PACIFIC REGIONAL OCEANIC AND COASTAL FISHERIES DEVELOPMENT PROGRAMME (PROCFish/C/CoFish)

VANUATU COUNTRY REPORT:

PROFILES AND RESULTS FROM SURVEY WORK AT PAUNANGISU VILLAGE, MOSO ISLAND, URI AND URIPIV ISLANDS AND THE MASKELYNE ARCHIPELAGO

(July to December 2003)

by

Kim Friedman, Kalo Pakoa, Mecki Kronen, Lindsay Chapman,
Samasoni Sauni, Laurent Vigliola, Pierre Boblin and Franck Magron

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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.

PROCFish/C and CoFish staff work (or used to work) for the Secretariat of the Pacific Community, BP D5, 98848 Noumea Cedex, New Caledonia under this EU-funded project. All PROCFish/C and CoFish staff work as a team, so even those not directly involved in fieldwork usually assist in data analysis, report writing, or reviewing drafts of site and country reports.

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EXECUTIVE SUMMARY

The coastal component of the Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) conducted fieldwork in four locations around Vanuatu from July to December 2003. Vanuatu 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 Vanuatu 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 two local attachments from the Fisheries Department. The fieldwork included capacity building for the two 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 Vanuatu, the four sites selected for the survey were Paunangisu and Moso on the island of Efate, and Uri-Uripiv and the Maskelyne Archipelago, either on or close to Malakula Island. These sites were selected based on specific criteria, which included:

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

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

Results from fieldwork at Paunangisu village

Paunangisu village is located on Efate Island, approximately 60 km from the capital, Port Vila. When this survey was conducted the village comprised 76 households and had an estimated population of 388. Paunangisu has a relatively small fishing ground covering an area of about 9 km^2, with approximately 7 km^2 of reef area. The reefs of Paunangisu village are highly dominated by lagoon back-reef (5 km^2, 69% of habitat); the remainder comprises 1.2 km^2 (17%) sheltered coastal reef, 0.2 km^2 (3%) lagoon intermediate reef and 0.8 km^2 (11%) outer reef. The lagoon is greatly influenced by terrestrial runoff, with poor visibility in those areas of the lagoon close to the coast. Land and reef tenure in Paunangisu is traditional, with the village owning the land and the fishing ground. Some sustainable management measures relating to the reef fishery were reported to be in place at the time of survey, but these were limited due to internal community conflicts, which had been ongoing for several years.

Socioeconomics: Paunangisu

The socioeconomic study revealed that agriculture is the most important first income source (55% of all households), followed by fisheries (29%), others (small business, 13%) and salaries (5%). However, another 26% of all households reported relying on fisheries as a complementary second income. Respondents reported that 21 households fished regularly (four days per week) and sold fish at the village shop, at the Port Vila market and to restaurants. They also reported the presence of three motorised boats and 18 dugout canoes in the village. The average per capita fresh fish consumption was 16.7 kg/year. Fishers interviewed indicated that invertebrate fisheries are mainly for subsistence purposes (60%) and are only partially commercially oriented (up to 33%). In contrast, 45-65% of all finfish fishing trips (dependent on habitat) are for the purpose of generating income; 83% of the finfish catch (by weight) is for export. Female fishers harvest the majority (79%) of the invertebrate catch, most of which is removed from mangroves (67%). Men harvest the vast majority (96%) of the finfish catch.

Finfish: Paunangisu

A total of 21 families, 48 genera and 145 species were recorded during the finfish surveys. Finfish resources differed substantially across the four main reef types present in Paunangisu. The highest finfish biodiversity, density, size and biomass were recorded in the outer reef, with biomass four times higher than in the lagoon back-reef (fewer species and fewer and smaller individuals recorded). Sheltered coastal and lagoon intermediate reefs scored between these extremes. The sheltered coastal reef environment of Paunangisu village was dominated by carnivorous Lutjanidae (snappers) and Nemipteridae (threadfin breams). The substrate was characterised by a dominant proportion of soft bottom (48% cover). The lagoon intermediate-reef environment was dominated by herbivorous Scaridae (parrotfish) and Acanthuridae (surgeonfish), and carnivorous Mullidae (goatfish or red mullet), Lutjanidae and Nemipteridae. The lagoon back-reef environment was dominated by herbivorous Acanthuridae, Scaridae, Siganidae (rabbitfish) and carnivorous Nemipteridae. This reef environment was particularly shallow (1 m) and relatively diversified, with hard bottom predominating (39%, primarily pavement) over rubble and boulders (22%). The outer-reef environment was largely dominated by herbivorous Acanthuridae. The substrate was characterised by an abundance of hard bottom (47% cover); this environment had the greatest average live coral cover (27%) recorded in Paunangisu's reefs. Overall there was no obvious sign of negative human impact on the finfish resource, except for unusually poor populations of Scaridae in the outer-reef environment.

Invertebrates: Paunangisu

Approximately 50% of Paunangisu's fishing area consists of shallow reef. Results from broad- and fine-scale assessment of the benthos showed mean live coral cover to be at 21%. During the time of the survey, fishers gleaning the reef collected a range of common resource species, including clams, gastropods and sea urchins. Fishers gleaning the shallow-water reef areas concentrated efforts on octopus fishing; fishers from Pele were also regularly seen on the reeftop. Giant clam stocks were impacted by environmental conditions or fishing pressure and the abundance of large edible species in infaunal shell beds within soft-benthos areas was low. Stocks of mother-of-pearl and trochus were present in Paunangisu, but at low levels. Commercialisation of trochus had affected the presence and density of stocks, although recruitment was apparently still occurring in one instance. The area fronting Paunangisu, which was partially protected from fishing, was where the live trochus were found. The complement of sea cucumber species was still intact, but the presence and density estimates for sea cucumbers revealed that these resources had been impacted by harvesting. The more valuable species were present only as remnants of former populations (sandfish) or were not currently found (blackfish). Although sea cucumber habitat was limited in extent in Paunangisu, even those stocks well suited to exposed reef areas (surf redfish) were considered to be sparsely distributed and present at low densities.

Based on the survey work undertaken and the assessments made, the following recommendations are made for the Paunangisu village fishing area:

- Further development of reef finfish fisheries to improve the food and financial security of the people of Paunangisu may be limited by environmental factors, and the development of alternative sources of food and income is consequently recommended.

- The potential for targeting stocks of deep-water fish (*Pristipomoides* spp. or 'poulet' in local language) that are of high commercial value in Port Vila markets, and that can be relatively easily accessed, has been examined by some fishers in Paunangisu. Investigation into the capacity of this fishery to contribute to the food and financial security of the people of Paunangisu may be warranted.

- Given habitat constraints, Paunangisu's finfish resources appear to be in relatively good condition. However, any measures to protect the ecosystem (e.g. marine protected areas) should be encouraged and supported.

- Resource owners should be made aware of the harvest and management strategies currently in use in other parts of the Pacific and refrain from harvesting mother-of-pearl stocks.

- Stocks of peanutfish (bêche-de-mer) should be monitored to assess the potential for future harvest. The fishing for other sea cucumbers should be restricted at Paunangisu, and local resource owners should seek expert advice prior to opening a fishery.

Results from fieldwork at Moso Island

The island of Moso is located on the northwest coast of Efate Island, about 28 km from the country's capital, Port Vila, a journey that takes approximately one hour by road plus 15 minutes by boat. Land and reef tenure in Moso is traditional, with the village owning the land and the fishing grounds. The Moso fishing grounds are about 23 km^2 in area, with approximately 5 km^2 of reef. A narrow fringing reef characterised by a few coral heads growing on mineral rock lies along the northern (ocean) side of Moso Island, while a narrow sheltered coastal reef extends along the southern side of the island, where the pseudo-lagoon is located, and also along the coast of Efate where it fronts Moso. The reefs of Moso village are composed of roughly equal proportions of outer reef (2.49 km^2, 54% of habitat) and sheltered coastal reef (2.15 km^2, 46%).

Socioeconomics: Moso Island

The Moso community is composed of 32 active households and 187 people. The study revealed that around 15% of first incomes of households in the village is generated from fisheries. By comparison, 69% of all households generate their main income from agriculture, another 12% from other sources (small business) and 8% from salaries. Fisheries are the most important secondary income source (58% of all households). Respondents confirmed that all 32 households were fishing, some were selling fish outside the village and most, if not all, owned at least one dugout canoe. There were three motorised boats in the village, two of which were privately owned and the other community owned, with the community boat rarely used for fishing. Moso's people consume 18.5 kg/capita annually of fresh fish and canned fish also at a rate of 18.5 kg/capita/year. On the other hand, the frequencies of fresh fish and invertebrate consumption are low (1.4 times/week and 0.3 times/week respectively) compared to canned fish (3.5 times/week). Finfish are caught for both subsistence consumption and income, but the proportion of the catch used for commercial purposes (78.9%) far exceeds that used for subsistence (21.1%). Likewise, invertebrate fisheries are mainly commercial, with about 78% of all catches (by weight) being sold and just 13% harvested exclusively for subsistence purposes. The remainder may or may not be sold.

Finfish: Moso Island

A total of 19 families, 50 genera and 159 species were recorded during the finfish surveys. Finfish resources were similar between the two types of reef present in Moso, but with a slightly higher biodiversity in the sheltered coastal reef and a somewhat higher biomass in the outer reef. The similar density and size but slightly different biomass suggests the presence of a structural difference in the fish assemblage between the two types of reef (different species with a different size structure). The sheltered coastal reef of Moso Island was dominated by herbivorous Scaridae, Acanthuridae and Siganidae (in terms of both density and biomass) and carnivorous Chaetodontidae (butterflyfish) (density only). The habitat was well diversified. The outer reef was largely dominated by herbivorous Acanthuridae and, to a lesser extent, herbivorous Scaridae. The outer-reef habitat was essentially characterised by hard bottom (69% cover, mostly mineral slab). The populations of Scaridae and, to a lesser extent, Lutjanidae on the outer reef were unusually poor, possibly due to fishing activities. The sheltered coastal reef population of carnivorous fish (Lutjanidae in particular) was also unusually poor – again, possibly due to fishing activities.

Invertebrates: Moso Island

Moso Island's outer fringing reef was exposed to swell, had poor live coral cover (approximately 5%) and generally comprised reef and dead coral. Coral coverage and soft benthos were more plentiful along the coastal strip, in the lee of the island. The area of soft benthos supporting shell beds was not extensive (around 4% of the fishing grounds and study area) and was characterised by muddy patches among sandy areas, with significant seagrass cover (51%). Fishers targeted reef and soft-benthos areas for clams and other bivalves, gastropods and echinoderms. Giant clam stocks were impacted by environmental conditions and/or fishing pressure, although the small boring clam, *Tridacna crocea,* was present at high density in an area especially well suited to recruitment and growth of this species. Seagrass and infaunal shell bed areas were also impacted by fishing, although *Hippopus hippopus* was relatively common on soft benthos, and a reserve of broodstock near the main village was protected from fishing. Mother-of-pearl and trochus stocks were present, but only found at low levels. The green snail was not found. Sea cucumbers were present, but the available habitat, with a significant oceanic influence, did not provide optimal conditions for many commercial species. The resource is considered impacted by environmental conditions and/or fishing pressure. Evidence of fishing pressure was most noticeable for species well suited to the exposed reef conditions; surf redfish were absent and the high-value black teatfish were rare in survey. Despite the impacts suggested, the durable nature of sea cucumber stocks was highlighted, as the total species complement was not severely reduced at Moso and some medium-value species (blackfish) were detected at reasonable density in shallow water.

Based on the survey work undertaken and the assessments made, the following recommendations are made for the Moso Island fishing area:

- At this stage of the analysis, we believe that strong ecosystem protection measures (i.e. establishment of a marine protected area) are not required to ensure sustainable use of the finfish resource. However, large groups of herbivorous Acanthuridae (*Acanthurus blochii* in particular) are present in the area and could be targeted instead of Scaridae, which may assist in the recovery of these parrotfish populations as these are probably being impacted by fishing at present.

- The natural, medium-rich quality of the habitat suggests that finfish resources in Moso should be considered as a complementary (rather than principal) source of food and income, as Moso may not have a sufficiently rich environment to sustain intense fishing pressure for a long period of time. Easy access to open pelagic waters may render pelagic and deep-water finfish species particularly attractive for fishery development. The capacity of such fisheries to contribute to the food and financial security of the people of Moso should be investigated.

- Commercialisation of trochus has affected stocks, and the population is considered close to collapse despite the presence of extensive habitat suitable for adults. Resource owners should consider keeping the fishery closed into the medium-term future (e.g. 10 years).

- Advice should be sought by local resource owners prior to the opening of the sea cucumber fishery, with respect to fishing options and to ensure post-harvest processing maximises returns.

Results from fieldwork at Uri and Uripiv islands

The islands of Uri and Uripiv are located on the east coast of Malekula, 3–4 km by boat from Lakatoro. The two islands are separated from Malekula by Port Stanley, a pseudo-lagoon. The people of Uripiv and Uri consider that they make up a single fishing community, with one clan in Uri and six clans in Uripiv. For this report, the villages have been combined and called Uri-Uripiv. Uri-Uripiv has a traditional, village-owned fishing system, with a fishing ground of about 7 km^2, including 4 km^2 of reef. A fringing outer reef lies along the ocean (northern) side of both Uripiv and Uri islands. A narrow sheltered coastal reef extends along the sheltered (southern) sides of both islands, with sandy areas and small mangroves becoming increasingly dense (and coral increasingly patchy) farther inside Port Stanley, along the sheltered side of Uri. The reefs of Uri-Uripiv are highly dominated by outer reef (2.77 km^2, 67% of habitat); the remainder comprises 1.36 km^2 (33%) of sheltered coastal reef. There are three small marine protected areas (MPAs) around Uripiv Island (each with about 300 m of shoreline), where fishing has been completely banned for the last ten, six and two years, respectively.

Socioeconomics: Uri and Uripiv Islands

On Uripiv, the number of active households and the resident population for this study are assumed at 84 households and less than 500 people. On Uri, a total of 14 households were counted but only eight were reported to be active, with an estimated total current resident population of 130. The socioeconomic study conducted in Uri-Uripiv revealed that fisheries are the most important first income source (38%), followed by salaries (28%), agriculture and other sources (small business) with 17% each. In addition, fisheries account as secondary revenue for another 15% of all households surveyed. Respondents indicated that most households were fishing regularly (six days per week) for subsistence but that only 30 households were selling fish. They also reported the presence of 12 motorised boats and 20 dugout canoes in the village. Residents of Uri-Uripiv consumed fresh and canned finfish infrequently (1.3 and 1.2 times per week, respectively). Fresh fish consumption was low at 9.9 kg/capita/year, as was canned fish consumption at 4.5 kg/capita/year. About half of all invertebrate catches were used exclusively for subsistence purposes, with the other half sometimes but not necessarily used for commercial purposes. The proportion of the finfish catch (84% by weight) that was intended for sale (export) exceeded the subsistence catch by a factor of five, revealing the community's economic dependency on fisheries. Male fishers took slightly over half (54%) of the invertebrate harvest, but the single largest share of the invertebrate catch (30%) was composed of women's catch from mangroves. Men took the majority (77%) of the finfish harvest.

Finfish: Uri and Uripiv Islands

A total of 23 families, 62 genera and 190 species were recorded during the finfish surveys. The outer reef supported more species, more fish and fish of larger size, and hence a larger biomass, than did the sheltered coastal reef, although the differences were substantial only for biomass (1.6 times larger). The sheltered coastal reef at Uri-Uripiv was dominated by herbivorous Acanthuridae and Scaridae and carnivorous Lutjanidae, Mullidae and Nemipteridae, as well as Chaetodontidae (density only). Remarkably, the rare and vulnerable (to fishing) bumphead parrotfish (*Bolbometopon muricatum*) ranked sixth in terms of biomass. The substrate was well diversified, with hard bottom predominating. Habitat complexity may partly explain the relative complexity of the fish assemblage on this reef.

The outer-reef environment at Uri-Uripiv was largely dominated by herbivorous Acanthuridae and, to a lesser extent, Scaridae. Simarly to the sheltered coastal reef, the bumphead parrotfish ranked seventeenth in terms of biomass. Substrate was essentially characterised by hard bottom (66% cover), which, in combination with the direct oceanic influence found in outer reefs, may explain the dominance of large groups of medium- to large-sized herbivorous fish. It would appear that Uri-Uripiv's sheltered coastal reef and outer-reef environments have a general trend towards greater mean densities and biomass of edible species, and the presence of large, rare and vulnerable species in an otherwise similar habitat may indicate that impact from fishing is low.

Invertebrates: Uri and Uripiv Islands

The exposed outer fringing reef at Uri-Uripiv was subject to heavy swell and oceanic conditions. Within Port Stanley there was plentiful shallow-water soft-benthos and rubble-and-boulder habitat. More protected areas of the port generally had coral covered in silt. Giant clams in Uri-Uripiv were not negatively impacted by environmental conditions or fishing pressure. The abundance and density of trochus were low, and other mother-of-pearl species, such as *Pinctada margaritifera* and *Turbo marmoratus,* were also found at densities too low for commercial harvest to be viable. Records of mother-of-pearl species mostly originated from one of the MPAs close to Uripiv Island. Sea cucumber stocks were found to generally be in good condition; there was relatively high coverage and abundance of valuable species at Uri-Uripiv, and the resource was judged to be lightly impacted by fishing. There was effective customary management in the form of a fishery closure between harvest periods, although some harvesting by commercial fishers from outside the community had taken place in the recent past. Areas of soft benthos were found near Uri village but were very restricted, consisting only of small patches bordering channels in the mangrove. No marked shell beds were identified. Collection of infaunal lucinid bivalves (*Anodontia philippiana*) from mangrove mud was continuing during the survey period. Customary reef management provisions, which close areas to fishing and limit the collection and sale of resources, were observed during the period of survey, but the positive influence of these controls was generally limited to the localised areas that were protected (large clams were found at elevated abundance in protected areas within Port Stanley).

Based on the survey work undertaken and the assessments made, the following recommendations are made for the Uri and Uripiv islands fishing area:

- Initial analysis suggests that existing management measures are adequate to ensure sustainable use of finfish resources at the current fishing level.

- Despite the good condition of the resource, reef finfish should be considered as a complementary rather than principal source of food and/or money, as the band of reef surrounding Uri-Uripiv may be too narrow to sustain intense fishing pressure over the long term.

- Easy access to offshore waters may render pelagic and deep-water finfish species particularly attractive for fishery development. The capacity of these fisheries to contribute to the food and financial security of the people of Uri-Uripiv should be investigated.

- Resource owners should be made aware of current harvest strategies and yields for mother-of-pearl species elsewhere in the Pacific.

- Advice should be sought by local resource owners prior to the opening of the sea cucumber fishery, both on fishing options and to ensure that post-harvest processing maximises returns to the community.

- Sandfish (*Holothuria scabra*) was not found and future surveys should concentrate on further assessing the area to see if this species can be located in Port Stanley.

Results from fieldwork at Maskelyne Archipelago

The Maskelyne Archipelago comprises a group of small, relatively isolated islands located off the southeast tip of Malakula Island in Vanuatu's Malampa province, approximately 40 minutes by boat from Point Doucere landing and 7 km from Lamap airstrip. Only two islands in the archipelago are inhabited: Uliveo and Avokh. Uliveo is the largest island and supports three villages: Pellonk, Peskarus and Lutes. The combined fishing grounds of Uliveo's three villages cover a total area of about 38 km^2, including 20.4 km^2 of reef. The reefs of Uliveo's three villages are highly dominated by outer reef (16.2 km^2, 80% of habitat), and there is 4.05 km^2 (20%) of sheltered coastal reef and 0.09 km^2 (<0.4%) of lagoon intermediate reef. Stands of mangrove separate the village of Pellonk from the extensive lagoon. The lagoon drains through the passage between Uliveo and Sakao islands. All the passages (Uliveo, Sakao and between Sakao and Malakula) are very dynamic, with strong tidal movement.

The traditional management system of customary marine tenure (CMT) is still strong in the Maskelyne Archipelago. The three villages on Uliveo have clearly demarcated reef areas and each village shares access to the village reef area for subsistence purposes. All villages restrict the use of gillnets and night diving using spears, and have also recently introduced an annual quota for sea turtles. There is also a no-take MPA in front of Pellonk and Peskarus villages, which has been in place for over a decade. Mangroves are exempted from management rules and can be targeted for any purpose throughout the year. Compliance with community regulations and the total ban on trochus and sea cucumber harvesting was reported to be high. However, the western coast of Sakao Island cannot be monitored and was reported to be subject to poaching by external fishers as well as being exempted from any community regulation. While CMT is constitutionally recognised, the local provincial authority also enforces some controls on operators and has a say in any activities in provincial waters.

Socioeconomics: Maskelyne Archipelago

Uliveo supports a population of 1058 in the three villages; Pellonk has 48 households, Peskarus 99 households and Lutes 35 households. The Maskelyne community remains strongly subsistence oriented, as evidenced by a range of socioeconomic factors and patterns of resource use. The survey found low levels of average household expenditure, high consumption of fresh fish and invertebrates, a high level of non-monetary exchange of marine resources, a high proportion of households fishing for their own consumption, and a high number of fishers (100% of all households) and boats (97% of all households). High participation in fisheries was recorded for both sexes, with the women interviewed engaged primarily in subsistence activities and primarily targeting invertebrates. Fresh fish consumption per capita recorded among respondents was high (22.2 kg/capita/year). Fisheries were not important as first income source. Only 4% of all households surveyed reported fisheries as the main revenue source, but 90% did so for agriculture. However, fisheries represented the most important complementary secondary income source (61% of all households). Salaries and other sources (handicrafts, small business) were not important for either primary or secondary income. Fisheries-related income appeared to be derived primarily from finfish. In contrast, more than 90% of the invertebrates (by wet weight) collected by respondents were used for subsistence purposes.

Finfish: Maskelyne Archipelago

A total of 23 families, 62 genera and 198 species were recorded during the finfish surveys. The outer-reef habitat supported greater numbers of fish and fish of larger size than the sheltered coastal environment, and hence had a larger overall biomass (almost twice as great on average). The sheltered coastal reef environment was dominated by five families: herbivorous Acanthuridae and Scaridae (both in terms of density and biomass), carnivorous Lutjanidae and Lethrinidae (emperor breams) (biomass only), and Chaetodontidae (density only). This reef environment presented a diverse habitat, with good live coral cover (20%) and hard bottom predominating. The outer-reef environment was largely dominated by herbivorous Acanthuridae and Scaridae, and to a lesser extent by carnivorous Lutjanidae. Remarkably, the rare and vulnerable (to fishing) bumphead parrotfish (*Bolbometopon muricatum*) ranked first in terms of biomass. This reef environment was characterised by relatively high live coral cover (24%). Overall, the finfish resource appears to be in good condition. It is possible that difficulties in accessing (and hence fishing) the very exposed reefs on the southern coast of Uliveo, combined with the many management actions undertaken, have contributed to the apparent healthy status of the area's finfish resources, including the sighting of a large group of bumphead parrotfish in the outer-reef environment.

Invertebrates: Maskelyne Archipelago

Invertebrate fishers target a wide range of species for subsistence purposes, but are very species-selective for commercial purposes. Invertebrate fisheries in mangrove habitats were found to impose the highest pressure, measured by total biomass (wet weight) removed annually, possibly because these areas are not subject to periodic closure. Mangrove fishers mainly harvest species of the genus *Terebra*, while *Anadara*, *Cypraea*, *Gafrarium* and *Periglypta* are removed primarily from soft-benthos environments. Species targeted in reeftop areas are more diverse and include the genera *Octopus*, *Tridacna, Turbo, Lambis* and *Conus*. Considering the small area of the soft-benthos habitat as compared to the reeftop area, fishing pressure per unit of habitat may be much higher in the soft benthos. Overall, the smaller species of giant clams appeared marginally impacted by environmental conditions and/or fishing pressure, while fishing pressure was the most likely cause of the lower densities of larger species. Shell beds appeared only lightly impacted by fishing and held reasonable densities of large arc shells despite the sandy and compacted condition of the area. Green snail was absent, but *Trochus niloticus* and *Pinctada margaritifera* were present. Commercial harvesting of trochus had affected both occurrence and density of stocks. Some recruitment was noted. Sea cucumber stocks appeared to be in good condition, with effective customary management in place (There was a fishery closure in effect at the time of survey.). At the time of survey sea cucumber resources were judged to be lightly impacted or not impacted.

Based on the survey work undertaken and the assessments made, the following recommendations are made for the Maskelyne Archipelago fishing area:

- In order to ensure security of food and income supply from finfish and invertebrates for the community of Maskelyne Archipelago, no further commercial development of the fisheries should take place.

- Existing community-based fisheries management is working well and should be strengthened to ensure that resources remain available to maintain the livelihood (food and income) by future generations. Should further management measures be required, MPAs should be considered as a primary management tool considering the high quality of habitat and the high compliance with the MPAs established by the community.

- Resources should be closely monitored, to detect any adverse effects of fishing, especially if any expansion of commercial finfish resource harvesting does occur, e.g. if there is a shift to the use of more efficient fishing technology, e.g. the use of motorised boats, or the installation of ice-making machines.

- There is little spare capacity to allow further exploitation of the existing invertebrate resource. There is a need for management intervention to protect large clams and trochus stocks. Periods of low recruitment or environmental disturbance will likely further increase pressure on stocks.

- Current management mechanisms in place for protecting aggregations of sea cucumbers should be encouraged, and the community would benefit from receiving market advice prior to recommencing commercial fishing. Any monitoring programme that could give an insight into stock recovery following a pulse fishing event would provide important information for the sandfish (*Holothuria scabra*) fishery.

- There would be benefit in undertaking some studies on the effectiveness of the seasonal six-month closure. Such a closure, if followed by six months of intense fishing (as appears to be the case here), may have the effect of just balancing extraction levels and replenishment rates. A perturbation in the system (e.g. a low recruitment period or a cyclone) could disturb this balance considerably. The dynamics of the effects of the closure regime need to be better understood.

RÉSUMÉ

Les équipes de la composante côtière du Projet régional de développement des pêches océaniques et côtières dans les PTOM français et pays ACP (PROCFish/C) et du Projet de développement de la pêche côtière (CoFish) ont mené des études de terrain sur quatre sites de l'archipel de Vanuatu de juillet à décembre 2003. Les quatre sites ont été sélectionnés en fonction de critères bien définis tels que les suivants : le site doit faire l'objet de pêche récifale régulière, être représentatif du pays, constituer un système relativement fermé (les populations pêchent dans une aire bien délimitée), avoir une taille appropriée, accueillir des habitats diversifiés, être simple d'accès sur le plan logistique, avoir fait l'objet d'études antérieures, et présenter un intérêt particulier pour le Service des pêches de Vanuatu. Les sites choisis pour l'étude sont Paunangisu et Moso sur l'île d'Efate, et Uri-Uripiv et les Maskelyne Archipelago, sur l'île de Malakula ou à proximité.

Le but de l'étude consiste à obtenir des données de référence sur l'état des ressources récifales et à combler l'énorme manque d'informations qui entrave la gestion efficace des ressources récifales. Vanuatu est l'un des 17 États et Territoires visés par les études PROCFish/C et CoFish sur une période de cinq à six ans. Globalement, ces deux projets permettront également d'obtenir d'autres résultats : la conduite, pour la première fois en Océanie, d'une évaluation comparative exhaustive des ressources récifales de plusieurs pays (intégrant la composante des ressources ainsi que l'aspect social de leur exploitation), grâce à une méthode uniformisée appliquée à chaque site d'étude ; la diffusion des résultats des études menées dans des rapports nationaux où sera exposé un ensemble de « descriptifs 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 ; l'élaboration d'un jeu d'indicateurs, ou points de référence pour l'évaluation de l'état des stocks, permettant d'étayer l'élaboration de plans de gestion des ressources récifales à l'échelle locale et nationale, et de programmes de suivi ; et l'élaboration de systèmes de gestion des données et de l'information, dont des bases de données régionales et nationales.

Pour chaque site, les études menées à Vanuatu ciblaient trois volets : l'inventaire des poissons, l'inventaire des invertébrés et l'étude des facteurs socioéconomiques. À chaque mission, deux sites étaient étudiés par une équipe de cinq scientifiques du Projet et de deux agents du Service des pêches affectés au projet. Durant les travaux de terrain, l'équipe a également formé les deux agents ni-vanuatu aux méthodes d'enquête et d'inventaire utilisées dans chaque volet des études, notamment la collecte de données et leur saisie dans la base de données du Projet.

Résultats des études de terrain au village de Paunangisu

Le village de Paunangisu se situe sur l'île d'Efate, à environ 60 km de la capitale de Vanuatu, Port-Vila. Lors de l'étude, le village comptait 76 ménages et une population estimée à 388 habitants. Paunangisu possède un secteur de pêche relativement peu étendu qui couvre une superficie marine d'environ 9 km^2, dont à peu près 7 km^2 de zone récifale. La zone récifale de Paunangisu est principalement formée d'un arrière-récif lagonaire (5 km^2, 69 % des habitats) ; la surface restante est occupée par un récif côtier abrité (1,2 km^2, 17 %), un récif intermédiaire lagonaire (0,2 km^2, 3 %) et une pente externe (0,8 km^2, 11 %). Les eaux du lagon sont fortement marquées par les apports terrigènes, qui réduisent grandement la visibilité dans les zones proches de la côte. Régi par un régime traditionnel de propriété foncière et récifale, le village de Paunangisu est propriétaire des terres et des aires de pêche.

D'après les informations recueillies, lors de l'étude, certaines mesures de gestion durable des ressources récifales étaient en place, mais restaient limitées en raison de litiges qui existent depuis plusieurs années au sein de la communauté.

Socioéconomie : Paunangisu

L'étude socioéconomique a révélé que l'agriculture constitue la première source de revenus (pour 55 % des ménages), suivie des pêches (29 %), d'autres activités comme les petites entreprises (13 %) et des emplois salariés (5 %). Toutefois, 26 % des ménages ont déclaré que la pêche constituait une deuxième source complémentaire de revenus. D'après les personnes interrogées, 21 ménages pratiquent régulièrement la pêche (quatre jours par semaine) et vendent leurs produits au magasin du village, sur le marché de Port-Vila et aux restaurants. Selon les mêmes sources, le village compte trois bateaux à moteur et 18 pirogues. La consommation moyenne de poisson frais par habitant s'élève à 16,7 kg par an. Les pêcheurs interrogés ont indiqué que les ressources en invertébrés sont principalement ciblées par la pêche de subsistance (60 %) et, dans une moindre mesure, par la pêche commerciale (jusqu'à 33 %). En revanche, 45 à 65 % des sorties de pêche ciblant le poisson (en fonction de l'habitat) sont effectuées pour générer des revenus, tandis que 83 % des prises de poisson (pourcentage du poids) sont destinées à l'exportation. Les pêcheuses enregistrent la majorité (79 %) des captures d'invertébrés, dont la plupart sont ramassés dans les mangroves (67 %). Quant aux hommes, ils pêchent la quasi-totalité des poissons capturés sur le site (96 %).

Poissons : Paunangisu

Au total, 21 familles, 48 genres et 145 espèces ont été recensés au cours de l'inventaire des poissons. Les ressources en poissons variaient sensiblement d'un grand type de récif à l'autre, sur les quatre présents à Paunangisu. La pente externe abritait la plus grande richesse de poissons en termes de biodiversité, de densité, de taille et de biomasse ; celle ci était quatre fois plus élevée que dans l'arrière-récif lagonaire (où les espèces étaient moins diversifiées et les individus plus petits et moins nombreux). Entre ces deux extrêmes figuraient le récif côtier abrité et le récif intermédiaire lagonaire. Les habitats du récif côtier abrité du village de Paunangisu comprenaient principalement des Lutjanidae et des Nemipteridae carnivores. Le substrat était caractérisé par son importante proportion de substrat meuble (48 % du couvert). Dans les habitats du récif intermédiaire vivaient essentiellement des Scaridae et des Acanthuridae herbivores, ainsi que des Mullidae, Lutjanidae et Nemipteridae carnivores. L'arrière-récif lagonaire était peuplé en grande partie par des Scaridae, Acanthuridae et Siganidae herbivores, et par des Nemipteridae carnivores. Ce dernier milieu était caractérisé par une faible profondeur (1 m) et une assez riche diversité, et se composait principalement de substrat dur (39 %, surtout de la dalle corallienne) et, dans une moindre mesure, de blocs et débris (22 %). La pente externe était peuplée principalement d'Acanthuridae herbivores et caractérisée par une abondance de substrat dur (47 % du couvert). C'est sur la pente externe qu'a été recensé le couvert corallien vivant moyen le plus étendu (27 %) des milieux récifaux de Paunangisu. Dans l'ensemble, aucun signe négatif manifeste de l'activité humaine n'a été observé sur les ressources en poissons, à l'exception des populations inhabituellement pauvres de Scaridae (perroquets) sur la pente externe.

Invertébrés : Paunangisu

Environ 50 % de la zone de pêche de Paunangisu est composée de récifs peu profonds. D'après les études à grande et petite échelles du benthos, le couvert corallien vivant moyen s'élevait à 21 %. Pendant la durée de l'étude, les pêcheurs ont ramassé sur le récif un large éventail d'espèces communes comme des bivalves, des gastropodes et des oursins. Les pêcheurs qui opéraient dans les zones récifales peu profondes ramassaient essentiellement des pieuvres et des poulpes ; les pêcheurs de Pele ont également été aperçus régulièrement sur le haut du récif. Les stocks de bénitiers ont souffert des conditions environnementales ou de la pression de pêche, et l'abondance d'espèces comestibles de grande taille était faible parmi les bancs de mollusques endofauniques enfouis dans les substrats benthiques meubles. Des stocks de mollusques nacriers et de trocas ont été observés à Paunangisu, mais à de faibles abondances. La pêche commerciale des trocas a affecté la présence et la densité des stocks, même si le recrutement semblait se poursuivre dans l'un des cas. Des trocas vivants ont été observés dans la zone située en face de Paunangisu, partiellement protégée de la pêche. Le nombre d'espèces différentes d'holothuries restait inchangé, mais les estimations d'abondance et de densité ont révélé que les ressources en holothuries avaient pâti de la pêche. Dans le cas des espèces à forte valeur marchande, seuls des individus issus d'anciennes populations ont pu être observés (holothuries de sable) ou l'espèce était introuvable à l'époque de l'étude (holothurie noire). Si les habitats adaptés aux holothuries sont peu étendus à Paunangisu, même les stocks d'espèces pouvant vivre dans les zones récifales battues (holothuries brunes des brisants) étaient jugés épars et peu denses.

Sur la base des inventaires et des évaluations de l'équipe, les recommandations suivantes s'appliquent à la zone de pêche du village de Paunangisu :

- Il se peut que des facteurs environnementaux limitent le développement de la pêche de poissons récifaux destinée à améliorer la sécurité alimentaire et financière des habitants de Paunangisu. Il est donc préconisé de trouver de nouvelles sources d'aliments et de revenus.

- Certains pêcheurs de Paunangisu ont envisagé la possibilité de cibler les stocks de poissons de grand fond (*Pristipomoides* spp. ou « poulet » dans la langue locale) qui ont une valeur commerciale élevée sur les marchés de Port-Vila et sont relativement faciles d'accès. Le potentiel qu'a cette pêcherie de contribuer à la sécurité alimentaire et financière des habitants de Paunangisu mériterait d'être étudié.

- Compte tenu des limites que présentent les habitats, les ressources en poissons de Paunangisu semblent afficher une assez bonne santé. Toutefois, toutes mesures de protection de l'écosystème (comme les aires marines protégées) devraient être encouragées et soutenues.

- Les propriétaires des ressources devraient être informés des stratégies de pêche et de gestion actuellement en place dans d'autres régions du Pacifique et s'abstenir de collecter des mollusques nacriers.

- Il convient de surveiller les stocks de *Stichopus horrens* afin d'en déterminer le potentiel de pêche. Il est conseillé de restreindre la pêche des autres espèces d'holothuries, et les propriétaires des ressources locales devraient demander l'avis d'experts avant d'ouvrir une pêcherie.

Résultats des études de terrain sur l'île de Moso

L'île de Moso se situe au large de la côte nord-ouest de l'île d'Efate, à environ 28 km de la capitale du pays, Port-Vila. Il faut à peu près une heure de route et 15 minutes de bateau pour rejoindre le site depuis la capitale. Régi par un régime traditionnel de propriété foncière et récifale, le village de Moso est propriétaire des terres et des zones de pêche. Son aire de pêche s'étend sur quelque 23 km^2, dont environ 5 km^2 de récif. Un récif frangeant allongé, caractérisé par la présence de quelques patates de corail reposant sur des roches minérales, se trouve au large de la côte septentrionale (tournée vers l'océan) de l'île, tandis qu'un étroit récif côtier abrité s'étire le long de la côte méridionale, où se trouve le pseudo-lagon de l'île, et le long de la côte d'Efate faisant face à Moso. Les récifs du village de Moso sont répartis en proportions presque égales entre une pente externe (2,49 km^2, 54 % des habitats) et un récif côtier abrité (2,15 km^2, 46 %).

Socioéconomie : île de Moso

La communauté de Moso comprend 32 ménages actifs et 187 habitants. D'après l'étude, environ 15 % des ménages tirent leur principale source de revenus de la pêche. À titre de comparaison, 69 % des ménages vivent principalement de l'agriculture, 12 % d'autres activités (petites entreprises) et 8 % d'emplois salariés. La pêche est la principale source complémentaire de revenus (pour 58 % des ménages). Les personnes interrogées ont indiqué que les 32 ménages de l'île pratiquaient la pêche, parfois pour vendre leurs produits en dehors du village, et la plupart des ménages, voire la totalité, possèdent au moins une pirogue. Le village compte trois bateaux à moteurs, dont deux appartiennent à des particuliers et un à la communauté. Le bateau collectif est rarement utilisé pour la pêche. Les habitants de Moso consomment 18,5 kg de poissons frais par an et par habitant, et la même quantité annuelle de poisson en conserve. Par contre, les habitants mangent peu souvent du poisson frais et des invertébrés (1,4 fois par semaine et 0,3 fois par semaine, respectivement) alors qu'ils consomment du poisson en conserve 3,5 fois par semaine. Si le poisson est ciblé tant par la pêche de subsistance que par la pêche commerciale, les prises commerciales (78,9 %) dépassent de loin les captures vivrières (21,1 %). De même, les invertébrés sont principalement collectés à des fins commerciales, environ 78 % des captures (pourcentage du poids) étant vendues contre seulement 13 % des captures consommées par la population. Le pourcentage restant est peut-être vendu.

Poissons : île de Moso

Les inventaires de poissons ont permis d'identifier au total 19 familles, 50 genres et 159 espèces. Les deux catégories de récifs de Moso abritaient les mêmes types de poissons. Toutefois, la biodiversité du récif côtier abrité était un peu plus riche et la biomasse de la pente externe était légèrement plus élevée. Le fait que la densité et la taille des populations soient semblables, mais que la biomasse diffère légèrement, laisse à penser qu'il existe une différence structurelle dans l'assemblage des poissons des deux types de récifs (à savoir des espèces différentes avec une structure de taille différente). Le récif côtier abrité de Moso était principalement peuplé de Scaridae, d'Acanthuridae et de Siganidae herbivores (en termes à la fois de densité et de biomasse) et de Chaetodontidae (en densité uniquement). Les habitats étaient bien diversifiés. La pente externe abritait surtout des Acanthuridae herbivores et, dans une moindre mesure, des Scaridae herbivores. Les habitats de la pente externe se composaient essentiellement de substrat dur (69 % du couvert, principalement de la dalle minérale). Les populations de Scaridae (perroquets) et, dans une moindre mesure, de

Lutjanidae (vivaneaux), étaient inhabituellement pauvres sur la pente externe, peut-être en raison de la pêche. Les populations de poissons carnivores du récif côtier abrité (en particulier de Lutjanidae) étaient, elles aussi, très pauvres, probablement pour les mêmes raisons.

Invertébrés : île de Moso

Battu par la houle, le platier frangeant océanique de Moso se composait d'un couvert corallien vivant pauvre (environ 5 %) et plus généralement de matière récifale et de coraux morts. Le couvert corallien et le benthos vivant dans les substrats meubles étaient plus abondants le long de la frange côtière, du côté de l'île situé sous le vent. Le substrat benthique meuble accueillant les bancs de mollusques avait une étendue limitée (environ 4 % de l'aire de pêche et de la zone étudiée) et se caractérisait par des zones vaseuses accolées à des zones sablonneuses, et par une superficie importante d'herbiers (51 %). Les pêcheurs ciblaient les zones récifales et les substrats benthiques meubles en quête de bénitiers et d'autres bivalves, de gastropodes et d'échinodermes. Les stocks de bénitiers ont souffert des conditions environnementales et/ou de la pression de pêche, même si le bénitier crocus *Tridacna crocea* était présent en densité élevée dans une zone particulièrement adaptée à son recrutement et à sa croissance. Les herbiers et les bancs de mollusques endofauniques ont également pâti de la pêche. Toutefois, *Hippopus hippopus* était habituellement présent dans les habitats benthiques meubles et une réserve de géniteurs proche du principal village était protégée de la pêche. Des stocks de mollusques nacriers et de trocas ont été observés, mais uniquement à de faibles densités. Le burgau n'a pas été observé. Des holothuries étaient présentes, mais les habitats disponibles étaient fortement exposés à l'influence océanique et n'offraient pas des conditions optimales pour l'exploitation commerciale de nombreuses espèces. D'après l'étude, les holothuries sont victimes des conditions environnementales et/ou de la pression de pêche. Les signes de la pression de pêche étaient plus marqués chez les espèces bien adaptées aux zones récifales battues. Aucune holothurie brune des brisants n'a été aperçue, et l'holothurie noire à mamelles, à forte valeur commerciale, n'a été recensée que rarement durant l'inventaire. En dépit des répercussions soupçonnées sur les stocks, le caractère durable des stocks d'holothuries a été mis en évidence pendant l'étude, puisque le nombre total d'individus n'a pas gravement diminué à Moso et certaines espèces à valeur marchande moyenne ont été observées à des densités raisonnables dans les eaux peu profondes (holothurie noire).

Sur la base des inventaires et des évaluations de l'équipe, les recommandations suivantes s'appliquent à la zone de pêche de l'île de Moso :

- À ce stade de l'analyse, nous estimons que des mesures strictes de protection de l'écosystème (à savoir la création d'une aire marine protégée) ne sont pas requises pour assurer l'exploitation durable des ressources en poissons. Cela dit, de grandes concentrations d'Acanthuridae herbivores (*Acanthurus blochii* en particulier) présentes dans la zone de pêche pourraient être ciblées à la place des perroquets, ce qui contribuerait à la reconstitution des populations de perroquets, probablement victimes de la pêche en ce moment.

- La qualité naturelle de l'habitat, moyenne à riche, tend à indiquer que les poissons de Moso devraient faire figure de source alimentaire et financière secondaire (plutôt que principale), étant donné que l'île ne dispose peut-être pas d'un environnement suffisamment riche pour supporter une pression de pêche intense pendant une longue période. Compte tenu de l'accès aisé aux eaux libres pélagiques, les espèces de poissons pélagiques et de grand fond peuvent être particulièrement attrayantes pour le développement de pêcheries. Il convient d'étudier la contribution potentielle de ce type de pêcheries à la sécurité alimentaire et financière des habitants de Moso.

- L'exploitation commerciale des trocas a porté atteinte aux stocks, qui sont, d'après les évaluations, proches de l'effondrement malgré la présence d'habitats étendus, adaptés aux adultes. Il est conseillé aux propriétaires des ressources d'envisager de fermer ces zones à la pêche, pendant une dizaine d'année par exemple.

- Il est recommandé aux propriétaires des ressources locales de demander l'avis d'experts, avant l'ouverture de la pêche d'holothuries, concernant les différentes pratiques possibles, en vue d'assurer une rentabilité maximale de la valorisation des produits de la pêche.

Résultats des études de terrain sur les îles d'Uri et d'Uripiv

Les îles d'Uri et d'Uripiv se situent au large de la côte est de Malekula, à 3 ou 4 km de Lakatoro en bateau. Les deux îles sont séparées de Malekula par Port Stanley, un pseudo-lagon. Les populations d'Uripiv et d'Uri considèrent qu'elles forment une seule communauté de pêcheurs, Uri comptant un clan et Uripiv six. Pour les besoins du présent rapport, les villages ont été fusionnés et appelés Uri-Uripiv. La pêche à Uri-Uripiv est régie par un système traditionnel de propriété collective des zones de pêche, s'étendant sur à peu près 7 km^2, dont 4 km^2 de récif. Un platier frangeant océanique s'étire le long de la côte septentrionale (tournée vers l'océan) des deux îles. Un récif côtier abrité s'étend le long des côtes sous le vent (au sud) des deux îles ; les zones sablonneuses et les petites mangroves deviennent de plus en plus denses (et le corail, de plus en plus épars), à mesure que l'on avance à l'intérieur de la baie de Port Stanley, le long de la côte abritée d'Uri. Les récifs d'Uri-Uripiv sont principalement constitués d'une pente externe (2,77 km^2, 67 % des habitats), et, dans une moindre mesure, d'un récif côtier abrité (1,36 km^2, 33 %). Trois petites aires marines protégées entourent Uripiv (situées chacune à environ 300 mètres du rivage), et la pêche y est entièrement interdite depuis dix, six et deux ans, respectivement.

Socioéconomie : îles d'Uri et d'Uripiv

Le nombre de ménages actifs et d'habitants sur l'île d'Uripiv a été estimé respectivement à 84 et à moins de 500. Sur Uri, au total, 14 ménages ont été recensés, mais seuls huit d'entre eux seraient actifs ; la population totale actuelle estimée atteint 130 habitants. L'étude socioéconomique réalisée à Uri-Uripiv a montré que la pêche constitue la principale source de revenus des habitants (38 %), suivie des emplois salariés (28 %), de l'agriculture et d'autres activités (petites entreprises) comptabilisant 17 % respectivement. En outre, la pêche apporte des revenus complémentaires à 15 % de plus des ménages interrogés. D'après les personnes interrogées, la plupart des ménages pratiquent régulièrement la pêche de subsistance (six jours par semaine), mais seuls 30 ménages vendent du poisson. D'après les mêmes sources, les résidents possèdent douze bateaux à moteur et vingt pirogues. Les habitants d'Uri-Uripiv consomment peu souvent du poisson frais ou du poisson en conserve (1,3 et 1,2 fois par semaine, respectivement). La consommation de poisson frais par habitant et par an ne s'élève qu'à 9,9 kg, contre seulement 4,5 kg par habitant et par an pour le poisson en conserve. Près de la moitié de tous les invertébrés étaient capturés exclusivement pour la consommation propre, l'autre moitié étant parfois, mais pas toujours, destinée à la vente. La proportion des captures de poisson (84 % du poids des prises) destinée à la vente (exportation) était cinq fois supérieure au pourcentage de captures vivrières, ce qui témoigne de la dépendance économique de la communauté par rapport à la pêche. Les hommes récoltaient un peu plus de la moitié des invertébrés (54 %), mais les femmes rapportaient 30 % des prises d'invertébrés des mangroves. Les hommes pêchaient la majorité des poissons capturés (77 %).

Poissons : îles d'Uri et d'Uripiv

Au total, 23 familles, 62 genres et 190 espèces ont été recensés durant les inventaires de poissons. La pente externe constituait l'habitat d'un plus grand nombre d'espèces et d'individus, ainsi que de poissons de plus grande taille, et donc d'une biomasse plus importante, par rapport au récif côtier abrité, bien que les écarts ne soient marqués que pour la biomasse (1,6 fois supérieure). Le récif côtier abrité d'Uri-Uripiv était principalement peuplé d'Acanthuridae et de Scaridae herbivores, de Lutjanidae, de Mullidae et de Nemipteridae carnivores, ainsi que de Chaetodontidae (en termes de densité uniquement). Fait remarquable, le perroquet à bosse (*Bolbometopon muricatum*), pourtant rare et vulnérable à la pêche, arrivait en sixième place dans le classement de la biomasse. Les substrats étaient bien diversifiés, dominés par du substrat dur. La complexité des habitats peut apporter un élément d'explication à la complexité relative de l'assemblage de poissons peuplant ce récif. Les zones de pente externe d'Uri-Uripiv abritaient surtout des Acanthuridae herbivores et, dans une moindre mesure, des Scaridae. Similairement au récif côtier, le perroquet à bosse enregistrait la dixeptième biomasse la plus élevée. Les substrats se composaient essentiellement de substrat dur (66 % du couvert), ce qui peut, associé à l'influence océanique directe à laquelle sont soumises les pentes externes, expliquer la prépondérance de grands groupes de poissons herbivores de taille moyenne à grande. Il semble que les habitats de récif côtier abrité et de pente externe d'Uri-Uripiv tendent de façon générale à accueillir des densités et des biomasses moyennes d'espèces comestibles supérieures aux chiffres habituels, et la présence d'espèces rares et fragiles de grande taille dans des habitats somme toute communs peut traduire la faible incidence de la pêche.

Invertébrés : îles d'Uri et d'Uripiv

Le platier frangeant océanique battu d'Uri-Uripiv était soumis à une forte houle et à une mer agitée. Port Stanley recelait une quantité abondante de benthos peuplant les fonds meubles peu profonds et de substrats détritiques. Dans les zones protégées de la baie, les coraux étaient généralement recouverts de limon. Les bénitiers d'Uri-Uripiv ne souffraient pas des conditions environnementales ou de la pression de pêche. L'abondance et la densité des trocas étaient faibles, et la densité d'autres espèces nacrières, telles que *Pinctada margaritifera* et *Turbo marmoratus,* n'était pas suffisante pour permettre une exploitation commerciale viable. Les espèces nacrières ont principalement été recensées dans l'une des aires marines protégées située à proximité d'Uripiv. L'équipe a constaté que les stocks d'holothuries étaient en bonne santé : la couverture et l'abondance d'espèces à forte valeur marchande étaient relativement élevées à Uri-Uripiv, et l'incidence de la pêche a été jugée faible. Un régime efficace de gestion coutumière imposait une fermeture de la pêche entre les périodes d'activités, bien que certains pêcheurs n'appartenant pas à la communauté aient pratiqué la pêche commerciale récemment pendant les périodes d'interdiction. Des zones benthiques meubles ont été observées près du village d'Uri, mais il ne s'agissait que d'étendues très restreintes bordant les chenaux de la mangrove. Aucun banc de mollusque massif n'a été recensé. La collecte de bivalves endofauniques de la famille des Lucinidae (*Anodontia philippiana*) dans la vase de la mangrove s'est poursuivie durant l'étude. Dans le cadre des réglementations coutumières de gestion récifale, en place lors de l'étude, la pêche était interdite dans des zones délimitées, et la pêche et la vente des ressources halieutiques étaient restreintes. Toutefois, les retombées positives de ces mesures de gestion restaient généralement limitées aux petites zones placées sous protection (des bénitiers ont été observés en grande abondance dans les aires protégées de la baie de Port Stanley).

Sur la base des inventaires et des évaluations de l'équipe, les recommandations suivantes s'appliquent à la zone de pêche des îles d'Uri et d'Uripiv :

- Les résultats préliminaires de l'analyse semblent indiquer que les mesures de gestion actuellement en vigueur sont suffisantes pour assurer l'exploitation durable des poissons dans les conditions de pêche actuelles.

- Malgré le bon état des stocks, les poissons récifaux devraient être envisagés comme une source alimentaire et/ou financière secondaire, plutôt que principale, étant donné que la bande récifale qui entoure Uri-Uripiv peut être trop mince pour permettre une intense pression de pêche, viable sur le long terme.

- Compte tenu de l'accès aisé aux eaux du large, les espèces de poissons pélagiques et de grand fond peuvent être particulièrement attrayantes pour le développement de pêcheries. Il convient d'étudier la contribution potentielle de ce type de pêcheries à la sécurité alimentaire et financière des habitants d'Uri-Uripiv.

- Les propriétaires des ressources devraient être informés des stratégies de pêche et de rendement actuellement en place dans d'autres régions du Pacifique pour l'exploitation des mollusques nacriers.

- Il est recommandé aux propriétaires des ressources locales de demander l'avis d'experts, avant l'ouverture de la pêche des holothuries, concernant les différentes pratiques possibles, en vue d'assurer une rentabilité maximale de la valorisation des produits de la pêche.

- L'holothurie de sable (*Holothuria scabra*) était absente des inventaires et, dans le cadre d'études à venir, il convient d'axer le travail sur l'exploration de la zone afin de déterminer si cette espèce vit dans la baie de Port Stanley.

Résultats des études de terrain dans l'archipel des Maskelyne

Les Maskelyne Archipelago se composent de petites îles, assez isolées, situées au large de la pointe sud-est de l'île de Malakula dans la province de Malampa à Vanuatu, à environ 40 minutes de bateau du débarcadère de Point Doucere et à 7 km de la piste d'atterrissage de Lamap. Seules deux îles sont habitées sur l'ensemble de l'archipel : Uliveo et Avokh. Uliveo est la plus grande des deux et compte trois villages : Pellonk, Peskarus et Lutes. Les aires de pêche des trois villages mesurent, réunies, environ 38 km^2, dont 20,4 km^2 de zones récifales. Les zones récifales des trois villages d'Uliveo sont principalement occupées par des zones de pente externe (16,2 km^2, 80 % des habitats), et le restant se compose d'un récif côtier abrité (4,05 km^2, 20 %) et d'un récif intermédiaire lagonaire (0,09 km^2, < 0,4 %). Des étendues de mangrove séparent le village de Pellonk d'un vaste lagon. Les eaux du lagon se renouvellent au niveau de la passe située entre les îles d'Uliveo et de Sakao. Toutes les autres passes

(Uliveo, Sakao et la zone entre Sakao et Malakula) sont le siège d'un grand dynamisme et de fortes marées.

Le régime de propriété coutumier des zones maritimes, système traditionnel de gestion, reste en vigueur et est respecté dans les Maskelyne Archipelago. Les trois villages d'Uliveo disposent de zones récifales clairement délimitées et chaque village partage l'accès aux zones récifales qu'il possède pour la pêche de subsistance. Tous les villages restreignent l'utilisation de filets maillants et la chasse sous-marine de nuit au harpon, et ont récemment adopté un quota annuel pour la pêche des tortues marines. Une aire marine protégée où la pêche est interdite a, par ailleurs, été établie il y a plus de dix ans en face des villages de Pellonk et de Peskarus. Les mangroves ne sont soumises à aucune réglementation en matière de gestion et peuvent être ciblées à toute fin tout au long de l'année. D'après l'étude, les habitants respectent fortement les réglementations communautaires et l'interdiction totale de la pêche de trocas et d'holothuries. Néanmoins, la côte ouest de l'île de Sakao, qui ne peut être surveillée, serait victime du braconnage pratiqué par les pêcheurs extérieurs et ne tomberait pas sous le coup des réglementations communautaires. Si le régime de propriété coutumier des zones maritimes est reconnu par la constitution, les autorités provinciales locales assurent également le respect de certaines mesures de contrôle par les exploitants et peuvent prendre des décisions sur toute activité pratiquée dans les eaux provinciales.

Socioéconomie : archipel des Maskelyne

Uliveo compte 1 058 habitants répartis dans les trois villages : 48 ménages vivent à Pellonk, 99 à Peskarus et 35 à Lutes. Dans l'archipel des Maskelyne, la pêche est pratiquée par la communauté essentiellement à des fins de subsistance, comme en témoignent les nombreux facteurs socioéconomiques et les formes d'exploitation des ressources. L'enquête a montré que les ménages effectuaient en moyenne peu de dépenses, consommaient des quantités importantes de poisson frais et d'invertébrés, pratiquaient beaucoup le troc de leurs ressources marines, pêchaient pour la plupart pour leur propre consommation, et comptaient un grand nombre de pêcheurs (100 % des ménages) et de bateaux (97 % des ménages). Tant les hommes que les femmes participent intensément aux activités halieutiques, les femmes interrogées se concentrant davantage sur la pêche de subsistance et ciblant essentiellement les invertébrés. La consommation de poisson frais par habitant était élevée chez les personnes interrogées (22,2 kg par habitant et par an). La pêche n'est pas considérée comme une importante source principale de revenus. Seuls 4 % des ménages interrogés ont déclarés qu'elle constituait leur principale source de revenus, contre 90 % pour l'agriculture. Cela dit, la pêche constituait la plus importante source complémentaire de revenus (pour 61 % des ménages). Les emplois salariés et autres activités (artisanat, petites entreprises) ne constituaient pas une source importante de revenus, qu'elle soit principale ou secondaire. Les revenus tirés de la pêche venaient surtout du poisson. En revanche, plus de 90 % des invertébrés (pourcentage du poids) ramassés par les personnes interrogées étaient consommés par la population.

Poissons : archipel des Maskelyne

Les inventaires de poissons ont permis d'identifier au total 23 familles, 62 genres et 198 espèces. La pente externe abritait des poissons en grand nombre et de taille supérieure aux individus vivant dans les milieux côtiers abrités, et possédait ainsi une biomasse globale plus importante (près de deux fois supérieure en moyenne). Le récif côtier abrité comprenait essentiellement cinq familles : Acanthuridae et Scaridae herbivores (en termes à la fois de densité et de biomasse), Lutjanidae et Lethrinidae (en termes de biomasse uniquement), et Chaetodontidae (densité uniquement). Ce milieu récifal affichait une bonne diversité d'habitats et un bon couvert corallien vivant (20 %), les substrats étant dominés par du dur. Les habitats de la pente externe accueillaient surtout des Acanthuridae et des Scaridae herbivores et, dans une moindre mesure, des Lutjanidae carnivores. Fait remarquable, le perroquet à bosse (*Bolbometopon muricatum*), pourtant rare et vulnérable à la pêche, représentait la biomasse la plus élevée du site. Ce milieu récifal était caractérisé par un couvert corallien vivant assez élevé (24 %). Dans l'ensemble, l'état des stocks de poissons semblait bon. Il est possible que les difficultés d'accès aux récifs très battus de la côte méridionale d'Uliveo (et donc les difficultés d'y pêcher), associées aux nombreuses mesures de gestion appliquées, aient contribué à la bonne santé apparente des poissons dans cette zone, et notamment à l'observation d'une concentration de perroquets à bosse près de la pente externe.

Invertébrés : archipel des Maskelyne

Les pêcheurs d'invertébrés ciblaient un large éventail d'espèces pour leur alimentation, mais étaient beaucoup plus sélectifs lorsqu'ils ciblaient ces ressources à des fins commerciales. Il a été constaté que la pêche d'invertébrés dans les habitats de mangrove exerçait la plus forte pression sur le milieu, exprimée en biomasse totale (poids humide) capturée annuellement, peut-être parce que ces zones ne sont pas soumises à des fermetures périodiques. Les pêcheurs qui opéraient dans les mangroves capturaient principalement les espèces du genre *Terebra*, alors que *Anadara*, *Cypraea*, *Gafrarium* et *Periglypta* étaient prélevés surtout dans les milieux benthiques meubles. Les espèces ciblées sur le haut du récif étaient plus diversifiées et appartenaient notamment aux genres *Octopus*, *Tridacna, Turbo, Lambis* et *Conus*. Compte tenu de la maigre proportion d'habitats benthiques meubles par rapport aux zones situées sur le haut du récif, la pression de pêche par unité de surface de l'habitat pourrait être de loin supérieure dans les substrats benthiques meubles. Dans l'ensemble, les petites espèces de bénitiers semblaient peu pâtir des conditions environnementales et/ou de la pêche, alors que la pression de pêche était très probablement à l'origine des faibles densités des espèces de grande taille. Les bancs de mollusques semblaient n'être que légèrement affectés par la pêche et présentaient des densités raisonnables d'arches à larges coquilles en dépit de l'aspect sablonneux et compact de l'habitat. Le burgau était absent des inventaires, mais *Trochus niloticus* et *Pinctada margaritifera* ont été recensés. La pêche commerciale des trocas a porté atteinte au nombre d'individus présents et à la densité des stocks. Des épisodes de recrutement ont été observés. L'état des stocks d'holothuries semblait bon, aidé par une gestion coutumière efficace (une mesure de fermeture de la pêche était en vigueur lors de l'étude). L'équipe a estimé que, durant l'étude, les ressources en holothuries ne souffraient guère ou pas du tout de l'exploitation.

Sur la base des inventaires et des évaluations de l'équipe, les recommandations suivantes s'appliquent à la zone de pêche des Maskelyne Archipelago :

- Afin de garantir pour la communauté de l'archipel des Maskelyne une sécurité alimentaire et financière provenant de l'exploitation des poissons et des invertébrés, toute expansion commerciale ultérieure de la pêche devrait être évitée.

- La gestion actuelle des pêcheries par la communauté fonctionne bien et devrait être renforcée afin de s'assurer que les ressources marines restent disponibles pour la subsistance des générations à venir. Si des mesures de gestion deviennent nécessaires, les aires marines protégées devraient être considérées comme un premier outil de gestion ceci en tenant compte de la haute qualité de l'habitat et de la haute conformité avec les règles des aires marines protégées établies par la communauté.

- Les ressources devraient être contrôlées avec des suivis réguliers afin de pouvoir détecter tout effet négatif des pêches, en particulier si le développement de la pêche de poissons se produit i.e. s'il y a un changement vers l'utilisation de techniques de pêche plus efficaces comme par exemple l'emploi de bateaux motorisés ou l'installation de machines à glace.

- Les stocks d'invertébrés sont peu en mesure de supporter une intensification de leur exploitation. Il est nécessaire d'appliquer des mesures de gestion visant à protéger les stocks de bénitiers et de trocas. Les périodes de faible recrutement et les perturbations environnementales risquent d'augmenter la pression que subissent d'ores et déjà les stocks.

- Les mécanismes actuels de gestion établis pour protéger les concentrations d'holothuries devraient être consolidés, et il serait intéressant pour la communauté de recevoir des conseils sur les marchés avant de reprendre la pêche commerciale. Un programme de suivi des pêches, qui permettrait d'avoir une idée globale de la reconstitution des stocks après une période ponctuelle de pêche intensive, fournirait des informations précieuses pour la pêche d'holothuries de sable (*Holothuria scabra*).

- Il serait intéressant d'entreprendre des études sur l'efficacité des fermetures semestrielles saisonnières de la pêche. Si l'interdiction de six mois est suivie de six mois de pêche intensive (comme cela semble être le cas), cette mesure n'aura peut-être pour effet que d'équilibrer les taux de capture et les taux de reconstitution des stocks. Toute perturbation du système (comme une période de faible recrutement ou un cyclone) pourrait rompre cet équilibre. Il convient aujourd'hui de mieux comprendre la dynamique des effets de ce régime de fermeture.

ACRONYMS AND ABBREVIATIONS

ACIAR	Australian Centre for International Agricultural Research
ACP	African, Caribbean and Pacific Group of States
ADB	Asian Development Bank
AIMS	Australian Institute of Marine Science
BdM	bêche-de-mer (or sea cucumber)
B-S	broad-scale
CCA	crustose coralline algae
CITES	Convention on International Trade in Endangered Species
CMT	customary marine tenure
CoFish	Pacific Regional Coastal Fisheries Development Programme
COTS	crown of thorns starfish
CPUE	catch per unit effort
CSPODP	Canada South Pacific Ocean Development Programme
Ds	day search
D-UVC	distance-sampling underwater visual census
EDF	European Development Fund
EEZ	exclusive economic zone
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
GIFT	genetically improved farmed tilapia
GPS	global positioning system
ha	hectare
HH	household
JICA	Japan International Cooperation Agency
MCRMP	Millennium Coral Reef Mapping Project
MIRAB	Migration, Remittances, Aid and Bureaucracy (model explaining the economies of small island nations)
MOP	mother-of-pearl
MOPs	mother-of-pearl search
MOPt	mother-of-pearl transect
MPA	marine protected area
MRAG	marine resource assessment group
MRM	marine resource management
MSA	medium-scale approach
MSY	maximum sustainable yield
NASA	National Aeronautics and Space Administration (USA)

NCA	nongeniculate coralline algae
Ns	night search
OCT	Overseas Countries and Territories
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
REDI	Regional Economic Development Initiative
RFID	Reef Fisheries Integrated Database
RFs	reef-front search
RFs_w	reef-front search by walking
SBq	soft-benthos quadrat
SBt	soft-benthos transect
SCUBA	self-contained underwater breathing apparatus
SE	standard error
SPC	Secretariat of the Pacific Community
SPADP	South Pacific Aquaculture Development Project
SPFC	South Pacific Fishing Company
USD	United States dollar(s)
VFDP	Village Fisheries Development Project
VT	Vanuatu vatu
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 project (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).

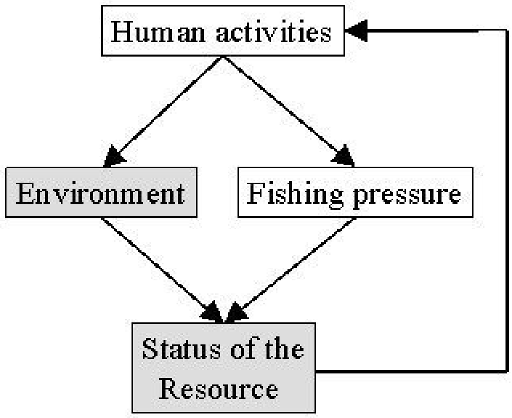

Figure 1.1: Synopsis of the PROCFish/C* multidisciplinary approach.
PROCFish/C conducts coastal fisheries assessment through simultaneous collection of data on the three major components of fishery systems: people, the environment and the resource. This multidisciplinary information should provide the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

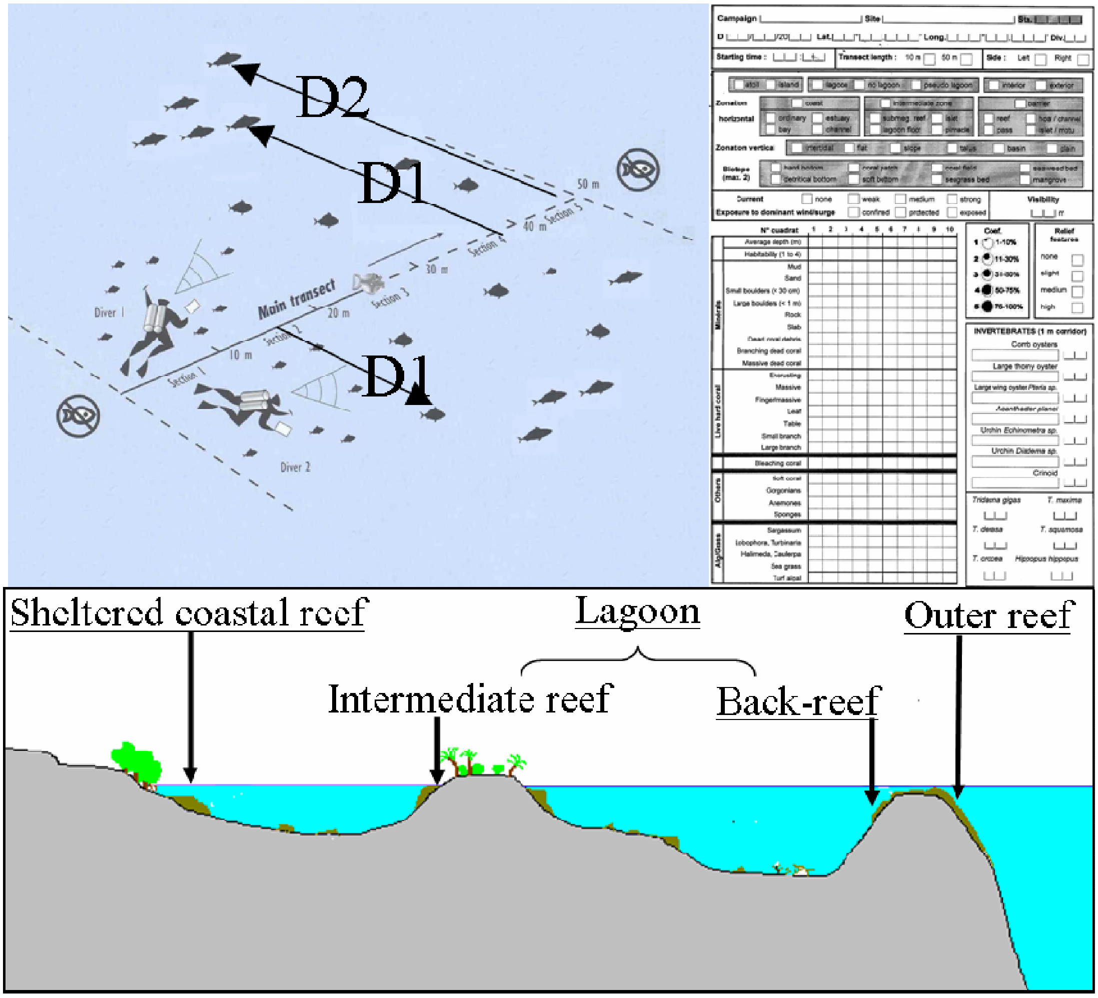

Figure 1.2: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver recorded the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys 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).).[3]

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.).

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

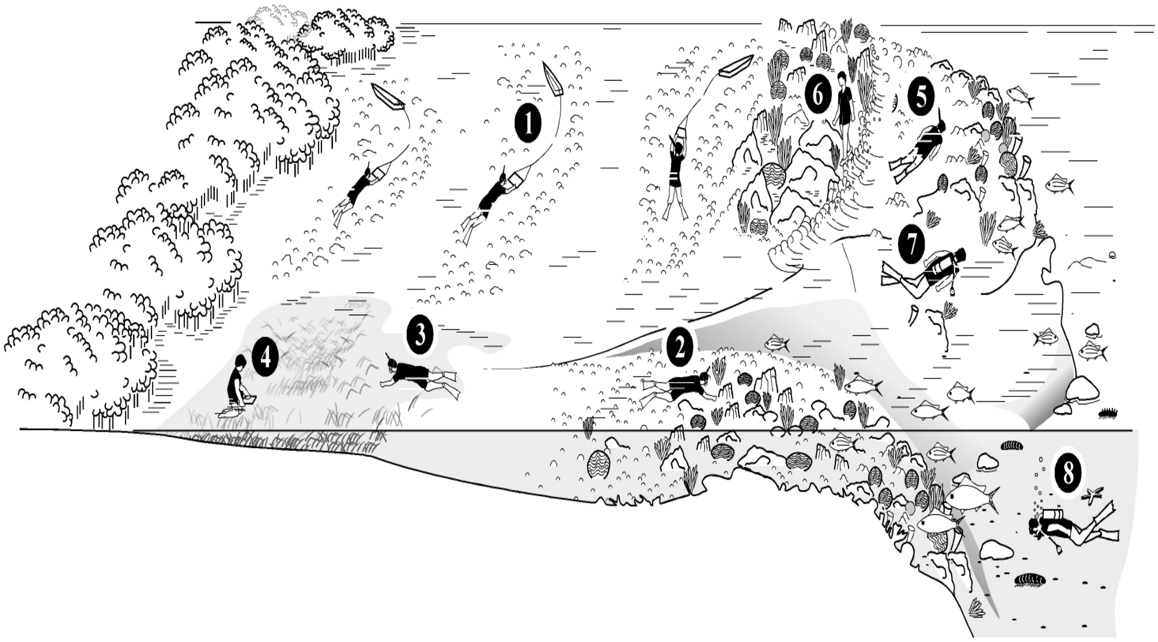

Figure 1.3: Assessment of invertebrate resources and associated environments.
Techniques used include: broad-scale assessments to record large sedentary invertebrates (1); fine-scale assessments to record epi-benthic resources and potential indicator species (2) and (3); quadrats to count targeted infaunal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

1.3.1 General

Vanuatu is composed of 80 volcanic islands, 67 of which are inhabited and 12 of which are described as major islands. The islands are predominantly volcanic with limestone derived from fringing reef formations (Done and Navin 1990). Most islands are mountainous and continually experience earthquake activities, which have been catastrophic for coral reef areas at times. There are nine active volcanoes, all the result of tectonic actions along the New Hebrides subduction zone. The country's total land area is 12,200 km^2, of which 45% is considered as potential arable land. Inner reefs and mangrove areas are small compared to neighbouring countries, comprising only 448 and 25 km^2 respectively, and drop-offs are steep closer to the shore. Maritime borders are shared with neighbours France (New Caledonia), Solomon Islands and Fiji, with Vanuatu's EEZ being 680,000 km^2 in total. The climate is generally tropical with high humidity and rainfall. Cyclones are regular, ranging in frequency from one in three years to three in a year (Anon. 1984 quoted in Bell and Amos 1994).

The country's population at the 1999 census was 186,678, with an annual growth rate of 2.6% (Statistics Office 2000). The majority (80%) of the population is rurally based, relying on subsistence farming and fishing for livelihood. Urban population growth is high at 4.2% while rural areas continue to experience a lower growth of 2.2% (Statistics Office 2000).

Vanuatu, formerly the New Hebrides and a joint French-British Condominium administration for 74 years, became politically independent in 1980. The country was divided into 11 political provinces after independence but later reduced to six provinces (Figure 1.4). Each province has its own administration and development plans. The provinces also claim a maritime zone of three nautical miles from the beach of each island in the province, known as 'provincial waters'. Although this has created internal conflicts, especially regarding the management responsibility of inshore resources, efforts are being made for the Fisheries Department and provinces to work together. A national council of chiefs plays an advisory role to the government on matters relating to custom, culture and traditions.

Vanuatu's economy is driven by agriculture, tourism and financial centres. Tourism is the fastest-growing sector and the country's main foreign exchange earner following increased arrivals of visitors. The agriculture sector remains the traditional economic base of the country, with potential to grow. Copra is by far the most important cash crop (making up more than 35% of the country's exports), followed by timber, beef, cocoa and kava. The fisheries sector was once important in the country's economy through the South Pacific Fishing Company's operations, but today it is a minor player. Subsistence fisheries, however, remain extremely important in the local economy for household income and food security. The three major sectors of development identified by the Vanuatu Investment Promotion Authority are tourism, agriculture and fisheries. With increasing direct foreign investments, there are positive signs of economic improvement in the country (www.investinvanuatu.com).

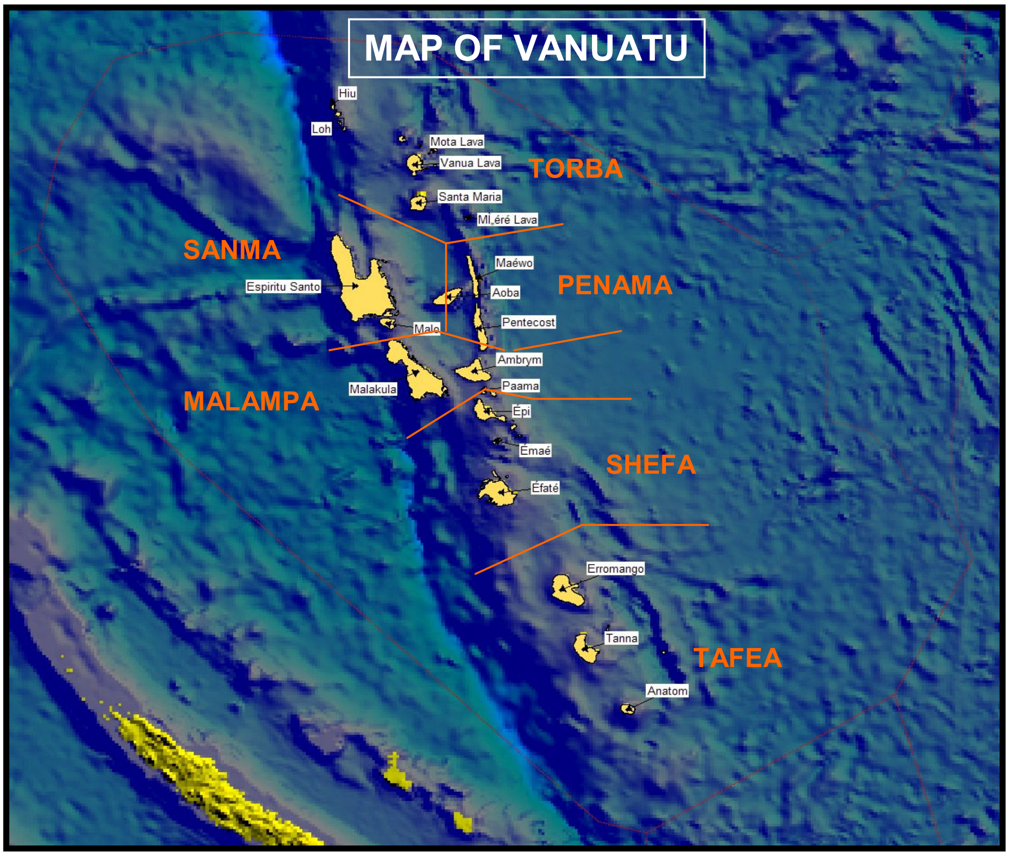

Figure 1.4: The six provinces that make up Vanuatu.

1.3.2 The fisheries sector

Vanuatu's fisheries comprise the offshore fishery for tuna and other pelagic species, the game fishery, the deep-water bottom fishery for snapper and related species, and the reef fishery for a range of fish and invertebrate species.

Tuna fishery

Vanuatu is located south of the tuna 'hot spots' of the western and central Pacific Ocean (WCPO) region, thus few tuna stocks straddle the country's EEZ (ADB 2001). According to the Forum Fisheries Agency (FFA), the total allowable annual tuna catch in Vanuatu's EEZ is estimated at 8250 t. This comprises 3000 t of albacore (*Thunnus alalunga*), 3000 t of skipjack (*Katsuwonus pelamis*), 2000 t of yellowfin (*T. albacares*) and 250 t of bigeye (*T. obesus*) (ADB 2002). Recent catch statistics show that albacore dominates catch composition from Vanuatu's EEZ (Naviti 2005). Prior to the 1980s, the fisheries sector was second to copra in the country's economy, mainly from the activities of the South Pacific Fishing Company (SPFC) transhipment base in Santo. Albacore, bigeye and yellowfin were the target species. Since this operation ceased in 1987, there have been no other shore-based tuna industry activities in Vanuatu.

The country's tuna industry is entirely offshore, based on the licensing of foreign fishing vessels. In 2004 and 2005, the majority of the 118 foreign longliners licensed by Vanuatu were from China, Korea and Fiji. The decrease in the number of Taiwanese vessels is attributed to more stringent compliance measures imposed by Vanuatu (Naviti 2004). A total longline catch of 4449 mt in 2004 represents the highest catch taken from the Vanuatu EEZ in five years, with albacore featuring as the dominant species (Naviti 2005). Income derived from foreign licence fees provides significant revenue to the central government. Catch data collection from these vessels remains problematic, but there are plans to improve it through cooperative arrangements with Fiji and New Caledonia.

Vanuatu operates a shipping registry, of which about 80 of the registered vessels are tuna longliners and purse seiners operating in the WCPO region and elsewhere (Naviti 2000). Catches from these vessels are offloaded in processing facilities in regional island countries or transhipped to distant markets. Vanuatu is party to the multilateral fishing treaty between the United States and the FFA member countries, and derives benefits from the treaty funds.

Sportfishing or gamefishing is another component of the Vanuatu tuna industry (Chapman 2004). The sector has 20–30 gamefishing boats. Many of these vessels also carry out commercial fishing activities and sell their catch on the local market. Sportfishing charter boats are now categorised as fishing vessels under the revised Vanuatu Fishing Act of 2004, meaning it is a licensed fishing activity (Naviti 2000). Some fish aggregating devices (FADs) have been deployed on Efate and Santo by the local small-scale sector to attract coastal tuna activities. The main beneficiaries of these FADs are the gamefishing boats.

Deep-water snapper fishery

Vanuatu's deep-water snapper fishery is well documented in the Vanuatu fisheries atlas (Cillaurren *et al.* 2001). There are about 107 species of deep-water fish, best represented by the families Lutjanidae, Serranidae, Epinephelinae and Lethrinidae (Brouard and Grandperrin 1985). Of these, 11 species – comprising three species each of the genera *Etelis*, *Pristipomoides* and *Epinephelus* and a species each of the genera *Aphareus* and *Lutjanus* – are the top targeted species. Total maximum sustainable yield (MSY) for the resource was estimated to be 300 t annually (Cillaurren *et al.* 2001). However, production to date has remained well below this figure (Mourgues 2004).

Deep-water snapper fishing activities today are modest, although it is believed that the fishery has potential for small-scale activities. It thus presents an opportunity for the domestic market as a source of small-scale income activity and food security. The government, via the Department of Fisheries, has begun to revive fishing centres in the country with the support of provincial governments under Regional Economic Development Initiative (REDI) programmes (Chapman 2004). So far, new ice machines have been installed at Lenakel, Tanna, Pamma, Pentecost, Port Olry-Santo and Emae, with plans for more on other islands. To facilitate this initiative, the government has moved to discourage large-scale fishing arrangements inside the country's 12-mile territorial zone, to protect local small-scale fishing operations and activities. Deep-water snapper will be one of the main target species for these small-scale fishing activities in the provinces.

Shallow reef fishery

A total of 469 species of shallow-water reef fish have been recorded on Vanuatu reefs (Done and Navin 1990). Reef fish communities on Cook Reef and East Santo were found to be rich, but on the whole not different to that of the Great Barrier Reef in Australia (Williams 1990). Out of all the fish recorded, 25 species of the families Pomacentridae, Scaridae, Labridae, Acanthuridae, Siganidae and Chaetodontidae are easily distinguishable (Williams 1990), and 22 species constitute the major reef fish landings (Bell and Amos 1994). The shallow reef fishery is the main source of fish protein for the majority of Vanuatu's population.

In the 1999 household census, over 61% of Vanuatu households fished regularly, with 90% of those fishing for subsistence purposes and only 10% fishing to sell their catch (Statistics Office 2000). Also in 1999, fish and shellfish formed the greatest proportion of catch taken by more than 50% of the rural population (David 1985). Combined annual production for the subsistence and artisanal sectors was estimated at 2400 t (ADB 2002). This represents a significant contribution to national food security needs.

Marketing of reef fish to urban markets in Port Vila and Luganville is limited. Collection of reef fish by a Port Vila-based vessel from Emae, Epi and South Malekula is the only way for rural communities to market their catch. Reef fish comprise the main catch and are estimated at 1–3 t per trip (Pakoa pers. comm.). Suspicion of ciguatera fish poisoning often restricts the sale of reef fish. Recent statistics on subsistence production are not available, but are estimated to maintain an increasing trend (Preston 1996; ADB 2002). Fish exports remain negligible compared to high importation of canned fish (ADB 2002). In 2003, 236 t of fish were exported compared to importation of 1335 t of canned fish at a cost of VT 188 million (Mourgues 2004). Reef fish resources near main population centres like Efate and some parts of Santo are showing signs of depletion, while resources in the outer islands are known to be underfished.

Stock assessment surveys conducted on Efate in 2001 revealed that stocks of commercial food fish were low, and therefore not sufficient to warrant the development of a live reef food fish trade (Naviti and Hickey 2001). Assessments conducted on Efate reefs in 2004 also revealed very low stocks of reef food fish (Sykes 2004; Hill 2004). While stocks are known to be underfished in much of the country, the general feeling is that the resource is limited and not sufficient to stand any export-oriented activities.

The main fishing methods used are handlining, spearing, bow and arrow, speargun, gillnetting and fish fencing. Use of traditional fish poison is rare nowadays and dynamiting is absent because of strict laws on the importation of explosives. Use of explosives and poisons for fishing is illegal under the fisheries law. Fishing with SCUBA gear is restricted to aquarium fish collection, and a new mesh size regulation is in place for gillnets. Traditional marine tenure and village-based management remain important mechanisms for reef resources management (Johannes and Hickey 2004). Information on the performance of customary marine tenure in Vanuatu is available (MRAG 1999b). Vanuatu has supported the latest inclusion of humphead wrasse (*Cheilinus undulatus*) in Appendix II of CITES in 2005.

Marine aquarium trade

A small marine aquarium fishery is based on Efate. Ornamental fish is the main product, but invertebrates, 'live rocks' (dead coral rock with coralline algae), cultured corals and giant clams are also exported. There are around 300 species of non-food reef fish targeted by this fishery. Established some 13 years ago, the aquarium trade in Vanuatu experienced a major increase in 2003, with a new American-owned company being established. Angelfish (Pomacanthidae) is the most traded family, with flame angelfish (*Centropyge loriculus*) being the main species, followed by wrasses (Labridae), gobies and blennies (Gobiidae/Blenniidae), damselfish (Pomacentridae), butterflyfish (Chaetodontidae) and tangs (Acanthuridae). In value terms, angelfish are the most valued species, contributing 42% of the export value, followed by wrasses and others, including rare and unusual species, damsels and tangs (Vanuatu Fisheries Department 2004).

Marine aquarium product exports in 2005 comprised 117,000 fish, 14,503 invertebrates, 763 live cultured corals and 19 tonnes of live rock, altogether worth around VT 100 million in export value (Vanuatu Fisheries Department 2006). The industry is estimated to contribute about USD 1 million to the local economy, making it the most important export fishery for Vanuatu (Pakoa pers. comm., May 2004). While other reef fisheries are demanding urgent management attention, the marine aquarium trade presents some opportunity to expand to other islands in Vanuatu. However, recent growth has attracted concern from the general public because of a lack of knowledge and inadequate monitoring of the operations and its potential impact on ecotourism activities. Only three companies are allowed in the country, and a national aquarium fishery management and monitoring plan is being developed.

Bêche-de-mer fishery

Vanuatu's bêche-de-mer resource, though small, represents an important source of income for coastal villages on the main islands. There are 18 commercial sea cucumber species present on reefs around the country, but stock densities are naturally low (Chambers 1990). Seven species are the most important commercially: *Holothuria nobilis*, *H. scabra*, *H. atra*, *Actinopyga miliaris*, *A. echinites*, *A. mauritiana* and *Thelenota ananas*. Monitoring activities conducted by the Fisheries Department have confirmed the scarcity of the high- to medium-value species (Lamont *et al.* 1999; Gibbs *et al.* 1998; Saunders *et al.* 2000). High densities of low-value species such as *H. atra* have been noted in some areas. Vanuatu's bêche-de-mer fishery is best described by a 'boom and bust' phenomenon. The last 'boom' was in 1994, when 66 t of dried product was exported. Since then production has dropped to an annual average of around 23 t over the last five years (Vanuatu Fisheries Department 2005). There is growing demand for bêche-de-mer products, which is leading to increasing competition for access to resources and changes in local prices for products. The existing management policy includes an annual export quota of 35 t per exporter, but no exporter has been able to attain such a volume since enforcement was implemented 20 years ago.

Trochus and green snail fisheries

The trochus shell fishery is a mature fishery dating back to the early 1900s (Bell and Amos 1994). It is an important cash crop for remote areas and an important fisheries export commodity. Sales of trochus shell have contributed around VT 25 million annually to communities over the last 14 years (Wright 2000), and VT 107 million of exported shell products in 2000 (ADB 2002). However, weak management has led to overharvesting of the resource in many areas. The number of shell processing companies has dropped from six some 15 years ago to only one today, and the existing company is facing difficulties due to lack of sufficient supplies. The company has been importing raw trochus shells from Australia and incidences of illegal-size harvesting are common.

Current management regulations include 9 cm minimum and 13 cm maximum shell diameter, a ban on the export of raw shell, and an annual quota of 75 t of raw shell per processing factory per year, although this has not been enforced. The green snail fishery, which is similar to the trochus fishery, is in a worse state than trochus. The green snail resource is near extinction; the last annual production was 44 t in 1991. Production fell progressively until 1998, when supplies of green snail stopped. The stocks in known fishing areas have been seriously depleted. Existing regulations include a minimum size limit of 15 cm basal diameter. A 15-year moratorium on harvest and export of green snail is now being enforced.

Cooperative management adopted in the 1990s to strengthen community management has been effective in stabilising and maintaining resources (Johannes and Hickey 2004). A new Japan International Cooperation Agency (JICA) mariculture project aims to restock reefs in the country with cultured shellfish (trochus and green snail) and bêche-de-mer, utilising the co-management system already in place to manage the resources.

Giant clams

Four species of giant clam (*Tridacna maxima*, *T. squamosa*, *T. crocea* and *Hippopus hippopus*) exist in small populations throughout Vanuatu. *T. gigas* and *T. derasa*, recorded by Rosewater (1965), are believed to be locally extinct (Zann and Ayling 1988). Giant clam meat is an important component of subsistence diets, but the resource is now scarce and the sale of clam meat in local markets is rare (Pakoa pers. comm.). Trade in live wild giant clams for the aquarium trade was active briefly in the late 1990s, with *T. crocea* being the most sought-after species. However, due to uncontrolled harvesting, the fishery was banned in 2000. Mariculture is being encouraged to restore giant clam populations and to supply the aquarium trade.

Crustaceans

Five species of rock lobster are present in Vanuatu, the most important being *Panulirus penicillatus*. Besides the subsistence fishery, rock lobsters are collected and sold to restaurants and hotels in Port Vila and Luganville. There is limited information on stocks at present, but irregular supplies experienced by lobster export operators in the past indicate the resource is small and cannot support such activities (Pakoa pers. comm.). The growing local demand for lobster propelled by tourism activities indicates a need to protect this fishery for domestic use.

Coconut crab (*Birgus latro*) is an important subsistence and commercial resource for communities in some area in the Banks-Torres and Santo-Malo regions (Fletcher 1992). For the Torres Islands, coconut crab is the main cash crop, with production ranging from 500 to 700 crabs a month (Vanuatu Fisheries Department 2004). The main markets for coconut crab are restaurants and hotels in Port Vila and Luganville. Coconut crab is locally protected from commercial export activities. The resource is experiencing decline in heavily fished areas such as the Santo-Malo region, while it is showing signs of recovery in areas that have not experienced much collection as a result of community-based management (Fletcher 2003). Existing regulations include a minimum size limit, a regional quota and a ban on harvest in the Santo-Malo region.

Freshwater aquaculture

Freshwater aquaculture is being promoted with the assistance of SPC's Aquaculture Section (Ponia 2003). Trials on freshwater fish and prawns are being conducted and a private-sector development of brackish-water prawn farming is ongoing.

1.3.3 Fisheries development projects

Vanuatu has benefited from two large fisheries development projects between 1983 and 1996: the Village Fisheries Development Project (VFDP) and the Fisheries Training and Extension Services Project, funded by the European Union, Japan, Canada and New Zealand. The aims of the two projects were to initiate fisheries development by subsidising the cost of boats, fishing gear and fuel to village communities; set up rural fishing centres in the islands; and provide training on various aspects of fisheries, including fishing techniques, fish processing, boat maintenance, ice-machine maintenance, fish marketing and business management. A fisheries training centre was established in Santo; the training centres are now the Vanuatu Maritime College and a boat-building yard that is run by the Fisheries Department.

At the end of the project funding, fishing ventures could not be sustained as they were heavily dependent on the subsidies provided by the projects. The fishing centres in the islands could not be sustained either, due to lack of national government funds. The country seemed unready for such large-scale projects, and the technologies introduced seemed too complex or not appropriate for communities whose lifestyle was largely subsistence at the time (ADB 2002). For the government, the projects raised expectations among the communities that it was not able to accommodate. Although the projects provided some training benefits to ni-Vanuatu fishers, the lessons learned discouraged the government from becoming involved with large projects.

The present direction is to involve the private sector in developments to revive fisheries activities by means of partnerships with institutions such as the Cooperative and Rural Business Department and the Ni-Vanuatu Business Department. These activities should be within the regional economic development guidelines of the provincial governments. With funding from FFA project development funds, six rural fish marketing centres on Tanna, Santo, Pentecost, Pamma and Emae have been established. Local fishers' associations are responsible for managing these facilities, while the Vanuatu Fisheries Department and provincial governments maintain an advisory role.

In support of this initiative a new FAD programme is in place, funded partly by the ice-machine project and partly by a French Government small-grant scheme. Several FADs were deployed in 2003 in the Banks group, Santo, Malekula and Efate. The most-used FADs are the ones off Efate and Santo. When funds are made available the programme has plans to deploy FADs in areas where ice plants have been set up.

1.3.4 Marine research activities

Past research activities

Vanuatu relies on assistance from outside institutions to conduct marine research as there are no such institutions in the country. The 10-year VFDP project conducted a comprehensive study on the deep-water bottom fish resources of Vanuatu; detailed information on this is available in the Coastal Fisheries Atlas of Vanuatu (Cillaurren *et al.* 2001). The most comprehensive study on Vanuatu reef resources was carried out in 1988 and 1989 by the Australian Institute of Marine Science (AIMS); details of the various resources assessed are presented in Done and Navin (1990). Other biological surveys of coral reefs provide inventories of resources and descriptions of the condition of these environments (David 1985; Kaly 1998). A joint collection of reef fish in 1996 and 1997 by the Australian Museum, Smithsonian Institute and Vanuatu Fisheries (www.amonline.net.au) recorded many reef fish found down to 30 m, although no report of this work is available.

Several studies on traditional marine tenure and community-based management have been conducted in Vanuatu. They include studies on the performance of traditional marine tenure systems in community fisheries management (MRAG 1999a, b); the evolution of village-based marine resource management in Vanuatu from 1990 to 2001 (Johannes and Hickey 2004); the government-supported, village-based management of marine resources in Vanuatu (Johannes 1998); and reef and lagoon tenure in the Republic of Vanuatu and its prospects for mariculture development (Fairbairn 1992).

Stock assessments of giant clam, bêche-de-mer and rock lobster have been executed by Vanuatu Fisheries in collaboration with New Zealand's Bay of Plenty Polytechnic and funded by FFA (Lamont *et al.* 1999; Gibbs *et al.* 1998; Saunders *et al.* 2000). Coral reef monitoring activities were initiated in 2000 with funds provided by the Canada South Pacific Ocean Development Programme (CSPODP-II) and FFA. Assessment of the stock of aquarium fish provided baseline data on the aquarium fish resources of Efate (Sykes 2004; Hill 2004); these data are currently held at SPC.

Mariculture of *Trochus niloticus* and green snail was initiated in 1990 with the support of the FAO South Pacific Aquaculture Development Project (SPADP). Successful production of trochus juveniles led to a trochus reseeding research project commissioned from 1995 to 2000 and funded by the Australian Centre for International Agricultural Research (ACIAR). The aim of this study was to test the viability of stock restoration with cultured shells (Crowe *et al.* 2002). A recent extension of this project from 2002 to 2004 involved the reseeding of wild adult trochus and assessment of recruitment potential. The idea, proposed by Vanuatu, is based on historical successful translocation activities in the Pacific Islands. The ongoing study utilises traditional marine tenure systems for management of the seeded areas (Jimmy and Amos 2004).

Seaweed trials were conducted in various areas in the country in 1999 and 2000, funded by FFA. Despite good growth in some areas, grazing by rabbitfish and cyclone damage caused problems. Some communities showed interest in farming seaweed, but the lack of large reef areas in the country made any commercial-scale seaweed farming unfeasible. As a result, the trials were discontinued.

Present research and development

Aquaculture is currently generating a lot of interest from foreign investors and local communities. Trials on genetically improved farmed tilapia (GIFT) tilapia (*Tilapia niloticus*) initiated by the Fisheries Department in 2000 have been successful and the fish has been widely accepted. The trials were funded by FFA with advice provided by SPC's Aquaculture Section and have sparked local interest in freshwater farming. More trials are being conducted in Santo and Tanna. Another trial culture of wild juvenile monkey river prawn (*Macrobrachium lar*) in Santo is underway. Results so far indicate potential for small-scale activities (Jimmy pers. comm., March 2006).

Vanuatu signed an agreement with the Government of Japan in 2005 for a major mariculture project to be managed by JICA. The new project will target perfection of farming of trochus, green snail, giant clam and bêche-de-mer and the reseeding of juveniles on the reef, using customary marine tenure as the basis for managing seeded areas. It is envisaged that the project will boost the country's efforts to strengthen reef resources management and community-based involvement in reef resources management.

As for the private sector, trials on prawns, live coral, freshwater eels and giant clams are currently being undertaken by various private companies. Teouma Prawn commenced construction of its facility in 2003 and successfully harvested its first batch of penaeid prawns in 2005. Sale of the prawns locally was successful, and the company is looking at exporting. It plans to support prawn farming locally by supplying prawn fry to other farmers.

1.4 Selection of PROCFish/C sites in Vanuatu

Four PROCFish/C sites were selected in Vanuatu: two on Efate island (Paunangisu and Moso) and two on or near Malakula Island (Uri-Uripiv and the Maskelyne Archipelago) (Figure 1.5). These sites were selected after two visits to Vanuatu by SPC staff. The first trip, to Port Vila, identified potential study sites on the islands of Efate, Epi and Malakula, and the second included visits to 28 villages on the three islands.

Paunangisu, Moso, Uri-Uripiv and the Maskelyne Archipelago 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 [4], 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

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

particular interest for Vanuatu's Department of Fisheries. Second, preliminary data (Vigliola 2003) indicated that the sites could provide contrasting views of Vanuatu. The two sites on the capital island were more influenced by the market economy than the two sites on Malakula Island (but Moso to a lesser degree than Paunangisu). Of the Malakula Island sites, Uri-Uripiv had greater potential for marketing fish than the Maskelyne Archipelago due to the proximity of Norsup, a major town on Malakula; the Maskelyne Archipelago constituted a very remote and traditional community.

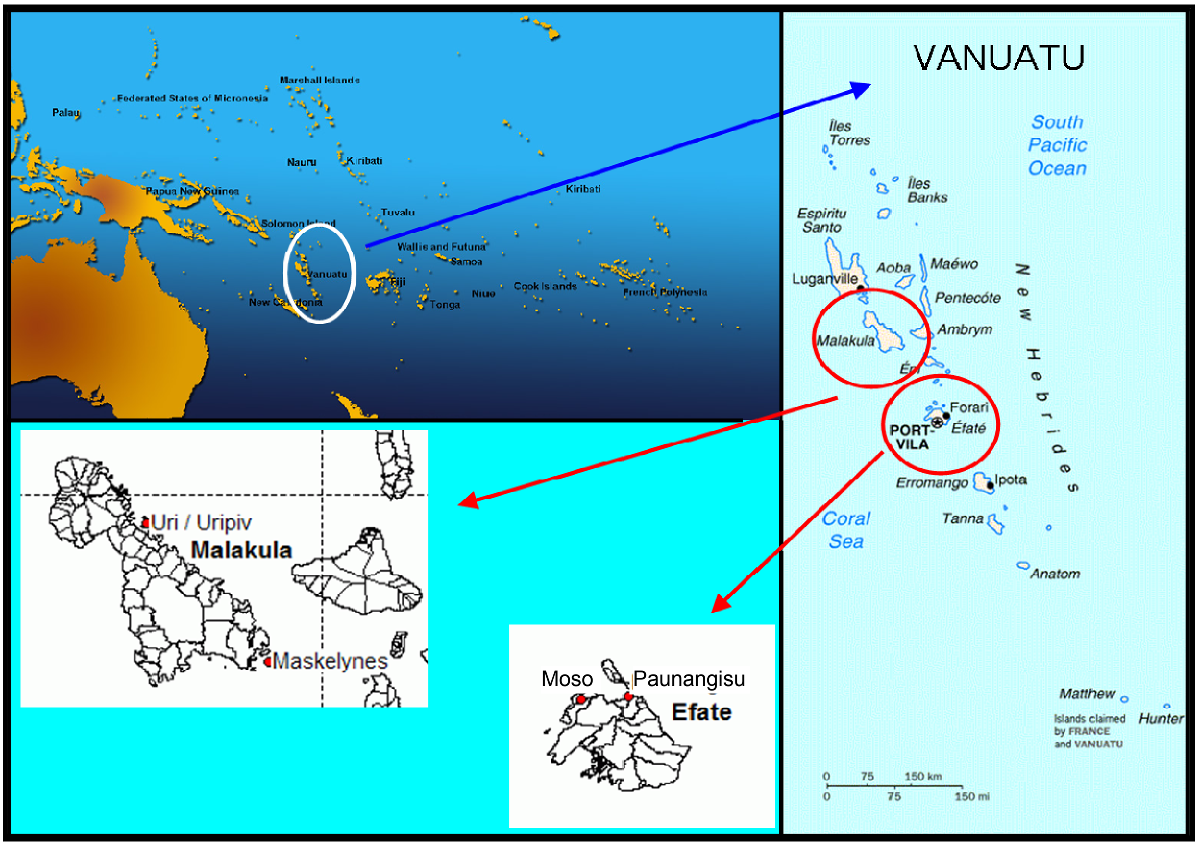

Figure 1.5: Location of the four selected sites for PROCFish/C in Vanuatu: Paunangisu and Moso on Efate Island, and Uri-Uripiv and the Maskelyne Archipelago on Malakula Island.

2. PROFILE AND RESULTS FOR PAUNANGISU VILLAGE

2.1 Site characteristics

Paunangisu village (Figure 2.1) is located on Efate Island, approximately 60 km from the capital, Port Vila. When this survey was conducted the village comprised 76 households, with an estimated population of 388. Land and reef tenure in Paunangisu are traditional, with the village owning the land and the fishing ground. This enables the village to make decisions regarding the use of their resources, including extending access to external fishers; in theory, villages such as Paunangisu have the right to control access to their resources and determine penalties in cases of abuse. However, only limited fishery management activities were operational in Paunangisu at the time of the survey, due to internal community conflicts that had been ongoing for several years and were far from being resolved. Paunangisu is home to two major groups with no mutually recognised leadership and hence no authority to make, control or enforce fisheries (or other) management decisions.

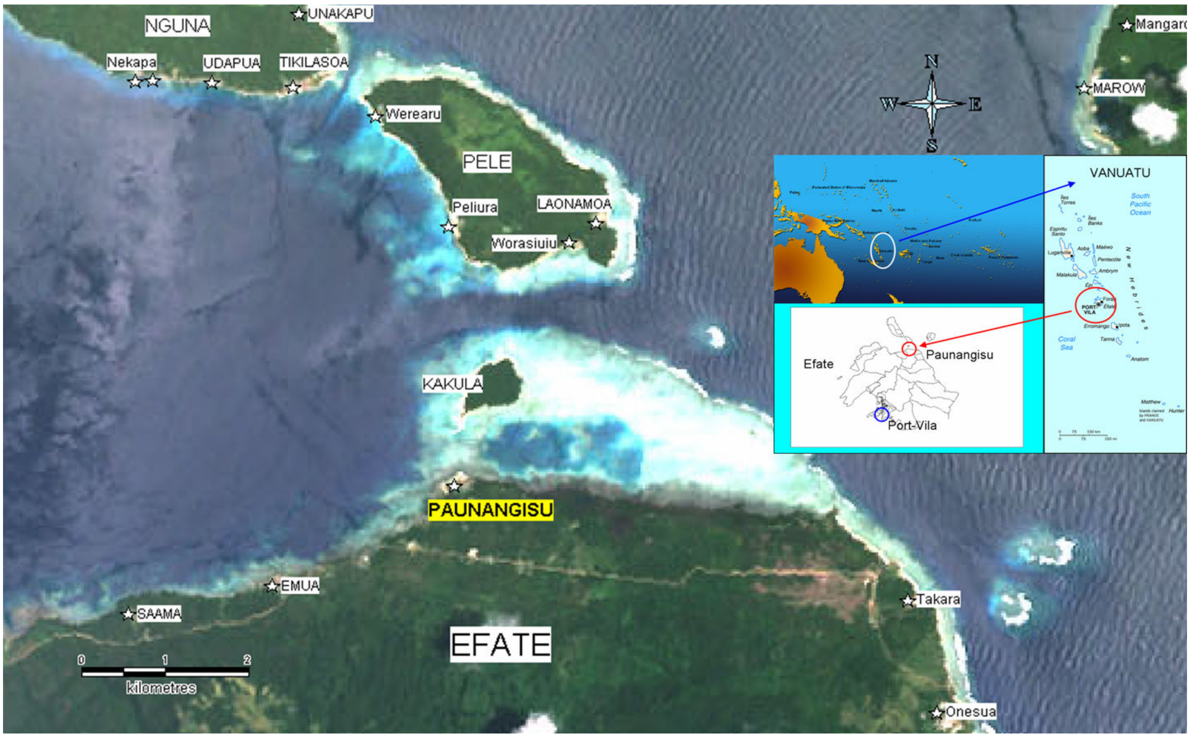

Figure 2.1: Location of Paunangisu village.

The evolution of community-based marine resource management (MRM) in Vanuatu has been documented over the last decade and more than 80 communities are now reported to be engaged in MRM (Govan 2004). According to Johannes and Hickey (2004) in a report comparing marine management measures in place across 21 villages in Vanuatu, MRM measures in place in Paunangisu in 2001 included a taboo on the taking of bêche-de-mer and turtles, and a permanent closure of waters adjacent to a resort. Johannes and Hickey noted that a long-running leadership dispute had reduced conservation efforts, but indicated that the dispute had been resolved. They noted that the need for another fishing-ground closure (Half of the fishing ground was closed from 1995 to 1997.) was being actively discussed.

Unfortunately, as noted above, at the time of this survey (October 2003) the leadership conflict was again ongoing. There were indications that some of the management measures that had been put in place prior to the conflict were still being observed (e.g. fishers from Paunangisu did not target bêche-de-mer). Fishers from outside Paunangisu were reported not to be following these restrictions, however, indicating that at the time of the survey the village was not able to control its fishing grounds; informants voiced complaints about this to the survey team.

In addition to community management efforts, the Fisheries Act, which is enforced by the national Fisheries Department, includes regulations on size limits for shellfish and crustaceans, no-take of gravid crustaceans (those with egg masses), harvest and export quotas for some products, and requirements for licences and permits in some cases.

Paunangisu has a relatively small fishing ground covering an area of about 9 km^2 (Figure 2.2), with approximately 7 km^2 of reef area. The fishing ground includes a small, shallow lagoon (depth <5–10 m) with a few intermediate patch reefs encircled by an outer reef. A sheltered coastal reef (characterised by small, diffuse and patchy coral heads on a soft bottom, and partly colonised by mangroves) is present along the coastline of the fishing ground. A small channel on the lagoon's west side connects the lagoon to the ocean; a second small channel is located to the north of a small islet (Kakula). The reefs of Paunangisu village are highly dominated by lagoon back-reef (5 km^2, 69% of habitat) and include 1.2 km^2 (17%) sheltered coastal reef, 0.2 km^2 (3%) lagoon intermediate reef and 0.8 km^2 (11%) outer reef. It is possible to take a small boat across the outer-reef crest in places at high tide. The lagoon is greatly influenced by terrestrial runoff, with poor visibility in those areas of the lagoon close to the coast. Fine particles and fine-grained silt, mud and sand are common features among the mangrove stands.

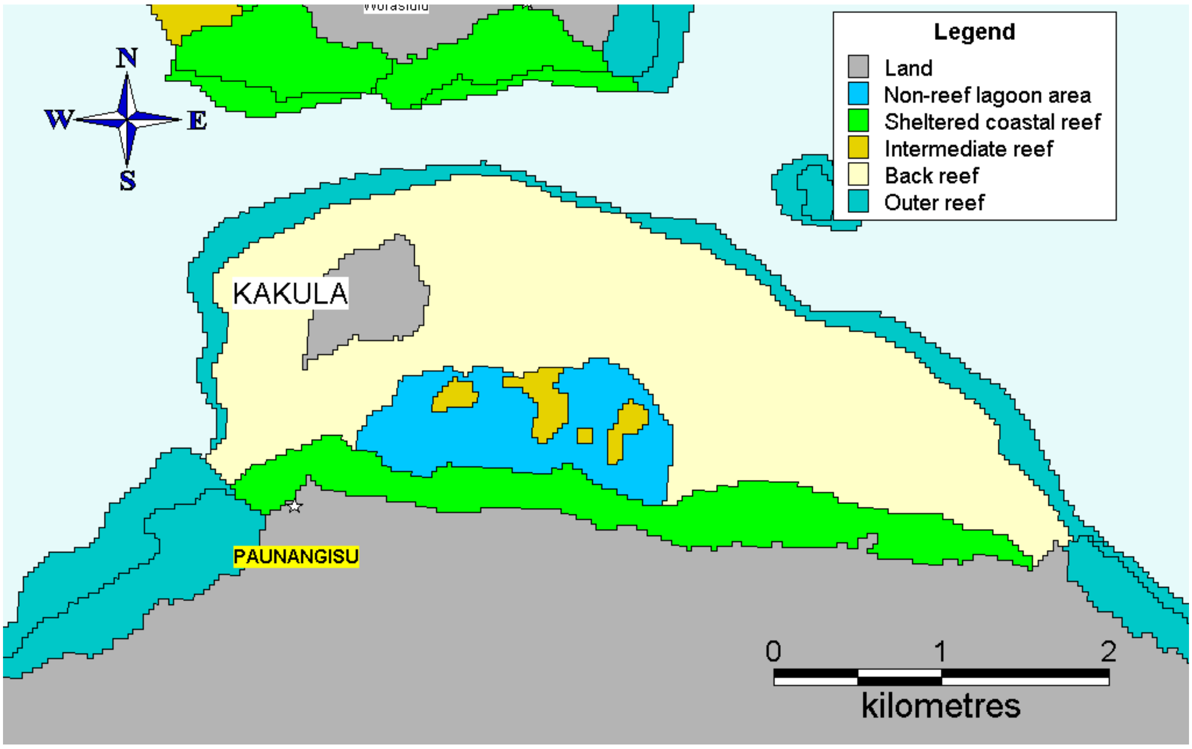

Figure 2.2: Main reef structures adjoining Paunangisu village.

2.2 Socioeconomic surveys: Paunangisu village

Socioeconomic fieldwork was carried out in the community of Paunangisu from 13 to 20 October 2003. The survey covered 50% of all households (38 out of 76) and approximately 50% of the total population (192 out of 388).

Household interviews focused on the collection of general demographic, socioeconomic and consumption data. In addition, 20 individual interviews of finfish fishers (15 males, 5 females) and 18 invertebrate fishers (7 males, 11 females) were conducted. In some cases the same person was interviewed for both finfish fishing and invertebrate harvesting.

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

Survey results indicate an average of 1.8 fishers per household. If this average is consistent for all households in Paunangisu, when extrapolated the total number of fishers in Paunangisu would be 137 fishers, including 79 males and 58 females.

Data on income sources suggest that fisheries are not the most significant source of income in the Paunangisu economy (Figure 2.3). Agriculture was either the primary (55%) or secondary (40%) income source for almost all households surveyed. Fisheries were a primary income for 29%, and a secondary income for 26% of households[5]. Few households were reliant on salaries or other sources (e.g. handicrafts, private businesses) as their primary or secondary source of income (Salaries were a primary source for 5% and a secondary source for 8%.). Only 15% of all households received remittances, averaging USD 112 per year[6]. This external input is low when compared to the annual average expenditure of USD 1218 per household.

