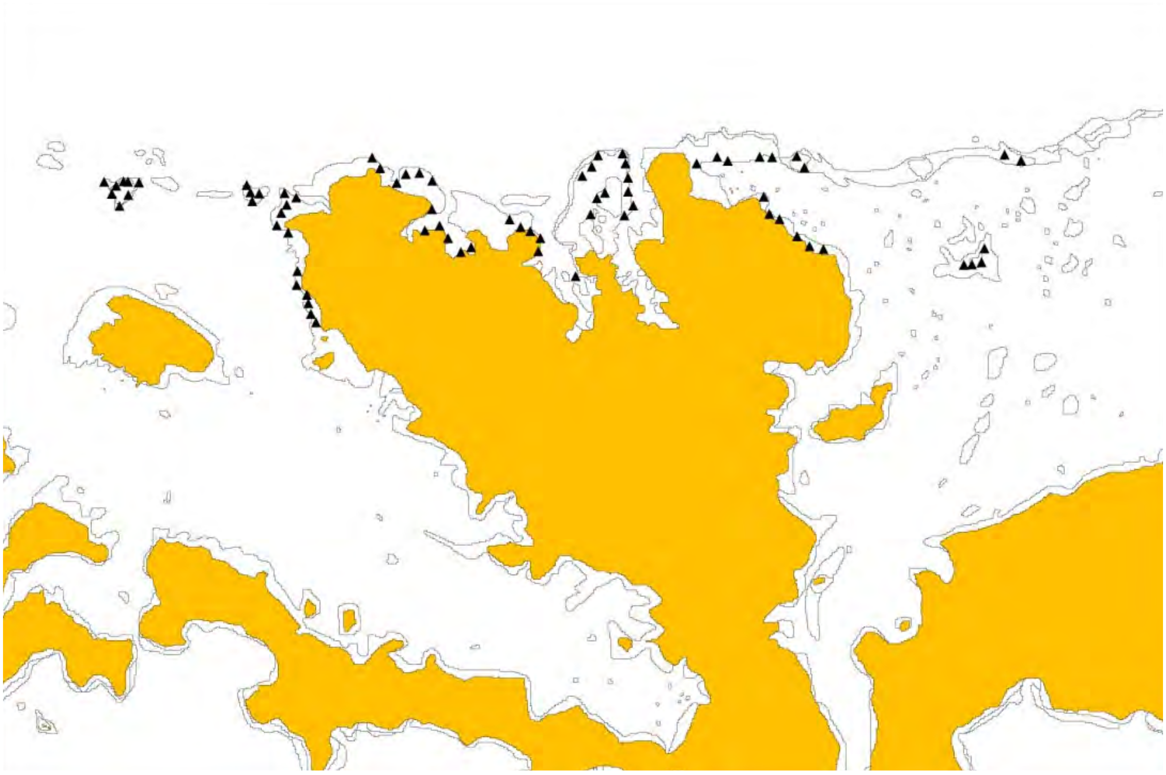

Figure 4.24: Broad-scale survey stations for invertebrates in Sideia.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

Figure 4.25: Fine-scale reef-benthos transect survey stations for invertebrates in Sideia.
Black squares: reef-benthos transect stations (RBt).

Figure 4.26: Fine-scale survey stations for invertebrates in Sideia.
Inverted black triangles: reef-front search stations (RFs);
grey squares: mother-of-pearl search stations (MOPs);
grey stars: sea cucumber day search stations (Ds).

Sixty-eight species or species groupings (groups of species within a genus) were recorded in the Sideia invertebrate surveys: 12 bivalves, 26 gastropods, 17 sea cucumbers, 5 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: Sideia

At Sideia, shallow-reef habitat suitable for giant clams was not as extensive as at the other PROCFish site in Milne Bay (13.8 km²: ~8.9 km² of more inshore lagoon reef, and 4.9 km² on the reef front and slope of the barrier reef). The high island at Sideia was large (83.7 km²) and most of the reef immediately adjacent to the shoreline was influenced by land inputs. Reefs more distant to the shore extended west and east where a semi-sunken barrier reef existed, with patch reefs at various positions along its length; these were more oceanic-influenced.

Broad-scale sampling provided an overview of giant clam distribution and density. Reefs at Sideia held six species of giant clam: the elongate clam *Tridacna maxima*, the boring clam *T. crocea*, the smooth clam *T. derasa*, the true giant clam *T. gigas*, and the horse-hoof or bear's paw clam *Hippopus hippopus*. The smallest species, *T. crocea*, had the widest occurrence (recorded in 12 stations and 57 transects), followed by *T. maxima* (found in 11 stations and 50 transects), *T. squamosa* (7 stations and 12 transects), *T. gigas* (3 stations and 3 transects) and *T. derasa* (2 stations and 2 transects). *H. hippopus*, which is well camouflaged and usually relatively sparsely distributed, was recorded in seven stations (13 transects in total; see Figure 4.27).

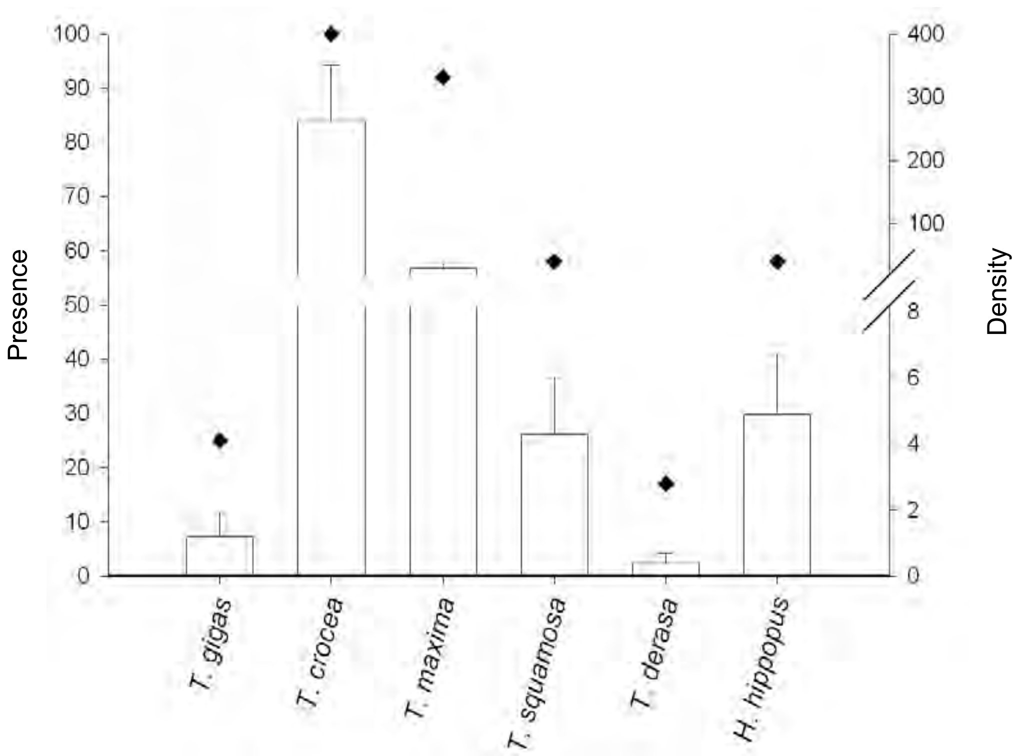

Figure 4.27: Presence and mean density of giant clam species in Sideia based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 4.28). In these reef-benthos assessments (RBt), *T. maxima* was present in 95% of stations and *T. crocea* was also common (recorded in 80% of stations). These smaller species reached maximum station densities of 375 /ha for *T. maxima* and 2958 /ha for *T. crocea*. The larger species *T. squamosa*, which is normally recorded at lower density in survey and is prone to over-fishing, also had relatively good coverage (recorded in 40% of stations) and average density (27.1 /ha ±8.7). At Sideia the free-standing *H. hippopus* was noted in 35% of stations and reached a maximum station density of 167 /ha (Figure 4.28). In most PROCFish sites in the Pacific, the largest clam (*T. gigas*) is generally lost to the live species record; however, this species and *T. derasa* were still present at Sideia. In the full survey, these species were not common, with only six *T. gigas* and five *T. derasa* individuals recorded; both these larger clam species were more commonly noted as dead shells rather than live individuals.

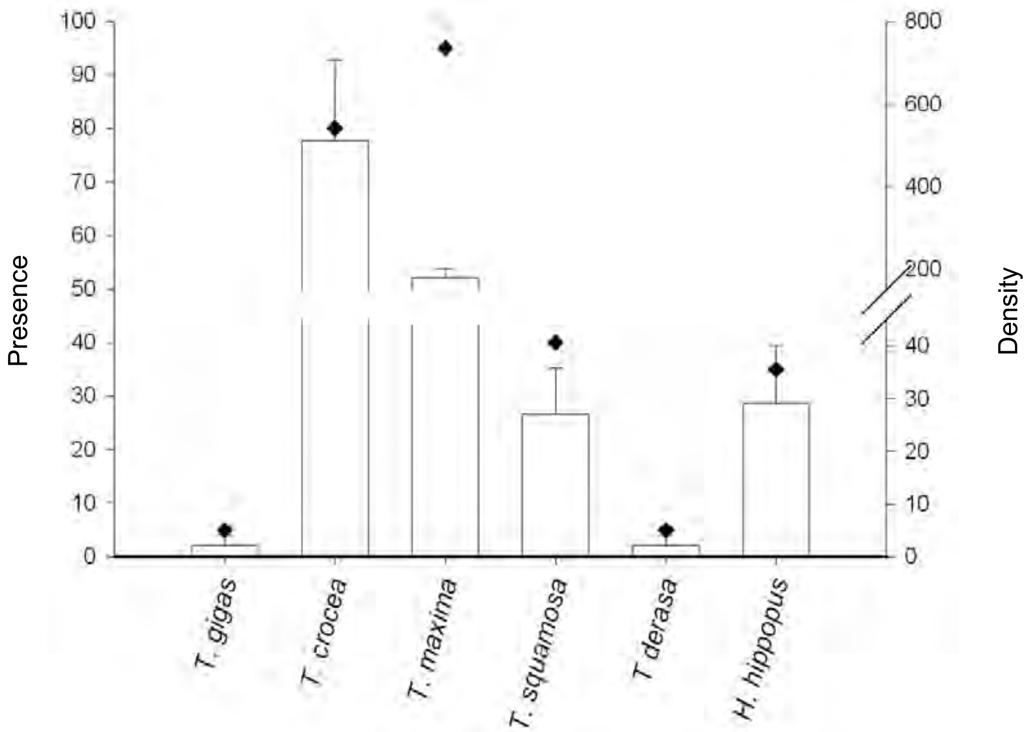

Figure 4.28: Presence and mean density of giant clam species in Sideia based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

A full range of small and large individuals of *T. maxima* was recorded in survey. The presence of many larger clams in the size distribution is reflected in the larger mean size (14.8 cm ±0.4), which was similar for the complete data set and for shallow reefs alone (This size represents a clam of ~7 years old.). The faster growing *T. squamosa* (which grows to an asymptotic length L∞ of 40 cm) averaged 22.8 cm ±1.2 (~7–8 years old), whereas *T. crocea* averaged 8.4 cm ±0.2 (>5 years old) and *H. hippopus* averaged 18.7 cm ±1.1 (~3–4 years old). The five *T. derasa* clams measured an average of 20.1 cm and the six *T. gigas* measured an average of 64.2 cm. Three of the *T. gigas* were well over twenty years in age; however, records from surveys of this larger species also included individuals from more recent spawnings (probably 6 years old, see Figure 4.29). *T. gigas* takes 8–10 years of growth to reach a size where it can produce eggs.

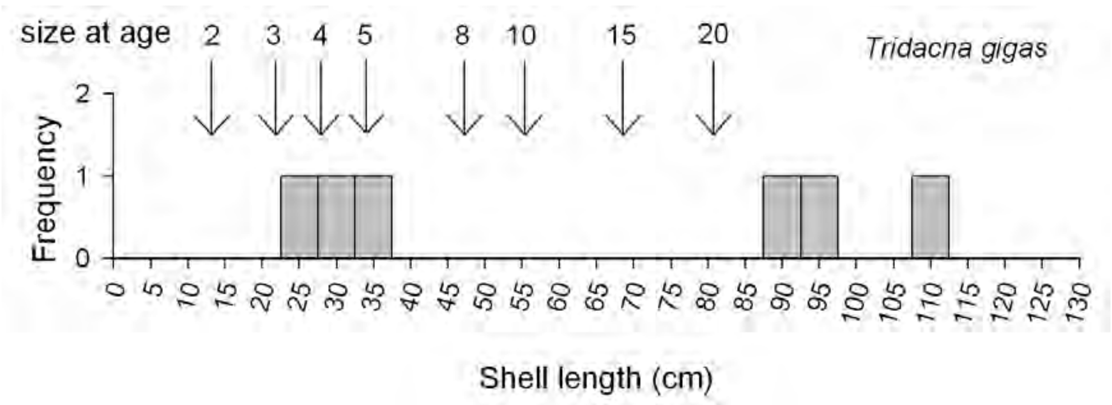

Figure 4.29: Size frequency histogram of the true giant clam *Tridacna gigas* shell length (cm) for Sideia.

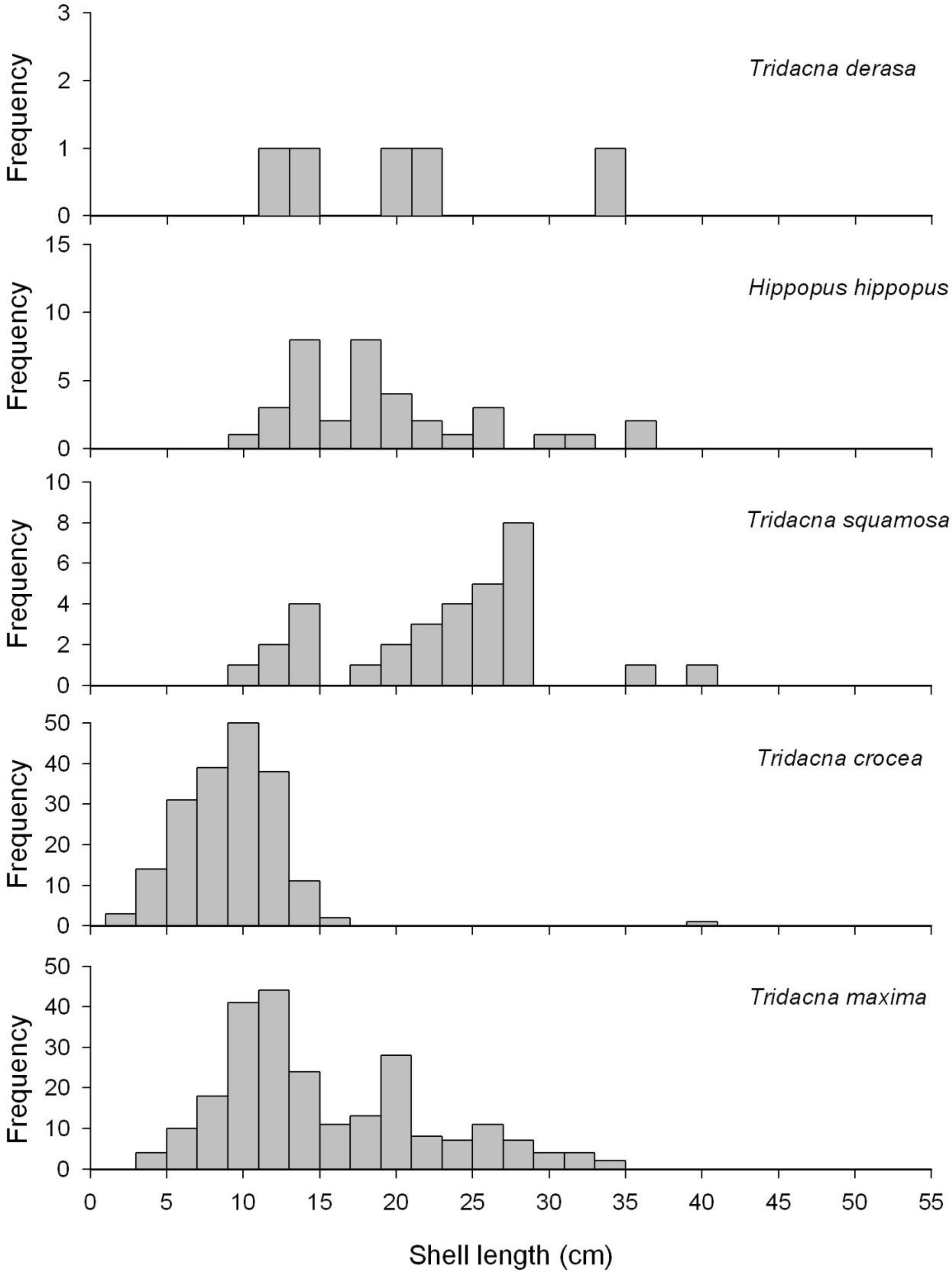

Figure 4.30: Size frequency histograms of giant clam shell length (cm) for Sideia.

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

Papua New Guinea is within the natural distribution of the commercial topshell *Trochus niloticus* and giant turban snail *Turbo marmoratus* in the Pacific. The outer and lagoon reef at Sideia constitute a suitable benthos for *T. niloticus* and this area could potentially be a small but self-sustaining fishery for this commercial species (4.9 km lineal distance of exposed reef perimeter). Although not extensive, the reef along the shoreline and the barrier reef was quite suitable for trochus, with hard limestone fore-reefs (suitable adult habitat) and coral rubble back-reefs (suitable juvenile habitat). In general, the reef slope outside the inshore lagoons sloped more steeply into deeper water than would be optimal, and this would moderately limit the scale of the adult habitat.

PROCFish survey work revealed that *T. niloticus* was present on both the barrier reef (outer-reef slope and reeftop) and on reef close to the mainland of Sideia (Table 4.10). The giant turban snail *T. marmoratus* was absent in the survey.

Table 4.10: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Sideia
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	1/73 = 1
RBt	16.7	7.6	7/20 = 35	7/120 = 6
RFs	0	0	0/4 = 0	0/24 = 0
MOPs	5.7	3.6	2/4 = 50	3/24 = 13
Tectus pyramis				
B-S	3.2	1.2	7/12 = 58	10/73 = 14
RBt	37.5	11.3	10/20 = 50	16/120 = 13
RFs	6.9	5.6	2/4 = 50	6/24 = 25
MOPs	15.2	10.7	2/4 = 50	7/24 = 29
Pinctada margaritifera				
B-S	4.3	1.1	9/12 = 75	15/73 = 21
RBt	10.4	5.1	4/20 = 20	5/120 = 4
RFs	2.9	2.9	1/4 = 25	2/24 = 8
MOPs	3.8	3.8	1/4 = 25	2/24 = 8

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

No large aggregations of trochus were found in survey (only n = 12 individuals recorded in total), and stock that was recorded occurred at low density and below abundances considered appropriate for commercial fishing (See Appendix 4.5.). Although trochus was found at various locations around Sideia, densities in most cases were so low as to jeopardise the potential for successful fertilisation; spawning in these separate-sexed animals relies on eggs and sperm to meet in the water column for regeneration of stock.

The mean basal width of trochus at Sideia was 9.0 cm ±0.8 (Figure 4.31). The shell size-class frequencies indicate that, despite the low numbers of trochus found, stock at Sideia was from a range of size classes and there was evidence of new recruitment of young trochus (First maturity of trochus is at 7–8 cm in Papua New Guinea, ~3 years of age). For this cryptic species, younger shells are normally more easily seen from about 5.5 cm, when small trochus are emerging from their more cryptic lifestyle to join the main stock. Despite the low numbers, this portion of the population was still evident in Sideia.

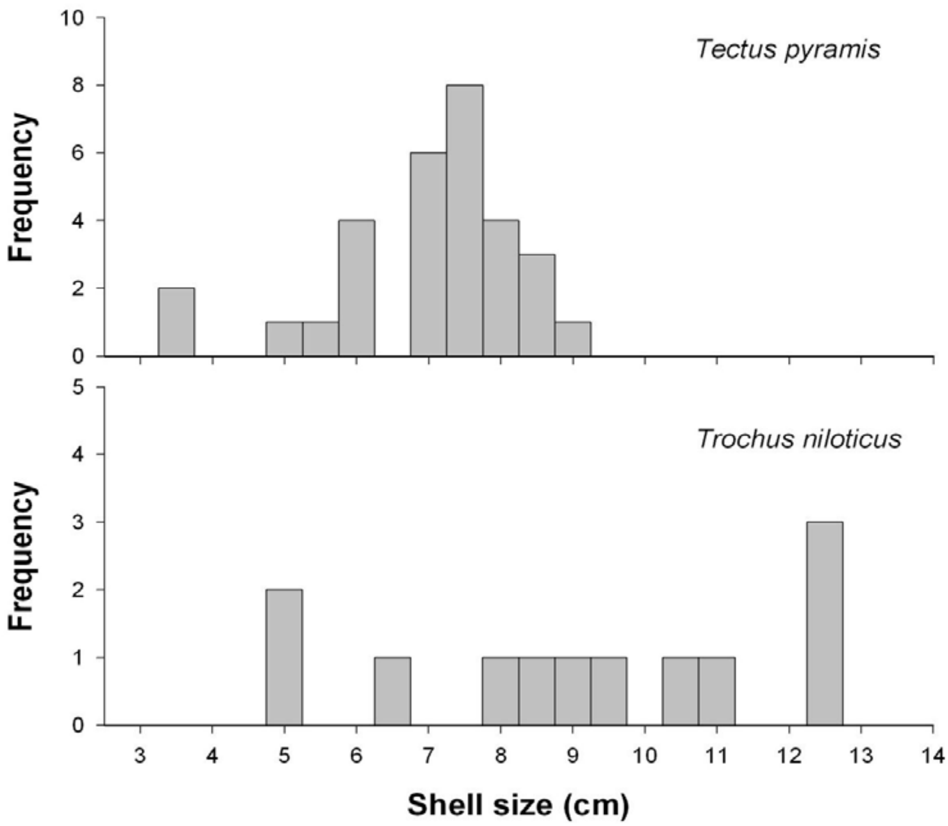

Figure 4.31: Size frequency histograms of trochus (*Trochus niloticus*) and 'false' trochus (*Tectus pyramis*) shell base diameter (cm) for Sideia.

The suitability of reefs for grazing gastropods was highlighted by results collected for the false trochus or green topshell (*Tectus pyramis*). This related, but less valuable species of topshell (an algal-grazing gastropod with a similar life history to trochus) was recorded in moderate numbers at Sideia (n = 30 recorded in survey). The mean size (basal width) of *T. pyramis* was 6.8 cm ±0.2. Small *Tectus* (<5.5 cm) were recorded in survey, which may suggest that *Tectus* and possibly *Trochus* have had favourable spawning and/or settlement conditions in recent years.

Despite blacklip pearl oysters (*Pinctada margaritifera*) being cryptic and normally sparsely distributed in open lagoon systems (such as found at Sideia), the number of blacklip seen during assessments was relatively high (n = 26). The mean shell length (anterior–posterior measure) was 13.6 cm ±0.5.

4.4.3 Infaunal species and groups: Sideia

The coastal margin at Sideia Island was generally unsuitable for seagrass meadows and no concentrations of in-ground resources (shell 'beds') were recorded. Therefore, no fine-scale assessments or infaunal stations (quadrat surveys) were completed.

4.4.4 Other gastropods and bivalves: Sideia

Seba's spider conch (*Lambis truncata*), the larger of the two common spider conchs, was rare in survey (n = 4 individuals recorded), but *L. lambis* was recorded at low-to-moderate density in reef-benthos transects (average 20.8 /ha, n = 20 individuals recorded in all surveys). Other *Lambis* species were also recorded (*L. chiragra*, *L. crocata*, *L. millepeda*, *L. scorpius*). The strawberry or red-lipped conch (*Strombus luhuanus*) was also present at moderate density within broad- and fine-scale surveys (n = 247 individuals noted, see Appendices 4.3.1 to 4.3.6).

Three species of turban shell (*T. argyrostomus*, *T. chrysostomus* and *T. petholatus*) were recorded at low density. The larger silver-mouthed turban (*T. argyrostomus*) was not recorded in reef-front search stations and less than a handful turned up in other survey stations. No *Turbo setosus* was seen in surveys. Other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Haliotis*, *Ovula*, *Pleuroploca*, *Tectus*, *Thais*, *Tutufa* and *Vasum*) were also recorded during independent survey (Appendices 4.3.1 to 4.3.6).

Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Hyotissa* and *Spondylus*, are also in Appendices 4.3.1 to 4.3.6. No creel survey was conducted at Sideia.

4.4.5 Lobsters: Sideia

There was no dedicated night reef-front assessment of lobsters (See Methods.). There was also no night assessment of nocturnal sea cucumber species (Ns) at inshore areas because of the number of crocodiles that were present. However, in general surveys twenty-two lobsters (*Panulirus* spp.) were recorded in survey and two prawn killers (*Lysiosquillina maculata*) were also noted.

4.4.6 Sea cucumbers[9]: Sideia

The study area at Sideia has a moderately extensive lagoon (open lagoon 33.4 km^2, which is difficult to determine accurately as the system is not well defined). Sideia Island presents a large elevated land mass (83.7 km^2), with large land masses to the east and west, also with adjoining reef systems. This meant that there was significant land influence on fringing reefs and reef systems close to shorelines. Riverine input (and other inputs from land) was most notable within embayments, which extended relatively far inland. Further offshore, general water movement (flushing of oceanic water) was dynamic. There was more exposure around the predominantly oceanic-influenced 'open' barrier reef (which mainly extended to the east). The presence of valuable commercial species reflected the varied environment of Sideia, which suited these deposit-feeding resources (which eat detritus and other organic matter in the upper few mm of bottom substrates).

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (No night assessments were conducted, Table 4.11, Appendices 4.3.1 to

[9] 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.

4.3.6; also see Methods), which noted a total of sixteen commercial species of sea cucumber (plus one indicator species, see Table 4.4). This result was similar to that in the other PROCFish site in Milne Bay Province of Papua New Guinea.

Sea cucumber species associated with shallow reef areas, such as leopardfish (*Bohadschia argus*) and the high-value black teatfish (*Holothuria nobilis*), were rarely recorded (found in ≤ 15% of broad-scale and fine-scale assessments) and never at high density (<10 /ha). The fast growing and medium/high-value greenfish (*Stichopus chloronotus*), which has been recorded at most sites in the Pacific, was not recorded at all at Sideia.

Surf redfish (*Actinopyga mauritiana*) were also rare and recorded at low density, despite the suitable environment. In reef-front searches, no *A. mauritiana* were recorded and the density was low in reef-benthos transect stations (average 2.1 /ha).

More protected areas of reef and soft benthos in the more enclosed areas near the mainland did not return more species data. No blackfish (*A. miliaris*) or stonefish (*A. lecanora*) were found, although these species are best targeted at night, due to their nocturnal feeding habit. As mentioned, night searches were abandoned due to crocodiles that are common in the area. A few lower-value species, e.g. lollyfish (*H. atra*), pinkfish (*H. edulis*) and brown sandfish (*B. vitiensis*), were recorded but again they were uncommon and at low density.

No high-value sandfish (*H. scabra*) or lower-value false sandfish (*B. similis*) were found despite the presence of mangrove shorelines (This species generally prefers the ‘richer’ environments that were present around Sideia.). Although night assessments were not completed, small numbers of *Stichopus vastus* (n = 2) were noted under the main wharf close to the mission.

Deep-water assessments were completed to obtain a preliminary abundance estimate for white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*) and amberfish (*T. anax*). Deeper-water dives (average depth 27.1 m) also recorded the ‘redlined’ or ‘candy-cane’ fish *T. rubrolineata*. Reef slopes in parts of the more oceanic-influenced lagoon had benthos at between 20–35 m, which is a suitable depth to support *H. fuscogilva*. White teatfish were recorded at low density for all the six sea cucumber day stations completed (36 five-minute searches, plus one observation point dive; maximum station density was 28.6 individuals/ha). The presence and density records for prickly redfish (*T. ananas*), amberfish (*T. anax*) and elephant trunkfish (*H. fuscopunctata*) were generally low. The presence of candy-cane fish (*T. rubrolineata*), although low, was important, as this species was reliably found in three of the six stations across Sideia, despite being very rare across other PROCFish sites in the Pacific.

4.4.7 Other echinoderms: Sideia

No edible collector urchins (*Tripneustes gratilla*) were found at Sideia, although slate urchins (*Heterocentrotus mammillatus* and *Echinothrix* spp.) were noted at low density along the inshore and offshore reefs. Other urchins, such as *Diadema* spp. and *Echinometra mathaei*, can be used within assessments as potential indicators of habitat condition, but these species were also uncommon and recorded at relatively low abundance (Appendices 4.3.1 to 4.3.6).

Table 4.11: Sea cucumber species records for Sideia

Species	Common name	Commercial value [5]	B-S transects n = 73			Reef-benthos stations n = 20			Other stations RFs = 4; MOPs = 4			Other stations Ds = 6		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga caerulea	-	M/H												
Actinopyga echinites	Deepwater redfish	M/H												
Actinopyga lecanora	Stonefish	M/H												
Actinopyga mauritiana	Surf redfish	M/H				2.1	41.7	5						
Actinopyga miliaris	Blackfish	M/H												
Bohadschia argus	Leopardfish	M	0.9	16.7	5	4.2	41.7	10	1.9	7.6	25 MOPs	1.2	3.6	33
Bohadschia graeffei	Flowerfish	L	3.9	23.6	16	6.3	62.5	10	1.0 3.8	3.9 15.2	25 RFs 25 MOPs	2.0	3.0	67
Bohadschia similis	False sandfish	L												
Bohadschia vitiensis	Brown sandfish	L	1.4	16.7	8	2.1	41.7	5						
Holothuria atra	Lollyfish	L	2.1	21.4	10	39.6	88.0	45	6.9 1.9	13.7 7.6	50 RFs 25 MOPs	6.0	11.9	50
Holothuria coluber	Snakefish	L												
Holothuria edulis	Pinkfish	L	0.5	16.7	3				5.7	22.7	25 MOPs	2.4	3.6	67
Holothuria fuscogilva [4]	White teatfish	H	1.1	20.8	5	2.1	41.7	5				9.1	9.1	100
Holothuria fuscopunctata	Elephant trunkfish	M										1.2	3.6	33
Holothuria leucospilota	-	L												
Holothuria nobilis [4]	Black teatfish	H	0.2	16.7	1	6.3	41.7	15						
Holothuria scabra	Sandfish	H												
Stichopus chloronotus	Greenfish	H/M												
Stichopus hermanni	Curryfish	H/M										0.4	2.4	17
Stichopus horrens	Peanutfish	M/L												
Stichopus pseudhorrens	-	M												
Stichopus vastus	Brown curryfish	H/M												Noted [6]

[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; [6] noted under main wharf at Sideia; B-S transects= broad-scale transects; RFs = reef-front search; MOPs = mother-of-pearl search; Ds = sea cucumber day search.

Table 4.11: Sea cucumber species records for Sideia (continued)

Species	Common name	Commercial value [5]	B-S transects n = 73			Reef-benthos stations n = 20			Other stations RFs = 4; MOPs = 4			Other stations Ds = 6		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Synapta spp.	-	-	0.7	25.0	3									
Thelenota ananas	Prickly redfish	H	0.2	16.7	1									
Thelenota anax	Amberfish	M				2.1	41.7	5	1.9	7.6	25 MOPs	7.9	15.9	50
Thelenota rubrolineata	Candy-cane fish	L										4.0	7.9	50

[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; [6] noted under main wharf at Sideia; B-S transects= broad-scale transects; RFs = reef-front search; MOPs = mother-of-pearl search; Ds = sea cucumber day search.

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Starfish (e.g. *Linckia laevigata*, the blue starfish) were moderately common (found in 44% of broad-scale transects) but not at high density. Other coralivore (coral eating) starfish were at moderate density, with thirty-one recordings of a pincushion star (*Culcita novaeguineae*) or rare, with just three crown of thorns (*Acanthaster planci*, COTS). There were six recordings of the doughboy sea star (*Choriaster granulatus*) but the horned or chocolate-chip star (*Protoreaster nodosus*) was absent.

4.4.8 Discussion and conclusions: invertebrate resources in Sideia

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 within the body of the invertebrate chapter.

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

- The sheltered inshore and more exposed barrier reefs at Sideia provided a range of habitats suitable for giant clams (Land-influenced reefs close to the shoreline suited the small species, *T. crocea.)*. A range of shallow-water reef environments extended to offshore patch reefs that were more oceanic-influenced.

- There was a complete range of giant clam species present at Sideia, some of which are becoming rare in other parts of the Pacific.

- Giant clam density at Sideia was moderately high for the more common, smaller species, e.g. *T. maxima*, and relatively high for larger species, which are more susceptible to fishing pressure, e.g. *T. squamosa* and *H. hippopus*. The largest species, *T. gigas* and *T. derasa*, were noted but at low density. This suggests that the fishery is only moderately impacted when compared with other regions of the Pacific, and recovery of the fishery should be more easily achieved through simple controls on fishing. Such controls would include protecting high-density areas and larger clams (Clams have both sexes in the same individual, but do not mature as females and produce eggs until they reach a large size.).

- *T. gigas*, the true giant clam, has been lost to many other lagoons in the Pacific but was still present at Sideia. This species was recorded both in large and smaller sizes. This is unusual, as successful breeding generally declines as numbers become depleted. This survey suggests there had still been recruitment of *T. gigas* around Sideia in recent years.

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

- Trochus (*Trochus niloticus*) at Sideia were rare and severely overfished. This statement is based on the scale of habitat available, the wide distribution but low density of trochus, the density of other grazing gastropods (e.g. *Tectus pyramis*) and evidence from meetings with trochus fishers, who continue to fish stocks for only 2–8 pieces per trip. Presence and density records suggest stocks are below the level at which commercial fishing is recommended and in need of protection to allow a recovery.

- No green snail was recorded during the survey.

- The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common at Sideia, which may encourage potential investments in aquaculture, but densities are not sufficient to encourage commercial fishing of shell other than to supply broodstock for hatchery culture.

Data on sea cucumbers suggest that:

- Considering the variety of suitable environments present at Sideia, the range of sea cucumber species recorded was not as extensive as may have been expected.
- Presence and density data collected in survey suggest that stocks have been under very high fishing pressure and are now at extreme levels of depletion.

- Sea cucumbers play an important role in 'cleaning' hard (limestone) and soft (sands and muds) benthic substrates. When these species are removed, there is the potential for detritus to build up, creating conditions that can promote the development of non-palatable algal mats (blue–green algae) or anoxic conditions (oxygen-poor areas unsuitable for life). The condition of reef and other benthic substrates around Sideia was notably 'dirty' compared to other places in the Pacific.

4.5 Overall recommendations for Sideia

- The community seek further assistance, either from NFA or NGOs to undertake under-water stock assessment and monitoring of major resource status. Results may be useful to establish community regulations on the various fisheries, in particular commercial harvesting of bêche-de-mer, trochus and others.

- Immediate fisheries management intervention actions be taken to reduce the current exploitation level, in particular on mangrove and reeftop fisheries.

- Spear diving be regulated and night spearfishing banned.

- Use of *tabu* areas be considered as a primary management measure.

- The giant clam fishery be controlled by protecting high-density areas and larger-sized clams.

- Trochus (*Trochus niloticus*) fishing needs to be urgently controlled to ensure there is a future for this fishery. Stock should be 'rested' from fishing for a medium term (5–10 years, or until densities at the major fishing areas recover to 500–600 per ha).

- Strict controls on sea-cucumber fishing be implemented to allow a medium- to long-term resting period to allow these important resource stocks to recover. Under the present stock status, commercial fishing needs to cease.

5. PROFILE AND RESULTS FOR PANAPOMPOM

5.1 Site characteristics

Panaeati-Panapompom (Figure 5.1) is an atoll-like formation that can be reached in two hours by dinghy from Misima. Panapompom is a high island in the centre of a large lagoon system. The main settlement of Panaeati lies on the northern border of the lagoon and is another high island. The population of both islands is around 3000–3500 people and the main income sources are copra, bêche-de-mer, trochus shells, and betel nut. In the past, reef fish were sold to the mine workers in Misima, but the mine closed down in 2004. Bêche-de-mer is a big income earner for the community and fishing for sea cucumbers covers an extensive area, extending as far as the remote uninhabited atolls. The islanders also trade sailing canoes with other islanders in the area and are well-known for their pigs.

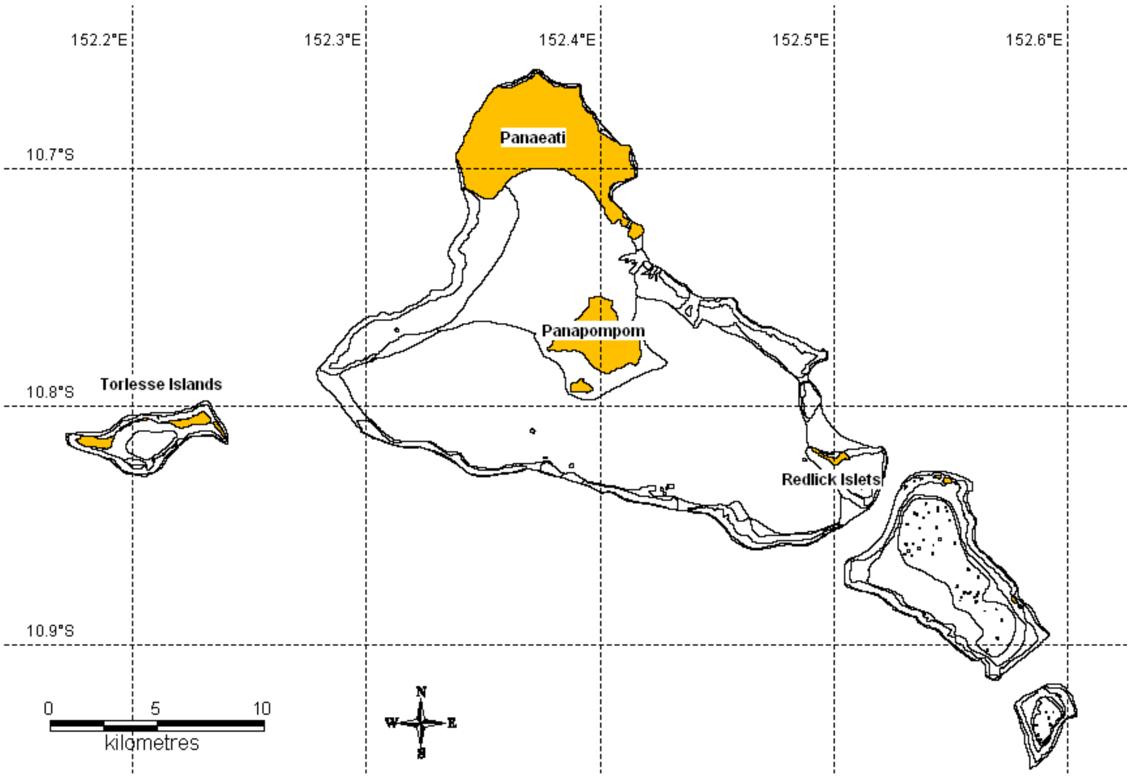

Figure 5.1: Map of Panapompom.

The rest of the system very much resembles an atoll system, with some small, low sand islands on the encircling barrier reef. Intermediate reefs were rare in the lagoon, although some patches could be found on the generally sandy bottom. Currents were present throughout the lagoon. The barrier reef was not rich in coral. The back-reef was on the whole made up of sand, and the reeftops were covered in rubble and boulder habitat. The reef crests were also not complex, although the reef fronts were complex and rich in coral. The reef fronts were generally walls, which dropped off steeply rather than sloping into shoal habitat. There were numerous shallow and deep passages linking the lagoon to the open ocean, with pavement, coral-rich benthos, coral garden and rubble habitats.

5.2 Socioeconomic surveys: Panapompom

Socioeconomic fieldwork was carried out on Panapompom, located in Milne Bay Province in November 2006. Panapompom, as common to Milne Bay Province in general, is a high island with rich agricultural potential.

Panapompom is a Ward on its own. In addition there is Panaeati, administratively comprising a northern and a southern Ward. People from the southern Ward frequently use the passage and lagoon area of Panapompom. Thus, both Panapompom and the southern Ward of Panaeati were included in the socioeconomic survey, with two-thirds of interviews conducted on Panapompom and one-third on Panaeati.

In total, 30 households were surveyed, which included 144 people, representing 43% of the total number of households (70) and population (336) on the island.

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 31 individual interviews of finfish fishers (27 males, 4 females) and 30 invertebrate fishers (24 males, 6 females) were conducted. These fishers belonged to one of the 30 households surveyed. Sometimes, the same person was interviewed for both finfish fishing and invertebrate harvesting.

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

Our survey results (Table 5.1) suggest an average of 2–3 fishers per household. If we apply this average to the total number of households, we arrive at a total of 194 fishers on Panapompom. Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of 16 males and 5 females who only go finfish fishing and another two males and two females who exclusively collect invertebrates. However, the majority of all fishers (82 males, 86 females) do both finfish fishing and invertebrate collection, although not necessarily at the same time.

Almost two-thirds of all households on Panapompom have a boat. Most (94%) are non-motorised paddling or sailing canoes, and only very few boats have an outboard engine (4%).

Ranked income sources (Figure 5.2) highlight the fact that fishing is the most important income source for people on Panapompom. Forty-three per cent of all households reported that fishing provides first income and 33% that fishing is a secondary income source. Other sources, mainly handicrafts, are second in importance, i.e. 27% of all households consider these as first and 40% as second revenue. Agriculture supplies 20% of all households and salaries another 13% of all households with first income. The average annual household expenditure level is low, USD ~468 /household/year, suggesting that people on Panapompom are among the most self-sufficient communities surveyed in Papua New Guinea. Remittances are insignificant and only very few households receive small amounts of money from their relatives at times. On average, these small amounts total USD ~88 /year for households that receive these payments.

The importance of fisheries shows further in the fact that all households eat fresh and canned fish and most (97%) also eat invertebrates. Almost all households also confirmed that, normally the fresh fish and invertebrates they eat are caught by somebody from the household, or are received as a gift from a family or community member. Only in very rare cases (~10–13% of all responses) are fresh fish and invertebrates bought. These figures highlight the high dependency on reef and lagoon resources for protein, but also the high level of self-sufficiency, as well as the strong social network among community members and families on Panapompom.

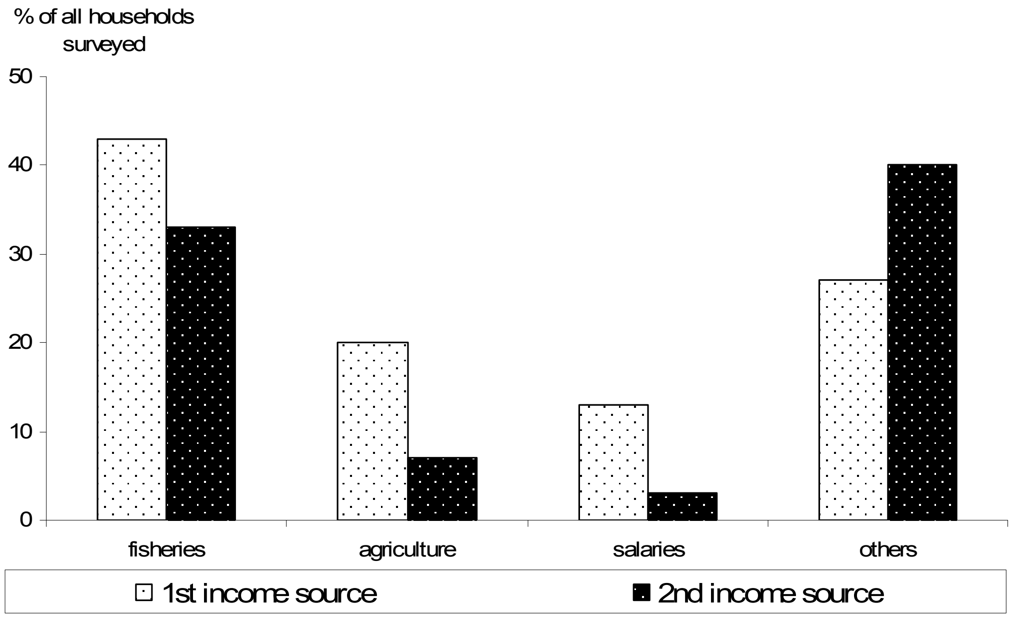

Figure 5.2: Ranked sources of income (%) in Panapompom.
Total number of households = 30 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses.

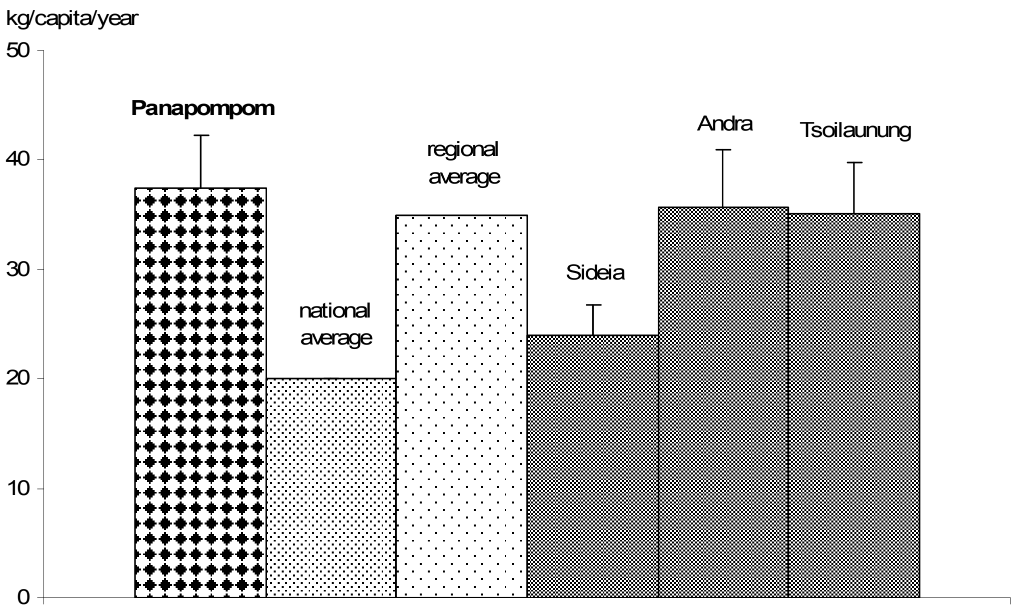

Figure 5.3: Per capita consumption (kg/year) of fresh fish in Panapompom (n = 30) compared to the national (DFMR 1993) and regional (FAO 2008) averages and the other three PROCFish/C sites in Papua New Guinea.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

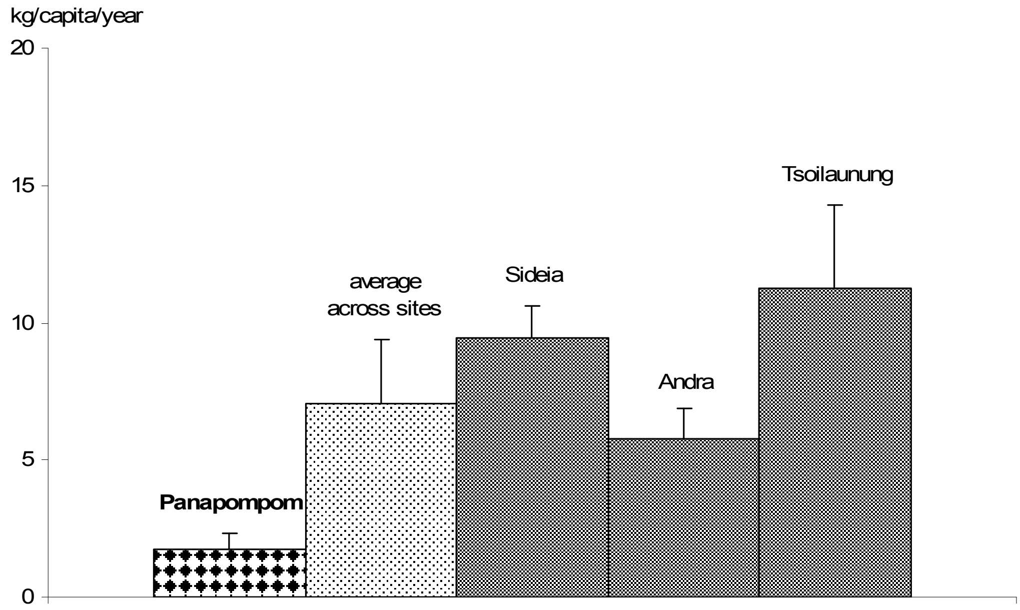

Figure 5.4: Per capita consumption (kg/year) of invertebrates (meat only) in Panapompom (n = 30) compared to the other three PROCFish/C sites in Papua New Guinea.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Fresh fish consumption (~37.4 ±4.9 kg/person/year) on Panapompom is above the regional average (FAO 2008), one of the highest among the PROCFish sites surveyed in Papua New Guinea (Figure 5.3) and significantly higher than the average consumption determined nationwide (DFMR 1993). The consumption of invertebrates (meat only) is ~1.8 ±0.54 kg/person/year (Figure 5.4) and the lowest of all PROCFish sites in Papua New Guinea. Although most people eat canned fish, they do so infrequently and in small amounts (about once a fortnight, 2.7 kg/person/year). Compared to the average across all sites surveyed in the country, this is one of the lowest consumption rates of canned fish (Table 5.1).

Comparison of results among all sites investigated in Papua New Guinea (Table 5.1) shows that people on Panapompom are less dependent than average upon fisheries for income and more dependent than average on agriculture. The Panapompom community eats more fresh fish than average, and more often, but less invertebrates and canned fish, and these also less often than average. The average household expenditure level on Panapompom is extremely low, and well below the average across all four PROCFish sites, suggesting a very high self-sufficiency level in primary produce, and confirming the rich agricultural potential of this high island. Remittances do not play any role on Panapompom, or at any other sites surveyed in Papua New Guinea.

Table 5.1: Fishery demography, income and seafood consumption patterns in Panapompom

Survey coverage	Site (n = 30 HH)	Average across sites (n = 120 HH)
Demography		
HH involved in reef fisheries (%)	100.0	100.0
Number of fishers per HH	2.77 (±0.28)	2.65 (±0.13)
Male finfish fishers per HH (%)	8.4	9.1
Female finfish fishers per HH (%)	2.4	1.9
Male invertebrate fishers per HH (%)	1.2	0.9
Female invertebrate fishers per HH (%)	1.2	0.6
Male finfish and invertebrate fishers per HH (%)	42.2	40.6
Female finfish and invertebrate fishers per HH (%)	44.6	46.9
Income		
HH with fisheries as 1st income (%)	43.3	53.3
HH with fisheries as 2nd income (%)	33.3	32.5
HH with agriculture as 1st income (%)	20.0	9.2
HH with agriculture as 2nd income (%)	6.7	18.3
HH with salary as 1st income (%)	13.3	13.3
HH with salary as 2nd income (%)	3.3	3.3
HH with other source as 1st income (%)	26.7	26.7
HH with other source as 2nd income (%)	40.0	25.0
Expenditure (USD/year/HH)	467.95 (±68.57)	982.39 (±80.23)
Remittance (USD/year/HH) (1)	87.78 (±19.49)	110.91 (±16.64)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	37.39 (±4.91)	33.03 (±2.29)
Frequency fresh fish consumed (times/week)	2.78 (±0.26)	3.34 (±0.14)
Quantity fresh invertebrate consumed (kg/capita/year)	1.77 (±0.54)	7.07 (±2.29)
Frequency fresh invertebrate consumed (times/week)	0.77 (±0.08)	1.49 (±0.10)
Quantity canned fish consumed (kg/capita/year)	2.70 (±0.93)	5.64 (±0.66)
Frequency canned fish consumed (times/week)	0.53 (±0.23)	0.93 (±0.11)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	96.7	99.2
HH eat canned fish (%)	100.0	97.5
HH eat fresh fish they catch (%)	100.0	100.0
HH eat fresh fish they buy (%)	13.3	20.0
HH eat fresh fish they are given (%)	93.3	86.7
HH eat fresh invertebrates they catch (%)	96.7	100.0
HH eat fresh invertebrates they buy (%)	10.0	0.0
HH eat fresh invertebrates they are given (%)	90.0	63.3

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

5.2.2 Fishing strategies and gear: Panapompom

Degree of specialisation in fishing

Fishing on Panapompom is performed by both males and females (Figure 5.5). However, very rarely do male or female fishers specialise in only one fishery but most fish for both finfish and invertebrates.

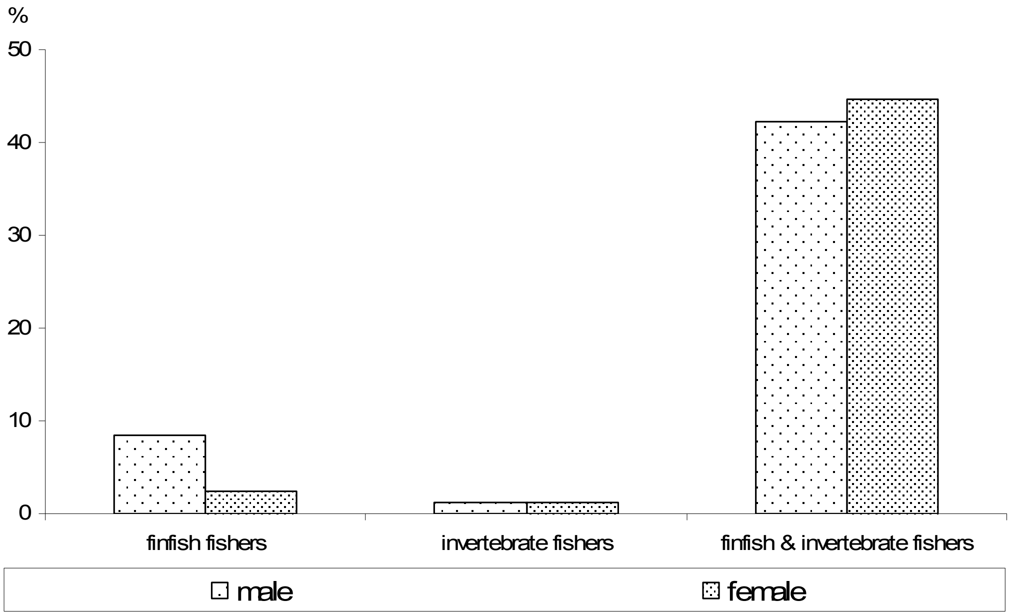

Figure 5.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Panapompom.
All fishers = 100%.

Targeted stocks/habitat

Table 5.2: Proportion (%) of male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Panapompom

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	25.9	25.0
	Lagoon	88.9	100.0
	Lagoon & outer reef	3.7	0.0
	Outer reef	51.9	25.0
Invertebrates	Reeftop	16.7	0.0
	Soft benthos	4.2	0.0
	Soft benthos & mangrove	4.2	0.0
	Soft benthos & reeftop	4.2	66.7
	Soft benthos & intertidal	0.0	33.3
	Mangrove	4.2	0.0
	Mangrove & intertidal	4.2	0.0
	Bêche-de-mer	91.7	16.7
	Lobster	37.5	0.0
	Trochus	58.3	0.0

Finfish fisher interviews, males: n = 27; females: n = 4. Invertebrate fisher interviews, males: n = 24; females: n = 6.

While male and female fishers are similar in that they both target the sheltered coastal reef less than the lagoon, male fishers' participation in outer-reef fishing is double that of female fishers. Gender differences are much more apparent in invertebrate fisheries. Males very rarely collect in soft-benthos, intertidal, reeftop or mangrove habitats. Males on Panapompom engage in commercial fisheries, mainly the bêche-de-mer fishery, followed by the trochus and lobster fisheries. Females, on the other hand, mainly target the combined soft-benthos and reeftop areas, or soft-benthos and intertidal areas for gleaning. The proportion of females on Panapompom who participate in the bêche-de-mer fishery is relatively small (Table 5.2).

Fishing patterns and strategies

The combined information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip is the basic factor used to estimate the fishing pressure imposed by people from Panapompom on their fishing grounds (Tables 5.2 and 5.3).

Our survey sample suggests that fishers on Panapompom have the choice among sheltered coastal reef, lagoon and outer-reef fishing. However, reeftop, mangrove, soft-benthos and, to a lesser extent, intertidal areas are the main habitats that support invertebrate fisheries on Panapompom (Figure 5.6). Gender participation shows that females dominate the gleaning fisheries but do not participate much in the collection of bêche-de-mer. Females do not engage in trochus or lobster diving (Figure 5.7).

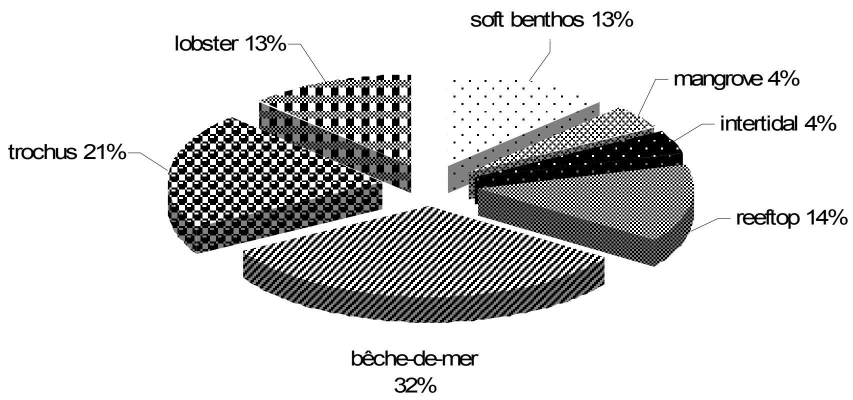

Figure 5.6: Proportion (%) of fishers targeting the seven primary invertebrate habitats found in Panapompom.
Data based on individual fisher surveys; data for combined fisheries are disaggregated.

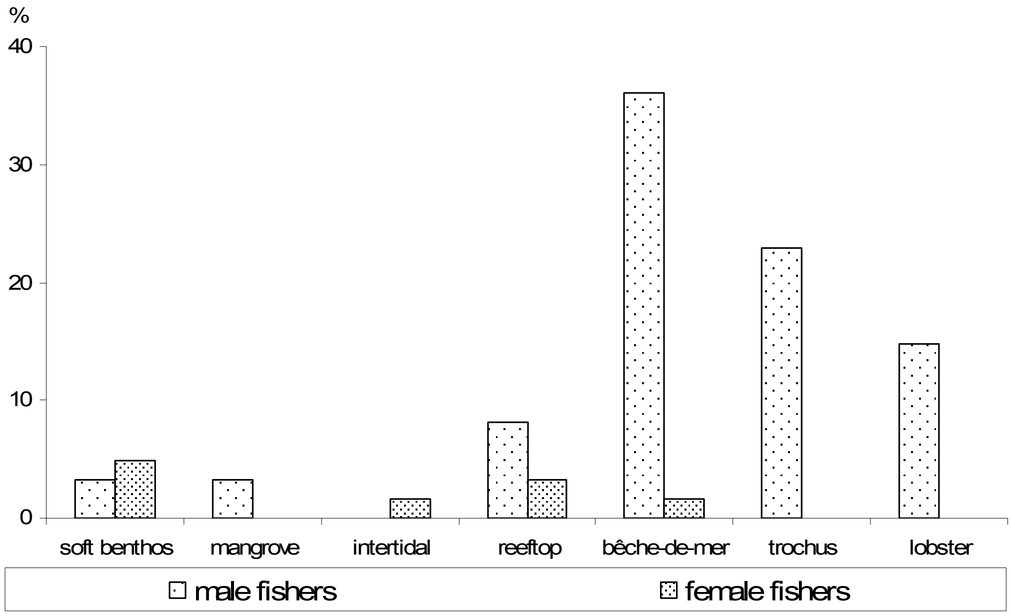

Figure 5.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Panapompom.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers who target each habitat: n = 24 for males, n = 6 for females.

Gear

Figure 5.8 shows that fishers on Panapompom use mainly handlines to catch fish in the sheltered coastal reef area. Handlines are complemented by the use of trolling or deep-bottom lines in any of the other habitats, including the lagoon, the outer reef, and the lagoon and outer reef combined during the same fishing trip. Fishing on Panapompom always involves the use of a non-motorised paddling or sailing canoe; rarely do fishers venture out by walking. Only mangrove areas are visited without a boat. All other invertebrate collection trips require paddling or sailing canoes.

Gleaning and free-diving for invertebrates is done using very simple tools only. Reeftop gleaning is usually done by walking during low tide and mostly during the day on the dried reef flats that have been reached by paddling canoe. Edible gastropods or other invertebrates are picked up by hand, and mask, snorkel and fins are used for free-diving. Knives or sometimes a speargun are used to catch giant clams, octopus or lobsters. The periodical bêche-de-mer fishery includes two different approaches. Females and males collect in the shallow water by hand, using canoes to bring back their catch to shore on a daily basis. Also, groups of fishers may establish camp over a couple of weeks in uninhabited areas or on atolls where they harvest and process bêche-de-mer continuously. In addition, bêche-de-mer and trochus are collected at the outer reef. Trochus is collected by free-diving using mask, snorkel and fins.

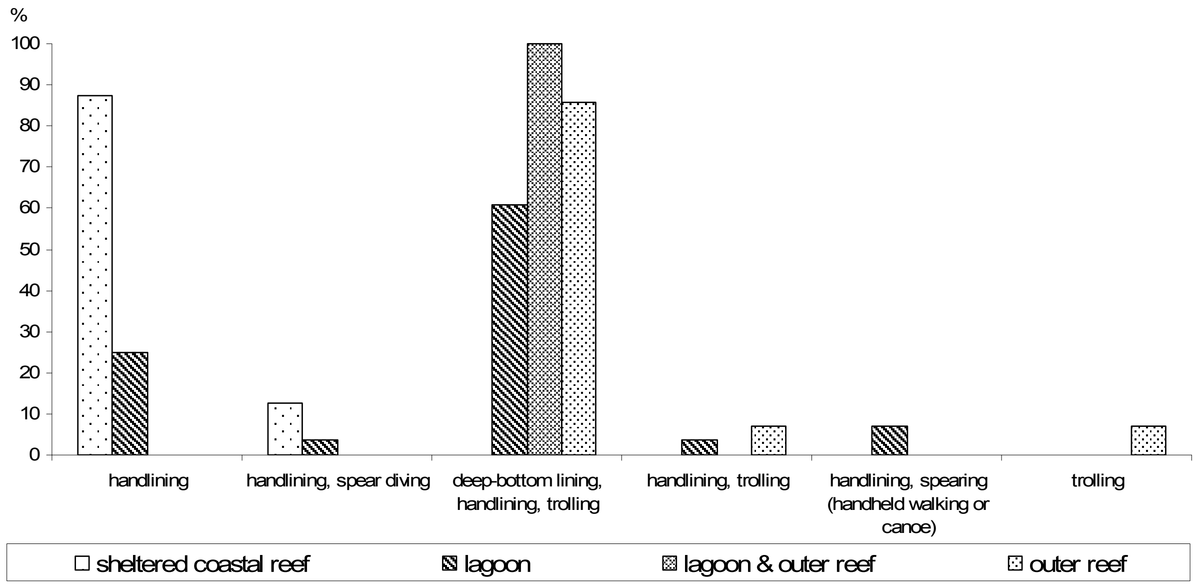

Figure 5.8: Fishing methods commonly used in different habitat types in Panapompom. Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Frequency and duration of fishing trips

As shown in Table 5.3, the frequency of fishing trips made by male and female fishers on Panapompom is usually 1–2 times/week. An average trip lasts 5–6.5 hours. The longest trips are made by males to the outer reef. The frequency of invertebrate fishing trips is similar (1–2 times/week). However, bêche-de-mer collection is done more frequently during the open season; the average frequency of 3–4 times/week also includes the camping trips. Compared to finfish fishing trips, invertebrate collection trips are shorter. On average, gleaning trips take ~2–2.5 hours. Diving trips for trochus and lobster are longer (3–6 hours). Also, bêche-de-mer collection trips may take up to 8 hours, i.e. the whole day.

Females mainly prefer fishing during the day. Males, on the other hand, mainly catch finfish according to the tide. At least half of all male fisher respondents stated that they target the lagoon and outer reef either at day or at night, depending on tidal conditions. With the exception of bêche-de-mer and lobsters, all other invertebrates are collected during the day. Most (74%) of all bêche-de-mer fishers collect according to tidal conditions, i.e. either during the day or night. All lobster fishers fish at night.

Finfish fishing is mostly done throughout the year. Only about 15% of all fishers reported not being able to visit the outer reef if weather and sea conditions are unfavourable. Most invertebrate fisheries are performed continuously during the year. Bêche-de-mer is subject to the governmental (NFA) open season (usually 6 months, from mid-January to mid-July) and the decision of the community leaders' group. Lobsters are caught during two months of the year only, and reeftop gleaning is also subject to interruptions throughout the year.

Table 5.3: Average frequency and duration of fishing trips reported by male and female fishers in Panapompom

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	2.36 (±0.42)	1.00 (n/a)	4.93 (±0.71)	5.00 (n/a)
	Lagoon	1.25 (±0.11)	1.13 (±0.13)	5.19 (±0.34)	4.50 (±0.96)
	Lagoon & outer reef	1.50 (n/a)	0	10.00 (n/a)	0
	Outer reef	0.75 (±0.11)	0.46 (n/a)	6.27 (±0.53)	7.00 (n/a)
Invertebrates	Reeftop	0.81 (±0.19)	0	1.63 (±0.13)	0
	Soft benthos	1.00 (n/a)	0	2.50 (n/a)	0
	Soft benthos & reeftop	0.23 (n/a)	1.25 (±0.25)	3.00 (n/a)	2.38 (±0.13)
	Soft benthos & intertidal	0	1.50 (±0.50)	0	2.00 (±0.50)
	Soft benthos & mangrove	1.00 (n/a)	0	1.50 (n/a)	0
	Mangrove	1.00 (n/a)	0	3.00 (n/a)	0
	Mangrove & intertidal	0.23 (n/a)	0	2.00 (n/a)	0
	Bêche-de-mer	3.41 (±0.20)	3.00 (n/a)	8.23 (±0.38)	5.00 (n/a)
	Lobster	3.03 (±0.61)	0	2.83 (±0.14)	0
	Trochus	0.89 (±0.07)	0	5.68 (±0.38)	0

Figures in brackets denote standard error; n/a = standard error not calculated.
Finfish fisher interviews, males: n = 27; females: n = 4. Invertebrate fisher interviews, males: n = 24; females: n = 6.

5.2.3 Catch composition and volume – finfish: Panapompom

The catch composition reported from the sheltered coastal reef is diverse. However, there are a few species groups that dominate, including Lutjanidae (*Lutjanus gibbus*, *Symphorus nematophorus*, *Symphorichthys spilurus*, *L. bohar*, *L. kasmira*, *Aprion virescens*, *L. quinquelineatus*), which alone account for 50% of the reported catch, *Rhinecanthus* sp. (~ 7%) and *Pentapodus paradiseus* (~6% of the reported catch by weight).

Reported lagoon catches are more diverse but, again, are dominated by Lutjanidae (accounting for 43% of the reported catch), Lethrinidae (~17%), Serranidae (~8%) and Carangidae (~5%).

The reported outer-reef catches include over 30 vernacular names. The proportion of Lutjanidae is significant but less as compared to the reported catch from the sheltered coastal reef and lagoon, i.e. ~32%. Another 15% of the reported catch by weight is accounted for each by Scombridae and Carangidae (Details are provided in Appendix 2.4.1.).

Our survey sample of finfish fishers interviewed represents ~16% of the projected total number of finfish fishers on Panapompom. Although the group of fishers interviewed includes both commercial and subsistence fishers, the limited sample size may jeopardise extrapolation of survey results. Accordingly, caution is advised in using the extrapolated figures given here to estimate the total annual fishing pressure imposed by the people of Panapompom on their fishing ground. The survey showed that Panapompom people are highly dependent on reef fisheries for income and most of their catch is sold. This shows also in Figure 5.9, where the share of catch required to satisfy the community's subsistence needs accounts for only 17% of the total catch. Females' contribution to the total annual catch is small (10%). This may be due to the fact that most females mainly catch for food rather than for sale. Most of the catch is sourced from the lagoon (~49% of the total reported catch), followed by the outer reef (~37%); least is taken from the sheltered coastal reef. The proportion of females' catches from the lagoon, which is the most targeted area and where the fishing is mainly for the family's daily meals, represents about 8% only.

