PACIFIC REGIONAL OCEANIC AND

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(PROCFish/C/CoFish)

SAMOA COUNTRY REPORT:

PROFILES AND RESULTS FROM SURVEY WORK AT MANONO-UTA, SALELAVALU, VAILOA AND VAISALA

(June 2005 and August/September 2005)

by

Aliti Vunisea, Kim Friedman, Ribanataake Awira, Mecki Kronen, Silvia Pinca, Lindsay Chapman, Franck Magron, Samasoni Sauni, Kalo Pakoa, and Ferral Lasi

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

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EXECUTIVE SUMMARY

The coastal component of the Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) conducted fieldwork in four locations around Samoa in June 2005 and August/September 2005. Samoa 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 Samoa covered three disciplines (finfish, invertebrate and socioeconomic) in each site, with two sites surveyed on each trip by a team of five programme scientists and many local attachments from the Fisheries Department. The fieldwork included capacity building for the local counterparts through instruction on survey methodologies in all three disciplines, including the collection of data and inputting the data into the programme's database.

In Samoa, the four sites selected for the survey were Manono-uta, Salelavalu, Vailoa and Vaisala.

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 Samoa's Department of Fisheries.

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Results of fieldwork at Manono-uta

The two villages of Manono-uta (on the Upolu mainland) and Manono-tai (island) were combined for the purposes of this survey, as inhabitants of these two villages belong to the same clan, sharing fishing rights and access to the same fishing areas. Manono-uta is a village of 1997 people and 146 households. The local population resides along the immediate coastal area, about 2 km long. With approximately the same ratio of males to females, the village population represents a substantial 28% of the whole district of Aiga I Le Tai. Manono-tai is an island located a little over 4 km NW of Manono-uta and Upolu mainland and is connected by A'ana reefal platform. This particular reef habitat appears to be the largest and provides the most important inshore fishery in Samoa. There are several settlements or minor sub-villages on the island with separate communal arrangements.

Socioeconomics: Manono-uta

Manono-uta's population is highly dependent on marine resources for home consumption as well as to generate income. Consumption of fresh fish is high (79.4 kg/person/year); invertebrates are consumed to a much lesser extent (4 kg/person/year). Traditional gender roles continue, with males much more involved in finfish fisheries and females mainly focusing on collecting invertebrates, both gender groups are organised in fishing and marketing groups. Finfish are mainly sourced from the lagoon and outer reef areas. Due to the highly organised fishing networks, boat transport is provided by middle sellers, and/or fish buyers. The outer reef and passages are fished for commercial purposes, while lagoon fishing is mainly subsistence-oriented. Gillnetting is the main method used in the lagoon, and spear fishing at the outer-reef.

The total annual invertebrate catch is mainly of bêche-de-mer, followed by giant clams. This situation gives cause for concern, especially since there is a nationwide ban on bêche-de-mer fishing, and giant clams stocks are recognised to be in decline. While 65% of all invertebrate catches are used for home consumption, 35% are sold either at the roadside or on the nearby Apia market.

Finfish resources: Manono-uta

Overall, finfish resources in Manono-uta appeared to be in good condition**,** with the second highest biomass and highest size ratio of fish among the four sampled sites. The richest conditions were found in the outer and back-reefs. The outer reefs displayed the highest values for the main biological indicators (density, biomass, size and biodiversity, this last particularly high), followed by healthy back-reefs, with high values for density, size and biomass. Back-reefs showed also the highest live coral percentage cover among all habitats. However, Manono-uta has the highest percentage of people involved in fishing for both food and income. Moreover, the market in Apia is close and easily accessible. Consequently, the fishing pressure is rather high and visible, especially in the lagoon and coastal reefs. First signs of impacts are evident as decreased stocks of Acanthuridae and Scaridae in the coastal and lagoon habitats.

Invertebrate resources: Manono-uta

Present densities of giant clams are so low that they have reached a 'critical threshold' where reproductive success and subsequent recruitment is severely impaired. The presence, density and size range of clams indicate that the resource is degraded. Fishing pressure was the most likely cause for the low density of *T. maxima* and rarity of *T. squamosa* at Manono-uta.

There is a limited range of sea cucumber species available for commercial fishing; stocks are patchy and *Stichopus horrens* (*sea*) was not generally abundant at suitable fishing areas in the lagoon. Some potential exists for the commercial fishing of brown sandfish (*Bohadschia vitiensis*), and greenfish (*Stichopus chloronotus*) but, before a management plan can be developed for such a fishery, more comprehensive results from Samoa will be needed (A follow-up study has been arranged in collaboration with Uppsala University to sample further sites across Upolu and Savai'i, see Friedman *et al.* 2006.). The presence of high-value teatfish and other deep-water stocks are of interest for commercialisation, but stocks look to be insufficient to support regular fishing.

Recommendations for Manono-uta

Based on the survey work undertaken and the assessments made, the following recommendations are made for Manono-uta:

- A community fisheries management programme and the necessary bylaws to protect the community's reef and lagoon resources from further overfishing and to sustain their fisheries for future use be implemented by the Manono-uta community, in close cooperation with the Council of Elders, the pastors, and male and female fishers.

- Marine protected areas be considered as a primary management tool. Measures should be put in place to regulate commercial finfish fishing and these should be accompanied by regular monitoring to ensure that finfish resources remain available for subsistence use by future generations.

- SCUBA diving at night on the outer reef and net fishing in the much poorer coastal and lagoon reefs be regulated to reduce the heavy impact on reef resources.

- Immediate action be taken to protect giant clams in the lagoon and reintroduce clams to areas which have been cleared completely to prevent further decline of these critically depleted stocks.

- The position of the stockpile of *Tridacna derasa*, close to the island of Manono is not optimal, and mortalities seen at this site are likely a result of environmental stresses. At this shallow-water location, boats were moored above the clams and wave movement was too severe. If security issues allow, these clams should be moved to deeper water (2–4 m), in areas which are subject to moderate current and more oceanic influence.

- Some potential exists for the commercial fishing of brown sandfish (*Bohadschia vitiensis*) and greenfish (*Stichopus chloronotus*) but, before a management plan can be developed for such a fishery, more comprehensive results from Samoa will be needed.

- Crown of thorn starfish (COTS) were present in Manono. The population of COTS should be closely monitored by measuring size and abundance of these starfish and the scars they make on coral when feeding, to forewarn of an outbreak.

- Any consideration for future releases of trochus may consider initially placing transplanted shells on reefs within the lagoon, or on the more protected northern sections of the barrier reef, where epiphytic growth (and potential food sources for trochus) is more developed but crustose coralline algae is still present.

Results of fieldwork at Salelavalu

The surveys concentrated mainly in the sea areas adjacent to Salelavalu. Generally, Salelavalu is further divided into two main areas: Salelavalu-uta, with a population of 571, and Salelavalu-tai with a population of 338 people. The reef boundaries adopted during resource surveys stretched from the borders between Saleiloaga and Salelavalu all the way to Lalomalava. Due to the fact that Salelavalu is close to Salelologa (one of the largest reef areas in Samoa, with a complex structure, habitat diversity and high coral cover), the coral reefs around the Salelavalu area also enjoy a high level of nutrients, supplied by the Apolima Strait upwelling.

Socioeconomics: Salelavalu

Due to its close proximity to Saleloga, Savaii's major urban centre, and also the regular ferry transport services to Apia on mainland Upolu, the Salelavalu community relies heavily on fishing for first or second income and is highly dependent on remittances to meet its many traditional and religious obligations. Additionally, income from agricultural produce and salaries is also very important. The Salelavalu community has not yet participated in the national community-based fisheries management programme, and thus only a few village rules and regulations are in place.

Consumption of fresh fish (58 kg/person/year) is lower than the average across the four sites surveyed (61 kg/person/year), but the consumption of invertebrates is much higher (13.4 kg/person/year compared to the average 9.6 kg). Consumption and income patterns both suggest a traditional and remote rural lifestyle that benefits from commercial activities due to access to nearby urban markets. Gender roles also confirm a very traditional lifestyle, with females basically responsible for household chores, while males are the main finfish fishers. Females mainly collect invertebrates; they never dive, and mostly focus on gleaning mangroves and harvesting *sea* (bêche-de-mer). Finfish are mainly caught in the easily accessible habitats due to the limited numbers of boats. A wide range of techniques are used; gillnets are used more than average. Bêche-de-mer and giant clams are the major invertebrate resources targeted for both subsistence and commercial purposes. Indicators of fishing pressure calculated for finfish and invertebrate fisheries suggest that, due to the reef and overall fishing ground area, fisher densities and average annual catch rates, as well as catches per unit area, are moderate to high.

Finfish resources: Salelavalu

Finfish resources in Salelavalu appeared to be in poor condition**,** with the lowest mean values of density, biomass, sizes, size ratios and numbers of fish among the four sampled sites. The poorest conditions were found in the coastal and lagoon reefs, where most fishing is concentrated. The signs of impacts from fishing are seen in the decreased stocks of Scaridae, Acanthuridae and Mullidae, as well as all carnivore species, especially in the coastal habitats. The fish community was largely dominated by herbivores. This is another sign of weakening of the fish assemblage. Mean fish sizes in Salelavalu were below 50% of known maximum values for most commercial families, and the smallest of all the survey sites, which indicates a more depleted resource. Total fish density and biomass in Salelavalu were the lowest among the four sites surveyed in Samoa.

Invertebrate resources: Salelavalu

The presence, density and size range of giant clams in Salelavalu indicate that the resource is degraded, most probably due to fishing pressure. Present densities are so low that they have passed the 'critical threshold' where reproductive success and subsequent recruitment is severely impaired. Stocks are likely to decline if action is not taken to protect and re-introduce clams. In terms of environmental conditions, *Tridacna derasa* (a giant clam species introduced at other PROCFish sites) would be better suited to Salelavalu, which has an extensive lagoon system with suitable reef habitat.

Mother-of-pearl stocks, *Trochus niloticus* and *Pinctada margaritifera*, were absent from Salelavalu, whilst *Tectus pyramis*, a species with a similar life history to trochus, was only found at low-to-medium density. Reefs in Salelavalu are suitable for trochus, although there is little habitat for adult trochus on the ocean side of the reef, as it drops off steeply onto a sandy bottom.

There is a limited number of sea cucumber species available for commercial fishing, stocks are patchy and *Stichopus horrens* (*sea*) is under significant fishing pressure at suitable fishing locations. Some potential exists for commercially fishing greenfish (*Stichopus chloronotus*) but, before a management plan can be developed for such a fishery, more comprehensive results from Samoa will be needed. The presence of high-value teatfish and other deep-water stocks are of interest for commercialisation, but stocks in this section of Savaii are insufficient to support fishing at present.

Recommendations for Salelavalu

Based on the survey work undertaken and the assessments made, the following recommendations are made for Salelavalu:

- Salelavalu should delay no further in participating in the national community-based fisheries management programme. A community management scheme should be set up in cooperation between the five villages and the Fisheries Department, with additional help from non-governmental organisations if possible. Traditional village or community leadership and social institutions are still well defined and respected in Salelavalu and will therefore serve well to effectively develop a community fisheries management programme. Certain reef and lagoon areas could be identified and declared as marine protected areas to allow stocks to recover because of the large size of the community's reef and lagoon resources.

- New marine resource management measures for finfish and invertebrate resources need to be put in place. Commercial fishing needs to be regulated and a monitoring programme established to ensure that resources remain available for subsistence use by future generations.

- The use of SCUBA for spear diving and spear fishing activities undertaken at night may need to be restricted. The use of gillnets may need to be regulated. Instead, handlining, rod-fishing and deep-water line fishing, which are still of minor impact, should be encouraged.

- Urgent action is needed to protect declining giant clam stocks and re-introduce new stocks. The giant clam *Tridacna derasa* (which has been introduced to other PROCFish sites) should be introduced to Salelavalu, which has an extensive lagoon system with suitable reef habitat and better environmental conditions than the other sites.

- Some potential exists for commercially fishing greenfish (*Stichopus chloronotus*) but, before a management plan can be developed for such a fishery, more comprehensive results from Samoa are needed.

- Crown of thorns starfish (COTS) were present in Salelavalu and their deleterious effect on live coral was noticeable in some locations. The population of COTS should be closely managed by encouraging the removal of individuals, and their size and abundance need to be closely monitored to forewarn of an outbreak.

Results of fieldwork at Vailoa

Vailoa is part of the Aleipata District, about 60 km southeast of Apia. Southern Aleipata consists of a narrow coastal plain backed by volcanic slopes and cliffs, with two offshore islands, Nu'utele and Nu'ulua. Nu'utele Island is a sanctuary for birds, where fishing is prohibited; it has a narrow fringing reef to the north, and a very steep reef slope with high coral cover dropping off to a sand/rubble bottom at about 27 m (Zann 1989). The inner lagoon is mainly of fine sand, dominated by seagrass communities with mixed coral assemblages around Lolamanu.

Resource surveys concentrated mainly in the sea areas adjacent to Vailoa, Ulutogia and Satitoa villages on the eastern side of Upolu Island. Vailoa (population: 335; households: 36) and Ulutogia (population: 194; households: 21) villages are in the District of Aleipata Itupa I Luga, while Satitoa village (population: 520; households: 71) is located in Aleipata Itupa I Lalo District (Statistical Services Division 2001). The community is well aware of the necessity to maintain their marine resources for long-term benefit and is considered as having one of the best community-based management projects in place. Several no-fishing areas and an important coral reef fishing reserve opposite Vailoa village have been established, monitored and respected over the past six years.

Socioeconomics: Vailoa

Vailoa's population is very dependent upon their marine resources for home consumption, but to a lesser degree for income generation. The distance to the urban market of Apia hinders regular and larger-scale marketing of fisheries produce. About 60% of all finfish catches and about 70% of all invertebrate catches serve the community's own subsistence needs. Remittances are as important as the community's own cash-earning activities, and handicrafts, as well as small private businesses, are important.