[5] However, despite the lower economic importance of fisheries vis-à-vis agriculture, the proportion of fish caught for sale (export) substantially exceeded that caught for subsistence purposes.
[6] The VT/USD exchange rate at time of survey was 1/0.00916.

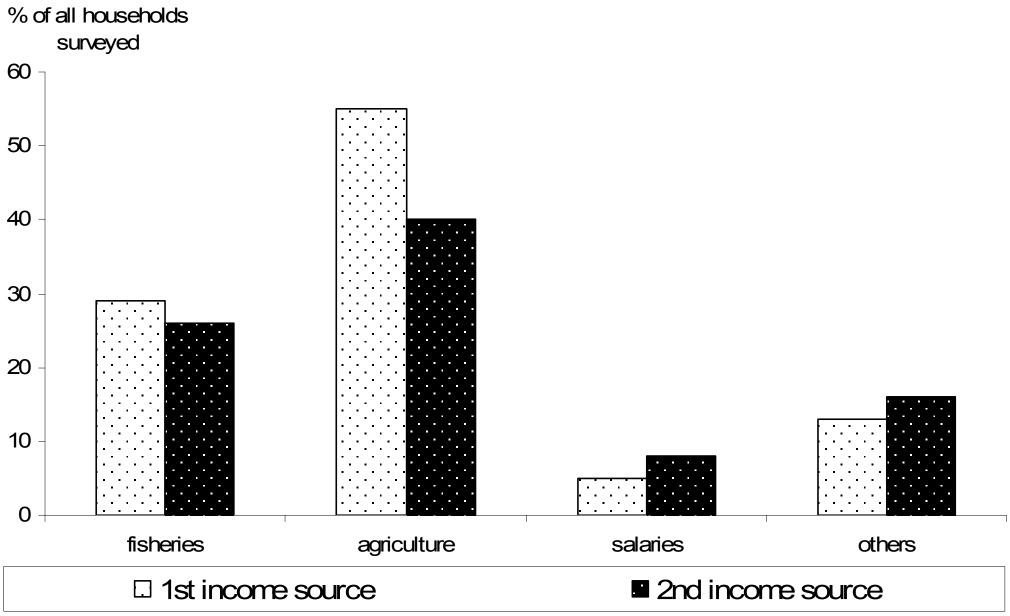

Figure 2.3: Ranked sources of income (%) in Paunangisu.
Total number of households = 38 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly handicrafts and private businesses.

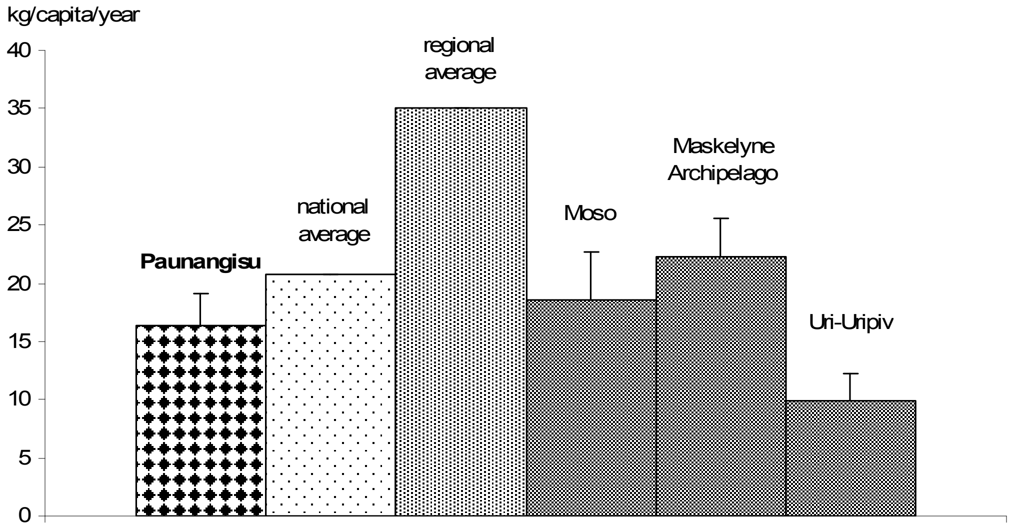

Figure 2.4: Per capita consumption (kg/year) of fresh fish in Paunangisu (n = 38) compared to national and regional averages (FAO 2002), and other PROCFish/C sites in Vanuatu.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

The average per capita consumption of fresh fish of 16.7 kg/year is relatively low compared to the published national average of 20.8 kg (Consumption ranged from 15.9 to 25.7 kg.); it is also low in comparison with the published regional average of 35 kg for fresh fish (FAO 2002) and most of the other PROCFish/C sites in Vanuatu (Figure 2.4). Canned fish was consumed more frequently than fresh fish or invertebrates, although in lesser quantities (12.3 kg/capita/year).

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

Survey coverage	Paunangisu (n = 38 HH)	Average across sites (n = 124 HH)
Demography		
HH involved in reef fisheries (%)	87	96
Number of fishers per HH	1.79 (±0.20)	2.68 (±0.15)
Male finfish fishers per HH (%)	38.2	21.1
Female finfish fishers per HH (%)	4.4	3.0
Male invertebrate fishers per HH (%)	4.4	1.2
Female invertebrate fishers per HH (%)	27.9	19.3
Male finfish and invertebrate fishers per HH (%)	14.7	32.2
Female finfish and invertebrate fishers per HH (%)	10.3	23.2
Income		
HH with fisheries as 1st income (%)	28.9	21.8
HH with fisheries as 2nd income (%)	26.3	38.7
HH with agriculture as 1st income (%)	55.3	58.1
HH with agriculture as 2nd income (%)	39.5	25.8
HH with salary as 1st income (%)	5.3	10.5
HH with salary as 2nd income (%)	7.9	3.2
HH with other source as 1st income (%)	13.2	11.3
HH with other source as 2nd income (%)	15.8	12.9
Expenditure (USD/year/HH)	1217.59 (±144.54)	864.00 (±28.44)
Remittance (USD/year/HH) (1)	111.47 (±29.01)	120.11 (±72.93)
Seafood consumption		
Quantity fresh fish consumed (kg/capita/year)	16.37 (±2.71)	16.79 (±1.60)
Frequency fresh fish consumed (time/week)	1.73 (±0.23)	1.90 (±0.14)
Quantity fresh invertebrate consumed (kg/capita/year)	n/a	n/a
Frequency fresh invertebrate consumed (time/week)	0.66 (±0.13)	1.15 (±0.11)
Quantity canned fish consumed (kg/capita/year)	12.10 (±2.03)	9.04 (±1.24)
Frequency canned fish consumed (time/week)	3.18 (±0.43)	2.12 (±0.20)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	68.4	84.7
HH eat canned fish (%)	89.5	94.4
HH eat fresh fish they catch (%)	76.3	100.0
HH eat fresh fish they buy (%)	42.1	32.3
HH eat fresh fish they are given (%)	55.3	54.8
HH eat fresh invertebrates they catch (%)	63.2	90.3
HH eat fresh invertebrates they buy (%)	0.0	0.0
HH eat fresh invertebrates they are given (%)	5.3	6.5

HH = household; n/a = no information available; (1) average sum for households that receive remittances; numbers in brackets are standard error.

When compared with other PROCFish/C sites in Vanuatu with respect to a number of parameters that characterise the importance of reef fisheries, Paunangisu rates as somewhat below average (Table 2.1); these parameters include the proportion of households for which fisheries is the first or second income source (moderate to low), number of fishers per household (low), number of households that own a boat (low), frequency and quantity of fresh fish and invertebrates consumed (low), and number of households that catch finfish and invertebrates for their own consumption (moderate). Paunangisu does not substantially benefit from external financial input, i.e. remittances are received by only a few households, and the annual amount received is moderate. Annual household expenditures in Paunangisu were high, and Paunangisu had the highest frequency of canned fish consumption. By comparison with all sites investigated, residents of Paunangisu purchase the fresh fish they consume moderately often.

2.2.2 Fishing strategies and gear: Paunangisu village

No effective management regime was in place at the time of survey. Fishers from Paunangisu were not actively targeting bêche-de-mer (BdM) or trochus, however, and giant clams were being targeted at very low levels.

Degree of specialisation in fishing

Participation by females in fisheries was high, but the engagement of males and females in the various fisheries differed significantly. Figure 2.5 suggests that finfish fisheries in Paunangisu are dominated by males, with females focused primarily on invertebrate harvesting. Approximately 15% of all males and 10% of all females fished for both finfish and invertebrates, although not necessarily during one fishing trip.

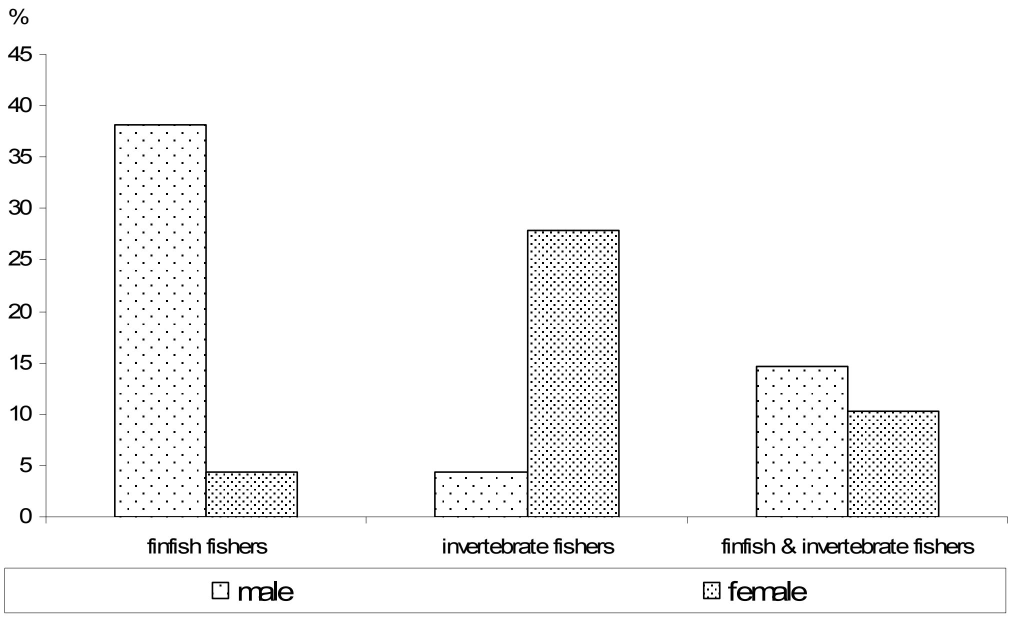

Figure 2.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Paunangisu.
All fishers = 100%.

Four primary habitats were targeted in Paunangisu by invertebrate fishers (Figure 2.6). Most invertebrates were targeted through gleaning, and this technique was used in all habitats, i.e. soft benthos (seagrass), mangrove, intertidal (sand/beach) and reeftops. Several of these habitats were often targeted during a single fishing trip. A small proportion of fishers (3%) targeted octopus and giant clams by free diving (This fishery may be practised in combination with spear diving for finfish.).

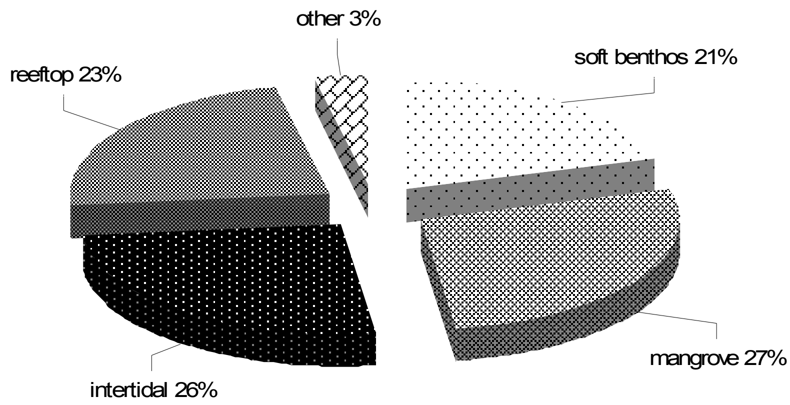

Figure 2.6: Proportion (%) of fishers targeting the five primary invertebrate habitats found in Paunangisu.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the octopus and giant clam fishery, targeted by free diving.

Fishing strategies

In Paunangisu 25% (19) of all households own a boat; 15 of these are dugout outrigger canoes, and two are non-motorised aluminium hulls. There are only two operational boats fitted with an outboard engine.

About 93% of all male fishers interviewed used a boat for finfish fishing. However, only 7% used a motorised boat while the remaining 86% used a paddling canoe. By comparison, 60% of all respondent female fishers used paddling canoes for finfish fishing.

Invertebrate fishing is a low-investment activity. Fishers reported that they walk or use dugout canoes to access fishing grounds (Canoes were used in 100% of all trips when free diving for octopus and giant clams, in 67% of all trips to soft-benthos habitats and in 50% of all trips to the reeftop.).

Fishing trips occurred almost exclusively during the day. Some free-diving trips to target octopus and giant clams (which were often combined with spear diving for finfish) occurred at night. Fishing trips averaged between 3 and 4.5 hours. The longest trips were made to mangroves and reeftops; trips that combined visits to soft-benthos, reeftop and intertidal environments were also lengthy.

Targeted stocks/habitats

Female fishers were engaged to a much greater degree in invertebrate fisheries than males, targeting all habitats where gleaning was used (Table 2.2). Free diving for octopus and giant clams was practised exclusively by males (Figure 2.7).

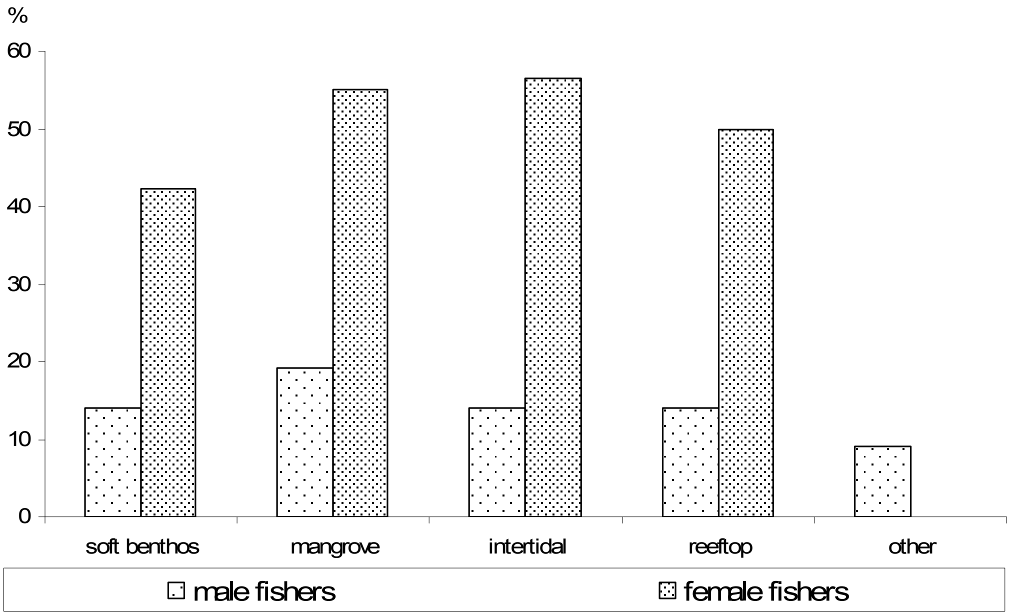

Figure 2.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Paunangisu.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 15 for males, n = 28 for females; 'other' refers to the octopus and giant clam fishery, targeted by free diving.

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

Resource	Habitat	% male fishers interviewed	% female fishers interviewed
Finfish	Sheltered coastal reef	53	40
	Lagoon	47	20
	Mangrove	0	40
	Outer reef	27	0
Invertebrates	Mangrove	57	73
	Other	29	0
	Reeftop	43	0
	Intertidal	14	0
	Soft benthos	29	0
	Intertidal and reeftop (1)	0	9
	Soft benthos, mangrove, intertidal and reeftop (1)	0	9
	Soft benthos, intertidal and reeftop (1)	14	55

'other' refers to the octopus and giant clam fishery; (1) combined in one fishing trip.
Finfish fisher interviews, males: n = 15; females: n = 5. Invertebrate fisher interviews, males: n = 7; females, n = 11.

Gear

Various fishing techniques were used in targeting finfish in Paunangisu (Figure 2.8). Most fishers used more than one technique, although not necessarily during one trip. Gillnets and handlines were the dominant techniques in lagoon and sheltered coastal environments and handlines were dominant in mangroves. Spear diving was used exclusively at the outer reef.

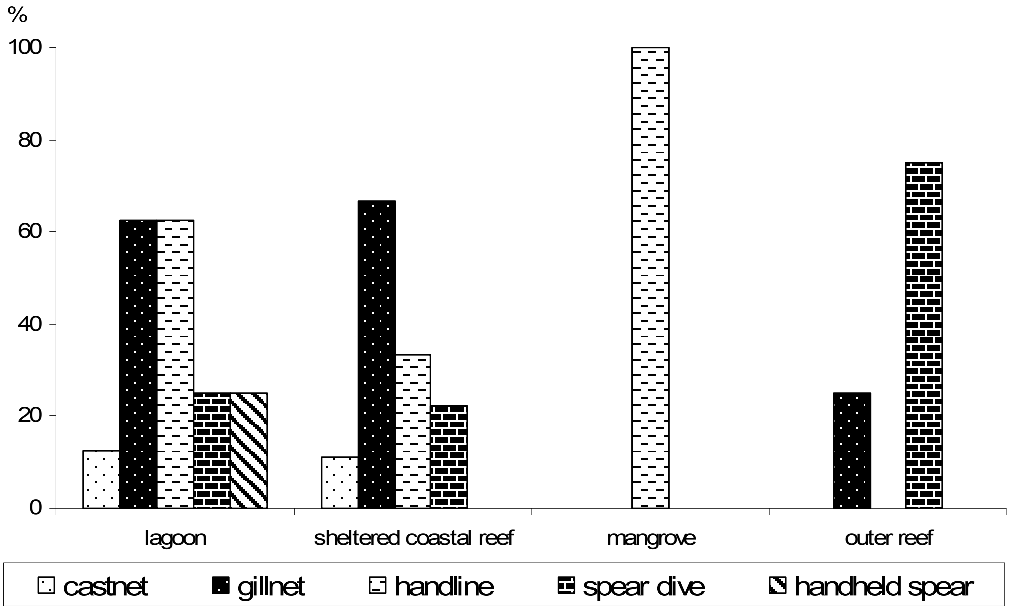

Figure 2.8: Fishing methods commonly used in different habitat types in Paunangisu. Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Fishing pressure

Information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip was used to estimate the fishing pressure imposed by the inhabitants of Paunangisu on their fishing grounds (Table 2.3).

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

Resource	Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef and lagoon [(1)]	2.69 (±0.57)	1.75 (±0.25)	6.31 (±1.03)	5.50 (±3.50)
	Lagoon	2.21 (±0.38)	1.00	5.21 (±0.67)	2.00
	Mangrove	0	0.54 (±0.46)	0	4.25 (±1.75)
	Outer reef	0.54 (±0.27)	0	6.50 (±0.96)	0
Invertebrates	Mangrove	0.83 (±0.27)	0.69 (±0.18)	2.88 (±0.63)	5.31 (±0.60)
	Other	0.48 (±0.02)	0	3.00 (±1.00)	0
	Reeftop	0.42 (±0.10)	0	4.67 (±0.33)	0
	Intertidal	0.23	0	3.50	0
	Intertidal and reeftop [(1)]	0	1.50	0	3.50
	Soft benthos	0.23 (±0.00)	0	3.50 (±0.00)	0
	Soft benthos, mangrove, intertidal and reeftop [(1)]	0	2.00	0	3.00
	Intertidal, soft benthos and reeftop	1.00	0.65 (±0.16)	1.50	4.58 (±0.66)

Figures in brackets denote standard error; 'other' refers to the octopus and giant clam fishery; [(1)] combined in one fishing trip.
Finfish fisher interviews, males: n = 15; females: n = 5. Invertebrate fisher interviews, males: n = 7; females: n = 11.

Frequency and duration of fishing trips

Fishers from Paunangisu targeted the lagoon and sheltered coastal reef on average 2 and 2.5 times per week, respectively (Table 2.3). Mangroves and the outer reef were less frequently visited (0.5 times/week). The average duration of a fishing trip varied between 4 and 6.5 hours; the longest trips were to sheltered coastal reefs or the outer reef.

2.2.3 Catch composition and volume – finfish: Paunangisu village

The estimated total annual catch by survey respondents was 12.1 t (0.4 t for females, 11.7 t for males). If this figure is extrapolated by the estimated number of fishers in the village, the total annual catch would equal 46 t. Assigning proportions of this estimated total catch to each habitat in accordance with respondents' activity patterns reveals that the majority of the catch was taken from sheltered coastal reef and lagoon areas (Figure 2.9). Female fishers' finfish fishing activities accounted for just 3.5% of total annual catches (Details on recorded annual catch by vernacular and scientific names are given in Appendix 2.1.1.).

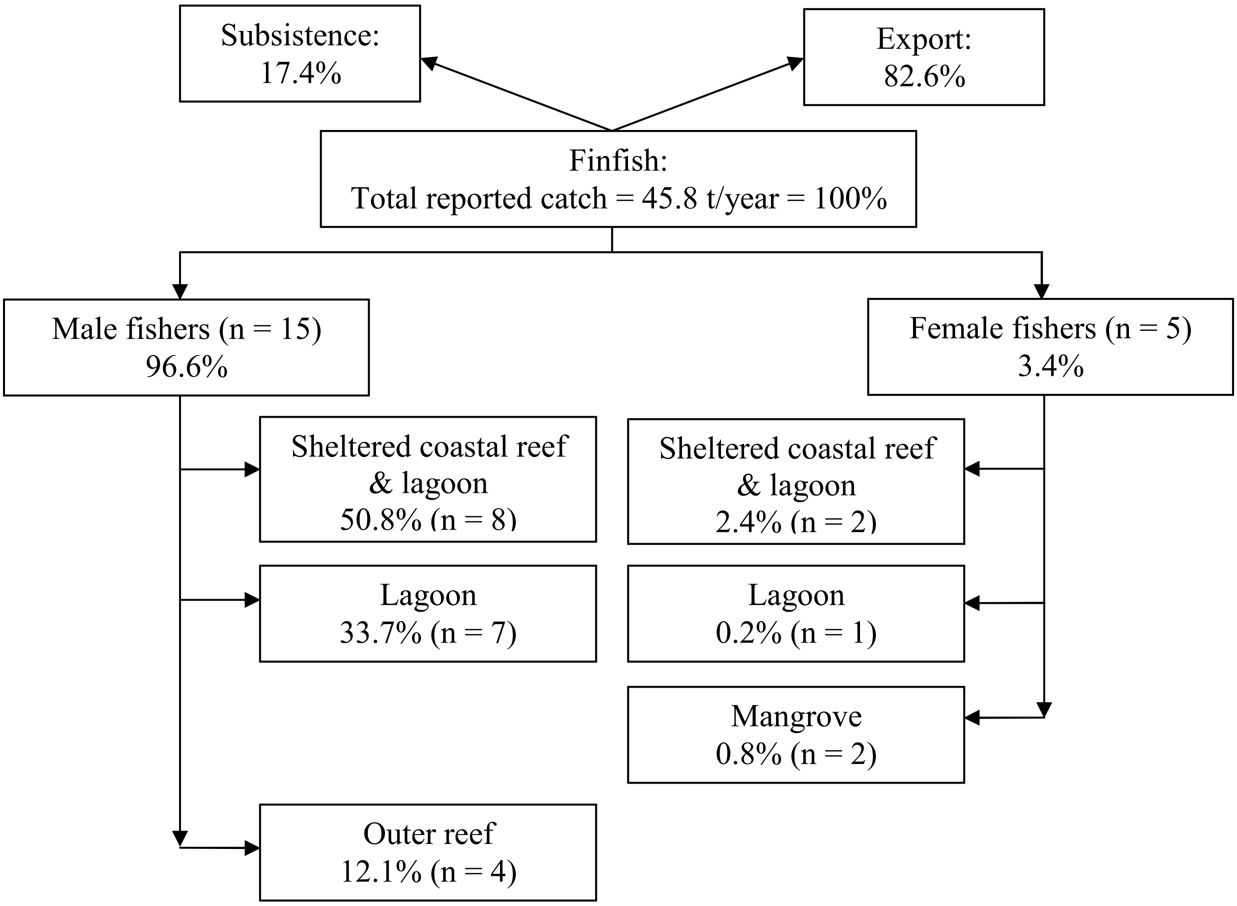

Figure 2.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Paunangisu.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

Respondents indicated that between approximately 45% and 65% of all trips (dependent on habitat) were for the purpose of generating income (Figure 2.10). All other trips (including all trips to mangrove habitats) served to meet subsistence needs, including non-monetary distribution of catch among community members.

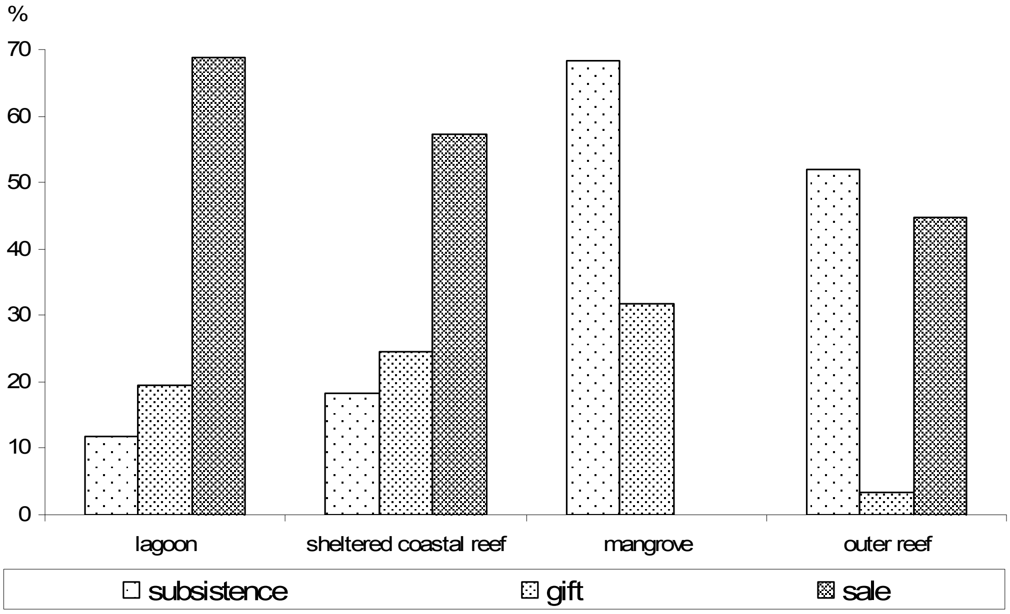

Figure 2.10: The use of finfish catches for subsistence, gift and sale, by habitat in Paunangisu.
Proportions are expressed in % of the total number of trips per habitat.

The catch per unit effort (CPUE) calculated for males exceeded that for female fishers in lagoon and sheltered coastal reef areas. The highest CPUE occurred at the outer reef, which is targeted exclusively by males (Figure 2.11).

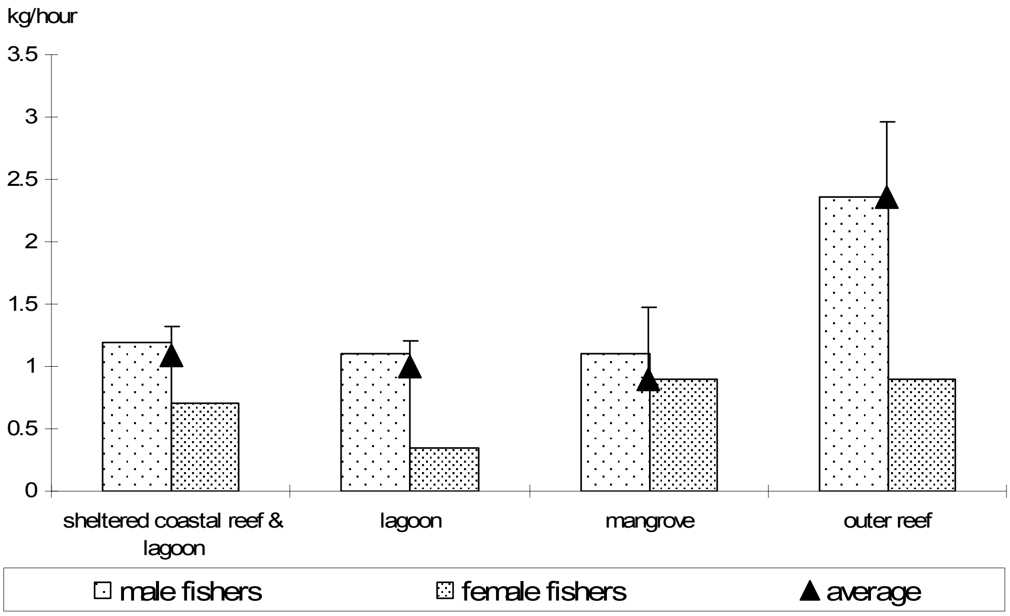

Figure 2.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in Paunangisu.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Catches from the lagoon were composed predominantly of species from the families Mugilidae, Lethrinidae, Carangidae, Siganidae and Mullidae. Sheltered coastal reef catches included the families Siganidae, Mugilidae, Lethrinidae, Acanthuridae and Carangidae, while at the outer reef primarily Scaridae, Kyphosidae (sea chubs) and Haemulidae (grunts) were caught (Detailed information on the distribution of fish families in reported catches and the percentage of total weight per habitat fished is provided in Appendix 2.1.1.).

Comparison of the average size of fish of various families across the different habitats where these fish were caught (Figure 2.12) reveals that, in general, larger fish were caught at the outer reef. This was particularly the case for Scaridae. However, in the case of Acanthuridae, fish caught in lagoon and sheltered coastal reef areas were on average significantly larger than those caught at the outer reef.

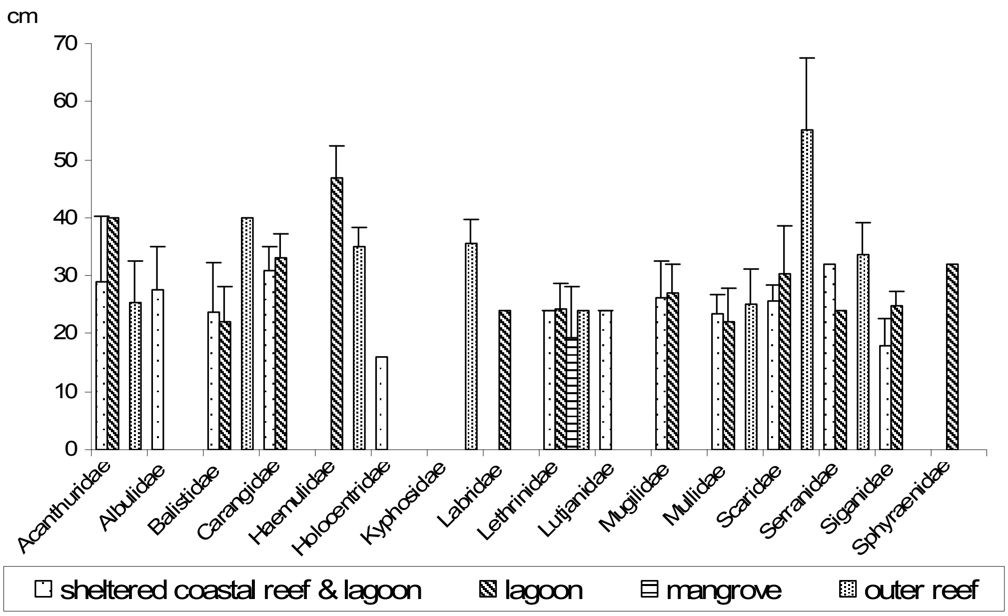

Figure 2.12: Average sizes (cm fork length) of fish caught by family and habitat in Paunangisu. Bars represent standard error (+SE).

Estimates of fishing pressure, based on survey responses and extrapolated to the entire population, suggest that, while fisher density and fishing pressure were high at the outer reef, the total annual catch from the outer reef was much less than that harvested from coastal reef and lagoon habitats (Table 2.4).

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

Parameters	Habitat					
	Coastal reef	Lagoon	Mangrove	Outer reef	Total reef	Total fishing ground
Fishing ground area (km^2)	1.22	5.23		0.84	7.10	7.28
Density of fishers (number of fishers/km^2 fishing ground) (1)	31	5	n/a	18	13	13
Population density (people/km^2) (3)					55	54
Average annual finfish catch (kg/fisher/year) (2)	642 (±183.7)	513 (±164.9)	48 (±35.7)	365 (±219.0)		
Total fishing pressure of subsistence catches (t/km^2)					0.9	0.9

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) total population = 390; total subsistence demand = 6.39 t/year.

2.2.4 Catch composition and volume – invertebrates: Paunangisu village

The number of species (as represented by the number of vernacular names) reported to be regularly caught from various habitats is indicative of the importance of these habitats and the fisheries they support. Figure 2.13 indicates that reeftop environments support the greatest number of species of any single habitat, while fishers targeting soft-benthos, intertidal and mangrove habitats reported that they target a very low diversity of species (1–3). When multiple habitats (e.g. soft-benthos, intertidal and reeftop) were combined in one fishing trip, a greater number of vernacular names may have been reported than for trips targeting a single habitat.

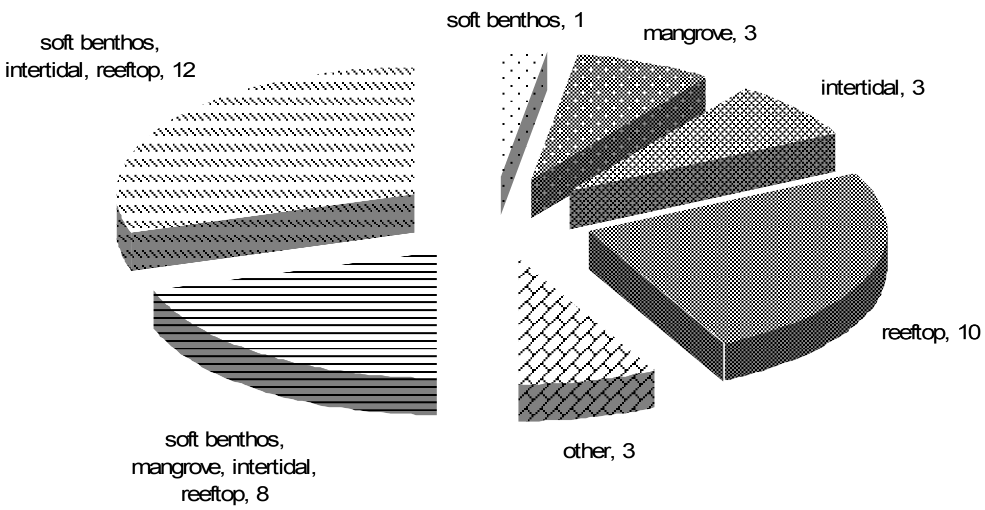

Figure 2.13: Number of vernacular names recorded for each invertebrate fishery in Paunangisu.

The estimated total annual catch from interviewed fishers equalled 10.3 t (7.4 t for females, 2.9 t for males). Extrapolation of the average annual recorded catch per fisher to the estimated total number of invertebrate fishers in Paunangisu suggests that approximately 50 t of biomass (wet weight) are removed annually (Figure 2.14).

Female fishers harvest the majority (72%) of the biomass, most of which is removed from mangroves (67% of the total annual catch for males and females). Moderate impact is recorded for soft-benthos and reeftop fisheries, and the impact is least for intertidal and other dive fisheries (which mainly target giant clams and octopus).

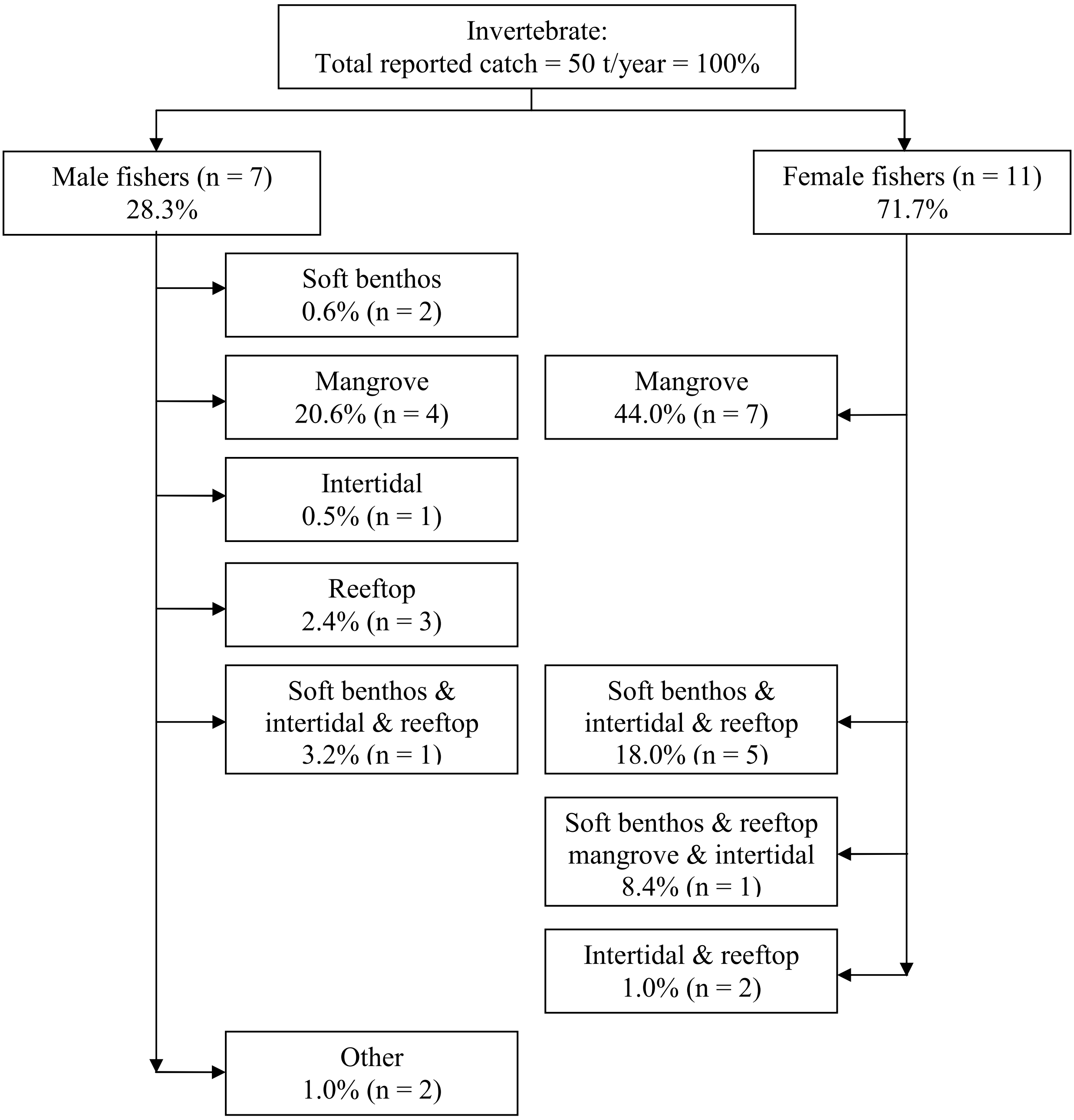

Figure 2.14: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Paunangisu.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

Calculation of the total annual impact per species group (Figure 2.15) shows that the highest annual catches (in terms of kg wet weight removed) occurred in four major species groups, i.e. *Cardisoma* spp., *Terebra* spp. and *Gafarium* spp. (including some *Periglypta* spp.). In addition, there are five further species groups that contribute, though to a much lesser extent, i.e. *Scylla* spp., *Tridacna* spp., *Atactodea* spp., *Conus* spp. and *Octopus* spp.

Details on species distribution per habitat, and on size distribution by species, are provided in Appendices 2.1.2 and 2.1.3, respectively.

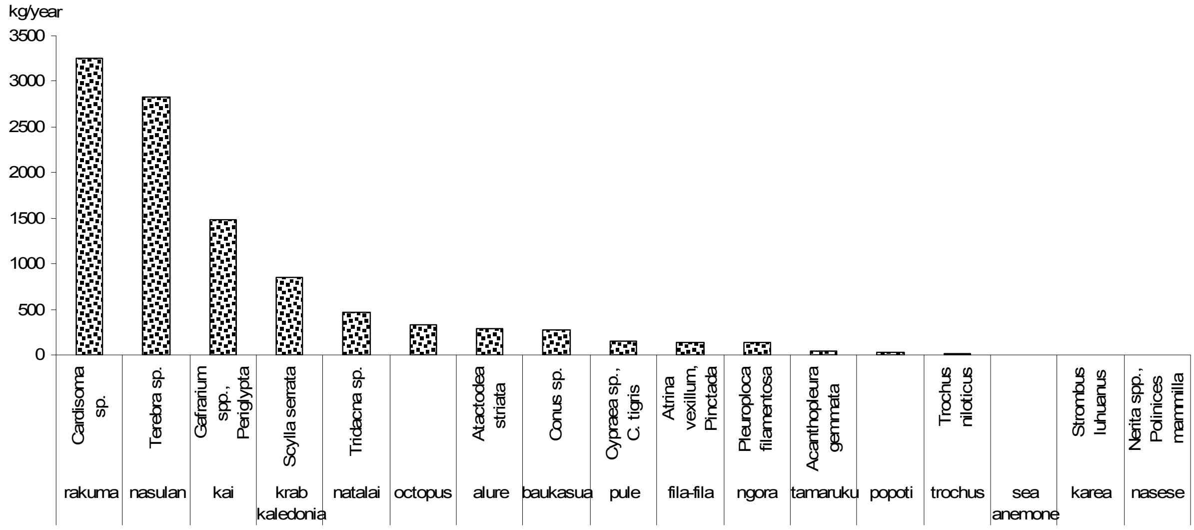

Figure 2.15: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Paunangisu.

Fishers interviewed indicated that invertebrates are targeted more for subsistence purposes than for sale (Figure 2.16). Thirty-three per cent of all catches are used exclusively for consumption, with about 60% possibly (but not necessarily) used for commercial purposes. Even if a conservative assumption is made that the proportion of the catch used for both purposes (consumption and sale) is equal, the total annual biomass (wet weight) caught for external sale will remain below 40%.

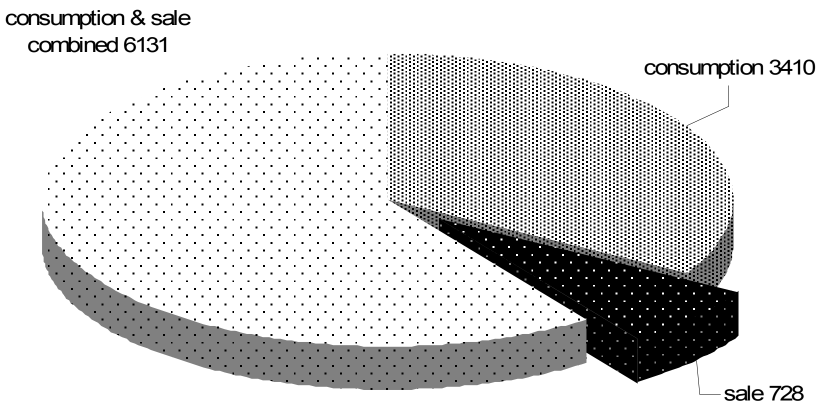

Figure 2.16: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Paunangisu.

Some genera are used exclusively for subsistence consumption, such as *Atactodea* and *Conus*. *Cardisoma* and *Terebra* are used for both consumption and income generation. *Scylla serrata* (Caledonian crab) is the most important species targeted for income, but it is also consumed by villagers (More details on the role that species play in subsistence and sale are provided in Appendix 2.1.4.).

As indicated earlier, both sexes participate in invertebrate fisheries, although in different ways. Comparison of the total biomass (kg wet weight/fisher) removed annually from various habitats by males and females shows that females are more productive invertebrate fishers than males. This is particularly the case in mangrove, reeftop and soft-benthos habitats, where gleaning is practised (Figure 2.17).

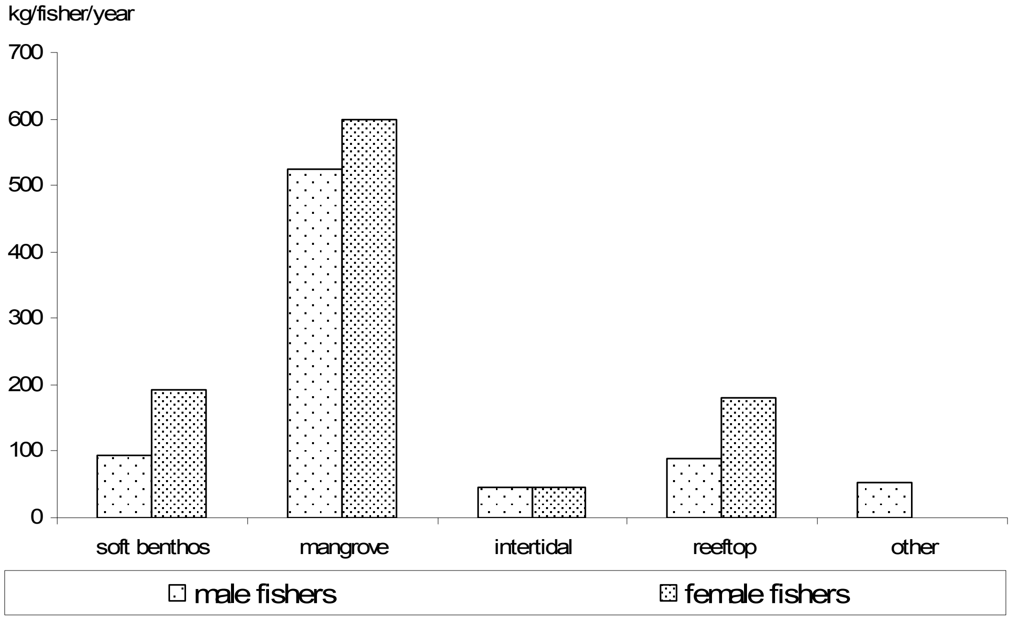

Figure 2.17: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Paunangisu.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 7 for males, n = 11 for females).

The highest fisher density and highest annual catch per fisher (kg wet weight/fisher/year) occur in mangrove habitats (Table 2.5). The annual catch per fisher (kg wet weight) is much lower for reeftop fisheries; the large size of this fishing ground may help to compensate for the high fishing pressure, and serves to reduce the pressure per unit area.

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

Fishery	Soft benthos	Mangrove	Intertidal	Reeftop	Other [(3)]
Fishing ground area (km^2)	1	0.7	1	4.8	9.5
Number of fishers (per fishery) [(1)]	44	58	37	48	7
Density of fishers (number of fishers/km^2 fishing ground)	44	83	37	10	1
Average annual invertebrate catch (kg/fisher/year) [(2)]	28.7 (±21.3)	603.6 (±152.1)	50.0	83.1 (±58.0)	50.6 (±9.1)

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)] linear measure km reef length; 'Other' refers to the octopus and giant clam fishery, targeted by free diving.

2.2.5 Discussion and conclusions: socioeconomics in Paunangisu village

- From a socioeconomic point of view, Paunangisu represents a rural coastal community that has a variety of options to sustain its livelihood in terms of subsistence needs, maintenance of social coherence and generation of income. The dominant resource and activity, for both subsistence consumption and income, is agriculture rather than fisheries, which explains the comparatively low per capita consumption of fresh fish (16.4 kg/capita/year).

- The close proximity and road connection to Port Vila, Vanuatu's capital city and principal market, facilitate commercialisation and have resulted in >80% of all finfish caught in Paunangisu being sold externally, with <20% used for the community's own consumption needs. Strong urban influences may also contribute to the frequent and relatively high consumption of canned fish.

- The use of ice to ensure preservation of the catch during fishing trips is very rare, due to the combined factors of cost, difficulty in organising transport if ice is to be purchased at Port Vila, and the fact that fish may be marketed to various village shops (located adjacent to landing points) without requiring the use of ice.

- The inhabitants of Paunangisu enjoy easy access (by foot or dugout canoe) to a variety of different habitats, including sheltered coastal and outer reefs, lagoon and mangroves. When compared to the average across all PROCFish/C sites in Vanuatu, Paunangisu's fisher density was relatively low, but annual catches per fisher were high, albeit with moderate to low CPUE values.

- The reported catch data indicate that most catches were sourced from combined fishing of the sheltered coastal reef and lagoon (~54%) and the lagoon area (35%), while a much smaller proportion was harvested from the outer reef (12%). This observation is supported by the fact that the highest fisher density was recorded for the lagoon and coastal reefs combined, although the fisher density at the outer reef was also considerable. Fishing techniques varied considerably between these two major habitats. While gillnet and handlines were predominantly used by fishers targeting the sheltered coastal reef and lagoon, spear diving was the main technique used at the outer reef. The species composition reflected the relative dominance of each technique (i.e. the pronounced proportion of Scaridae, Acanthuridae and Kyphosidae in catches reported from the outer reef, and the share of species from the families of Mugilidae, Siganidae and Lethrinidae in catches from the sheltered coastal reef and lagoon zones). In general, fish caught at the outer reef were of larger average size than those caught elsewhere; fish caught in the mangroves were the smallest on average.

- Paunangisu's fishing grounds are accessible by all community members, with two major factors distinguishing fishing activities. Involvement of females in finfish fisheries is generally low; females target finfish mainly to satisfy subsistence needs, using low-investment handlines. Data indicate females' finfish fishing activities are less efficient and productive than those of males. Males may fish either predominantly for income or for subsistence. The latter group also includes those who occasionally sell their catch at the village shop. Although household interviews suggested that a relatively small proportion of families depend on fishing as their major source of income, those fishers that often fish for income do so effectively and record the highest overall catches per fisher and year.

- Dependency of Paunangisu's households on finfish fisheries is relatively low, as shown by the per capita consumption figures and the proportion of families depending on fisheries as their major source of income. Fishing is mainly a low-investment operation, with fishing grounds accessed by walking or dugout canoes. Fishing techniques range from very low investment (handlines) to moderately high investment (such as gillnets and dive spears); ice is rarely used.

- The relatively high proportion of finfish distributed among community members on a non-monetary basis suggests a high degree of interest in maintaining the community's social networking and insurance system. However, a dispute between two community groups was reported during the survey, which may pose a risk to social coherence and hence to the community's strength to jointly agree on and ensure compliance with resource management measures, and to deal with the reported – although limited – number of external intruders into their fishing grounds.

- Fisher density in Paunangisu is low, but annual catches per fisher are high and, combined with the size of the available fishing ground, result in the highest catch rates per reef area of all the PROCFish/C sites in Vanuatu. The level of existing fishing pressure can be further discerned in the low-to-moderate CPUE values.

- All gleaning fisheries practised in Paunangisu are dominated by single species or small groups of species, resulting in relatively high amounts of total biomass of these species or small groups of species being removed. This applies in particular to the genera *Cardisoma*, *Terebra*, *Gafrarium*/*Periglypta*, *Scylla*, *Tridacna*, *Atactodea*, *Conus* and *Octopus*. The size composition of catches shows no clear pattern or trend that would indicate the detrimental effects of past and/or current fishing activities. In the case of *Cardisoma* spp., however, the majority of the catch of all species falls into the smaller sizes. Given that *Cardisoma* spp. are marketed externally, this may be a result of fishing pressure.

- The existence of a village shop and Paunangisu's proximity to Port Vila offer villagers easy options for generating income. Fish is sold in Port Vila in response to demand from the capital. Consequently, finfish fishing activity could increase in the future in response to various factors, including improvements in transport, the establishment of new and attractive marketing channels between Paunangisu's fishers and the greater Port Vila market, and market demand and prices.

- Based on reports from fishers, there are a considerable number of external fishers (primarily from Pele and Takara) who illegally but regularly harvest from Paunangisu's fishing grounds. Thus, the actual pressure on the community's fisheries is presumably much higher than presented here. This also applies to fisheries such as bêche-de-mer, which at the time of survey was targeted by external fishers but not by Paunangisu villagers.

- Both invertebrate and finfish fisheries are characterised by a low level of investment and operational cost, which may result from the role both of these fisheries play in maintaining villagers' livelihoods. Both resources are used for subsistence, although at a low-to-moderate level when compared with other villages nationally. The major difference between the fisheries is in terms of their contribution to income generation. The difference stems neither from villagers' reliance on agriculture (rather than fisheries) as a first source of income, nor from access to local marketing opportunities (i.e. the village shop), as both conditions apply equally to both fisheries. Instead, it stems from the traditional value given to invertebrates versus finfish. The comparatively high share of finfish and low proportion of invertebrates exchanged among community members on a non-monetary basis suggest invertebrates have a lower recognised value. However, invertebrates are an integral component of the villagers' traditional nutrition, which may explain the market demand (from urban people at Port Vila) for octopus, crabs, giant clams and other invertebrates. The existence of this demand provides an opportunity for Paunangisu's people to generate income from selected species, including some that are marketed as processed food items.

2.3 Finfish resource surveys: Paunangisu village

Finfish resources and associated habitats were assessed from a total of 24 transects (four sheltered coastal transects, six lagoon intermediate transects, eight lagoon back-reef transects and six outer transects) between 16 and 23 July 2003 (See Figure 2.18 and Appendix 3.1.1 for transect locations and coordinates, respectively.).

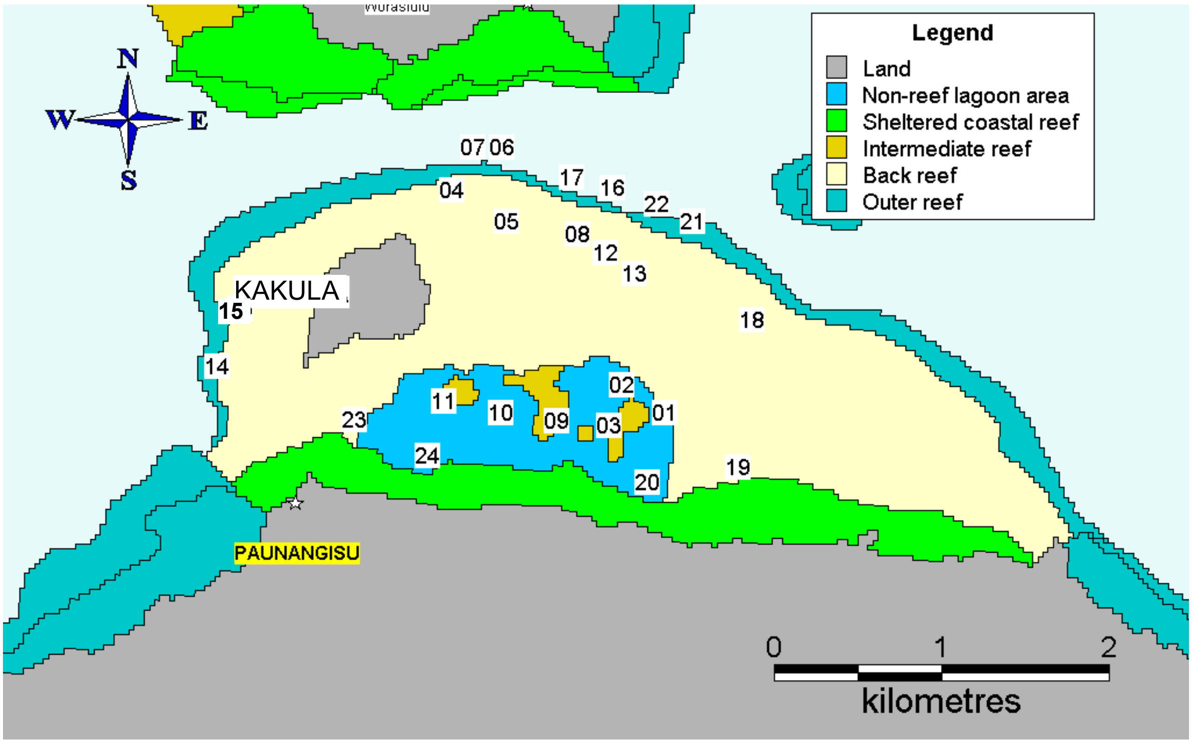

Figure 2.18: Habitat types and transect locations for finfish assessment in Paunangisu.

2.3.1 Finfish assessment results: Paunangisu village

A total of 21 families, 48 genera, 145 species and 8249 fish were recorded in the 24 transects (See Appendix 3.1.2 for list of species.). The data presented below cover only the 13 most dominant families (See Appendix 1.2 for species selection.), which include 39 genera, 133 species and 7399 individuals.

Finfish resources strongly differed among the four main types of reef present in Paunangisu (Figure 2.18, Table 2.6). The highest biodiversity, density, size and biomass were recorded in the outer reef; fewer species and fewer and smaller individuals (and hence less biomass) were recorded in the lagoon back-reef. The difference between the outer reef and lagoon back-reef was quite substantial: for example, biomass in the outer reef was four times that recorded in the lagoon back-reef (175 versus 41 g/m^2). Sheltered coastal and lagoon intermediate reefs scored between these extremes; biodiversity, density and biomass were slightly greater in the intermediate lagoon reef than in the sheltered coastal reef.

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

Parameters	Habitat				
	Sheltered coastal reef [(1)]	Intermediate reef [(1)]	Back-reef [(1)]	Outer reef [(1)]	All reefs [(2)]
Number of transects	4	6	8	6	24
Total habitat area (km^2)	1.22	0.18	5.05	0.83	7.28
Depth (m)	2 (1-3) [(3)]	2 (0-4) [(3)]	1 (1-1) [(3)]	5 (1-10) [(3)]	2 (0-10) [(3)]
Soft bottom (% cover)	48 ±8	25 ±8	19 ±3	3 ±1	22
Rubble & boulders (% cover)	21 ±12	24 ±5	22 ±3	11 ±5	21
Hard bottom (% cover)	20 ±4	32 ±7	39 ±6	47 ±6	36
Live coral (% cover)	11 ±2	18 ±4	13 ±2	27 ±3	14
Soft coral (% cover)	0 ±0	1 ±1	7 ±6	12 ±2	6
Biodiversity (species/transect)	32 ±3	39 ±5	29 ±4	45 ±6	36 ±3
Density (fish/m^2)	0.44 ±0.10	0.67 ±0.16	0.34 ±0.07	0.65 ±0.07	0.40
Size (cm FL) [(4)]	17.6 ±0.9	15.9 ±0.6	16.4 ±0.6	20.0 ±0.8	17.0
Size ratio (%)	54 ±3	50 ±24	60 ±2	65 ±3	59
Biomass (g/m^2)	68 ±21	80.4 ±14	41 ±9	175 ±23	61

[(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: Paunangisu village

The sheltered coastal reef of Paunangisu village was dominated by carnivorous Lutjanidae and Nemipteridae (Figure 2.19). Those two families were represented by 10 species, with particularly high abundance and biomass of *Lutjanus fulvus*, *L. fulviflamma*, S*colopsis bilineata*, *L. kasmira* and *S. trilineatus* (See Table 2.7.). Lutjanidae are often found in large numbers in sheltered coastal reefs with large coral heads, rocks or rubble on sandy bottoms, while Nemipteridae are generally associated with patchy sandy areas. This kind of habitat was characteristic of the sheltered coastal reef of Paunangisu, where the underwater survey indicated a dominant proportion of soft bottom (48% cover; see Table 2.6).

Table 2.7: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Paunangisu

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus fulvus*	Yellow-margined seaperch	0.06	15.9
	Lutjanus fulviflamma	Black-spot snapper	0.01	6.2
	Lutjanus kasmira	Bluestripe seaperch	0.03	2.4
Nemipteridae	*Scolopsis bilineata*	Bridled monocle bream	0.02	4.2
	Scolopsis trilineatus	Threelined monocle bream	0.02	2.3

Compared to the other PROCFish/C study sites in Vanuatu, the sheltered coastal reef environment of Paunangisu supported fewer finfish species and individuals; those finfish present were of smaller size, giving a resultant second lowest biomass across the study sites in Vanuatu. However, substrate in the sheltered coastal reef environment was strongly dominated by soft bottom, while other sites were characterised by more diverse habitats, with hard bottom slightly dominant (Table 2.6). These natural differences in substrate may explain the difference in resource status in Paunangisu's sheltered coastal reef, compared to the average across all PROCFish/C sites. Herbivorous Acanthuridae and Scaridae, species more generally associated with hard bottom, were virtually absent in Paunangisu (represented by only a few individuals); those species usually represent in the PROCFish/C study sites a major component of the finfish assemblage in the sheltered coastal reefs. However, carnivorous fish (mainly Lutjanidae, Mullidae and Nemipteridae), species more generally associated with soft-bottom habitats[7] were better represented in Paunangisu (Figure 2.19). However, the abundance of carnivorous fish in Paunangisu did not compensate, in terms of total biomass and density, for the deficit in herbivorous fish.

[7] Soft-bottom environments are generally rich in small invertebrates, which are the main food item of carnivorous fish.

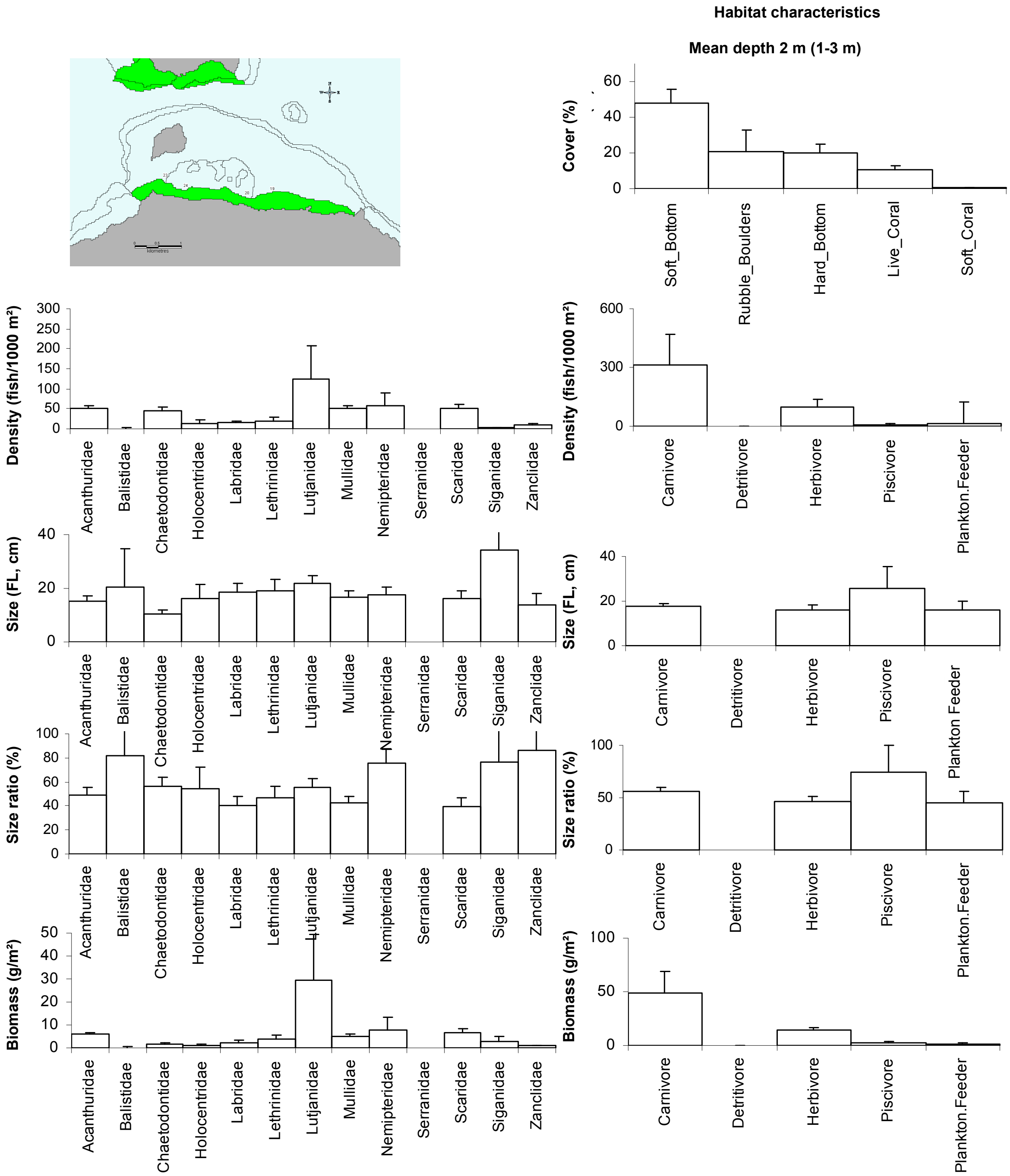

Figure 2.19: Profile of finfish resources in the sheltered coastal reef environment of Paunangisu.
Bars represent standard error (+SE); FL = fork length.

Intermediate-reef environment: Paunangisu village

Paunangisu's lagoon intermediate reef was dominated by herbivorous Scaridae and Acanthuridae and carnivorous Mullidae, Lutjanidae and Nemipteridae (Figure 2.20). These five families were represented by 39 species, with particularly high abundance/biomass of *Chlorurus sordidus*, *Ctenochaetus striatus*, *Scolopsis trilineatus*, *Lutjanus fulvus* and *Mulloidichthys vanicolensis* (See Table 2.8.). The habitat was well diversified (See Table 2.6, Figure 2.20.), which may explain the relative complexity of the fish assemblage in this reef.

Table 2.8: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Paunangisu

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Chlorurus sordidus*	Bullethead parrotfish	1.13	12.4
Acanthuridae	*Ctenochaetus striatus*	Lined bristletooth	0.07	8.2
Mullidae	*Mulloidichthys vanicolensis*	Yellowfin goatfish	0.05	3.2
Lutjanidae	*Lutjanus fulvus*	Yellow-margined seaperch	0.02	5.7
Nemipteridae	*Scolopsis trilineatus*	Threelined monocle bream	0.04	6.3

A comparison of Paunangisu's lagoon intermediate reef with the other PROCFish/C Vanuatu study sites was not possible because intermediate reefs were not present in the three other sites surveyed in Vanuatu. Consequently, no comparisons regarding the status of the finfish resource in this particular reef can be made at this stage of the project (Future comparison on a regional basis may be possible.). In general, intermediate reefs can naturally sustain a relatively high abundance of finfish, although they are generally less abundant than on outer reefs. This ranking was verified in Paunangisu. The poorest resource was observed on the lagoon back-reef; finfish were most abundant on the outer reef, and a medium-level resource was observed in sheltered coastal and lagoon intermediate reefs. The combination of a relatively diverse habitat, a relatively complex finfish assemblage and a medium-level resource in Paunangisu's lagoon intermediate reef suggests that human impact on this resource is moderate.

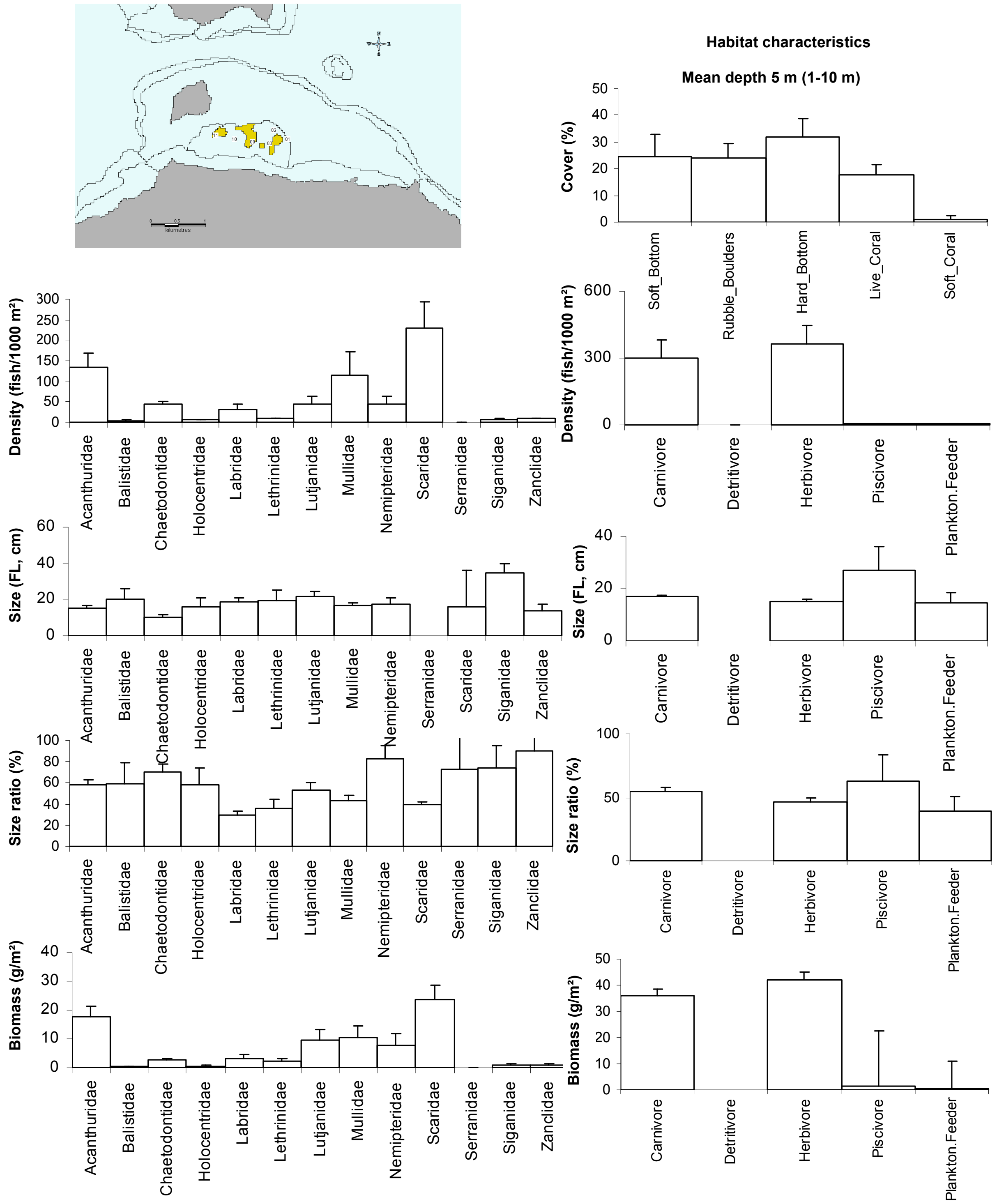

Figure 2.20: Profile of finfish resources in the intermediate-reef environment of Paunangisu. Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Paunangisu village

Paunangisu's lagoon back-reef was dominated by herbivorous Acanthuridae, Scaridae and Siganidae and carnivorous Nemipteridae (Figure 2.21). These four families were represented by 23 species, with particularly high abundance and biomass of *Ctenochaetus striatus*, *Scolopsis lineatus*, *Scarus rivulatus*, *Chlorurus sordidus* and *Acanthurus triostegus* (See Table 2.9.). This habitat was particularly shallow (1 m) and relatively diversified, with hard bottom predominating (39%, primarily pavement) over rubble and boulders (22%) (See Table 2.6, Figure 2.21.).

Table 2.9: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Paunangisu

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus triostegus*	Convict surgeonfish	0.30	2.2
	Ctenochaetus striatus	Lined bristletooth	0.05	5.9
Scaridae	*Chlorurus sordidus*	Bullethead parrotfish	0.03	3.7
	Scarus psittacus	Palenose parrotfish	0.02	2.6
	Scarus rivulatus	Surf parrotfish	0.03	3.9
Nemipteridae	*Scolopsis lineatus*	Lined monocle bream	0.03	5.0
Siganidae	*Siganus spinus*	Little spinefoot	0.04	3.9

A comparison between Paunangisu's lagoon back-reef and the other PROCFish/C study sites in Vanuatu was not possible because back-reefs were not present in the three other sites surveyed in Vanuatu. Consequently, no comparisons regarding the status of the finfish resource in this particular reef can be made at this time (Future comparison on a regional basis may be possible.). In general, back-reefs are characterised by naturally poor finfish resources and are often inhabited by small species and juveniles associated with flat, shallow, rocky pavements. Paunangisu's lagoon back-reef did not appear to differ from this general picture, except in terms of the particularly shallow depth, which may serve to further decrease the natural abundance (already poor) of finfish resources.

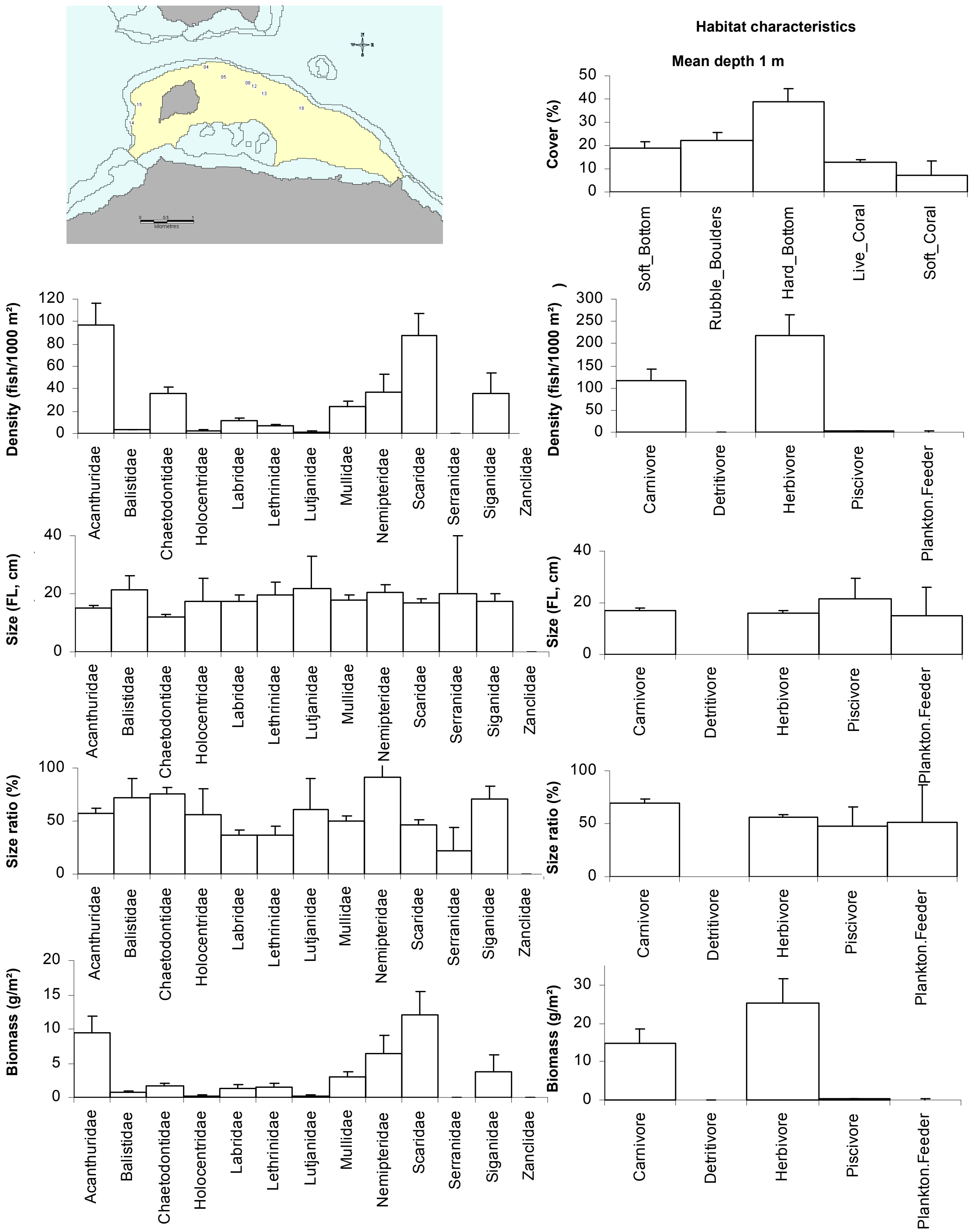

Figure 2.21: Profile of finfish resources in the back-reef environment of Paunangisu.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Paunangisu village

Paunangisu's outer reef was largely dominated by herbivorous Acanthuridae (Figure 2.22). This family was represented by 14 species, with particular high abundance and biomass of *Acanthurus lineatus*, *Ctenochaetus striatus*, *Naso unicornis*, *N. lituratus* and *Zebrasoma scopas* (See Table 2.10.). The substrate was characterised by clear dominance of hard bottom (47% cover); this environment had the greatest average live coral cover (27%) recorded in Paunangisu's reefs (Table 2.6). The dominance of the hard bottom in combination with the direct oceanic influence found in the outer reefs may serve to enhance algal production and explain the dominance of medium-sized (*A. lineatus*) and large-sized (*N. unicornis* and *N. lituratus*) herbivorous fish.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus lineatus*	Striped surgeonfish	0.10	52.2
	Ctenochaetus striatus	Lined bristletooth	0.17	23.9
	Naso unicornis	Bluespine unicornfish	0.02	10.6
	Naso lituratus	Orangespine unicornfish	0.01	6.5
	Zebrasoma scopas	Brushtail tang	0.01	0.8

Finfish resources in Paunangisu's outer reef had higher biodiversity, density, size and biomass than in Moso but lower than the other two PROCFish/C study sites in Vanuatu (Table 2.6). The outer-reef fish assemblage was dominated by Acanthuridae in Paunangisu while in outer-reef habitats in the three other sites in Vanuatu both Acanthuridae and Scaridae were dominant (Figure 2.22), suggesting a deficit of Scaridae in Paunangisu's outer reef. Scaridae are often associated with hard-bottom environments, and the deficit may be explained by the smaller proportion of hard bottom in Paunangisu compared to the other sites. Alternatively, Scaridae populations may have been impacted by human activities in Paunangisu relative to other sites studied in Vanuatu.

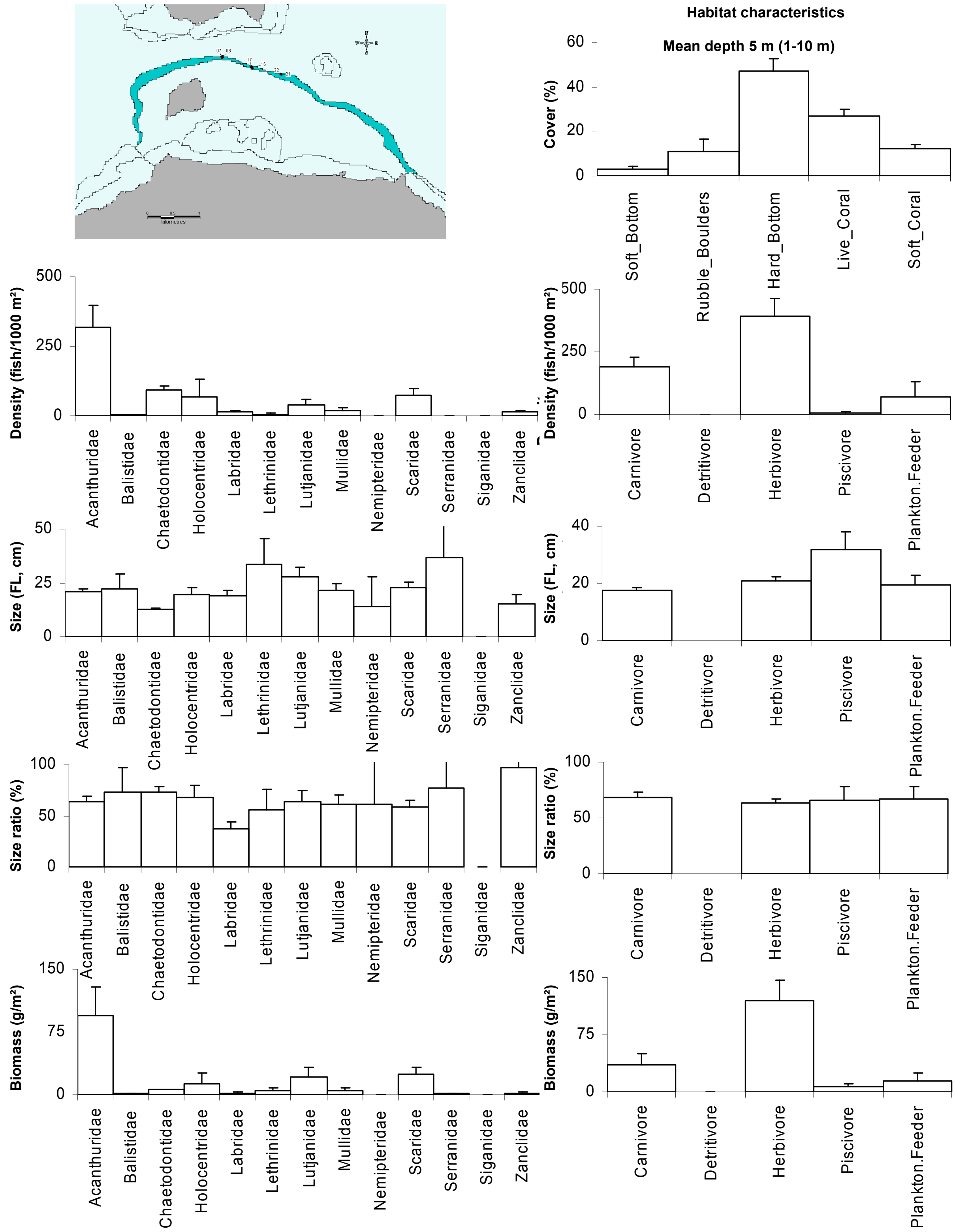

Figure 2.22: Profile of finfish resources in the outer-reef environment of Paunangisu.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Paunangisu village

Paunangisu's overall fish assemblage comprised five main families, with Acanthuridae predominating, and Scaridae, Nemipteridae, Mullidae and Lutjanidae present to a lesser extent (Figure 2.23). Those families were represented by a total of 53 species, dominated in terms of densities and biomass by *Ctenochaetus striatus*, *Acanthurus lineatus*, *Chlorurus sordidus*, *Lutjanus fulvus*, *Scolopsis lineatus*, *Scarus rivulatus*, *Scarus psittacus*, *A. triostegus*, *Parupeneus multifasciatus* and *P. barberinus* (For details see Table 2.11.). As expected, the overall fish assemblage in Paunangisu more closely resembled that recorded in the highly dominant lagoon back-reef (69% of habitat) than that from the sheltered coastal (17%), outer (11%) or lagoon intermediate reefs (3%).

Table 2.11: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Paunangisu (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Lined bristletooth	0.06	7.4
	Acanthurus triostegus	Convict surgeonfish	0.02	1.6
	Acanthurus lineatus	Striped surgeonfish	0.01	6.0
Scaridae	*Chlorurus sordidus*	Bullethead parrotfish	0.03	4.2
	Scarus psittacus	Palenose parrotfish	0.02	1.8
Nemipteridae	*Scolopsis lineatus*	Lined monocle bream	0.02	3.7
Mullidae	*Parupeneus multifasciatus*	Manybar goatfish	0.01	0.9
	Parupeneus barberinus	Dash-and-dot goatfish	0.01	0.7
Lutjanidae	*Lutjanus fulvus*	Yellow-margined seaperch	0.01	3.8

Overall, Paunangisu appears to support far poorer finfish resources than the other PROCFish/C study sites in Vanuatu, with lower biodiversity, density, size and biomass (Table 2.6). Detailed assessment at reef level suggests that this trend is mostly linked to a naturally poor habitat. It is possible, however, that these results also reflect a greater impact from fishing at Paunangisu compared to the average for study sites in Vanuatu, particularly with respect to Scaridae populations on the outer reef.

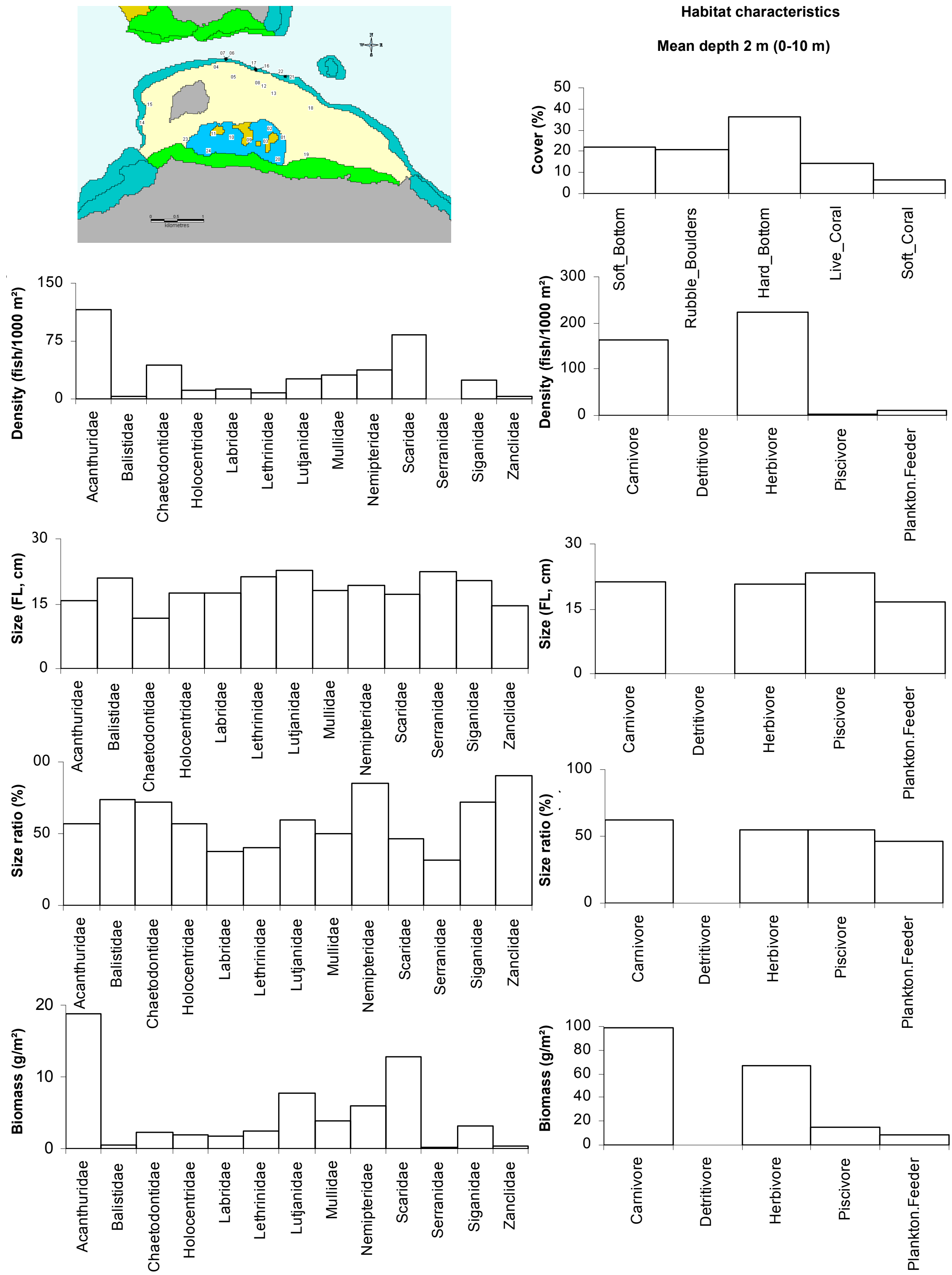

Figure 2.23: Profile of finfish resources in the combined reef habitats of Paunangisu (weighted average).
FL = fork length.

2.3.2 Discussion and conclusions: finfish resources in Paunangisu village

- The finfish resource assessment indicated that Paunangisu's finfish resources were much poorer than those surveyed at the other three PROCFish/C study sites in Vanuatu. Preliminary results suggest that this trend was mostly linked to a naturally poorer habitat in Paunangisu. However, greater fishing pressure in Paunangisu compared to other sites studied in Vanuatu could not be eliminated as a contributing factor without further analysis. This was particularly the case for the outer-reef population of Scaridae (parrotfish), which was unusually poor in Paunangisu compared to the remaining sites in Vanuatu.

- Overall, considering the naturally poor habitat, Paunangisu's finfish resources appear to be in relatively meager condition. Based on the analysis done to date, we believe that any measures taken to protect the ecosystem are unlikely to substantially increase the productivity of the finfish resource.

- Further development of reef finfish fisheries to improve the food and financial security of the people of Paunangisu may be limited by environmental factors, and consequently the development of alternative sources of food and income is recommended.

- The potential for targeting stocks of deep-water fish (*Pristipomoides* spp. or 'poulet' in the local language) that are of high commercial value in Port Vila markets, and that can be relatively easily accessed, has been examined by some fishers in Paunangisu. Investigation into the capacity of this fishery to contribute to the food and financial security of the people of Paunangisu may be warranted.

2.4 Invertebrate resource surveys: Paunangisu village

The diversity and abundance of invertebrate species at Paunangisu were independently determined using a range of survey techniques, including broad-scale assessment (using the manta tow technique; locations shown in Figure 2.24) and finer-scale assessment of specific reef and benthic habitats (Table 2.12, locations shown in Figures 2.24 and 2.25).

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. Fine-scale assessments were conducted in target areas (areas with naturally higher abundance and/or the most suitable habitat) to specifically describe resource status.

Table 2.12: Number of stations and replicates completed at Paunangisu

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	8 + 1 (Pele)	54 transects
Reef-benthos transects (RBt)	12	72 transects
Soft-benthos transects (SBt)	6	36 transects
Soft-benthos infaunal quadrats (SBq)	6	48 quadrat groups
Mother-of-pearl transects (MOPt)	0	0 transect
Mother-of-pearl searches (MOPs)	4	24 search periods
Reef-front searches (RFs)	3	18 search periods
Sea cucumber night searches (Ns)	2	12 search periods
Sea cucumber day searches (Ds)	0	0 search period

Pele is the name of the marine protected area (MPA).

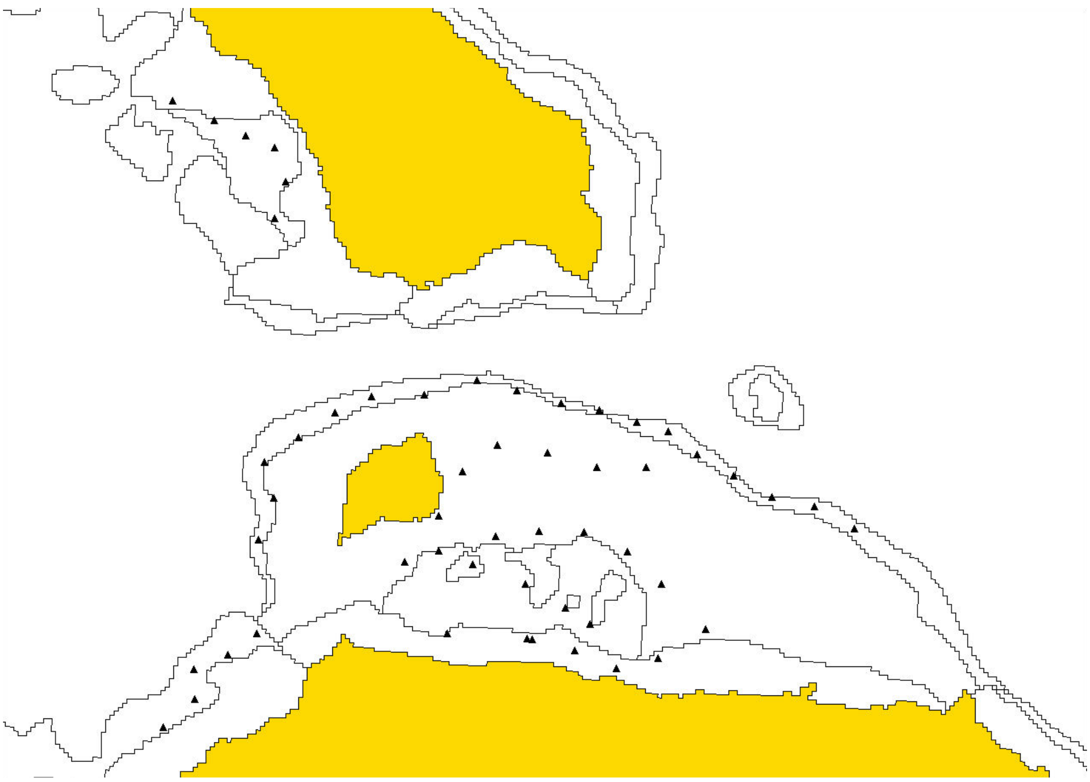

Figure 2.24: Broad-scale survey stations for invertebrates in Paunangisu.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

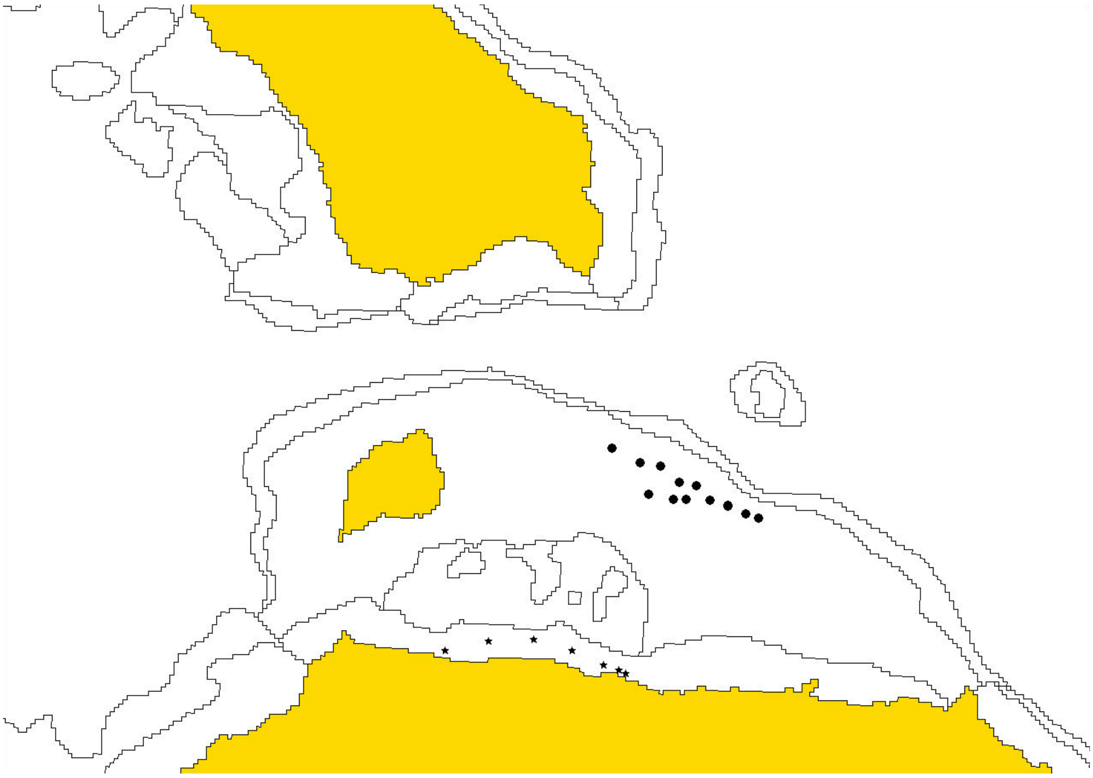

Figure 2.25: Fine-scale reef-benthos transect survey stations and soft-benthos survey stations for invertebrates in Paunangisu.
Black circles: reef-benthos transect stations (RBt); black stars: soft-benthos stations.

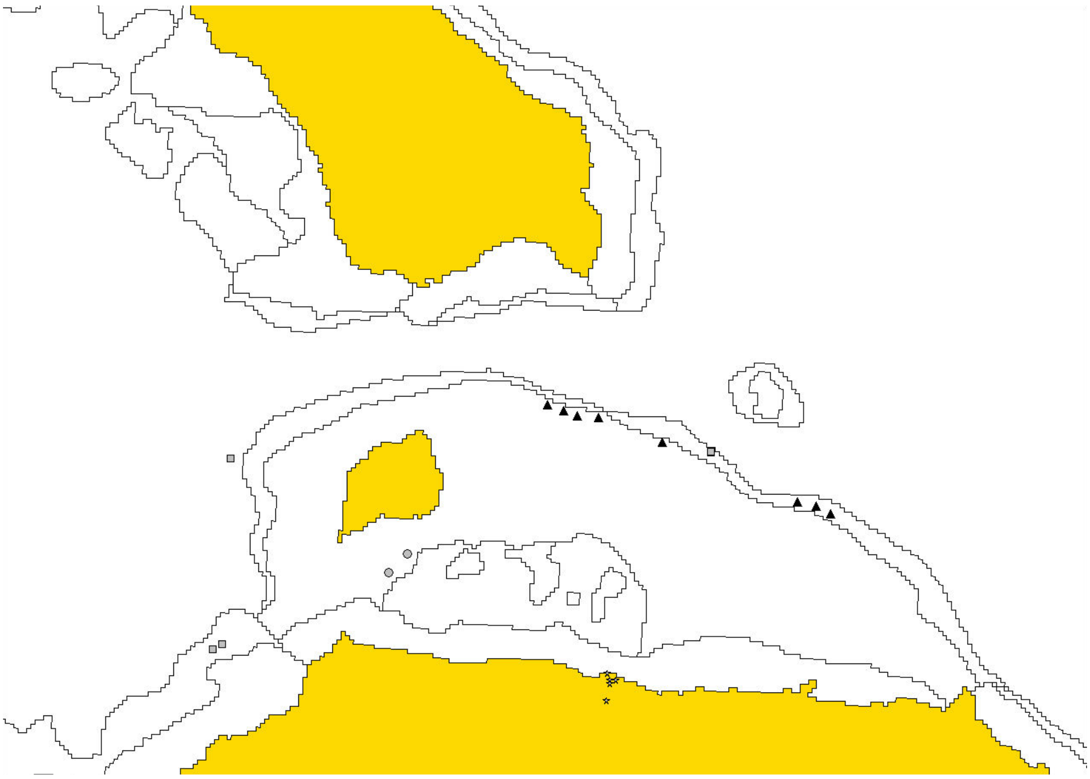

Figure 2.26: Fine-scale survey stations for invertebrates in Paunangisu.
Grey stars: soft-benthos quadrat stations (SBq);
grey circles: sea cucumber night search stations (Ns);
black triangles: reef-front search stations (RFs);
grey squares: mother-of-pearl transect stations (MOPt).

Fifty-three species (or species groupings) were recorded in the Paunangisu invertebrate surveys: 12 bivalves, 13 gastropods, 17 sea cucumbers, 5 urchins, 3 sea stars, 2 cnidarians and 1 lobster (For listing see Appendix 4.1.1.). Information on key families and species is detailed below.

2.4.1 Giant clams: Paunangisu village

Broad-scale sampling provided an overview of giant clam distribution across Paunangisu's coastal environment. Shallow reef habitat (suitable for giant clams) within the area surveyed was not extensive (4.8 km^2) and four giant clam species were recorded: *Tridacna crocea*, *T. maxima*, *T. squamosa* and *Hippopus hippopus*. *T. crocea* and *T. maxima* had the widest occurrence (four stations + the Pele MPA), followed by *T. crocea* (four stations) and *T. squamosa* (found only in the Pele MPA) (Figure 2.27).

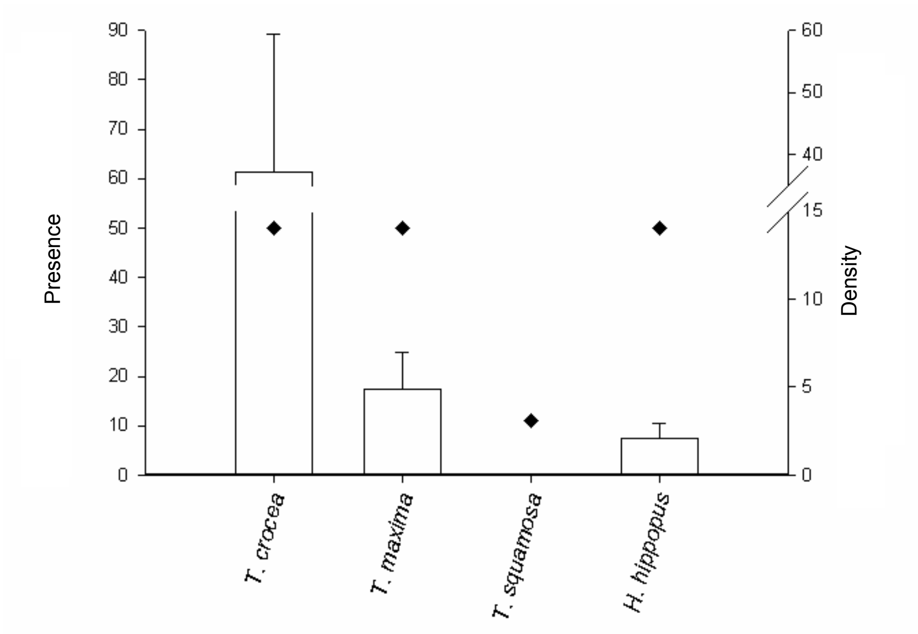

Figure 2.27: Presence and mean density of giant clam species at Paunangisu based on broad-scale 'manta' survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE); the only record of *T. squamosa* during broad-scale surveys was from the Pele marine protected area.

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat. In these reef-benthos assessments (RBt), elongate clams (*T. maxima*) had the widest distribution (67% of stations), followed by *T. crocea* (58% of stations) (Figure 2.28). When density is calculated based on the approximately 60% of stations where clams were recorded (density in their aggregated areas), *T. maxima* had a mean (±SE) density of 52.1 ±6.9 per ha, whereas *T. crocea* were at a slightly higher mean density of 71.4 ±23.6 per ha (See Appendix 4.1.3.).

H. hippopus and *T. squamosa* were rare, both being recorded irregularly and at low density. Although *H. hippopus* and the larger *T. squamosa* are generally found at lower density than the smaller reef species, even when they are not fished these species were found at only a few assessment stations in Paunangisu. Munro (1989) notes that these species are commonly rare at sites experiencing high fishing pressure. Live specimens of *T. gigas* (a generalist species of clam) and *T. derasa* (a species found at sites with oceanic influence) were not found during the survey, although empty *T. gigas* shells were still present in the village. Both species have been recorded at ~5 per ha on Australia's Great Barrier Reef (Munro 1993), and Rosewater (1965) included Vanuatu (at that time the New Hebrides) in the distribution of these species. However, both this survey and a previous study in Vanuatu (on nearby Moso Island; Zann and Ayling 1988) failed to record their presence, and we consider them commercially extinct[8] at this site.

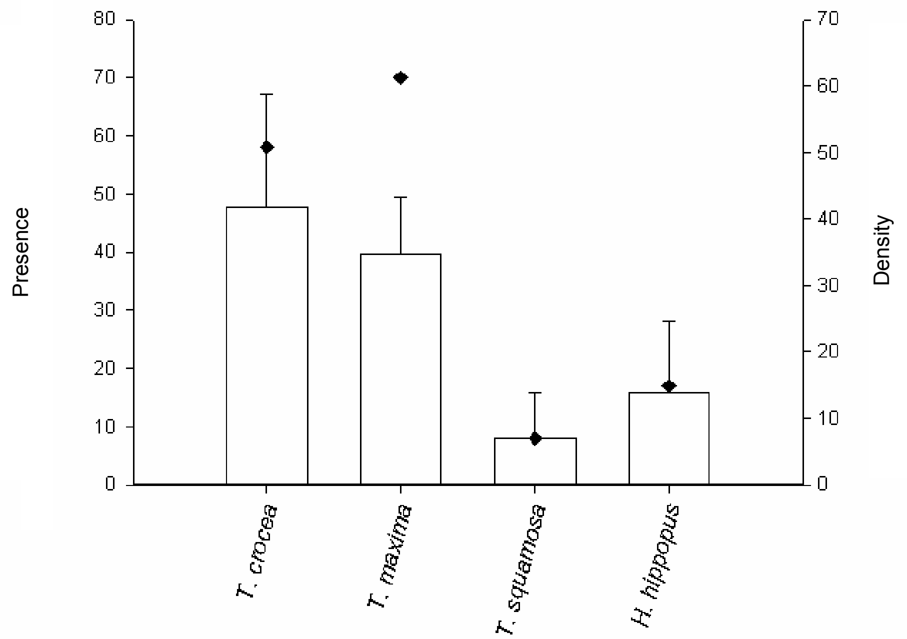

Figure 2.28: Presence and mean density of giant clam species at Paunangisu based on fine-scale reef-benthos survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE); the only record of *T. squamosa* during broad-scale surveys was from the Pele marine protected area.

The distribution of clams in Paunangisu was generally sparse and clam aggregations were at low densities, especially in comparison with the results from the two Malekula Island sites. In descriptive terms, in shallow-water reef areas suitable for giant clams, fewer than 1–2 clams were present per 100 m × 2 m swathe. Densities of *T. crocea* at Paunangisu were lower than the exceptional densities recorded at Moso Island.

The mean length (cm ±SE) of giant clams at Paunangisu was 8.2 ±0.4 for *T. crocea*, 13.1 ±2.0 for *T. maxima*, 16.5 ±1.3 for *H. hippopus* and 16.0 cm for the single measure of *T. squamosa* (Figure 2.29). The average age of *T. maxima* and *T. crocea* was approximately 5–6 years, whereas the larger but faster-growing species of *H. hippopus* and *T. squamosa* averaged about three and five years old, respectively.

[8] 'Commercially extinct' refers to scarcity such that collection is not possible to service commercial or subsistence fishing, but the species is or may be present at very low densities.

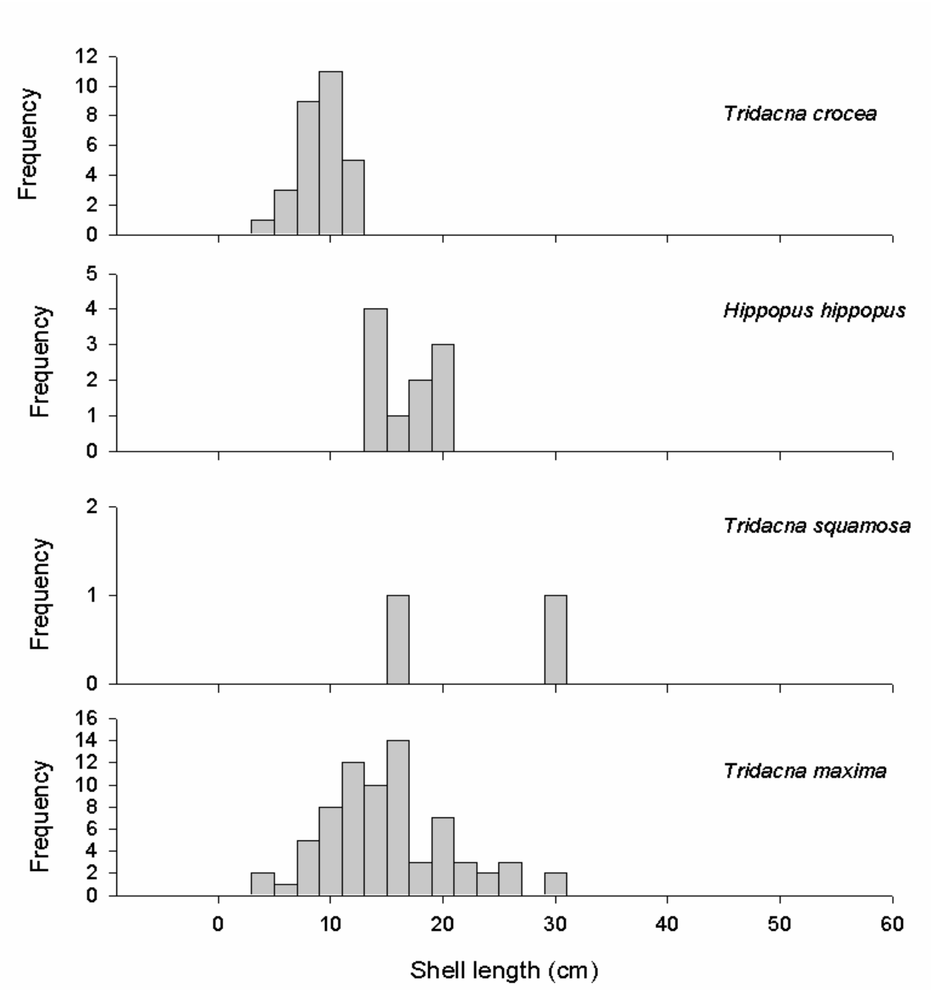

Figure 2.29: Size frequency histogram of giant clam shell length (cm) for Paunangisu.

2.4.2 Mother-of-pearl species (MOP): trochus and pearl oysters - Paunangisu village

The 7–8 km (lineal measure) barrier reef at Paunangisu, with extensive back-reef habitat, constitutes a relatively extensive and suitable habitat for *Trochus niloticus*; the area could potentially support significant populations of this commercial species. Live adult trochus were found in wave-exposed fore-reef areas, whereas back-reef areas suitable for juvenile recruitment and growth had a significant rubble component (46% ±3.3), with crustose coralline algae (CCA) cover of 17% ±1.9.

Despite the presence of suitable habitat, only four live specimens of *T. niloticus* were recorded at Paunangisu (all in broad-scale surveys, 4% of transects). Mother-of-pearl searches (24 MOP search periods on SCUBA) conducted in the area where trochus were seen from the tow board, and on reef exposed to the prevailing swell, did not locate live *T. niloticus,* although eroded dead shells were found. Three of the four live shells found during the broad-scale assessment were large and near the asymptotic length (12–12.5 cm basal measurement), but the fourth, at 60 mm, was barely post juvenile (~2 years old).

Other MOP species were also rare at Paunangisu (Table 2.13). No green snail (*Turbo marmoratus*) was found at Paunangisu, although the blacklip pearl oyster (*Pinctada margaritifera*) was found in three out of eight broad-scale stations and in the adjacent Pele reserve. A single gleaned shell was recorded during creel survey but *P. margaritifera* was not found in other finer-scale assessments despite the environment being suitable for this species.

Table 2.13: Presence and mean density of *Pinctada margaritifera*, *Tectus pyramis* and *Trochus niloticus* in Paunangisu
Based on various assessment techniques; mean density measured in numbers/ha (±SE).

	Density	SE	% of stations with species	% of transects or search periods with species
Pinctada margaritifera				
Manta	2.1	1.1	3/8 = 38	3/48 = 6
RBt	0	0	0/12 = 0	0/72 = 0
Tectus pyramis				
Manta	0	0	0/8 = 0	0/48 = 0
RBt	10.4	10.4	1/12 = 8	3/72 = 4
Trochus niloticus				
Manta	1.4	1.1	2/8 = 25	2/48 = 4
RBt	0	0	0/12 = 0	0/72 = 0

Manta = broad-scale survey; RBt = reef-benthos transect.
No MOP species were found in MOP searches or other fine-scale assessments at Paunangisu.