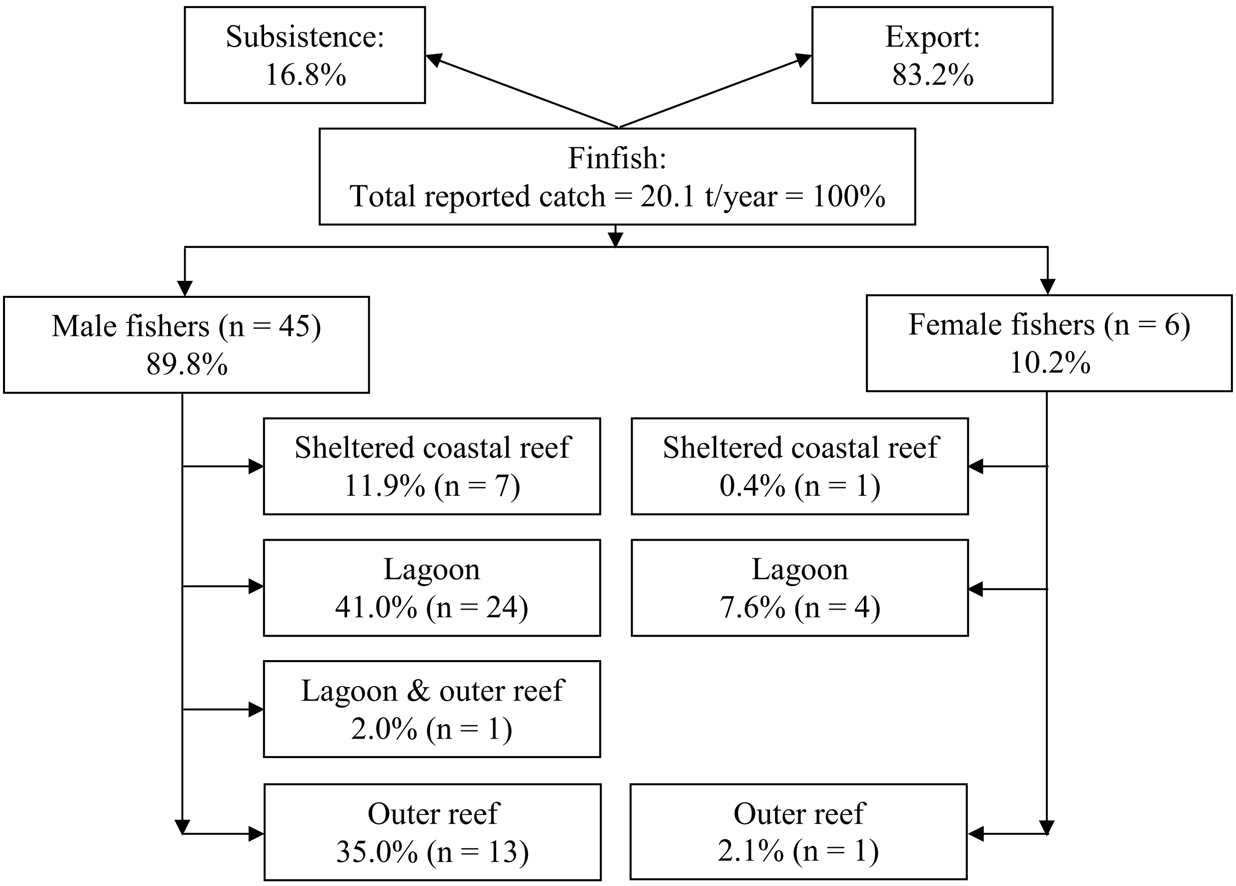

Figure 5.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Panapompom.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

As shown in Figure 5.9, the minor share (17%) of impact is due to the demand imposed by the population of Panapompom on its reef resources, while most (83%) impact is determined by external demand.

The differences in impact on the various habitats is more a question of the number of fishers targeting each area rather than substantial differences in the average annual catch rates. As shown in Figure 5.10, there are no major differences in catch rates between female and male finfish fishers except for the sheltered coastal reef. However, this difference may be simply due to the small sample size (n = 1) for female fishers. The highest fluctuation in average annual catches is reported between male fishers' catches from the sheltered coastal reef (~300 kg/fisher/year) and the outer reef (~550 kg/fisher/year).

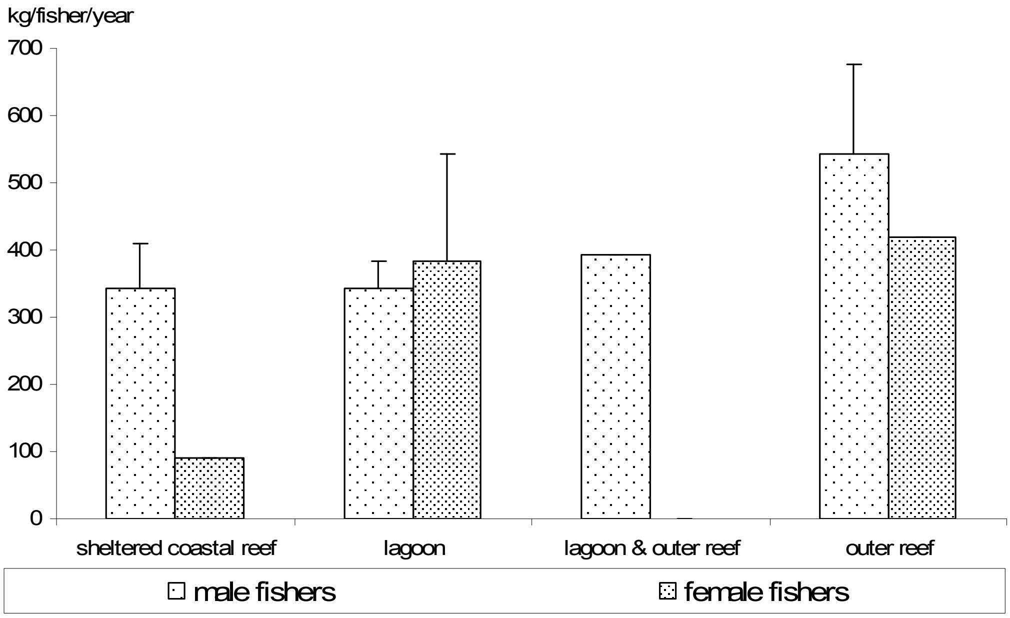

Figure 5.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Panapompom (based on reported catch only).

Comparing CPUEs shown for Panapompom fishers in Figure 5.11, the higher catches for male fishers at the outer reef seem to be explained by the much higher productivity rates (~3.5 kg/hour of fishing trip) achieved here. The lowest CPUE figures are for the sheltered coastal reef (<1 kg/hour fished); lagoon productivity is less than half that of the outer reef. Figure 5.11 also shows that CPUE does not vary significantly between genders.

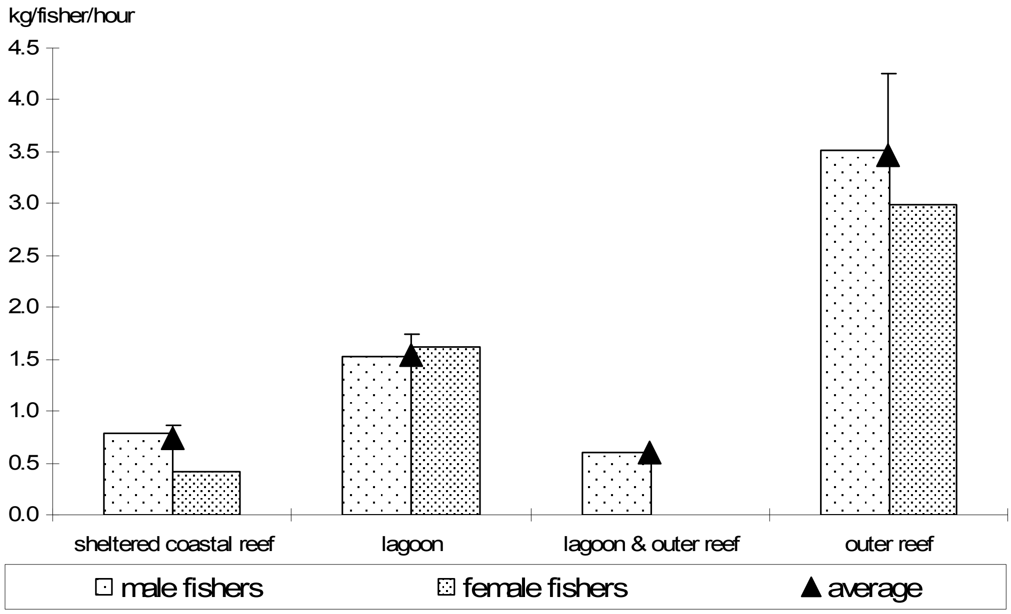

Figure 5.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Panapompom.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

The overall high interest in commercial fishing shows when comparing data on the objectives of fishing trips provided by respondents (Figure 5.12). The interest in fishing for sale increases substantially from the sheltered coastal reef to the lagoon and outer reef. Figure 5.12 also highlights the importance of sharing catch on a non-commercial basis as this objective is as important (if not more so) as catching for the household's own needs.

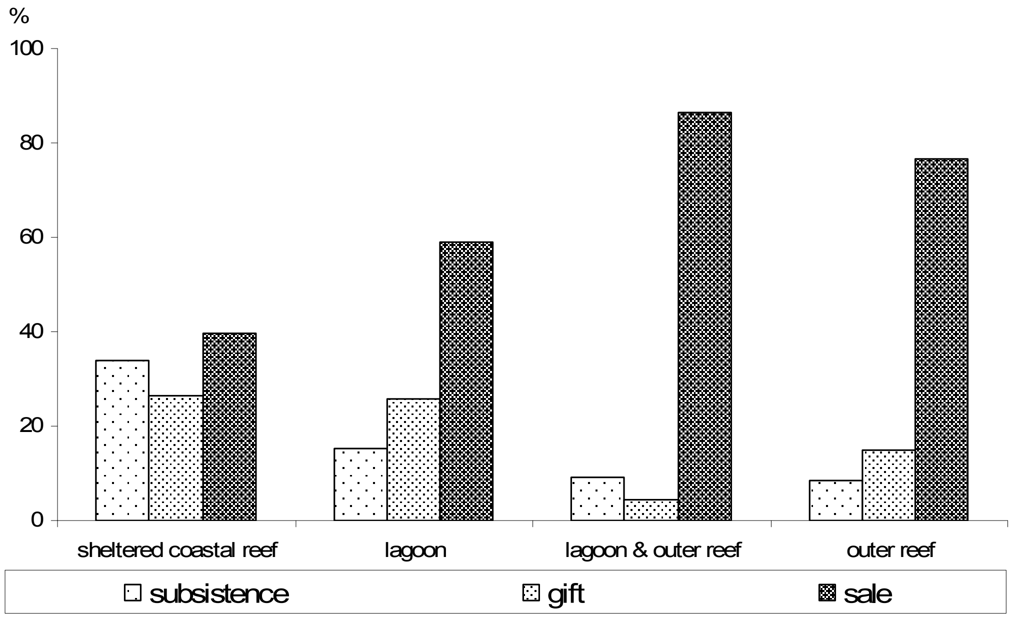

Figure 5.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Panapompom.
Proportions are expressed in % of the total number of trips per habitat.

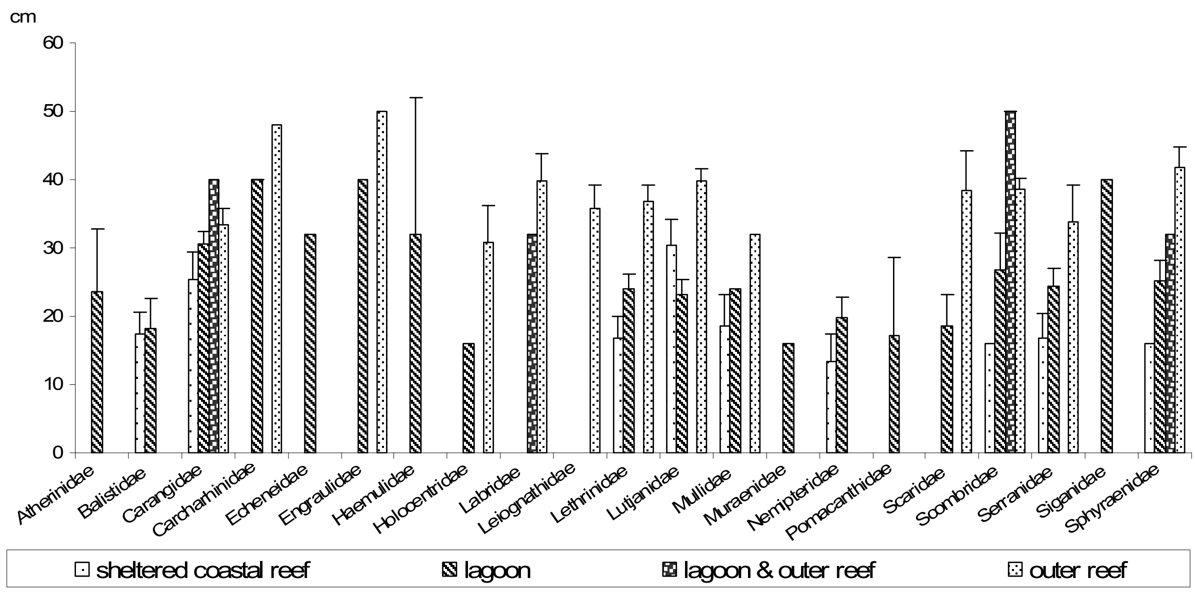

Figure 5.13: Average sizes (cm fork length) of fish caught by family and habitat in Panapompom.
Bars represent standard error (+SE).

Data on the average reported finfish sizes by family and habitat as shown in Figure 5.13 shows a great variability in fish size by family. As expected, average fish size increases in catches reported from the sheltered coastal reef to the lagoon and the outer reef. Generally, average fish sizes reported for catches from the sheltered coastal reef are smallest (~15 cm), while fish sizes in lagoon catches are 15–30 cm, and ≥ 30 cm in outer-reef catches. Only in the case of Lutjanidae, fish size dropped from 30 cm in sheltered coastal reef catches to ~20 cm in lagoon catches. The average size of Lutjanidae at the outer reef was, however, the longest, with 40 cm.

Some parameters selected to assess the current fishing pressure on Panapompom reef resources are shown in Table 5.4. Fishing pressure is compared among sheltered coastal reef, lagoon and outer reef, as well as total reef area versus total fishing ground area. The latter includes reef and lagoon or soft-benthos habitats. The surface areas of the three main habitats targeted by fishers vary substantially. The sheltered coastal reef is the smallest (~15 km^2); the outer reef is double that size (~30 km^2). The lagoon covers the largest area (~44 km^2), which is also targeted by most fishers. Because of the relation among habitat size, number of fishers and total population, all indicators calculated to assess current fishing pressure are low. This result is not influenced by the fact that catch rates are about 1.5 times higher at the outer reef than at the other two habitats fished. Total fishing pressure due to Panapompom's subsistence needs is very low (0.1–0.2 t/km^2). This estimate does not change even if the proportion of commercial catches is taken into account, i.e. ~83% of the total annual catches. Fishing pressure, calculated for the total reef and total fishing ground areas, and total annual catch both remain low, 0.6–1.8 t/km^2.

Table 5.4: Parameters used in assessing fishing pressure on finfish resources in Panapompom

Parameters	Habitat					
	Sheltered coastal reef	Lagoon	Lagoon & outer reef	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	15.16	192.60	n/a	36.71	82.57	244.48
Density of fishers (number of fishers/km^2 fishing ground) (1)	2	1		1	2	1
Population density (people/km^2) (2)					4	1
Average annual finfish catch (kg/fisher/year) (3)	310.95 (±65.92)	349.35 (±40.31)	392.88 (n/a)	533.51 (±123.37)		
Total fishing pressure of subsistence catches (t/km^2)					0.1	0.0
Total number of fishers	30	112	2	45	189	189

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 = 336; total number of fishers = 189; total subsistence demand = 11.8 t/year; (3) catch figures are based on recorded data from survey respondents only.

5.2.4 Catch composition and volume – invertebrates: Panapompom

Calculations of the recorded annual catch rates per species groups are shown in Figure 5.14. The graph shows that the major impact by wet weight of fishing pressure imposed by collectors on Panapompom invertebrate resources is determined by bêche-de-mer fisheries, in particular four species: *Holothuria fuscogilva*, *H. fuscopunctata*, *Thelenota ananas*, and *H. nobilis.* No other species collected make any significant contribution to the reported catch by wet weight (Detailed data are provided in Appendices 2.4.2 and 2.4.3.).

In summary, the total impact of gleaning and subsistence collection is negligible when compared to the total catch of commercial bêche-de-mer species.

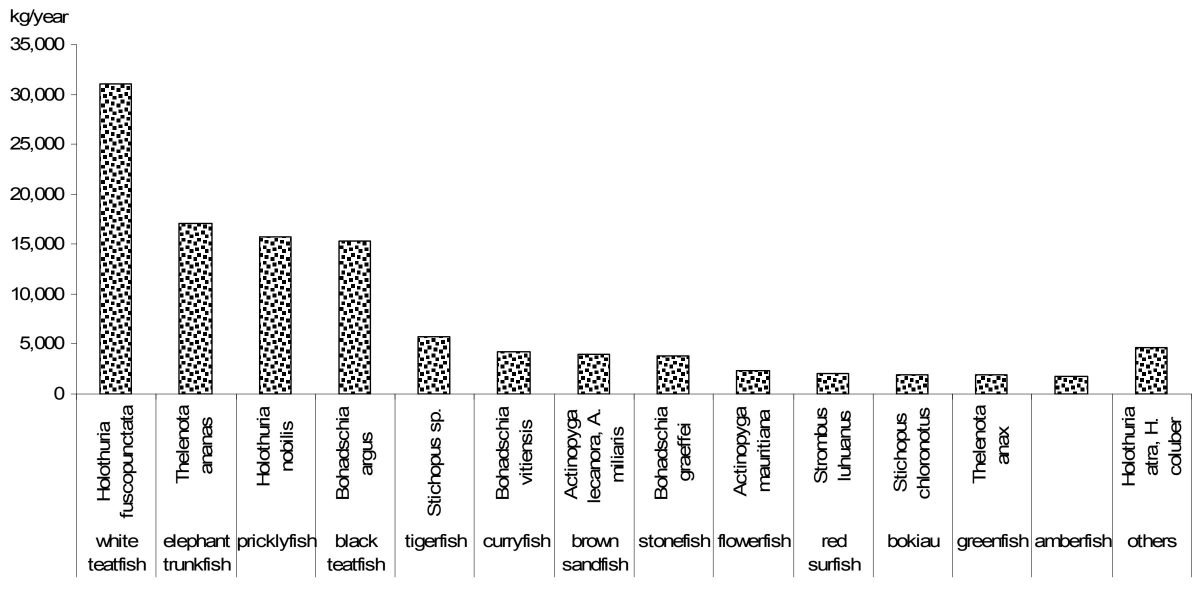

Figure 5.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Panapompom.

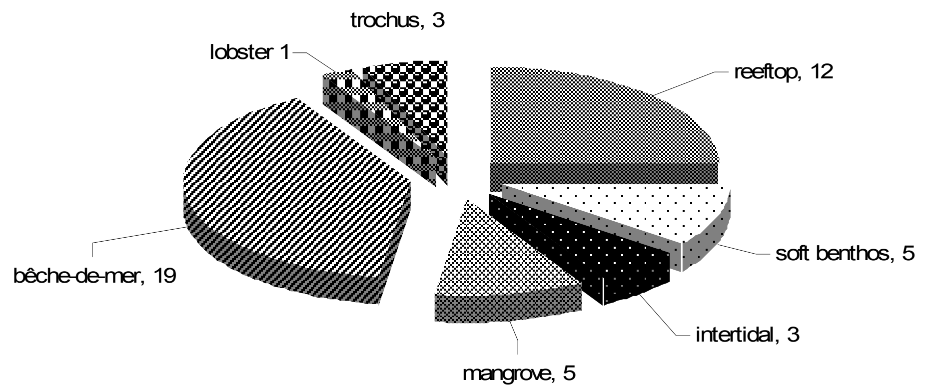

Figure 5.15: Number of vernacular names recorded for each invertebrate fishery in Panapompom.

As stated earlier, invertebrate fisheries on Panapompom are conducted in a wide variety of habitats. The highest number of vernacular names was recorded for the most important fishery, i.e. bêche-de-mer. Otherwise, a higher diversity of target species as expressed in vernacular names was reported only for reeftop gleaning (Figure 5.15).

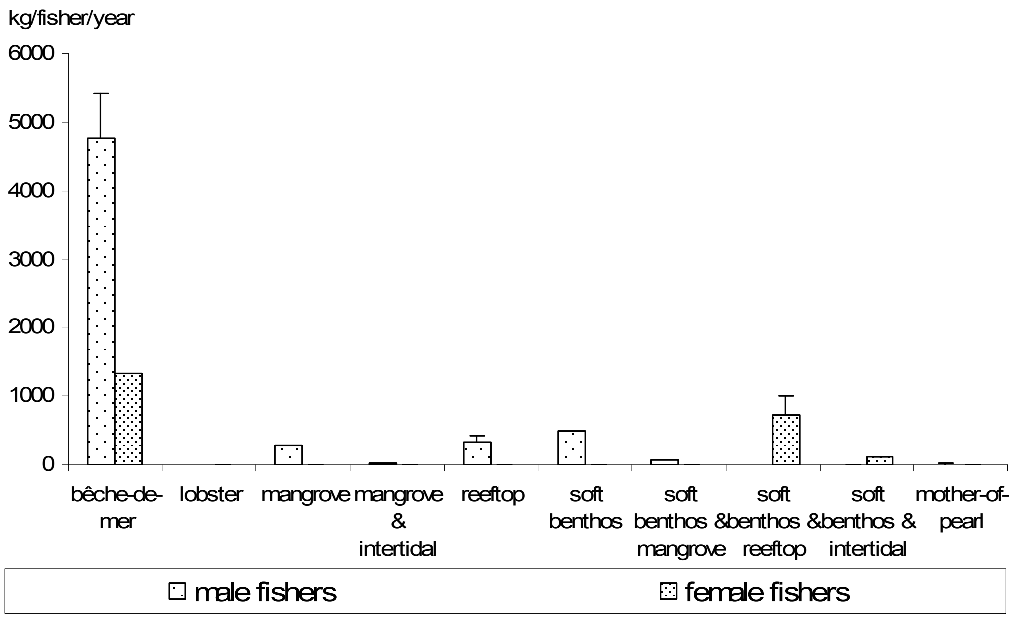

Figure 5.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Panapompom.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 24 for males, n = 6 for females).

Figure 5.16 shows that the productivity of male and female fishers engaged in subsistence fisheries is low. Females targeting the soft benthos reach the highest yields with an average of about 900 kg/fisher/year. Substantial catch rates are only reported for male bêche-de-mer fishers, who reported a harvest of ~5000 kg/fisher/year wet weight. Because females do not participate much in bêche-de-mer fishing, the sample size is limited. Thus, no comparison is made of catch rates between male and female bêche-de-mer fishers.

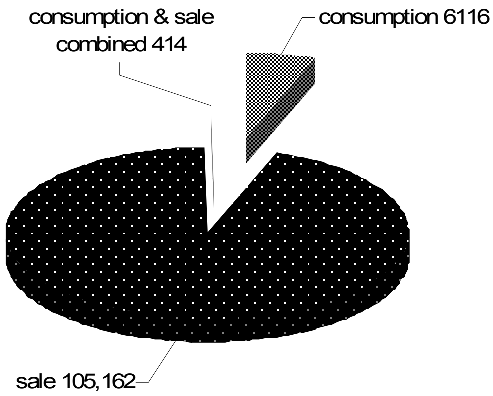

Figure 5.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Panapompom.

As shown in Figure 5.17, the proportion of invertebrates caught for subsistence purposes is insignificant, accounting for about 6% of the total annual biomass reported for sale. The high proportion of biomass reported for sale is mainly from the bêche-de-mer fishery.

Table 5.5: Parameters used in assessing fishing pressure on invertebrate resources in Panapompom

Parameters	Fishery / Habitat									
	Bêche-de-mer (3)	Lobster (4)	Mangrove	Mangrove & intertidal	Reeftop	Soft benthos	Soft benthos & mangrove	Soft benthos & reeftop	Soft benthos & intertidal	Trochus (5)
Fishing ground area (km^2)	11.47	99.29	n/a	n/a	11.47	n/a	n/a	n/a	n/a	17.19
Number of fishers (per fishery) (1)	92	32	3	3	14	3	3	63	30	49
Density of fishers (number of fishers/km^2 fishing ground)	8	0.3	n/a	n/a	1	n/a	n/a	n/a	n/a	3
Average annual invertebrate catch (kg/fisher/year) (2)	4,616.49 (±642.34)		268.82 (n/a)	19.92 (n/a)	337.70 (±93.41)	501.60 (n/a)	68.04 (n/a)	584.75 (±254.87)	113.25 (±9.02)	10.99 (±5.97)

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 surface considered only; (4) outside reef length (km); (5) outer-reef area considered only.

The parameters presented in Table 5.5 show high fisher densities for bêche-de-mer, the combined gleaning of soft benthos and reeftop, trochus and lobster fisheries. Taking into account the average annual reported catch per fisher, figures reported for bêche-de-mer are alarming as they exceed 4.6 t/fisher/year. There are no other average annual catches reported for any of the other fisheries that are considered as alarmingly high. However, the combination of a high fisher density for the combined harvesting of soft benthos and reeftop habitats and an average annual reported catch of ~585 kg/fisher also suggest that fishing pressure on these resources is high.

The total annual catch volume (expressed in wet weight based on recorded data from all respondents interviewed) amounts to 111.69 t/year (Figure 5.18). The graph supports two earlier observations. Firstly, that males are the main invertebrate fishers on Panapompom; females only contribute 4% of the total annual reported catch (wet weight). Secondly, the bêche-de-mer fishery accounts for 95% of all reported annual catch (wet weight); hence all other fisheries are relatively insignificant.

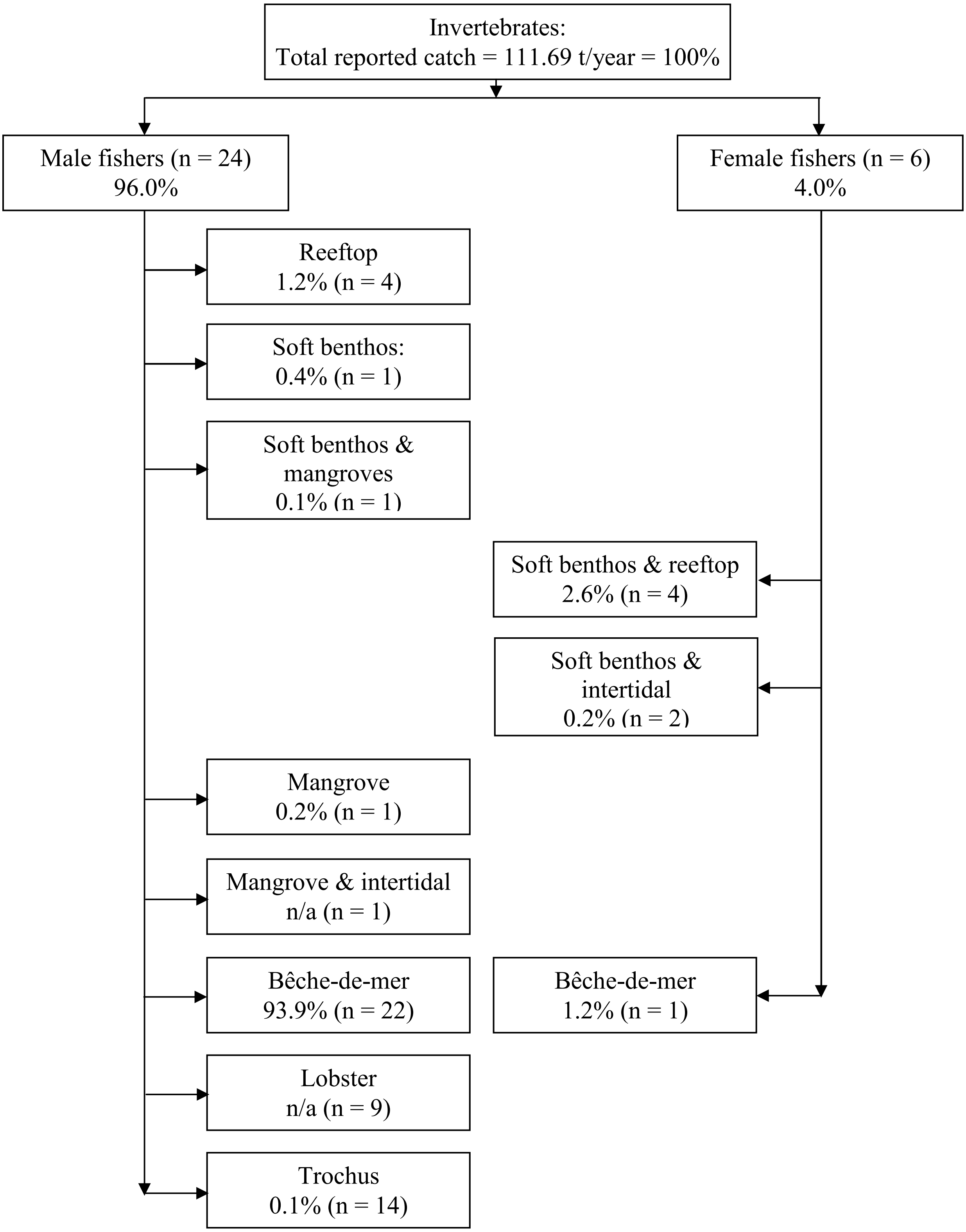

Figure 5.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Panapompom.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey; n/a = no information available.

Commercialisation

The commercial fisheries of fish and invertebrates mainly target the Misima town market. Access to the mainland Alotau or Misima is either provided by a local regular passenger/cargo ferry or sailing canoes. Only a few people, who work for the government and have a regular income, such as teachers, health extension officers, village policemen, etc., can afford to pay the ferry fee of PGK 140 return to Alotau, or PGK 80 return to Misima town. Most people prefer to sail there in their own canoe, free of charge. However, a return trip to Misima town takes about two days. Accordingly, the marketing frequency of Panapompom fishers is much lower than elsewhere. In general, marine produce is sold only once or twice every three months. Another limiting factor is that mangrove and other habitats are not extensive enough to provide enough surplus invertebrate catch for sale.

Finfish and bêche-de-mer can be sold to mobile buyers, who come to the Panapompom fishing ground and pay fishers directly, or fishers bring their catch to Alotau or Bwagaioa, Misima, to sell to established agents. Male fishers from Panapompom complained about the fact that mobile buyers and crews cheat local people, as they do not fully understand English or Topisin. Due to the long journey and expensive transport to the market, Panapompom fishers feel that they do not get enough money for their catches.

For the people on Panapompom, as on Sideia, subsistence gardening and bêche-de-mer fishing for income are the most important activities. During the bêche-de-mer fishing period, gardening is reduced to harvesting only.

Fisheries management

Information provided by local people suggests that most people comply with fisheries regulations. However, some fishers may still dive at night using torches to collect bêche-de-mer. Also, sometimes, the use of fish poison (*Derris derris*) is reported. It seems, nevertheless, that such activities are not that frequent. Non-compliance is usually not tolerated and is punished by the local authorities and village policemen.

5.2.5 Discussion and conclusions: socioeconomics in Panapompom

- Fisheries are the most important source of income for the people on Panapompom. Forty-three per cent of all households depend on fisheries for first income and another 33% of all households for second income. Other sources, mainly handicrafts, also play an important role as first (27%) and second (40%) income source. Agriculture supplies 20% of all households with first income and salaries 13%.

- Fisheries are an important source of protein, and fresh-fish consumption is among the highest of all PROCFish sites surveyed in the country. All households eat fresh and canned fish, and most also eat invertebrates. All households consume fish and seafood that is mainly caught by a member of the household or given by somebody else from the community but hardly ever bought.

- Fresh-fish consumption is relatively high (~37.4 kg/person/year) but invertebrate consumption is rather low (1.8 kg/person/year). The low canned-fish consumption confirms that purchased foods are limited and that people on the high island of Panapompom are highly self-sufficient in terms of food supply.

- Self-sufficiency in food supply, associated with a relatively low living standard also shows in the average household expenditure level, which is significantly lower than the average of all four PROCFish sites in Papua New Guinea.

- Finfish fishing is done by males and females; hardly any males or females specialise in finfish fishing or invertebrate collection alone.

- Females participate in fishing far less than males. Both genders target less the sheltered coastal reef, and mostly the lagoon; males also substantially target the outer reef. Sheltered coastal reef fishing mainly serves subsistence needs, while lagoon and outer-reef fishing is mostly commercially oriented. Invertebrate habitats, particularly mangroves, are limited and do not provide surplus catch for sale. Again, invertebrate fishing is mostly done by males, and the commercial bêche-de-mer fishery, which operates during the 6-month open season, accounts for ~95% of the total annual reported catch (wet weight). Most fishing is done using paddling canoes, but some sail canoes are also available.

- Various techniques are used for finfish fishing, mainly handlines in the sheltered coastal reef. Handlines are complemented by trolling or deep-bottom lines in any of the other habitats targeted, including the lagoon, outer reef or a combination of both during one fishing trip. Apparently, *Derris derris* fish poison is still used but not to a large extent.

- All the parameters calculated to assess the current finfish fishing pressure are low: fisher density, population density, subsistence and total annual catch per unit area.

- Invertebrates are collected for subsistence needs only and, overall, consumption is low. However, the commercial catches estimated for bêche-de-mer are substantial and considered the island's major income source.

- The calculated level of fishing pressure for bêche-de-mer fishery is alarmingly high and calls for immediate fisheries management interventions. Also, the exploitation level of soft benthos and reeftop fisheries is high and, if confirmed by the resource status assessment, also calls for immediate fisheries management interventions to reduce stress considerably.

Data collected and discussions held with people from Panapompom suggest that the island's reef and lagoon resources still provide a good basis for subsistence and income needs. Concerning the island's finfish resources, the estimated current fishing pressure is low and does not give any cause for alarm. If today's situation has not changed substantially as compared to the past, the geographical isolation of the island and the high transport cost, which limit marketing access, may be a possible explanation. Mobile buyers and boat crews who come to Panapompom to purchase finfish and bêche-de-mer from fishers are considered to often abuse the limited English and Topisin language capabilities of the local fishers.

The people interviewed stressed the importance of local finfish catches and agricultural produce for subsistence, and reported that the bêche-de-mer resource is the community's main income source. The differentiation between finfish and bêche-de-mer resources for nutrition and income may be another possible reason why the current finfish pressure is low. The number of people on Panapompom who benefit from government salaries is limited.

No information on the ongoing community-based or governmental project aiming to improve management of local fisheries resources is available. However, survey data suggest that the status of the finfish resource is healthy. The average finfish sizes reported increase with distance from the sheltered coastal reef to the lagoon and outer reef. Also, average annual catch rates and CPUEs support the finding that sheltered coastal reef fishing serves subsistence needs, while lagoon and outer-reef fishing is done to gain income. Most catch by weight is sourced from the lagoon. This is due to the number of fishers rather than the annual average catch rate. Fewer fishers with higher annual catch rates and higher CPUEs target the outer reef. The lower number of fishers targeting the outer reef is due to the fact that accessibility (mainly by paddling canoes) is subject to sea and weather conditions.

Bêche-de-mer catch rates are very high. The reported catch is mainly accounted for by only four species, which highlights the need to assess the detrimental effects of past and current harvesting. The fact that fishers no longer engage much in trochus fishing, and that the annual catches reported are insignificant, suggests that the resource has been depleted. Otherwise, trochus shells would offer a commercial commodity that is less sensitive than any fresh produce to infrequent marketing.

5.3 Finfish resource surveys: Panapompom

The island of Panapompom is located inside a lagoon system to the west of Misima Island (Figure 5.19).

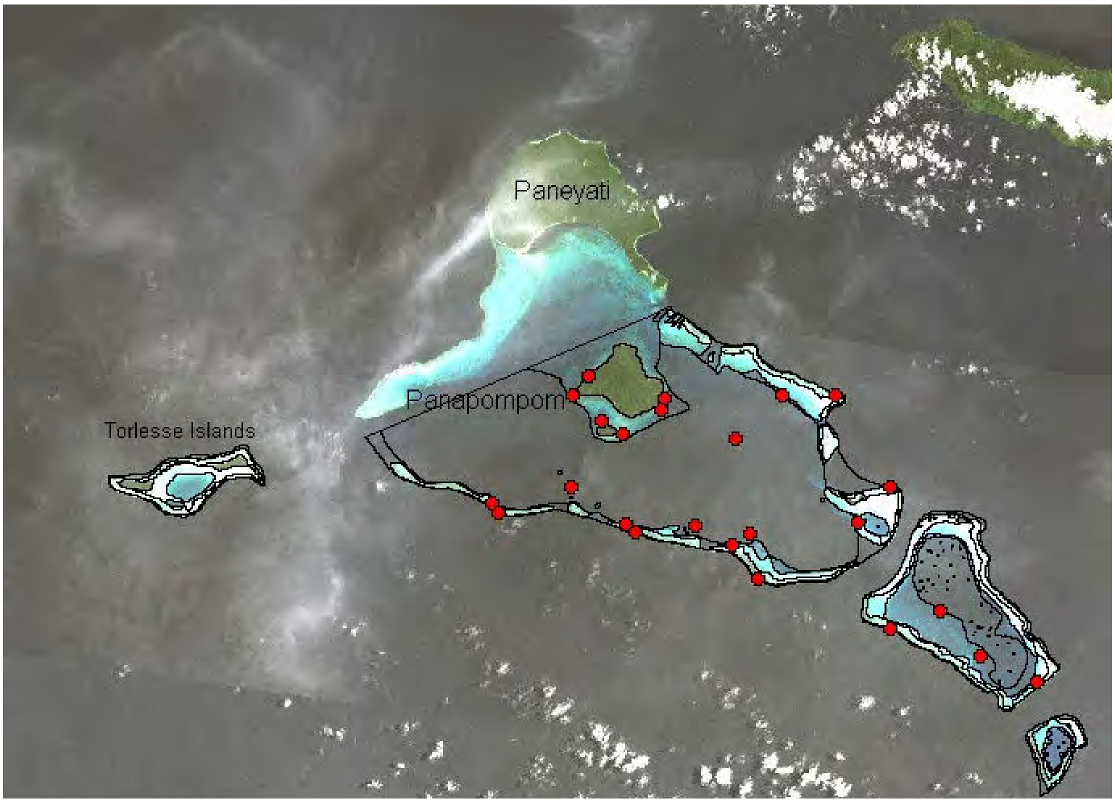

Figure 5.19: Location of the selected site of Panapompom Island.

Finfish resources and associated habitats were assessed in Panapompom between 6 and 13 November 2006, from a total of 24 transects (6 sheltered coastal, 6 intermediate-, 6 back- and

6 outer-reef transects, see Figure 5.20 and Appendix 3.4.2 for transect locations and coordinates respectively).

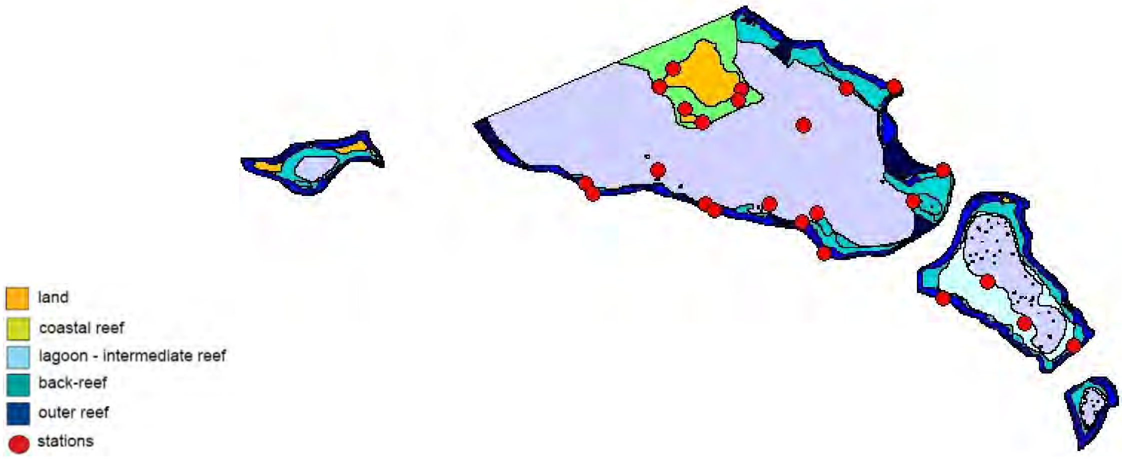

Figure 5.20: Habitat types and transect locations for finfish assessment in Panapompom.

5.3.1 Finfish assessment results: Panapompom

A total of 26 families, 71 genera, 238 species and 19,671 fish were recorded in the 24 transects (See Appendix 4.4.3 for list of species.). Only data on the 15 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 53 genera, 204 species and 13,286 individuals.

Finfish resources varied widely among the four reef environments found in Panapompom (Table 5.16). The coastal reef contained the far highest density and biomass of the site (1.2 fish/m², 207 g/m²), while outer reefs displayed the highest biodiversity (75 species/transect, the third regional highest) and largest size and size ratios. Intermediate reef and back-reef displayed values of density and biomass that were intermediate between the coastal and outer reefs. Back-reefs had the lowest biomass, size and size ratio recorded at the site.

Table 5.6: Primary finfish habitat and resource parameters recorded in Panapompom (average values ±SE)

Parameters	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)	15.2	13.2	30.7	29.7	88.7
Depth (m)	1(1-4)	5 (1-9)	3 (1-9)	9 (5-20)	5 (1-20)
Soft bottom (% cover)	7 ±3	19 ±7	20 ±9	10 ±5	14
Rubble & boulders (% cover)	9 ±3	9 ±3	7 ±2	4 ±1	7
Hard bottom (% cover)	54 ±10	39 ±7	42 ±9	52 ±7	47
Live coral (% cover)	28 ±11	31 ±5	30 ±6	31 ±3	30
Soft coral (% cover)	1 ±1	1 ±0	1 ±0	3 ±1	2
Biodiversity (species/transect)	38 ±7	56 ±8	42 ±5	75 ±3	53±4
Density (fish/m^2)	1.2 ±0.6	0.4 ±0.1	0.4 ±0.1	0.3 ±0	0.5
Size (cm FL) (4)	18 ±1	18 ±1	16 ±1	21 ±1	18
Size ratio (%)	54 ±2	56 ±2	48 ±2	59 ±2	54
Biomass (g/m^2)	207.4 ±142.4	73.3 ±25.8	50.9 ±15.6	101.0 ±6.8	97.7

(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: Panapompom

The sheltered coastal reef environment of Panapompom was dominated by five families: carnivorous Holocentridae, Lethrinidae and Mullidae, and herbivorous Scaridae and Acanthuridae (Figure 5.21). These five families were represented by 49 species; particularly high biomass and abundance were recorded for *Mulloidichthys flavolineatus*, *Scarus rivulatus*, *Monotaxis grandoculis*, *Lutjanus gibbus*, *M. vanicolensis*, *Chlorurus sordidus*, *Acanthurus lineatus*, *Myripristis violacea*, *Gnathodentex aureolineatus*, *Ctenochaetus striatus* and *Neoniphon opercularis* (Table 5.7). This reef environment presented a moderately diverse habitat with hard bottom strongly dominating (54%), live corals in high cover (28%), and mobile bottom in low percentage (16% for soft bottom and rubble together) (Table 5.6 and Figure 5.21).

Table 5.7: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Panapompom

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.09 ±0.07	28.7 ±21.9
	Mulloidichthys vanicolensis	Yellowfin goatfish	0.03 ±0.03	13.4 ±13.4
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.04 ±0.03	19.5 ±17.7
	Chlorurus sordidus	Daisy parrotfish	0.18 ±0.16	11.8 ±11.1
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.06 ±0.03	15.9 ±10.2
	Gnathodentex aureolineatus	Goldlined seabream	0.09 ±0.09	8.6 ±8.6
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.03 ±0.03	13.9 ±13.9
Holocentridae	*Myripristis violacea*	Lattice soldierfish	0.08 ±0.05	9.6 ±6.6
Acanthuridae	*Acanthurus lineatus*	Lined surgeonfish	0.04 ±0.02	10.9 ±6.5
	Ctenochaetus striatus	Striated surgeonfish	0.08 ±0.03	8.5 ±3.7

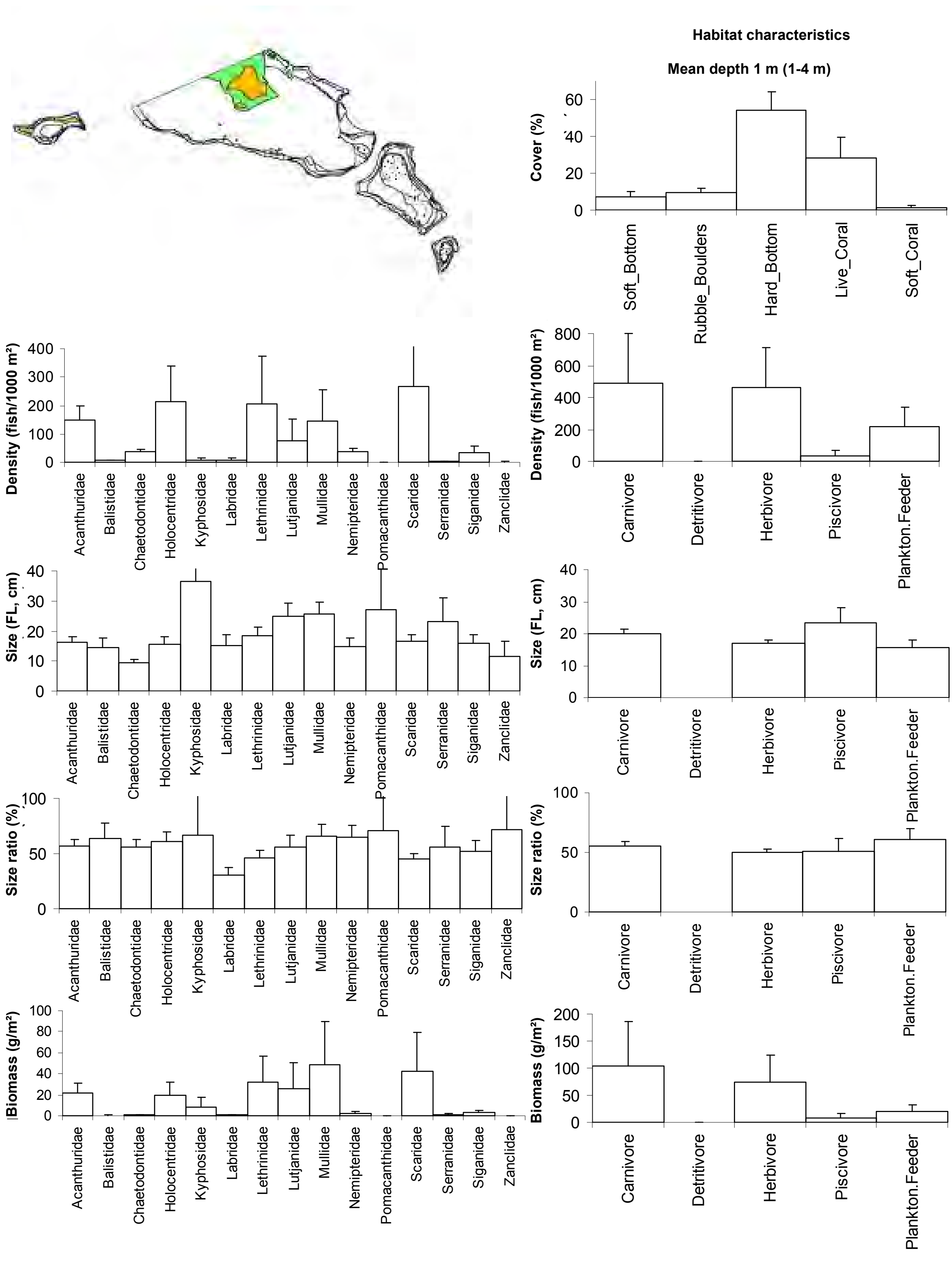

Figure 5.21: Profile of finfish resources in the sheltered coastal reef environment of Panapompom.
Bars represent standard error (+SE); FL = fork length.

The density and biomass of finfish in the sheltered coastal reefs were the highest among all the habitats in Panapompom. Size (18 cm FL) was the second-highest of the four habitats. Even when comparing Panapompom to the other two country sites with coastal reef habitat, density and biomass were the highest. Size ratio was the second-lowest among the four habitats at this site, and the overall lowest among the three coastal reefs of the country sites. Biodiversity displayed the smallest value (38 species/transect) at the site and was lower than at the Andra coastal reef. The trophic structure of the fish community was equally composed of herbivores and carnivores and also had a good representation of plankton-feeding fish. Biomass was dominated by carnivores, followed by herbivores; plankton feeders only contributed <10% to the total biomass. The fish community composition was very complex and diverse, suggesting a very healthy system. Size ratio distribution by family showed smaller-than-average size only for Scaridae. The substrate was dominated by hard bottom and live coral (82% together), while soft bottom was very rare.

Intermediate-reef environment: Panapompom

The intermediate-reef environment of Panapompom was dominated by four main families: herbivorous Acanthuridae and Scaridae, and carnivorous Holocentridae and Lethrinidae. In addition, Chaetodontidae were important in terms of density (Figure 5.22). These five families were represented by 67 species; particularly high biomass and abundance were recorded for *Ctenochaetus striatus*, *Naso vlamingii*, *Monotaxis grandoculis*, *N. brevirostris*, *Acanthurus mata*, *Myripristis violacea*, *Scarus altipinnis*, *Chlorurus sordidus*, *Myripristis adusta* and *S. niger* (Table 5.8). This reef environment presented a very diverse habitat with high cover of hard bottom (39%), live coral (31%), and mobile bottom (28%, Table 5.6).

Table 5.8: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Panapompom

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.07 ±0.01	9.1 ±2.0
	Naso vlamingii	Bignose unicornfish	0.01 ±0.01	7.4 ±7.4
	Naso brevirostris	Spotted unicornfish	0.01 ±0.01	3.8 ±3.8
	Acanthurus mata	Elongate surgeonfish	0.01 ±0.01	3.1 ±3.1
Holocentridae	*Myripristis violacea*	Lattice soldierfish	0.01 ±0.01	2.1 ±0.8
	Myripristis adusta	Shadowfin soldierfish	0.01 ±0.00	1.8 ±1.1
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.05 ±0.04	6.5 ±5.2
Scaridae	*Scarus altipinnis*	Filament-finned parrotfish	0.01 ±0.01	2.0 ±2.0
	Chlorurus sordidus	Daisy parrotfish	0.01 ±0.00	1.9 ±0.5
	Scarus niger	Black parrotfish	0.01 ±0.00	1.8 ±0.4

The density and biomass of finfish in the intermediate reefs of Panapompom were the second-lowest of the site, biomass being higher only than the back-reef value (73 versus 51 g/m^2). Size, size ratio and biodiversity were lower only to the top values, recorded at the outer reef. When compared to the intermediate reefs of other sites, Panapompom displayed intermediate values: biomass and density were lower than in Andra and higher than in Tsoilaunung intermediate reefs. However, size, size ratio and biodiversity were highest at Panapompom. Trophic composition was well balanced among carnivores (35%), herbivores (38%) and plankton feeders (21%) in terms of density. Biomass was only slightly dominated by herbivores (40%), followed by plankton feeders (30%) and carnivores (21%).

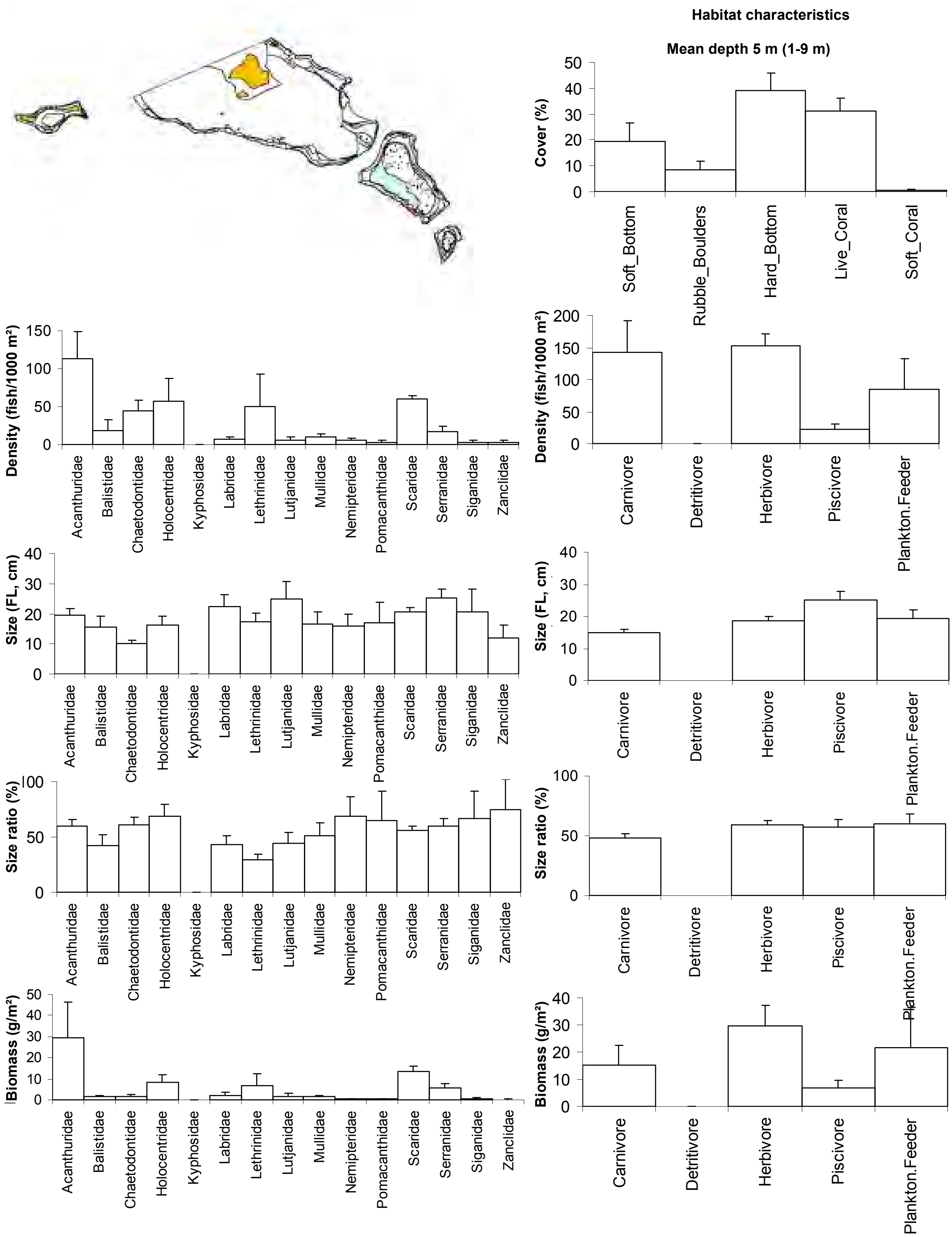

Figure 5.22: Profile of finfish resources in the intermediate-reef environment of Panapompom. Bars represent standard error (+SE); FL = fork length.

The fish community composition was diverse and rich, with several families and many species contributing to the majority of the biomass. These are further signs of a rich and healthy ecosystem. Balistidae, Lethrinidae and Lutjanidae displayed sizes that were much lower than 50% of the average largest size for the family, probably indicating some fishing pressure on these selected families. Lutjanidae and Lethrinidae made up, in fact, more than half of the catches for lagoon reefs. The intermediate reefs of Panapompom displayed a fairly diverse composition of hard bottom, rubble, soft bottom and coral, normally supporting a wide range of families that were well represented here.

Back-reef environment: Panapompom

The back-reef environment of Panapompom was dominated by six families for both density and biomass: herbivorous Acanthuridae and Scaridae, and carnivorous Mullidae, Lutjanidae, Nemipteridae and Lethrinidae, followed by Chaetodontidae only for density, and by Serranidae only for biomass (Figure 5.23). These were represented by 55 species; particularly high biomass and abundance were recorded for *Ctenochaetus striatus*, *Mulloidichthys flavolineatus*, *Scolopsis* sp., *Lutjanus gibbus*, *Monotaxis grandoculis*, *Plectropomus laevis*, *Scarus dimidiatus*, *Chlorurus sordidus* and *L. lutjanus* (Table 5.9). This reef environment presented a quite diverse habitat with very high cover of hard bottom (42%) and a high cover of live coral (30%) and of mobile bottom (27%, Table 5.6).

Table 5.9: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Panapompom

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.09 ±0.03	9.8 ±3.1
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.03 ±0.03	4.9 ±4.9
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.01 ±0.01	2.5 ±2.5
	Lutjanus lutjanus	Bigeye snapper	0.01 ±0.01	1.0 ±0.9
Nemipteridae	*Scolopsis* sp.	Monocle bream	0.03 ±0.03	3.6 ±3.6
Scaridae	*Scarus dimidiatus*	Yellow-barred parrotfish	0.01 ±0.01	1.5 ±0.9
	Chlorurus sordidus	Daisy parrotfish	0.01 ±0.01	1.4 ±0.8
Serranidae	*Plectropomus laevis*	Blacksaddle coralgrouper	<0.01 ±0.00	1.9 ±1.9
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.02 ±0.01	2.5 ±1.2

The density of finfish was equal to the density recorded in the intermediate reefs, lower than in the coastal reefs, but higher than in the outer reefs. Biomass, size and size ratio were the lowest recorded for this site and biodiversity was at the lower end of the range, higher only than the coastal-reef value (42 versus 38 species/transect). When compared to the back-reefs of Andra and Sideia, Panapompom values of biomass and size ratio were the lowest, while density, size, and biodiversity were the second-lowest among the three sites. Trophic composition was almost equally composed of herbivore and carnivore families. Acanthuridae dominated the herbivore biomass, while Lutjanidae, Mullidae, Serranidae and Nemipteridae were equally important and Lethrinidae a little less important in the carnivore biomass composition. Lethrinidae and Nemipteridae displayed average size ratios that were ~20% lower than the maximum size recorded. Lethrinidae were highly important in the catch composition of internal reefs. The back-reefs of Panapompom had a fairly diverse substrate, dominated by hard coral (40%) but with a good amount of mobile bottom as well (20%), offering habitat for carnivore as well as herbivore species.

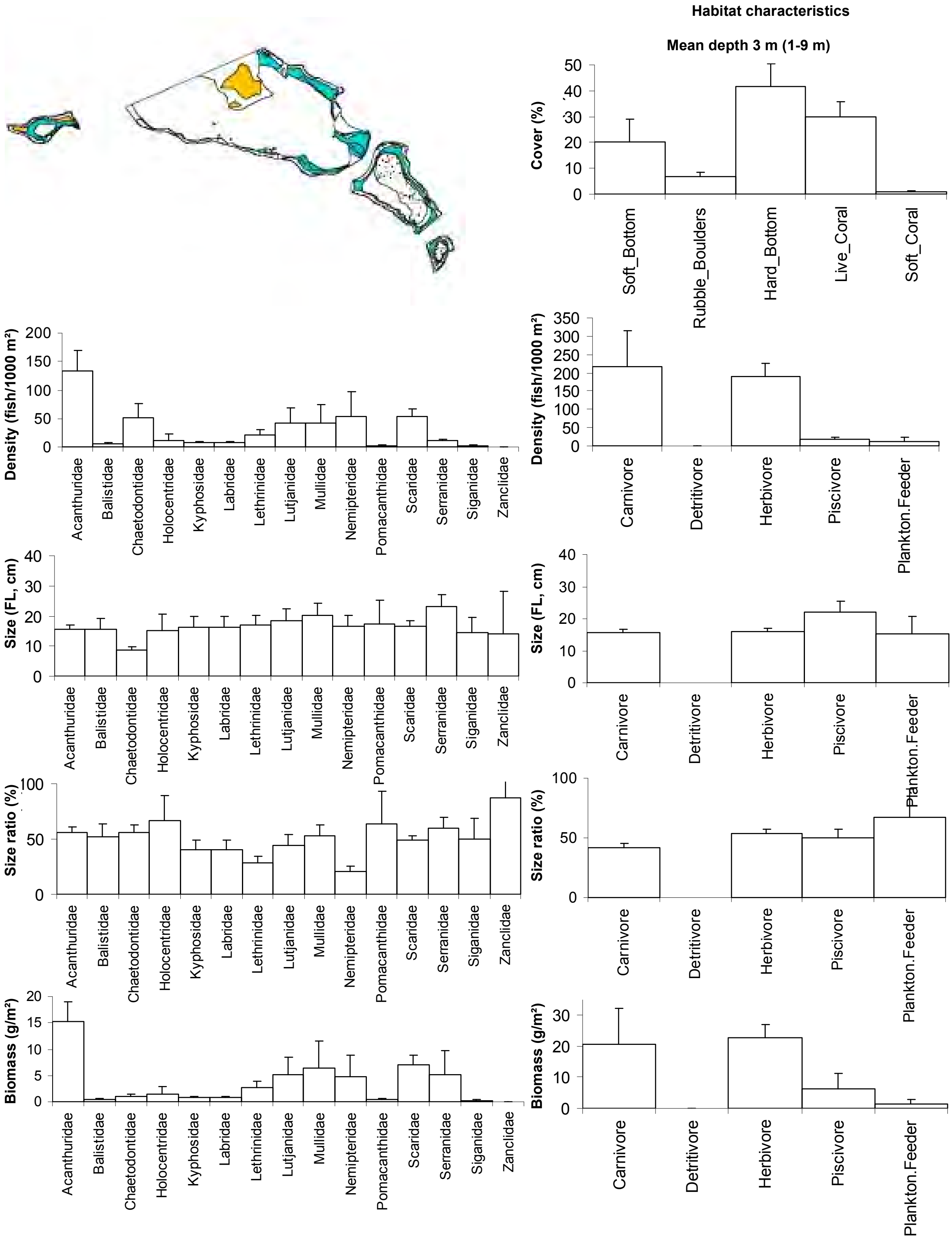

Figure 5.23: Profile of finfish resources in the back-reef environment of Panapompom.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Panapompom

The outer reef of Panapompom was dominated by two herbivorous families: Acanthuridae and Scaridae, and two carnivorous families: Lutjanidae and Lethrinidae, for both density and biomass and, in terms of biomass only, by Chaetodontidae and Holocentridae (Figure 5.24). These six families were represented by 76 species; particularly high biomass and abundance were recorded for *Scarus altipinnis*, *Lutjanus gibbus*, *Lutjanus bohar*, *Naso hexacanthus*, *Monotaxis grandoculis*, *Myripristis kuntee*, *Myripristis violacea* and *Acanthurus thompsoni* (Table 5.10). More than half of the substrate was occupied by hard bottom (52%) and live coral was in high abundance (31%). Only 14% of the substrate was composed of soft bottom and rubble (Table 5.6 and Figure 5.24).

Table 5.10: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Panapompom

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Naso hexacanthus*	Sleek unicornfish	0.01 ±0.01	6.4 ±3.1
	Acanthurus thompsoni	Thompson's surgeonfish	0.01 ±0.01	1.5 ±1.0
Scaridae	*Scarus altipinnis*	Filamentfinned parrotfish	0.01 ±0.01	12.8 ±12.8
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.02 ±0.01	9.2 ±5.0
	Lutjanus bohar	Twinspot snapper	0.01 ±0.01	8.6 ±4.7
Holocentridae	*Myripristis kuntee*	Shoulderbar soldierfish	0.02 ±0.01	3.5 ±2.4
	Myripristis violacea	Lattice soldierfish	0.02 ±0.01	2.1 ±1.0
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.02 ±0.01	4.0 ±2.4

Fish biomass in the outer reef was lower than the coastal-reef values and higher than in the back-reefs and intermediate reefs. Density was the lowest recorded at the site, and the lowest of all country outer reefs. However, size, size ratio and biodiversity were extremely high and the highest over all habitats and all four outer reefs surveyed in the country. Average size ratio was much lower than 50% of the maximum value for Lethrinidae (32%). Substrate was dominated by hard bottom and live coral, normally favouring herbivores and some carnivores, such as snappers, here represented by *Lutjanus gibbus* and *L. bohar*. Lutjanidae constituted the majority of the catches from this reef.

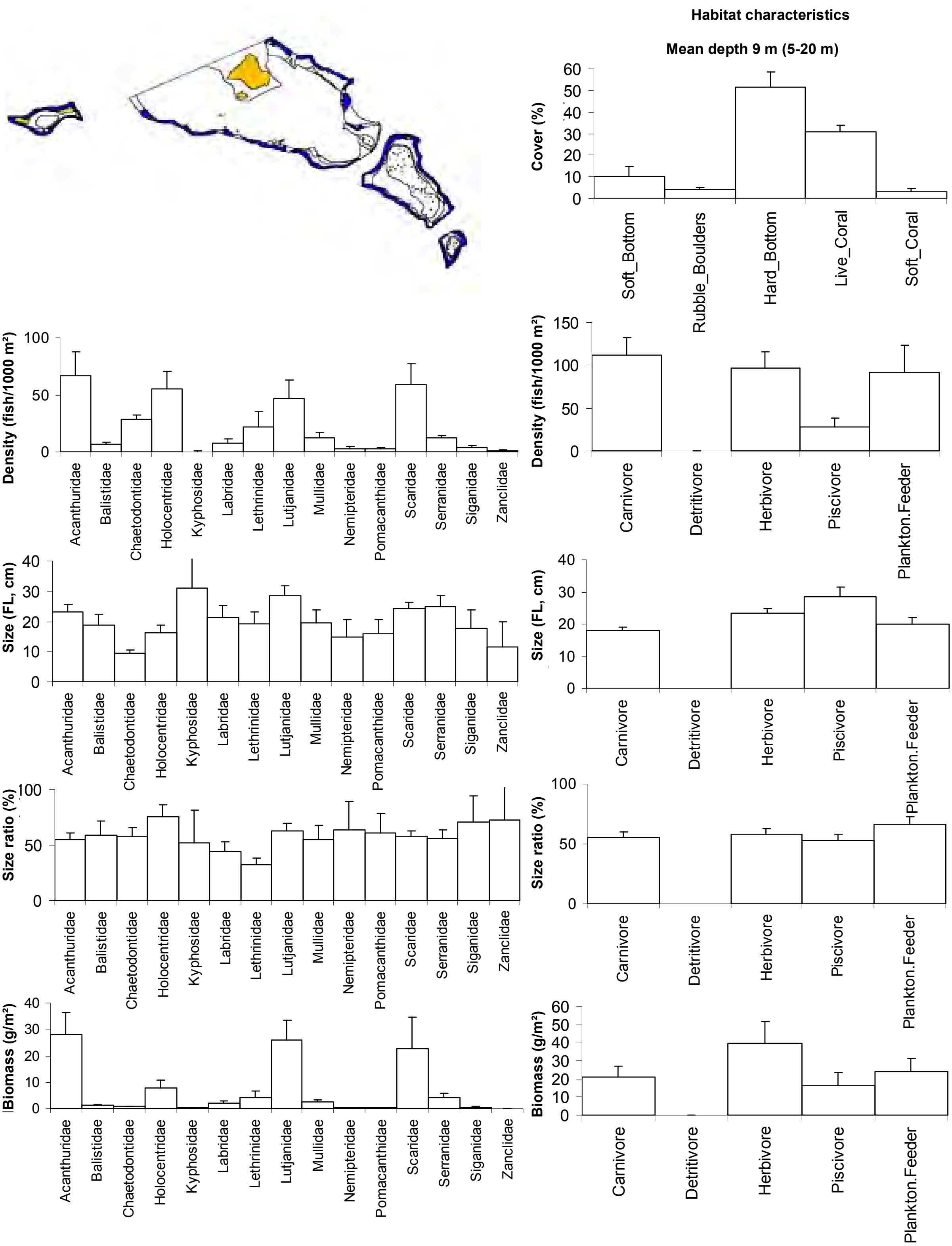

Figure 5.24: Profile of finfish resources in the outer-reef environment of Panapompom.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Panapompom

Overall, the fish assemblage of Panapompom was composed of several families: herbivorous Acanthuridae and Scaridae (Figure 5.25), carnivorous Holocentridae, Lethrinidae, Lutjanidae and Mullidae and, for density only, Chaetodontidae and Nemipteridae. These eight most abundant families were represented by a total of 120 species, dominated (in terms of biomass and density) by *Mulloidichthys flavolineatus*, *Ctenochaetus striatus*, *Lutjanus gibbus*, *Monotaxis grandoculis*, *Scarus altipinnis*, *S. rivulatus*, *L. bohar*, *Chlorurus sordidus* and *Myripristis violacea* (Table 5.11). The average substrate at this site was dominated by hard bottom (47%), with a good cover of live coral (30%, the highest value among the four sites), and a smaller proportion of mobile bottom (21%). The overall fish assemblage in Panapompom shared characteristics of back-reefs (35% of total habitat) and outer reefs (33% of habitat) in similar proportion, followed by coastal reefs (17%) and intermediate reefs (15%).