Fresh-fish consumption (47.7 kg/person/year) is moderate and that of invertebrates rather low (8.52 kg/person/year). Both figures are lower than the average across all four sites surveyed in Samoa. However, the amount of canned fish consumed is large (28.3 kg/person/year), which may be explained by the frequent use of canned fish for *falavelave* (traditional and religious obligations, e.g. weddings, funerals). Consumption and income patterns both suggest that Vailoa's people still enjoy a rather traditional lifestyle. Men are mainly responsible for finfish fishing, while women are the main collectors of invertebrates, including bêche-de-mer, which they sell on a small scale. Finfish is mainly sourced from the lagoon and sheltered coastal reef, due to the limited access to boats, especially motorised boats. Consequently, only the closest passages and outer reefs are fished when male fishers venture further out. CPUEs are low, ~1.5 kg fish/hour of fishing trip (2 kg/hour at the outer reef). Average fish sizes are small (25 cm), and finfish fisher densities and catch rates are moderate.

Finfish resources: Vailoa

The finfish resources in the reefs surveyed in Vailoa-Aleipata appeared to be generally healthy, with a high abundance of fish, and species diversity, especially biomass, displaying higher values compared to the other sites. However, reef fish resources were healthier in the outer-reef slope and offshore-island habitats, while resources in the reef shallows and lagoon were poor. The outer reefs showed the highest fish density, particularly of Acanthuridae. Nu'utele Island is a sanctuary for birds, where fishing is prohibited. With a narrow fringing reef that drops off to over 1000 m depth, fish resources are still in good abundance in the outer-reef slope. In particular, diversity, abundance and biomass were very high on the rarely fished offshore islands; comparatively high on the moderately fished reef slopes of the main island; and low on the heavily fished reef shallows and lagoon. This indicates that the deeper reef slopes act as a population reservoir for the heavily fished lagoons. No differences were observed between fish resources inside and outside of the MPAs adjacent to the villages of Vaiola, Ulutogia and Satitoa, probably due to the fact that there was poor policing of the marine protected areas (MPAs) (Fishing activities were observed during the time of surveys.).

Coral cover was generally good (15–24%), mainly at the outer-reef crest (0–5 m) and back-reef behind the breakers. Also, good coral cover was recorded along the sheltered coastal reef (within 15 m of the shore) of Lalomanu, Vailoa and Ulutogia villages. Massive and sub-massive *Porites* corals were predominant in reef areas close to shore while branching and tabulate *Acropora* corals dominated coral cover at the back-reef. Coral cover mid-lagoon was low and the substrate there was mainly composed of fine sand.

Invertebrate resources: Vailoa

The density and size range of giant clams in Vailoa indicate that the clam resource is degraded, most probably due to fishing pressure, as the conditions within the lagoon and offshore reefs were suitable for clams. Only *Tridacna maxima* was found to occur naturally; *Hippopus hippopus* is already extinct and *T. squamosa* was not detected in this survey[3]. It is encouraging to note that the *T. derasa* translocated to the MPA are still showing recruitment and are nearing a mature size at which they can hopefully produce second-generation stock.

The introduction of *Trochus niloticus*, the commercial topshell, into Vailoa has not been successful. Presence and recruitment of *Tectus pyramis* was poor to moderate, but habitat was available for grazing gastropods and recruitment was occurring. The blacklip pearl oyster, *Pinctada margaritifera*, is considered overfished. The general scarcity of these three mother-

[3] Can be seen as being 'commercially extinct'– refering to a scarcity such that collection is not possible to service commercial or subsistence fishing, but species is or may still be present at very low densities.

of-pearl species is considered a result of poor release strategies for the introduction of trochus, the limited reef area available, and overfishing.

There is a limited number of sea cucumber species available for commercial fishing, stocks are patchy and the regularly fished *Stichopus horrens* (*sea*) is currently at low densities in comparison to other areas of the Pacific. The presence of high-value teatfish and other deep-water sea cucumber stocks is of interest for commercialisation, but habitat and stocks are insufficient to support a regular fishery.

Recommendations for Vailoa

Based on the survey work undertaken and the assessments made, the following recommendations are made for Vailoa:

- Risk zones, i.e. areas within Vailoa's fishing ground that are potentially the most vulnerable to over-harvesting, need to be mapped to complement current management practices, and indicators found to assist in monitoring resources and determining which invertebrates and finfish species need closer surveillance.

- Existing community fisheries management programmes need to be continued and improved. More involvement of female fishers in the community's management work is needed as they are the main harvesters of bêche-de-mer for subsistence and small-scale sales, and the main subsistence gleaners.

- A cautionary approach to using resources is required to immediately safeguard current stocks and thus maintain marine resources for the subsistence and economic livelihoods of the people.

- The resource management plans already in place for the Aleipata area should be implemented to allow restoration of resources in the lagoon. Even though the long-term ecological benefits of MPAs have not been fully realised, fishing activities such as spearfishing and netting should be banned inside the MPAs and these conservation sites regularly patrolled.

- Fishing in the outer-reef slope, although difficult during adverse sea conditions, should be encouraged to relieve pressure on resources in the lagoon.

- Immediate action is required to protect and reintroduce giant clams, as present densities are so low that they have reached a 'critical threshold', where reproductive success and subsequent recruitment are impaired and stocks are likely to decline. The present MPA arrangement does not protect any broodstock of clams naturally occurring in Vailoa.

- Recovery of greenfish, *S. chloronotus*, presents an option for redeveloping a limited fishery for sea cucumbers in Samoa, but developing a management plan for such a fishery will need to wait for more comprehensive results.

- Present densities of crown of thorns starfish (COTS) at Vailoa are not critical but, to prevent an outbreak, adult COTS should be periodically removed from the small lagoon, and their numbers closely monitored.

Results of fieldwork at Vaisala

Vaisala is located close to the northwest end of Savaii Island, about three hours' drive from the main town of Saleloga. The population of Vaisala at the time of the survey was 611, constituting 24.1% of the entire district. Most of the 86 households were located along the narrow margin of the coastal area.

Vaisala has a narrow coastal strip composed of older lava flows with some topsoil development. The Vaisala bay area (our survey site) has a distinct fringing and barrier reef. Underground tunnels discharge freshwater directly into the lagoon. The intermediate lagoon area is quite narrow, 2–4 m deep, with pools of slightly deeper water. The substrate is mainly sand, with scattered coral patches with high live-coral cover. Coral reefs are better developed here than on the south and east areas of Savaii and are relatively healthy, with more cover of live corals in the sheltered lagoon than on the outer-reef slope.

The fishing ground of Vaisala is relatively small, with no legal demarcation of its boundary. Fishing is predominantly restricted to reef areas next to the village, although there is free access to fishing areas elsewhere. In addition to fishing activities, several natural disasters have affected the reef system, including repeated cyclones in the 1990s and more recent ones. Also, there were signs of a previous crown of thorns starfish (COTS) outbreak, with a handful of COTS sighted during the surveys. The area is well-suited to development of a near-shore fishery as the coastline is protected during the prevailing summer tradewinds. The preferred fishing spots on the outer-reef slope for spearfishing and deep sea fishing are relatively close to shore. Vaisala has one localised *tabu* area/MPA, which was established some five years ago with assistance from an AusAID project.

Vaisala is a community that has access to agricultural land and marine resources. However, due to its geographical isolation and distance from Samoa's main centre, opportunities to earn income from salaries are limited. As a consequence, people are highly dependent on remittances to meet their many traditional and religious obligations. Additionally, agricultural produce provides more income than do fisheries, as it is less sensitive to storage and transportation time. The Vaisala community has participated in the national community-based fisheries management programme at an early stage and thus has established a reserve area, where fishing is banned within their demarcated reef and lagoon fishing grounds.

Socioeconomics: Vaisala

Vaisala's population is highly dependent on marine resources as a source of food rather than income, mainly due to the lack of market access and storage capacities. Fresh-fish consumption is not as high as expected (51.6 kg/person/year), presumably due to the availability of alternative protein sources. However, invertebrate and canned-fish consumption levels (14.8 kg and 30 kg/person/year respectively) are both high, due to the fact that females gather invertebrates as easily available food items, and because canned fish is used for *falavelave* (traditional and religious obligations, e.g. weddings, funerals), which occur very often. Consumption and income patterns both suggest a highly traditional and remote, rural lifestyle. Gender roles also suggest a very traditional lifestyle, with females collecting invertebrates, while males fish for finfish and do all the diving. Finfish fishing is limited to easily accessible habitats due to the limited numbers of boats, especially boats equipped with outboard motors. Invertebrates are mainly harvested by gleaning reeftops and soft benthos. Bêche-de-mer and giant clams are the major target species groups for subsistence and, to a lesser extent, commercial purposes.

Finfish resources: Vaisala

Finfish resources in Vaisala appeared rather poor, with low values of density, biomass and species number. Total biomass is the second lowest after Salelavalu. Only two habitats were surveyed at this site; the outer-reef habitat was richer than the back-reef, displaying higher stock, due to the presence of larger fish. Fishing activities at Vaisala are intense and fishing pressure is especially concentrated in the outer reefs. Spearfishing is the most common fishing method used, in both the outer reef and back-reef. This fishing technique could hasten the overfishing of specific targeted resources. In fact, Scaridae, which, along with Acanthuridae, is the most fished family at this site and the main target of spearfishing, appears to be decreasing in abundance in the outer reefs. This impact from targeted fishing is evident when comparing densities among the outer-reef habitats of the other survey sites.

Invertebrate resources: Vaisala

The presence, density and size range of giant clams in Vaisala indicate that the resource is degraded; *T. maxima* abundance was low and *T. squamosa* was rare in the limited area of reef available to fishers. Fishing pressure is the most likely cause for the depleted stock. Present densities of giant clams are so low that they have reached a 'critical threshold', where reproductive success and subsequent recruitment is severely impaired and stocks are likely to further decline if action is not taken to protect and reintroduce clams.

Mother-of-pearl stocks, *T. niloticus* and *P. margaritifera*, were absent from survey records taken in Vaisala, whilst *T. pyramis*, a species with a similar life history to trochus, was rare. Reefs in Vaisala are suitable for trochus stocks, although the limited scale of the reef and inshore areas, plus the small number of other gastropod grazers, suggest that Vaisala does not offer much potential for future translocations.

Sea cucumber stocks are patchy, and there is a limited number of species available for commercial fishing. The regularly fished *sea* (*Stichopus horrens*) is currently found at low densities in comparison to other areas of the Pacific. Sizes of *S. horrens* in Vaisala were larger than those found Salelavalu and Vailoa. The presence of high-value teatfish and other deep-water stocks is of interest for commercialisation, but these resources appear from preliminary assessment to be insufficient for regular fishing.

Recommendations for Vaisala

Based on the survey work undertaken and the assessments made, the following recommendations are made for Vaisala:

- A precautionary approach to resource use needs to be immediately adopted and ongoing monitoring is needed in order to properly manage marine resources to protect current stocks and thus provide for the future subsistence needs and economic livelihoods of the people.

- Any commercial fishing (of finfish and invertebrates) should be accompanied by monitoring activities, to ensure that resources remain available for subsistence use by future generations.

- SCUBA diving at night on the outer reef should be regulated to limit the heavy impact on reef resources, especially Scaridae.

- The marine protected area in front of the village of Vaisala needs to be regularly patrolled and monitored in order to make this reserve profitable as a management tool.

- To sustain healthy populations of giant clams, urgent action is required to protect existing clams, including larger, older individuals, and to reintroduce clams.

- The stocks of the smooth clam, *Tridacna derasa*, that are stockpiled inshore, are held in sub-optimal locations (too silty with too little water flow), and no recruitment (second-generation settlement) was detected from this resource. If security issues allow, these clams should be moved to deeper water (2–4 m), where water temperatures are less variable and there is greater oceanic influence.

- Excellent recovery of greenfish, *Stichopus chloronotus*, presents an option for redeveloping a limited fishery for sea cucumbers. There is also a possibility of fishing the ubiquitous brown sandfish (*Bohadschia vitiensis*).

- Crown of thorns starfish were common in Vaisala and their deleterious effect on live corals was noticeable. Due to the small size of the lagoon, populations of COTS can be closely managed by removing individuals and monitoring their size and abundance to forewarn of an outbreak.

RÉSUMÉ

Les agents de la composante côtière du Programme régional de développement des pêches océaniques et côtières dans les PTOM français et pays ACP du Pacifique (PROCFish/C) ont conduit des travaux de terrain sur quatre sites du Samoa, en juin 2005 et en août/septembre 2005. Le Samoa est l'un des 17 États et Territoires insulaires océaniens qui font l'objet d'enquêtes échelonnées sur 5 à 6 ans, conduites dans le cadre de PROCFish ou de son programme associé CoFish (projet régional de développement de la pêche côtière)[4]. Le but de ces enquêtes était de recueillir des données de référence sur l'état des ressources récifales et de combler l'énorme manque d'informations qui entrave la gestion efficace de ces ressources.

Le projet visait en outre à obtenir les résultats suivants :

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

Les enquêtes conduites au Samoa couvraient trois disciplines (poissons, invertébrés et aspects socioéconomiques) sur chaque site. Une équipe de cinq chercheurs du projet et de nombreux stagiaires locaux détachés par le Service des pêches a enquêté sur deux sites par sortie. Les travaux de terrain consistaient à former les homologues locaux aux méthodes d'enquête dans les trois disciplines, notamment la collecte de données et leur saisie dans la base de données du projet.

Au Samoa, les quatre sites retenus étaient : Manono-uta, Salelavalu, Vailoa et Vaisala.

Les sites ont été sélectionnés selon des critères particuliers :

- Existence d'une pêche récifale active,
- Sites représentatifs du pays,
- Systèmes relativement fermés (les habitants du site pêchent dans des zones bien définies),
- Taille appropriée,
- Habitat diversifié,
- Absence de problèmes logistiques majeurs,
- Études déjà effectuées auparavant, et
- Intérêt particulier des sites pour le Service des pêches du Samoa.