Mother-of-pearl species, such as *Trochus niloticus* and *Pinctada margaritifera*, were rare at Paunangisu. The densities described are well below those where a commercial fishery could be considered, despite the suitable environment present at Paunangisu. These densities are considered below the critical point where stocks can survive and may describe a stock that is below the level where recovery is likely.

The different spawning and life history characteristics of *T. niloticus* and *P. margaritifera* have significant implications for their resilience to environmental stress and fishing pressure. Whereas blacklip pearl oysters have a broad habitat and depth tolerance and a long larval life in plankton (16–20 days), trochus populations are commonly aggregated in shallow water and have a shorter life in plankton (0–60 hours). Because of these characteristics, trochus are more vulnerable to fishing pressure as recruitment from distant populations is usually limited.

The Vanuatu Fisheries Department and a nearby community have restocked adult *T. niloticus* within a marine protected area in the hope of assisting in the recovery of stocks in the nearby village of Emua (located 4 km from Paunangisu; see Appendix 4.1.10). The trochus found during the survey (including a single post-juvenile and a small number of adults) suggest that spawning still continues in the vicinity of Paunangisu.

2.4.3 Infaunal species and groups: Paunangisu village

Bivalves and gastropods can be collected by digging in shell beds (inshore areas of soft benthos, which hold aggregations of resources). A small component (less than 1 km^2) of the fishing area of Paunangisu comprised this habitat type, and it was generally found on the margins of the small, protected, semi-enclosed lagoon. Despite being protected behind a barrier reef system, and the presence of areas of soft benthos and seagrass along the edges of the mangrove, there was a relatively high mean oceanic influence (grade 3 out of 5) and low grade for epiphytes (grade 2 out of 5). This indicates the area was well flushed with oceanic water coming over the lagoon's barrier reef.

Soft benthos was also found inside the mangrove, where lagoon pools formed. The banks of these lagoons formed poor habitat as they were excessively muddy, while outside the mangrove the benthos was equally unsuitable as it was very compacted. Freshwater springs discharged hot water into the back of the mangrove area, which may have had some effect on the system.

The shell beds of Paunangisu were not a rich source of bivalves or other resources characteristic of such a habitat (infaunal survey; see Appendix 4.1.6). Within these areas the only larger-sized shellfish present were venus shells, *Gafrarium* spp., which were found at low densities (*G. tumidum* and *G. pectinatum* were found at six stations at densities of 0.6 ±0.4 per m^2). *Gafrarium* spp. were detected in only 10% of quadrat groups (n = 48); average size was 4.6 cm ±0.7 (n = 7), which is relatively large for this species.

Although arc shells (*Anadara* spp.) were present in sand patches in the more exposed areas of the lagoon (data from catch records), there were no obvious concentrations of this resource within the seagrass beds and soft-benthos habitats that were assessed. Anecdotal reports from fishers suggest the area within the mangrove once supported significant numbers of *Anadara*.

2.4.4 Other gastropods and bivalves: Paunangisu village

Lambis lambis specimens were detected in broad-scale and fine-scale (reef-benthos) surveys, but none of the larger Seba's spider conch (*L. truncata*) were recorded. Unusually, *Turbo* spp. (*T. argyrostomus*, *T. chrysostomus*, *T. crassus* and *T. setosus*) were not recorded in reef-benthos assessments. Gastropod genera such as *Cerithium*, *Conus*, *Cypraea*, *Pleuroploca*, *Strombus* and *Tectus* were noted on the reef benthos; densities are listed in Appendix 4.1.2.

Other bivalves, such as *Atrina*, *Chama*, *Hyotissa* and *Spondylus*, were also noted in broad-scale and fine-scale benthos surveys (Appendices 4.1.2 and 4.1.3). Reef gleaners in Paunangisu collected a range of common resource bivalves (*T. maxima*, *H. hippopus*, *Periglypta puerpera*, *P. margaritifera*), gastropods (*L. lambis*, *Strombus luhuanus*, *Cypraea tigris*, *Conus* spp., *V. turbinellum*, *P. filamentosa*) and the urchin *Tripneustes gratilla*. At the time of the survey, fishers gleaning the shallow-water reef areas concentrated their efforts on octopus, and fishers from nearby Pele Island were also regularly seen gleaning on the reef.

2.4.5 Lobsters: Paunangisu village

A single lobster, *Panulirus* sp., was recorded during the broad-scale assessment (mean density at all stations 0.4 per ha). No lobsters were recorded in the reef-benthos survey, or during night searches of the lagoon.

2.4.6 Sea cucumbers[9]: Paunangisu village

A wide range of suitable environments for sea cucumbers (reef margin, shallow mixed hard and soft substrate, and mangrove) were present at Paunangisu. Despite the area's limited size (approximately 5 km^2) and the significant oceanic influence (A large portion of the reefs is exposed to swells from the northeast.), Paunangisu held an extensive complement of sea cucumber species (Table 2.14), including 16 commercial and/or subsistence species (17 if a record from the Pele MPA is included) and one non-target species.

The presence and density of sea cucumber species were determined through broad-scale, fine-scale and dedicated survey methods (Table 2.14, Appendices 4.1.2 and 4.1.3. For a general description of survey methods for invertebrates, see Appendix 1.3.). Note that no deep diving was conducted in this study, which would be required to give advice on deep-water stocks, such as the high-value white teatfish (*Holothuria fuscogilva*) and the lower-value amberfish (*Thelonata anax*).

Despite the extensive complement of sea cucumbers, the density of commercial species was moderate to low when compared with the average for the four PROCFish/C sites in Vanuatu (Table 2.14). Of those species generally associated with reefs, greenfish (*Stichopus chloronotus*), stonefish (*Actinopyga lecanora*) and leopard or tigerfish (*Bohadschia argus*) were recorded at moderate density. Two higher-value species – black teatfish (*H. nobilis*) and prickly redfish (*Thelonata ananas*) – were present at low density, as was the surf redfish (*A. mauritiana*). Both the black teatfish and surf redfish are well suited to reeftop environments similar to that found at Paunangisu, but both of these shallow-water species are easily targeted by fishers.

Lower-value species (lollyfish, *H. atra*; pinkfish, *H. edulis*; and snakefish, *H. coluber*) were common within shallow-water lagoonal areas, which were found in less exposed locations. Blackfish (*A. miliaris*) was not found in the protected lagoon, mangrove edges or seagrass areas (e.g. areas of patch reef and soft benthos), but remnant populations of other highly marketable species that are generally associated with soft benthos were present at very low densities, including sandfish (*H. scabra*), false sandfish (*B. similis*) and curryfish (*S. hermanni*). Two notable records from the survey were the presence of peanutfish (*S. horrens*, termed 'small curry' in Fiji), which was found in a single high-density patch on seagrass near Paunangisu village, and the observation of a single specimen of *H. scabra versicolor*, a high-value species not found at the other PROCFish/C sites in Vanuatu.

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

Table 2.14: Sea cucumber species records for Paunangisu

Species	Common name	Commercial value [6]	B-S transects n = 48 Pele MPA, n=6			Reef-benthos stations n = 12			Soft-benthos stations SBt = 6			Other stations RFs = 3; MOPs = 4		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga lecanora	Stonefish	M/H										8.3	16.7	50 MOPs
Actinopyga mauritiana	Surf redfish	M/H										2.1 2.1	4.4 8.3	67 RFs 25 MOPs
Actinopyga miliaris	Blackfish	M/H												
Bohadschia argus	Leopardfish	M	3.4	26.2	15	6.9	83.3	8				4.2	16.7	25 MOPs
Bohadschia graeffei	Flowerfish	L	1.9	16.7	8							3.4	11.1	75 MOPs
Bohadschia similis	False sandfish	L							20.8	125	17			
Bohadschia vitiensis [4]	Brown sandfish	L	1.9	16.7	3									
Holothuria atra	Lollyfish	L	235	598	44	104	139	75	194.4	194.4	100			
Holothuria coluber	Snakefish	L	1.2	22.2	6	17.4	52.1	33	6.9	41.7	17			
Holothuria edulis	Pinkfish	L	2.5	26.7	10	41.7	83.3	50	6.9	41.7	17	12.5	16.7	75 MOPs
Holothuria fuscogilva [5]	White teatfish	H												
Holothuria fuscopunctata	Elephant trunkfish	M	0.3	16.7	2									
Holothuria nobilis [5]	Black teatfish	H	0.3	16.7	2							10.4	13.9	75 MOPs
Holothuria scabra [7]	Sandfish	H												
Holothuria scabra versicolor [8]	Golden sandfish	H												
Stichopus chloronotus	Greenfish	M/H	7.1	30.6	13	45.1	135.4	33						
Stichopus hermanni	Curryfish	M/H	1.9	27.8	6							21.8	8.3	25 MOPs
Stichopus horrens	Peanutfish	M							136,125	816,750	17			
Stichopus vastus	Brown curryfish	M/H												
Synapta spp.	-	M/H	0.9	25.0	4	3.5	41.7	8						
Thelenota ananas	Prickly redfish	H				3.5	41.7	8				4.2	16.7	25 MOPs
Thelenota anax	Amberfish	M												

[1] D = mean density (numbers/ha); [2] DwP = mean density (numbers/ha) for transects or stations where the species was present; [3] PP = percentage presence (units where the species was found); [4] recorded from Pele MPA during broad-scale survey; [5] 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. [6] L = low value; M = medium value; H= high value; [7] two observations were made independently from the survey; [8] one observation was made out of the broad-scale transect; B-S transects= broad-scale transects; SBt = soft-benthos transect; RFs = reef-front search; MOPs = mother-of-pearl search.

2.4.7 Other echinoderms: Paunangisu village

The edible slate urchin (*Heterocentrotus mammillatus*) and pincushion urchin (*Tripneustes gratilla*) were detected during both broad- and fine-scale surveys. These species are vulnerable to fish predation and are characteristically cryptic within reef environments. On reef-benthos assessments *H. mammillatus* was rare, whereas *T. gratilla* was relatively common compared to other PROCFish/C sites (67% of reef-benthos stations, mean density of 156.3 ±115.2 per ha).

Crown of thorns starfish (COTS; *Acanthaster planci*) and non-edible urchins were recorded as potential indicators of habitat condition. Six adult *A. planci* were recorded during Paunangisu surveys, three during broad-scale surveys (in the Pele MPA) and three on reef-benthos transects in front of Paunangisu village. Such a density of *A. planci* is of no present concern[10], although considering the small area of reef that is present, active monitoring and management of this species are recommended. Both urchin species (resource and subsistence) and the starfish *L. laevigata* were somewhat more widely distributed than at other sites, although densities were generally similar.

2.4.8 Discussion and conclusions: invertebrate resources in Paunangisu village

- A large proportion (approximately 50%) of the area surveyed at Paunangisu consisted of shallow reef. Mean live coral coverage was above average for PROCFish/C sites studied in Vanuatu (Broad- and fine-scale surveys of the benthos produced live coral cover figures of 20% and 21%, respectively.). Fine-scale assessment of reef benthos revealed significant oceanic influence (oceanic influence of 4 on a scale of 1–5); the presence of significant amounts of rubble and boulders (46%) highlights the dynamic nature of the reef flat opposite Paunangisu village.

- Marine resources typically targeted by fishers through gleaning (on reef and soft benthos) were generally less common than the average for the four PROCFish/C sites in Vanuatu, and when present they were found at lower densities. The presence, density and size range of clams at Paunangisu would indicate that the resource is impacted (possibly heavily) by fishing pressure or environmental conditions. In addition, although the large species of clams (*H. hippopus* and *T. squamosa*) are generally found at lower density in surveys, the level of occurrence, density and size of these species reflect fisheries-related impacts.

- Bivalves and gastropods that can be collected by digging in inshore soft-benthos shell beds were rare in Paunangisu. Larger species, such as arc shells (*Anadara* spp.), were harvested but were at very low density, and only the smaller venus shell (*Gafrarium* spp.) was found in soft benthos near the mangrove.

- Mother-of-pearl stocks (*P. margaritifera* and trochus) were present but not common (less so than at PROCFish/C sites on Malekula). Green snail (*T. marmoratus*) was not found during surveys. The assessment of trochus stocks, from dedicated MOP searches and reef-benthos assessments, reveals a depleted resource and one that is heavily impacted by

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[10] For additional information on COTS see http://www.aims.gov.au/docs/research/biodiversity-ecology/threats/cots.html.

fishing, although some recruitment was still occurring (A single instance was recorded.) (Appendix 4.1.7). The remaining small numbers of trochus were found in an area partially protected from fishing (at the front and east of Paunangisu). Resource owners should be made aware of the harvest and management strategies currently in use in other parts of the Pacific and refrain from harvesting MOP stocks.

- The complement of sea cucumber species at Paunangisu was still relatively intact, but presence and density estimates reveal a largely depleted stock, heavily impacted and/or degraded by fishing. Individuals of the more valuable species (e.g. sandfish) are remnants of former populations, while other species (blackfish) were absent. Although the amount of protected lagoonal habitat was limited in Paunangisu, even those species well suited to the exposed reef conditions (e.g. surf redfish, *A. mauritiana*) were sparsely distributed and present at low densities.

- Stocks of peanutfish should be monitored to assess the potential for future harvest. Fishing for other sea cucumbers should be restricted at Paunangisu, and local resource owners should seek expert advice prior to opening a fishery (See Appendix 4.1.12 for catch records for Paunangisu fishers.).

2.5 Overall recommendations for Paunangisu village

Based on the survey work undertaken and the assessments made across all three disciplines (socioeconomics, finfish and invertebrates), the following recommendations are made for the Paunangisu village fishing area:

- Further development of reef finfish fisheries to improve the food and financial security of the people of Paunangisu may be limited by environmental factors, and the development of alternative sources of food and income are consequently recommended.

- The potential for targeting stocks of deep-water fish (*Pristipomoides* spp. or 'poulet' in local language) that are of high commercial value in Port Vila markets, and that can be relatively easily accessed, has been examined by some fishers in Paunangisu. Investigation into the capacity of this fishery to contribute to the food and financial security of the people of Paunangisu may be warranted.

- Given habitat constraints, Paunangisu's finfish resources appear to be in relatively good condition. However, any measures to protect the ecosystem (e.g. marine protected areas) should be encouraged and supported.

- Resource owners should be made aware of the harvest and management strategies currently in use in other parts of the Pacific and refrain from harvesting mother-of-pearl stocks.

- Stocks of peanutfish (bêche-de-mer) should be monitored to assess the potential for future harvest. Fishing for other sea cucumbers should be restricted at Paunangisu, and local resource owners should seek expert advice prior to opening a fishery.

3. PROFILE AND RESULTS FOR MOSO ISLAND

3.1 Site characteristics

The island of Moso (Figure 3.1) is located on the northwest coast of Efate Island, about 2 km by boat from Port Havannah. Moso is 28 km from the country's capital, Port Vila, a journey that takes approximately one hour by road plus 15 minutes by boat, depending on weather, road and transport conditions. The island of Moso is separated from Efate by a pseudo-lagoon, Havannah Harbour. Land and reef tenure in Moso are traditional, with the villagers owning the land and the fishing ground.

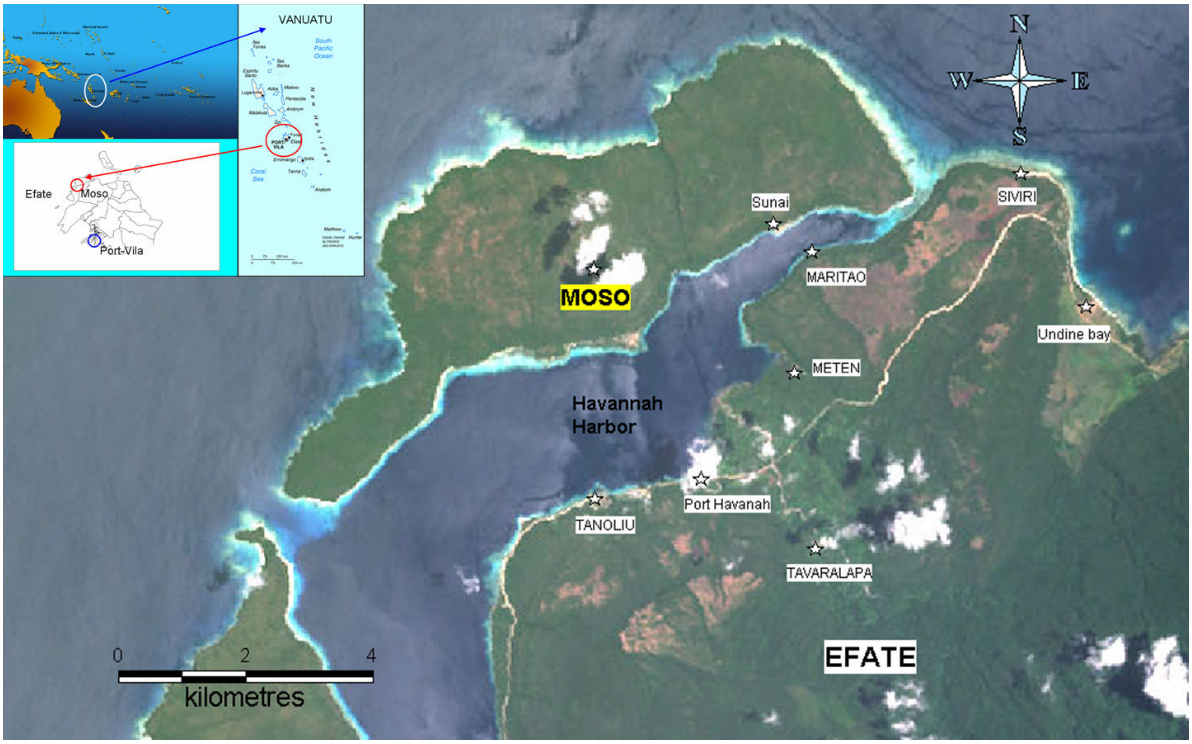

Figure 3.1: Location of Moso Island.

The evolution of community-based marine resource management (MRM) in Vanuatu has been documented over the last decade and more than 80 communities are now reported to be engaged in it (Govan 2004).

Village inhabitants indicated that fishing was completely banned on the sheltered side of Moso Island every second year (i.e. for 12 months in 24), indicating that the people were taking specific measures to manage their reef fisheries in a sustainable manner. In addition, a giant clam garden has been established fronting Tassiriki Primary School on the island. During the PROCFish/C invertebrate survey about 150–200 *H. hippopus* clams (sizes 10–30 cm) were recorded, with small numbers of *T. crocea* also present.

In addition to community management efforts, the Fisheries Act, which is enforced by the national Fisheries Department, includes regulations on size limits for shellfish and crustaceans, no-take of gravid crustaceans (those with egg masses), harvest and export quotas for some products and in some cases requirements for licences and permits. National law also prohibits the export of wild (i.e. not cultured) giant clams from the island of Efate and its offshore islands.

The Moso fishing grounds are about 23 km^2 in area, with approximately 5 km^2 of reef (Figure 3.2). A narrow fringing reef characterised by a few coral heads growing on mineral rock lies along the northern (ocean) side of Moso Island, while a narrow sheltered coastal reef extends along the southern side of the island, where the pseudo-lagoon is located, and also along the coast of Efate where it fronts Moso. The reefs of Moso village are composed equally of outer reef (2.49 km^2, 54% of habitat) and sheltered coastal reef (2.15 km^2, 46%).

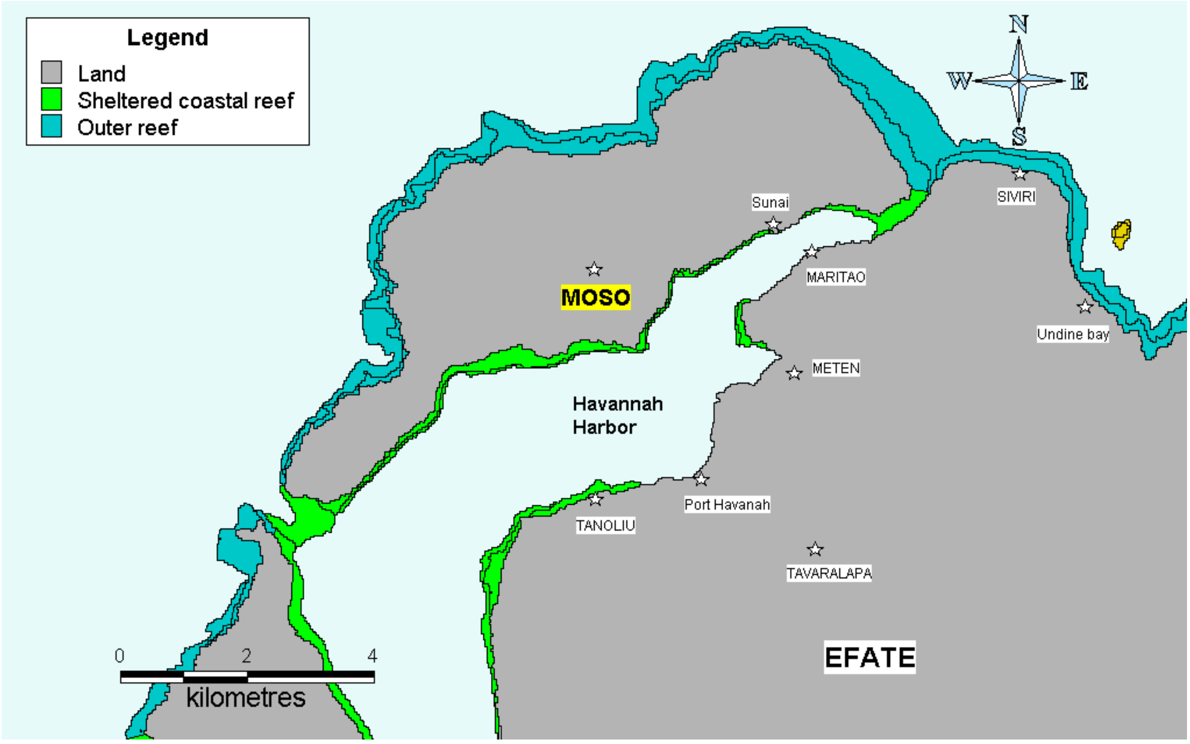

Figure 3.2: Main reef structures adjoining Moso Island.

3.2 Socioeconomic surveys: Moso Island

Socioeconomic fieldwork was carried out in the community of Moso between 20 and 25 October 2003. The survey covered 81% (26 out of 32) of households and ~80% of the total population (152 of 187 individuals).

Household interviews focused on the collection of general demographic, socioeconomic and consumption parameters. In addition, 24 individual interviews with finfish fishers (21 males, 3 females) and 19 with invertebrate fishers (10 males, 9 females) were conducted. In some cases the same person was interviewed for both finfish and invertebrate fishing.

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

Extrapolating the average of 2.65 fishers per household surveyed by the total number of households gives a total of 85 fishers in Moso: 51 males and 34 females.

Fisheries play an important role as a secondary income source (58% of all households), while agriculture represents the first source of income for most inhabitants (69%) (Figure 3.3). The combined contributions of salaries and other sources (including handicrafts and private businesses) exceeds fisheries as a first source of income (19% versus 15% of all households). However, despite the lower dependence on fisheries for income, the proportion of fish caught for sale (export) is substantial and exceeds that caught to satisfy subsistence needs by a factor of 3.7. Only 15% of all households receive remittances, which average USD 165[11] per year. This external input is low when compared to the annual average expenditure of USD 1420 per household.

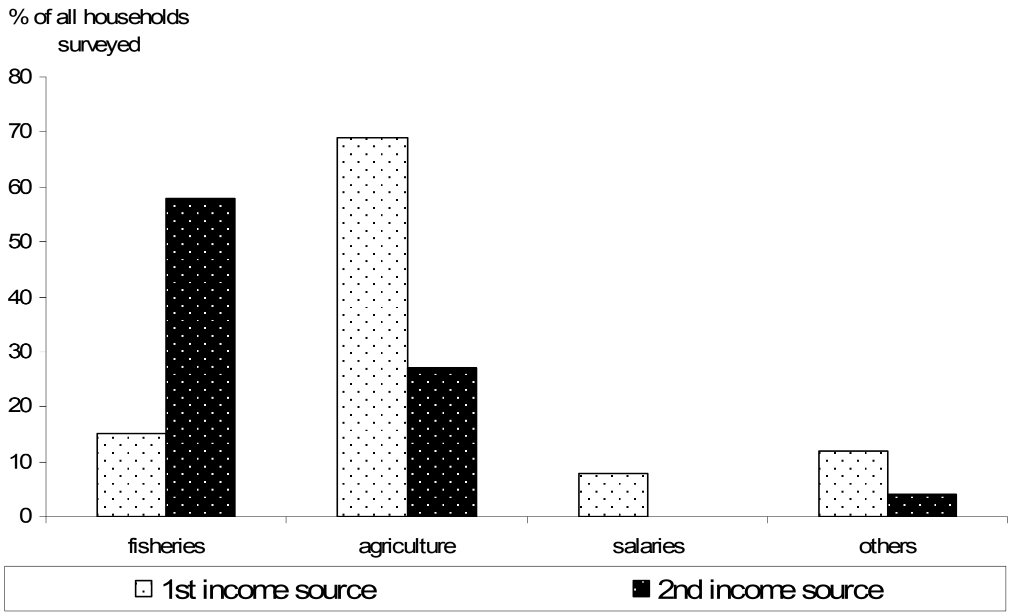

Figure 3.3: Ranked sources of income (%) in Moso.
Total number of households = 26 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly handicrafts and private businesses.

[11] The exchange rate was 0.00916 VT to 1 USD at the end of 2003.

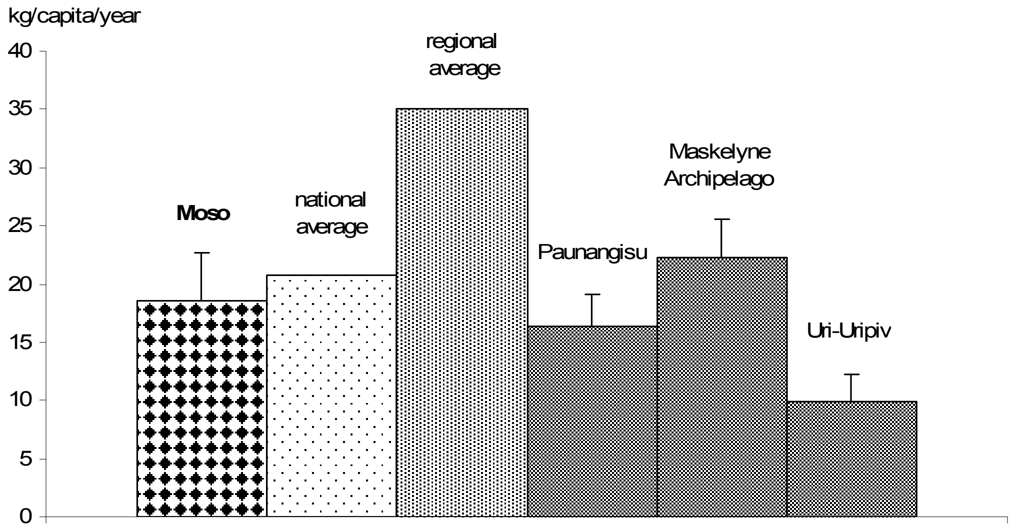

Figure 3.4: Per capita consumption (kg/year) of seafood in Moso (n = 26) compared to national and regional averages (FAO 2002) and other three PROCFish/C sites in Vanuatu.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

The average per capita consumption of fresh finfish (18.5 kg/year) is relatively low compared to the published national average of 20.8 kg and the published regional average of 35 kg for fresh fish (FAO 2002), but is second only to that in the Maskelyne Archipelago, which has the highest fresh fish consumption among the PROCFish/C sites in Vanuatu (Figure 3.4). Canned fish consumption per capita is very high and equal to consumption of fresh fish (18.5 kg/year); canned fish is consumed twice as often as fresh fish, with the frequency of invertebrate consumption very low.

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

Survey coverage	Moso (n = 26 HH)	Average across sites (n = 124 HH)
Demography		
HH involved in reef fisheries (%)	100	96
Number of fishers per HH	2.65 (±0.29)	2.68 (±0.15)
Male finfish fishers per HH (%)	23.2	21.1
Female finfish fishers per HH (%)	4.3	3.0
Male invertebrate fishers per HH (%)	0.0	1.2
Female invertebrate fishers per HH (%)	20.3	19.3
Male finfish and invertebrate fishers per HH (%)	36.2	32.2
Female finfish and invertebrate fishers per HH (%)	15.9	23.2
Income		
HH with fisheries as 1st income (%)	15	22
HH with fisheries as 2nd income (%)	58	39
HH with agriculture as 1st income (%)	69	58
HH with agriculture as 2nd income (%)	27	26
HH with salary as 1st income (%)	8	11
HH with salary as 2nd income (%)	0	3
HH with other source as 1st income (%)	12	11
HH with other source as 2nd income (%)	4	13
Expenditure (USD/year/HH)	1420 (±158.64)	864 (±72.93)
Remittance (USD/year/HH) (1)	165 (±49.05)	120 (±28.44)
Seafood consumption		
Quantity fresh fish consumed (kg/capita/year)	18.5 (±4.17)	16.8 (±1.60)
Frequency fresh fish consumed (time/week)	1.4 (±0.24)	1.90 (±0.14)
Quantity fresh invertebrate consumed (kg/capita/year)	n/a	n/a
Frequency fresh invertebrate consumed (time/week)	0.30 (±0.07)	1.15 (±0.11)
Quantity canned fish consumed (kg/capita/year)	18.49 (±4.18)	9.01 (±1.24)
Frequency canned fish consumed (time/week)	3.48 (±0.35)	2.12 (±0.20)
HH eat fresh fish (%)	100	100
HH eat invertebrates (%)	77	85
HH eat canned fish (%)	96	94
HH eat fresh fish they catch (%)	96	94
HH eat fresh fish they buy (%)	58	32
HH eat fresh fish they are given (%)	27	55
HH eat fresh invertebrates they catch (%)	73	90
HH eat fresh invertebrates they buy (%)	0	0
HH eat fresh invertebrates they are given (%)	4	7

HH = household; n/a = no information available; (1) average sum for households that receive remittances; numbers in brackets are standard error.

Comparison shows that Moso's community has a very low dependence on fisheries as its first income source, and receives little in the way of remittances (Table 3.1). The fact that Moso's fisheries are important as a second income source (the highest of all sites surveyed), and that Moso still has quite a high proportion of households with boats and fishers, may explain why the average amount of fresh fish caught by households is high. However, in comparison with other PROCFish/C sites in Vanuatu, the proportion of households that buy fresh fish at times is also high (58% in Moso versus 32% on average). The high proportion of households that buy fresh fish, combined with highest canned fish consumption, may explain why average household expenditure is the highest among PROCFish/C sites. The frequency with which

Moso's people consume canned fish is very high, while frequencies of fresh fish and invertebrate consumption are low and very low, respectively.

3.2.2 Fishing strategies and gear: Moso Island

Village inhabitants indicated that fishing was completely banned on the sheltered side of Moso Island every second year, indicating that the people were taking specific measures to manage their reef fisheries in a sustainable manner.

Degree of specialisation in fishing

Female's participation in fisheries is lower than that of males and engagement by females and males in the various fisheries differs significantly (Figure 3.5). Finfish fisheries in Moso are dominated by males, with females more focused on invertebrate harvesting. Males's involvement in invertebrate fisheries is considerable but they do not target invertebrates exclusively, i.e. 36% of all male fishers target both finfish and invertebrate fisheries. Only 16% of female fishers target both finfish and invertebrates.

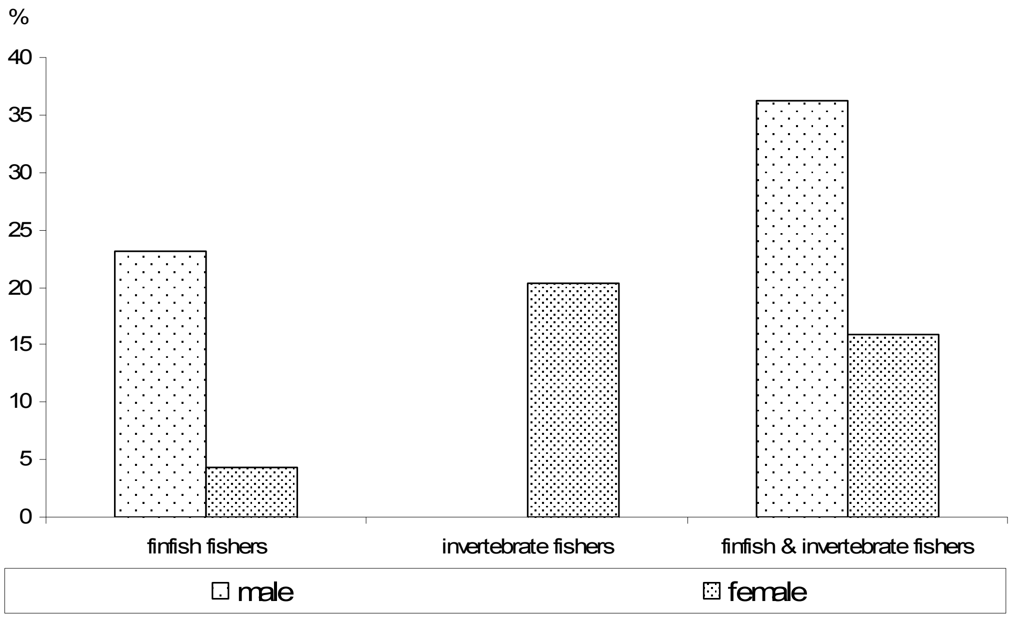

Figure 3.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Moso.
All fishers = 100%.

In Moso, community members were engaged in eight different invertebrate fisheries (Figure 3.6). Half of these were associated with gleaning, including soft benthos (seagrass), mangrove, intertidal (sand/beach) and reeftop gleaning. It was common for respondents to visit several of these habitats during a single fishing trip. The other four fisheries were practised by free diving, and targeted trochus (MOP), bêche-de-mer (BdM), lobster and 'other' (mainly octopus, squid and giant clams). Fishing trips that targeted trochus, BdM and lobster were usually exclusive (multiple resources were not typically targeted during a single fishing trip), but fishers did target octopus, squid and giant clams in combination with finfish spear diving.

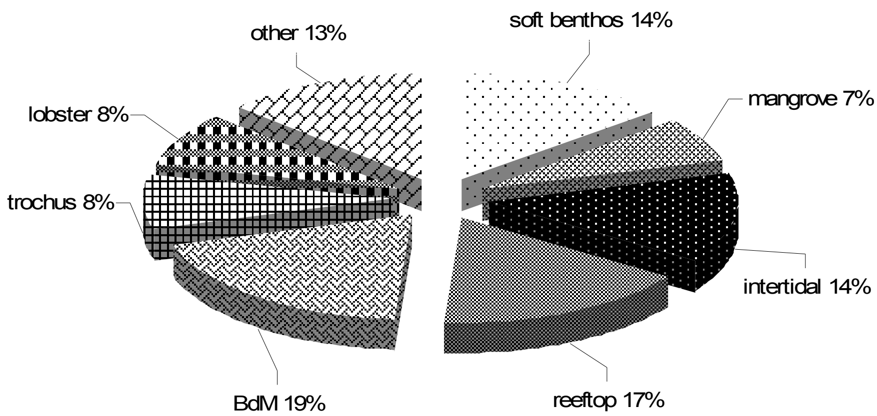

Figure 3.6: Proportion (%) of fishers targeting the eight primary invertebrate habitats found in Moso.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the octopus, squid and giant clam fishery.

Fishing strategies

In Moso most households own one or two dugout canoes. Only two private boats are fitted with outboard engines, and both are owned by a community member who works in Port Vila. In addition, the community owns a motorised boat (equipped with an outboard engine) that mainly serves to transport villagers between Efate and Moso Island.

Invertebrate fisheries are low-investment activities. All gleaning fishers (females and males) reported that they walk to the fishing grounds, except when fishing in mangroves, which are visited with dugout canoes on 50% of all trips. BdM, lobster, trochus and other 'free-diving' fisheries typically use non-motorised canoes (In the case of trochus fishing, 25% of all trips are done by motorised boat.). Simple techniques are used to dry BdM. According to the agent based at Port Vila, the resulting product quality is often unsatisfactory.

The duration of fishing trips varies considerably. The shortest trips target mangrove and free-diving fisheries for octopus, squid and giant clams (~2 hours/trip). Other gleaning activities and lobster diving usually take between 2.5 and 3.5 hours, and up to six hours if targeting the distant reef at the opposite coast of the island. BdM and trochus trips are long as they target specific specimens during a limited time only (>5 hours/trip).

Targeted stocks/habitats

Regarding gender participation (Figure 3.7, Table 3.2), female and male fishers are both engaged in invertebrate fisheries, but females engage mostly in gleaning and males almost exclusively in free-diving fisheries. BdM fishing is conducted in intensive sessions that last about two weeks each. During these periods the entire family sets up camp on the opposite shore of Moso Island from where the village is located. It is thus not surprising that females (and children) participate in BdM collection and processing.

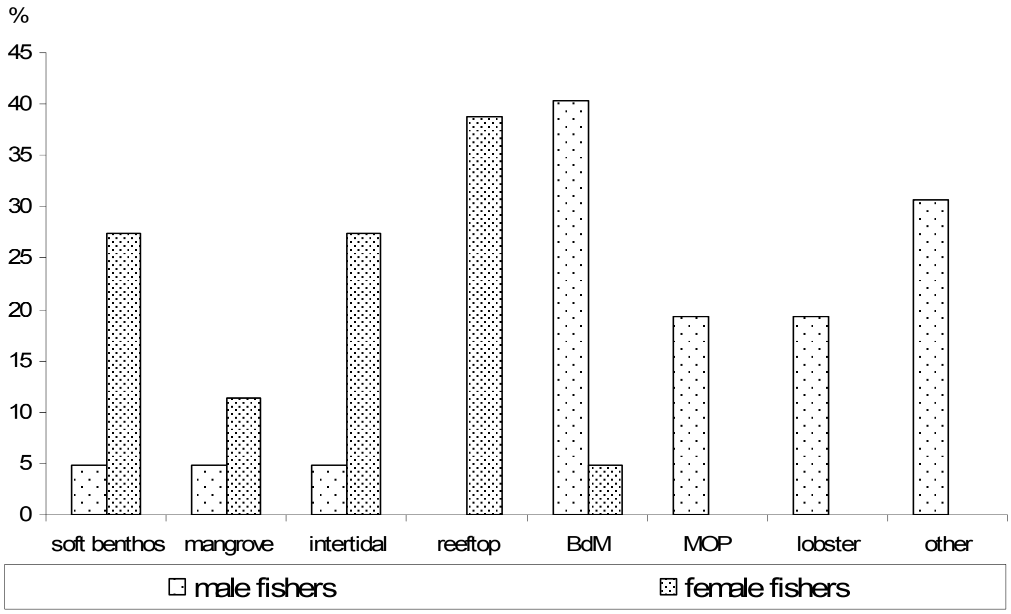

Figure 3.7: Proportion (%) of male and female fishers harvesting invertebrate stocks in Moso. Data based on individual fisher surveys; data for combined fisheries are disaggregated; figures refer to the proportion of all fishers involved in each fishery: n = 10 for males, n = 9 for females; 'other' refers to octopus, squid and giant clams.

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

Resource	Habitat	% male fishers interviewed	% female fishers interviewed
Finfish	Sheltered coastal reef	76	67
	Outer reef	76	67
Invertebrates	Mangrove	0	22
	Reeftop	0	67
	Soft benthos		
	Soft benthos, mangrove and intertidal [(1)]	10	11
	Soft benthos and intertidal [(1)]	0	44
	Soft benthos, intertidal and reeftop [(1)]	0	11
	Bêche-de-mer	80	11
	Mother-of-pearl (MOP)	40	0
	Lobster	40	0
	Other	60	0

[(1)] Combined in one fishing trip.
Finfish fisher interviews, males: n = 21; females: n = 3. Invertebrate fisher interviews, males: n = 10; females: n = 9.

Gear

A number of techniques are used in Moso's finfish fisheries (Figure 3.8). Most fishers use more than one technique, although not necessarily during a single trip. However, gillnet was the most frequently used technique in the sheltered coastal reef, and spear diving was the most frequently used in the outer reef.

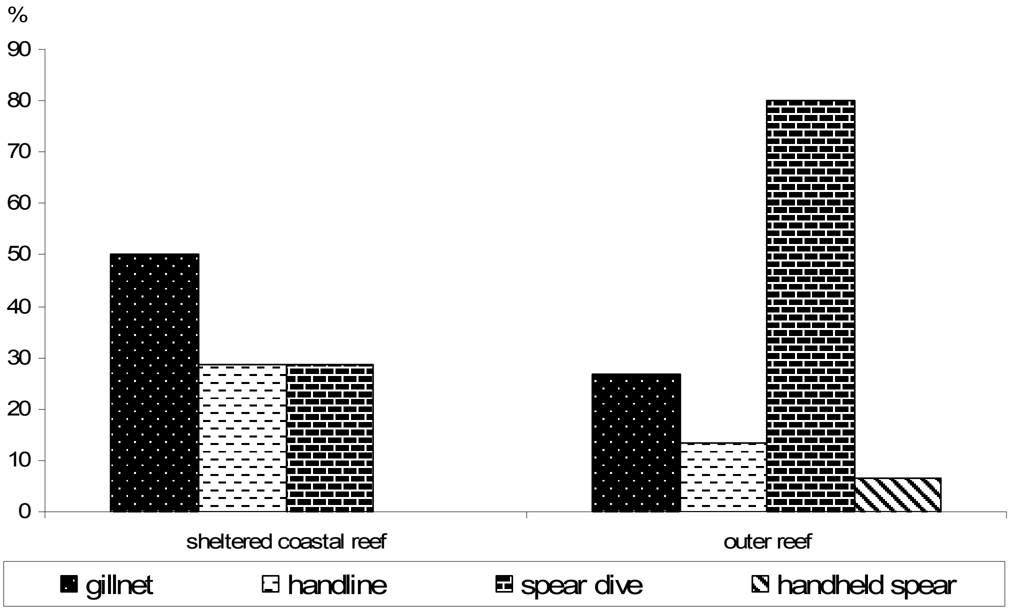

Figure 3.8: Fishing methods commonly used in different habitat types in Moso.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Fishing pressure

Information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip was used to estimate the fishing pressure imposed by the inhabitants of Moso on their fishing grounds.

Frequency and duration of fishing trips

Finfish fishers from Moso targeted either the sheltered coastal reef or the outer reef, and on average fished 1 and 1.2 times/week, respectively (Table 3.3).

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

Resource	Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	1.22 (±0.28)	1.18 (±0.33)	3.96 (±0.63)	4.75 (±2.25)
	Outer reef	1.19 (±0.17)	3.50	4.43 (±0.71)	3.50
Invertebrates	Mangrove	0	1.28 (±1.22)	0	1.75 (±0.25)
	Other (1)	0.56 (±0.16)		2.08 (±0.80)	
	Reeftop		0.95 (±0.25)		5.75 (±1.12)
	Soft benthos, mangrove and intertidal (2)	1.00	0	3.50	0
	Soft benthos and intertidal (2)	0	0.62 (±0.22)	0	3.38 (±0.88)
	Soft benthos, intertidal and reeftop (2)	0	1.00	0	2.50
	Mother-of-pearl	0.08 (±0.05)	0	6.50 (±0.50)	0
	Bêche-de-mer	4.40 (±0.60)	5.00	5.25 (±0.67)	6.00
	Lobster	0.10 (±0.05)	0	2.38 (±0.24)	0

Figures in brackets denote standard error; (1) refers primarily to octopus, squid and giant clams; (2) combined in one fishing trip.
Finfish fisher interviews, males: n = 21; females: n = 3. Invertebrate fisher interviews, males: n = 10; females: n = 9.

The duration of each trip was slightly longer if targeting the outer reef (4.4 hours/trip) as compared to the sheltered coastal reef (4.0 hours/trip). Pelagic fishing was reported to be marginal.

3.2.3 Catch composition and volume – finfish: Moso Island

The total annual recorded catch by survey respondents was 10.4 t (0.2 t for females and 10.2 t for males). If this figure is extrapolated by the total number of fishers in Moso, the total annual catch would equal 20.5 t. Assigning proportions of this estimated catch to each habitat in accordance with respondents' activity patterns reveals that most of the catch is taken from the outer reef (61.6%) and less from the sheltered coastal reef (38.4%) (Figure 3.9). Females' finfish fishing activities accounted for just 1.8% of the total annual catch, but females did target both habitats (Details on recorded annual catch by vernacular species and scientific family are given in Appendix 2.2.1.).

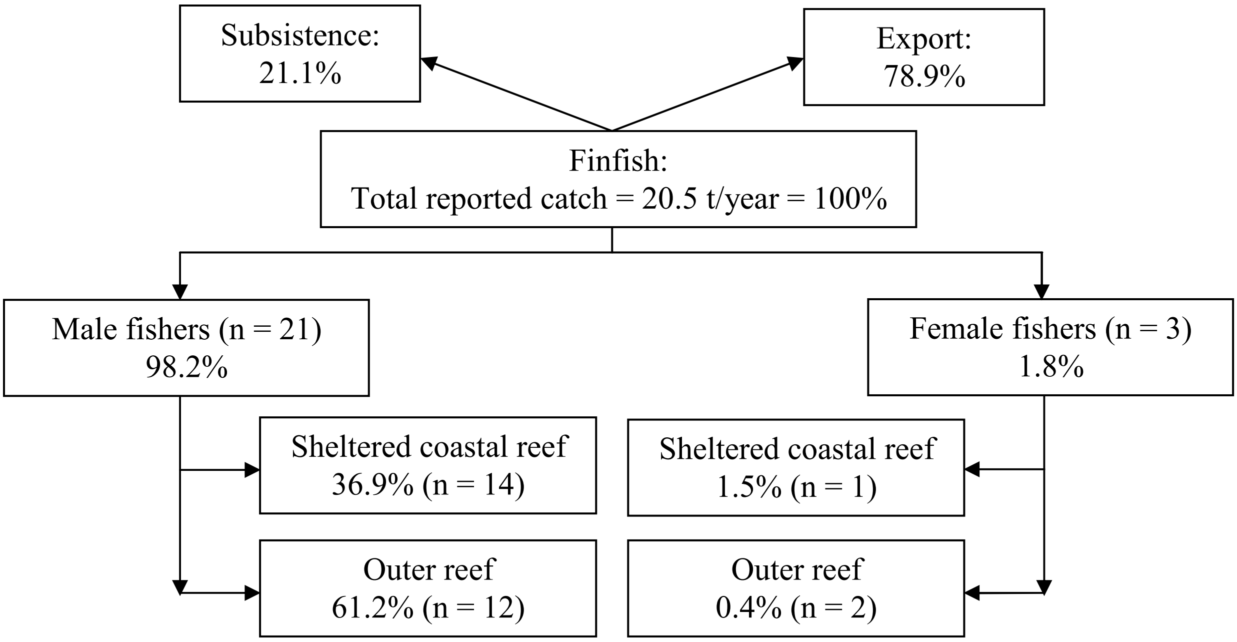

Figure 3.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Moso.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and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

In general terms finfish are caught to meet both subsistence needs and income generation, but the proportion of the catch used for commercial purposes far exceeds that used for subsistence in all habitats fished (Figure 3.10).

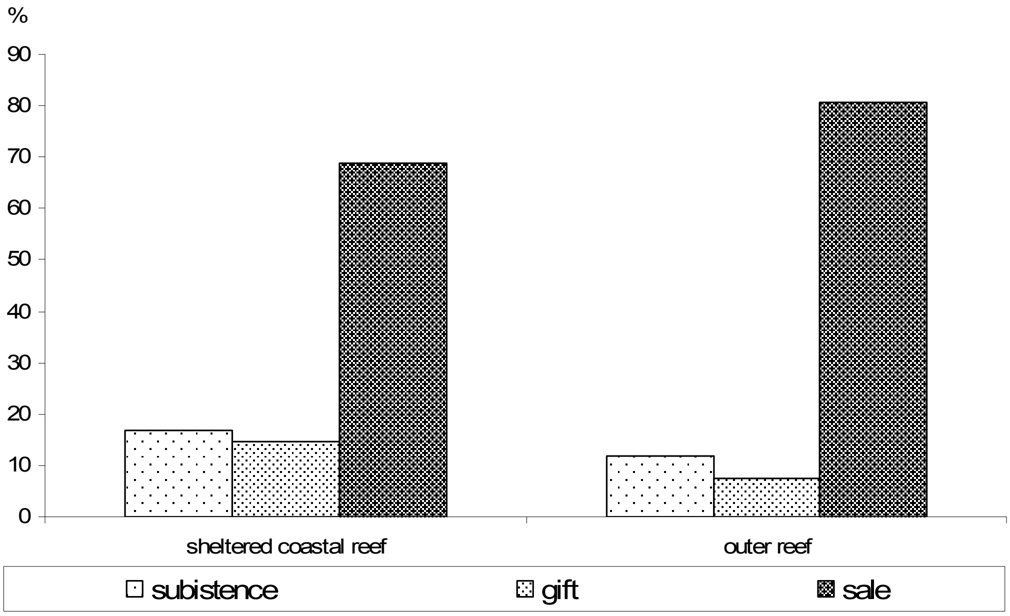

Figure 3.10: The use of finfish catches for subsistence, gift and sale, by habitat in Moso.
Proportions are expressed in % of the total number of trips per habitat.

The catch per unit effort (CPUE) for males was far higher than that for females. The highest CPUE was recorded for males's fishing at the outer reef, which was almost double the CPUE for males's sheltered coastal reef fishing (Figure 3.11).

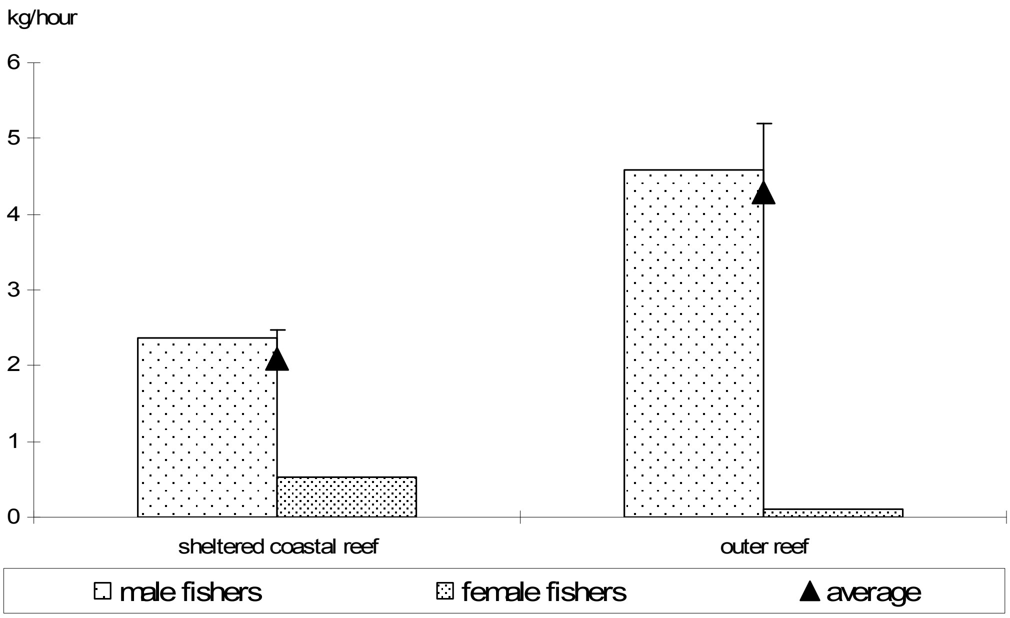

Figure 3.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Moso.
Effort includes time spent transporting, fishing and landing catch.

The reported catch compositions in each habitat show a great number of equally important families for the sheltered coastal reef, including Gerreidae, Siganidae, Lethrinidae, Mullidae and Carangidae. Catches for the outer reef are dominated by species from two prominent families: Scaridae and Acanthuridae (Detailed information on the distribution of fish families of reported catches in percentage of total weight per habitat fished is provided in Appendix 2.2.1.).

Comparison of the average size per family in the different habitats (Figure 3.12) indicates that, in general, larger fish are caught at the outer reef. This is particularly true for Scaridae, Mullidae and Acanthuridae. However, the opposite occurs for Serranidae, Balistidae and Holocentridae, with the average size of fish caught from the sheltered coastal reef larger than those caught on the outer reef.

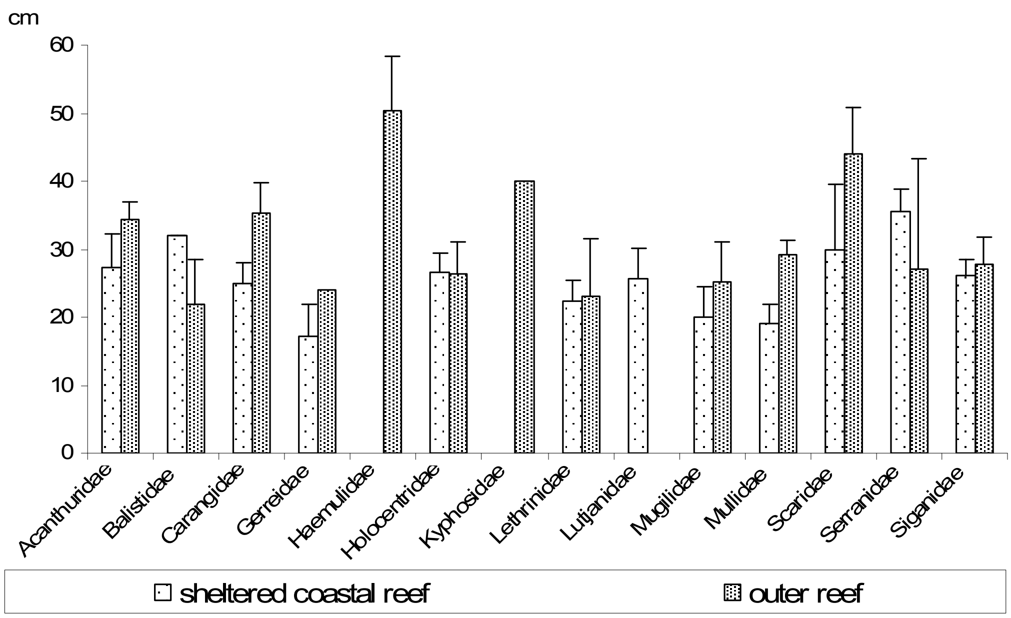

Figure 3.12: Average sizes (cm fork length) of fish caught by family and habitat in Moso.
Bars represent standard error (+SE).

Several parameters used to characterise the current level of fishing pressure in Moso's fishing grounds are presented in Table 3.4.

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

Parameters	Habitat			
	Sheltered coastal reef	Outer reef	Total reef	Total fishing ground [(1)]
Fishing ground area (km^2)	1.79	2.65	4.44	22.70
Density of fishers (number of fishers/km^2 fishing ground) [(2)]	19	13	15	3
Population density (people/km^2) [(4)]			42	8
Average annual finfish catch (kg/fisher/year) [(3)]	284 (±96.9)	425 (±111.2)		
Total fishing pressure of subsistence catches (t/km^2)			1.0	0.2

Figures in brackets denote standard error; [(1)] includes lagoon area of 18.26 km^2; [(2)] total number of fishers is extrapolated from household surveys; [(3)] catch figures are based on recorded data from survey respondents only; [(4)] total population = 187, total subsistence demand = 3.06 t/year.

3.2.4 Catch composition and volume – invertebrates: Moso Island

Data indicate that all gleaning activities are primarily subsistence oriented, regardless of whether they are engaged in as sole activities or in combination with other activities during one fishing trip. Income generation plays only a minor role, specifically in the case of reeftop and combined soft-benthos and intertidal gleaning. In contrast, free-diving fisheries are almost exclusively commercially oriented, with the sole exception being 'other' free diving (primarily for octopus, squid and giant clams), which serves both subsistence and commercial purposes. While mangrove, soft-benthos and intertidal fisheries areas are close to the village, reeftop gleaning is primarily done on the side of Moso Island opposite to where the village is located, and consequently requires several hours of travel time.

None of the invertebrate fisheries in Moso are practised throughout the year. The shortest periods were reported for BdM (a total of about two months annually), with fishers engaging in reeftop, mangrove, intertidal and soft-benthos fisheries for 4–8 months per year. The longest periods were reported for lobster diving and the combined soft-benthos, intertidal and reeftop gleaning fishery (10–12 months). Most fishing trips are made during the day, with gleaning activities and trochus harvesting done in daylight. Two-thirds of all lobster diving occurs at night, and some diurnal–nocturnal activities target BdM, octopus and squid (~50%).

The number of species (as represented by the number of vernacular names) reported to be regularly caught from various habitats is indicative of the importance of these habitats and the fisheries they support. The BdM fishery and the combined soft-benthos, intertidal and reeftop gleaning fishery are much more diverse in vernacular names than other combined gleaning fisheries (Figure 3.13). Based on vernacular names, lobster, mangrove and MOP (trochus) fisheries are each represented by single species groups.

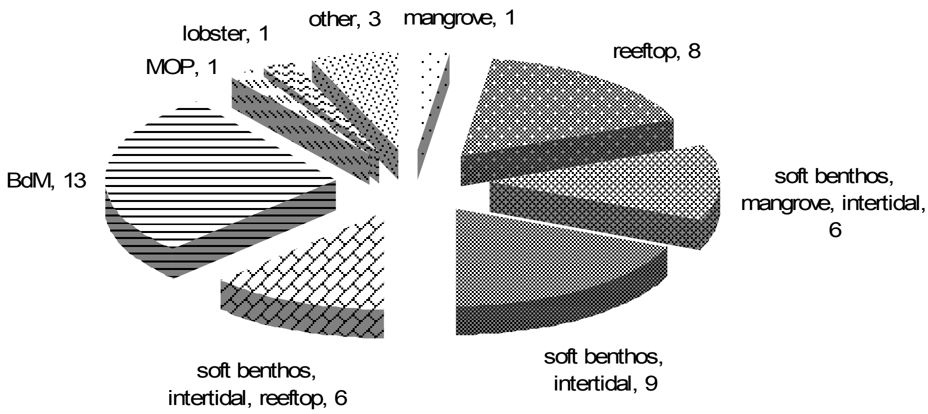

Figure 3.13: Number of vernacular names recorded for each invertebrate fishery in Moso.

The total annual catch from fishers interviewed was estimated to total 18.3 t (3.4 t for females and 14.9 t for males). Extrapolation of the average annual recorded catch per fisher to the estimated total number of invertebrate fishers in Moso suggests that approximately 57.8 t of biomass (wet weight) is removed annually.

Figure 3.14 shows that the lion's share removed annually from Moso's fishing grounds is accounted for by males (81%), with BdM harvesting accounting for 75% of the total annual catch. All other impacts are low by comparison. Quantities harvested by diving for octopus, giant clams and squid are low, and amounts of MOP, lobster and mangrove resources harvested are marginal.

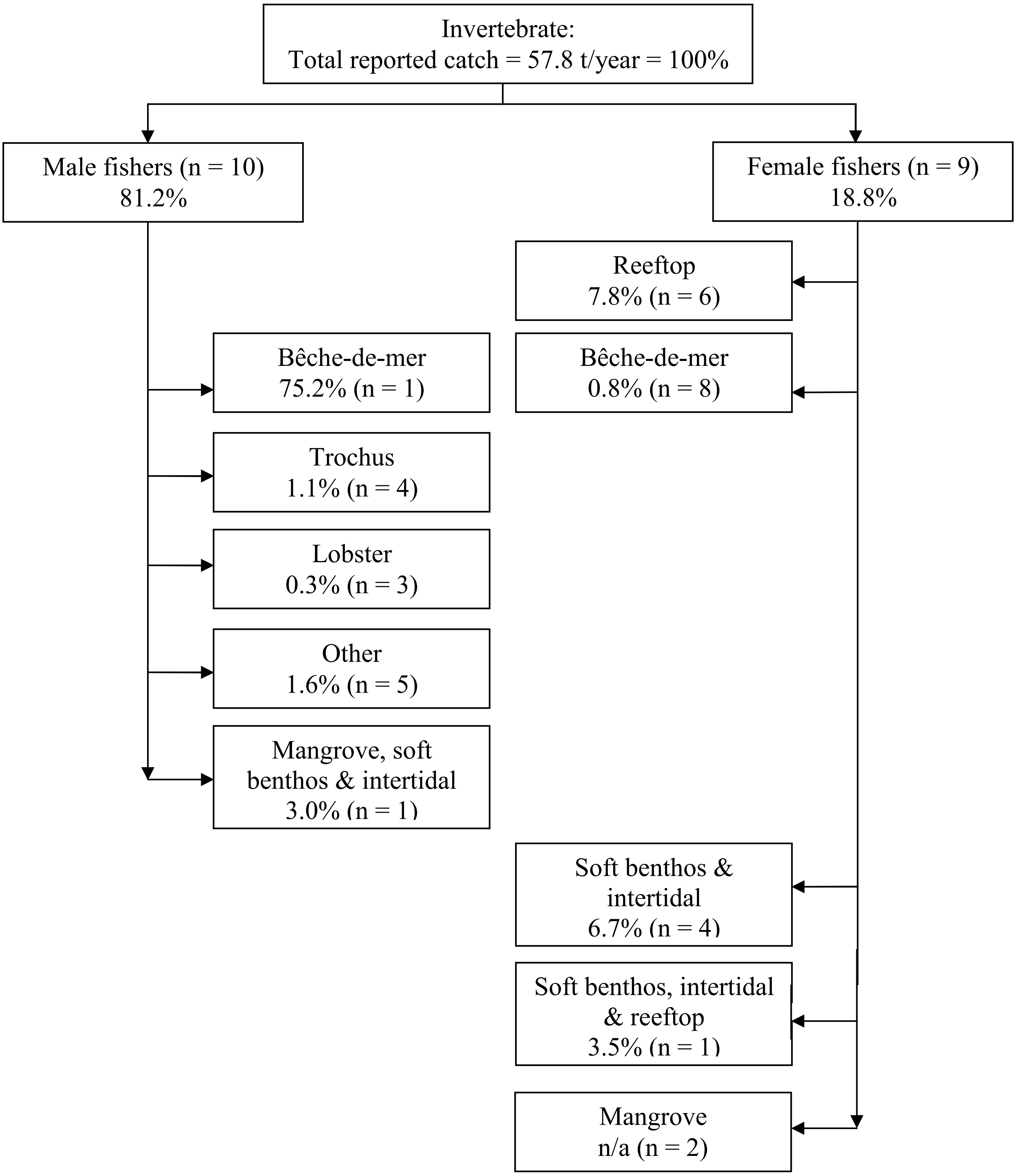

Figure 3.14: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Moso.
n is the total number of interviews conducted per each fishery; n/a = no information available; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey only. 'Other' refers primarly to octopus, squid and giant clams. The 75.2% figure for bêche-de-mer is reported by fishers but only applies when the BdM fishery is open.

Calculation of the total annual harvest per species group, regardless of fishery, indicates that the highest annual catches (in terms of kg wet weight removed) are from the sea cucumber fishery, with *Thelenota ananas* and *T. anax*, *Actinogypa mauritiana* and *Holothuria atra* or

H. coluber the most dominant species groups (Figure 3.15). *Tridacna* spp. and *Anadara* spp. catches are far lower, but still significant.

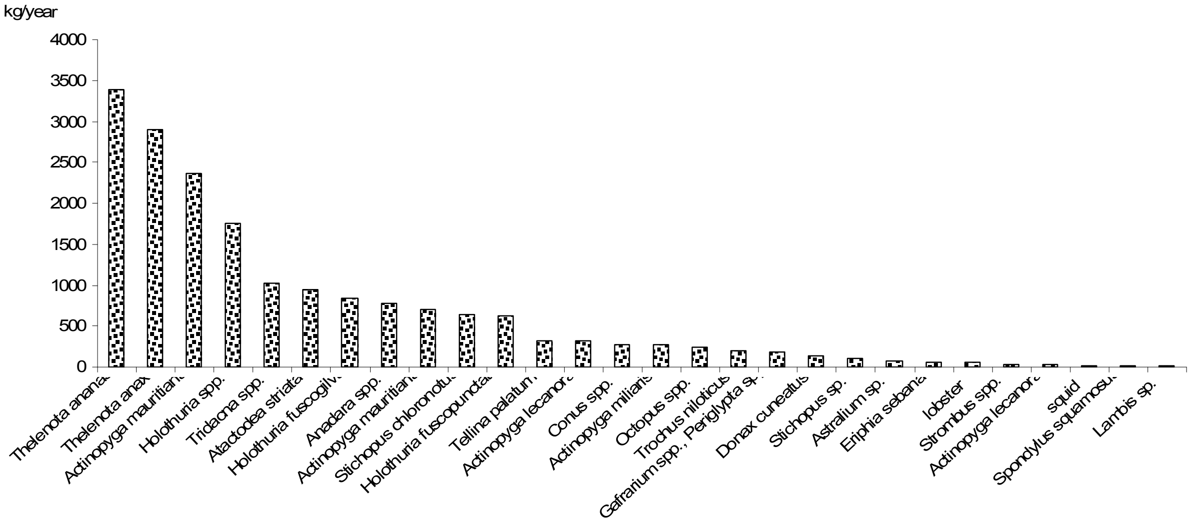

Figure 3.15: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Moso.

Details on species distribution by habitat, and on size distribution by species, are provided in Appendices 2.2.2 and 2.2.3, respectively.

Fishers interviewed indicated that invertebrates are harvested primarily for sale, which is confirmed by data on the total annual biomass used for sale, for consumption, and for both purposes. The total amount used exclusively for sale represents two-thirds of all catches (Figure 3.16), with only ~14% collected exclusively for subsistence purposes. The remainder may or may not be sold. In short, invertebrate fishing in Moso is a commercial activity.

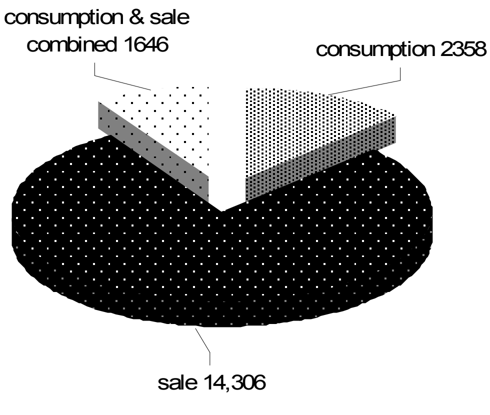

Figure 3.16: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Moso.

A number of species are used exclusively for consumption (in particular, *Conus* spp. and *Atactodea* spp.). Sea cucumbers and lobsters are harvested exclusively for sale. *Tridacna* spp. and *Anadara* spp. in particular serve both consumption and (if needed) income generation (More details on the role that species play for consumption, sale or both purposes are provided in Appendix 2.2.4.).

As indicated earlier, both sexes participate in invertebrate fisheries but to a different extent. Comparison of the total biomass (wet weight kg/fisher) removed annually from various habitats by males and females shows that females are more productive than males in reeftop and soft-benthos fisheries. Males dominate intertidal and free-diving fisheries, most of which females do not participate in (Figure 3.17).

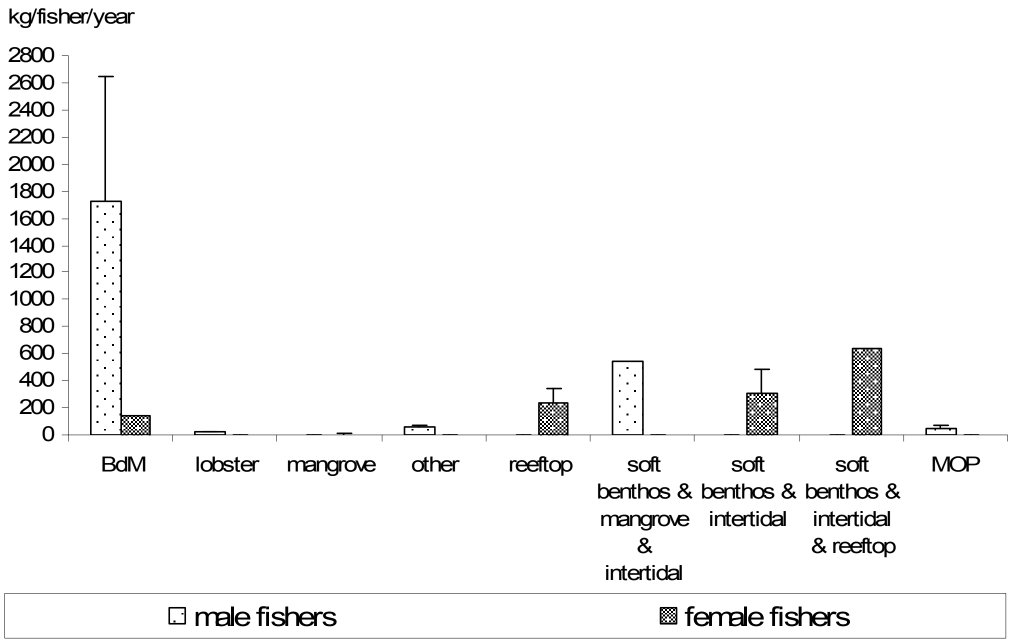

Figure 3.17: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Moso.
BdM = bêche-de-mer, MOP = mother-of-pearl.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 10 for males, n = 9 for females). Bars represent standard error (+SE).

The highest fisher density but the lowest average annual catch (in terms of wet weight) per fisher occurs in mangrove habitats (Table 3.5). The highest average catch (exceeding all others combined) is recorded for the BdM fishery.

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

Parameters	Mangrove	Reeftop	Soft benthos and intertidal	Intertidal and others	MOP	BdM	Lobster	Other (3)
Fishing ground area (km^2)	0.05	4.7	0.3	13.3	8.5	7.4	8.5	8.5
Number of fishers (per fishery) (1)	7	21	14	3	12	28	12	19
Density of fishers (number of fishers/km^2 fishing ground)	137	4	0.2	46	1	4	1	2
Average annual invertebrate catch (kg/fisher/year) (2)	3.45 (±2.82)	236.9 (±108.5)	307.1 (±181.7)	545.0 (n/a)	51.2 (±22.6)	1547.9 (±835.7)	18.3 (±10.8)	57.2 (±17.5)

Figures in brackets denote standard error; n/a = standard error not calculated; MOP = mother-of-pearl; BdM = bêche-de-mer; (1) number of fishers extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; (3) linear measure km reef length.

3.2.5 Discussion and conclusions: socioeconomics in Moso Island

- The fact that agriculture plays a dominant role in the livelihood of Moso's people is illustrated by the fact that they stop fishing during the most important agricultural season (i.e. April–October or May–September). While per capita consumption of fresh fish is moderately high, compared to other sites investigated in Vanuatu consumption frequency is low. Moso has a surprisingly high per capita consumption of canned fish, however.

- The fact that most households are primarily engaged in agriculture explains some of these observations and the finfish fishing patterns. Most agricultural land is located on Efate Island (the 'mainland'), and people need boat transport and travel time to tend their gardens. As a result, opportunities to go fishing are limited and canned fish may be a quick and easy substitute.

- As shown by total annual catch figures, the highest proportion of the catch is sold. Some sales are performed in the village, but most take place at Port Vila's municipal market. Figures clearly show that men's fishing productivity (CPUE) at the outer reef is almost double that at the sheltered coastal reef. However, the travel time required to reach the outer reef (on the opposite coast of Moso Island) and the need to purchase ice at Port Vila and to transport the catch to and from the urban market makes the marketing of outer-reef fishery products difficult. It is therefore not surprising that most fishers diversify, targeting invertebrates as well as finfish, and mainly for sale. In Moso the BdM fishery is the only commercial invertebrate fishery. It is generally performed in two sessions per year, each lasting about two weeks, with most households participating. Income generated from BdM fishing is comparatively high and fishing can be undertaken despite the limited time villagers have for fishing due to their agricultural activities.

- In comparison with the BdM fishery, the finfish fishery is less lucrative (due to higher costs for transport, inputs and marketing, and the time required) but offers villagers an option to continuously complement their other income sources.

- From a gender perspective, the data suggest that males are responsible for commercial fisheries while females contribute to subsistence needs. Thus, females focus on fringing-reef and lagoon fishing rather than outer-reef fishing, and use handlines more frequently than gillnets. Spear diving and the use of hand-held spears is performed exclusively by males.

- Spear diving, which is generally considered to be less productive than gillnetting, is mainly employed at the outer reef, underpinning the latter's high productivity. The dominance of spear diving also shows in the high proportion of Scaridae in outer-reef catches (46%) and the large average sizes caught (>40 cm).

- The use of gillnets and the comparatively low productivity recorded for sheltered coastal reef fishing may suggest less favourable conditions. This is also supported by the overall smaller average fish sizes caught. Nevertheless, these conclusions have to take into account that the smallest average fish sizes caught are considerable, i.e. 16 cm. The generally favourable conditions may explain why community management rules that aim at temporary closure of certain areas do not target finfish fisheries. The lagoon area between Moso and Efate is closed for the BdM, giant clam and trochus fisheries, while the outer reef has not been closed for any activity since 1994/1995. It should also be noted that Moso's outer reef is frequently the target of poaching by fishers from Lelepa. These illegal but uncontrollable visits usually involve a total of 16 fishers distributed among four motorised boats. The fishers' identities are known but discussions to end the illegal activities have thus far been unsuccessful.

- The finfish fishery plays an important role in complementing villagers' incomes and also contributes to subsistence needs. The relatively small size of the community and its significant dependence on agriculture for income limit the total number of fishers and hence fisher density. Illegal intrusions by fishers from Lelepa, who target the community's outer-reef area, add to the community's fishing pressure. Income opportunities from finfish fisheries alone are limited due to the distance to the most productive fishing grounds (the outer reef) and the distance, time and costs involved in marketing finfish at Port Vila's municipal market.

- Fishing pressure is low, as suggested by the low fisher density and low catch per fishing ground area. The moderate to high catch per km^2 at the outer reef is not alarming if the high productivity and the high total annual catch per fisher are taken into account. Catch data are also very favourable in terms of average fish sizes (≥16 cm). The average size of fish caught at the outer reef exceeds that of fish taken from sheltered coastal reef areas. This may be a consequence of more favourable conditions at the outer reef and the fact that spear diving is the most prominent technique employed, as compared to gillnetting, which is mainly used in the sheltered coastal reef.

- Comparison of fishing pressure (expressed as total biomass removed annually per available fishery area) reveals no alarming patterns, except in the case of the BdM fishery. The typical size and value of BdM specimens that are caught suggests that certain species may already be showing a reaction to fishing pressure. Catches of species such as *Thelenota ananas* and *Actinopyga mauritiana*, high grade 2 and high grade 3 respectively, are mostly represented by smaller lengths. This is also true for low-grade species, such as *Holothuria atra* and *H. coluber*. Although the data do not indicate a high level of fishing pressure on any of Moso's gleaning fisheries, catch sizes of *Tridacna* spp. are mainly small.

- Several factors suggest that further potential for finfish fisheries development is limited, including:
  - the dependency by Moso's inhabitants on finfish fisheries for consumption, and as their second most important income source;
  - the relatively more lucrative (but temporary) income possibilities provided by invertebrate fisheries, in particular BdM; and
  - the difficulty of marketing finfish at Port Vila, which involves considerable effort in terms of fishing time, transport and input cost.

- This conclusion is determined primarily by socioeconomic factors rather than resource data, as the latter are quite favourable. Finfish fishing is mainly a moderate-investment operation (involving spear diving and gillnetting, predominantly making use of non-motorised boat transport, but requiring the purchase of ice from Port Vila). Any future development would require that production and transport costs be lowered if commercial finfish fisheries at Moso were to become competitive with those in villages on Efate, which have easier and less costly access to urban markets.

- Gleaning fisheries play a complementary role in Moso (The frequency of invertebrate consumption is lowest across all four PROCFish/C sites in Vanuatu.). Gleaning targets mainly *Atactodea striata*, an intertidal species, and reeftop *Tridacna* spp. *Atactodea* catches are complemented by *Anadara* harvesting. Both soft-benthos and intertidal fisheries are easy to access and adjacent to the village. However, reeftop gleaning requires several hours of travel to the opposite shore of the island, which may help to explain why invertebrates are consumed relatively infrequently.

- The fact that the community of Moso is not able to enforce rules governing access to its fishing grounds and suffers from frequent illegal intrusions at the distant outer reef by fishers from Lelepa highlights the need for support from governmental fisheries authorities. The very limited access that Moso's people have to motorised boat transport, which means they cannot patrol the outer-reef areas, does not justify access by fishers from other villages.

3.3 Finfish resource surveys: Moso Island

Finfish resources and associated habitats were assessed between 24 and 30 July 2003 from a total of 24 transects (12 sheltered coastal reef transects and 12 outer-reef transects. See Figure 3.18 for transect locations and Appendix 3.2.1 for transect coordinates.).

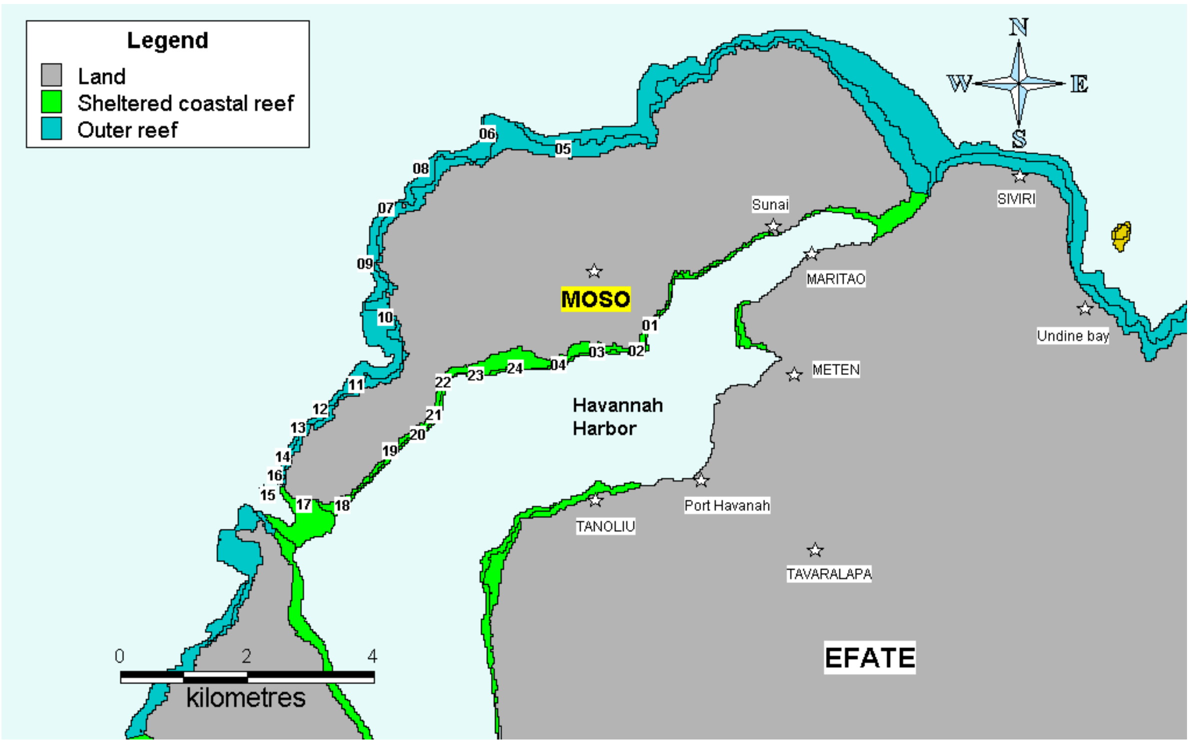

Figure 3.18: Habitat types and transect locations for finfish assessment in Moso.

3.3.1 Finfish assessment results: Moso Island

A total of 19 families, 50 genera, 158 species and 9792 fish were recorded in the 24 transects (See 3.2.2 for list of species.). The data presented below cover only the 14 most dominant families (See Appendix 1.2 for methods used for species selection.), representing 41 genera, 146 species and 7105 individuals.

The finfish resources were similar between the two types of reefs present in Moso (Figure 3.18, Table 3.6), with slightly higher biodiversity in the sheltered coastal reef (45 versus 40 species per transect) and higher biomass in the outer reef (126 versus 76 g per m^2). The similarities in density and size but slight difference in biomass suggest a structural difference in the fish assemblage between the two types of reef (different species with a different size structure).

Table 3.6: Primary finfish habitat and resource parameters recorded in Moso (average values ±SE; range for depth)

Parameters	Habitat		
	Sheltered coastal reef (1)	Outer reef (1)	All reefs (2)
Number of transects	12	12	24
Total habitat area (km^2)	2.15	2.49	4.63
Depth (m)	3 (1-8) (3)	4 (1-7) (3)	4 (1-8) (3)
Soft bottom (% cover)	14 ±3	9 ±3	11
Rubble & boulders (% cover)	36 ±3	12 ±2	22
Hard bottom (% cover)	26 ±3	69 ±4	51
Live coral (% cover)	23 ±4	8 ±1	14
Soft coral (% cover)	1 ±0	3 ±1	2
Biodiversity (species/transect)	45 ±2	40 ±4	42 ±2
Density (fish/m^2)	0.42 ±0.03	0.47 ±0.06	0.45
Biomass (g/m^2)	76 ±15	126 ±29	106
Size (cm FL) (4)	18.1 ±0.5	19.9 ±0.6	19.2
Size ratio (%)	61 ±2	64 ±2	63

(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: Moso Island

The sheltered coastal reef of Moso was dominated by herbivorous Scaridae, Acanthuridae and Siganidae (in terms of both density and biomass) and carnivorous Chaetodontidae (density only) (Figure 3.19). These four families were represented by 67 species, with particular high abundance and biomass of *Chlorurus bleekeri*, *Siganus lineatus*, *Scarus rivulatus*, *Acanthurus lineatus*, *Ctenochaetus striatus*, *Chlorurus sordidus*, *Scarus psittacus*, *Scarus dimidiatus* and *Chaetodon lunulatus* (Table 3.7). This habitat was well diversified (Table 3.6, Figure 3.19), which may explain the relative complexity of the fish assemblage. The relatively good live coral cover (23% on average) was echoed by noticeable densities of butterflyfish (Chaetodontidae).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Chlorurus bleekeri*	Bleeker's parrotfish	0.03	9.7
	Chlorurus sordidus	Bullethead parrotfish	0.02	3.0
	Scarus dimidiatus	Yellowbarred parrotfish	0.01	1.8
	Scarus psittacus	Palenose parrotfish	0.02	2.4
	Scarus rivulatus	Surf parrotfish	0.01	4.5
Acanthuridae	*Acanthurus lineatus*	Striped surgeonfish	0.01	4.0
	Ctenochaetus striatus	Lined bristletooth	0.03	3.1
Siganidae	*Siganus lineatus*	Goldlined rabbitfish	0.02	7.0
Chaetodontidae	*Chaetodon lunulatus*	Redfin butterflyfish	0.02	1.0

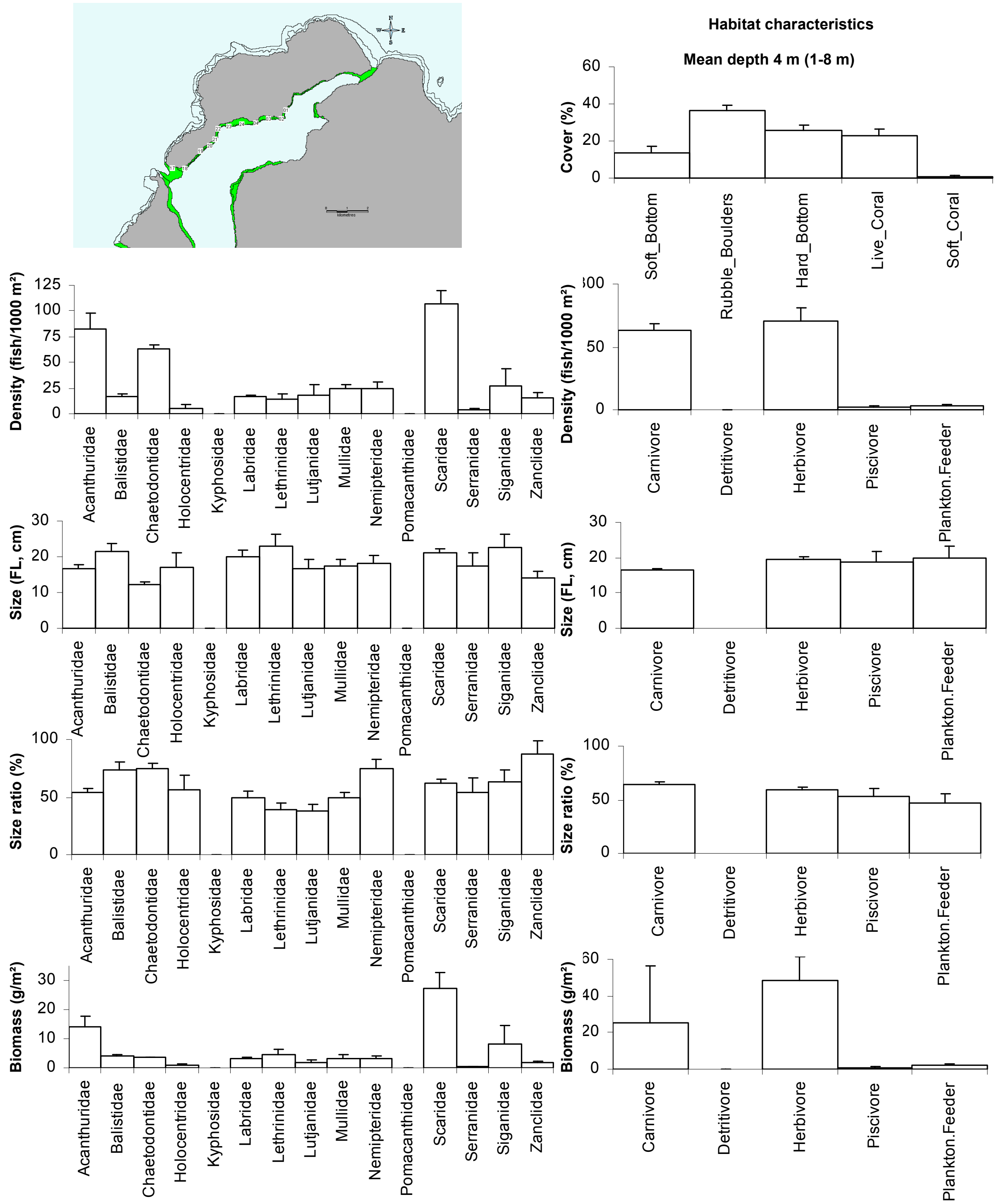

Figure 3.19: Profile of finfish resources in the sheltered coastal reef environment of Moso.
Bars represent standard error (+SE); FL = fork length.

Biomass was slightly reduced in Moso's sheltered coastal reef compared to the other PROCFish/C study sites in Vanuatu, except for Paunangisu, with fewer but similar-sized fish. Both biodiversity and habitat were similar to general trends, but with more rubble and slightly less soft and hard bottom in Moso compared to the other sites (Table 3.6). Sandy areas are generally rich in small invertebrates, the main food item of carnivorous fish. Hence, the slightly lower proportion of soft bottom in Moso's sheltered coastal reef habitat may partly explain why the number of carnivorous fish (particularly Lutjanidae) in Moso was so much smaller than the average across study sites (Figure 3.19). However, Lutjanidae and other carnivorous fish are also associated with rubble, a substrate well represented in Moso. This suggests that rather than being due to natural, habitat-related causes, reduced numbers of carnivorous fish in general (and Lutjanidae in particular) in Moso's sheltered coastal reef may be caused by fishing or other human activities.

Outer-reef environment: Moso Island

Moso's outer reef was largely dominated by herbivorous Acanthuridae and, to a lesser extent, herbivorous Scaridae (Figure 3.20). These two families were represented by 39 species, with particularly high abundance and biomass of *Acanthurus lineatus*, *A. blochii*, *Ctenochaetus striatus*, *Chlorurus sordidus*, *Scarus altipinnis*, *S. niger*, *S. rivulatus* and *S. psittacus* (Table 3.8). The habitat was essentially characterised by hard bottom (69% cover, primarily mineral slab), which, in combination with the direct oceanic influence found in outer reefs, may explain the dominance of large groups of medium-sized herbivorous fish, such as *A. blochii*, which are well adapted to uniform, low-complexity habitat dominated by mineral slab.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus lineatus*	Striped surgeonfish	0.04	23.5
	Acanthurus blochii	Ringtail surgeonfish	0.03	22.3
	Ctenochaetus striatus	Lined bristletooth	0.16	22.1
Scaridae	*Chlorurus sordidus*	Bullethead parrotfish	0.02	7.0
	Scarus altipinnis	Minifin parrotfish	0.02	4.1
	Scarus niger	Swarthy parrotfish	0.01	4.0
	Scarus rivulatus	Surf parrotfish	0.01	3.4
	Scarus psittacus	Palenose parrotfish	0.01	2.6

The finfish resources in Moso's outer reef had fewer species and fish (though those present were of similar size) than the other study sites in Vanuatu; biomass was the lowest among the sites (Table 3.6). Most of the difference in biomass was due to the Scaridae family (Figure 3.20). Although Acanthuridae had similar densities and biomass in Moso compared to the other sites, Scaridae were much less abundant, especially compared to the Maskelyne Archipelago. The low abundance of Scaridae is unlikely to reflect differences in substrate composition, as the habitat in Moso was very similar to that of the other study sites, with marked dominance of hard bottom, a substrate well suited to herbivorous fish. It is possible, however, that the Scaridae population may have been impacted by human activities in Moso relative to the other sites. Carnivorous Lutjanidae were also much less abundant (in terms of density and biomass) in Moso compared to the remaining sites, possibly for similar reasons.

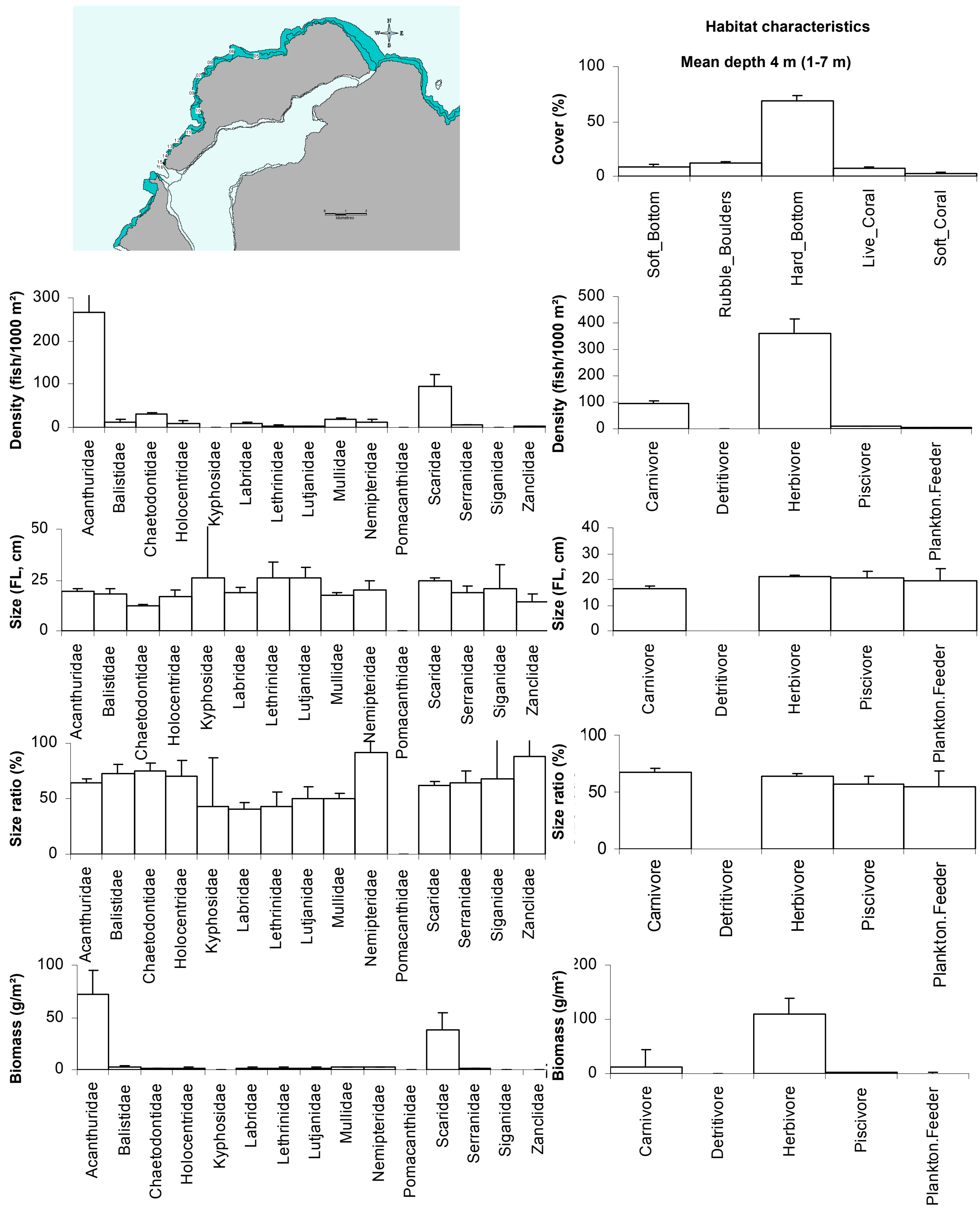

Figure 3.20: Profile of finfish resources in the outer-reef environment of Moso.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Moso Island

Overall, the fish assemblage of Moso comprised two main families, Acanthuridae and Scaridae, with Chaetodontidae ranking third in density (Figure 3.21). These three families were represented by a total of 72 species, dominated in terms of density and biomass by *Acanthurus lineatus*, *Ctenochaetus striatus*, *A. blochii*, *Chlorurus sordidus*, *C. bleekeri*, *Scarus rivulatus*, *S. niger*, *S. altipinnis*, *S. psittacus* and *Chaetodon lunulatus* (Table 3.9). As expected, the overall fish assemblage in Moso was intermediate between that recorded in the sheltered coastal reef (46% of habitat) and outer reef (54% of habitat).

Table 3.9: Finsfish species contributing most to main families in terms of densities and biomass across all reefs of Moso (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus lineatus*	Striped surgeonfish	0.03	15.6
	Ctenochaetus striatus	Lined bristletooth	0.12	14.4
	Acanthurus blochii	Ringtail surgeonfish	0.02	13.5
Scaridae	*Chlorurus sordidus*	Bullethead parrotfish	0.02	5.4
	Chlorurus bleekeri	Bleeker's parrotfish	0.01	4.6
	Scarus rivulatus	Surf parrotfish	0.01	3.9
	Scarus niger	Swarthy parrotfish	0.01	3.2
	Scarus altipinnis	Minifin parrotfish	0.01	2.8
	Scarus psittacus	Palenose parrotfish	0.02	2.5
Chaetodontidae	*Chaetodon lunulatus*	Redfin butterflyfish	0.01	0.5

When finfish resource status is considered at habitat level, taking into account habitat quality (with relatively equal areas of medium-rich sheltered coastal and rich outer-reef environments), Moso would appear to support a slightly poorer resource than the rest of study sites in Vanuatu, except for Paunangisu. Density was lower, as was biomass, but biodiversity was similar, as was size (Table 3.6). Detailed assessment at reef level suggests that this trend was not only linked to the naturally medium-rich habitat but possibly also to greater impact from fishing compared to the other study sites in Vanuatu; this is particularly the case for carnivorous fish (mostly Lutjanidae) in the sheltered coastal reef and Scaridae (and Lutjanidae to a lesser extent) in the outer reef.

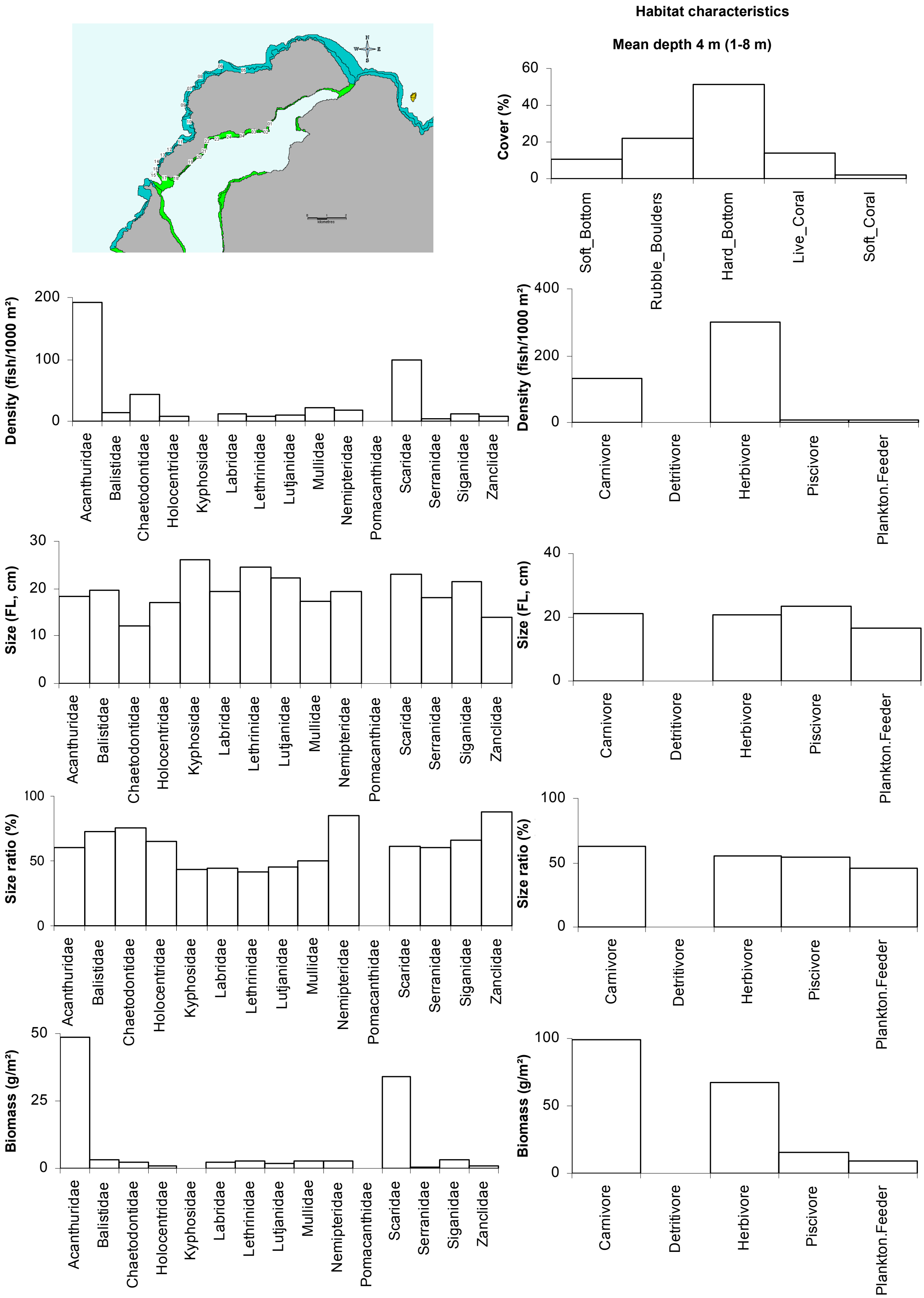

Figure 3.21: Profile of finfish resources in the combined reef habitats of Moso (weighted average).
FL = fork length.

3.3.2 Discussion and conclusions: finfish resources in Moso

- The finfish resource assessment indicated that Moso had a similar or slightly poorer resource than those surveyed at the other study sites in Vanuatu, except for Paunangisu. Preliminary results suggest that the differences may be a consequence of both a naturally medium-rich habitat with equal expanse of medium-rich sheltered coastal and rich outer reefs, and fishing activities, which may have a greater-than-average impact on Moso's finfish assemblage. This was particularly suspected for the outer reef population of Scaridae (and Lutjanidae to a lesser extent) and the sheltered coastal reef population of carnivorous fish (Lutjanidae in particular). In conclusion, finfish resources in Moso appear to be in relatively good condition, although impact from fishing is suspected.

- At this stage of the analysis, we believe that strong ecosystem protection measures (i.e. establishment of an MPA) are not required to ensure sustainable use of the resource. However, large groups of herbivorous Acanthuridae (*Acanthurus blochii* in particular) are present in the area and could be targeted instead of parrotfish (Scaridae); this could assist in the recovery of parrotfish populations, which are probably being impacted by fishing at present.

- The natural medium-rich quality of the habitat suggests that finfish resources in Moso should be considered as a complementary (rather than principal) source of food and income, as Moso may not have a sufficiently rich environment to sustain intense fishing pressure for a long period of time. Easy access to open pelagic waters may render pelagic and deep-water finfish species particularly attractive for fishery development. The capacity of such fisheries to contribute to the food and financial security of the people of Moso should be investigated.

3.4 Invertebrate resource surveys: Moso Island

The diversity and abundance of invertebrate species at Moso were independently determined using a range of survey techniques, including broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 3.22) and finer-scale assessment of specific reef and benthic habitats (Table 3.10; locations shown in Figures 3.24 and 3.25).

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. Fine-scale assessments were conducted in target areas (areas with naturally higher abundance and/or the most suitable habitat) to specifically describe resource status.

Table 3.10: Number of stations and replicates completed at Moso

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	7	43 transects
Reef-benthos transects (RBt)	7	42 transects
Soft-benthos transects (SBt)	9	54 transects
Soft-benthos infaunal quadrats (SBq)	12	96 quadrat groups
Mother-of-pearl transects (MOPt)	n/a	0 transect
Mother-of-pearl searches (MOPs)	4	12 search periods
Reef-front searches (RFs)	0	0 search period
Sea cucumber night searches (Ns)	2	12 search periods
Sea cucumber day searches (Ds)	0	0 search period

n/a = no information available.

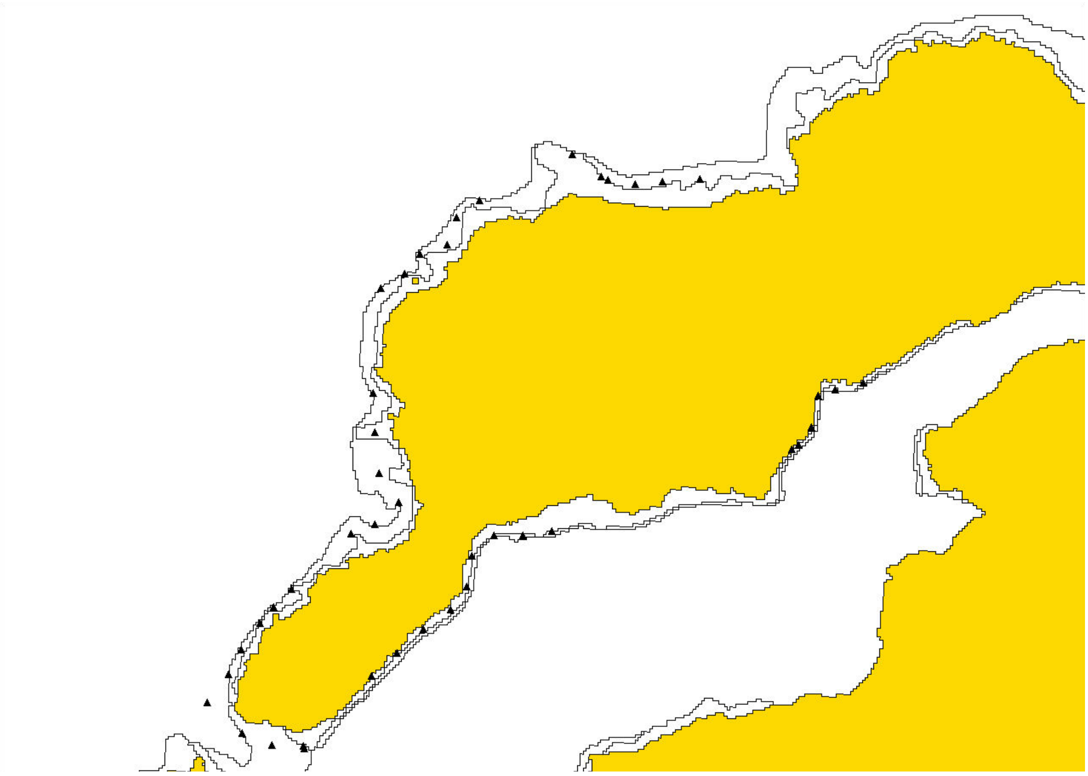

Figure 3.22: Broad-scale survey stations for invertebrates in Moso.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

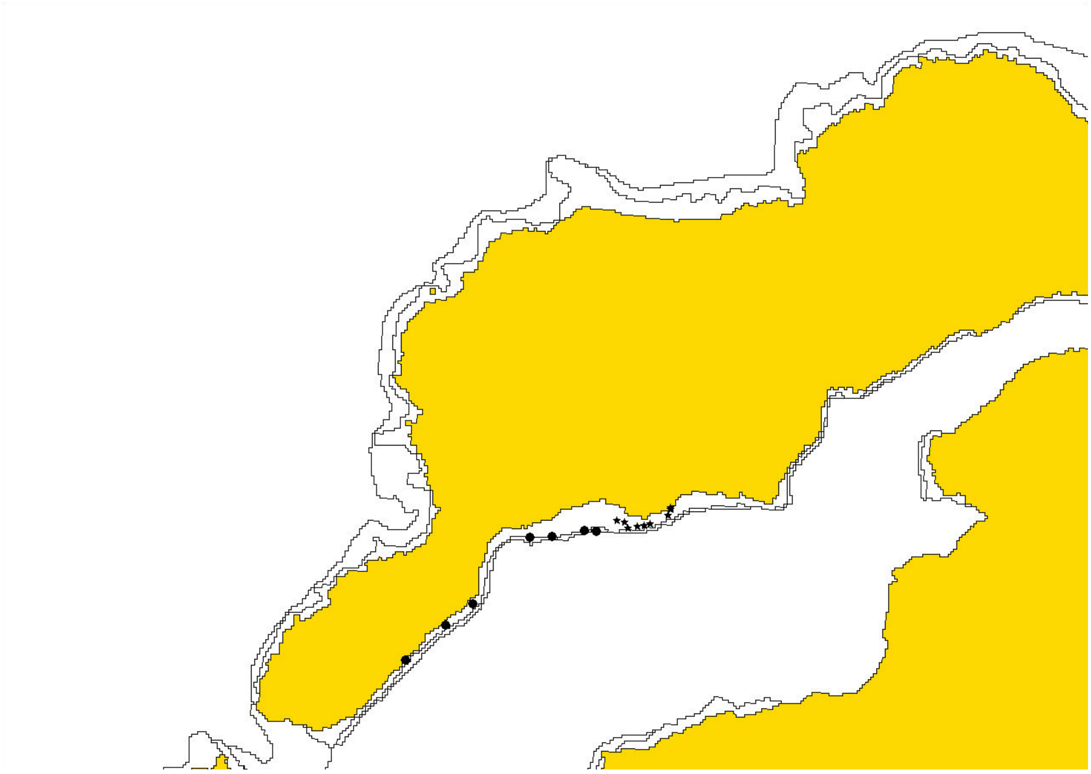

Figure 3.23: Fine-scale reef-benthos transect survey stations and soft-benthos transect stations for invertebrates in Moso.
Black circles: reef-benthos transect stations (RBt);
black stars: soft-benthos transect stations (SBt).

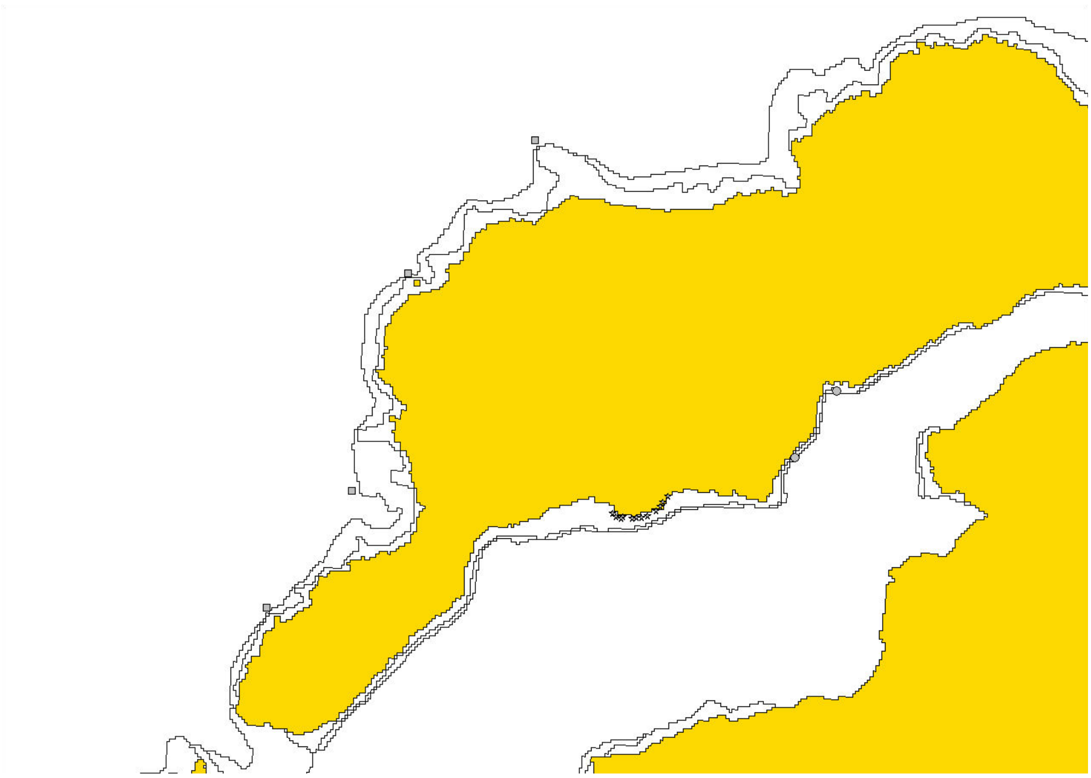

Figure 3.24: Fine-scale survey stations for invertebrates in Moso.
Grey stars: soft-benthos quadrat stations (SBq);
grey circles: sea cucumber night search stations (Ns);
grey squares: mother-of-pearl search stations (MOPs).