Table 5.11: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Panapompom (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.06	6.3
Scaridae	*Scarus altipinnis*	Filamentfinned parrotfish	0.01	4.6
	Scarus rivulatus	Rivulated parrotfish	0.01	3.3
	Chlorurus sordidus	Daisy parrotfish	0.04	3.1
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.02	6.3
	Lutjanus bohar	Twinspot snapper	0.01	3.2
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.03	5.9
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.03	6.6
Holocentridae	*Myripristis violacea*	Lattice soldierfish	0.02	2.7

Overall, Panapompom appeared to support a fairly good finfish resource, with the lowest density (0.5 fish/m^2) and second-lowest biomass (98 g/m^2), but highest size and biodiversity among the surveyed country sites. A detailed assessment at the family level revealed a high diversity of the fish community, composed of equally important families in terms of both density and biomass. Trophic composition was made of equal amounts of herbivores and carnivores, with good representation of plankton feeders and some piscivores as well. These observations strengthen the conclusion that this site is in good condition. Overall, size ratios were above the 50% threshold except for Lethrinidae. The reduced size of some families could be a first sign of impact from selective fishing. Lethrinidae were frequently caught in lagoon reefs, the habitat with the highest number of fishers, while Lutjanidae comprised the major share of catches on both coastal and outer reefs.

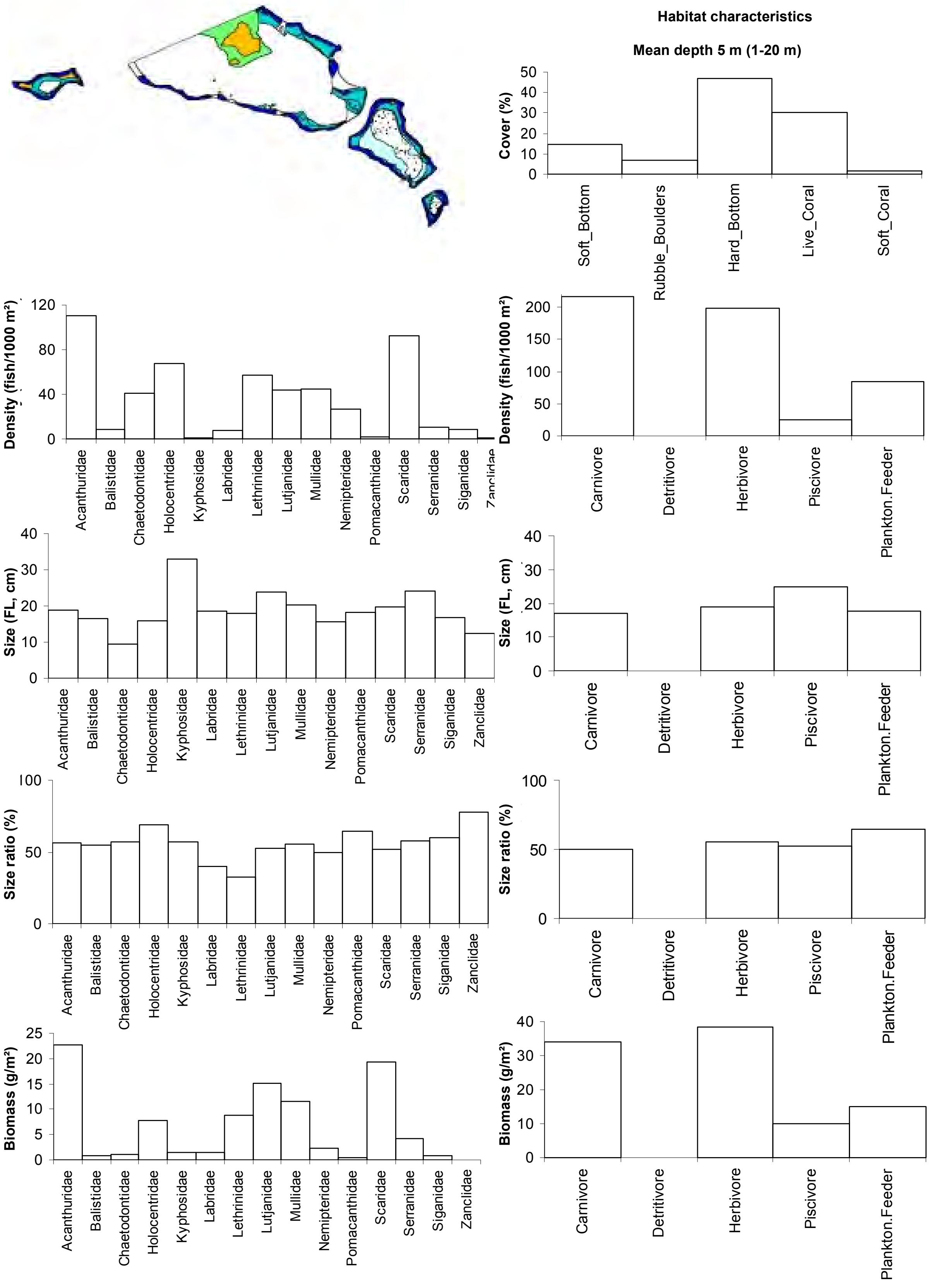

Figure 5.23: Profile of finfish resources in the combined reef habitats of Panapompom (weighted average).
FL = fork length.

5.3.2 Discussion and conclusions: finfish resources in Panapompom

- The assessment indicated that the status of finfish resources in Panapompom was good at the time of surveys. Fishing in Panapompom has subsided in the past few years due to the decommissioning of the nearby goldmine, which was acting as the main trading centre. This might partially explain the rich condition of the reefs at the time of surveys; the fish were highly abundant, probably in response to decreased fishing pressure. Furthermore, fishing is done exclusively from sailing outrigger canoes, imposing less pressure on the reefs compared to fishing from motorised boats. Panapompom had also the lowest annual catches among the four country sites surveyed.

- The reefs appeared healthy and rich in live-coral cover, more so than the other country sites. The reef habitat was also rather diverse, with good composition of all substrate types.

- The fish community showed the highest diversity among the country sites, particularly in the intermediate and outer reefs. The trophic community was equally composed of herbivores and carnivores, further suggesting that the ecosystem is healthy. Large parrotfish and surgeonfish and large groupers were fairly abundant. Lethrinidae, Lutjanidae and Mullidae were present at all habitats in higher density than at the other sites.

- At the reef habitat level, resources were very variable:

  - The coastal reefs were particularly rich in density and biomass, displaying the highest values of all the habitats in Panapompom as well as among all the coastal reefs surveyed in the country. Average fish size was the second-highest of the four habitats. The fish community composition was very complex and diverse and the trophic structure was composed of equal numbers of herbivores and carnivores, while biomass was dominated by carnivores, suggesting a very healthy system. Scaridae, however, were smaller than average in size.

  - The intermediate reefs presented record high levels of biodiversity for this type of reef and size ratios were also quite high. The fish community composition was diverse and rich, with several families and many species contributing to the majority of the biomass. Trophic composition was well balanced among carnivores, herbivores and plankton feeders. These are signs of a rich and healthy ecosystem. Balistidae, Lethrinidae and Lutjanidae were small in size, probably indicating some fishing pressure on these selected families. Lutjanidae and Lethrinidae together composed more than half of the catches for lagoon reefs.

  - The back-reefs displayed the lowest values of biomass, size and size ratio for this site and biodiversity was at the lower end of the range. Such values were low even when compared to those in Andra and Sideia. But, as found in the other reef habitats in Panapompom, trophic composition was almost equally made of herbivore and carnivore families. Acanthuridae dominated the herbivore biomass, while Lutjanidae, Mullidae, Serranidae, Nemipteridae and Lethrinidae were equally important in the carnivore biomass composition. Lethrinidae (highly represented in lagoon catches) and Nemipteridae displayed high size ratios (only ~20% lower than the maximum size recorded).

  - The outer reefs displayed an extremely high biodiversity, higher than the other habitats at the site and than all the outer reefs surveyed in the country. The biomass was lower than in the coastal reef, and density was the lowest recorded at the site, as well as the lowest of all country outer reefs. However, size and size ratio were extremely high and the highest of all habitats and all four outer reefs surveyed. The average size ratio of Lethrinidae was much lower than 50% of the maximum value, a first suggestion of fishing impact. Other signs of fishing impact were visible in the western part of the site, where fishing was carried out also by the people of the larger island of Panaeati.

- The unusually high density and biomass of coastal reefs might have been caused by the small area closed to fishing, which was recently established as a result of a community decision.

5.4 Invertebrate resource surveys: Panapompom

The diversity and abundance of invertebrate species at Panapompom were independently determined using a range of survey techniques (Table 5.12): broad-scale assessment (using the 'manta tow'; locations shown in Figure 5.26) and finer-scale assessment of specific reef and benthic habitats (Figures 5.27 and 5.28).

The main objective of the broad-scale assessment was 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 assessments were 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 replicate measures completed at Sideia

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	14	81 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)	0	0 transect
Mother-of-pearl searches (MOPs)	6	36 search periods
Reef-front searches (RFs)	9	54 search periods
Sea cucumber day searches (Ds)	7	42 search periods
Sea cucumber night searches (Ns)	2	12 search periods

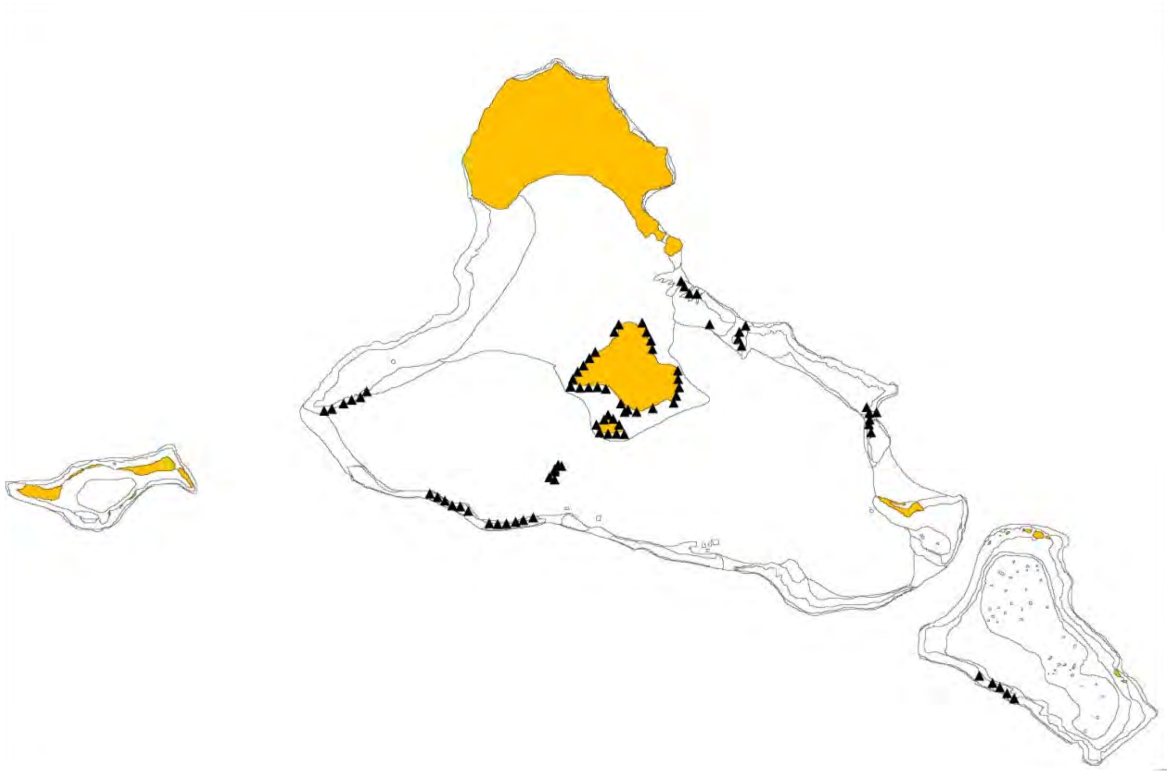

Figure 5.26: Broad-scale survey stations for invertebrates in Panapompom.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

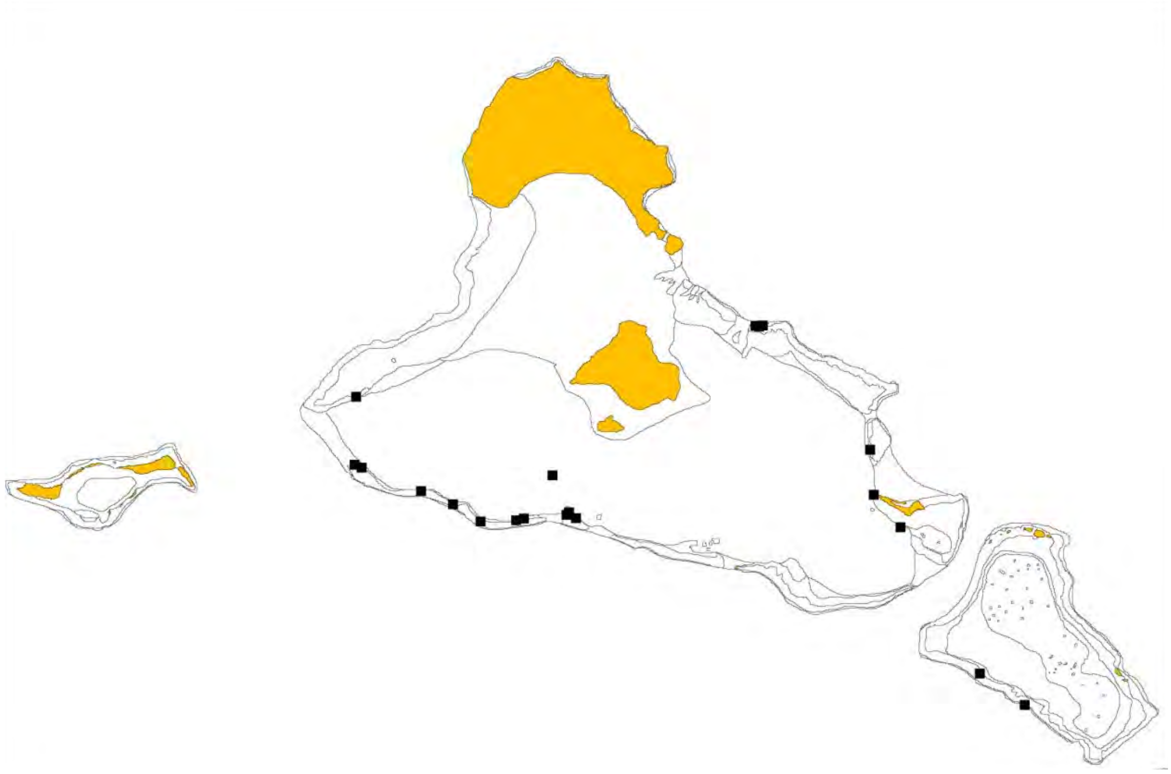

Figure 5.27: Fine-scale reef-benthos transect survey stations for invertebrates in Panapompom.
Black squares: reef-benthos transect stations (RBt).

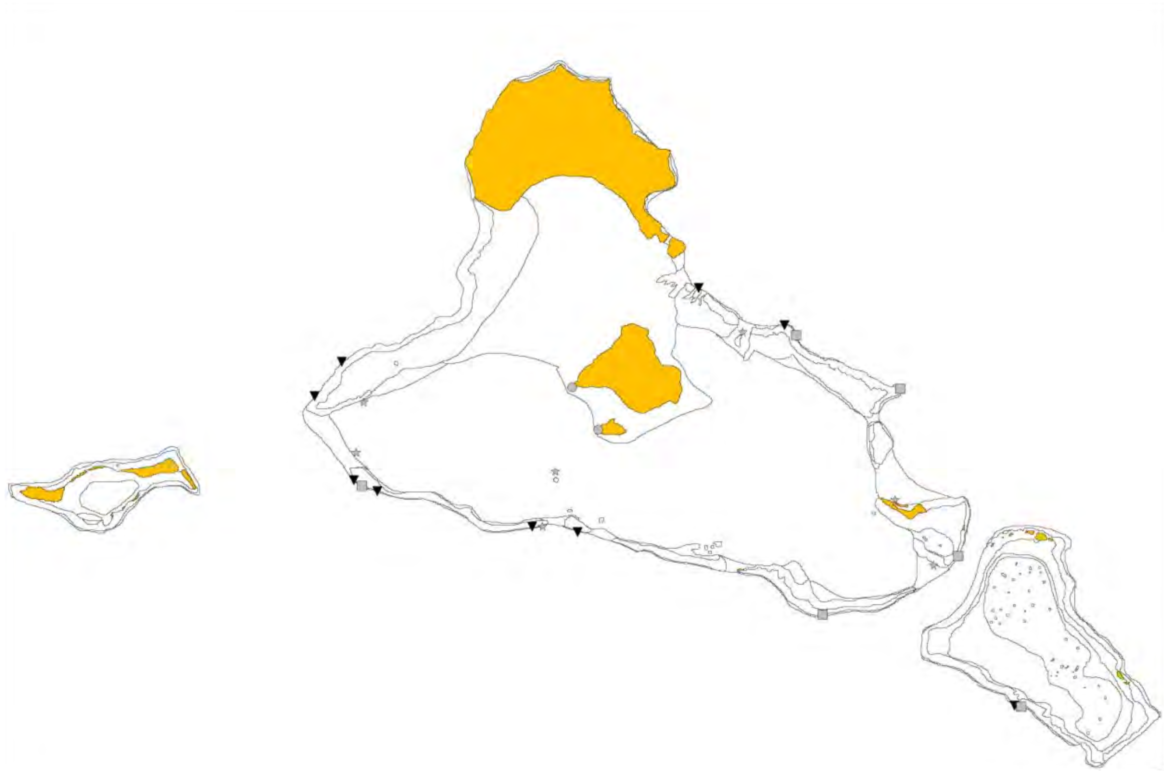

Figure 5.28: Fine-scale survey stations for invertebrates in Panapompom.
Inverted black triangles: reef-front search stations (RFs);
grey squares: mother-of-pearl search stations (MOPs);
grey stars: sea cucumber day search stations (Ds);
grey circles: sea cucumber night search stations (Ns).

Seventy-one species or species groupings (groups of species within a genus) were recorded in the Panapompom invertebrate surveys: 14 bivalves, 24 gastropods, 16 sea cucumbers, 6 urchins, 6 sea stars, 1 cnidarian and 3 lobsters (Appendix 4.4.1). Information on key families and species is detailed below.

5.4.1 Giant clams: Panapompom

Shallow reef habitat that is suitable for giant clams was extensive at Panapompom (28.7 km^2: ~11.5 km^2 within the lagoon and 17.2 km^2 on the reef front or slope of the barrier reef). Although there was a large area available, it was mostly restricted to the barrier reef that surrounds the main lagoon (main lagoon area is 199.5 km^2), with the shorelines of the two inhabited islands (Panaeati and Panapompom) not supporting a large amount of hard substrate (mainly composed of sand, with some rubble).

There was little influence from the land (riverine inputs) and exposure within the lagoon was not a problem, as there was a range of depths present (Intermediate patch reef was present in the outer parts of the lagoon.) and reefs were somewhat protected by the surrounding islands. There was dynamic water flow across the passages in the barrier reef located east and west of Panapompom.

Using all survey techniques, six species of giant clam were noted. Although broad-scale sampling provided a good overview of giant clam distribution and density, the fluted clam *Tridacna squamosa* was not recorded using this method. The five clam species recorded in broad-scale surveys were: the elongate clam *T. maxima*, the boring clam *T. crocea*, 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 14 stations and 55 transects), followed by *T. crocea* (in 7 stations and 15 transects), *T. derasa* (3 stations and 3 transects) and *T. gigas* (2 stations and 2 transects). *H. hippopus*, which is well camouflaged and usually relatively sparsely distributed, was recorded in seven stations (11 transects in total, see Figure 5.29).

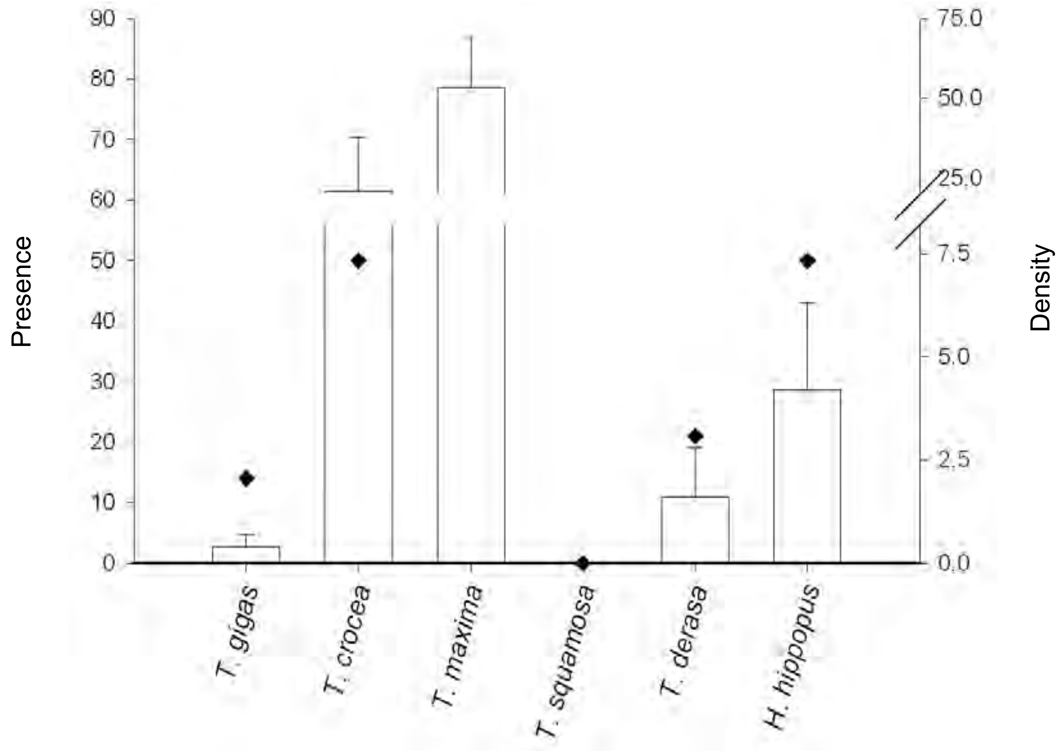

Figure 5.29: Presence and mean density of giant clam species in Panapompom based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 5.30). In these reef-benthos assessments (RBt), *T. maxima* was present in 100% of stations, the highest average station density being 1541.7 /ha ±361.8. *H. hippopus* was also relatively common (recorded in 40% of stations), with moderate density. In this case, the highest average station density (333.0 /ha ±52.7) was recorded in the small atoll lagoon south of the main site. *T. crocea*, *T. squamosa* and *T. derasa* were rarely recorded (Figure 5.30) and, in both broad-scale and reef-benthos transects, the larger clam species were more evident as dead shells than live individuals.

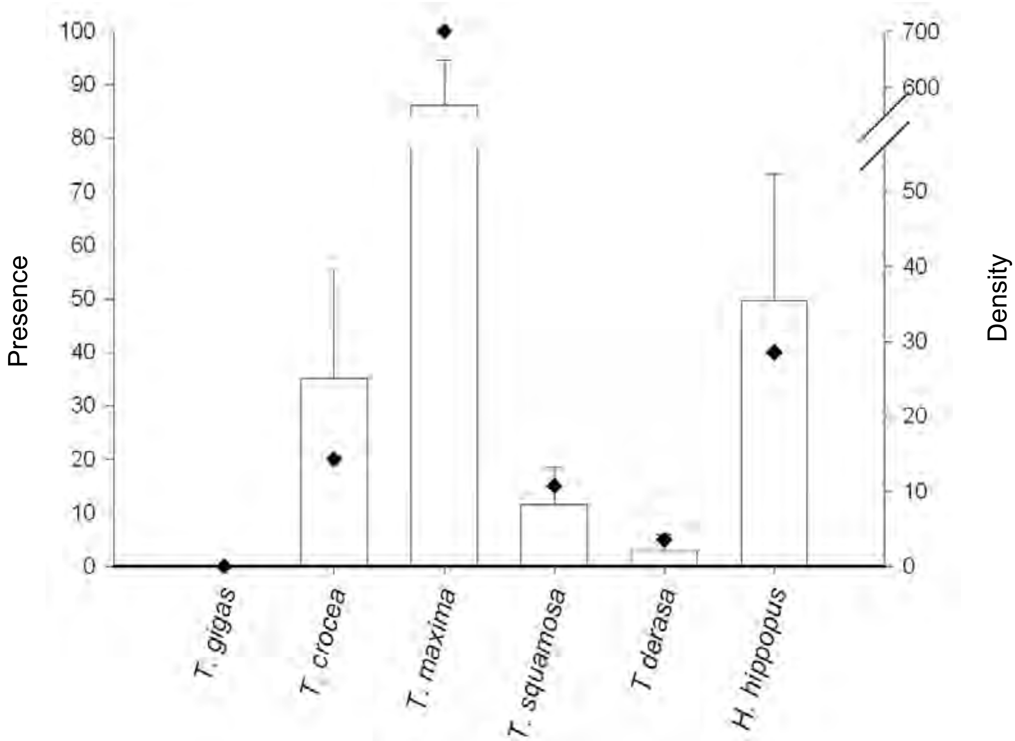

Figure 5.30: Presence and mean density of giant clam species in Panapompom based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

A full range of small and large individuals of *T. maxima* were recorded in survey (mean size 14.0 cm ±0.3). *T. maxima* from reef-benthos transects alone (on shallow-water reefs) had a slightly smaller mean length (11.9 cm ±0.3, which represents a clam just under 5 years old). The faster-growing *T. squamosa* (which grows to an asymptotic length L_∞ of 40 cm) averaged 20.1 cm ±2.5 (~6 years old), whereas *T. crocea* averaged 9.5 cm ±0.8 (>5 years old). *H. hippopus* averaged 14.1 cm ±0.6 (3–4 years old). The two *T. derasa* individuals measured averaged 28.0 cm and the *T. gigas* individuals were 40 cm and 105 cm in length (Figure 5.31).

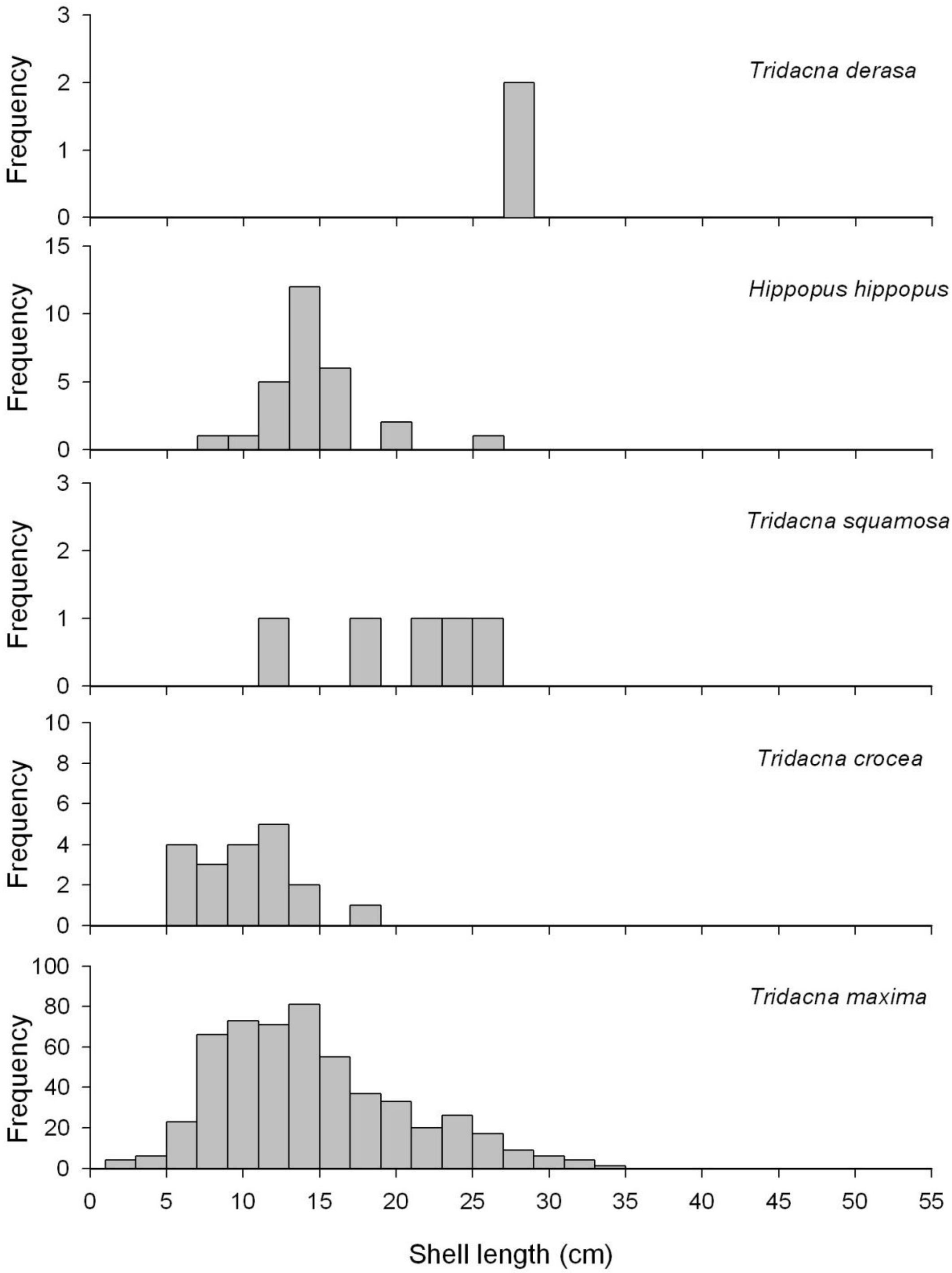

Figure 5.31: Size frequency histograms of giant clam shell length (cm) for Panapompom.

5.4.2 Mother-of-pearl species (MOP) – trochus and pearl oysters: Panapompom

Papua New Guinea is within the natural distribution of the commercial topshell *Trochus niloticus* and the green snail *Turbo marmoratus* in the Pacific. The outer reef and back-reef at Panapompom constitute an extensive benthos for *T. niloticus* and this area could potentially support significant populations of trochus (99.3 km lineal distance of exposed reef perimeter). Although extensive, the reef in the lagoon was not optimal for trochus (mostly too sandy) and, in general, reefs at the exposed side of the barrier reef sloped steeply into deeper water, with limited amounts of shoal environment, which is ideal habitat for trochus.

PROCFish survey work revealed that *T. niloticus* was present on both the barrier reef (outer-reef slope and reeftop) and on reefs within the lagoon. The green snail *Turbo marmoratus* was absent in this survey (Table 5.13).

Table 5.13: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Panapompom
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	1.0	0.5	3/14 = 21	4/81 = 5
RBt	0	0	0/20 = 0	0/120 = 0
RFs	3.1	1.4	4/9 = 44	4/54 = 7
MOPs	3.8	2.6	2/6 = 33	3/36 = 8
Tectus pyramis				
B-S	6.2	1.4	9/14 = 64	19/81 = 23
RBt	112.5	21.8	15/20 = 75	39/120 = 33
RFs	5.7	1.9	6/9 = 67	10/54 = 19
MOPs	3.8	2.6	2/6 = 33	3/36 = 8
Pinctada margaritifera				
B-S	3.3	0.9	6/14 = 43	13/81 = 16
RBt	33.3	15.6	5/20 = 25	9/120 = 8
RFs	0.4	0.4	1/9 = 11	1/54 = 2
MOPs	2.5	1.6	2/6 = 33	2/36 = 6

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

No large aggregations of trochus were found in survey (only n = 17 individuals recorded in total), and stock that was recorded occurred at low density and below the level of abundance considered high enough for commercial fishing (See Appendix 4.5.). Although trochus was found in various locations around Panapompom, densities in most cases were so low as to jeopardise the success of fertilisation among these single-sexed gastropods. For spawning to be successful, males and females need to be in close proximity so that eggs can be fertilised and the stock can produce future generations.

The mean basal width of trochus at Panapompom was 10.2 cm ±0.5 (Figure 5.32). Shell size-class frequencies indicate that the bulk of stock at Panapompom is mature. No noted recruitment pulse of young trochus was evident. In Papua New Guinea, trochus reach first maturity at a size of 7–8 cm (at ~3 years of age). 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 and joining the main stock. This portion of the population was hardly evident in Panapompom.

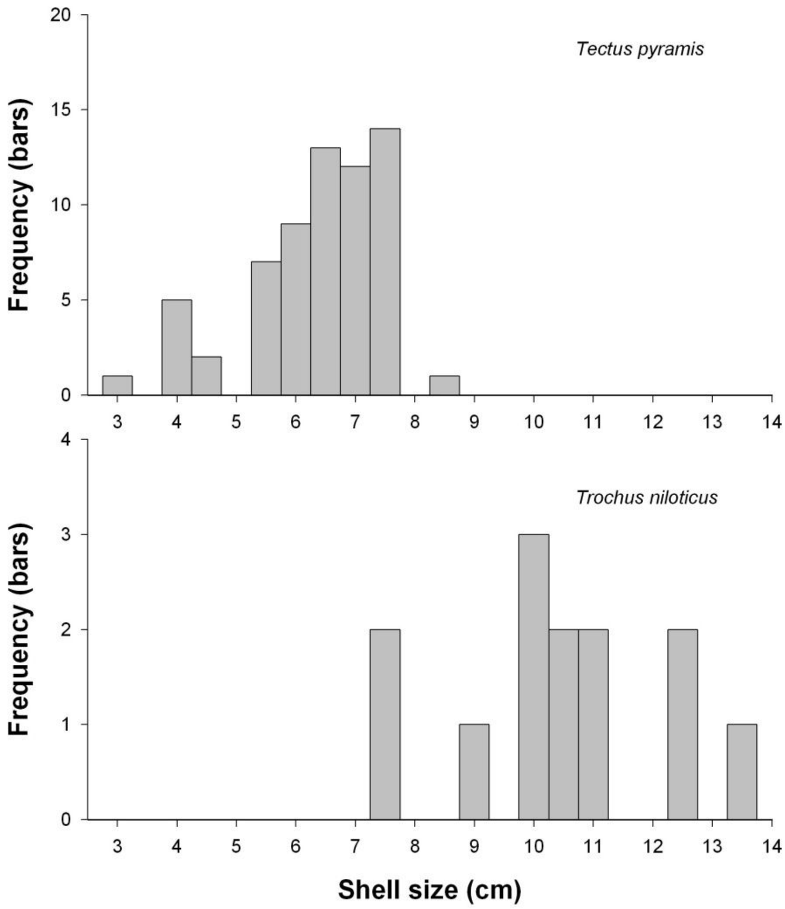

Figure 5.32: Size frequency histograms of trochus (*Trochus niloticus*) and 'false' trochus (*Tectus pyramis*) shell base diameter (cm) for Panapompom.

The suitability of reefs for grazing gastropods was highlighted by results collected for the false trochus or green topshell (*Tectus pyramis*). This related, but less valuable species of topshell (an algal-grazing gastropod with a similar life history to trochus) was abundant at Panapompom (n = 88 recorded in survey). The mean size (basal width) of *T. pyramis* was 6.2 cm ±0.1. Small *Tectus* (<5.5 cm) were also recorded in survey, which may suggest that conditions for recent spawning and/or settlement of these gastropods have been favourable in recent years.

Despite blacklip pearl oysters *Pinctada margaritifera* being cryptic and normally sparsely distributed in open lagoon systems (such as found at Panapompom), the number of blacklip seen during assessments was reasonably high (n = 34). The mean shell length (anterior–posterior measure) was 13.9 cm ±0.5.

5.4.3 Infaunal species and groups: Panapompom

Soft benthos at the coastal margins of Panapompom Island was generally suitable for seagrass, but meadows were very sparsely populated and no concentrations of in-ground resources (shell 'beds') were recorded. Therefore, no fine-scale assessments or infaunal stations (quadrat surveys) were completed.

5.4.4 Other gastropods and bivalves: Panapompom

Seba's spider conch (*Lambis truncata*), the larger of the two common spider conchs, was rarely recorded in survey (n = 5 individuals), but *Lambis lambis* was recorded at moderate density in broad-scale surveys (9.3 /ha, n = 47 individuals). Other *Lambis* species were also recorded (*L. chiragra*, *L. millepeda*, *L. crocata*). The strawberry or red-lipped conch *Strombus luhuanus* was also relatively common and present at moderate-to-high density within broad- and fine-scale surveys (Appendices 4.4.1 to 4.4.7).

Three species of turban shell (*T. argyrostomus*, *T. chrysostomus* and *T. petholatus*) were recorded at low-to-moderate density. The larger silver-mouthed turban (*T. argyrostomus*) was relatively common (recorded in 78% of reef-front search stations) and was recorded at a mean density of 18.3 /ha ±6.7. No *T. setosus* was seen in reef or MOP surveys. Other resource species targeted by fishers (e.g. *Astralium*, *Cassis*, *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Latirolagena*, *Ovula*, *Pleuroploca*, *Tectus*, *Thais* and *Vasum*) were also recorded during independent surveys (Appendices 4.4.1 to 4.4.7).

Data on other bivalves recorded in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Hyotissa*, *Pinna*, *Pteria* and *Spondylus*, are also in Appendices 4.4.1 to 4.4.7. No creel survey was conducted at Panapompom.

5.4.5 Lobsters: Panapompom

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, general surveys and night assessments for nocturnal sea cucumber species (Ns) were conducted, which offered an opportunity to record lobster species. Lobsters (*Panulirus versicolor* and *P.* spp.) were relatively common in surveys (n = 34), and both slipper lobsters (*Parribacus caledonicus*, n = 2) and prawn killers (*Lysiosquillina maculata*, n = 1) were noted in survey.

5.4.6 Sea cucumbers[10]: Panapompom

The study area around Panapompom Island has an extensive lagoon (main lagoon: 199.5 km^2, small lagoon to the south: 34.7 km^2) bordering small but elevated land masses (Panapompom 8.8 km^2 and Panaeati 30.1 km^2, plus some small, low sand islands on the encircling barrier reef). If not for the two main land masses, the encircling barrier reef and predominant oceanic influence would characterise this system as a typical atoll system.

Reef margins and areas of shallow, mixed hard- and soft-benthos habitat (suitable for sea cucumbers) were extensive in the lagoon. In general, the lagoon was shallow and most back-reef areas were more sandy than is preferred by a range of sea cucumber species. The best coral was recorded in the south and southeast. Riverine inputs and other inputs from land were notable at inner lagoon areas between the larger and smaller land masses of Panapompom but, in general, water was oceanic-influenced and movement (flushing of oceanic water) was most dynamic through the large passage in the west and the smaller

[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.

passages in the south and east. Despite this, algal blooms (blue–green algae) were noted across the system, both on reefs and on sand as deep as 35 m.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 5.14, Appendices 4.4.1 to 4.4.7, see also Methods). With completion of the full range of assessments, fifteen commercial species of sea cucumber (plus one indicator species) were recorded (Table 5.14), which is similar to the number at the other PROCFish site surveyed in Milne Bay Province of Papua New Guinea, and slightly lower than expected considering the varied environment of the lagoon. Panapompom is well suited to many of these deposit-feeding species, which eat detritus and other organic matter in the upper few mm of bottom substrates.

Sea cucumber species associated with shallow reef areas, such as the leopardfish (*Bohadschia argus*) and the high-value black teatfish (*Holothuria nobilis*), were rarely recorded (found in ≤ 5% of broad- and fine-scale assessments) and were never at high density when recorded. The fast growing and medium/high-value greenfish (*Stichopus chloronotus*) was also not as common, found in 1% of broad-scale transects, not recorded in reef-benthos assessments, and only noted at low density; see Appendix 4.4.3.

Surf redfish (*Actinopyga mauritiana*) was rare and only recorded at low density despite the suitable environment. In reef-front searches and MOP work on SCUBA on the reef slope, the density of this species was always below 2 /ha.

More protected areas of reef and soft benthos in the more enclosed areas of the lagoon (e.g. between the large and small land masses of Panapompom) did not return more favourable data. No blackfish (*Actinopyga miliaris*) was found and stonefish (*A. lecanora*), although recorded in more exposed locations at low density, was also absent. A few lower-value species, e.g. lollyfish (*Holothuria atra*) and pinkfish (*H. edulis*) were recorded but again they were rare and at low density. No high-value sandfish (*H. scabra*) was found, but there was little in the way of mangrove shorelines present (This species generally prefers a 'richer' environment, which was present around Panapompom.). The lower-value 'false' sandfish (*Bohadschia similis*) was also absent.

Deep-water assessments (42 five-minute searches, average depth 29 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*). Oceanic-influenced lagoon benthos with suitably dynamic water movement was present at a reasonable scale and *H. fuscogilva* was recorded in four of the seven stations at a maximum station density of 38 /ha. The presence and density recorded for the prickly redfish (*T. ananas*) and amberfish (*T. anax*) were low.

5.4.7 Other echinoderms: Panapompom

Close to Panapompom, the edible collector urchin (*Tripneustes gratilla*) was found at moderate-to-high density in broad-scale assessments over patchy seagrass (average transect density 200.0 /ha ±139.9). The station to the east of the smaller land mass at Panapompom had exceptionally high densities (average 2652 /ha ±1711) and, even at this station, the standard error was high as only three of the six replicates (300 m transects) held collector urchins. Other urchins, such as the slate urchin (*Heterocentrotus mammillatus*), were rare along the barrier reef, the preferred habitat. Urchins, such as *Diadema* sp. and *Echinothrix* spp., can be used within assessments as potential indicators of habitat condition. These species and *Echinometra mathaei* were also recorded at relatively high levels on occasion (Appendices 4.4.1 to 4.4.7).

Starfish (e.g. *Linckia laevigata*, the blue starfish) were relatively common considering the amount of sandy areas present (found in 59% of broad-scale transects) but were not at high density. Coralivore (coral eating) starfish were relatively rare, with 26 recordings of a pincushion star (*Culcita novaeguineae*) and only three crown of thorns (*Acanthaster planci*) noted in survey. The horned or chocolate-chip star (*Protoreaster nodosus*) and the doughboy sea star (*Choriaster granulatus*) were also noted at low density on occasion.

Table 5.14: Sea cucumber species records for Tsoilaunung

Species	Common name	Commercial value [5]	B-S transects n = 81			Reef-benthos stations n = 20			Other stations RFs = 9; MOPs = 6			Other stations Ds = 7 ; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga caerulea	-	M/H										0.3	2.4	14 Ds
Actinopyga echinites	Deepwater redfish	M/H												
Actinopyga lecanora	Stonefish	M/H				2.1	41.7	5	2.2	9.8	22 RFs			
Actinopyga mauritiana	Surf redfish	M/H							0.4 1.3	3.9 7.6	11 RFs 17 MOPs	4.4	8.9	50 Ns
Actinopyga miliaris	Blackfish	M/H												
Bohadschia argus	Leopardfish	M	0.6	16.7	4	2.1	41.7	5				0.7	2.4	29 Ds
Bohadschia graeffei	Flowerfish	L							3.1 7.6	13.7 15.2	22 RFs 50 MOPs			
Bohadschia similis	False sandfish	L												
Bohadschia vitiensis	Brown sandfish	L	0.2	16.7	1	4.2	83.3	5						
Holothuria atra	Lollyfish	L	1.4	29.2	5	2.1	41.7	5						
Holothuria coluber	Snakefish	L												
Holothuria edulis	Pinkfish	L				2.1	41.7	5						
Holothuria fuscogilva [4]	White teatfish	H										11.6	20.2	57 Ds
Holothuria fuscopunctata	Elephant trunkfish	M										1.0	2.4	43 Ds
Holothuria leucospilota	-	L												
Holothuria nobilis [4]	Black teatfish	H	0.6	16.7	4									
Holothuria scabra	Sandfish	H												
Stichopus chloronotus	Greenfish	H/M	0.2	16.7	1									
Stichopus hermanni	Curryfish	H/M												
Stichopus horrens	Peanutfish	M/L												
Stichopus pseudhorrens	-	M										0.7	4.8	14 Ds
Stichopus vastus	Brown curryfish	H/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; [6] noted under main wharf at Sideia; B-S transects= broad-scale transects; RFs = reef-front search; MOPs = mother-of-pearl search; Ds = sea cucumber day search.

Table 5.14: Sea cucumber species records for Tsoilaunung (continued)

Species	Common name	Commercial value [5]	B-S transects n = 81			Reef-benthos stations n = 20			Other stations RFs = 9; MOPs = 6			Other stations Ds = 7 ; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Synapta spp.	-	-	1.2	20.0	6	4.2	83.3	5				26.7	26.7	100 Ns
Thelenota ananas	Prickly redfish	H				2.1	41.7	5	1.3	7.6	17 MOPs			
Thelenota anax	Amberfish	M							1.3	7.6	17 MOPs	1.4	3.2	43 Ds
Thelenota rubrolineata	Candy canefish	L												

[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; [6] noted under main wharf at Sideia; B-S transects= broad-scale transects; RFs = reef-front search; MOPs = mother-of-pearl search; Ds = sea cucumber day search.

5.4.8 Discussion and conclusions: invertebrate resources in Panapompom

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 within the body of the invertebrate chapter.

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

- The shallow-water lagoon and surrounding barrier reef were very suitable for clams, although the best reef habitats were not common around the shores of Panapompom Island itself.

- There was a complete range of giant clam species present, some of which are becoming rare in other parts of the Pacific.

- Giant clam density at Panapompom was reasonably high for the most common species *Tridacna maxima*. Although a 'full' range of size classes was present, the lack of numbers in the >15 cm size classes seen for this population, especially during shallow-reef assessments, indicates an impacted stock. This supports the assumption that clam stocks are moderately impacted by fishing.

- *Hippopus hippopus* was relatively common, although *T. crocea*, *T. squamosa* and *T. derasa* were more depleted. Despite the low abundance of the larger species (*T. squamosa*, *T. derasa* and *T. gigas*), their continued presence is promising for conservation efforts. These species are usually the first to decline when fishing pressure impacts giant clam stocks and, if fishing controls can be instituted, natural recovery is probable.

Data collected on MOP stocks suggest that:

- Panapompom Atoll had extensive habitat suitable for the commercial topshell (*Trochus niloticus*), although adult habitat (reef slopes) sloped relatively steeply into deeper water.

- The distribution and abundance of trochus reflected a severely over-fished resource. Considering the scale of habitat available and the density of other grazing gastropods (e.g. *Tectus pyramis*), trochus stocks are in need of urgent protection from fishing. The presence and density records suggest stocks are below the level at which commercial fishing should proceed.

- Presently, the trochus stock is dominated by mostly large, old shells, with no strong record of ongoing recruitment. Protection of this broodstock resource will result in recruitment and stock growth over time. If suitable trochus fishing areas can be successfully protected from fishing, some aggregation of the remaining adult trochus might facilitate recovery.

- The giant turban shell (*Turbo marmoratus*) was absent in this survey.

- The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common at Panapompom, which may encourage potential investments in aquaculture, but densities are not sufficient to encourage commercial fishing of shell.

Data collected on sea cucumbers suggest that:

- The range of sea cucumber species recorded at Panapompom was not as extensive as may have been expected for a site with diverse habitats and depths. Although protected inshore habitat was present between the two land masses of Panapompom, the oceanic influence that prevailed in most of the lagoon may have been an influencing factor in this result.

- Presence and density data collected suggest that sea cucumber stocks have been under very high fishing pressure and are now at extreme levels of depletion.

- Sea cucumbers play an important role in cleaning substrates of organic matter, and mixing ('bioturbating') sands and muds, which oxygenates the lagoon floor. When these species are removed, there is the potential for detritus to build up and substrates to become compacted, creating conditions that can promote the development of non-palatable algal mats (blue-green algae) and anoxic (oxygen-poor) conditions unsuitable for life. These conditions were recorded on substrates in Panapompom.

- Sea cucumber fishing remains an important activity at Panaeati-Panapompom and other fishing grounds at Conflict Atoll and reefs north of these islands.

5.5 Overall recommendations for Panapompom

- The community seek assistance, either from NFA or NGOs to (a) improve marketing conditions, in particular in view of prices paid by mobile buyers; and (b) undertake under-water stock assessment and monitoring of major resource status. Results may be useful to establish community regulations for finfish fisheries and, in particular, commercial harvesting of bêche-de-mer.

- There be no further increase in finfish catches.

- Fishing controls on giant clams be established, especially for the larger species (*Tridacna squamosa*, *T. derasa* and *T. gigas*), which are usually the first to decline when fishing pressure impacts giant clam stocks. Once controls are in place, natural recovery of stocks is probable.

- Stocks of the commercial topshell (*Trochus niloticus*) be immediately protected from fishing to ensure there is a future for this fishery. An extended resting period is suggested for the medium term (5–10 years), until densities at the major fishing areas recover to 500–600 /ha.

- Strict controls be implemented on the sea cucumber fishery to allow an extended resting period for these depleted resources. Given the current high level of depletion of stocks, commercial fishing needs to cease.

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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.

We can use the frequency and amount of remittances received from family members working elsewhere in the country or overseas 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 yet 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).

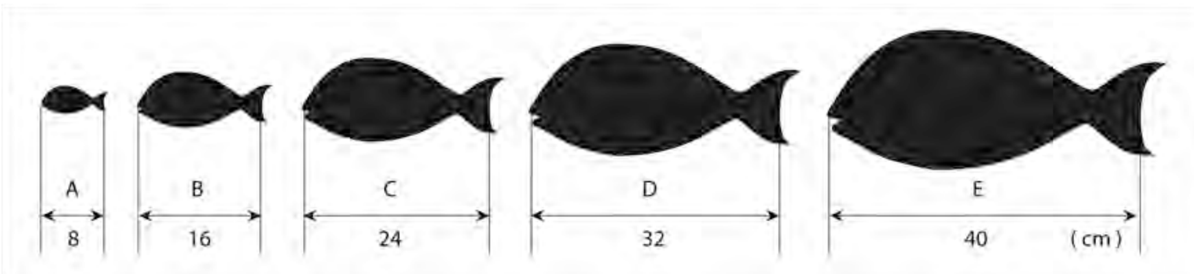

Figure A1.1.1: Finfish size field survey chart for estimating average length of reef and lagoon fish (including five size classes from A = 8 cm to E = 40 cm, in 8 cm intervals).

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.

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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

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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

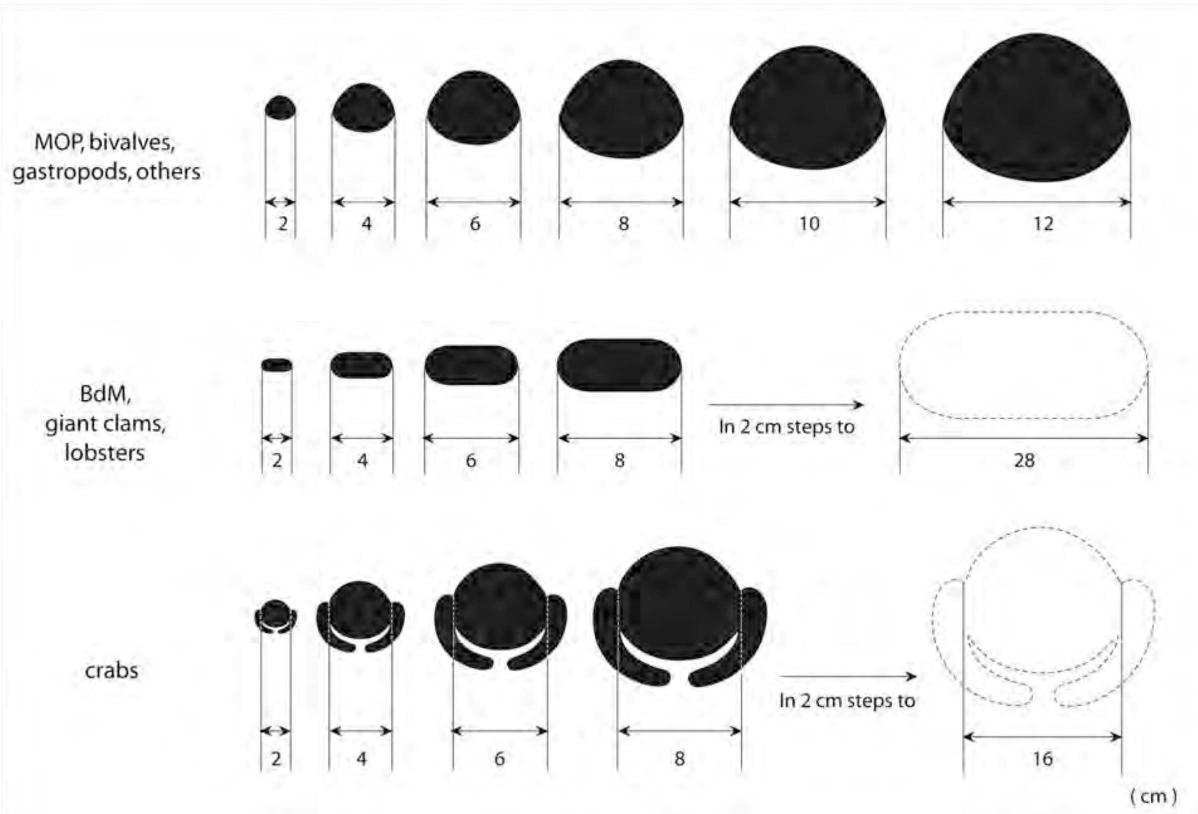

Figure A1.1.2: Invertebrate size field survey chart for estimating average length of different species groups (2 cm size intervals).

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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).

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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).

Total annual finfish export:

$$E = TAC - \left(\frac{F_{tot}}{1000} \bullet \frac{1}{0.8}\right)$$

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 fishing pressure, 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.

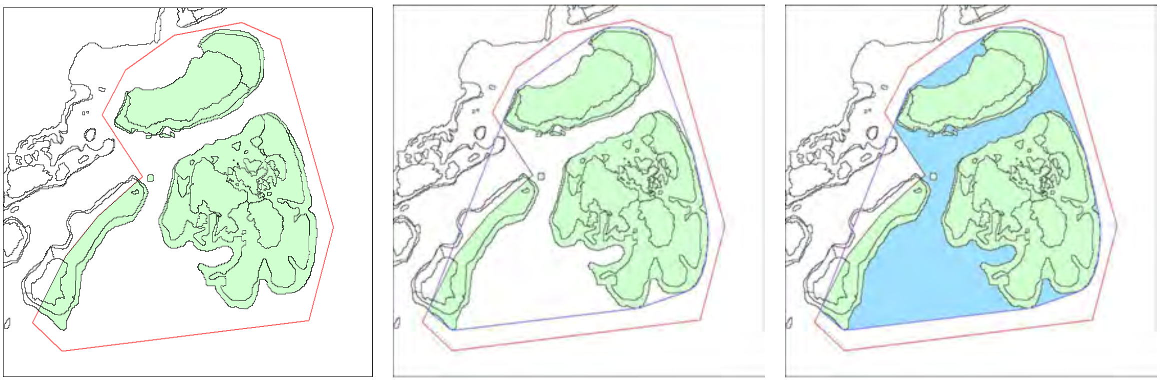

Figure A1.1.3: Determination of lagoon area.
The fishing ground (in red) is initially delineated using information from fishers. Reef areas within the fishing area (in green; interpreted from satellite data) are then identified. The remaining non-reef areas within the fishing grounds are labelled as 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:

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(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).

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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 <u>catch volumes</u> 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 <u>total annual impact</u>, 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).

<u>Total annual catch:</u>

$$\text{TACj} = \sum_{h=1}^{N_h} \frac{F_{inv}f_h \bullet Ac_{inv}f_{hj} + F_{inv}m_h \bullet Ac_{inv}m_{hj}}{1000}$$

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:

$$\text{Ac}_{\text{inv}}\text{f}_{\text{hj}} = \frac{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cf_{ij}}{I_{inv}f_h} \bullet \frac{\sum_{k=1}^{R_{inv}f_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

$I_{inv}f_h$ = 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:____

Appendix 1: Survey methods
Socioeconomics

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 <u>OR:</u>

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 ☐ <u>OR:</u>

size class	A	B	C	D	E	>E (cm)
no	☐	☐	☐	☐	☐	☐

and the rest you gift? yes ☐

how much? kg ☐ <u>OR:</u>

size class	A	B	C	D	E	>E (cm)
no.	☐	☐	☐	☐	☐	☐

and/or sell? yes ☐

how much? kg ☐ <u>OR</u>:

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 ☐ <u>if yes</u> 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?

(if the fisher can't specify, tick the box)

	times/week		duration in hours <2	2–4	4–6	>6	glean/dive at D	N	D&N	fish no. of months/year
☐ 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 **<u>FINFISH</u>** species that you do not catch during the total year? Can you specify the particular months that they are **<u>NOT</u>** 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 sp.	21	35	65	7.35	Bivalves
Asaphis violascens	15	35	65	5.25	Bivalves
Astralium sp.	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 sp.	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 sp.	25	35	65	8.75	Bivalves
Codakia punctata	20	35	65	7	Bivalves
Coenobita sp.	50	35	65	17.5	Crustacean
Conus miles, *Strombus gibberulus gibbosus*	240	25	75	60	Gastropods
Conus sp.	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 sp.	95	25	75	23.75	Gastropods
Cypraea tigris	95	25	75	23.75	Gastropods
Dardanus sp.	10	35	65	3.5	Crustacean
Dendropoma maximum	15	25	75	3.75	Gastropods
Diadema sp.	50	48	52	24	Echinoderm
Dolabella auricularia	35	50	50	17.5	Others
Donax cuneatus	15	35	65	5.25	Bivalves
Drupa sp.	20	25	75	5	Gastropods
Echinometra mathaei	50	48	52	24	Echinoderm
Echinothrix sp.	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 sp.	2000	10	90	200	BdM (1)
Lambis lambis	25	25	75	6.25	Gastropods
Lambis sp.	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 sp.	550	90	10	495	Octopus
Panulirus ornatus	1000	35	65	350	Crustacean
Panulirus penicillatus	1000	35	65	350	Crustacean
Panulirus sp.	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 sp., *Periglypta* sp., *Spondylus* sp., *Spondylus* sp.,	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 cuccullata	35	35	65	12.25	Bivalves
Saccostrea sp.	35	35	65	12.25	Bivalves
Scylla serrata	700	35	65	245	Crustacean
Serpulorbis sp.	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 sp.	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
Tellina sp.	20	35	65	7	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
Terebra sp.	37.5	25	75	9.39	Gastropods
Thais armigera	20	25	75	5	Gastropods
Thais sp.	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 sp.	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 sp.	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.

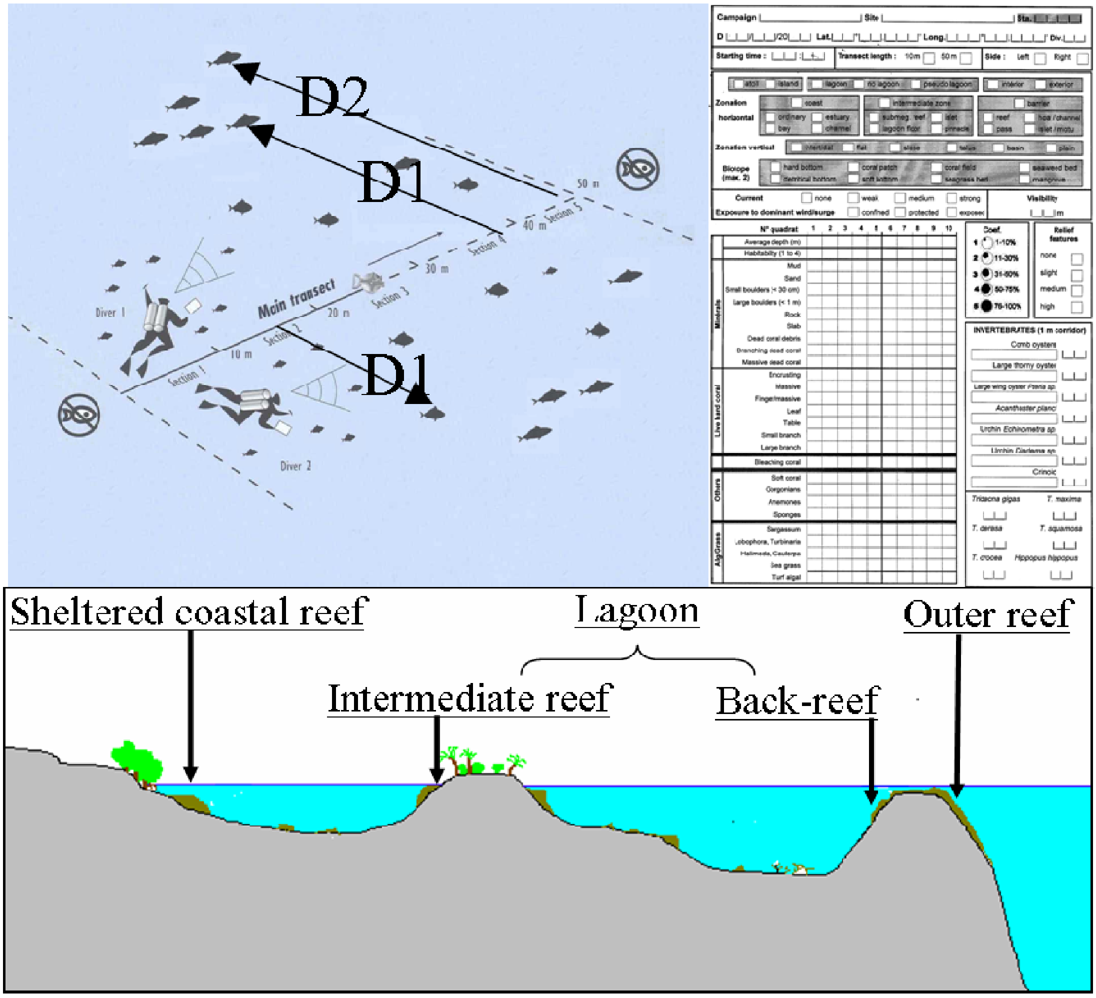


Figure A1.2.1: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver records the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys 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.

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

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.

Appendix 1: Survey methods
Finfish

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 m 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/m^2) – 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 1000 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.

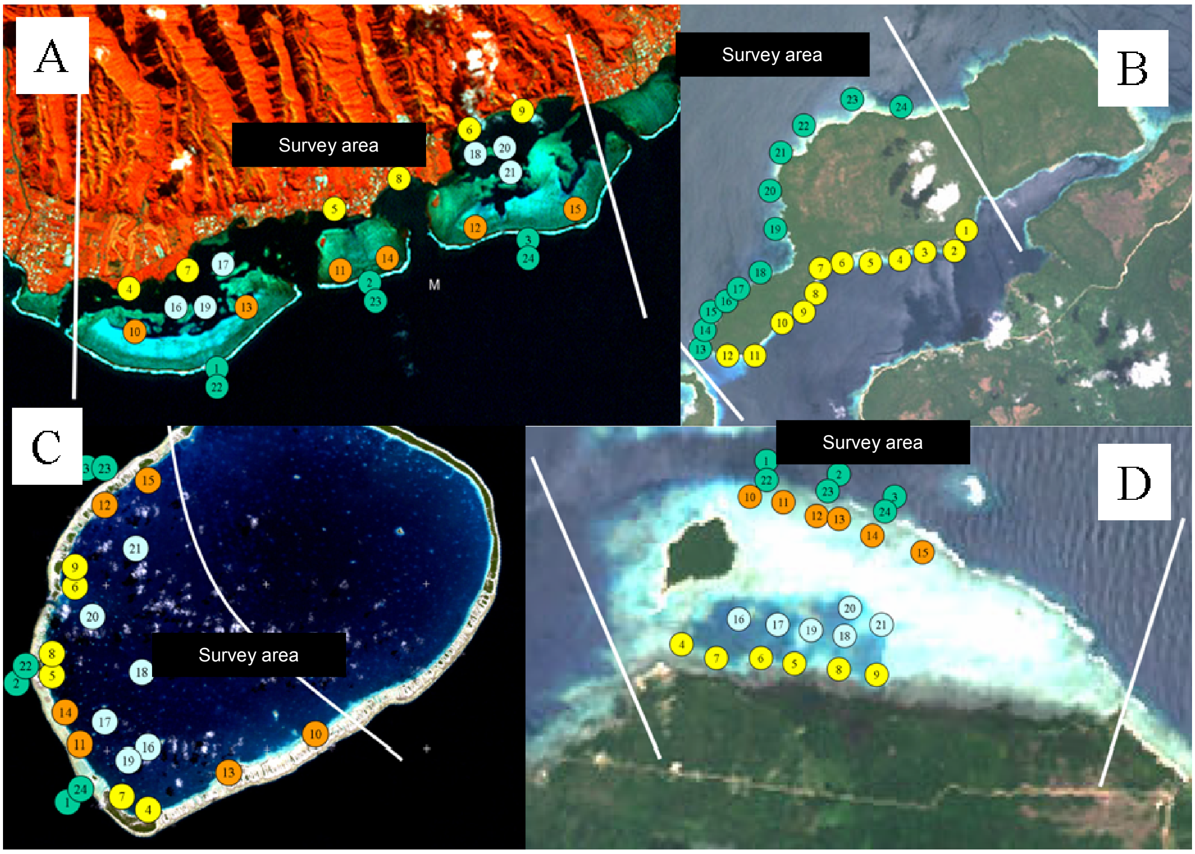


Figure A1.2.2: Position of the 24 D-UVC transects surveyed in A) an island with a lagoon, B) an island with a pseudo-lagoon C) an atoll and D) an island with an extensive reef enclosing a small lagoon pool.
Sheltered coastal reef transects are in yellow, lagoon intermediate-reef transects in blue, lagoon 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:

$$\mathrm{B}_{\mathrm{Vk}} = \sum j_l \, [B_{Hj} \bullet S_{Hj}] \, / \sum_j S_{Hj}$$

Where:

B_{Vk} = computed biomass or fish stock for village k
B_{Hj} = average biomass in habitat $\mathrm{H_j}$
S_{Hj} = surface of that habitat $\mathrm{H_j}$

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 |_|_| Transcept |_|_|_|

D |_|_|/|_|_|/20|_|_| Lat.|_|_|°|_|_|,|_|_|_|' Long.|_|_|_|°|_|_|,|_|_|_|' WT |_|_|_|

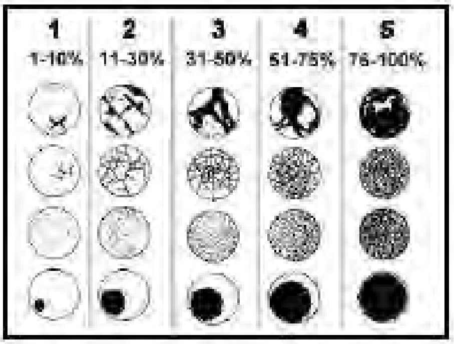
Starting time : |_|_|:|_|_| Visibility |_|_| m Side : Left ☐ Right ☐

☐ 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

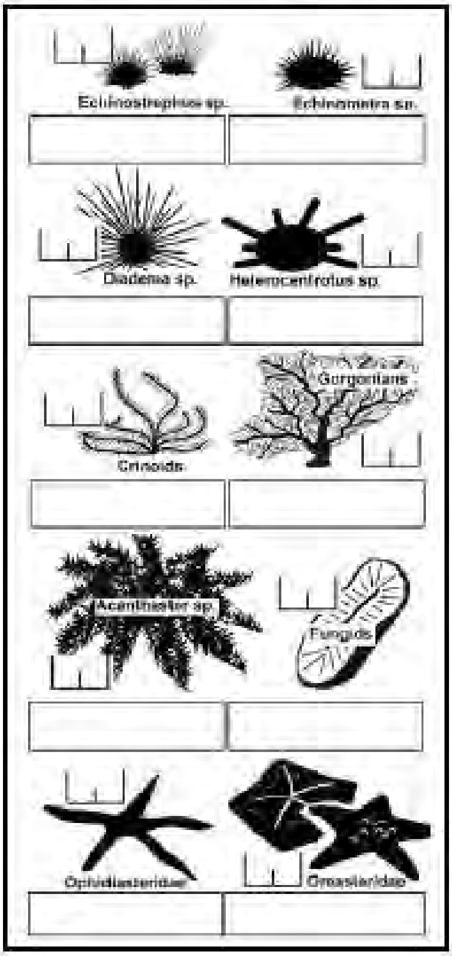
☐ intertidal ☐ flat ☐ gentle slope ☐ steep slope ☐ talus ☐ basin ☐ lagoon plain

☐ 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	☐	☐	☐	☐	☐



	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 ☐

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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).