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

Résultats des travaux de terrain à Manono-uta

Les deux villages de Manono-uta (sur l'île principale d'Upolu) et Manono-tai (île) ont été associés pour les besoins de cette enquête, étant donné que les habitants des deux villages appartiennent au même clan, partagent des droits de pêche et ont accès aux mêmes zones de pêche. Manono-uta compte 1 997 habitants et 146 ménages. La population locale réside le long de la côte, qui fait 2 kilomètres de long. Avec un rapport hommes-femmes équivalent, la population du village représente 28 pour cent de celle du district d'Aiga I Le Tai tout entier. Manono-tai est une île située à un peu plus de 4 km au nord-ouest de Manono-uta et de l'île d'Upolu, à laquelle elle est reliée par la plate-forme récifale d'A'ana. Cet habitat récifal particulier semble être le plus grand, et il abrite les principales ressources côtières du Samoa. Il y a plusieurs établissements humains ou petits sous-villages sur l'île, régis par des dispositifs communaux distincts.

Aspects socioéconomiques : Manono-uta

La population de Manono-uta est fortement tributaire des ressources marines dont elle tire nourriture et revenus. La consommation de poisson frais est élevée (79,4 kg par personne et par an) ; les invertébrés sont consommés dans une moindre mesure (4 kg par personne et par an). Le partage des rôles traditionnellement dévolus aux hommes et aux femmes se maintient ; ce sont surtout les hommes qui pratiquent la pêche de poissons, tandis que les femmes se chargent de ramasser des invertébrés. Hommes et femmes sont organisés en groupes qui s'occupent de la pêche et de la commercialisation. Les poissons sont principalement capturés dans le lagon et sur le récif externe. Les réseaux de pêche étant bien organisés, le transport par bateaux est assuré par des revendeurs intermédiaires et/ou des acheteurs de poissons. Le récif externe et les passes sont exploités à des fins commerciales, tandis que la pêche dans le lagon est surtout pratiquée à des fins de subsistance. La pêche au filet maillant est la principale méthode utilisée dans le lagon, la pêche au harpon sur le récif externe.

Les prises totales annuelles d'invertébrés consistent surtout en holothuries, suivies de bénitiers. Cette situation est préoccupante, d'autant plus que la pêche d'holothuries est interdite dans tout le pays et qu'il est reconnu que les stocks de bénitiers diminuent. Alors que 65 pour cent des prises d'invertébrés sont destinés à la consommation domestique, 35 pour cent sont vendus soit sur le bord de la route, soit sur le marché d'Apia tout proche.

Poissons : Manono-uta

Dans l'ensemble, les ressources en poisson de Manono-uta semblent en bon état. Elles viennent au second rang des quatre sites échantillonnés pour la biomasse, et au premier pour le rapport de taille. L'abondance la plus grande a été observée sur les récifs extérieur et arrière. Les récifs extérieurs présentent les valeurs les plus élevées des principaux indicateurs biologiques (densité, biomasse, taille et biodiversité, celle-ci étant particulièrement grande). Ils sont suivis par des récifs arrière en bon état, avec des valeurs élevées pour la densité, la taille et la biomasse. Les récifs arrière présentaient aussi le pourcentage le plus élevé de coraux vivants de tous les habitats. Manono-uta a le plus fort pourcentage de personnes pratiquant la pêche à des fins alimentaires et financières. En outre, le marché d'Apia est proche et facilement accessible. En conséquence, la pression de pêche est assez élevée et visible, surtout dans le lagon et sur les récifs côtiers. Les premiers signes d'impact sont apparents : les stocks d'Acanthuridae et de Scaridae dans les habitats côtiers et lagonaires diminuent.

Invertébrés : Manono-uta

La densité de bénitiers est actuellement si faible que cette espèce a atteint un « seuil critique », au point que le succès de la reproduction et le recrutement ultérieur sont compromis. La présence, la densité et la fourchette de taille des bénitiers indiquent que la ressource est dégradée. La pression de pêche est la cause la plus probable de la faible densité de *T. maxima* et de la rareté de *T. squamosa* sur Manono-uta.

Il y a une gamme limitée d'espèces d'holothuries ciblées par la pêche commerciale ; les stocks sont disséminés, et *Stichopus horrens* (nom local : *sea*) était en général peu abondante dans les zones de pêche appropriées du lagon. Il existe un potentiel de pêche commerciale pour *Bohadschia vitiensis* et *Stichopus chloronotus*, mais il faudra obtenir des résultats plus exhaustifs au Samoa avant de pouvoir établir un plan de gestion de ces ressources. (Une étude de suivi a été organisée, en collaboration avec l'Université d'Uppsala, afin d'échantillonner d'autres sites sur Upolu et Savai'i ; voir Friedman *et al.* 2006.). La présence d'holothuries à mamelles de grande valeur marchande et d'autres stocks d'eau profonde est intéressante en vue de leur commercialisation, mais les stocks semblent insuffisants pour supporter une pêche régulière.

Recommandations pour Manono-uta

Sur la base des enquêtes conduites et des évaluations réalisées, les recommandations suivantes s'appliquent à Manono-uta :

- En collaboration avec le Conseil des anciens, les pasteurs, les pêcheurs et pêcheuses, la population de Manono-uta devrait mettre en œuvre un programme de gestion communautaire des ressources halieutiques et les règlements nécessaires pour protéger les ressources du récif et du lagon contre la surpêche et les conserver en vue de leur exploitation future.

- Les aires marines protégées devraient être considérées comme un outil de gestion prioritaire. Il conviendrait de prendre des dispositions pour réglementer la pêche de poissons à des fins commerciales, et les accompagner de mesures de suivi régulier, afin de faire en sorte que les ressources halieutiques puissent être exploitées à des fins de subsistance par les générations futures.

- La plongée en scaphandre autonome de nuit sur le récif extérieur et la pêche au filet sur les récifs côtiers et lagonaires beaucoup plus pauvres devraient être réglementées afin de réduire leur impact sur les ressources récifales.

- Il faudrait prendre des mesures immédiates pour protéger les bénitiers dans le lagon, et les réintroduire dans les zones qui ont été complètement épuisées, afin d'éviter le déclin de ces stocks appauvris à un point critique.

- La position du stock de *Tridacna derasa*, près de l'île de Manono, n'est pas optimale, et les taux de mortalité constatés sur ce site sont probablement dus à des stress environnementaux. À cette faible profondeur, des bateaux mouillaient au-dessus des bénitiers, et la houle était trop importante. Si les conditions de sécurité le permettent, il faudrait déplacer ces bénitiers à de plus grandes profondeurs (de 2 à 4 m), dans des zones exposées à des courants modérés et à une influence plus océanique.

- Il existe un potentiel de pêche commerciale d'holothuries *Bohadschia vitiensis* et *Stichopus chloronotus*, mais avant de pouvoir établir un plan de gestion de cette pêcherie, il faudrait recueillir des résultats plus exhaustifs du Samoa.

- Il y a des étoiles de mer Acanthaster à Manono. Leur population doit être surveillée de près, en mesurant leur taille et leur abondance, ainsi que les cicatrices qu'elles laissent sur le corail dont elles se nourrissent, afin de prévenir une invasion.

- Avant d'envisager de futurs lâchers de trocas, il faudrait commencer par placer les coquillages transplantés sur des récifs, au sein du lagon, ou sur des parties nord, mieux protégées, du récif barrière, où il y a une végétation épiphyte (et des sources de nourriture potentielles pour le troca) plus développée, mais où des algues coralliennes encroûtantes sont encore présentes.

Résultats des travaux de terrain à Salelavalu

Les enquêtes se sont concentrées sur les zones maritimes adjacentes à Salelavalu. En règle générale, Salelavalu se divise en deux grandes zones : Salelavalu-uta, avec une population de 571 habitants, et Salelavalu-tai avec une population de 338 habitants. Les limites du récif adoptées pour les besoins des enquêtes s'étendaient depuis les frontières entre Saleiloaga et Salelavalu, jusqu'à Lalomalava. Salelavalu étant proche de Salelologa (l'une des plus grandes zones récifales du Samoa, présentant une structure complexe, un habitat diversifié et une grande couverture corallienne), les récifs coralliens autour de la zone de Salelavalu bénéficient d'un grand apport de nutriments, issus de la remontée d'eaux froides ("*upwelling*") du détroit d'Apolima.

Aspects socioéconomiques : Salelavalu

Du fait de sa proximité de Saleloga, principal centre urbain de Savai'i, et des services de transport régulier par ferry à Apia, sur l'île principale d'Upolu, la population de Salelavalu est tributaire de la pêche, dont elle tire ses revenus principaux ou secondaires, ainsi que des virements d'argent qui lui servent à honorer nombre d'obligations coutumières et religieuses. En outre, les revenus tirés des produits agricoles et des salaires sont également très importants. La communauté de Salelavalu n'a pas encore participé au programme de gestion national communautaire des ressources halieutiques ; seules quelques règles et règlementations sont en vigueur à l'échelon des villages.

La consommation de poisson frais (58 kg par personne et par an) est inférieure à la moyenne des quatre sites étudiés (61 kg/personne/an), mais celle d'invertébrés est bien supérieure (13,4 kg contre une moyenne de 9,6 kg par personne et par an). Les observations concernant la consommation et les revenus suggèrent un mode de vie traditionnel et rural qui bénéficie des activités commerciales liées aux marchés urbains voisins. Les rôles dévolus aux hommes et aux femmes confirment un mode de vie très traditionnel ; les femmes sont essentiellement chargées des tâches ménagères, tandis que les hommes pêchent des poissons. Les femmes récoltent surtout des invertébrés ; elles ne plongent jamais, et la plupart d'entre elles vont récolter dans les mangroves et pêcher des holothuries (nom vernaculaire : *sea*). Les poissons sont surtout capturés dans les habitats aisément accessibles, le nombre de bateaux étant limité. Diverses techniques sont utilisées : les filets maillants sont plus utilisés qu'en moyenne. Les holothuries et les bénitiers sont les principaux invertébrés ciblés à des fins vivrières et commerciales. D'après les indicateurs de pression de pêche calculés pour les poissons et les invertébrés, la densité de pêcheurs et les taux moyens de prises annuelles, ainsi que les prises par unité de surface sont modérés à élevés, en raison de la superficie du récif et des zones de pêche.

Poissons : Salelavalu

Les ressources en poisson de Salelavalu semblaient en médiocre état et présentaient les valeurs moyennes les plus basses des quatre sites échantillonnés pour la densité, la biomasse, la taille, les rapports de taille et les quantités de poissons. Les plus mauvaises conditions ont été observées dans les récifs côtiers et lagonaires où la plupart des activités de pêche se concentrent. L'impact de la pêche se manifeste par le déclin des stocks de Scaridae, d'Acanthuridae et de Mullidae, ainsi que de toutes les espèces carnivores, en particulier dans les habitats côtiers. La population de poisson est largement dominée par des herbivores. C'est là un autre signe d'affaiblissement de la composition des espèces. Les tailles moyennes des poissons à Salelavalu étaient inférieures de 50 pour cent aux valeurs maximales connues pour la plupart des familles d'intérêt commercial, et les plus petites de tous les sites observés, ce qui dénote une ressource plus appauvrie. À Salelavalu, la densité totale des poissons et la biomasse étaient les plus basses des quatre sites étudiés au Samoa.

Invertébrés : Salelavalu

La présence, la densité et la taille des bénitiers à Salelavalu indiquent que cette ressource est dégradée, très probablement du fait de la pression de pêche. Les densités présentes sont si faibles qu'elles ont dépassé le « seuil critique », au point que le succès de la reproduction et le recrutement ultérieur sont gravement compromis. Les stocks vont probablement diminuer si l'on ne prend pas des dispositions pour protéger et réintroduire des bénitiers. Du point de vue des conditions environnementales, *Tridacna derasa* (espèce de bénitier introduite sur d'autres sites ciblés par PROCFish) conviendrait mieux à Salelavalu, qui possède un vaste système lagonaire et un habitat récifal approprié.

Les stocks de nacre, *Trochus niloticus* et *Pinctada margaritifera*, étaient absents de Salelavalu, tandis que *Tectus pyramis*, espèce présentant les mêmes caractéristiques biologiques que le troca, n'a été observé qu'à une densité faible à moyenne. Les récifs de Salelavalu conviennent au troca, bien que l'habitat des trocas adultes soit réduit, sur la pente océanique du récif, car celui-ci tombe en pente raide vers un fond sablonneux.

Il y a un nombre limité d'espèces d'holothuries qui peuvent faire l'objet d'une pêche commerciale ; les stocks sont éparpillés, et *Stichopus horrens* (*sea*) est exposée à une pression de pêche importante dans les zones de pêche appropriées. La pêche commerciale de *Stichopus chloronotus* présente un certain potentiel, mais il faudra disposer de résultats plus complets du Samoa avant de pouvoir établir un plan de gestion de cette ressource. La présence d'holothuries à mamelles de grande valeur marchande et d'autres stocks d'eau profonde peut être intéressante en vue d'une commercialisation, mais les stocks, dans cette partie de Savaii, sont insuffisants pour l'instant pour supporter la pêche.

Recommandations pour Salelavalu

Sur la base des enquêtes conduites et des évaluations réalisées, les recommandations suivantes s'appliquent à Salelavalu :

- Salelavalu ne devrait plus hésiter à participer au programme national de gestion communautaire des ressources halieutiques. Un plan de gestion communautaire devrait être établi, sur la base d'une coopération entre les cinq villages et le Service des pêches, avec, si possible, l'aide d'organisations non gouvernementales. L'autorité, dans les villages traditionnels ou la communauté, et celle des institutions sociales sont encore bien définies et respectées à Salelavalu, et permettront de mettre au point un programme communautaire de gestion halieutique efficace. Certaines zones du récif et du lagon pourraient être identifiées, et le statut d'aires marines protégées pourrait leur être attribué, afin de laisser les stocks se reconstituer, vu l'abondance des ressources récifales et lagonaires de la communauté.

- De nouvelles mesures de gestion des poissons et invertébrés devraient être prises. La pêche commerciale doit être réglementée, et un programme de surveillance établi pour faire en sorte que les ressources puissent continuer d'être exploitées à des fins vivrières par les générations futures.