Fifty-two species (or species groupings) were recorded in the Moso invertebrate surveys: 13 bivalves, 10 gastropods, 17 sea cucumbers, 4 urchins, 5 sea stars, 1 cnidarian and 1 lobster (For listing see Appendix 4.2.1.). Information on key families and species is detailed below.

3.4.1 Giant clams: Moso Island

Broad-scale sampling provided an overview of giant clam distribution around Moso Island. Shallow reef habitat (suitable for giant clams) within the area surveyed was moderate in extent (approximately 4.7 km^2) and three giant clam species were recorded: *Tridacna crocea*, *T. maxima* and *Hippopus hippopus*. *T. crocea* was the most common species (recorded at seven broad-scale stations, 51% of transects), followed by *T. maxima* (six stations, 21% of transects). *H. hippopus* was not recorded in broad-scale assessments (Figure 3.25).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat. In these reef-benthos assessments (Figure 3.26), *T. crocea* was generally restricted to a strip of reef bordering the southeast coast of Moso Island (3 km in length), where this 'boring' clam was ubiquitous and present at high density; a single station situated in an area protected from fishing (Moso's Tranquillity Resort) held a mean density of 28,458 *T. crocea* per hectare. A single 40 m^2 transect within this station held an exceptionally high density of clams (>6.5 clams/m^2 of suitable substrate).

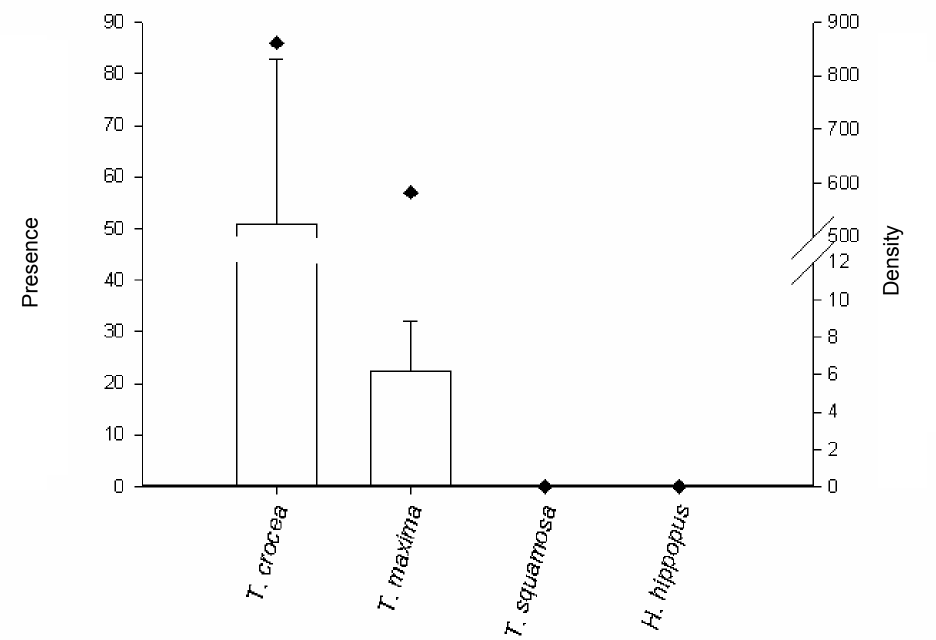

Figure 3.25: Presence and mean density of giant clam species in Moso based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

The second most common clam, the elongate clam (*T. maxima*, also the second smallest), was found to be sparsely distributed, and at low densities (Figure 3.26).

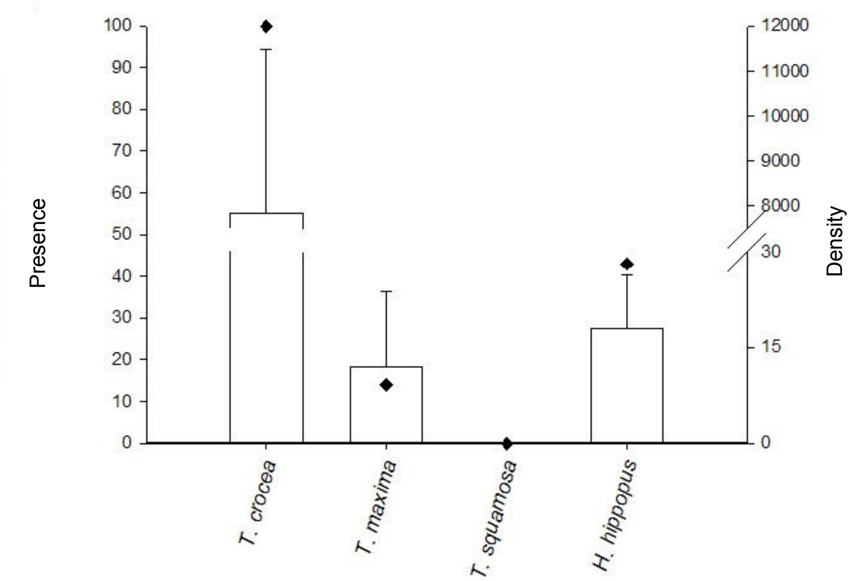

Figure 3.26: Presence and mean density of giant clam species in Moso based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

The horse hoof or bear paw clam (*H. hippopus*) was well suited to the conditions found in the lee of Moso Island, where a mix of reef and soft-benthos environments bordered the semi-enclosed lagoon. *H. hippopus* (and some *T. crocea*) were also amassed and protected from fishing in a small clam garden/protected area (See Appendix 4.2.11.) near the village of Tassiriki. Other studies of *H. hippopus* have found that they are generally present at lower densities than the smaller reef species, and are commonly rare at sites experiencing high fishing pressure (Munro 1989). In lightly exploited areas, densities of 30–90 per ha appear normal (Hardy and Hardy 1969; Tarnawsky 1980), which is in agreement with the mean density at all Vanuatu reef-benthos stations where these clams were present (26.67 per ha). Nine individuals were recorded in transects at Moso Island reef and soft-benthos stations (Figure 3.26 and Table 3.11).

Table 3.11: Presence and mean density of *Hippopus hippopus* in Moso
Based on fine-scale soft-benthos transect survey (9 stations, 54 transects); mean density measured in numbers/ha (±SE).

Species	Density	SE	% of stations with species present	% of transects with species present
Hippopus hippopus	27.8	9.8	56	56

Two fluted or scaly clams (*T. squamosa*) were collected by gleaners during the period of survey in Moso, but no *T. squamosa* were detected during these independent assessments. Although *T. gigas* (a generalist species found across most lagoon habitats) and *T. derasa* (a species found at sites with oceanic influence) were not found during the survey, empty *T. gigas* shells were still present in the village. Rosewater (1965) included Vanuatu (at that time the New Hebrides) in the distribution of these species. This and a previous study in Vanuatu

(Zann and Ayling 1988) failed to record their presence, and we consider the species commercially extinct[12] at this site.

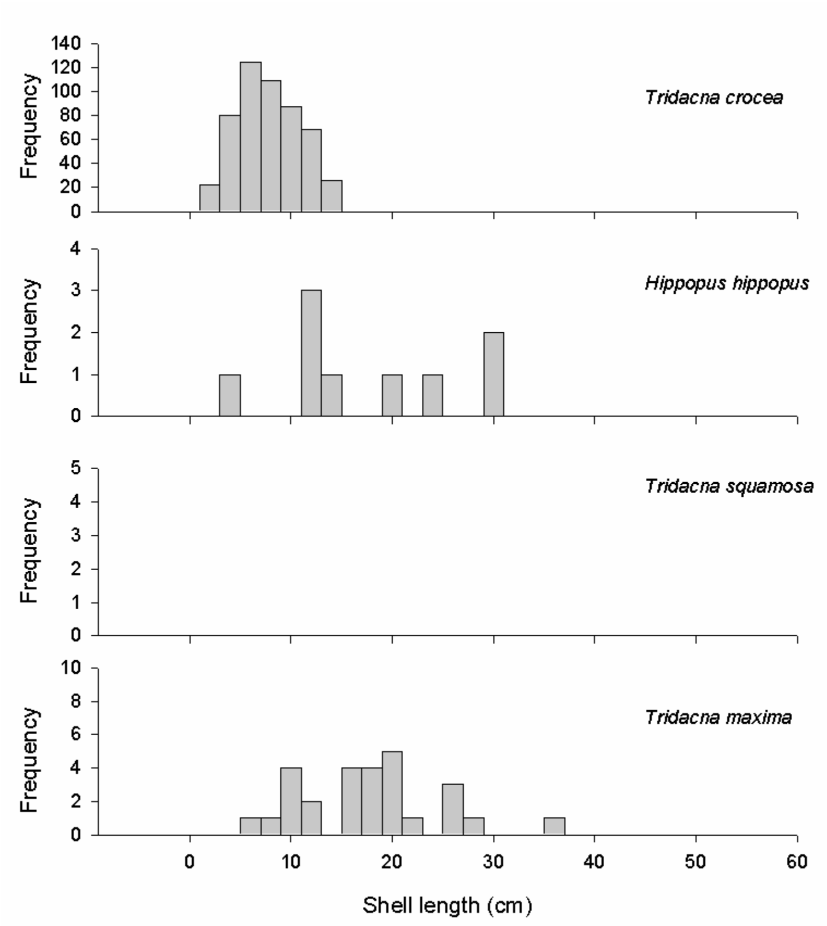

Figure 3.27: Size frequency histograms of giant clams shell length (cm) for Moso.

T. crocea from shallow-water reefs had an average length of 7.3 ±0.1 cm (See Figure 3.27.). Based on mean shell size, the *T. crocea* that dominated the shallow-water reef in Paunangisu had an average age of around 4–5 years (less than that at two other PROCFish/C sites, one on Efate and one at Malekula). The largest *T. crocea* recorded at Moso was 14 cm in length, below the asymptotic length (L_∞ = 16.5 cm). The mean for *T. maxima* was larger, at 17.4 ±1.3 cm, although most records originated from stocks on the outer reefs where *T. maxima* were sparsely distributed and exposed to oceanic conditions. *T. maxima* records from fine-scale reef-benthos stations on the lee of the island averaged 8.5 cm. *H. hippopus* found on soft benthos averaged 16.6 cm ±3.0. The age of the faster-growing *H. hippopus* found on reef and soft benthos was 3–4 years, based on their average size.

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

The reefs around Moso constitute an extensive and suitable habitat for adult *Trochus niloticus*, with ~4.7 km^2 of shallow, hard reef benthos; this area could potentially support significant populations of this commercial species. The complexity of the reef was medium to

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[12] 'Commercially extinct' refers to scarcity such that collection is not possible to service commercial or subsistence fishing, but the species is or may still be present at very low densities.

high (Appendix 4.2.9) and CCA cover was significant (a mean CCA for MOP searches of 64% ±3.5). Habitat that is most suitable for juvenile trochus (reef flat with extensive submerged rubble and coral flats) was limited in extent. In the lee of the island the fringing reef was composed primarily of coral heads or outcrops on sand, which is not considered to be a good benthos for juvenile trochus.

Searches for trochus were conducted with divers from Tassiriki village and targeted the best areas within their fishing grounds, but trochus abundance was negligible (Table 3.12). None were seen in broad-scale surveys, and dedicated MOP searches (n = 24) yielded only two shells near the asymptotic length for this species (one live trochus 13.5 cm in length, and one dead shell). This single live record described an approximate station density of 8.3 individuals/ha. Outside our search area we located a further four trochus on an isolated reef head in very shallow water. These trochus were also mature adults >12 cm in length.

Table 3.12: Presence and mean density of *Pinctada margaritifera*, *Tectus pyramis* and *Trochus niloticus* in Moso
Based on broad-scale transect survey, reef-benthos stations and MOP search stations; mean density measured in numbers/ha (±SE).

	Density	SE	% of stations with species	% of transects or search periods with species
Pinctada margaritifera				
Manta	3.5	1.4	7/7 = 100	7/43 = 16
RBt	11.9	11.9	1/7 = 14	2/42 = 5
MOPs	2.1	2.1	1/4 = 25	1/24 = 4
Tectus pyramis				
Manta	0	0	0/7 = 0	0/43 = 0
RBt	0	0	0/7 = 0	0/42 = 0
MOPs	8.3	8.3	2/4 = 50	2/24 = 8
Trochus niloticus				
Manta	0	0	0/7 = 0	0/43 = 0
RBt	0	0	0/7 = 0	0/42 = 0
MOPs	2.1	2.1	1/4 = 25	1/24 = 4

Manta = broad-scale survey; RBt = reef-benthos transect; MOPs = mother-of-pearl search.

Other mother-of-pearl species, such as the blacklip pearl oyster (*Pinctada margaritifera*), were relatively common in Moso (found in broad-scale, reef-soft benthos and MOP assessments). A species with similar life history characteristics to trochus, the lower-value green topshell (*Tectus pyramis*), was recorded at low density; green snail (*Turbo marmoratus*) was not found.

Both blacklip pearl oysters and commercial trochus were found at densities considered well below those required to support a commercial fishery (See Appendix 4.2.6.). The decline of the trochus fishery described by divers may have been exacerbated by the lack of good juvenile habitat for trochus. However, as habitat for adult trochus is suitable and relatively extensive, it is worth noting that there is also an opportunity to rear and hold trochus at a local on-shore tank facility. At the time of the survey the Tranquillity Resort operated a rudimentary pump and tank system (used to hold juvenile turtles), which could be adapted for rearing trochus without substantial expense. Such a facility could supply juveniles for research experiments on reseeding, or as a venture to supply the local aquarium trade. Presently, research suggests that support or replenishment of depleted fisheries is best accomplished through protection and aggregation of adults (broodstock) rather than via juvenile release; however, the opportunity to rear juveniles does exist locally.

3.4.3 Infaunal species and groups: Moso Island

The area of soft benthos along the northwest edge of the semi-enclosed lagoon (the side bounded by Moso Island) was not extensive (approximately 0.3 km^2, or 4% of the fishing grounds and study area; Figure 3.23). Shell beds had a relatively high mean oceanic influence (3 out of 5) and a low grade for epiphytes (2.5 out of 5), suggesting the area was dynamic, with regular flushing of clear seawater. Shell beds were characterised by muddy patches among sandy areas, with significant seagrass cover (51%). This soft-benthos area of Moso Island was located close to Tassiriki village and was targeted by fishers for infaunal bivalves, gastropods and echinoderms (Appendix 4.2.4).

Shell beds held arc shell, *Anadara* spp. And venus shell *Gafrarium* spp., which are important resources for village communities in Vanuatu. In addition to the broad-scale and fine-scale assessments, which included soft-benthos areas, quadrats were used to examine the complement distribution and density of infaunal species (See Appendix 4.2.5.). Arc shells were relatively common, recorded in 11 of 12 stations and 25% of quadrat groups (Appendix 4.2.5), whereas *Gafrarium* spp. were rare (recorded in one of 12 stations). The mean density (±SE) for *Anadara* spp. was 1.0 ±0.3 per m^2, whereas *Gafrarium* spp. were recorded at 0.04 ±0.04 per m^2. Data from other infaunal species recorded during this assessment are also available in Appendix 4.2.5.

Arc shells at Moso were relatively small, averaging 5.2 cm ±0.2 (Figure 3.28; see Maskelyne Archipelago invertebrate site report for comparison.). Small shells were recorded in the independent survey, indicating that recruitment was continuing, but there was a general absence of arc shell sizes greater than 6 cm in length (Figure 3.28).

Despite the small size of the shell beds at Moso Island, arc shells were present across the area and densities were moderate. In general, infaunal stocks were not diverse (Appendix 4.2.5), and other genera commonly found in seagrass areas were uncommon (*Lambis*, *Dollabella*, *Strombus*) or absent (*Tripneustes gratilla*). The lack of these other genera, along with the lower numbers of larger-sized *Anadara*, suggests that fishing pressure on the soft-benthos area of Moso Island was impacting infaunal resources.

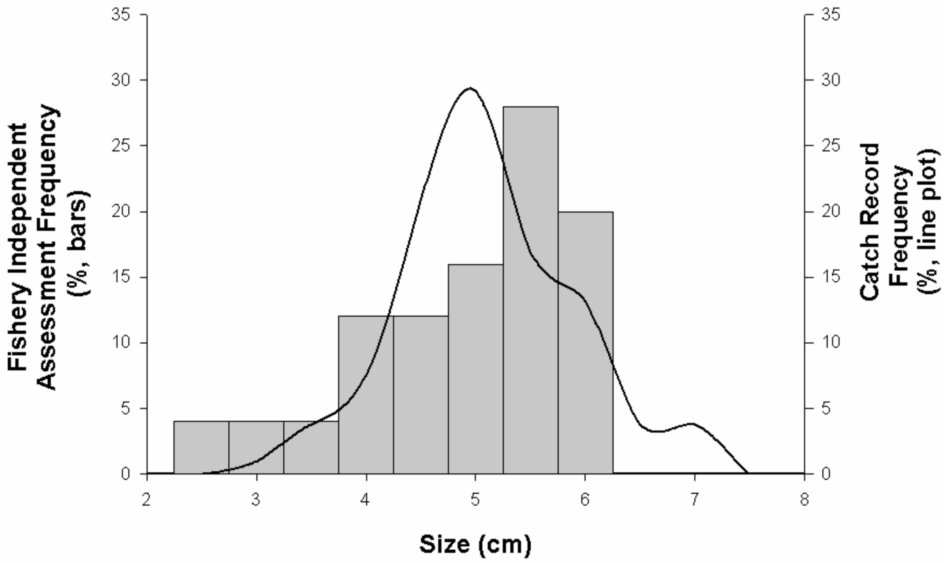

Figure 3.28: Arc shell, *Anadara* spp., shell size frequency from fishery independent assessment (bars, soft-benthos quadrats, n = 25) and catch (line, n = 106).

3.4.4 Other gastropods and bivalves: Moso Island

Lambis lambis and the larger Seba's spider conch (*L. truncata*) were detected in broad- and fine-scale survey (Appendices 4.2.2 and 4.2.3). Other gastropods, such as *Cerithium*, *Conus*, *Cypraea*, *Pleuroploca*, *Strombus* and *Tectus*, were not found on reef benthos. Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Hyotissa* and *Spondylus*, are also in Appendices 4.2.2 and 4.2.3.

During the time of the survey, fishers walked along the coastline collecting a range of common resources from the shallows and shoreline. Organisms collected included clams and other bivalves (*Tridacna maxima*, *T. crocea*, *T. squamosa*, *Pinctada margaritifera*, *Atactodea striata*, *Asaphis violascens*, *Donax cuneatus* and *Saccostrea* spp.), gastropods (*Vasum* spp., *Conus* spp., *Thais* spp., *Turbo* spp., *Australium complex*, *Nerita polita*, *Cypraea* spp., *Vermetus maxima*, *Narita* spp., *Cerithium nodulosum*, *Tectus pyramis*, *Pleuroploca filamentosa* and *Trochus* spp.), crabs (*Grapsus albolineatus*, *Eriphia sebana* and *Ocypode ceratophthalmus*), chitons and slugs (*Acanthopleura* spp. and *Onchidium* spp.), anemone and octopus (See catch data, Appendix 4.2.10.).

3.4.5 Lobsters: Moso Island

Two lobsters, *Panulirus* spp., were recorded on broad-scale assessment at a low mean density of 0.7 per ha (5% of transects). Three others were recorded during reef-benthos assessment (mean density 17.9 ±8.4 per ha, 43% of stations), and a single slipper lobster (*Parribacus caledonicus*) was found during BdM night searches.

3.4.6 Sea cucumbers[13]: Moso Island

Within the main study area of Moso, there was access to areas of seagrass, protected reef bordering a sheltered lagoon, a lagoon passage and large areas of windward reef suitable for sea cucumbers. Moso Island's outer fringing reef was exposed to heavy swell (oceanic influence 4.46 out of 5), had poor live coral cover (approximately 5%) and generally comprised reef and dead coral. Coral coverage and soft benthos (22.6%) were more plentiful along the coastal strip, in the lee of the island. Despite the lack of extensive areas of shallow protected lagoon (i.e. mixed reef and soft benthos), there was a reasonable to good complement of sea cucumber species recorded at Moso (Table 3.13).

Sixteen commercial/subsistence species and one non-target species were recorded during in-water assessments (Table 3.13). The presence and density of species were determined through broad-scale, fine-scale and dedicated survey methods (Appendices 4.2.2 to 4.2.5; also see Appendix 1.3.). Note that no deep dives were conducted during this study, which would be required to give advice on deep-water stocks such as the high-value white teatfish (*Holothuria fuscogilva*) and the lower-value amberfish (*Thelonata anax*).

Reef areas on both sides of Moso Island had moderate to low presence and density of valuable commercial sea cucumber species, as compared to the other PROCFish/C study sites in Vanuatu (Table 3.13). The presence and densities of species generally associated with reef (greenfish, *Stichopus chloronotus*, and leopardfish, *Bohadschia argus*) were moderate to low, with only a single individual of the high-value, slow-growing black teatfish, *Holothuria nobilis* (which is easily targeted by fishers), found during the survey period. Shallow-water surf species (e.g. surf redfish, *Actinopyga mauritiana*) were also at low density considering the suitable nature of the reef and surge zone.

The inshore seagrass area in the lee of Moso Island was limited in size and held fewer than its full potential of sea cucumber species. The shallow-water reef in the lee of the island (approximately 6 km in length) was protected from swell but dropped off quickly into deeper lagoon water. These areas held remnant stocks of medium- to high-value species (curryfish, *Stichopus hermanni*), while embayments in the shoreline still held populations of blackfish, *Actinopyga miliaris*. The medium-value blackfish were found in reasonable numbers during night searches at shallow-water sites close to the main village of Tassiriki, despite the fact that these stocks were easily accessible to villagers and that spear fishers were targeting this species during our survey period. In the seagrass areas, where bivalves, gastropods and urchins were collected by gleaners, lower-value sea cucumber species were abundant (lollyfish, *Holothuria atra*; pinkfish, *H. edulis*; and snakefish, *H. coluber*) and remnant populations of the small species peanutfish (*S. horrens*, termed 'small curry' in Fiji) were recorded. None of the high-value, soft-benthos species (sandfish, *H. scabra* or *H. scabra versicolor*) were found. Based on the presence and density of sea cucumbers on Moso, the stocks are considered impacted or heavily impacted by environmental conditions and/or fishing pressure.

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

Table 3.13: Sea cucumber species records for Moso

Species	Common name	Commercial value [6]	B-S transects n = 43			Reef-benthos stations n = 7			Soft-benthos stations SBt = 9; SBq = 12			Other stations MOPs = 4			Other stations Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga lecanora	Stonefish	M/H	0.8	16.7	5							8.3	16.7	50			
Actinopyga mauritiana	Surf redfish	M/H															
Actinopyga miliaris	Blackfish	M/H														33.3	100
Bohadschia argus	Leopardfish	M	7.8	47.6	16							4.2	8.3	50			
Bohadschia graeffei	Flowerfish	L	0.4	16.7	2							4.2	16.7	25			
Bohadschia similis	False sandfish	L								833.3	7 SBq						
Bohadschia vitiensis [4]	Brown sandfish	L	1.6	33.3	5				4.6	41.7	11 SBt				5.6	11.1	50
Holothuria atra	Lollyfish	L	41.2	57.3	72	41.7	145.8	29		1152.8	100 SBt		66.7	50			
Holothuria coluber	Snakefish	L							4.6	41.7	11 SBt						
Holothuria edulis	Pinkfish	L	13.7	39.1	35	35.7	83.3	43	13.9	62.5	22 SBt						
Holothuria fuscogilva [5]	White teatfish	H	No deep dive completed														
Holothuria fuscopunctata	Elephant trunkfish	M	0.4	16.7	2												
Holothuria nobilis [5]	Black teatfish	H	0.2	10.1	2												
Holothuria scabra	Sandfish	H															
Holothuria scabra versicolor	Golden sandfish	H															
Stichopus chloronotus	Greenfish	M/H	9.2	32.8	28	6.0	41.7	14				19.7	37.5	100			
Stichopus hermanni	Curryfish	M/H	0.4	16.7	2												
Stichopus horrens	Peanutfish	M								416.7	8 SBq						
Stichopus vastus	Brown curryfish	M/H															
Synapta spp.	-	M/H							37.0	111.1	33 SBt						
Thelenota ananas	Prickly redfish	H	0.4	16.7	2							2.1	8.3	25			
Thelenota anax	Amberfish	M	0.4	16.7	2												

[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] scaled-up soft quadrat measures should be used with caution when thay are collected from limited records; [5] 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. [6] L = low value; M = medium value; H= high value; B-S transects = broad-scale transects; SBt = soft-benthos transect; SBq = soft-benthos quadrat; MOPs = mother-of-pearl search; Ns = night search.

3.4.7 Other echinoderms: Moso Island

The edible slate urchin, *Heterocentrotus mammillatus*, was detected at broad-scale survey at a mean density of 26.9 ±8.1 per ha (35% of transects). No collector urchins, *Tripneustes gratilla*, were recorded in broad- or fine-scale surveys. The pencil or slate urchin was somewhat more common than at other sites, but other urchins (resource and subsistence) and starfish were generally found at similar coverage and densities.

Starfish such as crown of thorns starfish (COTS, *Acanthaster planci*) and non-edible urchins were also recorded as potential indicators of habitat condition (Appendices 4.2.1 to 4.2.7). COTS were uncommon in Vanuatu, and only two COTS were recorded around Moso Island (during the fine-scale reef-benthos survey only). An outbreak or incipient outbreak would be marked by higher densities[14].

3.4.8 Discussion and conclusions: invertebrate resources in Moso Island

- Marine resources typically targeted by fishers through gleaning (on reef and soft benthos) were generally less widely distributed and present in lower densities than the average for PROCFish/C sites in Vanuatu. The presence, density and size range of giant clams indicate a resource impacted or heavily impacted by environmental conditions and/or fishing pressure. Although stock are positioned on habitat that is particularly well suited to their recruitment and growth, the small mean size of *Tridacna crocea* and lack of *T. maxima* signal a fishing impact. However, *T. crocea* was present at high density in an area especially well suited to recruitment and growth of this species. Seagrass and infaunal shell bed areas were also impacted by fishing, although the high presence of *Hippopus hippopus* on soft benthos was encouraging, as this species is easily collected in shallow water but was nevertheless found in reasonable numbers, and a reserve of broodstock near the main village was protected from fishing.

- MOP stocks *Trochus niloticus* and *Pinctada margaritifera* were present at Moso Island but only found at low levels (less common than at PROCFish/C sites on Malekula). The green snail, *Turbo marmoratus*, was not found. Commercialisation of trochus has affected stocks, and the population is considered close to collapse despite the presence of extensive habitat suitable for adults. Resource owners should consider keeping the fishery closed into the medium-term future (e.g. 10 years). Other MOP species (*Pinctada margaritifera*, *Tectus pyramis*, *Turbo marmoratus*) were found at low densities or were absent at Moso (See Appendix 4.2.6.).

- Sea cucumbers were present, but the available habitat, with its significant oceanic influence, did not provide conditions where high densities of many commercial species would be found. The resource is considered impacted by environmental conditions and/or fishing pressure. Evidence of fishing pressure was most noticeable for species well suited to exposed reef conditions; surf redfish were absent and the high-value black teatfish were rare in survey. Despite the impacts suggested, the durable nature of sea cucumber stocks was highlighted, as the total species complement was not severely reduced at Moso and some medium-value species (blackfish) were detected at reasonable density in

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[14] For additional information on COTS see http://www.aims.gov.au/docs/research/biodiversity-ecology/threats/cots.html.

shallow water. Given this situation, advice should be sought by local resource owners prior to the opening of the sea cucumber fishery, with respect to fishing options and to ensure post-harvest processing maximises returns.

3.5 Overall recommendations for Moso Island

Based on the survey work undertaken and the assessments made across all three disciplines (socioeconomics, finfish and invertebrates), the following recommendations are made for the Moso Island fishing area:

- At this stage of the analysis, we believe that strong ecosystem protection measures (i.e. establishment of an MPA) are not required to ensure sustainable use of the finfish resource. However, large groups of herbivorous surgeonfish (Acanthuridae, in particular *Acanthurus blochii*) are present in the area and could be targeted instead of parrotfish (Scaridae). This may assist in the recovery of parrotfish populations as these are probably being impacted by fishing at present.

- The natural medium-rich quality of the habitat suggests that finfish resources in Moso should be considered as a complementary (rather than principal) source of food and income, as Moso may not have a sufficiently rich environment to sustain intense fishing pressure for a long period of time. Easy access to open pelagic waters may render pelagic and deep-water finfish species particularly attractive for fishery development. The capacity of such fisheries to contribute to the food and financial security of the people of Moso should be investigated.

- Commercialisation of trochus has affected stocks, and the population is considered close to collapse despite the presence of extensive habitat suitable for adults. Resource owners should consider keeping the fishery closed into the medium-term future (e.g. 10 years).

- Advice should be sought by local resource owners prior to the opening of the sea cucumber fishery, with respect to fishing options and to ensure post-harvest processing maximises returns.

4. PROFILE AND RESULTS FOR URI AND URIPIV ISLANDS

4.1 Site characteristics

The islands of Uri and Uripiv are located on the east coast of Malekula, 3–4 km by boat from Lakatoro (Lakatoro is 5 km by road from Norsup airport) (Figure 4.1). The two islands are separated from Malekula by Port Stanley, a pseudo-lagoon. The people of Uripiv and Uri consider that they make up a single fishing community, with one clan in Uri and six clans in Uripiv (Potum, Vitani, Tewivi, Jinuis, Tena and Port Nambe). Consequently, Uri was investigated in conjunction with Uripiv (the communities are referred to as Uri-Uripiv in this report).

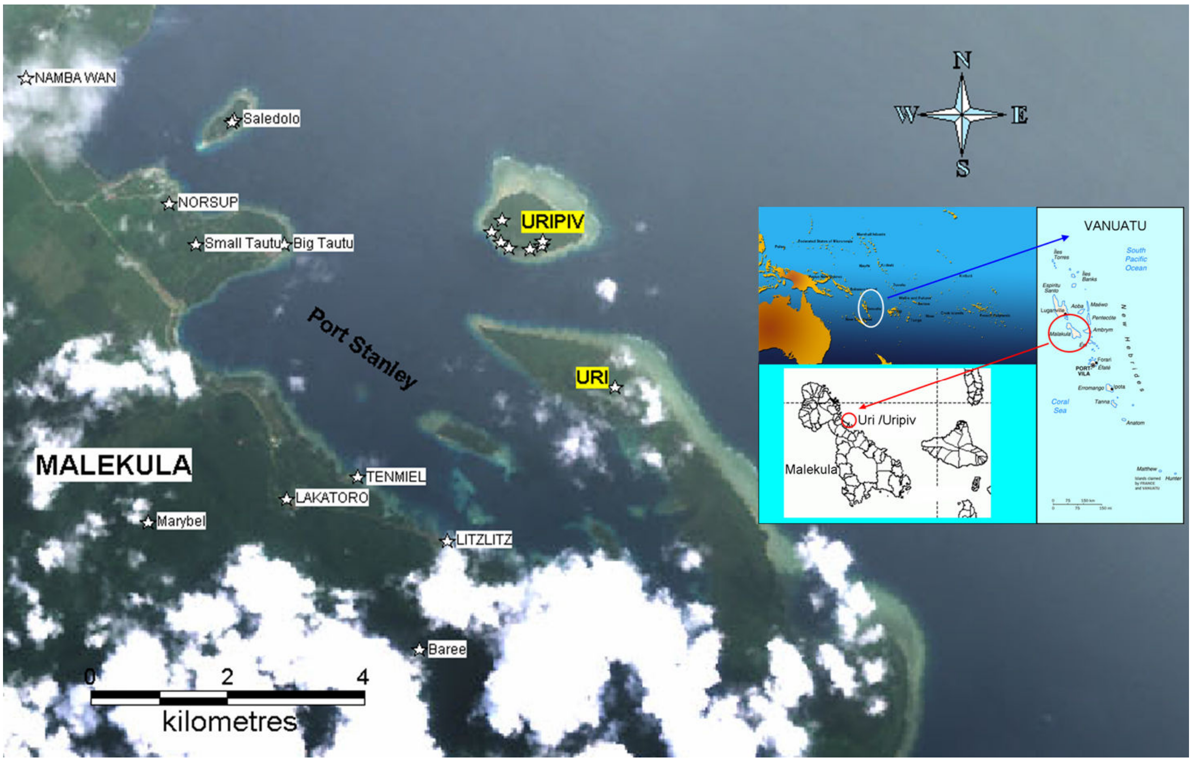

Figure 4.1: Location of Uri and Uripiv Islands.

The social organisation on both Uri and Uripiv is determined by two major authorities. The first is the traditional chiefly system, with four chiefs on Uripiv and one on Uri. The church represents the second major authority and includes three different congregations on Uripiv (Presbyterian, Neil Thomas Ministry and Latter-day Saints) and one on Uri (Presbyterian).

The evolution of community-based marine resource management (MRM) in Vanuatu has been documented over the last decade and more than 80 communities are now reported to be engaged in it (Govan 2004). During the PROCFish/C study in Uri-Uripiv, respondents indicated there were three small MPAs around Uripiv Island (each with about 300 m of shoreline) where fishing has been completely banned for the last ten, six and two years, respectively.

In a report comparing marine management measures in place across 21 villages in Vanuatu, Johannes and Hickey (2004) found that Uri had the greatest number of village-based marine management measures (12) of all villages surveyed (Table 4.1). Uripiv had close to the average for all villages.

Table 4.1: Community-based marine management measures in place in Uri and Uripiv

Village	Trochus	Closures	Turtle	BdM	Spear fishing	Nets use	MPA	Giant clams	Crabs	Miscellaneous
Uri		X (1)	X	X	X	X	X (1)	X	X	X (1)
Uripiv		X			X	X				

BdM = bêche-de-mer; MPA = marine protected area; (1) more than one measure of this type in place; source: Johannes and Hickey 2004.

According to Johannes and Hickey (2004), in 2001 Uri had a permanent 100-hectare reserve designated as a park (Narong Park), which was permanently protected from all harvesting. Uri restricted all fishing within its giant clam reserve, and had a taboo on oyster gathering in one mangrove area and a taboo on the cutting of mangroves in another area. Total fishing bans (of different lengths) were in effect in two different locations. Bêche-de-mer was not collected in Uri, night spear fishing and night netting were taboo, and a ban on commercial collecting of shore crabs was in place for six months of every year (including the season when crabs are gravid, or have egg masses). Only limited catch of turtles was allowed by the chief. Controls on the harvesting of mangrove crabs, bivalves and trochus were under consideration. Overall, strong support for marine conservation was noted in Uri.

Controls in place in Uripiv in 2001 included one fishing ground being closed to all but line fishing and another fishing ground being completely closed; the main purpose in both cases was to stop spear fishing and the use of nets. Inter-clan disputes over land and reef ownership were in evidence, and the community had requested assistance in drawing up plans for additional marine conservation measures, in particular a marine sanctuary.

Information collected during the socioeconomic survey confirmed that, under the authority of the chiefs and with the consent of the community, a no-take MPA about 2 km in length had been established on Uripiv about five years before (in 1998). In addition, three areas were designated by the community as areas where bêche-de-mer and trochus fisheries were prohibited. This decision affected at least 15 former trochus fishers. The trochus fishery was to be reopened in March 2005.

Community rules also limited the sale and hence harvest of crabs (*Terebra* spp. and *Codakia* spp.). For *Scylla serrata* (mud crabs), catch limits were 50 pieces per person and trip; for *Terebra* spp. (and other shells) two baskets/trip/person; and in the case of *Codakia* spp. five plastic bags/trip/person. Only married women were allowed to sell the maximum quantity (five ropes, each holding 10 crabs) at the market.

During the field survey no further bans or limitations were reported. For instance, oysters are targeted by about 13–14 local fishers in response to the monthly visits of a commercial boat (Havannah) that serves clients in Noumea. Fishing pressure on white crabs is particularly high during December and on octopus from April to August, but this is due to seasonal factors rather than factors associated with fishery regulations.

In addition to village-level management measures, the Fisheries Act, which is enforced by the national Fisheries Department, includes regulations on size limits for shellfish and crustaceans, no-take of gravid crustaceans, harvest and export quotas for some products and in some cases requirements for licences and permits.

Uri-Uripiv has a traditional, village-owned fishing system, with a fishing ground of about 7 km^2, including 4 km^2 of reef. A fringing outer reef lies along the ocean (northern) side of both Uripiv and Uri islands. A narrow sheltered coastal reef extends along the sheltered (southern) sides of both islands, with sandy areas and small mangroves becoming increasingly dense (and coral increasingly patchy) further inside Port Stanley, along the sheltered side of Uri (Figure 4.2). The reefs of Uri-Uripiv are highly dominated by outer reef (2.77 km^2, 67% of habitat) and include 1.36 km^2 (33%) of sheltered coastal reef.

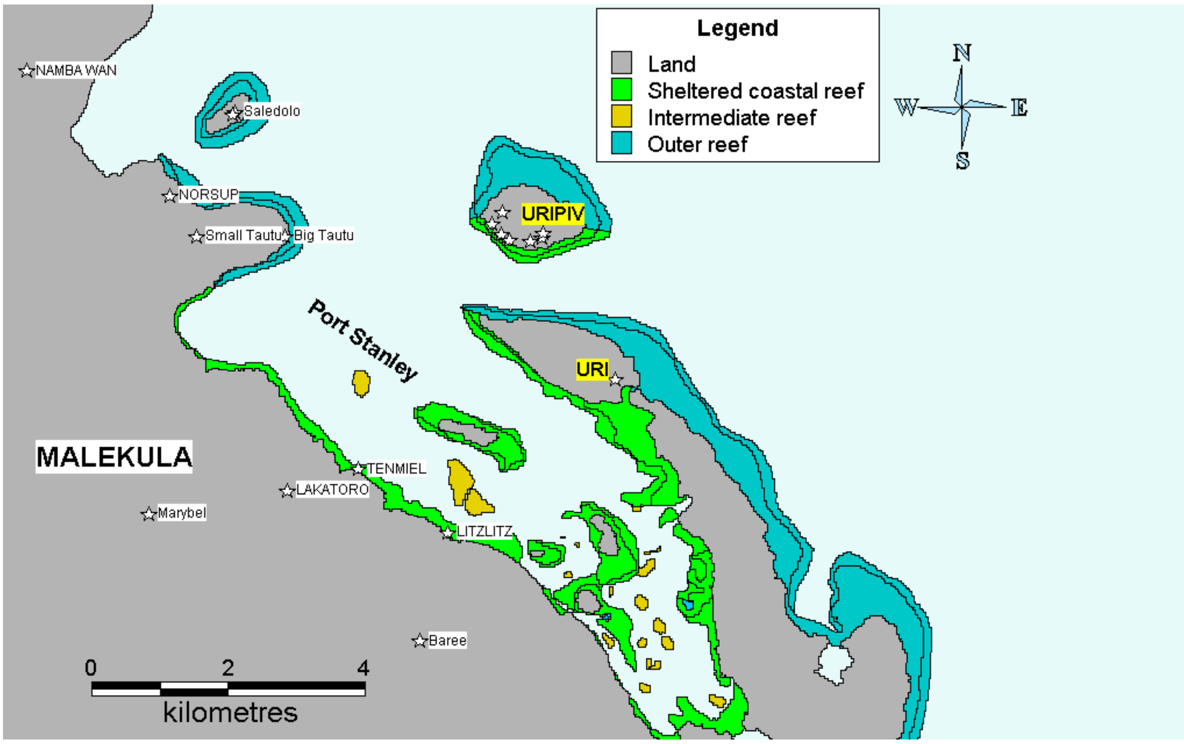

Figure 4.2: Main reef structures in Uri and Uripiv Islands.

4.2 Socioeconomic survey: Uri and Uripiv Islands

Socioeconomic fieldwork was carried out in the community of Uri-Uripiv between 28 November and 5 December 2003. The survey covered 24 out of 84 (29%) active households on Uri and five out of eight (63%) on Uripiv. Based on data from the 2000 census and information collected on site, the total resident population of Uri-Uripiv (as considered in this study) was 684; the household survey covered 23% of the total population.

Household interviews were aimed at the collection of general demographic, socioeconomic and consumption parameters. In addition, 25 individual interviews of finfish fishers (20 males, 5 females) and 22 invertebrate fishers (12 males, 10 females) were conducted. In some cases the same person was interviewed for both finfish fishing and invertebrate harvesting.

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

The number of household members (3.24 per household) involved in fisheries in Uri-Uripiv is the highest across all study sites in Vanuatu; when extrapolated to the total number of households, this gives a total of 298 fishers in Uri-Uripiv (165 males, 133 females).

Income sources in Uri-Uripiv are diverse. While fisheries were ranked as the most important source, providing first and second income for 38% and 14% of all households, respectively, salaries were also important (first income for 30% of all households; Figure 4.3). The proportion of the finfish catch that is intended for sale (export) exceeds the subsistence catch by a factor of 5, revealing the community's economic dependency on fisheries. Agriculture and other sources (handicrafts, small businesses) were both listed as primary income sources by 17% of households; agriculture served as a secondary source for 24%, and other sources for 14%. Taking into account that about one-quarter (27%) of all households receive remittances, and that on average this annual input meets over one-third (USD 141)[15] of the annual household expenditure of USD 362, Uri-Uripiv's community displays a certain dependency on external financial input.

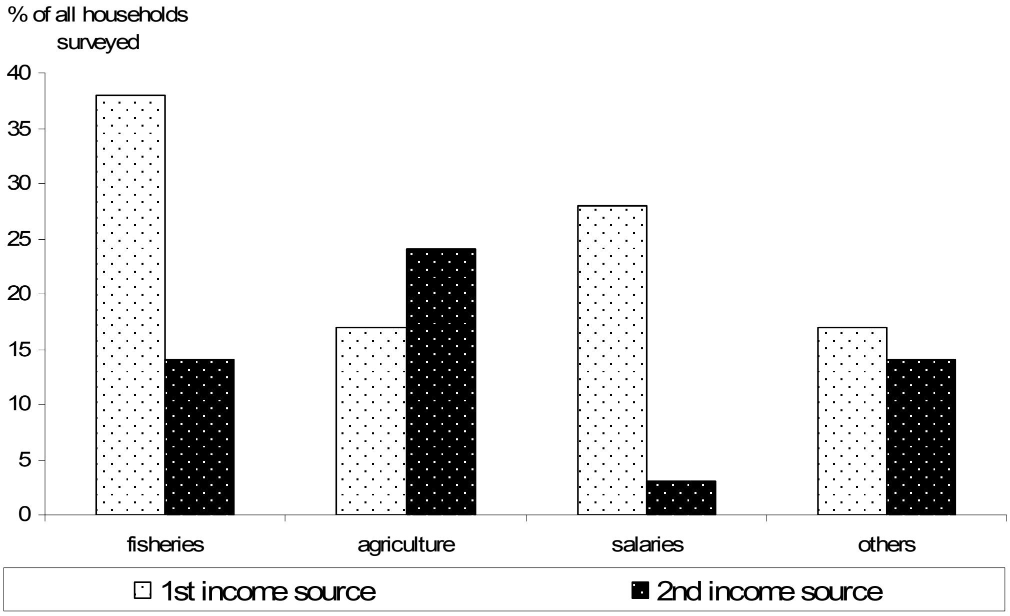

Figure 4.3: Ranked sources of income (%) in Uri-Uripiv.
Total number of households = 29 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.
'Others' are mostly handicrafts and private businesses.

Fresh and canned finfish are consumed infrequently (1.3 and 1.2 times/week, respectively). The average per capita fresh finfish consumption in Uri-Uripiv (9.9 kg/capita/year) is the lowest across all four PROCFish/C sites surveyed (Figure 4.4), and only 60% of the average. The similarly low canned fish consumption (4.5 kg/capita/year; 50% of the average) indicates that canned fish has not been adopted as a substitute. Invertebrates are frequently eaten (2 times/week compared to the average of 1.15 times/week across all four PROCFish/C sites).

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[15] Exchange rate at end of 2003: USD 0.00916 = VT 1.

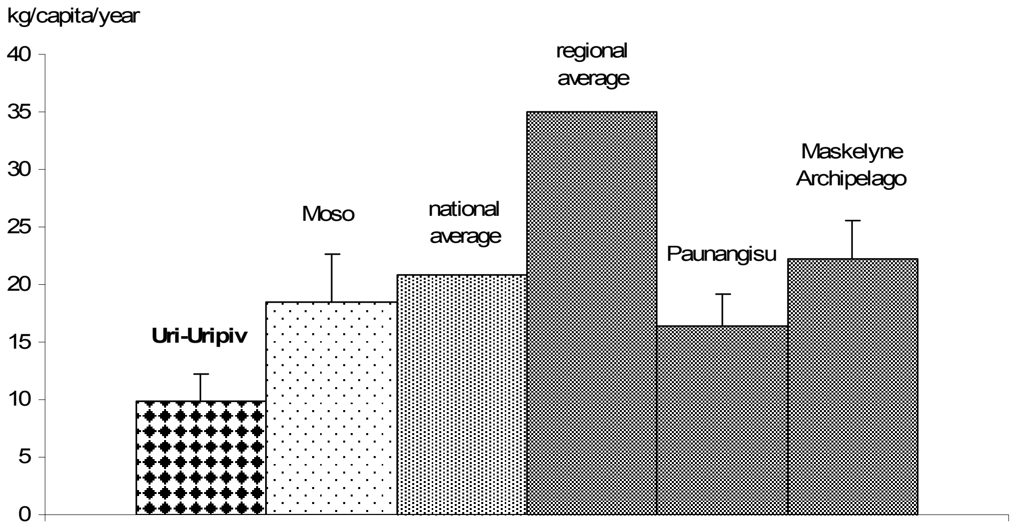

Figure 4.4: Per capita consumption (kg/year) of seafood in Uri-Uripiv (n = 29) compared to national and regional averages (FAO 2002) and other three PROCFish/C sites in Vanuatu. Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

Compared with other PROCFish/C sites in Vanuatu, the Uri-Uripiv community is highly dependent on fisheries for income generation. The number of household members involved in fisheries (3.2) is the highest across all study sites, as is the proportion of fish and invertebrates caught for their own consumption (Table 4.2). Fresh and canned finfish consumption are both well below average, due to the low frequency of consumption reported. The moderate number of households receiving remittances and the comparatively high annual amount they receive indicate a certain degree of dependency on external financial input. The relatively high share of salary-based income described earlier, the importance of agriculture, the influx of external money and the comparatively low level of household expenditure suggest that the livelihood of people from Uri-Uripiv is strongly subsistence oriented on one hand, but on the other hand is also exposed to and influenced by urbanisation.

Table 4.2: Fishery demography, income and seafood consumption patterns in Uri-Uripiv

Survey coverage	Uri-Uripiv (n = 29 HH)	Average across sites (n = 124 HH)
Demography		
HH involved in reef fisheries (%)	100	97
Number of fishers per HH	3.24 (±0.30)	2.68 (±0.15)
Male finfish fishers per HH (%)	23.4	21.1
Female finfish fishers per HH (%)	2.1	3.0
Male invertebrate fishers per HH (%)	1.1	1.2
Female invertebrate fishers per HH (%)	14.9	19.3
Male finfish and invertebrate fishers per HH (%)	30.9	32.2
Female finfish and invertebrate fishers per HH (%)	27.7	23.2
Income		
HH with fisheries as 1st income (%)	38	22
HH with fisheries as 2nd income (%)	14	39
HH with agriculture as 1st income (%)	17	58
HH with agriculture as 2nd income (%)	24	26
HH with salary as 1st income (%)	28	11
HH with salary as 2nd income (%)	3	3
HH with other source as 1st income (%)	17	11
HH with other source as 2nd income (%)	14	13
Expenditure (USD/year/HH)	362 (±46.54)	864 (±72.93)
Remittance (USD/year/HH) (1)	141 (±105.72)	120 (±28.44)
Seafood consumption		
Quantity fresh fish consumed (kg/capita/year)	9.9 (±2.31)	16.8 (±1.60)
Frequency fresh fish consumed (time/week)	1.30 (±0.22)	1.90 (±0.14)
Quantity fresh invertebrate consumed (kg/capita/year)	n/a	n/a
Frequency fresh invertebrate consumed (time/week)	1.99 (±0.26)	1.15 (±0.11)
Quantity canned fish consumed (kg/capita/year)	4.53 (±1.04)	9.04 (±1.24)
Frequency canned fish consumed (time/week)	1.16 (±0.19)	2.12 (±0.20)
HH eat fresh fish (%)	100	100
HH eat invertebrates (%)	100	85
HH eat canned fish (%)	100	94
HH eat fresh fish they catch (%)	100	100
HH eat fresh fish they buy (%)	62	32
HH eat fresh fish they are given (%)	35	55
HH eat fresh invertebrates they catch (%)	100	90
HH eat fresh invertebrates they buy (%)	0	0
HH eat fresh invertebrates they are given (%)	0	6.5

HH = household; n/a = no information available; (1) average sum for households that receive remittances; numbers in brackets are standard error.

4.2.2 Fishing strategies and gear: Uri and Uripiv Islands

Key informants and chiefs confirmed that while official and community regulations are well known, they are not necessarily always followed. The community can punish those members who do not comply with the rules, in particular the community rules, but in actual fact such measures are hardly ever exercised.

Degree of specialisation in fishing

While females' participation in fisheries is generally high, the engagement of males and females in the various fisheries differs significantly. Among fishers who target finfish or invertebrates exclusively, finfish fisheries in Uri-Uripiv are dominated by males, while a higher proportion of females pursue invertebrate harvesting (Figure 4.5). However, for both sexes the highest share is represented by fishers who engage in both finfish fishing and invertebrate harvesting (Both activities may or may not be combined during one fishing trip.).

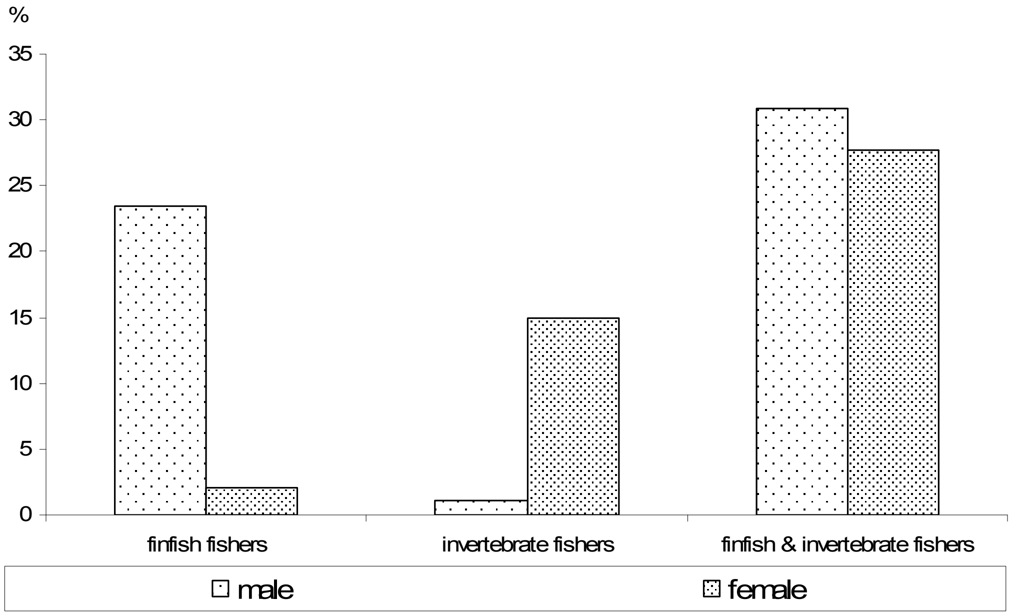

Figure 4.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Uri-Uripiv.
All fishers = 100%.

Females dominate invertebrate fisheries in general (Figure 4.6), and reeftop, intertidal and mangrove fisheries in particular. Soft-benthos and free-diving fisheries (MOP and other) are exclusively performed by males.

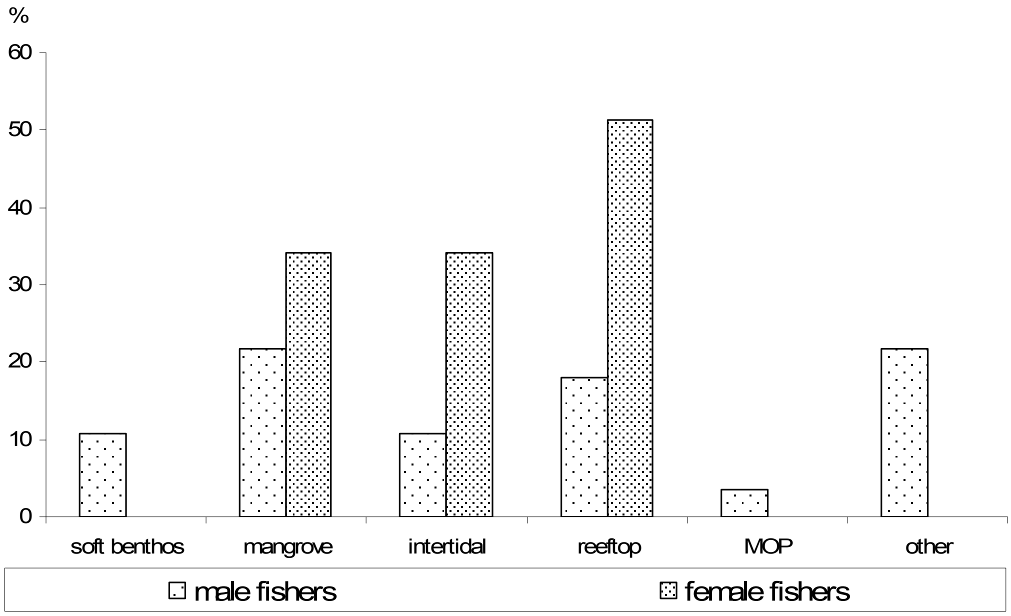

Figure 4.6: Proportion (%) of male and female fishers targeting various invertebrate habitats in Uri-Uripiv.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 16 for males, n = 20 for females; 'other' refers to the octopus and giant clam fishery, targeted by free diving. MOP = mother-of-pearl.

Fishing strategies

In Uri-Uripiv more than two-thirds (78%) of all households own a boat, the majority of which (>60%) are dugout canoes. Nine boats (constructed of aluminium or wood) were fitted with outboard engines; six of those were operational. Only non-motorised canoes are used whenever boat transport is needed for invertebrate fisheries (in the case of mangrove, other free-diving and trochus fisheries). All other invertebrate fishers reported that they walk to access the reeftop, intertidal and soft-benthos environments.

Only two free-diving fisheries were reported in Uri-Uripiv, with all gleaning fisheries represented (Figure 4.7). Most fishers pursue gleaning activities, with reeftop (34%), mangrove (27%) and intertidal fisheries (22%) the most popular. Free-diving fisheries were less active and more fishers were engaged in 'other' fisheries than in MOP fisheries. In the case of Uri-Uripiv, only intertidal and reeftop fisheries are sometimes combined in one fishing trip. While not common, other free diving that mainly aims at octopus, giant clams and trochus may be done as a side activity of finfish spear fishing.

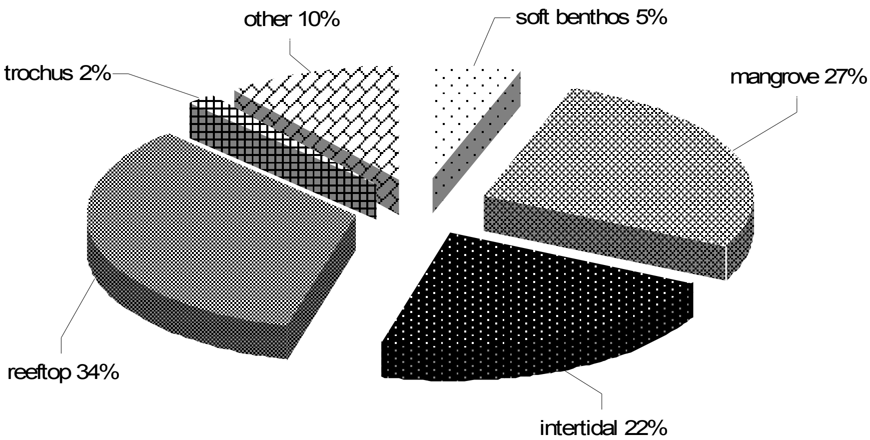

Figure 4.7: Proportion (%) of fishers targeting the six primary invertebrate habitats found in Uri-Uripiv.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; 'other' refers to the octopus and giant clam fishery.

Targeted stocks/habitats

The number of months during which invertebrates are collected varies between fisheries. While reeftop, intertidal and soft-benthos fisheries are active throughout virtually the entire year (10–11 months), mangroves are fished for only nine months. The shortest periods were recorded for other free-diving and trochus fisheries, with four months and one month respectively. Most fishing is done during the day, but reeftop and other free diving may also be performed at night. Mangroves are rarely fished at night. Due to the distance, fishing trips to mangroves are generally the longest (5.5 hours on average). Other invertebrate fishing trips are rather short and take 2–3 hours on average.

Almost all fishers from Uri-Uripiv targeted the sheltered coastal reef, with just 20% targeting the outer reef (Table 4.3). Those fishers targeting the outer reef did so once a week, while fishing at the sheltered coastal reef was done every two weeks, on average. The duration of a trip averaged 4.5 hours on the outer reef and 2.5 hours on the sheltered coastal reef. The survey also showed that about 60% of all fishers targeting either habitat do so year round. The other 40% stop during certain periods to focus on other (mainly agricultural) activities.

Table 4.3: Proportion (%) of interviewed male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Uri-Uripiv

Resource	Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	95	100
	Outer reef	25	0
Invertebrates	Mangrove	50	60
	Reeftop	17	30
	Soft benthos	25	0
	Intertidal and reeftop (1)	25	60
	Other	50	0
	Mother-of-pearl (commercial trochus fishery)	8	0

(1) Combined in one fishing trip; 'Other' refers to the octopus and giant clam fishery.
Finfish fisher interviews, males: n = 20; females: n = 5. Invertebrate fisher interviews, males: n = 12; females: n = 10.

Gear

Multiple techniques are used to target finfish in Uri-Uripiv (Figure 4.8). Most fishers use more than one technique, although not necessarily during one trip. Handlines are used by a majority of fishers (65%) targeting the sheltered coastal reef. Gillnets are employed by most fishers making trips to the outer reef (80%) but are also used at the sheltered coastal reef (40%). Gillnetting is often combined with handheld spearing done from canoes to target particularly large fish caught in the net. Traditional spearing (handheld, used when walking or from canoes) and bow and arrow are only practised by a few fishers when targeting the sheltered coastal reef. Spear diving is used more frequently on the sheltered coastal reef than at the outer reef.

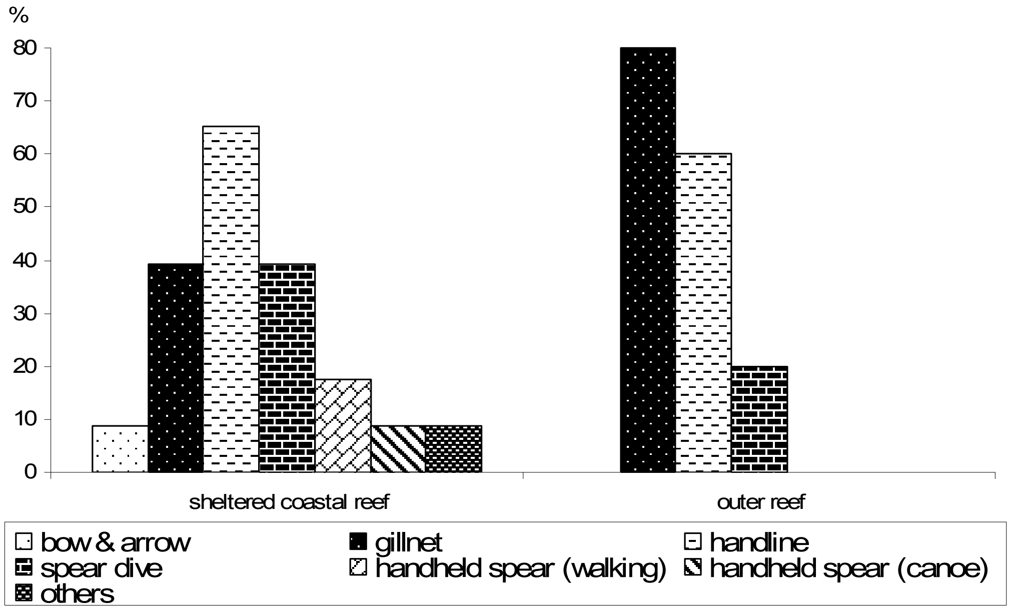

Figure 4.8: Fishing methods commonly used in different habitat types in Uri-Uripiv.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Fishing pressure

Information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip was used to estimate the fishing pressure imposed by the inhabitants of Uri-Uripiv on their fishing grounds.

Frequency and duration of fishing trips

Male finfish fishers from Uri-Uripiv targeted the sheltered coastal reefs on average 0.44 times/week, while female fishers did so almost twice as often (0.84 times/week) (Table 4.4). The outer reef was visited more than twice as often by males (0.99 times/week), and not at all by females. The average duration of a fishing trip to the sheltered coastal reef was 4.6 hours, and to the outer reef 2.3 hours.

Table 4.4: Average frequency and duration of fishing trips reported by male and female fishers in Uri-Uripiv

Resource	Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	0.44 (±0.11)	0.84 (±0.20)	4.61 (±0.66)	4.60 (±1.176)
	Outer reef	0.99 (±0.42)	0	2.30 (±0.20)	0
Invertebrates	Mangrove	0.90 (±0.25)	0.87 (±0.09)	5.00 (±0.63)	6.00 (±0.00)
	Other	0.92 (±0.27)		2.50 (±0.22)	
	Reeftop	1.00 (±0.00)	0.58 (±0.23)	2.00 (±0.00)	2.00 (±0.00)
	Intertidal and reeftop (1)	1.17 (±0.17)	1.31 (±0.21)	2.17 (±0.17)	2.08 (±0.08)
	Soft benthos	1.00 (±0.00)	0	2.00 (±0.00)	0
	Mother-of-pearl	0.02	0	3.00	0

Figures in brackets denote standard error; (1) Combined in one fishing trip; 'Other' refers to the octopus and giant clam fishery.
Finfish fisher interviews, males: n = 20; females: n = 5. Invertebrate fisher interviews, males: n = 12; females: n = 10.

4.2.3 Catch composition and volume – finfish: Uri and Uripiv Islands

Total annual recorded catches in Uri-Uripiv equalled 4.1 t (1 t for females, 3.1 t for males). Extrapolation of these figures for all fishers in Uri-Uripiv renders a total annual catch of 37.9 t. The proportion of the total catch associated with each of the habitats fished mirrors the fishing activity pattern, i.e. most (63.7%) of the overall catch is extracted from the sheltered coastal reef and less (36.3%) from the outer reef (Figure 4.9). Females' finfish fishing activities are significant (23% of the total annual catch). Outer-reef fishing is an exclusively male activity representing ~36% of the total annual catch. The annual amount of finfish caught for export by members of the Uri-Uripiv community greatly exceeds (by a factor of 5) the total annual subsistence catch (Figure 4.9) (Details on recorded annual catch by vernacular species and scientific family are given in Appendix 2.3.1.).

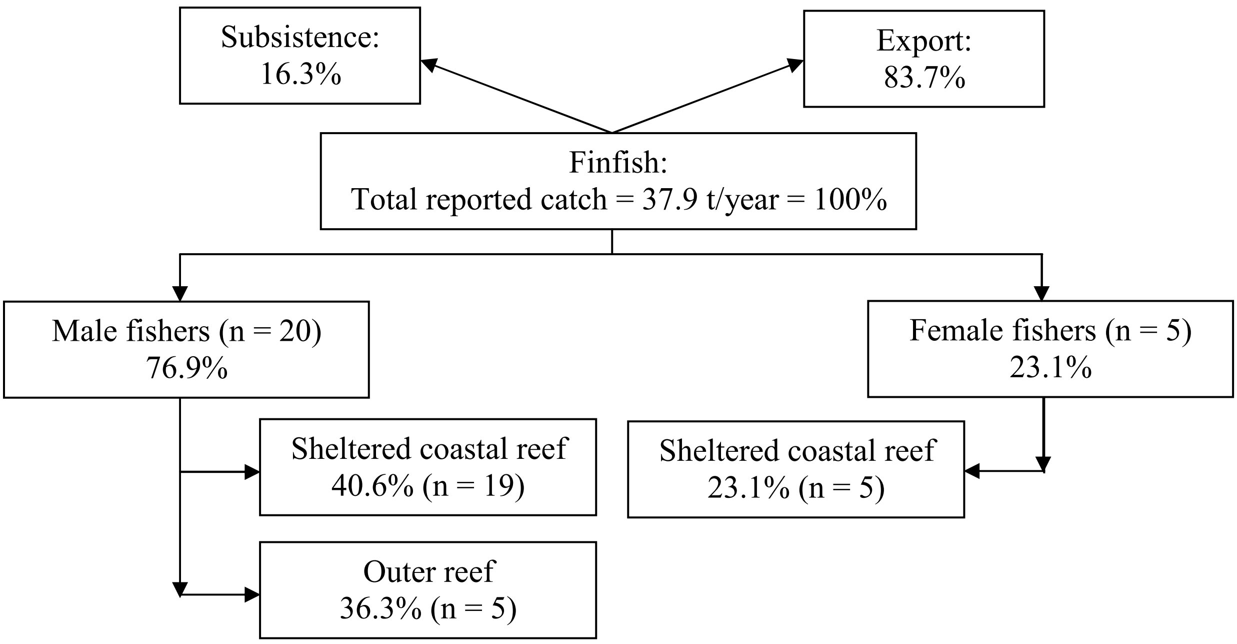

Figure 4.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Uri-Uripiv.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

Respondents indicated that about half of all trips to the sheltered coastal reef were to generate income, with the other half meeting subsistence needs, including non-monetary fish distribution among community members. The proportion of outer-reef trips made for commercial purposes was much lower (20%) (Figure 4.10).

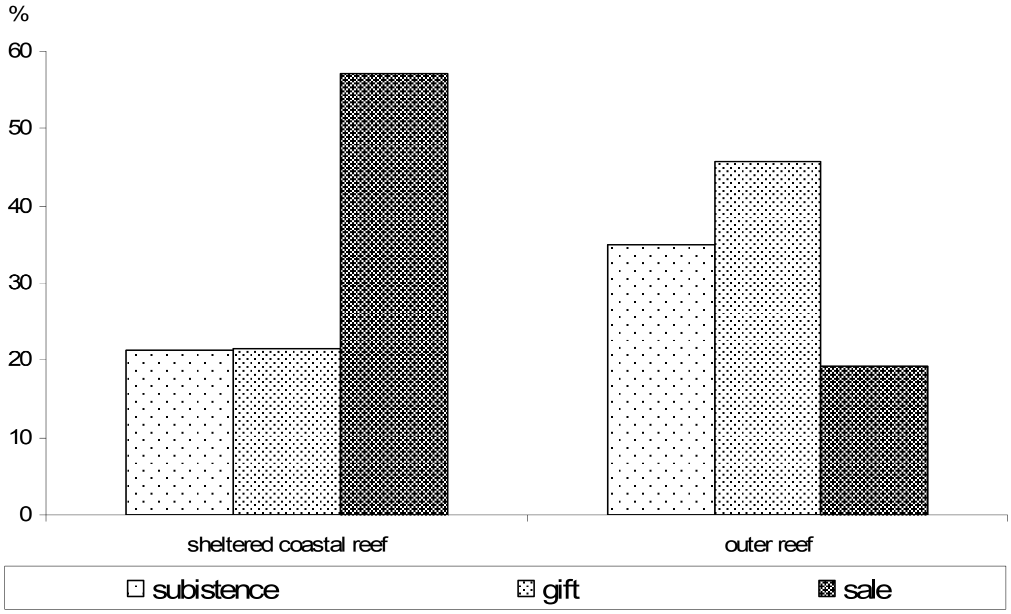

Figure 4.10: The use of finfish catches for subsistence, gifts and sale, by habitat in Uri-Uripiv.
Proportions are expressed in % of the total number of trips per habitat.

The catch per unit effort (CPUE) calculated for female and male fishers is comparable in the sheltered coastal reef. CPUE at the outer reef is almost four times as high as at the sheltered coastal reef (Figure 4.11).

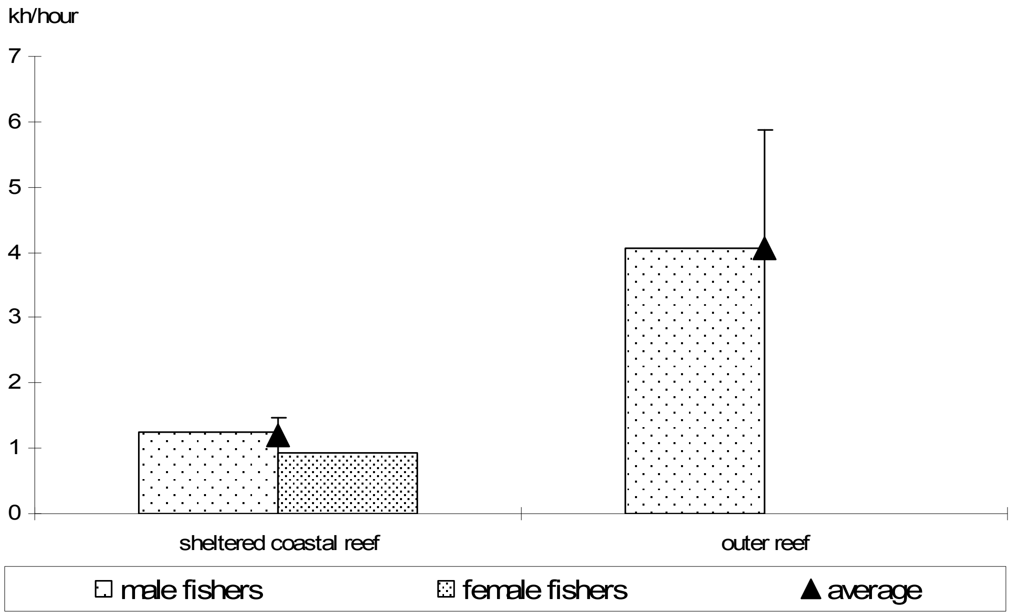

Figure 4.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Uri-Uripiv.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

Catches from the sheltered coastal reef were fairly equally distributed over several families, including Lethrinidae, the most prominent, but also Scaridae, Mugilidae, Kyphosidae, Carangidae, Acanthuridae and Siganidae. Outer-reef catches included a large share of pelagic species such as Carangidae and Kyphosidae, although Lethrinidae, Siganidae and Mugilidae still contributed significantly (Detailed information on the distribution of fish families of reported catches in percentage of total weight per habitat fished is provided in Appendix 2.3.1.).

Comparison of the average size per family in the different habitats (Figure 4.12) reveals major differences, with generally larger sizes caught at the outer reef. This observation is particularly true in the case of Carangidae, Kyphosidae, Mugilidae, Lethrinidae, Serranidae and Siganidae. However, the inverse occurs for Scaridae, Acanthuridae and Gerreidae, for which average sizes are larger from sheltered coastal reef catches than from outer-reef catches.

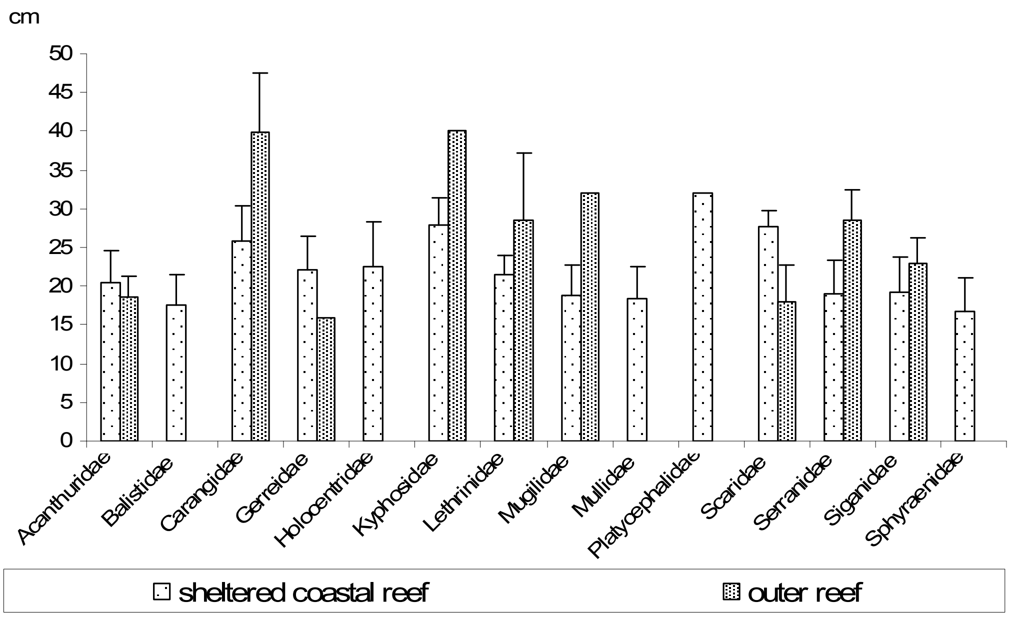

Figure 4.12: Average sizes (cm fork length) of fish caught by family and habitat in Uri-Uripiv. Bars represent standard error (+SE).

Estimates of fishing pressure, based on survey responses and extrapolated to the entire population, suggest that fisher density is moderate considering the total reef or fishing ground area. However, a high fisher density and thus possibly the highest fishing pressure was found at the sheltered coastal reef, and low fisher density at the outer reef (Table 4.5).

Table 4.5: Parameters used in assessing fishing pressure on finfish resources in Uri-Uripiv

Parameters	Habitat			
	Coastal reef	Outer reef	Total reef	Total fishing ground [(1)]
Fishing ground area (km^2)	1.36	2.77	4.12	7.28
Density of fishers (number of fishers/km^2 fishing ground)	160	12	61	34
Population density (people/km^2)			121	68
Average annual finfish catch (kg/fisher/year)	108 (±34.3)	296 (±219.7)		
Total fishing pressure of subsistence catches (t/km^2)			1.5	0.9

Figures in brackets denote standard error; [(1)] total lagoon area = 3.16 km^2 included; total population = 498. Catch figures are based on recorded data from survey respondents only. Total number of fishers is extrapolated from household surveys. Total subsistence demand = 5.16 t/year.

4.2.4 Catch composition and volume – invertebrates: Uri and Uripiv Islands

The number of species (as represented by the number of vernacular names) reported to be regularly caught from various habitats indicates the importance of these habitats and the fisheries they support. Mangrove and soft-benthos fisheries were particularly important in Uri-Uripiv, with nine and six different vernacular names respectively (Figure 4.13). Reeftop, other free-diving and MOP fisheries were more species specific, and included 1–3 species groups.

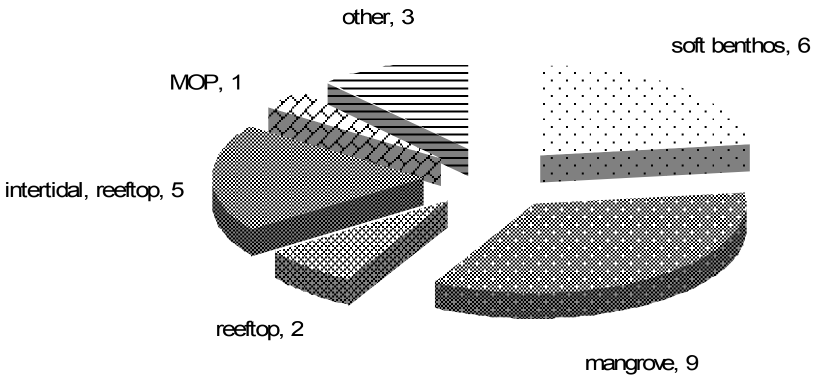

Figure 4.13: Number of vernacular names recorded for each invertebrate fishery in Uri-Uripiv.

The total annual catch records from fishers interviewed amounted to 8.7 t (4 t for females, 4.7 t for males) (Figure 4.14). Extrapolation of the average annual recorded catch per fisher to the total number of invertebrate fishers in Uri-Uripiv indicated that 85.9 t of biomass (wet weight) is removed annually.

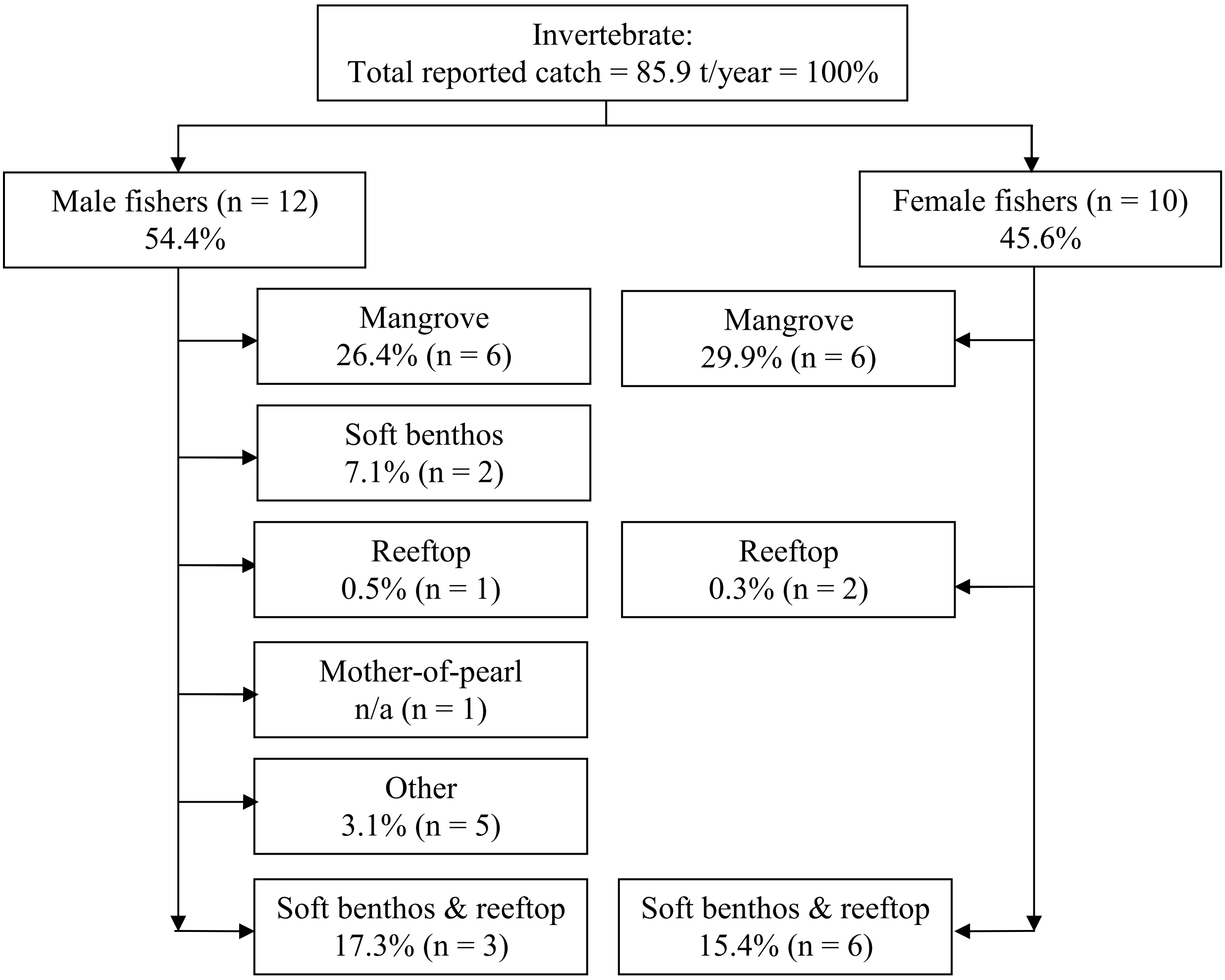

Figure 4.14: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Uri-Uripiv.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey. 'Other' refers primarily to octopus, giant clams and trochus.

Slightly over half (54.4%) of the total biomass removed annually from Uri-Uripiv fishing grounds is harvested by male fishers. Most (56.3%) of the biomass is removed from mangroves. Moderate impact was recorded for soft-benthos and reeftop fisheries, with the lowest impact, in terms of total biomass removed annually, recorded for other diving (3.1%, which includes mainly octopus, giant clams and trochus) and MOP (trochus) fisheries.

Calculation of the total annual impact per species group, regardless of the fishery, shows that the highest annual catches (in terms of kg wet weight removed) are distributed over seven species groups. The highest catches are recorded for the genera *Terebra*, *Codakia* and *Nerita*/*Polineces*, followed by the genera *Scylla* (mud crabs), the genera *Planaxis* and *Asaphis*/*Gafrarium* and *Octopus* (Figure 4.15).

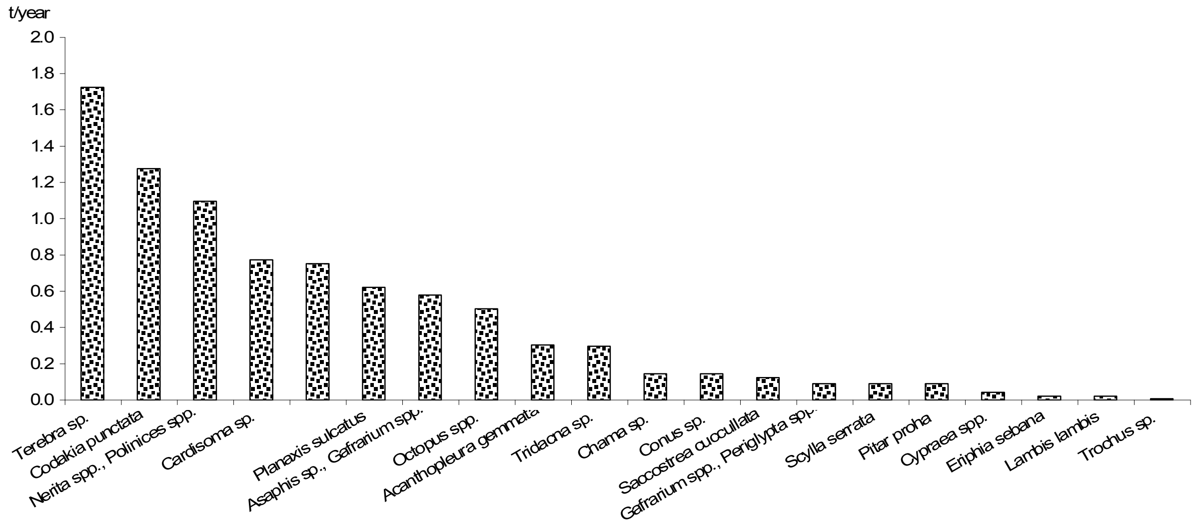

Figure 4.15: Total annual invertebrate catch (t wet weight /year) by species (reported catch) in Uri-Uripiv.

Details on the species distribution per habitat and size distribution by species are provided in Appendices 2.3.1 and 2.3.3, respectively.

Results from fisher interviews indicate that none of the invertebrate fisheries in Uri-Uripiv is exclusively commercially oriented. People from Uri-Uripiv use a wide range of invertebrates to satisfy their protein needs, but target particular fisheries and species groups to generate income. The total annual amount that is used exclusively for sale is marginal (Figure 4.16). About half of all catches are used only for consumption, or for consumption and sometimes (but not necessarily) for commercial purposes. If the proportion of the catch that is used for both consumption and sale is divided equally between subsistence and sale purposes, the total annual amount of biomass (wet weight) caught for external sale represents about one-quarter of the total annual biomass removed.

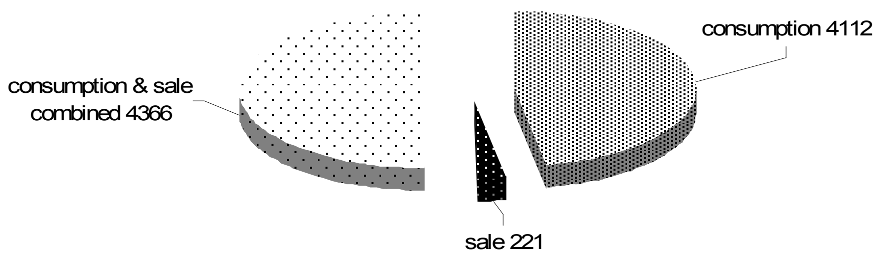

Figure 4.16: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale and consumption and sale combined (reported catch) in Uri-Uripiv.

Some genera are caught for consumption only, such as *Nerita*/*Polineces*, *Planaxis* and *Asaphis*/*Gafrarium*. Mud crabs and oysters are the only species that are particularly targeted for commercial purposes by some – although not all – of Uri-Uripiv's fishers. *Terebra*, *Codakia* and *Scylla* represent the most important species that serve both consumption and sale as needed (More details on the role that species play for consumption, sale or both purposes, are provided in Appendix 2.3.4.).

As indicated earlier, both sexes participate in invertebrate fisheries, although in different ways. Comparison of the total biomass (kg wet weight) removed annually by each fisher, by gender group and fishery, confirms that females are more productive in reeftop and mangrove fisheries (Figure 4.17), while males are more productive in intertidal gleaning; other fisheries cannot be compared due to the fact that they are not targeted by Uri-Uripiv's females.

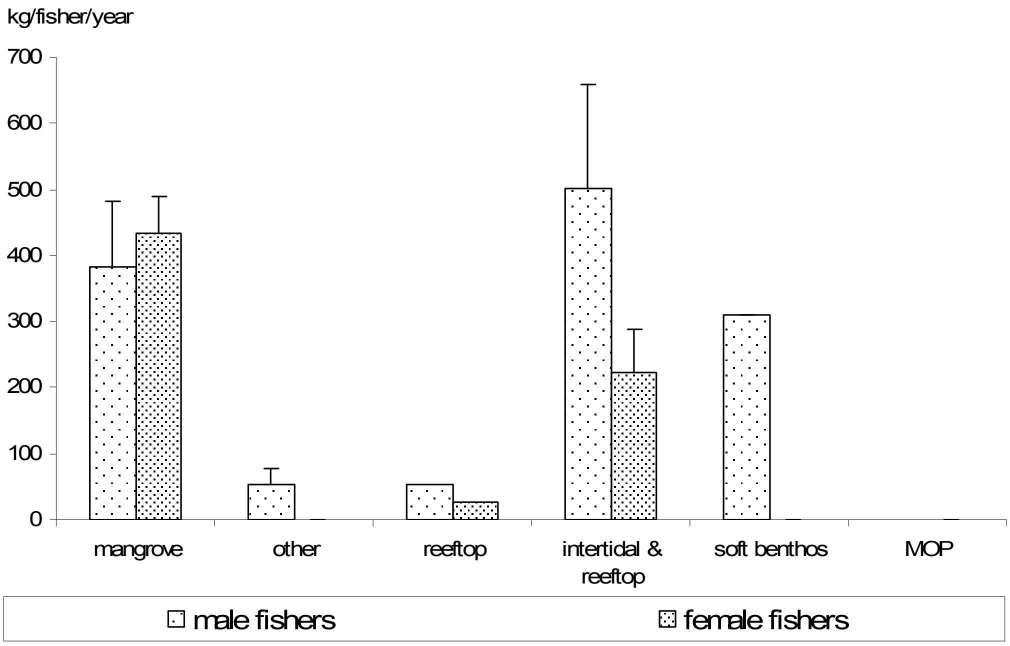

Figure 4.17: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Uri-Uripiv.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 12 for males, n = 10 for females). Bars represent standard error (+SE). MOP = mother-of-pearl; 'other' refers primarily to octopus, giant clams and trochus.

Fishing grounds for MOP and other dive fisheries are about 10 times larger than those for gleaning fisheries. The highest number of fishers is found in the intertidal fishery, but the highest fisher density and fishing pressure are imposed on mangroves. Pressure on reeftop, MOP and other dive fisheries appears low to marginal (Table 4.6).

Table 4.6: Parameters used in assessing fishing pressure on invertebrate resources in Uri-Uripiv

Fishery	Mangrove	Intertidal	Reeftop	Soft benthos	MOP	Other
Fishing ground area (km^2)	0.9	7	1.9	0.3	8.6	10.1
Number of fishers (per fishery) [(1)]	124	154	99	24	8	48
Density of fishers (number of fishers/km^2 fishing ground)	138	22	52	94	1	5
Average annual invertebrate catch (kg/fisher/year) [(2)]	407.9 (±55.0)	315.5 (±77.9)	39.6 (±12.7)	309.0 (±0.0)	0.3	53.4 (±23.0)

MOP = mother-of-pearl; [(1)] number of fishers extrapolated from household surveys; [(2)] catch figures are based on recorded data from survey respondents only; 'other' refers primarily to octopus, giant clams and trochus.

4.2.5 Discussion and conclusions: socioeconomics in Uri and Uripiv Islands

- Finfish fisheries contribute to the income and livelihood of Uri-Uripiv's people to a limited extent, due to a number of factors:
  - the relatively low market demand of the closest semi-urban centres;
  - the presence and dominance of a non-commercial system for distributing finfish among community members; and
  - the availability of alternative income and nutrition sources.

- This conclusion is reinforced by Uri-Uripiv's per capita consumption of fresh fish (the lowest of all PROCFish/C sites investigated in Vanuatu) and the low frequency of invertebrate consumption. Although the number of fishers per household is relatively high, frequency of fishing trips is low, and finfish fisheries are often halted during certain months in order to pursue agricultural activities.

- Finfish are more important for households that are dependent on fisheries as a major income source, while invertebrate fisheries play a more complementary role. As reported by fishers and supported by the data collected, two-thirds of all invertebrates harvested by Uri-Uripiv people serve subsistence needs. Subsistence fisheries target a wide range of species groups, with a preference for easily accessible areas that do not require boat transport. In contrast, commercially oriented invertebrate collection is selective as far as species are concerned and mainly targets areas that require (non-motorised) boat transport.

- The reported catch data suggest that conditions are more favourable at the outer reef than at the sheltered coastal reef. This is supported by the significantly higher CPUEs calculated for the outer reef, the shorter duration of an average fishing trip, and the relatively high contribution the outer reef makes to the total annual catch despite the smaller number of fishers targeting this habitat. However, other factors may also partly explain these differences, including the predominant use of gillnets (and handlines) at the sheltered coastal reef (rather than the handlines used at the outer reef), and the dominance of pelagic rather than reef fish at the outer reef (A high proportion of Carangidae was reported for outer-reef catches, although they are not targeted by trolling.). The dominance of reef versus pelagic fish may also explain the average finfish sizes reported, i.e. ≤32 cm from the sheltered coastal reef and 40 cm from the outer reef.

- In terms of fishing strategy, the choice between the outer and the sheltered coastal reef seems to be based on weather conditions and the availability of adequate boat transport rather than maximisation of catch (and income). This conclusion is supported by the fact that sheltered coastal reef finfish fishing was reported to be mainly pursued for income generation, while outer-reef fishing was mainly done to provide fish for the family.

- Comparison of key parameters across all PROCFish/C sites in Vanuatu reveals that fishing pressure on Uri-Uripiv's fishing grounds is moderate to high. The highest fishing pressure was found on the sheltered coastal reef, with moderate fishing pressure for the total reef and the total fishing ground area. This was expressed in terms of high fisher densities, a low annual catch rate/fisher, and high rates of total annual catch/reef area and total annual catch/fishing ground area. This picture varies slightly when the two major habitats fished by Uri-Uripiv inhabitants are compared. For instance, CPUEs are moderate for the sheltered coastal reef but relatively high for the outer reef. Similarly, the average annual catch rate per fisher is almost four times higher at the outer reef than at the sheltered coastal reef. These findings also indicate that conditions are more favourable at the outer reef. Nevertheless, overall average fish sizes, whether caught at the sheltered coastal or the outer reef, are on the small side when compared to all PROCFish/C sites in Vanuatu.

- Overall, and as would be expected from the relatively low commercial orientation, none of the fisheries or species show conspicuous signs of fishing pressure. However, the size–frequency distribution patterns that emerged from fishers' reports indicate that some species groups show reactions to past and/or existing fishing pressure. This appears to be particularly the case for *Scylla* (Most were only 6 cm in length.), *Asaphis*/*Gafrarium* catches (predominantly 6 cm in length) and *Codakia* specimens (mainly 6–8 cm in length). On the other hand, the *Terebra* specimens that determine most of the total annual catch are on average 2 cm longer than reported elsewhere (average length 12 cm).

- In view of the above observations and findings, Uri-Uripiv does not present favourable conditions for further finfish fisheries development due to the apparently relatively poor resource conditions revealed by the sheltered coastal reef catch data, in combination with the marketing limitations. It appears that the Uri-Uripiv community is mainly subsistence oriented, uses marine resources to complement both nutrition and income, and has developed into a diversified society to cope with natural and economic limitations. Community management rules are in place for invertebrates, and marine protected no-take areas apply for both fisheries. This indicates that the community is aware of its marine resource status but has also made the decision to put aside certain areas and/or decrease the intensity of its fisheries in view of the need to enact conservation measures.

- Collected information suggests that the selection of commercial invertebrate species is a result of the existing (limited) market demand at Norsup and Lakatoro, the distance to these markets and costs of transport, limitations in preservation and the existence of a regular, once-a-month visit of a boat that purchases oysters to serve clients in Noumea, New Caledonia. Community regulations concerning catch limits per trip, person and species and that aim to regulate access to the sale of crabs may further shape catch patterns. It should be remembered, however, that these regulations are not necessarily followed in detail.

- A considerable proportion of the easily accessible fishing ground around Uripiv is reserved as a no-take MPA, and a further three taboo areas are dedicated to trochus and BdM conservation. These restrictions are generally respected, prompting the following observations:
  - there is a high commitment from the community towards sustainable management and/or conservation of their marine resources; and
  - the high compliance by people from Uri-Uripiv with management restrictions (particularly given the large areas under protection and the further regulative measures in place, e.g. catch and sale limitations) may be due in part to the existence of options other than fisheries for income generation and nutrition. This view is reinforced by the fact that the complete closure of the trochus fishery (in place since 1998) is rarely violated. Tight social networking and community control help to keep violations to a minimum. The trochus fishery is scheduled to reopen in March 2005.

4.3 Finfish resource surveys: Uri and Uripiv Islands

Finfish resources and associated habitats were assessed between 17 November and 5 December 2003 from a total of 24 transects (12 sheltered coastal transects and 12 outer transects; see Figure 4.18 for transect locations and Appendix 3.3.1 for transect coordinates.).

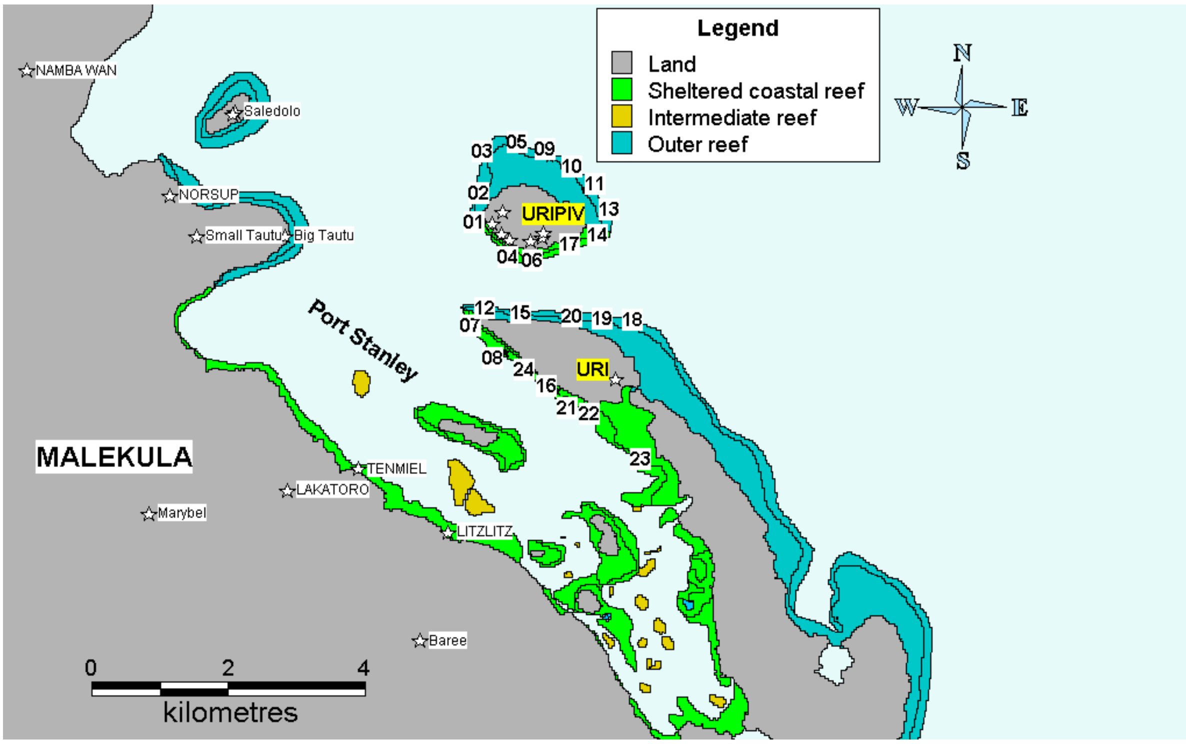

Figure 4.18: Habitat types and transects locations for finfish assessment in Uri-Uripiv.

4.3.1 Finfish assessment results: Uri and Uripiv Islands

A total of 23 families, 59 genera, 190 species and 11,690 fish were recorded in the 24 transects (See Appendix 3.3.2 for species list.). Data on the most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 15 families, 47 genera, 164 species and 10,065 individuals.

Finfish resources differed greatly between the sheltered coastal and the outer-reef habitats in Uri-Uripiv (Table 4.7). The outer reef supported more species, more fish and fish of larger size, and hence a larger biomass than the sheltered coastal reef, although the differences were substantial only for biomass (242 versus 144 g/m^2, or 1.6 times larger).

Table 4.7: Primary finfish habitat and resource parameters recorded in Uri-Uripiv (average values ±SE; range for depth)

Parameters	Habitat		
	Sheltered coastal reef (1)	Outer reef (1)	All reefs (2)
Number of transects	12	12	24
Total habitat area (km^2)	1.36	2.77	4.12
Depth (m)	3 (0-9) (3)	5 (1-10)	4 (0-10)
Soft bottom (% cover)	18 ±5	5 ±2	10
Rubble & boulders (% cover)	21 ±4	6 ±2	11
Hard bottom (% cover)	38 ±5	66 ±5	57
Live coral (% cover)	19 ±3	19 ±3	19
Soft coral (% cover)	3 ±1	3 ±1	3
Biodiversity (species/transect)	45 ±5	53 ±6	49 ±4
Density (fish/m^2)	0.58 ±0.10	0.72 ±0.10	0.67
Biomass (g/m^2)	144 ±32	242 ±47	210
Size (cm FL) (4)	19.9 ±0.6	21.2 ±0.6	20.7
Size ratio (%)	66 ±2	64 ±2	64

(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: Uri and Uripiv Islands

The sheltered coastal reef at Uri-Uripiv was dominated by herbivorous Acanthuridae and Scaridae, carnivorous Nemipteridae, Lutjanidae, Mullidae and Chaetodontidae (density only) (Figure 4.19). Those six families were represented by 87 species, with particularly high abundance and biomass of *Lutjanus fulvus, Mulloidichthys flavolineatus, L. gibbus, Acanthurus blochii, Ctenochaetus striatus, Scolopsis margaritifer, L. monostigma, Chlorurus bleekeri, Acanthurus lineatus, S. ciliatus, Chlorurus sordidus* and *Scarus psittacus* (Table 4.8). The substrate was well diversified (Table 4.7, Figure 4.19), with hard bottom predominating. Habitat complexity may partly explain the relative complexity of the fish assemblage on this reef. The relatively good live coral cover (19% on average) was accompanied by significant densities of butterflyfish (Chaetodontidae).

Table 4.8: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Uri-Uripiv

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	Ringtail surgeonfish	0.01	5.6
	Ctenochaetus striatus	Lined bristletooth	0.05	5.1
	Acanthurus lineatus	Striped surgeonfish	0.01	3.7
Scaridae	*Chlorurus bleekeri*	Bleeker's parrotfish	0.01	3.8
	Chlorurus sordidus	Bullethead parrotfish	0.02	3.0
	Scarus psittacus	Palenose parrotfish	0.02	2.9
Nemipteridae	*Scolopsis margaritifer*	Pearly monocle bream	0.02	4.3
	Scolopsis ciliatus	Saw-jawed monocle bream	0.03	3.3
Lutjanidae	*Lutjanus fulvus*	Yellow-margined seaperch	0.04	16.4
	Lutjanus gibbus	Paddletail	0.01	6.4
	Lutjanus monostigma	Onespot seaperch	0.01	3.9
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.03	7.7

The biodiversity, density and biomass of finfish resources in Uri-Uripiv's sheltered coastal reef were either similar to or greater than the other study sites in Vanuatu (Table 4.7). However, differences were small except for biomass. Both habitat and finfish community structure were very similar to the other sites (Figure 4.19). The most obvious difference between Uri-Uripiv and the remaining Vanuatu study sites was the slightly higher abundance of many species in Uri-Uripiv (Fish from the families Mullidae and Nemipteridae were more abundant in Uri-Uripiv and Acanthuridae and Lutjanidae were second in abundance compared to the other sites, but Scaridae were slightly less abundant.); this resulted in the greatest biomass of some families in Uri-Uripiv and second largest biomass of Acanthuridae and Scaridae compared to the other study sites. This general trend – of largest mean densities and biomass of some edible species and the presence of large, rare and vulnerable species in an otherwise similar habitat – may indicate that the impact from fishing in Uri-Uripiv's sheltered coastal reef is below the average recorded across PROCFish/C study sites in Vanuatu.

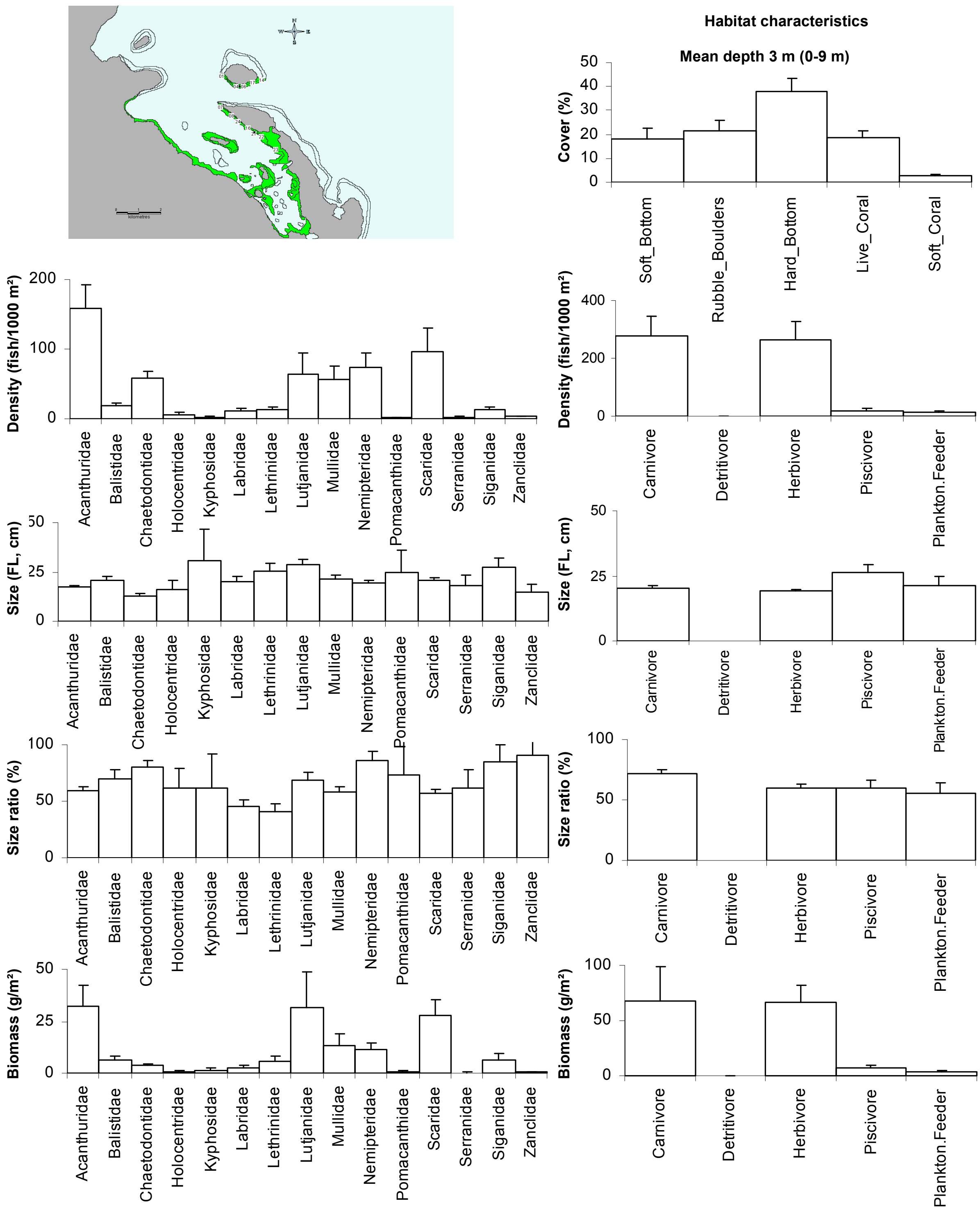

Figure 4.19: Profile of finfish resources in the sheltered coastal reef environment of Uri-Uripiv. Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Uri and Uripiv Islands

The outer-reef environment at Uri-Uripiv was largely dominated by herbivorous Acanthuridae and, to a lesser extent, by herbivorous Scaridae (Figure 4.20). These two families were represented by 37 species, with particular high abundance and biomass of *Acanthurus lineatus*, *Ctenochaetus striatus*, *Naso tuberosus*, *Acanthurus blochii*, *Hipposcarus longiceps*, *Chlorurus microrhinos*, *N. lituratus*, *Scarus psittacus*, *Chlorurus bleekeri* and *C. sordidus* (Table 4.9). As was true for the sheltered coastal reef, the rare and vulnerable bumphead parrotfish (*Bolbometopon muricatum*) ranked seventeenth in terms of biomass (4.0 g/m^2), which is a positive sign for the resource status (The species ranked only 103rd in density and hence is not included in Table 4.9.). Substrate was essentially characterised by hard bottom (66% cover), which, in combination with the direct oceanic influence found in outer reefs, may explain the dominance of large groups of medium- to large-sized herbivorous fish such as *Acanthurus lineatus*, *A. blochii*, *Naso tuberosus* and *N. lituratus*. The relatively good live coral cover (19% on average) was accompanied by significant densities of butterflyfish (Chaetodontidae).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Lined bristletooth	0.14	14.1
	Naso tuberosus	Humpnose unicornfish	0.01	12.3
	Acanthurus blochii	Ringtail surgeonfish	0.02	10.6
	Naso lituratus	Orangespine unicornfish	0.02	6.5
	Acanthurus lineatus	Striped surgeonfish	0.09	3.5
Scaridae	*Hipposcarus longiceps*	Pacific longnose parrotfish	0.01	8.7
	Chlorurus microrhinos	Steephead parrotfish	0.01	8.7
	Scarus psittacus	Palenose parrotfish	0.02	5.9
	Chlorurus bleekeri	Bleeker's parrotfish	0.01	2.7
	Chlorurus sordidus	Bullethead parrotfish	0.01	1.8

The density, size and biomass of the finfish resources in the outer reef of Uri-Uripiv were similar to or greater than the other study sites in Vanuatu (Table 4.7); average biodiversity (53 ±6 species/transect) was the greatest among all reefs surveyed. The substrate was dominated by hard bottom, which is a habitat well suited to herbivorous fish, particularly Acanthuridae and Scaridae. Despite the similar habitat, abundance of Acanthuridae in the Uri-Uripiv outer reef was slightly higher, except for Maskelyne Archipelago, and carnivorous fish were more abundant (Lethrinidae and Nemipteridae in particular) (Figure 4.20). These factors resulted in Uri-Uripiv rating second highest among the four sites for all resource parameters (Table 4.7). As was true in Uri-Uripiv's sheltered coastal reef, a general trend towards greater mean densities and biomass of edible species, and the presence of large, rare and vulnerable species in an otherwise similar habitat, may indicate that impact from fishing in Uri-Uripiv's outer reef is lower than in the other study sites in Vanuatu.