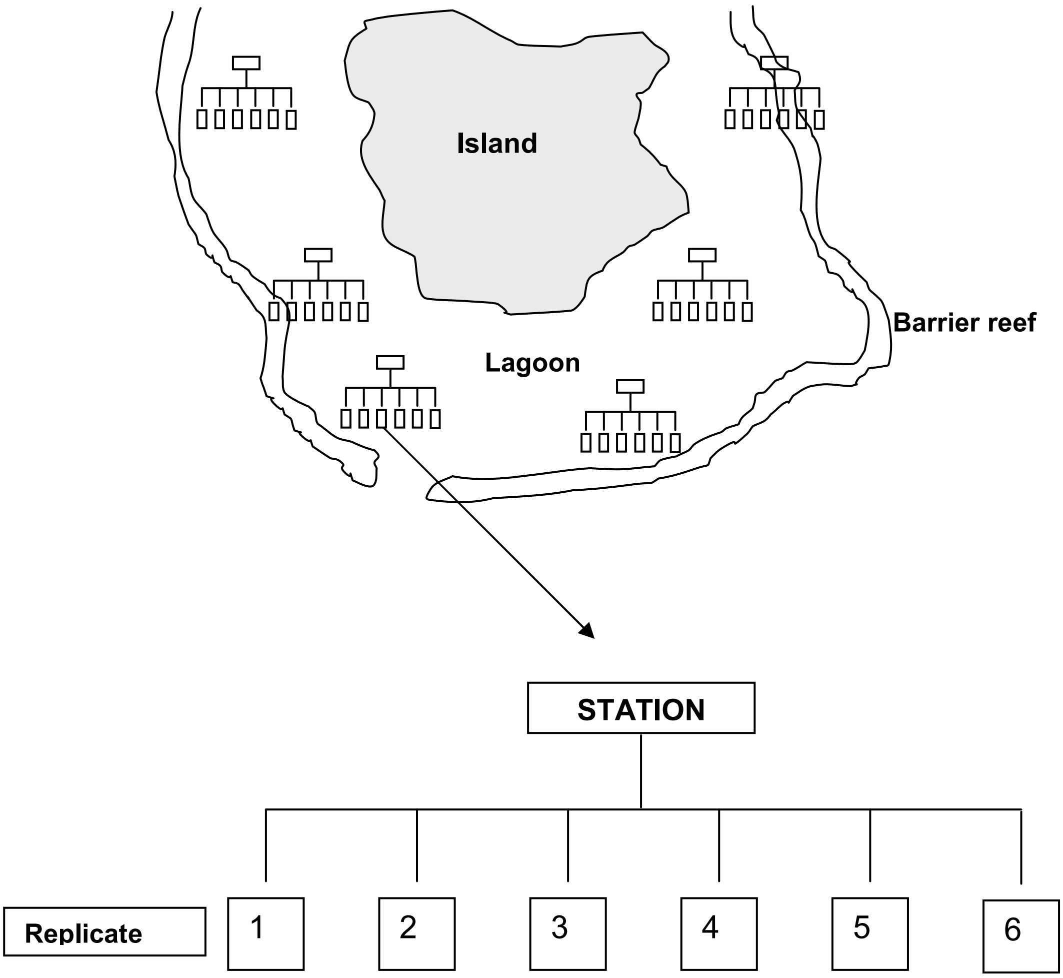

Figure A1.3.1: Stations and replicate measures at a given site.
A replicate measure could be a transect, search period or quadrat group.

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).

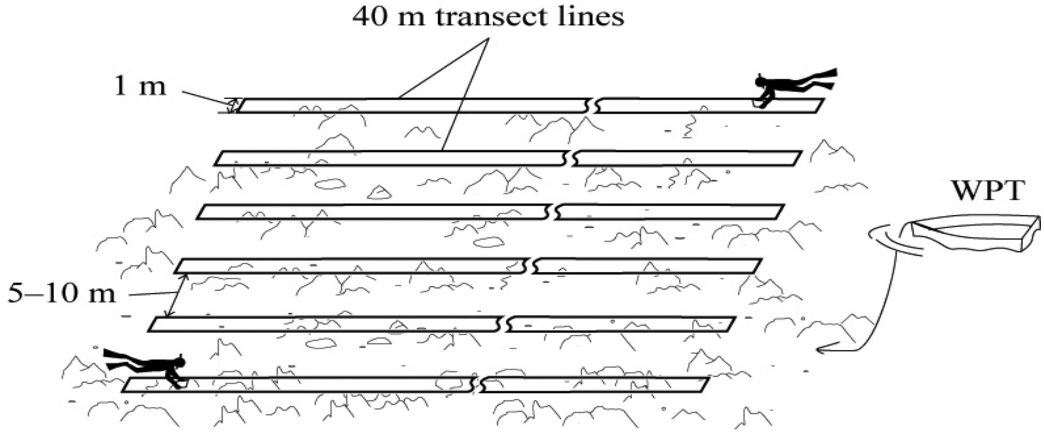

Figure A1.3.2: Example of a reef-benthos transect station (RBt).

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 x 25 cm 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.

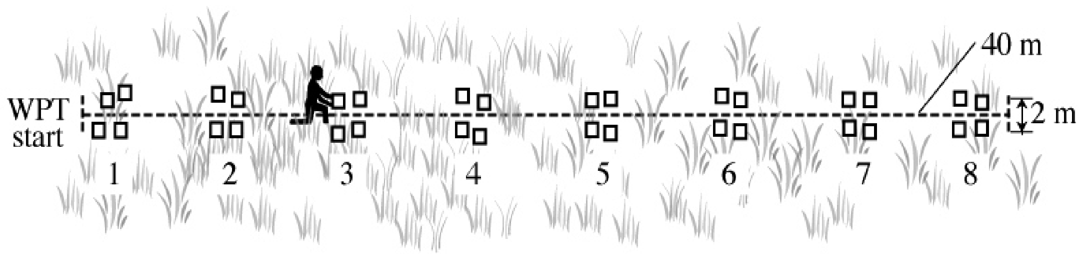

Figure A1.3.3: Soft-benthos (infaunal) quadrat station (SBq).
Single quadrats are 25 cm x 25 cm in size and four make up one 'quadrat group'.

Mother-of-pearl (MOP) or sea cucumber (BdM) fisheries

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.

Reef-front searches (RFs and RFs_w)

If swell conditions allowed, three 5-min search periods (conducted by two snorkellers, i.e. 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).

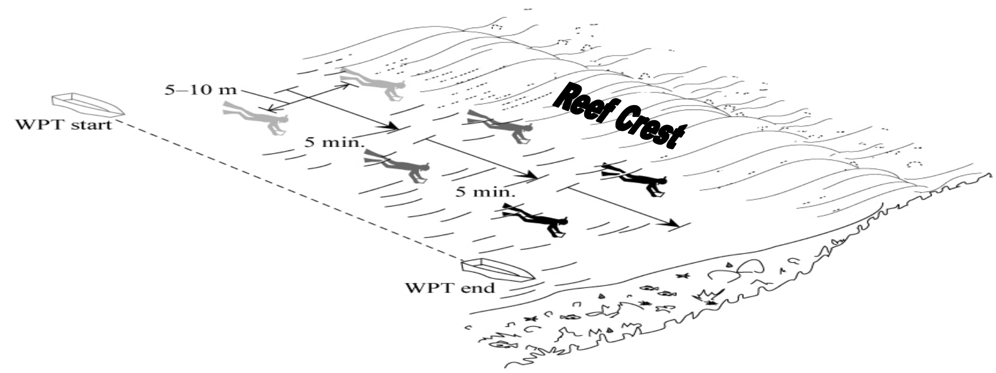

Figure A1.3.4: Reef-front search (RFs) station.

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.

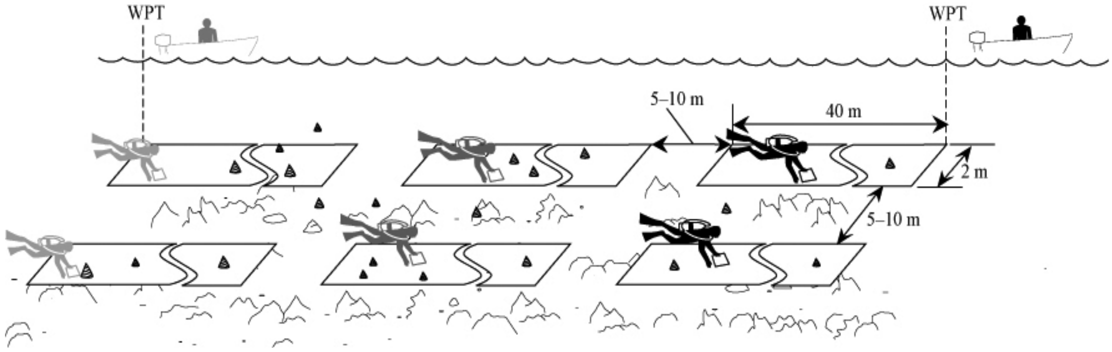

Figure A1.3.5: Mother-of-pearl transect station (MOPt).

<u>Sea cucumber day search (Ds)</u>

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.

<u>Sea cucumber night search (Ns)</u>

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 benthos																		
entered / checked	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/

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.

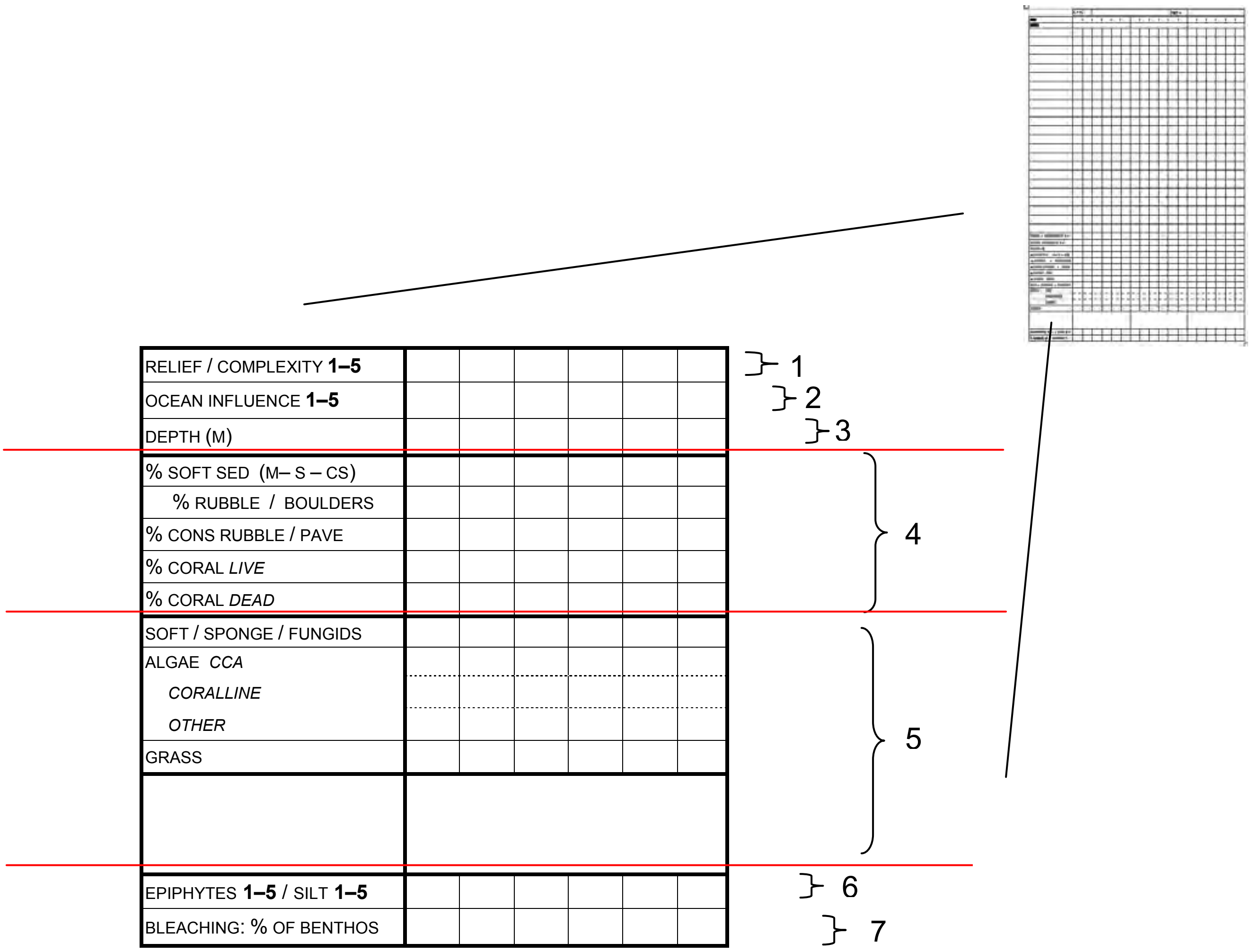

Figure A1.3.7: Sample of the invertebrate habitat part of survey form.

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* spp.)
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 spp. 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 Andra socioeconomic survey data

2.1.1 Annual catch (kg) of fish groups per habitat – Andra
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Kamatu	Scaridae	*Bolbometopon muricatum*	468	11.7
Mah			468	11.7
Ulah	Scaridae	*Scarus schlegeli*	370	9.2
Arau	Scaridae	*Scarus* spp.	280	7.0
Nimei			262	6.5
Chehero			221	5.5
Mbulea	Lethrinidae	*Lethrinus olivaceus, Lethrinus semicinctus*	220	5.5
Mam			206	5.2
Lu	Haemulidae	*Plectorhinchus* spp.	158	3.9
Alipat			111	2.8
Aredal			111	2.8
Ahu			111	2.8
Kasi	Lethrinidae	*Lethrinus olivaceus*	105	2.6
Mbrun	Balistidae	*Balistoides* spp.	88	2.2
Oleng	Lethrinidae	*Lethrinus harak*	78	1.9
Moses	Mullidae	*Parupeneus barberinus*	77	1.9
Pamurer	Lethrinidae	*Lethrinus miniatus*	60	1.5
Pavaul	Haemulidae	*Plectorhinchus chaetodonoides*	56	1.4
Kih	Haemulidae	*Plectorhinchus chaetodonoides*	52	1.3
Sawii	Lethrinidae	*Gymnocranius euanus*	46	1.1
Kali	Serranidae	*Epinephelus merra*	45	1.1
Ngundruput	Haemulidae	*Plectorhinchus flavomaculatus*	44	1.1
Pipiu			44	1.1
Kapah			44	1.1
Kirau	Acanthuridae	*Acanthurus* spp.	42	1.0
Ndrangah	Labridae	*Cheilinus chlorourus*	33	0.8
Chapang	Acanthuridae	*Acanthurus nubilus*	33	0.8
Mareku	Acanthuridae	*Acanthurus lineatus*	31	0.8
Mbrusuwiu	Labridae	*Cheilinus undulatus*	29	0.7
Chawuh			28	0.7
Mbrupat	Carangidae	*Carangoides plagiotaenia*	24	0.6
Hii			13	0.3
Ndrok	Siganidae	*Siganus spinus*	12	0.3
Drau			11	0.3
Tuh	Lethrinidae	*Lethrinus genivittatus*	7	0.2
Pirau			6	0.2
Soso	Holocentridae	*Myripristis* spp.	5	0.1
Nos	Lethrinidae	*Lethrinus rubrioperculatus*	3	0.1
Osang	Lethrinidae	*Lethrinus atkinsoni*	1	0.0
Hu'uh	Scaridae	*Hipposcarus longiceps*	1	0.0
Total:			**4003**	**100**

2.1.1 Annual catch (kg) of fish groups per habitat – Andra (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon				
Sawii	Lethrinidae	*Gymnocranius euanus*	540	16.8
Kasi	Lethrinidae	*Lethrinus olivaceus*	280	8.7
Kamatu	Scaridae	*Bolbometopon muricatum*	248	7.7
Moses	Mullidae	*Parupeneus barberinus*	248	7.7
Nos	Lethrinidae	*Lethrinus rubrioperculatus*	240	7.5
Pipiu			230	7.2
Pologai	Haemulidae	*Plectorhinchus pictus*	229	7.1
Kameyah			180	5.6
Ndrih			180	5.6
Mbulea	Lethrinidae	*Lethrinus olivaceus, Lethrinus semicinctus*	156	4.9
Mah			98	3.0
Ralis			90	2.8
Bulea			73	2.3
Ngundruput	Haemulidae	*Plectorhinchus flavomaculatus*	58	1.8
Pavaul	Haemulidae	*Plectorhinchus chaetodonoides*	56	1.7
Parekel	Carangidae	*Caranx sexfasciatus*	55	1.7
Kali	Serranidae	*Epinephelus merra*	51	1.6
Munui			49	1.5
Lu	Haemulidae	*Plectorhinchus* spp.	45	1.4
Pwah	Lutjanidae	*Lutjanus russellii*	41	1.3
Mbudut			39	1.2
Rat			15	0.5
Arau	Scaridae	*Scarus* spp.	4	0.1
Mareku	Acanthuridae	*Acanthurus lineatus*	4	0.1
Mbrun	Balistidae	*Balistoides* spp.	2	0.1
Total:			**3213**	**100**
Outer reef				
Kasi	Lethrinidae	*Lethrinus olivaceus*	2873	10.9
Kowow			2694	10.3
Ngundruput	Haemulidae	*Plectorhinchus flavomaculatus*	2246	8.6
Marenal	Lutjanidae	*Aprion virescens*	2129	8.1
Ndralis	Lutjanidae	*Lutjanus gibbus*	2017	7.7
Nos	Lethrinidae	*Lethrinus rubrioperculatus*	1714	6.5
Kih	Haemulidae	*Plectorhinchus chaetodonoides*	1665	6.3
Paleau	Carangidae	*Caranx* spp.	1484	5.7
Ralis			1337	5.1
Pipiu			1196	4.6
Kali	Serranidae	*Epinephelus merra*	752	2.9
Sawii	Lethrinidae	*Gymnocranius euanus*	680	2.6
Molet	Mugilidae	*Mugil* spp.	660	2.5
Kameyah			627	2.4
Ur	Carangidae	*Caranx sexfasciatus*	582	2.2
Pologai	Haemulidae	*Plectorhinchus pictus*	557	2.1

2.1.1 Annual catch (kg) of fish groups per habitat – Andra (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef (continued)				
Ndrih			531	2.0
Nimei			484	1.8
Al	Sphyraenidae	*Sphyraena barracuda*	469	1.8
Kurur			311	1.2
Pavaul	Haemulidae	*Plectorhinchus chaetodonoides*	259	1.0
Mbrun	Balistidae	*Balistoides* spp.	137	0.5
Mbulea	Lethrinidae	*Lethrinus olivaceus, Lethrinus semicinctus*	112	0.4
Bulea			105	0.4
Malicip			103	0.4
Parnal			90	0.3
Poporou			90	0.3
Lu	Haemulidae	*Plectorhinchus* spp.	52	0.2
Liliu	Balistidae	*Pseudobalistes flavimarginatus*	52	0.2
Mbrupat	Carangidae	*Carangoides plagiotaenia*	52	0.2
Parekel	Carangidae	*Caranx sexfasciatus*	46	0.2
Mamau	Carangidae	*Caranx ignobilis*	46	0.2
Kamatu	Scaridae	*Bolbometopon muricatum*	39	0.2
Pulia			39	0.2
Nidul	Carangidae	*Scomberoides lysan*	33	0.1
Total:			**26,264**	**100.0**

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Andra

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Reeftop	Paruwoh	*Hippopus hippopus*, Tridacna spp.	38.9	4484	2242	43,887	21,943
	Octopus	*Octopus* spp.	22.8	2385	1312	23,346	12,840
	Lut	*Turbo crassus*	9.9	7158	573	70,066	5605
	Horo'hor	*Tripneustes gratilla*	5.7	3301	330	32,306	3231
	Ndrayang	*Lambis lambis*	4.3	8660	217	96,658	2416
	Palanchapou	*Cypraea tigris*	5.3	1969	30	31,164	2961
	Nakaris	*Thais aculeata*	1.4	4126	83	40,382	808
	Peheri	*Donax cuneatus*	11.7	40,317	605	437,863	6568
Total:			**100.0**	**72,399**	**5390**	**77,5671**	**56,372**

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Andra

Vernacular name	Scientific name	Size class	% of total catch (weight)
Horo'hor	*Tripneustes gratilla*	10 cm	53.9
		10-12 cm	19.7
		12 cm	26.3
Lut	*Turbo crassus*	04 cm	60.7
		04-06 cm	33.3
		08 cm	6.1
Nakaris	*Thais aculeata*	06 cm	15.8
		06-08 cm	21.1
		08 cm	63.2
Ndrayang	*Lambis lambis*	06-08 cm	30.1
		08-10 cm	18.7
		10-12 cm	36.1
		12 cm	15.0
Octopus	*Octopus* spp.	06-08 cm	18.2
		08 cm	11.8
		10 cm	35.8
		10-12 cm	6.8
		12 cm	27.3
Palanchapou	*Cypraea tigris*	05-06 cm	3.0
		06-08 cm	20.5
		08 cm	44.1
		08-10 cm	32.4
Paruwoh	*Hippopus hippopus*, *Tridacna* spp.	10-14 cm	5.3
		14-16 cm	1.3
		16-18 cm	86.2
		20-22 cm	1.8
		22-26 cm	5.3
Peheri	*Donax cuneatus*	04-06 cm	
		06 cm	
		06-08 cm	

2.1.4 Catch details for bêche-de-mer: average length and total reported catch – Andra

Vernacular name	Scientific name	Length (cm)		% of total catch (weight)
		From	To	
Lollyfish	*Holothuria coluber*	8	10	9.5
Leopardfish	*Bohadschia argus*	14	16	5
Deep-water redfish	*Actinopyga echinites*	14	16	5
White teatfish	*Holothuria fuscogilva*	26	28	50
Surf redfish	*Actinopyga mauritiana*	16	18	5
Sandfish	*Holothuria scabra*	26	28	2
Curryfish	*Stichopus variegates*	26	28	5
Elephant trunkfish	*Holothuria fuscopunctata*	26	28	5
Greenfish	*Stichopus chloronotus*	26	28	5
Prickly redfish	*Thelenota ananas*	26	28	5
Black teatfish	*Holothuria nobilis*	24	26	1
Stonefish	*Actinopyga lecanora*	16	18	2.5

2.1.5 Market price inventory of canned fish, corned beef and boiled/smoked fish at Loringau (Manus) and Andra

Item	MANUS			ANDRA		
	PGK	g	PGK/kg	PGK	g	PGK/kg
Mackerel, tomato	3.65	425	8.59			
Mackerel, tomato	2.3	425	5.41	4.5	425	10.59
Mackerel, oil	2.2	425	5.18	4	425	9.41
Mackerel, oil	3.5	425	8.24	2.5	185	13.51
Tuna, oil	3.45	425	8.12	3.5	185	18.92
Tuna, tomato	1.6	185	8.65			
Tuna, oil	1.5	185	8.11			
Mackerel, tomato	1.65	155	10.65			
Mackerel, oil	1.4	155	9.03			
		Average	**8.00**		**Average**	**13.11**
Corned beef	2.65	200	13.25	5	200	25.00
Corned beef	3.7	370	10.00	9.5	340	27.94
Corned beef	5.05	300	16.83			
Corned beef	3.65	200	18.25			
Corned beef	25.5	1570	16.24			
Corned beef	18.9	1570	12.04			
		Average	**14.44**		**Average**	**26.47**

	MANUS		
	PGK	g	PGK/kg
Boiled/smoked fish	0.5	200	2.50
Boiled/smoked fish	8	1500	5.33
Boiled/smoked fish	4	1000	4.00
Boiled/smoked fish	5	1000	5.00
		Average	**4.21**
Boiled/smoked octopus	5	1 piece	
Boiled/smoked octopus	8	1 piece	
Fresh mud crab	3	1 piece	
Fresh mud crab	5	1 piece	
Fresh mud crab	8	1 piece	

2.1.6 Prices of bêche-de-mer and trochus – Andra

Bêche-de-mer

Vernacular name	Scientific name	Price (PGK/kg)		Total annual catch (kg/year)	
		From	To	From	To
Lollyfish	*Holothuria coluber*	8	10	1211.25	1615
Leopardfish	*Bohadschia argus*	20	25	637.50	850
Deep-water redfish	*Actinopyga echinites*	20	20	637.50	850
White teatfish	*Holothuria fuscogilva*	120	135	6375.00	8500
Surf redfish	*Actinopyga mauritiana*	60	80	637.50	850
Sandfish	*Holothuria scabra*	120	170	255.00	340
Curryfish	*Stichopus variegatus*	60	80	637.50	850
Elephant trunkfish	*Holothuria fuscopunctata*	10	10	637.50	850
Greenfish	*Stichopus chloronotus*	60	80	637.50	850
Prickly redfish	*Thelenota ananas*	60	80	637.50	850
Black teatfish	*Actinopyga lecanora*	60	80	318.75	425
Stonefish	*Holothuria nobilis*	50	60	127.50	170
Total:				**12,750**	**17,000**

Trochus

Vernacular name	Scientific name	Price (PGK/kg)	Price (PGK/10 pieces per stick)	Total annual catch (kg/year)
		Shell	Meat (boiled, smoked)	
Trochus, lal, lalei	*Trochus niloticus*	10	0.50	11000

2.2 Tsoilaunung socioeconomic survey data

2.2.1 Annual catch (kg) of fish groups per habitat – Tsoilaunung
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Vugata			36	47.9
Sungui	Lethrinidae	*Lethrinus olivaceus*	32	41.5
Osang	Lethrinidae	*Lethrinus atkinsoni*	7	9.8
Koruwan	Serranidae	*Epinephelus merra*	0	0.3
Kilo	Acanthuridae	*Acanthurus triostegus*	0	0.3
Total:			**76**	**99.9**
Lagoon				
Osang	Lethrinidae	*Lethrinus atkinsoni*	1260	9.5
Sui	Lethrinidae	*Lethrinus xanthochilus*	1015	7.7
Magai			980	7.4
Taswan	Lutjanidae	*Lutjanus gibbus*	969	7.3
Makarau	Nemipteridae	*Scolopsis lineata*	942	7.1
Rauwan	Mugilidae	*Liza* spp.	929	7.0
Bil	Carangidae	*Caranx* spp.	860	6.5
Gagaus	Siganidae	*Siganus lineatus*	836	6.3
Kulawa	Carangidae	*Caranx* spp.	672	5.1
Ulah	Scaridae	*Scarus schlegeli*	485	3.7
Ungaus	Siganidae	*Siganus lineatus*	371	2.8
Awing	Lethrinidae	*Lethrinus nebulosus*	351	2.7
Kaingoto	Acanthuridae	*Acanthurus xanthopterus*	346	2.6
Labusak	Lethrinidae	*Lethrinus obsoletus*	328	2.5
Ukal	Siganidae	*Siganus argenteus*	292	2.2
Sungui	Lethrinidae	*Lethrinus olivaceus*	261	2.0
Kuga	Serranidae	*Cephalopholis* spp., *Epinephelus* spp.	216	1.6
Ivata	Balistidae	*Pseudobalistes flavimarginatus*	214	1.6
Taringingel	Lethrinidae	*Lethrinus lentjan*	202	1.5
Kalang	Lutjanidae	*Lutjanus semicinctus*	190	1.4
Pavaul	Haemulidae	*Plectorhinchus chaetodonoides*	134	1.0
Ulai	Siganidae	*Siganus rivulatus*	101	0.8
PGKri	Acanthuridae	*Acanthurus lineatus*	92	0.7
Munis			92	0.7
Koruwan	Serranidae	*Epinephelus merra*	87	0.7
Kalaiyas			83	0.6
Mamin	Labridae	*Cheilinus undulatus*	80	0.6
Samung			78	0.6
Konkonakawal	Lutjanidae	*Lutjanus argentimaculatus*	64	0.5
Dowen	Mugilidae	*Valamugil seheli*	56	0.4
Arage	Lutjanidae	*Lutjanus argentimaculatus*	54	0.4
Malisa			54	0.4
Iyanipat			50	0.4
Aruma	Belonidae	*Tylosurus crocodilus crocodilus*	47	0.4
Amatung	Scaridae	*Bolbometopon muricatum*	41	0.3
Tuh	Lethrinidae	*Lethrinus genivittatus*	37	0.3

2.2.1 Annual catch (kg) of fish groups per habitat – Tsoilaunung
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon (continued)				
Pangama	Acanthuridae	*Acanthurus* spp.	36	0.3
Lu	Haemulidae	*Plectorhinchus* spp.	36	0.3
Tingang	Lutjanidae	*Lutjanus bohar*	28	0.2
Ranganlava			28	0.2
Makago	Scaridae	*Scarus rubroviolaceus*	28	0.2
matarangai	Lutjanidae	*Aphareus furca*	28	0.2
Teb	Lutjanidae	*Lutjanus russellii*	22	0.2
Ga	Scombridae	*Rastrelliger kanagurta*	21	0.2
Samu			19	0.1
Vugata			18	0.1
Oton	Acanthuridae	*Naso* spp.	15	0.1
Mangava	Scaridae	*Scarus rubroviolaceus*	15	0.1
Bukata	Balistidae	*Rhinecanthus verrucosus*	11	0.1
Mawa	Scaridae	*Scarus ghobban*	9	0.1
Soso	Holocentridae	*Myripristis* spp.	7	0.1
Total:			**13,193**	**100.0**
Outer reef				
Amatung	Scaridae	*Bolbometopon muricatum*	1259	26.5
Kulawa	Carangidae	*Caranx* spp.	857	18.0
Ukal	Siganidae	*Siganus argenteus*	398	8.4
Ungaus	Siganidae	*Siganus lineatus*	325	6.8
Osang	Lethrinidae	*Lethrinus atkinsoni*	286	6.0
Aruma	Belonidae	*Tylosurus crocodilus crocodilus*	259	5.5
Samu			217	4.6
Laing	Haemulidae	*Plectorhinchus orientalis*	217	4.6
Punga	Serranidae	*Epinephelus* spp.	217	4.6
Magai			141	3.0
Taswan	Lutjanidae	*Lutjanus gibbus*	111	2.3
Ivata	Balistidae	*Pseudobalistes flavimarginatus*	90	1.9
Kuga	Serranidae	*Cephalopholis* spp., *Epinephelus* spp.	80	1.7
Awing	Lethrinidae	*Lethrinus nebulosus*	56	1.2
Arage	Lutjanidae	*Lutjanus argentimaculatus*	53	1.1
Samung			38	0.8
Kaingoto	Acanthuridae	*Acanthurus xanthopterus*	29	0.6
Mamin	Labridae	*Cheilinus undulatus*	28	0.6
Iabusak	Lethrinidae	*Lethrinus obsoletus*	24	0.5
Ulai	Siganidae	*Siganus rivulatus*	24	0.5
Inari			24	0.5
Munis			12	0.3
Koga	Muraenidae	*Gymnothorax* spp.	6	0.1
Taringingel	Lethrinidae	*Lethrinus lentjan*	3	0.1
Total:			**4756**	**100.0**

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Tsoilaunung

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Reeftop	Tuwaga	*Cardisoma* spp.	0.2	43		included below	
	Mulimuli	*Cypraea tigris*	1.8	869		included below	
	Matamalek	*Eriphia sebana*	0.2	261	9	11,607	406
	Wutil	*Gafrarium* spp.	2.7	5863	123	604,406	12,693
	Salsal	*Hippopus hippopus*	44.5	3995	1998	94,068	47,034
	Langa	*Lambis lambis*	2.4	4386	110	146,068	3652
	Unang	*Lysiosquillina maculata*	1.5	261	65	6756	1689
	Octopus	*Octopus* spp.	5.3	434	239	11,260	6193
	Almang	*Scylla serrata*	6.8	434	304	110,263	77,184
	Muya	*Strombus luhuanus*	2.0	3605	90	147,403	3685
	Kunim	*Tridacna maxima*	27.8	2497	1249	64,747	32,374
	Wutwut	*Turbo crassus*	4.6	2606	208	67,562	5405
Total:			**100**	**25,254**	**4395**	**1,264,141**	**190,315**
Soft benthos	Kangniu	*Acrosterigma* spp.	0.2	100		included below	
	Tuas	*Anadara* spp.	20.6	10,078		included below	
	Kangraula	*Asaphis violascens*	4.8	3301	50	85,579	1284
	Kales	*Atactodea striata* , *Donax cuneatus*	0.2	900	2	23,323	64
	Pusi-pusi	*Conus* spp.	20.3	869	208	22,521	5405
	Mulimuli	*Cypraea tigris*	4.0	434	41	33,781	3209
	Wutil	*Gafrarium* spp.	24.8	12,117		included below	
	Langa	*Lambis lambis*	4.2	1737		included above	
	Viu	*Modiolus auriculatus*	8.8	4274	90	104,967	2204
	Muya	*Strombus luhuanus*	7.7	3154		included above	
	Kangpilik	*Tapes literatus*	4.2	2171		included above	
	Ngisngisatanyanga			3474	0	90,083	
	Seaweed			43	0	1126	
Total:			**100**	**42,652**	**391**	**361,381**	**12,166**
Mangrove	Almang	*Scylla serrata*	53.4	4112		included above	
	Kangniu	*Acrosterigma* spp.	0.5	1346	28	37,499	788
	Tuas	*Anadara* spp.	5.1	13,072	275	546,769	11,482
	Tuwaga	*Cardisoma* spp.	31.9	7536	1717	148,889	33,922
	Wutil	*Gafrarium* spp.	3.0	7817		included above	
	Tubiak	*Onchidium* spp.	1.2	2606	65	67,562	1689
	Angi	*Pinctada* spp.	4.8	1303	261	33,781	6756
	Kangpilik	*Tapes literatus*	0.0	43	1	57,428	1149
	Kure			34,743	0	900,833	
	Peen			28,923	0	749,943	
Total:			**100**	**101,502**	**2346**	**2,542,705**	**55,785**

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Tsoilaunung (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Bêche-de-mer	Deep-water redfish	*Actinopyga echinites*	4.1	7332	2200	157,168	47,150
	Stonefish	*Actinopyga lecanora, Actinopyga miliaris*	2.6	4667	1400	96,002	28,801
	Red surffish	*Actinopyga mauritiana*	2.7	4069	1424	95,830	33,540
	Tigerfish	*Bohadschia argus*	1.2	1344	621	25,012	11,568
	Flowerfish	*Bohadschia graeffei*	0.4	478	221	8893	4113
	Chalkfish	*Bohadschia similis*	5.3	6142	2841	158,809	73,449
	Lollyfish	*Holothuria atra, Holothuria coluber*	2.2	11,670	1167	264,438	26,444
	White teatfish	*Holothuria fuscogilva*	11.1	2953	5907	61,331	122,663
	Elephant trunkfish	*Holothuria fuscopunctata*	5.9	1743	3138	37,212	66,982
	Black teatfish	*Holothuria nobilis*	11.1	2959	5918	64,448	128,897
	Sandfish	*Holothuria scabra*	29.0	7741	15,483	186,984	373,969
	Greenfish	*Stichopus chloronotus*	0.0	261	26	4851	485
	Curryfish	*Stichopus* spp.	3.4	3339	1813	74,467	40,435
	Pricklyfish	*Thelenota ananas*	20.9	4468	11,171	98,743	246,858
Total:			**100**	**59,165**	**53,329**	**1,334,187**	**1,205,354**
Lobster	Matamalek	*Eriphia sebana*	0.1	261		included above	
	Malmalang	*Panulirus longipes*	22.7	1850	1850	34,442	34,442
	Harak	*Panulirus longipes*	22.5	1859	1859	34,606	34,606
	Walakniu	*Panulirus penicillatus*	10.8	886	886	16,499	16,499
	Yen	*Panulirus versicolor*	6.9	565	565	10,510	10,510
	Pawa	*Parribacus antarcticus, Parribacus caledonicus*	36.7	4019	3015	74,822	56,116
	Bokiau	*Strombus luhuanus*	0.3	869	22	16,169	404
	Wulatniu			912	0	16,977	
	Buankavak			651	0	12,127	
Total:			**100**	**11,872**	**8196**	**216,150**	**152,576**
Trochus	Trochus	*Trochus niloticus*	100.0	10103	2011	188,980	37,616

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Tsoilaunung

Vernacular name	Scientific name	Size class	% of total catch (weight)
Almang	*Scylla serrata*	08-16 cm	9.6
		10 cm	10.2
		14 cm	9.6
		14-16 cm	47.8
		16 cm	22.9
Angi	*Pinctada* spp.	12 cm	100.0
Black teatfish	*Holothuria nobilis*	12 cm	31.6
		16 cm	18.3
		20 cm	6.6
		22-24 cm	12.5
		24 cm	2.9
		26 cm	12.7
		26-28 cm	11.0
		28 cm	4.4
Bokiau	*Strombus luhuanus*	28 cm	100.0
Buankavak		26 cm	
Chalkfish	*Bohadschia similis*	04-06 cm	1.0
		10 cm	42.4
		10-14 cm	26.5
		12 cm	23.0
		20 cm	7.1
Curryfish	*Stichopus* spp.	10-12 cm	1.9
		12 cm	7.8
		14 cm	3.9
		14-16 cm	6.5
		16 cm	13.0
		18 cm	29.9
		20 cm	7.2
		20-22 cm	0.4
		26 cm	1.0
		28 cm	28.5
Elephant trunkfish	*Holothuria fuscopunctata*	22 cm	37.4
		24 cm	50.2
		28 cm	12.5
Flowerfish	*Bohadschia graeffei*	16 cm	45.5
		20 cm	54.5
Greenfish	*Stichopus chloronotus*	08 cm	100.0
Harak	*Panulirus longipes*	20 cm	9.4
		20-26 cm	11.7
		22 cm	9.7
		22-24 cm	1.1
		24 cm	9.4
		28 cm	58.7
Kales	*Atactodea striata*, *Donax cuneatus*	02 cm	100.0
Kangniu	*Acrosterigma* spp.	04 cm	90.1
		04-06 cm	6.9
		06-08 cm	3.0

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Tsoilaunung (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Kangpilik	*Tapes literatus*	06-08 cm	2.0
		08 cm	98.0
Kangraula	*Asaphis violascens*	06 cm	21.1
		08 cm	78.9
Kunim	*Tridacna maxima*	08-14 cm	28.7
		12 cm	1.7
		16 cm	34.8
		18 cm	34.8
		06-08 cm	
		12 cm	
Langa	*Lambis lambis*	06 cm	42.6
		08-10 cm	7.1
		10-12 cm	36.2
		12 cm	14.2
Lollyfish	*Holothuria atra*, *Holothuria coluber*	04 cm	14.9
		08 cm	4.5
		10 cm	18.6
		10-14 cm	11.4
		14 cm	12.3
		16 cm	3.6
		18 cm	3.7
		20 cm	7.4
		20-22 cm	0.1
		22 cm	17.9
		26 cm	5.6
Malmalang	*Panulirus longipes*	20 cm	35.0
		20-22 cm	1.9
		20-26 cm	7.0
		22 cm	18.7
		26 cm	37.4
Matamalek	*Eriphia sebana*	08 cm	50.0
		16-18 cm	50.0
Mulimuli	*Cypraea tigris*	06 cm	33.3
		12 cm	66.7
Muya	*Strombus luhuanus*	04 cm	38.6
		04-06 cm	1.9
		06 cm	49.9
		12 cm	9.6
Ngisngisatanyanga		06 cm	
Octopus	*Octopus* spp.	12-16 cm	100.0
Pawa	*Parribacus antarcticus*, *Parribacus caledonicus*	20 cm	95.7
		20-22 cm	4.3
Peen		08 cm	
		10-12 cm	

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Tsoilaunung (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Deep-water redfish	*Actinopyga echinites*	08 cm	3.6
		10-12 cm	0.9
		12 cm	22.2
		18 cm	15.8
		18-19 cm	5.3
		20 cm	11.8
		22 cm	23.7
		24 cm	10.7
		26 cm	5.9
Pricklyfish	*Thelenota ananas*	08 cm	8.7
		12 cm	12.1
		12-14 cm	2.8
		16 cm	18.0
		20 cm	22.4
		22 cm	8.7
		24 cm	22.4
		26 cm	4.9
Pusi-pusi	*Conus* spp.	08 cm	100.0
Red surffish	*Actinopyga mauritiana*	08 cm	8.0
		08-10 cm	1.5
		10 cm	13.3
		14 cm	37.4
		14-16 cm	16.0
		20 cm	17.1
		22 cm	6.7
Salsal	*Hippopus hippopus*	08-12 cm	10.9
		10-12 cm	32.6
		12-14 cm	23.9
		14-16 cm	10.9
		16 cm	21.7
Sandfish	*Holothuria scabra*	10 cm	1.5
		10-14 cm	14.0
		18 cm	21.0
		20 cm	19.4
		20-22 cm	0.2
		22 cm	5.6
		24 cm	0.7
		24-26 cm	35.1
		26 cm	2.5
Stonefish	*Actinopyga lecanora*, *Actinopyga miliaris*	10 cm	9.7
		10-14 cm	14.0
		14 cm	11.6
		16 cm	1.2
		20 cm	48.2
		22 cm	5.6
		24 cm	9.8

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Tsoilaunung (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Tigerfish	*Bohadschia argus*	10-12 cm	4.6
		12 cm	24.2
		20 cm	17.8
		22 cm	45.3
		28 cm	8.1
Trochus	*Trochus niloticus*	04-06 cm	19.3
		08-10 cm	17.7
		08-12 cm	63.0
Tuas	*Anadara* spp.	04 cm	3.5
		04-06 cm	5.6
		06 cm	58.7
		06-08 cm	28.3
		08-12 cm	3.8
		14-16 cm	0.2
Tubiak	*Onchidium* spp.	12 cm	100.0
Tuwaga	*Cardisoma* spp.	06-08 cm	85.9
		08 cm	0.6
		08-10 cm	0.6
		12 cm	12.9
Unang	*Lysiosquillina maculata*	14-16 cm	100.0
Viu	*Modiolus auriculatus*	06 cm	100.0
Walakniu	*Panulirus penicillatus*	20-26 cm	9.6
		22 cm	16.9
		24 cm	29.4
		26 cm	44.1
White teatfish	*Holothuria fuscogilva*	14-16 cm	3.7
		16 cm	36.8
		22-24 cm	14.7
		26 cm	22.8
		28 cm	22.1
Wulatniu		22 cm	
		24 cm	
		28 cm	
Wutil	*Gafrarium* spp.	02 cm	34.2
		04 cm	22.9
		04-06 cm	30.3
		08 cm	7.6
		10 cm	5.1
Wutwut	*Turbo crassus*	06 cm	100.0
Yen	*Panulirus versicolor*	20 cm	69.2
		22 cm	30.8
Wutil	*Gafrarium* spp.	02 cm	34.2
		04 cm	22.9
		04-06 cm	30.3
		08 cm	7.6
		10 cm	5.1
Wutwut	*Turbo crassus*	06 cm	100.0

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Tsoilaunung (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Yen	*Panulirus versicolor*	20 cm	69.2
		22 cm	30.8

2.3 Sideia socioeconomic survey data

2.3.1 Annual catch (kg) of fish groups per habitat – Sideia

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Gelogelolo	Scaridae	*Cetoscarus bicolor*, *Scarus ghobban*	198	11.9
Kaukauli	Serranidae	*Epinephelus* spp.	129	7.7
Loloya	Nemipteridae	*Pentapodus emeryii*	107	6.4
Kibi	Balistidae	*Rhinecanthus* spp.	106	6.3
Iyesela	Acanthuridae	*Naso unicornis*	103	6.2
Wadumu	-	-	103	6.2
Igomida	Scaridae	*Scarus* spp.	78	4.7
Napunapu	Holocentridae	*Neoniphon sammara*	74	4.4
Semile	Lutjanidae	*Lutjanus semicinctus*	65	3.9
Gamokaya	Serranidae	*Plectropomus leopardus*	61	3.7
Hopahopa	Haemulidae	*Plectorhinchus chaetodonoides*	54	3.2
Petapeta	Chaetodontidae	*Chaetodon fasciatus*	51	3.0
Soki	Bramidae	*Brama orcini*	50	3.0
Bahibahi	Mullidae	*Parupeneus* spp.	50	3.0
Debidebi	Siganidae	*Siganus fuscescens*	43	2.6
Deadeasi	Scombridae	*Scomberomorus commerson*	42	2.5
Buhubuhu	Lethrinidae	*Lethrinus xanthochilus*	40	2.4
Kebolia	Kyphosidae	*Kyphosus vaigiensis*	35	2.1
Kumkum	Scombridae	*Gymnosarda unicolor*	33	2.0
Kasiwa	Balistidae	*Pseudobalistes flavimarginatus*	25	1.5
Ulegohi	Siganidae	*Siganus lineatus*	24	1.4
Moiyale	Nemipteridae	*Nemipterus* spp.	24	1.4
Amohali	Scaridae	*Hipposcarus longiceps*	23	1.4
Getula	Carangidae	*Carangoides orthogrammus*	22	1.3
Halakausi	Serranidae	*Cephalopholis argus*	17	1.0
Gaigaidi	Holocentridae	*Sargocentron caudimaculatum*	17	1.0
Ewaewa	Nemipteridae	*Scolopsis trilineata*	12	0.7
Waiya	Engraulidae	*Stolephorus commersonnii*	12	0.7
Wenawenao	Carangidae	*Decapterus macarellus*	12	0.7
Busmalao	Lethrinidae	*Lethrinus erythracanthus*	9	0.6
Modamahina	Pomacanthidae	*Pomacanthus sexstriatus*	9	0.5
Lealea	Nemipteridae	*Nemipterus* spp.	7	0.4
Waitalana	Carangidae	*Elagatis bipinnulata*	5	0.3
Bilawan	Scombridae	*Acanthocybium solandri*	5	0.3
Bumubumule	Lethrinidae	*Lethrinus amboinensis*	5	0.3
Keakeatu	Balistidae	*Abalistes stellaris*	5	0.3
Halimagiluwana	Nemipteridae	*Nemipterus* spp.	4	0.2
Gwadumo	Belonidae	*Tylosurus* spp.	3	0.2
Matapou	Holocentridae	*Myripristis berndti*	3	0.2
Koliwala	Sphyraenidae	*Sphyraena* spp.	2	0.1
Total:			**1668**	**100.0**

2.3.1 Annual catch (kg) of fish groups per habitat – Sideia (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon				
Getula	Carangidae	*Carangoides orthogrammus*	293	13.3
Kasepwala	Lethrinidae	*Lethrinus* spp.	255	11.6
Deadeasi	Scombridae	*Scomberomorus commerson*	248	11.3
Moiyale	Nemipteridae	*Nemipterus* spp.	154	7.0
Kebolia	Kyphosidae	*Kyphosus vaigiensis*	135	6.1
Petapeta	Chaetodontidae	*Chaetodon fasciatus*	128	5.8
Semile	Lutjanidae	*Lutjanus semicinctus*	120	5.4
Lealea	Nemipteridae	*Nemipterus* spp.	102	4.7
Waitalana	Carangidae	*Elagatis bipinnulata*	94	4.3
Baewa	Carcharhinidae	*Carcharhinus* spp.	92	4.2
Gamokaya	Serranidae	*Plectropomus leopardus*	78	3.5
Koliwala	Sphyraenidae	*Sphyraena* spp.	54	2.5
Debidebi	Siganidae	*Siganus fuscescens*	51	2.3
Kasiwa	Balistidae	*Pseudobalistes flavimarginatus*	48	2.2
Wadumu	-	-	43	2.0
Napunapu	Holocentridae	*Neoniphon sammara*	33	1.5
Ulegohi	Siganidae	*Siganus lineatus*	33	1.5
Mitamita	-	-	33	1.5
Bwagilam	Istiophoridae	*Makaira* spp.	33	1.5
Kibi	Balistidae	*Rhinecanthus* spp.	29	1.3
Bahibahi	Mullidae	*Parupeneus* spp.	27	1.2
Tokeli	Nemipteridae	*Pentapodus paradiseus*	21	1.0
Gelogelolo	Scaridae	*Cetoscarus bicolor*, *Scarus ghobban*	17	0.8
Gasawa	Scombridae	*Rastrelliger kanagurta*	17	0.8
Loloya	Nemipteridae	*Pentapodus emeryii*	14	0.7
Yaboan	-	-	13	0.6
Kaukauli	Serranidae	*Epinephelus* spp.	11	0.5
Buhubuhu	Lethrinidae	*Lethrinus xanthochilus*	10	0.5
Kumkum	Scombridae	*Gymnosarda unicolor*	6	0.3
Waiya	Engraulidae	*Stolephorus commersonnii*	6	0.3
Total:			**2199**	**100.0**
Sheltered coastal reef & outer reef				
Semile	Lutjanidae	*Lutjanus semicinctus*	293	30.5
Deadeasi	Scombridae	*Scomberomorus commerson*	240	24.9
Waitalana	Carangidae	*Elagatis bipinnulata*	138	14.4
Moiyale	Nemipteridae	*Nemipterus* spp.	41	4.3
Kebolia	Kyphosidae	*Kyphosus vaigiensis*	37	3.9
Bwokabwokalana	Lethrinidae	*Monotaxis grandoculis*	33	3.5
Tokeli	Nemipteridae	*Pentapodus paradiseus*	27	2.8
Kaukauli	Serranidae	*Epinephelus* spp.	22	2.3
Loloya	Nemipteridae	*Pentapodus emeryii*	22	2.3
Pakila	Sillaginidae	*Sillago sihama*	21	2.1
Petapeta	Chaetodontidae	*Chaetodon fasciatus*	20	2.1

2.3.1 Annual catch (kg) of fish groups per habitat – Sideia (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 (continued)				
Kumkum	Scombridae	*Gymnosarda unicolor*	17	1.7
Gaigaidi	Holocentridae	*Sargocentron caudimaculatum*	17	1.7
Kibi	Balistidae	*Rhinecanthus* spp.	12	1.2
Halakausi	Serranidae	*Cephalopholis argus*	12	1.2
Gelogelolo	Scaridae	*Cetoscarus bicolor*, *Scarus ghobban*	9	1.0
Total:			**962**	**100.0**
Outer reef				
Waitalana	Carangidae	*Elagatis bipinnulata*	561	14.6
Kebolia	Kyphosidae	*Kyphosus vaigiensis*	368	9.5
Deadeasi	Scombridae	*Scomberomorus commerson*	331	8.6
Getula	Carangidae	*Carangoides orthogrammus*	237	6.2
Igomida	Scaridae	*Scarus* spp.	231	6.0
Semile	Lutjanidae	*Lutjanus semicinctus*	212	5.5
Moiyale	Nemipteridae	*Nemipterus* spp.	164	4.2
Gamokaya	Serranidae	*Plectropomus leopardus*	131	3.4
Gwadumo	Belonidae	*Tylosurus* spp.	131	3.4
Bilawan	Scombridae	*Acanthocybium solandri*	124	3.2
Lealea	Nemipteridae	*Nemipterus* spp.	112	2.9
Suila	Mullidae	*Mulloidichthys flavolineatus*	106	2.8
Kibukibu	Scombridae	*Rastrelliger kanagurta*	94	2.4
Maimua	Scombridae	*Sarda orientalis*	94	2.4
Kaniwala	Sphyraenidae	*Sphyraena barracuda*	91	2.4
Loloya	Nemipteridae	*Pentapodus emeryii*	87	2.2
Petapeta	Chaetodontidae	*Chaetodon fasciatus*	86	2.2
Ulegohi	Siganidae	*Siganus lineatus*	58	1.5
Halakausi	Serranidae	*Cephalopholis argus*	51	1.3
Soki	Bramidae	*Brama orcini*	50	1.3
Wadumu	-	-	48	1.2
Dumolatwotu	Serranidae	*Anyperodon leucogrammicus*	48	1.2
Haboli	Kyphosidae	*Kyphosus cinerascens*	48	1.2
Hopahopa	Haemulidae	*Plectorhinchus chaetodonoides*	47	1.2
Kulawa	Carangidae	*Caranx* spp.	41	1.1
Tokeli	Nemipteridae	*Pentapodus paradiseus*	40	1.0
Bahibahi	Mullidae	*Parupeneus* spp.	39	1.0
Kaukauli	Serranidae	*Epinephelus* spp.	37	1.0
Matapou	Holocentridae	*Myripristis berndti*	33	0.8
Mihali	Mugilidae	*Mugil* spp.	30	0.8
Kasepwala	Lethrinidae	*Lethrinus* spp.	27	0.7
Kibi	Balistidae	*Rhinecanthus* spp.	15	0.4
Tabibina	Lutjanidae	*Lutjanus sebae*	15	0.4
Gelogelolo	Scaridae	*Cetoscarus bicolor*, *Scarus ghobban*	13	0.3
Hinaya	Siganidae	*Siganus* spp.	12	0.3

2.3.1 Annual catch (kg) of fish groups per habitat – Sideia (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef (continued)				
Kasiwa	Balistidae	*Pseudobalistes flavimarginatus*	10	0.3
Sikauha	Nemipteridae	*Scolopsis bilineata*	9	0.2
Kosakosa	Scaridae	*Scarus* spp.	8	0.2
Keakeatu	Balistidae	*Abalistes stellaris*	8	0.2
Napunapu	Holocentridae	*Neoniphon sammara*	5	0.1
Kwatutuha	Ephippidae	*Platax* spp.	3	0.1
Total:			**3857**	**100.0**

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Sideia

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Soft benthos & mangrove	Duduna	*Terebralia palustris*	38.9	57,812.3	2171.4	included below	
	Bokiau	*Strombus luhuanus*	38.9	86,857.1	2171.4	included below	
	Sikil	*Lambis chiragra, Lambis lambis*	8.0	17,805.7	445.1	included below	
	Pohapoha	*Hippopus hippopus*	7.8	868.6	434.3	included below	
	Lauma	*Scylla serrata*	6.5	521.1	364.8	included below	
	Kepo	*Polymesoda* spp.					
Soft benthos & mangrove & reeftop	Piloma	*Saccostrea cucullata*	24.7	37,224.5	1302.9	268,714.3	9405
	Gwameme	*Cerithium nodulosum*	18.4	4053.3	972.8	included below	
	Duduna	*Terebralia palustris*	16.7	23,559.2	589.0	included below	
	Walu	*Anadara* spp.	16.4	41,360.5	868.6	included below	
	Bokiau	*Strombus luhuanus*	16.4	34,742.9	868.6	included below	
	Lauma	*Scylla serrata*	6.9	521.1	364.8	included below	
	Sikil	*Lambis chiragra, Lambis lambis*	0.4	868.6	21.7	included below	
	Kepo			434.3	0.0	included below	
Mangrove	Duduna	*Terebralia palustris*	34.7	21,686.5	814.5	1,696,160	63,707.8
	Bokiau	*Strombus luhuanus*	27.7	26,057.1	651.4	2,311,540	57,788.5
	Sikil	*Lambis chiragra, Lambis lambis*	18.5	17,371.4	434.3	1,262,360	31,559
	Lauma	*Scylla serrata*	18.1	608.0	425.6	36,115.2	25,280.6
	Alitabu	*Tridacna gigas*	0.9	43.4	21.7	4012.8	2006.4
	Kepo	*Polymesoda* spp.		4342.9	0.0	32,395	
Mangrove & reeftop	Duduna	*Terebralia palustris*	28.7	109,843.3	4125.7	included above	
	Bokiau	*Strombus luhuanus*	24.2	138,971.4	3474.3	included above	
	Sikil	*Lambis chiragra, Lambis lambis*	18.2	104,662.9	2616.6	included above	

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Sideia (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Reeftop	Lauma	*Scylla serrata*	14.4	2953.1	2067.2	included above	
	Pohapoha	*Hippopus hippopus*	6.8	1954.3	977.1	27,065.5	13,532.7
	Gwameme	*Cerithium nodulosum*	6.0	3619.0	868.6	55,385	13,292.4
	Alitabu	*Tridacna gigas*	1.5	434.3	217.1	included above	
	Walu	*Anadara* spp.	0.2	1034.0	21.7	306,035.7	6426.7
	Nekwali	*Mammilla melanostoma*	0.0	608.0	6.1	4389	43.9
	Kepo	*Polymesoda* spp.					
Mangrove & Intertidal	Bokiau	*Strombus luhuanus*	27.4	34,742.9	868.6	included above	
	Duduna	*Terebralia palustris*	27.4	23,124.9	868.6	included above	
	Sikil	*Lambis chiragra, Lambis lambis*	27.4	34,742.9	868.6	included above	
	Lauma	*Scylla serrata*	9.6	434.3	304.0	included above	
	Pohapoha	*Hippopus hippopus*	8.2	521.1	260.6	included above	
	Kepo	*Polymesoda* spp.					
Reeftop	Tuwaga	*Cardisoma* spp.	0.2	43		included below	
	Mulimuli	*Cypraea tigris*	1.8	869		included below	
	Matamalek	*Eriphia sebana*	0.2	261	9	11,607	406
	Wutil	*Gafrarium* spp.	2.7	5863	123	604,406	12,693
	Salsal	*Hippopus hippopus*	44.5	3995	1998	94,068	47,034
	Langa	*Lambis lambis*	2.4	4386	110	146,068	3652
	Unang	*Lysiosquillina maculata*	1.5	261	65	6756	1689
	Octopus	*Octopus* spp.	5.3	434	239	11,260	6193
	Almang	*Scylla serrata*	6.8	434	304	110,263	77,184
	Muya	*Strombus luhuanus*	2.0	3605	90	147,403	3685
	Kunim	*Tridacna maxima*	27.8	2497	1249	64,747	32,374
	Wutwut	*Turbo crassus*	4.6	2606	208	67,562	5405
			100	25,254	4395	1,264,141	190,315
Bêche-de-mer	Prickly redfish	*Thelenota ananas*	16.8	3648.0	9120.0	24,745.6	61,864
	Elephant trunkfish	*Holothuria fuscopunctata*	16.1	4864.0	8755.2	32,959.3	59,326.7
	White teatfish	*Holothuria fuscogilva*	15.3	4169.1	8338.3	28,727	57,454.1
	Black teatfish	*Holothuria nobilis*	14.9	4060.6	8121.1	27,671.6	55,343.2
	Curryfish	*Stichopus* spp.	7.0	6992.0	3796.7	48,414.8	26,289.3
	Leopardfish	*Bohadschia argus*	6.8	7969.1	3685.7	54,319.1	25,122.6
	Stonefish	*Actinopyga lecanora, Actinopyga miliaris*	4.8	8750.9	2625.3	59,679.9	17,904
	Dragon fish	*Stichopus horrens*	4.1	4104.0	2228.5	27,901.5	15,150.5

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Sideia (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Bêche-de-mer	Flowerfish	*Bohadschia graeffei*	3.9	4581.7	2119.0	31,099.2	14,383.4
	Brown sandfish	*Bohadschia vitiensis*	2.8	3257.1	1506.4	21,945	10,149.6
	Amberfish	*Thelenota anax*	2.4	6536.0	1307.2	44,391.6	8878.3
	Lollyfish	*Holothuria atra*, *Holothuria coluber*	2.3	12,702.9	1270.3	86,431.9	8643.2
	Sandfish	*Holothuria scabra*	1.6	434.3	868.6	3135	6270
	Pinkfish	*Holothuria edulis*	0.5	2627.4	262.7	18,224.8	1822.5
	Greenfish	*Stichopus chloronotus*	0.5	2562.3	256.2	17,263.4	1726.3
	Red surfish	*Actinopyga mauritiana*	0.2	347.4	121.6	2340.8	819.3
Lobster	Kwalaisa	*Panulirus* spp.	100.0	30.0	30.0	202	202
Trochus	Waguwagu	*Cassis cornuta*, *Conus* spp.	100.0	586.3	11.7	3950.1	79
Other	Pohapoha	*Hippopus hippopus*	81.6	434.3	217.1	included above	
	Alitabu	*Tridacna gigas*	16.3	86.9	43.4	included above	
	Limolimo	*Telescopium telescopium*	2.0	217.1	5.4	1463	36.6

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Sideia

Vernacular name	Scientific name	Size class	% of total catch (weight)
Alitabu	*Tridacna gigas*	20-22 cm	15.4
		20-28 cm	15.4
		24 cm	38.5
		24-26 cm	7.7
		26-28 cm	23.1
Amberfish	*Thelenota anax*	16 cm	4.7
		16-18 cm	10.6
		20 cm	2.7
		22 cm	8.0
		24-28 cm	4.0
		26 cm	28.2
		26-28 cm	30.6
		28 cm	11.3

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Sideia (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Black teatfish	*Holothuria nobilis*	16 cm	2.1
		16-18 cm	7.5
		18 cm	13.9
		18-20 cm	8.0
		20 cm	5.3
		20-22 cm	27.3
		20-24 cm	4.8
		24 cm	20.3
		24-26 cm	2.1
		26 cm	4.3
		26-28 cm	4.3
Bokiau	*Strombus luhuanus*	06-08 cm	10.8
		08 cm	5.4
		08-10 cm	24.3
		08-12 cm	2.7
		10-12 cm	40.5
		10-14 cm	8.1
		12 cm	8.1
Brown sandfish	*Bohadschia vitiensis*	10-14 cm	16.0
		16 cm	10.7
		18 cm	54.7
		20 cm	18.7
Curryfish	*Stichopus* spp.	14 cm	12.4
		14-16 cm	6.8
		14-18 cm	8.7
		16-18 cm	2.5
		16-20 cm	8.4
		18 cm	5.0
		18-26 cm	3.7
		20 cm	16.1
		22 cm	0.9
		24 cm	17.4
		26 cm	5.6
		26-28 cm	12.4
Dragonfish	*Stichopus horrens*	08 cm	7.9
		14 cm	52.9
		14-16 cm	5.3
		16-18 cm	8.5
		18 cm	12.7
		26-28 cm	12.7
Duduna	*Terebralia palustris*	08 cm	2.4
		08-10 cm	22.0
		08-12 cm	16.5
		10 cm	14.7
		10-12 cm	9.8
		12 cm	34.5

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Sideia (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Elephant trunkfish	*Holothuria fuscopunctata*	16 cm	35.7
		18 cm	1.8
		18-20 cm	2.7
		20-22 cm	9.8
		22 cm	26.8
		24 cm	1.8
		26 cm	14.3
		26-28 cm	7.1
Flowerfish	*Bohadschia graeffei*	06-08 cm	6.6
		08 cm	13.3
		08-10 cm	11.4
		10 cm	26.1
		14 cm	13.3
		16 cm	2.8
		16-18 cm	26.5
Greenfish	*Stichopus chloronotus*	12-16 cm	6.8
		14 cm	5.1
		16 cm	6.8
		16-18 cm	13.6
		20 cm	67.8
Gwameme	*Cerithium nodulosum*	10 cm	94.3
		12 cm	5.7
Kepo	*Polymesoda* spp.	06-08 cm	
		08 cm	
		08-10 cm	
		08-12 cm	
		10 cm	
		10-12 cm	
		12 cm	
Kwalaisa	*Panulirus* spp.	26-28 cm	100.0
Flowerfish	*Scylla serrata*	08 cm	3.4
		10-12 cm	6.9
		12-14 cm	12.1
		12-16 cm	18.1
		14 cm	6.9
		14-16 cm	41.4
		16 cm	11.2
Limolimo	*Telescopium telescopium*	08 cm	100.0

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Sideia (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Lollyfish	*Holothuria atra, Holothuria coluber*	06-08 cm	11.3
		08 cm	3.4
		08-18 cm	5.1
		10 cm	6.2
		10-12 cm	7.7
		12 cm	23.9
		12-14 cm	6.8
		14-16 cm	13.7
		16 cm	13.7
		18 cm	5.5
		18-22 cm	2.7
Nekwali	*Mammilla melanostoma*	06-08 cm	100.0
Piloma	*Saccostrea cuccullata*	10 cm	66.7
		10-12 cm	33.3
Pink	*Holothuria edulis*	06-08 cm	26.4
		08-14 cm	5.0
		10 cm	17.4
		12-14 cm	24.8
		14 cm	9.9
		18-22 cm	16.5
Pohapoha	*Hippopus hippopus*	06-08 cm	51.7
		10-12 cm	13.8
		10-16 cm	11.5
		12 cm	23.0
Pricklyfish	*Thelenota ananas*	11 cm	2.4
		16 cm	16.7
		16-18 cm	2.4
		16-20 cm	15.5
		20-26 cm	6.0
		22-24 cm	3.6
		24 cm	13.1
		24-26 cm	7.1
		26 cm	14.3
		26-28 cm	4.8
		28 cm	14.3
Red surffish	*Actinopyga mauritiana*	18-20 cm	100.0
Sandfish	*Holothuria scabra*	24-26 cm	100.0

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Sideia (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Sikil	*Lambis chiragra*, *Lambis lambis*	08 cm	14.9
		08-10 cm	5.0
		08-12 cm	24.8
		10 cm	0.2
		10-12 cm	34.7
		10-14 cm	14.9
		12 cm	5.7
Stonefish	*Actinopyga lecanora*, *Actinopyga miliaris*	08-12 cm	5.2
		12-14 cm	9.9
		14 cm	3.0
		14-16 cm	2.0
		16 cm	13.9
		16-18 cm	11.9
		16-20 cm	5.0
		18 cm	19.4
		20 cm	6.0
		22 cm	2.0
		24-26 cm	2.0
		24-28 cm	19.9
Leopardfish	*Bohadschia argus*	12 cm	16.3
		12-14 cm	6.0
		14 cm	2.7
		14-16 cm	9.8
		16 cm	12.5
		16-18 cm	12.5
		18 cm	17.2
		18-20 cm	7.6
		22 cm	6.5
		24 cm	6.5
		26-28 cm	2.2
Waguwagu	*Cassis cornuta*, *Conus* spp.	08-12 cm	55.6
		10-12 cm	44.4
Walu	*Anadara* spp.	08-10 cm	2.4
		10 cm	97.6
White teatfish	*Holothuria fuscogilva*	20 cm	4.7
		20-22 cm	4.2
		20-24 cm	16.1
		22-24 cm	6.3
		24-26 cm	4.2
		26 cm	4.2
		26-28 cm	45.8
		28 cm	14.6

2.4 Panapompom socioeconomic survey data

2.4.1 Annual catch (kg) of fish groups per habitat – Panapompom
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Yabwau	Lutjanidae	*Lutjanus gibbus*	529	23.7
Tomalemale	Lutjanidae	*Symphorus nematophorus*	333	14.9
Awalalu	Lethrinidae	*Lethrinus olivaceus*	257	11.5
Kibi	Balistidae	*Rhinecanthus* spp.	163	7.3
Tokeli	Nemipteridae	*Pentapodus paradiseus*	136	6.1
Euna	Lutjanidae	*Symphorichthys spilurus*	126	5.6
Ulihela	Serranidae	*Variola louti*	89	4.0
Labeta	Lethrinidae	*Lethrinus nebulosus*	86	3.8
Tupatupa	Carangidae	*Caranx melampygus*	66	3.0
Aniat	Lethrinidae	*Lethrinus erythracanthus*	58	2.6
Bahibahi	Mullidae	*Parupeneus* spp.	53	2.4
Anipola	Lutjanidae	*Lutjanus bohar*, *Lutjanus kasmira*	50	2.3
Utul	Lutjanidae	*Aprion virescens*	50	2.3
Vilu	Carangidae	*Caranx melampygus*	49	2.2
Kakauwola	Serranidae	*Epinephelus merra*	39	1.8
Mayumul	Lethrinidae	*Gymnocranius grandoculis*	36	1.6
Olalu	n/a	n/a	28	1.3
Unanatokite	Nemipteridae	*Scolopsis temporalis*	28	1.3
Anual	Sphyraenidae	*Sphyraena* spp.	20	0.9
Magoga	Carangidae	*Caranx ignobilis*	11	0.5
Takalibwelam	n/a	n/a	11	0.5
Gasawa	Scombridae	*Rastrelliger kanagurta*	7	0.3
Tatan	Lutjanidae	*Lutjanus quinquelineatus*	4	0.2
Alipat	n/a	n/a	4	0.2
Total:			**2232**	**100.0**
Lagoon				
Tomalemale	Lutjanidae	*Symphorus nematophorus*	994	11.5
Yabwau	Lutjanidae	*Lutjanus gibbus*	1186	13.7
Awalalu	Lethrinidae	*Lethrinus olivaceus*	944	10.9
Anipola	Lutjanidae	*Lutjanus bohar*, *Lutjanus kasmira*	484	5.6
Labeta	Lethrinidae	*Lethrinus nebulosus*	465	5.4
Ulihela	Serranidae	*Variola louti*	431	5.0
Nelom	Lutjanidae	*Lutjanus goldiei*	383	4.4
Kaniwala	Sphyraenidae	*Sphyraena barracuda*	362	4.2
Tupatupa	Carangidae	*Caranx melampygus*	326	3.8
Tabibina	Lutjanidae	*Lutjanus sebae*	319	3.7
Kakauwola	Serranidae	*Epinephelus merra*	265	3.1
Alipat	n/a	n/a	249	2.9
Bwagilam	Istiophoridae	*Makaira* spp.	196	2.3
Utul	Lutjanidae	*Aprion virescens*	191	2.2
Bueta	Lutjanidae	*Aphareus rutilans*	185	2.1