- L'utilisation du scaphandre autonome et la pêche au harpon de nuit devront éventuellement être limitées. Il faudra peut-être réglementer l'emploi de filets maillants. Il faut au contraire encourager la pratique de la pêche à la ligne à main, à la canne et à la ligne en eau profonde, qui ne causent encore qu'un impact mineur.

- Il faut intervenir d'urgence pour prévenir le déclin des stocks de bénitiers et réintroduire de nouveaux stocks. Le bénitier *Tridacna derasa* (introduit sur d'autres sites ciblés par PROCFish) devrait être introduit à Salelavalu, qui possède un vaste système lagonaire, un habitat récifal approprié et de meilleures conditions environnementales que les autres sites.

- Il existe un potentiel de pêche commerciale de *Stichopus chloronotus*, mais il faudrait disposer de résultats plus exhaustifs du Samoa avant d'établir un plan de gestion de cette ressource.

- Des étoiles de mer Acanthaster étaient présentes à Salelavalu, et leur effet dévastateur sur les coraux vivants était visible en certains endroits. La population de ces étoiles de mer devrait être surveillée de près et l'élimination des individus encouragée. Il faut suivre attentivement leur taille et leur abondance pour prévenir une invasion.

Résultats des travaux de terrain à Vailoa

Vailoa fait partie du district d'Aleipata, à une soixantaine de kilomètres au sud-est d'Apia. Le sud d'Aleipata consiste dans une étroite plaine côtière, bordée de pentes volcaniques et de falaises, ainsi qu'en deux îles, Nu'utele et Nu'ulua. Nu'utele est un sanctuaire d'oiseaux où la pêche est interdite. Cette île possède un étroit récif frangeant, au nord, et une pente récifale très raide et une couverture corallienne élevée, qui descend vers un fond de sable et de graviers jusqu'à 27 m de profondeur environ (Zann 1989). Le lagon intérieur consiste surtout en sable fin, dominé par des herbiers avec des assemblages coralliens mixtes autour de Lolamanu.

Les inventaires des ressources se sont concentrés sur les zones marines adjacentes aux villages de Vailoa, Ulutogia et Satitoa, du côté est de l'île d'Upolu. Vailoa (335 habitants, 36 ménages) et Ulutogia (194 habitants, 21 ménages) se trouvent dans le district d'Aleipata Itupa I Luga, tandis que le village de Satitoa (520 habitants, 71 ménages) est situé dans celui d'Aleipata Itupa I Lalo (Division Services statistiques, 2001). La communauté est consciente de la nécessité de conserver ses ressources marines à long terme, et elle est considérée comme ayant mis en place l'un des meilleurs projets de gestion communautaire. Plusieurs zones de pêche interdite et une grande réserve de récifs coralliens, en face du village de Vailoa, ont été aménagées, et sont surveillées et respectées depuis six ans.

Aspects socioéconomiques : Vailoa

La population de Vailoa est très tributaire de ses ressources marines, dont elle tire sa nourriture ; elle en dépend moins sur le plan des revenus. L'éloignement du marché urbain d'Apia empêche la vente régulière et à plus grande échelle des produits de la mer. Près de 60 pour cent des prises de poissons et 70 pour cent de celles d'invertébrés répondent aux besoins vivriers de la population. Les virements de l'étranger jouent un rôle aussi important que les activités rémunératrices de la communauté, et l'artisanat, ainsi que les petites entreprises du secteur privé sont également bien présents.

La consommation de poisson frais (47,7 kg par personne et par an) est modérée et celle d'invertébrés plutôt faible (8,52 kg/personne/an). Ces deux chiffres sont inférieurs à la moyenne des quatre sites étudiés au Samoa. La consommation de poisson en conserve est toutefois élevée (28,3 kg/personne/an), ce qui peut s'expliquer par le recours fréquent à des conserves pour les *falavelave* (cérémonies coutumières et religieuses, par exemple mariages, funérailles). Les habitants de Vailoa mènent encore une vie plutôt traditionnelle. Les hommes se chargent surtout de la pêche de poissons, tandis que les femmes récoltent des invertébrés, y compris des holothuries, qu'elles vendent à une modeste échelle. Le poisson est surtout pêché dans le lagon et sur le récif côtier abrité, l'accès aux bateaux, surtout ceux à moteur, étant limité. En conséquence, seuls les passes les plus proches et les récifs extérieurs sont exploités lorsque les pêcheurs s'aventurent hors du lagon. Les prises par unité d'effort sont faibles : environ 1,5 kg de poisson par heure de sortie (2 kg/heure sur le récif extérieur). La taille moyenne des poissons est petite (25 cm), et la densité de pêcheurs et les taux de prises modérés.

Poissons : Vailoa

Les ressources en poissons sur les récifs étudiés à Vailoa-Aleipata semblent généralement en bonne santé, avec une grande abondance de poissons, et la diversité des espèces, en particulier de la biomasse, affiche des valeurs plus élevées que sur les autres sites. Les ressources en poissons de récif sont toutefois en meilleur état sur la pente du récif extérieur et dans les habitats des îles, tandis que les ressources des parties peu profondes du récif et du lagon étaient appauvries. Les récifs extérieurs présentaient la plus forte densité de poissons, en particulier d'Acanthuridae. L'île de Nu'utele est un sanctuaire aviaire où la pêche est interdite. Elle possède un étroit récif frangeant qui chute à plus de 1000 m de profondeur. L'abondance des poissons est encore satisfaisante sur la pente du récif extérieur. La diversité, l'abondance et la biomasse sont très élevées sur les îles où la pêche est rarement pratiquée, relativement élevées sur les pentes du récif modérément ciblées de l'île principale, et faibles dans les eaux peu profondes du récif et dans le lagon, fortement exploitées. Cela indique que les pentes plus profondes du récif font office de réservoir pour les lagons fortement pêchés. On n'a pas observé de différences entre les ressources en poissons à l'intérieur ni à l'extérieur des AMP adjacentes aux villages de Vailoa, Ulutogia et Satitoa, ce qui s'explique probablement par le fait que ces AMP sont mal surveillées (on a observé des activités de pêcheurs pendant les enquêtes).

La couverture corallienne était généralement bonne (15-24 %), surtout sur la crête du récif extérieur (à 0-5 m) et sur le récif arrière, derrière les brisants. Une bonne couverture corallienne a également été observée le long du récif côtier abrité (à moins de 15 m du littoral) de Lalomanu, Vailoa et Ulutogia. Des coraux *Porites* massifs et sub-massifs étaient prédominants dans les zones récifales proches du littoral, tandis que des coraux *Acropora* branchus et tabulaires étaient majoritaires dans la couverture corallienne de l'arrière récif. La couverture corallienne au milieu du lagon était faible, et le substrat se composait surtout de sable fin.

Invertébrés : Vailoa

La densité et la taille des bénitiers de Vailoa indiquent que cette ressource est dégradée, très probablement du fait de la pression de pêche, tandis que les conditions à l'intérieur du lagon et sur les récifs du large conviennent bien aux bénitiers. Seuls des individus *Tridacna maxima* ont été observés dans la nature ; *Hippopus hippopus* est déjà éteint, et *T. squamosa* n'a pas été détecté pendant cette enquête[5]. Il est encourageant de noter que les individus *T. derasa* transplantés dans l'AMP manifestent encore un recrutement et approchent une taille à maturité à laquelle ils peuvent, espère-t-on, produire un stock de deuxième génération.

L'introduction de *Trochus niloticus*, troca d'intérêt commercial, à Vailoa, n'a pas été couronnée de succès. La présence et le recrutement de *Tectus pyramis* étaient médiocres à modérés, mais l'habitat convenait à des gastropodes brouteurs, et un recrutement se produit. L'huître perlière à lèvres noires *Pinctada margaritifera* est considérée comme surpêchée. On voit dans la rareté générale de ces trois espèces de nacres le résultat de mauvaises stratégies de lâcher qui ont présidé à l'introduction du troca, de l'exiguïté de la surface de récif disponible, et de la surpêche.

Le nombre d'espèces d'holothuries se prêtant à la pêche commerciale est limité, les stocks éparpillés, et la densité de *Stichopus horrens* (*sea*), qui est récolté régulièrement, est actuellement faible par rapport à d'autres régions du Pacifique. La présence d'holothuries à mamelles de grande valeur marchande et d'autres holothuries d'eau profonde est intéressante du point de vue de la commercialisation, mais l'habitat et le volume des stocks sont insuffisants pour supporter une pêche régulière.

Recommandations pour Vailoa

Sur la base des enquêtes conduites et des évaluations réalisées, les recommandations suivantes s'appliquent à Vailoa :

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[5] Cette espèce peut être considérée comme « éteinte sur le plan commercial » : elle est rare au point que sa collecte ne saurait être qualifiée de pêche commerciale ou vivrière ; elle est toutefois (ou peut être) encore présente à de très faibles densités.

- Il faut dresser la carte des zones à risque, c'est-à-dire des endroits, au sein de la zone de pêche de Vailoa, qui sont potentiellement le plus exposés à la surpêche, en complément des pratiques de gestion actuelles, et trouver des indicateurs facilitant le suivi des ressources et le choix des espèces d'invertébrés et de poissons à surveiller de plus près.

- Il convient de poursuivre les programmes existants de gestion communautaire des ressources et de les améliorer. Les pêcheuses devraient s'investir davantage dans la gestion communautaire, puisque ce sont elles qui récoltent des holothuries à des fins de subsistance et de vente à petite échelle, et qui pourvoient principalement à la subsistance des ménages.

- Il faut respecter le principe de précaution dans l'exploitation des ressources, afin de préserver immédiatement les stocks actuels et de conserver les ressources marines pour assurer la nourriture et les moyens économiques et de subsistance des populations.

- Les plans de gestion déjà mis en place pour la région d'Aleipata devraient être déployés de manière à permettre la reconstitution des stocks dans le lagon. Bien que les avantages écologiques à long terme des AMP ne soient pas encore bien perçus, les activités halieutiques telles que la pêche au harpon et au filet devraient être interdites dans les AMP et ces sites protégés surveillés par des patrouilles régulières.

- La pêche sur la pente du récif extérieur, bien que difficile par mer forte, devrait être encouragée pour atténuer la pression sur les ressources du lagon.

- Il faut prendre immédiatement des dispositions pour protéger et réintroduire les bénitiers, dont la densité est actuellement si faible qu'ils ont atteint un « seuil critique », au point que le succès de la reproduction et le recrutement ultérieur sont compromis et que les stocks vont probablement diminuer. Le statut d'AMP actuel ne protège pas le stock reproducteur naturel de bénitiers présent à Vailoa.

- La reconstitution du stock de *S. chloronotus* offre une possibilité de développer à nouveau une pêcherie limitée d'holothuries *sea* au Samoa, mais il faudra recueillir des résultats plus exhaustifs avant de pouvoir établir un plan de gestion de cette ressource.

- Actuellement, la densité d'étoiles de mer Acanthaster n'est pas critique à Vailoa, mais pour prévenir toute invasion, il faut périodiquement retirer les individus adultes du petit lagon et surveiller de près leurs effectifs.

Résultats des travaux de terrain à Vaisala

Vaisala est situé près de l'extrémité nord-ouest de l'île de Savai'i, à environ trois heures en voiture de la ville principale, Saleloga. La population de Vaisala, à l'époque de l'enquête, était de 611 habitants, soit 24,1 pour cent du district. La majorité des 86 ménages vit le long de l'étroite bande littorale.

Vaisala possède une étroite bande côtière, composée d'anciennes coulées de lave, recouvertes d'une mince couche de terre arable. La baie de Vaisala (notre site d'enquête) a un récif frangeant et un récif barrière distincts. Des tunnels souterrains déversent directement l'eau douce dans le lagon. La zone intermédiaire du lagon, très étroite, a une profondeur de 2 à 4 m, avec des bassins légèrement plus profonds. Le substrat est principalement sablonneux, avec des pâtés dispersés de coraux vivants élevés. Les récifs coralliens sont mieux développés ici que dans les zones sud et est de Savaii, et relativement sains, la couverture de coraux vivants étant plus développée dans le lagon abrité que sur la pente du récif extérieur.

La zone de pêche de Vaisala est relativement petite, sans délimitation officielle. La pêche se limite surtout aux zones récifales proches du village, mais les pêcheurs peuvent librement accéder à d'autres zones. Outre les activités halieutiques, plusieurs catastrophes naturelles ont endommagé le système récifal, notamment les cyclones à répétition des années 90 et les cyclones plus récents. On observe des signes d'invasion antérieure d'étoiles de mer Acanthaster, dont plusieurs individus ont été repérés au cours des enquêtes. La zone se prête au développement de la pêche côtière, le littoral étant protégé en été, quand les alizés soufflent. Les lieux de pêche préférés des pêcheurs au harpon sur la pente du récif externe et en haute mer sont relativement proches du rivage. Vaisala a une zone tabou ou AMP, aménagée il y a cinq ans avec le concours de l'AusAID.

La communauté de Vaisala possède des terres agricoles et des ressources marines. Toutefois, en raison de son isolement géographique et de son éloignement du centre principal du Samoa, les possibilités d'emploi salarié sont limitées. En conséquence, les gens sont tributaires des virements des parents vivant à l'étranger pour remplir nombre de leurs obligations coutumières et religieuses. En outre, les produits agricoles leur rapportent davantage que ceux de la mer, moins liés à des contraintes de durée en matière de stockage et de transport. La population de Vaisala a participé d'emblée au programme national de gestion communautaire des ressources marines et aménagé une réserve marine où la pêche est interdite dans les limites matérialisées des zones de pêche récifales et lagonaires.