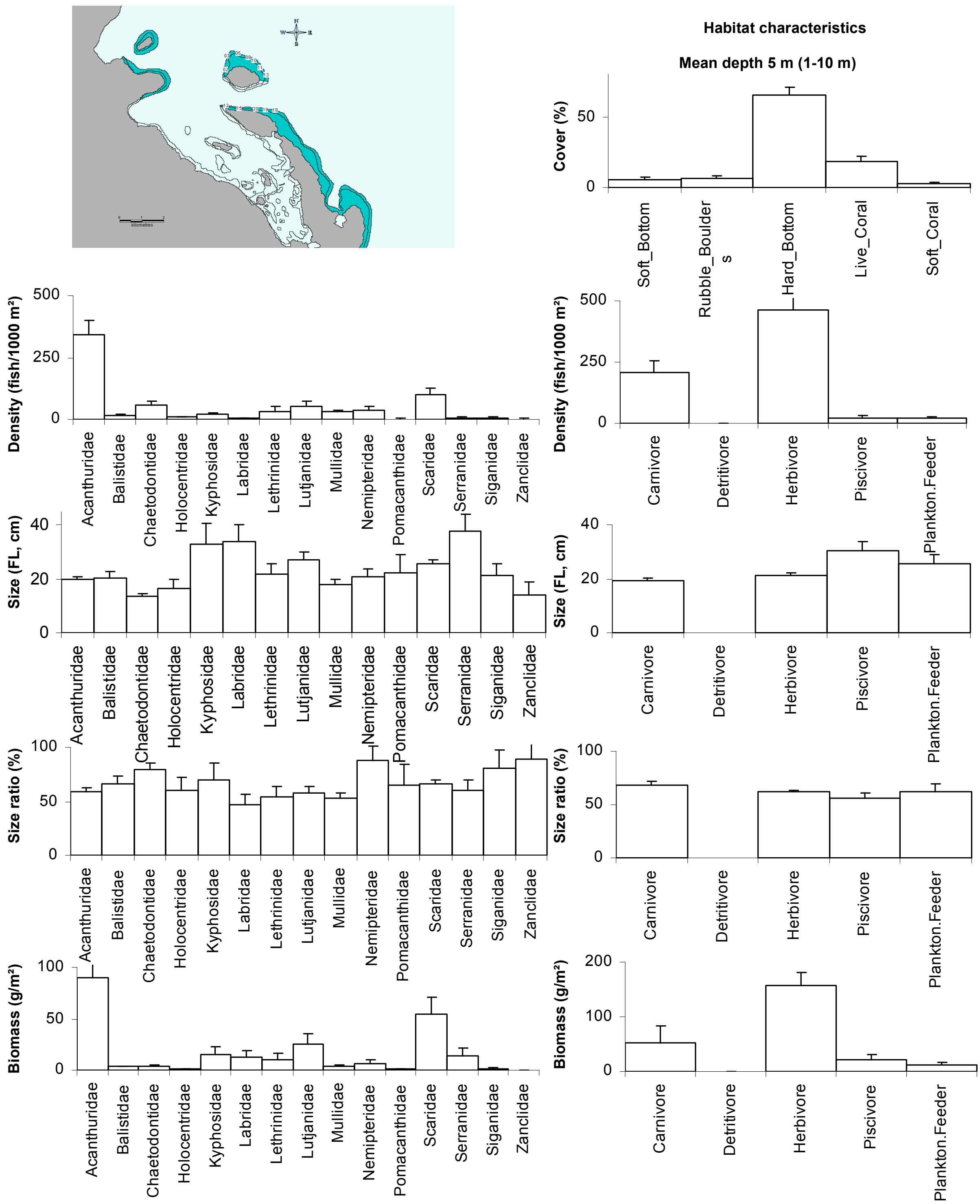

Figure 4.20: Profile of finfish resources in the outer-reef environment of Uri-Uripiv.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Uri and Uripiv Islands

The overall fish assemblage in Uri-Uripiv comprised two main families, Acanthuridae and Scaridae, with Chaetodontidae ranking third in density. Other carnivorous species were well represented, in particular Lutjanidae, Nemipteridae, Mullidae and Lethrinidae (Figure 4.21). Acanthuridae and Scaridae were represented by a total of 44 species, dominated in terms of density and biomass by *Acanthurus lineatus*, *Ctenochaetus striatus*, *Acanthurus blochii*, *Naso tuberosus*, *Hipposcarus longiceps*, *Naso lituratus* and *Scarus psittacus* (Table 4.10). Bumphead parrotfish (*Bolbometopon muricatum*) ranked tenth (among all Scaridae and Acanthuridae) in terms of biomass (4.24 g/m^2). As expected, the overall fish assemblage in Uri-Uripiv more closely resembled that recorded in the outer reef (67% of habitat) than in the sheltered coastal reef (33% of habitat).

Table 4.10: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Uri-Uripiv (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus lineatus*	Striped surgeonfish	0.07	22.3
	Ctenochaetus striatus	Lined bristletooth	0.11	11.2
	Acanthurus blochii	Ringtail surgeonfish	0.02	8.9
	Naso tuberosus	Humpnose unicornfish	0.01	8.3
	Naso lituratus	Orangespine unicornfish	0.01	5.8
Scaridae	*Hipposcarus longiceps*	Pacific longnose parrotfish	0.01	6.1
	Scarus psittacus	Palenose parrotfish	0.02	4.9

Considering the finfish resource status at habitat level, and in view of the habitat quality (with a greater expanse of outer reef), Uri-Uripiv appears to support a slightly greater finfish resource than recorded on other study sites in Vanuatu, as recorded for the highest biodiversity (52 species/transect) and size (21 cm FL), the second highest density (0.72 fish/m^2 versus 0.91 fish/m^2 in Maskelyne Archipelago) and the second highest biomass (242 g/m^2 in Uri-Uripiv versus 320 g/m^2 in Maskelyne Archipelago) (Table 4.7). Detailed assessment at reef level suggests that this trend is linked to the naturally diverse habitat but possibly also to lower impact from fishing as compared to the other study sites in Vanuatu.

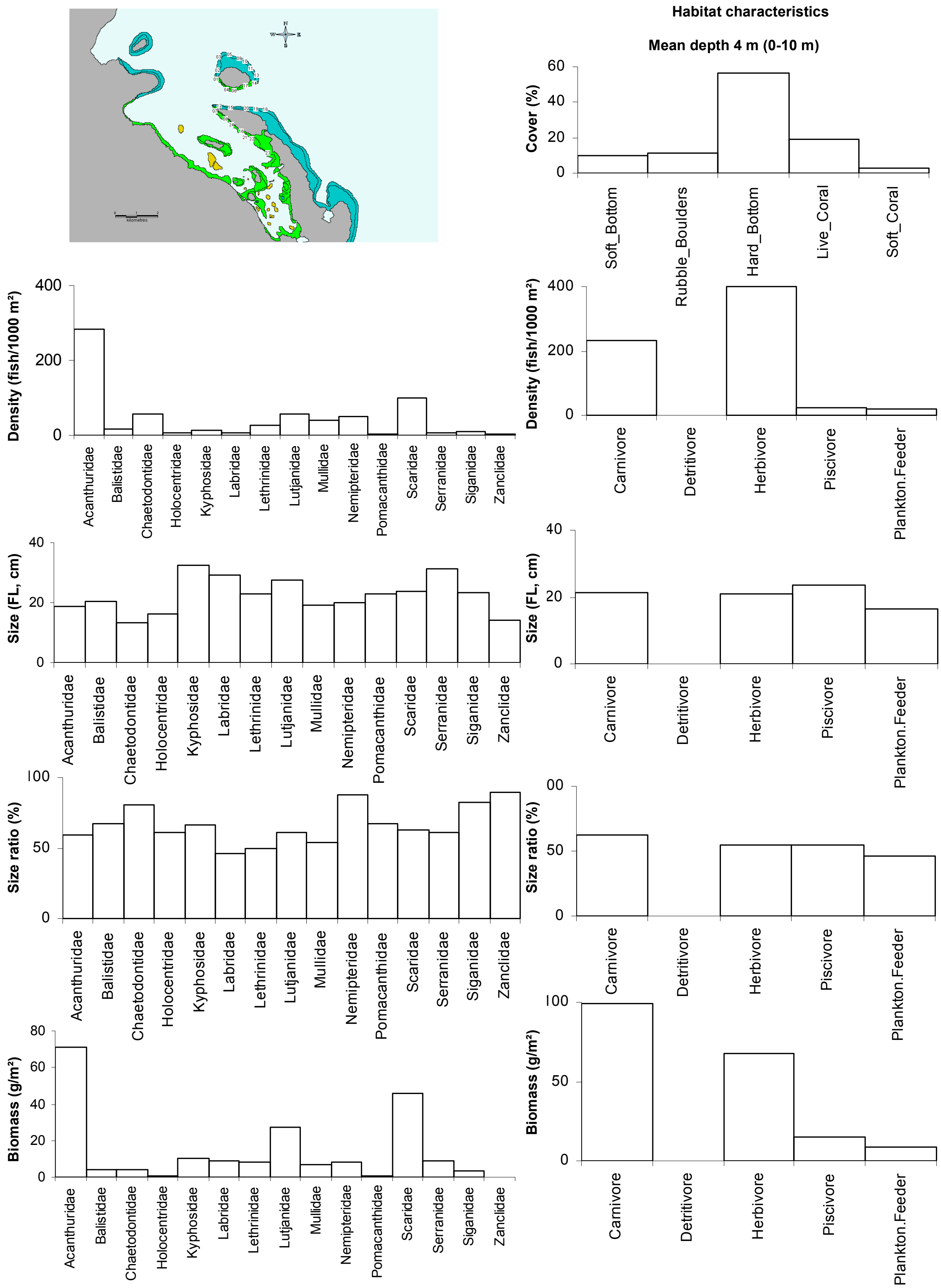

Figure 4.21: Profile of finfish resources in the combined reef habitats of Uri-Uripiv (weighted average).
FL = fork length.

4.3.4 Discussion and conclusions: finfish resources in Uri and Uripiv Islands

- The finfish resource assessment indicated that Uri-Uripiv's finfish resources were better than in the other three study sites in Vanuatu, possibly as a consequence of a better habitat in Uri-Uripiv (with the rich outer-reef environment accounting for 67% of all habitat) in combination with lower-than-average impact from fishing activities. The taboo area that includes most of the Uripiv outer reef may also have contributed to the apparent good condition of finfish resources in the area.

- Our initial analysis suggests that existing management measures are adequate to ensure sustainable use of finfish resources at the current fishing level. However, despite the good condition of the resource, reef finfish should be considered as a complementary rather than a principal source of food and/or money, as the band of reef surrounding Uri-Uripiv may be too narrow to sustain intense fishing pressure over the long term.

- In addition, easy access to offshore waters may render pelagic and deep-water finfish species particularly attractive for fishery development. The capacity of these fisheries to contribute to the food and financial security of the people of Uri-Uripiv should be investigated.

4.4 Invertebrate resource surveys: Uri and Uripiv Islands

The diversity and abundance of invertebrate species at Uri-Uripiv were independently determined using a range of survey techniques (Table 4.11), broad-scale assessments (using the 'manta tow' technique; locations shown in Figure 4.22) and finer-scale assessments of specific reef and benthic habitats (Figures 4.23 and 4.24).

Table 4.11: Number of stations and replicates completed at Uri-Uripiv

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	72 transects
Reef-benthos transects (RBt)	15	90 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	2	12 transects
Mother-of-pearl searches (MOPs)	2	12 search periods
Reef-front searches (RFs)	0	0 search period
Sea cucumber night searches (Ns)	2	12 search periods
Sea cucumber day searches (Ds)	0	0 search period

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. Then fine-scale assessments were conducted in target areas (areas with naturally higher abundance and/or the most suitable habitat) to specifically describe resource status.

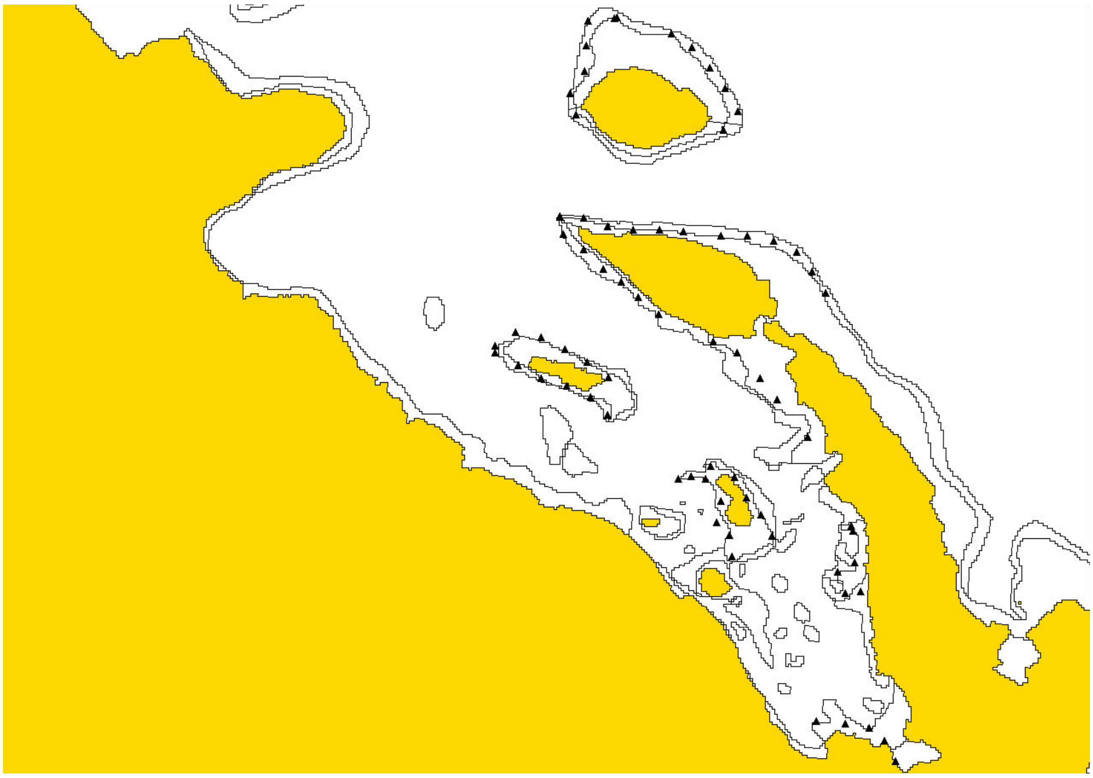

Figure 4.22: Broad-scale survey stations for invertebrates in Uri-Uripiv.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

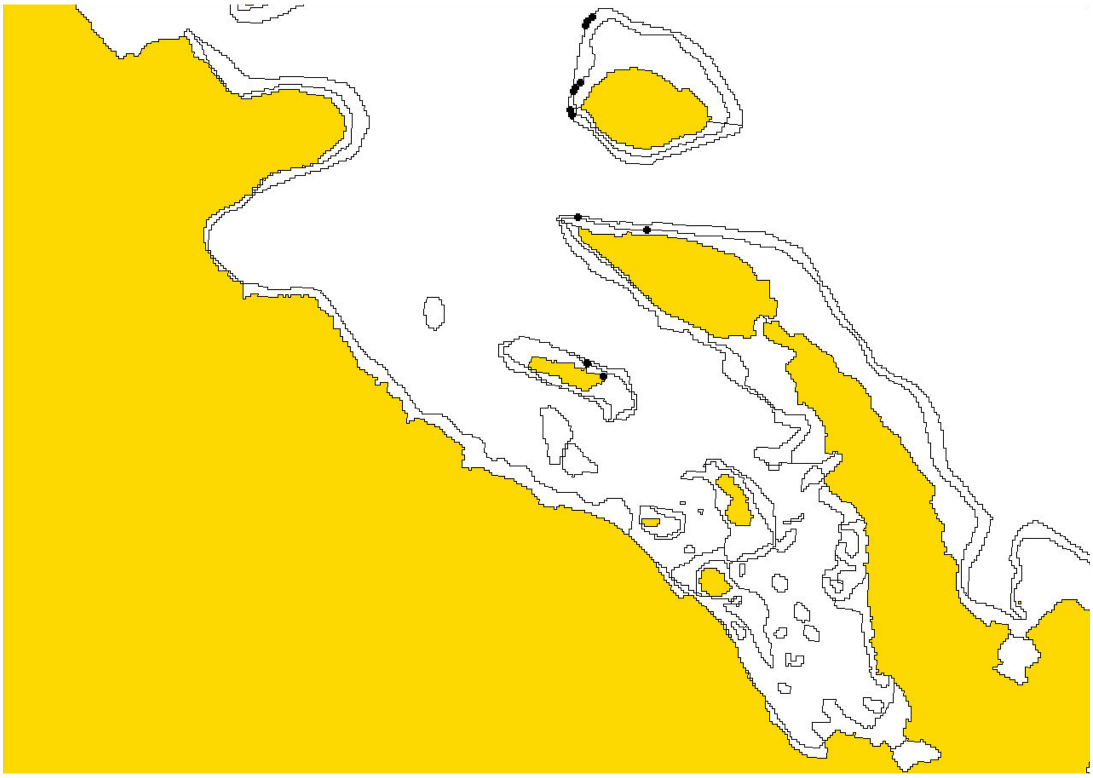

Figure 4.23: Fine-scale reef-benthos transect survey stations for invertebrates in Uri-Uripiv.
Black circles: reef-benthos transect stations (RBt).

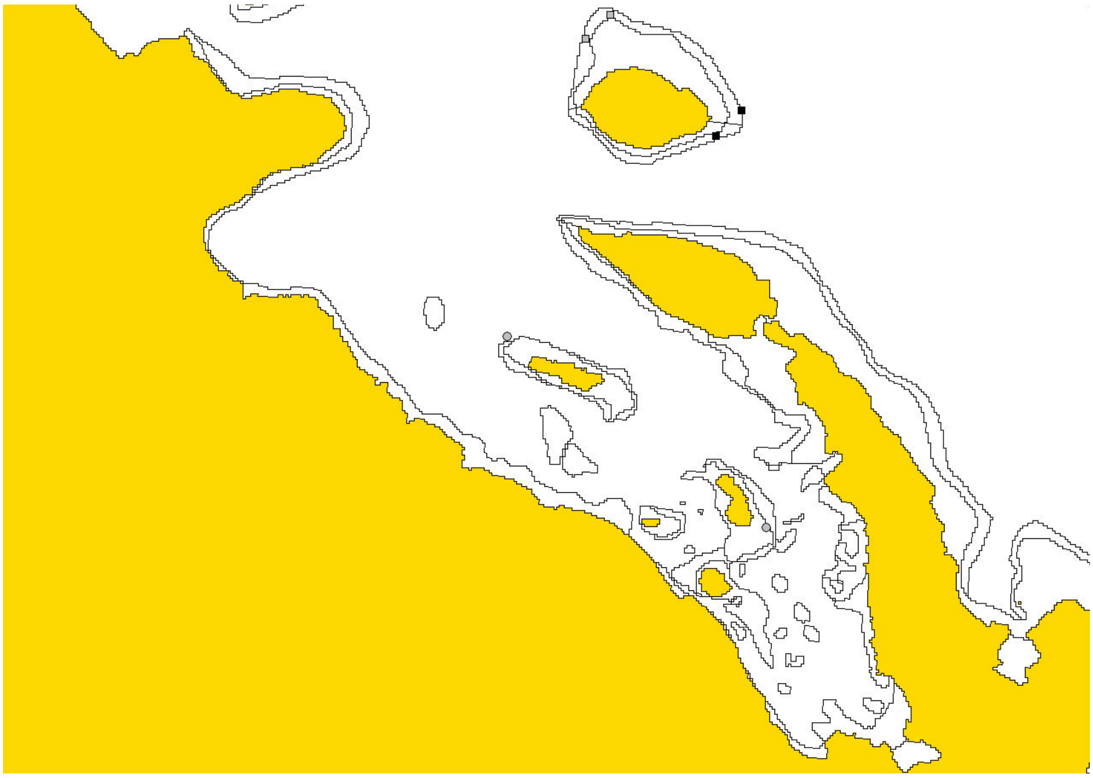

Figure 4.24: Fine-scale survey stations for invertebrates in Uri-Uripiv.
Grey circles: sea cucumber night search stations (Ns);
grey squares: mother-of-pearl search stations (MOPs);
black squares: mother-of-pearl transect stations (MOPt).

Fifty-four species (or species groups) were recorded in Uri-Uripiv invertebrate assessments, including 9 bivalves, 15 gastropods, 17 sea cucumbers, 5 urchins, 4 sea stars, 2 cnidarians and 1 lobster (For details see Appendix 4.3.1.). Information on the key families and species assessed within Uri-Uripiv is detailed below.

4.4.1 Giant clams: Uri and Uripiv Islands

Broad-scale sampling provided an overview of giant clam distribution across Uri-Uripiv's coastal environment. Shallow reef habitat (suitable for giant clams) within the area surveyed was relatively restricted (1.9 km^2) and four species of giant clam were recorded: *Tridacna crocea*, *T. maxima*, *T. squamosa* and *Hippopus hippopus*. *T. maxima* was the most common species (found in eight broad-scale stations) followed by *T. crocea* (three stations), whereas *H. hippopus* and *T. squamosa* were less common (two stations each; see Figure 4.25.).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 4.26). The elongate clam, *T. maxima*, was found within all reef-benthos transect stations, and at the highest density of all PROCFish/C sites in Vanuatu (76.19 per ha above average). In descriptive terms, in shallow-water reef areas, five elongate clams were present per 100 m × 2 m swathe. The other coral species (boring clam, *T. crocea*) was recorded at similar densities to those recorded at Paunangisu and Moso (found at three broad-scale stations in Port Stanley) but was not found in fine-scale assessments.

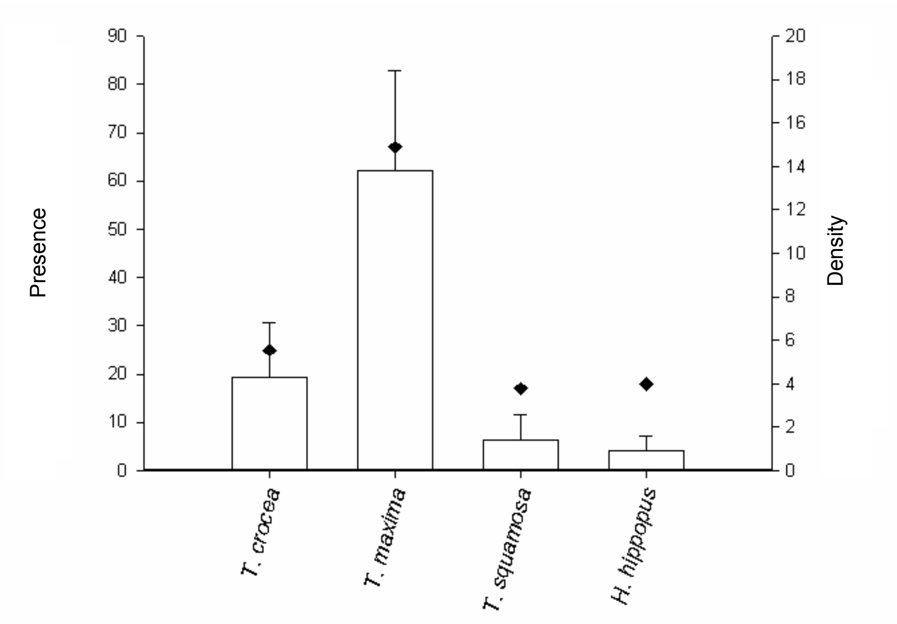

Figure 4.25: Presence and mean density of giant clam species in Uri-Uripiv based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

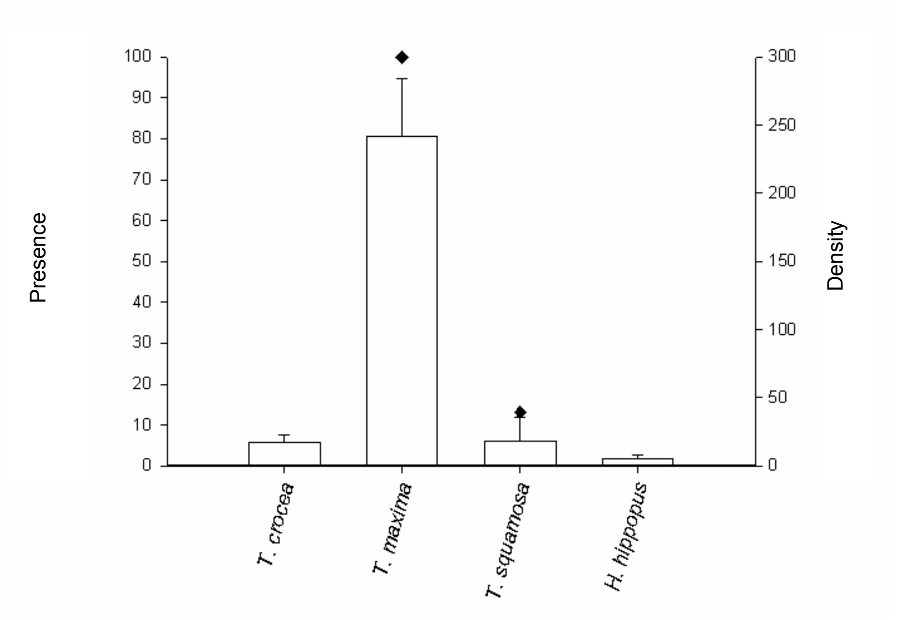

Figure 4.26: Presence and mean density of giant clam species in Uri-Uripiv based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE). *T. crocea* and *H. hippopus* density records were taken from broad-scale stations (3 and 2, respectively) as no records of these species were made during fine-scale assessments.

The larger free-standing *H. hippopus* and *T. squamosa* were not found at high density in Uri-Uripiv despite the presence of suitable conditions within Port Stanley (particularly for *H. hippopus*) and an MPA near Uri. Elsewhere, in lightly exploited areas, densities of 30–90 individuals per ha appear normal for these species (Hardy and Hardy 1969; Tarnawsky 1980). Larger clam species (i.e. *T. gigas* and *T. derasa*) were not recorded in this survey, although empty *T. gigas* shells were seen in the village, where they were used as troughs for feeding livestock. Both this and a previous study in Vanuatu (Zann and Ayling 1988, which addressed Atchin Island, Port Sandwich and the Maskelyne Archipelago) failed to record their presence and we therefore consider them commercially extinct[16] at this site.

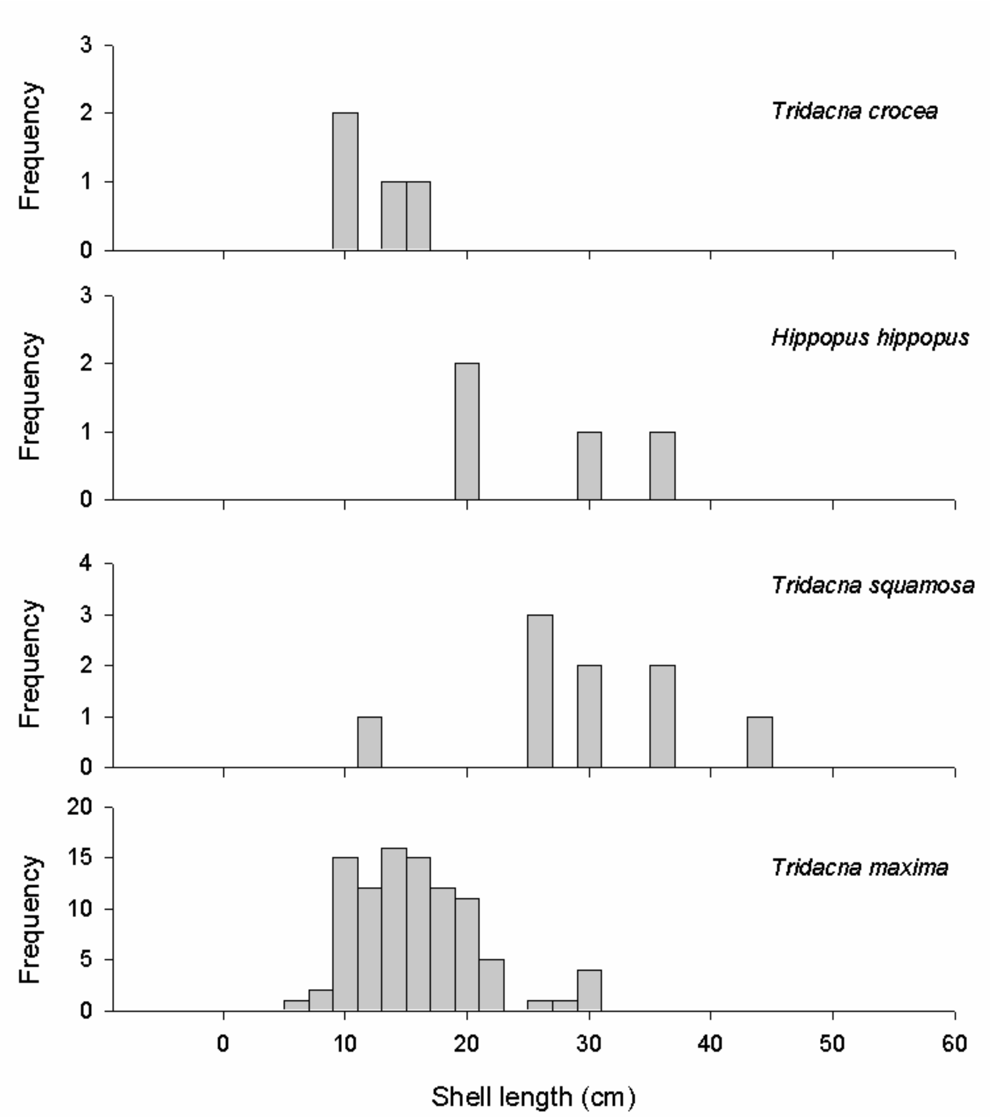

Figure 4.27: Size frequency histograms of giant clams shell length (cm) for Uri-Uripiv.

The mean length (cm ±SE) of all clams recorded was 12.2 ±1.3 for *T. crocea*, 13.6 ±0.4 for *T. maxima*, 26.5 ±3.0 for *T. squamosa*, and 26.5 ±3.9 for *H. hippopus* (Figure 4.27). Clams measured within reef-benthos assessments yielded a smaller average (*T. maxima* and *T. squamosa*, 11.6 ±0.6 and 15.5 ±0.5 cm respectively). Based on mean shell length, *T. maxima* at Uri-Uripiv had an average age of around five years (*T. maxima* asymptotic length L_∞ is approximately 30 cm). This average length was influenced by a large proportion of small clams (44% were ≤10 cm) in the recorded data, but the most common size class (mode) was ~13.0 cm shell length. The larger average length of *T. crocea* (>6 years; L_∞ = 16.5 cm),

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[16] 'Commercially extinct' refers to scarcity such that collection is not possible to service commercial or subsistence fishing, but the species is or may still be present at very low densities.

T. squamosa (5 years; L_∞ = 40 cm) and *H. hippopus* (~6 yrs; L_∞ = 40 cm) suggests stocks of clams in Uri-Uripiv are not as negatively impacted by environmental conditions or fishing pressure as are clams at other PROCFish/C sites, especially those on Efate.

4.4.2 Mother-of-pearl species (MOP): trochus and pearl oysters – Uri and Uripiv Islands

The reefs around Uripiv Island and to the north and east of Uri offer habitat for adult populations of the commercial topshell *Trochus niloticus*, including a ~13.5 km exposed reef front (linear measure). The habitat for juveniles (in the form of reef flat and extensive submerged rubble and coral) was not ideal, as reef margins are generally narrow and reef flats are uplifted with low relief (drying at low tide, without cryptic places for trochus). Despite this, the relief and complexity of submerged reef benthos were above average (See Appendix 4.3.8.), and crustose coralline algae (CCA) was a significant component of the reef cover (mean CCA of 37% on reef benthos and 50% on dedicated MOP assessments).

T. niloticus specimens were not commonly seen on the windward reef-crest areas (from observations on outer 'manta' tows), and fine-scale surveys identified limited areas where MOP was present (Table 4.12).

Table 4.12: Presence and mean density of *Turbo marmoratus*, *Tectus pyramis* and *Trochus niloticus* in Uri-Uripiv
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
Turbo marmoratus				
RBt	0	0	0/15 = 0	0/90 = 0
MOPs	0	0	0/2 = 0	0/12 = 0
MOPt	72.9	10.4	2/2 = 100	0/12 = 0
Tectus pyramis				
RBt	16.7	6.8	15/15 = 100	6/90 = 7
MOPs	8.3	8.3	2/2 = 100	2/12 = 17
MOPt	125.0	20.8	2/2 = 100	9/12 = 75
Trochus niloticus				
RBt	5.6	5.6	15/15 = 100	2/90 = 2
MOPs	4.2	n/a	2/2 = 100	1/12 = 8
MOPt	52.1	52.1	2/2 = 100	1/12 = 8

n/a: standard error not calculated; RBt = reef-benthos transect; MOPs = mother-of-pearl search; MOPt = mother-of-pearl transect.

MOP searches located just one trochus, whereas searches in other locations identified aggregations at sufficiently high abundance to warrant the use of transects (MOPt) to determine a density measure (See Appendix 1.3.). The latter areas were protected from fishing at the time of the survey, and held green snail (*Turbo marmoratus*), a valuable MOP species. Green snail is becoming increasingly rare in the Western Pacific and this remnant population was only recorded in a single reef-front area, approximately 500 m in length. This was the only record of live green snail at any of the PROCFish/C sites in Vanuatu (although many dead shells were seen in the village in the Maskelyne Archipelago). Although *T. marmoratus* was recorded in both transect stations (two station measures), trochus density was only recorded from one of the two MOPt stations (Trochus fell outside the six transects at the other station.). The maximum number of trochus per 80 m^2 transect was three individuals, which equates to a very localised density of 375 per ha.

A species closely related to trochus, the green topshell *Tectus pyramis*, was recorded in relatively high abundance at Uri-Uripiv (See Appendices 4.3.1 to 4.3.5.), indicating the suitability of the benthos for grazing gastropods. Other MOP species, such as the blacklip pearl oyster (*Pinctada margaritifera*), were found at low density (in 3 out of 12 broad-scale stations, but not in reef-benthos or MOP surveys). Coverage and density of the blacklip pearl oyster were similar to the average for all PROCFish/C sites in Vanuatu.

The range in shell sizes for MOP species was limited, and particularly so in the case of trochus. Most individuals consisted of large, older shells (trochus mean size = 13.6 ±0.3 cm, n = 7 for MOPs and MOPt). The mean size for trochus from all assessments in Uri-Uripiv was similar (13.3 cm, n = 15).

4.4.3 Infaunal species and groups: Uri and Uripiv Islands

Areas of soft benthos were found near Uri village but were very restricted, consisting only of small patches bordering channels in the mangrove. No marked shell beds were identified to allow dedicated PROCFish/C assessment of infaunal resources (SBq; see Appendix 1.3.). Digging for infaunal bivalves was mainly restricted to searching for the common Pacific asaphis, *Asaphis violascens*, which were plentiful along the high-tide line in consolidated rubble basement (stone and sand) on the east reeftop of Uripiv Island. This species requires digging around embedded stones, generally with a knife or similar tool, and does not lend itself to strip or quadrat survey.

Within the mangrove there was active fishing in soft benthos (daily during the survey period) for the lucinid bivalve *banu* (*Anodontia philippiana*; FAO name *imbao* or 'toothless lucine') along with collection of crabs (mainly land crabs, *Cardisoma* spp.). The effort required to get to areas suitable for digging and to access this infaunal stock within mangrove mud was significant (*Banu* were found at depths of up to ~1 m.), and it was therefore not practical to run quadrat surveys for *banu* (See Appendix 4.3.9.).

4.4.4 Other gastropods and bivalves: Uri and Uripiv Islands

Lambis lambis was recorded during the Uri-Uripiv reef-benthos survey, but not the larger Seba's spider conch (*L. truncata*). Other gastropods such as *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Pleuroploca*, *Turbo* spp. and *Tectus* were found on reef-benthos transects (See Appendices 4.3.1 to 4.3.5.). Port Stanley has low oceanic influence and exposure, riverine inputs and developed mangroves, resulting in filter feeders (*Atrina* spp., *Spondylus* spp., comb oysters, pearl oysters and edible oysters) being found at higher-than-average density. For broad-scale and fine-scale benthos survey data on bivalves, such as *Atrina* and *Spondylus*, see Appendices 4.3.1 to 4.3.5.

During the time of the survey, fishers made shoreline collections on the north and north-northeast reeftop of Uripiv Island. A small range of resource species was recorded, including *Asaphis violascens*, *Thais* spp., *Nerita* spp., *Acanthopleura* spp., and *Isognom* spp.; for details see Appendices 4.3.1 and 4.3.9.

4.4.5 Lobsters: Uri and Uripiv Islands

No dedicated night reef-front assessment of lobsters was made (See Appendix 1.3.). However, six lobsters (*Panulirus* spp.) were recorded, three during the broad-scale assessment (mean density 0.7 per ha, 4% of transects) and three during the two MOP transect assessments made within the fishing reserve (mean density 31.25 ±10.42 per ha, at one of two stations).

4.4.6 Sea cucumbers[17]: Uri and Uripiv Islands

Habitat suitable for sea cucumbers (reef margin and shallow, mixed hard and soft substrate) was relatively extensive in the Uripiv and Uri site, with access to large areas of sheltered lagoon, mangrove and exposed reef, totalling ~8.6 km^2. Sixteen commercial and subsistence species and one non-target species of sea cucumber were recorded during in-water assessments (Table 4.13).

The exposed outer fringing reef at Uri-Uripiv was subject to heavy swell (oceanic influence 3.9 out of 5) and was mainly hard benthos (reef and dead coral, <20% soft benthos, rubble and boulders). Within Port Stanley there was plentiful (5–6 km^2) shallow-water soft benthos (43.3%) and rubble-and-boulder habitat (31.7%). The more protected areas of Port Stanley were largely affected by influences from the land (high allochthonous input, oceanic influence 2.5 out of 5), with coral generally covered in silt, as is characteristic of inshore depositional reef environments (Visibility decreased and epiphyte levels increased the further one travelled into the semi-enclosed lagoon.).

The presence or absence and density of species were determined through broad-scale, fine-scale and dedicated survey methods (Table 4.13, Appendices 4.3.1 to 4.3.6, and 1.3). Note that no deep dives were conducted in this study, which would be required to give anecdotal advice on deep-water stocks such as the high-value white teatfish (*Holothuria fuscogilva*) and the lower-value amberfish (*Thelonata anax*).

The presence and density of valuable commercial species was moderate to high when compared with records across the four PROCFish/C sites in Vanuatu. Wave and surge zone species, such as surf redfish (*Actinopyga mauritiana*), had a greater distribution and density than the average for all PROCFish/C sites, but considering the suitable nature of the habitat outside Port Stanley, surf redfish abundance had the potential to be higher than was recorded. Within the class of species generally associated with reef, the high- to medium-value greenfish (*Stichopus chloronotus*) had a very wide distribution (on both exposed and protected reefs) and was recorded at high density. The high-value, shallow-water species black teatfish (*H. nobilis*), and the medium-value leopardfish (*Bohadschia argus*) were not plentiful, although more common than the average for all PROCFish/C sites in Vanuatu.

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

Table 4.13: Sea cucumber species records for Uri-Uripiv

Species	Common name	Commercial value [6]	B-S transects n = 72			Reef-benthos stations n = 15			Other stations MOPs = 2 MOPt = 2			Other stations Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga lecanora	Stonefish	M/H				2.8	41.7	7						
Actinopyga mauritiana	Surf redfish	M/H	4.1	29.2	14	30.6	76.4	40	29.2	58.3 83.3	50 MOPs 100 MOPt			
Actinopyga miliaris	Blackfish	M/H	1.2	20.7	6							122.2	244.4	50
Bohadschia argus	Leopardfish	M	7.1	28.3	25	2.8	41.7	7						
Bohadschia graeffei	Flowerfish	L	9.6	49.5	19	8.3	41.7	20	12.5	12.5	100 MOPs			
Bohadschia similis	False sandfish	L												
Bohadschia vitiensis	Brown sandfish	L	17.7	70.7	25									
Holothuria atra	Lollyfish	L	134.5	242.1	56	33.3	250.0	13						
Holothuria coluber	Snakefish	L										133.3	266.7	50
Holothuria edulis	Pinkfish	L	6.4	28.9	22	16.7	125.0	13	8.3	8.3	100 MOPs			
Holothuria fuscogilva [4]	White teatfish	H	None						No deep dive completed					
Holothuria fuscopunctata	Elephant trunkfish	M	0.2	16.5	1									
Holothuria nobilis [4]	Black teatfish	H	1.4	16.2	8				10.4	20.8	50 MOPt			
Holothuria scabra	Sandfish	H												
Holothuria scabra versicolor	Golden sandfish	H												
Stichopus chloronotus	Greenfish	M/H	109.8	188.3	58	852.8	852.8	100	121 197.9	121 197.9	100 MOPs 100 MOPt			
Stichopus hermanni	Curryfish	M/H	11.0	41.8	26							5.6	11.1	50
Stichopus horrens [5]	Peanutfish	M										5.6	11.1	50
Stichopus vastus	Brown curryfish	M/H	0.5	33.3	1							105.6	211.1	50
Synapta spp.	-	M/H	0.5	32.8	1									
Thelenota ananas	Prickly redfish	H	0.2	16.7	1									
Thelenota anax	Amberfish	M												

[1] D = mean density (numbers/ha); [2] DwP = mean density (numbers/ha) for transects or stations where the species was present; [3] PP = percentage presence (units where the species was found); [4] the scientific name of the black teatfish has recently changed from *Holothuria* (*Microthele*) *nobilis* to *H. whitmaei* and the white teatfish (*H. fuscogilva*) may have also changed name before this report is published. [5] Known in Fiji as 'small curry'; there is confusion over this species, which is sometimes listed under *Stichopus hermanni*. [6] L = low value; M = medium value; H= high value; B-S transects = broad-scale transects; MOPs = mother-of-pearl search; MOPt = mother-of-pearl transect; Ns = night search.

The shallow-water lagoon areas of Port Stanley held a large range of sea cucumber species (Table 4.13), including *Stichopus vastus*, a species not found at other PROCFish/C sites in Vanuatu. Stocks of medium- to high-value species (curryfish) were common and present at relatively high densities, while embayments held robust populations of blackfish (*Actinopyga miliaris*). These stocks were found in very shallow water and were easily accessible to fishers. The only species that was noticeably absent from the inshore area was sandfish (*Holothuria scabra*); this was unexpected, as the habitat in Port Stanley was well suited for this high-value species.

4.4.7 Other echinoderms: Uri and Uripiv Islands

The presence of the pencil urchin (*Heterocentrotus mammillatus*) was somewhat more common on reefs in Uri-Uripiv (10% of reef-benthos transects) than at other PROCFish/C sites, but other edible urchins (e.g. collector urchins, *Tripneustes gratilla* and *Echinothrix* spp.) were generally found at similar coverage and densities. The boring urchin (*Echinometra mathei*) was somewhat more common, and was recorded in 14 of 15 reef-benthos stations at a mean density of 3994 per ha ±1008.

Starfish such as crown of thorns (*Acanthaster planci*) were rare (found in one of 12 broad-scale stations, and two transects) and none were recorded in reef-benthos stations. No bleached coral was detected.

4.4.8 Discussion and conclusions: invertebrate resources in Uri and Uripiv Islands

- Resources taken by reef gleaners were generally present at a greater number of stations and at higher densities than the average for PROCFish/C sites in Vanuatu. Infaunal shell beds within the mangrove area were not well assessed by PROCFish/C resource assessments, but anecdotal evidence suggested that these were impacted by fishing.

- The density and size range of clams at Uri-Uripiv indicate an impacted or marginally impacted resource. *T. maxima*, the most common species, was well distributed within Uri-Uripiv reefs, but the lack of significant numbers of larger clams in the size distribution suggests a fisheries-related impact. Although the large species of clams (*H. hippopus* and *T. squamosa*) are generally found at lower densities in surveys, fishing pressure was the most likely cause for the rarity of these species. *T. crocea* stocks appear to be only marginally impacted by fishing pressure or environmental conditions, although the density of these clams was not high.

- Species important in the MOP fishery (trochus, *Pinctada margaritifera* and green snail, *Turbo marmoratus*) were present in Uri-Uripiv, but at low densities and mainly restricted to a single location that was protected from fishing. Despite the low density of green snail, the remnant population identified by the assessments is important, as *T. marmoratus* is now rare in Melanesia due to overfishing. The green snail recorded within the Uripiv MPA was the only record of this species from the four PROCFish/C sites surveyed. There is a need for urgent management intervention to protect the MOP fishery, especially for trochus and green snail.

- Despite searching with divers from Uripiv village and targeting the best areas for trochus (including those protected from fishing), the abundance and density of this species was low (Commercial harvest of trochus is generally not recommended at densities of less than 500–600 per ha from suitable habitat[18].). Finding only a small number of adult trochus and *T. marmoratus*, but reasonably high numbers and recruitment of a related but low-value species (*Tectus pyramis*), suggests that fishing pressure is the most likely explanation for the poor status of commercial stocks. The restricted distribution of commercial stocks and the absence of juvenile trochus (a sign that there is no recruitment) further support this assumption.

- On a more positive note, the moderate densities of MOP that remain at Uripiv are testament to the effectiveness of customary reef management, which has preserved remnant stocks; in the few instances where these species were recorded, it was generally in the area at Uripiv Island that is protected from fishing. In addition, resource owners should be made aware of current harvest strategies and yields for MOP species elsewhere in the Pacific (Appendix 4.5.1).

- Sea cucumber stocks were found to generally be in good condition; there was relatively high coverage and abundance of valuable species at Uri-Uripiv, and the resource is judged to be lightly impacted or impacted by fishing (or generally recovered from past fishing activity). There was effective customary management in the form of a fishery closure between harvest periods, although some harvesting by commercial fishers from outside the community had taken place in the recent past. Advice should be sought by local resource owners prior to the opening of the fishery, both on fishing options and to ensure that post-harvest processing maximises returns to the community. Sandfish (*Holothuria scabra*) was not found and future surveys should concentrate on further assessing the area to see if this species can be located in Port Stanley.

- Customary reef management provisions, which close areas to fishing and limit the collection and sale of resources, were observed during the period we spent at the site, but the positive influence of these controls was generally limited to localised areas (Large clams were found at elevated abundance in protected areas within Port Stanley.).

4.5 Overall recommendations for Uri and Uripiv Islands

Based on the survey work undertaken and the assessments made across all three disciplines (socioeconomics, finfish and invertebrates), the following recommendations are made for Uri and Uripiv islands' fishing area:

- Initial analysis suggests that existing management measures are adequate to ensure sustainable use of finfish resources at the current fishing level.

- Despite the good condition of the resource, reef finfish should be considered as a complementary rather than principal source of food and/or money, as the band of reef surrounding Uri-Uripiv may be too narrow to sustain intense fishing pressure over the long term.

- Easy access to offshore waters may render pelagic and deep-water finfish species particularly attractive for fishery development. The capacity of these fisheries to

[18] See Appendix 4.5.

contribute to the food and financial security of the people of Uri-Uripiv should be investigated.

- Resource owners should be made aware of current harvest strategies and yields for mother-of-pearl species elsewhere in the Pacific.

- Advice should be sought by local resource owners prior to the opening of the sea cucumber fishery, both on fishing options and to ensure that post-harvest processing maximises returns to the community.

- Sandfish (*Holothuria scabra*) was not found and future surveys should concentrate on further assessing the area to see if this species can be located in Port Stanley.

5. PROFILE AND RESULTS FOR THE MASKELYNE ARCHIPELAGO

5.1 Site characteristics

The Maskelyne Archipelago (Figure 5.1) comprises a group of small, relatively isolated islands located off the southeast tip of Malakula Island in the Malampa province, approximately 40 minutes by boat from Point Doucere landing (which is 7 km from Lamap airstrip). Only two islands in the archipelago are inhabited: Uliveo and Avokh. The largest island, Uliveo, supports a population of 1058 in three villages (Pellonk with 48 households, Peskarus with 99 households and Lutes with 35 households).

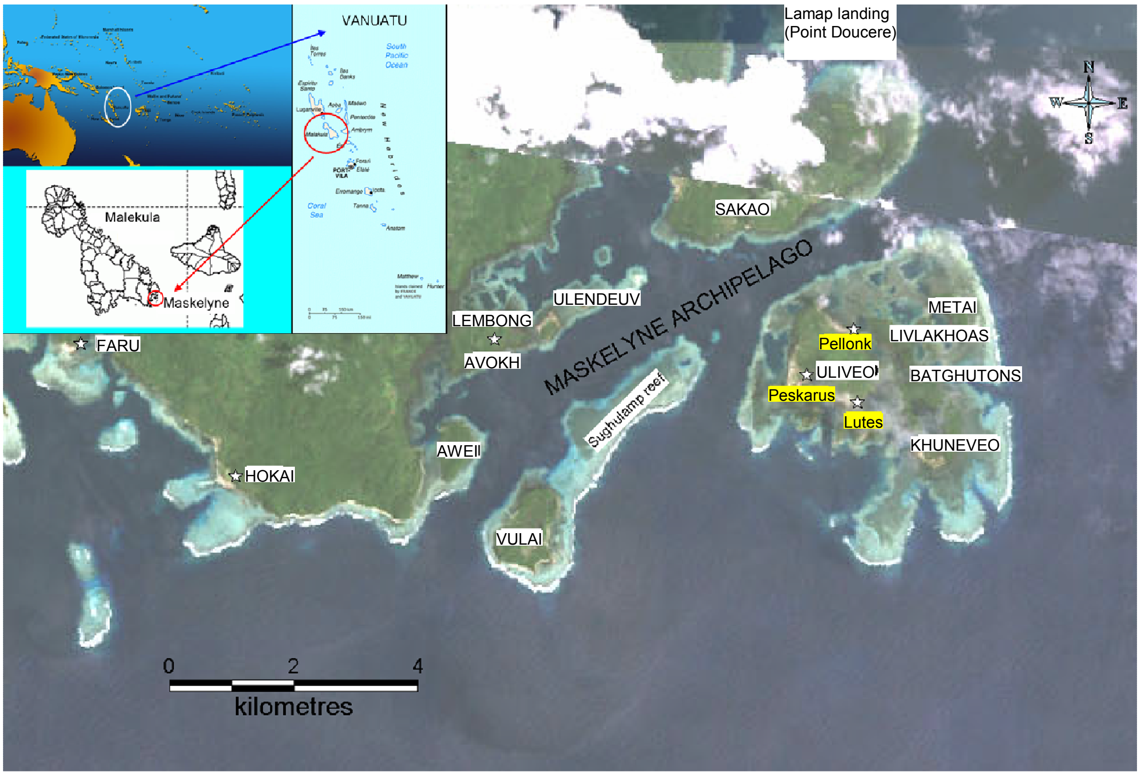

Figure 5.1: Location of the Maskelyne Archipelago.

The traditional structure of customary marine tenure (CMT) persists to varying degrees in contemporary Vanuatu, and is still strong in the Maskelyne Archipelago. Marine tenure is exercised at family and clan levels and increasingly at community level, with members of the community referring to a 'loose arrangements of clans' (MRAG 1999b).

The situation in the Maskelyne Archipelago mirrors what is happening more broadly in Vanuatu. The three villages on Uliveo have clearly demarcated reef areas and members of each village share access to their village's reef area for subsistence purposes, as is common in Vanuatu (MRAG 1999b). In addition, it was reported to the survey team during village meetings that, upon request, access was also granted to members of all other communities. This is supported by previous surveys (MRAG 1999a), which also indicated that the use of particular fishing grounds was determined predominantly by issues related to physical access and weather conditions (i.e. whether the shore was to windward or leeward, and the distance of the fishing ground from a village) and not by clan membership.

Management of marine resources on Uliveo Island is now more focused at communal rather than clan level, and authority rests with the village chiefs, with the support of the village councils. The Maskelyne Island Council of Chiefs (which includes Uliveo, Avok, Hokai and Sakau) jointly regulates, for all villages, those resources that require broader-scale management measures. While CMT is constitutionally recognised, the local provincial authority also enforces some controls on operators and has a say in activities in provincial waters. In addition, the Fisheries Act spells out resource management measures enforced by the national Fisheries Department.

The evolution of community-based MRM in Vanuatu has been documented over the last decade and more than 80 communities are now reported to be engaged in it (Govan 2004). According to Johannes and Hickey (2004), in a report comparing marine management measures in place across more than 25 villages in Vanuatu, the three Maskelyne villages surveyed (Peskarus, Lutes and Pellonk) had more than twice as many MRM measures (Table 5.1), covering various resources and/or activities, than the average for all villages surveyed.

Table 5.1: Community-based marine management measures in place in the Maskelyne Archipelago

Village	Trochus	Closures	Turtle	BdM	Spear fishing	Nets use	MPA	Giant clams	Crabs
Peskarus	X	X	X	X	X	X	X	X	X
Lutes	X	X	X	X	X	X			X
Pellonk	X	X			X	X	X	X	X

BdM = bêche-de-mer; MPA = marine protected area; source: Johannes and Hickey 2004.

All villages restrict the use of nets and spear night diving from September to March every year (a six-month seasonal closure), and have also recently introduced an annual quota for sea turtles. Sakau and the adjacent mainland are not covered by these restrictions. There is also a no-take MPA in front of Pellonk and Peskarus villages. In the case of Pellonk the MPA has been in place for over a decade and is reported to be strictly enforced. There are also bans on harvesting of trochus, bêche-de-mer, giant clam species and crabs.

In addition, the Fisheries Act includes regulations on size limits for shellfish and crustaceans, no-take of gravid crustaceans (those with egg masses), harvest and export quotas for some products and in some cases requirements for licences and permits.

The fishing grounds of Uliveo's three villages cover a total area of about 38 km^2, including 20 km^2 of reef (Figure 5.2). A sheltered coastal reef lies along the northern coast of Uliveo, the southern and western coasts of Sakao and around Avokh Island. An extensive reef exposed to oceanic influence extends along the rest of the coast of the archipelago, in particular around most of Uliveo, the east coast of Sakao and along Vulai (Sughulamp reef). There are also some small patch reefs at the tip of Sughulamp reef and off the south coast of Sakao. The reefs of Uliveo's three villages are highly dominated by outer reef (16.20 km^2, 80% of habitat) and include 4.05 km^2 (20%) of sheltered coastal reef and 0.09 km^2 (<0.4%) of lagoon intermediate reef.

Stands of mangrove separate the village of Pellonk from the extensive lagoon. Mangrove also predominates around the small islands in the lagoon (Livlakhoas and Metai) and to the west to Lutes village. The lagoon drains through the passage between Uliveo and Sakao Islands. All the passages (Uliveo, Sakao and between Sakao and Malekula) are very dynamic, with strong tidal movement.

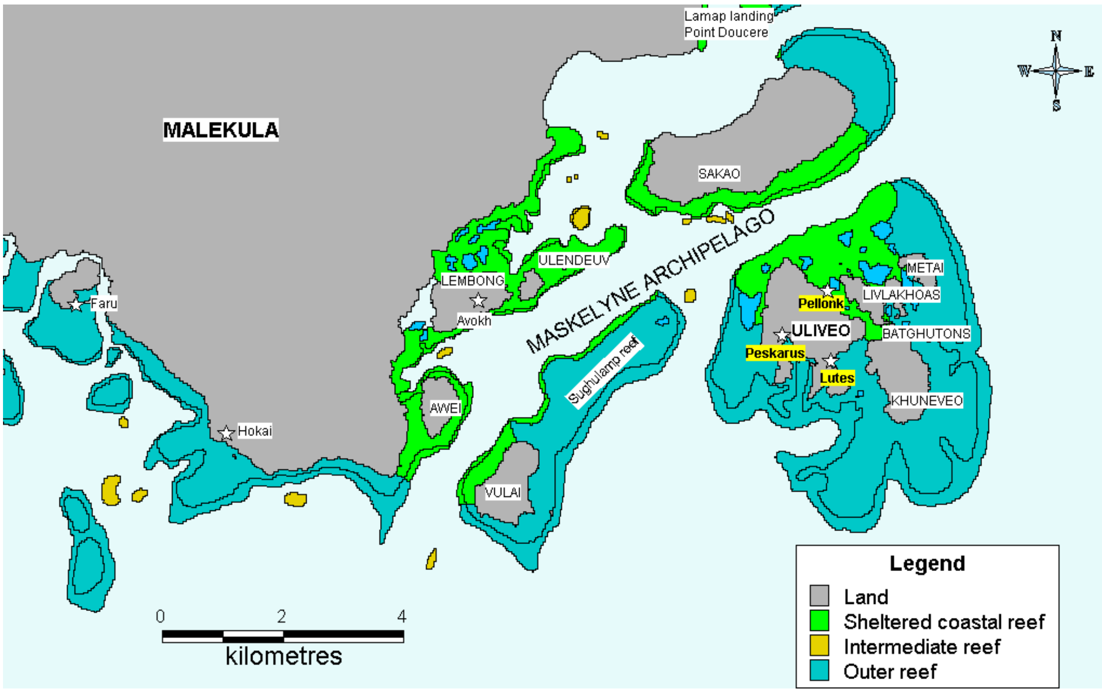

Figure 5.2: Main reef structures in the Maskelyne Archipelago.

5.2 Socioeconomic survey: Maskelyne Archipelago

The largest island of the Maskelyne Archipelago, Uliveo, supports a population of 1058 in three villages: Pellonk (48 households), Peskarus (99 households) and Lutes (35 households). The survey covered 31 out of 182 households (17%), with greatest emphasis on Pellonk village, where 21 households (44%) were sampled; complementary sampling was conducted in Lutes (five households, 14%) and Peskarus (five households, 5%). In addition, 29 individual finfish fishers interviews (22 males, 7 females) and 32 invertebrate fisher interviews (18 males, 14 females) were conducted. In some cases the same person was interviewed as both a finfish and invertebrate fisher.

As described in the overview, the inhabitants of Uliveo's three villages share a fishing ground, which covers an area of about 38 km^2, including 20 km^2 of reef (Figure 5.2). The traditional structure of CMT is still strong in the Maskelyne Archipelago. The three villages have clearly demarcated reef areas. Each village shares access to the village reef area for subsistence purposes, a practice common in Vanuatu. Management of resources on the island is at the communal rather than clan level and rests with the village chiefs, with the support of the individual village councils and the Maskelyne Island Council of Chiefs (which includes Uliveo, Avok, Hokai and Sakau).

5.2.1 The role of fisheries in the Maskelyne Archipelago community: fishery demographics, income and seafood consumption patterns

Virtually all households (99.8% of those surveyed) were involved in reef fisheries, with active fishers representing more than half the total surveyed population (59%). Survey results indicated an average of five people and 3.3 (±0.34) adult fishers per household, with 49% of males fishing for finfish and/or invertebrates (1.6 per household) and 51% of females fishing for finfish and/or invertebrates (1.7 per household). When extrapolated to the entire population (182 households) this result suggests a total of about 593 fishers in Uliveo, with 288 male fishers and 305 female fishers.

While fisheries play a prominent role as a secondary income source (60% of households surveyed), agriculture was the most important income source for almost all households surveyed (primary income source for 90%, second-ranked source for 10%). Fisheries were ranked as the primary source by just one household (Figure 5.3). The contribution of salaries was reported as marginal. However, other income sources (handicrafts – mat weaving in particular) represented the second most important income source for about 16% of households. About half (54%) of the households surveyed reported that they received remittances, most of which came from within Vanuatu (i.e. family members working in an urban centre, generally Port Vila). The average annual amount received from external sources (103 ±31.26 USD) was reported to meet about one-quarter (25%) of average annual household expenditures (419 ±87.86 USD).

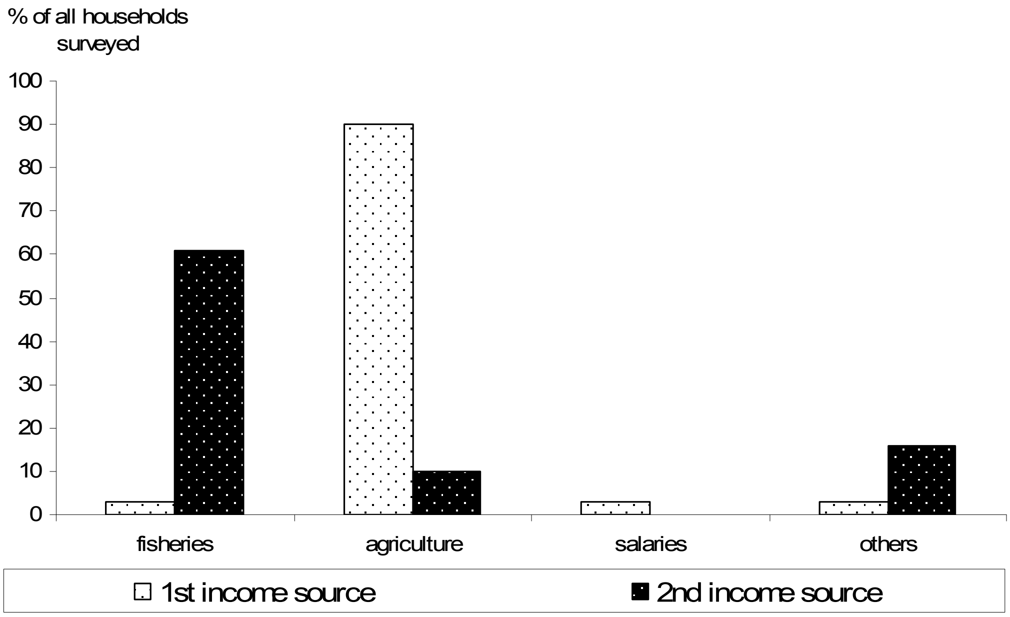

Figure 5.3: Ranked sources of income (%) in the Maskelyne Archipelago.
Total number of households = 31 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.
'Others' are mostly handicrafts and private businesses.

Data on seafood consumption indicated that most seafood consumed in the Maskelyne Archipelago was fresh and caught by a member of the household where it was consumed. Average annual per capita fresh fish consumption (22.2 kg) among survey respondents was slightly higher than the reported national average of 20.8 kg (consumption ranged from 15.9 to 25.7 kg), and was the highest among all PROCFish/C sites in Vanuatu (Figure 5.4). Frequency and quantity of canned fish consumption were low (~0.5 times/week; 1.6 kg/capita/year). Invertebrates were consumed frequently (~2 times/week).

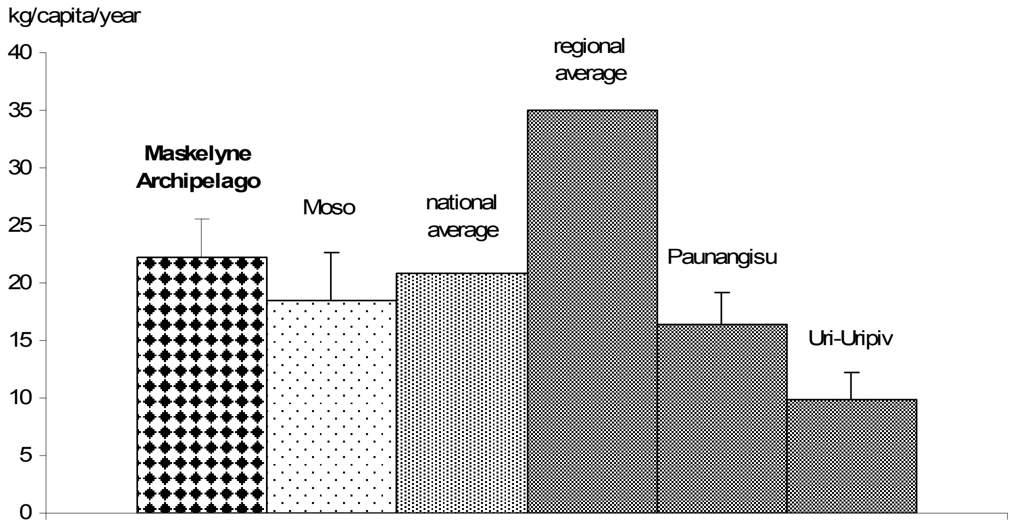

Figure 5.4: Per capita consumption (kg/year) of fresh fish in the Maskelyne Archipelago (n = 31) compared to national and regional averages (FAO 2002) and other three PROCFish/C sites in Vanuatu.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

When compared with other PROCFish/C sites in Vanuatu with respect to a number of parameters that characterise the importance of reef fisheries to the community, the Maskelyne Archipelago rates above average for many (Table 5.2); these include number of fishers per household, number of households with boat(s), and frequency and amount of fresh fish and invertebrates consumed. Conversely, the Maskelyne Archipelago rates well below the average for PROCFish/C sites in Vanuatu with respect to other parameters, including fisheries as primary income, average household expenditure, and frequency and amount of canned fish consumed. These observations suggest that the lifestyle of the inhabitants of the Maskelyne Archipelago remains mainly subsistence oriented, i.e. they have low cash expenditures and are highly dependent on fisheries for their subsistence needs, with virtually the entire population relying to some extent on fishing for food security.

Table 5.2: Fishery demography, income and seafood consumption patterns in the Maskelyne Archipelago

Survey coverage	Maskelyne Archipelago (n = 31 HH)	Average across sites (n = 124 HH)
Demography		
HH involved in reef fisheries (%)	100	97
Number of fishers per HH	3.26 (±0.34)	2.68 (±0.15)
Male finfish fishers per HH (%)	5.9	21.1
Female finfish fishers per HH (%)	2.0	3.0
Male invertebrate fishers per HH (%)	0	1.2
Female invertebrate fishers per HH (%)	16.8	19.3
Male finfish and invertebrate fishers per HH (%)	42.6	32.2
Female finfish and invertebrate fishers per HH (%)	32.7	23.2
Income		
HH with fisheries as 1st income (%)	3	22
HH with fisheries as 2nd income (%)	61	39
HH with agriculture as 1st income (%)	90	58
HH with agriculture as 2nd income (%)	10	26
HH with salary as 1st income (%)	3	10
HH with salary as 2nd income (%)	0	3
HH with other source as 1st income (%)	3	11
HH with other source as 2nd income (%)	16	13
Expenditure (USD/year/HH)	419 (±87.86)	864 (±72.93)
Remittance (USD/year/HH) (1)	103 (±31.26)	120 (±28.44)
Seafood consumption		
Quantity fresh fish consumed (kg/capita/year)	22.16 (±3.39)	16.8 (±1.60)
Frequency fresh fish consumed (time/week)	3.08 (±0.30)	1.90 (±0.14)
Quantity fresh invertebrate consumed (kg/capita/year)	n/a	n/a
Frequency fresh invertebrate consumed (time/week)	1.67 (±0.19)	1.15 (±0.11)
Quantity canned fish consumed (kg/capita/year)	1.58 (±0.48)	9.04 (±1.24)
Frequency canned fish consumed (time/week)	0.58 (±0.24)	2.12 (±0.20)
HH eat fresh fish (%)	100	100
HH eat invertebrates (%)	97	85
HH eat canned fish (%)	94	94
HH eat fresh fish they catch (%)	100	100
HH eat fresh fish they buy (%)	32	32
HH eat fresh fish they are given (%)	55	55
HH eat fresh invertebrates they catch (%)	90	90
HH eat fresh invertebrates they buy (%)	0	0
HH eat fresh invertebrates they are given (%)	7	7

HH = household; n/a = no information available; (1) average sum for households that receive remittances; numbers in brackets are standard error.

5.2.2 Fishing strategies and gear: Maskelyne Archipelago

Compliance with community regulations was reported to be high. This applied in particular to the strictly enforced no-take MPA in front of Peskarus and the six-month seasonal ban on commercial finfish fishing and invertebrate collection (with the exemption of invertebrate fisheries in mangrove areas). Compliance with the total ban on trochus and bêche-de-mer harvest was also high, although exemptions were made based on the fact that some of the reefs are owned by clans rather than by the community. While size limits and other rules imposed by governmental regulations are known, they may not always be followed, particularly if fishing is not for commercial purposes.

Degree of specialisation in fishing

Households surveyed indicated that both male and female fishers in the Maskelyne Archipelago were mostly generalists, fishing both invertebrates and finfish (86% of reported male fishers, 60% of reported female fishers) (Figure 5.5). Specialisation in invertebrate harvesting was more common for females (34% of reported female fishers) while specialisation in finfish fishing was rare for both males (7%) and females (3%).

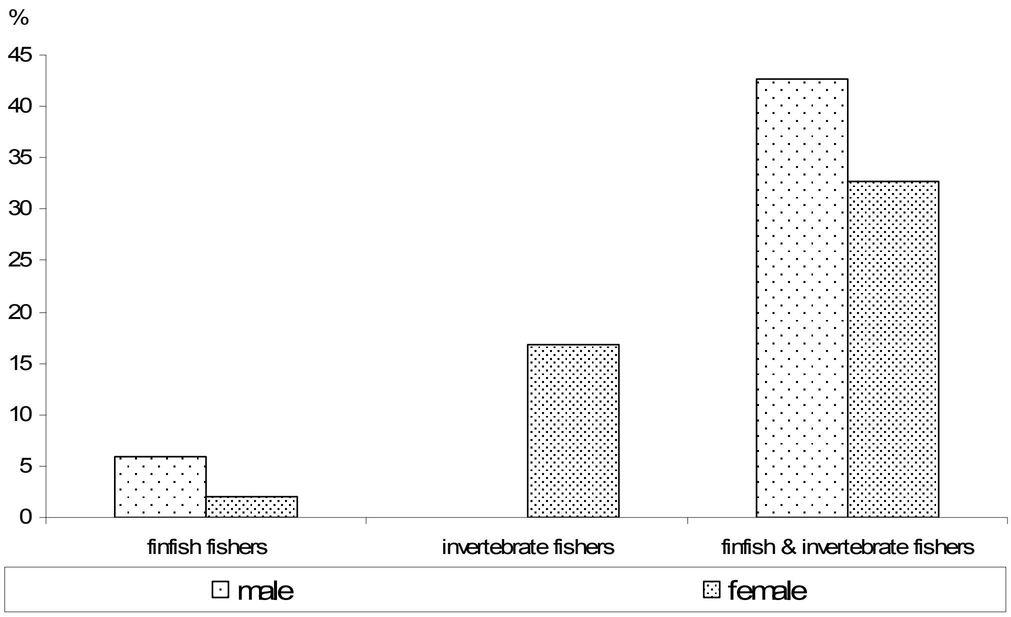

Figure 5.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in the Maskelyne Archipelago.
All fishers = 100%.

Fishing strategies

All (100%) male and female fishers interviewed reported using a boat for fishing, generally a paddling or a sailing canoe. This result was reinforced by the data collected during the household survey, with virtually all households (97% of those interviewed) reporting having one or more boats. Data indicated 1.7 boats per household (±0.16) on average, most of which (96%) were dugout canoes. There were only two motorised boats in Uliveo and these were primarily used for transport rather than fishing.

Targeted stocks/habitats

Subsistence fishers in the Maskelyne Archipelago benefit from a wide range of habitats, but there are also species-specific small-scale commercial fisheries practised that target the entire range of habitats (Table 5.3).

Table 5.3: Proportion of interviewed finfish fishers and invertebrate fishers harvesting the various finfish and invertebrate stocks across a range of habitats in the Maskelyne Archipelago

Resource	Habitat	% male fishers interviewed	% female fishers interviewed
Finfish	Sheltered coastal reef	86	86
	Outer reef	36	14
Invertebrates	Mangrove	78	93
	Reeftop	44	79
	Soft benthos	50	93
	Soft benthos and mangrove [1]	0	7
	MOP (commercial trochus fishery)	83	0

[1] Combined in one fishing trip.
Finfish fisher interviews, males: n = 22; females: n = 7. Invertebrate fisher interviews, males: n = 18; females, n = 14.

Most invertebrate fishers (85%) pursue gleaning activities, with mangrove environments targeted most frequently, followed by soft-benthos and reeftop habitats. Free diving is undertaken by 14% of fishers, and only to harvest MOP (Figure 5.6).

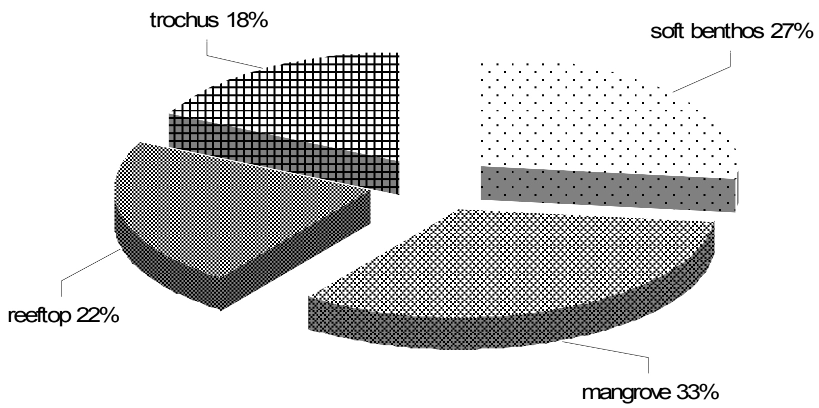

Figure 5.6: Proportion (%) of fishers targeting the four primary invertebrate habitats found in the Maskelyne Archipelago.
Data based on individual fisher surveys; data for combined fisheries are disaggregated.

Gear

Most finfish fishers used more than one technique (Figure 5.7), although not necessarily during a single fishing trip. Handlines are used by all and are generally the dominant method in both habitats. Gillnets play a dominant role in sheltered coastal reefs, but their use is banned for six months of each year. At the outer reef, spear diving is used by more than 40% of all fishers.

Invertebrate fishing involves very little financial investment. Most (~70–85%) gleaners in our surveys used non-motorised canoes, and ~20% walked. Individuals targeting reeftop areas sometimes used motorised boat transport as some of the reefs, particularly on the landward coast of Sakao reef, are distant. Trochus diving was always done with paddling canoes.

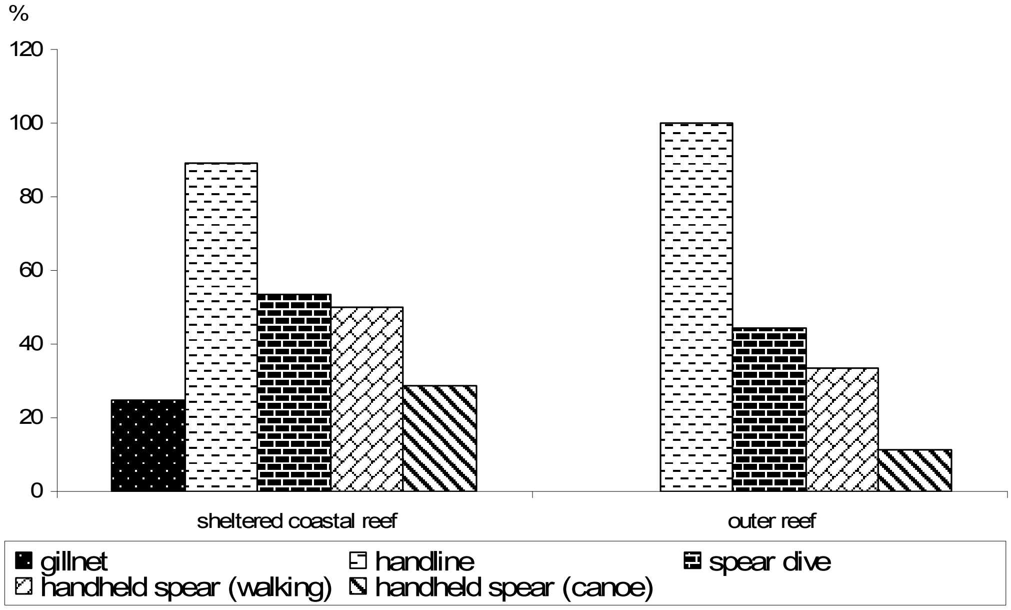

Figure 5.7: Fishing methods commonly used in different habitat types in the Maskelyne Archipelago.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Fishing pressure

Information on the number of fishers per km^2 of fishing ground (habitat), the frequency of fishing trips, the average catch per fishing trip (and consequently the average catch per fisher per year) and the catch composition were used to estimate the fishing pressure imposed by the inhabitants of the Maskelyne Archipelago on their fishing grounds (Table 5.4).

Frequency and duration of fishing trips

On average fishers targeted the sheltered coastal reef 1.7 times/week and the outer reef 1.6 times/week. The average trip duration was slightly shorter at the outer reef (3.3 hours) than at the sheltered coastal reef (4.1 hours) (Table 5.4). Minimal pelagic fishing was reported.

Invertebrate fishing trips were reported to be moderately long, ranging from 2.5 to 4.3 hours each, with a frequency of 1–1.7 times/week. Trochus diving was performed whenever certain reef areas were opened.

Table 5.4: Average frequency and duration of fishing trips reported by male and female fishers in the Maskelyne Archipelago

Resource	Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	1.70 (±0.24)	1.42 (±0.24)	4.39 (±0.51)	3.25 (±0.48)
	Outer reef	1.75 (±0.27)	1.00 (n/a)	3.25 (±0.37)	4.00 (n/a)
Invertebrates	Mangrove	1.14 (±0.21)	1.07 (±0.15)	3.14 (±0.25)	2.92 (±0.21)
	Reeftop	1.56 (±0.38)	1.73 (±0.24)	3.38 (±0.26)	3.09 (±0.21)
	Soft benthos	0.91 (±0.20)	1.17 (±0.14)	2.44 (±0.18)	2.54 (±0.14)
	Soft benthos and mangrove (1)	0	1.00 (n/a)	0	3.00 (n/a)
	Mother-of-pearl	0.25 (±0.11)	0	4.33 (±0.36)	0

Figures in brackets denote standard error; n/a = standard error not calculated; (1) Combined in one fishing trip.
Finfish fisher interviews, males: n = 78; females: n = 20. Invertebrate fisher interviews, males: n = 47; females: n = 44.

5.2.3 Catch composition and volume – finfish: Maskelyne Archipelago

Catches from the outer reef predominantly comprised the families Carangidae and Lethrinidae and the genera *Siganus*, *Parupeneus* and *Valamugil,* while catches from the sheltered coastal reef are made up mostly of the families Lethrinidae and Scaridae and the genera *Siganus* and *Parupeneus*. Details on the estimated annual recorded catch by vernacular species and scientific family are given in Appendix 2.4.1.

Detailed information on the distribution of fish families in reported catches, in percentage of total weight per habitat fished, is provided in Appendix 2.4.2.

The estimated reported total annual catch amounted to 8.9 t (0.4 t for female fishers and 8.5 t for male fishers). The proportion of the total catch associated with each of the habitats fished mirrored the fishing activity pattern, i.e. most of the catch was taken from the sheltered coastal reef (~55%), and less from the outer reef (~45%). Females' finfish fishing activity accounted for just 5.2% of the estimated total annual catch by respondents (Figure 5.8).

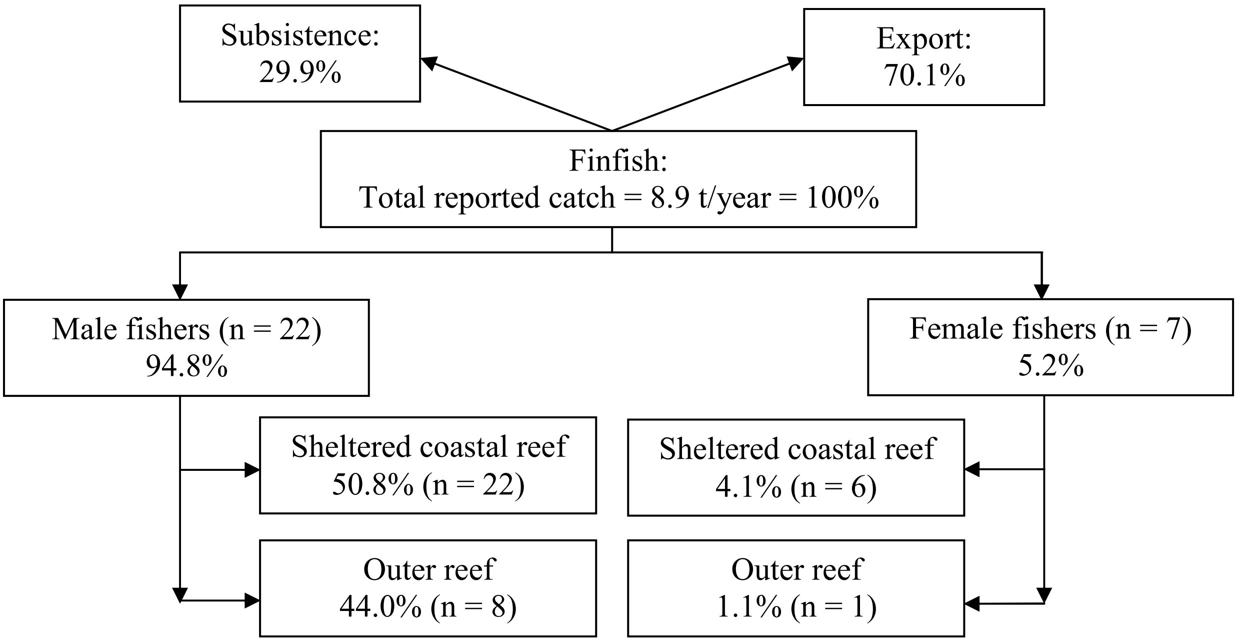

Figure 5.8: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in the Maskelyne Archipelago.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey only.

The higher contribution by male fishers results not only from the greater number of males fishing but also the much higher average annual catch as compared to female fishers (Figure 5.9). Although fewer fishers target the outer reef, the average annual catch from that habitat exceeded that from the sheltered coastal reef by a factor of 2.5.

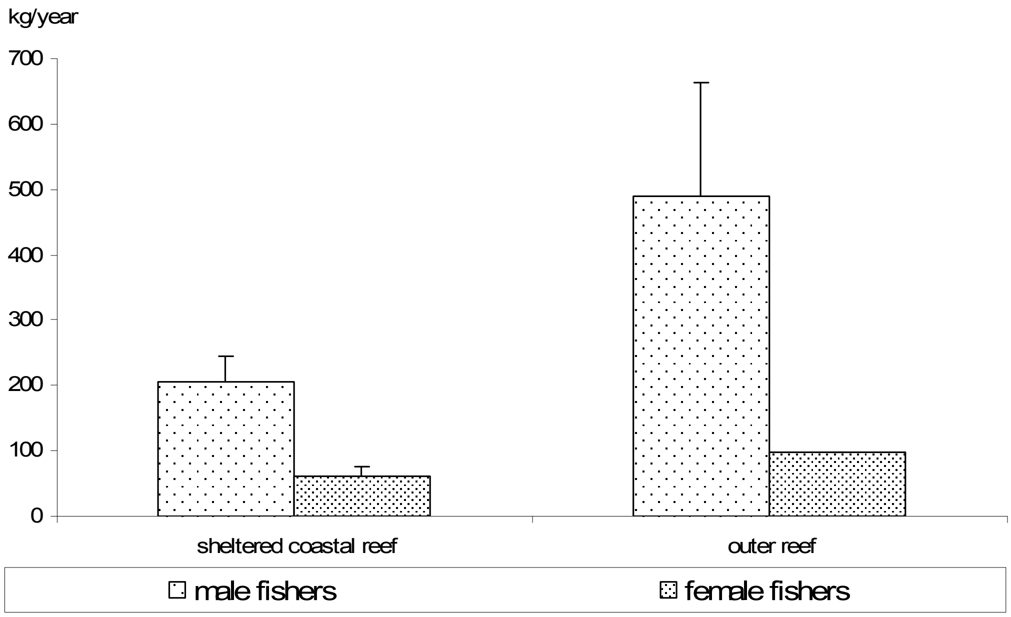

Figure 5.9: Average annual finfish catch (kg/year) per fisher by habitat and gender in the Maskelyne Archipelago.
Bars represent standard error (+SE).

The CPUE calculated for male fishers exceeds that for female fishers for both the sheltered coastal reef and outer-reef environments (Figure 5.10).

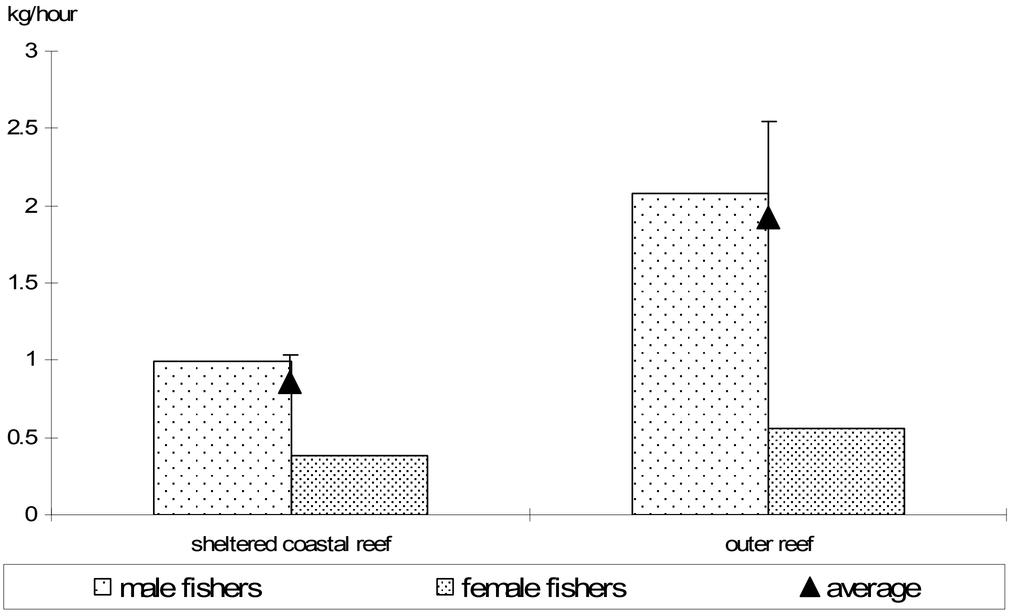

Figure 5.10: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in the Maskelyne Archipelago.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Survey results indicate that 45% of all trips to the sheltered coastal reef are aimed at generating income. Fishing at the outer reef serves subsistence needs and non-monetary exchange only (Figure 5.11).

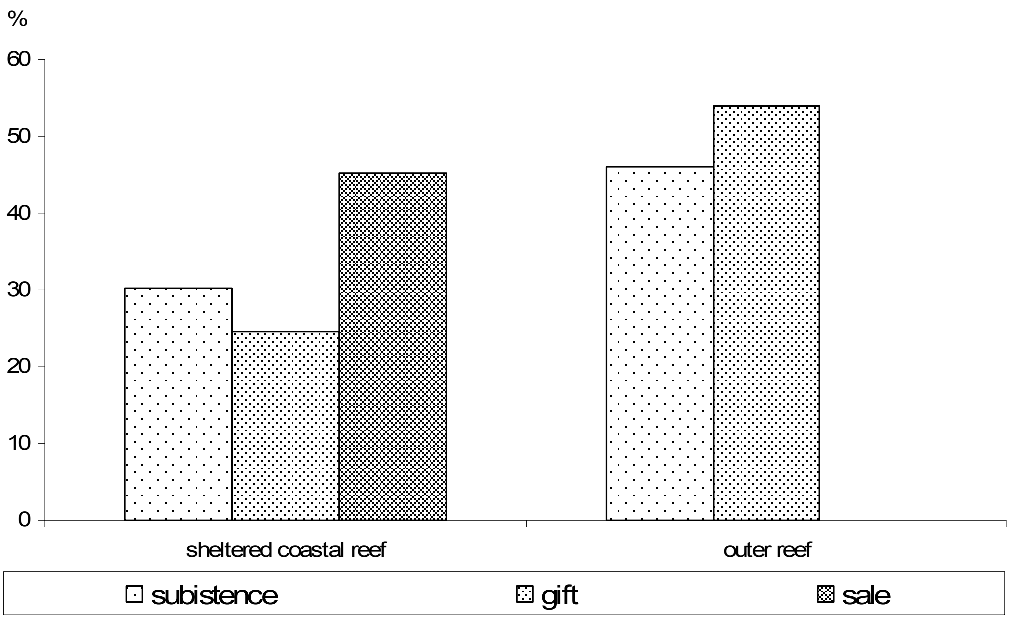

Figure 5.11: The use of finfish catches for subsistence, gift and sale, by habitat in the Maskelyne Archipelago.
Proportions are expressed in % of the total number of trips per habitat.

Comparing the average finfish size per family in the two different habitats (Figure 5.12) indicates that fish caught at the outer reef are generally larger; this is particularly the case for the families Carangidae, Lutjanidae, Serranidae and Balistidae. However, the reverse is true for Scaridae and Acanthuridae, for which the average finfish size is larger for catches from the sheltered coastal reef than the outer reef.

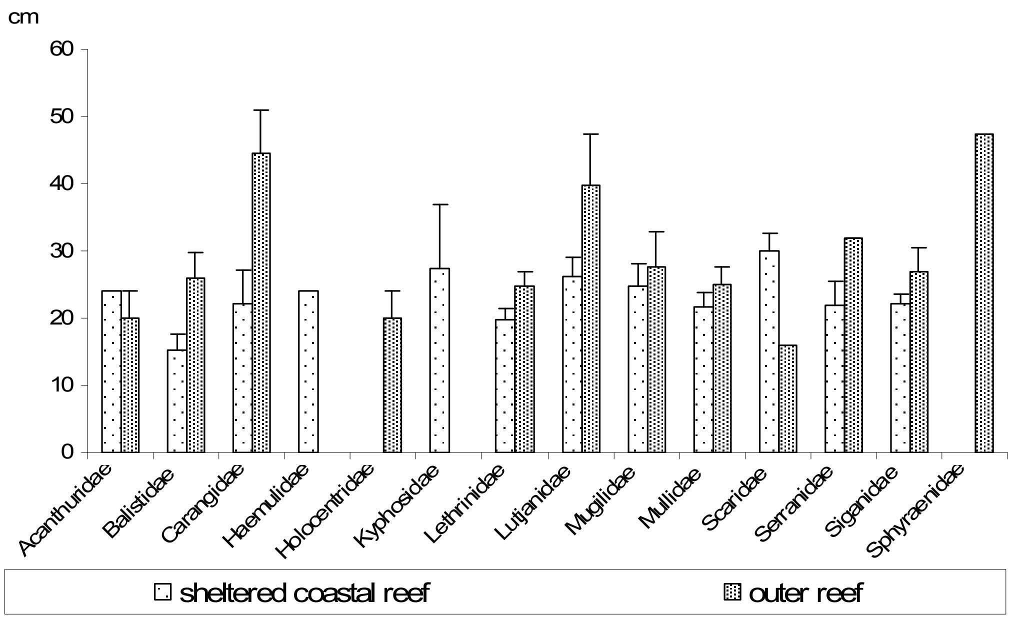

Figure 5.12: Average sizes (cm fork length) of fish caught by family and habitat in the Maskelyne Archipelago.
Bars represent standard error (+SE).

The following parameters have been selected to characterise the current level of fishing pressure in the Maskelyne Archipelago fishing grounds. The figures are extrapolated from the survey results (as presented in Table 5.5).

Table 5.5: Parameters used in assessing fishing pressure on finfish resources in the Maskelyne Archipelago

Parameters	Habitat			
	Coastal reef	Outer reef	Total reef	Total fishing ground (1)
Fishing ground area (km^2)	4.06	16.20	20.26	38.67
Density of fishers (number of fishers/km^2 fishing ground) (3)	96	6	24	13
Population density (people/km^2) (4)			52	27
Average annual finfish catch (kg/fisher/year) (2)	174.9 (±32.5)	447.1 (±158.1)		
Total fishing pressure of subsistence catches (t/km^2)			1.4	0.7

Figures in brackets denote standard error; (1) total lagoon area = 18.41 km²; (2) catch figures are based on recorded data from survey respondents only; (3) total number of fishers is extrapolated from household surveys; (4) total population = 1016; total subsistence demand = 22.81 t/year.

5.2.4 Catch composition and volume – invertebrates: Maskelyne Archipelago

Calculation of the total annual recorded harvest of each invertebrate species group shows the dominance of *Terebra* spp., which represent more than half of the total annual recorded invertebrate catch in the Maskelyne Archipelago by weight (Figure 5.13).

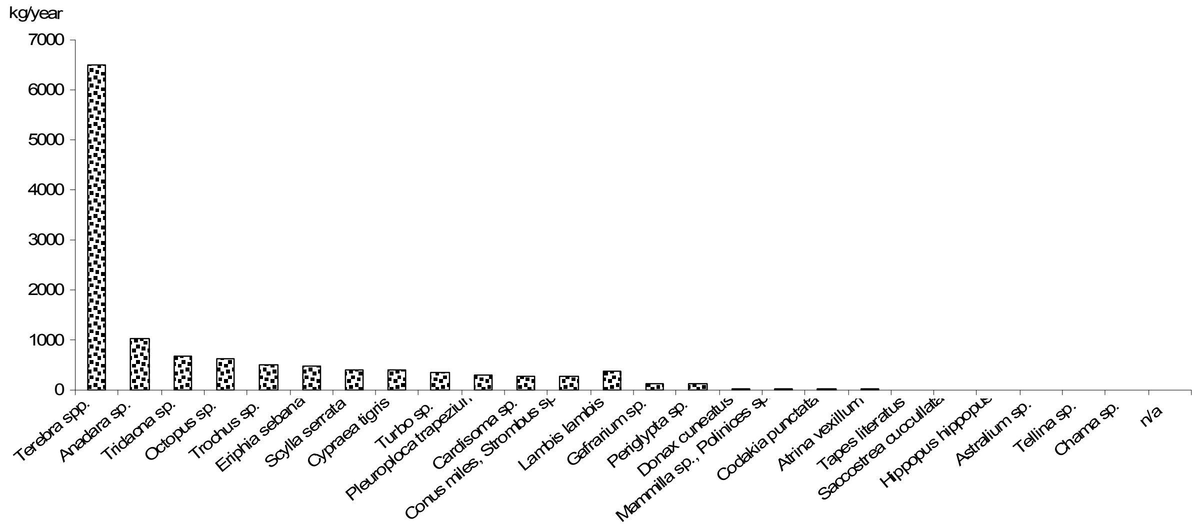

Figure 5.13: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in the Maskelyne Archipelago.
n/a refers to nakotav.

The number of species (based on vernacular names) reported to be regularly caught in various habitats illustrates the diversity of the invertebrate fishery on Uliveo Island. The results (Figure 5.14) illustrate the importance of gleaning activities, with eight different species groups reported by vernacular name by fishers targeting mangroves and 18 species reported for soft benthos.

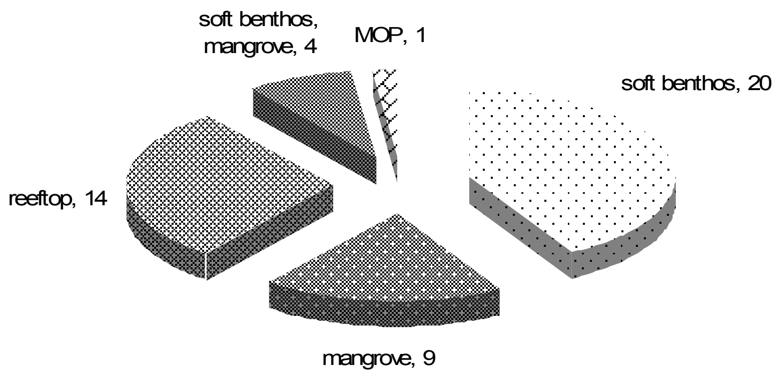

Figure 5.14: Number of vernacular names recorded for each invertebrate fishery in the Maskelyne Archipelago.
MOP = mother-of-pearl.

Details on the species distribution per habitat and on size distribution by species are provided in Appendices 2.4.2 and 2.4.3, respectively.

Comparison of the total biomass (kg wet weight) removed annually by gender group and habitat type provides an indication of the pressure on the resource and shows that females are more productive in reeftop environments, and equally as productive as males in harvesting from soft benthos. Males are more productive in mangrove environments. The productivity of trochus fishers appears low (Figure 5.15).

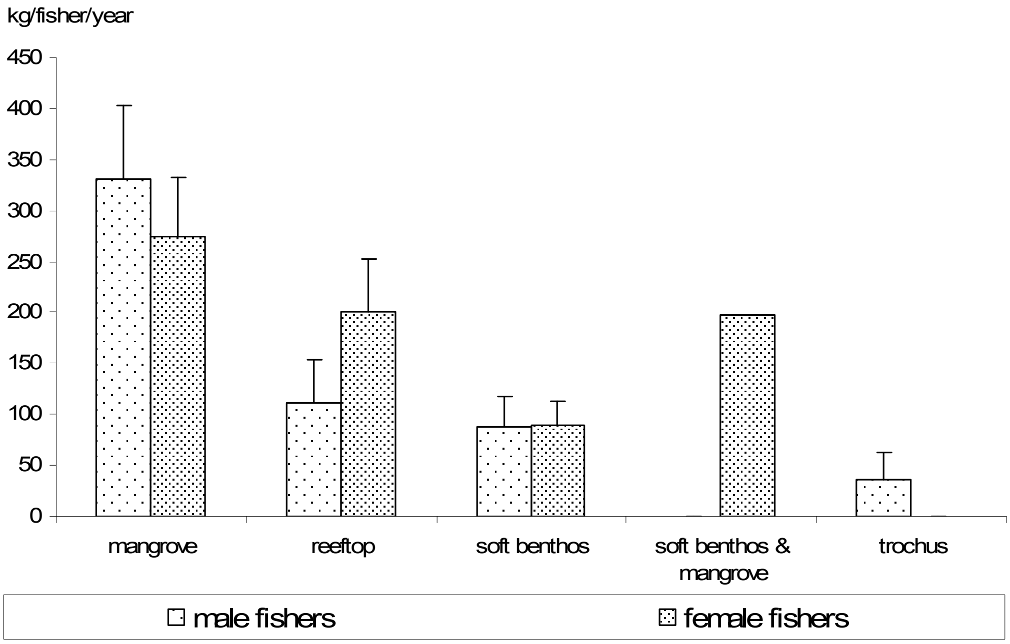

Figure 5.15: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in the Maskelyne Archipelago.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 18 for males, n = 14 for females). Bars represent standard error (+SE).

Most of the biomass (60%) is removed from mangrove environments, with a considerable share removed from reeftop areas (21%). The catch from soft-benthos areas accounts for 13% of the total catch, while the MOP (trochus) harvest equals just 4% of the total catch by weight.

Fishers interviewed indicated that most invertebrates are targeted for subsistence purposes, and none are targeted exclusively for commercial purposes. Trochus shells are harvested for their commercial value; shells are sold and the meat consumed, although at times the meat is also sold. The total annual invertebrate harvest exclusively used for sale is insignificant (Figure 5.16). About 90% of all catches are used for consumption only, with approximately 10% used for both consumption and sale.

There are a number of species that are caught for consumption only, and the highest catches in this exclusive category are from the genera *Octopus* and *Eriphia*, followed by *Periglypta* and *Gafrarium*. Only *Trochus* and *Cypraea* were reported to be targeted exclusively for sale at times. The genera *Terebra*, *Turbo*, *Lambis* and *Tridacna* have the highest proportion of their annual catch used for both consumption and sale.

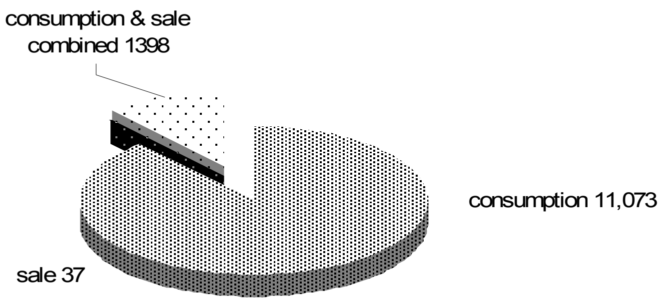

Figure 5.16: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in the Maskelyne Archipelago.

The total annual recorded catch for fishers interviewed amounted to 12.5 t (6.8 t by females, 5.7 t by males). The proportion (% of total annual reported catch) for each habitat/fishery and for each gender is provided in Figure 5.17.

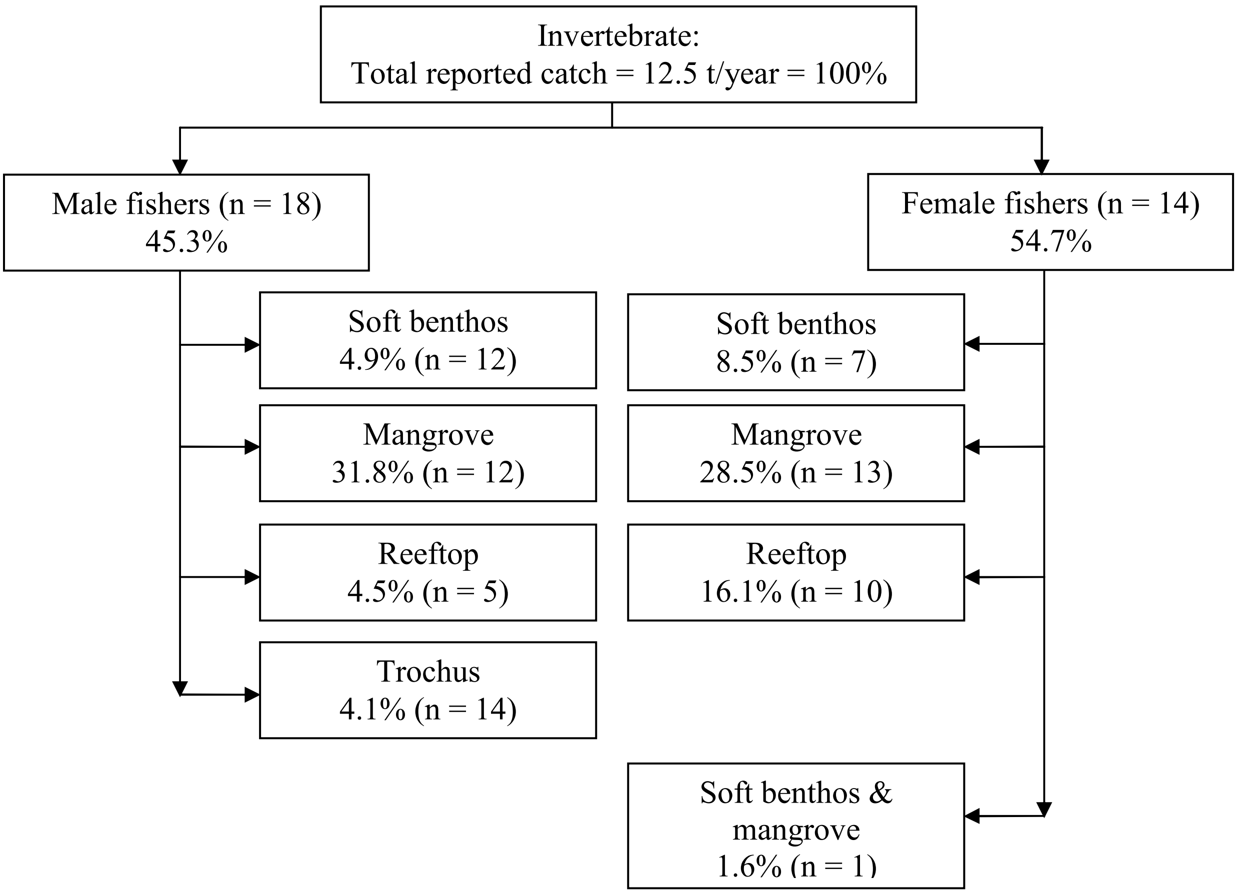

Figure 5.17: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Moso.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey only.

The following parameters have been selected to characterise the current level of invertebrate fishing pressure on the Maskelyne Archipelago fishing grounds (Table 5.6). The figures are extrapolated from the survey results.

Table 5.6: Parameters used in assessing fishing pressure on invertebrate resources in the Maskelyne Archipelago

Fishery	Mangrove	Reeftop	Soft benthos	MOP
Fishing ground area (km^2) (1)	0.6	9.71	1.1	18
Number of fishers (per fishery) (2)	490	343	420	210
Density of fishers (number of fishers/km^2 fishing ground)	817	35	382	12
Average annual invertebrate catch (kg/fisher/year) (3)	301.9 (±45.0)	171.4 (±37.9)	88.5 (±17.8)	36.6 (±25.8)

Figures in brackets denote standard error; MOP = mother-of-pearl; (1) total lagoon area = 18.41 km²; (2) total population = 1058; total number of fishers is extrapolated from household surveys; (3) catch figures are based on recorded data from survey respondents only.

As these figures demonstrate, the habitat area available to the various fisheries is highly variable. The mangrove fishery yields the highest annual catches, has a potentially high fisher density and targets a small habitat, with the result that fishing pressure on mangroves may be outstandingly high. By comparison, the average recorded catch from soft-benthos habitat is low; however, given the small size of the habitat and the potentially high density of fishers, fishing pressure may still be high. In comparison with the mangrove and soft-benthos fisheries, pressure on the reeftop and on MOP fisheries is relatively insignificant.

5.2.2 Discussion and conclusions: socioeconomics in the Maskelyne Archipelago

- People in the Maskelyne Archipelago are highly dependent on fisheries for their subsistence needs. In addition, fisheries represent a second and thus complementary source of income for about 60% of all households. The importance of fisheries is additionally supported by the following observations:
  - all households are engaged in fisheries;
  - almost all households own at least one boat (paddling canoe);
  - the frequency of both fresh fish and invertebrate consumption is high; and
  - the per capita amount of fresh fish consumed is larger than in other sites in Vanuatu.

- Subsistence needs are the driving force behind invertebrate fisheries, which may explain why productivity is generally low when compared to other PROCFish/C sites investigated in Vanuatu. Reeftop gleaning is an exception, where productivity may be higher due to the fact that certain organisms (*Cypraea*, *Tridacna*) are collected in part – though not exclusively – for commercial sale. Income from invertebrate sales appears to stem mainly from trochus (MOP), which is sold by villagers to a locally based middleman and to a commercial boat from Port Vila, which visits each month.

- Fishing pressure was found to be outstandingly high on mangroves and above average in the soft-benthos and trochus fisheries. While the average sizes reported for catches of most invertebrate species do not suggest that fishing pressure is having a major detrimental impact, the size frequency distribution of *Tridacna* and octopus catches from reeftops is less favourable, with an average length of ≤14 cm and head diameter of ≤6 cm, respectively. These figures may be indicative of a response to past or present fishing activities.

- Fishing pressure on finfish resources was found to be higher on the sheltered coastal reef, but was also significant on the outer reef. The first is mainly a result of the fisher density and the high catch per reef area. The high pressure on the outer reef results primarily from the comparatively high average annual catch rate. The fact that the average lengths of

Scaridae and Acanthuridae caught from the sheltered coastal reef were larger than those caught on the outer reef may be explained by the frequent use of spear fishing at the outer reef.

- The temporary and prolonged reef closures for both invertebrate and commercial finfish fishing limits the exploitation of all reef fish and most invertebrates (in particular commercially exploitable species, i.e. trochus and bêche-de-mer species). The fact that such management measures are in place, with active compliance and only rare exemptions (Some reefs may be temporarily opened if cash is urgently needed.), suggests a high degree of awareness on the part of the community and a willingness to actively support the recovery or conservation of the community's resources. This was underlined by the recurrent complaints by villagers regarding what they perceived as increasing degradation of their reef and lagoon resources.

- Marketing of finfish is limited due to the geographical isolation of the site, the distance to major urban markets (such as Port Vila), the lack of infrastructure to refrigerate and preserve products, and dependency on continuing, regular visits by the commercial boat that transports marine resources to clients in Port Vila.

- Given the current level of exploitation of finfish and especially invertebrates, and the fact that agriculture also has the potential to sustain the livelihood of the inhabitants of the Maskelyne Archipelago, further intensification of fisheries in this area is not believed to be appropriate. Fishery management advice should focus on alleviating or reducing already observable resource impacts (through control of the fishing techniques used, selection of target species, and catch levels). Future development of fisheries in the archipelago is likely to be closely linked to developments in marketing infrastructure, such as visits of commercial boats, the presence of agents and the introduction of preservation techniques.

5.3 Finfish resource surveys: Maskelyne Archipelago

Finfish resources and associated habitats were assessed between 26 November and 2 December 2003 from a total of 24 transects (11 sheltered coastal transects and 13 outer-reef transects; see Figure 5.18 for transect locations and Appendix 3.4.1 for transect coordinates.). Lagoon patch reefs were not surveyed, as they represented a fraction of 1% of the total habitat.

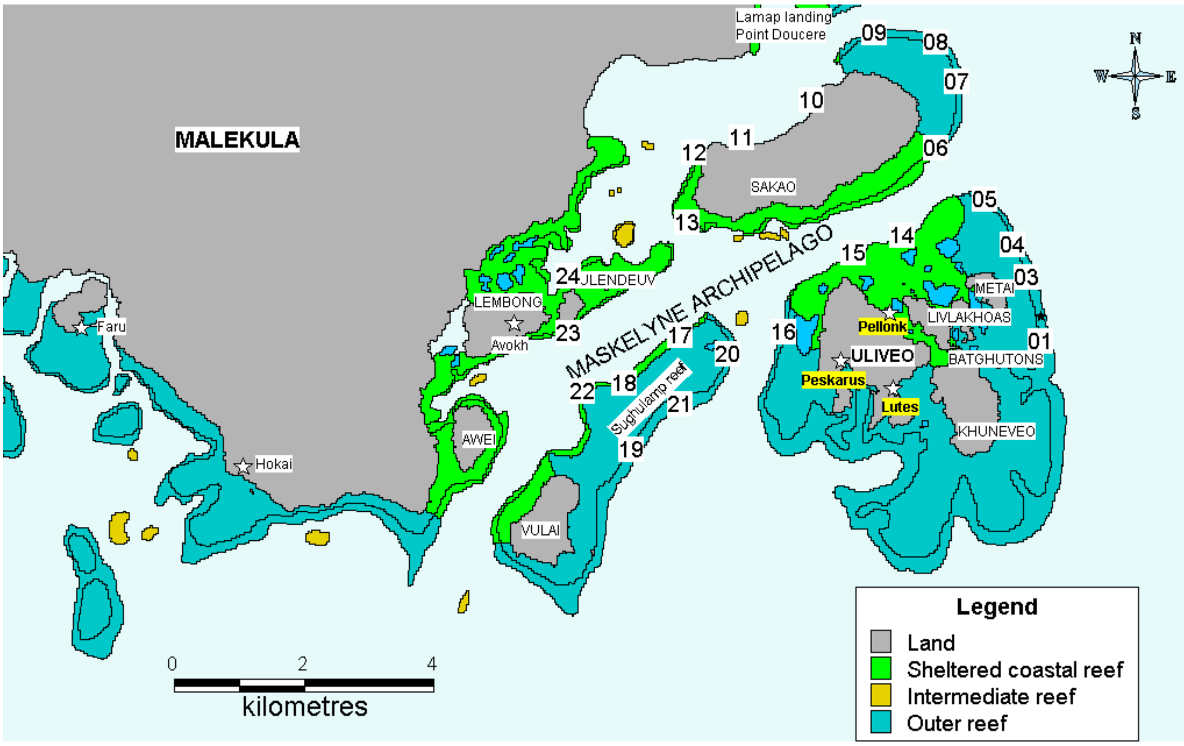

Figure 5.18: Habitat types and transect locations for finfish assessment in the Maskelyne Archipelago.

5.3.1 Finfish assessment results: Maskelyne Archipelago

A total of 23 families, 62 genera, 198 species and 11,703 fish were recorded in the 24 transects (See Appendix 3.4.2 for species list.). Data on the 15 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 50 genera, 175 species and 10,833 individuals.

Finfish resources differed greatly between the sheltered coastal and outer-reef habitats in the Maskelyne Archipelago (Table 5.7). The outer reef contained a greater number of fish than the sheltered coastal environment (density of 0.91 fish/m^2 versus 0.59). Fish were also larger in size, and the outer reef consequently had a larger biomass than the sheltered coastal environment (biomass 320 g/m^2 versus 115).