2.4.1 Annual catch (kg) of fish groups per habitat – Panapompom (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon (continued)				
Matanabobotana	n/a	n/a	173	2.0
Pulia	n/a	n/a	126	1.5
Bilawan	Scombridae	*Acanthocybium solandri*	113	1.3
Vilu	Carangidae	*Caranx melampygus*	108	1.2
Baewa	Carcharhinidae	*Carcharhinus* spp.	96	1.1
Tokalibwelam	Sphyraenidae	*Sphyraena barracuda*	94	1.1
Lablab	Echeneidae	*Echeneis naucrates*, *Remora remora*	75	0.9
Euna	Lutjanidae	*Symphorichthys spilurus*	73	0.8
Lu	Haemulidae	*Plectorhinchus* spp.	72	0.8
Mumuya	Siganidae	*Siganus canaliculatus*	72	0.8
Magoga	Carangidae	*Caranx ignobilis*	72	0.8
Tokeli	Nemipteridae	*Pentapodus paradiseus*	70	0.8
Tatan	Lutjanidae	*Lutjanus quinquelineatus*	69	0.8
Totoli	Pomacanthidae	*Chaetodontoplus* spp.	62	0.7
Kibi	Balistidae	*Rhinecanthus* spp.	53	0.6
Samama	Atherinidae	*Atherinomorus* spp.	52	0.6
Tamalemale	Lutjanidae	*Symphorus nematophorus*	38	0.4
Nidul	Carangidae	*Scomberoides lysan*	37	0.4
Kawabum	n/a	n/a	35	0.4
Unanatokite	Nemipteridae	*Scolopsis temporalis*	26	0.3
Mayumul	Lethrinidae	*Gymnocranius grandoculis*	25	0.3
Waiya	Engraulidae	*Stolephorus commersonnii*	24	0.3
Lalami	Scombridae	*Grammatorcynus bilineatus*	22	0.3
Deadeasi	Scombridae	*Scomberomorus commerson*	22	0.3
Talayan	Holocentridae	*Sargocentron spiniferum*	13	0.2
Kibukibu	Scombridae	*Rastrelliger kanagurta*	13	0.1
Pelihul	Mullidae	*Parupeneus ciliatus*	11	0.1
Aluya	Scaridae	*Scarus* spp.	9	0.1
Koga	Muraenidae	*Gymnothorax* spp.	3	0.0
Gasawa	Scombridae	*Rastrelliger kanagurta*	1	0.0
Total:			**8638**	**100.0**
Lagoon & outer reef				
Suwasuwa	Carangidae	*Elagatis bipinnulata*	72	22
Bilawan	Scombridae	*Acanthocybium solandri*	69	21
Kibukibu	Scombridae	*Rastrelliger kanagurta*	69	21
Matanabobotana	n/a	n/a	49	15
Salianababalona	Labridae	*Cheilinus undulatus*	38	11
Kaniwala	Sphyraenidae	*Sphyraena barracuda*	38	11
Total:			**335**	**100**

2.4.1 Annual catch (kg) of fish groups per habitat – Panapompom (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef				
Tomalemale	Lutjanidae	*Symphorus nematophorus*	1156	18.3
Nelom	Lutjanidae	*Lutjanus goldiei*	422	6.7
Salianababalona	Labridae	*Cheilinus undulatus*	377	6.0
Matanabobotana	n/a	n/a	361	5.7
Polupolu	Leiognathidae	*Leiognathus equulus*	316	5.0
Bilawan	Scombridae	*Acanthocybium solandri*	278	4.4
Maimua	Scombridae	*Sarda orientalis*	274	4.3
Tupatupa	Carangidae	*Caranx melampygus*	272	4.3
Awalalu	Lethrinidae	*Lethrinus olivaceus*	260	4.1
Kibukibu	Scombridae	*Rastrelliger kanagurta*	256	4.1
Kaniwala	Sphyraenidae	*Sphyraena barracuda*	220	3.5
Tawia	Serranidae	*Plectropomus* spp.	218	3.5
Magoga	Carangidae	*Caranx ignobilis*	218	3.5
Wilu	Carangidae	*Scomberoides lysan*	194	3.1
Makago	Scaridae	*Scarus rubroviolaceus*	190	3.0
Anipola	Lutjanidae	*Lutjanus bohar*, *Lutjanus kasmira*	188	3.0
Donadona	Holocentridae	*Myripristis violacea*	170	2.7
Kolabilabi	Carangidae	*Seriola* spp.	160	2.5
Utul	Lutjanidae	*Aprion virescens*	138	2.2
Lalami	Scombridae	*Grammatorcynus bilineatus*	117	1.8
Ulilawat	Serranidae	*Variola louti*	94	1.5
Bwagilam	Istiophoridae	*Makaira* spp.	75	1.2
Vilu	Carangidae	*Caranx melampygus*	61	1.0
Yalyal	Scombridae	*Grammatorcynus bilineatus*	50	0.8
Yabwau	Lutjanidae	*Lutjanus gibbus*	50	0.8
Waiya	Engraulidae	*Stolephorus commersonnii*	46	0.7
Baewa	Carcharhinidae	*Carcharhinus* spp.	41	0.6
Tonukululu	n/a	n/a	36	0.6
Paleau	Carangidae	*Caranx* spp.	30	0.5
Sadin	n/a	n/a	30	0.5
Bahibahi	Mullidae	*Parupeneus* spp.	25	0.4
Ulihela	Serranidae	*Variola louti*	0	0.0
Total:			**6325**	**100.0**

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Panapompom

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Reeftop	Bokiau	*Strombus luhuanus*	51.9	28,056	701	included below	
	Sikil	*Lambis chiragra, Lambis lambis*	24.6	13,287	332	included below	
	Kunim	*Tridacna maxima*	9.6	261	130	16,616	8308
	Onon	*Turbo* spp.	8.2	5509	110	21,133	423
	Pohapoha	*Hippopus hippopus*	3.2	87	43	included below	
	Halhal	*Thais* spp.	0.6	434	9	271,815	5436
	Matahup	*Turbo* spp.	0.6	434	9	1520	30
	Guna	*Cypraea tigris*	0.6	80	40	included below	
	Tulu	*Nerita plicata*	0.2	500	2	1749	9
	Binauni	*Nerita polita*	0.2	434	2	included below	
	Kalomi	*Turbo* spp.	0.2	109	2	18,824	376
	Aluman	*Eriphia sebana, Scylla serrata*	0.1	43	2	included below	
Total:			**100**	**49,234**	**1383**	**331,658**	**14583**
Soft benthos	Bokiau	*Strombus luhuanus*	86.6	17,371	434	included below	
	Kunim	*Tridacna maxima*	13.0	130	65	included above	
	Sikil	*Lambis chiragra, Lambis lambis*	0.4	87	2	included below	
Total:			**100**	**17,589**	**502**		
Soft benthos & mangrove	Kunim	*Tridacna maxima*	79.8	109	54	included above	
	Kalomi	*Turbo* spp.	6.4	217	4	included above	
	Onon	*Turbo* spp.	4.8	163	3	included above	
	Sikil	*Lambis chiragra, Lambis lambis*	4.0	109	3	Included below	
	Aluman	*Eriphia sebana, Scylla serrata*	3.7	72	3	included below	
	Bokiau	*Strombus luhuanus*	1.3	36	1	included below	
Total:			**100**	**706**	**68**		
Soft benthos & reeftop	Pohapoha	*Hippopus hippopus*	22.3	1303	651	included below	
	Bokiau	*Strombus luhuanus*	18.7	21,855	546	included below	
	Binauni	*Nerita polita*	18.6	108,902	545	included below	
	Halhal	*Thais* spp.	12.4	18,182	364	included above	
	Kunim	*Tridacna maxima*	12.4	724	362	included above	
	Sikil	*Lambis chiragra, Lambis lambis*	8.4	9769	244	included below	
	Pwepwet	*Planaxis sulcatus*	6.2	12,107	182	178,913	2684
	Kalomi	*Turbo* spp.	0.7	1096	22	included above	
	Aluman	*Eriphia sebana, Scylla serrata*	0.1	87	3	included below	
	Waguwagu	*Cassis cornuta, Conus* spp.	0.1	100	2	9463	189
	Kalambutum	*Anadara* spp.	0.1	87	2	1284	27
	Legusi	*Asaphis violascens*	0.0	87	1	included below	
	Umwaya			60		210	
Total:			**100**	**174,357**	**2924**	**189,869**	**2900**

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Panapompom (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Soft benthos & Intertidal	Kunim	*Tridacna maxima*	62.3	282	141	included above	
	Binauni	*Nerita polita*	28.8	13,029	65	included below	
	Sikil	*Lambis chiragra* *Lambis lambis*	2.9	261	7	included below	
	Bokiau	*Strombus luhuanus*	1.9	174	4	included below	
	Aluman	*Eriphia sebana, Scylla serrata*	1.3	87	3	included below	
	Kalomi	*Turbo* spp.	1.0	109	2	included above	
	Halhal	*Thais* spp.	1.0	109	2	included above	
	Onon	*Turbo* spp.	0.8	87	2	included below	
	Kavalia	*Atactodea striata*	0.1	87	0	included below	
	Kepo			65		963	
	Kaikeke			87		2424	
	Lotupa	*Terebra* spp.		87		1284	
Total:			**100**	**14,462**	**227**	**4670**	
Mangrove	Bokiau	*Strombus luhuanus*	80.8	8686	217	514,974	12,874
	Legusi	*Asaphis violascens*	9.7	1737	26	7399	111
	Binauni	*Nerita polita*	4.0	2171	11	1,808,723	9044
	Sikil	*Lambis chiragra, Lambis lambis*	3.2	347	9	196,640	4916
	Aluman	*Eriphia sebana, Scylla serrata*	2.3	174	6	4106	144
Total:			**100**	**13,115**	**269**	**2,531,842**	**27,089**
Mangrove & intertidal	Pohapoha	*Hippopus hippopus*	75.3	30	15	19,662	9831
	Guna	*Cypraea tigris*	19.1	40	20	19,662	9831
	Aluman	*Eriphia sebana, Scylla serrata*	3.5	20	1	included above	
	Bokiau	*Strombus luhuanus*	1.3	10	0	included above	
	Legusi	*Asaphis violascens*	0.8	10	0	included above	
	Kavalia	*Atactodea striata*	0.1	10	0	5017	14
Total:			**100**	**120**	**36**	**44342**	**19676**
Bêche-de-mer	White teatfish	*Holothuria fuscogilva*	29.2	15,493	30,986	57,165	114,329
	Elephant trunkfish	*Holothuria fuscopunctata*	16.1	9478	17,061	34,643	62,358
	Pricklyfish	*Thelenota ananas*	14.9	6308	15,770	22,078	55,195
	Black teatfish	*Holothuria nobilis*	14.4	7665	15,330	26,828	53,656
	Leopardfish	*Bohadschia argus*	5.4	12,442	5755	45,752	21,160
	Curryfish	*Stichopus* spp.	4.0	7817	4245	28,829	15,654
	Brown sandfish	*Bohadschia vitiensis*	3.7	8588	3972	32,997	15,261
	Stonefish	*Actinopyga lecanora, Actinopyga miliaris*	3.6	12,898	3869	52,491	15,747
	Flowerfish	*Bohadschia graeffei*	2.2	5125	2370	17,936	8295
	Red surfish	*Actinopyga mauritiana*	2.0	5971	2090	20,900	7315
	Greenfish	*Stichopus chloronotus*	1.8	18,978	1898	69,363	6936
	Amberfish	*Thelenota anax*	1.7	8968	1794	35,061	7012

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Panapompom (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded		Extrapolated	
				no/year	kg/year	no/year	kg/year
Bêche-de-mer	Lollyfish	*Holothuria atra*, *Holothuria coluber*	0.8	8414	841	29,450	2945
	Chalkfish	*Bohadschia similis*	0.1	195	90	684	316
	Pinkfish	*Holothuria edulis*	0.1	543	54	1900	190
Total:			**100**	**128,885**	**106,126**	**476,077**	**386,371**
Lobster	Ulabo			383	383	1340	1340
Trochus	Trochus	*Trochus niloticus*	64.3	494	99	1730	346
	Waguwagu	*Cassis cornuta*, *Conus* spp.	33.9	2604	52	included above	
	Kavalia	*Atactodea striata*	1.9	1057	3	included above	
Total:			**100**	**4155**	**154**	**1730**	**346**

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Panapompom

Vernacular name	Scientific name	Size class	% of total catch (weight)
Aluman	*Eriphia sebana*, *Scylla serrata*	02-04 cm	28.3
		12 cm	7.1
		12-16 cm	3.3
		14 cm	14.2
		16 cm	47.2
Amberfish	*Thelenota anax*	16-20 cm	1.5
		18-20 cm	4.8
		18-24 cm	3.6
		20 cm	7.3
		20-24 cm	7.7
		20-28 cm	6.5
		22 cm	1.0
		24 cm	18.2
		26 cm	13.6
		26-28 cm	7.7
		28 cm	28.1
Binauni	*Nerita polita*	02 cm	39.7
		02-04 cm	0.1
		04 cm	59.9
		04-06 cm	0.3
Black teatfish	*Holothuria nobilis*	18-20 cm	26.6
		18-24 cm	5.7
		20 cm	1.1
		20-24 cm	3.7
		20-26 cm	2.5
		20-28 cm	4.5
		22-24 cm	1.7
		24 cm	7.9
		24-28 cm	5.9
		26 cm	12.5
		26-28 cm	27.8

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Panapompom (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Bokiau	*Strombus luhuanus*	04 cm	0.0
		04-06 cm	19.8
		04-08 cm	19.0
		06-08 cm	28.7
		08 cm	22.8
		08-10 cm	9.5
		08-12 cm	0.1
Brown sandfish	*Bohadschia vitiensis*	16 cm	1.9
		16-18 cm	12.1
		16-20 cm	21.2
		18 cm	14.7
		20 cm	18.2
		22 cm	1.5
		26-28 cm	29.6
		28 cm	0.8
Chalkfish	*Bohadschia similis*	16-20 cm	100.0
Curryfish	*Stichopus* spp.	16 cm	6.7
		16-18 cm	27.8
		16-20 cm	2.5
		18 cm	22.5
		18-20 cm	6.1
		20 cm	6.4
		22 cm	0.6
		22-26 cm	2.8
		24 cm	18.9
		28 cm	5.8
Elephant trunkfish	*Holothuria fuscopunctata*	16 cm	5.5
		16-20 cm	1.7
		18 cm	2.7
		18-24 cm	15.1
		20 cm	18.3
		20-22 cm	8.7
		20-26 cm	3.2
		20-28 cm	2.7
		22-24 cm	1.8
		24 cm	20.8
		26 cm	4.1
		26-28 cm	2.7
		28 cm	12.4
Flowerfish	*Bohadschia graeffei*	08-10 cm	12.7
		12 cm	1.7
		14 cm	13.6
		14-16 cm	43.6
		16-18 cm	4.2
		16-20 cm	15.3
		24 cm	8.9

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Panapompom (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Greenfish	*Stichopus chloronotus*	10-16 cm	11.4
		12-16 cm	9.2
		14-16 cm	0.9
		14-18 cm	0.5
		16 cm	45.8
		16-20 cm	14.9
		18 cm	3.4
		18-20 cm	7.3
		20 cm	0.3
		22-24 cm	2.4
		24-28 cm	3.4
		28 cm	0.5
Guna	*Cypraea tigris*	08 cm	33.3
		08-10 cm	66.7
Halhal	*Thais* spp.	04 cm	96.6
		06-08 cm	0.5
		08-10 cm	2.3
		10 cm	0.6
Kaikeke	-	08 cm	
		12 cm	
Kalambutum	*Anadara* spp.	04 cm	100.0
Kalomi	*Turbo* spp.	04 cm	0.7
		08-12 cm	21.3
		10 cm	78.1
Kavalia	*Atactodea striata*	04 cm	0.9
		06 cm	7.5
		08-12 cm	91.6
Kepo	-	12 cm	
Kunim	*Tridacna maxima*	08-12 cm	5.8
		10-20 cm	7.2
		12 cm	36.1
		12-14 cm	16.3
		14 cm	8.7
		14-16 cm	14.4
		16-26 cm	4.3
		20 cm	7.2
Legusi	*Asaphis violascens*	02 cm	4.7
		02-04 cm	0.5
		14 cm	94.7
Lolli fish	*Holothuria atra*, *Holothuria coluber*	10 cm	22.7
		10-14 cm	2.1
		14 cm	18.1
		16 cm	5.7
		16-18 cm	43.4
		16-20 cm	3.5
		18-19 cm	3.1
		28 cm	1.5
Lotupa	*Terebra* spp.	12 cm	

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Panapompom (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Malina	*Tridacna gigas*	14 cm	100.0
Matahup	*Turbo* spp.	04-06 cm	100.0
Onon	*Turbo* spp.	04 cm	95.8
		08-10 cm	1.4
		08-12 cm	2.8
Pinkfish	*Holothuria edulis*	10 cm	32.0
		12 cm	32.0
		14 cm	36.0
Pohapoha	*Hippopus hippopus*	06-10 cm	6.1
		12 cm	2.1
		16-28 cm	91.8
Pricklyfish	*Thelenota ananas*	12-14 cm	6.2
		16 cm	0.7
		16-20 cm	2.6
		18 cm	2.1
		18-20 cm	4.5
		20-24 cm	4.1
		20-26 cm	5.5
		20-28 cm	27.5
		22 cm	12.4
		24 cm	6.9
		26 cm	9.6
		26-28 cm	3.1
		28 cm	14.8
Pwepwet	*Planaxis sulcatus*	02 cm	100.0
Red surfish	*Actinopyga mauritiana*	14 cm	7.3
		16 cm	2.9
		16-18 cm	11.6
		16-20 cm	18.5
		16-26 cm	0.7
		18 cm	50.2
		18-20 cm	8.7
Sikil	*Lambis chiragra*, *Lambis lambis*	04-06 cm	0.4
		06 cm	29.5
		06-08 cm	1.4
		06-12 cm	2.1
		08 cm	3.6
		08-12 cm	23.2
		10 cm	38.1
		12 cm	1.3
		18 cm	0.4

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Panapompom (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Stonefish	*Actinopyga lecanora*, *Actinopyga miliaris*	10-18 cm	8.1
		12 cm	7.7
		16 cm	9.1
		16-18 cm	15.8
		16-20 cm	12.8
		18-20 cm	2.7
		18-22 cm	5.4
		20 cm	23.2
		20-22 cm	8.1
		22 cm	2.0
		24 cm	5.1
Leopardfish	*Bohadschia argus*	14-16 cm	6.3
		16 cm	1.7
		16-18 cm	11.0
		16-20 cm	5.2
		18 cm	23.9
		20 cm	20.2
		20-24 cm	3.5
		22 cm	10.5
		22-24 cm	2.1
		24 cm	15.5
Trochus	*Trochus niloticus*	08-12 cm	100.0
Tulu	*Nerita plicata*	02-04 cm	100.0
Ulabo	-	16-26 cm	
		18-20 cm	
		20 cm	
		20-22 cm	
		20-24 cm	
		22 cm	
		22-28 cm	
		24-26 cm	
Umwaya	-	08 cm	
Waguwagu	*Cassis cornuta*, *Conus* spp.	06 cm	3.7
		08-10 cm	12.9
		08-12 cm	39.3
		09 cm	12.0
		10-12 cm	32.1
White teatfish	*Holothuria fuscogilva*	16-18 cm	0.8
		16-20 cm	1.5
		20-24 cm	10.5
		20-28 cm	13.6
		24 cm	0.3
		24-26 cm	1.7
		24-28 cm	1.3
		26-28 cm	56.6
		28 cm	13.7

APPENDIX 3: FINFISH SURVEY DATA

3.1 Andra finfish survey data

3.1.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Andra

Station name	Habitat	Latitude	Longitude
TRA01	Outer reef	1°55'43.9788" S	146°59'56.2812" E
TRA02	Outer reef	1°55'49.3788" S	147°00'36.0612" E
TRA03	Lagoon	1°56'39.84" S	147°01'22.62" E
TRA04	Back-reef	1°56'30.84" S	147°01'15.24" E
TRA05	Coastal reef	1°58'01.3188" S	147°01'35.04" E
TRA06	Coastal reef	1°58'19.8012" S	147°03'54.6012" E
TRA07	Lagoon	1°57'44.0388" S	147°01'17.76" E
TRA08	Lagoon	1°57'50.8212" S	147°01'03.18" E
TRA09	Outer reef	1°55'00.5412" S	146°55'24.42" E
TRA10	Outer reef	1°55'27.1812" S	146°56'03.5988" E
TRA11	Outer reef	1°55'29.2188" S	146°56'36.42" E
TRA12	Outer reef	1°55'30.8388" S	146°57'32.6412" E
TRA13	Coastal reef	1°57'51.48" S	146°58'52.32" E
TRA14	Coastal reef	1°57'53.3412" S	146°57'28.3212" E
TRA15	Back-reef	1°56'30.9588" S	146°57'56.52" E
TRA16	Back-reef	1°56'29.1588" S	146°59'56.76" E
TRA17	Lagoon	1°56'10.32" S	146°55'28.74" E
TRA18	Lagoon	1°56'16.08" S	146°55'45.9012" E
TRA19	Back-reef	1°55'55.6212" S	146°55'55.6788" E
TRA20	Back-reef	1°55'32.5812" S	146°55'34.7412" E
TRA21	Coastal reef	1°57'52.9812" S	146°56'40.02" E
TRA22	Coastal reef	1°57'54.0612" S	146°55'43.68" E
TRA23	Lagoon	1°56'27.1212" S	146°57'01.8" E
TRA24	Back-reef	1°56'19.68" S	146°57'12.3012" E

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Acanthuridae	*Acanthurus blochii*	0.0018	0.684
Back-reef	Acanthuridae	*Acanthurus guttatus*	0.0013	0.211
Back-reef	Acanthuridae	*Acanthurus lineatus*	0.0972	24.129
Back-reef	Acanthuridae	*Acanthurus nigricans*	0.0183	1.302
Back-reef	Acanthuridae	*Acanthurus pyroferus*	0.0107	1.275
Back-reef	Acanthuridae	*Acanthurus triostegus*	0.0642	0.688
Back-reef	Acanthuridae	*Ctenochaetus striatus*	0.2269	21.122
Back-reef	Acanthuridae	*Naso brevirostris*	0.0013	0.370
Back-reef	Acanthuridae	*Zebrasoma scopas*	0.0248	0.844
Back-reef	Acanthuridae	*Zebrasoma veliferum*	0.0007	0.029
Back-reef	Balistidae	*Balistapus undulatus*	0.0067	0.789
Back-reef	Balistidae	*Rhinecanthus verrucosus*	0.0003	0.000
Back-reef	Caesionidae	*Caesio cuning*	0.0030	0.513
Back-reef	Caesionidae	*Caesio teres*	0.0140	1.678

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Caesionidae	*Pterocaesio tile*	0.0100	0.283
Back-reef	Caesionidae	*Pterocaesio trilineata*	0.0333	0.955
Back-reef	Carangidae	*Carangoides ferdau*	0.0007	0.364
Back-reef	Carangidae	*Caranx papuensis*	0.0003	0.107
Back-reef	Chaetodontidae	*Chaetodon auriga*	0.0003	0.000
Back-reef	Chaetodontidae	*Chaetodon baronessa*	0.0043	0.249
Back-reef	Chaetodontidae	*Chaetodon bennetti*	0.0010	0.050
Back-reef	Chaetodontidae	*Chaetodon citrinellus*	0.0060	0.100
Back-reef	Chaetodontidae	*Chaetodon ephippium*	0.0020	0.166
Back-reef	Chaetodontidae	*Chaetodon kleinii*	0.0067	0.088
Back-reef	Chaetodontidae	*Chaetodon lineolatus*	0.0017	0.060
Back-reef	Chaetodontidae	*Chaetodon lunula*	0.0007	0.102
Back-reef	Chaetodontidae	*Chaetodon lunulatus*	0.0113	0.293
Back-reef	Chaetodontidae	*Chaetodon melannotus*	0.0013	0.055
Back-reef	Chaetodontidae	*Chaetodon meyeri*	0.0007	0.033
Back-reef	Chaetodontidae	*Chaetodon ornatissimus*	0.0047	0.218
Back-reef	Chaetodontidae	*Chaetodon rafflesii*	0.0043	0.173
Back-reef	Chaetodontidae	*Chaetodon semeion*	0.0047	0.252
Back-reef	Chaetodontidae	*Chaetodon trifascialis*	0.0013	0.024
Back-reef	Chaetodontidae	*Chaetodon ulietensis*	0.0013	0.047
Back-reef	Chaetodontidae	*Chaetodon unimaculatus*	0.0013	0.081
Back-reef	Chaetodontidae	*Chaetodon vagabundus*	0.0080	0.283
Back-reef	Chaetodontidae	*Forcipiger longirostris*	0.0010	0.030
Back-reef	Chaetodontidae	*Heniochus varius*	0.0017	0.056
Back-reef	Holocentridae	*Myripristis adusta*	0.0013	0.210
Back-reef	Holocentridae	*Myripristis berndti*	0.0013	0.126
Back-reef	Holocentridae	*Myripristis murdjan*	0.0003	0.022
Back-reef	Holocentridae	*Myripristis violacea*	0.0007	0.119
Back-reef	Holocentridae	*Sargocentron caudimaculatum*	0.0003	0.023
Back-reef	Holocentridae	*Sargocentron spiniferum*	0.0003	0.091
Back-reef	Kyphosidae	*Kyphosus cinerascens*	0.0010	0.369
Back-reef	Kyphosidae	*Kyphosus vaigiensis*	0.0027	1.631
Back-reef	Labridae	*Cheilinus chlorourus*	0.0023	0.032
Back-reef	Labridae	*Cheilinus fasciatus*	0.0007	0.168
Back-reef	Labridae	*Choerodon anchorago*	0.0003	0.090
Back-reef	Labridae	*Hemigymnus melapterus*	0.0040	0.637
Back-reef	Labridae	*Oxycheilinus digramma*	0.0003	0.048
Back-reef	Lethrinidae	*Lethrinus erythracanthus*	0.0003	0.099
Back-reef	Lethrinidae	*Lethrinus erythropterus*	0.0003	0.058
Back-reef	Lethrinidae	*Lethrinus harak*	0.0203	3.253
Back-reef	Lethrinidae	*Monotaxis grandoculis*	0.0050	1.219
Back-reef	Lutjanidae	*Aphareus furca*	0.0003	0.083
Back-reef	Lutjanidae	*Lutjanus fulvus*	0.0037	1.356
Back-reef	Lutjanidae	*Lutjanus gibbus*	0.0100	6.910
Back-reef	Lutjanidae	*Lutjanus semicinctus*	0.0003	0.000
Back-reef	Lutjanidae	*Macolor macularis*	0.0010	0.670

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Lutjanidae	*Symphorichthys spilurus*	0.0003	0.162
Back-reef	Mullidae	*Mulloidichthys vanicolensis*	0.0048	1.246
Back-reef	Mullidae	*Parupeneus barberinus*	0.0073	1.409
Back-reef	Mullidae	*Parupeneus multifasciatus*	0.0023	0.392
Back-reef	Mullidae	*Parupeneus trifasciatus*	0.0013	0.404
Back-reef	Nemipteridae	*Scolopsis bilineata*	0.0020	0.072
Back-reef	Nemipteridae	*Scolopsis margaritifera*	0.0027	0.302
Back-reef	Pomacanthidae	*Pygoplites diacanthus*	0.0047	0.647
Back-reef	Scaridae	*Cetoscarus bicolor*	0.0003	0.004
Back-reef	Scaridae	*Chlorurus bleekeri*	0.0143	2.724
Back-reef	Scaridae	*Chlorurus japanensis*	0.0007	0.109
Back-reef	Scaridae	*Chlorurus microrhinos*	0.0003	0.030
Back-reef	Scaridae	*Chlorurus sordidus*	0.0370	2.737
Back-reef	Scaridae	*Hipposcarus longiceps*	0.0080	2.328
Back-reef	Scaridae	*Scarus altipinnis*	0.0007	0.107
Back-reef	Scaridae	*Scarus chameleon*	0.0020	0.060
Back-reef	Scaridae	*Scarus dimidiatus*	0.0150	1.837
Back-reef	Scaridae	*Scarus flavipectoralis*	0.0067	0.862
Back-reef	Scaridae	*Scarus frenatus*	0.0013	0.219
Back-reef	Scaridae	*Scarus ghobban*	0.0010	0.056
Back-reef	Scaridae	*Scarus hypselopterus*	0.0007	0.126
Back-reef	Scaridae	*Scarus niger*	0.0063	1.306
Back-reef	Scaridae	*Scarus oviceps*	0.0010	0.034
Back-reef	Scaridae	*Scarus prasiognathos*	0.0100	5.442
Back-reef	Scaridae	*Scarus psittacus*	0.0137	0.835
Back-reef	Scaridae	*Scarus quoyi*	0.0047	0.654
Back-reef	Scaridae	*Scarus rivulatus*	0.0033	0.808
Back-reef	Scaridae	*Scarus spinus*	0.0010	0.164
Back-reef	Serranidae	*Cephalopholis cyanostigma*	0.0003	0.031
Back-reef	Serranidae	*Epinephelus merra*	0.0027	0.191
Back-reef	Siganidae	*Siganus doliatus*	0.0027	0.487
Back-reef	Siganidae	*Siganus lineatus*	0.0013	0.638
Back-reef	Siganidae	*Siganus puellus*	0.0007	0.136
Back-reef	Siganidae	*Siganus spinus*	0.0007	0.186
Back-reef	Siganidae	*Siganus vulpinus*	0.0013	0.259
Back-reef	Zanclidae	*Zanclus cornutus*	0.0017	0.113
Coastal reef	Acanthuridae	*Acanthurus blochii*	0.0080	4.862
Coastal reef	Acanthuridae	*Acanthurus lineatus*	0.0649	14.114
Coastal reef	Acanthuridae	*Acanthurus maculiceps*	0.0033	0.672
Coastal reef	Acanthuridae	*Acanthurus mata*	0.0003	0.227
Coastal reef	Acanthuridae	*Acanthurus pyroferus*	0.0047	0.453
Coastal reef	Acanthuridae	*Acanthurus thompsoni*	0.0020	0.147
Coastal reef	Acanthuridae	*Ctenochaetus striatus*	0.1288	12.394
Coastal reef	Acanthuridae	*Naso annulatus*	0.0017	0.471
Coastal reef	Acanthuridae	*Naso brevirostris*	0.0003	0.069
Coastal reef	Acanthuridae	*Naso lituratus*	0.0027	0.761

Appendix 3: Finfish survey data
Andra

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Coastal reef	Acanthuridae	*Naso thynnoides*	0.0027	0.929
Coastal reef	Acanthuridae	*Naso unicornis*	0.0010	0.545
Coastal reef	Acanthuridae	*Zebrasoma scopas*	0.0017	0.061
Coastal reef	Balistidae	*Balistapus undulatus*	0.0070	0.741
Coastal reef	Caesionidae	*Caesio caerulaurea*	0.0130	1.194
Coastal reef	Caesionidae	*Caesio cuning*	0.0130	1.184
Coastal reef	Caesionidae	*Caesio teres*	0.0583	3.582
Coastal reef	Caesionidae	*Pterocaesio tile*	0.0040	0.179
Coastal reef	Carangidae	*Caranx ignobilis*	0.0003	1.578
Coastal reef	Carangidae	*Caranx melampygus*	0.0003	0.318
Coastal reef	Carangidae	*Caranx sexfasciatus*	0.0003	0.433
Coastal reef	Chaetodontidae	*Chaetodon auriga*	0.0003	0.024
Coastal reef	Chaetodontidae	*Chaetodon baronessa*	0.0103	0.294
Coastal reef	Chaetodontidae	*Chaetodon citrinellus*	0.0040	0.059
Coastal reef	Chaetodontidae	*Chaetodon ephippium*	0.0007	0.039
Coastal reef	Chaetodontidae	*Chaetodon kleinii*	0.0113	0.180
Coastal reef	Chaetodontidae	*Chaetodon lineolatus*	0.0017	0.054
Coastal reef	Chaetodontidae	*Chaetodon lunula*	0.0003	0.016
Coastal reef	Chaetodontidae	*Chaetodon lunulatus*	0.0090	0.241
Coastal reef	Chaetodontidae	*Chaetodon meyeri*	0.0033	0.182
Coastal reef	Chaetodontidae	*Chaetodon ornatissimus*	0.0023	0.108
Coastal reef	Chaetodontidae	*Chaetodon rafflesii*	0.0020	0.078
Coastal reef	Chaetodontidae	*Chaetodon semeion*	0.0013	0.074
Coastal reef	Chaetodontidae	*Chaetodon trifascialis*	0.0003	0.008
Coastal reef	Chaetodontidae	*Chaetodon vagabundus*	0.0093	0.370
Coastal reef	Chaetodontidae	*Heniochus chrysostomus*	0.0010	0.049
Coastal reef	Chaetodontidae	*Heniochus monoceros*	0.0003	0.021
Coastal reef	Chaetodontidae	*Heniochus varius*	0.0013	0.051
Coastal reef	Diodontidae	*Diodon hystrix*	0.0003	0.184
Coastal reef	Haemulidae	*Plectorhinchus lineatus*	0.0003	0.322
Coastal reef	Haemulidae	*Plectorhinchus orientalis*	0.0003	0.252
Coastal reef	Holocentridae	*Myripristis kuntee*	0.0020	0.178
Coastal reef	Holocentridae	*Sargocentron caudimaculatum*	0.0013	0.112
Coastal reef	Holocentridae	*Sargocentron spiniferum*	0.0007	0.285
Coastal reef	Kyphosidae	*Kyphosus cinerascens*	0.0037	1.078
Coastal reef	Labridae	*Cheilinus chlorourus*	0.0037	0.320
Coastal reef	Labridae	*Cheilinus fasciatus*	0.0020	0.212
Coastal reef	Labridae	*Hemigymnus fasciatus*	0.0003	0.011
Coastal reef	Labridae	*Hemigymnus melapterus*	0.0013	0.048
Coastal reef	Lethrinidae	*Lethrinus harak*	0.0003	0.051
Coastal reef	Lethrinidae	*Monotaxis grandoculis*	0.0007	0.113
Coastal reef	Lutjanidae	*Lutjanus carponotatus*	0.0023	0.503
Coastal reef	Lutjanidae	*Lutjanus fulvus*	0.0077	1.424
Coastal reef	Lutjanidae	*Lutjanus gibbus*	0.0050	0.673
Coastal reef	Lutjanidae	*Lutjanus rivulatus*	0.0007	0.738
Coastal reef	Lutjanidae	*Lutjanus semicinctus*	0.0030	0.397

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Coastal reef	Lutjanidae	*Macolor macularis*	0.0007	0.049
Coastal reef	Lutjanidae	*Macolor niger*	0.0017	0.812
Coastal reef	Mullidae	*Mulloidichthys vanicolensis*	0.0003	0.021
Coastal reef	Mullidae	*Parupeneus barberinus*	0.0153	3.661
Coastal reef	Mullidae	*Parupeneus cyclostomus*	0.0003	0.034
Coastal reef	Mullidae	*Parupeneus indicus*	0.0133	5.670
Coastal reef	Mullidae	*Parupeneus multifasciatus*	0.0037	0.518
Coastal reef	Mullidae	*Parupeneus trifasciatus*	0.0103	3.504
Coastal reef	Mullidae	*Upeneus tragula*	0.0017	0.063
Coastal reef	Nemipteridae	*Scolopsis bilineata*	0.0007	0.032
Coastal reef	Nemipteridae	*Scolopsis ciliata*	0.0117	0.749
Coastal reef	Nemipteridae	*Scolopsis margaritifera*	0.0007	0.099
Coastal reef	Nemipteridae	*Scolopsis temporalis*	0.0057	1.680
Coastal reef	Pomacanthidae	*Pygoplites diacanthus*	0.0013	0.156
Coastal reef	Scaridae	*Cetoscarus bicolor*	0.0007	0.193
Coastal reef	Scaridae	*Chlorurus bleekeri*	0.0238	5.461
Coastal reef	Scaridae	*Chlorurus japanensis*	0.0153	2.076
Coastal reef	Scaridae	*Chlorurus sordidus*	0.0053	1.270
Coastal reef	Scaridae	*Scarus altipinnis*	0.0042	1.536
Coastal reef	Scaridae	*Scarus chameleon*	0.0010	0.122
Coastal reef	Scaridae	*Scarus dimidiatus*	0.0057	0.694
Coastal reef	Scaridae	*Scarus flavipectoralis*	0.0137	2.301
Coastal reef	Scaridae	*Scarus frenatus*	0.0007	0.080
Coastal reef	Scaridae	*Scarus niger*	0.0030	0.731
Coastal reef	Scaridae	*Scarus oviceps*	0.0007	0.109
Coastal reef	Scaridae	*Scarus psittacus*	0.0300	3.134
Coastal reef	Scaridae	*Scarus quoyi*	0.0063	0.705
Coastal reef	Scaridae	*Scarus rivulatus*	0.0097	3.217
Coastal reef	Scaridae	*Scarus rubroviolaceus*	0.0017	1.037
Coastal reef	Scaridae	*Scarus sp.*	0.0047	0.645
Coastal reef	Serranidae	*Epinephelus coeruleopunctatus*	0.0003	0.131
Coastal reef	Siganidae	*Siganus argenteus*	0.0580	6.467
Coastal reef	Siganidae	*Siganus corallinus*	0.0003	0.073
Coastal reef	Siganidae	*Siganus doliatus*	0.0027	0.706
Coastal reef	Siganidae	*Siganus lineatus*	0.0197	8.299
Coastal reef	Siganidae	*Siganus puellus*	0.0010	0.103
Coastal reef	Siganidae	*Siganus vulpinus*	0.0040	0.480
Coastal reef	Zanclidae	*Zanclus cornutus*	0.0060	0.295
Lagoon	Acanthuridae	*Acanthurus blochii*	0.0027	1.394
Lagoon	Acanthuridae	*Acanthurus guttatus*	0.0007	0.049
Lagoon	Acanthuridae	*Acanthurus lineatus*	0.0912	21.022
Lagoon	Acanthuridae	*Acanthurus nigricans*	0.0279	2.230
Lagoon	Acanthuridae	*Acanthurus nigricauda*	0.0003	0.074
Lagoon	Acanthuridae	*Acanthurus olivaceus*	0.0010	0.213
Lagoon	Acanthuridae	*Acanthurus pyroferus*	0.0137	1.392
Lagoon	Acanthuridae	*Ctenochaetus binotatus*	0.0037	0.124

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lagoon	Acanthuridae	*Ctenochaetus striatus*	0.2161	20.111
Lagoon	Acanthuridae	*Naso annulatus*	0.0010	0.434
Lagoon	Acanthuridae	*Naso lituratus*	0.0017	0.324
Lagoon	Acanthuridae	*Zebrasoma scopas*	0.0207	0.683
Lagoon	Acanthuridae	*Zebrasoma veliferum*	0.0003	0.008
Lagoon	Balistidae	*Balistapus undulatus*	0.0073	0.862
Lagoon	Balistidae	*Sufflamen chrysopterum*	0.0040	0.303
Lagoon	Caesionidae	*Caesio caerulaurea*	0.0100	0.429
Lagoon	Caesionidae	*Caesio cuning*	0.0108	1.208
Lagoon	Caesionidae	*Caesio teres*	0.0207	2.068
Lagoon	Carangidae	*Carangoides ferdau*	0.0013	1.344
Lagoon	Carangidae	*Caranx melampygus*	0.0007	0.431
Lagoon	Carangidae	*Scomberoides tol*	0.0003	0.209
Lagoon	Carcharhinidae	*Carcharhinus melanopterus*	0.0003	4.485
Lagoon	Chaetodontidae	*Chaetodon baronessa*	0.0047	0.131
Lagoon	Chaetodontidae	*Chaetodon citrinellus*	0.0050	0.059
Lagoon	Chaetodontidae	*Chaetodon kleinii*	0.0113	0.165
Lagoon	Chaetodontidae	*Chaetodon lineolatus*	0.0010	0.101
Lagoon	Chaetodontidae	*Chaetodon lunula*	0.0007	0.010
Lagoon	Chaetodontidae	*Chaetodon lunulatus*	0.0090	0.190
Lagoon	Chaetodontidae	*Chaetodon meyeri*	0.0020	0.071
Lagoon	Chaetodontidae	*Chaetodon octofasciatus*	0.0027	0.025
Lagoon	Chaetodontidae	*Chaetodon ornatissimus*	0.0007	0.026
Lagoon	Chaetodontidae	*Chaetodon rafflesii*	0.0007	0.026
Lagoon	Chaetodontidae	*Chaetodon semeion*	0.0027	0.127
Lagoon	Chaetodontidae	*Chaetodon trifascialis*	0.0017	0.021
Lagoon	Chaetodontidae	*Chaetodon ulietensis*	0.0007	0.026
Lagoon	Chaetodontidae	*Chaetodon unimaculatus*	0.0017	0.113
Lagoon	Chaetodontidae	*Chaetodon vagabundus*	0.0083	0.283
Lagoon	Chaetodontidae	*Forcipiger longirostris*	0.0007	0.033
Lagoon	Chaetodontidae	*Heniochus chrysostomus*	0.0007	0.036
Lagoon	Chaetodontidae	*Heniochus varius*	0.0007	0.028
Lagoon	Haemulidae	*Plectorhinchus lessonii*	0.0003	0.130
Lagoon	Holocentridae	*Myripristis adusta*	0.0013	0.164
Lagoon	Holocentridae	*Myripristis kuntee*	0.0007	0.048
Lagoon	Holocentridae	*Myripristis violacea*	0.0007	0.162
Lagoon	Holocentridae	*Sargocentron caudimaculatum*	0.0020	0.174
Lagoon	Kyphosidae	*Kyphosus cinerascens*	0.0004	0.164
Lagoon	Kyphosidae	*Kyphosus vaigiensis*	0.0010	0.535
Lagoon	Labridae	*Cheilinus chlorourus*	0.0013	0.064
Lagoon	Labridae	*Cheilinus fasciatus*	0.0030	0.333
Lagoon	Labridae	*Cheilinus trilobatus*	0.0003	0.069
Lagoon	Labridae	*Choerodon anchorago*	0.0003	0.090
Lagoon	Labridae	*Hemigymnus melapterus*	0.0027	0.277
Lagoon	Labridae	*Oxycheilinus digramma*	0.0003	0.003
Lagoon	Lethrinidae	*Lethrinus harak*	0.0003	0.060

Appendix 3: Finfish survey data
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3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lagoon	Lethrinidae	*Monotaxis grandoculis*	0.0057	0.941
Lagoon	Lutjanidae	*Lutjanus bohar*	0.0003	0.036
Lagoon	Lutjanidae	*Lutjanus ehrenbergii*	0.0007	0.069
Lagoon	Lutjanidae	*Lutjanus fulvus*	0.0030	0.155
Lagoon	Lutjanidae	*Lutjanus gibbus*	0.0260	0.827
Lagoon	Lutjanidae	*Lutjanus semicinctus*	0.0027	0.271
Lagoon	Lutjanidae	*Macolor macularis*	0.0017	0.254
Lagoon	Lutjanidae	*Symphorichthys spilurus*	0.0003	0.132
Lagoon	Mullidae	*Parupeneus barberinoides*	0.0003	0.101
Lagoon	Mullidae	*Parupeneus barberinus*	0.0057	0.833
Lagoon	Mullidae	*Parupeneus cyclostomus*	0.0007	0.268
Lagoon	Mullidae	*Parupeneus indicus*	0.0017	0.124
Lagoon	Mullidae	*Parupeneus multifasciatus*	0.0053	0.615
Lagoon	Mullidae	*Parupeneus trifasciatus*	0.0057	1.883
Lagoon	Mullidae	*Upeneus tragula*	0.0007	0.011
Lagoon	Nemipteridae	*Scolopsis affinis*	0.0007	0.060
Lagoon	Nemipteridae	*Scolopsis bilineata*	0.0033	0.259
Lagoon	Nemipteridae	*Scolopsis ciliata*	0.0043	0.287
Lagoon	Nemipteridae	*Scolopsis lineata*	0.0010	0.071
Lagoon	Nemipteridae	*Scolopsis margaritifera*	0.0003	0.030
Lagoon	Nemipteridae	*Scolopsis temporalis*	0.0030	0.594
Lagoon	Nemipteridae	*Scolopsis trilineata*	0.0027	0.372
Lagoon	Pomacanthidae	*Centropyge vrolikii*	0.0003	0.009
Lagoon	Pomacanthidae	*Pomacanthus navarchus*	0.0003	0.078
Lagoon	Pomacanthidae	*Pygoplites diacanthus*	0.0033	0.480
Lagoon	Scaridae	*Cetoscarus bicolor*	0.0030	0.792
Lagoon	Scaridae	*Chlorurus bleekeri*	0.0117	1.725
Lagoon	Scaridae	*Chlorurus japanensis*	0.0010	0.142
Lagoon	Scaridae	*Chlorurus sordidus*	0.0133	1.255
Lagoon	Scaridae	*Hipposcarus longiceps*	0.0007	0.160
Lagoon	Scaridae	*Scarus chameleon*	0.0013	0.219
Lagoon	Scaridae	*Scarus dimidiatus*	0.0208	2.253
Lagoon	Scaridae	*Scarus flavipectoralis*	0.0070	1.021
Lagoon	Scaridae	*Scarus frenatus*	0.0007	0.103
Lagoon	Scaridae	*Scarus ghobban*	0.0010	0.624
Lagoon	Scaridae	*Scarus niger*	0.0030	0.724
Lagoon	Scaridae	*Scarus oviceps*	0.0027	0.572
Lagoon	Scaridae	*Scarus psittacus*	0.0273	1.854
Lagoon	Scaridae	*Scarus quoyi*	0.0043	0.412
Lagoon	Scaridae	*Scarus rivulatus*	0.0230	8.587
Lagoon	Scaridae	*Scarus rubroviolaceus*	0.0007	0.419
Lagoon	Scaridae	*Scarus schlegeli*	0.0007	0.152
Lagoon	Scaridae	*Scarus sp.*	0.0003	0.055
Lagoon	Scaridae	*Scarus spinus*	0.0013	0.166
Lagoon	Serranidae	*Aethaloperca rogaa*	0.0003	0.039
Lagoon	Serranidae	*Cephalopholis cyanostigma*	0.0010	0.092

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lagoon	Serranidae	*Cephalopholis miniata*	0.0003	0.024
Lagoon	Siganidae	*Siganus doliatus*	0.0013	0.344
Lagoon	Siganidae	*Siganus puellus*	0.0017	0.227
Lagoon	Siganidae	*Siganus punctatissimus*	0.0003	0.197
Lagoon	Siganidae	*Siganus punctatus*	0.0007	0.274
Lagoon	Siganidae	*Siganus spinus*	0.0003	0.011
Lagoon	Siganidae	*Siganus vulpinus*	0.0013	0.209
Lagoon	Zanclidae	*Zanclus cornutus*	0.0023	0.181
Outer reef	Acanthuridae	*Acanthurus blochii*	0.2449	97.274
Outer reef	Acanthuridae	*Acanthurus fowleri*	0.0040	2.453
Outer reef	Acanthuridae	*Acanthurus guttatus*	0.0013	0.244
Outer reef	Acanthuridae	*Acanthurus lineatus*	0.2457	50.111
Outer reef	Acanthuridae	*Acanthurus maculiceps*	0.0081	3.232
Outer reef	Acanthuridae	*Acanthurus nigricans*	0.0374	3.134
Outer reef	Acanthuridae	*Acanthurus nigricauda*	0.0010	0.455
Outer reef	Acanthuridae	*Acanthurus olivaceus*	0.0003	0.037
Outer reef	Acanthuridae	*Acanthurus pyroferus*	0.0172	1.708
Outer reef	Acanthuridae	*Acanthurus sp.*	0.0003	0.238
Outer reef	Acanthuridae	*Ctenochaetus binotatus*	0.0027	0.078
Outer reef	Acanthuridae	*Ctenochaetus striatus*	0.2738	27.047
Outer reef	Acanthuridae	*Naso annulatus*	0.0047	2.218
Outer reef	Acanthuridae	*Naso brachycentron*	0.0037	2.266
Outer reef	Acanthuridae	*Naso brevirostris*	0.0097	4.273
Outer reef	Acanthuridae	*Naso lituratus*	0.0018	0.432
Outer reef	Acanthuridae	*Naso thynnoides*	0.0047	4.517
Outer reef	Acanthuridae	*Naso unicornis*	0.0007	0.485
Outer reef	Acanthuridae	*Zebrasoma scopas*	0.0030	0.075
Outer reef	Balistidae	*Balistapus undulatus*	0.0152	1.570
Outer reef	Balistidae	*Balistoides viridescens*	0.0003	0.557
Outer reef	Balistidae	*Melichthys vidua*	0.0114	1.880
Outer reef	Balistidae	*Rhinecanthus rectangulus*	0.0003	0.009
Outer reef	Balistidae	*Sufflamen bursa*	0.0003	0.025
Outer reef	Balistidae	*Sufflamen chrysopterum*	0.0007	0.055
Outer reef	Caesionidae	*Caesio caerulaurea*	0.0111	2.618
Outer reef	Caesionidae	*Caesio cuning*	0.0131	2.234
Outer reef	Caesionidae	*Caesio lunaris*	0.0030	0.648
Outer reef	Caesionidae	*Caesio teres*	0.0003	0.053
Outer reef	Caesionidae	*Pterocaesio tile*	0.0067	0.388
Outer reef	Carangidae	*Caranx melampygus*	0.0003	0.456
Outer reef	Carangidae	*Scomberoides commersonnianus*	0.0003	2.610
Outer reef	Chaetodontidae	*Chaetodon baronessa*	0.0033	0.103
Outer reef	Chaetodontidae	*Chaetodon citrinellus*	0.0077	0.079
Outer reef	Chaetodontidae	*Chaetodon ephippium*	0.0050	0.318
Outer reef	Chaetodontidae	*Chaetodon kleinii*	0.0093	0.135
Outer reef	Chaetodontidae	*Chaetodon lineolatus*	0.0007	0.011
Outer reef	Chaetodontidae	*Chaetodon lunula*	0.0023	0.126

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Chaetodontidae	*Chaetodon lunulatus*	0.0067	0.165
Outer reef	Chaetodontidae	*Chaetodon melannotus*	0.0007	0.014
Outer reef	Chaetodontidae	*Chaetodon meyeri*	0.0027	0.126
Outer reef	Chaetodontidae	*Chaetodon ornatissimus*	0.0070	0.255
Outer reef	Chaetodontidae	*Chaetodon rafflesii*	0.0007	0.020
Outer reef	Chaetodontidae	*Chaetodon semeion*	0.0023	0.105
Outer reef	Chaetodontidae	*Chaetodon trifascialis*	0.0007	0.016
Outer reef	Chaetodontidae	*Chaetodon vagabundus*	0.0040	0.141
Outer reef	Chaetodontidae	*Forcipiger longirostris*	0.0003	0.010
Outer reef	Chaetodontidae	*Heniochus chrysostomus*	0.0007	0.027
Outer reef	Chaetodontidae	*Heniochus varius*	0.0023	0.177
Outer reef	Haemulidae	*Plectorhinchus lineatus*	0.0007	0.725
Outer reef	Haemulidae	*Plectorhinchus orientalis*	0.0055	2.704
Outer reef	Holocentridae	*Myripristis adusta*	0.0037	0.887
Outer reef	Holocentridae	*Myripristis kuntee*	0.0164	1.798
Outer reef	Holocentridae	*Myripristis pralinia*	0.0007	0.161
Outer reef	Holocentridae	*Myripristis violacea*	0.0209	3.329
Outer reef	Holocentridae	*Neoniphon opercularis*	0.0077	0.789
Outer reef	Holocentridae	*Neoniphon sammara*	0.0087	0.756
Outer reef	Holocentridae	*Sargocentron caudimaculatum*	0.0133	1.427
Outer reef	Holocentridae	*Sargocentron cornutum*	0.0017	0.140
Outer reef	Holocentridae	*Sargocentron spiniferum*	0.0003	0.091
Outer reef	Kyphosidae	*Kyphosus cinerascens*	0.0020	0.831
Outer reef	Kyphosidae	*Kyphosus vaigiensis*	0.0080	6.882
Outer reef	Labridae	*Cheilinus undulatus*	0.0003	0.465
Outer reef	Labridae	*Epibulus insidiator*	0.0010	0.164
Outer reef	Labridae	*Hemigymnus fasciatus*	0.0020	0.363
Outer reef	Labridae	*Hemigymnus melapterus*	0.0020	0.475
Outer reef	Lethrinidae	*Gnathodentex aureolineatus*	0.0020	0.284
Outer reef	Lethrinidae	*Lethrinus obsoletus*	0.0013	0.276
Outer reef	Lethrinidae	*Monotaxis grandoculis*	0.0073	2.941
Outer reef	Lutjanidae	*Aphareus furca*	0.0023	0.613
Outer reef	Lutjanidae	*Lutjanus biguttatus*	0.0067	0.603
Outer reef	Lutjanidae	*Lutjanus bohar*	0.0007	0.097
Outer reef	Lutjanidae	*Lutjanus gibbus*	0.0040	1.620
Outer reef	Lutjanidae	*Lutjanus monostigma*	0.0007	0.291
Outer reef	Lutjanidae	*Lutjanus semicinctus*	0.0020	0.290
Outer reef	Lutjanidae	*Macolor macularis*	0.0033	0.726
Outer reef	Mullidae	*Parupeneus cyclostomus*	0.0003	0.088
Outer reef	Mullidae	*Parupeneus multifasciatus*	0.0083	1.151
Outer reef	Mullidae	*Parupeneus trifasciatus*	0.0100	1.728
Outer reef	Nemipteridae	*Scolopsis bilineata*	0.0003	0.031
Outer reef	Pomacanthidae	*Centropyge vrolikii*	0.0027	0.042
Outer reef	Pomacanthidae	*Pomacanthus imperator*	0.0003	0.256
Outer reef	Pomacanthidae	*Pygoplites diacanthus*	0.0037	0.567
Outer reef	Scaridae	*Bolbometopon muricatum*	0.0027	26.701

3.1.2 Weighted average density and biomass of all finfish species recorded in Andra (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Scaridae	*Cetoscarus bicolor*	0.0013	0.890
Outer reef	Scaridae	*Chlorurus bleekeri*	0.0023	0.575
Outer reef	Scaridae	*Chlorurus japanensis*	0.0087	0.923
Outer reef	Scaridae	*Chlorurus microrhinos*	0.0007	0.183
Outer reef	Scaridae	*Chlorurus sordidus*	0.0432	4.011
Outer reef	Scaridae	*Hipposcarus longiceps*	0.0050	3.358
Outer reef	Scaridae	*Scarus chameleon*	0.0010	0.166
Outer reef	Scaridae	*Scarus dimidiatus*	0.0030	0.479
Outer reef	Scaridae	*Scarus flavipectoralis*	0.0030	0.610
Outer reef	Scaridae	*Scarus forsteni*	0.0003	0.094
Outer reef	Scaridae	*Scarus frenatus*	0.0030	0.443
Outer reef	Scaridae	*Scarus niger*	0.0055	0.942
Outer reef	Scaridae	*Scarus oviceps*	0.0130	3.297
Outer reef	Scaridae	*Scarus prasiognathos*	0.0267	27.711
Outer reef	Scaridae	*Scarus psittacus*	0.0135	1.440
Outer reef	Scaridae	*Scarus rubroviolaceus*	0.0030	0.485
Outer reef	Scaridae	*Scarus schlegeli*	0.0017	0.280
Outer reef	Scaridae	*Scarus sp.*	0.0003	0.055
Outer reef	Scaridae	*Scarus spinus*	0.0020	0.224
Outer reef	Scombridae	*Rastrelliger kanagurta*	0.0092	1.206
Outer reef	Serranidae	*Cephalopholis argus*	0.0037	0.721
Outer reef	Serranidae	*Cephalopholis boenak*	0.0007	0.113
Outer reef	Serranidae	*Cephalopholis urodeta*	0.0017	0.122
Outer reef	Serranidae	*Epinephelus maculatus*	0.0003	0.123
Outer reef	Serranidae	*Epinephelus sp.*	0.0003	0.107
Outer reef	Serranidae	*Epinephelus spilotoceps*	0.0003	0.076
Outer reef	Serranidae	*Plectropomus areolatus*	0.0003	0.104
Outer reef	Serranidae	*Plectropomus laevis*	0.0007	0.700
Outer reef	Serranidae	*Variola albimarginata*	0.0003	0.211
Outer reef	Siganidae	*Siganus argenteus*	0.0020	0.278
Outer reef	Siganidae	*Siganus corallinus*	0.0003	0.060
Outer reef	Siganidae	*Siganus doliatus*	0.0013	0.230
Outer reef	Siganidae	*Siganus puellus*	0.0027	0.857
Outer reef	Siganidae	*Siganus randalli*	0.0005	0.112
Outer reef	Siganidae	*Siganus spinus*	0.0003	0.061
Outer reef	Siganidae	*Siganus vulpinus*	0.0020	0.284
Outer reef	Zanclidae	*Zanclus cornutus*	0.0033	0.171

3.2 Tsoilaunung finfish survey data

3.2.1 Coordinates (WGS84) of the 18 D-UVC transects used to assess finfish resource status in Tsoilaunung

Station name	Habitat	Latitude	Longitude
TRA01	Outer reef	2°24'22.0788" S	150°25'25.14" E
TRA02	Outer reef	2°25'05.88" S	150°26'28.6188" E
TRA03	Outer reef	2°25'45.4188" S	150°27'17.28" E
TRA04	Outer reef	2°26'32.5212" S	150°28'39.2988" E
TRA05	Coastal reef	2°27'19.98" S	150°23'34.44" E
TRA06	Coastal reef	2°28'31.44" S	150°26'17.8188" E
TRA07	Lagoon	2°28'51.1788" S	150°26'37.5612" E
TRA08	Lagoon	2°28'55.2612" S	150°26'46.7988" E
TRA09	Coastal reef	2°29'45.1212" S	150°26'46.9212" E
TRA10	Coastal reef	2°32'02.76" S	150°27'41.2812" E
TRA11	Coastal reef	2°33'09.72" S	150°27'28.3212" E
TRA12	Coastal reef	2°33'38.52" S	150°27'21.6" E
TRA13	Lagoon	2°33'17.7588" S	150°28'46.74" E
TRA14	Lagoon	2°34'09.5988" S	150°28'41.88" E
TRA15	Lagoon	2°34'53.94" S	150°29'26.5812" E
TRA16	Lagoon	2°33'46.1412" S	150°29'22.8588" E
TRA17	Outer reef	2°27'18.1188" S	150°29'34.8612" E
TRA18	Outer reef	2°28'06.8412" S	150°30'23.5188" E

3.2.2 Weighted average density and biomass of all finfish species recorded in Tsoilaunung
(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Coastal reef	Acanthuridae	*Acanthurus blochii*	0.0097	3.231
Coastal reef	Acanthuridae	*Acanthurus guttatus*	0.0007	0.017
Coastal reef	Acanthuridae	*Acanthurus lineatus*	0.0007	0.216
Coastal reef	Acanthuridae	*Acanthurus nigricauda*	0.0027	0.666
Coastal reef	Acanthuridae	*Acanthurus pyroferus*	0.0023	0.236
Coastal reef	Acanthuridae	*Ctenochaetus striatus*	0.0450	4.089
Coastal reef	Acanthuridae	*Zebrasoma scopas*	0.0003	0.010
Coastal reef	Acanthuridae	*Zebrasoma veliferum*	0.0010	0.011
Coastal reef	Balistidae	*Pseudobalistes flavimarginatus*	0.0003	0.780
Coastal reef	Caesionidae	*Caesio cuning*	0.0174	1.156
Coastal reef	Carangidae	*Caranx sexfasciatus*	0.0020	3.428
Coastal reef	Chaetodontidae	*Chaetodon auriga*	0.0003	0.002
Coastal reef	Chaetodontidae	*Chaetodon baronessa*	0.0043	0.077
Coastal reef	Chaetodontidae	*Chaetodon citrinellus*	0.0013	0.003
Coastal reef	Chaetodontidae	*Chaetodon ephippium*	0.0070	0.284
Coastal reef	Chaetodontidae	*Chaetodon kleinii*	0.0033	0.046
Coastal reef	Chaetodontidae	*Chaetodon lineolatus*	0.0003	0.005
Coastal reef	Chaetodontidae	*Chaetodon lunulatus*	0.0190	0.261
Coastal reef	Chaetodontidae	*Chaetodon melannotus*	0.0013	0.014
Coastal reef	Chaetodontidae	*Chaetodon octofasciatus*	0.0010	0.012
Coastal reef	Chaetodontidae	*Chaetodon rafflesii*	0.0030	0.089

Appendix 3: Finfish survey data
Tsoilaunung

3.2.2 Weighted average density and biomass of all finfish species recorded in Tsoilaunung (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Coastal reef	Chaetodontidae	*Chaetodon semeion*	0.0027	0.167
Coastal reef	Chaetodontidae	*Chaetodon trifascialis*	0.0010	0.012
Coastal reef	Chaetodontidae	*Chaetodon ulietensis*	0.0037	0.078
Coastal reef	Chaetodontidae	*Chaetodon vagabundus*	0.0100	0.244
Coastal reef	Chaetodontidae	*Chelmon marginalis*	0.0007	0.036
Coastal reef	Chaetodontidae	*Coradion altivelis*	0.0003	0.005
Coastal reef	Chaetodontidae	*Heniochus acuminatus*	0.0003	0.019
Coastal reef	Chaetodontidae	*Heniochus chrysostomus*	0.0013	0.041
Coastal reef	Chaetodontidae	*Heniochus varius*	0.0007	0.036
Coastal reef	Haemulidae	*Plectorhinchus chaetodonoides*	0.0003	0.080
Coastal reef	Haemulidae	*Plectorhinchus flavomaculatus*	0.0017	0.693
Coastal reef	Holocentridae	*Myripristis murdjan*	0.0003	0.013
Coastal reef	Holocentridae	*Myripristis sp.*	0.0003	0.017
Coastal reef	Holocentridae	*Neoniphon sammara*	0.0013	0.111
Coastal reef	Labridae	*Cheilinus undulatus*	0.0010	0.065
Coastal reef	Labridae	*Choerodon anchorago*	0.0057	1.409
Coastal reef	Labridae	*Choerodon jordani*	0.0007	0.070
Coastal reef	Labridae	*Hemigymnus melapterus*	0.0030	0.376
Coastal reef	Lethrinidae	*Lethrinus harak*	0.0007	0.233
Coastal reef	Lethrinidae	*Monotaxis grandoculis*	0.0050	0.344
Coastal reef	Lutjanidae	*Lutjanus carponotatus*	0.0177	4.910
Coastal reef	Lutjanidae	*Lutjanus ehrenbergii*	0.0007	0.048
Coastal reef	Lutjanidae	*Lutjanus fulvus*	0.0040	0.804
Coastal reef	Lutjanidae	*Lutjanus gibbus*	0.0003	0.006
Coastal reef	Lutjanidae	*Lutjanus semicinctus*	0.0007	0.045
Coastal reef	Mullidae	*Mulloidichthys flavolineatus*	0.0023	0.247
Coastal reef	Mullidae	*Parupeneus barberinus*	0.0110	1.454
Coastal reef	Mullidae	*Parupeneus heptacanthus*	0.0010	0.057
Coastal reef	Mullidae	*Parupeneus indicus*	0.0007	0.164
Coastal reef	Mullidae	*Parupeneus spilurus*	0.0003	0.083
Coastal reef	Mullidae	*Upeneus tragula*	0.0080	0.467
Coastal reef	Nemipteridae	*Pentapodus sp.*	0.0037	0.445
Coastal reef	Nemipteridae	*Pentapodus trivittatus*	0.0087	1.534
Coastal reef	Nemipteridae	*Scolopsis affinis*	0.0003	0.013
Coastal reef	Nemipteridae	*Scolopsis aurata*	0.0007	0.016
Coastal reef	Nemipteridae	*Scolopsis bilineata*	0.0007	0.082
Coastal reef	Nemipteridae	*Scolopsis ciliata*	0.0033	0.253
Coastal reef	Nemipteridae	*Scolopsis margaritifera*	0.0007	0.060
Coastal reef	Nemipteridae	*Scolopsis sp.*	0.0017	0.122
Coastal reef	Nemipteridae	*Scolopsis temporalis*	0.0060	1.043
Coastal reef	Nemipteridae	*Scolopsis trilineata*	0.0070	0.406
Coastal reef	Pomacanthidae	*Chaetodontoplus mesoleucus*	0.0007	0.027
Coastal reef	Scaridae	*Bolbometopon muricatum*	0.0003	0.019
Coastal reef	Scaridae	*Cetoscarus bicolor*	0.0007	0.021
Coastal reef	Scaridae	*Chlorurus bleekeri*	0.0190	2.764
Coastal reef	Scaridae	*Chlorurus japanensis*	0.0063	0.953

3.2.2 Weighted average density and biomass of all finfish species recorded in Tsoilaunung (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Coastal reef	Scaridae	*Chlorurus sordidus*	0.0293	2.410
Coastal reef	Scaridae	*Hipposcarus longiceps*	0.0037	0.173
Coastal reef	Scaridae	*Scarus dimidiatus*	0.0077	0.563
Coastal reef	Scaridae	*Scarus flavipectoralis*	0.0560	6.372
Coastal reef	Scaridae	*Scarus forsteni*	0.0007	0.294
Coastal reef	Scaridae	*Scarus psittacus*	0.0877	11.671
Coastal reef	Serranidae	*Cephalopholis cyanostigma*	0.0003	0.065
Coastal reef	Serranidae	*Epinephelus merra*	0.0003	0.028
Coastal reef	Serranidae	*Gracila albomarginata*	0.0007	0.107
Coastal reef	Serranidae	*Plectropomus leopardus*	0.0003	0.158
Coastal reef	Siganidae	*Siganus doliatus*	0.0050	0.541
Coastal reef	Siganidae	*Siganus lineatus*	0.0010	0.399
Coastal reef	Sphyraenidae	*Sphyraena barracuda*	0.0003	0.117
Coastal reef	Zanclidae	*Zanclus cornutus*	0.0067	0.275
Lagoon	Acanthuridae	*Acanthurus blochii*	0.0080	1.192
Lagoon	Acanthuridae	*Acanthurus guttatus*	0.0027	0.234
Lagoon	Acanthuridae	*Acanthurus mata*	0.0007	0.267
Lagoon	Acanthuridae	*Acanthurus nigricauda*	0.0097	3.169
Lagoon	Acanthuridae	*Ctenochaetus striatus*	0.0280	3.367
Lagoon	Acanthuridae	*Zebrasoma scopas*	0.0003	0.005
Lagoon	Acanthuridae	*Zebrasoma veliferum*	0.0040	0.177
Lagoon	Balistidae	*Balistapus undulatus*	0.0033	0.722
Lagoon	Balistidae	*Balistoides viridescens*	0.0003	0.234
Lagoon	Balistidae	*Pseudobalistes flavimarginatus*	0.0003	0.940
Lagoon	Balistidae	*Rhinecanthus verrucosus*	0.0003	0.034
Lagoon	Carangidae	*Carangoides chrysophrys*	0.0020	1.614
Lagoon	Carangidae	*Caranx melampygus*	0.0027	2.213
Lagoon	Carangidae	*Caranx papuensis*	0.0133	17.424
Lagoon	Chaetodontidae	*Chaetodon auriga*	0.0017	0.049
Lagoon	Chaetodontidae	*Chaetodon baronessa*	0.0017	0.044
Lagoon	Chaetodontidae	*Chaetodon citrinellus*	0.0003	0.001
Lagoon	Chaetodontidae	*Chaetodon ephippium*	0.0063	0.242
Lagoon	Chaetodontidae	*Chaetodon lunulatus*	0.0193	0.391
Lagoon	Chaetodontidae	*Chaetodon melannotus*	0.0003	0.001
Lagoon	Chaetodontidae	*Chaetodon octofasciatus*	0.0030	0.053
Lagoon	Chaetodontidae	*Chaetodon rafflesii*	0.0020	0.050
Lagoon	Chaetodontidae	*Chaetodon semeion*	0.0017	0.052
Lagoon	Chaetodontidae	*Chaetodon trifascialis*	0.0010	0.003
Lagoon	Chaetodontidae	*Chaetodon ulietensis*	0.0077	0.234
Lagoon	Chaetodontidae	*Chaetodon vagabundus*	0.0090	0.283
Lagoon	Chaetodontidae	*Chelmon marginalis*	0.0017	0.104
Lagoon	Chaetodontidae	*Chelmon rostratus*	0.0007	0.051
Lagoon	Chaetodontidae	*Coradion altivelis*	0.0003	0.005
Lagoon	Chaetodontidae	*Heniochus chrysostomus*	0.0013	0.016
Lagoon	Holocentridae	*Myripristis kuntee*	0.0027	0.036
Lagoon	Holocentridae	*Sargocentron spiniferum*	0.0003	0.059