Aspects socioéconomiques : Vaisala

Les ressources marines constituent surtout, pour la population de Vaisala, une source de nourriture plus qu'une source de revenus, faute d'accès au marché et de capacités de stockage. La consommation de poissons frais n'est pas aussi élevée qu'on pourrait le penser (51,6 kg par personne et par an), sans doute du fait qu'il existe d'autres sources de protéines. La consommation d'invertébrés et de poisson en conserve, en revanche (14,8 kg et 30 kg/personne/an respectivement) est élevée, les femmes ramassant des invertébrés, aliments faciles à trouver, et le poisson en conserve étant utilisé pour les très fréquentes cérémonies coutumières et religieuses (*falavelave*) telles que mariages, funérailles, etc. Les statistiques de consommation et de revenus dénotent un mode de vie rural, très traditionnel et isolé. Les rôles respectifs des hommes et des femmes sont également caractéristiques d'un mode de vie très traditionnel. Les femmes ramassent des invertébrés, tandis que les hommes pêchent des poissons et plongent. La pêche de poissons est limitée aux habitats aisément accessibles, étant donné le nombre limité de bateaux, surtout de bateaux équipés d'un moteur hors-bord. Les invertébrés sont principalement récoltés sur la crête des récifs et sur les fonds meubles. Les holothuries et les bénitiers sont les principales espèces ciblées à des fins de subsistance et, dans une moindre mesure, à des fins commerciales.

Poissons : Vaisala

Les ressources en poissons de Vaisala semblent assez pauvres ; leur densité, leur biomasse et le nombre d'espèces sont faibles. La biomasse totale vient à l'avant-dernier rang après Salelavalu. Deux habitats seulement ont été étudiés sur ce site. Celui du récif extérieur était plus riche que celui de l'arrière-récif ; il possède un stock plus abondant, du fait de la présence de poissons plus gros. Les activités de pêche à Vaisala sont intenses et la pression de pêche se concentre en particulier sur les récifs extérieurs. La pêche au harpon est la méthode la plus courante, tant sur le récif extérieur que sur l'arrière-récif. Cette technique pourrait accélérer la surpêche de certaines ressources ciblées. De fait, l'abondance des Scaridae – la famille la plus pêchée sur ce site avec les Acanthuridae, et la principale cible des pêcheurs au harpon – semble décroître sur les récifs extérieurs. Cet impact de la pêche ciblée ressort avec évidence lorsqu'on compare les densités dans les habitats du récif extérieur des autres sites étudiés.

Invertébrés : Vaisala

La présence, la densité et la taille des bénitiers de Vaisala indiquent que la ressource est dégradée. L'abondance de *T. maxima* était faible, et *T. squamosa* était rare dans la zone limitée du récif accessible aux pêcheurs. La pression de pêche est la cause la plus probable de l'épuisement du stock. La densité des bénitiers est si faible à l'heure actuelle que cette espèce a atteint un seuil critique, au point que le succès de la reproduction et le recrutement ultérieur sont gravement compromis et que les stocks vont probablement continuer à diminuer si l'on ne prend pas de disposition pour réintroduire et protéger les bénitiers.

Les stocks de nacres, *T. niloticus* et *P. margaritifera*, étaient absents des relevés effectués à Vaisala, tandis que *T. pyramis*, espèce présentant les mêmes caractéristiques biologiques que le trocas, était rare. Les récifs de Vaisala offrent un habitat approprié aux stocks de troca, bien que Vaisala n'offre pas un grand potentiel pour des transplantations futures, vu l'étendue limitée du récif et des zones intérieures, et le faible nombre d'autres gastropodes brouteurs.

Les stocks d'holothuries sont dispersés, et le nombre d'espèces se prêtant à la pêche commerciale est limité. *Stichopus horrens (sea)*, régulièrement pêchée, se trouve actuellement à faibles densités par rapport à d'autres régions du Pacifique. Les individus de *S. horrens* trouvés à Vaisala étaient plus grands qu'à Salelavalu et Vailoa. La présence d'holothuries à mamelles de grande valeur marchande et d'autres stocks d'eau profonde est intéressante à des fins de commercialisation, mais une première évaluation indique que ces ressources ne sont pas suffisantes pour faire l'objet d'une pêche régulière.

Recommandations pour Vaisala

Sur la base des enquêtes conduites et des évaluations réalisées, les recommandations suivantes s'appliquent à Vaisala :

- Il faut immédiatement appliquer le principe de précaution à l'exploitation des ressources, et effectuer un suivi permanent pour gérer correctement les ressources marines, afin de protéger les stocks actuels et pouvoir répondre aux besoins futurs, alimentaires et économiques, de la population.

- Toute pêche commerciale (de poissons ou d'invertébrés) devrait s'accompagner d'activités de suivi, de manière que les ressources puissent être exploitées à des fins de subsistance par les générations futures.

- La plongée en scaphandre autonome de nuit sur le récif extérieur devrait être réglementée, afin de limiter l'impact excessif sur les ressources récifales, en particulier les Scaridae.

- L'aire marine protégée devant le village de Vaisala devrait être surveillée par des patrouilles régulières, afin de faire de cette réserve un outil de gestion rentable.

- Pour conserver les populations de bénitiers en bon état, il faut agir d'urgence et protéger les bénitiers existants, y compris les individus âgés et de grande taille, et en réintroduire.

- Les stocks de bénitiers lisses *Tridacna derasa*, stockés à terre, sont conservés dans des sites inappropriés (trop vaseux, avec une circulation d'eau insuffisante), et aucun recrutement (peuplement de deuxième génération) n'a été observé. Si les conditions de sécurité le permettent, il faut transplanter ces bénitiers à plus grande profondeur (2 à 4 mètres) où la température de l'eau est moins variable et où l'influence océanique est plus sensible.

- L'excellente reconstitution des stocks de *Stichopus chloronotus* offre une possibilité de développer à nouveau une pêcherie limitée d'holothuries de mer. Il est également possible de pêcher l'holothurie *Bohadschia vitiensis* que l'on trouve partout.

- Les étoiles de mer Acanthaster sont communes à Vaisala, et leur effet néfaste sur les coraux vivants est visible. Du fait de l'exiguïté du lagon, les populations peuvent être gérées en éliminant les individus et en surveillant leur taille et leur abondance, afin de prévenir une invasion.

ACRONYMS AND ABBREVIATIONS

ACP	African, Caribbean and Pacific Group of States
AIMS	Australian Institute of Marine Science
AusAID	Australian Agency for International Development
BdM	bêche-de-mer (or sea cucumber)
CoFish	Pacific Regional Coastal Fisheries Development Programme
CPUE	catch per unit effort
Ds	day search
D-UVC	distance-sampling underwater visual census
EDF	European Development Fund
EEZ	exclusive economic zone
EU/EC	European Union/European Commission
FAO	Food and Agricultural Organization (UN)
FL	fork length
GDP	gross domestic product
GPS	global positioning system
ha	hectare
HH	household
IUCN	International Union for the Conservation of Nature and Natural Resources (World Conservation Union)
MCRMP	Millennium Coral Reef Mapping Project
MIRAB	Migration, Remittances, Aid and Bureaucracy (model explaining the economies of small island nations)
MOP	mother-of-pearl
MOPt	mother-of-pearl transect
MPA	marine protected area
MRM	marine resource management
MSA	medium-scale approach
MSY	maximum sustainable yield
NASA	National Aeronautics and Space Administration (USA)
NCA	nongeniculate coralline algae
NGO	non-governmental organisation
Ns	night search
OCT	Overseas Countries and Territories
PICTs	Pacific Island countries and territories
PROCFish	Pacific Regional Oceanic and Coastal Fisheries Development programme
PROCFish/C	Pacific Regional Oceanic and Coastal Fisheries Development programme (coastal component)
RBt	reef-benthos transect
RFID	Reef Fisheries Integrated Database

RFs	reef-front search
RFs_w	reef-front search: walking
SBq	soft-benthos quadrat
SCUBA	self-contained underwater breathing apparatus
SE	standard error
SPC	Secretariat of the Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
USD	United States dollar(s)
WCPO	western and central Pacific Ocean
WHO	World Health Organization

1. INTRODUCTION AND BACKGROUND

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

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

1.1 The PROCFish and CoFish programmes

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

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

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

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

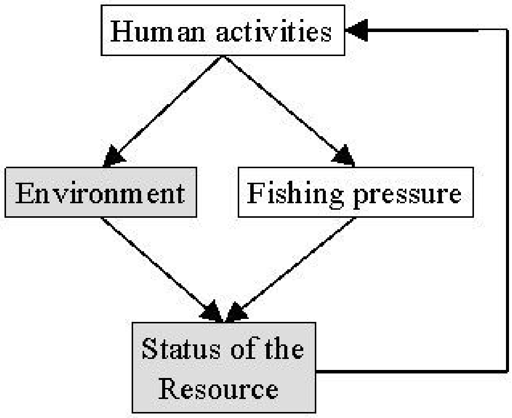

Figure 1.1: Synopsis of the PROCFish/C* multidisciplinary approach.
PROCFish/C conducts coastal fisheries assessment through simultaneous collection of data on the three major components of fishery systems: people, the environment and the resource. This multidisciplinary information should provide the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

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

Expected outputs of the project include:

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

1.2 PROCFish/C and CoFish methodologies

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

1.2.1 Socioeconomic assessment

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

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

Socioeconomic assessments also relied on additional complementary data, including:

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

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

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

1.2.2 Finfish resource assessment

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

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

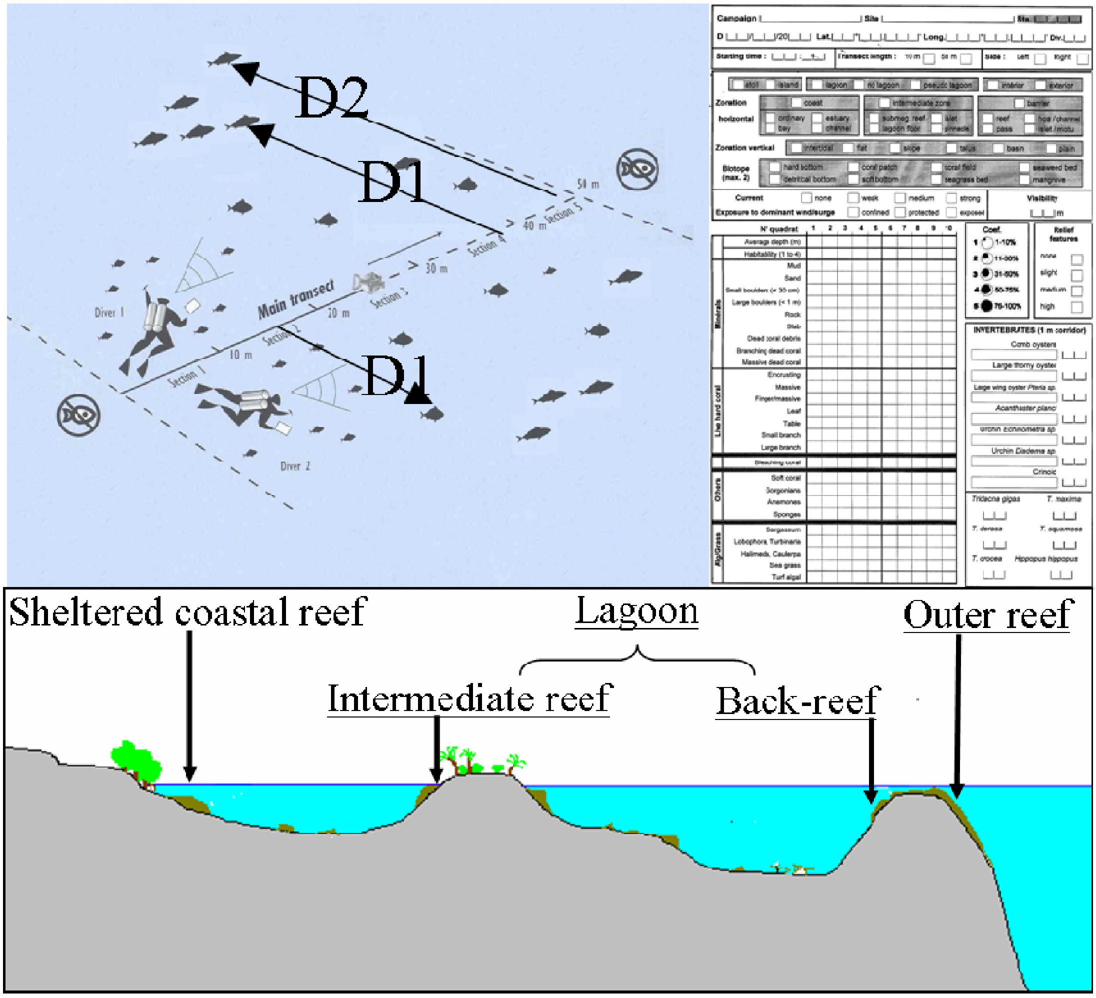

Figure 1.2: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver recorded the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys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

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

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

1.2.3 Invertebrate resource assessment

The status of invertebrate resources within a targeted habitat, or the status of a commercial species (or a group of species), was determined through:
1. resource measures at scales relevant to the fishing ground;
2. resource measures at scales relevant to the target species; and
3. concentrated assessments focussing on habitats and commercial species groups, with results that could be compared with other sites, in order to assess relative resource status.

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

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

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

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

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

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

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

1.3 Samoa

The coastal component of the Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C) conducted fieldwork in four locations around Samoa in June 2005 and August/September 2005. Samoa 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)[7].

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;

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[7] 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.

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

In Samoa, the four sites selected for the survey were Manono-uto and Vailoa on the island of Upolu, and Salelavalu and Vaisala on the island of Savai'i. 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 Samoa's Department of Fisheries.

1.3.1 General

Samoa (Figure 1.4), previously known as 'Western Samoa', is made up of the two main large islands of Upolu and Savaii, two smaller inhabited islands (Manono and Apolima) and several other rocky islets and outcrops, making up a total land area of 2935 km^2 (Talbot and Swaney 1998). The country is located between 13 S and 15 S and 171 W and 173 W. Samoa's EEZ is only 120,000 km^2 and the length of the coastline is estimated at about 447 km (Gillett 2002). The two large islands are made of volcanic rock formed from past volcanic activities. The craters of the volcanoes are aligned approximately east–west along the high central spine of the islands (Nunn 1998). The smaller islands are the remains of individual cones. Samoa is located near the southern edge of the intertropical convergence zone.