Table 5.7: Primary finfish habitat and resource parameters recorded in the Maskelyne Archipelago (average values ±SE; range for depth)

Parameters	Habitat		
	Sheltered coastal reef [(1)]	Outer reef [(1)]	All reefs [(2)]
Number of transects	11	13	24
Total habitat area (km^2)	4.05	16.20	20.34
Depth (m)	4 (1-10) [(3)]	5 (1-11)	5 (1-11)
Soft bottom (% cover)	16 ±2	2 ±1	5
Rubble & boulders (% cover)	20 ±4	9 ±3	11
Hard bottom (% cover)	37 ±4	57 ±4	53
Live coral (% cover)	20 ±4	25 ±2	24
Soft coral (% cover)	7 ±2	5 ±1	5
Biodiversity (species/transect)	46 ±5	50 ±5	48 ±3
Density (fish/m^2)	0.59 ±0.11	0.91 ±0.10	0.84
Biomass (g/m^2)	115 ±29	320 ±126	278
Size (cm FL) [(4)]	16.7 ±0.5	19.1 ±0.5	18.6
Size ratio (%)	56 ±2	57 ±1	60

[(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: Maskelyne Archipelago

The sheltered coastal reef environment of the Maskelyne Archipelago was dominated by five families: herbivorous Acanthuridae and Scaridae (both in terms of density and biomass), carnivorous Lutjanidae and Lethrinidae (biomass only), and Chaetodontidae (density only) (Figure 5.19). These five families were represented by 78 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Naso unicornis*, *Lutjanus gibbus*, *Monotaxis grandoculis*, *Chlorurus sordidus*, *C. bleekeri*, *Scarus dimidiatus*, *Scarus psittacus*, and *Acanthurus lineatus* (Table 5.8).

Table 5.8: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of the Maskelyne Archipelago

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Lined bristletooth	0.09	9.9
	Naso unicornis	Bluespine unicornfish	0.01	9.8
	Acanthurus lineatus	Striped surgeonfish	0.01	2.6
Scaridae	*Chlorurus sordidus*	Bullethead parrotfish	0.08	5.8
	Chlorurus bleekeri	Bleeker's parrotfish	0.02	5.7
	Scarus dimidiatus	Yellowbarred parrotfish	0.02	4.2
	Scarus psittacus	Palenose parrotfish	0.01	3.4
Lutjanidae	*Lutjanus gibbus*	Paddletail	0.01	9.8
Lethrinidae	*Monotaxis grandoculis*	Big-eye bream	0.01	7.4
Chaetodontidae	*Chaetodon lunulatus*	Redfin butterflyfish	0.01	0.5

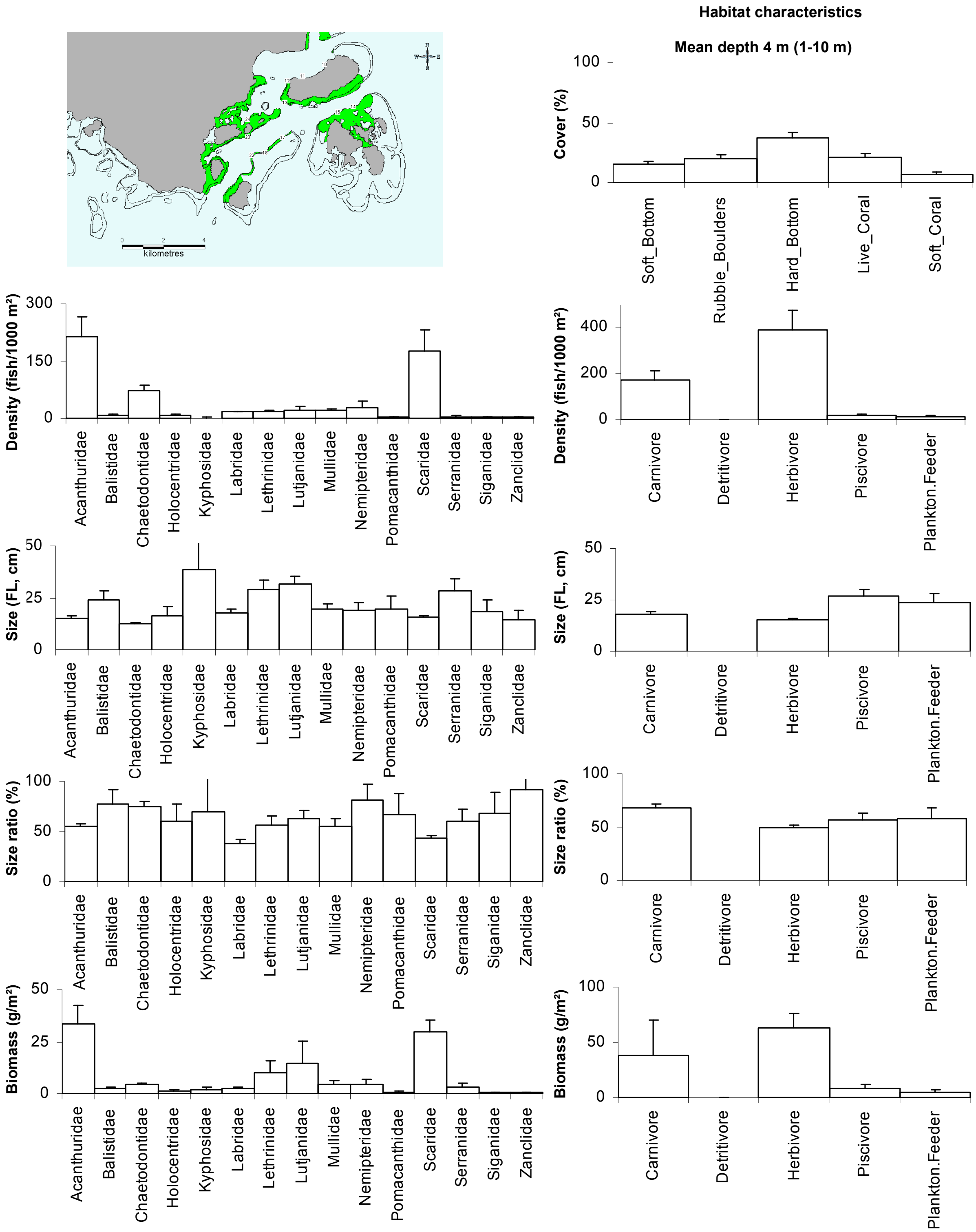

Figure 5.19: Profile of finfish resources in the sheltered coastal reef environment of the Maskelyne Archipelago.
Bars represent standard error (+SE); FL = fork length.

This reef environment presented a diverse habitat (Table 5.7 and Figure 5.19), with hard bottom predominating; habitat complexity may partly explain the relative complexity of the fish assemblage on this reef. The relatively good live coral cover (20% average) was accompanied by notable densities of butterflyfish (Chaetodontidae).

The biodiversity, density, size and biomass of finfish resources in the sheltered coastal reefs of the Maskelyne Archipelago were similar to those recorded in other study sites in Vanuatu. However, the substrate was less diverse than the other sites, with more hard bottom and less soft bottom and similar rubble (Table 5.7). These differences in substrate may partially explain why there were more herbivorous Acanthuridae and Scaridae (fish more commonly associated with hard bottoms) and fewer carnivorous Lutjanidae, Mullidae and Nemipteridae (fish more often associated with soft bottom and rubble) in the sheltered coastal reefs of the Maskelyne Archipelago, as compared to the other study sites (Figure 5.19).

Outer-reef environment: Maskelyne Archipelago

The outer reef of the Maskelyne Archipelago was largely dominated by herbivorous Acanthuridae and Scaridae, and to a lesser extent by carnivorous Lutjanidae (Figure 5.20). These three families were represented by 55 species, with particularly high abundance or biomass of *Bolbometopon muricatum*, *Acanthurus lineatus*, *Ctenochaetus striatus*, *Lutjanus gibbus*, *L. bohar*, *Naso lituratus*, *L. fulvus*, *Chlorurus sordidus*, *Scarus oviceps* and *Zebrasoma scopas* (Table 5.9).

Table 5.9: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of the Maskelyne Archipelago

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Bolbometopon muricatum*	Bumphead parrotfish	0.01	102.7
	Chlorurus sordidus	Bullethead parrotfish	0.09	6.8
	Scarus oviceps	Egghead parrotfish	0.02	4.9
Acanthuridae	*Acanthurus lineatus*	Striped surgeonfish	0.11	35.0
	Ctenochaetus striatus	Lined bristletooth	0.17	28.2
	Naso lituratus	Orangespine unicornfish	0.02	9.2
	Zebrasoma scopas	Brushtail tang	0.37	2.2
Lutjanidae	*Lutjanus gibbus*	Paddletail	0.02	21.1
	Lutjanus bohar	Red bass	0.01	9.5
	Lutjanus fulvus	Yellow-margined seaperch	0.02	7.8

Remarkably, the rare and vulnerable (to fishing) bumphead parrotfish (*Bolbometopon muricatum*) ranked first in terms of biomass (133 g/m^2). However, this result was the consequence of a single record of a large group of fish (40 individuals), and the resultant large biomass of Scaridae in the outer reefs of the Maskelyne Archipelago should be interpreted with caution.

Substrate in the outer reef was characterised by a dominance of hard bottom (55% cover). Relatively high live coral cover (25%) was accompanied by the presence of substantial numbers of butterflyfish. The prevalence of hard bottom substrate, in combination with the direct oceanic influence found in the outer-reef environment, may explain the dominance of medium-sized herbivorous fish, such as *Acanthurus lineatus* and *Naso lituratus*.

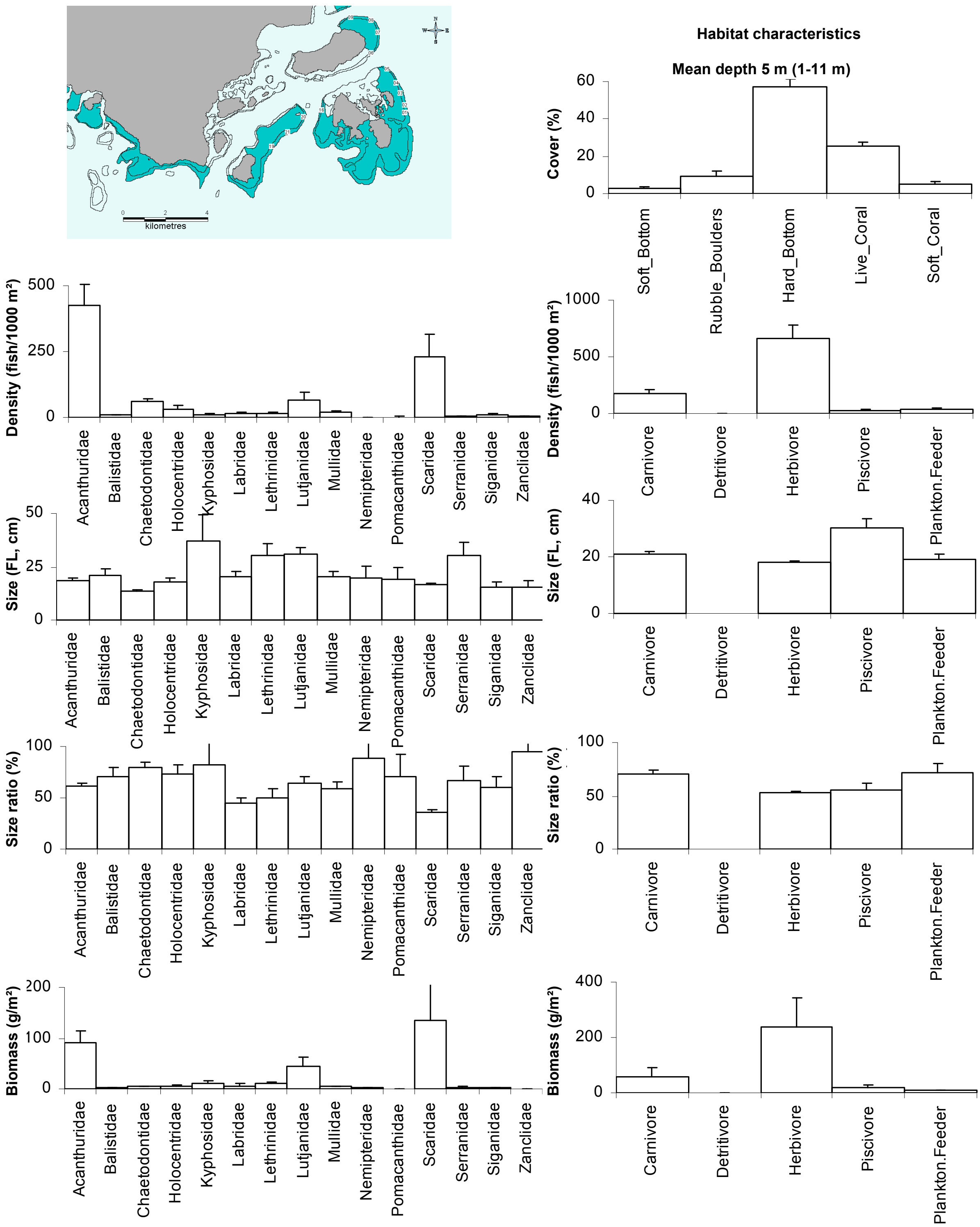

Figure 5.20: Profile of finfish resources in the outer-reef environment of the Maskelyne Archipelago.
Bars represent standard error (+SE); FL = fork length.

Finfish resources in the outer reefs of the Maskelyne Archipelago displayed the greatest average density and biomass of all reefs surveyed in Vanuatu (Table 5.7), however average fish sizes and size ratios were lower than at most other survey sites. Substrate composition was similar to the average on outer reefs across all study sites in Vanuatu, with a dominance of hard bottom, a habitat well suited to herbivorous fish, particularly Acanthuridae and Scaridae. Despite the similarities in habitat, the number of Acanthuridae and Scaridae and carnivorous Lutjanidae in the Maskelyne Archipelago was above those recorded at the other sites (Figure 5.20), which resulted in higher ratings in the Maskelyne Archipelago for all finfish resource parameters. The presence of a large group of bumphead parrotfish further increased the biomass in the Maskelyne Archipelago outer reef compared to the average, as stated previously. The higher observed mean densities and biomass of edible species, and the presence of large, rare and vulnerable species in an otherwise similar habitat, may indicate that the Maskelyne Archipelago outer reef is subject to less fishing impact than other study sites in Vanuatu.

Overall reef environment: Maskelyne Archipelago

Overall, the fish assemblage of the Maskelyne Archipelago comprised two main families, Acanthuridae and Scaridae, with Chaetodontidae and Lutjanidae ranking third in density and biomass respectively (Figure 5.21). These four families were represented by a total of 89 species, dominated (in terms of density and biomass) by *Bolbometopon muricatum* (ranking first only in terms of biomass (82 g/m^2), *Acanthurus lineatus*, *Ctenochaetus striatus*, *Lutjanus bohar*, *Naso lituratus*, *Chlorurus sordidus*, *Lutjanus gibbus*, *L. fulvus*, *Scarus oviceps*, *Scarus niger*, *Zebrasoma scopas* and *Acanthurus triostegus* (Table 5.10).

Table 5.10: Finfish species contributing most to main families in terms of densities and biomass across all reefs of the Maskelyne Archipelago (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Bolbometopon muricatum*	Bumphead parrotfish	0.01	81.8
	Chlorurus sordidus	Bullethead parrotfish	0.08	6.6
	Scarus oviceps	Egghead parrotfish	0.02	4.1
	Scarus niger	Black parrotfish	0.01	2.9
Acanthuridae	*Acanthurus lineatus*	Striped surgeonfish	0.09	28.4
	Ctenochaetus striatus	Lined bristletooth	0.2	24.4
	Naso lituratus	Orangespine unicornfish	0.02	7.6
	Zebrasoma scopas	Brushtail tang	0.04	2.0
	Acanthurus triostegus	Convict surgeonfish	0.02	1.7
Lutjanidae	*Lutjanus gibbus*	Paddletail	0.02	18.8
	Lutjanus bohar	Red bass	0.01	8.1
	Lutjanus fulvus	Yellow-margined seaperch	0.02	6.2

As expected, the overall fish assemblage more closely resembled that recorded in the outer-reef environment (80% of habitat) than in the sheltered coastal reef environment (20% of habitat).

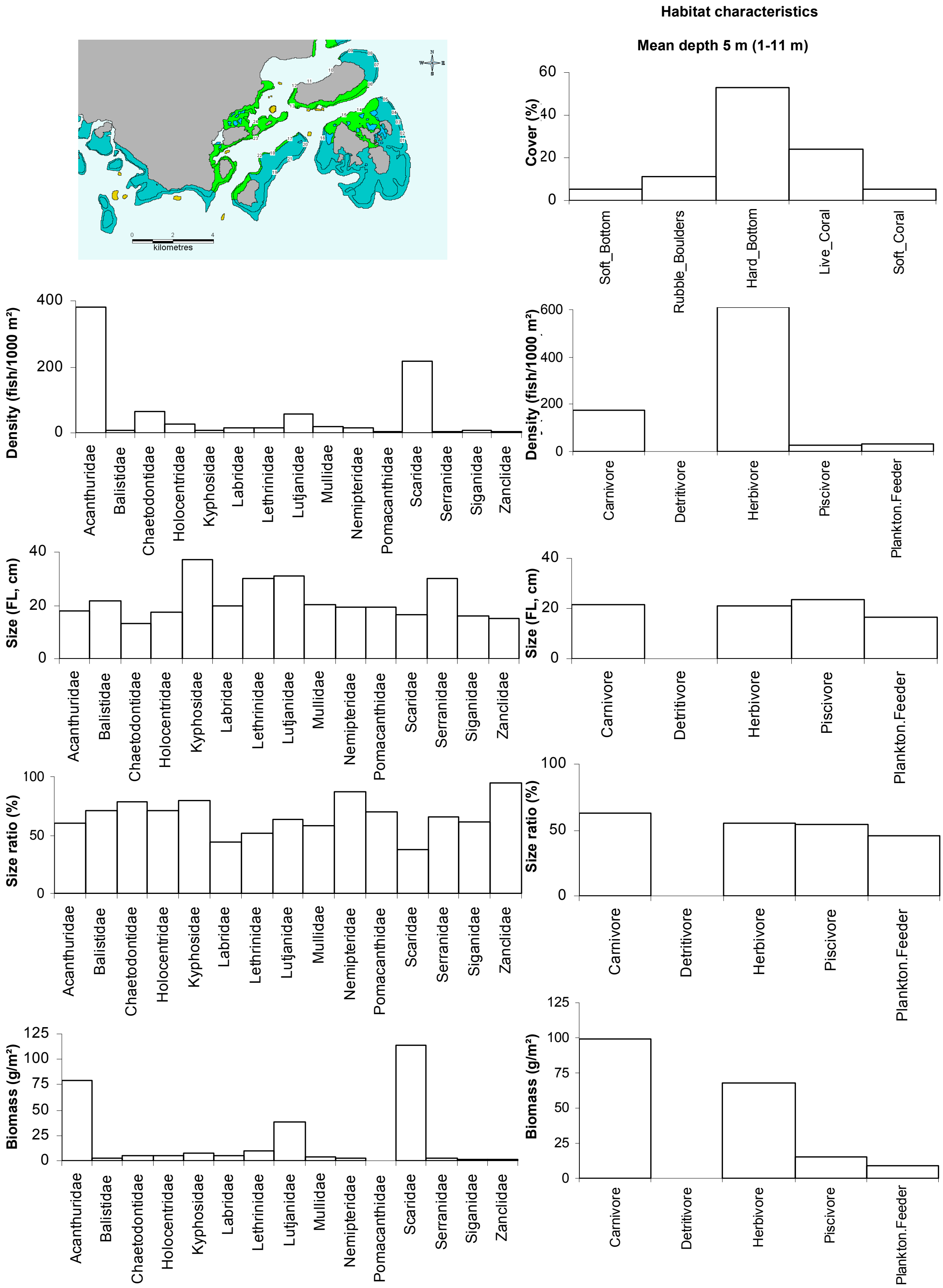

Figure 5.21: Profile of finfish resources in the combined reef habitats of the Maskelyne Archipelago (weighted average).
FL = fork length.

When compared to the remaining Vanuatu PROCFish/C study sites, the Maskelyne Archipelago displays a healthier finfish resource, with greater density and biomass and similar to slightly greater biodiversity (Table 5.7). Detailed assessment at reef level suggested that this trend was linked not only to the naturally diverse habitat but possibly also to less impact from fishing compared to the average across study sites in Vanuatu.

5.3.2 Discussion and conclusions: finfish resources in the Maskelyne Archipelago

- Finfish resources in the Maskelyne Archipelago appeared to be in good condition, possibly in part through difficulties in accessing exposed reefs. The latter may change if changes in fishing practices occur (e.g. if sailing canoes are replaced with motorised boats).

- The finfish resources are well managed by the existing community-based management activities. However, any increase in the frequency or number of visits by the commercial boats from Port Vila, could change this situation. The current management measures in place need to be strengthened. The resources should be closely monitored, and should any increase in fishing pressure be detected, new MRM measures be considered. Considering the high quality of habitat in the Maskelyne Archipelago, MPAs should be considered as a primary management tool.

- The quality and quantity of finfish resources in the Maskelyne Archipelago are sufficient to allow the continuity of food supply and income generation. If there is any expansion of commercial finfish harvesting, it is essential that it be closely monitored, to ensure that finfish resources remain available for subsistence use by future generations.

5.4 Invertebrate resource survey: Maskelyne Archipelago

The diversity and abundance of invertebrate species at Maskelyne Archipelago were independently determined using a range of survey techniques, including broad-scale assessment (using the manta tow technique; locations shown in Figure 5.22) and finer-scale assessment of specific reef and benthic habitats (Table 5.11; locations shown in Figures 5.22 and 5.23).

Table 5.11: Number of stations and replicates completed at Maskelyne Archipelago

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	11	66 transects
Reef-benthos transects (RBt)	16	96 transects
Soft-benthos transects (SBt)	21	126 transects
Soft-benthos infaunal quadrats (SBq)	9	72 quadrat groups
Mother-of-pearl transects (MOPt)	4	24 transects
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	2	12 search periods
Sea cucumber night searches (Ns)	2	12 search periods
Sea cucumber day searches (Ds)	0	0 search period

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. Fine-scale assessments were conducted in target areas (areas with naturally higher abundance and/or the most suitable habitat) to specifically describe resource status.

Figure 5.22: Broad-scale survey stations for invertebrates in the Maskelyne Archipelago.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

Figure 5.23: Fine-scale reef-benthos transect survey stations and soft-benthos transect stations for invertebrates in the Maskelyne Archipelago.
Black circles: reef-benthos transect stations (RBt);
black stars: soft-benthos transect stations (SBt).

Figure 5.24: Fine-scale survey stations for invertebrates in the Maskelyne Archipelago.
Grey stars: soft-benthos quadrat stations;
grey circles: sea cucumber night search stations (Ns);
grey triangles: reef-front search stations (RFs);
black squares: mother-of-pearl transect stations (MOPt).

Sixty-seven species or species groupings (groups of species within a genus) were recorded in the Maskelyne Archipelago invertebrate surveys: 15 bivalves, 19 gastropods, 19 sea cucumbers, 5 urchins, 4 sea stars and 2 cnidarians (See Appendix 4.4.1.). Information on key families and species is detailed below.

5.4.1 Giant clams: Maskelyne Archipelago

Broad-scale sampling provided an overview of giant clam distribution across the Maskelyne Archipelago. Shallow reef habitat (suitable for giant clams) within the area surveyed was relatively extensive (12.8 km^2), and four species of giant clam were recorded: *Tridacna crocea*, *T. maxima*, *T. squamosa* and *Hippopus hippopus*. *T. maxima* was the most common (found in nine stations and 23 transects), followed by *T. crocea* (four stations and eight transects), *H. hippopus* (two stations and two transects) and *T. squamosa* (one station and one transect) (Figure 5.25).

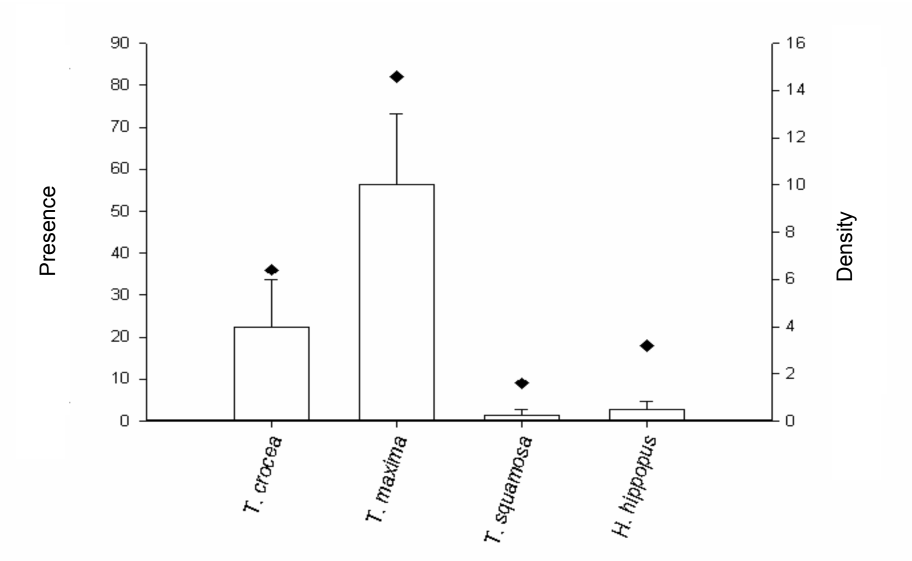

Figure 5.25: Presence and mean density of giant clam species in the Maskelyne Archipelago based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

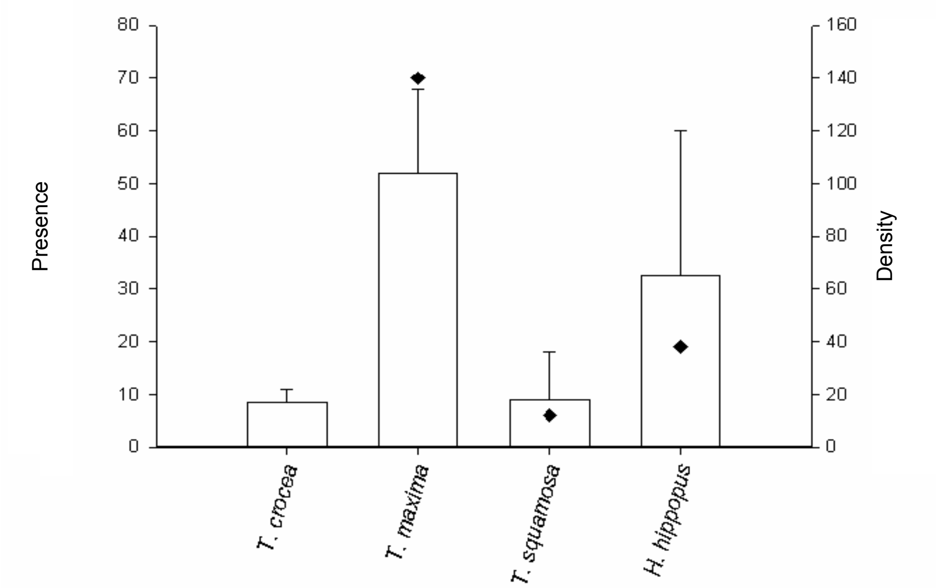

Figure 5.26: Presence and mean density of giant clam species in the Maskelyne Archipelago based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE). *T. crocea* density records are from three broad-scale assessment stations, as no individuals of this species were recorded during fine-scale assessments.

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat. In these reef-benthos assessments (RBt) *T. maxima* was again the most common species recorded and was present at 69% of stations (Figure 5.26). At those stations where clams were present, the mean density was 152 per ha. *H. hippopus* and *T. squamosa* were rare throughout the Maskelyne Archipelago, although localised density measures were high, primarily as a result of densities recorded within the MPA fronting Pellonk[19] (mean of 347 per ha for *H. hippopus* and 292 per ha for *T. squamosa* from stations where these species were present).

The smallest reef-boring species, *T. crocea*, was highly localised along the mainland of Malekula. *H. hippopus*, which characteristically can be found over a wider range of substrates (including reef areas and sandy lagoon flats), was restricted to just three reef stations and not recorded in soft-benthos assessments. Although *T. gigas* (a generalist species) and *T. derasa* (a species found at sites with oceanic influence) were not found during the survey, empty *T. gigas* shells were present in the village. Rosewater (1965) included Vanuatu (at that time the New Hebrides) in the distribution of these species. As this and a previous study in Vanuatu (Zann and Ayling 1988) failed to record their presence, they could be considered commercially extinct[20] at this site.

T. maxima had an average length/age of 11.9 cm ±0.6/5–6 years. *T. crocea* had a relatively large mean length of 12.7 cm ±0.5 (Figure 5.27). The faster-growing *H. hippopus* and *T. squamosa*, found within the MPA, were at the maximum size range for these species, reflecting the protected status of the reserve.

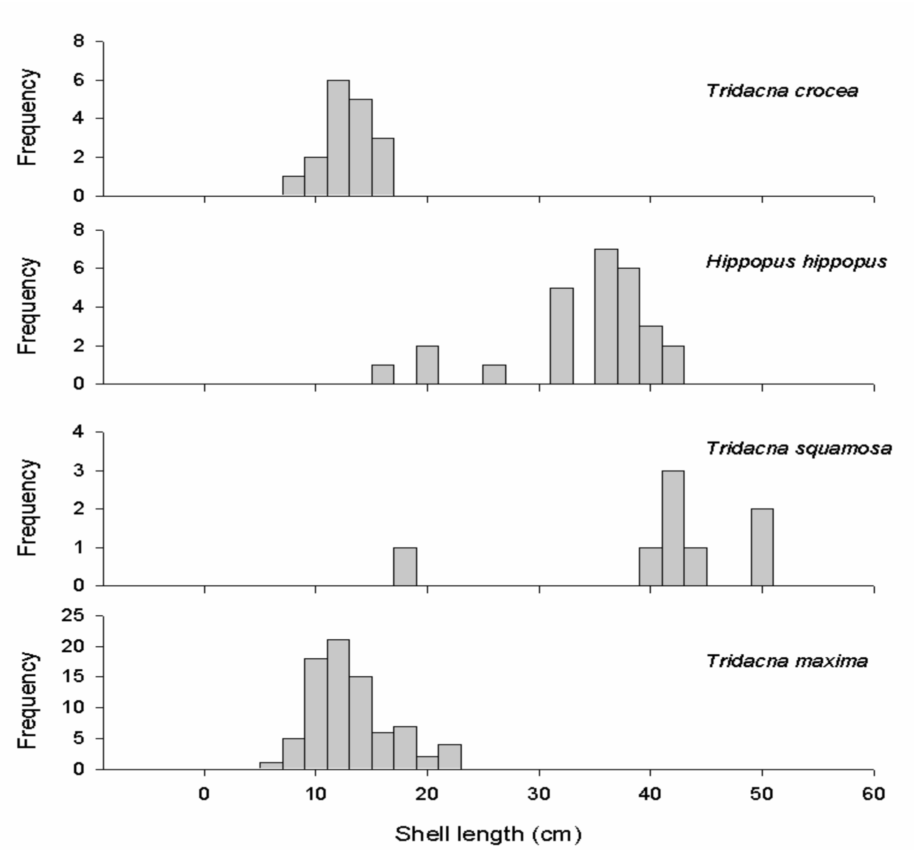

Figure 5.27: Size frequency histograms of giant clams shell length (cm) for the Maskelyne Archipelago.

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[19] See Appendix 4.4.10.
[20] 'Commercially extinct' refers to scarcity such that collection is not possible to service commercial or subsistence fishing. A commercially extinct species may still be present at very low densities.

5.4.2 Mother-of-pearl species (MOP): trochus and pearl oysters – Maskelyne Archipelago

The reefs around the Maskelyne Archipelago constitute an extensive suitable habitat for *Trochus niloticus*; the area could potentially support significant populations of this commercial species. Around Uliveo Island alone the reef front is approximately 18 km in length, with some 7.7 km^2 of shallow reef benthos with medium to high complexity (Appendix 4.4.11) and a mean CCA cover of 56% ±1.8. Habitat that is most suitable for juvenile trochus (consisting of reef flat with extensive submerged rubble and coral flats) was also present and the extensive shallow-water reef had a significant proportion of rubble-and-boulder substrate (21%), with a mean CCA cover of 17% ±1.7.

T. niloticus were commonly seen on the windward reef crest at estimated densities of 11–100 per ha. On the outer-reef slope the mean density of trochus was higher (Table 5.12), with the highest density per station being 270.8 trochus per ha.

Table 5.12: Presence and mean density of *Trochus niloticus* in the Maskelyne Archipelago
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				
RFs	34.3	12.0	2/2 = 100	12/12 = 100
MOPt	171.9	39.3	4/4 =100	15/24 = 63

RFs = reef-front search; MOPt = mother-of-pearl transect.

Mean size (basal width) of surveyed *T. niloticus* was 11.0 cm ±0.5 (n = 38); average basal width of shells held on shore by a local agent was 10.7 cm ±0.2 (n = 58) (Figure 5.28).

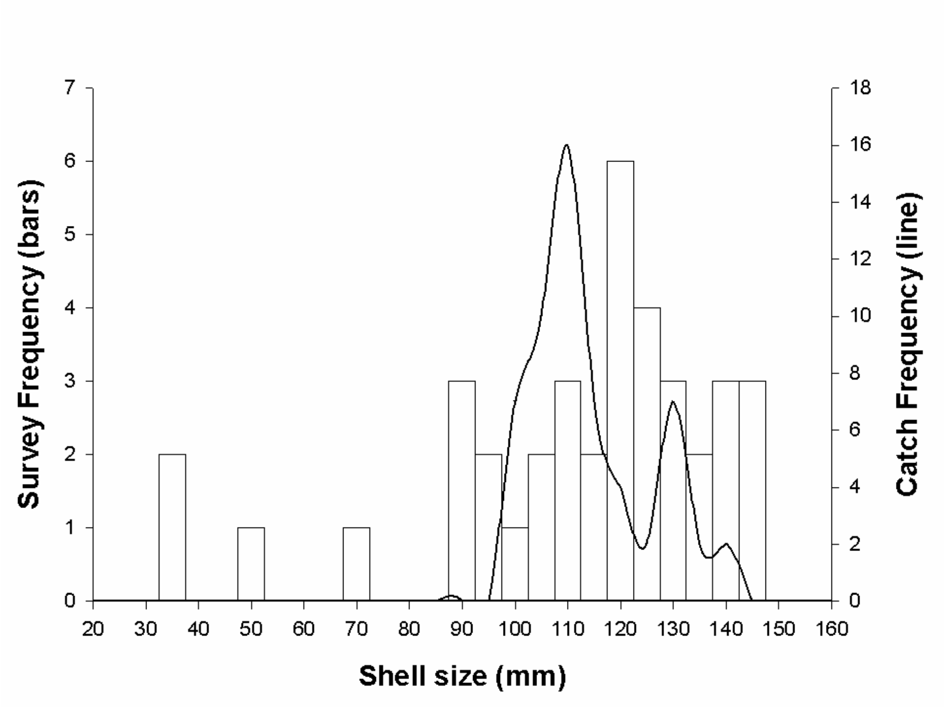

Figure 5.28: *Trochus niloticus* shell size frequency in the Maskelyne Archipelago.

Tectus pyramis, a closely related species with similar distribution and life history characteristics but lower commercial value, was abundant and common. The great green turban or green snail, *Turbo marmoratus,* was found as dead shell around the village, but no live specimens were found on reefs in the Maskelyne Archipelago.

Pinctada margaritifera, a normally cryptic and sparsely distributed pearl oyster species, was recorded in one broad-scale station (3% of transects). On fine-scale assessments of reef benthos *P. margaritifera* was also rare (13% of stations), with a mean density (±SE) in all reef-benthos stations of 5.21 ±3.6 per ha. The mean size of blacklip pearl oysters recorded in this study was 14.8 cm ±1.0.

Although the presence and density of *P. margaritifera* across the site was low and *T. marmoratus* was absent, commercial trochus were more common here than at other PROCFish/C sites in Vanuatu. Divers who accompanied the survey to locate their normal fishing areas and trochus aggregations explained that small sections of reef come under customary management by different groups of 'reef owners', who decide when to open or close an area. Despite the relatively high trochus densities (for Vanuatu sites) and the apparently effective customary reef management in place, further commercial harvesting is not recommended at this time as densities should be allowed to build to 500–600 individuals/ha within the main aggregations before commercial harvest is allowed (Appendix 4.5).

5.4.3 Infaunal species and groups: Maskelyne Archipelago

The soft benthos (sandy bottom) of the shallow-water lagoon, which included an area of shell beds near Pellonk, was reasonably extensive (1.1 km^2). In addition to broad-scale and fine-scale assessments, infaunal stations (quadrat surveys) were used to assess the in-ground species complement. Special permission was needed to access these beds as the area was closed to fishing during the survey period.

The shellfish beds southeast of Metai Island identified by local fishers were sandy with high grass coverage (68%). Assessment of these beds (9 infaunal stations, 72 quadrat groups, 288 quadrats) gave a mean density of 1.61 ±0.6 individuals/m^2 for arc shells (*Anadara* spp.). Shell distribution was not regular, with arc shells detected in seven of the nine stations and 20% of quadrat groups. A full range of shell size classes was present, indicating continued recruitment; the mean shell length was relatively large (Figure 5.29).

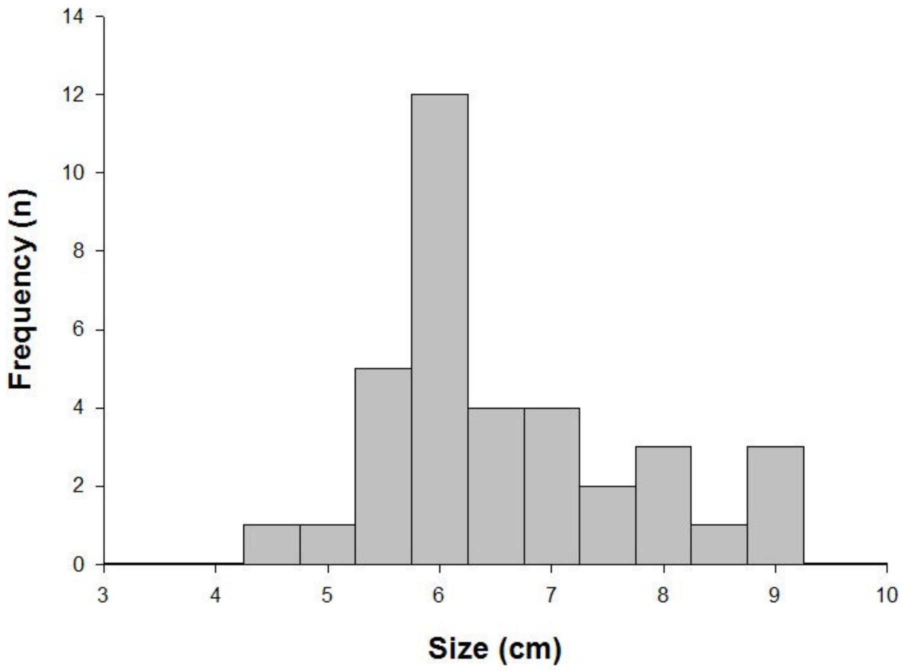

Figure 5.29: Shell length frequency of arc shells (*Anadara* spp.) in the Maskelyne Archipelago soft-benthos fishery.

5.4.4 Other gastropods and bivalves: Maskelyne Archipelago

Both *Lambis lambis* and the larger Seba's spider conch, *L. truncata*, were detected in surveys. *Turbo* spp. (*T. argyrostomus*, *T. chrysostomus*) were recorded at reef stations at low density, and other species targeted by fishers (such as resource species belonging to the genera *Cerithium*, *Conus*, *Cypraea*, *Pleuroploca*, *Tectus* and *Vasum*) were also recorded (Appendices 4.4.1 to 4.4.7; these appendices also contain data on other bivalves such as *Atrina* and *Spondylus*. Note also the catch assessment in Appendix 4.4.12.).

5.4.5 Sea cucumbers[21]: Maskelyne Archipelago

Habitat suitable for sea cucumbers (reef margin and shallow, mixed hard and soft substrate), was extensive in the Maskelyne Archipelago (13.53 km^2). Despite the exposure of some reefs to heavy swell and the lack of deep-water protected lagoons (The lagoon in front of Pellonk was relatively shallow.), 17 species targeted for commercial and subsistence purposes and one non-target species were recorded (Table 5.13). Note that deep diving, which would be required to give advice on deep-water stocks such as the high-value white teatfish (*Holothuria fuscogilva*) and the lower-value amberfish (*Thelonata anax*), was not conducted for this study.

The presence and density of valuable commercial species were high to moderate when compared with records across the four sites in Vanuatu. Within the group of species generally associated with reefs, greenfish (*Stichopus chloronotus*), leopardfish (*Bohadschia argus*) and

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

black teatfish (*H. nobilis*) were widely distributed on both outer and inshore reefs, and were found at relatively high densities. Eighteen black teatfish (*H. nobilis*) were recorded, including a juvenile within seagrass in the lagoon opposite Pellonk (Juveniles are rarely found during surveys.). This high-value species lives in shallow water, is slow growing and is especially vulnerable to fishing. *Actinopyga mauritiana* was common on the exposed reef-front (recorded within 67% of search periods during RFs), although the density of *A. mauritiana* was not high considering the suitable nature and extent of the reef and surge zone in the Maskelyne Archipelago.

More protected areas of reef and soft benthos held other medium- to high-value species (e.g. curryfish, *S. hermanni*) and the lower-value species lollyfish and pinkfish (*H. atra* and *H. edulis*) at reasonable densities. The sheltered areas of mangrove, seagrass and mixed reef and soft substrate at Uliveo were extensive (approximately 10 km^2) and provided suitable environments for sandfish (*H. scabra*), blackfish (*A. miliaris*) and false sandfish (*B. similis*); these were found over an extensive area and at high densities. *H. scabra*, one of the highest-value sea cucumbers, was particularly common (mean density 2131 ±662.4 individuals/ha) at the seven benthos stations fringing mangrove. Patch reefs within the shallow lagoon held small numbers of sandfish but robust populations of the medium- to high-value blackfish, which were in very shallow water and easily accessible to villagers.

5.4.6 Other echinoderms: Maskelyne Archipelago

The edible slate urchin *Heterocentrotus mammillatus* was rarely detected and occurred at low densities in the broad-scale survey. Similarly, *Tripneustes gratilla* was found at low densities. The presence of pencil or slate urchin species was somewhat less common than at other PROCFish/C sites, but *Linckia laevigata*, the blue starfish, was more common in this site than elsewhere in Vanuatu. Other starfish and urchins (resource and subsistence use) were generally found at similar coverage and densities to other sites in Vanuatu (Presence and density estimates can be found in Appendices 4.4.1 to 4.4.7.).

Starfish, such as COTS (*Acanthaster planci*) and non-edible urchins were recorded as potential indicators of habitat condition. COTS were not recorded during broad-scale surveys in the Maskelyne Archipelago, but were seen at low density at 25% of reef-benthos stations.

Table 5.13: Sea cucumber species records for the Maskelyne Archipelago

Species	Common name	Commercial value [6]	B-S transects n = 66			Reef-benthos stations n = 16			Soft-benthos stations SBt = 21; SBq = 9			Other stations RFs = 2; MOPt = 4			Other stations Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga lecanora	Stonefish	M/H	0.3	16.2	2	2.6	41.7	6				5.2	20.4	25 MOPt			
Actinopyga mauritiana	Surf redfish	M/H	1.0	16.5	6	5.2	83.3	6				20.4 15.6	20.4 31.3	100 RFs 50 MOPt			
Actinopyga miliaris	Blackfish	M/H	0.3	16.3	2	31.3	166.7	19	11.9	83.3	14 SBt				411.1	411.1	100
Bohadschia argus	Leopardfish	M	3.7	18.8	20	41.7	111.1	38									
Bohadschia graeffei	Flowerfish	L	9.1	31.7	29												
Bohadschia similis	False sandfish	L							1125	2363	48 SBt [5] SBq				16.7	33.3	50
Bohadschia vitiensis	Brown sandfish	L							6.0	41.7	14 SBt						
Holothuria atra	Lollyfish	L	4.2	27.7	15	104.2	208.3	50	861	1005	86 SBt						
Holothuria coluber	Snakefish	L	2.0	43.6	5	831	3323	25	27.8	116.7	24 SBt				33.3	33.3	100
Holothuria edulis	Pinkfish	L	6.2	22.8	27	67.7	246.7	31	17.9	375.0	5 SBt						
Holothuria fuscogilva [4]	White teatfish	H	No deep dive completed														
Holothuria fuscopunctata	Elephant trunkfish	M	0.5	16.5	3												
Holothuria nobilis [4]	Black teatfish	H	2.0	18.8	11	7.8	41.7	19	2.0	41.7	5 SBt	31.3	31.3	100 MOPt			
Holothuria scabra	Sandfish	H				197.9	1583	13	734	1713	43 SBt						
Holothuria scabra versicolor	Golden sandfish	H															
Stichopus chloronotus	Greenfish	M/H	5.2	34.4	15	91.2	208.3	44									
Stichopus hermanni	Curryfish	M/H	6.7	27.5	24	13.0	69.4	19							27.8	27.8	100
Stichopus horrens	Peanutfish	M													16.7	16.7	100

Table 5.13: Sea cucumber species records for the Maskelyne Archipelago (continued)

Species	Common name	Commercial value (6)	B-S transects n = 66			Reef-benthos stations n = 16			Soft-benthos stations SBt = 21; SBq = 9			Other stations RFs = 2; MOPt = 4			Other stations Ns = 2		
			D (1)	DwP (2)	PP (3)	D	DwP	PP	D	DwP	PP	D	DwP	PP	D	DwP	PP
Stichopus vastus	Brown curryfish	M/H															
Synapta spp.	-	M/H	2.5	40.4	6	5.2	41.7	13	23.8	100.0	25 SBt						
Thelenota ananas	Prickly redfish	H	2.1	19.7	11												
Thelenota anax	Amberfish	M															

(1) D = mean density (numbers/ha); (2) DwP = mean density (numbers/ha) for transects or stations where the species was present; (3) PP = percentage presence (units where the species was found); (4) the scientific name of the black teatfish has recently changed from *Holothuria* (*Microthele*) *nobilis* to *H. whitmaei* and the white teatfish (*H. fuscogilva*) may have also changed name before this report is published. (5) See Appendix 4.4.6; (6) L = low value; M = medium value; H= high value; B-S transects= broad-scale transects; SBt = soft-benthos transect; RFs = reef-front search; MOPs = mother-of-pearl search.

5.4.7 Discussion and conclusions: invertebrate resources in Maskelyne Archipelago

- Invertebrate species typically targeted by fishers through gleaning (on reef and soft substrate) were generally more widely distributed and present in greater densities than the average for PROCFish/C sites in Vanuatu.

- The density and size range of giant clams in the Maskelyne Archipelago would indicate that the resource is impacted. Fishing pressure was the most likely cause for the rarity of *T. squamosa* and *H. hippopus* outside the reserve. *T. maxima* was well distributed within Maskelyne reefs, but the lack of significant numbers of larger clams reflects the impact of fishing pressure. The smaller-sized *T. crocea* appeared to be only marginally impacted.

- Infaunal shell beds within soft-benthos areas were only lightly impacted by fishing and held reasonable densities of large arc shells. Customary reef management provisions, which close these areas to fishing when the shell spawning cycle is most active, may assist in maintaining the status of *Anadara* stocks in the Maskelyne site as compared to other sites. Despite this snapshot assessment of the status of the resource, which suggests the stock is well managed, the density of *Anadara* at the Maskelyne Archipelago is not high compared to arc shell beds at other PROCFish/C sites within the region.

- Green snail (*T. marmoratus*) was absent (although old shells were found within the village), but *T. niloticus* and *P. margaritifera* were present. *P. margaritifera* was found at low levels across the site, but was nonetheless more common than at other PROCFish/C sites in Vanuatu. Commercial harvesting of trochus has affected stocks. Although recruitment is still noted, harvesting of reefs should be discouraged until densities increase.

- Sea cucumber stocks are in good condition, with effective customary management in the form of a fishery closure between harvest periods; the resource is judged to be lightly impacted at present. The stock of high-value sandfish presents an unusual opportunity for monitoring the effects of fishing and recovery when the community decides to re-open the fishery.

5.5 Overall recommendations for the Maskelyne Archipelago

Based on the survey work undertaken and the assessments made across all three disciplines (socioeconomics, finfish and invertebrates), the following recommendations are made for the Maskelyne Archipelago fishing area:

- In order to ensure security of food and income supply from finfish and invertebrates for the community of Maskelyne Archipelago, no further commercial development of the fisheries should take place.

- Existing community-based fisheries management is working well and should be strengthened to ensure that resources remain available for subsistence use by future generations. Should further management measures be required, MPAs should be considered as a primary management tool considering the high quality of habitat and the high compliance with the MPAs established by the community.

- Resources should be closely monitored, to detect any adverse effects of fishing, especially if any expansion of commercial finfish resource harvesting does occur, e.g. if there is a shift to the use of more efficient fishing technology, e.g. the use of motorised boats, or the installation of ice-making machines.

- There is little spare capacity to allow further exploitation of the existing invertebrate resources. There is a need for management intervention to protect large clams and trochus stocks. Periods of low recruitment or environmental disturbance would likely further increase pressure on stocks.

- Current management mechanisms in place for protecting aggregations of sea cucumbers should be encouraged, and the community would benefit from receiving market advice prior to re-commencing commercial fishing. Any monitoring programme that could give an insight into stock recovery following a pulse fishing event would provide important information for the sandfish (*H. scabra*) fishery.

- There would be benefit in undertaking some studies on the effectiveness of the seasonal six-month closure. Such a closure, if followed by six months of intense fishing (as appears to be the case here), may have the effect of just balancing extraction levels and replenishment rates. A perturbation in the system (e.g. a low recruitment period or a cyclone) could disturb the balance considerably. The dynamics of the effects of the closure regime need to be better understood.

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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).

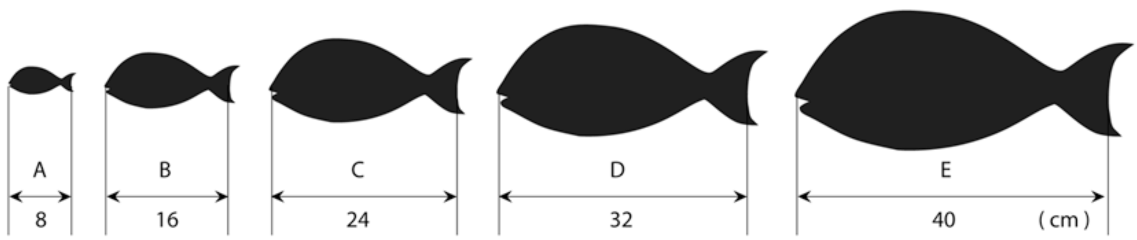


Figure A1.1.1: Finfish size field survey chart for estimating average length of reef and lagoon fish (including five size classes from A = 8 cm to E = 40 cm, in 8 cm intervals).

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.

Equation for canned fish:

Canned fish data are entered as total number of cans per can size consumed by the household at a daily meal, i.e.:

$$CF_{wj} = \sum_{i=1}^{n} (N_{cij} \bullet W_{ci}) \bullet F_{dcj} \bullet 52$$

CF_{wj} = canned fish net weight consumption (kg meat/household/year) of household$_j$
N_{cij} = number of cans of can size$_i$ for household$_j$
n = number and size of cans consumed by household$_j$
W_{ci} = average net weight (kg)/can size$_i$
F_{dcj} = frequency of canned fish consumption (days/week) for household$_j$
52 = total number of weeks/year

Age-gender correction factors are used because simply dividing total household consumption by the number of people in the household will result in underestimating per head consumption. For example, imagine the difference in consumption levels between a 40-year-old man as compared to a five-year-old child. We use simplified gender-age correction factors following the system established and used by the World Health Organization (WHO; Becker and Helsing 1991), i.e. (Kronen *et al.* 2006):

Age (years)	**Gender**	**Factor**
≤ 5	All	0.3
6–11	All	0.6
12–13	Male	0.8
≥ 12	Female	0.8
14–59	Male	1.0
≥ 60	Male	0.8

The per capita finfish, invertebrate and canned fish consumptions are then calculated by selecting the relevant formula from the three provided below:

Finfish per capita consumption:

$$F_{pcj} = \frac{F_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

F_{pcj} = Finfish net weight consumption (kg/capita/year) for household$_j$
F_{wj} = Finfish net weight consumption (kg/household/year) for household$_j$
n = number of age-gender classes
AC_{ij} = number of people for age class i and household j
C_i = correction factor of age-gender class$_i$

Invertebrate per capita consumption:

$$Inv_{pcj} = \frac{Inv_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

Inv_{pcj} = Invertebrate weight consumption (kg edible meat/capita/year) for household$_j$
Inv_{wj} = Invertebrate weight consumption (kg edible meat/household/year) for household$_j$
n = number of age-gender classes
AC $_{ij}$ = number of people for age class i and household j
C $_i$ = correction factor of age-gender class$_i$

Canned fish per capita consumption:

$$CF_{pcj} = \frac{CF_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) for household$_j$
CF_{wj} = canned fish net weight consumption (kg/household/year) for household$_j$
n = number of age-gender classes
AC_{ij} = number of people for age class$_i$ and household$_j$
C_i = correction factor of age-gender class$_i$

The total finfish, invertebrate and canned fish consumption of a known population is calculated by extrapolating the average per capita consumption for finfish, invertebrates and canned fish of the sample size to the entire population.

Total finfish consumption:

$$F_{tot} = \frac{\sum_{j=1}^{n} F_{pcj}}{n_{ss}} \bullet n_{pop}$$

F_{pcj} = finfish net weight consumption (kg/capita/year) for household$_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

Total invertebrate consumption:

$$Inv_{tot} = \frac{\sum_{j=1}^{n} Inv_{pcj}}{n_{ss}} \bullet n_{pop}$$

Inv_{pcj} = invertebrate weight consumption (kg edible meat/capita/year) for household$_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

Total canned fish consumption:

$$CF_{tot} = \frac{\sum_{j=1}^{n} CF_{pcj}}{n_{ss}} \bullet n_{pop}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) of household$_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

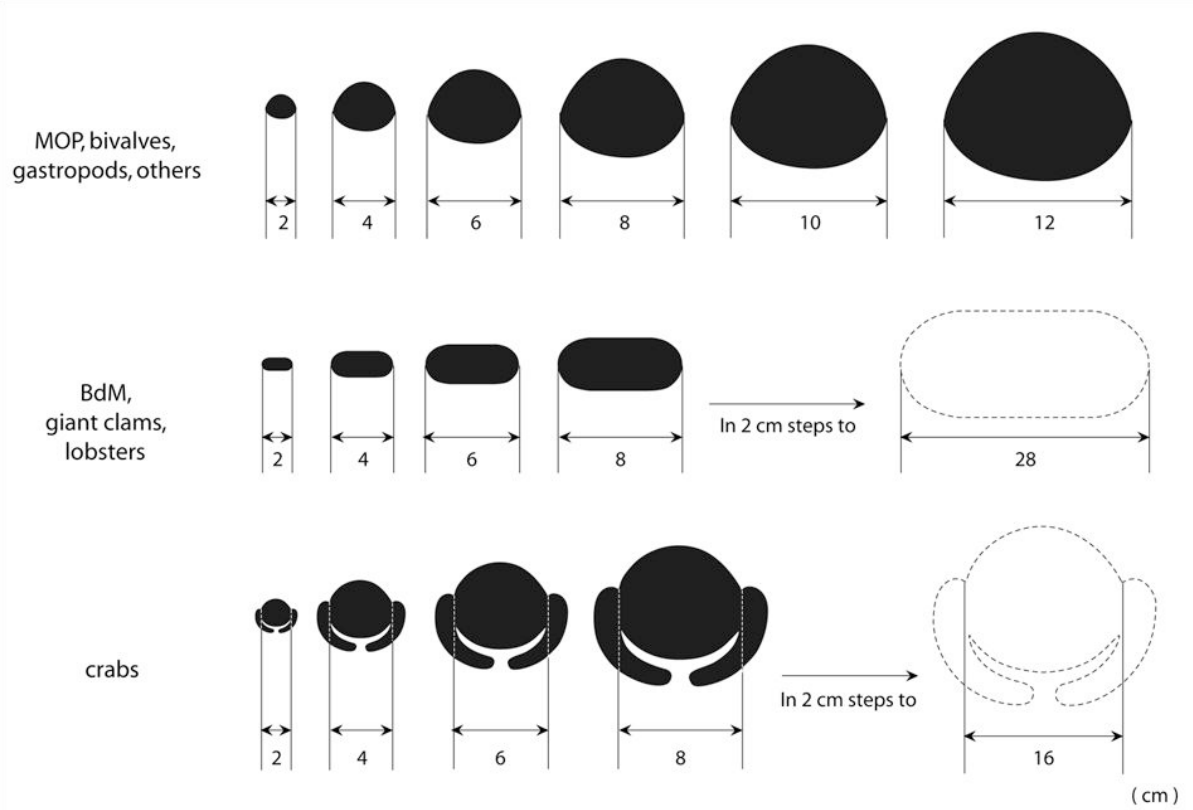


Figure A1.1.2: Invertebrate size field survey chart for estimating average length of different species groups (2 cm size intervals).

Appendix 1: Survey methods

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).

Data from the household survey regarding the number of fishers (by gender and type of fishery) in each household interviewed are extrapolated to determine the total number of men and women that target finfish, invertebrates, or both.

Data from the fisher survey are used to determine what proportion of men and women fishers target various habitats or combinations of habitats. These figures are assumed to be representative of the community as a whole, and hence are applied to the total number of fishers (as determined by the household survey). The total number of finfish fishers is the sum of all fishers who solely target finfish, and those who target both finfish and invertebrates; the same system is applied for invertebrate fishers (i.e. it includes those who collect only invertebrates and those who target both invertebrates and finfish. These numbers are also disaggregated by gender.

The total annual catch per fisher interviewed is calculated, and the average total annual catch reported for each type of fishing activity/fishery (including finfish and invertebrates) by gender is then multiplied by the total number of fishers (calculated as detailed above, for each type of fishing activity/fishery and both genders). More details on the calculation applied to invertebrate fisheries are provided below.

<u>Total annual catch (t/year):</u>

$$\text{TAC} = \sum_{h=1}^{N_h} \frac{Fif_h \bullet Acf_h + Fim_h \bullet Acm_h}{1000}$$

TAC = total annual catch t/year
Fif_h = total number of female fishers for habitat_h
Acf_h = average annual catch of female fishers (kg/year) for habitat_h
Fim_h = total number of male fishers for habitat_h
Acm_h = average annual catch of male fishers (kg/year) for habitat_h
N_h = number of habitats

Where:

$$\text{Acf}_h = \frac{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cfi}{If_h} \bullet \frac{\sum_{k=1}^{Rf_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

If_h = number of interviews of female fishers for habitat_h (total number of interviews where female fishers provided detailed information for habitat_h)
f_i = frequency of fishing trips (trips/week) as reported on interview_i
Fm_i = number of months fished (reported in interview_i)
Cf_i = average catch reported in interview_i (all species)
Rf_h = number of targeted habitats as reported by female fishers for habitat_h (total numbers of interviews where female fishers reported targeting habitat_h but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat_k
Fm_k = number of months fished for reported habitat_k (fishers = sum of finfish fishers and mixed fishers, i.e. people pursuing both finfish and invertebrate fishing)

Thus, we obtain the total annual catch by habitat and gender group. The sum of all catches from all habitats and both genders equals the total annual impact of the community on its fishing ground.

The accuracy of this calculation is determined by reliability of the data provided by interviewees, and the extrapolation procedure. The variability of the data obtained through fisher surveys is illuminated by providing standard errors for the calculated average total annual catches. The size of any error stemming from our extrapolation procedure will vary according to the total population at each site. As mentioned above, this approach is best suited to assess small and predominantly traditional coastal communities. Thus, the risk of over- or underestimating fishing impact increases in larger communities, and those with greater urban influences. We provide both the total annual catch by interviewees (as determined from fisher records) and the extrapolated total impact of the community, so as to allow comparison between recorded and extrapolated data.

The total annual finfish consumption of the surveyed community is used to determine the share of the total annual catch that is used for subsistence, with the remainder being the proportion of the catch that is exported (sold externally).

<u>Total annual finfish export:</u>

$$E = TAC - \left(\frac{F_{tot}}{1000} \bullet \frac{1}{0.8}\right)$$

Where:

E = total annual export (t)
TAC = total annual catch (t)
F_{tot} = total annual finfish consumption (net weight kg)
$\frac{1}{0.8}$ = to calculate total biomass/weight, i.e. compensate for the earlier deduction by 0.8 to determine edible weight parts only

In order to establish <u>fishing pressure</u>, we use the habitat areas as determined by satellite interpretation. However, as already mentioned, resource surveys and satellite interpretation do not include lagoon areas. Thus, we determine the missing areas by calculating the smallest possible polygon (Figure A1.1.3) that encompasses the total fishing ground determined with fishers and local people during the fieldwork. In cases where fishing grounds are gazetted, owned and managed by the community surveyed, the missing areas are determined using the community's fishing ground limits.

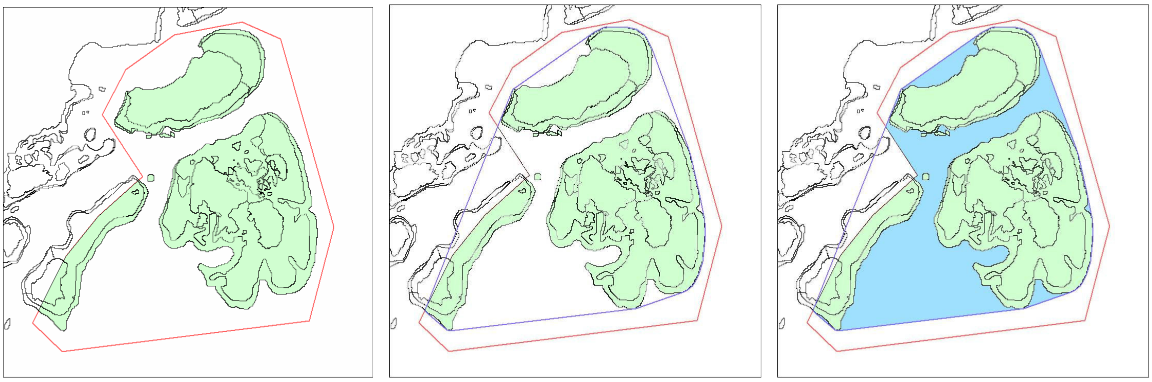


Figure A1.1.3: Determination of lagoon area.
The fishing ground (in red) is initially delineated using information from fishers. Reef areas within the fishing area (in green; interpreted from satellite data) are then identified. The remaining non-reef areas within the fishing grounds are labelled as lagoon (in blue) (Developed using MapInfo).

We use the calculated total annual impact and fishing ground areas to determine relative fishing pressure. Fishing pressure indicators include the following:

- annual catch per habitat
- annual catch per total reef area
- annual catch per total fishing ground area.

Fisher density includes the total number of fishers per km^2 of reef and total fishing ground area, and productivity is the annual catch per fisher. Due to the lack of baseline data, we compare selected indicators, such as fisher density, productivity (catch per fisher and year) and total annual catch (per reef and total fishing ground area), across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The catch per unit effort (CPUE) is generally acknowledged as an indicator of the status of a resource. If an increasing amount of time is required to obtain a certain catch, degradation of the resource is assumed. However, taking into account that our project is based on a snapshot approach, CPUE is used on a comparative basis between sites within a country, and will be employed later on a regional scale. Its application and interpretation must also take into account the fact that fishing in the Pacific Islands does not necessarily follow efficiency or productivity maximisation strategies, but is often an integral component of people's lifestyles. As a result, CPUE has limited applicability.

In order to capture comparative data, in calculating CPUE we use the entire time spent on a fishing trip, including travel, fishing and landing. Thus, we divide the total average catch per fisher by the total average time spent per fishing trip. CPUE is determined as an overall average figure, by gender and habitat fished.

Invertebrate fisher survey

The objective, purpose and design of the invertebrate fisher survey largely follow those of the finfish fisher survey. Thus, the primary aim of the invertebrate fisher survey is to collect data needed to understand the strategies, patterns and dimensions of invertebrate fisheries, and hence the possible impacts on invertebrate resources. Invertebrate data collection faces several challenges, as retrieval of information from local people needs to match the resource survey parameters in order to enable joint data analysis. Some of the major issues are:

Appendix 1: Survey methods

(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).

The number of different vernacular names recorded for each fishery is useful to distinguish between opportunistic and specialised harvesting strategies. This distribution is particularly interesting when comparing gleaning fisheries, while commercial dive fisheries are species specific by definition.

The calculation of catch volumes is based on the determination of the total number of invertebrate fishers and fishers targeting both finfish and invertebrates, by gender group and by fishery, as described above.

The average invertebrate catch composition by number, size and species (with vernacular names transferred to scientific nomenclature), and by fishery and gender group, is extrapolated to include all fishers concerned. Conversion of numbers and species by average weight factors (Appendix 1.1.3) results in a determination of total biomass (wet weight) removed, by fishery and by gender. The sum of all weights determines the total annual impact, in terms of biomass removed.

To calculate total annual impact, we determine the total numbers of months fished by each interviewee. As mentioned above, seasonality of complementary activities, seasonal closing of fishing areas, etc. may result in distinct fishing patterns. Based on data provided by interviewees, we apply – as for finfish – a correction factor of 0.83 to take into account exceptional periods throughout the year when fishing is not possible or not pursued (this is determined on the basis that about two months (304/365 days) of each year are not used for fishing due to festivals, funerals and bad weather conditions).

Total annual catch:

$$\mathrm{TACj} = \sum_{h=1}^{N_h} \frac{F_{inv}f_h \bullet Ac_{inv}f_{hj} + F_{inv}m_h \bullet Ac_{inv}m_{hj}}{1000}$$

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:

$$\mathrm{Ac_{inv}f_{hj}} = \frac{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cf_{ij}}{I_{inv}f_h} \bullet \frac{\sum_{k=1}^{R_{inv}f_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

$I_{inv}f_h$ = number of interviews of female invertebrate fishers for $habitat_h$ (total numbers of interviews where female invertebrate fishers provided detailed information for $habitat_h$)
f_i = frequency of fishing trips (trips/week) as reported in $interview_i$

Fm_i = number of months fished as reported in interview$_i$
Cf_{ij} = average catch reported for species$_j$ as reported in interview$_i$
$R_{inv}f_h$ = number of targeted habitats reported by female invertebrate fishers for habitat$_h$ (total numbers of interviews where female invertebrate fishers reported targeting habitat$_h$ but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat$_k$
Fm_k = number of months fished for reported habitat$_k$

The total annual biomass (t/year) removed is also calculated and presented by species after transferring vernacular names to scientific nomenclature. Size frequency distributions are provided for the most important species, by total annual weight removed, expressed in percentage of each size group of the total annual weight harvested. The size frequency distribution may reveal the impact of fishing pressure for species that are represented by a wide size range (from juvenile to adult state). It may also be a useful parameter to compare the status of a particular species or species group across various sites at the national or even regional level.

To further determine fishing strategies, we also inquire about the purpose of harvesting each species (as recorded by vernacular name). Results are depicted as the proportion (in kg/year) of the total annual biomass (net weight) removed for each purpose: consumption, sale or both. We also provide an index of all species recorded through fisher interviews and their use (in percentage of total annual weight) for any of the three categories.

In order to gain an idea of the productivity of and differences between the fisheries practices used in each site we calculate the average annual catch per fisher, by gender and fishery. This calculation is based on the total biomass (net weight) removed from each fishery and the total number of fishers by gender group.

For invertebrate species that are marketed, detailed information is collected on total numbers (weight and/or combination of number and size), processing level, location of sale or client, frequency of sales and price received per unit sold. At this stage of our project we do not fully analyse this marketing information. However, prices received for major commercial species, as well as an approximation of sale volumes by fishery and fisher, help to assess what role invertebrate fisheries (or a particular fishery) play(s) in terms of income generation for the surveyed community, and in comparison to the possible earnings from finfish fisheries.

We use the calculated total annual impact in combination with the fishing ground area to determine relative fishing pressure. Fishing pressure indicators are calculated as the annual catch per km^2 for each area that is considered to support any of the fisheries present at each study site. In some instances (e.g. intertidal fisheries), areas are replaced by linear km; accordingly, fishing pressure is then related to the length (in km) of the supporting habitat. Due to the lack of baseline data, we compare selected indicators, such as the fisher density (number of fishers per km^2 – or linear km – of fishing ground, for each fishery), productivity (catch per fisher and year) and total annual catch per fishery, across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The differing nature of invertebrate species that may be caught during one fishing trip, and hence the great variability between edible and non-edible, useful and non-useful parts of species caught, make the determination of CPUE difficult. Substantial differences in the economic value of species add another challenge. We have therefore refrained from calculating CPUE values at this stage of the project.

Data entry and analysis

Data from all questionnaire forms are entered in the Reef Fisheries Integrated Database (RFID) system. All data entered are first verified and 'cleaned' prior to analysis. In the process of data entry, a comprehensive list of vernacular and corresponding scientific names for finfish and invertebrate species is developed.

Database queries have been defined and established that allow automatic retrieval of the descriptive statistics used when summarising results at the site and national levels.

1.1.2 Socioeconomic survey questionnaires

- Household census and consumption survey
- Finfish fishing and marketing survey (for fishers)
- Invertebrate fishing and marketing survey (for fishers)
- Fisheries (finfish and invertebrate and socioeconomics) general information survey

HOUSEHOLD CENSUS AND CONSUMPTION SURVEY

HH NO. ☐

Name of head of household: ________________ Village: _________________

Name of person asked: _____________________ Date: __________________

Surveyor's ID: __________________

1. Who is the head of your household? male ☐ female ☐
   (must be living there; tick box)

2. How old is the head of household? *(enter year of birth)* ☐

3. How many people ALWAYS live in your household? ☐
   (enter number)

4. How many are male and how many are female?
   (*tick box and enter age in years or year of birth)*

male	age	female	age

5. Does this household have any agricultural land?

   yes ☐ no ☐

6. How much (*for this household only*)?

   for permanent/regular cultivation ☐ (unit)

   for permanent/regular livestock ☐ (unit)
   type of animals__________ no. ☐

7. How many fishers live in your household? ☐
(*enter number of people who go fishing/collecting regularly)*

invertebrate fishers		finfish fishers		invertebrate & finfish fishers	
M	F	M	F	M	F
☐	☐	☐	☐	☐	☐

8. Does this household own a boat? yes ☐ no ☐

9a. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP
9b. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP
9c. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP

10. Where does the CASH money in this household come from? (*rank options, 1 = most money, 2 = second important income source, 3 = 3rd important income source, 4 = 4th important income source*)

Fishing/seafood collection ☐

Agriculture (crops & livestock) ☐

Salary ☐

Others (handicrafts, etc.) ☐ specify: ____________________

11. Do you get remittances? yes ☐ no ☐

12. How often?

1 per month	1 per 3 months	1 per 6 months	other *(specify)*
☐	☐	☐	☐

13. How much? *(enter amount)* Every time? (currency) [ ]

14. How much CASH money do you use on average for household expenditures (food, fuel for cooking, school bus, etc.)?

(currency) [ ] per week/2-weekly/month (or? specify_______)

15. What is the educational level of your household members?

no. of people	having achieved:
[ ]	elementary/primary education
[ ]	secondary education
[ ]	tertiary education (college, university, special schools, etc.)

CONSUMPTION SURVEY

16. During an average/normal week, on how many days do you prepare fish, other seafood and canned fish for your family? *(tick box)*

	7 days	6 days	5 days	4 days	3 days	2 days	1 day	other, specify
Fresh fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Other seafood	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Canned fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

17. Mainly at	breakfast	lunch	supper
Fresh fish	[ ]	[ ]	[ ]
Other seafood	[ ]	[ ]	[ ]
Canned fish	[ ]	[ ]	[ ]

18. How much do you cook on average per day for your household? *(tick box)*

	number	kg	size: A	B	C	D	E	> E (cm)
Fresh fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Other seafood

name:	no.	size	kg	plastic bag ¼	½	¾	1
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐

19. Canned fish   No. of cans: ☐   Size of can: ☐ small

☐ medium

☐ big

20. Where do you normally get your fish and seafood from?

Fish:

☐ caught by myself/member of this household

☐ get it from somebody in the family/village (no money paid)

☐ buy it at ______________________

Which is the most important source? ☐ caught ☐ given ☐ bought

Invertebrates:

☐ caught by myself/member of this household

☐ get it from somebody in the family/village (no money paid)

☐ buy it at ______________________

Which is the most important source? ☐ caught ☐ given ☐ bought

21. Which is the last day you had fish? ______________________

22. Which is the last day you had other seafood? ______________________

–THANK YOU–

FISHING (FINFISH) AND MARKETING SURVEY

Name: ____________________ F ☐ M ☐ **HH NO.** ☐

Name of head of household: ______________________ Village: ______________

Surveyor's name: _____________________ Date: ______________

1. Which areas do you fish?

coastal reef ☐ lagoon ☐ outer reef ☐ mangrove ☐ pelagic ☐

2. Do you go to only one habitat per trip?

Yes ☐ no ☐

3. If no, how many and which habitats do you visit during an average trip?

total no. ☐ habitats: coastal reef ☐ lagoon ☐ mangrove ☐ outer reef ☐

4. How often (days/week) do you fish in each of the habitats visited?

coastal reef	lagoon	mangrove	outer reef	
☐	☐	☐	☐	__________/times per week/month
☐	☐	☐	☐	__________/times per week/month
☐	☐	☐	☐	__________/times per week/month

5. Do you use a boat for fishing?

	Always	sometimes	never
coastal reef	☐	☐	☐
lagoon	☐	☐	☐
mangrove	☐	☐	☐
outer reef	☐	☐	☐

6. If you use a boat, which one?

1 canoe (paddle) ☐ sailing ☐

motorised ☐ HP outboard ☐ 4-stroke engine ☐

coastal reef ☐ lagoon ☐ outer reef ☐

2	canoe (paddle)	☐			sailing	☐
	motorised	☐	HP outboard	☐	4-stroke engine	☐
	coastal reef	☐	lagoon ☐	outer reef	☐	
3	canoe (paddle)	☐			sailing	☐
	motorised	☐	HP outboard	☐	4-stroke engine	☐
	coastal reef	☐	lagoon ☐	outer reef	☐	

7. How many fishers ALWAYS go fishing with you?

Names:____

INFORMATION BY FISHERY **Name of fisher:** ______________ **HH NO.** ☐

coastal reef ☐ lagoon ☐ mangrove ☐ outer reef ☐

1. HOW OFTEN do you normally go out FISHING for this habitat? *(tick box)*

Every Day	5 days/ week	4 days/ week	3 days/ week	2 days/ week	1 day/ week	other, specify:
☐	☐	☐	☐	☐	☐	____________________

2. What time do you spend fishing this habitat per average trip? ____________________
(if the fisher can't specify, tick a box)

< 2 hrs	2–6 hrs	6–12 hrs	> 12 hrs
☐	☐	☐	☐

3. WHEN do you go fishing? *(tick box)* day ☐ night ☐ day & night ☐

4. Do you go all year?

Yes ☐ no ☐

5. If no, which months <u>don't</u> you fish?

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6. Which fishing techniques do you use (*in the habitat referred to here*)?

☐ handline

☐ castnet ☐ gillnet

☐ spear (dive) ☐ longline

☐ trolling ☐ spear (handheld) walking ☐ canoe ☐

☐ deep bottom line ☐ poison: which one? ______________

☐ other, specify: ____

7. Do you use more than one technique per trip for this habitat? If yes, which ones usually?

☐ one technique/trip ☐ more than one technique/trip:

____

8. Do you use ice on your fishing trips?

☐ always ☐ sometimes ☐ never

☐ is it homemade? ☐ or bought?

9. What is your average catch (kg) per trip? ☐ Kg <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 ☐ if yes for consumption? ☐ sale? ☐

–THANK YOU–

INVERTEBRATE FISHING AND MARKETING SURVEY
FISHERS

HH NO. ☐

Name: ____

Gender: ☐ female ☐ male Age: ☐

Village: ____

Date: ________________ Surveyor's name: ____________________

Invertebrates = everything that is not a fish with fins!

1. Which type of fisheries do you do?

☐ seagrass gleaning ☐ mangrove & mud gleaning

☐ sand & beach gleaning ☐ reeftop gleaning

☐ bêche-de mer diving ☐ mother-of-pearl diving trochus, pearl shell, etc.

☐ lobster diving ☐ other, such as clams, octopus

2. *(if more than one fishery in question 1):* Do you usually go fishing at only one of the fisheries or do you visit several during one fishing trip?

☐ one only ☐ several

If several fisheries at a time, which ones do you combine?

----

3. How often do you go gleaning/diving (*tick as from questions 1 and 2 above and watch for combinations*) and for how long, and do you also finfish at the same time?

	times/week		duration in hours *(if the fisher can't specify, tick the box)* < 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				

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit							
			1	3/4	1/2	1/4				

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐ other (clams, octopus) ☐

SHEET 2: SPECIES SOLD PER FISHER INTERVIEWED: **HH NO**. ☐ **Name of fisher:** ______________________

Copy all species that have been named for 'SALE' in previous sheet

Who markets your products? ☐ you ☐ your wife ☐ your husband ☐ a group of fishers ☐ other _______________

Species for sale – copy from sheet 2 (for each fishery per fisher) above	Processing level of product sold (see list)	Where do you sell? (see list)	How often? Days/week?	How much each time? Quantity/unit	Price

FISHERIES (FINFISH AND INVERTEBRATE AND SOCIOECONOMICS) GENERAL INFORMATION SURVEY

Target group: key people, groups of fishers, fisheries officers, etc.

1. Are there management rules that apply to your fisheries? Do they specifically target finfish or invertebrates, or do they target both sectors?

a) legal/Ministry of Fisheries

b) traditional/community/village determined:

2. What do you think – do people obey:

traditional/village management rules?

mostly ☐ sometimes ☐ hardly ☐

legal/Ministry of Fisheries management rules?

mostly ☐ sometimes ☐ hardly ☐

3. Are there any particular rules that you know people do not respect or follow at all? And do you know why?

4. What are the main techniques used by the community for:

a) finfishing

gillnets – most-used mesh sizes:

What is usually used for bait? And is it bought or caught?

b) invertebrate fishing → ***see end!***

5. Please give a quick inventory and characteristics of boats used in the community (length, material, motors, etc.).

Seasonality of species

What are the **FINFISH** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

Seasonality of species

What are the **INVERTEBRATE** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

How many people carry out the invertebrate fisheries below, from inside and from outside the community?

GLEANING	no. from this village	no.	from village	no.	from village
☐ seagrass gleaning	☐	☐	____	☐	____
☐ mangrove & mud gleaning	☐	☐	____	☐	____
☐ sand & beach gleaning	☐	☐	____	☐	____
☐ reeftop gleaning	☐	☐	____	☐	____
DIVING					
☐ bêche-de-mer diving	☐	☐	____	☐	____
☐ lobster diving	☐	☐	____	☐	____
☐ mother-of-pearl diving trochus, pearl shell, etc.	☐	☐	____	☐	____
☐ other (clams, octopus)	☐	☐	____	☐	____

What gear do invertebrate fishers use? *(tick box of technique per fishery)*

GLEANING (soft bottom = seagrass)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other ________		

GLEANING (soft bottom = mangrove & mud)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other ________		

GLEANING (soft bottom = sand & beach)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

GLEANING (hard bottom = reeftop)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (bêche-de-mer)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (lobster)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (mother-of-pearl, trochus, pearl shell, etc.)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other ___________

DIVING (other, such as clams, octopus)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other ___________

Any traditional/customary/village fisheries?

Name:

Season/occasion:

Frequency:

Quantification of marine resources caught:

Species name	Size	Quantity (unit?)

1.1.3 Average wet weight applied for selected invertebrate species groups

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Acanthopleura gemmata	29	35	65	10.15	Chiton
Actinopyga lecanora	300	10	90	30	BdM [(1)]
Actinopyga mauritiana	350	10	90	35	BdM [(1)]
Actinopyga miliaris	300	10	90	30	BdM [(1)]
Anadara 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.

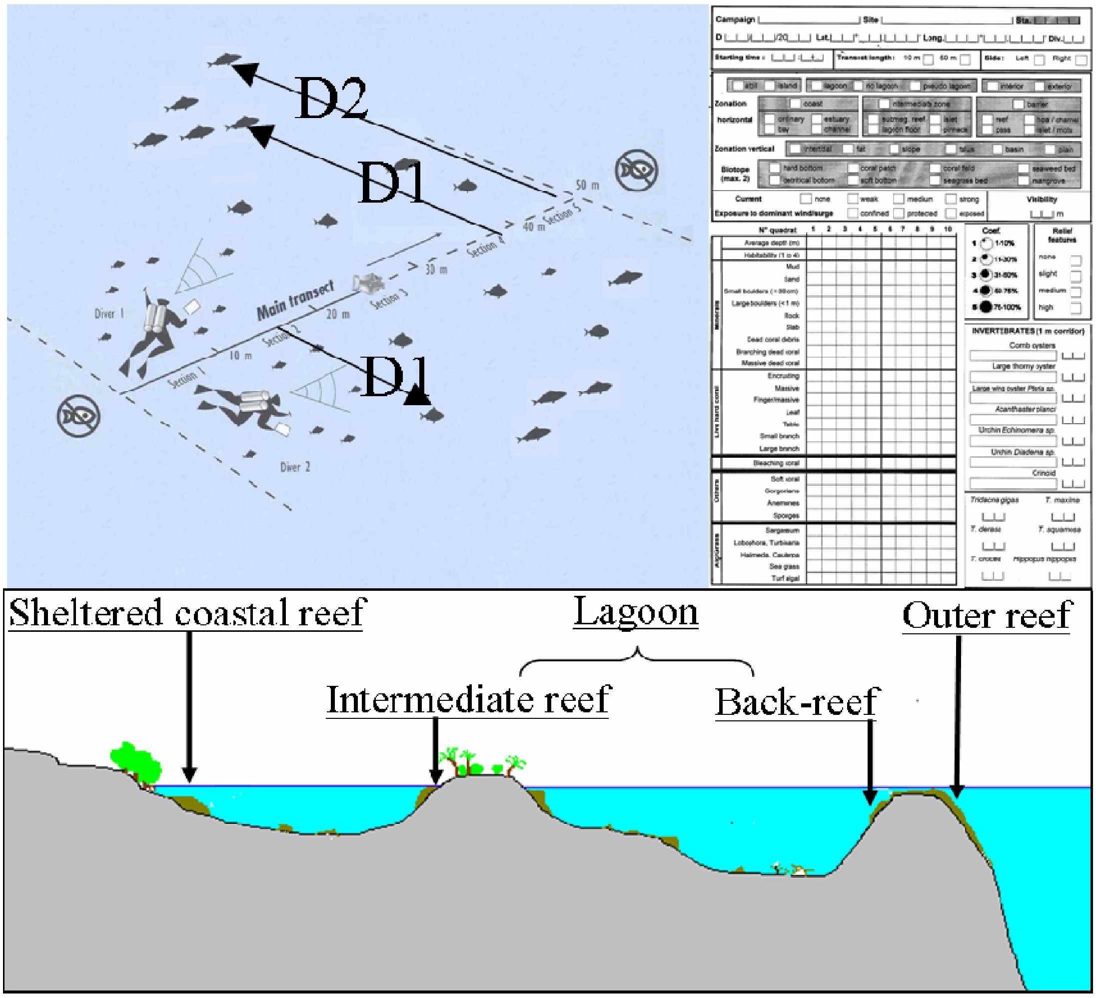


Figure A1.2.1: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver records the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys 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.

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.

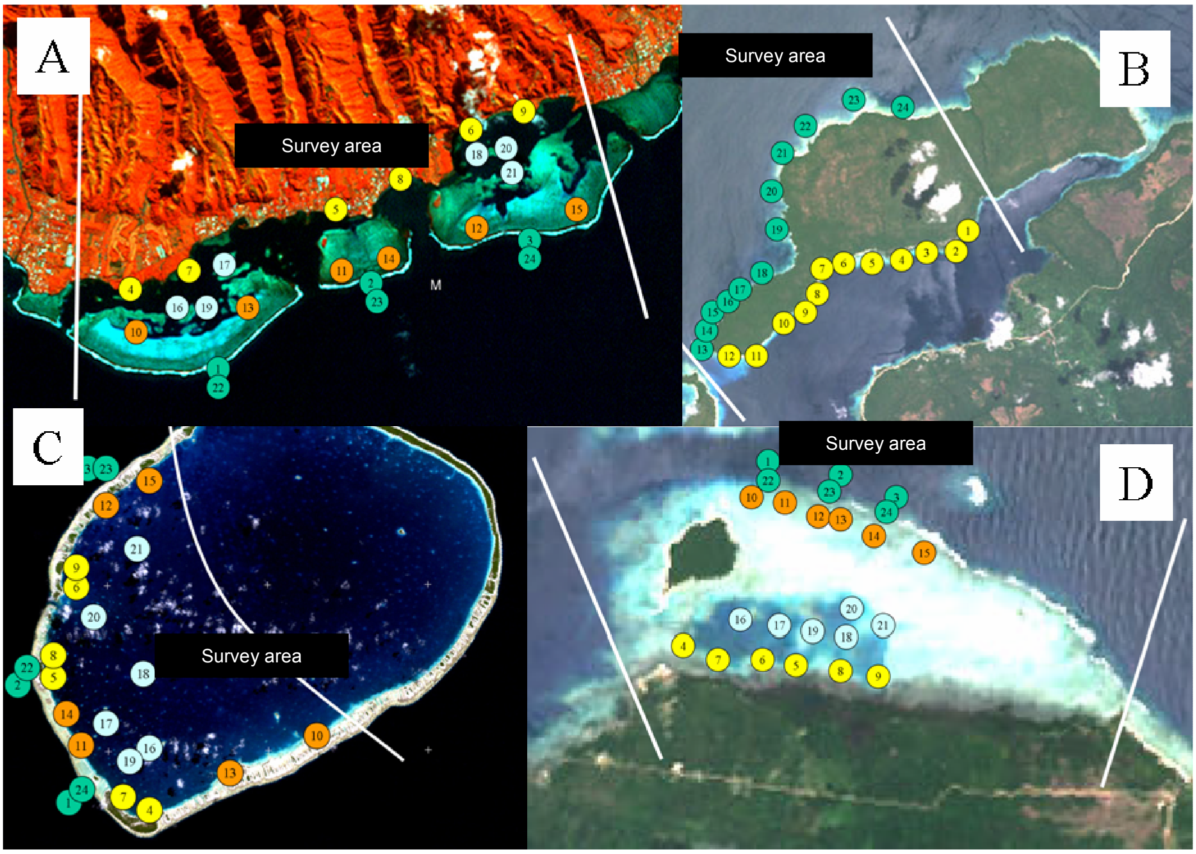


Figure A1.2.2: Position of the 24 D-UVC transects surveyed in A) an island with a lagoon, B) an island with a pseudo-lagoon C) an atoll and D) an island with an extensive reef enclosing a small lagoon pool.
Sheltered coastal reef transects are in yellow, lagoon intermediate-reef transects in blue, lagoon 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:

$$B_{Vk} = \sum j_l \, [B_{Hj} \bullet S_{Hj}] \, / \sum_j S_{Hj}$$

Where:

B_{Vk} = computed biomass or fish stock for village k
B_{Hj} = average biomass in habitat H_j
S_{Hj} = surface of that habitat H_j

A comparative approach only

Density and biomass estimated by D-UVC for each species recorded in the country are given in Appendix 3.2. However, it should be stressed that, since estimates of fish density and biomass (and other parameters) are largely dependent upon the assessment method used (this is true for any assessment), the resource assessment provided in this report can only be used for management in a comparative manner. Densities, biomass and other figures given in this report provide only estimates of the available resource; it would be a great mistake (possibly leading to mismanagement) to consider these as true indicators of the actual available resource.

Campaign |__________________| Site |______________________________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|,|__|__|__|' Long.|__|__|__|°|__|__|,|__|__|__|' WT |__|__|__|

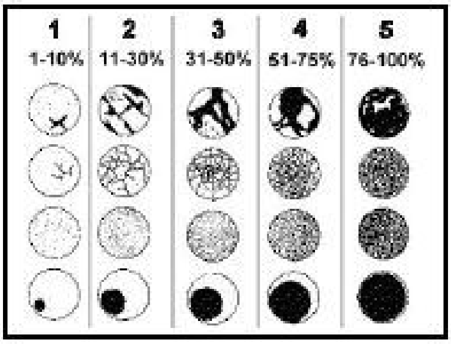
Starting time : |__|__| :|__|__|	Visibility |__|__| m	Side : Left ☐ Right ☐

☐ coast		☐ intermediate zone		☐ barrier	
☐ linear	☐ cape	☐ submerg. reef	☐ pinnacle	☐ outer slope	☐ pass
☐ bay mouth	☐ back of bay	☐ near surf. reef	☐ islet lagoon	☐ reef crest	☐ hoa/channel
☐ estuary	☐ channel	☐ lagoon floor	☐ islet fringing reef	☐ back reef	☐ motu

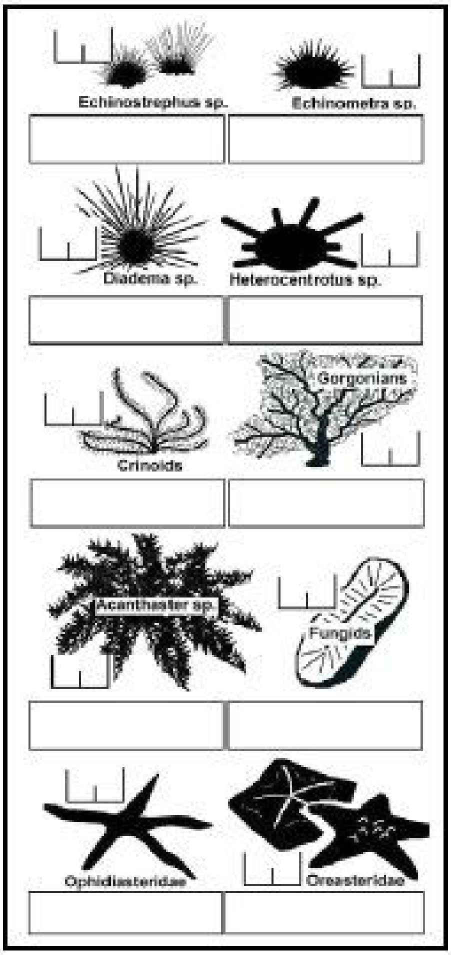
☐ intertidal ☐ flat ☐ gentle slope ☐ steep slope ☐ talus ☐ basin ☐ lagoon plain

☐ hard bottom	☐ large coral patches	☐ small coral patches	☐ coral field	☐ seaweed bed
☐ detritical bottom	☐ soft bottom		☐ seagrass bed	☐ mangrove

	current	relief features	exposure to dominant wind	oceanic influence	terrigenous influence
none	☐	☐	☐	☐	☐
medium	☐	☐	☐	☐	☐
strong	☐	☐	☐	☐	☐



	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 :										



Campaign |____________________| Site |______________________________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|,|__|__|__|__|' Long.|__|__|__|°|__|__|,|__|__|__|__|' Left ☐ Right ☐

ST	SCIENTIFIC NAME	NBER	LGT	D1	D2	COMMENTS

1.3 Invertebrate resource survey methods

1.3.1 Methods used to assess the status of invertebrate resources

Introduction

Coastal communities in the Pacific access a range of invertebrate resources. Within the PROCFish/C study, a range of survey methods were used to provide information on key invertebrate species commonly targeted. These provide information on the status of resources at scales relevant to species (or species groups) and the fishing grounds being studied that can be compared across sites, countries and the region, in order to assess relative status.

Species data resulting from the resource survey are combined with results from the socioeconomic survey of fishing activity to describe invertebrate fishing activity within specific 'fisheries'. Whereas descriptions of commercially orientated fisheries are generally recognisable in the literature (e.g. the sea cucumber fishery), results from non-commercial stocks and subsistence-orientated fishing activities (e.g. general reef gleaning) will also be presented as part of the results, so as to give managers a general picture of invertebrate fishery status at study sites.

Field methods

We examined invertebrate stocks (and fisheries) for approximately seven days at each site, with at least two research officers (SPC Invertebrate Biologist and Fisheries Officer) plus officers from the local fisheries department. The work completed at each site was determined by the availability of local habitats and access to fishing activity.

Two types of survey were conducted: fishery-dependent surveys and fishery independent surveys.

- Fishery-dependent surveys rely on information from those engaged in the fishery, e.g. catch data;
- Fishery-independent surveys are conducted by the researchers independently of the activity of the fisheries sector.

Fishery-dependent surveys were completed whenever the opportunity arose. This involved accompanying fishers to target areas for the collection of invertebrate resources (e.g. reef-benthos, soft-benthos, trochus habitat). The location of the fishing activity was marked (using a GPS) and the catch composition and catch per unit effort (CPUE) recorded (kg/hour).

This record was useful in helping to determine the species complement targeted by fishers, particularly in less well-defined 'gleaning' fisheries. A CPUE record, with related information on individual animal sizes and weights, provided an additional dataset to expand records from reported catches (as recorded by the socioeconomic survey). In addition, size and weight measures collected through fishery-dependent surveys were compared with records from fishery-independent surveys, in order to assess which sizes fishers were targeting.

For a number of reasons, not all fisheries lend themselves to independent snapshot assessments: density measures may be difficult to obtain (e.g. crab fisheries in mangrove systems) or searches may be greatly influenced by conditions (e.g. weather, tide and lunar conditions influence lobster fishing). In the case of crab or shoreline fisheries, searches are very subjective and weather and tidal conditions affect the outcome. In such cases, observed and reported catch records were used to determine the status of species and fisheries.

A further reason for accompanying groups of fishers was to gain a first-hand insight into local fishing activities and facilitate the informal exchange of ideas and information. By talking to fishers in the fishing grounds, information useful for guiding independent resource assessment was generally more forthcoming than when trying to gather information using maps and aerial photographs while in the village. Fishery-independent surveys were not conducted randomly over a defined site 'study' area. Therefore assistance from knowledgeable fishers in locating areas where fishing was common was helpful in selecting areas for fishery-independent surveys.

A series of fishery-independent surveys (direct, in-water resource assessments) were conducted to determine the status of targeted invertebrate stocks. These surveys needed to be wide ranging within sites to overcome the fact that distribution patterns of target invertebrate species can be strongly influenced by habitat, and well replicated as invertebrates are often highly aggregated (even within a single habitat type).

PROCFish/C assessments do not aim to determine the size of invertebrate populations at study sites. Instead, these assessments aim to determine the status of invertebrates within the main fishing grounds or areas of naturally higher abundance. The implications of this approach are important, as the haphazard measures taken in main fishing grounds are indicative of stock health in these locations only and should not be extrapolated across all habitats within a study site to gain population estimates.

This approach was adopted due to the limited time allocated for surveys and the study's goal of 'assessing the status of invertebrate resources' (as opposed to estimating the standing stock). Making judgements on the status of stocks from such data relies on the assumption that the state of these estimates of 'unit stock'[2] reflects the health of the fishery. For example, an overexploited trochus fishery would be unlikely to have high-density 'patches' of trochus, just as a depleted shallow-reef gleaning fishery would not hold high densities of large clams. Conversely, a fishery under no stress would be unlikely to be depleted or show skewed size ratios that reflected losses of the adult component of the stock.

In addition to examining the density of species, information on spatial distribution and size/weight was collected, to add confidence to the study's inferences.

The basic assumption that looking at a unit stock will give a reliable picture of the status of that stock is not without weaknesses. Resource stocks may appear healthy within a much-restricted range following stress from fishing or environmental disturbance (e.g. a cyclone), and historical information on stock status is not usually available for such remote locations. The lack of historical datasets also precludes speculation on 'missing' species, which may be 'fished-out' or still remain in remnant populations at isolated locations within study sites.

[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).

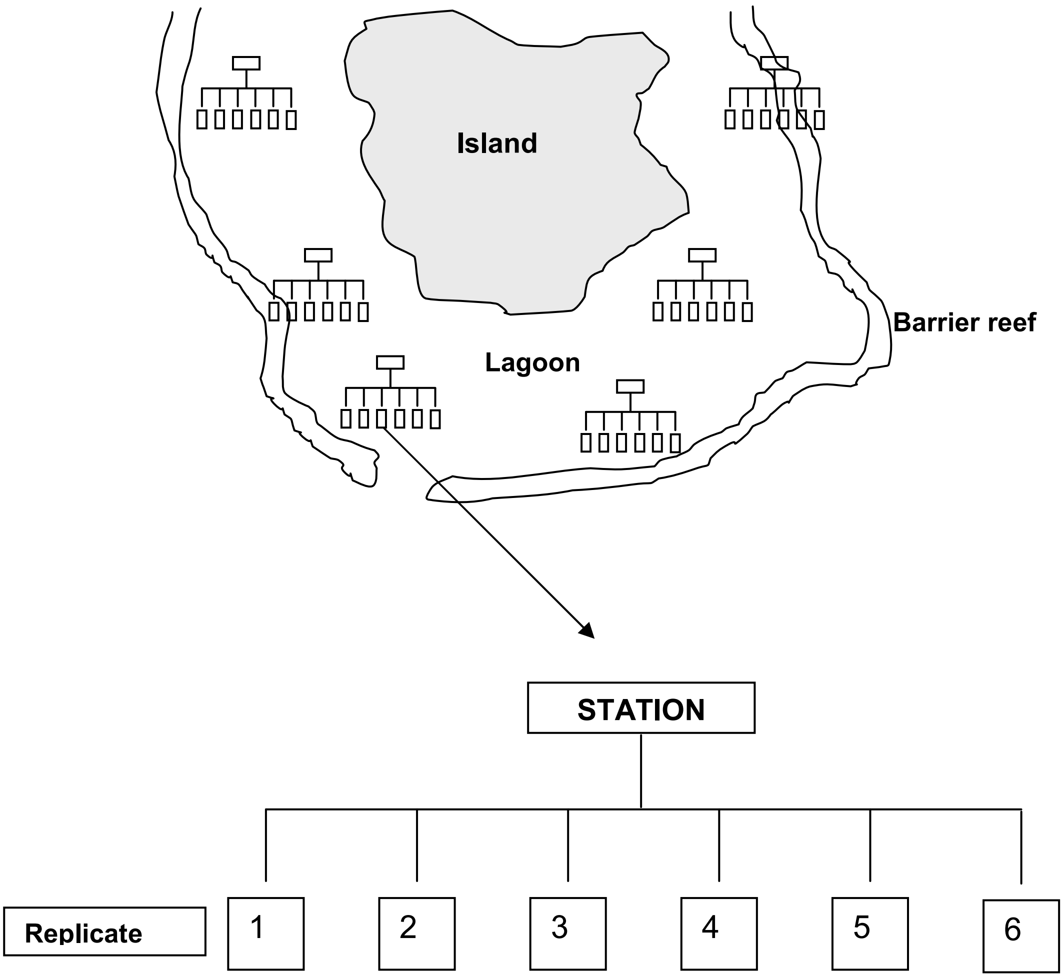


Figure A1.3.1: Stations and replicate measures at a given site.
A replicate measure could be a transect, search period or quadrat group.

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).

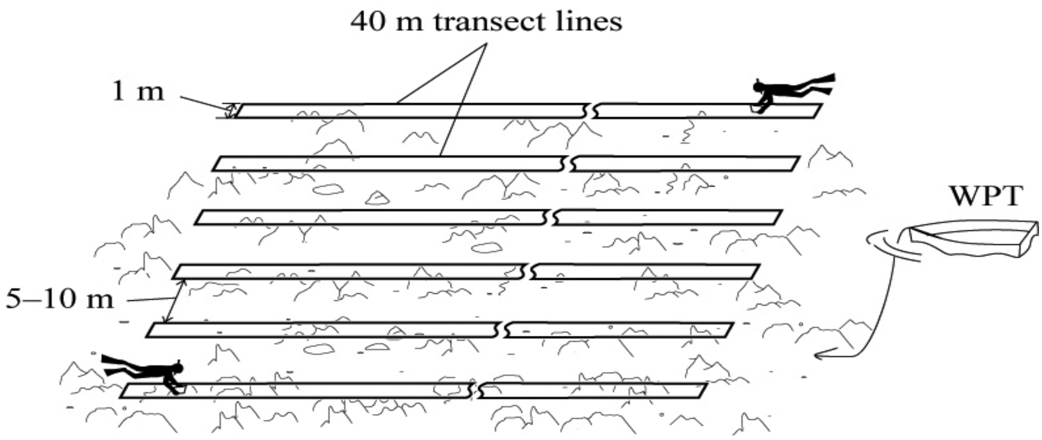


Figure A1.3.2: Example of a reef-benthos transect station (RBt).

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.

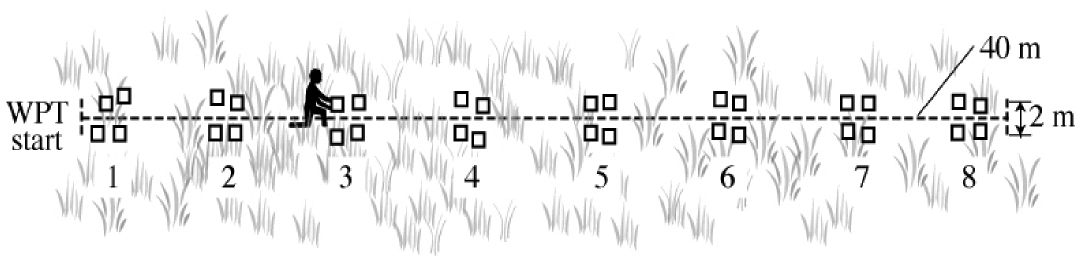


Figure A1.3.3: Soft-benthos (infaunal) quadrat station (SBq).
Single quadrats are 25 cm x 25 cm in size and four make up one 'quadrat group'.

<u>Mother-of-pearl (MOP) or sea cucumber (BdM) fisheries</u>

To assess fisheries such as those for trochus or sea cucumbers, results from broad-scale, reef- and soft-benthos assessments were used. However, other specific surveys were incorporated into the work programme, to more closely target species or species groups not well represented in the primary assessments.

<u>Reef-front searches (RFs and RFs_w)</u>

If swell conditions allowed, three 5-min search periods (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).

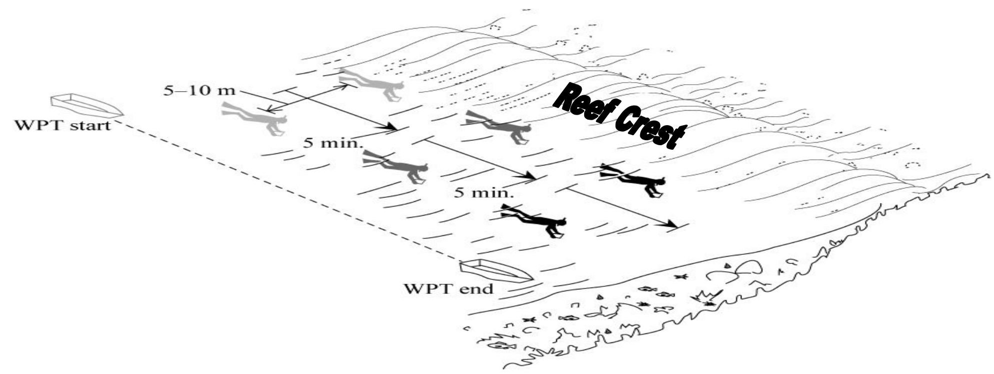


Figure A1.3.4: Reef-front search (RFs) station.

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.

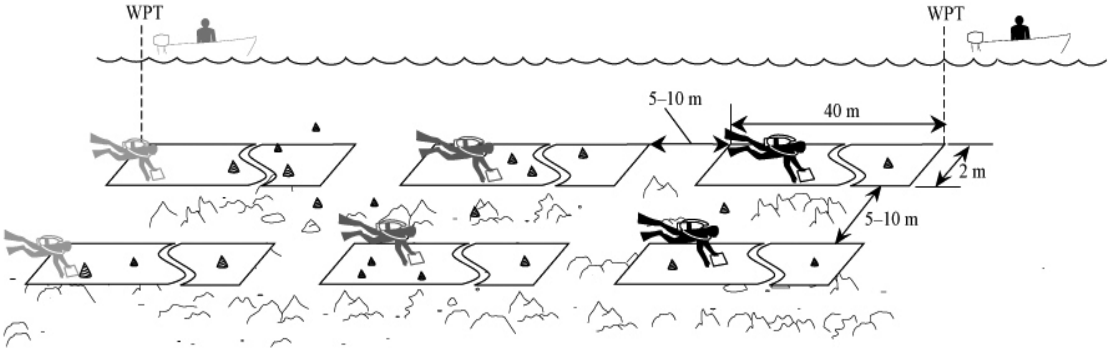


Figure A1.3.5: Mother-of-pearl transect station (MOPt).

Sea cucumber day search (Ds)

When possible, dives to 25–35 m were made to establish if white teatfish (*Holothuria (Microthele) fuscogilva*) populations were present and give an indication of abundance. In these searches two divers recorded the number and sizes of valuable deep-water sea cucumber species within three 5-min search periods (30 min total). This assessment from deep water does not yield sufficient presence/absence data for a very reliable inference on the status (i.e. 'health') of this and other deeper-water species.

Sea cucumber night search (Ns)

In the case of sea cucumber fisheries, dedicated night searches (Ns) for sea cucumbers and other echinoderms were conducted using snorkel for predominantly nocturnal species (blackfish *Actinopyga miliaris*, *A. lecanora*, and *Stichopus horrens*). Sea cucumbers were collected for three 5-min search periods by two snorkellers (30 min total), and if possible weighed (length and width measures for *A. miliaris* and *A. lecanora* are more dependent on the condition than the age of an individual).

Reporting style

For country site reports, results highlight the presence and distribution of species of interest, and their density at scales that yield a representative picture. Generally speaking, mean densities (average of all records) are presented, although on occasion mean densities for areas of aggregation ('patches') are also given. The later density figure is taken from records (stations or transects, as stated) where the species of interest is present (with an abundance > zero). Presentation of the relative occurrence and densities (without the inclusion of zero records) can be useful when assessing the status of aggregations within some invertebrate stocks.

An example and explanation of the reporting style adopted for invertebrate results follows.

1. The mean density range of *Tridacna* spp. on broad-scale stations (n = 8) was 10–120 per ha.

Density range includes results from all stations. In this case, replicates in each station are added and divided by the number of replicates for that station to give a mean. The lowest and highest station averages (here 10 and 120) are presented for the range. The number in brackets (n = 8) highlights the number of stations examined.

2. The mean density (per ha, ±SE) of all *Tridacna* clam species observed in broad-scale transects (n = 48) was 127.8 ±21.8 (occurrence in 29% of transects).

Mean density is the arithmetic mean, or average of measures across all replicates taken (in this case broad-scale transects). On occasion mean densities are reported for stations or transects where the species of interest is found at an abundance greater than zero. In this case the arithmetic mean would only include stations (or replicates) where the species of interest was found (excluding zero replicates). If this was presented for stations, even stations with a single clam from six transects would be included. (Note: a full breakdown of data is presented in the appendices.)

Written after the mean density figure is a descriptor that highlights variability in the figures used to calculate the mean. Standard error[3] (SE) is used in this example to highlight variability in the records that generated the mean density (SE = (standard deviation of records)/√n). This figure provides an indication of the dispersion of the data when trying to estimate a population mean (the larger the standard error, the greater variation of data points around the mean presented).

Following the variability descriptor is a presence/absence indicator for the total dataset of measures. The presence/absence figure describes the percentage of stations or replicates with a recording > 0 in the total dataset; in this case 29% of all transects held *Tridacna* spp., which equated to 14 of a possible 48 transects (14/48*100 = 29%).

3. The mean length (cm, ±SE) of *T. maxima* was 12.4 ±1.1 (n = 114).

The number of units used in the calculation is indicated by *n*. In the last case, 114 clams were measured.

[3] In order to derive confidence limits around the mean, a transformation (usually y = log (x+1)) needs to be applied to data, as samples are generally non-normally distributed. Confidence limits of 95% can be generated through other methods (bootstrapping methods) and will be presented in the final report where appropriate.

1.3.2 General fauna invertebrate recording sheet with instructions to users

DATE		RECORDER		Pg No	

STATION NAME																		
WPT - WIDTH																		
RELIEF / COMPLEXITY **1–5**																		
OCEAN INFLUENCE **1–5**																		
DEPTH (M)																		
% SOFT SED (M – S – CS)																		
% RUBBLE / BOULDERS																		
% CONSOL RUBBLE / PAVE																		
% CORAL *LIVE*																		
% CORAL *DEAD*																		
SOFT / SPONGE / FUNGIDS																		
ALGAE *CCA*																		
CORALLINE																		
OTHER																		
GRASS																		
EPIPHYTES **1–5** / SILT **1–**																		
bleaching: % of																		
entered /	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/

Figure A1.3.6: Sample of the invertebrate fauna survey sheet.

The sheet above (Figure A1.3.6) has been modified to fit on this page (the original has more line space (rows) for entering species data). When recording abundance or length data against species names, columns are used for individual transects or 5-min search replicates. If more space is needed, more than a single column can be used for a single replicate.

A separate sheet is used by a recorder in the boat to note information from handheld GPS equipment. In addition to the positional information, this boat sheet has space for manta transect distance (from GPS odometer function) and for sketches and comments.

1.3.3 Habitat section of invertebrate recording sheet with instructions to users

Figure A1.3.7 depicts the habitat part of the form used during invertebrate surveys; it is split into seven broad categories.