Appendix 3: Finfish survey data
Tsoilaunung

3.2.2 Weighted average density and biomass of all finfish species recorded in Tsoilaunung (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lagoon	Labridae	*Cheilinus chlorourus*	0.0007	0.119
Lagoon	Labridae	*Cheilinus fasciatus*	0.0010	0.318
Lagoon	Labridae	*Choerodon anchorago*	0.0060	2.199
Lagoon	Labridae	*Hemigymnus melapterus*	0.0043	0.490
Lagoon	Lethrinidae	*Gnathodentex aureolineatus*	0.0003	0.016
Lagoon	Lethrinidae	*Monotaxis grandoculis*	0.0083	0.427
Lagoon	Lutjanidae	*Lutjanus bohar*	0.0007	0.085
Lagoon	Lutjanidae	*Lutjanus carponotatus*	0.0050	1.033
Lagoon	Lutjanidae	*Lutjanus fulvus*	0.0020	0.743
Lagoon	Lutjanidae	*Lutjanus lutjanus*	0.0003	0.010
Lagoon	Lutjanidae	*Lutjanus monostigma*	0.0013	0.583
Lagoon	Lutjanidae	*Lutjanus semicinctus*	0.0017	0.349
Lagoon	Mullidae	*Parupeneus barberinus*	0.0163	1.867
Lagoon	Mullidae	*Parupeneus multifasciatus*	0.0003	0.003
Lagoon	Mullidae	*Parupeneus trifasciatus*	0.0003	0.041
Lagoon	Mullidae	*Upeneus tragula*	0.0010	0.029
Lagoon	Nemipteridae	*Scolopsis affinis*	0.0003	0.017
Lagoon	Nemipteridae	*Scolopsis aurata*	0.0033	0.626
Lagoon	Nemipteridae	*Scolopsis bilineata*	0.0057	0.380
Lagoon	Nemipteridae	*Scolopsis ciliata*	0.0003	0.025
Lagoon	Nemipteridae	*Scolopsis lineata*	0.0037	0.197
Lagoon	Nemipteridae	*Scolopsis margaritifera*	0.0013	0.143
Lagoon	Nemipteridae	*Scolopsis sp.*	0.0027	0.286
Lagoon	Nemipteridae	*Scolopsis temporalis*	0.0077	0.827
Lagoon	Nemipteridae	*Scolopsis trilineata*	0.0120	0.710
Lagoon	Pomacanthidae	*Chaetodontoplus mesoleucus*	0.0017	0.053
Lagoon	Pomacanthidae	*Pomacanthus sexstriatus*	0.0003	0.235
Lagoon	Pomacanthidae	*Pygoplites diacanthus*	0.0010	0.313
Lagoon	Scaridae	*Cetoscarus bicolor*	0.0007	0.218
Lagoon	Scaridae	*Chlorurus bleekeri*	0.0100	3.522
Lagoon	Scaridae	*Chlorurus japanensis*	0.0003	0.082
Lagoon	Scaridae	*Chlorurus sordidus*	0.0013	0.306
Lagoon	Scaridae	*Hipposcarus longiceps*	0.0023	0.189
Lagoon	Scaridae	*Scarus dimidiatus*	0.0213	2.913
Lagoon	Scaridae	*Scarus flavipectoralis*	0.0130	2.555
Lagoon	Scaridae	*Scarus ghobban*	0.0003	0.171
Lagoon	Scaridae	*Scarus hypselopterus*	0.0020	0.587
Lagoon	Scaridae	*Scarus niger*	0.0027	0.392
Lagoon	Scaridae	*Scarus oviceps*	0.0007	0.161
Lagoon	Scaridae	*Scarus psittacus*	0.0327	3.751
Lagoon	Scaridae	*Scarus quoyi*	0.0010	0.190
Lagoon	Scaridae	*Scarus schlegeli*	0.0003	0.004
Lagoon	Scaridae	*Scarus spinus*	0.0003	0.063
Lagoon	Serranidae	*Cephalopholis argus*	0.0003	0.021
Lagoon	Serranidae	*Epinephelus merra*	0.0003	0.013
Lagoon	Serranidae	*Plectropomus leopardus*	0.0010	0.206

Appendix 3: Finfish survey data
Tsoilaunung

3.2.2 Weighted average density and biomass of all finfish species recorded in Tsoilaunung (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lagoon	Serranidae	*Plectropomus maculatus*	0.0003	0.073
Lagoon	Siganidae	*Siganus doliatus*	0.0013	0.195
Lagoon	Siganidae	*Siganus lineatus*	0.0003	0.010
Lagoon	Siganidae	*Siganus puellus*	0.0010	0.078
Lagoon	Zanclidae	*Zanclus cornutus*	0.0007	0.032
Outer reef	Acanthuridae	*Acanthurus blochii*	0.0693	56.732
Outer reef	Acanthuridae	*Acanthurus guttatus*	0.0037	0.540
Outer reef	Acanthuridae	*Acanthurus lineatus*	0.1905	27.576
Outer reef	Acanthuridae	*Acanthurus mata*	0.0003	0.300
Outer reef	Acanthuridae	*Acanthurus nigricans*	0.0667	6.120
Outer reef	Acanthuridae	*Acanthurus nigricauda*	0.0062	1.908
Outer reef	Acanthuridae	*Acanthurus nigrofuscus*	0.0107	0.257
Outer reef	Acanthuridae	*Acanthurus pyroferus*	0.0040	0.573
Outer reef	Acanthuridae	*Acanthurus xanthopterus*	0.0010	0.703
Outer reef	Acanthuridae	*Ctenochaetus striatus*	0.2430	22.566
Outer reef	Acanthuridae	*Naso annulatus*	0.0013	1.219
Outer reef	Acanthuridae	*Naso lituratus*	0.0131	5.432
Outer reef	Acanthuridae	*Naso thynnoides*	0.0069	3.941
Outer reef	Acanthuridae	*Naso unicornis*	0.0033	4.040
Outer reef	Acanthuridae	*Zebrasoma scopas*	0.0027	0.095
Outer reef	Acanthuridae	*Zebrasoma veliferum*	0.0007	0.259
Outer reef	Balistidae	*Balistapus undulatus*	0.0214	2.663
Outer reef	Balistidae	*Balistoides viridescens*	0.0010	1.368
Outer reef	Balistidae	*Melichthys niger*	0.0061	0.424
Outer reef	Balistidae	*Melichthys vidua*	0.0033	0.570
Outer reef	Balistidae	*Odonus niger*	0.0648	8.695
Outer reef	Balistidae	*Sufflamen bursa*	0.0040	0.434
Outer reef	Balistidae	*Sufflamen chrysopterum*	0.0007	0.103
Outer reef	Caesionidae	*Caesio caerulaurea*	0.0057	0.547
Outer reef	Caesionidae	*Caesio cuning*	0.0538	15.268
Outer reef	Caesionidae	*Caesio lunaris*	0.0071	0.803
Outer reef	Caesionidae	*Caesio teres*	0.0067	3.553
Outer reef	Carangidae	*Caranx melampygus*	0.0017	0.951
Outer reef	Carangidae	*Caranx papuensis*	0.0007	0.191
Outer reef	Carcharhinidae	*Carcharhinus melanopterus*	0.0003	6.265
Outer reef	Chaetodontidae	*Chaetodon baronessa*	0.0030	0.100
Outer reef	Chaetodontidae	*Chaetodon citrinellus*	0.0030	0.023
Outer reef	Chaetodontidae	*Chaetodon ephippium*	0.0047	0.299
Outer reef	Chaetodontidae	*Chaetodon kleinii*	0.0043	0.053
Outer reef	Chaetodontidae	*Chaetodon lunula*	0.0013	0.082
Outer reef	Chaetodontidae	*Chaetodon lunulatus*	0.0033	0.110
Outer reef	Chaetodontidae	*Chaetodon meyeri*	0.0020	0.096
Outer reef	Chaetodontidae	*Chaetodon ornatissimus*	0.0020	0.107
Outer reef	Chaetodontidae	*Chaetodon rafflesii*	0.0040	0.091
Outer reef	Chaetodontidae	*Chaetodon semeion*	0.0043	0.287
Outer reef	Chaetodontidae	*Chaetodon trifascialis*	0.0043	0.051

3.2.2 Weighted average density and biomass of all finfish species recorded in Tsoilaunung (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Chaetodontidae	*Chaetodon vagabundus*	0.0063	0.202
Outer reef	Chaetodontidae	*Forcipiger longirostris*	0.0013	0.053
Outer reef	Chaetodontidae	*Heniochus varius*	0.0020	0.108
Outer reef	Haemulidae	*Plectorhinchus lineatus*	0.0003	0.375
Outer reef	Haemulidae	*Plectorhinchus orientalis*	0.0003	0.130
Outer reef	Holocentridae	*Myripristis kuntee*	0.0003	0.024
Outer reef	Holocentridae	*Neoniphon sammara*	0.0040	0.335
Outer reef	Holocentridae	*Sargocentron caudimaculatum*	0.0100	1.207
Outer reef	Kyphosidae	*Kyphosus cinerascens*	0.0024	0.839
Outer reef	Kyphosidae	*Kyphosus vaigiensis*	0.0050	1.289
Outer reef	Labridae	*Cheilinus chlorourus*	0.0020	0.166
Outer reef	Labridae	*Cheilinus fasciatus*	0.0010	0.292
Outer reef	Labridae	*Cheilinus trilobatus*	0.0007	0.287
Outer reef	Labridae	*Cheilinus undulatus*	0.0010	3.213
Outer reef	Labridae	*Hemigymnus fasciatus*	0.0025	0.239
Outer reef	Labridae	*Hemigymnus melapterus*	0.0053	1.272
Outer reef	Labridae	*Oxycheilinus digramma*	0.0003	0.019
Outer reef	Lethrinidae	*Gnathodentex aureolineatus*	0.0067	0.586
Outer reef	Lethrinidae	*Lethrinus obsoletus*	0.0087	5.266
Outer reef	Lethrinidae	*Lethrinus olivaceus*	0.0027	2.355
Outer reef	Lethrinidae	*Lethrinus xanthochilus*	0.0007	0.886
Outer reef	Lethrinidae	*Monotaxis grandoculis*	0.0188	13.686
Outer reef	Lutjanidae	*Aphareus furca*	0.0003	0.132
Outer reef	Lutjanidae	*Aprion virescens*	0.0003	0.346
Outer reef	Lutjanidae	*Lutjanus fulvus*	0.0124	2.053
Outer reef	Lutjanidae	*Lutjanus gibbus*	0.2230	101.597
Outer reef	Lutjanidae	*Lutjanus monostigma*	0.0023	1.011
Outer reef	Lutjanidae	*Lutjanus semicinctus*	0.0033	0.655
Outer reef	Lutjanidae	*Macolor macularis*	0.0023	1.166
Outer reef	Mullidae	*Parupeneus barberinus*	0.0047	0.838
Outer reef	Mullidae	*Parupeneus cyclostomus*	0.0027	1.749
Outer reef	Mullidae	*Parupeneus indicus*	0.0003	0.304
Outer reef	Mullidae	*Parupeneus multifasciatus*	0.0100	1.176
Outer reef	Mullidae	*Parupeneus trifasciatus*	0.0194	2.672
Outer reef	Nemipteridae	*Scolopsis bilineata*	0.0010	0.052
Outer reef	Nemipteridae	*Scolopsis temporalis*	0.0033	0.906
Outer reef	Pomacanthidae	*Centropyge vrolikii*	0.0010	0.016
Outer reef	Pomacanthidae	*Chaetodontoplus mesoleucus*	0.0007	0.020
Outer reef	Pomacanthidae	*Pomacanthus imperator*	0.0003	0.234
Outer reef	Pomacanthidae	*Pygoplites diacanthus*	0.0027	0.855
Outer reef	Scaridae	*Bolbometopon muricatum*	0.0003	0.565
Outer reef	Scaridae	*Calotomus carolinus*	0.0007	0.038
Outer reef	Scaridae	*Cetoscarus bicolor*	0.0003	0.054
Outer reef	Scaridae	*Chlorurus bleekeri*	0.0023	0.354
Outer reef	Scaridae	*Chlorurus japanensis*	0.0077	1.258
Outer reef	Scaridae	*Chlorurus sordidus*	0.0223	3.211

3.2.2 Weighted average density and biomass of all finfish species recorded in Tsoilaunung (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Scaridae	*Hipposcarus longiceps*	0.0060	4.522
Outer reef	Scaridae	*Scarus dimidiatus*	0.0010	0.164
Outer reef	Scaridae	*Scarus flavipectoralis*	0.0040	1.419
Outer reef	Scaridae	*Scarus forsteni*	0.0002	0.041
Outer reef	Scaridae	*Scarus frenatus*	0.0014	0.195
Outer reef	Scaridae	*Scarus ghobban*	0.0223	11.559
Outer reef	Scaridae	*Scarus globiceps*	0.0073	2.895
Outer reef	Scaridae	*Scarus niger*	0.0043	1.162
Outer reef	Scaridae	*Scarus oviceps*	0.0111	2.519
Outer reef	Scaridae	*Scarus psittacus*	0.0384	7.889
Outer reef	Scaridae	*Scarus rubroviolaceus*	0.0020	0.638
Outer reef	Scaridae	*Scarus sp.*	0.0069	0.076
Outer reef	Scaridae	*Scarus spinus*	0.0007	0.109
Outer reef	Serranidae	*Cephalopholis argus*	0.0007	0.088
Outer reef	Serranidae	*Cephalopholis urodeta*	0.0033	0.267
Outer reef	Serranidae	*Epinephelus merra*	0.0023	0.194
Outer reef	Siganidae	*Siganus argenteus*	0.0007	0.066
Outer reef	Siganidae	*Siganus corallinus*	0.0023	0.502
Outer reef	Siganidae	*Siganus doliatus*	0.0013	0.456
Outer reef	Siganidae	*Siganus punctatissimus*	0.0007	0.318
Outer reef	Zanclidae	*Zanclus cornutus*	0.0027	0.129

3.3 Sideia finfish survey data

3.3.1 Coordinates (WGS84) of the 18 D-UVC transects used to assess finfish resource status in Sideia

Station name	Habitat	Latitude	Longitude
TRA01	Outer reef	10°31'57.9" S	150°49'00.7212" E
TRA02	Outer reef	10°31'50.7612" S	150°48'12.96" E
TRA03	Outer reef	10°32'11.1588" S	150°47'01.32" E
TRA04	Outer reef	10°31'51.42" S	150°54'57.96" E
TRA05	Outer reef	10°31'52.2588" S	150°54'47.7612" E
TRA06	Outer reef	10°31'48.0612" S	150°53'28.0788" E
TRA07	Outer reef	10°31'35.5188" S	150°53'02.4" E
TRA08	Back-reef	10°32'05.5788" S	150°54'56.9988" E
TRA09	Back-reef	10°32'06.36" S	150°54'48.96" E
TRA10	Back-reef	10°31'52.4388" S	150°53'36.1788" E
TRA11	Back-reef	10°31'58.5588" S	150°53'29.2812" E
TRA12	Outer reef	10°31'45.0588" S	150°51'37.7388" E
TRA13	Outer reef	10°31'37.38" S	150°52'08.1588" E
TRA14	Outer reef	10°32'05.1612" S	150°50'50.7588" E
TRA15	Outer reef	10°32'01.86" S	150°47'45.1212" E
TRA16	Back-reef	10°32'14.1612" S	150°46'57.0612" E
TRA17	Outer reef	10°32'03.0012" S	150°45'30.5388" E
TRA18	Back-reef	10°32'10.0788" S	150°45'35.1" E

3.3.2 Weighted average density and biomass of all finfish species recorded in Sideia (using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Acanthuridae	*Ctenochaetus striatus*	0.0719	12.51
Back-reef	Acanthuridae	*Ctenochaetus binotatus*	0.0033	0.11
Back-reef	Acanthuridae	*Acanthurus pyroferus*	0.0013	0.14
Back-reef	Acanthuridae	*Ctenochaetus strigosus*	0.0010	0.16
Back-reef	Acanthuridae	*Zebrasoma veliferum*	0.0010	0.24
Back-reef	Acanthuridae	*Acanthurus blochii*	0.0027	1.42
Back-reef	Acanthuridae	*Naso lituratus*	0.0030	0.83
Back-reef	Acanthuridae	*Zebrasoma scopas*	0.0180	0.54
Back-reef	Acanthuridae	*Acanthurus lineatus*	0.0043	1.10
Back-reef	Acanthuridae	*Acanthurus nigricauda*	0.0003	0.12
Back-reef	Balistidae	*Balistapus undulatus*	0.0027	0.26
Back-reef	Balistidae	*Rhinecanthus verrucosus*	0.0030	0.19
Back-reef	Caesionidae	*Caesio caerulaurea*	0.0833	9.46
Back-reef	Caesionidae	*Pterocaesio tile*	0.0153	0.61
Back-reef	Caesionidae	*Caesio cuning*	0.0110	2.45
Back-reef	Carangidae	*Caranx ignobilis*	0.0003	5.18
Back-reef	Carangidae	*Selar crumenophthalmus*	0.0048	0.66
Back-reef	Chaetodontidae	*Heniochus acuminatus*	0.0007	0.03
Back-reef	Chaetodontidae	*Chaetodon rafflesii*	0.0080	0.36
Back-reef	Chaetodontidae	*Chaetodon semeion*	0.0047	0.27
Back-reef	Chaetodontidae	*Chaetodon ulietensis*	0.0023	0.12
Back-reef	Chaetodontidae	*Chaetodon octofasciatus*	0.0013	0.01

3.3.2 Weighted average density and biomass of all finfish species recorded in Sideia (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Chaetodontidae	*Chaetodon trifascialis*	0.0013	0.02
Back-reef	Chaetodontidae	*Chaetodon vagabundus*	0.0030	0.09
Back-reef	Chaetodontidae	*Chaetodon lunulatus*	0.0027	0.07
Back-reef	Chaetodontidae	*Chaetodon citrinellus*	0.0086	0.05
Back-reef	Chaetodontidae	*Heniochus varius*	0.0020	0.12
Back-reef	Chaetodontidae	*Chaetodon ephippium*	0.0083	0.89
Back-reef	Chaetodontidae	*Chaetodon lineolatus*	0.0017	0.11
Back-reef	Chaetodontidae	*Chaetodon bennetti*	0.0010	0.07
Back-reef	Chaetodontidae	*Chaetodon baronessa*	0.0063	0.15
Back-reef	Holocentridae	*Myripristis murdjan*	0.0003	0.03
Back-reef	Holocentridae	*Myripristis kuntee*	0.0080	1.42
Back-reef	Holocentridae	*Myripristis pralinia*	0.0027	0.28
Back-reef	Holocentridae	*Myripristis violacea*	0.0063	0.74
Back-reef	Labridae	*Cheilinus chlorourus*	0.0007	0.11
Back-reef	Labridae	*Oxycheilinus unifasciatus*	0.0007	0.11
Back-reef	Labridae	*Cheilinus fasciatus*	0.0010	0.06
Back-reef	Labridae	*Choerodon jordani*	0.0043	0.46
Back-reef	Labridae	*Hemigymnus fasciatus*	0.0010	0.08
Back-reef	Labridae	*Hemigymnus melapterus*	0.0120	1.50
Back-reef	Labridae	*Choerodon anchorago*	0.0007	0.27
Back-reef	Lethrinidae	*Lethrinus atkinsoni*	0.0003	0.16
Back-reef	Lethrinidae	*Lethrinus erythropterus*	0.0067	1.98
Back-reef	Lethrinidae	*Lethrinus harak*	0.0051	1.26
Back-reef	Lethrinidae	*Monotaxis grandoculis*	0.0118	2.98
Back-reef	Lutjanidae	*Lutjanus bohar*	0.0003	0.41
Back-reef	Lutjanidae	*Lutjanus semicinctus*	0.0017	0.44
Back-reef	Mullidae	*Parupeneus barberinus*	0.0033	0.36
Back-reef	Mullidae	*Parupeneus multifasciatus*	0.0257	3.12
Back-reef	Nemipteridae	*Scolopsis bilineata*	0.0090	0.68
Back-reef	Nemipteridae	*Scolopsis margaritifera*	0.0097	1.40
Back-reef	Nemipteridae	*Scolopsis temporalis*	0.0013	0.04
Back-reef	Nemipteridae	*Scolopsis trilineata*	0.0017	0.06
Back-reef	Nemipteridae	*Pentapodus sp.*	0.0030	0.18
Back-reef	Pomacanthidae	*Pomacanthus semicirculatus*	0.0003	0.38
Back-reef	Pomacanthidae	*Pomacanthus imperator*	0.0003	0.33
Back-reef	Pomacanthidae	*Pygoplites diacanthus*	0.0007	0.12
Back-reef	Scaridae	*Chlorurus sordidus*	0.0060	0.66
Back-reef	Scaridae	*Scarus xanthopleura*	0.0067	5.72
Back-reef	Scaridae	*Scarus chameleon*	0.0007	0.06
Back-reef	Scaridae	*Bolbometopon muricatum*	0.0024	24.03
Back-reef	Scaridae	*Scarus flavipectoralis*	0.0090	1.06
Back-reef	Scaridae	*Scarus psittacus*	0.0237	6.32
Back-reef	Scaridae	*Scarus niger*	0.0070	1.08
Back-reef	Scaridae	*Chlorurus bleekeri*	0.0101	1.57
Back-reef	Scaridae	*Scarus oviceps*	0.0137	1.16
Back-reef	Scaridae	*Scarus schlegeli*	0.0007	0.04

3.3.2 Weighted average density and biomass of all finfish species recorded in Sideia (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Scaridae	*Hipposcarus longiceps*	0.0067	3.62
Back-reef	Scaridae	*Scarus quoyi*	0.0194	3.58
Back-reef	Scaridae	*Chlorurus microrhinos*	0.0007	0.55
Back-reef	Scaridae	*Scarus ghobban*	0.0013	0.91
Back-reef	Scaridae	*Scarus spinus*	0.0003	0.03
Back-reef	Scaridae	*Scarus rivulatus*	0.0412	5.05
Back-reef	Scaridae	*Scarus dimidiatus*	0.0302	3.37
Back-reef	Scaridae	*Scarus frenatus*	0.0010	0.15
Back-reef	Scaridae	*Cetoscarus bicolor*	0.0010	0.86
Back-reef	Serranidae	*Epinephelus cyanopodus*	0.0003	0.07
Back-reef	Serranidae	*Epinephelus merra*	0.0046	0.47
Back-reef	Serranidae	*Anyperodon leucogrammicus*	0.0003	0.12
Back-reef	Serranidae	*Cephalopholis cyanostigma*	0.0003	0.08
Back-reef	Serranidae	*Plectropomus laevis*	0.0007	0.19
Back-reef	Serranidae	*Plectropomus oligacanthus*	0.0003	0.84
Back-reef	Serranidae	*Plectropomus leopardus*	0.0013	0.15
Back-reef	Serranidae	*Plectropomus areolatus*	0.0003	0.07
Back-reef	Siganidae	*Siganus puellus*	0.0010	0.17
Back-reef	Siganidae	*Siganus randalli*	0.0002	0.01
Back-reef	Siganidae	*Siganus doliatus*	0.0053	0.53
Back-reef	Siganidae	*Siganus corallinus*	0.0278	3.67
Back-reef	Siganidae	*Siganus spinus*	0.0231	0.84
Back-reef	Zanclidae	*Zanclus cornutus*	0.0017	0.09
Outer reef	Acanthuridae	*Acanthurus nigricauda*	0.0002	0.07
Outer reef	Acanthuridae	*Zebrasoma scopas*	0.0077	0.22
Outer reef	Acanthuridae	*Acanthurus blochii*	0.0067	2.28
Outer reef	Acanthuridae	*Acanthurus fowleri*	0.0015	1.00
Outer reef	Acanthuridae	*Zebrasoma veliferum*	0.0012	0.27
Outer reef	Acanthuridae	*Acanthurus lineatus*	0.0253	6.19
Outer reef	Acanthuridae	*Ctenochaetus striatus*	0.1041	11.58
Outer reef	Acanthuridae	*Naso lituratus*	0.0025	0.83
Outer reef	Acanthuridae	*Acanthurus guttatus*	0.0008	0.21
Outer reef	Acanthuridae	*Naso annulatus*	0.0010	0.27
Outer reef	Acanthuridae	*Ctenochaetus binotatus*	0.0010	0.05
Outer reef	Acanthuridae	*Naso thynnoides*	0.0003	0.05
Outer reef	Acanthuridae	*Acanthurus pyroferus*	0.0018	0.31
Outer reef	Balistidae	*Balistapus undulatus*	0.0050	0.63
Outer reef	Balistidae	*Balistapus sp.*	0.0002	0.02
Outer reef	Balistidae	*Balistoides viridescens*	0.0003	0.83
Outer reef	Balistidae	*Rhinecanthus verrucosus*	0.0002	0.01
Outer reef	Belonidae	*Tylosurus crocodilus crocodilus*	0.0002	0.07
Outer reef	Caesionidae	*Pterocaesio trilineata*	0.0173	0.71
Outer reef	Caesionidae	*Caesio cuning*	0.0166	3.02
Outer reef	Caesionidae	*Pterocaesio tile*	0.0571	7.10
Outer reef	Caesionidae	*Caesio teres*	0.0433	11.39
Outer reef	Carangidae	*Caranx tille*	0.0003	0.61

3.3.2 Weighted average density and biomass of all finfish species recorded in Sideia (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Carangidae	*Carangoides bajad*	0.0003	0.10
Outer reef	Carangidae	*Caranx melampygus*	0.0012	0.66
Outer reef	Carangidae	*Caranx papuensis*	0.0003	0.06
Outer reef	Carcharhinidae	*Carcharhinus amblyrhynchos*	0.0096	21.87
Outer reef	Carcharhinidae	*Carcharhinus melanopterus*	0.0002	4.25
Outer reef	Chaetodontidae	*Chaetodon octofasciatus*	0.0003	0.00
Outer reef	Chaetodontidae	*Chaetodon lineolatus*	0.0020	0.09
Outer reef	Chaetodontidae	*Heniochus chrysostomus*	0.0007	0.05
Outer reef	Chaetodontidae	*Chaetodon ulietensis*	0.0009	0.02
Outer reef	Chaetodontidae	*Chaetodon vagabundus*	0.0033	0.14
Outer reef	Chaetodontidae	*Chaetodon trifascialis*	0.0003	0.01
Outer reef	Chaetodontidae	*Heniochus singularius*	0.0003	0.02
Outer reef	Chaetodontidae	*Chaetodon pelewensis*	0.0003	0.00
Outer reef	Chaetodontidae	*Heniochus varius*	0.0053	0.34
Outer reef	Chaetodontidae	*Chaetodon lunulatus*	0.0078	0.23
Outer reef	Chaetodontidae	*Chaetodon baronessa*	0.0107	0.28
Outer reef	Chaetodontidae	*Chaetodon mertensii*	0.0013	0.02
Outer reef	Chaetodontidae	*Chaetodon rafflesii*	0.0017	0.06
Outer reef	Chaetodontidae	*Chaetodon citrinellus*	0.0023	0.03
Outer reef	Chaetodontidae	*Chaetodon melannotus*	0.0013	0.03
Outer reef	Chaetodontidae	*Chaetodon semeion*	0.0025	0.21
Outer reef	Chaetodontidae	*Chaetodon bennetti*	0.0003	0.02
Outer reef	Chaetodontidae	*Heniochus acuminatus*	0.0003	0.03
Outer reef	Diodontidae	*Diodon holocanthus*	0.0002	0.09
Outer reef	Haemulidae	*Plectorhinchus obscurus*	0.0003	1.53
Outer reef	Haemulidae	*Plectorhinchus celebicus*	0.0003	0.53
Outer reef	Haemulidae	*Plectorhinchus lineatus*	0.0025	1.89
Outer reef	Haemulidae	*Plectorhinchus chaetodonoides*	0.0007	1.00
Outer reef	Holocentridae	*Myripristis adusta*	0.0003	0.05
Outer reef	Holocentridae	*Myripristis kuntee*	0.0008	0.09
Outer reef	Holocentridae	*Myripristis sp.*	0.0012	0.13
Outer reef	Holocentridae	*Myripristis violacea*	0.0088	1.20
Outer reef	Holocentridae	*Neoniphon sammara*	0.0012	0.13
Outer reef	Holocentridae	*Sargocentron spiniferum*	0.0004	0.12
Outer reef	Kyphosidae	*Kyphosus vaigiensis*	0.0015	1.30
Outer reef	Labridae	*Epibulus insidiator*	0.0002	0.04
Outer reef	Labridae	*Oxycheilinus digramma*	0.0003	0.05
Outer reef	Labridae	*Cheilinus undulatus*	0.0003	1.12
Outer reef	Labridae	*Choerodon anchorago*	0.0007	0.27
Outer reef	Labridae	*Oxycheilinus unifasciatus*	0.0002	0.03
Outer reef	Labridae	*Cheilinus chlorourus*	0.0013	0.10
Outer reef	Labridae	*Cheilinus trilobatus*	0.0005	0.18
Outer reef	Labridae	*Hemigymnus fasciatus*	0.0029	0.13
Outer reef	Labridae	*Hemigymnus melapterus*	0.0050	0.56
Outer reef	Labridae	*Choerodon jordani*	0.0001	0.01
Outer reef	Labridae	*Cheilinus fasciatus*	0.0033	0.54

3.3.2 Weighted average density and biomass of all finfish species recorded in Sideia (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Lethrinidae	*Lethrinus atkinsoni*	0.0008	0.32
Outer reef	Lethrinidae	*Lethrinus erythropterus*	0.0010	0.34
Outer reef	Lethrinidae	*Lethrinus erythracanthus*	0.0002	0.07
Outer reef	Lethrinidae	*Monotaxis grandoculis*	0.0057	2.49
Outer reef	Lethrinidae	*Lethrinus olivaceus*	0.0002	0.07
Outer reef	Lutjanidae	*Aprion virescens*	0.0002	0.40
Outer reef	Lutjanidae	*Lutjanus gibbus*	0.0042	3.54
Outer reef	Lutjanidae	*Lutjanus bohar*	0.0005	1.00
Outer reef	Lutjanidae	*Lutjanus biguttatus*	0.0018	0.26
Outer reef	Lutjanidae	*Lutjanus carponotatus*	0.0038	2.32
Outer reef	Lutjanidae	*Lutjanus fulvus*	0.0043	1.77
Outer reef	Lutjanidae	*Lutjanus semicinctus*	0.0033	0.75
Outer reef	Mullidae	*Parupeneus trifasciatus*	0.0010	0.19
Outer reef	Mullidae	*Parupeneus barberinus*	0.0005	0.21
Outer reef	Mullidae	*Parupeneus pleurostigma*	0.0002	0.03
Outer reef	Mullidae	*Parupeneus cyclostomus*	0.0002	0.02
Outer reef	Nemipteridae	*Scolopsis temporalis*	0.0002	0.02
Outer reef	Nemipteridae	*Scolopsis trilineata*	0.0002	0.02
Outer reef	Nemipteridae	*Scolopsis margaritifera*	0.0112	1.44
Outer reef	Nemipteridae	*Scolopsis bilineata*	0.0035	0.32
Outer reef	Nemipteridae	*Scolopsis ciliata*	0.0003	0.04
Outer reef	Pomacanthidae	*Chaetodontoplus mesoleucus*	0.0005	0.01
Outer reef	Pomacanthidae	*Pygoplites diacanthus*	0.0028	0.41
Outer reef	Pomacanthidae	*Pomacanthus navarchus*	0.0019	0.66
Outer reef	Pomacanthidae	*Pomacanthus imperator*	0.0002	0.14
Outer reef	Scaridae	*Hipposcarus longiceps*	0.0007	0.48
Outer reef	Scaridae	*Scarus rubroviolaceus*	0.0005	0.78
Outer reef	Scaridae	*Scarus rivulatus*	0.0244	5.76
Outer reef	Scaridae	*Scarus frenatus*	0.0017	0.26
Outer reef	Scaridae	*Scarus psittacus*	0.0069	0.52
Outer reef	Scaridae	*Scarus dimidiatus*	0.0219	1.92
Outer reef	Scaridae	*Chlorurus microrhinos*	0.0011	1.30
Outer reef	Scaridae	*Scarus flavipectoralis*	0.0053	0.82
Outer reef	Scaridae	*Scarus niger*	0.0057	0.64
Outer reef	Scaridae	*Scarus schlegeli*	0.0018	0.31
Outer reef	Scaridae	*Scarus spinus*	0.0002	0.03
Outer reef	Scaridae	*Chlorurus bleekeri*	0.0258	3.02
Outer reef	Scaridae	*Scarus chameleon*	0.0003	0.03
Outer reef	Scaridae	*Scarus quoyi*	0.0048	0.58
Outer reef	Scaridae	*Cetoscarus bicolor*	0.0025	2.30
Outer reef	Scaridae	*Chlorurus sordidus*	0.0320	2.80
Outer reef	Scaridae	*Scarus oviceps*	0.0047	1.05
Outer reef	Scaridae	*Scarus globiceps*	0.0024	0.27
Outer reef	Scombridae	*Rastrelliger kanagurta*	0.0938	8.30
Outer reef	Serranidae	*Epinephelus hexagonatus*	0.0002	0.01
Outer reef	Serranidae	*Plectropomus leopardus*	0.0013	0.45

3.3.2 Weighted average density and biomass of all finfish species recorded in Sideia (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Serranidae	*Variola louti*	0.0002	0.03
Outer reef	Serranidae	*Epinephelus merra*	0.0003	0.02
Outer reef	Serranidae	*Cephalopholis sp.*	0.0003	0.04
Outer reef	Serranidae	*Epinephelus coioides*	0.0001	0.27
Outer reef	Serranidae	*Plectropomus laevis*	0.0002	0.56
Outer reef	Serranidae	*Epinephelus fasciatus*	0.0007	0.13
Outer reef	Serranidae	*Cephalopholis boenak*	0.0002	0.01
Outer reef	Serranidae	*Anyperodon leucogrammicus*	0.0005	0.04
Outer reef	Serranidae	*Cephalopholis cyanostigma*	0.0010	0.12
Outer reef	Siganidae	*Siganus puellus*	0.0028	0.34
Outer reef	Siganidae	*Siganus corallinus*	0.0053	0.40
Outer reef	Siganidae	*Siganus punctatus*	0.0001	0.02
Outer reef	Siganidae	*Siganus lineatus*	0.0003	0.01
Outer reef	Siganidae	*Siganus doliatus*	0.0033	0.29
Outer reef	Siganidae	*Siganus randalli*	0.0002	0.04
Outer reef	Siganidae	*Siganus punctatissimus*	0.0018	0.44
Outer reef	Siganidae	*Siganus spinus*	0.0010	0.02
Outer reef	Siganidae	*Siganus vulpinus*	0.0027	0.21
Outer reef	Zanclidae	*Zanclus cornutus*	0.0005	0.03

3.4 Panapompom finfish survey data

3.4.1 Coordinates (WGS 84) of the 24 D-UVC transects used to assess finfish resource status in Panapompom

Station name	Habitat	Latitude	Longitude
TRA01	Back-reef	10°46'36.7788" S	152°28'10.9812" E
TRA02	Outer reef	10°46'36.2388" S	152°29'36.1788" E
TRA03	Lagoon	10°47'43.08" S	152°26'55.5" E
TRA04	Coastal reef	10°46'40.6812" S	152°25'03.2988" E
TRA05	Lagoon	10°50'14.8812" S	152°27'19.5588" E
TRA06	Back-reef	10°49'59.0412" S	152°24'01.3212" E
TRA07	Outer reef	10°50'10.0788" S	152°24'15.9588" E
TRA08	Lagoon	10°49'00.7788" S	152°22'34.7988" E
TRA09	Coastal reef	10°46'34.7412" S	152°22'37.6212" E
TRA10	Outer reef	10°52'44.22" S	152°31'01.2612" E
TRA11	Lagoon	10°52'15.4812" S	152°32'22.6212" E
TRA12	Lagoon	10°53'26.7" S	152°33'26.5212" E
TRA13	Back-reef	10°54'07.0812" S	152°34'55.02" E
TRA14	Outer reef	10°49'01.1388" S	152°31'02.8812" E
TRA15	Back-reef	10°49'55.2612" S	152°30'10.1412" E
TRA16	Back-reef	10°50'30.84" S	152°26'50.9388" E
TRA17	Outer reef	10°51'25.38" S	152°27'32.3388" E
TRA18	Lagoon	10°50'00.1788" S	152°25'53.1012" E
TRA19	Outer reef	10°49'41.4588" S	152°20'38.8788" E
TRA20	Back-reef	10°49'23.9412" S	152°20'27.42" E
TRA21	Coastal reef	10°46'59.34" S	152°24'57.6" E
TRA22	Coastal reef	10°47'37.2588" S	152°23'55.3812" E
TRA23	Coastal reef	10°47'15.4212" S	152°23'23.7588" E
TRA24	Coastal reef	10°46'03.6012" S	152°23'01.86" E

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Acanthuridae	*Acanthurus blochii*	0.0010	0.337
Back-reef	Acanthuridae	*Acanthurus guttatus*	0.0013	0.133
Back-reef	Acanthuridae	*Acanthurus lineatus*	0.0027	0.513
Back-reef	Acanthuridae	*Acanthurus nigricauda*	0.0037	1.170
Back-reef	Acanthuridae	*Acanthurus pyroferus*	0.0007	0.049
Back-reef	Acanthuridae	*Acanthurus triostegus*	0.0126	0.713
Back-reef	Acanthuridae	*Ctenochaetus binotatus*	0.0020	0.059
Back-reef	Acanthuridae	*Ctenochaetus striatus*	0.0945	9.836
Back-reef	Acanthuridae	*Naso brevirostris*	0.0080	2.303
Back-reef	Acanthuridae	*Zebrasoma scopas*	0.0060	0.176
Back-reef	Balistidae	*Balistapus undulatus*	0.0063	0.462
Back-reef	Caesionidae	*Pterocaesio tile*	0.0993	7.072
Back-reef	Caesionidae	*Pterocaesio trilineata*	0.0500	2.337
Back-reef	Carcharhinidae	*Carcharhinus melanopterus*	0.0003	4.178
Back-reef	Chaetodontidae	*Chaetodon baronessa*	0.0040	0.140

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Chaetodontidae	*Chaetodon citrinellus*	0.0053	0.060
Back-reef	Chaetodontidae	*Chaetodon ephippium*	0.0017	0.055
Back-reef	Chaetodontidae	*Chaetodon kleinii*	0.0117	0.143
Back-reef	Chaetodontidae	*Chaetodon lunulatus*	0.0067	0.152
Back-reef	Chaetodontidae	*Chaetodon melannotus*	0.0007	0.004
Back-reef	Chaetodontidae	*Chaetodon pelewensis*	0.0020	0.031
Back-reef	Chaetodontidae	*Chaetodon trifascialis*	0.0147	0.314
Back-reef	Chaetodontidae	*Chaetodon ulietensis*	0.0010	0.036
Back-reef	Chaetodontidae	*Chaetodon vagabundus*	0.0043	0.122
Back-reef	Dasyatidae	*Dasyatis kuhlii*	0.0003	0.279
Back-reef	Holocentridae	*Myripristis adusta*	0.0010	0.135
Back-reef	Holocentridae	*Myripristis kuntee*	0.0043	0.833
Back-reef	Holocentridae	*Myripristis murdjan*	0.0017	0.293
Back-reef	Holocentridae	*Myripristis pralinia*	0.0013	0.161
Back-reef	Holocentridae	*Neoniphon sammara*	0.0033	0.094
Back-reef	Holocentridae	*Sargocentron caudimaculatum*	0.0003	0.028
Back-reef	Labridae	*Cheilinus chlorourus*	0.0030	0.298
Back-reef	Labridae	*Epibulus insidiator*	0.0007	0.218
Back-reef	Labridae	*Hemigymnus fasciatus*	0.0003	0.015
Back-reef	Labridae	*Hemigymnus melapterus*	0.0023	0.182
Back-reef	Labridae	*Oxycheilinus digramma*	0.0003	0.035
Back-reef	Lethrinidae	*Lethrinus obsoletus*	0.0010	0.106
Back-reef	Lethrinidae	*Lethrinus olivaceus*	0.0003	0.031
Back-reef	Lethrinidae	*Monotaxis grandoculis*	0.0191	2.457
Back-reef	Lutjanidae	*Lutjanus bohar*	0.0047	0.743
Back-reef	Lutjanidae	*Lutjanus gibbus*	0.0133	2.457
Back-reef	Lutjanidae	*Lutjanus kasmira*	0.0033	0.174
Back-reef	Lutjanidae	*Lutjanus lutjanus*	0.0091	0.988
Back-reef	Lutjanidae	*Lutjanus quinquelineatus*	0.0114	0.738
Back-reef	Mullidae	*Mulloidichthys flavolineatus*	0.0317	4.859
Back-reef	Mullidae	*Parupeneus barberinus*	0.0010	0.060
Back-reef	Mullidae	*Parupeneus multifasciatus*	0.0063	0.688
Back-reef	Mullidae	*Parupeneus trifasciatus*	0.0020	0.775
Back-reef	Nemipteridae	*Scolopsis bilineata*	0.0093	0.664
Back-reef	Nemipteridae	*Scolopsis ciliata*	0.0033	0.132
Back-reef	Nemipteridae	*Scolopsis sp.*	0.0333	3.579
Back-reef	Nemipteridae	*Scolopsis temporalis*	0.0067	0.395
Back-reef	Pomacanthidae	*Pomacanthus navarchus*	0.0003	0.234
Back-reef	Pomacanthidae	*Pygoplites diacanthus*	0.0017	0.154
Back-reef	Scaridae	*Cetoscarus bicolor*	0.0007	0.035
Back-reef	Scaridae	*Chlorurus bleekeri*	0.0007	0.202
Back-reef	Scaridae	*Chlorurus sordidus*	0.0143	1.422
Back-reef	Scaridae	*Hipposcarus longiceps*	0.0030	0.862
Back-reef	Scaridae	*Scarus dimidiatus*	0.0107	1.498
Back-reef	Scaridae	*Scarus flavipectoralis*	0.0033	0.432
Back-reef	Scaridae	*Scarus frenatus*	0.0020	0.229

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Back-reef	Scaridae	*Scarus globiceps*	0.0007	0.109
Back-reef	Scaridae	*Scarus niger*	0.0038	1.271
Back-reef	Scaridae	*Scarus oviceps*	0.0023	0.398
Back-reef	Scaridae	*Scarus psittacus*	0.0123	0.569
Back-reef	Scaridae	*Scarus quoyi*	0.0003	0.034
Back-reef	Serranidae	*Aethaloperca rogaa*	0.0003	0.630
Back-reef	Serranidae	*Cephalopholis argus*	0.0023	0.752
Back-reef	Serranidae	*Cephalopholis miniata*	0.0013	0.340
Back-reef	Serranidae	*Cephalopholis urodeta*	0.0017	0.138
Back-reef	Serranidae	*Epinephelus merra*	0.0040	0.173
Back-reef	Serranidae	*Epinephelus polyphekadion*	0.0007	1.330
Back-reef	Serranidae	*Plectropomus laevis*	0.0003	1.855
Back-reef	Siganidae	*Siganus corallinus*	0.0023	0.231
Back-reef	Siganidae	*Siganus puellus*	0.0003	0.011
Back-reef	Zanclidae	*Zanclus cornutus*	0.0003	0.036
Coastal reef	Acanthuridae	*Acanthurus guttatus*	0.0003	0.037
Coastal reef	Acanthuridae	*Acanthurus lineatus*	0.0362	10.915
Coastal reef	Acanthuridae	*Acanthurus mata*	0.0003	0.021
Coastal reef	Acanthuridae	*Acanthurus pyroferus*	0.0003	0.030
Coastal reef	Acanthuridae	*Acanthurus triostegus*	0.0159	1.345
Coastal reef	Acanthuridae	*Ctenochaetus striatus*	0.0808	8.480
Coastal reef	Acanthuridae	*Zebrasoma scopas*	0.0140	0.386
Coastal reef	Acanthuridae	*Zebrasoma veliferum*	0.0013	0.018
Coastal reef	Balistidae	*Balistapus undulatus*	0.0003	0.002
Coastal reef	Balistidae	*Rhinecanthus verrucosus*	0.0030	0.258
Coastal reef	Balistidae	*Sufflamen bursa*	0.0003	0.020
Coastal reef	Balistidae	*Sufflamen chrysopterum*	0.0023	0.138
Coastal reef	Carangidae	*Caranx melampygus*	0.0003	1.521
Coastal reef	Chaetodontidae	*Chaetodon auriga*	0.0003	0.012
Coastal reef	Chaetodontidae	*Chaetodon baronessa*	0.0007	0.041
Coastal reef	Chaetodontidae	*Chaetodon citrinellus*	0.0067	0.051
Coastal reef	Chaetodontidae	*Chaetodon ephippium*	0.0013	0.039
Coastal reef	Chaetodontidae	*Chaetodon kleinii*	0.0003	0.005
Coastal reef	Chaetodontidae	*Chaetodon lineolatus*	0.0010	0.134
Coastal reef	Chaetodontidae	*Chaetodon lunula*	0.0017	0.082
Coastal reef	Chaetodontidae	*Chaetodon lunulatus*	0.0090	0.186
Coastal reef	Chaetodontidae	*Chaetodon melannotus*	0.0003	0.001
Coastal reef	Chaetodontidae	*Chaetodon ornatissimus*	0.0007	0.026
Coastal reef	Chaetodontidae	*Chaetodon plebeius*	0.0007	0.017
Coastal reef	Chaetodontidae	*Chaetodon rafflesii*	0.0030	0.067
Coastal reef	Chaetodontidae	*Chaetodon trifascialis*	0.0007	0.008
Coastal reef	Chaetodontidae	*Chaetodon ulietensis*	0.0020	0.069
Coastal reef	Chaetodontidae	*Chaetodon vagabundus*	0.0050	0.134
Coastal reef	Chaetodontidae	*Heniochus chrysostomus*	0.0013	0.072
Coastal reef	Chaetodontidae	*Heniochus monoceros*	0.0003	0.051
Coastal reef	Chaetodontidae	*Heniochus varius*	0.0023	0.088

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Coastal reef	Haemulidae	*Plectorhinchus chrysotaenia*	0.0109	10.951
Coastal reef	Haemulidae	*Plectorhinchus lessonii*	0.0007	0.156
Coastal reef	Haemulidae	*Plectorhinchus lineatus*	0.0037	3.490
Coastal reef	Holocentridae	*Myripristis adusta*	0.0033	0.410
Coastal reef	Holocentridae	*Myripristis kuntee*	0.0040	0.428
Coastal reef	Holocentridae	*Myripristis murdjan*	0.0003	0.022
Coastal reef	Holocentridae	*Myripristis sp.*	0.0003	0.034
Coastal reef	Holocentridae	*Myripristis trachyacron*	0.0013	0.109
Coastal reef	Holocentridae	*Myripristis violacea*	0.0787	9.558
Coastal reef	Holocentridae	*Neoniphon argenteus*	0.0183	1.494
Coastal reef	Holocentridae	*Neoniphon opercularis*	0.0703	5.118
Coastal reef	Holocentridae	*Neoniphon sammara*	0.0373	2.593
Coastal reef	Holocentridae	*Sargocentron caudimaculatum*	0.0003	0.041
Coastal reef	Holocentridae	*Sargocentron sp.*	0.0003	0.049
Coastal reef	Kyphosidae	*Kyphosus cinerascens*	0.0027	1.893
Coastal reef	Kyphosidae	*Kyphosus vaigiensis*	0.0050	6.786
Coastal reef	Labridae	*Cheilinus chlorourus*	0.0003	0.078
Coastal reef	Labridae	*Choerodon anchorago*	0.0003	0.252
Coastal reef	Labridae	*Choerodon jordani*	0.0003	0.035
Coastal reef	Labridae	*Hemigymnus melapterus*	0.0073	0.433
Coastal reef	Lethrinidae	*Gnathodentex aureolineatus*	0.0897	8.621
Coastal reef	Lethrinidae	*Lethrinus harak*	0.0167	2.198
Coastal reef	Lethrinidae	*Lethrinus obsoletus*	0.0383	5.617
Coastal reef	Lethrinidae	*Lethrinus xanthochilus*	0.0013	0.025
Coastal reef	Lethrinidae	*Monotaxis grandoculis*	0.0584	15.875
Coastal reef	Lutjanidae	*Lutjanus carponotatus*	0.0093	0.814
Coastal reef	Lutjanidae	*Lutjanus ehrenbergii*	0.0090	2.598
Coastal reef	Lutjanidae	*Lutjanus fulviflamma*	0.0028	0.213
Coastal reef	Lutjanidae	*Lutjanus fulvus*	0.0079	1.354
Coastal reef	Lutjanidae	*Lutjanus gibbus*	0.0270	13.919
Coastal reef	Lutjanidae	*Lutjanus monostigma*	0.0137	5.446
Coastal reef	Lutjanidae	*Lutjanus russellii*	0.0070	1.227
Coastal reef	Lutjanidae	*Lutjanus semicinctus*	0.0007	0.045
Coastal reef	Lutjanidae	*Macolor macularis*	0.0003	0.016
Coastal reef	Mullidae	*Mulloidichthys flavolineatus*	0.0936	28.678
Coastal reef	Mullidae	*Mulloidichthys vanicolensis*	0.0300	13.359
Coastal reef	Mullidae	*Parupeneus barberinus*	0.0003	0.036
Coastal reef	Mullidae	*Parupeneus multifasciatus*	0.0033	0.032
Coastal reef	Mullidae	*Parupeneus trifasciatus*	0.0176	6.546
Coastal reef	Nemipteridae	*Scolopsis bilineata*	0.0167	1.238
Coastal reef	Nemipteridae	*Scolopsis lineata*	0.0122	0.754
Coastal reef	Nemipteridae	*Scolopsis trilineata*	0.0080	0.549
Coastal reef	Pomacanthidae	*Pomacanthus semicirculatus*	0.0003	0.176
Coastal reef	Scaridae	*Calotomus carolinus*	0.0003	0.181
Coastal reef	Scaridae	*Chlorurus sordidus*	0.1802	11.755
Coastal reef	Scaridae	*Scarus chameleon*	0.0013	0.587

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Coastal reef	Scaridae	*Scarus dimidiatus*	0.0033	0.978
Coastal reef	Scaridae	*Scarus frenatus*	0.0007	0.282
Coastal reef	Scaridae	*Scarus globiceps*	0.0013	0.375
Coastal reef	Scaridae	*Scarus niger*	0.0007	0.204
Coastal reef	Scaridae	*Scarus oviceps*	0.0010	0.336
Coastal reef	Scaridae	*Scarus psittacus*	0.0403	7.752
Coastal reef	Scaridae	*Scarus rivulatus*	0.0363	19.508
Coastal reef	Scaridae	*Scarus spinus*	0.0003	0.055
Coastal reef	Serranidae	*Cephalopholis argus*	0.0007	0.483
Coastal reef	Serranidae	*Epinephelus merra*	0.0020	0.128
Coastal reef	Serranidae	*Epinephelus sp.*	0.0003	0.193
Coastal reef	Serranidae	*Plectropomus areolatus*	0.0003	0.157
Coastal reef	Siganidae	*Siganus argenteus*	0.0060	0.406
Coastal reef	Siganidae	*Siganus corallinus*	0.0007	0.063
Coastal reef	Siganidae	*Siganus doliatus*	0.0023	0.416
Coastal reef	Siganidae	*Siganus fuscescens*	0.0080	1.078
Coastal reef	Siganidae	*Siganus puellus*	0.0030	0.237
Coastal reef	Siganidae	*Siganus sp.*	0.0003	0.033
Coastal reef	Siganidae	*Siganus spinus*	0.0150	0.644
Coastal reef	Siganidae	*Siganus vulpinus*	0.0007	0.111
Coastal reef	Zanclidae	*Zanclus cornutus*	0.0013	0.074
Lagoon	Acanthuridae	*Acanthurus guttatus*	0.0007	0.060
Lagoon	Acanthuridae	*Acanthurus lineatus*	0.0003	0.094
Lagoon	Acanthuridae	*Acanthurus mata*	0.0113	3.142
Lagoon	Acanthuridae	*Acanthurus nigricans*	0.0010	0.246
Lagoon	Acanthuridae	*Acanthurus nigricauda*	0.0013	0.600
Lagoon	Acanthuridae	*Acanthurus pyroferus*	0.0027	0.322
Lagoon	Acanthuridae	*Ctenochaetus binotatus*	0.0007	0.020
Lagoon	Acanthuridae	*Ctenochaetus flavicauda*	0.0007	0.009
Lagoon	Acanthuridae	*Ctenochaetus striatus*	0.0668	9.110
Lagoon	Acanthuridae	*Naso annulatus*	0.0010	0.678
Lagoon	Acanthuridae	*Naso brevirostris*	0.0071	3.752
Lagoon	Acanthuridae	*Naso lituratus*	0.0023	0.970
Lagoon	Acanthuridae	*Naso thynnoides*	0.0050	2.277
Lagoon	Acanthuridae	*Naso vlamingii*	0.0062	7.357
Lagoon	Acanthuridae	*Paracanthurus hepatus*	0.0003	0.005
Lagoon	Acanthuridae	*Zebrasoma scopas*	0.0033	0.137
Lagoon	Acanthuridae	*Zebrasoma veliferum*	0.0027	0.415
Lagoon	Balistidae	*Balistapus undulatus*	0.0033	0.325
Lagoon	Balistidae	*Balistoides viridescens*	0.0003	0.042
Lagoon	Balistidae	*Odonus niger*	0.0143	0.909
Lagoon	Balistidae	*Rhinecanthus rectangulus*	0.0003	0.015
Lagoon	Balistidae	*Sufflamen chrysopterum*	0.0007	0.035
Lagoon	Caesionidae	*Caesio caerulaurea*	0.5000	77.820
Lagoon	Caesionidae	*Pterocaesio tile*	0.0456	4.598
Lagoon	Carangidae	*Caranx melampygus*	0.0020	2.774

Appendix 3: Finfish survey data
Panapompom

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lagoon	Carangidae	*Caranx papuensis*	0.0003	0.325
Lagoon	Carangidae	*Elagatis bipinnulata*	0.0174	22.914
Lagoon	Chaetodontidae	*Chaetodon auriga*	0.0007	0.024
Lagoon	Chaetodontidae	*Chaetodon baronessa*	0.0107	0.318
Lagoon	Chaetodontidae	*Chaetodon citrinellus*	0.0033	0.030
Lagoon	Chaetodontidae	*Chaetodon ephippium*	0.0027	0.134
Lagoon	Chaetodontidae	*Chaetodon kleinii*	0.0050	0.041
Lagoon	Chaetodontidae	*Chaetodon lineolatus*	0.0007	0.038
Lagoon	Chaetodontidae	*Chaetodon lunula*	0.0007	0.102
Lagoon	Chaetodontidae	*Chaetodon lunulatus*	0.0053	0.149
Lagoon	Chaetodontidae	*Chaetodon meyeri*	0.0010	0.032
Lagoon	Chaetodontidae	*Chaetodon ornatissimus*	0.0007	0.041
Lagoon	Chaetodontidae	*Chaetodon oxycephalus*	0.0003	0.215
Lagoon	Chaetodontidae	*Chaetodon rafflesii*	0.0020	0.073
Lagoon	Chaetodontidae	*Chaetodon trifascialis*	0.0023	0.061
Lagoon	Chaetodontidae	*Chaetodon ulietensis*	0.0013	0.100
Lagoon	Chaetodontidae	*Chaetodon unimaculatus*	0.0023	0.100
Lagoon	Chaetodontidae	*Chaetodon vagabundus*	0.0007	0.023
Lagoon	Chaetodontidae	*Forcipiger longirostris*	0.0007	0.015
Lagoon	Chaetodontidae	*Heniochus acuminatus*	0.0003	0.011
Lagoon	Chaetodontidae	*Heniochus chrysostomus*	0.0013	0.082
Lagoon	Chaetodontidae	*Heniochus varius*	0.0027	0.110
Lagoon	Haemulidae	*Plectorhinchus chaetodonoides*	0.0020	0.559
Lagoon	Holocentridae	*Myripristis adusta*	0.0103	1.819
Lagoon	Holocentridae	*Myripristis berndti*	0.0020	0.133
Lagoon	Holocentridae	*Myripristis kuntee*	0.0103	1.547
Lagoon	Holocentridae	*Myripristis murdjan*	0.0073	0.822
Lagoon	Holocentridae	*Myripristis sp.*	0.0017	0.205
Lagoon	Holocentridae	*Myripristis violacea*	0.0143	2.112
Lagoon	Holocentridae	*Neoniphon argenteus*	0.0013	0.106
Lagoon	Holocentridae	*Neoniphon opercularis*	0.0003	0.109
Lagoon	Holocentridae	*Sargocentron caudimaculatum*	0.0083	0.767
Lagoon	Holocentridae	*Sargocentron spiniferum*	0.0007	0.380
Lagoon	Labridae	*Cheilinus fasciatus*	0.0027	0.781
Lagoon	Labridae	*Cheilinus undulatus*	0.0010	1.019
Lagoon	Labridae	*Hemigymnus fasciatus*	0.0013	0.098
Lagoon	Labridae	*Hemigymnus melapterus*	0.0023	0.260
Lagoon	Labridae	*Oxycheilinus digramma*	0.0003	0.048
Lagoon	Lethrinidae	*Lethrinus atkinsoni*	0.0003	0.065
Lagoon	Lethrinidae	*Lethrinus erythropterus*	0.0003	0.140
Lagoon	Lethrinidae	*Lethrinus obsoletus*	0.0007	0.173
Lagoon	Lethrinidae	*Monotaxis grandoculis*	0.0493	6.492
Lagoon	Lutjanidae	*Aphareus furca*	0.0010	0.442
Lagoon	Lutjanidae	*Lutjanus bohar*	0.0025	0.554
Lagoon	Lutjanidae	*Lutjanus monostigma*	0.0003	0.214
Lagoon	Lutjanidae	*Macolor macularis*	0.0006	0.329

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lagoon	Lutjanidae	*Macolor niger*	0.0007	0.064
Lagoon	Mullidae	*Parupeneus barberinus*	0.0010	0.197
Lagoon	Mullidae	*Parupeneus multifasciatus*	0.0083	0.577
Lagoon	Mullidae	*Parupeneus trifasciatus*	0.0013	0.656
Lagoon	Nemipteridae	*Scolopsis bilineata*	0.0064	0.577
Lagoon	Pomacanthidae	*Pygoplites diacanthus*	0.0033	0.445
Lagoon	Priacanthidae	*Priacanthus hamrur*	0.0027	0.951
Lagoon	Scaridae	*Cetoscarus bicolor*	0.0003	0.054
Lagoon	Scaridae	*Chlorurus bleekeri*	0.0050	1.562
Lagoon	Scaridae	*Chlorurus microrhinos*	0.0013	0.623
Lagoon	Scaridae	*Chlorurus sordidus*	0.0132	1.859
Lagoon	Scaridae	*Hipposcarus longiceps*	0.0007	0.160
Lagoon	Scaridae	*Scarus altipinnis*	0.0057	2.016
Lagoon	Scaridae	*Scarus dimidiatus*	0.0080	1.629
Lagoon	Scaridae	*Scarus flavipectoralis*	0.0045	0.673
Lagoon	Scaridae	*Scarus forsteni*	0.0007	0.266
Lagoon	Scaridae	*Scarus frenatus*	0.0010	0.173
Lagoon	Scaridae	*Scarus globiceps*	0.0003	0.047
Lagoon	Scaridae	*Scarus niger*	0.0063	1.765
Lagoon	Scaridae	*Scarus oviceps*	0.0003	0.181
Lagoon	Scaridae	*Scarus psittacus*	0.0103	0.825
Lagoon	Scaridae	*Scarus rubroviolaceus*	0.0007	1.368
Lagoon	Scaridae	*Scarus schlegeli*	0.0010	0.230
Lagoon	Serranidae	*Aethaloperca rogaa*	0.0010	0.222
Lagoon	Serranidae	*Anyperodon leucogrammicus*	0.0017	0.691
Lagoon	Serranidae	*Cephalopholis cyanostigma*	0.0017	0.443
Lagoon	Serranidae	*Cephalopholis miniata*	0.0007	0.255
Lagoon	Serranidae	*Cephalopholis urodeta*	0.0073	0.818
Lagoon	Serranidae	*Epinephelus maculatus*	0.0003	0.070
Lagoon	Serranidae	*Epinephelus merra*	0.0007	0.047
Lagoon	Serranidae	*Plectropomus areolatus*	0.0020	0.954
Lagoon	Serranidae	*Plectropomus leopardus*	0.0013	1.651
Lagoon	Serranidae	*Variola albimarginata*	0.0003	0.297
Lagoon	Serranidae	*Variola louti*	0.0007	0.208
Lagoon	Siganidae	*Siganus guttatus*	0.0003	0.126
Lagoon	Siganidae	*Siganus puellus*	0.0007	0.119
Lagoon	Siganidae	*Siganus punctatissimus*	0.0003	0.040
Lagoon	Siganidae	*Siganus vulpinus*	0.0020	0.321
Lagoon	Zanclidae	*Zanclus cornutus*	0.0033	0.239
Outer reef	Acanthuridae	*Acanthurus lineatus*	0.0003	0.082
Outer reef	Acanthuridae	*Acanthurus nigricauda*	0.0003	0.132
Outer reef	Acanthuridae	*Acanthurus nigrofuscus*	0.0003	0.013
Outer reef	Acanthuridae	*Acanthurus pyroferus*	0.0067	0.700
Outer reef	Acanthuridae	*Acanthurus thompsoni*	0.0147	1.528
Outer reef	Acanthuridae	*Ctenochaetus binotatus*	0.0030	0.107
Outer reef	Acanthuridae	*Ctenochaetus striatus*	0.0050	0.333

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Acanthuridae	*Ctenochaetus strigosus*	0.0013	0.063
Outer reef	Acanthuridae	*Naso brachycentron*	0.0017	1.340
Outer reef	Acanthuridae	*Naso brevirostris*	0.0020	1.363
Outer reef	Acanthuridae	*Naso hexacanthus*	0.0120	6.438
Outer reef	Acanthuridae	*Naso lituratus*	0.0050	2.350
Outer reef	Acanthuridae	*Naso thynnoides*	0.0020	1.070
Outer reef	Acanthuridae	*Naso tuberosus*	0.0023	5.222
Outer reef	Acanthuridae	*Naso unicornis*	0.0027	4.385
Outer reef	Acanthuridae	*Naso vlamingii*	0.0043	2.902
Outer reef	Acanthuridae	*Zebrasoma scopas*	0.0027	0.125
Outer reef	Balistidae	*Balistapus undulatus*	0.0037	0.466
Outer reef	Balistidae	*Balistoides conspicillum*	0.0003	0.328
Outer reef	Balistidae	*Melichthys vidua*	0.0017	0.232
Outer reef	Balistidae	*Sufflamen bursa*	0.0010	0.064
Outer reef	Caesionidae	*Caesio cuning*	0.0333	7.681
Outer reef	Caesionidae	*Pterocaesio pisang*	0.0133	0.775
Outer reef	Caesionidae	*Pterocaesio tile*	0.0400	1.495
Outer reef	Carangidae	*Carangoides ferdau*	0.0003	0.072
Outer reef	Carangidae	*Carangoides orthogrammus*	0.0003	0.124
Outer reef	Carangidae	*Caranx melampygus*	0.0523	30.785
Outer reef	Carangidae	*Caranx papuensis*	0.0003	0.351
Outer reef	Carangidae	*Caranx sp.*	0.0007	0.249
Outer reef	Carangidae	*Elagatis bipinnulata*	0.0043	17.492
Outer reef	Carangidae	*Scomberoides lysan*	0.0048	1.547
Outer reef	Carcharhinidae	*Carcharhinus amblyrhynchos*	0.0003	4.202
Outer reef	Carcharhinidae	*Triaenodon obesus*	0.0007	1.368
Outer reef	Chaetodontidae	*Chaetodon baronessa*	0.0040	0.117
Outer reef	Chaetodontidae	*Chaetodon bennetti*	0.0010	0.055
Outer reef	Chaetodontidae	*Chaetodon ephippium*	0.0010	0.042
Outer reef	Chaetodontidae	*Chaetodon kleinii*	0.0030	0.028
Outer reef	Chaetodontidae	*Chaetodon lineolatus*	0.0003	0.010
Outer reef	Chaetodontidae	*Chaetodon lunulatus*	0.0037	0.075
Outer reef	Chaetodontidae	*Chaetodon mertensii*	0.0007	0.005
Outer reef	Chaetodontidae	*Chaetodon meyeri*	0.0007	0.026
Outer reef	Chaetodontidae	*Chaetodon ornatissimus*	0.0010	0.045
Outer reef	Chaetodontidae	*Chaetodon pelewensis*	0.0027	0.009
Outer reef	Chaetodontidae	*Chaetodon plebeius*	0.0020	0.038
Outer reef	Chaetodontidae	*Chaetodon rafflesii*	0.0007	0.033
Outer reef	Chaetodontidae	*Chaetodon ulietensis*	0.0010	0.031
Outer reef	Chaetodontidae	*Chaetodon unimaculatus*	0.0013	0.065
Outer reef	Chaetodontidae	*Chaetodon vagabundus*	0.0013	0.053
Outer reef	Chaetodontidae	*Hemitaurichthys polylepis*	0.0010	0.039
Outer reef	Chaetodontidae	*Heniochus chrysostomus*	0.0013	0.063
Outer reef	Chaetodontidae	*Heniochus varius*	0.0017	0.058
Outer reef	Haemulidae	*Plectorhinchus chaetodonoides*	0.0010	0.954
Outer reef	Haemulidae	*Plectorhinchus chrysotaenia*	0.0007	0.866

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Haemulidae	*Plectorhinchus lineatus*	0.0003	0.375
Outer reef	Haemulidae	*Plectorhinchus picus*	0.0003	0.155
Outer reef	Holocentridae	*Myripristis adusta*	0.0050	0.824
Outer reef	Holocentridae	*Myripristis berndti*	0.0033	0.256
Outer reef	Holocentridae	*Myripristis kuntee*	0.0197	3.504
Outer reef	Holocentridae	*Myripristis murdjan*	0.0017	0.284
Outer reef	Holocentridae	*Myripristis pralinia*	0.0010	0.146
Outer reef	Holocentridae	*Myripristis trachyacron*	0.0003	0.022
Outer reef	Holocentridae	*Myripristis violacea*	0.0157	2.130
Outer reef	Holocentridae	*Neoniphon argenteus*	0.0003	0.022
Outer reef	Holocentridae	*Neoniphon sammara*	0.0040	0.314
Outer reef	Holocentridae	*Sargocentron caudimaculatum*	0.0043	0.358
Outer reef	Kyphosidae	*Kyphosus vaigiensis*	0.0003	0.225
Outer reef	Labridae	*Cheilinus chlorourus*	0.0013	0.166
Outer reef	Labridae	*Cheilinus fasciatus*	0.0017	0.303
Outer reef	Labridae	*Cheilinus trilobatus*	0.0003	0.218
Outer reef	Labridae	*Cheilinus undulatus*	0.0003	0.577
Outer reef	Labridae	*Hemigymnus fasciatus*	0.0007	0.044
Outer reef	Labridae	*Hemigymnus melapterus*	0.0033	0.714
Outer reef	Labridae	*Oxycheilinus digramma*	0.0003	0.076
Outer reef	Lethrinidae	*Lethrinus erythracanthus*	0.0003	0.021
Outer reef	Lethrinidae	*Lethrinus erythropterus*	0.0003	0.036
Outer reef	Lethrinidae	*Monotaxis grandoculis*	0.0209	3.987
Outer reef	Lutjanidae	*Aphareus furca*	0.0020	0.969
Outer reef	Lutjanidae	*Aprion virescens*	0.0003	1.141
Outer reef	Lutjanidae	*Lutjanus biguttatus*	0.0086	1.154
Outer reef	Lutjanidae	*Lutjanus bohar*	0.0103	8.554
Outer reef	Lutjanidae	*Lutjanus gibbus*	0.0176	9.183
Outer reef	Lutjanidae	*Lutjanus kasmira*	0.0007	0.067
Outer reef	Lutjanidae	*Lutjanus monostigma*	0.0010	0.364
Outer reef	Lutjanidae	*Lutjanus semicinctus*	0.0007	0.215
Outer reef	Lutjanidae	*Macolor macularis*	0.0048	4.262
Outer reef	Lutjanidae	*Macolor niger*	0.0003	0.024
Outer reef	Mullidae	*Parupeneus barberinus*	0.0003	0.059
Outer reef	Mullidae	*Parupeneus cyclostomus*	0.0017	0.554
Outer reef	Mullidae	*Parupeneus multifasciatus*	0.0047	0.421
Outer reef	Mullidae	*Parupeneus trifasciatus*	0.0060	1.393
Outer reef	Nemipteridae	*Scolopsis bilineata*	0.0033	0.238
Outer reef	Pomacanthidae	*Pygoplites diacanthus*	0.0033	0.359
Outer reef	Scaridae	*Cetoscarus bicolor*	0.0007	0.658
Outer reef	Scaridae	*Chlorurus bleekeri*	0.0023	0.610
Outer reef	Scaridae	*Chlorurus microrhinos*	0.0007	1.107
Outer reef	Scaridae	*Chlorurus sordidus*	0.0083	0.909
Outer reef	Scaridae	*Hipposcarus longiceps*	0.0017	1.105
Outer reef	Scaridae	*Scarus altipinnis*	0.0146	12.766
Outer reef	Scaridae	*Scarus chameleon*	0.0047	0.741

3.4.2 Weighted average density and biomass of all finfish species recorded in Panapompom (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Habitat	Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Outer reef	Scaridae	*Scarus dimidiatus*	0.0098	1.473
Outer reef	Scaridae	*Scarus flavipectoralis*	0.0033	0.702
Outer reef	Scaridae	*Scarus frenatus*	0.0017	0.340
Outer reef	Scaridae	*Scarus globiceps*	0.0013	0.221
Outer reef	Scaridae	*Scarus niger*	0.0057	1.127
Outer reef	Scaridae	*Scarus oviceps*	0.0003	0.055
Outer reef	Scaridae	*Scarus psittacus*	0.0013	0.199
Outer reef	Scaridae	*Scarus rivulatus*	0.0003	0.042
Outer reef	Scaridae	*Scarus rubroviolaceus*	0.0007	0.572
Outer reef	Scaridae	*Scarus schlegeli*	0.0013	0.158
Outer reef	Scaridae	*Scarus spinus*	0.0003	0.063
Outer reef	Serranidae	*Aethaloperca rogaa*	0.0003	0.034
Outer reef	Serranidae	*Anyperodon leucogrammicus*	0.0017	0.489
Outer reef	Serranidae	*Cephalopholis argus*	0.0003	0.124
Outer reef	Serranidae	*Cephalopholis cyanostigma*	0.0007	0.127
Outer reef	Serranidae	*Cephalopholis urodeta*	0.0047	0.403
Outer reef	Serranidae	*Epinephelus fasciatus*	0.0003	0.082
Outer reef	Serranidae	*Epinephelus polyphekadion*	0.0003	1.246
Outer reef	Serranidae	*Gracila albomarginata*	0.0007	0.268
Outer reef	Serranidae	*Plectropomus areolatus*	0.0013	0.444
Outer reef	Serranidae	*Plectropomus laevis*	0.0003	0.355
Outer reef	Serranidae	*Plectropomus maculatus*	0.0003	0.313
Outer reef	Serranidae	*Variola albimarginata*	0.0003	0.014
Outer reef	Serranidae	*Variola louti*	0.0007	0.413
Outer reef	Siganidae	*Siganus corallinus*	0.0013	0.273
Outer reef	Siganidae	*Siganus randalli*	0.0003	0.065
Outer reef	Siganidae	*Siganus vulpinus*	0.0027	0.270
Outer reef	Zanclidae	*Zanclus cornutus*	0.0010	0.059

APPENDIX 4: INVERTEBRATE SURVEY DATA

4.1 Andra invertebrate survey data

4.1.1 Invertebrate species recorded in different assessments in Andra

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	*Actinopyga miliaris*				+
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 leucospilota*			+	
Bêche-de-mer	*Holothuria nobilis*	+	+	+	
Bêche-de-mer	*Holothuria scabra*			+	
Bêche-de-mer	*Stichopus chloronotus*	+	+	+	
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* spp.	+			
Bivalve	*Chama* spp.	+			
Bivalve	*Hippopus hippopus*		+	+	
Bivalve	*Hyotissa* spp.	+			
Bivalve	*Pinctada margaritifera*	+		+	
Bivalve	*Pinctada maxima*				+
Bivalve	*Pinna* spp.			+	
Bivalve	*Spondylus* spp.	+		+	
Bivalve	*Tridacna crocea*	+	+		+
Bivalve	*Tridacna gigas*			+	
Bivalve	*Tridacna maxima*	+	+	+	+
Bivalve	*Tridacna squamosa*	+	+	+	
Cnidarians	*Stichodactyla* spp.	+	+		+
Crustacean	*Panulirus* spp.	+	+		+
Crustacean	*Panulirus versicolor*				+
Crustacean	*Parribacus caledonicus*				+
Crustacean	*Scylla serrata*			+	
Gastropod	*Astralium* spp.		+		+
Gastropod	*Cerithium nodulosum*				+
Gastropod	*Chicoreus* spp.		+		
Gastropod	*Conus litteratus*			+	

+ = presence of the species.