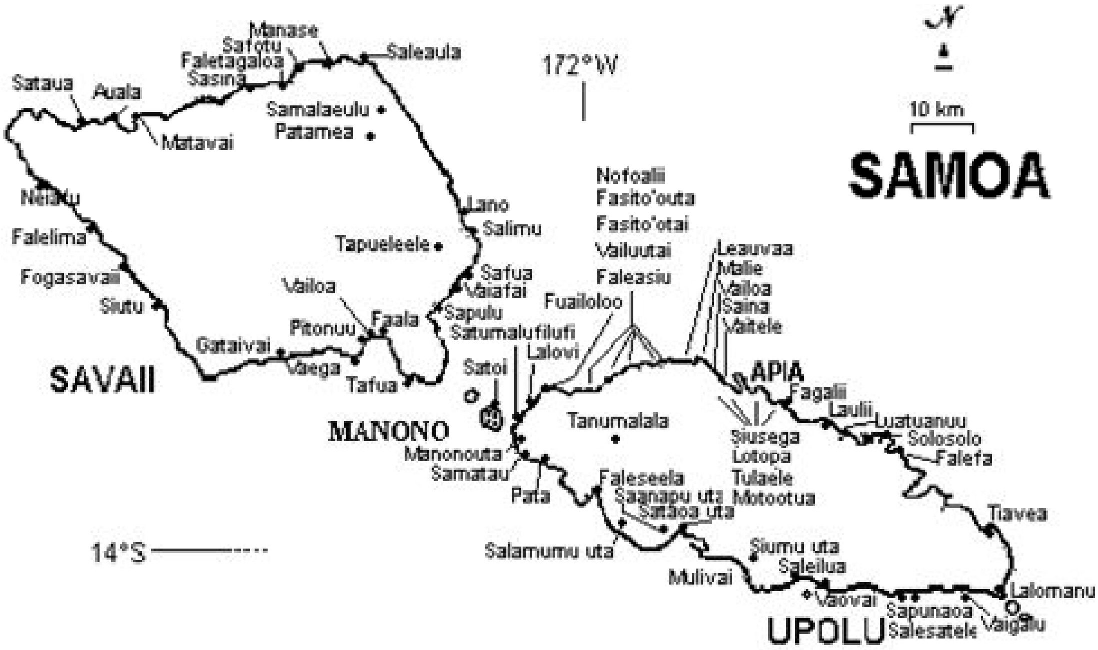

Figure 1.4: Map of Samoa.

The Samoan coastline is encircled by a barrier reef, which creates a narrow lagoon, except for the north coast of the main island, Upolu, where an extensive shelf area extends up to 14 miles offshore (Gillett 2002). There are no important inland fisheries as there are few freshwater bodies, although a number of aquaculture projects are underway.

In mid 2004, Samoa had a population of around 182,700, with an annual intercensal growth rate of 0.9%, and a population density of 62 people/km^2 (SPC 2005). About 22% of the population resides in the main urban centre and district of Apia. The population density of coastal areas is increasing, which almost always results in higher pressures on inshore resources. This is particularly true for the more accessible lagoon resources commonly harvested by village fishers who are increasing in numbers as more and more people are looking to the inshore fishing grounds for their subsistence (Passfield *et al*. 2001).

Over 70% of the villages are located on the coastal fringe of the islands, and village level fishing is a major activity of the inhabitants of these villages. A household fisheries survey in late 2000 found that there were approximately 10,800 fishers living in these coastal villages, with a further 900 living inland (Passfield *et al*. 2001).

1.3.2 The fisheries sector

Samoa's fisheries comprise the offshore fishery for tuna and other pelagic species, the small-scale tuna fishery around fish aggregating devices (FADs), the deep-water snapper fishery, and reef fisheries for a range of fish and invertebrate species. In addition, work has been undertaken in the past on deep-water shrimp fishing, and Samoa has ongoing aquaculture projects.

Offshore tuna fishery

Early surveys of the tuna and baitfish resources of Samoa were undertaken by the United States National Marine Fisheries Service, the first in February/March 1970 and the second in

March 1972 and January/February 1973 (Kearney and Hallier 1978). The conclusions from these surveys were that skipjack tuna (*Katsuwonus pelamis*) were abundant, but baitfish resources for pole-and-line operations were limited.

The SPC's Skipjack Survey and Assessment Programme (SSAP) conducted a tagging cruise in Samoan waters for nine days in June 1978, with 1768 skipjack tuna tagged, as well as 78 yellowfin tuna (*Thunnus albacares*), out of a total catch of 5440 tuna. Baitfish catches were low except for one night in Apia harbour (Kearney and Hallier 1978). Further tagging by the SSAP was undertaken for five days in February 1980, with 159 skipjack tuna tagged out of a total catch of 465 tuna (SPC 1984).

Pole-and-line fishing operations by locally based vessels have only been attempted on a small scale in Samoa. The Samoan Government acquired a 16 mt Japanese-style pole-and-line vessel (*Tautai Samoa*) in early 1978. This vessel was used for training and exploratory fishing until August 1980, resuming operations in 1982 (SPC 1984). Catches recorded by this vessel were low at around 8 mt during 1979 and 1980. In support of this operation, the Fisheries Division, with financial support from FAO/UNDP, attempted to culture mollies in 1978 as baitfish for pole-and-line fishing operations (Popper 1979). This project was terminated in 1982/83 because of the high costs and low catch-to-bait ratio (Philipp 1983).

The next development in offshore tuna fishing came as an offshoot to small-scale tuna fishing around FADs. This included the development of the *alia* catamaran (See next section for more details.) and subsequent modification of these vessels for small-scale tuna longlining in the mid 1990s, following impressive catches achieved by a 15 m tuna longliner (F/V *Marengo Bay*), which successfully demonstrated the effectiveness of horizontal longline fishing in Samoan waters (Passfield and Mulipola 1999).

The expansion of tuna longlining after the mid 1990s was swift, with *alia* catamarans being modified through a 20 cm increase in the height of the gunwale; the vessels' length being 'stretched' to 10.5 m; the addition of aluminium wheelhouses; and a strengthening of the outboard mounting area to take larger and more powerful outboard engines (Chapman 1998; Chapman 2004). It was estimated that there were around 200 vessels tuna longlining in Samoan waters in 1999, most of these being *alia* catamarans (Sokimi *et al*. 2000; Sokimi and Chapman 2000).

The increase in vessel numbers through the late 1990s saw catch rates fall, while fishing effort, or the number of hooks set per *alia* increased from 180 per set in 1995 to 320 per set in 1999 (Passfield and Mulipola 1999). Catches and export earnings went up during this period from 2092 mt (WST 13.8 million) in 1996 (one WST = USD 0.33 cents); to 4872 mt in 1997 (WST 27.5 million); and 5072 mt (WST 29.6 million), thus making fisheries the major export earner in Samoa at the time (Watt and Moala 1999). In 2000, the fleet numbers dropped to 154 vessels, with 4505 mt of fish exported for a value of WST 38.9 million (Watt *et al*. 2001).

In 1999 and 2000, the Fisheries Division requested technical assistance from SPC to conduct fishing trials on a newly designed 'super *alia*' (F/V *Ulimasao*). This vessel was an aluminium catamaran 12.2 m long and 5 m wide, powered by two 48 HP diesel engines, one mounted in each hull. The trials of this vessel were very encouraging, with 16,838 kg of fish caught in 11 trips, with over 80% of the catch being tunas: yellowfin, bigeye and albacore (Sokimi *et al*. 2000; Sokimi and Chapman 2000).

There was a serious downturn in catch rates of albacore tuna (*Thunnus alalunga*), the target species of the Samoan longline fishery, across the South Pacific from 2002. This downturn saw longline vessel numbers drop in Samoa, especially the *alia*. Vessels of <11 m (the *alia*) dropped from 116 in 2001 to 31 in 2002, 6 in 2003, and 2 in 2004, with vessels numbers for larger vessels (>11 m in length) also declining from 27 in 2002, to 18 in 2003 and 15 in 2004 (Fa'asili Jr and Time 2006). Catch rates in 2005 and 2006 improved, with *alia* vessel numbers increasing to 17 in 2005 and >22 in 2006, while the numbers of larger vessels remained at around 14–15 (Fa'asili Jr and Time 2006).

Small-scale tuna fishery around fishing aggregation devices (FADs)

Traditionally, tuna fishing has been carried out in Samoa by groups of masterfishers using specialised canoes and pearl-shell lures, the same as those used in other Polynesian countries (Hiroa 1930). During the 1960s, outboard motors were introduced to Samoa and used to power some fishing canoes (Van Pel 1960). A big advancement came with the introduction of the 8.5 m plywood *alia* catamaran in the mid 1970s through a joint FAO/DANIDA project (Fa'asili and Time 1997). From 1975 to 1979, around 120 of these plywood catamarans were constructed, each powered by a 25 HP outboard motor (Chapman 1998). By the end of the 1970s, boat builders started using aluminium to construct the *alia*. In doing this, the aluminium *alia* was lengthened to 9.0 m and a 40 HP outboard used to power them. During the 1980s, over 200 *alia* were built, mainly for fishers in Samoa, although some were exported to other countries in the region (King and Fa'asili 1997). All of the *alia* were used for both deep-water snapper fishing (See next section.) and tuna fishing, mainly trolling. Trolling catches of tuna totalled 413 t in 1972 (before the *alia*) and increased to 950 t in 1977 after the *alia* entered the fishery (Philipp 1982).

The Fisheries Division in Samoa introduced FADs to the small-scale tuna fishery in 1979 and, by late 1982, 15 FADs were deployed around the country (Philipp 1983). The trolling catch of tuna greatly increased with the introduction of FADs and was recorded at 1440 t in 1982 (Philipp 1983).

In October 1980, the Fisheries Division converted an *alia* (*Tautai Nouei*) for small-scale pole-and-line fishing trials around FADs (Philipp 1981). Two private operators also converted their *alia* for pole-and-line fishing in 1981 (Philipp 1982). These trials used the cultured mollies as baitfish; however, the results from fishing activities were mixed as the mollies were not good bait for tuna fishing activities. The trials were stopped when the mollies' project ceased in 1982/83 (Philipp 1983).

Another fishing method trialled around the FADs in the first half of 1983 was a gillnet. The net had a mesh size of 150 mm (6 inches), with the net 1700 meshes long and 120 meshes deep. The net was hung on a 10 mm polypropylene head rope with floats every 3 m (10 feet). There was no foot rope; the net was left free to entangle fish that encountered the net (Anon 1983). Three trials were undertaken. The first set yielded a catch of 198 skipjack of around 2 kg (4–5 lb) each. The second trial used mollies to attract the tuna to the net, with a catch of 980 yellowfin and skipjack tuna of around 1–1.5 kg (2–3 lb) each. Some net damage occurred during the second trial, caused by sharks. The third trial produced very few fish, with the middle of the net torn by large fish, probably marlin or sharks (Anon 1983).

Trolling was the main catching method used by Samoan tuna fishers in the 1980s, with catches peaking at over 1600 t in 1986 and 1988 (Anon. 1998). This changed in 1990 and

1991, when two cyclones devastated the *alia* fleet, destroying over half the vessels and damaging many others (Fa'asili 1997; Sokimi *et al*. 2000). The Samoan government used its funds to rebuild the fleet, with around 60 vessels back in operation by 1993 (Fa'asili and Time 1997).

Also during 1990 and 1991, the Samoan Fisheries Division requested technical assistance from SPC to conduct mid-water fishing trials around FADs, targeting the larger, deeper-swimming fish. The Fisheries Division vessel, R/V *Tautai Matapalapala*, was fitted out for these trials, which focused on using vertical longlines with baited hooks fishing at different depths (Watt *et al*. 1998). Eleven fishing trips were undertaken during the initial trials, using 10 vertical longlines, each with a length of either 275 or 365 m, with 10–15 hooks per line. A total of 130 fish, primarily tunas, were taken for a weight of 1866 kg (Watt *et al*. 1998). Following the success of the initial trials, a second set of trials was undertaken, with the aim of transferring the equipment and technology to the *alia*. A wooden reel was constructed and mounted on an *alia* for storing the mainlines. The trials were very successful, with 20 trips undertaken resulting in 181 fish weighing 2819 kg being caught (Watt *et al*. 1998).

The results of the vertical longlining trials created a lot of interest among local tuna fishers with *alia* catamarans. Some geared up with vertical longlines, while others followed the success of horizontal longline fishing trials in 1994/95, which led to the rapid expansion of the *alia* fleet into small-scale tuna longlining. With most of the *alia* fleet converting to tuna longlining in the late 1990s, the Fisheries Division cut back on FAD deployments and the troll fishery also reduced. However, the decline in the tuna longline fishery from 2002 to 2005 saw the Fisheries Division scale up their FAD programme as more *alia* fishers converted back to trolling for tuna to earn a living.

There are also several charter and gamefishing vessels that troll both in open water and around the FADs (Whitelaw 2001). In 2000 around 20 charter vessels were estimated, ranging from 4.3 m aluminium runabouts to *alia*. Other vessels were also involved in gamefishing, with an annual tournament held in August and monthly tournaments held throughout the year (Whitelaw 2001).

Deep-water snapper fishery

Initial deep-water snapper fishing trials were undertaken from Asau, Savai'i, by the SPC's Outer Reef Artisanal Fishing project in 1975 (Hume and Eginton 1976). The project brought in two vessels to conduct the trials and also used one of the locally built, plywood *alia*. Nine fisheries staff and 13 fishers were trained in deep-water snapper fishing gears and techniques, while the results of the trials were used to assess the potential for a deep-water (100–400 m) snapper fishery in Samoa. A total of 77 fishing trips were undertaken with a catch of around 6370 kg (Hume and Eginton 1976).

Following the success of the deep-water fishing trials, the FAO/DANIDA project set up a training team of fisheries staff, using two *alia* to promote this fishing method (Gulbrandsen 1977). Over an 11-month period, 27 villages were visited by the team, with 540 fishers trained and a total catch of 16.7 t recorded. This training was also to promote the *alia* catamaran, and 50 fishers placed orders for these vessels by the end of 1976. The boat-building project also designed a simple wooden handreel (the 'Samoan handreel') to install on the vessels to make deep-water snapper fishing easier (Gulbrandsen 1977).