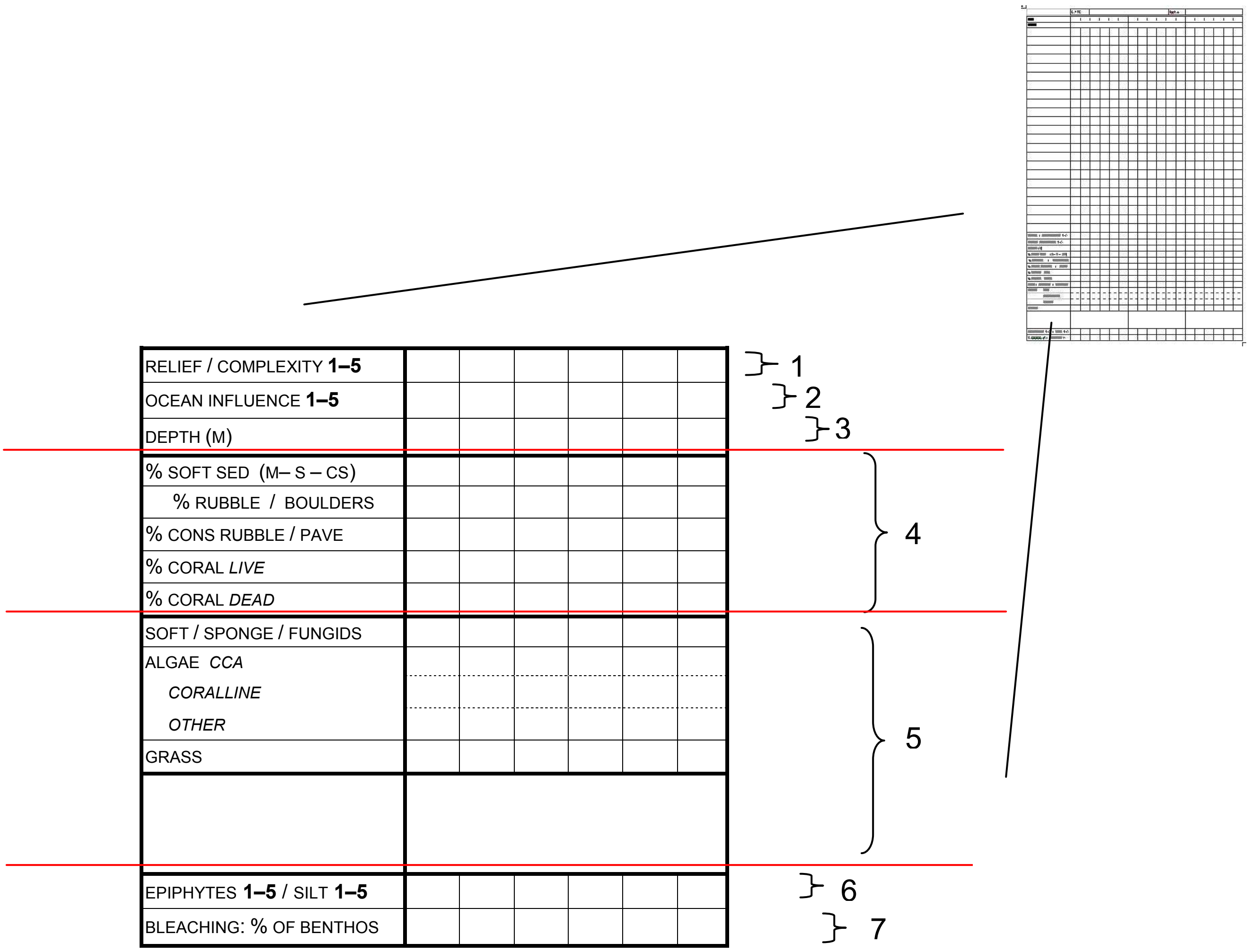


Figure A1.3.7: Sample of the invertebrate habitat part of survey form.

Relief and complexity (section 1 of form)

Each is on a scale of 1 to 5. If a record is written as 1/5, relief is 1 and complexity is 5, with the following explanation.

Relief describes average height variation for hard (and soft) benthos transects:

1 = flat (to ankle height)
2 = ankle up to knee height
3 = knee to hip height
4 = hip to shoulder/head height
5 = over head height

Complexity describes average surface variation for substrates (relative to places for animals to find shelter) for hard (and soft) benthos transects:

1 = smooth – no holes or irregularities in substrate
2 = some complexity to the surfaces but generally little

3 = generally complex surface structure
4 = strong complexity in surface structure, with cracks, spaces, holes, etc.
5 = very complex surfaces with lots of spaces, nooks, crannies, under-hangs and caves

Ocean influence (section 2 of form)

1 = riverine, or land-influenced seawater with lots of allochthonous input
2 = seawater with some land influence
3 = ocean and land-influenced seawater
4 = water mostly influenced by oceanic water
5 = oceanic water without land influence

Depth (section 3 of form)

Average depth in metres

Substrate – bird's-eye view of what's there (section 4 of form)

All of section 4 must make up 100%. Percentage substrate is estimated in units of 5% so, e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Soft substrate	Soft sediment – mud
Soft substrate	Soft sediment – mud and sand
Soft substrate	Soft sediment – sand
Soft substrate	Soft sediment – coarse sand
Hard substrate	Rubble
Hard substrate	Boulders
Hard substrate	Consolidated rubble
Hard substrate	Pavement
Hard substrate	Coral live
Hard substrate	Coral dead

Mud, sand, coarse sand: The sand is not sieved – it is estimated visually and manually. Surveyors can use the 'drop test', where sand drops through the water column and mud stays in suspension. Patchy settled areas of silt/clay/mud in very thin layers on top of coral, pavement, etc. are not listed as soft substrate unless the layer is significant (> a couple of cm).

Rubble is small (< 25–30 cm) fragments of coral (reef), pieces of coral stone and limestone debris. AIMS' definition is very similar to that for Reefcheck (found on the 'C-nav' interactive CD): 'pieces of coral (reef) between 0.5 and 15 cm. If smaller, it is sand; if larger, then rock or whatever organism is growing upon it'.

Boulders are detached, big pieces (> 30 cm) of stone, coral stone and limestone debris.

Consolidated rubble is attached, cemented pieces of coral stone and limestone debris. We tend to use 'rubble' for pieces or piles loose in the sediment of seagrass, etc., and 'consolidated rubble' for areas that are not flat pavement but concreted rubble on reeftops and cemented talus slopes.

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 Paunangisu village socioeconomic survey data

2.1.1 Annual catch (kg) of fish groups per habitat (includes only reported catch data by interviewed finfish fishers) – Paunangisu village

Vernacular name	Family	Scientific name	Total weight (kg)	% of total annual reported catch
Sheltered coastal reef and lagoon (combined in one fishing trip)				
Pico	Siganidae	*Siganus* sp.	1027	24
Malet	Mugilidae	*Valamugil seheli*	717	17
San pepa	Acanthuridae	*Acanthurus* sp., *Ctenochaetus* sp., *Naso* sp., *Prionurus* sp., *Zebrasoma* sp.	536	12
Karong	Carangidae	*Caranx* sp.	489	11
Bun fish	Albulidae	*Albula* sp.	445	10
Moustas fis	Mullidae	*Parupeneus* sp.	363	8
	Balistidae	*Rhinecanthus aculeatus*, *Rhinecanthus rectangulus*	304	7
Parot fis	Scaridae	*Scarus* sp.	174	4
Red maot	Lethrinidae	*Gnathodentex aureolineatus*, *Gnathodentex* sp., *Gymnocranius elongatus*, *Gymnocranius euanus*	102	2
Blu fis	Scaridae	*Hipposcarus* sp., *Scarus* sp.	68	2
Skuiral fis	Holocentridae	*Holocentrus* sp., *Myripristis* sp., *Plectrypops* sp., *Sargocentron* sp.	36	1
Rif snapper	Lutjanidae	*Lutjanus fulvus*	33	1
Mata miela, Rif snappa	Lutjanidae	*Lutjanus gibbus*	15	0
Loch	Serranidae	*Variola louti*	15	0
Total:			**3884**	**99**
Lagoon				
Malet	Mugilidae	*Valamugil seheli*	920	23
Red maot	Lethrinidae	*Gnathodentex aureolineatus*, *Gnathodentex* sp., *Gymnocranius elongatus*, *Gymnocranius euanus*	731	18
Pico	Siganidae	*Siganus* sp.	587	15
Karong	Carangidae	*Caranx* sp.	574	14
Moustas fis	Mullidae	*Parupeneus* sp.	534	13
Strong skin	Balistidae	*Rhinecanthus aculeatus*, *Rhinecanthus rectangulus*	152	4
Mangaru	Carangidae	*Atule mate*	130	3
Blu fis, Parrot fis	Scaridae	*Scarus* sp.	100	3
Big bel	Haemulidae	*Diagramma* sp.	81	2
Red maot	Lethrinidae	*Lethrinus semicinctus*	65	2
Blu fis, Parot fis	Sphyraenidae	*Sphyraena barracuda*	53	1

2.1.1 Annual catch (kg) of fish groups per habitat (includes only reported catch data by interviewed finfish fishers) – Paunangisu village (continued)

Vernacular name	Family	Scientific name	Total weight (kg)	% of total annual reported catch
Lagoon (continued)				
Strong skin	Acanthuridae	*Acanthurus* sp., *Ctenochaetus* sp., *Naso* sp., *Prionurus* sp., *Zebrasoma* sp.	33	1
Losh	Serranidae	*Epinephelus* sp.	23	1
Napoleon	Labridae	*Cheilinus undulates*	11	0
Total:			**2578**	**100**
Outer reef				
Blu fis	Scaridae	*Hipposcarus* sp., *Scarus* sp.	385	39
Bik bel	Kyphosidae	*Kyphosus vaigiensis, Kyphosus cinerascens*	254	26
Bik bel	Haemulidae	*Diagramma* sp.	225	23
San pepa	Acanthuridae	*Acanthurus* sp., *Ctenochaetus* sp., *Naso* sp., *Prionurus* sp., *Zebrasoma* sp.	35	4
Blak pico	Mullidae	*Parupeneus* sp.	24	2
San pepa	Acanthuridae	*Acanthurus lineatus*	18	2
Blu fis, Parot fis	Scaridae	*Bolbometopon muricatum*	17	2
Blu fis, Parot fis	Scaridae	*Scarus* sp.	14	1
Losh	Serranidae	*Epinephelus* sp.	10	1
Strong skin	Balistidae	*Rhinecanthus aculeatus, Rhinecanthus rectangulus*	7	1
Red maot	Lethrinidae	*Gnathodentex aureolineatus, Gnathodentex* sp., *Gymnocranius elongatus, Gymnocranius euanus*	1	0
Total:			**989**	**100**
Mangrove				
Red maot	Lethrinidae	*Gnathodentex aureolineatus, Gnathodentex* sp., *Gymnocranius elongatus, Gymnocranius euanus*	85	88
Red maot	Lethrinidae	*Lethrinus semicinctus*	11	12
Total:			**96**	**100**

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Paunangisu village

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Mangrove	Rakuma Tuupa	*Cardisoma* spp.	44.6
	Nasulan	*Terebra* spp.	42.5
	Krab kaldonia	*Scylla serrata*	12.9
Other	Natalai	*Tridacna* spp.	83.7
	Oktopus		16.3
Reeftop	Paukasua	*Conus* spp.	48.1
	Ngora	*Pleuroploca filamentosa*	27.1
	Karau Natalai	*Tridacna* sp.	10.0
	Pule	*Cypraea* sp., *Cypraea tigris*	7.6
	Wita Oktopus		5.5
	Sea anemone		1.7
Intertidal	Alure	*Atactodea striata*	50.0
	Popoti		50.0
Intertidal & reeftop	Pule	*Cypraea* sp., *Cypraea tigris*	35.6
	Karau Natalai	*Tridacna* spp.	25.0
	Paukasua	*Conus* spp.	12.0
	Ngora	*Pleuroploca filamentosa*	7.5
	Arumau	*Pleuroploca filamentosa*	7.5
	Fila-fila	*Atrina vexillum,* *Pinctada margaritifera*	5.6
	Kai	*Gafrarium pectinatum,* *Gafrarium tumidum,* *Periglypta puerpera,* *Periglypta reticulata*	5.3
	Karea	*Strombus luhuanus*	1.3
	Nasese	*Nerita balteata,* *Nerita plicata,* *Nerita polita,* *Polinices mammilla*	0.3
Soft benthos	Kai	*Gafrarium pectinatum,* *Gafrarium tumidum,* *Periglypta puerpera,* *Periglypta reticulata*	100.0
Soft benthos & mangrove & intertidal & reeftop	Kai	*Gafrarium pectinatum,* *Gafrarium tumidum,* *Periglypta puerpera,* *Periglypta reticulata*	50.2
	Rakuma	*Cardisoma* spp.	33.1
	Wita Oktopus	*Octopus cyanea*	5.5
	Karau Natalai	*Tridacna* spp.	5.0
	Fila-fila	*Atrina vexillum,* *Pinctada margaritifera*	3.4
	Pule	*Cypraea* sp., *Cypraea tigris*	1.4
	Simiri Wael troka	*Tectus niloticus*	1.1
	Alure	*Atactodea striata*	0.3

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Paunangisu village (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Soft benthos & intertidal & reeftop	Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	45.0
	Karau Natalai	*Tridacna* spp.	12.9
	Alure	*Atactodea striata*	12.0
	Wita Oktopus		11.7
	Paukasua	*Conus* spp.	6.2
	Fila-fila	*Atrina vexillum, Pinctada margaritifera*	4.7
	Pule	*Cypraea* sp., *Cypraea tigris*	3.2
	Tamaruku	*Acanthopleura gemmata*	2.0
	Arumau	*Pleuroploca filamentosa*	1.9
	Ngora	*Pleuroploca filamentosa*	0.4

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Paunangisu village

Vernacular name	Scientific name	Size class	% of total catch (weight)
Alure	*Atactodea striata*	02 cm	9.5
		04 cm	45.2
		04–06 cm	45.2
Arumau	*Pleuroploca filamentosa*	06 cm	18.8
		06–08 cm	81.3
Paukasua	*Conus* spp.	04–08 cm	5.8
		06–08 cm	76.8
		07 cm	17.4
Krab kaledonia	*Scylla serrata*	02–20 cm	14.3
		08–20 cm	18.7
		12 cm	2.9
		16–20 cm	64.1
Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	04–06 cm	29.5
		04–08 cm	0.5
		06 cm	50.4
		06–08 cm	0.5
		10–12 cm	19.1
Karea	*Strombus luhuanus*	02 cm	100.0
Nasese	*Nerita balteata, Nerita plicata, Nerita polita, Polinices mammilla*	02 cm	100.0
Nasulan	*Terebra* spp.	07–10 cm	100.0
Karau, Natalai	*Tridacna* spp.	14–16 cm	9.3
		16 cm	12.3
		16–18 cm	4.7
		18–20 cm	2.3
		20 cm	2.0
		20–22 cm	41.9
		22–24 cm	9.3
		26–28 cm	5.4
		30–35 cm	12.8
Ngora	*Pleuroploca filamentosa*	04–06 cm	9.5
		06 cm	11.4
		08–10 cm	43.9
		12 cm	35.1
Wita, Oktopus, Nawita		06 cm	4.1
		08–10 cm	53.7
		10 cm	22.9
		10–12 cm	19.3
Popoti		01 cm	100.0
Pule	*Cypraea* sp., *Cypraea tigris*	06 cm	72.3
		06–08 cm	14.7
		08 cm	12.9

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Paunangisu village (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Rakuma, Tuupa, Lan krab	*Cardisoma* spp.	02–06 cm	4.4
		06–08 cm	50.3
		06–10 cm	18.3
		10 cm	8.8
		12 cm	18.3
Sea anemone		04–06 cm	100.0
Tamaruku	*Acanthopleura gemmata*	08–10 cm	100.0
Simiri, Wael troka	*Tectus niloticus*	08–10 cm	100.0
Fila-fila	*Atrina vexillum, Pinctada margaritifera*	06–08 cm	3.5
		08 cm	28.1
		08–10 cm	31.6
		08–12 cm	10.5
		10 cm	21.1
		12 cm	5.3

2.1.4 Total annual catch of invertebrates (wet weight, kg/year) by species and category of use – Paunangisu village

Scientific name	Vernacular name	Total catch (wet weight, kg/year)			
		Consumption	Sale	Consumption and sale	Total
Atactodea striata	Alure	288	0	0	288
Pleuroploca filamentosa	Arumau	52	0	0	52
Conus spp.	Paukasua	269	0	0	269
Scylla serrata	Krab kaledonia	24	547	282	854
Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata	Kai	1138	50	290	1477
Strombus luhuanus	Karea	2	0	0	2
Nerita balteata, Nerita plicata, Nerita polita, Polinices mammilla	Nasese	0	0	0	0
Terebra spp.	Nasulan	804	0	2020	2823
Tridacna spp.	Karau Natalai	293	0	174	466
Pleuroploca filamentosa	Ngora	37	30	18	85
	Wita Octopus	106	0	227	333
	Popoti	25	0	0	25
Cypraea sp., *Cypraea tigris*	Pule	0	100	46	147
Cardisoma spp.	Rakuma Tuupa	265	0	2985	3250
	Sea anemone	4	0	0	4
Acanthopleura gemmata	Tamaruku	43	0	0	43
Tectus pyramis	Simiri Wael troka	0	0	9	9
Atrina vexillum, Pinctada margaritifera	Fila-fila	59	0	81	139
Total:		**3410**	**728**	**6131**	**10,268**

2.2 Moso Island socioeconomic survey data

2.2.1 Annual catch (kg) of fish groups per habitat (includes only reported catch data by interviewed finfish fishers) – Moso Island

Vernacular name	Family	Scientific name	Total weight (kg)	% of total annual reported catch
Sheltered coastal reef				
Marie	Gerreidae	*Gerres oyena*	1226	31
Red maot	Lethrinidae	*Gnathodentex aureolineatus*, *Gnathodentex.* sp., *Gymnocranius elongatus*, *Gymnocranius euanus*	536	13
Moustas fis	Mullidae	*Parupeneus* sp.	404	10
Mangaru	Carangidae	*Atule mate*	243	6
Waet pico (rare)	Siganidae	*Siganus canaliculatus*	239	6
Picot	Acanthuridae	*Naso lituratus*	220	6
Malet	Mugilidae	*Valamugil seheli*	154	4
Kaptoro			119	3
Blu fis	Scaridae	*Scarus* sp.	114	3
Titipaki Blu fis (bumphead)	Scaridae	*Bolbometopon muricatum*	114	3
Tofe	Siganidae	*Siganus lineatus*	109	3
Pico	Siganidae	*Siganus* sp.	103	3
Pelepele	Holocentridae	*Holocentrus* sp., *Myripristis* sp., *Plectrypops* sp., *Sargocentron* sp.	81	2
Karong	Carangidae	*Caranx* sp.	72	2
Red snappa	Lutjanidae	*Lutjanus gibbus*	65	2
Blak pico	Acanthuridae	*Acanthurus* sp., *Ctenochaetus* sp., *Naso* sp., *Prionurus* sp., *Zebrasoma* sp.	60	2
Loche	Serranidae	*Epinephelus* sp.	46	1
Strong skin	Balistidae	*Rhinecanthus aculeatus*, *Rhinecanthus rectangulus*	46	1
Renbow fis	Acanthuridae	*Acanthurus lineatus*	14	0
Blak pico	Acanthuridae	*Acanthurus blochii*	8	0
Yalow red maot	Lutjanidae	*Lutjanus fulvus*	2	0
Sama			1	0
Total:			**3976**	**100**

2.2.1 Annual catch (kg) of fish groups per habitat (includes only reported catch data by interviewed finfish fishers) – Moso Island (continued)

Vernacular name	Family	Scientific name	Total weight (kg)	% of total annual reported catch
Outer reef				
Blu fis	Scaridae	*Scarus* sp.	2147	34
Blak pico	Acanthuridae	*Acanthurus* sp., *Ctenochaetus* sp., *Naso* sp., *Prionurus* sp., *Zebrasoma* sp.	1163	18
Titipaki Blu fis (bumphead)	Scaridae	*Bolbometopon muricatum*	711	11
Strong skin	Balistidae	*Rhinecanthus aculeatus, Rhinecanthus rectangulus*	283	4
Rainbow fis	Acanthuridae	*Acanthurus lineatus*	248	4
Naika maeto	Acanthuridae	*Ctenochaetus striatus, Ctenochaetus strigosus*	199	3
Blak pico	Acanthuridae	*Acanthurus blochii*	181	3
Moustas fis	Mullidae	*Parupeneus* sp.	176	3
Yalow tel			169	3
Pico	Siganidae	*Siganus* sp.	132	2
Mangaru	Carangidae	*Atule mate*	119	2
Karong	Carangidae	*Caranx* sp.	107	2
Red maot	Lethrinidae	*Gnathodentex aureolineatus, Gnathodentex* sp., *Gymnocranius elongatus, Gymnocranius euanus*	86	1
Big lips Tik lip	Haemulidae	*Diagramma* sp.	81	1
Tofe	Siganidae	*Siganus lineatus*	80	1
Malet	Mugilidae	*Valamugil seheli*	76	1
Pelepele	Holocentridae	*Holocentrus* sp., *Myripristis* sp., *Plectrypops* sp., *Sargocentron* sp.	74	1
Big bel	Kyphosidae	*Kyphosus vaigiensis, Kyphosus cinerascens*	72	1
Loche	Serranidae	*Epinephelus* sp.	62	1
Wait blufis (white)	Scaridae	*Scarus* sp.	40	1
Sosio red maot	Lethrinidae	*Lethrinus lentjan*	36	1
Pico	Siganidae	*Siganus* sp.	20	0
Blu pico	Siganidae	*Siganus argenteus*	20	0
Pico	Acanthuridae	*Naso lituratus*	16	0
Marie	Gerreidae	*Gerres oyena*	14	0
Sama			11	0
Total:			**6322**	**100**

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Moso Island

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Bêche-de-mer	Prikly fis	*Thelenota ananas*	24.3
	Umber fis	*Thelenota anax*	20.8
	Tiga	*Actinopyga mauritiana*	16.9
	Lolli fis	*Holothuria atra, Holothuria coluber*	12.6
	Waet tit	*Holothuria fuscogilva*	6.0
	Sefret	*Actinopyga mauritiana*	5.0
	Kreen fis	*Stichopus chloronotus*	4.6
	Elefen trank	*Holothuria fuscopunctata*	4.4
	Seakau	*Actinopyga lecanora*	2.3
	Blak fis	*Actinopyga miliaris*	1.9
	Kary fis	*Stichopus* sp.	0.8
	Ston fis	*Actinopyga lecanora*	0.2
	Alure	*Atactodea striata*	0.1
Mangrove	Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	100.0
Other	Natalai	*Tridacna* spp.	75.1
	Wita Oktopus		17.3
Reeftop	Alure	*Atactodea striata*	42.7
	Natalai	*Tridacna* spp.	32.2
	Wita Oktopus		11.5
	Paukasua	*Conus* spp.	4.2
	Krab	*Eriphia sebana*	3.5
	Keleti	*Lambis* sp.	0.3
	Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	0.2
Soft benthos & mangrove & intertidal	Natalai	*Tridacna* spp.	29.2
	Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	23.9
	Kaiwi	*Donax cuneatus*	23.9
	Alure	*Atactodea striata*	15.9
	Paukasua	*Conus* spp.	6.4
	Keleti	*Lambis* sp.	0.7

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Moso Island (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Soft benthos & intertidal	Kai tuas	*Anadara* sp.	31.8
	Kai pari	*Tellina palatum*	26.5
	Alure	*Atactodea striata*	20.0
	Natalai	*Tridacna* spp.	7.3
	Paukasua	*Conus* spp.	5.9
	Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	3.1
	Memera	*Strombus gibberulus gibbosus, Strombus luhuanus*	3.1
	Wita Oktopus		2.1
	Keleti	*Lambis* sp.	0.2
Soft benthos & intertidal & reeftop	Kai tuas	*Anadara* sp.	61.8
	Karau Natalai	*Tridacna* spp.	17.2
	Paukasua	*Conus* spp.	16.5
	Mata lele	*Spondylus squamosus*	2.7
	Krab	*Eriphia sebana*	1.1
	Keleti	*Lambis* sp.	0.7
Trochus (MOP)	Troka	*Trochus niloticus*	100.0

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Moso Island

Vernacular name	Scientific name	Size class	% of total catch (weight)
Alure	*Atactodea striata*	02 cm	14.5
		02-04 cm	20.7
		06 cm	8.4
		06-08 cm	41.3
		08 cm	14.3
		12 cm	0.4
		20-22 cm	0.3
		22 cm	0.1
		22-24 cm	0.0
		26-28 cm	0.0
		28 cm	0.0
Paukasua	*Conus* spp.	02-04 cm	12.9
		06 cm	12.8
		06-08 cm	1.4
		06-12 cm	13.3
		08 cm	7.4
		08-10 cm	38.3
		10 cm	14.0
Blak fis	*Actinopyga miliaris*	22 cm	100.0
Krab	*Eriphia sebana*	06-08 cm	29.8
		06-10 cm	13.3
		08-10 cm	53.8
		10 cm	3.1
Kurry fis	*Stichopus* sp.	24 cm	87.0
		28 cm	13.0
Elefen trank	*Holothuria fuscopunctata*	24 cm	81.5
		26-28 cm	18.5
Kreen fis	*Stichopus chloronotus*	12-14 cm	34.2
		14 cm	4.3
		18-20 cm	18.5
		20 cm	11.4
		20-22 cm	17.1
		24 cm	8.6
		24-26 cm	5.9
Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	04 cm	0.4
		06 cm	72.9
		06-08 cm	21.3
		10-12 cm	2.0
		12 cm	3.5
Kai pari	*Tellina palatum*	04-06 cm	100.0
Kai tuas	*Anadara* sp.	06 cm	8.3
		06-08 cm	91.7
Kaiwi	*Donax cuneatus*	04 cm	100.0
Keleti	*Lambis* sp.	06-08 cm	32.5
		06-12 cm	1.9
		08 cm	44.0
		08-10 cm	21.6

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Moso Island (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Ura Lobster Naura	*Panulirus* sp.	18-22 cm	27.3
		24 cm	72.7
Loli fis	*Holothuria atra,* *Holothuria coluber*	04 cm	10.3
		06-08 cm	3.1
		06-10 cm	6.4
		08-10 cm	66.9
		10-14 cm	10.3
		14 cm	3.1
Mata lele	*Spondylus squamosus*	08-10 cm	100.0
Memera	*Strombus gibberulus gibbosus,* *Strombus luhuanus*	06 cm	100.0
Karau Natalai	*Tridacna* spp.	06-08 cm	10.5
		08 cm	8.4
		08-28 cm	4.2
		10 cm	5.8
		10-22 cm	2.9
		14 cm	7.0
		16-20 cm	21.1
		16-22 cm	1.0
		18 cm	1.5
		18-22 cm	4.2
		20 cm	2.4
		20-22 cm	8.1
		20-24 cm	10.0
		20-26 cm	1.5
Karau/natalai	*Tridacna* spp.	24-26 cm	9.7
		26-28 cm	1.6
Wita Oktopus		06 cm	5.8
		10 cm	4.3
		10-12 cm	89.9
Prikly fis	*Thelenota ananas*	20-22 cm	80.2
		22-24 cm	8.0
		26-28 cm	4.4
		28 cm	7.4
Sakelo	*Astralium* sp.	08 cm	100.0
Seakau	*Actinopyga lecanora*	18-20 cm	100.0
Sefret	*Actinopyga mauritiana*	12 cm	45.5
		18 cm	54.5
Squid		10 cm	100.0
Ston fis	*Actinopyga lecanora*	18 cm	100.0
Tiga	*Actinopyga mauritiana*	12-18 cm	37.6
		18 cm	2.7
		20 cm	22.8
		20-28 cm	8.0
		22 cm	8.0
		22-28 cm	14.8
		26-28 cm	6.1

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Moso Island (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Troka	*Trochus niloticus*	10-12 cm	43.1
		12 cm	56.9
Amber fis	*Thelenota anax*	28 cm	100.0
Waet tit	*Holothuria fuscogilva*	12-14 cm	43.5
		24 cm	21.7
		28 cm	34.8

2.2.4 Total annual catch of invertebrates (wet weight, kg/year) by species and category of use – Moso Island

Scientific name	Vernacular name	Total catch (wet weight, kg/year)			
		Consumption	Sale	Consumption and sale	Total
Atactodea striata	Alure	723	8	215	946
Conus spp.	Paukasua	272	0	0	272
Actinopyga miliaris	Blak fis	0	271	0	271
Eriphia sebana	Krab	32	0	25	57
Stichopus sp.	Kurry fis	0	113	0	113
Holothuria fuscopunctata	Elephant trunk	0	620	0	620
Stichopus chloronotus	Kreen fis	0	635	0	635
Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata	Kai	141	0	38	179
Tellina palatum	Kai pari	0	0	326	326
Anadara sp.	Kai tuas	426	0	356	782
Donax cuneatus	Kaiwi	130	0	0	130
Lambis sp.	Keleti	14	0	0	14
	Ura Lobsta Naura	0	55	0	55
Holothuria atra, Holothuria coluber	Loli fis	0	1759	0	1759
Spondylus squamosus	Mata lele	17	0	0	17
Strombus gibberulus gibbosus, Strombus luhuanus	Memera	38	0	0	38
Tridacna sp.	Natalai	541	115	374	1029
	Wita Oktopus	24	0	215	239
Thelenota ananas	Prikly fis	0	3384	0	3384
Astralium sp.	Sakelo	0	0	76	76
Actinopyga lecanora	Seakau	0	326	0	326
Actinopyga mauritiana	Sefret	0	697	0	697
	Squid	0	0	22	22
Actinopyga lecanora	Ston fis	0	30	0	30
Actinopyga mauritiana	Tiger	0	2361	0	2361
Trochus niloticus	Troka	0	205	0	205
Thelenota anax	Amber fis	0	2895	0	2895
Holothuria fuscogilva	Waet tit	0	832	0	832
Total:		**2358**	**14,306**	**1646**	**18,310**

2.3 Uri and Uripiv Islands socioeconomic survey data

2.3.1 Annual catch (kg) of fish groups per habitat (includes only reported catch data by interviewed finfish fishers) – Uri and Uripiv Islands

Vernacular name	Family	Scientific name	Total weight (kg)	% of total annual reported catch
Sheltered coastal reef				
Red maot	Lethrinidae	*Gnathodentex aureolineatus*, *Gnathodentex* sp., *Gymnocranius elongatus*, *Gymnocranius euanus*	653	25
Karong	Carangidae	*Caranx* sp.	245	9
Big bel	Kyphosidae	*Kyphosus vaigiensis*, *Kyphosus cinerascens*	244	9
Blu fis	Scaridae	*Scarus* sp.	256	10
Malet	Mugilidae	*Valamugil seheli*	244	9
Blak pico	Acanthuridae	*Acanthurus* sp., *Ctenochaetus* sp., *Naso* sp., *Prionurus* sp., *Zebrasoma* sp.	236	9
Pico	Siganidae	*Siganus* sp.	201	8
Moustas fis	Mullidae	*Parupeneus* sp.	165	6
Strong skin	Balistidae	*Rhinecanthus aculeatus*, *Rhinecanthus rectangulus*	66	3
Sanpepa	Acanthuridae	*Acanthurus triostegus*	32	1
Marie	Gerreidae	*Gerres oyena*	52	2
Pelepele	Holocentridae	*Holocentrus* sp., *Myripristis* sp., *Plectrypops* sp., *Sargocentron* sp.	51	2
Big eye			47	2
Long maot	Belonidae Hemiramphidae	*Tylosurus* sp., *Hemiramphus* sp.	38	1
Pico	Siganidae	*Siganus spinus*	26	1
Bueti	Serranidae	*Variola louti*	18	1
Nambue			12	0
Rainbow fis	Acanthuridae	*Acanthurus lineatus*	11	0
Barrakuda	Sphyraenidae	*Sphyraena barracuda*	3	0
Naenurebibi			2	0
Long maot	Platycephalidae	*Cymbacephalus beauforti*	2	0
Bwitdaval			2	0
Total:			**2606**	**100**

2.3.1 Annual catch (kg) of fish groups per habitat (includes only reported catch data by interviewed finfish fishers) – Uri and Uripiv Islands (continued)

Vernacular name	Family	Scientific name	Total weight (kg)	% of total annual reported catch
Outer reef				
Red maot	Lethrinidae	*Gnathodentex aureolineatus*, *Gnathodentex* sp., *Gymnocranius elongatus*, *Gymnocranius euanus*	150	10
Karong	Carangidae	*Caranx* sp.	474	32
Big bel	Kyphosidae	*Kyphosus vaigiensis*, *Kyphosus cinerascens*	468	32
Blu fis	Scaridae	*Scarus* sp.	55	4
Malet	Mugilidae	*Valamugil seheli*	78	5
Pico	Siganidae	*Siganus* sp.	64	4
Sanpepa	Acanthuridae	*Acanthurus triostegus*	57	4
Marie	Gerreidae	*Gerres oyena*	12	1
Pico	Siganidae	*Siganus spinus*	32	2
Miser			25	2
Movid			24	2
Bueti	Serranidae	*Variola louti*	15	1
Mirago			12	1
Depat			12	1
Total:			**1479**	**100**

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Uri and Uripiv Islands

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Mangrove	Nasulan	*Terebra* spp.	35.2
	Banu	*Codakia punctata*	26.1
	Rakuma	*Cardisoma* spp.	15.7
	Naori (mud crabs)		15.4
	Oyster	*Saccostrea cuccullata*	2.5
	Krab kaledonia	*Scylla serrata*	1.8
	Dirong	*Pitar proha*	1.8
	Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	0.9
	Crab	*Eriphia sebana*	0.5
Other	Oktopas Nawita		67.9
	Natalai	*Tridacna* spp.	28.5
	Troka	*Trochus niloticus*	3.7
Reeftop	Nar	*Asaphis violascens, Gafrarium pectinatum, Gafrarium tumidum*	67.0
	Strong bak	*Acanthopleura gemmata*	33.0
Intertidal & reeftop	Nasese	*Nerita balteata, Nerita plicata, Nerita polita, Polinices mammilla*	38.5
	Nako	*Planaxis sulcatus*	21.8
	Nar	*Asaphis violascens, Gafrarium pectinatum, Gafrarium tumidum*	18.6
	Oktopas Nawita		11.4
	Strong bak	*Acanthopleura gemmata*	9.7
Soft benthos	Natalai	*Tridacna* spp.	35.1
	Nambaso	*Chama* sp.	23.4
	Kon sel	*Conus* spp.	23.4
	Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	7.9
	Pule	*Cypraea* sp., *Cypraea tigris*	7.2
	Nirang	*Lambis lambis*	2.9
Mother-of-pearl	Troka	*Trochus niloticus*	100.0

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Uri and Uripiv Islands

Vernacular name	Scientific name	Size class	% of total catch (weight)
Banu	*Codakia punctata*	04-06 cm	20.4
		06 cm	17.0
		06-08 cm	49.5
		08-12 cm	3.5
		10 cm	9.6
Paukasua/kon sel	*Conus* spp.	06 cm	100.0
Rif krab	*Eriphia sebana*	08-12 cm	100.0
Krab kledonia	*Scylla serrata*	10-16 cm	32.8
		14-16 cm	67.2
Dirong	*Pitar proha*	06-08 cm	97.9
		08-10 cm	2.1
Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	06-08 cm	47.2
		08 cm	52.8
Nako	*Planaxis sulcatus*	02 cm	100.0
Nambaso	*Chama* sp.	06 cm	100.0
Naori (mud crabs)		04-08 cm	15.9
		06 cm	41.7
		06-08 cm	18.0
		08-10 cm	10.1
		10-12 cm	14.4
Nar	*Asaphis violascens, Gafrarium pectinatum, Gafrarium tumidum*	04-06 cm	47.1
		06 cm	4.2
		06-08 cm	18.9
		08 cm	29.8
Nasese	*Nerita balteata, Nerita plicata, Nerita polita, Polinices mammilla*	02 cm	100.0
Nasulan	*Terebra* spp.	08-10 cm	5.8
		08-12 cm	15.5
		10 cm	15.1
		10-12 cm	59.4
		12 cm	4.2
Natalai	*Tridacna* spp.	04 cm	74.1
		16-18 cm	5.6
		24-28 cm	1.8
		28-33 cm	18.5
Nirang	*Lambis lambis*	12 cm	100.0
Octopus Nawita		04-06 cm	21.3
		06 cm	10.7
		06-08 cm	33.2
		08-12 cm	2.8
		10 cm	8.3
		10-12 cm	23.7
Oyster	*Saccostrea cuccullata*	08-12 cm	89.8
		10 cm	10.2

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Uri and Uripiv Islands (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Pule	*Cypraea* sp., *Cypraea tigris*	08 cm	100.0
Lan krab	*Cardisoma* spp.	06-10 cm	64.3
		08-12 cm	27.1
		10-12 cm	8.6
Strong bak	*Acanthopleura gemmata*	04-06 cm	69.0
		06 cm	3.4
		06-08 cm	13.8
		08 cm	5.5
		08-10 cm	8.3
Troka	*Trochus niloticus*	08-12 cm	3.1
		10 cm	96.9

2.3.4 Total annual catch of invertebrates (wet weight, kg/year) by species and category of use – Uri and Uripiv Islands

Scientific name	Vernacular name	Total catch (wet weight, kg/year)			
		Consumption	Sale	Consumption and sale	Total
Codakia punctata	Banu	130	0	1147	1277
Conus spp.	Paukasua	72	0	72	145
Eriphia sebana	Rif krab	0	0	23	23
Scylla serrata	Krab kaldonia	0	0	91	91
Pitar proha	Dirong	1	0	89	90
Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata	Kai	24	0	68	92
Planaxis sulcatus	Nako	619	0	0	619
Chama sp.	Nambaso	145	0	0	145
	Naori (mud crabs)	76	109	571	755
Asaphis violascens, Gafrarium pectinatum, Gafrarium tumidum	Nar	582	0	0	582
Nerita balteata, Nerita plicata, Nerita polita, Polinices mammilla	Nasese	1093	0	0	1093
Terebra spp.	Nasulan	420	0	1302	1721
Tridacna spp.	Natalai	179	0	114	293
Lambis lambis	Nirang	9	0	9	18
	Oktopus Nawita	370	0	133	504
Saccostrea cuccullata	Oyster	0	112	13	125
Cypraea sp., *Cypraea tigris*	Pule	22	0	22	45
Cardisoma spp.	Rakuma Lan krab	66	0	703	769
Acanthopleura gemmata	Strong bak	302	0	0	302
Trochus niloticus	Troka	0	0	10	10
Total:		**4112**	**221**	**4366**	**8699**

2.4 Maskelyne Archipelago socioeconomic survey data

2.4.1 Annual catch (kg) of fish groups per habitat (includes only reported catch data by interviewed finfish fishers) – Maskelyne Archipelago

Vernacular name	Family	Scientific name	Total weight (kg)	% of total annual reported catch
Sheltered coastal reef				
Red maot	Lethrinidae	*Gnathodentex aureolineatus*, *Gnathodentex*. sp., *Gymnocranius elongatus*, *Gymnocranius euanus*	1724	36
Pico	Siganidae	*Siganus* sp.	1095	23
Karong	Carangidae	*Caranx* sp.	52	1
Moustas fis	Mullidae	*Parupeneus* sp.	292	6
Navut			555	11
Blu fis	Scaridae	*Scarus* sp.	280	6
Malet	Mugilidae	*Valamugil seheli*	29	1
Loche	Serranidae	*Epinephelus* sp.	184	4
Big bel	Kyphosidae	*Kyphosus vaigiensis*, *Kyphosus cinerascens*	148	3
Strong skin	Balistidae	*Rhinecanthus aculeatus, Rhinecanthus rectangulus*	108	2
Long maot			100	2
Black pico	Acanthuridae	*Acanthurus* sp., *Ctenochaetus* sp., *Naso* sp., *Prionurus* sp., *Zebrasoma* sp.	100	2
Red snapper	Lutjanidae	*Lutjanus gibbus*	60	1
Navut (rare)			40	1
Red rifsnapper	Lutjanidae	*Lutjanus gibbus*	31	1
Batufis			24	1
Big lips	Haemulidae	*Diagramma* sp.	12	0
Manut			12	0
Mangaru	Carangidae	*Atule mate*	8	0
Total:			**4853**	**100**

2.4.1 Annual catch (kg) of fish groups per habitat (includes only reported catch data by interviewed finfish fishers) – Maskelyne Archipelago (continued)

Vernacular name	Family	Scientific name	Total weight (kg)	% of total annual reported catch
Sheltered coastal reef				
Karong	Carangidae	*Caranx* sp.	875	22
Pico	Siganidae	*Siganus* sp.	845	21
Red maot	Lethrinidae	*Gnathodentex aureolineatus*, *Gnathodentex* sp., *Gymnocranius elongatus*, *Gymnocranius euanus*	776	20
Moustas fis	Mullidae	*Parupeneus* sp.	564	14
Malet	Mugilidae	*Valamugil seheli*	273	7
Big eye			121	3
Strong skin	Balistidae	*Rhinecanthus aculeatus*, *Rhinecanthus rectangulus*	118	3
Snapper	Lutjanidae	*Lutjanus gibbus*	88	2
Barrakuda	Sphyraenidae	*Sphyraena barracuda*	88	2
Loche	Serranidae	*Epinephelus* sp.	84	2
Blak pico	Acanthuridae	*Acanthurus* sp., *Ctenochaetus* sp., *Naso* sp., *Prionurus* sp., *Zebrasoma* sp.	40	1
Pelepele	Holocentridae	*Holocentrus* sp., *Myripristis* sp., *Plectrypops* sp., *Sargocentron* sp.	40	1
Red rifsnapper	Lutjanidae	*Lutjanus gibbus*	28	1
Navut			12	0
Parrotfish	Scaridae	*Hipposcarus sp.*, *Scarus sp.*	4	0
Total:			**3956**	**100**

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Maskelyne Archipelago

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Mangrove	Nasulan	*Terebra* spp.	84.1
	Krab	*Eriphia sebana*	6.4
	Krab kaledonia	*Scylla serrata*	5.0
	Rakuma Lan krab	*Cardisoma* spp.	3.8
	Tugrot	*Anadara* sp.	0.2
	Natu	*Codakia punctata*	0.2
	Nabukbuk	*Turbo* spp. (*Turbo argyrostomus*, *Turbo chrysostomus,* *Turbo crassus,* *Turbo marmoratus,* *Turbo setosus*)	0.1
	Oyster	*Saccostrea cucullata*	0.1
Reeftop	Octopus Nawita		24.2
	Natalai	*Tridacna* spp.	24.0
	Nabukbuk	*Turbo* spp. (*Turbo argyrostomus*, *Turbo chrysostomus,* *Turbo crassus,* *Turbo marmoratus,* *Turbo setosus*)	12.6
	Navusai	*Conus miles,* *Strombus gibberulus gibbosus*	10.0
	Buisos	*Pleuroploca trapezium*	9.2
	Nambul	*Cypraea tigris*	7.5
	Namulai	*Lambis lambis*	6.3
	Mulai	*Lambis lambis*	5.1
	Tugrot	*Anadara* sp.	0.5
	Mistimorgol	*Astralium* sp.	0.3
	Nmash	*Mammilla melanostoma,* *Polinices mammilla*	0.2
	Nasulan	*Terebra* spp.	0.2
	Nambidew	*Tellina* sp.	0.1
	Krab	*Eriphia sebana*	0.0
Soft benthos	Tugrot	*Anadara* sp.	58.9
	Nambul	*Cypraea tigris*	11.8
	Kai	*Gafrarium pectinatum,* *Gafrarium tumidum,* *Periglypta puerpera,* *Periglypta reticulata*	7.3
	Tumbur	*Periglypta puerpera,* *Periglypta reticulata*	6.8
	Namulai	*Lambis lambis*	3.7
	Natalai	*Tridacna* spp.	3.4
	Buisos	*Pleuroploca trapezium*	3.2
	Wagtambugol	*Atrina vexillum*	0.9
	Navusai	*Conus miles,* *Strombus gibberulus gibbosus*	0.7
	Nmash	*Mammilla melanostoma,* *Polinices mammilla*	0.7

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Maskelyne Archipelago (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Soft benthos	Tubalasvaif	*Tapes literatus*	0.6
	Groultar	*Hippopus hippopus*	0.4
	Mulai	*Lambis lambis*	0.4
	Tumbar	*Donax cuneatus*	0.4
	Barle	*Chama* sp.	0.3
	Keleti	*Lambis* sp.	0.2
	Nakotav		0.2
	Nambidew	*Tellina* sp.	0.2
Soft benthos & mangrove	Nasulan	*Terebra* spp.	76.9
	Tumbar	*Donax cuneatus*	11.0
	Krab kaledonia	*Scylla serrata*	7.7
	Nabukbuk	*Turbo* spp. (*Turbo argyrostomus*, *Turbo chrysostomus*, *Turbo crassus*, *Turbo marmoratus*, *Turbo setosus*)	4.4
Mother-of-pearl	Troka	*Trochus niloticus*	100.0

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Maskelyne Archipelago

Vernacular name	Scientific name	Size class	% of total catch (weight)
Barle	*Chama* sp.	10 cm	100.0
Buisos	*Pleuroploca trapezium*	04-06 cm	8.9
		06 cm	46.2
		06-08 cm	16.2
		08 cm	13.6
		10 cm	15.0
Rif krab	*Eriphia sebana*	06-08 cm	8.2
		06-10 cm	0.3
		06-12 cm	1.4
		08-10 cm	43.2
		08-12 cm	29.6
		08-14 cm	1.0
		10 cm	7.6
		10-12 cm	8.7
Krab kaldonia	*Scylla serrata*	10-12 cm	96.2
		14 cm	3.8
Groultar	*Hippopus hippopus*	08 cm	100.0
Kai	*Gafrarium pectinatum, Gafrarium tumidum, Periglypta puerpera, Periglypta reticulata*	04-08 cm	35.3
		08-10 cm	64.7
Keleti	*Lambis* sp.	10 cm	100.0
Mistimorgol	*Astralium* sp.	04 cm	100.0
Mulai	*Lambis lambis*	08 cm	95.2
		08-10 cm	4.8
Nabukbuk	*Turbo* spp. *(Turbo argyrostomus, Turbo chrysostomus, Turbo crassus, Turbo marmoratus, Turbo setosus)*	04 cm	0.3
		04-06 cm	34.6
		06 cm	15.8
		06-08 cm	44.3
		08 cm	1.5
		08-10 cm	3.4
Nakotav		08 cm	100.0
Nambidew	*Tellina* sp.	06-08 cm	100.0
Nambul	*Cypraea tigris*	04-06 cm	4.2
		04-08 cm	4.2
		06 cm	37.9
		06-08 cm	10.0
		08 cm	1.3
		08-10 cm	3.5
		08-12 cm	26.2
		10 cm	11.7
		10-12 cm	1.0
Namulai	*Lambis lambis*	06-08 cm	3.0
		06-10 cm	2.0
		08 cm	5.8
		08-10 cm	17.6
		10 cm	69.3
		12 cm	2.4

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Maskelyne Archipelago (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Nasulan	*Terebra* spp.	06-08 cm	3.9
		08 cm	2.3
		08-10 cm	26.8
		08-12 cm	28.2
		10 cm	12.5
		10-12 cm	25.1
		12 cm	1.2
Natalai	*Tridacna* spp.	06-14 cm	20.2
		06-22 cm	20.6
		08-10 cm	3.2
		08-14 cm	7.3
		08-22 cm	12.1
		10-12 cm	11.3
		10-14 cm	1.1
		10-20 cm	14.5
		16-18 cm	3.2
		20 cm	3.2
		22-24 cm	3.2
Natu	*Codakia punctata*	04 cm	4.4
		06-08 cm	95.6
Navusai	*Conus miles,* *Strombus gibberulus gibbosus*	02 cm	48.3
		04 cm	14.5
		04-06 cm	32.9
		04-08 cm	0.0
		06-08 cm	4.2
Nmash	*Mammilla melanostoma,* *Polinices mammilla*	02-04 cm	90.8
		04 cm	9.2
Oktopus Nawita		04-08 cm	36.1
		06 cm	6.7
		06-08 cm	9.6
		08-10 cm	8.7
		10 cm	17.3
		10-12 cm	13.0
		12 cm	8.7
Oyster	*Saccostrea cuccullata*	10-12 cm	67.7
		12 cm	32.3
Rakuma	*Cardisoma* spp.	06 cm	13.8
		08 cm	34.5
		10-12 cm	51.7
Trochus		08-10 cm	5.0
		08-12 cm	22.9
		10-12 cm	71.8
		12 cm	0.3
Tubalasvaif	*Tapes literatus*	06 cm	100.0

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Maskelyne Archipelago (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Tugrot	*Anadara* spp.	04 cm	10.7
		04-06 cm	27.7
		04-08 cm	0.5
		06 cm	5.8
		06-08 cm	45.8
		06-10 cm	7.0
		08-10 cm	1.3
		10-12 cm	1.3
Tumbar	*Donax cuneatus*	04 cm	23.1
		04-06 cm	76.9
Tumbur	*Periglypta puerpera, Periglypta reticulata*	04-06 cm	14.3
		06 cm	38.1
		08 cm	47.6
Wagtambugol	*Atrina vexillum*	08-10 cm	100.0

2.4.4 Total annual catch of invertebrates (wet weight, kg/year) by species and category of use – Maskelyne Archipelago

Scientific name	Vernacular name	Total catch (wet weight, kg/year)			
		Consumption	Sale	Consumption and sale	Total
Chama sp.	Barle	4	0	0	4
Pleuroploca trapezium	Buisos	278	0	15	292
Eriphia sebana	Krab	481	0	0	481
Scylla serrata	Krab kaldonia	380	0	15	395
Hippopus hippopus	Groultar	7	0	0	7
Gafrarium pectinatum, *Gafrarium tumidum*, *Periglypta puerpera*, *Periglypta reticulata*	Kai	123	0	0	123
Lambis sp.	Keleti	4	0	0	4
Astralium sp.	Mistimorgol	7	0	0	7
Lambis lambis	Mulai	137	0	0	137
Turbo spp. (*Turbo argyrostomus*, *Turbo chrysostomus*, *Turbo crassus*, *Turbo marmoratus*, *Turbo setosus)*	Nabukbuk	202	0	141	343
	Nakotav	3	0	0	3
Tellina sp.	Nambidew	5	0	0	5
Cypraea tigris	Nambul	252	10	131	392
Lambis lambis	Namulai	92	0	130	223
Terebra spp.	Nasulan	6181	0	326	6506
Tridacna spp.	Natalai	575	0	98	672
Codakia punctata	Natu	15	0	0	15
Conus miles, *Strombus gibberulus gibbosus*	Navusai	269	0	0	269
Mammilla melanostoma, *Polinices mammilla*	Nmash	16	0	0	16
Octopus cyanea	Oktopus Nawita	621	0	0	621
Saccostrea cucculata	Oyster	8	0	0	8
Cardisoma spp.	Rakuma Lan krab	287	0	0	287
	Trochus	0	27	485	512
Tapes literatus	Tubalasvaif	11	0	0	11
Anadara sp.	Tugrot	974	0	43	1018
Donax cuneatus	Tumbar	28	0	0	28
Periglypta puerpera, *Periglypta reticulata*	Tumbur	114	0	0	114
Atrina vexillum	Wagtambugol	0	0	15	15
Total:		**11,073**	**37**	**1398**	**12,508**

APPENDIX 3: FINFISH SURVEY DATA

3.1 Paunangisu village finfish survey data

3.1.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Paunangisu village

Transect	Habitat	Latitude	Longitude
TRA01	Lagoon	16°31'24.96" S	167°51'21.6" E
TRA02	Lagoon	16°31'12.36" S	167°51'21.6" E
TRA03	Lagoon	16°30'53.28" S	167°51'14.4" E
TRA04	Back-reef	16°30'37.08" S	167°51'07.2" E
TRA05	Back-reef	16°30'14.76" S	167°50'52.8" E
TRA06	Outer reef	16°29'48.84" S	167°50'27.6" E
TRA07	Outer reef	16°29'16.08" S	167°50'38.4" E
TRA08	Back-reef	16°28'56.28" S	167°50'27.6" E
TRA09	Lagoon	16°28'51.6" S	167°49'55.2" E
TRA10	Lagoon	16°29'25.08" S	167°49'22.8" E
TRA11	Lagoon	16°29'43.8" S	167°48'46.8" E
TRA12	Back-reef	16°29'51.36" S	167°48'21.6" E
TRA13	Back-reef	16°30'25.92" S	167°48'18" E
TRA14	Back-reef	16°30'32.76" S	167°50'09.6" E
TRA15	Back-reef	16°30'41.4" S	167°49'44.4" E
TRA16	Outer reef	16°31'20.64" S	167°49'08.4" E
TRA17	Outer reef	16°31'22.08" S	167°48'14.4" E
TRA18	Back-reef	16°31'46.2" S	167°47'45.6" E
TRA19	Coastal reef	16°32'19.32" S	167°47'49.2" E
TRA20	Coastal reef	16°31'31.44" S	167°48'39.6" E
TRA21	Outer reef	16°31'56.28" S	167°48'14.4" E
TRA22	Outer reef	16°31'50.16" S	167°47'24" E
TRA23	Coastal reef	16°31'21" S	167°47'16.8" E
TRA24	Coastal reef	16°30'52.56" S	167°47'16.8" E

Appendix 3: Finfish survey data
Paunangisu village

3.1.2 Weighted average density and biomass of all finfish species recorded in Paunangisu village using distance-sampling underwater visual censuses (D-UVC)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	0.0027	0.45
Acanthuridae	*Acanthurus dussumieri*	0.0003	0.03
Acanthuridae	*Acanthurus lineatus*	0.0117	5.99
Acanthuridae	*Acanthurus mata*	0.0000	0.00
Acanthuridae	*Acanthurus nigricans*	0.0006	0.12
Acanthuridae	*Acanthurus nigricauda*	0.0013	0.18
Acanthuridae	*Acanthurus nigrofuscus*	0.0017	0.14
Acanthuridae	*Acanthurus olivaceus*	0.0007	0.08
Acanthuridae	*Acanthurus pyroferus*	0.0002	0.02
Acanthuridae	*Acanthurus triostegus*	0.0217	1.63
Acanthuridae	*Acanthurus xanthopterus*	0.0002	0.10
Acanthuridae	*Ctenochaetus binotatus*	0.0009	0.06
Acanthuridae	*Ctenochaetus striatus*	0.0594	7.42
Acanthuridae	*Ctenochaetus strigosus*	0.0000	0.00
Acanthuridae	*Naso annulatus*	0.0007	0.06
Acanthuridae	*Naso lituratus*	0.0012	0.75
Acanthuridae	*Naso unicornis*	0.0024	1.28
Acanthuridae	*Zebrasoma scopas*	0.0089	0.45
Acanthuridae	*Zebrasoma veliferum*	0.0008	0.05
Balistidae	*Balistapus undulatus*	0.0017	0.35
Balistidae	*Balistoides viridescens*	0.0002	0.09
Balistidae	*Rhinecanthus aculeatus*	0.0005	0.11
Balistidae	*Rhinecanthus rectangulus*	0.0000	0.00
Balistidae	*Sufflamen chrysopterum*	0.0004	0.06
Chaetodontidae	*Chaetodon auriga*	0.0035	0.17
Chaetodontidae	*Chaetodon baronessa*	0.0014	0.09
Chaetodontidae	*Chaetodon bennetti*	0.0002	0.01
Chaetodontidae	*Chaetodon citrinellus*	0.0100	0.30
Chaetodontidae	*Chaetodon ephippium*	0.0026	0.15
Chaetodontidae	*Chaetodon kleinii*	0.0004	0.01
Chaetodontidae	*Chaetodon lineolatus*	0.0001	0.01
Chaetodontidae	*Chaetodon lunula*	0.0003	0.02
Chaetodontidae	*Chaetodon lunulatus*	0.0062	0.32
Chaetodontidae	*Chaetodon melannotus*	0.0004	0.02
Chaetodontidae	*Chaetodon mertensii*	0.0002	0.01
Chaetodontidae	*Chaetodon ornatissimus*	0.0008	0.02
Chaetodontidae	*Chaetodon pelewensis*	0.0021	0.10
Chaetodontidae	*Chaetodon plebeius*	0.0002	0.01
Chaetodontidae	*Chaetodon rafflesii*	0.0027	0.17
Chaetodontidae	*Chaetodon reticulatus*	0.0003	0.03
Chaetodontidae	*Chaetodon speculum*	0.0000	0.00
Chaetodontidae	*Chaetodon trifascialis*	0.0018	0.09
Chaetodontidae	*Chaetodon ulietensis*	0.0003	0.01
Chaetodontidae	*Chaetodon unimaculatus*	0.0016	0.12
Chaetodontidae	*Chaetodon vagabundus*	0.0061	0.33
Chaetodontidae	*Forcipiger longirostris*	0.0007	0.04
Chaetodontidae	*Heniochus acuminatus*	0.0004	0.06
Chaetodontidae	*Heniochus chrysostomus*	0.0009	0.09

3.1.2 Weighted average density and biomass of all finfish species recorded in Paunangisu village using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Heniochus monoceros*	0.0000	0.00
Chaetodontidae	*Heniochus singularius*	0.0000	0.00
Chaetodontidae	*Heniochus varius*	0.0004	0.04
Holocentridae	*Myripristis berndti*	0.0037	0.85
Holocentridae	*Myripristis kuntee*	0.0000	0.00
Holocentridae	*Myripristis murdjan*	0.0000	0.00
Holocentridae	*Myripristis violacea*	0.0005	0.10
Holocentridae	*Neoniphon sammara*	0.0066	0.79
Holocentridae	*Sargocentron caudimaculatum*	0.0003	0.06
Holocentridae	*Sargocentron spiniferum*	0.0004	0.09
Labridae	*Cheilinus chlorourus*	0.0028	0.25
Labridae	*Cheilinus fasciatus*	0.0001	0.01
Labridae	*Cheilinus trilobatus*	0.0002	0.07
Labridae	*Cheilinus undulatus*	0.0000	0.00
Labridae	*Choerodon anchorago*	0.0015	0.38
Labridae	*Coris aygula*	0.0001	0.02
Labridae	*Coris gaimard*	0.0000	0.00
Labridae	*Hemigymnus fasciatus*	0.0015	0.11
Labridae	*Hemigymnus melapterus*	0.0063	0.86
Labridae	*Oxycheilinus digramma*	0.0002	0.02
Lethrinidae	*Lethrinus atkinsoni*	0.0011	0.20
Lethrinidae	*Lethrinus genivittatus*	0.0008	0.10
Lethrinidae	*Lethrinus harak*	0.0023	1.22
Lethrinidae	*Lethrinus obsoletus*	0.0014	0.10
Lethrinidae	*Lethrinus* sp.	0.0000	0.01
Lethrinidae	*Lethrinus xanthochilus*	0.0007	0.39
Lethrinidae	*Monotaxis grandoculis*	0.0025	0.35
Lutjanidae	*Aphareus furca*	0.0000	0.04
Lutjanidae	*Lutjanus bohar*	0.0002	0.46
Lutjanidae	*Lutjanus fulviflamma*	0.0023	1.06
Lutjanidae	*Lutjanus fulvus*	0.0132	3.76
Lutjanidae	*Lutjanus gibbus*	0.0041	1.19
Lutjanidae	*Lutjanus kasmira*	0.0048	0.44
Lutjanidae	*Lutjanus monostigma*	0.0001	0.10
Lutjanidae	*Lutjanus russellii*	0.0001	0.01
Lutjanidae	*Lutjanus semicinctus*	0.0017	0.56
Lutjanidae	*Macolor niger*	0.0000	0.04
Mullidae	*Mulloidichthys flavolineatus*	0.0062	0.45
Mullidae	*Mulloidichthys vanicolensis*	0.0025	0.32
Mullidae	*Parupeneus barberinus*	0.0070	0.68
Mullidae	*Parupeneus cyclostomus*	0.0008	0.20
Mullidae	*Parupeneus multifasciatus*	0.0071	0.92
Mullidae	*Parupeneus pleurostigma*	0.0003	0.05
Mullidae	*Parupeneus spilurus*	0.0033	0.62
Mullidae	*Parupeneus trifasciatus*	0.0032	0.70
Nemipteridae	*Scolopsis bilineata*	0.0062	1.15
Nemipteridae	*Scolopsis ciliata*	0.0002	0.01
Nemipteridae	*Scolopsis lineata*	0.0229	3.67

3.1.2 Weighted average density and biomass of all finfish species recorded in Paunangisu village using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Nemipteridae	*Scolopsis trilineata*	0.0078	1.15
Scaridae	*Cetoscarus bicolor*	0.0001	0.42
Scaridae	*Chlorurus bleekeri*	0.0038	1.10
Scaridae	*Chlorurus sordidus*	0.0337	4.22
Scaridae	*Hipposcarus longiceps*	0.0002	0.02
Scaridae	*Scarus altipinnis*	0.0009	0.41
Scaridae	*Scarus chameleon*	0.0011	0.09
Scaridae	*Scarus dimidiatus*	0.0021	0.38
Scaridae	*Scarus flavipectoralis*	0.0000	0.02
Scaridae	*Scarus frenatus*	0.0000	0.00
Scaridae	*Scarus ghobban*	0.0007	0.22
Scaridae	*Scarus globiceps*	0.0001	0.03
Scaridae	*Scarus longipinnis*	0.0004	0.12
Scaridae	*Scarus niger*	0.0002	0.16
Scaridae	*Scarus oviceps*	0.0025	0.54
Scaridae	*Scarus psittacus*	0.0166	1.83
Scaridae	*Scarus rivulatus*	0.0197	3.04
Scaridae	*Scarus rubroviolaceus*	0.0001	0.03
Scaridae	*Scarus schlegeli*	0.0003	0.02
Scaridae	*Scarus* sp.	0.0004	0.02
Scaridae	*Scarus spinus*	0.0004	0.07
Serranidae	*Cephalopholis argus*	0.0001	0.07
Serranidae	*Epinephelus fuscoguttatus*	0.0002	0.02
Serranidae	*Epinephelus merra*	0.0000	0.00
Serranidae	*Variola louti*	0.0000	0.03
Siganidae	*Siganus doliatus*	0.0000	0.01
Siganidae	*Siganus puellus*	0.0000	0.00
Siganidae	*Siganus punctatus*	0.0000	0.00
Siganidae	*Siganus spinus*	0.0245	2.69
Siganidae	*Siganus vermiculatus*	0.0004	0.43
Zanclidae	*Zanclus cornutus*	0.0033	0.42

3.2 Moso Island finfish survey data

3.2.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Moso Island

Transect	Habitat	Latitude	Longitude
TRA01	Coastal reef	17°32'41.64" S	168°16'04.62" E
TRA02	Coastal reef	17°32'54.96" S	168°15'57.1788" E
TRA03	Coastal reef	17°32'55.0788" S	168°15'36.0612" E
TRA04	Coastal reef	17°33'02.0412" S	168°15'15.5412" E
TRA05	Outer reef	17°31'11.28" S	168°15'17.5788" E
TRA06	Outer reef	17°31'03.7812" S	168°14'37.32" E
TRA07	Outer reef	17°31'41.88" S	168°13'43.14" E
TRA08	Outer reef	17°31'21.4212" S	168°14'01.7412" E
TRA09	Outer reef	17°32'09.8988" S	168°13'32.2212" E
TRA10	Outer reef	17°32'37.68" S	168°13'42.3012" E
TRA11	Outer reef	17°33'11.9412" S	168°13'26.8788" E
TRA12	Outer reef	17°33'24.48" S	168°13'07.5" E
TRA13	Outer reef	17°33'34.0812" S	168°12'55.8612" E
TRA14	Outer reef	17°33'48.78" S	168°12'47.7612" E
TRA15	Outer reef	17°34'00.0588" S	168°12'45.8388" E
TRA16	Outer reef	17°34'04.8" S	168°12'37.0188" E
TRA17	Coastal reef	17°34'13.1988" S	168°12'58.7988" E
TRA18	Coastal reef	17°34'13.5012" S	168°13'19.6212" E
TRA19	Coastal reef	17°33'46.0188" S	168°13'45.1812" E
TRA20	Coastal reef	17°33'37.5588" S	168°13'59.8188" E
TRA21	Coastal reef	17°33'27.2988" S	168°14'08.88" E
TRA22	Coastal reef	17°33'10.8612" S	168°14'13.4988" E
TRA23	Coastal reef	17°33'07.2612" S	168°14'31.0812" E
TRA24	Coastal reef	17°33'03.78" S	168°14'52.5012" E

3.2.2 Weighted average density and biomass of all finfish species recorded in Moso Island using distance-sampling underwater visual censuses (D-UVC)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus albipectoralis*	0.0001	0.01
Acanthuridae	*Acanthurus blochii*	0.0196	13.47
Acanthuridae	*Acanthurus dussumieri*	0.0001	0.01
Acanthuridae	*Acanthurus lineatus*	0.0267	15.62
Acanthuridae	*Acanthurus mata*	0.0003	0.10
Acanthuridae	*Acanthurus nigricans*	0.0003	0.05
Acanthuridae	*Acanthurus nigricauda*	0.0010	0.47
Acanthuridae	*Acanthurus nigrofuscus*	0.0030	0.15
Acanthuridae	*Acanthurus olivaceus*	0.0010	0.08
Acanthuridae	*Acanthurus pyroferus*	0.0020	0.23
Acanthuridae	*Acanthurus thompsoni*	0.0004	0.06
Acanthuridae	*Acanthurus triostegus*	0.0031	0.23
Acanthuridae	*Acanthurus xanthopterus*	0.0001	0.06
Acanthuridae	*Ctenochaetus binotatus*	0.0070	0.32
Acanthuridae	*Ctenochaetus striatus*	0.1066	14.40
Acanthuridae	*Ctenochaetus strigosus*	0.0007	0.03
Acanthuridae	*Naso annulatus*	0.0015	0.49
Acanthuridae	*Naso brachycentron*	0.0003	0.11
Acanthuridae	*Naso brevirostris*	0.0003	0.18
Acanthuridae	*Naso hexacanthus*	0.0003	0.04
Acanthuridae	*Naso lituratus*	0.0057	1.61
Acanthuridae	*Naso unicornis*	0.0012	0.27
Acanthuridae	*Zebrasoma scopas*	0.0077	0.36
Acanthuridae	*Zebrasoma veliferum*	0.0031	0.35
Balistidae	*Balistapus undulatus*	0.0079	1.71
Balistidae	*Balistoides viridescens*	0.0001	0.23
Balistidae	*Melichthys vidua*	0.0003	0.08
Balistidae	*Odonus niger*	0.0001	0.01
Balistidae	*Rhinecanthus aculeatus*	0.0008	0.19
Balistidae	*Sufflamen bursa*	0.0011	0.12
Balistidae	*Sufflamen chrysopterum*	0.0045	0.73
Chaetodontidae	*Chaetodon auriga*	0.0023	0.15
Chaetodontidae	*Chaetodon baronessa*	0.0004	0.02
Chaetodontidae	*Chaetodon citrinellus*	0.0083	0.27
Chaetodontidae	*Chaetodon ephippium*	0.0031	0.22
Chaetodontidae	*Chaetodon flavirostris*	0.0002	0.03
Chaetodontidae	*Chaetodon kleinii*	0.0009	0.03
Chaetodontidae	*Chaetodon lineolatus*	0.0001	0.01
Chaetodontidae	*Chaetodon lunula*	0.0001	0.00
Chaetodontidae	*Chaetodon lunulatus*	0.0093	0.48
Chaetodontidae	*Chaetodon melannotus*	0.0001	0.00
Chaetodontidae	*Chaetodon mertensii*	0.0007	0.03
Chaetodontidae	*Chaetodon ornatissimus*	0.0001	0.00
Chaetodontidae	*Chaetodon pelewensis*	0.0016	0.08
Chaetodontidae	*Chaetodon rafflesii*	0.0049	0.31
Chaetodontidae	*Chaetodon semeion*	0.0003	0.03
Chaetodontidae	*Chaetodon speculum*	0.0001	0.01
Chaetodontidae	*Chaetodon trifascialis*	0.0001	0.01

Appendix 3: Finfish survey data
Moso Island

3.2.2 Weighted average density and biomass of all finfish species recorded in Moso Island using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Chaetodon ulietensis*	0.0006	0.03
Chaetodontidae	*Chaetodon unimaculatus*	0.0010	0.07
Chaetodontidae	*Chaetodon vagabundus*	0.0039	0.21
Chaetodontidae	*Forcipiger flavissimus*	0.0004	0.03
Chaetodontidae	*Forcipiger longirostris*	0.0015	0.09
Chaetodontidae	*Heniochus acuminatus*	0.0003	0.03
Chaetodontidae	*Heniochus chrysostomus*	0.0011	0.10
Chaetodontidae	*Heniochus monoceros*	0.0002	0.02
Chaetodontidae	*Heniochus varius*	0.0017	0.15
Holocentridae	*Myripristis berndti*	0.0020	0.34
Holocentridae	*Myripristis murdjan*	0.0001	0.01
Holocentridae	*Myripristis* sp.	0.0003	0.06
Holocentridae	*Myripristis violacea*	0.0006	0.08
Holocentridae	*Neoniphon sammara*	0.0008	0.06
Holocentridae	*Sargocentron caudimaculatum*	0.0033	0.40
Holocentridae	*Sargocentron spiniferum*	0.0002	0.05
Kyphosidae	*Kyphosus vaigiensis*	0.0004	0.16
Labridae	*Bodianus loxozonus*	0.0009	0.21
Labridae	*Cheilinus chlorourus*	0.0013	0.19
Labridae	*Cheilinus fasciatus*	0.0022	0.47
Labridae	*Cheilinus trilobatus*	0.0003	0.22
Labridae	*Cheilinus undulatus*	0.0001	0.05
Labridae	*Choerodon anchorago*	0.0021	0.57
Labridae	*Coris aygula*	0.0009	0.16
Labridae	*Hemigymnus fasciatus*	0.0025	0.17
Labridae	*Hemigymnus melapterus*	0.0017	0.18
Labridae	*Oxycheilinus digramma*	0.0007	0.06
Lethrinidae	*Lethrinus atkinsoni*	0.0003	0.07
Lethrinidae	*Lethrinus harak*	0.0019	0.90
Lethrinidae	*Lethrinus obsoletus*	0.0003	0.03
Lethrinidae	*Monotaxis grandoculis*	0.0054	1.67
Lutjanidae	*Aphareus furca*	0.0002	0.07
Lutjanidae	*Lutjanus bohar*	0.0005	0.54
Lutjanidae	*Lutjanus fulviflamma*	0.0002	0.04
Lutjanidae	*Lutjanus fulvus*	0.0009	0.26
Lutjanidae	*Lutjanus gibbus*	0.0059	0.43
Lutjanidae	*Lutjanus kasmira*	0.0001	0.03
Lutjanidae	*Lutjanus quinquelineatus*	0.0002	0.06
Lutjanidae	*Lutjanus semicinctus*	0.0008	0.27
Lutjanidae	*Macolor macularis*	0.0001	0.03
Lutjanidae	*Macolor niger*	0.0003	0.05
Mullidae	*Mulloidichthys flavolineatus*	0.0007	0.21
Mullidae	*Parupeneus barberinus*	0.0024	0.26
Mullidae	*Parupeneus ciliatus*	0.0001	0.00
Mullidae	*Parupeneus cyclostomus*	0.0021	0.30
Mullidae	*Parupeneus indicus*	0.0005	0.25
Mullidae	*Parupeneus multifasciatus*	0.0082	0.78
Mullidae	*Parupeneus pleurostigma*	0.0015	0.11

3.2.2 Weighted average density and biomass of all finfish species recorded in Moso Island using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Mullidae	*Parupeneus spilurus*	0.0012	0.17
Mullidae	*Parupeneus trifasciatus*	0.0051	0.80
Nemipteridae	*Scolopsis bilineata*	0.0040	0.72
Nemipteridae	*Scolopsis lineata*	0.0083	1.32
Nemipteridae	*Scolopsis margaritifera*	0.0038	0.41
Nemipteridae	*Scolopsis trilineata*	0.0011	0.08
Scaridae	*Cetoscarus bicolor*	0.0008	2.69
Scaridae	*Chlorurus bleekeri*	0.0124	4.56
Scaridae	*Chlorurus microrhinos*	0.0003	0.69
Scaridae	*Chlorurus sordidus*	0.0213	5.39
Scaridae	*Hipposcarus longiceps*	0.0003	0.12
Scaridae	*Scarus altipinnis*	0.0103	2.80
Scaridae	*Scarus chameleon*	0.0040	1.32
Scaridae	*Scarus dimidiatus*	0.0036	0.80
Scaridae	*Scarus flavipectoralis*	0.0009	0.33
Scaridae	*Scarus forsteni*	0.0018	0.64
Scaridae	*Scarus frenatus*	0.0008	0.20
Scaridae	*Scarus ghobban*	0.0018	0.35
Scaridae	*Scarus globiceps*	0.0016	0.43
Scaridae	*Scarus longipinnis*	0.0007	0.50
Scaridae	*Scarus niger*	0.0065	3.17
Scaridae	*Scarus oviceps*	0.0016	0.63
Scaridae	*Scarus psittacus*	0.0146	2.50
Scaridae	*Scarus quoyi*	0.0002	0.04
Scaridae	*Scarus rivulatus*	0.0105	3.87
Scaridae	*Scarus rubroviolaceus*	0.0016	1.27
Scaridae	*Scarus schlegeli*	0.0025	1.15
Scaridae	*Scarus spinus*	0.0014	0.52
Serranidae	*Cephalopholis argus*	0.0005	0.07
Serranidae	*Cephalopholis microprion*	0.0004	0.03
Serranidae	*Cephalopholis sexmaculata*	0.0001	0.03
Serranidae	*Cephalopholis urodeta*	0.0019	0.17
Serranidae	*Epinephelus fasciatus*	0.0002	0.01
Serranidae	*Epinephelus merra*	0.0013	0.15
Serranidae	*Plectropomus laevis*	0.0002	0.04
Serranidae	*Plectropomus leopardus*	0.0001	0.02
Siganidae	*Siganus doliatus*	0.0015	0.16
Siganidae	*Siganus lineatus*	0.0066	2.82
Siganidae	*Siganus puellus*	0.0002	0.07
Siganidae	*Siganus punctatus*	0.0002	0.10
Siganidae	*Siganus spinus*	0.0021	0.11
Siganidae	*Siganus vulpinus*	0.0007	0.12
Zanclidae	*Zanclus cornutus*	0.0079	0.88

3.3 Uri and Uripiv Islands finfish survey data

3.3.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Uri and Uripiv Islands

Transect	Habitat	Latitude	Longitude
TRA01	Coastal	17°31'23.4012" S	168°25'21.9612" E
TRA02	Outer reef	17°31'17.94" S	168°25'13.44" E
TRA03	Outer reef	17°31'25.9212" S	168°25'10.8588" E
TRA04	Coastal reef	17°30'40.0212" S	168°24'38.88" E
TRA05	Outer reef	17°30'46.0188" S	168°24'50.1012" E
TRA06	Coastal reef	17°30'35.3412" S	168°24'45.1188" E
TRA07	Coastal reef	17°30'35.3412" S	168°24'45.1188" E
TRA08	Coastal reef	17°30'49.7988" S	168°25'05.5812" E
TRA09	Outer reef	17°31'25.0788" S	168°25'00.12" E
TRA10	Outer reef	17°31'23.4588" S	168°24'48.8988" E
TRA11	Outer reef	17°31'21.18" S	168°24'37.26" E
TRA12	Outer reef	17°30'51.84" S	168°25'09.48" E
TRA13	Outer reef	17°30'56.34" S	168°25'15.8988" E
TRA14	Coastal	17°31'14.4012" S	168°23'51.4212" E
TRA15	Outer reef	17°31'03.1188" S	168°23'56.1588" E
TRA16	Coastal reef	17°30'41.6412" S	168°25'04.26" E
TRA17	Coastal reef	17°30'41.6412" S	168°25'04.26" E
TRA18	Outer reef	17°31'05.4012" S	168°25'39.7812" E
TRA19	Outer reef	17°31'34.14" S	168°25'36.9588" E
TRA20	Outer reef	17°31'37.0812" S	168°25'18.5988" E
TRA21	Coastal reef	17°30'45.7812" S	168°25'22.9188" E
TRA22	Coastal reef	17°30'45.7812" S	168°25'22.9188" E
TRA23	Coastal reef	17°31'24.7188" S	168°24'19.1988" E
TRA24	Coastal reef	17°31'31.8" S	168°24'34.02" E

3.3.2 Weighted average density and biomass of all finfish species recorded in Uri and Uripiv Islands using distance-sampling underwater visual censuses (D-UVC)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus albipectoralis*	0.0017	0.68
Acanthuridae	*Acanthurus blochii*	0.0164	8.94
Acanthuridae	*Acanthurus lineatus*	0.0663	22.34
Acanthuridae	*Acanthurus mata*	0.0004	0.03
Acanthuridae	*Acanthurus nigricans*	0.0013	0.31
Acanthuridae	*Acanthurus nigricauda*	0.0067	2.97
Acanthuridae	*Acanthurus nigrofuscus*	0.0003	0.05
Acanthuridae	*Acanthurus nigroris*	0.0005	0.05
Acanthuridae	*Acanthurus olivaceus*	0.0003	0.11
Acanthuridae	*Acanthurus pyroferus*	0.0100	1.43
Acanthuridae	*Acanthurus triostegus*	0.0132	0.86
Acanthuridae	*Acanthurus xanthopterus*	0.0020	1.93
Acanthuridae	*Ctenochaetus binotatus*	0.0002	0.02
Acanthuridae	*Ctenochaetus striatus*	0.1095	11.15
Acanthuridae	*Ctenochaetus strigosus*	0.0061	0.30
Acanthuridae	*Naso annulatus*	0.0021	1.12
Acanthuridae	*Naso lituratus*	0.0145	5.75
Acanthuridae	*Naso lopezi*	0.0008	0.97
Acanthuridae	*Naso tuberosus*	0.0058	8.27
Acanthuridae	*Naso unicornis*	0.0025	2.62
Acanthuridae	*Zebrasoma scopas*	0.0196	0.98
Acanthuridae	*Zebrasoma veliferum*	0.0014	0.13
Balistidae	*Balistapus undulatus*	0.0063	0.98
Balistidae	*Balistoides conspicillum*	0.0001	0.11
Balistidae	*Balistoides viridescens*	0.0005	0.81
Balistidae	*Melichthys vidua*	0.0030	0.99
Balistidae	*Pseudobalistes flavimarginatus*	0.0004	0.67
Balistidae	*Rhinecanthus aculeatus*	0.0003	0.02
Balistidae	*Rhinecanthus rectangulus*	0.0004	0.08
Balistidae	*Rhinecanthus verrucosus*	0.0006	0.10
Balistidae	*Sufflamen bursa*	0.0008	0.06
Balistidae	*Sufflamen chrysopterum*	0.0029	0.41
Chaetodontidae	*Chaetodon auriga*	0.0004	0.03
Chaetodontidae	*Chaetodon baronessa*	0.0087	0.54
Chaetodontidae	*Chaetodon bennetti*	0.0006	0.04
Chaetodontidae	*Chaetodon citrinellus*	0.0083	0.27
Chaetodontidae	*Chaetodon ephippium*	0.0014	0.11
Chaetodontidae	*Chaetodon kleinii*	0.0012	0.05
Chaetodontidae	*Chaetodon lineolatus*	0.0002	0.02
Chaetodontidae	*Chaetodon lunula*	0.0002	0.02
Chaetodontidae	*Chaetodon lunulatus*	0.0067	0.41
Chaetodontidae	*Chaetodon melannotus*	0.0005	0.04
Chaetodontidae	*Chaetodon ornatissimus*	0.0021	0.17
Chaetodontidae	*Chaetodon pelewensis*	0.0015	0.08
Chaetodontidae	*Chaetodon plebeius*	0.0008	0.04
Chaetodontidae	*Chaetodon rafflesii*	0.0029	0.17
Chaetodontidae	*Chaetodon semeion*	0.0003	0.02
Chaetodontidae	*Chaetodon trifascialis*	0.0009	0.04

3.3.2 Weighted average density and biomass of all finfish species recorded in Uri and Uripiv Islands using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m²)	Biomass (g/m²)
Chaetodontidae	*Chaetodon ulietensis*	0.0012	0.06
Chaetodontidae	*Chaetodon unimaculatus*	0.0014	0.11
Chaetodontidae	*Chaetodon vagabundus*	0.0044	0.33
Chaetodontidae	*Forcipiger longirostris*	0.0018	0.12
Chaetodontidae	*Heniochus chrysostomus*	0.0002	0.02
Chaetodontidae	*Heniochus monoceros*	0.0002	0.05
Chaetodontidae	*Heniochus singularius*	0.0006	0.14
Chaetodontidae	*Heniochus varius*	0.0115	1.16
Holocentridae	*Myripristis berndti*	0.0037	0.53
Holocentridae	*Myripristis kuntee*	0.0002	0.02
Holocentridae	*Myripristis murdjan*	0.0014	0.16
Holocentridae	*Myripristis violacea*	0.0007	0.10
Holocentridae	*Neoniphon sammara*	0.0008	0.07
Holocentridae	*Sargocentron caudimaculatum*	0.0007	0.08
Holocentridae	*Sargocentron spiniferum*	0.0001	0.06
Kyphosidae	*Kyphosus cinerascens*	0.0098	8.36
Kyphosidae	*Kyphosus vaigiensis*	0.0032	2.22
Labridae	*Bodianus axillaris*	0.0001	0.02
Labridae	*Cheilinus chlorourus*	0.0001	0.02
Labridae	*Cheilinus fasciatus*	0.0007	0.12
Labridae	*Cheilinus trilobatus*	0.0003	0.11
Labridae	*Cheilinus undulatus*	0.0008	8.05
Labridae	*Choerodon anchorago*	0.0021	0.48
Labridae	*Choerodon fasciatus*	0.0001	0.02
Labridae	*Choerodon graphicus*	0.0001	0.03
Labridae	*Coris aygula*	0.0001	0.00
Labridae	*Hemigymnus fasciatus*	0.0004	0.02
Labridae	*Hemigymnus melapterus*	0.0013	0.16
Labridae	*Oxycheilinus digramma*	0.0004	0.04
Lethrinidae	*Gnathodentex aureolineatus*	0.0077	2.72
Lethrinidae	*Lethrinus atkinsoni*	0.0006	0.20
Lethrinidae	*Lethrinus harak*	0.0003	0.15
Lethrinidae	*Lethrinus obsoletus*	0.0059	0.34
Lethrinidae	*Lethrinus olivaceus*	0.0003	0.20
Lethrinidae	*Lethrinus xanthochilus*	0.0004	0.49
Lethrinidae	*Monotaxis grandoculis*	0.0113	4.37
Lutjanidae	*Aphareus furca*	0.0005	0.15
Lutjanidae	*Lutjanus bohar*	0.0020	1.72
Lutjanidae	*Lutjanus fulviflamma*	0.0054	1.41
Lutjanidae	*Lutjanus fulvus*	0.0166	6.61
Lutjanidae	*Lutjanus gibbus*	0.0141	8.18
Lutjanidae	*Lutjanus kasmira*	0.0012	0.30
Lutjanidae	*Lutjanus monostigma*	0.0091	3.41
Lutjanidae	*Lutjanus rivulatus*	0.0001	0.59
Lutjanidae	*Lutjanus semicinctus*	0.0029	0.87
Lutjanidae	*Macolor macularis*	0.0006	0.34
Lutjanidae	*Macolor niger*	0.0027	3.55
Mullidae	*Mulloidichthys flavolineatus*	0.0096	2.54

3.3.2 Weighted average density and biomass of all finfish species recorded in Uri and Uripiv Islands using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Mullidae	*Mulloidichthys vanicolensis*	0.0027	0.55
Mullidae	*Parupeneus barberinoides*	0.0007	0.11
Mullidae	*Parupeneus barberinus*	0.0012	0.18
Mullidae	*Parupeneus ciliatus*	0.0001	0.00
Mullidae	*Parupeneus cyclostomus*	0.0008	0.15
Mullidae	*Parupeneus indicus*	0.0012	0.62
Mullidae	*Parupeneus multifasciatus*	0.0085	0.59
Mullidae	*Parupeneus pleurostigma*	0.0002	0.01
Mullidae	*Parupeneus spilurus*	0.0007	0.09
Mullidae	*Parupeneus trifasciatus*	0.0132	2.15
Mullidae	*Upeneus tragula*	0.0002	0.06
Nemipteridae	*Scolopsis bilineata*	0.0071	1.41
Nemipteridae	*Scolopsis ciliata*	0.0106	1.08
Nemipteridae	*Scolopsis lineata*	0.0138	1.37
Nemipteridae	*Scolopsis margaritifera*	0.0052	1.43
Nemipteridae	*Scolopsis trilineata*	0.0120	3.01
Pomacanthidae	*Pomacanthus sexstriatus*	0.0007	0.67
Pomacanthidae	*Pygoplites diacanthus*	0.0012	0.15
Scaridae	*Bolbometopon muricatum*	0.0004	4.24
Scaridae	*Cetoscarus bicolor*	0.0016	1.43
Scaridae	*Chlorurus bleekeri*	0.0118	3.07
Scaridae	*Chlorurus microrhinos*	0.0041	5.92
Scaridae	*Chlorurus sordidus*	0.0128	2.17
Scaridae	*Hipposcarus longiceps*	0.0058	6.05
Scaridae	*Scarus altipinnis*	0.0035	3.35
Scaridae	*Scarus chameleon*	0.0006	0.12
Scaridae	*Scarus dimidiatus*	0.0074	2.10
Scaridae	*Scarus forsteni*	0.0003	0.08
Scaridae	*Scarus frenatus*	0.0022	0.47
Scaridae	*Scarus ghobban*	0.0013	0.37
Scaridae	*Scarus globiceps*	0.0013	0.31
Scaridae	*Scarus niger*	0.0061	2.61
Scaridae	*Scarus oviceps*	0.0013	0.56
Scaridae	*Scarus psittacus*	0.0202	4.89
Scaridae	*Scarus quoyi*	0.0016	0.29
Scaridae	*Scarus rivulatus*	0.0047	2.15
Scaridae	*Scarus rubroviolaceus*	0.0042	3.47
Scaridae	*Scarus schlegeli*	0.0056	1.18
Scaridae	*Scarus* sp.	0.0003	0.00
Scaridae	*Scarus spinus*	0.0024	0.70
Serranidae	*Cephalopholis argus*	0.0008	0.14
Serranidae	*Cephalopholis* sp.	0.0001	0.03
Serranidae	*Cephalopholis urodeta*	0.0018	0.18
Serranidae	*Epinephelus coeruleopunctatus*	0.0001	0.09
Serranidae	*Epinephelus fuscoguttatus*	0.0001	0.41
Serranidae	*Epinephelus malabaricus*	0.0001	1.47
Serranidae	*Epinephelus merra*	0.0002	0.03
Serranidae	*Epinephelus polyphekadion*	0.0003	0.92

3.3.2 Weighted average density and biomass of all finfish species recorded in Uri and Uripiv Islands using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Serranidae	*Plectropomus laevis*	0.0013	5.38
Serranidae	*Plectropomus maculatus*	0.0003	0.22
Serranidae	*Variola louti*	0.0003	0.31
Siganidae	*Siganus argenteus*	0.0015	0.92
Siganidae	*Siganus corallinus*	0.0017	0.69
Siganidae	*Siganus doliatus*	0.0007	0.27
Siganidae	*Siganus puellus*	0.0014	0.61
Siganidae	*Siganus spinus*	0.0006	0.08
Siganidae	*Siganus vermiculatus*	0.0001	0.09
Siganidae	*Siganus vulpinus*	0.0027	0.51
Zanclidae	*Zanclus cornutus*	0.0026	0.31

3.4 Maskelyne Archipelago finfish survey data

3.4.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in the Maskelyne Archipelago

Transect	Habitat	Latitude	Longitude
TRA01	Outer reef	16°04'19.3188" S	167°26'38.5188" E
TRA02	Outer reef	16°04'05.6388" S	167°26'41.0388" E
TRA03	Outer reef	16°03'45.54" S	167°26'42.9" E
TRA04	Outer reef	16°04'33.3588" S	167°26'58.1388" E
TRA05	Outer reef	16°03'41.2812" S	167°26'59.9388" E
TRA06	Outer reef	16°04'34.5612" S	167°27'05.2812" E
TRA07	Outer reef	16°05'06.8388" S	167°26'36.8988" E
TRA08	Outer reef	16°05'20.1012" S	167°26'53.7" E
TRA09	Outer reef	16°03'47.5812" S	167°27'15.3612" E
TRA10	Coastal reef	16°03'51.66" S	167°27'24.66" E
TRA11	Coastal reef	16°04'02.82" S	167°27'33.5412" E
TRA12	Coastal reef	16°04'58.5588" S	167°26'41.82" E
TRA13	Coastal reef	16°04'13.26" S	167°27'43.02" E
TRA14	Coastal reef	16°04'25.3812" S	167°27'39.42" E
TRA15	Coastal reef	16°05'02.22" S	167°27'01.62" E
TRA16	Outer reef	16°05'38.6988" S	167°27'18.9612" E
TRA17	Coastal reef	16°04'29.46" S	167°27'25.6212" E
TRA18	Coastal reef	16°05'05.3412" S	167°27'56.88" E
TRA19	Outer reef	16°05'04.8012" S	167°27'41.58" E
TRA20	Outer reef	16°05'03.7212" S	167°27'27.1188" E
TRA21	Outer reef	16°05'44.0988" S	167°27'26.7588" E
TRA22	Coastal reef	16°05'44.0412" S	167°27'26.82" E
TRA23	Coastal reef	16°06'11.5812" S	167°28'00.9012" E
TRA24	Coastal reef	16°05'28.9788" S	167°27'03.42" E

Appendix 3: Finfish survey data
Maskelyne Archipelago

3.4.2 Weighted average density and biomass of all finfish species recorded in the Maskelyne Archipelago using distance-sampling underwater visual censuses (D-UVC)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus albipectoralis*	0.0006	0.50
Acanthuridae	*Acanthurus blochii*	0.0062	2.12
Acanthuridae	*Acanthurus lineatus*	0.0879	28.42
Acanthuridae	*Acanthurus mata*	0.0007	0.20
Acanthuridae	*Acanthurus nigricans*	0.0028	0.38
Acanthuridae	*Acanthurus nigricauda*	0.0036	0.81
Acanthuridae	*Acanthurus nigrofuscus*	0.0152	0.68
Acanthuridae	*Acanthurus nigroris*	0.0007	0.07
Acanthuridae	*Acanthurus olivaceus*	0.0001	0.02
Acanthuridae	*Acanthurus pyroferus*	0.0031	0.69
Acanthuridae	*Acanthurus* sp.	0.0001	0.00
Acanthuridae	*Acanthurus thompsoni*	0.0001	0.02
Acanthuridae	*Acanthurus triostegus*	0.0222	1.68
Acanthuridae	*Acanthurus xanthopterus*	0.0072	3.11
Acanthuridae	*Ctenochaetus binotatus*	0.0035	0.09
Acanthuridae	*Ctenochaetus* sp.	0.0005	0.06
Acanthuridae	*Ctenochaetus striatus*	0.1561	24.40
Acanthuridae	*Ctenochaetus strigosus*	0.0040	0.20
Acanthuridae	*Naso annulatus*	0.0011	0.40
Acanthuridae	*Naso brevirostris*	0.0001	0.15
Acanthuridae	*Naso caesius*	0.0002	0.25
Acanthuridae	*Naso lituratus*	0.0184	7.61
Acanthuridae	*Naso lopezi*	0.0004	0.49
Acanthuridae	*Naso tuberosus*	0.0001	0.20
Acanthuridae	*Naso unicornis*	0.0071	4.64
Acanthuridae	*Paracanthurus hepatus*	0.0010	0.11
Acanthuridae	*Zebrasoma scopas*	0.0361	2.04
Acanthuridae	*Zebrasoma veliferum*	0.0014	0.21
Balistidae	*Balistapus undulatus*	0.0049	1.34
Balistidae	*Balistes* sp.	0.0001	0.01
Balistidae	*Balistoides viridescens*	0.0000	0.06
Balistidae	*Melichthys vidua*	0.0025	0.62
Balistidae	*Rhinecanthus aculeatus*	0.0000	0.01
Balistidae	*Rhinecanthus rectangulus*	0.0007	0.09
Balistidae	*Sufflamen bursa*	0.0002	0.01
Balistidae	*Sufflamen chrysopterum*	0.0008	0.07
Chaetodontidae	*Chaetodon auriga*	0.0018	0.14
Chaetodontidae	*Chaetodon baronessa*	0.0043	0.29
Chaetodontidae	*Chaetodon citrinellus*	0.0101	0.32
Chaetodontidae	*Chaetodon ephippium*	0.0029	0.28
Chaetodontidae	*Chaetodon flavirostris*	0.0002	0.02
Chaetodontidae	*Chaetodon kleinii*	0.0008	0.02
Chaetodontidae	*Chaetodon lineolatus*	0.0001	0.01
Chaetodontidae	*Chaetodon lunula*	0.0014	0.07
Chaetodontidae	*Chaetodon lunulatus*	0.0072	0.47
Chaetodontidae	*Chaetodon melannotus*	0.0003	0.02
Chaetodontidae	*Chaetodon mertensii*	0.0004	0.01
Chaetodontidae	*Chaetodon ornatissimus*	0.0019	0.16

3.4.2 Weighted average density and biomass of all finfish species recorded in the Maskelyne Archipelago using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Chaetodon pelewensis*	0.0040	0.18
Chaetodontidae	*Chaetodon plebeius*	0.0000	0.00
Chaetodontidae	*Chaetodon rafflesii*	0.0032	0.20
Chaetodontidae	*Chaetodon* sp.	0.0002	0.02
Chaetodontidae	*Chaetodon trifascialis*	0.0049	0.23
Chaetodontidae	*Chaetodon ulietensis*	0.0008	0.04
Chaetodontidae	*Chaetodon unimaculatus*	0.0020	0.18
Chaetodontidae	*Chaetodon vagabundus*	0.0040	0.31
Chaetodontidae	*Forcipiger flavissimus*	0.0004	0.02
Chaetodontidae	*Forcipiger longirostris*	0.0022	0.17
Chaetodontidae	*Hemitaurichthys polylepis*	0.0002	0.02
Chaetodontidae	*Heniochus chrysostomus*	0.0011	0.10
Chaetodontidae	*Heniochus monoceros*	0.0004	0.15
Chaetodontidae	*Heniochus singularius*	0.0006	0.17
Chaetodontidae	*Heniochus varius*	0.0080	0.91
Holocentridae	*Myripristis adusta*	0.0007	0.09
Holocentridae	*Myripristis berndti*	0.0058	1.19
Holocentridae	*Myripristis kuntee*	0.0060	0.91
Holocentridae	*Myripristis murdjan*	0.0029	0.68
Holocentridae	*Myripristis* sp.	0.0005	0.05
Holocentridae	*Myripristis violacea*	0.0042	0.83
Holocentridae	*Myripristis vittata*	0.0011	0.11
Holocentridae	*Neoniphon sammara*	0.0029	0.31
Holocentridae	*Sargocentron caudimaculatum*	0.0019	0.30
Holocentridae	*Sargocentron* sp.	0.0004	0.02
Holocentridae	*Sargocentron spiniferum*	0.0000	0.03
Kyphosidae	*Kyphosus cinerascens*	0.0067	7.54
Kyphosidae	*Kyphosus vaigiensis*	0.0002	0.29
Labridae	*Bodianus loxozonus*	0.0002	0.09
Labridae	*Cheilinus chlorourus*	0.0027	0.29
Labridae	*Cheilinus fasciatus*	0.0019	0.47
Labridae	*Cheilinus trilobatus*	0.0002	0.11
Labridae	*Cheilinus undulatus*	0.0005	3.20
Labridae	*Choerodon anchorago*	0.0001	0.01
Labridae	*Choerodon fasciatus*	0.0012	0.21
Labridae	*Choerodon jordani*	0.0000	0.00
Labridae	*Coris gaimard*	0.0002	0.02
Labridae	*Epibulus insidiator*	0.0003	0.07
Labridae	*Hemigymnus fasciatus*	0.0014	0.11
Labridae	*Hemigymnus melapterus*	0.0050	0.88
Labridae	*Oxycheilinus digramma*	0.0008	0.02
Lethrinidae	*Gymnocranius* sp.	0.0001	0.06
Lethrinidae	*Lethrinus atkinsoni*	0.0008	0.40
Lethrinidae	*Lethrinus genivittatus*	0.0001	0.02
Lethrinidae	*Lethrinus harak*	0.0001	0.09
Lethrinidae	*Lethrinus obsoletus*	0.0005	0.10
Lethrinidae	*Lethrinus olivaceus*	0.0002	0.31

Appendix 3: Finfish survey data
Maskelyne Archipelago

3.4.2 Weighted average density and biomass of all finfish species recorded in the Maskelyne Archipelago using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lethrinidae	*Lethrinus variegatus*	0.0001	0.01
Lethrinidae	*Lethrinus xanthochilus*	0.0001	0.11
Lethrinidae	*Monotaxis grandoculis*	0.0116	8.60
Lutjanidae	*Aphareus furca*	0.0005	0.22
Lutjanidae	*Lutjanus bohar*	0.0088	8.12
Lutjanidae	*Lutjanus fulviflamma*	0.0005	0.12
Lutjanidae	*Lutjanus fulvus*	0.0167	6.18
Lutjanidae	*Lutjanus gibbus*	0.0203	18.76
Lutjanidae	*Lutjanus monostigma*	0.0053	3.45
Lutjanidae	*Lutjanus rivulatus*	0.0001	0.13
Lutjanidae	*Lutjanus semicinctus*	0.0032	0.77
Lutjanidae	*Macolor macularis*	0.0002	0.08
Lutjanidae	*Macolor niger*	0.0003	0.14
Mullidae	*Mulloidichthys vanicolensis*	0.0010	0.20
Mullidae	*Parupeneus barberinus*	0.0007	0.14
Mullidae	*Parupeneus ciliatus*	0.0001	0.02
Mullidae	*Parupeneus cyclostomus*	0.0015	0.31
Mullidae	*Parupeneus multifasciatus*	0.0038	0.45
Mullidae	*Parupeneus pleurostigma*	0.0001	0.02
Mullidae	*Parupeneus spilurus*	0.0012	0.36
Mullidae	*Parupeneus trifasciatus*	0.0111	2.66
Nemipteridae	*Scolopsis bilineata*	0.0017	0.16
Nemipteridae	*Scolopsis ciliata*	0.0004	0.05
Nemipteridae	*Scolopsis lineata*	0.0116	1.79
Nemipteridae	*Scolopsis margaritifera*	0.0009	0.30
Nemipteridae	*Scolopsis trilineata*	0.0002	0.02
Pomacanthidae	*Pomacanthus imperator*	0.0001	0.12
Pomacanthidae	*Pomacanthus sexstriatus*	0.0001	0.11
Pomacanthidae	*Pygoplites diacanthus*	0.0023	0.34
Scaridae	*Bolbometopon muricatum*	0.0049	81.77
Scaridae	*Cetoscarus bicolor*	0.0010	0.96
Scaridae	*Chlorurus bleekeri*	0.0054	2.17
Scaridae	*Chlorurus microrhinos*	0.0029	2.74
Scaridae	*Chlorurus sordidus*	0.0835	6.57
Scaridae	*Hipposcarus longiceps*	0.0031	2.02
Scaridae	*Leptoscarus vaigiensis*	0.0004	0.05
Scaridae	*Scarus altipinnis*	0.0029	2.63
Scaridae	*Scarus chameleon*	0.0014	0.22
Scaridae	*Scarus dimidiatus*	0.0073	1.75
Scaridae	*Scarus flavipectoralis*	0.0001	0.05
Scaridae	*Scarus forsteni*	0.0001	0.02
Scaridae	*Scarus frenatus*	0.0036	0.90
Scaridae	*Scarus ghobban*	0.0007	0.04
Scaridae	*Scarus globiceps*	0.0022	0.43
Scaridae	*Scarus niger*	0.0056	2.91
Scaridae	*Scarus oviceps*	0.0150	4.09
Scaridae	*Scarus psittacus*	0.0149	1.69

3.4.2 Weighted average density and biomass of all finfish species recorded in the Maskelyne Archipelago using distance-sampling underwater visual censuses (D-UVC) (continued)

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus quoyi*	0.0009	0.16
Scaridae	*Scarus rivulatus*	0.0006	0.49
Scaridae	*Scarus rubroviolaceus*	0.0013	0.65
Scaridae	*Scarus schlegeli*	0.0246	0.37
Scaridae	*Scarus* sp.	0.0313	0.41
Scaridae	*Scarus spinus*	0.0031	0.82
Serranidae	*Cephalopholis argus*	0.0002	0.15
Serranidae	*Cephalopholis urodeta*	0.0017	0.26
Serranidae	*Epinephelus corallicola*	0.0001	0.01
Serranidae	*Epinephelus maculatus*	0.0004	0.27
Serranidae	*Epinephelus merra*	0.0001	0.01
Serranidae	*Epinephelus ongus*	0.0002	0.08
Serranidae	*Epinephelus polyphekadion*	0.0002	0.67
Serranidae	*Epinephelus* sp.	0.0001	0.01
Serranidae	*Plectropomus laevis*	0.0006	1.11
Serranidae	*Plectropomus leopardus*	0.0003	0.30
Serranidae	*Plectropomus maculatus*	0.0000	0.03
Serranidae	*Variola louti*	0.0001	0.07
Siganidae	*Siganus corallinus*	0.0014	0.79
Siganidae	*Siganus doliatus*	0.0001	0.02
Siganidae	*Siganus puellus*	0.0007	0.08
Siganidae	*Siganus punctatus*	0.0003	0.02
Siganidae	*Siganus spinus*	0.0046	0.21
Siganidae	*Siganus vulpinus*	0.0020	0.26
Zanclidae	*Zanclus cornutus*	0.0049	0.68

APPENDIX 4: INVERTEBRATE SURVEY DATA

4.1 Paunangisu village invertebrate survey data

4.1.1 Invertebrate species recorded in different assessments in Paunangisu village

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga lecanora*				+
Bêche-de-mer	*Actinopyga mauritiana*				+
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Bohadschia graeffei*	+			+
Bêche-de-mer	*Bohadschia similis*			+	
Bêche-de-mer	*Bohadschia vitiensis*	+			
Bêche-de-mer	*Holothuria atra*	+	+	+	+
Bêche-de-mer	*Holothuria coluber*	+	+	+	
Bêche-de-mer	*Holothuria edulis*	+	+	+	+
Bêche-de-mer	*Holothuria fuscopunctata*	+			
Bêche-de-mer	*Holothuria hilla*		+		
Bêche-de-mer	*Holothuria nobilis*	+			+
Bêche-de-mer	*Stichopus chloronotus*	+	+		+
Bêche-de-mer	*Stichopus hermanni*	+			+
Bêche-de-mer	*Stichopus horrens*			+	
Bêche-de-mer	*Synapta* sp.	+	+		
Bêche-de-mer	*Thelenota ananas*		+		+
Bivalve	*Acrosterigma* sp.			+	
Bivalve	*Atrina vexillum*	+			
Bivalve	*Codakia interrupta*			+	
Bivalve	*Gafrarium pectinatum*			+	
Bivalve	*Gafrarium* sp.			+	
Bivalve	*Gafrarium tumidum*			+	
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Pinctada margaritifera*	+			+
Bivalve	*Spondylus squamosus*	+			
Bivalve	*Tellina palatum*			+	
Bivalve	*Tridacna crocea*	+	+		+
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+	+		
Cnidarian	*Actinodendron* sp.			+	
Cnidarian	*Cassiopea andromeda*	+			
Cnidarian	*Cassiopea* sp.			+	
Cnidarian	*Stichodactyla gigantea*		+		
Cnidarian	*Stichodactyla* sp.		+		
Crustacean	*Panulirus* sp.	+			
Gastropod	*Cerithium nodulosum*		+		
Gastropod	*Conus flavidus*		+		
Gastropod	*Conus litteratus*		+		
Gastropod	*Conus* sp.	+	+		
Gastropod	*Coralliophila neritoidea*		+		
Gastropod	*Cypraea annulus*		+		
Gastropod	*Cypraea tigris*	+	+	+	
Gastropod	*Lambis lambis*	+	+		

4.1.1 Invertebrate species recorded in different assessments in Paunangisu village (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Pleuroploca filamentosa*		+		
Gastropod	*Rhinoclavis aspera*			+	
Gastropod	*Strombus luhuanus*		+		
Gastropod	*Tectus pyramis*	+	+		
Gastropod	*Trochus maculata*		+		
Gastropod	*Trochus niloticus*	+			
Star	*Acanthaster planci*	+	+		+
Star	*Culcita novaeguineae*	+	+		
Star	*Linckia laevigata*	+	+		
Star	*Nardoa novaecaledoniae*	+	+		
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix diadema*		+		
Urchin	*Heterocentrotus mammillatus*	+	+		
Urchin	*Toxopneustes pileolus*		+		
Urchin	*Tripneustes gratilla*	+	+		

+ = presence of the species.

Appendix 4: Invertebrate survey data
Paunangisu village

4.1.2a Paunangisu village broad-scale assessment data review (data from Pele marine protected area survey not included)

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 vexillum	0.7	0.5	48	16.7	0.0	2	0.7	0.7	8	5.6		1
Bohadschia argus	3.8	1.7	48	26.2	7.1	7	3.8	2.7	8	7.6	4.9	4
Bohadschia graeffei	1.4	0.7	48	16.7	0.0	4	1.4	1.0	8	5.6	2.8	2
Bohadschia vitiensis	0.0	0.0	48			0	0.0	0.0	8			0
Cassiopea andromeda	1.0	0.6	48	16.7	0.0	3	1.0	0.7	8	4.2	1.4	2
Conus spp.	6.9	2.3	48	30.3	5.9	11	6.9	3.2	8	13.9	4.1	4
Culcita novaeguineae	3.1	1.2	48	21.4	3.1	7	3.1	1.3	8	5.0	1.6	5
Cypraea tigris	1.0	0.8	48	25.0	8.3	2	1.0	1.0	8	8.3		1
Echinometra mathaei	1.0	0.8	48	25.0	8.3	2	1.0	1.0	8	8.3		1
Heterocentrotus mammillatus	0.7	0.5	48	16.7	0.0	2	0.7	0.5	8	2.8	0.0	2
Hippopus hippopus	2.1	0.9	48	20.0	3.3	5	2.1	0.9	8	4.2	0.8	4
Holothuria atra	261.5	178.0	48	597.6	400.2	21	261.5	219.9	8	522.9	424.4	4
Holothuria coluber	1.4	0.8	48	22.2	5.6	3	1.4	0.9	8	5.6	0.0	2
Holothuria edulis	2.8	1.2	48	26.7	4.1	5	2.8	2.0	8	7.4	4.6	3
Holothuria fuscopunctata	0.3	0.3	48	16.7		1	0.3	0.3	8	2.8		1
Holothuria nobilis	0.3	0.3	48	16.7		1	0.3	0.3	8	2.8		1
Lambis lambis	1.0	0.6	48	16.7	0.0	3	1.0	0.7	8	4.2	1.4	2
Linckia laevigata	34.7	11.8	48	119.0	30.7	14	34.7	24.1	8	55.6	36.5	5
Nardoa novaecaledoniae	1.7	1.0	48	27.8	5.6	3	1.7	1.7	8	13.9		1
Panulirus spp.	0.3	0.3	48	16.7		1	0.3	0.3	8	2.8		1
Pinctada margaritifera	2.1	1.2	48	25.0	8.3	4	2.1	1.1	8	5.6	1.6	3
Spondylus squamosus	0.3	0.3	48	16.7		1	0.3	0.3	8	2.8		1
Stichopus chloronotus	3.8	1.6	48	30.6	5.1	6	3.8	2.3	8	7.6	4.0	4
Stichopus hermanni	1.7	1.1	48	27.8	11.1	3	1.7	1.4	8	6.9	4.2	2
Synapta spp.	1.0	0.8	48	25.0	8.3	2	1.0	1.0	8	8.3		1
Tectus pyramis	0.3	0.3	48	16.7		1	0.3	0.3	8	2.8		1
Tridacna crocea	37.2	10.5	48	127.4	21.8	14	37.2	22.2	8	74.3	37.1	4
Tridacna maxima	4.9	1.4	48	21.2	2.3	11	4.9	2.1	8	9.7	2.4	4

Appendix 4: Invertebrate survey data
Paunangisu village

4.1.2a Paunangisu village broad-scale assessment data review (data from Pele marine protected area survey not included) (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
Tridacna squamosa	0.0	0.0	48			0	0.0	0.0	8			0
Tripneustes gratilla	1.7	1.4	48	41.7	25.0	2	1.7	1.7	8	13.9		1
Trochus niloticus	1.4	1.1	48	33.3	16.7	2	1.4	1.0	8	5.6	2.8	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.2b Pele MPA 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	0.9	0.5	54	16.7	0.0	3	8.3		1	8.3		1
Atrina vexillum	0.9	0.5	54	16.7	0.0	3	8.3		1	8.3		1
Bohadschia argus	0.0	0.0	54			0	0.0		1			0
Bohadschia graeffei	0.6	0.6	54	33.3		1	5.6		1	5.6		1
Bohadschia vitiensis	0.6	0.4	54	16.7	0.0	2	5.6		1	5.6		1
Cassiopea andromeda	0.0	0.0	54			0	0.0		1			0
Conus spp.	0.0	0.0	54			0	0.0		1			0
Culcita novaeguineae	0.3	0.3	54	16.7		1	2.8		1	2.8		1
Cypraea tigris	0.0	0.0	54			0	0.0		1			0
Echinometra mathaei	0.0	0.0	54			0	0.0		1			0
Heterocentrotus mammillatus	0.0	0.0	54			0	0.0		1			0
Hippopus hippopus	0.0	0.0	54			0	0.0		1			0
Holothuria atra	2.2	1.2	54	29.2	8.0	4	19.4		1	19.4		1
Holothuria coluber	0.0	0.0	54			0	0.0		1			0
Holothuria edulis	0.0	0.0	54			0	0.0		1			0
Holothuria fuscopunctata	0.0	0.0	54			0	0.0		1			0
Holothuria nobilis	0.0	0.0	54			0	0.0		1			0
Lambis lambis	0.0	0.0	54			0	0.0		1			0
Linckia laevigata	1.9	1.1	54	33.3	9.6	3	16.7		1	16.7		1

4.1.2b Pele MPA 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
Nardoa novaecaledoniae	0.0	0.0	54			0	0.0		1			0
Panulirus spp.	0.0	0.0	54			0	0.0		1			0
Pinctada margaritifera	0.3	0.3	54	16.7		1	2.8		1	2.8		1
Spondylus squamosus	0.0	0.0	54			0	0.0		1			0
Stichopus chloronotus	3.7	2.1	54	40.0	16.3	5	33.3		1	33.3		1
Stichopus hermanni	0.3	0.3	54	16.7		1	2.8		1	2.8		1
Synapta spp.	0.0	0.0	54			0	0.0		1			0
Tectus pyramis	0.0	0.0	54			0	0.0		1			0
Tridacna crocea	7.4	3.3	54	66.7	16.7	6	66.7		1	66.7		1
Tridacna maxima	0.9	0.5	54	16.7	0.0	3	8.3		1	8.3		1
Tridacna squamosa	0.3	0.3	54	16.7		1	2.8		1	2.8		1
Tripneustes gratilla	0.0	0.0	54			0	0.0		1			0
Trochus niloticus	0.0	0.0	54			0	0.0		1			0

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.3 Paunangisu village 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	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Bohadschia argus	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Cerithium nodulosum	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Conus flavidus	34.7	11.4	72	277.8	27.8	9	34.7	14.4	12	83.3	18.6	5
Conus litteratus	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Conus spp.	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Coralliophila neritoidea	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Culcita novaeguineae	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 tigris	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Echinometra mathaei	128.5	33.5	72	544.1	83.7	17	128.5	66.2	12	171.3	84.3	9
Echinothrix diadema	20.8	9.6	72	300.0	50.0	5	20.8	10.9	12	62.5	20.8	4
Heterocentrotus mammillatus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Hippopus hippopus	13.9	8.4	72	333.3	83.3	3	13.9	10.7	12	83.3	41.7	2
Holothuria atra	104.2	22.0	72	340.9	38.7	22	104.2	27.4	12	138.9	27.8	9
Holothuria coluber	17.4	9.0	72	312.5	62.5	4	17.4	8.0	12	52.1	10.4	4
Holothuria edulis	41.7	17.8	72	428.6	105.1	7	41.7	17.8	12	83.3	26.4	6
Lambis lambis	17.4	9.0	72	312.5	62.5	4	17.4	9.5	12	69.4	13.9	3
Latirolagena smaragdula	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Linckia laevigata	600.7	51.8	72	697.6	50.2	62	600.7	87.6	12	600.7	87.6	12
Nardoa novaecaledoniae	27.8	11.7	72	333.3	52.7	6	27.8	12.9	12	83.3	17.0	4
Pleuroploca filamentosa	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Stichodactyla gigantea	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Stichodactyla spp.	72.9	31.1	72	656.3	182.6	8	72.9	42.6	12	218.8	96.8	4
Stichopus chloronotus	45.1	15.1	72	361.1	43.9	9	45.1	25.4	12	135.4	54.8	4
Strombus luhuanus	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Synapta spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Tectus pyramis	10.4	5.9	72	250.0	0.0	3	10.4	10.4	12	125.0		1

4.1.3 Paunangisu village 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
Thelenota ananas	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Toxopneustes pileolus	104.2	41.3	72	833.3	212.5	9	104.2	71.7	12	312.5	186.7	4
Tridacna crocea	41.7	13.1	72	300.0	33.3	10	41.7	17.0	12	71.4	23.6	7
Tridacna maxima	34.7	12.4	72	312.5	40.9	8	34.7	8.6	12	52.1	6.8	8
Tridacna squamosa	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Tripneustes gratilla	156.3	51.5	72	661.8	170.1	17	156.3	115.2	12	234.4	169.2	8
Trochus 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 of individuals; SE = standard error.