4.1.1 Invertebrate species recorded in different assessments in Andra (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Conus miles*		+		
Gastropod	*Conus* spp.	+	+		+
Gastropod	*Conus vexillum*		+		
Gastropod	*Coralliophila* spp.		+		
Gastropod	*Cypraea caputserpensis*		+		
Gastropod	*Cypraea lynx*		+		
Gastropod	*Cypraea* spp.		+		
Gastropod	*Cypraea tigris*	+	+	+	
Gastropod	*Dolabella* spp.			+	
Gastropod	*Drupella* spp.		+		
Gastropod	*Lambis chiragra*			+	
Gastropod	*Lambis lambis*	+		+	+
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Mitra mitra*		+		
Gastropod	*Ovula ovum*	+	+		
Gastropod	*Pleuroploca filamentosa*		+		
Gastropod	*Pleuroploca* spp.		+		
Gastropod	*Tectus pyramis*	+	+		+
Gastropod	*Thais* spp.	+	+		+
Gastropod	*Trochus niloticus*	+	+	+	+
Gastropod	*Trochus* spp.		+		
Gastropod	*Turbo argyrostomus*	+	+		+
Gastropod	*Turbo chrysostomus*		+		
Gastropod	*Turbo crassus*		+		
Gastropod	*Turbo petholatus*				+
Gastropod	*Turbo setosus*				+
Gastropod	*Vasum ceramicum*		+		+
Gastropod	*Vasum* spp.	+	+		
Gastropod	*Vasum turbinellum*		+		
Octopus	*Octopus cyanea*	+			
Octopus	*Octopus* spp.		+		+
Star	*Acanthaster planci*	+	+		+
Star	*Choriaster* spp.		+		+
Star	*Culcita novaeguineae*	+	+	+	+
Star	*Linckia laevigata*	+	+	+	
Star	*Protoreaster nodosus*	+	+	+	
Urchin	*Diadema* spp.	+		+	
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix calamaris*			+	
Urchin	*Echinothrix diadema*	+	+		+
Urchin	*Echinothrix* spp.	+			+
Urchin	*Mespilia globulus*			+	
Urchin	*Tripneustes gratilla*			+	

+ = presence of the species.

4.1.2 Andra 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	2.4	0.8	76	19.9	2.6	9	2.3	1.1	13	5.9	1.9	5
Actinopyga mauritiana	0.2	0.2	76	16.7		1	0.2	0.2	13	2.8		1
Atrina spp.	0.7	0.7	76	50.0		1	0.6	0.6	13	8.3		1
Bohadschia argus	4.8	1.7	76	33.4	7.5	11	4.4	1.6	13	8.2	2.0	7
Bohadschia graeffei	24.0	4.1	76	44.4	6.1	41	23.3	6.6	13	25.2	6.9	12
Bohadschia vitiensis	1.3	0.6	76	20.0	3.3	5	1.2	0.8	13	5.0	2.2	3
Chama spp.	1.1	0.7	76	27.8	5.6	3	1.5	0.9	13	6.5	2.4	3
Conus spp.	1.3	0.5	76	16.7	0.0	6	1.2	0.6	13	3.9	0.8	4
Culcita novaeguineae	0.9	0.4	76	16.7	0.0	4	0.8	0.4	13	2.7	0.1	4
Cypraea tigris	0.2	0.2	76	16.7		1	0.2	0.2	13	2.4		1
Diadema spp.	9.9	8.8	76	187.5	159.9	4	10.5	8.8	13	68.1	45.8	2
Echinometra mathaei	6.6	4.9	76	250.0	83.3	2	6.4	6.4	13	83.3		1
Echinothrix diadema	6.4	2.8	76	60.4	18.9	8	9.3	6.5	13	24.1	15.4	5
Echinothrix spp.	29.2	26.4	76	738.9	631.5	3	28.4	27.7	13	184.7	176.4	2
Holothuria atra	7.2	1.7	76	25.0	3.9	22	6.9	1.8	13	9.9	1.9	9
Holothuria coluber	6.4	3.6	76	80.6	35.9	6	5.3	4.4	13	34.7	22.8	2
Holothuria edulis	2.3	0.8	76	22.1	2.8	8	2.2	1.2	13	9.4	1.9	3
Holothuria fuscogilva	0.9	0.6	76	33.3	0.0	2	0.9	0.9	13	11.1		1
Holothuria nobilis	2.0	1.2	76	30.0	13.3	5	1.9	1.3	13	6.3	3.5	4
Hyotissa spp.	0.2	0.2	76	16.7		1	0.2	0.2	13	2.8		1
Lambis lambis	0.2	0.2	76	16.7		1	0.2	0.2	13	2.8		1
Linckia laevigata	80.3	15.6	76	156.5	24.9	39	80.2	26.7	13	115.8	32.1	9
Octopus cyanea	0.4	0.3	76	16.7	0.0	2	0.4	0.3	13	2.8	0.0	2
Ovula ovum	0.7	0.5	76	25.0	8.3	2	0.6	0.4	13	3.8	1.0	2
Panulirus spp.	0.7	0.4	76	16.7	0.0	3	0.7	0.4	13	2.9	0.2	3
Pinctada margaritifera	0.9	0.4	76	16.7	0.0	4	1.0	0.5	13	3.3	0.7	4
Protoreaster nodosus	0.9	0.5	76	22.2	5.6	3	0.9	0.6	13	5.6	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.

4.1.2 Andra 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
Spondylus spp.	0.4	0.3	76	16.7	0.0	2	0.6	0.5	13	4.0	1.6	2
Stichodactyla spp.	16.0	2.9	76	34.8	4.7	35	15.8	3.2	13	18.7	3.1	11
Stichopus chloronotus	1.3	0.7	76	25.0	8.3	4	1.3	0.7	13	5.6	1.6	3
Stichopus hermanni	0.4	0.3	76	17.0	0.3	2	0.4	0.2	13	2.4	0.0	2
Synapta spp.	0.2	0.2	76	16.7		1	0.2	0.2	13	2.6		1
Tectus pyramis	1.8	0.6	76	16.7	0.0	8	2.1	0.9	13	5.3	1.5	5
Thais spp.	1.1	0.8	76	41.7	8.3	2	1.1	1.1	13	13.9		1
Thelenota ananas	1.5	0.6	76	19.4	2.8	6	1.4	0.8	13	4.4	1.7	4
Thelenota anax	4.0	2.6	76	61.3	33.5	5	3.4	2.9	13	14.6	11.8	3
Tridacna crocea	41.8	13.4	76	132.4	36.6	24	50.9	30.2	13	94.5	51.9	7
Tridacna maxima	5.5	1.3	76	26.1	2.6	16	5.3	2.1	13	9.8	2.9	7
Tridacna squamosa	1.5	0.6	76	16.7	0.0	7	1.5	0.6	13	3.9	0.6	5
Trochus niloticus	2.2	0.8	76	20.8	4.2	8	2.2	1.3	13	5.6	2.8	5
Turbo argyrostomus	0.2	0.2	76	16.7		1	0.2	0.2	13	2.8		1
Vasum spp.	0.2	0.2	76	16.7		1	0.2	0.2	13	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.

4.1.3 Andra 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	13.9	6.4	108	300.0	50.0	5	13.9	6.7	18	62.5	12.0	4
Actinopyga lecanora	4.6	3.3	108	250.0	0.0	2	4.6	3.2	18	41.7	0.0	2
Actinopyga mauritiana	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Astralium spp.	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Bohadschia argus	23.1	8.4	108	312.5	40.9	8	23.1	12.2	18	83.3	32.3	5
Bohadschia graeffei	113.4	24.5	108	490.0	62.0	25	113.4	39.0	18	204.2	55.7	10
Chicoreus spp.	4.6	3.3	108	250.0	0.0	2	4.6	3.2	18	41.7	0.0	2
Choriaster spp.	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Cloth Cloth	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Conus miles	67.1	17.0	108	453.1	46.9	16	67.1	21.3	18	109.8	28.2	11
Conus spp.	125.0	24.5	108	450.0	54.1	30	125.0	24.8	18	150.0	25.0	15
Conus vexillum	67.1	16.3	108	402.8	45.8	18	67.1	16.6	18	109.8	17.1	11
Coralliophila spp.	9.3	9.3	108	1000.0		1	9.3	9.3	18	166.7		1
Culcita novaeguineae	32.4	8.8	108	269.2	19.2	13	32.4	10.4	18	64.8	14.1	9
Cypraea caputserpensis	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Cypraea lynx	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Cypraea spp.	9.3	4.6	108	250.0	0.0	4	9.3	6.4	18	83.3	0.0	2
Cypraea tigris	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Drupella spp.	23.1	19.0	108	1250.0	750.0	2	23.1	18.8	18	208.3	125.0	2
Echinometra mathaei	338.0	60.2	108	869.0	114.4	42	338.0	101.7	18	467.9	123.4	13
Echinothrix diadema	30.1	10.8	108	361.1	60.5	9	30.1	14.2	18	135.4	19.9	4
Hippopus hippopus	4.6	3.3	108	250.0	0.0	2	4.6	4.6	18	83.3		1
Holothuria atra	76.4	16.6	108	392.9	36.9	21	76.4	29.8	18	171.9	50.1	8
Holothuria coluber	9.3	5.6	108	333.3	83.3	3	9.3	7.2	18	83.3	41.7	2
Holothuria edulis	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Holothuria fuscogilva	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Holothuria nobilis	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Latirolagena smaragdula	20.8	10.5	108	375.0	125.0	6	20.8	10.8	18	93.8	26.2	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.

4.1.3 Andra 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
Linckia laevigata	495.4	55.5	108	775.4	66.3	69	495.4	116.0	18	594.4	124.1	15
Mitra mitra	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Octopus spp.	4.6	3.3	108	250.0	0.0	2	4.6	3.2	18	41.7	0.0	2
Ovula ovum	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Panulirus spp.	11.6	7.6	108	416.7	166.7	3	11.6	7.4	18	69.4	27.8	3
Plastic plastic	9.3	7.3	108	500.0	250.0	2	9.3	7.2	18	83.3	41.7	2
Pleuroploca filamentosa	2.3	2.3	108	250.0		1	2.3	2.3	18	41.7		1
Pleuroploca spp.	11.6	5.1	108	250.0	0.0	5	11.6	5.6	18	52.1	10.4	4
Protoreaster nodosus	4.6	3.3	108	250.0	0.0	2	4.6	3.2	18	41.7	0.0	2
Stichodactyla spp.	55.6	17.5	108	428.6	84.6	14	55.6	17.8	18	100.0	24.2	10
Stichopus chloronotus	27.8	10.0	108	333.3	58.9	9	27.8	12.1	18	71.4	23.6	7
Tectus pyramis	97.2	17.7	108	350.0	33.0	30	97.2	22.6	18	109.4	23.7	16
Thais spp.	50.9	14.2	108	366.7	53.8	15	50.9	16.7	18	101.9	23.1	9
Tridacna crocea	326.4	109.0	108	1468.8	419.3	24	326.4	231.7	18	734.4	500.6	8
Tridacna maxima	101.9	20.8	108	354.8	48.9	31	101.9	24.8	18	122.2	26.8	15
Tridacna squamosa	9.3	5.6	108	333.3	83.3	3	9.3	5.4	18	55.6	13.9	3
Trochus niloticus	122.7	22.7	108	368.1	46.2	36	122.7	28.3	18	138.0	29.6	16
Trochus spp.	18.5	7.9	108	333.3	52.7	6	18.5	10.2	18	83.3	29.5	4
Turbo argyrostomus	46.3	11.0	108	294.1	23.8	17	46.3	15.8	18	92.6	22.8	9
Turbo chrysostomus	44.0	13.5	108	339.3	62.1	14	44.0	16.7	18	99.0	27.2	8
Turbo crassus	39.4	11.9	108	354.2	48.2	12	39.4	15.2	18	118.1	22.6	6
Vasum ceramicum	37.0	10.3	108	307.7	30.4	13	37.0	12.1	18	66.7	16.7	10
Vasum spp.	13.9	8.6	108	500.0	144.3	3	13.9	11.7	18	125.0	83.3	2
Vasum turbinellum	25.5	9.3	108	343.8	45.7	8	25.5	12.7	18	91.7	30.6	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.

4.1.4 Andra 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
Actinopyga echinites	13.6	10.1	55	375.0	125.0	2	13.9	9.8	9	62.5	20.8	2
Bohadschia argus	27.3	19.1	55	500.0	250.0	3	27.8	19.6	9	125.0	41.7	2
Bohadschia similis	4.5	4.5	55	250.0		1	4.6	4.6	9	41.7		1
Bohadschia vitiensis	72.7	41.9	55	800.0	339.1	5	74.1	69.0	9	333.3	291.7	2
Conus litteratus	4.5	4.5	55	250.0		1	4.6	4.6	9	41.7		1
Culcita novaeguineae	13.6	7.7	55	250.0	0.0	3	13.9	13.9	9	125.0		1
Cypraea tigris	4.5	4.5	55	250.0		1	4.6	4.6	9	41.7		1
Diadema spp.	13.6	10.1	55	375.0	125.0	2	13.9	9.8	9	62.5	20.8	2
Dolabella spp.	13.6	13.6	55	750.0		1	13.9	13.9	9	125.0		1
Echinothrix calamaris	18.2	8.8	55	250.0	0.0	4	18.5	7.3	9	41.7	0.0	4
Hippopus hippopus	340.9	275.4	55	6250.0	4368.4	3	347.2	272.6	9	1041.7	728.1	3
Holothuria atra	1209.1	239.2	55	1750.0	308.7	38	1176.6	482.2	9	1176.6	482.2	9
Holothuria coluber	190.9	56.2	55	552.6	127.6	19	189.2	92.6	9	283.7	123.3	6
Holothuria fuscogilva	68.2	27.1	55	416.7	110.2	9	68.8	34.1	9	88.4	41.3	7
Holothuria leucospilota	13.6	10.1	55	375.0	125.0	2	13.9	9.8	9	62.5	20.8	2
Holothuria nobilis	9.1	6.4	55	250.0	0.0	2	9.3	6.1	9	41.7	0.0	2
Holothuria scabra	13.6	10.1	55	375.0	125.0	2	13.9	9.8	9	62.5	20.8	2
Lambis chiragra	4.5	4.5	55	250.0		1	4.6	4.6	9	41.7		1
Lambis lambis	9.1	6.4	55	250.0	0.0	2	9.3	9.3	9	83.3		1
Linckia laevigata	27.3	15.5	55	375.0	125.0	4	25.8	12.2	9	58.0	16.4	4
Mespilia globulus	4.5	4.5	55	250.0		1	4.6	4.6	9	41.7		1
Pinctada margaritifera	9.1	6.4	55	250.0	0.0	2	9.3	9.3	9	83.3		1
Pinna spp.	18.2	14.3	55	500.0	250.0	2	18.5	14.1	9	83.3	41.7	2
Protoreaster nodosus	900.0	159.1	55	1500.0	207.6	33	914.7	358.7	9	1029.0	385.5	8
Scylla serrata	4.5	4.5	55	250.0		1	4.6	4.6	9	41.7		1
Spondylus spp.	9.1	6.4	55	250.0	0.0	2	9.3	6.1	9	41.7	0.0	2
Stichopus chloronotus	18.2	8.8	55	250.0	0.0	4	17.2	9.1	9	51.6	9.9	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.

4.1.4 Andra 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
Synapta spp.	9.1	6.4	55	250.0	0.0	2	9.3	9.3	9	83.3		1
Tridacna gigas	72.7	45.3	55	1333.3	416.7	3	74.1	64.3	9	333.3	250.0	2
Tridacna maxima	4.5	4.5	55	250.0		1	4.6	4.6	9	41.7		1
Tridacna squamosa	31.8	31.8	55	1750.0		1	32.4	32.4	9	291.7		1
Tripneustes gratilla	22.7	11.7	55	312.5	62.5	4	23.1	14.1	9	69.4	27.8	3
Trochus niloticus	4.5	4.5	55	250.0		1	4.6	4.6	9	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 Andra 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	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Actinopyga mauritiana	7.8	1.9	54	28.2	2.5	15	7.8	1.8	9	10.1	1.4	7
Astralium spp.	10.0	4.0	54	77.3	15.2	7	10.0	4.3	9	22.5	4.3	4
Conus spp.	12.2	2.4	54	31.4	3.0	21	12.2	2.7	9	12.2	2.7	9
Echinometra mathaei	29.2	17.8	54	315.3	151.5	5	29.2	28.7	9	131.4	127.5	2
Holothuria atra	4.4	1.4	54	26.1	2.6	9	4.4	1.2	9	5.6	1.2	7
Octopus spp.	0.9	0.6	54	23.5	0.0	2	0.9	0.6	9	3.9	0.0	2
Panulirus spp.	2.2	1.1	54	29.4	5.9	4	2.2	0.9	9	4.9	1.0	4
Stichodactyla spp.	4.8	2.0	54	32.4	8.8	8	4.8	2.2	9	8.6	3.1	5
Tectus pyramis	3.5	1.3	54	26.9	3.4	7	3.5	1.2	9	6.3	1.0	5
Thais spp.	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Tridacna maxima	13.9	2.7	54	34.2	3.4	22	13.9	2.7	9	15.7	2.3	8
Trochus niloticus	9.2	2.7	54	32.9	6.4	15	9.2	3.1	9	13.7	3.3	6
Turbo argyrostomus	9.2	1.8	54	26.0	1.7	19	9.2	2.4	9	10.3	2.3	8
Turbo setosus	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Vasum ceramicum	1.7	1.1	54	31.4	7.8	3	1.7	0.9	9	5.2	1.3	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.

4.1.6 Andra mother-of-pearl transect (MOPt) assessment data review

Station: Six 1 m x 40 m.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	20.8	9.4	42	175.0	30.6	5	20.8	12.0	7	48.6	18.4	3
Astralium spp.	3.0	3.0	42	125.0		1	3.0	3.0	7	20.8		1
Bohadschia graeffei	3.0	3.0	42	125.0		1	3.0	3.0	7	20.8		1
Conus spp.	14.9	7.6	42	156.3	31.3	4	14.9	6.0	7	26.0	5.2	4
Holothuria atra	6.0	4.2	42	125.0	0.0	2	6.0	3.8	7	20.8	0.0	2
Lambis lambis	3.0	3.0	42	125.0		1	3.0	3.0	7	20.8		1
Panulirus versicolor	6.0	6.0	42	250.0		1	6.0	6.0	7	41.7		1
Stichodactyla spp.	59.5	18.2	42	208.3	38.7	12	59.5	20.0	7	83.3	18.6	5
Tectus pyramis	53.6	14.2	42	173.1	22.6	13	53.6	18.7	7	62.5	19.4	6
Tridacna maxima	23.8	8.8	42	142.9	17.9	7	23.8	7.1	7	33.3	5.1	5
Trochus niloticus	80.4	24.8	42	241.1	53.2	14	80.4	32.0	7	112.5	35.2	5
Turbo argyrostomus	20.8	13.4	42	291.7	110.2	3	20.8	12.0	7	48.6	18.4	3
Vasum ceramicum	3.0	3.0	42	125.0		1	3.0	3.0	7	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.

4.1.7 Andra 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	22.2	13.9	12	88.9	35.6	3	22.2	13.3	2	22.2	13.3	2
Actinopyga lecanora	71.1	24.9	12	121.9	30.2	7	71.1	35.6	2	71.1	35.6	2
Actinopyga miliaris	57.8	35.6	12	173.3	85.4	4	57.8	48.9	2	57.8	48.9	2
Bohadschia argus	31.1	15.3	12	93.3	25.5	4	31.1	22.2	2	31.1	22.2	2
Bohadschia vitiensis	13.3	7.0	12	53.3	0.0	3	13.3	13.3	2	26.7		1
Echinothrix diadema	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Echinothrix spp.	17.8	13.7	12	106.7	53.3	2	17.8	17.8	2	35.6		1
Holothuria coluber	17.8	12.0	12	106.7	0.0	2	17.8	0.0	2	17.8	0.0	2
Parribacus caledonicus	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Stichopus hermanni	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Stichopus horrens	13.3	7.0	12	53.3	0.0	3	13.3	4.4	2	13.3	4.4	2
Tridacna maxima	17.8	12.0	12	106.7	0.0	2	17.8	17.8	2	35.6		1
Trochus niloticus	13.3	13.3	12	160.0		1	13.3	13.3	2	26.7		1
Turbo petholatus	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.

4.1.8 Andra 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	1.6	0.9	36	19.0	4.8	3	1.6	0.8	6	3.2	0.8	3
Bohadschia graeffei	2.0	1.4	36	35.7	7.1	2	2.0	1.3	6	6.0	1.2	2
Cerithium nodulosum	7.9	7.5	36	142.9	128.6	2	7.9	7.5	6	23.8	21.4	2
Choriaster spp.	5.6	3.7	36	50.0	27.0	4	5.6	4.7	6	16.7	11.9	2
Culcita novaeguineae	0.8	0.6	36	14.3	0.0	2	0.8	0.8	6	4.8		1
Holothuria atra	2.4	1.7	36	42.9	0.0	2	2.4	2.4	6	14.3		1
Holothuria edulis	4.8	1.6	36	19.0	3.4	9	4.8	2.0	6	7.1	2.2	4
Holothuria fuscogilva	16.7	3.9	36	33.3	5.5	18	16.7	7.9	6	16.7	7.9	6
Holothuria fuscopunctata	3.2	1.2	36	16.3	2.0	7	3.2	0.8	6	3.8	0.6	5
Pinctada maxima	3.2	1.8	36	28.6	10.1	4	3.2	3.2	6	19.0		1
Stichopus hermanni	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Tectus pyramis	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Thelenota ananas	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Thelenota anax	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Tridacna crocea	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Tridacna maxima	6.0	2.9	36	53.6	3.6	4	6.0	6.0	6	35.7		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.

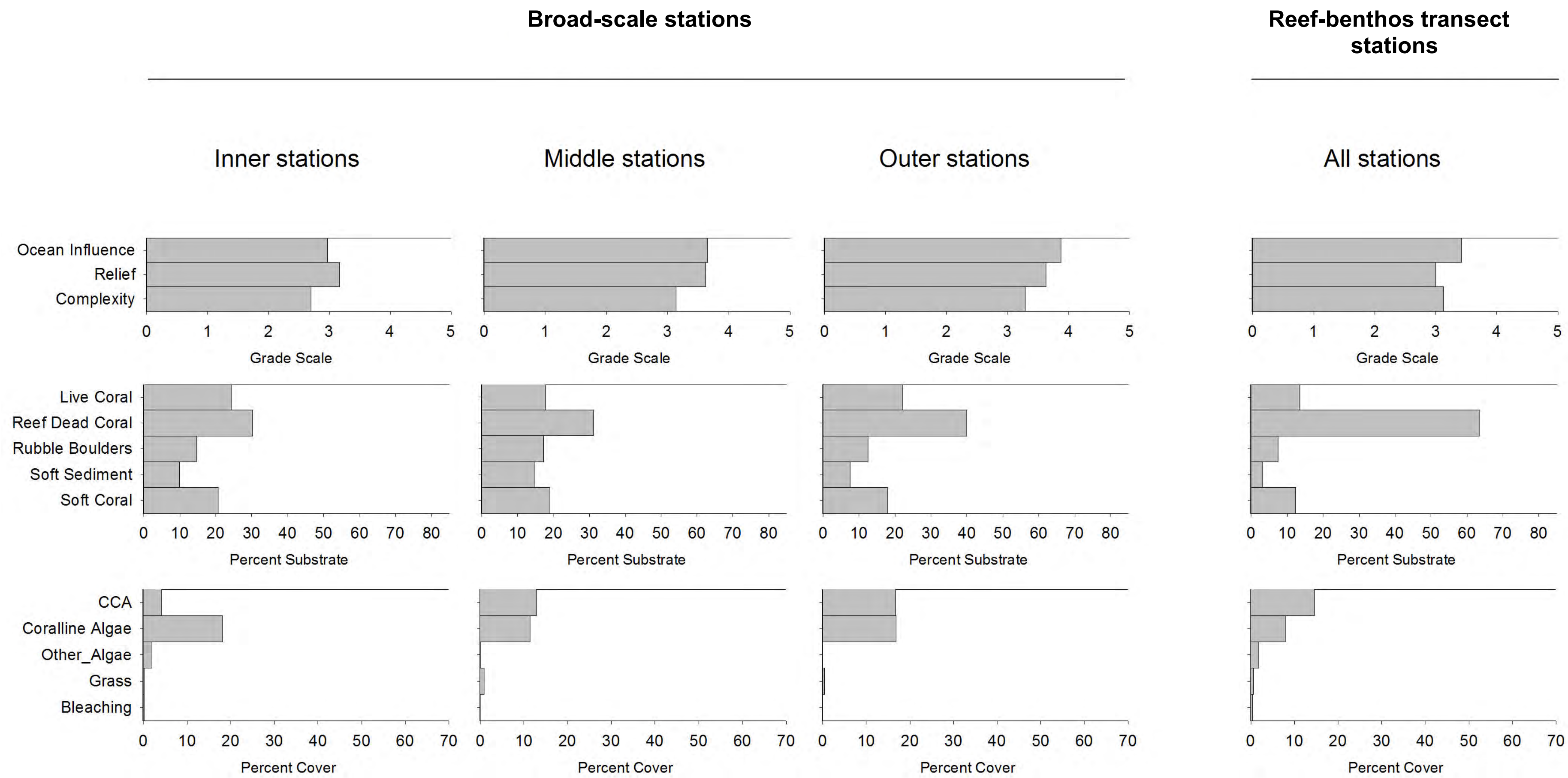
4.1.9 Andra species size review – all survey methods

Species	Mean length (cm)	SE	n
Tridacna crocea	10.2	0.3	115
Holothuria atra	16.5	0.8	105
Tridacna maxima	15.9	0.6	104
Trochus niloticus	9.5	0.2	99
Holothuria fuscogilva	27.9	1.1	51
Bohadschia graeffei	27.6	0.8	51
Tectus pyramis	5.5	0.2	49
Bohadschia argus	23.9	0.8	29
Conus vexillum	6.6	0.3	29
Conus miles	4.0	0.1	26
Stichopus chloronotus	23.8	1.5	19
Tridacna squamosa	22.7	1.5	18
Bohadschia vitiensis	17.7	1.1	14
Tridacna gigas	39.8	3.1	13
Hippopus hippopus	16.0	1.1	13
Conus spp.	4.6	0.6	13
Turbo argyrostomus	6.5	0.3	13
Holothuria nobilis	23.6	0.8	12
Thais spp.	4.9	0.3	12
Vasum turbinellum	3.3	0.2	11
Actinopyga mauritiana	16.2	0.7	10
Turbo crassus	6.6	0.3	10
Vasum ceramicum	10.1	0.2	10
Actinopyga lecanora	16.7	0.5	9
Thelenota ananas	38.6	1.2	8
Trochus spp.	3.3	0.1	6
Thelenota anax	45.6	6.3	5
Vasum spp.	4.4	0.3	5
Pleuroploca spp.	8.5	1.2	4
Pinctada margaritifera	13.3	0.8	4
Holothuria fuscopunctata	38.8	0.5	4
Turbo chrysostomus	5.0	0.2	4
Stichopus hermanni	33.0	5.0	3
Holothuria scabra	16.0	1.5	3
Lambis lambis	14.3	1.5	3
Cypraea spp.	3.8	0.7	3
Pinctada maxima	25.5	1.5	2
Holothuria coluber	31.5	0.5	2
Cypraea tigris	7.5	0.5	2
Chicoreus spp.	5.9	0.1	2
Astralium spp.	2.9	0.1	2
Stichopus horrens	36.0		1
Holothuria edulis	35.0		1
Bohadschia similis	20.0		1
Actinopyga miliaris	15.0		1
Actinopyga echinites	14.0		1
Scylla serrata	14.0		1
Pleuroploca filamentosa	13.0		1

4.1.9 Andra species size review – all survey methods (continued)

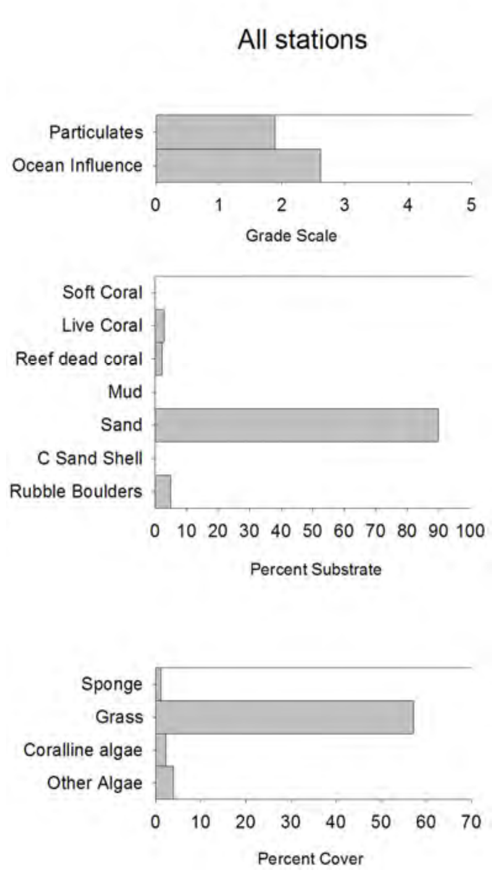
Species	Mean length (cm)	SE	n
Lambis chiragra	12.0		1
Holothuria leucospilota	10.0		1
Cerithium nodulosum	10.0		1
Conus litteratus	8.5		1
Ovula ovum	8.5		1
Panulirus spp.	7.5		1
Spondylus spp.	6.5		1
Linckia laevigata	3.3		1
Cypraea lynx	2.8		1

4.1.10 Habitat descriptors for independent assessment – Andra



4.1.10 Habitat descriptors for independent assessment – Andra (continued)

Soft-benthos transect stations



4.2 Tsoilaunung invertebrate survey data

4.2.1 Invertebrate species recorded in different assessments in Tsoilaunung

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	*Actinopyga miliaris*		+		
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 leucospilota*				+
Bêche-de-mer	*Holothuria nobilis*	+			+
Bêche-de-mer	*Holothuria pervicax*			+	
Bêche-de-mer	*Holothuria scabra*	+	+	+	
Bêche-de-mer	*Stichopus chloronotus*	+			
Bêche-de-mer	*Stichopus hermanni*	+			
Bêche-de-mer	*Stichopus horrens*			+	+
Bêche-de-mer	*Stichopus vastus*	+			
Bêche-de-mer	*Synapta* spp.	+		+	
Bêche-de-mer	*Thelenota ananas*	+			+
Bêche-de-mer	*Thelenota anax*	+			+
Bivalve	*Anadara antiquata*			+	
Bivalve	*Anadara* spp.			+	
Bivalve	*Atactodea striata*			+	
Bivalve	*Atrina* spp.	+			
Bivalve	*Atrina vexillum*	+	+		
Bivalve	*Chama* spp.	+	+	+	
Bivalve	*Codakia* spp.			+	
Bivalve	*Fragum fragum*			+	
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Hyotissa* spp.	+			
Bivalve	*Modiolus* spp..			+	
Bivalve	*Pinctada margaritifera*	+	+	+	
Bivalve	*Pinna* spp.		+	+	+
Bivalve	*Pteria* spp.	+			
Bivalve	*Spondylus* spp.	+	+	+	
Bivalve	*Tridacna crocea*	+	+		
Bivalve	*Tridacna gigas*	+	+		
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+	+		
Cnidarian	*Cassiopea andromeda*			+	
Cnidarian	*Stichodactyla* spp.	+	+	+	+

+ = presence of the species.

4.2.1 Invertebrate species recorded in different assessments in Tsoilaunung (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Crustacean	*Calappa* spp.			+	
Crustacean	*Lysiosquillina maculata*	+		+	
Crustacean	*Lysiosquillina* spp.			+	
Crustacean	*Panulirus* spp.	+			+
Crustacean	*Panulirus versicolor*		+		+
Crustacean	*Scylla serrata*				+
Gastropod	*Astralium* spp.		+		+
Gastropod	*Cerithium nodulosum*		+		
Gastropod	*Chicoreus* spp.		+		
Gastropod	*Conus litteratus*			+	
Gastropod	*Conus marmoreus*		+	+	
Gastropod	*Conus miles*		+		
Gastropod	*Conus sanguinolentus*		+		
Gastropod	*Conus* spp.	+	+	+	+
Gastropod	*Conus vexillum*		+		
Gastropod	*Conus virgo*			+	
Gastropod	*Cypraea annulus*		+		
Gastropod	*Cypraea arabica*		+		
Gastropod	*Cypraea moneta*		+	+	
Gastropod	*Cypraea tigris*	+	+	+	+
Gastropod	*Dolabella* spp.		+	+	
Gastropod	*Lambis chiragra*	+			
Gastropod	*Lambis crocata*		+	+	
Gastropod	*Lambis lambis*	+	+	+	+
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Mitra mitra*		+		
Gastropod	*Pleuroploca filamentosa*		+		
Gastropod	*Polinices mammilla*			+	
Gastropod	*Strombus gibberulus gibbosus*			+	
Gastropod	*Strombus labiatus*		+	+	
Gastropod	*Strombus luhuanus*	+			
Gastropod	*Strombus* spp.		+	+	
Gastropod	*Tectus conus*		+		
Gastropod	*Tectus pyramis*	+	+	+	+
Gastropod	*Thais* spp.		+		+
Gastropod	*Trochus niloticus*	+	+		+
Gastropod	*Trochus* spp.		+		+
Gastropod	*Turbo argyrostomus*		+		+
Gastropod	*Turbo chrysostomus*		+		+
Gastropod	*Turbo petholatus*				+
Gastropod	*Vasum ceramicum*		+		+
Gastropod	*Vasum* spp.		+		
Gastropod	*Vasum turbinellum*		+		
Octopus	*Octopus* spp.	+			+
Star	*Acanthaster planci*	+	+		+
Star	*Archaster* spp.			+	
Star	*Choriaster granulatus*	+			

+ = presence of the species.

4.2.1 Invertebrate species recorded in different assessments in Tsoilaunung (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Star	*Choriaster* spp.				+
Star	*Culcita novaeguineae*	+	+		+
Star	*Linckia laevigata*	+	+		+
Star	*Protoreaster nodosus*	+	+	+	+
Urchin	*Diadema* spp.	+	+		+
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix calamaris*		+		
Urchin	*Echinothrix diadema*	+	+	+	+
Urchin	*Heterocentrotus mammillatus*		+		+
Urchin	*Tripneustes gratilla*		+	+	

+ = presence of the species.

4.2.2 Tsoilaunung 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	6.5	1.9	72	31.1	5.6	15	6.5	3.0	12	15.6	5.0	5
Atrina spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Atrina vexillum	3.5	1.1	72	25.0	3.7	10	3.5	1.5	12	10.4	1.3	4
Bohadschia argus	1.2	0.5	72	16.7	0.0	5	1.2	0.6	12	4.6	0.9	3
Bohadschia graeffei	3.0	0.8	72	16.7	0.0	13	3.0	1.1	12	6.0	1.1	6
Bohadschia vitiensis	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Chama spp.	12.5	3.4	72	50.0	9.0	18	12.5	5.7	12	21.4	8.4	7
Choriaster granulatus	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	6.9	1.7	72	27.8	4.0	18	6.9	3.2	12	11.9	4.8	7
Cypraea tigris	1.9	0.6	72	16.7	0.0	8	1.9	1.0	12	5.6	2.0	4
Diadema spp.	14.6	6.0	72	116.7	32.5	9	14.6	9.1	12	35.0	19.1	5
Echinometra mathaei	1.6	1.2	72	58.3	25.0	2	1.6	1.6	12	19.4		1
Echinothrix diadema	1.4	0.6	72	20.0	3.3	5	1.4	0.6	12	4.2	0.8	4
Hippopus hippopus	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Holothuria atra	1.9	0.6	72	16.7	0.0	8	1.9	0.6	12	3.7	0.6	6
Holothuria coluber	1.2	1.0	72	41.7	25.0	2	1.2	1.2	12	13.9		1
Holothuria edulis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Holothuria fuscopunctata	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Holothuria nobilis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Holothuria scabra	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Hyotissa spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Lambis chiragra	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Lambis lambis	2.1	0.9	72	25.0	5.7	6	2.1	0.8	12	5.0	1.0	5
Linckia laevigata	85.4	13.3	72	136.7	17.3	45	85.4	19.1	12	93.2	19.1	11
Lysiosquillina maculata	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Octopus spp.	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.

4.2.2 Tsoilaunung 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
Panulirus spp.	1.2	0.5	72	16.7	0.0	5	1.2	0.5	12	3.5	0.7	4
Pinctada margaritifera	1.4	0.5	72	16.7	0.0	6	1.4	0.5	12	3.3	0.6	5
Protoreaster nodosus	261.1	134.6	72	2350.0	975.4	8	261.1	222.1	12	1566.7	1100.0	2
Pteria spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Spondylus spp.	14.8	5.1	72	82.1	19.5	13	14.8	7.1	12	35.6	12.0	5
Stichodactyla spp.	33.6	7.6	72	60.4	12.2	40	33.6	13.7	12	36.6	14.6	11
Stichopus chloronotus	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Stichopus hermanni	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Stichopus vastus	1.2	0.6	72	20.8	4.2	4	1.2	0.9	12	6.9	4.2	2
Strombus luhuanus	16.2	16.2	72	1166.7		1	16.2	16.2	12	194.4		1
Synapta spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tectus pyramis	2.1	0.9	72	25.0	5.7	6	2.1	1.3	12	8.3	3.2	3
Thelenota ananas	0.9	0.5	72	16.7	0.0	4	0.9	0.7	12	5.6	2.8	2
Thelenota anax	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna crocea	1291.2	346.0	72	1721.6	447.0	54	1291.2	734.8	12	1408.6	794.6	11
Tridacna gigas	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	0.0	3
Tridacna maxima	8.1	2.3	72	32.4	6.5	18	8.1	2.4	12	10.8	2.6	9

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 Tsoilaunung 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	18.2	11.3	96	437.5	187.5	4	18.2	11.4	16	97.2	36.7	3
Actinopyga miliaris	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Astralium spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Atrina vexillum	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Bohadschia argus	7.8	4.5	96	250.0	0.0	3	7.8	4.2	16	41.7	0.0	3
Bohadschia graeffei	7.8	7.8	96	750.0		1	7.8	7.8	16	125.0		1
Bohadschia similis	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Cerithium nodulosum	7.8	5.8	96	375.0	125.0	2	7.8	5.7	16	62.5	20.8	2
Chama spp.	36.5	15.7	96	437.5	122.7	8	36.5	17.8	16	97.2	36.7	6
Chicoreus spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Conus miles	7.8	4.5	96	250.0	0.0	3	7.8	4.2	16	41.7	0.0	3
Conus sanguinolentus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Conus spp.	18.2	6.7	96	250.0	0.0	7	18.2	6.6	16	48.6	6.9	6
Conus vexillum	10.4	7.3	96	500.0	0.0	2	10.4	7.1	16	83.3	0.0	2
Culcita novaeguineae	31.3	9.3	96	272.7	22.7	11	31.3	10.4	16	71.4	11.9	7
Cypraea annulus	5.2	5.2	96	500.0		1	5.2	5.2	16	83.3		1
Cypraea arabica	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Cypraea moneta	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Cypraea tigris	26.0	10.8	96	357.1	74.3	7	26.0	11.3	16	83.3	18.6	5
Diadema spp.	231.8	84.8	96	1711.5	457.2	13	231.8	183.7	16	927.1	678.4	4
Echinometra mathaei	158.9	45.4	96	635.4	144.3	24	158.9	69.0	16	282.4	107.3	9
Echinothrix calamaris	135.4	130.2	96	4333.3	4 083.3	3	135.4	132.7	16	1083.3	1041.7	2
Echinothrix diadema	39.1	14.5	96	468.8	73.8	8	39.1	25.9	16	208.3	96.2	3
Heterocentrotus mammillatus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Hippopus hippopus	13.0	5.7	96	250.0	0.0	5	13.0	6.3	16	52.1	10.4	4
Holothuria atra	13.0	5.7	96	250.0	0.0	5	13.0	7.3	16	69.4	13.9	3
Holothuria coluber	18.2	8.5	96	350.0	61.2	5	18.2	12.6	16	145.8	20.8	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.

4.2.3 Tsoilaunung 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
Lambis crocata	20.8	9.6	96	333.3	83.3	6	20.8	11.4	16	83.3	29.5	4
Lambis lambis	20.8	12.1	96	500.0	176.8	4	20.8	18.2	16	166.7	125.0	2
Latirolagena smaragdula	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Linckia laevigata	645.8	66.7	96	925.4	72.5	67	645.8	130.3	16	738.1	130.9	14
Mitra mitra	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Panulirus versicolor	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Pinctada margaritifera	15.6	7.2	96	300.0	50.0	5	15.6	6.4	16	50.0	8.3	5
Pleuroploca filamentosa	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Protoreaster nodosus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Spondylus spp.	13.0	7.7	96	416.7	83.3	3	13.0	10.6	16	104.2	62.5	2
Stichodactyla spp.	153.6	46.3	96	737.5	169.6	20	153.6	72.3	16	307.3	125.2	8
Strombus labiatus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Strombus spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Tectus conus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Tectus pyramis	135.4	29.1	96	448.3	67.3	29	135.4	35.8	16	197.0	39.8	11
Thais spp.	10.4	6.3	96	333.3	83.3	3	10.4	8.1	16	83.3	41.7	2
Tridacna crocea	1697.9	445.5	96	3622.2	869.2	45	1697.9	950.6	16	2263.9	1235.5	12
Tridacna maxima	72.9	16.1	96	350.0	33.4	20	72.9	18.0	16	106.1	18.9	11
Tridacna squamosa	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Tripneustes gratilla	20.8	11.5	96	500.0	144.3	4	20.8	18.2	16	166.7	125.0	2
Trochus niloticus	13.0	6.8	96	312.5	62.5	4	13.0	8.3	16	69.4	27.8	3
Trochus spp.	23.4	8.3	96	281.3	31.3	8	23.4	8.5	16	53.6	11.9	7
Turbo argyrostomus	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Turbo chrysostomus	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Vasum ceramicum	20.8	9.6	96	333.3	83.3	6	20.8	9.3	16	66.7	16.7	5
Vasum spp.	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Vasum turbinellum	7.8	5.8	96	375.0	125.0	2	7.8	5.7	16	62.5	20.8	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.

4.2.4 Tsoilaunung 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
Actinopyga echinites	13.9	6.8	72	250.0	0.0	4	13.9	5.9	12	41.7	0.0	4
Anadara antiquata	20.8	9.6	72	300.0	50.0	5	20.8	10.9	12	62.5	20.8	4
Anadara spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Bohadschia argus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Bohadschia similis	111.1	31.2	72	500.0	88.4	16	111.1	73.9	12	166.7	107.4	8
Bohadschia vitiensis	38.2	16.9	72	458.3	100.3	6	38.2	31.0	12	152.8	111.1	3
Cassiopea andromeda	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Chama spp.	17.4	12.4	72	625.0	125.0	2	17.4	17.4	12	208.3		1
Conus litteratus	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Conus marmoreus	24.3	12.3	72	350.0	100.0	5	24.3	12.0	12	72.9	19.9	4
Conus miles	121.5	121.5	72	8750.0		1	121.5	121.5	12	1458.3		1
Conus spp.	20.8	9.6	72	300.0	50.0	5	20.8	10.9	12	62.5	20.8	4
Conus virgo	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Cypraea annulus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Cypraea moneta	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Cypraea tigris	41.7	13.1	72	300.0	33.3	10	41.7	17.8	12	83.3	26.4	6
Dolabella spp.	24.3	8.8	72	250.0	0.0	7	24.3	8.0	12	48.6	6.9	6
Echinothrix diadema	48.6	24.5	72	875.0	125.0	4	48.6	48.6	12	583.3		1
Holothuria atra	10.4	7.7	72	375.0	125.0	2	10.4	7.5	12	62.5	20.8	2
Holothuria coluber	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Holothuria fuscogilva	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Holothuria pervicax	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Holothuria scabra	100.7	26.0	72	402.8	64.4	18	100.7	41.5	12	134.3	50.9	9
Lambis crocata	48.6	23.5	72	500.0	172.5	7	48.6	29.4	12	145.8	69.1	4
Lambis lambis	27.8	11.7	72	333.3	52.7	6	27.8	9.4	12	55.6	8.8	6
Linckia laevigata	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Lysiosquillina maculata	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 Tsoilaunung 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
Lysiosquillina spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Modiolus spp.	17.4	11.4	72	416.7	166.7	3	17.4	17.4	12	208.3		1
Pinctada margaritifera	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Pinna spp.	45.1	18.1	72	464.3	85.0	7	45.1	25.4	12	135.4	54.8	4
Protoreaster nodosus	1215.3	166.5	72	1411.3	181.5	62	1215.3	355.4	12	1215.3	355.4	12
Spondylus spp.	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Stichodactyla spp.	13.9	8.4	72	333.3	83.3	3	13.9	7.8	12	55.6	13.9	3
Strombus spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Synapta spp.	62.5	23.6	72	562.5	103.0	8	62.5	39.9	12	187.5	98.5	4
Tectus pyramis	31.3	16.4	72	450.0	145.8	5	31.3	16.3	12	93.8	31.3	4
Tridacna gigas	10.4	10.4	72	750.0		1	10.4	10.4	12	125.0		1
Tridacna maxima	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Tripneustes gratilla	1177.1	287.8	72	2733.9	560.0	31	1177.1	677.2	12	2017.9	1 076.4	7
Trochus spp.	13.9	9.8	72	500.0	0.0	2	13.9	13.9	12	166.7		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.

4.2.5 Tsoilaunung 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 antiquata	0.10	0.07	80	4.00	0.00	2	0.10	0.07	10	0.50	0.00	2
Anadara spp.	0.10	0.07	80	4.00	0.00	2	0.10	0.07	10	0.50	0.00	2
Archaster spp.	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Atactodea striata	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Bohadschia similis	0.25	0.13	80	5.00	1.00	4	0.25	0.15	10	1.00	0.50	2
Calappa spp.	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Chama spp.	0.20	0.12	80	5.33	1.33	3	0.20	0.15	10	1.50		1
Codakia spp.	0.25	0.13	80	5.00	1.00	4	0.25	0.20	10	1.25	0.75	2
Conus marmoreus	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Dolabella spp.	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Fragum fragum	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Holothuria scabra	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Modiolus spp.	0.80	0.45	80	16.00	5.16	4	0.80	0.80	10	8.00		1
Pinna spp.	0.15	0.09	80	4.00	0.00	3	0.15	0.11	10	0.75	0.25	2
Polinices mammilla	0.10	0.07	80	4.00	0.00	2	0.10	0.07	10	0.50	0.00	2
Protoreaster nodosus	0.30	0.12	80	4.00	0.00	6	0.30	0.13	10	0.83	0.17	3
Spondylus spp.	0.10	0.07	80	4.00	0.00	2	0.10	0.07	10	0.50	0.00	2
Stichopus horrens	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Strombus gibberulus gibbosus	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Strombus labiatus	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1
Strombus spp.	0.10	0.07	80	4.00	0.00	2	0.10	0.05	10	0.50		1
Tectus pyramis	0.05	0.05	80	4.00		1	0.35	0.35	10	3.50		1
Tripneustes gratilla	0.05	0.05	80	4.00		1	0.05	0.05	10	0.50		1

Mean = mean density (numbers/m^2); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.6 Tsoilaunung 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	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Actinopyga mauritiana	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Astralium spp.	1.0	1.0	48	47.1		1	1.0	1.0	8	7.8		1
Bohadschia graeffei	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Conus spp.	14.2	4.6	48	52.5	12.0	13	14.2	4.1	8	14.2	4.1	8
Cypraea tigris	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Echinometra mathaei	3.4	2.0	48	54.9	7.8	3	3.4	2.3	8	13.7	2.0	2
Echinothrix diadema	3.4	1.4	48	27.5	3.9	6	3.4	1.6	8	6.9	1.9	4
Heterocentrotus mammillatus	92.6	31.3	48	277.9	76.0	16	92.6	49.5	8	123.5	61.7	6
Holothuria atra	8.3	4.6	48	80.0	30.3	5	8.3	7.2	8	22.2	18.3	3
Holothuria nobilis	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Linckia laevigata	5.9	4.2	48	94.1	49.0	3	5.9	4.1	8	23.5	7.8	2
Octopus spp.	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Panulirus spp.	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Stichodactyla spp.	6.9	3.8	48	65.9	26.2	5	6.9	5.2	8	13.7	9.8	4
Tectus pyramis	5.4	1.7	48	28.8	3.5	9	5.4	2.0	8	8.6	1.9	5
Thais spp.	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Tridacna maxima	7.4	2.7	48	32.1	8.6	11	7.4	3.0	8	8.4	3.3	7
Trochus niloticus	1.5	0.8	48	23.5	0.0	3	1.5	0.7	8	3.9	0.0	3
Trochus spp.	11.8	4.0	48	51.3	10.9	11	11.8	3.3	8	15.7	2.9	6
Turbo argyrostomus	1.5	0.8	48	23.5	0.0	3	1.5	0.7	8	3.9	0.0	3
Turbo petholatus	0.5	0.5	48	23.5		1	0.5	0.5	8	3.9		1
Vasum ceramicum	7.4	3.0	48	44.1	11.3	8	7.4	4.2	8	11.8	5.9	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.

4.2.7 Tsoilaunung mother-of-pearl search (MOPs) 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	4.5	4.5	30	45.5		1	4.5	4.5	5	22.7		1
Actinopyga lecanora	1.5	1.5	30	45.5		1	1.5	1.5	5	7.6		1
Bohadschia argus	1.5	1.5	30	45.5		1	1.5	1.5	5	7.6		1
Bohadschia graeffei	1.5	1.5	30	90.9	28.7	5	1.5	1.5	5	7.6		1
Conus spp.	15.2	7.7	30	45.5		1	15.2	6.8	5	18.9	7.3	4
Linckia laevigata	1.5	1.5	30	45.5		1	1.5	1.5	5	7.6		1
Panulirus spp.	1.5	1.5	30	45.5	0.0	2	1.5	1.5	5	7.6		1
Stichodactyla spp.	3.0	2.1	30	62.5	8.3	8	3.0	3.0	5	15.2		1
Tectus pyramis	16.7	5.5	30	45.5	0.0	4	16.7	5.6	5	20.8	4.8	4
Tridacna maxima	6.1	2.9	30	45.5	0.0	4	6.1	4.4	5	15.2	7.6	2
Trochus niloticus	6.1	2.9	30	45.5	0.0	4	6.1	2.8	5	10.1	2.5	3
Turbo argyrostomus	6.1	2.9	30	45.5		1	6.1	4.4	5	15.2	7.6	2
Turbo chrysostomus	1.5	1.5	30	66.7	16.3	30	1.5	1.5	5	7.6		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.

4.2.8 Tsoilaunung 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
Holothuria atra	20.8	20.8	6	125.0		1	20.8		1	20.8		1
Lambis lambis	20.8	20.8	6	125.0		1	20.8		1	20.8		1
Tectus pyramis	62.5	42.7	6	187.5	62.5	2	62.5		1	62.5		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 Tsoilaunung 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
Actinopyga lecanora	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1
Culcita novaeguineae	40.0	30.9	12	160.0	106.7	3	40.0	31.1	2	40.0	31.1	2
Diadema spp.	40.0	18.7	12	96.0	31.1	5	40.0	4.4	2	40.0	4.4	2
Echinothrix diadema	26.7	18.0	12	106.7	53.3	3	26.7	26.7	2	53.3		1
Holothuria coluber	62.2	25.3	12	124.4	35.6	6	62.2	0.0	2	62.2	0.0	2
Holothuria fuscogilva	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Holothuria leucospilota	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Linckia laevigata	102.2	41.2	12	204.4	57.5	6	102.2	31.1	2	102.2	31.1	2
Panulirus spp.	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Panulirus versicolor	13.3	9.6	12	80.0	26.7	2	13.3	4.4	2	13.3	4.4	2
Pinna spp.	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Scylla serrata	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Stichopus horrens	17.8	13.7	12	106.7	53.3	2	17.8	17.8	2	35.6		1
Trochus niloticus	13.3	7.0	12	53.3	0.0	3	13.3	13.3	2	26.7		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.

4.2.10 Tsoilaunung 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	1.2	0.7	36	14.3	0.0	3	1.2	0.8	6	3.6	1.2	2
Choriaster spp.	3.2	1.4	36	19.0	4.8	6	3.2	2.0	6	9.5	0.0	2
Culcita novaeguineae	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Echinothrix diadema	0.8	0.8	36	28.6		1	0.8	0.8	6	4.8		1
Holothuria atra	1.6	0.8	36	14.3	0.0	4	1.6	0.8	6	3.2	0.8	3
Holothuria fuscogilva	9.1	2.2	36	21.9	3.1	15	9.1	3.2	6	11.0	3.2	5
Holothuria fuscopunctata	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Linckia laevigata	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Panulirus spp.	0.8	0.6	36	14.3	0.0	2	0.8	0.5	6	2.4	0.0	2
Protoreaster nodosus	2.0	1.4	36	35.7	7.1	2	2.0	2.0	6	11.9		1
Stichodactyla spp.	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Thelenota ananas	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Thelenota anax	1.6	0.8	36	14.3	0.0	4	1.6	0.8	6	3.2	0.8	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.

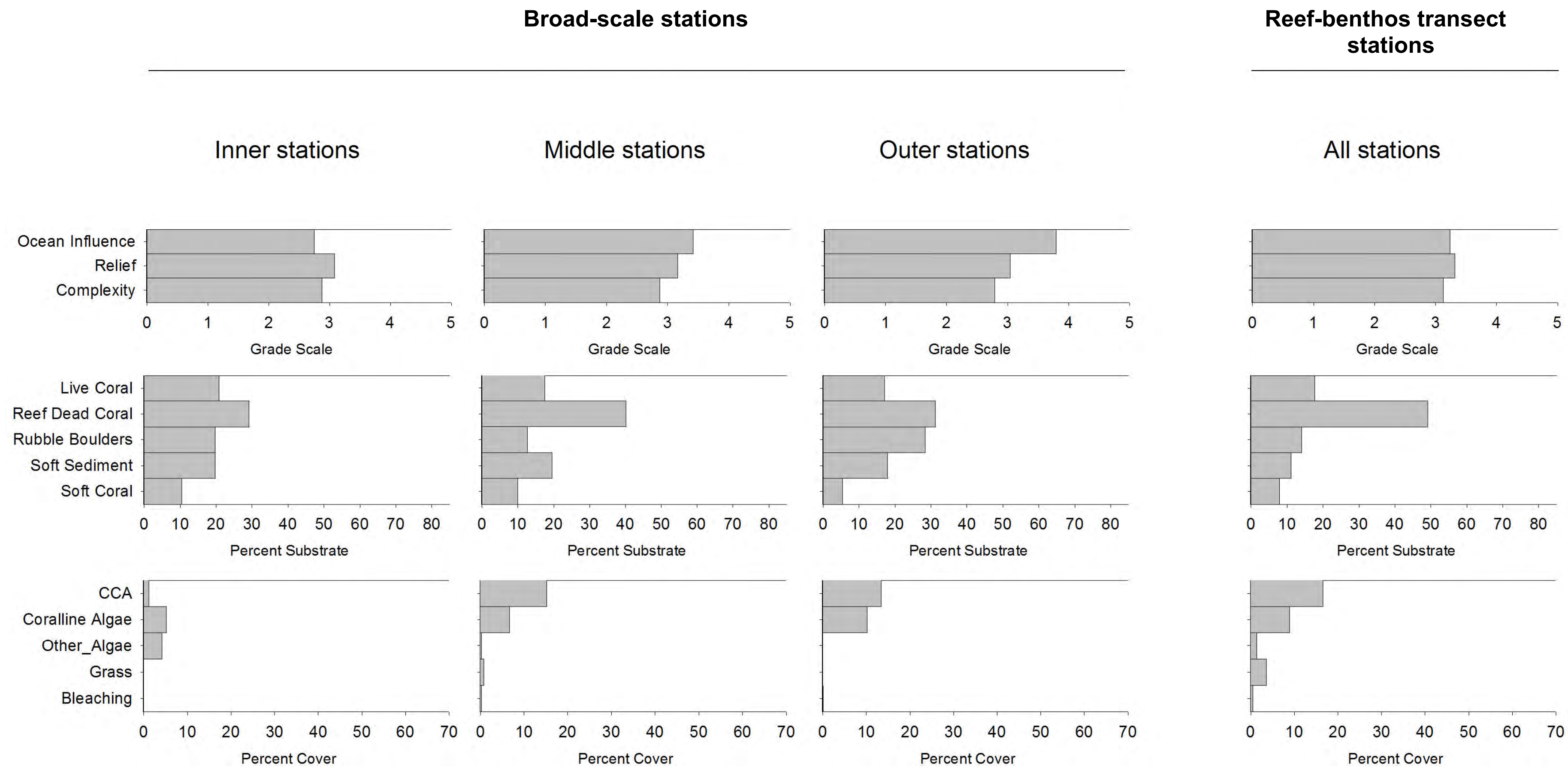
4.2.11 Tsoilaunung species size review – all survey methods

Species	Mean length (cm)	SE	n
Tridacna crocea	8.3	0.2	411
Tridacna maxima	14.0	0.8	72
Tectus pyramis	5.5	0.2	61
Bohadschia similis	15.0	0.6	35
Holothuria scabra	17.5	0.7	31
Holothuria fuscogilva	31.0	1.2	25
Cypraea tigris	7.3	0.1	22
Lambis crocata	13.0	0.5	21
Modiolus spp.	7.8	0.4	21
Lambis lambis	14.1	0.5	17
Trochus niloticus	7.4	0.5	14
Tripneustes gratilla	8.4	0.3	14
Bohadschia argus	30.5	3.7	11
Bohadschia vitiensis	17.3	1.1	11
Hippopus hippopus	16.7	2.0	8
Conus marmoreus	4.9	0.4	8
Trochus spp.	3.1	0.2	8
Holothuria atra	25.6	4.2	7
Vasum ceramicum	9.0	1.2	7
Anadara antiquata	5.9	0.3	7
Tridacna gigas	61.3	9.0	6
Tridacna squamosa	25.2	1.9	6
Pinctada margaritifera	12.8	0.4	6
Stichopus horrens	17.8	4.5	5
Thelenota ananas	39.6	3.2	5
Chama spp.	6.3	2.2	5
Stichopus vastus	31.2	1.4	5
Codakia spp.	5.2	0.3	5
Conus spp.	4.8	1.8	4
Bohadschia graeffei	29.3	1.3	4
Conus vexillum	7.6	0.3	4
Thelenota anax	51.0	5.6	3
Turbo argyrostomus	5.6	1.0	3
Conus miles	5.7	0.6	3
Actinopyga echinites	12.0	0.6	3
Cerithium nodulosum	9.1	0.3	3
Vasum turbinellum	4.4	0.1	3
Pinna spp.	18.5	3.5	2
Stichopus hermanni	26.0	2.0	2
Holothuria fuscopunctata	31.5	1.5	2
Spondylus spp.	5.0	1.0	2
Polinices mammilla	3.4	0.9	2
Strombus spp.	5.3	0.8	2
Holothuria nobilis	22.5	0.5	2
Strombus labiatus	3.4	0.2	2
Dolabella spp.	14.0	0.0	2
Actinopyga mauritiana	16.0		1
Actinopyga miliaris	17.0		1

4.2.11 Tsoilaunung species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Holothuria pervicax	17.0		1
Stichopus chloronotus	18.0		1
Anadara spp.	5.0		1
Atactodea striata	2.5		1
Fragum fragum	3.2		1
Panulirus versicolor	11.0		1
Astralium spp.	3.4		1
Chicoreus spp.	6.0		1
Conus litteratus	9.0		1
Conus virgo	8.5		1
Cypraea arabica	5.4		1
Mitra mitra	11.0		1
Pleuroploca filamentosa	4.0		1
Strombus gibberulus gibbosus	4.2		1
Tectus conus	3.7		1
Turbo chrysostomus	5.0		1
Vasum spp.	3.6		1
Archaster spp.	5.5		1

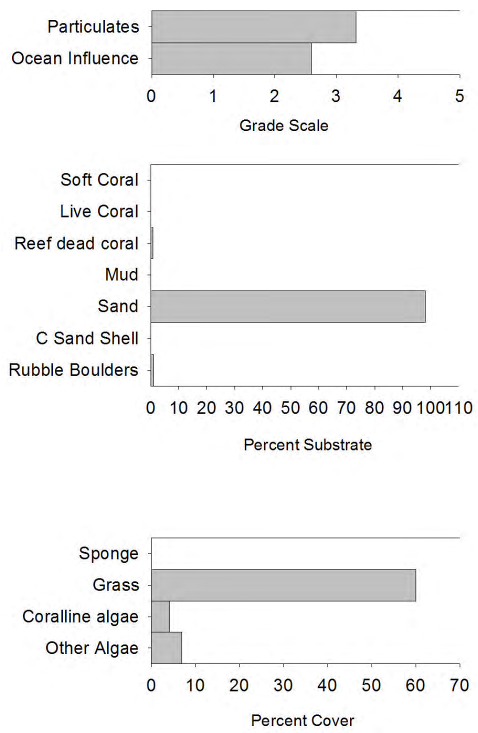
4.2.12 Habitat descriptors for independent assessment – Tsoilaunung



4.2.12 Habitat descriptors for independent assessment – Tsoilaunung (continued)

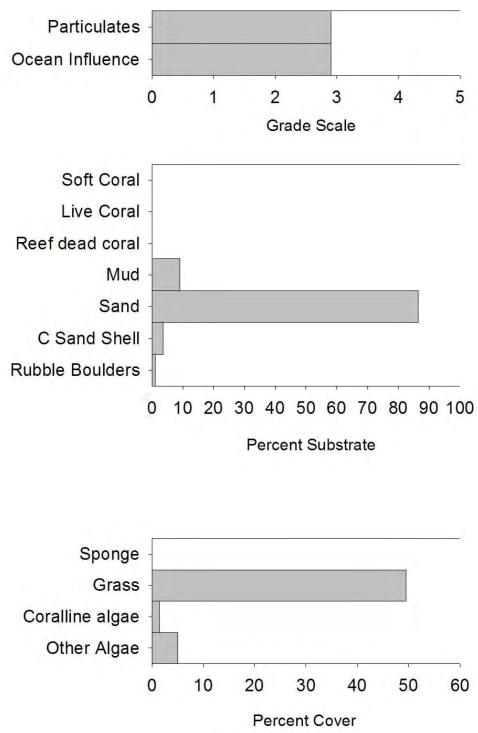
Soft-benthos transect stations

All stations



Soft-infaunal quadrat stations

All stations



4.3 Sideia invertebrate survey data

4.3.1 Invertebrate species recorded in different assessments in Sideia

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*		+		
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Bohadschia graeffei*	+	+		+
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 leucospilota*				+
Bêche-de-mer	*Holothuria nobilis*	+	+		
Bêche-de-mer	*Stichopus chloronotus*		+		
Bêche-de-mer	*Stichopus hermanni*				+
Bêche-de-mer	*Synapta* spp.	+			
Bêche-de-mer	*Thelenota ananas*	+			+
Bêche-de-mer	*Thelenota anax*		+		+
Bêche-de-mer	*Thelenota rubrolineata*				+
Bivalve	*Atrina* spp.	+			
Bivalve	*Chama* spp.	+	+		+
Bivalve	*Hippopus hippopus*	+	+		+
Bivalve	*Hyotissa* spp.	+			
Bivalve	*Lopha cristagalli*	+			
Bivalve	*Pinctada margaritifera*	+	+		+
Bivalve	*Spondylus* spp.	+	+		+
Bivalve	*Tridacna crocea*	+	+		+
Bivalve	*Tridacna derasa*	+	+		+
Bivalve	*Tridacna gigas*	+	+		
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+	+		+
Cnidarians	*Stichodactyla* spp.	+	+		+
Crustacean	*Lysiosquillina maculata*		+		
Crustacean	*Panulirus* spp.	+	+		+
Crustacean	*Panulirus versicolor*	+	+		+
Gastropod	*Astralium* spp.		+		
Gastropod	*Cerithium nodulosum*		+		+
Gastropod	*Chicoreus* spp.		+		
Gastropod	*Conus imperialis*		+		
Gastropod	*Conus leopardus*		+		
Gastropod	*Conus litteratus*		+		
Gastropod	*Conus marmoreus*		+		
Gastropod	*Conus miles*		+		
Gastropod	*Conus* spp.	+	+		+
Gastropod	*Conus textile*		+		
Gastropod	*Conus vexillum*		+		+
Gastropod	*Cypraea annulus*		+		
Gastropod	*Cypraea caputserpensis*		+		

+ = presence of the species.