Deep-water snapper fishing continued to expand, although the *alia* fishers switched between trolling for tunas and bottomfishing, depending on weather and the availability of fish (Chapman 2004). With the expansion of deep-water snapper fishing effort, the Samoan Fisheries Division requested SPC in 1982/83 to conduct some survey work, as fishers were reporting declining catches (Preston *et al*. 1997). Over a period of two months, 11 overnight fishing trips were undertaken across the northern coast of Upolu Island. A total of 341 fish weighing 1746 kg were taken during this survey, with the results indicating that the resource was not being overfished (Preston *et al*. 1997).

Several estimates have been made of MSY for the Samoan deep-water snapper fishery: 1000 t/year (Gulbrandsen 1977); 22–65 t/year (Dalzell and Preston 1992); and 88–118 t/year (King *et al.* 1990).

Fishing activities for deep-water snapper continued through the early 1980s, with catches averaging around 400 t/year, with the high-quality fish exported to Hawaii (Gillett 2002). In 1984, the catch of deep-water snappers increased to 500 t/year, and peaked at around 950 t in 1986 (Anon. 1998). By this time, catch rates for deep-water snappers were declining, with some vessels focusing more on trolling for tunas, while others dropped out of the fishery. By the late 1980s, the working *alia* fleet had reduced to around 100 vessels (Gillett 2002).

As stated in the previous section, the two cyclones of 1990 and 1991 devastated the *alia* fleet. When *alia* fishers started fishing again in the early to mid- 1990s, they focused on trolling, with some deep-water snapper fishing. In 1993/94 it was estimated that around 30 *alia* were targeting deep-water snappers (Mulipola 2002; Bell and Mulipola 1995), and landing data on these species indicated the resource was below sustainable levels (Mulipola 1997; Bell and Mulipola 1995). In the mid-1990s, there was a rapid change in fishing practices, to small-scale tuna longlining, with very little focus directed at the deep-water snapper fishery. However, with the downturn in tuna longlining in the early 2000s, some *alia* fishers switched back to deep-water snapper fishing. In 2003, the Fisheries Division started to conduct a survey of the deep-water snapper resources, collecting data for a stock assessment (Chapman 2004).

Deep-water shrimp survey

A survey for deep-water shrimps was undertaken off Apia, Samoa in September 1980. Baited traps were set in 306–846 m depth, with six species of Caridae and one species of Penaeidae shrimp identified (King 1980). Catch rates varied from 0.9 kg/trap for the shallower depths, reaching a maximum of 1.4 kg/trap in the 500–600 depth range. Results remain inconclusive given the limited time and restricted area surveyed (King 1980).

Aquaculture

Samoa has little tradition in the field of aquaculture (Mulipola 2002), although some communities traditionally placed some giant clams in a fenced-off area on village reef and lagoons for special occasions or for supplementary food during bad weather (Bell and Mulipola 1998). The first investigation for aquaculture potential was undertaken by SPC in 1954 (Van Pel 1954). This led to the introduction of Mozambique tilapia (*Oreochromis mossambicus*) to Samoa soon after (Ponia and Nandlal 2004).

1: Introduction and background

In 1970/71, the Samoa Fisheries Division commenced a hawksbill sea turtle (*Eretmochelys imbricata*) conservation programme, to build up depleted stocks by harvesting nesting animals and their eggs (Witzell 1973). Eggs were collected from the wild, hatched and the young turtles reared until 4 weeks old before being released to sea at dusk, 2–5 miles outside the reef (Witzell 1973). This project expanded and, in 1976, a total of 5254 eggs were collected, with 1856 sea turtles returned to the sea after being marked. By 1978 a total of around 13,000 hawksbill sea turtles had been released by the project (Travis 1980). It was felt that the project was successful, as there appeared to be more of these turtles around, and some were even being sold in the Apia market, which was not common in the past (Travis 1980). This project closed in 1983 (Bell and Ropeti 1995).

During the 1970s and early 1980s, several other commodities were introduced to Samoa for aquaculture projects. Seaweed (*Kappaphycus alvarezii* and *K. denticulatum*) was initially introduced in 1975 (Bell and Ropeti 1995). The Fisheries Department conducted culture trials on seaweed in 1991, but these ceased in 1992 (Ponia and Nandlal 2004; Bell and Ropeti 1995). In 1978, FAO funded aquaculture trials of the top minnow or mollie (*Poecilia mexicana*) as bait fish for pole-and-line fishing operations (See 'Offshore tuna fishery' section, above). While the trials were successful, the project was abandoned in 1983 because of the economics of the operation (Ponia and Nandlal 2004; Philipp 1983). The tiger prawn (*Penaeus monodon*) was introduced from Tahiti in 1979 by the Fisheries Division and FAO, with the aim of testing the commercial viability of production; however, this project did not develop any further (Bell and Ropeti 1995; Bell and Mulipola 1998).

Trials for culturing and growing Philippine green mussels (*Perna viridis*) were commenced in Samoa in 1981 at four sites; however, by 1983, operations had stopped at two locations due to localised problems (Bell and Albert 1984). The juvenile mussels were imported from Tahiti for the trials, and were reared on ropes attached to rafts. The 1983 trials allowed them to spawn; however, there was no success at collecting the spat. Good growth rates were recorded (just over 1 cm/month) and local marketing trials for the mussels were very successful in 1983 (Bell and Albert 1984). Trials continued through the 1980s, although the project was discontinued by 1990 (Bell and Ropeti 1995; Mulipola 2002).

The giant clam (*Tridacna derasa*) was first imported from Palau in 1982, which led to a private sector commercial farm being set up; however, the farm was destroyed by the 1990 and 1991 cyclones (Ponia and Nandlal 2004). The Fisheries Division also imported clams (*Tridacna* spp. and *Hippopus* spp.) in 1987 from several locations (Palau, Tokelau, Australia, Solomon Islands, Fiji Islands and American Samoa), mainly for farming and restocking purposes (Bell and Ropeti 1995). The cyclones also affected this operation (Ponia and Nandlal 2004). The AusAID community management project in the mid to late 1990s introduced hatchery-reared clams to village fishing reserves established under the project, with around 1700 young clams provided to villages in 1999/2000 (Gillett 2002). The recommendations of this project also led to the establishment of the Toloa giant clam hatchery in 2000 (Ponia and Nandlal 2004). The Toloa hatchery continues to propagate giant clams, with around 60,000 juveniles (around 4 cm in length) being cultured on-site in 2003. A lot of the broodstock for the hatchery perished in January 2004 as a result of Cyclone Heta (Ponia and Nandlal 2004). The Fisheries Division is continuing with this project.

Two other species were introduced to Samoa in 1990: the Pacific oyster (*Crassostrea gigas*) and the commercial topshell (*Trochus niloticus*). The oysters came from California and the trials were to test commercial viability; however, after the harvest in 1991, there was no further activity due to constraints that could not be overcome (Bell and Ropeti 1995; Ponia and Nandlal 2004). The trochus were brought in from Fiji Islands under an FAO/Fisheries Division project for seeding to enhance the resource (Bell and Ropeti 1995).

The green snail (*Turbo marmoratus*) was introduced to Samoa in April 1999, when 300 individuals were imported from Tonga (Trevor 2000). The animals were held in quarantine at the Fisheries Department's raceway ponds before being released at three locations that had the appropriate habitat. There were also village management arrangements in place as part of the community-based fisheries management programme.

A tilapia demonstration farm was established in 1993, which also saw the introduction of the Nile tilapia (*Oreochromis niloticus*), although there were some early problems encountered with feed quality and management at the farm. Several other tilapia farms were subsequently established and, by 2000, there were 19 tilapia farms: 11 on Upolu and 8 on Savai'i (Gillett 2002). From October 1999 to May 2000, around 4000 tilapia were stocked in 9 ponds, with the fish growing to a harvestable size in six months, when properly cared for (Gillett 2002). In 2004, the Fisheries Division's hatchery was upgraded with assistance from SPC, to allow for increased production of Nile tilapia fingerlings (Ponia and Nandlal 2004).

Tilapia rearing was not confined to ponds, and a project was undertaken in 2006/07 to restock Lake Saroalepai on the island of Savai'i. This lake had originally been stocked with Mozambique tilapia in 1966 and was restocked with Nile tilapia in 1994 and 2003 (Nandlal *et al*. 2007). In July 2006, 10,000 Nile tilapia fingerlings were transported from the Apia hatchery, tagged (clipping of the right pelvic fin with scissors) and released into the lake. Fishing was banned in the lake during these trials so that growth rates could be calculated. The fish were checked to see if there was any interbreeding between the wild Mozambique tilapia in the lake and the Nile tilapia. The final sampling took place in April 2007; the growth rate was calculated to be 0.44 g/day, which was low but acceptable given the overall condition of the lake environment (Nandlal *et al*. 2007).

Reef and reef fisheries (finfish and invertebrates)

The Samoan coral reefs and marine habitats have been impacted by natural and human perturbations for many decades. The natural disturbances include repeated crown-of-thorn outbreaks, with more recent infestations occurring from 1978 to 1983 and in 1993 (Zann and Su'a 1991; Mulipola 1997); cyclone damage (Ofa and Valerie in 1990/91); bleaching; and coral diseases (Mulipola 1997). Similarly, humans also pose major problems to the reef system by indiscriminately exploiting resources, causing pollution and sedimentation, and using dynamite for fishing (Mulipola 1997; Mulipola 2002).

The Samoan reef ecosystem and recent research on finfish and flora are described in several published works. Wass (1984) listed 991 species representing 113 families and 284 new records for Samoa (covering both American Samoa and Western Samoa). Zann (1989) compiled a scientific checklist, in English and Samoan, of marine fishes and other marine organisms excluding plants, although the list was incomplete. The status of important marine and freshwater fishery resources (including finfishes, crustaceans, molluscs, seaweeds, bêche-de-mer, sea urchins, *palolo*, and jellyfish) have been documented by Bell and Mulipola (1995).

Kramer (1994) and Gosliner *et al*. (1996) listed 50 hard coral species from Samoa; relatively few compared to in the neighbouring archipelagos of Fiji Islands (163 species). The recent compilation of algae from Samoa and American Samoa by Skelton and South (1999) listed 198 taxa, representing about 50–60% of the potential algal flora from Samoa. Two species of seagrass are found in Samoa: *Halophila ovalis* and *Syringodium isoetifolium* (Hartog 1970, cited in Skelton *et al*. 2000). Seagrass beds are limited in the country, with perhaps the best community found around Manono Island and in the northern part of Upolu Island, where the substratum is generally of soft, muddy sand (Bell and Mulipola 1995; Skelton 2000).

The Samoan people, similar to other Pacific Island populations, traditionally depend on coastal fisheries for subsistence, exploitating the shallow lagoons and relatively accessible reefs. Commercialisation (in varying degrees) has now become a major factor in the exploitation of these marine resources. Fishing is conducted from small vessels (including *alia*) and canoes, or on foot, and includes the use of spears, nets, hook and line or, in the case of some invertebrates, hand-gleaning (Gillett 2002).

According to data collected by the Fisheries Division, trends in commercial fish landings at the Apia fish market declined dramatically from 250 mt in 1986 to just over 50 mt in 1993, and increased again to 130 mt in 1997 (Horsman and Mulipola 1995; Mulipola 1997). Although significant, the commercial catch of reef fish and invertebrates is small compared to the total subsistence catch of these species, with Gillett (2002) estimating the subsistence catch in 1999 at 4293 mt. Samoa's most important resources for small-scale fisheries include finfish (surgeonfish, groupers, mullets, carangids and rabbit fish), octopus, giant clams, bêche-de-mer, *Turbo* spp. and crabs (Gillett 2002). Fishery production from subsistence and small-scale commercial inshore fisheries was estimated to be over 7000 mt in the year 2000 (Passfield *et al*. 2001).

Samoilys and Carlos (1991) reported a reduction in biomass and size of fish in shallower and more heavily fished areas, but found high biomass in less fished and deeper reef slopes. Green (1996) confirmed these findings after surveying seven sites in Upolu Island. She observed that deeper habitats had more species than shallower sites. Green (1996) also reported that, while the Samoans have continued to rely on their coral reef ecosystems, the inshore reefs are becoming severely degraded and threatened, mainly as a result of human activities.

Mulipola (1997) reported on a creel census conducted on Savai'i in 1996/97, where the majority of surgeonfish fell within the 16–20 cm length interval, indicating heavy fishing pressure. Other species recorded included parrotfish and wrasses (16–30 cm); emperors (70% were 16–20 cm.); snappers (16–30 cm); mullet (11–20 cm or >40 cm); and trevallies (16–30 cm). The majority of predatory species from the lagoon and reefs were 16–20 cm, with much of the recorded catch from the study below minimum legal size as allowed under the Fisheries Regulations of 1995 (Mulipola 2002).

There have been no live reef food fish activities in Samoa. However, a small aquarium fish trade was established in 1986, but stopped after one or two years (Mulipola 2002). Harvest and export of aquarium fish began again in late 1992, with 65,527 fish exported in 1992/93, and 30,405 fish in 1993/94. The main fish exported included assorted damsels, wrasses and angelfish (Mulipola 2002). A 1997 Cabinet decision by the Government of Samoa placed a total ban on the harvesting and export of ornamental fish. However, licences were issued for the export of 'bio-rock', with around 3890 pieces exported in 1997/98 and 7526 pieces exported in 1998/99 (Mulipola 2002). In 2008, the Government of Samoa asked SPC for assistance in conducting a survey of aquarium fish around Upolu Island, to assess the potential to re-open this fishery and recommend appropriate management measures if the assessment finds the fishery to be viable.