4.1.4 Paunangisu village reef front search by walking (RFs_w) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	0.7	0.7	18	13.3		1	0.7	0.7	3	2.2		1
Actinopyga mauritiana	3.0	1.7	18	17.8	4.4	3	3.0	2.0	3	4.4	2.2	2
Holothuria atra	11.1	2.9	18	22.2	2.2	9	11.1	5.9	3	16.7	3.3	2
Stichopus chloronotus	1.5	1.0	18	13.3	0.0	2	1.5	1.5	3	4.4		1
Tridacna maxima	5.9	2.7	18	21.3	5.3	5	5.9	2.0	3	5.9	2.0	3

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.5 Paunangisu village 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
Actinodendron spp.	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Bohadschia similis	20.8	15.3	36	375.0	125.0	2	20.8	20.8	6	125.0		1
Cassiopea spp.	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Cypraea tigris	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Holothuria atra	194.4	43.5	36	437.5	53.5	16	194.4	52.3	6	194.4	52.3	6
Holothuria coluber	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Holothuria edulis	6.9	6.9	36	250.0		1	6.9	6.9	6	41.7		1
Stichopus horrens	136,125.0	55,079.0	36	816,750.0	127,417.0	6	136,125.0	136,125.0	6	816,750.0		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.6 Paunangisu village soft-benthos quadrat (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
Acrosterigma spp.	0.1	0.1	48	4.0		1	0.1	0.1	6	0.5		1
Codakia interrupta	1.8	0.6	48	7.3	1.5	12	1.8	1.1	6	3.7	1.6	3
Gafrarium pectinatum	0.3	0.2	48	6.0	2.0	2	0.3	0.2	6	0.8	0.3	2
Gafrarium spp.	0.2	0.1	48	4.0	0.0	2	0.2	0.2	6	1.0		1
Gafrarium tumidum	0.2	0.2	48	8.0		1	0.2	0.2	6	1.0		1
Rhinoclavis aspera	0.1	0.1	48	4.0		1	0.1	0.1	6	0.5		1
Tellina palatum	0.5	0.5	48	24		1	0.5	0.5	6	3.0		1

Mean = mean density (numbers/m²); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.7 Paunangisu village 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 lecanora	8.3	5.8	24	100.0	0.0	2	8.3	4.8	4	16.7	0.0	2
Actinopyga mauritiana	2.1	2.1	24	50.0		1	2.1	2.1	4	8.3		1
Bohadschia argus	4.2	2.9	24	50.0	0.0	2	4.2	4.2	4	16.7		1
Bohadschia graeffei	8.3	3.9	24	50.0	0.0	4	8.3	3.4	4	11.1	2.8	3
Echinometra mathaei	2.1	2.1	24	50.0		1	2.1	2.1	4	8.3		1
Holothuria edulis	12.5	5.4	24	60.0	10.0	5	12.5	5.4	4	16.7	4.8	3
Holothuria nobilis	10.4	5.2	24	62.5	12.5	4	10.4	4.0	4	13.9	2.8	3
Pinctada margaritifera	2.1	2.1	24	50.0		1	2.1	2.1	4	8.3		1
Stichopus hermanni	2.1	2.1	24	50.0		1	2.1	2.1	4	8.3		1
Thelenota ananas	4.2	2.9	24	50.0	0.0	2	4.2	4.2	4	16.7		1
Tridacna crocea	79.2	20.6	24	190.0	16.3	10	79.2	31.3	4	105.6	23.7	3
Tridacna maxima	79.2	9.9	24	95.0	8.0	20	79.2	14.2	4	79.2	14.2	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.8 Paunangisu village sea cucumber night search (Ns) assessment data review

Station: Six 5-min search periods/station.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
None found			12						2			

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

Appendix 4: Invertebrate survey data
Paunangisu village

4.1.9 Paunangisu village species size review — all survey methods

Species	Mean length (cm)	SE	n
Stichopus horrens	6.45	0.01	19,602
Holothuria atra	18.73	0.22	577
Tridacna crocea	8.5	0.15	181
Tridacna maxima	14.65	0.66	73
Tripneustes gratilla	10.12	0.17	50
Echinometra mathaei	11.5	0	41
Stichopus chloronotus	17.05	0.6	38
Toxopneustes pileolus	10.6	0.3	30
Holothuria edulis	17.81	1.2	27
Conus spp.	9.85	0.48	23
Codakia interrupta	2.31	0.07	22
Bohadschia argus	26.69	1.71	15
Bohadschia graeffei	24.8	1.32	10
Hippopus hippopus	16.4	0.88	10
Conus flavidus	7.2	0.73	10
Pinctada margaritifera	15.14	0.83	8
Lambis lambis	14.35	0.63	8
Stichopus hermanni	33.86	2.7	7
Holothuria nobilis	29.4	1.62	6
Tellina palatum	4.1	0.33	6
Actinopyga mauritiana	23.02	1.57	5
Trochus niloticus	10.17	1.81	4
Tectus pyramis	6.6	0.99	4
Thelenota ananas	30	5.03	3
Tridacna squamosa	23	5.72	3
Bohadschia similis	16.33	2.85	3
Gafrarium pectinatum	4.5	0.23	3
Bohadschia vitiensis	30	0	2
Pleuroploca filamentosa	12.9	0.7	2
Cerithium nodulosum	8.1	0.1	2
Conus litteratus	7.3	0.1	2
Strombus luhuanus	5.1	0.9	2
Gafrarium spp.	4.9	0.7	2
Gafrarium tumidum	4.3	0.7	2
Holothuria coluber	20		10
Cypraea tigris	7		6
Holothuria fuscopunctata	30		1
Panulirus spp.	15		1
Rhinoclavis aspera	5.5		1
Trochus maculata	4.2		1
Acrosterigma spp.	2.8		1
Linckia laevigata			279
Stichodactyla spp.			21
Nardoa novaecaledoniae			13
Holothuria hilla			12
Culcita novaeguineae			11
Acanthaster planci			6
Echinothrix diadema			6

4.1.9 Paunangisu village species size review — all survey methods (continued)

Species	Mean length (cm)	SE	n
Atrina vexillum			5
Actinopyga lecanora			4
Synapta spp.			4
Cassiopea andromeda			3
Coralliophila neritoidea			3
Heterocentrotus mammillatus			3
Actinodendron spp.			1
Cassiopea spp.			1
Cypraea annulus			1
Latirolagena smaragdula			1
Spondylus squamosus			1
Stichodactyla gigantea			1

4.1.10 Efate, Trochus niloticus seeding sites at Emua Village, 4 km from Paunangisu village

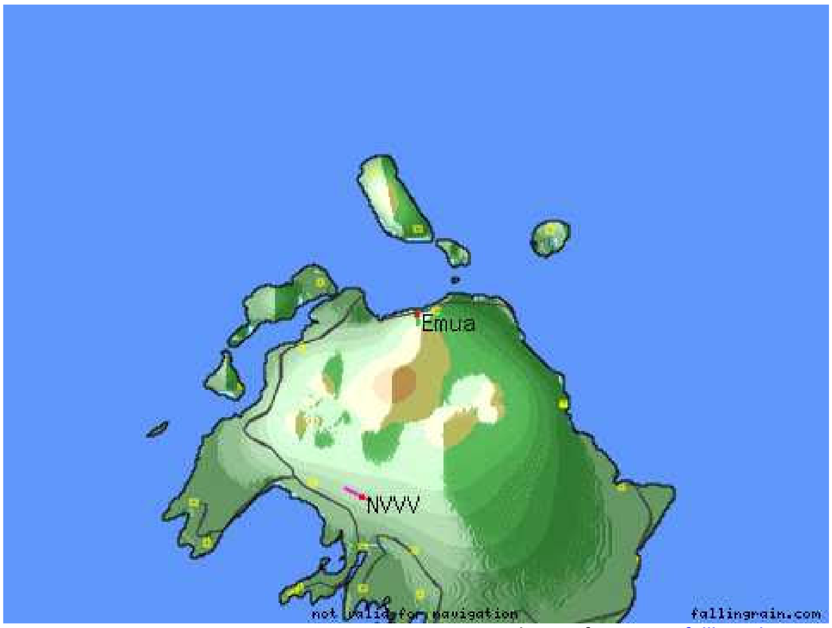
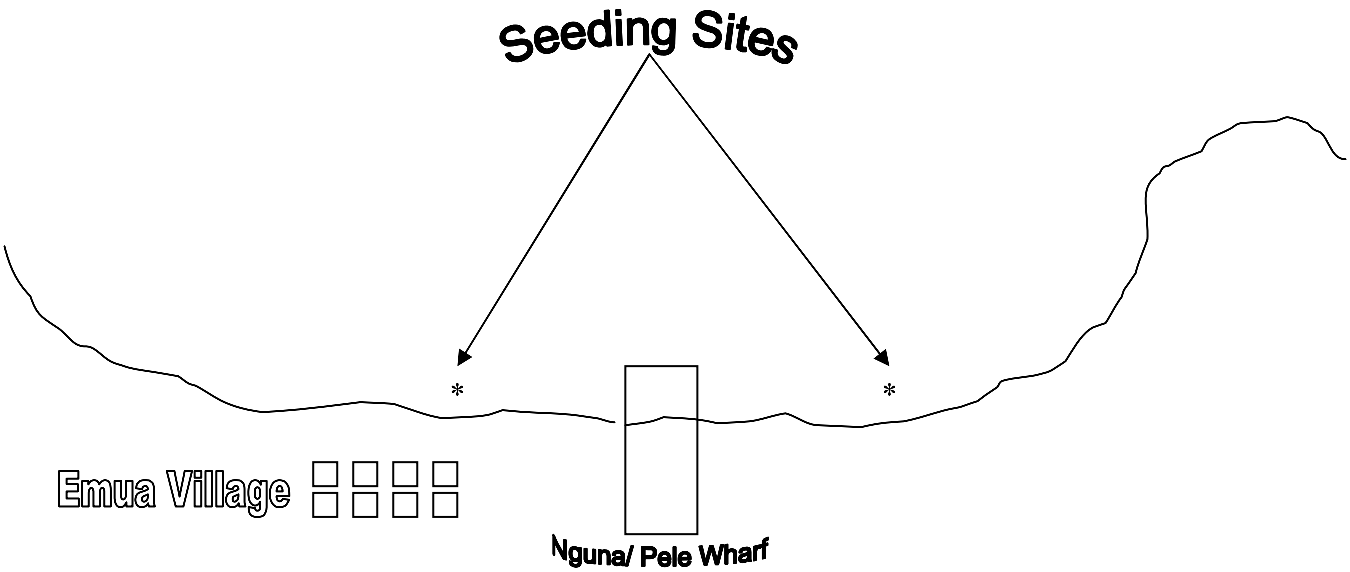
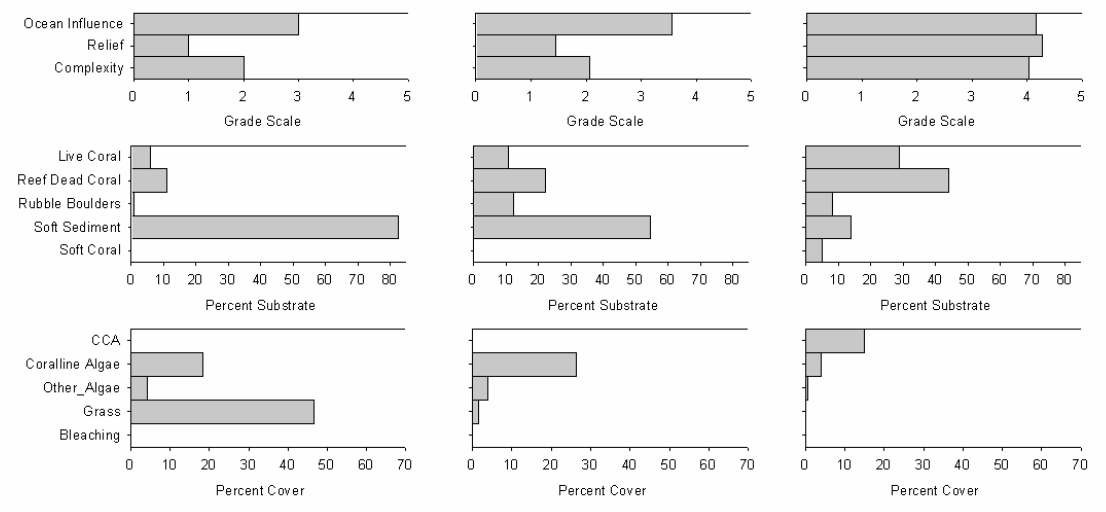


Image from www.fallingrain.com

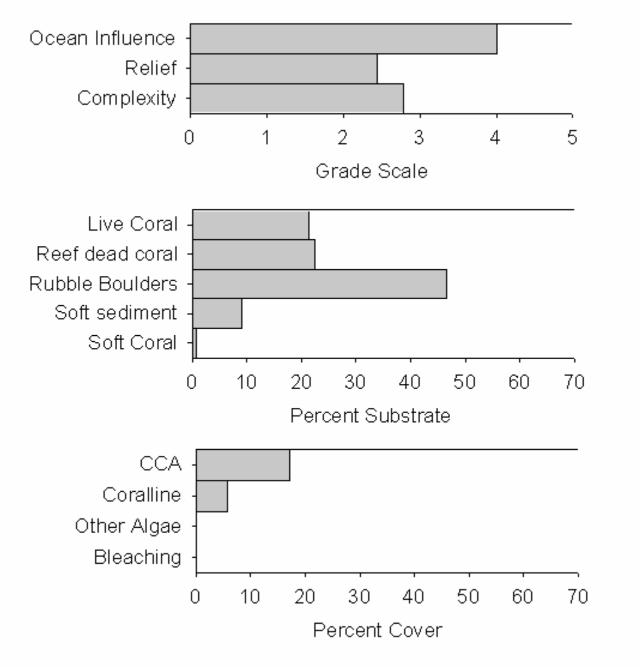


4.1.11 Habitat descriptors for independent assessments – Paunangisu village

Broad-scale inner, middle- and outer-reef assessments of habitat

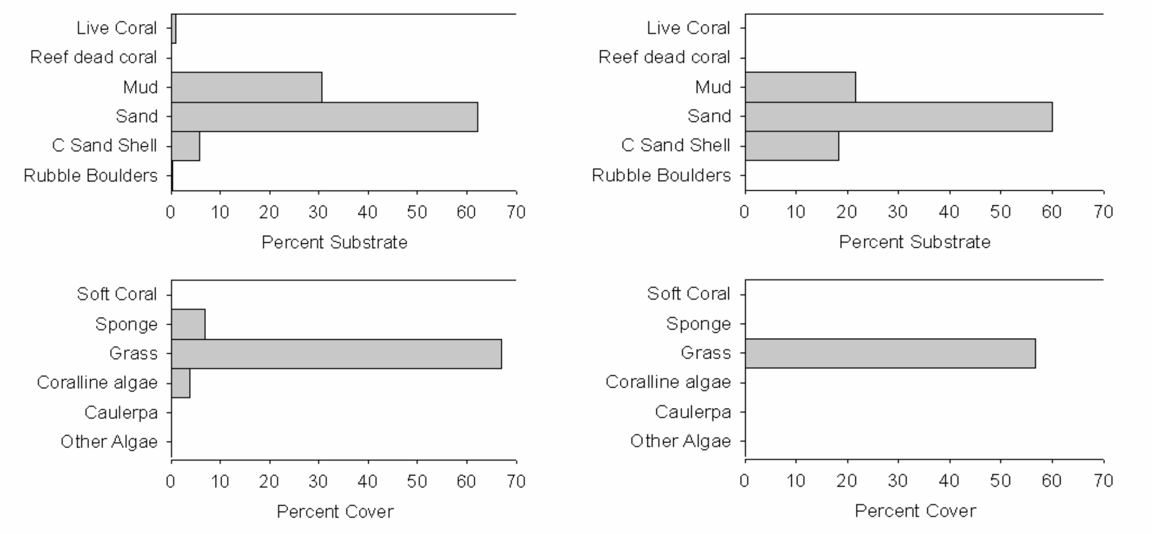


Reef-benthos assessment of habitat



4.1.11 Habitat descriptors for independent assessments – Paunangisu village (continued)

Soft-benthos transects and soft-benthos quadrats assessment of habitat



4.1.12 Paunangisu village catch assessment – creel survey – data review

Name	Mean length (cm)	SE	n (length records)	Mean weight (g)	SE	n (weight records)	n (total)
Anadara spp.	4.75	0.15	2	38.00	3.0	2	2
Anemone				54.00		1	1
Pinctada margaritifera	11.4	0.9	4	194.75	42.0	4	4
Pinctada margaritifera (meat)			1	12.00		1	1
Conus flavidus	7.0	1.6	5	177.20	29.8	5	5
Conus litteratus	9.2	0.2	31	240.27	18.9	30	31
Cypraea tigris	6.5	0.1	21	94.00	5.1	18	21
Hippopus hippopus	13.7	1.6	3	675.67	189.4	3	3
Hippopus hippopus (meat only)				137.36	38.2	11	11
Lambis lambis	15.7	0.7	11	231.18	29.4	11	11
Octopus spp. (gut removed)	14.2	0.5	43	530.18	63.5	63	63
Periglypta puerperal	6.1	0.6	5	287.50	159.5	2	5
Pleuroploca filamentosa	11.4	0.5	7	150.00	17.7	5	7
Strombus luhuanus	5.2	0.2	3	33.67	7.3	3	3
Tridacna crocea (meat only)				69.00		1	1
Tridacna maxima	12.3	3.2	3	405.33	284.4	3	3
Tridacna maxima (meat only)				92.11	25.1	9	9
Tripneustes gratilla				433.00		1	1
Vasum turbinellum	4.6		1	60.00		1	1
Triggerfish				111.70		1	3

4.2 Moso Island invertebrate survey data

4.2.1 Invertebrate species recorded in different assessments in Moso Island

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga lecanora*	+			+
Bêche-de-mer	*Actinopyga miliaris*		+		
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Bohadschia graeffei*	+			+
Bêche-de-mer	*Bohadschia 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 fuscopunctata*	+			
Bêche-de-mer	*Holothuria nobilis*	+			
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	*Anadara antiquata*			+	
Bivalve	*Atrina vexillum*	+		+	
Bivalve	*Fragum unedo*			+	
Bivalve	*Gafrarium tumidum*			+	
Bivalve	*Hippopus hippopus*		+	+	
Bivalve	*Hyotissa* spp.	+			
Bivalve	*Modiolus auriculatus*			+	
Bivalve	*Pinctada margaritifera*	+	+	+	+
Bivalve	*Pitar prora*			+	
Bivalve	*Spondylus* spp.	+	+	+	
Bivalve	*Spondylus squamosus*			+	
Bivalve	*Trachycardium* spp.			+	
Bivalve	*Tridacna crocea*	+	+	+	+
Bivalve	*Tridacna maxima*	+	+		+
Cnidarian	*Cassiopea andromeda*			+	
Crustacean	*Panulirus versicolor*	+	+	+	
Gastropod	*Conus flavidus*			+	
Gastropod	*Conus litteratus*			+	
Gastropod	*Conus* spp.	+		+	
Gastropod	*Cypraea annulus*			+	
Gastropod	*Cypraea tigris*			+	+
Gastropod	*Lambis lambis*	+	+	+	
Gastropod	*Lambis truncata*	+			
Gastropod	*Nassarius* spp.			+	
Gastropod	*Polinices* spp.			+	
Gastropod	*Strombus labiatus*			+	
Gastropod	*Tectus pyramis*				+
Gastropod	*Trochus niloticus*				+
Gastropod	*Trochus* spp.		+		

4.2.1 Invertebrate species recorded in different assessments in Moso Island (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Turbo chrysostomus*			+	
Octopus	*Octopus cyanea*		+		
Star	*Acanthaster planci*		+		
Star	*Archaster typicus*		+		
Star	*Choriaster granulatus*	+	+		
Star	*Culcita novaeguineae*	+	+		
Star	*Linckia laevigata*	+	+	+	
Urchin	*Diadema* spp.	+			
Urchin	*Echinometra mathaei*	+		+	+
Urchin	*Echinothrix diadema*				+
Urchin	*Heterocentrotus mammillatus*	+			+

+ = presence of the species.

4.2.2 Moso Island 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
Actinopyga lecanora	0.8	0.5	43	16.7	0.0	2	0.8	0.5	7	2.8	0.0	2
Atrina vexillum	1.9	1.0	43	20.8	4.2	4	1.8	1.0	7	4.2	1.5	3
Bohadschia argus	7.8	4.2	43	47.6	21.0	7	7.8	6.1	7	13.7	10.3	4
Bohadschia graeffei	0.4	0.4	43	16.7		1	0.3	0.3	7	2.4		1
Bohadschia vitiensis	1.6	1.2	43	33.3	16.7	2	1.5	1.2	7	5.4	3.0	2
Choriaster granulatus	1.6	0.7	43	16.7	0.0	4	1.5	1.0	7	5.2	0.4	2
Conus spp.	1.2	0.9	43	25.0	8.3	2	1.2	0.8	7	4.2	1.4	2
Culcita novaeguineae	3.1	1.1	43	19.0	2.4	7	3.1	1.0	7	4.4	0.7	5
Diadema spp.	0.4	0.4	43	16.7		1	0.4	0.4	7	2.8		1
Echinometra mathaei	0.8	0.5	43	16.7	0.0	2	0.8	0.8	7	5.6		1
Heterocentrotus mammillatus	26.9	8.1	43	77.2	17.1	15	27.6	12.2	7	48.2	13.7	4
Holothuria atra	41.3	7.5	43	57.3	8.8	31	41.6	10.0	7	41.6	10.0	7
Holothuria edulis	13.7	5.4	43	39.1	13.4	15	13.9	8.5	7	13.9	8.5	7
Holothuria fuscopunctata	0.4	0.4	43	16.7		1	0.4	0.4	7	2.8		1
Holothuria nobilis	0.2	0.2	43	10.1		1	0.2	0.2	7	1.7		1
Hyotissa spp.	0.4	0.4	43	16.7		1	0.4	0.4	7	2.8		1
Lambis lambis	1.2	0.7	43	16.7	0.0	3	1.2	0.8	7	4.2	1.4	2
Lambis truncata	0.8	0.5	43	16.7	0.0	2	0.8	0.5	7	2.8	0.0	2
Linckia laevigata	26.1	5.2	43	50.9	6.8	22	25.5	8.1	7	29.8	8.2	6
Panulirus versicolor	0.8	0.5	43	16.7	0.0	2	0.7	0.5	7	2.6	0.2	2
Pinctada margaritifera	3.5	1.4	43	21.4	4.8	7	3.3	1.5	7	5.9	1.8	4
Spondylus spp.	10.9	3.5	43	46.7	7.8	10	11.1	7.6	7	38.9	11.1	2
Stichopus chloronotus	9.2	3.2	43	32.8	8.6	12	9.1	2.7	7	12.7	1.9	5
Stichopus hermanni	0.4	0.4	43	16.7		1	0.3	0.3	7	2.4		1
Thelenota ananas	0.4	0.4	43	16.7		1	0.3	0.3	7	2.4		1
Thelenota anax	0.4	0.4	43	16.7		1	0.4	0.4	7	2.8		1
Tridacna crocea	556.6	166.1	43	1087.9	283.4	22	522.7	308.5	7	609.8	350.1	6
Tridacna maxima	4.6	1.6	43	21.9	3.8	9	4.6	2.1	7	6.5	2.5	5

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.2.3 Moso Island 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	11.9	8.3	42	250.0	0.0	2	11.9	11.9	7	83.3		1
Archaster typicus	11.9	8.3	42	250.0	0.0	2	11.9	7.7	7	41.7	0.0	2
Bohadschia argus	6.0	6.0	42	250.0		1	6.0	6.0	7	41.7		1
Choriaster granulatus	11.9	8.3	42	250.0	0.0	2	11.9	7.7	7	41.7	0.0	2
Culcita novaeguineae	35.7	13.7	42	250.0	0.0	6	35.7	14.2	7	62.5	12.0	4
Hippopus hippopus	17.9	10.1	42	250.0	0.0	3	17.9	8.4	7	41.7	0.0	3
Holothuria atra	41.7	22.4	42	437.5	119.7	4	41.7	30.2	7	145.8	62.5	2
Holothuria edulis	35.7	16.1	42	300.0	50.0	5	35.7	23.1	7	83.3	41.7	3
Lambis lambis	6.0	6.0	42	250.0		1	6.0	6.0	7	41.7		1
Linckia laevigata	125.0	46.9	42	437.5	127.3	12	125.0	54.6	7	145.8	59.7	6
Octopus cyanea	6.0	6.0	42	250.0		1	6.0	6.0	7	41.7		1
Panulirus versicolor	17.9	10.1	42	250.0	0.0	3	17.9	8.4	7	41.7	0.0	3
Pinctada margaritifera	11.9	8.3	42	250.0	0.0	2	11.9	11.9	7	83.3		1
Spondylus spp.	71.4	19.6	42	272.7	22.7	11	71.4	19.7	7	83.3	18.6	6
Stichopus chloronotus	6.0	6.0	42	250.0		1	6.0	6.0	7	41.7		1
Tridacna crocea	7839.3	1667.1	42	8442.3	1759.4	39	7839.3	3648.3	7	7839.3	3648.3	7
Tridacna maxima	11.9	11.9	42	500.0		1	11.9	11.9	7	83.3		1
Trochus spp.	6.0	6.0	42	250.0		1	6.0	6.0	7	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.2.4 Moso Island 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
Anadara antiquata	4.6	4.6	54	250.0		1	4.6	4.6	9	41.7		1
Atrina vexillum	4.6	4.6	54	250.0		1	4.6	4.6	9	41.7		1
Bohadschia vitiensis	4.6	4.6	54	250.0		1	4.6	4.6	9	41.7		1
Cassiopea andromeda	50.9	16.7	54	305.6	36.7	9	50.9	18.1	9	76.4	19.9	6
Conus flavidus	9.3	6.5	54	250.0	0.0	2	9.3	6.1	9	41.7	0.0	2
Conus litteratus	13.9	10.3	54	375.0	125.0	2	13.9	9.8	9	62.5	20.8	2
Conus spp.	23.1	10.0	54	250.0	0.0	5	23.1	10.1	9	52.1	10.4	4
Cypraea annulus	92.6	42.5	54	1000.0	176.8	5	92.6	54.1	9	277.8	97.2	3
Cypraea tigris	4.6	4.6	54	250.0		1	4.6	4.6	9	41.7		1
Echinometra mathaei	23.1	13.7	54	416.7	83.3	3	23.1	15.7	9	104.2	20.8	2
Hippopus hippopus	27.8	10.8	54	250.0	0.0	6	27.8	9.8	9	50.0	8.3	5
Holothuria atra	1152.8	181.5	54	1296.9	194.5	48	1152.8	379.9	9	1152.8	379.9	9
Holothuria coluber	4.6	4.6	54	250.0		1	4.6	4.6	9	41.7		1
Holothuria edulis	13.9	7.9	54	250.0	0.0	3	13.9	9.8	9	62.5	20.8	2
Lambis lambis	4.6	4.6	54	250.0		1	4.6	4.6	9	41.7		1
Linckia laevigata	13.9	7.9	54	250.0	0.0	3	13.9	6.9	9	41.7	0.0	3
Pinctada margaritifera	9.3	6.5	54	250.0	0.0	2	9.3	6.1	9	41.7	0.0	2
Spondylus spp.	13.9	7.9	54	250.0	0.0	3	13.9	9.8	9	62.5	20.8	2
Spondylus spp.	402.8	68.5	54	403.8	44.0	26	402.8	109.8	9	453.1	110.6	8
Strombus labiatus	9.3	6.5	54	250.0	0.0	2	9.3	6.1	9	41.7	0.0	2
Synapta spp.	37.0	13.9	54	285.7	35.7	7	37.0	20.2	9	111.1	27.8	3
Tridacna crocea	60.2	26.4	54	406.3	124.4	8	60.2	23.1	9	90.3	27.3	6
Turbo chrysostomus	9.3	6.5	54	250.0	0.0	2	9.3	6.1	9	41.7	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.2.5 Moso Island soft-benthos quadrat (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	1.0	0.2	96	4.8	0.5	20	1.0	0.3	12	1.1	0.3	11
Bohadschia similis	0.1	0.1	96	4.0	0.0	2	0.1	0.1	12	0.5	0.0	2
Conus litteratus	0.1	0.1	96	4.0	0.0	3	0.1	0.1	12	0.5	0.0	3
Cypraea annulus	0.0	0.0	96	4.0		1	0.0	0.0	12	0.5		1
Fragum unedo	0.1	0.1	96	8.0		1	0.1	0.1	12	1.0		1
Gafrarium tumidum	0.0	0.0	96	4.0		1	0.04	0.04	12	0.5		1
Holothuria atra	0.3	0.1	96	4.0	0.0	6	0.3	0.1	12	0.6	0.1	5
Modiolus auriculatus	0.5	0.1	96	4.4	0.4	10	0.5	0.2	12	0.9	0.4	6
Nassarius spp.	0.1	0.1	96	4.0	0.0	2	0.1	0.1	12	0.5	0.0	2
Pitar proha	0.8	0.2	96	5.7	0.8	14	0.8	0.2	12	1.1	0.2	9
Polinices spp.	0.5	0.2	96	5.2	0.6	10	0.5	0.2	12	1.3	0.3	5
Stichopus horrens	0.0	0.0	96	4.0		1	0.0	0.0	12	0.5		1
Trachycardium spp.	0.3	0.1	96	5.3	0.8	6	0.3	0.2	12	1.0	0.4	4

Mean = mean density (numbers/m^2); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.2.6 Moso Island 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 lecanora	8.3	3.9	24	50.0	0.0	4	8.3	5.9	4	16.7	8.3	2
Bohadschia argus	4.2	2.9	24	50.0	0.0	2	4.2	2.4	4	8.3	0.0	2
Bohadschia graeffei	4.2	2.9	24	50.0	0.0	2	4.2	4.2	4	16.7		1
Cypraea tigris	6.3	3.4	24	50.0	0.0	3	6.3	6.3	4	25.0		1
Echinometra mathaei	62.5	22.6	24	250.0	0.0	6	62.5	62.5	4	250.0		1
Echinothrix diadema	2.1	2.1	24	50.0		1	2.1	2.1	4	8.3		1
Heterocentrotus mammillatus	393.8	88.4	24	525.0	100.3	18	393.8	164.4	4	525.0	140.0	3
Holothuria atra	33.3	7.8	24	66.7	7.1	12	33.3	19.5	4	66.7	8.3	2
Pinctada margaritifera	2.1	2.1	24	50.0		1	2.1	2.1	4	8.3		1
Stichopus chloronotus	37.5	12.5	24	100.0	20.4	9	37.5	19.7	4	37.5	19.7	4
Tectus pyramis	8.3	5.8	24	100.0	0.0	2	8.3	8.3	4	33.3		1
Thelenota ananas	2.1	2.1	24	50.0		1	2.1	2.1	4	8.3		1
Tridacna crocea	8.3	4.9	24	66.7	16.7	3	8.3	4.8	4	16.7	0.0	2
Tridacna maxima	29.2	8.5	24	70.0	11.1	10	29.2	13.0	4	38.9	12.1	3
Trochus niloticus	2.1	2.1	24	50.0		1	2.1	2.1	4	8.3		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.2.7 Moso Island sea cucumber night search (Ns) assessment data review
Station: Six 5-min search periods/station.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga miliaris	33.3	15.4	12	100.0	19.2	4	33.3	0.0	2	33.3	0.0	2
Bohadschia vitiensis	5.6	5.6	12	66.7		1	5.6	5.6	2	11.1		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.2.8 Moso Island species size review – all survey methods

Species	Mean length (cm)	SE	n
Tridacna crocea	7.3	0.06	2770
Holothuria atra	11.74	0.3	385
Holothuria edulis	16.67	0.93	45
Stichopus chloronotus	13.24	1.31	43
Spondylus spp.	11.12	0.38	43
Spondylus squamosus	8.36	0.36	42
Tridacna maxima	17.41	1.25	29
Anadara antiquata	5.16	0.2	25
Bohadschia argus	30.23	1.7	23
Pitar proha	2.59	0.09	20
Pinctada margaritifera	14.57	1.34	14
Polinices spp.	1.92	0.11	13
Modiolus auriculatus	4.15	0.3	11
Hippopus hippopus	16.63	2.98	9
Conus spp.	6.55	0.88	8
Trachycardium spp.	2.69	0.34	8
Bohadschia vitiensis	32.9	5.84	6
Actinopyga lecanora	19	0.94	6
Actinopyga miliaris	15.6	0.86	6
Conus litteratus	5.1	0.95	6
Panulirus versicolor	5	0	6
Lambis lambis	9.4	2.91	5
Tectus pyramis	5.4	0.35	4
Bohadschia graeffei	28	0	3
Thelenota ananas	47.5	7.5	2
Nassarius spp.	8.2	0	2
Bohadschia similis	6	3	2
Conus flavidus	5.65	1.15	2
Strombus labiatus	3.2		2
Echinometra mathaei	8.5		37
Cypraea annulus	5.7		21
Cypraea tigris	5		4
Lambis truncata	20		2
Fragum unedo	3.2		2
Turbo chrysostomus	2.8		2
Holothuria fuscopunctata	40		1
Stichopus hermanni	35		1
Thelenota anax	35		1
Holothuria nobilis	25		1
Holothuria coluber	22		1
Hyotissa spp.	15		1
Trochus niloticus	13.5		1
Trochus spp.	4.5		1
Stichopus horrens	3		1
Gafrarium tumidum	2.8		1
Heterocentrotus mammillatus			262
Linckia laevigata			92
Culcita novaeguineae			14

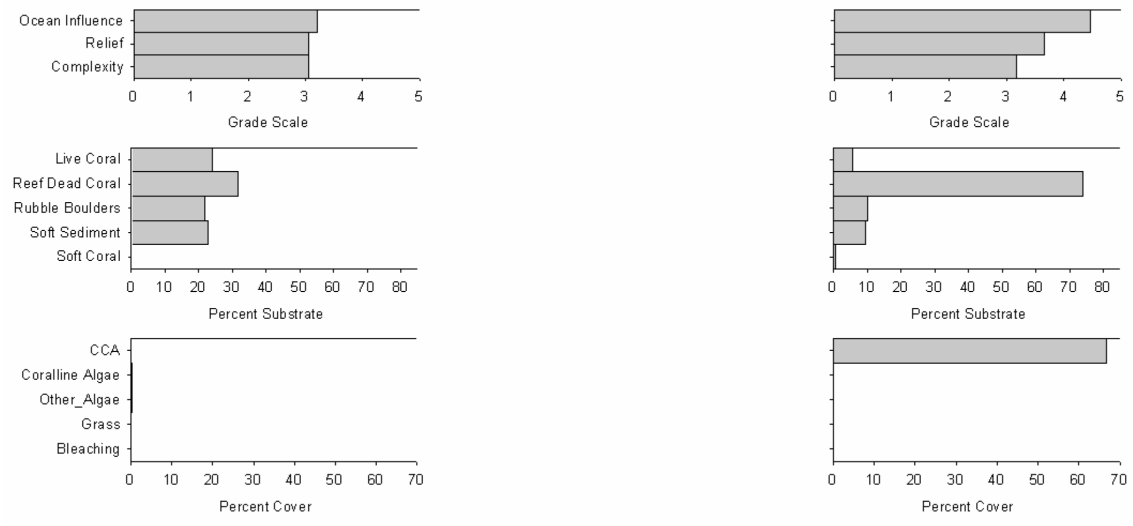
4.2.8 Moso Island species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Cassiopea andromeda			11
Synapta spp.			8
Atrina vexillum			6
Choriaster granulatus			6
Acanthaster planci			2
Archaster typicus			2
Diadema spp.			1
Echinothrix diadema			1
Octopus cyanea			1

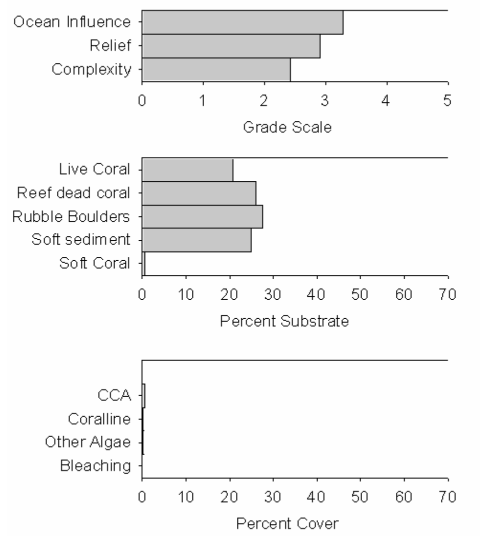
Appendix 4: Invertebrate survey data
Moso Island

4.2.9 Habitat descriptors for independent assessments – Moso Island

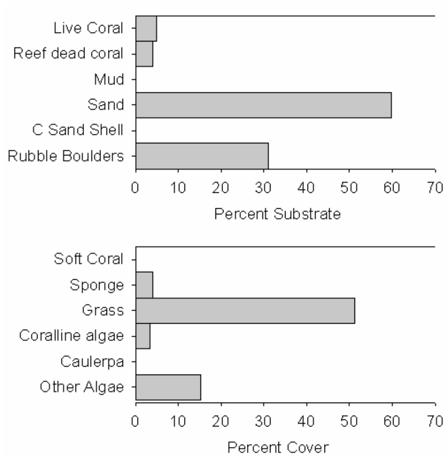
Broad-scale 'inner' and 'outer' assessments of habitat

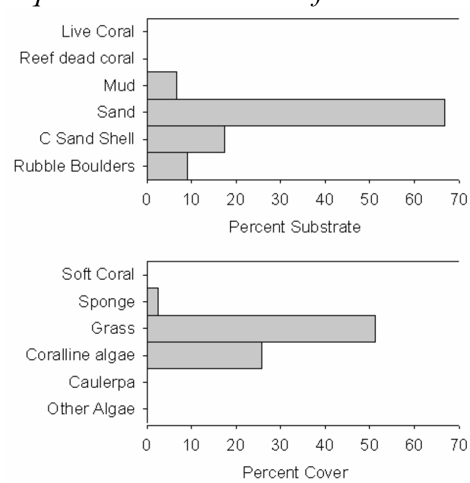


Reef-benthos assessment of habitat



Soft-benthos transects and soft-benthos quadrats assessment of habitat





Appendix 4: Invertebrate survey data
Moso Island

4.2.10 Moso Island catch assessment – creel survey – data review

Name	Mean length (cm)	SE	n total	n measured
Anadara spp.	5.4	0.1	114	98
Anemone	8.0	0.7	7	5
Asaphis spp.	5.2	0.1	48	48
Atrina spp.	17.5		3	2
Australium spp.	5.4	0.1	40	41
Calappa spp.	6.4	0.5	2	2
Cerithium spp.	8.8	0.3	2	2
Chiton			16	
Conus spp.	9.0	2.3	15	15
Cymatium spp.			1	
Cypraea annulus	1.0		35	1
Cypraea caputspensis	2.9	0.1	33	9
Cypraea mauritiana	6.8	0.2	8	8
Cypraea mauritiana	7.6	0.2	6	6
Cypraea moneta			23	
Cypraea spp.	9.4	2.4	37	35
Cypraea tigris	6.5		1	1
Dendropoma spp.	1.1		1	1
Donax & Atactodea spp.	5.2	0.3	96	9
Drupa spp.	3.2	0.6	10	6
Eriphia sebana	5.8	0.3	3	4
Gafrarium spp.	3.3	0.2	10	11
Grapsus spp.	5.0	0.1	28	28
Hippopus hippopus	32.2	15.3	15	9
Lambis lambis	11.3	0.9	9	9
Latirolagena spp.	3.1		1	1
Mangrove oyster			12	
Mangrove slug	9.9	0.6	7	7
Mitra spp.	8.7	1.3	2	2
Natica spp.			8	
Nerita spp.	10.5	1.4	464	43
Octopus spp.			1	
Ocypode spp.	3.6	0.0	3	3
Periglypta spp.	6.1	0.1	3	3
Pinctada margaritifera	9.6	1.8	3	3
Pinna spp.	11.1	1.2	3	3
Pitar spp.	3.1		1	1
Pleuroploca spp.	15.6		1	1
Scylla spp.	2.6		0	1
Spondylus spp.	7.9	0.3	14	14
Strombus gibberelus	3.7	0.1	59	9
Strombus luhuanus			2	3
Tridacna maxima	10.3	1.6	32	21
Tridacna crocea	6.8		27	11
Tridacna squamosa			2	
Tapes spp.	7.6	1.8	2	2
Tectus pyramis	5.2	0.1	9	9
Tellina scobinata	5.8		1	1

4.2.10 Moso Island catch assessment – creel survey – data review (continued)

Name	Mean length (cm)	SE	n total	n measured
Thais spp.	6.2	0.9	3	3
Thalamita spp.	5.0		1	1
Trochus maculatus	3.0		1	1
Turbo chrysostomus	4.5	0.1	11	11
Turbo spp.	6.0	0.2	24	19
Vasticardium spp.	3.6		3	1
Vasum spp.	4.9	0.4	14	14

4.2.11 Moso Island marine protected area: giant clam garden

Figure 4.2.11-1: The area in front of Tassiriki Primary School where *Hippopus hippopus* was amassed and protected (solid-line box). Tassiriki village is highlighted by the dashed-line box.

A giant clam garden in front of Tassiriki Primary School on Moso Island was set up some years ago by a reef owner from Tassiriki village. His main aim was to protect the disappearing *H. hippopus* population of the area. He started by collecting and buying from others to stock the garden. The garden measures about 50 m x 50 m of lagoon, between 1 to 3 m deep, and is marked by two buoys at both ends; it is a 'no take zone' for all fishing activities. The substrate is predominantly rubble (50%), with patches of sand, live coral and a few large rocks. The surrounding water is relatively clear with good visibility, and good water flow as compared to the Ringi Te Suh giant clam MPA in the Maskelyne Archipelago. During the PROCFish/C invertebrate surveys about 150-200 *H. hippopus* small and large adults (10 cm to 30 cm) and a few *Tridacna squamosa* were observed. A small number of *Tridacna crocea* were also present on the rocks and coral bomies.

The Vatumalulu MPA near the Tranquility Resort was implemented jointly between Tassiriki community and Resort owner Mr Owen Drew to protect *Tridacna crocea*. Stocks of *T. crocea* in the MPA were effectively protected from collection during the 1990s live giant clam collection for the aquarium trade. Obviously the MPA has good concentraton of *T. crocea* as observed by this survey as compared to areas outside.

4.3 Uri and Uripiv Islands invertebrate survey data

4.3.1 Invertebrate species recorded in different assessments in Uri and Uripiv Islands

Group	Species	Broad scale	Reef benthos	Others
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 vitiensis*	+		
Bêche-de-mer	*Holothuria atra*	+	+	
Bêche-de-mer	*Holothuria coluber*			+
Bêche-de-mer	*Holothuria edulis*	+	+	+
Bêche-de-mer	*Holothuria fuscopunctata*	+		
Bêche-de-mer	*Holothuria nobilis*	+		+
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*	+		
Bivalve	*Atrina* spp.	+		
Bivalve	*Chama* spp.	+	+	
Bivalve	*Hippopus hippopus*	+		
Bivalve	*Hyotissa* spp.	+		
Bivalve	*Pinctada margaritifera*	+		
Bivalve	*Spondylus* spp.	+	+	
Bivalve	*Tridacna crocea*	+		
Bivalve	*Tridacna maxima*	+	+	+
Bivalve	*Tridacna squamosa*	+	+	+
Cnidarian	*Cassiopea* spp.		+	
Cnidarian	*Stichodactyla* spp.	+	+	
Crustacean	*Panulirus* spp.	+		+
Gastropod	*Cerithium nodulosum*		+	
Gastropod	*Chicoreus ramosus*		+	
Gastropod	*Conus flavidus*		+	
Gastropod	*Conus geographus*		+	
Gastropod	*Conus miles*		+	
Gastropod	*Conus* spp.	+	+	
Gastropod	*Conus textile*		+	
Gastropod	*Cypraea caputserpensis*		+	
Gastropod	*Cypraea tigris*	+		
Gastropod	*Lambis lambis*		+	
Gastropod	*Latirolagena smaragdula*		+	
Gastropod	*Pleuroploca filamentosa*		+	
Gastropod	*Tectus pyramis*	+	+	+
Gastropod	*Thais kieneri*		+	
Gastropod	*Thais* spp.		+	
Gastropod	*Trochus maculata*		+	
Gastropod	*Trochus niloticus*	+	+	+

4.3.1 Invertebrate species recorded in different assessments in Uri and Uripiv Islands (continued)

Group	Species	Broad scale	Reef benthos	Others
Gastropod	*Turbo argyrostomus*		+	
Gastropod	*Turbo chrysostomus*		+	
Gastropod	*Turbo marmoratus*			+
Gastropod	*Vasum ceramicum*		+	
Gastropod	*Vasum* spp.		+	
Octopus	*Octopus cyanea*	+	+	
Star	*Acanthaster planci*	+		
Star	*Choriaster granulatus*		+	
Star	*Culcita novaeguineae*	+	+	+
Star	*Linckia laevigata*	+	+	
Star	*Nardoa* spp.	+	+	
Urchin	*Echinometra mathaei*	+	+	+
Urchin	*Echinothrix calamaris*		+	
Urchin	*Echinothrix diadema*	+	+	
Urchin	*Heterocentrotus mammillatus*		+	
Urchin	*Tripneustes gratilla*	+	+	

+ = presence of the species.

4.3.2 Uri and Uripiv Islands 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	0.9	0.7	72	33.1	16.5	2	0.9	0.9	12	11.0		1
Actinopyga mauritiana	4.0	1.6	72	29.2	7.9	10	4.0	2.4	12	16.2	5.6	3
Actinopyga miliaris	1.1	0.6	72	20.7	4.2	4	1.1	0.7	12	4.6	1.9	3
Atrina spp.	6.9	2.2	72	35.5	8.0	14	6.9	3.0	12	13.8	4.5	6
Bohadschia argus	7.1	1.8	72	28.3	4.1	18	7.1	2.5	12	14.1	2.6	6
Bohadschia graeffei	9.6	3.8	72	49.5	15.7	14	9.6	5.6	12	16.5	8.9	7
Bohadschia vitiensis	17.7	5.8	72	70.7	18.3	18	17.7	9.0	12	35.4	15.3	6
Chama spp.	0.5	0.3	72	16.5	0.2	2	0.5	0.5	12	5.5		1
Conus spp.	3.9	1.1	72	23.3	3.2	12	3.9	1.8	12	9.3	2.8	5
Culcita novaeguineae	26.3	4.5	72	51.1	6.6	37	26.3	8.9	12	31.5	9.9	10
Cypraea tigris	0.2	0.2	72	16.1		1	0.2	0.2	12	2.7		1
Echinometra mathaei	28.2	16.0	72	203.4	102.6	10	28.2	17.3	12	67.8	36.2	5
Echinothrix diadema	0.2	0.2	72	16.1		1	0.2	0.2	12	2.7		1
Hippopus hippopus	0.9	0.5	72	21.5	5.4	3	0.9	0.7	12	5.4	2.6	2
Holothuria atra	134.5	34.5	72	242.1	56.8	40	134.5	55.8	12	201.7	73.4	8
Holothuria edulis	6.4	1.7	72	28.8	4.1	16	6.4	2.9	12	9.6	3.9	8
Holothuria fuscopunctata	0.2	0.2	72	16.5		1	0.2	0.2	12	2.8		1
Holothuria nobilis	1.3	0.5	72	16.2	0.3	6	1.3	0.8	12	5.4	1.7	3
Hyotissa spp.	5.5	2.3	72	44.2	13.1	9	5.5	2.9	12	13.3	5.5	5
Linckia laevigata	15.1	3.5	72	41.8	7.1	26	15.1	5.9	12	20.1	7.1	9
Nardoa spp.	0.5	0.3	72	16.4	0.1	2	0.5	0.5	12	5.5		1
Octopus cyanea	0.2	0.2	72	16.6		1	0.2	0.2	12	2.8		1
Panulirus spp.	0.7	0.4	72	16.0	0.6	3	0.7	0.5	12	4.0	1.5	2
Pinctada margaritifera	1.4	0.5	72	16.4	0.1	6	1.4	0.8	12	5.5	1.6	3
Spondylus spp.	10.3	2.4	72	35.3	5.3	21	10.3	3.8	12	17.6	4.9	7
Stichodactyla spp.	1.6	1.0	72	38.2	14.4	3	1.6	1.4	12	9.5	6.8	2
Stichopus chloronotus	109.8	21.7	72	188.3	32.2	42	109.8	36.0	12	119.8	37.9	11
Stichopus hermanni	11.0	3.3	72	41.7	9.3	19	11.0	5.3	12	18.9	8.0	7

4.3.2 Uri and Uripiv Islands 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
Stichopus vastus	0.5	0.5	72	33.3		1	0.5	0.5	12	5.6		1
Synapta spp.	0.5	0.5	72	32.8		1	0.5	0.5	12	5.5		1
Tectus pyramis	0.2	0.2	72	16.6		1	0.2	0.2	12	2.8		1
Thelenota ananas	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna crocea	4.3	2.6	72	62.1	28.0	5	4.3	2.5	12	17.2	5.1	3
Tridacna maxima	13.9	3.0	72	34.5	5.6	29	13.9	4.6	12	20.8	5.4	8
Tridacna squamosa	1.4	1.2	72	50.0	33.4	2	1.4	1.2	12	8.3	5.6	2
Tripneustes gratilla	0.5	0.3	72	16.4	0.3	2	0.5	0.5	12	5.5		1
Trochus niloticus	1.5	1.0	72	36.1	12.3	3	1.5	1.0	12	9.0	0.8	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.3.3 Uri and Uripiv Islands 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	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Actinopyga mauritiana	30.6	15.2	90	392.9	142.9	7	30.6	16.5	15	76.4	34.7	6
Bohadschia argus	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Bohadschia graeffei	8.3	4.8	90	250.0	0.0	3	8.3	4.5	15	41.7	0.0	3
Cassiopea spp.	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Cerithium nodulosum	11.1	5.5	90	250.0	0.0	4	11.1	8.6	15	83.3	41.7	2
Chama spp.	22.2	14.6	90	500.0	250.0	4	22.2	14.0	15	83.3	41.7	4
Choriaster granulatus	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Conus flavidus	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Conus miles	52.8	15.5	90	365.4	53.8	13	52.8	22.8	15	113.1	38.3	7
Conus spp.	119.4	28.3	90	488.6	72.6	22	119.4	40.6	15	179.2	51.6	10
Conus textile	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Culcita novaeguineae	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Cypraea caputserpensis	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Echinometra mathaei	3994.4	464.7	90	5063.4	520.3	71	3994.4	1008.1	15	4279.8	1038.6	14
Echinothrix calamaris	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Echinothrix diadema	16.7	10.3	90	500.0	144.3	3	16.7	9.8	15	83.3	24.1	3
Heterocentrotus mammillatus	27.8	9.2	90	277.8	27.8	9	27.8	11.3	15	59.5	17.9	7
Holothuria atra	33.3	13.8	90	375.0	94.5	8	33.3	22.7	15	250.0	0.0	2
Holothuria edulis	16.7	6.6	90	250.0	0.0	6	16.7	12.1	15	125.0	41.7	2
Lambis lambis	36.1	12.8	90	361.1	60.5	9	36.1	20.3	15	108.3	48.6	5
Latirolagena smaragdula	88.9	24.1	90	571.4	66.4	14	88.9	37.7	15	222.2	63.3	6
Linckia laevigata	25.0	7.9	90	250.0	0.0	9	25.0	9.8	15	62.5	14.2	6
Nardoa spp.	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Octopus cyanea	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Pleuroploca filamentosa	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Spondylus spp.	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Stichodactyla spp.	50.0	16.4	90	450.0	62.4	10	50.0	18.3	15	107.1	25.5	7

4.3.3 Uri and Uripiv Islands 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
Stichopus chloronotus	852.8	132.3	90	1237.9	171.0	62	852.8	236.7	15	852.8	236.7	15
Tectus pyramis	16.7	6.6	90	250.0	0.0	6	16.7	6.8	15	50.0	8.3	5
Thais kieneri	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Thais spp.	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Tridacna maxima	241.7	35.2	90	505.8	48.1	43	241.7	41.9	15	241.7	41.9	15
Tridacna squamosa	5.6	3.9	90	250.0	0.0	2	5.6	3.8	15	41.7	0.0	2
Tripneustes gratilla	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Trochus maculata	16.7	7.7	90	300.0	50.0	5	16.7	6.8	15	50.0	8.3	5
Trochus niloticus	5.6	5.6	90	500.0		1	5.6	5.6	15	83.3		1
Turbo argyrostomus	136.1	34.2	90	612.5	96.8	20	136.1	61.2	15	408.3	107.4	5
Turbo chrysostomus	16.7	6.6	90	250.0	0.0	6	16.7	5.5	15	41.7	0.0	6
Vasum ceramicum	66.7	14.7	90	300.0	29.2	20	66.7	30.4	15	166.7	55.9	6
Vasum spp.	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.3.4 Uri and Uripiv Islands 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	29.2	14.4	12	87.5	23.9	4	29.2	29.2	2	58.3		1
Bohadschia graeffei	12.5	9.0	12	75.0	25.0	2	12.5	4.2	2	12.5	4.2	2
Holothuria edulis	8.3	5.6	12	50.0	0.0	2	8.3	0.0	2	8.3	0.0	2
Stichopus chloronotus	120.8	25.7	12	145.0	24.1	10	120.8	12.5	2	120.8	12.5	2
Tectus pyramis	8.3	5.6	12	50.0	0.0	2	8.3	0.0	2	8.3	0.0	2
Tridacna maxima	83.3	17.8	12	90.9	17.6	11	83.3	33.3	2	83.3	33.3	2
Tridacna squamosa	4.2	4.2	12	50.0		1	4.2	4.2	2	8.3		1
Trochus niloticus	4.2	4.2	12	50.0		1	4.2	4.2	2	8.3		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.3.5 Uri and Uripiv Islands mother-of-pearl transect (MOPt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	83.3	28.1	12	166.7	26.4	6	83.3	0.0	2	83.3	0.0	2
Bohadschia graeffei	52.1	24.1	12	156.3	31.3	4	52.1	52.1	2	104.2		1
Culcita novaeguineae	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Echinometra mathaei	20.8	20.8	12	250.0		1	20.8	20.8	2	41.7		1
Holothuria nobilis	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Panulirus spp.	31.3	22.4	12	187.5	62.5	2	31.3	10.4	2	31.3	10.4	2
Stichopus chloronotus	197.9	80.6	12	395.8	113.7	6	197.9	31.3	2	197.9	31.3	2
Tectus pyramis	125.0	30.8	12	166.7	29.5	9	125.0	20.8	2	125.0	20.8	2
Tridacna maxima	145.8	45.7	12	218.8	51.5	8	145.8	62.5	2	145.8	62.5	2
Tridacna squamosa	20.8	14.0	12	125.0	0.0	2	20.8	0.0	2	20.8	0.0	2
Trochus niloticus	52.1	35.9	12	312.5	62.5	2	52.1	52.1	2	104.2		1
Turbo marmoratus	72.9	32.5	12	175.0	50.0	5	72.9	10.4	2	72.9	10.4	2

4.3.6 Uri and Uripiv Islands sea cucumber night search (Ns) assessment data review

Station: Six 5-min search periods/station.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga miliaris	122.2	42.5	12	244.4	44.4	6	122.2	122.2	2	244.4		1
Bohadschia graeffei	5.6	5.6	12	66.7		1	5.6	5.6	2	11.1		1
Holothuria coluber	133.3	40.2	12	266.7	0.0	6	133.3	133.3	2	266.7		1
Stichopus hermanni	5.6	5.6	12	66.7		1	5.6	5.6	2	11.1		1
Stichopus horrens	5.6	5.6	12	66.7		1	5.6	5.6	2	11.1		1
Stichopus vastus	105.6	32.3	12	211.1	11.1	6	105.6	105.6	2	211.1		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.3.7 Uri and Uripiv Islands species size review – all survey methods

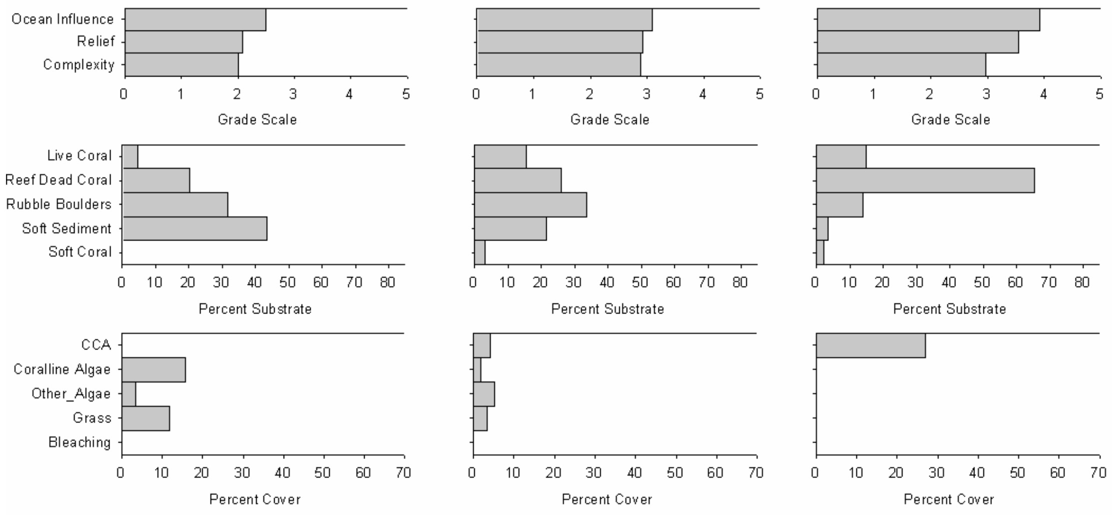
Species	Mean length (cm)	SE	n
Stichopus chloronotus	19.2	0.2	846
Holothuria atra	21.7	0.1	599
Tridacna maxima	13.6	0.4	182
Bohadschia vitiensis	30.1	0.5	78
Conus spp.	6.4	0.4	60
Bohadschia graeffei	33	0.8	54
Stichopus hermanni	37.7	0.8	49
Turbo argyrostomus	6.7	0.2	49
Actinopyga mauritiana	25.2	0.8	44
Holothuria edulis	19.5	0.6	36
Bohadschia argus	32.9	1.1	32
Actinopyga miliaris	18.8	0.7	27
Vasum ceramicum	5.6	0.4	24
Tectus pyramis	7.3	0.2	21
Tridacna crocea	12.3	0.6	19
Conus miles	4.2	0.1	19
Trochus niloticus	13.3	0.3	15
Lambis lambis	14.3	0.5	13
Tridacna squamosa	26.5	3	11
Holothuria nobilis	31.6	1	7
Turbo marmoratus	8.1	0.4	7
Panulirus spp.	25.6	0.2	6
Pinctada margaritifera	14	0.4	6
Turbo chrysostomus	3.9	0.2	6
Trochus maculata	3	0.3	6
Hippopus hippopus	26.5	3.9	4
Cerithium nodulosum	6.9	1.1	4
Tripneustes gratilla	7.7		3
Holothuria fuscopunctata	40		1
Thelenota ananas	40		1
Cassiopea spp.	28		1
Actinopyga lecanora	18		1
Chicoreus ramosus	9.1		1
Pleuroploca filamentosa	7.5		1
Thais spp.	4.8		1
Thais kieneri	4.5		1
Conus geographus	4		1
Conus textile	4		1
Conus flavidus	3.4		1
Echinometra mathaei			1565
Culcita novaeguineae			117
Linckia laevigata			75
Spondylus spp.			46
Latirolagena smaragdula			32
Atrina spp.			30
Stichodactyla spp.			25
Holothuria coluber			24
Hyotissa spp.			24

4.3.7 Uri and Uripiv Islands species size review – all survey methods (continued)

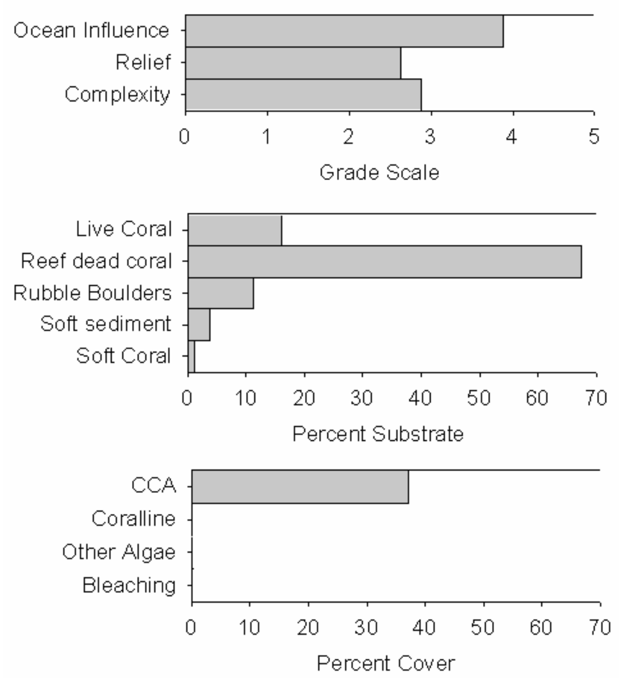
Stichopus vastus			21
Chama spp.			10
Heterocentrotus mammillatus			10
Echinothrix diadema			7
Acanthaster planci			4
Nardoa spp.			3
Octopus cyanea			2
Synapta spp.			2
Choriaster granulatus			1
Cypraea caputserpensis			1
Cypraea tigris			1
Echinothrix calamaris			1
Stichopus horrens			1
Vasum spp.			1

4.3.8 Habitat descriptors for independent assessments – Uri and Uripiv Islands

Broad-scale inner, middle and outer assessments of habitat



Reef-benthos assessment of habitat



4.2.10 Uri and Uripiv Islands catch assessment – creel survey – data review

Name	Mean length (cm)	SE	n total	n measured
Anodontid bivalve, 'Banu'	4.9	0.1	650	77
Asaphis violascens	5.9	0.1	144	122
Potamidid mud-whelks	8.2	0.3	769	20
Gafrarium spp.			9	
Acanthopleura gemmata, Chiton	6.7	0.3	58	12
Nerita undata			24	
Isognom spp., Hammer oyster	5.3	0.5	6	6
Thais spp.	3.8	0.2	21	11
Pitar prora, 'Dirong'	4.5	0.2	16	16

4.4 Maskelyne Archipelago invertebrate survey data

4.4.1 Invertebrate species recorded in different assessments in the Maskelyne Archipelago

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
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 flavomaculata*				+
Bêche-de-mer	*Holothuria fuscopunctata*	+			
Bêche-de-mer	*Holothuria hilla*			+	
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*	+			
Bivalve	*Anadara antiquata*			+	
Bivalve	*Anadara* spp.			+	
Bivalve	*Atrina* spp.	+		+	
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Modiolus* spp.			+	
Bivalve	*Periglypta puerpera*			+	
Bivalve	*Pinctada margaritifera*	+	+	+	
Bivalve	*Pinna* spp.			+	
Bivalve	*Pitar prora*			+	
Bivalve	*Spondylus* spp.	+	+		
Bivalve	*Tapes literatus*			+	
Bivalve	*Trachycardium* spp.			+	
Bivalve	*Tridacna crocea*	+			
Bivalve	*Tridacna maxima*	+	+	+	+
Bivalve	*Tridacna squamosa*		+	+	+
Cnidarian	*Cassiopea* spp.			+	
Cnidarian	*Stichodactyla* spp.	+	+	+	+
Crustacean	*Calappa hepatica*			+	
Crustacean	*Panulirus* spp.	+			
Gastropod	*Acanthopleura gemmata*			+	
Gastropod	*Cerithium nodulosum*		+		
Gastropod	*Conus leopardus*			+	
Gastropod	*Conus litteratus*			+	
Gastropod	*Conus marmoreus*			+	
Gastropod	*Conus miles*		+		+

4.4.1 Invertebrate species recorded in different assessments in the Maskelyne Archipelago (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Conus* spp.	+	+	+	+
Gastropod	*Cymatium* spp.			+	
Gastropod	*Cymbiola* spp.			+	
Gastropod	*Cypraea annulus*			+	
Gastropod	*Cypraea moneta*			+	
Gastropod	*Cypraea tigris*	+	+	+	
Gastropod	*Dolabella auricularia*			+	
Gastropod	*Drupella* spp.		+		
Gastropod	*Lambis lambis*		+	+	
Gastropod	*Lambis* spp.			+	
Gastropod	*Lambis truncata*	+			
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Nassarius* spp.			+	
Gastropod	*Pleuroploca filamentosa*		+		
Gastropod	*Strombus gibberulus gibbosus*			+	
Gastropod	*Strombus labiatus*			+	
Gastropod	*Strombus luhuanus*			+	
Gastropod	*Tectus pyramis*	+	+		+
Gastropod	*Trochus maculata*		+		+
Gastropod	*Trochus niloticus*	+	+	+	+
Gastropod	*Turbo argyrostomus*		+		+
Gastropod	*Turbo chrysostomus*		+		
Gastropod	*Vasum ceramicum*		+		+
Gastropod	*Vasum turbinellum*		+		
Octopus	*Octopus cyanea*		+		+
Star	*Acanthaster planci*		+		+
Star	*Archaster typicus*			+	
Star	*Culcita novaeguineae*	+	+	+	+
Star	*Linckia laevigata*	+	+	+	+
Urchin	*Echinometra mathaei*	+	+	+	+
Urchin	*Echinothrix diadema*		+		
Urchin	*Heterocentrotus mammillatus*	+			+
Urchin	*Tripneustes gratilla*		+	+	

+ = presence of the species.

4.4.2 Maskelyne Archipelago 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
Actinopyga lecanora	0.2	0.2	66	16.2		1	0.2	0.2	11	2.7		1
Actinopyga mauritiana	1.0	0.5	66	16.5	0.1	4	1.0	0.6	11	3.7	0.9	3
Actinopyga miliaris	0.2	0.2	66	16.3		1	0.2	0.2	11	2.7		1
Atrina spp.	0.7	0.6	66	24.5	8.4	2	0.7	0.7	11	8.2		1
Bohadschia argus	3.7	1.0	66	18.8	1.7	13	3.7	1.6	11	8.2	2.3	5
Bohadschia graeffei	9.1	2.4	66	31.7	5.9	19	9.1	4.8	11	16.7	7.7	6
Conus spp.	0.5	0.3	66	16.3	0.2	2	0.5	0.3	11	2.7	0.0	2
Culcita novaeguineae	2.2	0.8	66	18.5	2.1	8	2.2	0.8	11	4.1	0.9	6
Cypraea tigris	0.5	0.3	66	16.4	0.3	2	0.5	0.3	11	2.7	0.0	2
Echinometra mathaei	1.7	0.8	66	23.0	3.9	5	1.7	0.9	11	6.4	0.9	3
Heterocentrotus mammillatus	0.2	0.2	66	16.4		1	0.2	0.2	11	2.7		1
Hippopus hippopus	0.5	0.3	66	16.4	0.1	2	0.5	0.3	11	2.7	0.0	2
Holothuria atra	4.2	1.7	66	27.7	8.0	10	4.2	2.5	11	11.5	5.3	4
Holothuria coluber	2.0	1.1	66	43.6	5.5	3	2.0	2.0	11	21.8		1
Holothuria edulis	6.2	1.5	66	22.8	3.0	18	6.2	1.7	11	8.5	1.7	8
Holothuria fuscopunctata	0.5	0.4	66	16.5	0.0	2	0.5	0.5	11	5.5		1
Holothuria nobilis	2.0	0.8	66	18.8	2.4	7	2.0	0.9	11	5.5	1.1	4
Lambis lambis	0.5	0.5	66	32.7		1	0.5	0.5	11	5.4		1
Lambis truncata	0.2	0.2	66	16.1		1	0.2	0.2	11	2.7		1
Linckia laevigata	65.7	11.9	66	105.8	16.3	41	65.7	25.9	11	72.3	27.6	10
Panulirus spp.	0.5	0.3	66	16.4	0.0	2	0.5	0.3	11	2.7	0.0	2
Pinctada margaritifera	0.5	0.3	66	16.2	0.0	2	0.5	0.5	11	5.4		1
Spondylus spp.	2.2	0.9	66	20.9	3.0	7	2.2	1.0	11	6.1	0.7	4
Stichodactyla spp.	13.9	2.2	66	27.8	2.9	33	13.9	3.2	11	17.0	3.0	9
Stichopus chloronotus	5.2	1.8	66	34.4	6.7	10	5.2	2.5	11	8.2	3.4	7
Stichopus hermanni	6.7	1.8	66	27.5	4.1	16	6.7	3.2	11	9.2	4.0	8
Synapta spp.	2.4	1.2	66	40.4	4.6	4	2.4	2.4	11	26.9		1
Tectus pyramis	0.7	0.4	66	16.2	0.2	3	0.7	0.4	11	2.7	0.0	3

4.4.2 Maskelyne Archipelago 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
Thelenota ananas	2.1	0.8	66	19.7	3.5	7	2.1	0.9	11	4.6	1.3	5
Tridacna crocea	4.2	1.9	66	34.8	10.5	8	4.2	2.1	11	11.6	3.2	4
Tridacna maxima	9.9	2.2	66	28.5	4.1	23	9.9	3.2	11	12.1	3.5	9
Tridacna squamosa	0.2	0.2	66	16.3		1	0.2	0.2	11	2.7		1
Trochus niloticus	1.2	0.5	66	16.3	0.2	5	1.2	0.4	11	2.7	0.0	5

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.3 Maskelyne Archipelago reef-benthos transect (RBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	15.6	7.2	96	300.0	50.0	5	15.6	8.4	16	62.5	20.8	4
Actinopyga lecanora	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Actinopyga mauritiana	5.2	3.7	96	250.0	0.0	2	5.2	5.2	16	83.3		1
Actinopyga miliaris	31.3	11.3	96	333.3	58.9	9	31.3	20.3	16	166.7	72.2	3
Bohadschia argus	41.7	12.1	96	307.7	41.5	13	41.7	19.4	16	111.1	38.3	6
Cerithium nodulosum	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Conus miles	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Conus spp.	36.5	11.1	96	318.2	35.2	11	36.5	12.5	16	83.3	15.7	7
Coralliophila spp.	59.9	35.1	96	1916.7	300.5	3	59.9	59.9	16	958.3		1
Culcita novaeguineae	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Cypraea tigris	65.1	19.3	96	416.7	75.9	15	65.1	34.4	16	130.2	62.2	8
Echinometra mathaei	315.1	75.8	96	916.7	180.0	33	315.1	121.2	16	560.2	178.3	9
Echinothrix diadema	10.4	5.1	96	250.0	0.0	4	10.4	6.0	16	55.6	13.9	3
Hippopus hippopus	65.1	35.4	96	625.0	296.4	10	65.1	54.6	16	347.2	265.0	3
Holothuria atra	104.2	28.6	96	555.6	98.1	18	104.2	55.5	16	208.3	100.5	8
Holothuria coluber	830.7	278.6	96	6645.8	1359.7	12	830.7	673.9	16	3322.9	2514.4	4
Holothuria edulis	67.7	25.2	96	500.0	138.7	13	67.7	43.0	16	216.7	118.9	5
Holothuria nobilis	7.8	4.5	96	250.0	0.0	3	7.8	4.2	16	41.7	0.0	3
Holothuria scabra	197.9	121.3	96	3800.0	1813.8	5	197.9	145.3	16	1583.3	583.3	2
Lambis lambis	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Latirolagena smaragdula	7.8	7.8	96	750.0		1	7.8	7.8	16	125.0		1
Linckia laevigata	304.7	34.2	96	479.5	38.9	61	304.7	56.5	16	325.0	56.4	15
Octopus cyanea	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Pinctada margaritifera	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Pleuroploca filamentosa	7.8	5.8	96	375.0	125.0	2	7.8	5.7	16	62.5	20.8	2
Spondylus spp.	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Stichodactyla spp.	91.1	36.5	96	875.0	242.2	10	91.1	72.3	16	291.7	219.3	5
Stichopus chloronotus	91.1	29.2	96	625.0	130.4	14	91.1	48.7	16	208.3	97.5	7

4.4.3 Maskelyne Archipelago 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
Stichopus hermanni	13.0	5.7	96	250.0	0.0	5	13.0	7.3	16	69.4	13.9	3
Synapta spp.	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Tectus pyramis	7.8	5.8	96	375.0	125.0	2	7.8	7.8	16	125.0	!	1
Tridacna maxima	104.2	20.8	96	370.4	43.0	27	104.2	32.0	16	151.5	39.0	11
Tridacna squamosa	18.2	13.5	96	583.3	333.3	3	18.2	18.2	16	291.7		1
Tripneustes gratilla	10.4	5.1	96	250.0	0.0	4	10.4	10.4	16	166.7		1
Trochus maculata	23.4	8.3	96	281.3	31.3	8	23.4	8.5	16	62.5	9.3	6
Trochus niloticus	10.4	5.1	96	250.0	0.0	4	10.4	6.0	16	55.6	13.9	3
Turbo argyrostomus	5.2	3.7	96	250.0	0.0	2	5.2	3.6	16	41.7	0.0	2
Turbo chrysostomus	62.5	21.3	96	461.5	105.3	13	62.5	28.5	16	166.7	54.9	6
Vasum ceramicum	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1
Vasum turbinellum	2.6	2.6	96	250.0		1	2.6	2.6	16	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.4 Maskelyne Archipelago 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
Actinopyga mauritiana	20.4	5.1	12	30.6	4.1	8	20.4	7.4	2	20.4	7.4	2
Tridacna maxima	10.2	3.5	12	20.4	3.4	6	10.2	10.2	2	20.4		1
Trochus niloticus	34.3	7.3	12	34.3	7.3	12	34.3	12.0	2	34.3	12.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.5 Maskelyne Archipelago 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
Acanthopleura gemmata	4.0	4.0	126	500.0		1	4.0	4.0	21	83.3		1
Actinopyga miliaris	11.9	4.8	126	250.0	0.0	6	11.9	7.1	21	83.3	24.1	3
Anadara spp.	13.9	6.5	126	350.0	61.2	5	13.9	6.6	21	72.9	10.4	4
Archaster typicus	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Atrina spp.	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	41.7	0.0	2
Bohadschia similis	1125.0	196.1	126	3081.5	398.4	46	1125.0	444.2	21	2362.5	771.9	10
Bohadschia vitiensis	6.0	3.4	126	250.0	0.0	3	6.0	3.3	21	41.7	0.0	3
Cassiopea spp.	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Conus litteratus	15.9	6.8	126	333.3	52.7	6	15.9	9.7	21	111.1	36.7	3
Conus spp.	27.8	11.0	126	437.5	91.5	8	27.8	14.2	21	116.7	40.4	5
Cypraea annulus	430.6	114.5	126	1750.0	380.6	31	430.6	207.1	21	753.5	338.1	12
Cypraea tigris	19.8	7.8	126	357.1	50.5	7	19.8	9.4	21	83.3	22.8	5
Dolabella auricularia	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Holothuria atra	861.1	144.5	126	1550.0	229.3	70	861.1	318.3	21	1004.6	361.4	18
Holothuria coluber	27.8	15.7	126	700.0	278.4	5	27.8	15.0	21	116.7	46.4	5
Holothuria edulis	17.9	12.7	126	750.0	381.9	3	17.9	17.9	21	375.0		1
Holothuria nobilis	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Holothuria scabra	734.1	134.8	126	2202.4	295.4	42	734.1	305.2	21	1713.0	577.6	9
Lambis lambis	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	41.7	0.0	2
Lambis spp.	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Pinctada margaritifera	4.0	4.0	126	500.0		1	4.0	4.0	21	83.3		1
Pinna spp.	31.7	13.2	126	500.0	125.0	8	31.7	16.2	21	133.3	46.4	5
Pitar proha	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	41.7	0.0	2
Strombus gibberulus gibbosus	27.8	11.0	126	437.5	91.5	8	27.8	15.0	21	116.7	46.4	5
Strombus labiatus	6.0	3.4	126	250.0	0.0	3	6.0	4.3	21	62.5	20.8	2
Strombus luhuanus	7.9	3.9	126	250.0	0.0	4	7.9	4.7	21	55.6	13.9	3
Synapta spp.	23.8	6.6	126	250.0	0.0	12	23.8	11.0	21	100.0	25.0	5
Tripneustes gratilla	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Trochus niloticus	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.6 Maskelyne Archipelago soft-benthos quadrat (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	1.6	0.4	72	5.8	0.6	20	1.6	0.6	9	2.1	0.6	7
Archaster typicus	0.2	0.1	72	4.0	0.0	3	0.2	0.1	9	0.8	0.3	2
Bohadschia similis	0.4	0.1	72	4.0	0.0	8	0.4	0.2	9	1.0	0.2	4
Calappa hepatica	0.1	0.1	72	4.0		1	0.1	0.1	9	0.5		1
Conus leopardus	0.1	0.1	72	4.0		1	0.1	0.1	9	0.5		1
Conus litteratus	0.2	0.1	72	4.0	0.0	3	0.2	0.1	9	0.5	0.0	3
Conus marmoreus	0.1	0.1	72	4.0		1	0.1	0.1	9	0.5		1
Conus spp.	0.3	0.1	72	4.0	0.0	5	0.3	0.1	9	0.6	0.1	4
Cymatium spp.	0.5	0.2	72	5.1	1.1	7	0.5	0.3	9	1.1	0.4	4
Cymbiola spp.	0.1	0.1	72	4.0	0.0	2	0.1	0.1	9	1.0		1
Cypraea annulus	2.8	0.6	72	8.3	1.2	24	2.8	0.8	9	3.1	0.8	8
Cypraea moneta	0.3	0.1	72	4.0	0.0	5	0.3	0.2	9	0.8	0.3	3
Dolabella auricularia	0.1	0.1	72	4.0		1	0.1	0.1	9	0.5		1
Holothuria atra	0.5	0.2	72	4.5	0.5	8	0.5	0.2	9	0.9	0.3	5
Lambis lambis	0.1	0.1	72	4.0	0.0	2	0.1	0.1	9	0.5	0.0	2
Modiolus spp.	0.2	0.1	72	4.0	0.0	4	0.2	0.1	9	0.7	0.2	3
Nassarius spp.	0.1	0.1	72	4.0	0.0	2	0.1	0.1	9	1.0		1
Periglypta puerpera	0.1	0.1	72	4.0		1	0.1	0.1	9	0.5		1
Pinna spp.	0.1	0.1	72	4.0		1	0.1	0.1	9	0.5		1
Strombus gibberulus	0.1	0.1	72	4.0	0.0	2	0.1	0.1	9	0.5	0.0	2
Strombus labiatus	5.2	0.9	72	9.3	1.3	40	5.2	1.5	9	5.2	1.5	9
Tapes literatus	0.2	0.1	72	4.0	0.0	4	0.2	0.1	9	0.7	0.2	3
Trachycardium spp.	0.2	0.1	72	4.0	0.0	3	0.2	0.1	9	0.5	0.0	3
Tripneustes gratilla	0.1	0.1	72	4.0		1	0.1	0.1	9	0.5		1

Mean = mean density (numbers/m^2); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.7 Maskelyne Archipelago mother-of-pearl transect (MOPt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Actinopyga lecanora	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Actinopyga mauritiana	15.6	8.6	24	125.0	0.0	3	15.6	10.0	4	31.3	10.4	2
Conus miles	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Conus spp.	20.8	9.7	24	125.0	0.0	4	20.8	14.7	4	41.7	20.8	2
Culcita novaeguineae	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Echinometra mathaei	953.1	230.5	24	1525.0	278.2	15	953.1	396.4	4	1270.8	335.3	3
Heterocentrotus mammillatus	26.0	13.0	24	156.3	31.3	4	26.0	10.0	4	34.7	6.9	3
Holothuria nobilis	31.3	11.3	24	125.0	0.0	6	31.3	6.0	4	31.3	6.0	4
Linckia laevigata	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Octopus cyanea	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Stichodactyla spp.	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Tectus pyramis	67.7	16.8	24	147.7	15.2	11	67.7	17.8	4	67.7	17.8	4
Tridacna maxima	104.2	26.8	24	208.3	32.0	12	104.2	28.2	4	104.2	28.2	4
Tridacna squamosa	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Trochus maculata	10.4	10.4	24	250.0		1	10.4	10.4	4	41.7		1
Trochus niloticus	171.9	35.1	24	275.0	34.9	15	171.9	39.3	4	171.9	39.3	4
Turbo argyrostomus	78.1	36.7	24	208.3	83.3	9	78.1	39.3	4	78.1	39.3	4
Vasum ceramicum	10.4	10.4	24	250.0		1	10.4	10.4	4	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.8 Maskelyne Archipelago sea cucumber night search (Ns) assessment data review

Station: Six 5-min search periods/station.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga miliaris	411.1	79.5	12	448.5	76.9	11	411.1	233.3	2	411.1	233.3	2
Bohadschia similis	16.7	8.7	12	66.7	0.0	3	16.7	16.7	2	33.3		1
Holothuria coluber	33.3	15.4	12	100.0	19.2	4	33.3	11.1	2	33.3	11.1	2
Stichopus chloronotus	33.3	17.4	12	133.3	0.0	3	33.3	11.1	2	33.3	11.1	2
Stichopus hermanni	27.8	12.9	12	83.3	16.7	4	27.8	5.6	2	27.8	5.6	2
Stichopus horrens	16.7	8.7	12	66.7	0.0	3	16.7	5.6	2	16.7	5.6	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.9 Maskelyne Archipelago species size review – all survey methods

Species	Mean length (cm)	SE	n
Bohadschia similis	15.27	0.27	578
Holothuria atra	16.76	0.29	500
Holothuria scabra	19.3	0.28	446
Tridacna maxima	12.61	0.41	111
Strombus labiatus	2.76	0.16	96
Actinopyga miliaris	18.47	0.76	93
Trochus niloticus	11.05	0.4	80
Stichopus chloronotus	21.61	0.75	62
Holothuria edulis	18.94	0.57	60
Conus spp.	5.02	0.34	39
Cypraea tigris	6.85	0.18	37
Bohadschia graeffei	34.46	0.62	37
Stichopus hermanni	35.29	1.09	37
Bohadschia argus	25.5	1.12	31
Actinopyga mauritiana	21.03	1.45	31
Anadara antiquata	6.42	0.22	29
Hippopus hippopus	34.04	1.3	27
Turbo chrysostomus	3.6	0.16	24
Tectus pyramis	6.21	0.58	19
Holothuria nobilis	27.78	1.85	18
Turbo argyrostomus	6.48	0.45	17
Tridacna crocea	12.71	0.51	17
Strombus gibberulus gibbosus	3.32	0.15	16
Trochus maculata	3.66	0.36	11
Conus litteratus	6.85	0.58	11
Cymatium spp.	3.53	0.08	9
Tridacna squamosa	40.1	3.1	9
Thelenota ananas	39.88	1.86	8
Anadara spp.	6.27	0.41	7
Lambis lambis	15.62	1.16	7
Tripneustes gratilla	9.6	0.59	6
Pinctada margaritifera	14.8	0.96	6
Modiolus spp.	3.48	0.24	4
Tapes literatus	7.65	0.49	4
Conus miles	4.4	0.1	3
Trachycardium spp.	3.43	0.62	3
Pleuroploca filamentosa	8.87	0.9	3
Vasum ceramicum	5.33	1.59	3
Bohadschia vitiensis	16.33	2.95	3
Nassarius spp.	2.2	0	2
Pitar prora	4.25	0.25	2
Cymbiola spp.	4.8	0.3	2
Cerithium nodulosum	8.45	0.65	2
Holothuria fuscopunctata	34	6	2
Panulirus spp.	13.75	11.25	2
Stichodactyla spp.	2.5		92
Strombus luhuanus	5.8		4
Actinopyga lecanora	23		3

4.4.9 Maskelyne Archipelago species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Dolabella auricularia	13		2
Lambis spp.	10		1
Conus leopardus	7.5		1
Periglypta puerpera	6.2		1
Vasum turbinellum	5.5		1
Conus marmoreus	4.2		1
Linckia laevigata			383
Holothuria coluber			347
Echinometra mathaei			311
Cypraea annulus			267
Holothuria hilla			241
Synapta spp.			24
Drupella spp.			23
Pinna spp.			17
Culcita novaeguineae			12
Spondylus spp.			11
Acanthaster planci			7
Heterocentrotus mammillatus			6
Atrina spp.			5
Cypraea moneta			5
Archaster typicus			4
Echinothrix diadema			4
Holothuria flavomaculata			3
Stichopus horrens			3
Latirolagena smaragdula			3
Acanthopleura gemmata			2
Octopus cyanea			2
Cassiopea spp.			1
Calappa hepatica			1
Lambis truncata			1

4.4.10 Ringi Te Suh Marine Conservation Reserve – Maskelyne Archipelago

Two of the 16 fine-scale reef-benthos assessment stations were made within an MPA situated in front of Pellonk Village (12 transects, 40 m in length). Results from these assessments highlighted the abundance of giant clams in this sanctuary. Twenty four of the 25 *H. hippopus* (another two were recorded in the broad-scale assessment) and all the *T. squamosa* reef-benthos records originated from the MPA (*T. squamosa* also recorded in broad-scale and secondary assessments outside the MPA). Within the reserve the mean density for *H. hippopus* averaged 562.5 per ha (2 stations, 100%) whereas *T. squamosa* had a mean station density of 291.67 per ha (1 station, 50%). The horse hoof or bear paw clam *H. hippopus* is generally found at lower density than the smaller reef species and is commonly rare at sites experiencing high fishing pressure (Munro 1989). This species was well suited to the conditions found in the shallow lagoon in front of Pellonk where there was a mix of reef- and soft-benthos environments. The stock in this reserve represents a very high density for this species. Lightly exploited densities of *H. hippopus* have been reported at approx 30-90 ha (Hardy and Hardy 1969; Tarnawsky 1980), which is in line with the mean reef density at all Vanuatu stations (26.67 per ha). In Maskelyne Archipelago the reserve represents over 14 years of community protection and management.

Ministerial Conference on Environment and Development in Asia and the Pacific 2000

Kitakyushu, Japan 31 August - 5 September 2000
Source: www.unescap.org/mced2000/pacific/background/vanclam.htm

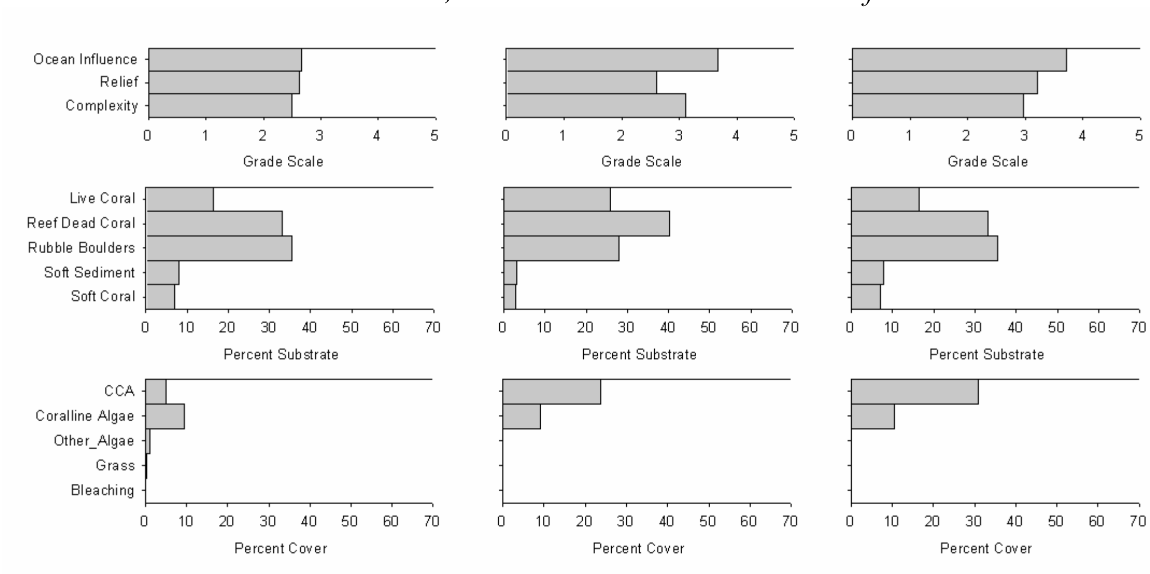
In 1991, Enrel Simon Bong Masang from Pellonk village on Uliveo Island in the Maskelynes Islands southeast of Malakula in Vanuatu went to Suva, Fiji to visit his daughter. He had been a fisher since he was a boy and knew very well that the fish, dugongs, turtles and giant clams around his island were vanishing. While he was in Suva he heard a radio program about how community giant clam sanctuaries were helping re-establish giant clams in parts of Tonga and Fiji where they had been fished out. When he returned to Vanuatu he stopped by the Vanuatu Fisheries department and asked for any information about giant clam sanctuaries. They gave him a booklet from the South Pacific Aguaculture Development Project Food and Agriculture Organization (FAO) entitled "12 steps to more giant clams" describing the experience of islanders in Vava'u, Tonga. He read it and began the process of setting up a giant clam sanctuary on the reef flat off their village.

They called the Sanctuary Ringi Te Suh Marine Conservation Reserve. Ringi Te Suh has two meanings; to leave something to multiply and to leave something alone. This fit well with Enrel' alarm at the steady decline of sea creatures on the coral reefs of the Meskelynes Islands. The giant clams, in particular, were vanishing rapidly. Two species, Tridacna gigas and Tridacna derasa had already become locally extinct. The bought over 500 giant clams from local fishers. These Hippopus hippopus and Tridacna squamosa were arranged in a reef area about one square kilometre in size and this was marked off using mangrove branches.

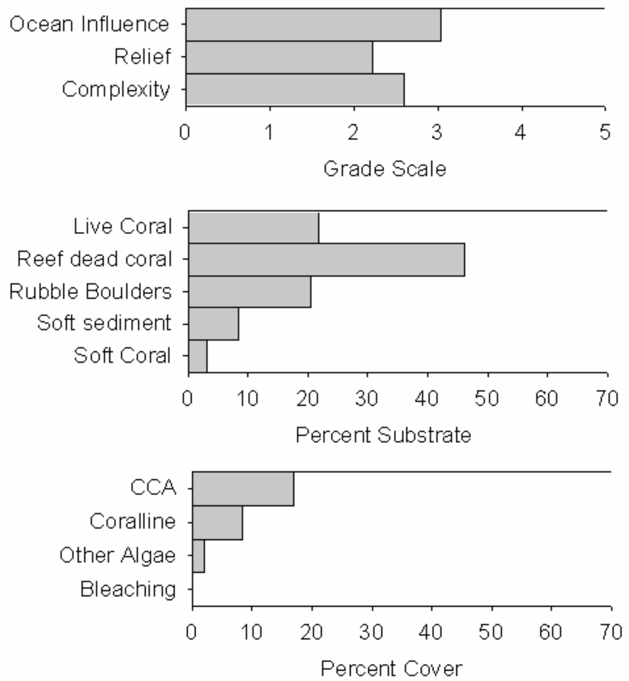
There was local opposition to closing off part of the reef, because some people did not want to restrict access to any part of the reef. To make matters worse, a national agency criticised the project because of the local opposition, and a biologist said the larval clams would all be carried away by currents, so it was not really going to do any good. No agency was willing to help fund the project. He wrote a letter to SPREP asking for assistance and never got a reply. In the end, however, Enrel and his friends and family overcame local objections and had formal community agreements drawn up and signed. Nobody stole the clams, and by 1998 there were over 1100 clams in the sanctuary; more than in any other community sanctuary in the Pacific

4.4.11 Habitat descriptors for independent assessments – Maskelyne Archipelago

Broad-scale inner, middle and outer assessments of habitat

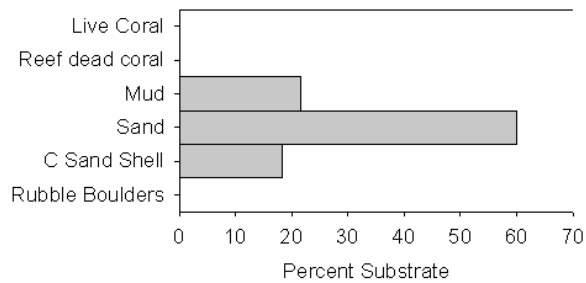


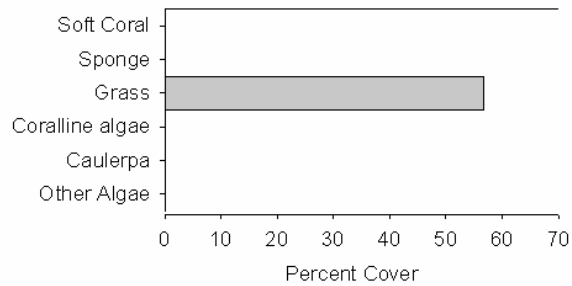
Reef-benthos assessment of habitat

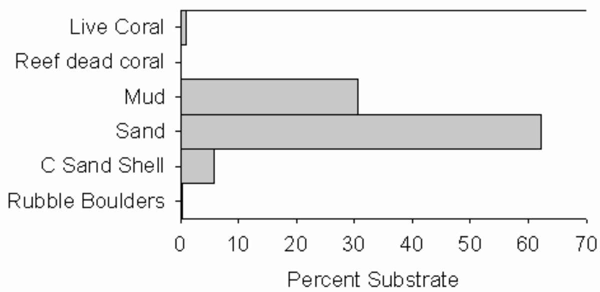


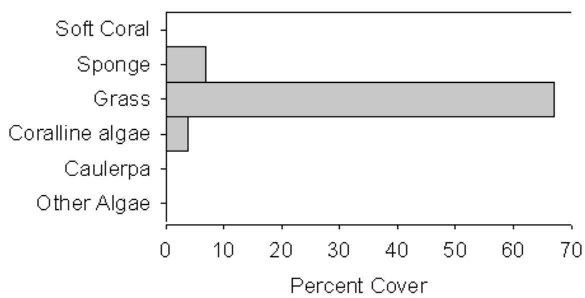
4.4.11 Habitat descriptors for independent assessments – Maskelyne Archipelago (continued)

Soft-benthos transects and soft-benthos quadrats assessment of habitat









4.4.12 Maskelyne Archipelago assessment – creel survey – data review

Species	Local name	Size range (cm)	n
Anadara spp.	Natuhot	4-9 cm	338
Acanthopleura	Nøtar	7-10 cm	3
Conus spp.	Naýideu	7-11 cm	21
Cypreae tigris	Nabøl	6-8 cm	11
Hippopus hippopus	Naholtav	8-14 cm	10
Lambis spp.	Naðulai, narivbuai	6-20 cm	130
Octopus spp.	Nahit	20-70 cm full length	18
Periglypta spp.	Natubur	6-8 cm	3
Pleuroploca spp.	Naþisos	10-13 cm	6
Polinices melanostoma	Nømasw	1.5-2 cm	6
Spondylus spp.	Nøpale	5-6 cm	2
Strombus lentiginosus	Natøtar loþulat	6 cm	1
Tridacna maxima	Nakontølai	4-16 cm	23
Vasum turbinellum	Nises barkobkob	6 cm	2

Data from catches collected by David and Sue Healey; fishers were followed and catches documented (using a digital camera and paper recordings). Data from >12 fishers collected after the closed season period 2005.

4.4.13 Maskelyne Archipelago review of catch from digital images with scale bar (using NIH image software for measurement of length (cm))

Genus	Species	Local name	Mean length (cm)	SE	n length	n total
Anadara	spp.	Natuhot	5.50	0.07	129	338
Lambis	spp. *lambis* & *crocata*	Naðulai, narivbuai	14.20	0.26	102	130
Conus	spp.	Naýideu	7.78	0.30	18	21
Cyprea	*tigris*	Nabøl	5.85	0.15	10	11
Hippopus	*hippopus*	Naholtav	11.03	3.70	5	10
Octopus	spp.	Nahit	12.18	0.66	4	18
Strombus	spp. *lentiginosus*	Natøtar loþulat	8.33	1.92	3	3
Polinices	spp.	Nømasw	2.30	0.29	2	6
Acanthopleura	spp.	Nøtar	6.15	0.28	2	3
Pinctada	*margaritifera*		5.50		1	1
Tridacna	*squamosa*		9.69		1	1
Pleuroploca	spp.	Naþisos	10.36		1	6
Vasum	*turbinellum*	Nises barkobkob				
Thais	spp.		5.25	0.29	2	2
Tridacna	*maxima*	Nakontølai				23
Periglypta	spp.	Natubur				3
Spondylus	spp.	Nøpale				2

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.

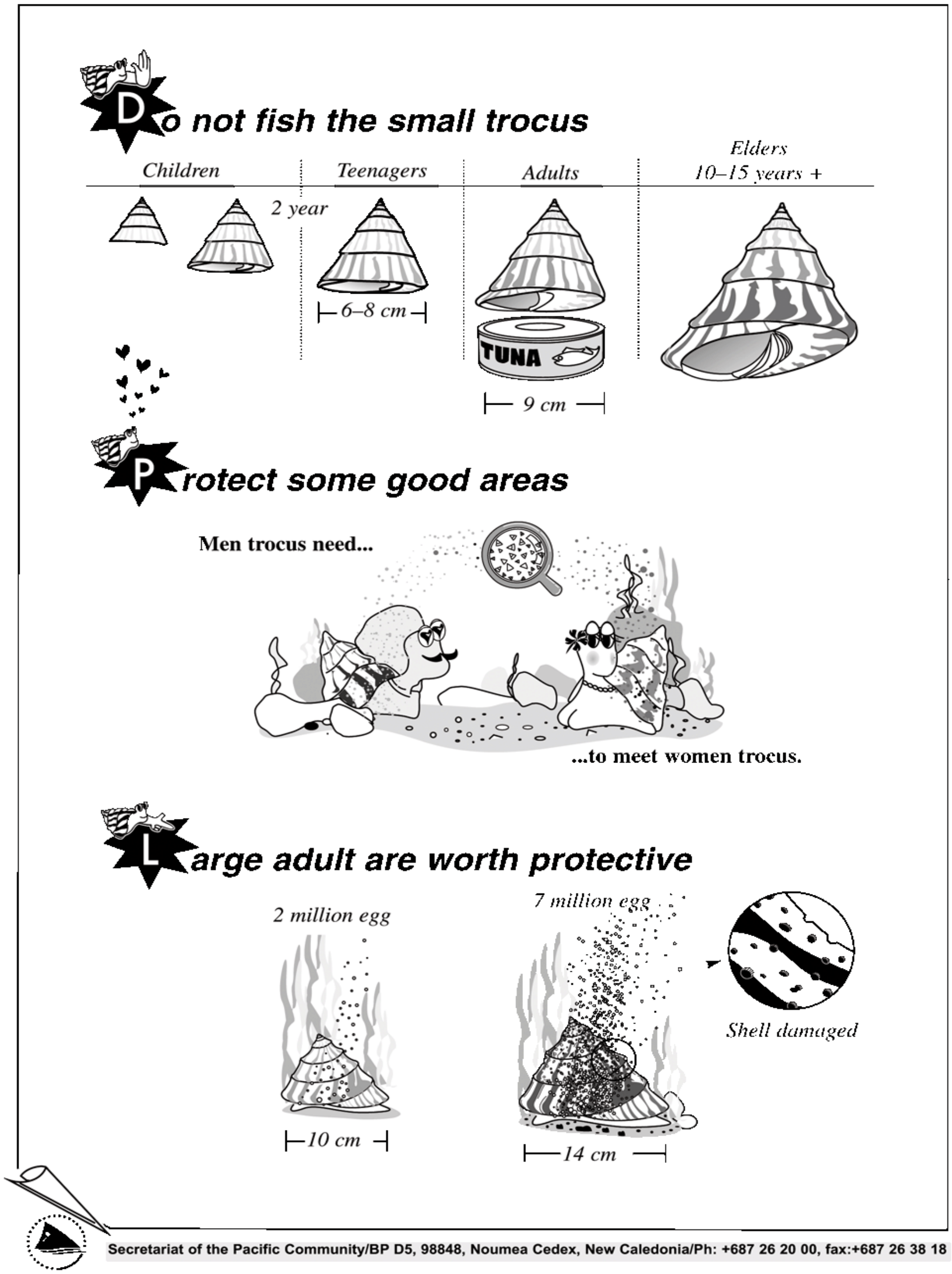


Figure 4.5.1-1: Small flyer made up for potential release with report.
Drawings prepared by Youngmi Choi in consultation with K. Friedman.

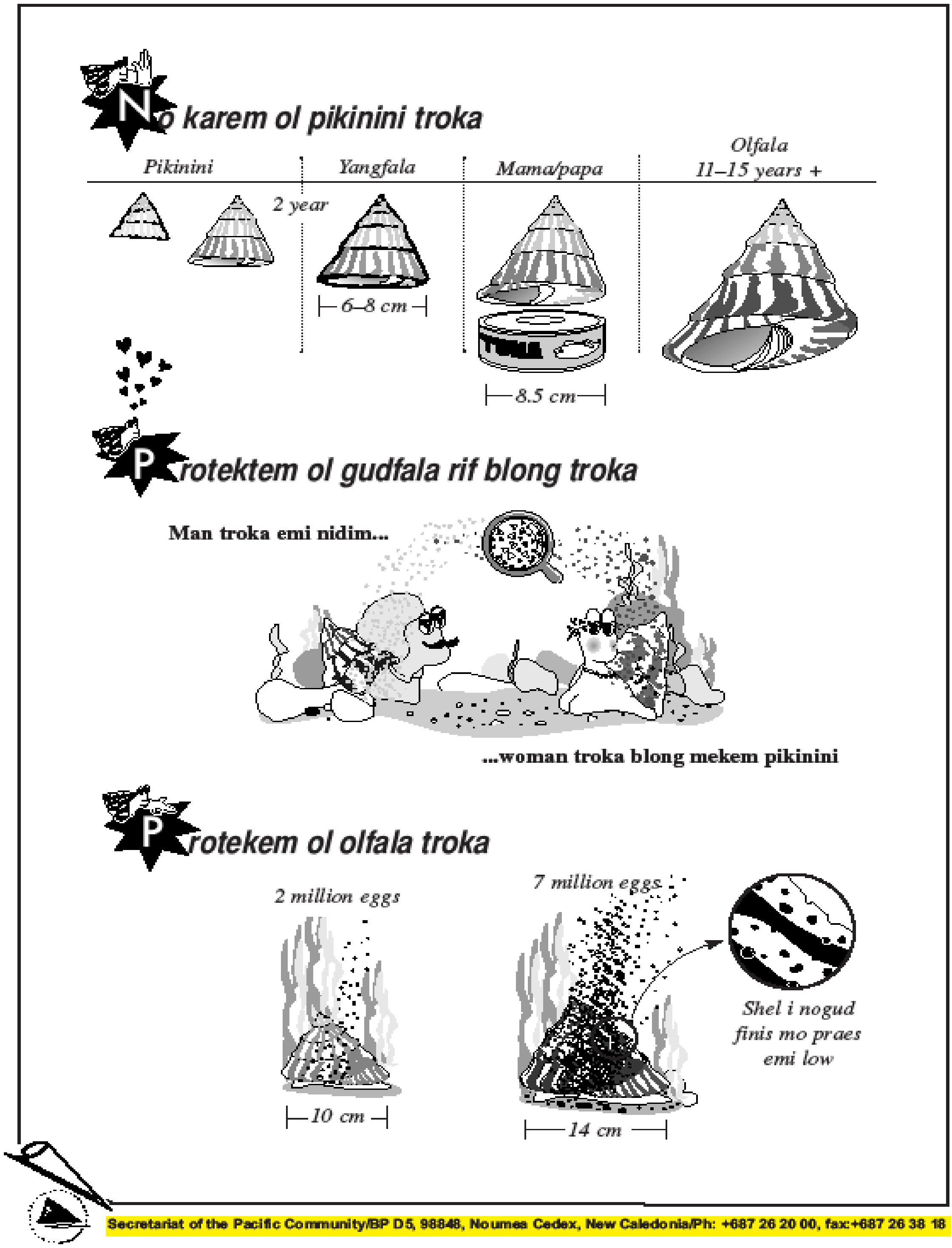


Figure 4.5.1-2: Small flyer made up for potential release with report.
Drawings prepared by Youngmi Choi in consultation with K. Friedman. Bishlama translation by K. Pakoa.

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.

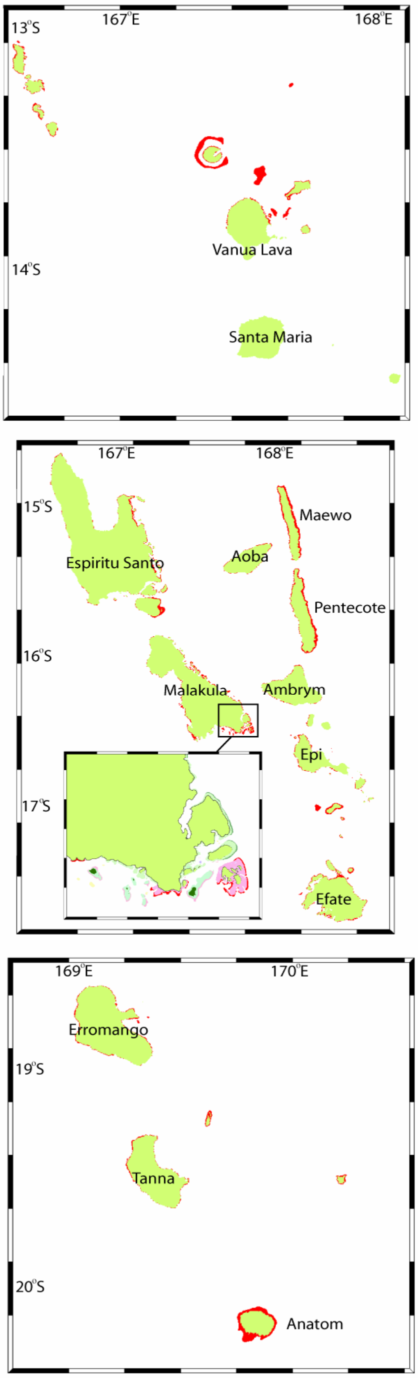
- **Codes of Practice:** Management can benefit significantly from education, training and dissemination of resource tools targeting all levels of the chain of custody as appropriate (e.g. local fishers, processors, buyers, middlemen, resource managers and owners, and enforcement officials), and focussing on:
  - sea cucumber identification;
  - best collection practices;
  - reporting provisions;
  - processing techniques; and
  - management approaches.

APPENDIX 5: MILLENIUM CORAL REEF MAPPING PROJECT, VANUATU

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 Vanuatu

(December 2006)



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 provide an exhaustive inventory of coral reefs worldwide using high-resolution multispectral satellite imagery (Landsat 7 images acquired between 1999 and 2002 at 30 meters resolution). Since mid-2003, the project is a partnership between Institut de Recherche Pour le Développement (IRD, France) and USF. The goal is to characterize, map and estimate the extent of shallow coral reef ecosystems in the main coral reef provinces (Caribbean-Atlantic, Pacific, Indo-Pacific, Red Sea). 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. We believe the data set generated by this research program will be critical for comparative geochemical, biological and geological studies. It provides a reliable, spatially well constrained data set for biogeochemical budgets, biodiversity assessment, reef structure comparisons, and management. It provides critical information for reef managers in terms of reef location, distribution and extent since this basic information is still of high priority for scientists and managers.

As part of this project, Vanuatu coral reefs are systematically mapped. The figure on the left shows the mapping status as in December 2006, with mapped reefs in red. The Malakula Island enlargement in the center panel suggests the level of detail that is achieved. Reefs are mapped at geomorphological level, the result of a compromise between richness of information and accuracy when no ground-truthing is available. As in December 2006, nearly 50 different geomorphological classes of reef types have been characterized and mapped for Vanuatu islands.

The PROCFish/Coastal project who is reporting in this document on Vanuatu fishery status has been using Millennium products in the last three years in all targeted countries in order to optimize sampling strategy, access reliable reef maps, and further help in fishery data interpretation. The level of mapping used by PROCFish/C is a thematically simplified version of the Millennium standard. PROCFish/C is using Millennium maps only for the calculation of reef-habitat surfaces surveyed by the project.

For further inquiries regarding the status of the coral reef mapping of Vanuatu and data availability (satellite images and Geographical Information Systems mapped products), please contact:

Dr Serge Andréfouët
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98848 New Caledonia;
E-mail: andrefou@noumea.ird.nc

For further information on the project: http://imars.marine.usf.edu/corals.

Reference: Andréfouët S, and 6 authors (2005), Global assessment of modern coral reef extent and diversity for regional science and management applications: a view from space. Proc 10th ICRS, Okinawa 2004, Japan: pp. 1732-1745.