4.3.1 Invertebrate species recorded in different assessments in Sideia (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Cypraea tigris*	+	+		
Gastropod	*Haliotis asinina*		+		
Gastropod	*Lambis chiragra*	+	+		+
Gastropod	*Lambis crocata*		+		
Gastropod	*Lambis lambis*	+	+		+
Gastropod	*Lambis millepeda*	+	+		+
Gastropod	*Lambis scorpius*	+	+		
Gastropod	*Lambis truncata*		+		+
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Ovula ovum*	+			
Gastropod	*Pleuroploca filamentosa*		+		
Gastropod	*Pleuroploca* spp.		+		
Gastropod	*Strombus luhuanus*	+	+		+
Gastropod	*Strombus sinuatus*				+
Gastropod	*Tectus pyramis*	+	+		+
Gastropod	*Tectus* spp.	+			
Gastropod	*Thais* spp.		+		+
Gastropod	*Trochus maculata*		+		
Gastropod	*Trochus niloticus*	+	+		+
Gastropod	*Trochus* spp.		+		+
Gastropod	*Turbo argyrostomus*	+	+		
Gastropod	*Turbo chrysostomus*		+		+
Gastropod	*Turbo petholatus*	+	+		
Gastropod	*Tutufa* spp.		+		
Gastropod	*Vasum ceramicum*		+		+
Gastropod	*Vasum* spp.				+
Gastropod	*Vasum turbinellum*	+	+		
Octopus	*Octopus cyanea*	+			
Star	*Acanthaster planci*		+		+
Star	*Choriaster granulatus*	+	+		
Star	*Culcita novaeguineae*	+	+		+
Star	*Linckia laevigata*	+	+		+
Urchin	*Diadema* spp.	+	+		
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix calamaris*	+	+		
Urchin	*Echinothrix diadema*	+	+		
Urchin	*Heterocentrotus mammillatus*	+			

+ = presence of the species.

4.3.2 Sideia 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
Atrina spp.	0.5	0.3	73	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Bohadschia argus	0.9	0.4	73	16.7	0.0	4	0.9	0.4	12	2.7	0.1	4
Bohadschia graeffei	3.9	1.2	73	23.6	3.8	12	3.9	1.4	12	7.9	1.7	6
Bohadschia vitiensis	1.4	0.5	73	16.7	0.0	6	1.4	0.7	12	4.1	1.4	4
Chama spp.	5.0	1.3	73	24.4	3.2	15	5.0	1.8	12	8.6	2.3	7
Choriaster granulatus	1.1	0.7	73	27.8	5.6	3	1.2	0.9	12	6.9	4.2	2
Conus spp.	1.6	0.7	73	19.4	2.8	6	1.6	1.2	12	6.5	3.7	3
Culcita novaeguineae	5.0	1.5	73	28.2	4.4	13	5.0	2.2	12	8.6	3.2	7
Cypraea tigris	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1
Diadema spp.	2.3	1.2	73	41.7	8.3	4	2.3	1.6	12	13.9	2.8	2
Echinometra mathaei	64.8	19.5	73	249.1	57.2	19	65.3	41.7	12	112.0	67.8	7
Echinothrix calamaris	0.7	0.5	73	25.0	8.3	2	0.7	0.7	12	8.3		1
Echinothrix diadema	7.8	3.3	73	63.0	19.6	9	7.8	6.9	12	31.3	26.0	3
Heterocentrotus mammillatus	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1
Hippopus hippopus	4.8	1.7	73	26.9	7.2	13	4.9	1.8	12	8.3	2.3	7
Holothuria atra	2.1	0.8	73	21.4	3.1	7	2.0	0.7	12	4.8	0.5	5
Holothuria edulis	0.5	0.3	73	16.7	0.0	2	0.5	0.5	12	5.6		1
Holothuria fuscogilva	1.1	0.6	73	20.8	4.2	4	1.2	0.5	12	3.5	0.7	4
Holothuria nobilis	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1
Hyotissa spp.	2.7	1.0	73	25.0	4.5	8	2.7	1.4	12	8.1	2.6	4
Lambis chiragra	0.5	0.3	73	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Lambis lambis	2.1	0.7	73	18.8	2.1	8	2.1	0.6	12	3.5	0.5	7
Lambis millepeda	0.9	0.4	73	16.7	0.0	4	0.9	0.5	12	3.6	1.0	3
Lambis scorpius	0.5	0.3	73	16.7	0.0	2	0.5	0.5	12	5.6		1
Linckia laevigata	27.4	6.3	73	62.5	11.9	32	27.5	7.8	12	30.0	8.1	11
Lopha cristagalli	1.1	0.8	73	27.8	11.1	3	1.2	0.9	12	6.9	4.2	2
Octopus cyanea	0.2	0.2	73	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.

4.3.2 Sideia 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
Ovula ovum	1.4	0.8	73	33.3	0.0	3	1.4	0.7	12	5.6	0.0	3
Panulirus spp.	1.6	1.0	73	29.2	12.5	4	1.6	0.9	12	4.9	2.1	4
Panulirus versicolor	0.7	0.4	73	16.7	0.0	3	0.7	0.3	12	2.6	0.1	3
Pinctada margaritifera	4.3	1.1	73	21.1	2.6	15	4.4	1.2	12	5.8	1.2	9
Spondylus spp.	2.7	1.1	73	25.0	6.3	8	2.8	1.4	12	5.6	2.3	6
Stichodactyla spp.	17.6	2.8	73	34.7	3.7	37	17.7	5.0	12	17.7	5.0	12
Strombus luhuanus	49.8	35.5	73	454.2	303.6	8	45.4	30.5	12	90.7	57.2	6
Synapta spp.	0.7	0.5	73	25.0	8.3	2	0.7	0.7	12	8.3		1
Tectus pyramis	3.2	1.2	73	23.3	5.1	10	3.1	1.1	12	5.3	1.4	7
Tectus spp.	0.5	0.5	73	33.3		1	0.5	0.5	12	5.6		1
Thelenota ananas	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1
Tridacna crocea	259.6	56.7	73	332.5	69.7	57	262.6	87.7	12	262.6	87.7	12
Tridacna derasa	0.5	0.3	73	16.7	0.0	2	0.4	0.3	12	2.6	0.2	2
Tridacna gigas	1.1	0.8	73	27.8	11.1	3	1.2	0.7	12	4.6	1.9	3
Tridacna maxima	30.6	4.1	73	44.7	4.8	50	30.6	6.8	12	33.3	6.7	11
Tridacna squamosa	4.3	1.5	73	26.4	5.6	12	4.3	1.7	12	7.4	2.3	7
Trochus niloticus	0.2	0.2	73	16.7		1	0.2	0.2	12	2.4		1
Turbo argyrostomus	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1
Turbo petholatus	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1
Vasum turbinellum	0.2	0.2	73	16.7		1	0.2	0.2	12	2.4		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 Sideia 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	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Actinopyga mauritiana	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
Bohadschia argus	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Bohadschia graeffei	6.3	3.6	120	250.0	0.0	3	6.3	4.6	20	62.5	20.8	2
Bohadschia vitiensis	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Cerithium nodulosum	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Chama spp.	12.5	5.8	120	300.0	50.0	5	12.5	5.3	20	50.0	8.3	5
Chicoreus spp.	6.3	6.3	120	750.0		1	6.3	6.3	20	125.0		1
Choriaster granulatus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus imperialis	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Conus leopardus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus litteratus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus marmoreus	10.4	4.6	120	250.0	0.0	5	10.4	5.1	20	52.1	10.4	4
Conus miles	12.5	7.2	120	375.0	125.0	4	12.5	6.8	20	62.5	20.8	4
Conus spp.	14.6	5.4	120	250.0	0.0	7	14.6	4.6	20	41.7	0.0	7
Conus textile	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus vexillum	16.7	5.7	120	250.0	0.0	8	16.7	7.0	20	66.7	10.2	5
Culcita novaeguineae	8.3	4.1	120	250.0	0.0	4	8.3	4.9	20	55.6	13.9	3
Cypraea annulus	18.8	7.9	120	375.0	55.9	6	18.8	8.3	20	75.0	15.6	5
Cypraea caputserpensis	8.3	6.6	120	500.0	250.0	2	8.3	8.3	20	166.7		1
Cypraea tigris	8.3	5.1	120	333.3	83.3	3	8.3	4.9	20	55.6	13.9	3
Diadema spp.	41.7	21.2	120	714.3	269.6	7	41.7	33.3	20	208.3	153.1	4
Echinometra mathaei	1368.8	243.3	120	1932.4	324.7	85	1368.8	414.7	20	1368.8	414.7	20
Echinothrix calamaris	18.8	6.7	120	281.3	31.3	8	18.8	9.3	20	75.0	24.3	5
Echinothrix diadema	79.2	24.8	120	593.8	126.8	16	79.2	43.4	20	263.9	118.7	6
Haliotis asinina	2.1	2.1	120	250.0		1	2.1	2.1	20	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 Sideia 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	29.2	9.0	120	318.2	35.2	11	29.2	10.9	20	83.3	18.2	7
Holothuria atra	39.6	11.1	120	365.4	36.0	13	39.6	12.3	20	88.0	16.2	9
Holothuria fuscogilva	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Holothuria nobilis	6.3	3.6	120	250.0	0.0	3	6.3	3.4	20	41.7	0.0	3
Lambis chiragra	10.4	5.5	120	312.5	62.5	4	10.4	8.5	20	104.2	62.5	2
Lambis crocata	6.3	3.6	120	250.0	0.0	3	6.3	3.4	20	41.7	0.0	3
Lambis lambis	20.8	7.0	120	277.8	27.8	9	20.8	6.4	20	52.1	6.8	8
Lambis millepeda	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Lambis scorpius	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Lambis truncata	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Latirolagena smaragdula	18.8	9.4	120	450.0	122.5	5	18.8	14.6	20	125.0	83.3	3
Linckia laevigata	168.8	36.7	120	547.3	93.3	37	168.8	70.3	20	259.6	100.4	13
Lysiosquillina maculata	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Panulirus spp.	14.6	6.8	120	350.0	61.2	5	14.6	6.3	20	58.3	10.2	5
Panulirus versicolor	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Pinctada margaritifera	10.4	4.6	120	250.0	0.0	5	10.4	5.1	20	52.1	10.4	4
Pleuroploca filamentosa	12.5	9.3	120	750.0	250.0	2	12.5	9.1	20	125.0	41.7	2
Pleuroploca spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Spondylus spp.	8.3	4.1	120	250.0	0.0	4	8.3	3.8	20	41.7	0.0	4
Stichodactyla spp.	39.6	11.5	120	339.3	49.8	14	39.6	12.6	20	88.0	17.6	9
Stichopus chloronotus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Strombus luhuanus	14.6	8.0	120	437.5	119.7	4	14.6	8.7	20	97.2	27.8	3
Tectus pyramis	37.5	9.2	120	281.3	21.3	16	37.5	11.3	20	75.0	15.0	10
Thais spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Thelenota anax	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Tridacna crocea	512.5	104.9	120	1464.3	239.4	42	512.5	194.1	20	640.6	232.8	16
Tridacna derasa	2.1	2.1	120	250.0		1	2.1	2.1	20	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 Sideia 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
Tridacna gigas	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Tridacna maxima	181.3	21.7	120	375.0	27.7	58	181.3	21.6	20	181.3	21.6	20
Tridacna squamosa	27.1	7.7	120	270.8	20.8	12	27.1	8.7	20	67.7	11.0	8
Trochus maculata	8.3	5.1	120	333.3	83.3	3	8.3	4.9	20	55.6	13.9	3
Trochus niloticus	16.7	6.4	120	285.7	35.7	7	16.7	7.6	20	66.7	16.7	5
Trochus spp.	10.4	4.6	120	250.0	0.0	5	10.4	4.1	20	41.7	0.0	5
Turbo argyrostomus	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Turbo chrysostomus	8.3	4.1	120	250.0	0.0	4	8.3	4.9	20	55.6	13.9	3
Turbo petholatus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Tutufa spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Vasum ceramicum	25.0	8.6	120	333.3	41.7	9	25.0	8.8	20	71.4	11.9	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.

4.3.4 Sideia 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
Bohadschia graeffei	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Chama spp.	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Culcita novaeguineae	2.9	1.6	24	23.5	0.0	3	2.9	1.9	4	5.9	2.0	2
Echinometra mathaei	39.2	17.6	24	156.9	44.5	6	39.2	16.7	4	52.3	14.7	3
Hippopus hippopus	2.9	1.6	24	23.5	0.0	3	2.9	1.9	4	5.9	2.0	2
Holothuria atra	6.9	3.0	24	32.9	5.8	5	6.9	5.6	4	13.7	9.8	2
Lambis chiragra	2.0	1.4	24	23.5	0.0	2	2.0	2.0	4	7.8		1
Lambis millepeda	2.0	2.0	24	47.1		1	2.0	2.0	4	7.8		1
Linckia laevigata	14.7	8.9	24	58.8	30.8	6	14.7	10.9	4	19.6	13.8	3
Panulirus spp.	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Panulirus versicolor	2.0	1.4	24	23.5	0.0	2	2.0	2.0	4	7.8		1
Pinctada margaritifera	2.9	2.2	24	35.3	11.8	2	2.9	2.9	4	11.8		1
Spondylus spp.	2.0	1.4	24	23.5	0.0	2	2.0	1.1	4	3.9	0.0	2
Stichodactyla spp.	4.9	2.0	24	23.5	0.0	5	4.9	2.5	4	6.5	2.6	3
Strombus luhuanus	3.9	3.9	24	94.1		1	3.9	3.9	4	15.7		1
Tectus pyramis	6.9	2.6	24	27.5	3.9	6	6.9	5.6	4	13.7	9.8	2
Tridacna crocea	5.9	3.2	24	35.3	11.8	4	5.9	4.7	4	11.8	7.8	2
Tridacna derasa	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Tridacna maxima	28.4	7.2	24	48.7	9.1	14	28.4	8.4	4	28.4	8.4	4
Turbo chrysostomus	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Vasum spp.	1.0	1.0	24	23.5		1	1.0	1.0	4	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.

4.3.5 Sideia mother-of-pearl search (MOPs) 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	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Bohadschia argus	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Bohadschia graeffei	3.8	2.6	24	45.5	0.0	2	3.8	3.8	4	15.2		1
Cerithium nodulosum	3.8	2.6	24	45.5	0.0	2	3.8	3.8	4	15.2		1
Conus spp.	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Conus vexillum	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Culcita novaeguineae	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Holothuria atra	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Holothuria edulis	5.7	5.7	24	136.4		1	5.7	5.7	4	22.7		1
Lambis lambis	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Lambis millepeda	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Lambis truncata	5.7	5.7	24	136.4		1	5.7	5.7	4	22.7		1
Panulirus spp.	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Panulirus versicolor	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Pinctada margaritifera	3.8	2.6	24	45.5	0.0	2	3.8	3.8	4	15.2		1
Stichodactyla spp.	20.8	7.7	24	71.4	13.5	7	20.8	7.2	4	27.8	2.5	3
Strombus luhuanus	34.1	19.6	24	272.7	52.5	3	34.1	34.1	4	136.4		1
Tectus pyramis	15.2	5.2	24	51.9	6.5	7	15.2	10.7	4	30.3	15.2	2
Thais spp.	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Thelenota anax	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Tridacna crocea	11.4	9.6	24	136.4	90.9	2	11.4	9.0	4	22.7	15.2	2
Tridacna derasa	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Tridacna maxima	26.5	12.2	24	90.9	31.4	7	26.5	17.1	4	35.4	20.7	3
Tridacna squamosa	3.8	3.8	24	90.9		1	3.8	3.8	4	15.2		1
Trochus niloticus	5.7	3.1	24	45.5	0.0	3	5.7	3.6	4	11.4	3.8	2
Trochus spp.	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Turbo chrysostomus	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Vasum ceramicum	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		1
Vasum spp.	1.9	1.9	24	45.5		1	1.9	1.9	4	7.6		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.

4.3.6 Sideia 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	1.2	0.7	36	14.3	0.0	3	1.2	0.8	6	3.6	1.2	2
Bohadschia graeffei	2.0	0.8	36	14.3	0.0	5	2.0	0.7	6	3.0	0.6	4
Culcita novaeguineae	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Holothuria atra	6.0	2.0	36	23.8	4.1	9	6.0	3.2	6	11.9	4.1	3
Holothuria edulis	2.4	0.9	36	14.3	0.0	6	2.4	0.9	6	3.6	0.7	4
Holothuria fuscogilva	9.1	2.4	36	23.5	3.5	14	9.1	4.1	6	9.1	4.1	6
Holothuria fuscopunctata	1.2	0.9	36	21.4	7.1	2	1.2	0.8	6	3.6	1.2	2
Holothuria leucospilota	1.2	0.9	36	21.4	7.1	2	1.2	1.2	6	7.1		1
Linckia laevigata	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Pinctada margaritifera	1.6	0.9	36	19.0	4.8	3	1.6	1.2	6	4.8	2.4	2
Spondylus spp.	1.2	0.7	36	14.3	0.0	3	1.2	0.8	6	3.6	1.2	2
Stichopus hermanni	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Strombus sinuatus	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Thelenota anax	7.9	3.1	36	28.6	8.5	10	7.9	6.1	6	15.9	11.2	3
Thelenota rubrolineata	4.0	1.5	36	20.4	2.9	7	4.0	2.7	6	7.9	4.4	3
Vasum ceramicum	1.2	1.2	36	42.9		1	1.2	1.2	6	7.1		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.

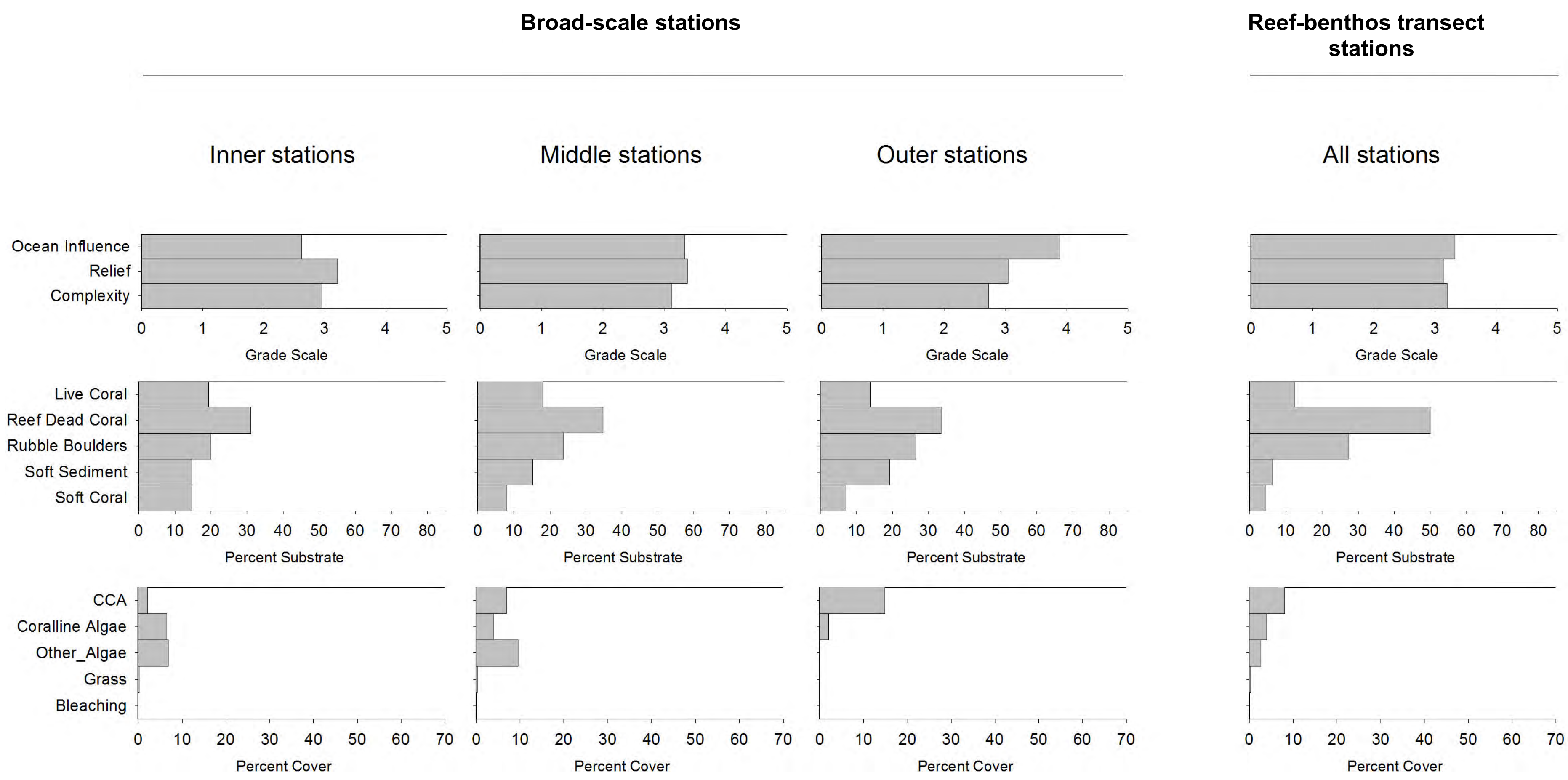
4.3.7 Sideia species size review – all survey methods

Species	Mean length (cm)	SE	n
Tridacna maxima	14.9	0.4	230
Tridacna crocea	8.5	0.2	167
Hippopus hippopus	18.7	1.1	36
Holothuria atra	28.4	1.7	31
Tridacna squamosa	22.7	1.3	31
Holothuria fuscogilva	32.0	1.4	30
Tectus pyramis	6.8	0.2	29
Pinctada margaritifera	13.6	0.5	26
Thelenota anax	52.3	2.9	19
Lambis lambis	15.3	0.4	14
Conus spp.	6.5	1.0	13
Trochus niloticus	9.0	0.8	12
Vasum ceramicum	8.6	0.3	11
Bohadschia argus	29.6	2.0	10
Thelenota rubrolineata	36.6	3.1	9
Conus vexillum	8.3	0.5	9
Lambis chiragra	20.3	0.8	8
Tridacna gigas	64.2	15.6	6
Bohadschia graeffei	34.5	2.3	6
Conus miles	5.5	0.4	6
Strombus luhuanus	4.8	0.2	6
Trochus spp.	4.2	0.2	6
Tridacna derasa	20.1	3.9	5
Lambis millepeda	16.2	0.9	5
Pleuroploca filamentosa	8.3	0.6	5
Conus marmoreus	7.2	0.4	5
Holothuria nobilis	21.8	2.9	4
Cerithium nodulosum	8.8	0.3	4
Latirolagena smaragdula	4.5	0.2	4
Panulirus versicolor	5.0	1.5	3
Lambis crocata	13.7	0.9	3
Cypraea tigris	8.4	0.6	3
Chicoreus spp.	6.0	0.1	3
Vasum spp.	4.7	1.9	2
Lambis truncata	26.5	1.5	2
Turbo argyrostomus	3.7	0.9	2
Spondylus spp.	11.0	0.0	2
Panulirus spp.	12.0	0.0	2
Actinopyga mauritiana	19.0		1
Bohadschia vitiensis	25.0		1
Holothuria edulis	38.0		1
Holothuria fuscopunctata	29.0		1
Holothuria leucospilota	28.0		1
Stichopus chloronotus	13.0		1
Stichopus hermanni	43.0		1
Thelenota ananas	20.0		1
Conus imperialis	5.6		1

4.3.7 Sideia species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Conus leopardus	8.1		1
Conus litteratus	8.1		1
Conus textile	4.5		1
Haliotis asinina	6.1		1
Lambis scorpius	17.0		1
Pleuroploca spp.	9.1		1
Trochus maculata	4.0		1
Turbo chrysostomus	3.8		1
Turbo petholatus	6.2		1
Tutufa spp.	5.1		1
Vasum turbinellum	7.5		1

4.3.8 Habitat descriptors for independent assessment – Sideia



4.4 Panapompom invertebrate survey data

4.4.1 Invertebrate species recorded in different assessments in Panapompom

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga caerulea*				+
Bêche-de-mer	*Actinopyga lecanora*		+		+
Bêche-de-mer	*Actinopyga mauritiana*				+
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Bohadschia graeffei*				+
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 chloronotus*	+			
Bêche-de-mer	*Stichopus pseudhorrens*				+
Bêche-de-mer	*Synapta* spp.	+	+		+
Bêche-de-mer	*Thelenota ananas*		+		+
Bêche-de-mer	*Thelenota anax*				+
Bivalve	*Atrina vexillum*	+	+		+
Bivalve	*Chama* spp.	+	+		+
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Hyotissa* spp.		+		
Bivalve	*Lopha cristagalli*	+	+		+
Bivalve	*Pinctada margaritifera*	+	+		+
Bivalve	*Pinna bicolor*		+		
Bivalve	*Pteria penguin*				+
Bivalve	*Spondylus* spp.	+	+		+
Bivalve	*Tridacna crocea*	+	+		
Bivalve	*Tridacna derasa*	+	+		
Bivalve	*Tridacna gigas*	+			
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*		+		+
Cnidarians	*Stichodactyla* spp.	+	+		+
Crustacean	*Lysiosquillina maculata*	+			
Crustacean	*Panulirus* spp.	+	+		+
Crustacean	*Panulirus versicolor*		+		+
Crustacean	*Parribacus caledonicus*				+
Gastropod	*Astralium* spp.		+		+
Gastropod	*Cassis cornuta*				+
Gastropod	*Cerithium nodulosum*		+		
Gastropod	*Chicoreus* spp.		+		+
Gastropod	*Conus ebraeus*		+		
Gastropod	*Conus marmoreus*		+		
Gastropod	*Conus miles*		+		+
Gastropod	*Conus* spp.	+	+		+
Gastropod	*Conus vexillum*		+		+
Gastropod	*Cypraea annulus*		+		

+ = presence of the species.

4.4.1 Invertebrate species recorded in different assessments in Panapompom (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Cypraea caputserpensis*		+		+
Gastropod	*Cypraea moneta*		+		+
Gastropod	*Cypraea tigris*	+	+		
Gastropod	*Drupa* spp.		+		+
Gastropod	*Lambis chiragra*	+	+		+
Gastropod	*Lambis crocata*		+		
Gastropod	*Lambis lambis*	+	+		
Gastropod	*Lambis millepeda*	+			+
Gastropod	*Lambis* spp.	+			
Gastropod	*Lambis truncata*	+			+
Gastropod	*Latirolagena smaragdula*		+		+
Gastropod	*Ovula ovum*	+	+		
Gastropod	*Pleuroploca filamentosa*		+		+
Gastropod	*Pleuroploca* spp.				+
Gastropod	*Strombus luhuanus*	+	+		
Gastropod	*Tectus conus*		+		
Gastropod	*Tectus pyramis*	+	+		+
Gastropod	*Tectus* spp.	+			+
Gastropod	*Thais armigera*				+
Gastropod	*Thais* spp.	+	+		+
Gastropod	*Trochus maculata*		+		+
Gastropod	*Trochus niloticus*	+			+
Gastropod	*Trochus* spp.		+		+
Gastropod	*Turbo argyrostomus*	+	+		+
Gastropod	*Turbo chrysostomus*		+		+
Gastropod	*Turbo petholatus*		+		+
Gastropod	*Vasum ceramicum*		+		+
Gastropod	*Vasum* spp.	+			
Gastropod	*Vasum turbinellum*		+		+
Octopus	*Octopus* spp.		+		
Star	*Acanthaster planci*	+			+
Star	*Choriaster granulatus*	+			+
Star	*Culcita novaeguineae*	+	+		+
Star	*Linckia laevigata*	+	+		+
Star	*Protoreaster nodosus*				+
Urchin	*Diadema* spp.	+	+		+
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix calamaris*		+		+
Urchin	*Echinothrix diadema*	+	+		+
Urchin	*Heterocentrotus mammillatus*		+		+
Urchin	*Tripneustes gratilla*	+			

+ = presence of the species.

4.4.2 Panapompom 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	81	16.7		1	0.2	0.2	14	2.8		1
Atrina vexillum	0.8	0.4	81	16.7	0.0	4	0.8	0.5	14	3.7	0.9	3
Bohadschia argus	0.6	0.4	81	16.7	0.0	3	0.6	0.3	14	2.8	0.0	3
Bohadschia vitiensis	0.2	0.2	81	16.7		1	0.2	0.2	14	2.8		1
Chama spp.	1.6	0.6	81	16.7	0.0	8	1.6	0.5	14	3.2	0.4	7
Choriaster granulatus	0.2	0.2	81	16.7		1	0.2	0.2	14	2.8		1
Conus spp.	8.2	1.7	81	30.3	2.8	22	7.9	2.3	14	11.1	2.7	10
Culcita novaeguineae	1.6	0.7	81	22.2	3.5	6	1.6	0.6	14	4.4	0.7	5
Cypraea tigris	0.6	0.4	81	16.7	0.0	3	0.6	0.4	14	4.2	1.4	2
Diadema spp.	9.3	5.3	81	62.5	32.8	12	8.9	6.5	14	25.0	16.9	5
Echinometra mathaei	370.0	155.7	81	696.9	285.6	43	356.7	176.9	14	454.0	217.6	11
Echinothrix diadema	66.0	29.6	81	232.6	97.4	23	63.7	50.8	14	127.4	99.1	7
Hippopus hippopus	4.3	1.8	81	31.8	10.4	11	4.2	2.1	14	8.3	3.6	7
Holothuria atra	1.4	0.9	81	29.2	12.5	4	1.4	0.8	14	4.9	2.1	4
Holothuria nobilis	0.6	0.4	81	16.7	0.0	3	0.6	0.4	14	4.2	1.4	2
Lambis chiragra	0.8	0.4	81	16.7	0.0	4	1.0	0.5	14	3.5	0.7	4
Lambis lambis	9.7	1.9	81	30.1	3.5	26	9.3	2.5	14	13.1	2.6	10
Lambis millepeda	0.2	0.2	81	16.7		1	0.2	0.2	14	2.8		1
Lambis spp.	0.2	0.2	81	16.7		1	0.2	0.2	14	2.8		1
Lambis truncata	0.4	0.4	81	33.3		1	0.4	0.4	14	5.6		1
Linckia laevigata	43.0	7.4	81	72.6	10.5	48	44.0	8.1	14	47.4	8.0	13
Lopha cristagalli	1.0	0.7	81	27.8	11.1	3	1.2	0.7	14	5.6	1.6	3
Lysiosquillina maculata	0.2	0.2	81	16.7		1	0.2	0.2	14	2.8		1
Ovula ovum	0.6	0.5	81	25.0	8.3	2	0.6	0.6	14	8.3		1
Panulirus spp.	1.9	0.7	81	21.4	3.1	7	1.8	0.9	14	5.0	1.6	5
Pinctada margaritifera	3.3	0.9	81	20.5	2.0	13	3.2	1.3	14	7.4	2.0	6
Spondylus spp.	4.7	0.9	81	18.3	1.1	21	5.0	1.1	14	5.8	1.1	12

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 Panapompom 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 spp.	19.8	3.5	81	42.1	5.6	38	19.2	5.8	14	19.2	5.8	14
Stichopus chloronotus	0.2	0.2	81	16.7		1	0.2	0.2	14	2.8		1
Strombus luhuanus	364.0	226.0	81	1842.7	1094.0	16	351.6	219.7	14	615.3	365.7	8
Synapta spp.	1.2	0.6	81	20.0	3.3	5	1.2	0.7	14	5.6	1.6	3
Tectus pyramis	6.2	1.4	81	26.3	2.6	19	6.0	2.2	14	9.3	2.8	9
Tectus spp.	0.6	0.5	81	25.0	8.3	2	1.2	1.2	14	16.7		1
Thais spp.	1.0	0.7	81	41.7	8.3	2	1.0	1.0	14	13.9		1
Tridacna crocea	21.4	10.5	81	115.6	51.1	15	20.8	16.8	14	41.7	32.9	7
Tridacna derasa	1.6	1.3	81	44.4	27.8	3	1.6	1.2	14	7.4	4.6	3
Tridacna gigas	0.4	0.3	81	16.7	0.0	2	0.4	0.3	14	2.8	0.0	2
Tridacna maxima	51.9	9.7	81	76.4	13.1	55	53.4	15.6	14	53.4	15.6	14
Tripneustes gratilla	200.0	139.9	81	2700.0	1 697.0	6	192.9	189.2	14	675.0	659.3	4
Trochus niloticus	1.0	0.5	81	20.8	4.2	4	1.0	0.6	14	4.6	1.9	3
Turbo argyrostomus	0.4	0.3	81	16.7	0.0	2	0.4	0.3	14	2.8	0.0	2
Vasum spp.	0.6	0.4	81	16.7	0.0	3	0.6	0.6	14	8.3		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 Panapompom 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
Actinopyga lecanora	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7	20.8	4
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
Bohadschia argus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7	72.2	3
Bohadschia vitiensis	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3	38.3	6
Cerithium nodulosum	8.3	4.1	120	250.0	0.0	4	8.3	3.8	20	41.7	0.0	2
Chama spp.	20.8	7.0	120	277.8	27.8	9	20.8	6.4	20	52.1	0.0	2
Chicoreus spp.	12.5	5.8	120	300.0	50.0	5	12.5	5.3	20	50.0	15.7	7
Conus ebraeus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus marmoreus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7	0.0	2
Conus miles	8.3	4.1	120	250.0	0.0	4	8.3	3.8	20	41.7	62.2	8
Conus spp.	41.7	10.4	120	294.1	32.1	17	41.7	12.1	20	75.8	178.3	9
Conus vexillum	10.4	6.2	120	416.7	83.3	3	10.4	6.0	20	69.4	13.9	3
Culcita novaeguineae	33.3	10.6	120	307.7	57.7	13	33.3	13.0	20	74.1	265.0	3
Cypraea annulus	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	100.5	8
Cypraea caputserpensis	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	2514.4	4
Cypraea moneta	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7	118.9	5
Cypraea tigris	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7	0.0	3
Diadema spp.	4.2	4.2	120	500.0		1	4.2	4.2	20	83.3	583.3	2
Drupa spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Echinometra mathaei	687.5	96.6	120	1100.0	133.7	75	687.5	184.6	20	763.9		1
Echinothrix calamaris	6.3	3.6	120	250.0	0.0	3	6.3	3.4	20	41.7	56.4	15
Echinothrix diadema	12.5	5.8	120	300.0	50.0	5	12.5	8.6	20	83.3		1
Heterocentrotus mammillatus	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Hippopus hippopus	35.4	9.0	120	283.3	22.7	15	35.4	16.9	20	88.5	20.8	2
Holothuria atra	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7	0.0	2
Holothuria edulis	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Hyotissa spp.	6.3	6.3	120	750.0		1	6.3	6.3	20	125.0		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 Panapompom 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
Lambis chiragra	10.4	4.6	120	250.0	0.0	5	10.4	6.7	20	69.4	27.8	3
Lambis crocata	6.3	3.6	120	250.0	0.0	3	6.3	3.4	20	41.7	0.0	3
Lambis lambis	6.3	4.6	120	375.0	125.0	2	6.3	4.6	20	62.5	20.8	2
Latirolagena smaragdula	64.6	22.2	120	553.6	134.1	14	64.6	32.6	20	184.5	77.1	7
Linckia laevigata	177.1	34.2	120	590.3	79.2	36	177.1	69.6	20	253.0	93.0	14
Lopha cristagalli	41.7	37.6	120	1666.7	1416.7	3	41.7	37.4	20	277.8	236.1	3
Octopus spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Ovula ovum	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Panulirus spp.	10.4	8.6	120	625.0	375.0	2	10.4	8.5	20	104.2	62.5	2
Panulirus versicolor	10.4	5.5	120	312.5	62.5	4	10.4	5.1	20	52.1	10.4	4
Pinctada margaritifera	31.3	11.3	120	416.7	72.2	9	31.3	14.1	20	125.0	29.5	5
Pinna bicolor	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Pleuroploca filamentosa	4.2	4.2	120	500.0		1	4.2	4.2	20	83.3		1
Spondylus spp.	10.4	4.6	120	250.0	0.0	5	10.4	4.1	20	41.7	0.0	5
Stichodactyla spp.	52.1	15.1	120	390.6	68.3	16	52.1	19.1	20	115.7	31.7	9
Strombus luhuanus	83.3	60.9	120	1111.1	769.5	9	83.3	60.7	20	333.3	221.7	5
Synapta spp.	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Tectus conus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Tectus pyramis	112.5	16.7	120	346.2	23.6	39	112.5	21.8	20	150.0	21.4	15
Thais spp.	12.5	7.2	120	375.0	125.0	4	12.5	6.8	20	62.5	20.8	4
Thelenota ananas	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Tridacna crocea	25.0	10.0	120	333.3	83.3	9	25.0	14.6	20	125.0	51.0	4
Tridacna derasa	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Tridacna maxima	572.9	50.2	120	747.3	53.6	92	572.9	80.1	20	572.9	80.1	20
Tridacna squamosa	8.3	5.1	120	333.3	83.3	3	8.3	4.9	20	55.6	13.9	3
Trochus maculata	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Trochus spp.	8.3	4.1	120	250.0	0.0	4	8.3	3.8	20	41.7	0.0	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.

4.4.3 Panapompom 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 argyrostomus	6.3	3.6	120	250.0	0.0	3	6.3	3.4	20	41.7	0.0	3
Turbo chrysostomus	14.6	5.4	120	250.0	0.0	7	14.6	6.3	20	58.3	10.2	5
Turbo petholatus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Vasum ceramicum	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Vasum turbinellum	12.5	5.8	120	300.0	50.0	5	12.5	7.5	20	83.3	24.1	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.

4.4.4 Panapompom 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	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Actinopyga lecanora	2.2	1.4	54	39.2	15.7	3	2.2	1.7	9	9.8	5.9	2
Actinopyga mauritiana	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Archaster spp.	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Atrina vexillum	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Bohadschia graeffei	3.1	1.4	54	32.9	5.8	5	3.1	2.0	9	13.7	2.0	2
Chama spp.	1.7	1.1	54	31.4	7.8	3	1.7	1.2	9	7.8	0.0	2
Chicoreus spp.	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Conus miles	2.2	1.3	54	39.2	7.8	3	2.2	1.2	9	6.5	1.3	3
Conus spp.	25.3	7.2	54	80.3	16.3	17	25.3	9.9	9	37.9	11.9	6
Conus vexillum	0.9	0.6	54	23.5	0.0	2	0.9	0.6	9	3.9	0.0	2
Culcita novaeguineae	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Cypraea caputserpensis	4.4	2.0	54	39.2	9.9	6	4.4	2.0	9	9.8	2.5	4
Cypraea moneta	2.6	2.2	54	70.6	47.1	2	2.6	2.2	9	11.8	7.8	2
Drupa spp.	3.9	2.0	54	52.9	11.3	4	3.9	2.8	9	17.6	5.9	2
Echinometra mathaei	7.0	3.8	54	53.8	23.4	7	7.0	3.4	9	12.5	5.0	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.

4.4.4 Panapompom 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
Heterocentrotus mammillatus	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Lambis chiragra	1.3	1.0	54	35.3	11.8	2	1.3	1.3	9	11.8		1
Latirolagena smaragdula	61.4	11.9	54	138.2	16.6	24	61.4	23.0	9	79.0	25.9	7
Linckia laevigata	5.7	4.4	54	76.5	52.9	4	5.7	4.2	9	12.7	8.8	4
Panulirus spp.	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Panulirus versicolor	2.6	1.6	54	47.1	13.6	3	2.6	1.5	9	7.8	2.3	3
Pinctada margaritifera	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Pleuroploca filamentosa	2.6	1.2	54	28.2	4.7	5	2.6	1.7	9	7.8	3.9	3
Pleuroploca spp.	5.7	2.4	54	43.7	10.8	7	5.7	3.3	9	17.0	5.7	3
Stichodactyla spp.	18.3	4.0	54	41.2	6.4	24	18.3	4.5	9	20.6	4.4	8
Tectus pyramis	5.7	1.9	54	30.6	5.0	10	5.7	1.9	9	8.5	1.9	6
Tectus spp.	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Thais armigera	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Thais spp.	29.6	7.2	54	80.0	13.3	20	29.6	14.3	9	38.1	17.3	7
Tridacna maxima	40.5	6.9	54	64.4	8.7	34	40.5	10.9	9	40.5	10.9	9
Tridacna squamosa	0.9	0.6	54	23.5	0.0	2	0.9	0.6	9	3.9	0.0	2
Trochus maculata	0.9	0.6	54	23.5	0.0	2	0.9	0.6	9	3.9	0.0	2
Trochus niloticus	3.1	1.7	54	41.2	11.3	4	3.1	1.4	9	6.9	1.9	4
Trochus spp.	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Turbo argyrostomus	18.3	3.7	54	41.2	5.3	24	18.3	6.7	9	23.5	7.5	7
Turbo chrysostomus	4.4	1.7	54	29.4	5.9	8	4.4	2.3	9	9.8	3.8	4
Turbo petholatus	0.4	0.4	54	23.5		1	0.4	0.4	9	3.9		1
Vasum ceramicum	5.7	2.1	54	34.0	8.0	9	5.7	3.4	9	12.7	6.3	4
Vasum turbinellum	0.4	0.4	54	23.5		1	0.4	0.4	9	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.

4.4.5 Panapompom mother-of-pearl search (MOPs) 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	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Astralium spp.	3.8	2.8	36	68.2	22.7	2	3.8	2.6	6	11.4	3.8	2
Bohadschia graeffei	7.6	3.4	36	54.5	9.1	5	7.6	3.9	6	15.2	4.4	3
Chama spp.	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Chicoreus spp.	2.5	1.8	36	45.5	0.0	2	2.5	1.6	6	7.6	0.0	2
Conus spp.	2.5	1.8	36	45.5	0.0	2	2.5	1.6	6	7.6	0.0	2
Cypraea caputserpensis	2.5	2.5	36	90.9		1	2.5	2.5	6	15.2		1
Drupa spp.	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Echinometra mathaei	6.3	4.5	36	113.6	22.7	2	6.3	6.3	6	37.9		1
Lambis millepeda	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Lambis truncata	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Panulirus spp.	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Pinctada margaritifera	2.5	1.8	36	45.5	0.0	2	2.5	1.6	6	7.6	0.0	2
Pleuroploca filamentosa	5.1	2.4	36	45.5	0.0	4	5.1	3.7	6	15.2	7.6	2
Spondylus spp.	5.1	3.0	36	60.6	15.2	3	5.1	2.5	6	10.1	2.5	3
Stichodactyla spp.	26.5	6.9	36	63.6	10.7	15	26.5	5.8	6	26.5	5.8	6
Tectus pyramis	3.8	2.8	36	68.2	22.7	2	3.8	2.6	6	11.4	3.8	2
Thais spp.	6.3	3.7	36	75.8	15.2	3	6.3	5.0	6	18.9	11.4	2
Thelenota ananas	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Thelenota anax	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Tridacna maxima	125.0	31.0	36	195.7	42.0	23	125.0	46.2	6	150.0	47.6	5
Tridacna squamosa	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Trochus maculata	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Trochus niloticus	3.8	2.1	36	45.5	0.0	3	3.8	2.6	6	11.4	3.8	2
Turbo argyrostomus	2.5	1.8	36	45.5	0.0	2	2.5	1.6	6	7.6	0.0	2
Turbo chrysostomus	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		1
Vasum ceramicum	1.3	1.3	36	45.5		1	1.3	1.3	6	7.6		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.

4.4.6 Panapompom 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
Actinopyga mauritiana	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Diadema spp.	44.4	28.5	12	177.8	77.5	3	44.4	35.6	2	44.4	35.6	2
Echinothrix calamaris	373.3	232.0	12	1120.0	559.8	4	373.3	364.4	2	373.3	364.4	2
Echinothrix diadema	2697.8	1001.3	12	2697.8	1001.3	12	2697.8	2546.7	2	2697.8	2546.7	2
Holothuria atra	13.3	9.6	12	80.0	26.7	2	13.3	13.3	2	26.7		1
Holothuria nobilis	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1
Panulirus spp.	13.3	9.6	12	80.0	26.7	2	13.3	13.3	2	26.7		1
Panulirus versicolor	13.3	13.3	12	160.0		1	13.3	13.3	2	26.7		1
Parribacus caledonicus	8.9	6.0	12	53.3	0.0	2	8.9	0.0	2	8.9	0.0	2
Synapta spp.	26.7	13.9	12	80.0	26.7	4	26.7	17.8	2	26.7	17.8	2
Trochus niloticus	13.3	7.0	12	53.3	0.0	3	13.3	4.4	2	13.3	4.4	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.

4.4.7 Panapompom 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	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Actinopyga caerulea	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Bohadschia argus	0.7	0.5	42	14.3	0.0	2	0.7	0.4	7	2.4	0.0	2
Cassis cornuta	0.7	0.5	42	14.3	0.0	2	0.7	0.7	7	4.8		1
Chama spp.	1.0	0.8	42	21.4	7.1	2	1.0	0.7	7	3.6	1.2	2
Choriaster granulatus	2.0	0.9	42	17.1	2.9	5	2.0	1.0	7	4.8	0.0	3
Culcita novaeguineae	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Holothuria fuscogilva	11.6	3.5	42	37.4	7.5	13	11.6	6.1	7	20.2	8.5	4
Holothuria fuscopunctata	1.0	0.6	42	14.3	0.0	3	1.0	0.5	7	2.4	0.0	3
Lopha cristagalli	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Panulirus spp.	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Protoreaster nodosus	1.4	1.0	42	28.6	0.0	2	1.4	1.4	7	9.5		1
Pteria penguin	1.4	1.4	42	57.1		1	1.4	1.4	7	9.5		1
Stichodactyla spp.	1.7	0.9	42	17.9	3.6	4	1.7	0.9	7	4.0	0.8	3
Stichopus pseudhorrens	0.7	0.7	42	28.6		1	0.7	0.7	7	4.8		1
Thelenota anax	1.4	0.8	42	19.0	4.8	3	1.4	0.7	7	3.2	0.8	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.

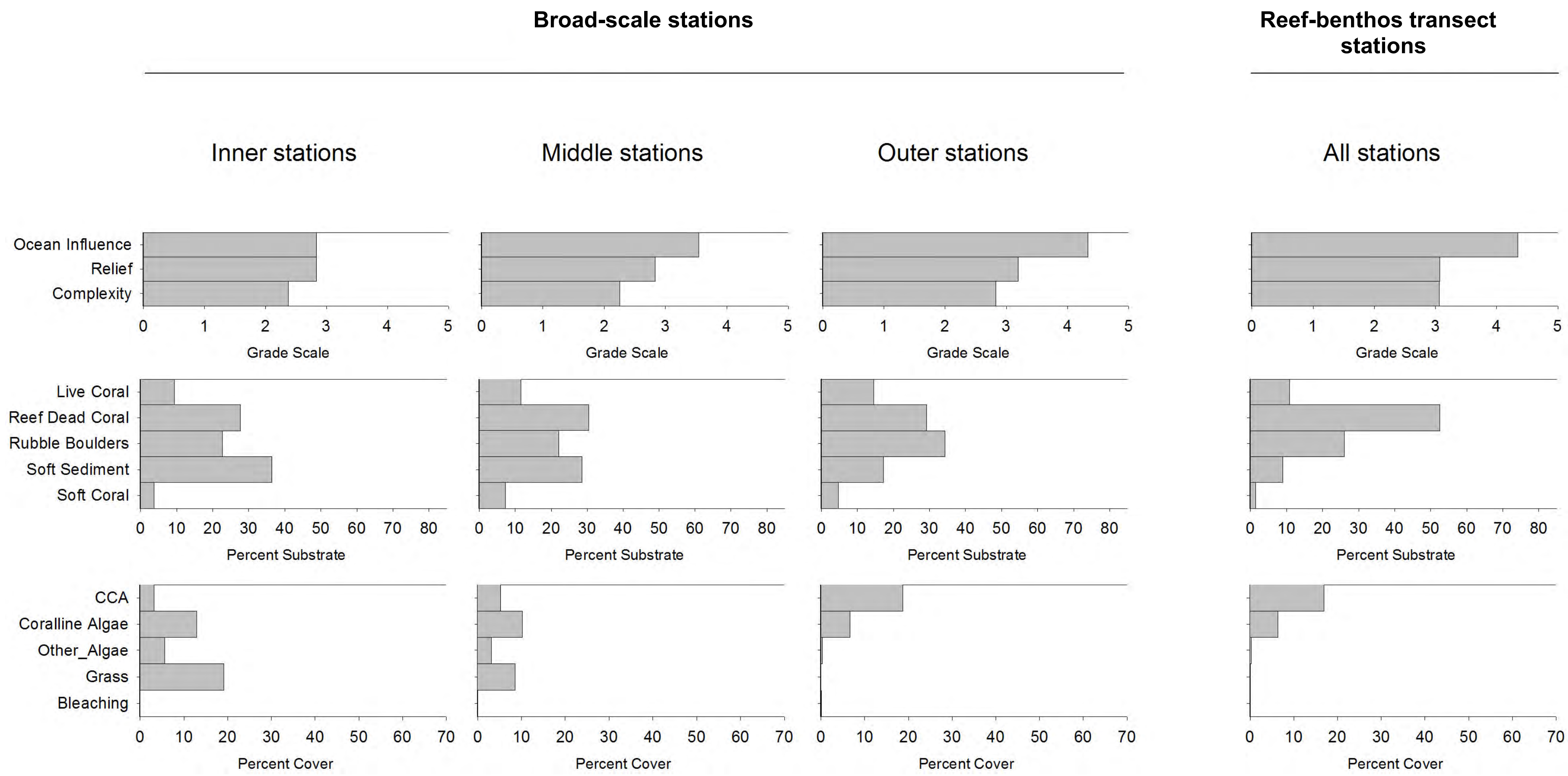
4.4.8 Panapompom species size review – all survey methods

Species	Mean length (cm)	SE	n
Tridacna maxima	14.0	0.3	532
Tectus pyramis	6.2	0.1	64
Conus spp.	8.0	0.5	37
Holothuria fuscogilva	36.4	0.4	35
Pinctada margaritifera	14.0	0.5	30
Hippopus hippopus	14.1	0.6	28
Tridacna crocea	9.5	0.8	19
Turbo argyrostomus	6.8	0.1	15
Trochus niloticus	10.2	0.5	13
Chicoreus spp.	8.5	1.6	8
Lambis chiragra	16.3	1.8	6
Pleuroploca filamentosa	9.7	1.3	6
Conus vexillum	9.2	1.0	6
Vasum turbinellum	5.9	0.5	6
Turbo chrysostomus	4.6	0.4	6
Thelenota anax	53.8	4.1	5
Tridacna squamosa	20.1	2.5	5
Bohadschia argus	28.2	2.1	5
Vasum ceramicum	8.9	1.4	5
Trochus spp.	3.7	0.4	5
Conus miles	4.8	0.3	5
Strombus luhuanus	5.2	0.2	5
Holothuria nobilis	25.3	4.3	4
Pleuroploca spp.	10.3	2.0	4
Holothuria fuscopunctata	40.5	1.6	4
Cerithium nodulosum	9.3	0.1	4
Holothuria atra	27.3	4.7	3
Actinopyga mauritiana	24.7	1.8	3
Lambis lambis	15.7	1.2	3
Lambis crocata	14.0	0.8	3
Tridacna gigas	72.5	32.5	2
Thelenota ananas	44.0	11.0	2
Bohadschia vitiensis	25.0	5.0	2
Chama spp.	6.4	2.6	2
Stichopus pseudhorrens	39.0	1.0	2
Parribacus caledonicus	18.5	0.5	2
Astralium spp.	3.0	0.5	2
Tridacna derasa	28.0	0.0	2
Actinopyga caerulea	28.0		1
Actinopyga lecanora	17.0		1
Bohadschia graeffei	26.0		1
Holothuria edulis	28.0		1
Stichopus chloronotus	30.0		1
Pinna bicolor	18.0		1
Cassis cornuta	27.0		1
Conus marmoreus	6.4		1
Lambis millepeda	17.0		1
Lambis truncata	25.0		1

4.4.8 Panapompom species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Latirolagena smaragdula	4.2		1
Ovula ovum	9.6		1
Tectus conus	4.5		1
Tectus spp.	7.1		1
Thais armigera	5.5		1
Turbo petholatus	5.5		1
Tripneustes gratilla	9.0		1

4.4.9 Habitat descriptors for independent assessment – Panapompom



4.5 Trochus and bêche-de-mer management

4.5.1 Trochus management sheet

Information for consideration when making decisions regarding the harvesting of trochus

Trochus is a relatively slow growing, locally recruiting commercial gastropod. There is value in protecting the smaller and largest individuals from fishing. In some trochus fisheries small and large size limits are in place ('gauntlet' style fishery[4]) to protect young shells which have not had sufficient time to spawn or produce valuable weight of nacre. The oldest shells, which have the greatest potential of producing the next generation (largest egg producers), and are often of low value due to infection by boring sponge (*Cliona* sp., 'rotten top'), are also protected. Studies have shown that trochus between 70 and 110 mm diameter show little increase in fecundity (related to number of eggs in gonad), but there is a markedly greater increase in egg production for large trochus. Trochus over 125 mm provide by far the largest supply, often double the amount produced by trochus just 10–20 mm smaller.

In successful trochus fisheries in the Pacific, stocks are allowed to reach densities of 500–600 individuals per hectare before pulse harvest commences. These pulse harvests on healthy stock seek to remove a portion of the legal stock (See notes above.), at a rate not exceeding 60 per cent of the egg production capability. Although this is hard to calculate and relies on adaptive management techniques, harvests are usually spread throughout the stock, and approximately 30 per cent of the total legally fishable stock is taken (less than 3 in 10 from a stock at good densities). This 30 per cent is a rough, 'ballpark' figure.

[4] A minimum-size limit of 80 mm and maximum-size limit of 125 mm applies to trochus fishing in the Torres Strait Trochus Fishery.

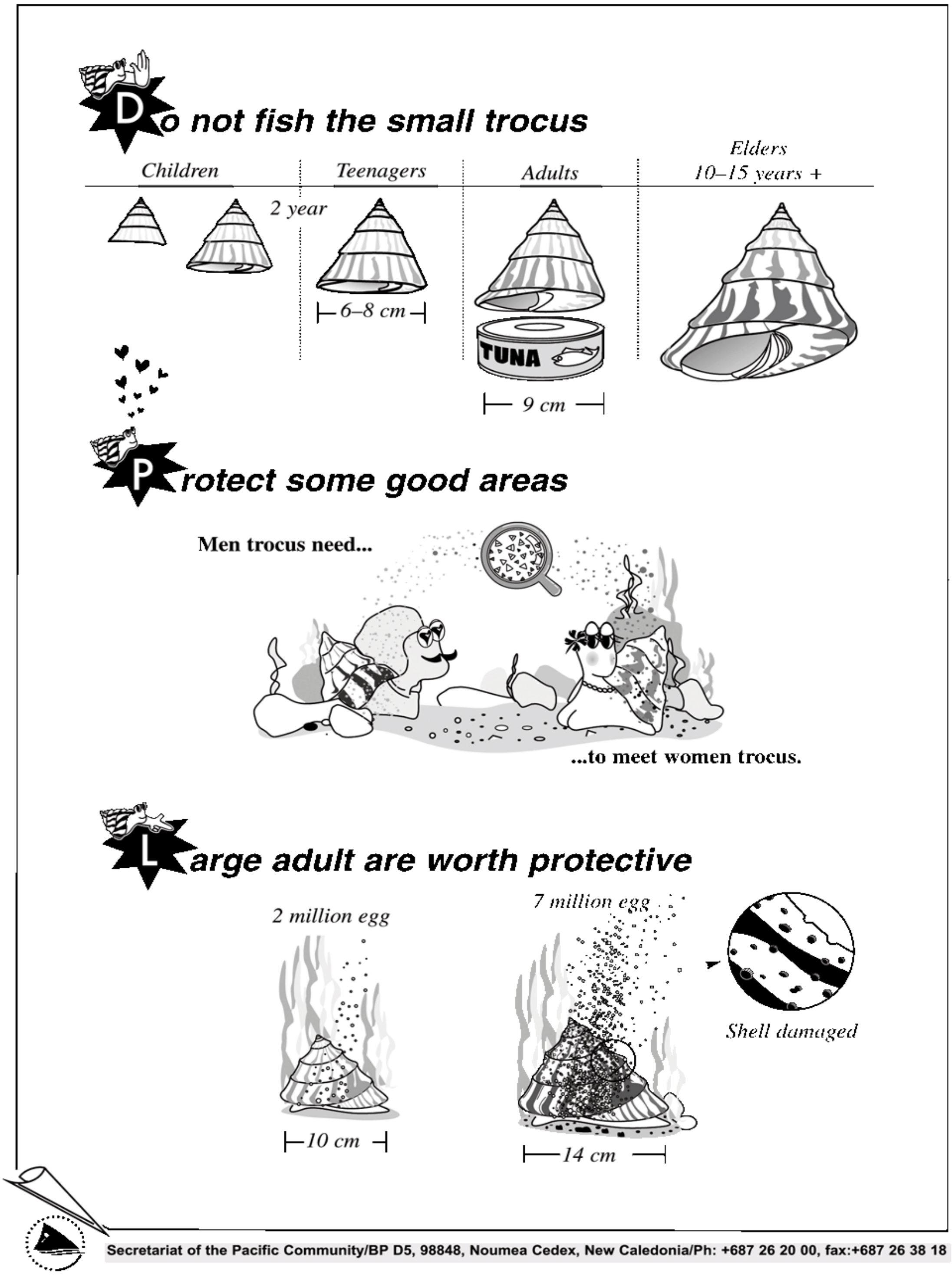


Figure 4.5.1-1: Small flyer made up for potential release with report.
Drawings prepared by Youngmi Choi in consultation with K. Friedman.

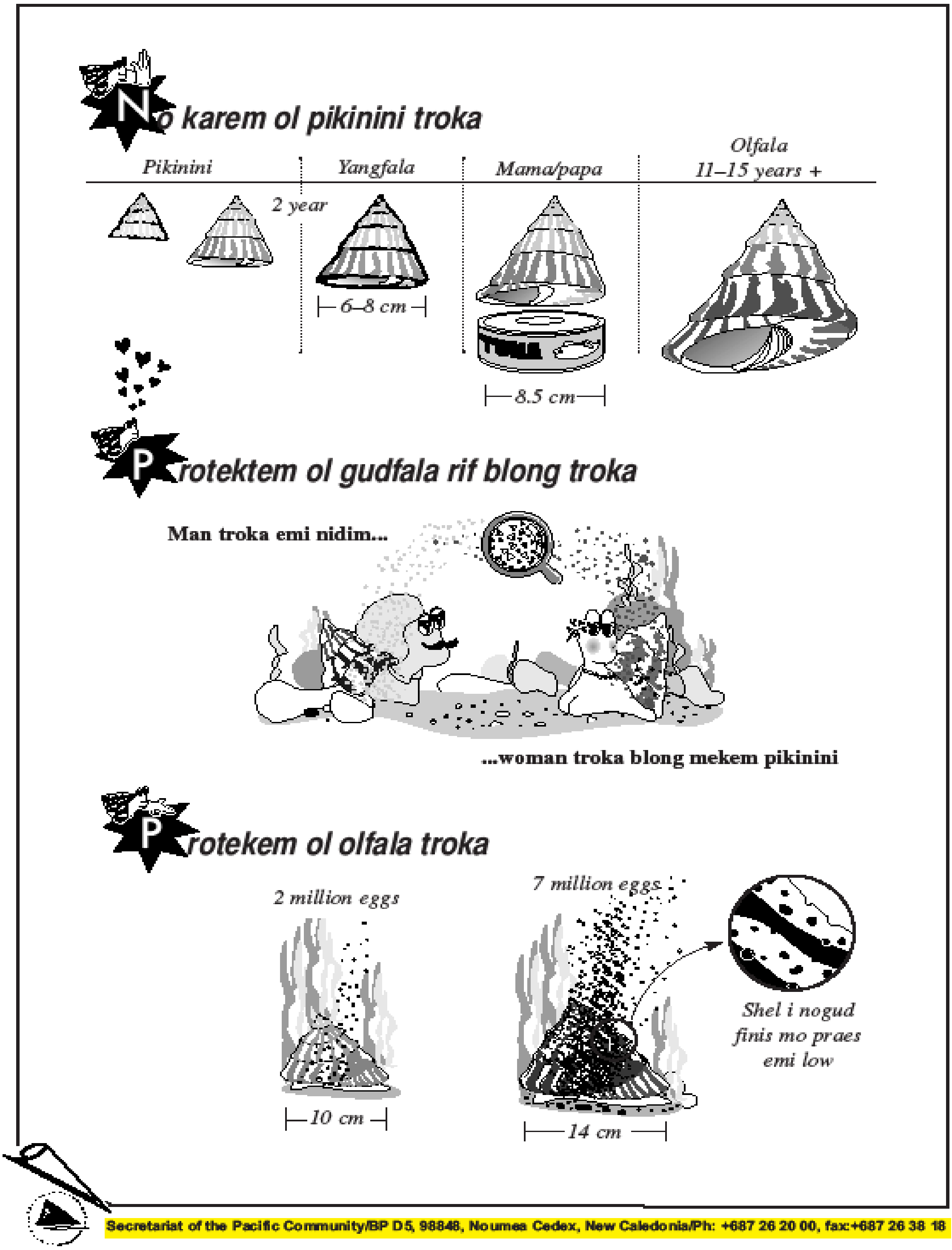


Figure 4.5.1-2: Small flyer made up for potential release with report.
Drawings prepared by Youngmi Choi in consultation with K. Friedman. Bishlama translation by K. Pakoa.

4.5.2 Bêche-de-mer management sheet

A range of measures can be used in combination to establish a management regime for the bêche-de-mer fishery. Specific management measures will depend on local circumstances, status of target species, and the capacity of the fishery division for monitoring and enforcement.

Input Controls

- **Limiting the number of fishers:** This is not generally recommended, both on the grounds of equity and due to enforcement difficulties.

- **Limiting the types of fishing gear used:** Restricting fishing techniques to low-technology methods that do not require capital investment in order to enter the industry or compete are recommended. The introduction of scuba gear, hookahs, or other types of underwater breathing equipment is not recommended. In addition to the very high risk of disability or death to divers (already experienced in some Pacific Island countries), management plans would need to be radically altered and strictly enforced to ensure the sustainability of the fishery. In the absence of such equipment, depth acts as a surrogate reserve for some high-value species.

- **Specific legislation:** The Government could specifically legislate against or otherwise prevent or discourage the use of various gear [underwater breathing apparatus, etc.]. Legislation will likely be required to support arrangements and allow effective enforcement of arrangements stipulated in the management plan that are needed to support sustainability in the fishery.

- **No-take areas:** The use of no-take areas can be useful but requires substantial resources for enforcement. No-take areas might however be worth considering for localised and specific stocks (e.g. *H. scabra versicolor*) and possibly by considering rotational fishing for stocks of *A. mauritiana*.

Further, specific zones for scientific study may be designated. These may play a role for fisheries department or community monitoring of un-fished stocks, be used to run fishery experiments or to experiment with enhancement, should hatchery juveniles become available. Recent success in the spawning and rearing of sea cucumbers in Kiribati (*H. fuscogilva*), Solomon Islands (*H. scabra*) and New Caledonia (*H. scabra*) should be monitored closely to see if there are opportunities for supplementing wild stocks with juveniles reared in the hatchery.

- **Spreading the fishing effort:** Ensuring that fishing effort is distributed will assist in countering local serial depletion of sea cucumbers, which is often masked when examining amalgamated catch reports. An apparently sustainable export trade through one or two ports can mask serial depletion at local sites as buyers move to more and more distant islands as resources near ports start to produce lower yields.

- **Periodic closures:** Periodic closures can be the most cost-effective management measure, but with 2 or 3 major buying periods a year from Asia, a ‘stop-start’ fishery can compromise fishing continuity, and marketing and exporting arrangements. Relying on longer-term fisheries closures to allow stocks to rebuild requires acceptance of periods of lower reproductive output. The time lag needed to build a critical spawning mass of sea cucumbers appears through preliminary research to be prolonged and therefore, although good for the fishery in the long term, this approach severely compromises medium-term profitability.

- **Limiting exporters:** Issuing of only a small number of licences leveraged against greater reporting and export controls can make the export process easier to control and monitor.

Output controls

- **Stock assessment:** It is recommended that the resource be rapidly re-assessed every three years, using similar methodologies and at a selection of the same sites, so as to provide resource-specific information to decision-makers.

- **Catch quotas:** Restriction on the amount that can be exported from the country or from individual island groups is likely to provide significant fishery protection. A 'trigger mechanism', which will automatically re-impose the moratorium across the whole country if certain well-publicised limits are exceeded in the country as a whole, or in an island group, could be established.

- **Monitoring exports and enforcement:** Monitoring and enforcement, concentrating on the port of export. All shipments of bêche-de-mer would need to be cleared by Fisheries Officers trained to recognise the major species groups. Data must be reported by species or species group (for lower value species). For higher value species, piece counts should accompany total weights in the documentation.

- **Size limits:** Exporters supply the market by species and grade (lower value groups are sometimes sold together, e.g. *H. atra* and *H. edulis*). A large part of the grade value, after presentation, is the piece per kilo rate (a higher rate is paid for larger pieces). Grades for different high value species groups have generally accepted numbers associated with them that are recognised in the market (e.g. 'A' grade white teatfish is listed as 3–4 pieces per kilo). A method that might be considered to push up the grade quality, income, and thereby reduce the catch of juvenile product would be to follow the lead of exporters themselves. This could be done by regulating minimum export grades within a management plan. If there was a realisation in the fishery early on that low grade stock was not marketable in Vanuatu there would be a chance to maximise the income from the fishery and support sustainability by discouraging the harvesting of juveniles.

There would initially be some waste in this approach as product is turned away by the buyers as shipments that didn't meet the regulations in the management plan could not be exported. Mechanisms would need to be in place in the management plan that jeopardises an agent's licence if an unacceptable amount of below-grade product is marketed. Also high grade (and weight) catches can be processed in such a way as to lose weight. Community education should emphasis not only when and how much to fish but also post-harvest processing techniques that will maximise income.

- **Codes of Practice:** Management can benefit significantly from education, training and dissemination of resource tools targeting all levels of the chain of custody as appropriate (e.g. local fishers, processors, buyers, middlemen, resource managers and owners, and enforcement officials), and focussing on:
  - sea cucumber identification;
  - best collection practices;
  - reporting provisions;
  - processing techniques; and
  - management approaches.

APPENDIX 5: MILLENNIUM CORAL REEF MAPPING PROJECT – PAPUA NEW GUINEA

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
Papua New Guinea
(April 2009)

Map of South East Papua New Guinea

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 Papua New Guinea 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.