Sea cucumbers have been traditionally collected for food in Samoa. The commercial harvest of sea cucumbers, processed to become bêche-de-mer, started in the 1960s and 1970s, although there are no catch records from this period (Mulipola 1994). Records show that there were five commercial companies exporting bêche-de-mer in the early 1990s. However, due to over-harvesting, the commercial fishery was closed in 1994 (Mulipola 1994). Sea cucumbers could still be legally collected, but only for subsistence or local sale. In tandem with the survey work conducted by the PROCFish/C project in 2005 and presented in this report, a study was also undertaken on the sea cucumber resource of Samoa by a Masters student, with the results presented in Eriksson (2006). Eriksson (2006) recorded seven species of sea cucumbers at a range of densities, which showed that stocks were limited, despite the commercial fishery being closed for over 10 years. Local fishers indicated that this was due to the previous commercial harvest and cyclones (Eriksson 2006).

1.3.3 Fisheries management

The use of legislation to regulate fishing and promote research, development, conservation and monitoring efforts recognises the *fa'a Samoa* (Samoan way) (Mulipola 2002). Harmonising State laws and the customary system has improved the management of marine resources in the country.

The management and conservation of marine resources have been scattered in different legislation. For instance, Land Ordinance (1959, amended in Fisheries Act 1988, part VIII: 27 [2a-b]) controls coastal aquaculture activities; the National Parks and Reserves Act (1974) provides for the establishment of marine parks and reserves; the Fisheries Act (1988) promotes the conservation, management and development of fisheries and the licensing and control of foreign fishing vessels, as well as the protection, preservation and development of fisheries (This Act is in the process of being repealed.); the Lands, Surveys and Environment Act (1989) was made to promote and ensure the protection of natural resources and environment; the Village Fono Bill (1990) verifies the power and authority of the village *fono* in the management of marine resources and also considers some of the decisions or penalties handed out by the village councils that are appropriate to traditional culture; Fisheries Regulations (1996) controls the catch of certain marine species, fishing practices and FADs; Village Bylaws (1998) promote the protection, conservation, management and sustainable development of the fishery waters and marine environment of each individual village in the AusAID-assisted Fisheries Extension Programme (So far, 57 fisheries bylaws have been gazetted and enforced by communities.) (Mulipola 2002). The Fisheries Act (1988, amended through the Fisheries Amendment Bill 2002), and the Fisheries Regulations (1996) are the legislation currently used in Samoa for fisheries and aquaculture, although this legislation is being reviewed.

Traditionally, the Samoans had elaborate customs of ownership and control of fishing rights. The right to fish in reef, lagoon and mangrove areas was owned by adjacent villages, families or chiefs. However, these customs have largely disappeared as far as reefs and lagoons are concerned, in part because all land below the low-water mark rests with the State. This gives the right to all people to navigate over the foreshore and fish within the limits of the territorial waters of the State (Bell 1985). However, the recent passing of the Fono Act (1990) gives the authority back to the village chiefs to control their traditional fishing grounds. Similarly, the introduction of village bylaws further promotes village 'ownership' and management of adjacent lagoon and reef fishery resources. However, the bylaws only cover people from that village, and they cannot be applied to someone from another village fishing in their traditional fishing grounds as this would contravene the 'public land section' of the Constitution (South *et al*. 1998).

In support of conservation, the Government of Samoa declared the first national marine reserve in 1974, Palolo Deep. Other government departments, NGOs and SPREP have further promoted conservation initiatives, mainly through the establishment of marine protected areas (MPAs). This was also one of the management tools used by the Fisheries Division as they assisted communities to establish community-based management plans for their village. There are many small MPAs around the country now as part of the community-based management initiative, and these are supported by legislation. Samoa has been a leader in the area of co-management; other countries are adopting a similar approach to managing their inshore resources.

1.4 Selection of sites in Samoa

In Samoa, 28 possible sites were investigated to some degree, with the number reduced to four, the usual number of sites covered in one country by the project. A site is defined as a fishing community and its associated fishing ground. These sites also shared most of the required characteristics for our study: they had active reef fisheries, were representative of the country, were relatively closed systems[8], were appropriate in size, possessed diverse habitats, presented no major logistic limitations that would make fieldwork unfeasible, had been investigated by previous studies, and presented particular interest for Samoa's department of fisheries. The site selection in Samoa was done in two stages, leading to the selection of two sites; Manono and Vailoa-Aleipate on Upolu Island; and two sites: Saleleloga and Vaiola on Savaii Island (Figure 1.4).

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

2. PROFILE AND RESULTS FOR MANONO-UTA

2.1 Site characteristics

The study concentrated on Manono, consisting of Manono-uta and Manono-tai (Figure 2.1). Manono-uta is a village of 1997 people and 146 households with an average of 9 people per household (Statistical Services Division 2001). Inhabitants of these two villages belong to the same clan, sharing fishing rights and access to the fishing areas. The local population resides along the immediate coastal area, about 2 km long. With approximately the same ratio of males to females, the village population represents a substantial 28% of the whole district of Aiga I Le Tai. Manono-tai is an island located a little over 4 km NW of Manono-uta and Upolu mainland and is connected by A'ana reefal platform. This particular reef habitat appears to be the largest and provides the most important inshore fishery in Samoa. There are several settlements or minor sub-villages on the island with separate communal arrangements.

Manono has a well defined and distinctive barrier reef that extends out over 4 km from mainland Manono-uta and encompasses Manono tai (Manono island). To the northwest of the island is the large island of Savaii over the Apolima Strait, which separates Upolu and Savaii and covers the boundary of Manono. This strait feeds oceanic current into Manono lagoon. The lagoon is naturally shallow (4–6 m deep and, in some areas, <1 m deep). While the lagoon allows easy access to the outer-reef slope on the eastern side, the western side of the Manono fishing ground is relatively exposed, particularly during westerly winds. The reef is relatively continuous, with a few reefs outcropping, located up to 50 m from the barrier reef and away towards the ocean. This might contribute to the rough seas and strong currents experienced when diving immediately outside the outer reef. The outer barrier reef steeply drops to over 15 m and then gently slopes off to the deeper ocean bottom. The top 5 m of the reef slope has a moderately high live-coral cover but the coral community assemblage was, at the time of survey, predominantly dead, with high algae coverage towards the deep. Most skeletal coral colonies are still standing but are heavily eroded, which suggests a recent mass mortality of corals.

The lagoon is predominantly sandy, at least for most of the Manono-uta coastal area, with a few scattered patch reefs. There is poor visibility in the lagoon on most occasions, perhaps caused by fine silt and sand suspended in the water column, stirred up by strong winds and currents. The survey sites in the lagoon were chosen to minimise the inclusion of large areas of open sand. The width of these reef sites was fixed arbitrarily at 60 m to enable the team to spread the 50 m transect line. Zann (1992) reported that the inner lagoon of Manono-uta has a coral sandy bottom, dominated by a wide band of seagrass. Similarly, the swampy coastal shores are generally made of fine, coralline sediments, which are fed by longshore currents from the southern lagoon.

There are patches of good coral cover at the back-reef, with excellent visibility in all cases. The back-reef drops off very gently into the deeper part of the lagoon. On the outer-reef slope, the survey sites were constituted by both the crest and slope of the reef. In most cases the slopes were steep, giving study sites of 20–50 m in width. There were several narrow passes around the fishing ground, which made it easy for the team to move in and out of the lagoon.

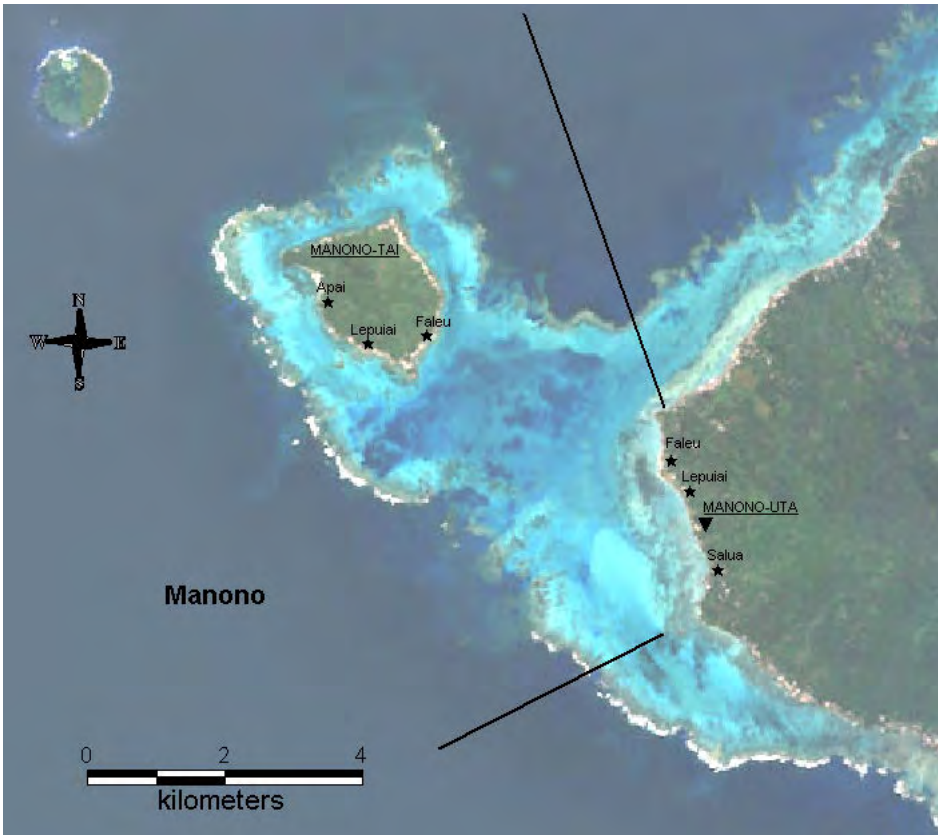

Figure 2.1: Map of survey site, including the coast and the island of Manono-uta.

2.2 Socioeconomic surveys: Manono-uta

Socioeconomic fieldwork was carried out in Manono-uta, Upolo, Samoa 8–19 June 2005. The fieldwork included household surveys in five villages: Lepunanaia, Faleu, Sautitoa and Apai on the mainland, and Manono-tai on Manono Island. Combined field survey results refer to the site as 'Manono-uta' in the following. Manono-uta is one of the main fishing communities close to Apia, the capital of Samoa, where demand for reef fish is highest. The community owns one of the biggest reef systems in Samoa, and depends very much on reef produce for income and subsistence needs. The close proximity to a major market (5 km), good road and carrier infrastructure (buses, private carriers, and public vans) and the availability of distribution outlets, have enabled fisheries products to be highly commercialised.

The Manono-uta community has a resident population of 1997 and about 200 households. A total of 67 households (33.5% of the total number of households in the Manono-uta community) were surveyed, with almost all (98.5%) of these households being engaged in some form of fishing activities. In addition, a total of 115 finfish fishers (96 males, 19 females) and 63 invertebrate fishers (46 males, 17 females) were interviewed. The household size is large (9 people on average), due to the practice of living together in extended families (*aiga*). The *aiga* or extended family grouping enables people to divide work so that everyone has designated tasks relating to farming, fishing or general community obligations.

From a demographic point of view, over 50% of the community's population is less than 25 years old, implying that, in future, the demand for employment, income generation and food will grow and that fishing pressure may possibly increase.

Household interviews focused on the collection of general demographic, socioeconomic and consumption data. General information on sales and distribution of fisheries resources was gained through interviews with shopkeepers and boat owners. A general survey of shops to establish prices of tinned fish and other food items consumed was also conducted.

People from Manono-uta have access to fringing reefs, a wide lagoon and outer-reef fishing areas, which overlap into the fishing areas of adjacent villages. The A'ana reef, the largest reef platform in Samoa, links Upolu with the near-shore island of Manono-tai. This reef is characterised by a distinctive barrier reef enclosing a deep, sandy lagoon. Its adjacent shores are swampy and the inner lagoon is dominated by seagrass. The A'ana reef is known in Samoa as one of the most important inshore fisheries in the country.

Travel from Manono-tai to the mainland takes about 10 minutes by boat. Regular boat transport is available throughout the day. Boats that are owned by households in the community, and that have been recorded in the survey, are therefore not all used only for fishing, but sometimes also for transport. People in Manono-uta (on the mainland) and Manono-tai belong to the same clan, share fishing rights and have access to the same fishing grounds. The study was therefore designed to cover both parts of the community. Survey results also showed that fishers from Manono sometimes venture to outer reefs that are outside their own fishing ground, i.e. the Apolima Strait, especially when fishing commercially.

There are a number of small-scale commercial fishing ventures in the community. These include groups selling under a form of cooperative arrangement where middle sellers hire groups of fishers to fish; these fishers in return get paid after the catch is sold. For example, a woman middle seller, who owns 8 canoes and 10 gillnets and has been in operation since 1980, hires male fishers who conduct three fishing trips per day with three separate loads of fish to be sold at the market daily. These commercial ventures significantly influence fishing patterns and foster commercial fishing. Apart from the available middle sellers and distributors, there are also specific buyers of fisheries products in Apia.

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

Our results (Figure 2.2) suggest that fisheries is by far the main source of household income with almost 65% of households stating fisheries as their primary (~33%) or secondary (~32%) source of revenue. This is followed by salaries, the second most important first income source (~28%), other forms of income, including handicrafts, occasional work, and small private business (~24%) and agriculture (~16%). The close proximity to Samoa's capital city may explain why salaries are more important for revenue than agriculture and other sources. Pigs and chickens are popularly reared for *falavelave* and for selling. Distribution of fish and seafood produce on a non-monetary basis is a very important and traditional practice all over Samoa, and thus also in Manono-uta. Certain key persons, such as the pastor of the village, usually get the largest fish from weekly catches as a gift, and people are also obliged to donate catch to church functions, services and family members. Catch is also a means to pay for the use of motorised boats, canoes and fishing gear, if borrowed. In fact, income from fisheries often is a mixture between barter and small-scale economic operations as various community members are engaged in both. Also, commercial fishing in Manono-uta is well organised through fishing networks and fishing groups who systematically distribute their catch to the various outlets and main markets in Apia.

Commercially oriented fishing networks include individuals selling their catch, fisher groups selling via a cooperative system, and the hiring of fishers by middle sellers or businessmen who buy and market the catch. These middle sellers and fish buyers usually own motorised or non-motorised boats, which they provide to the fishers they hire.

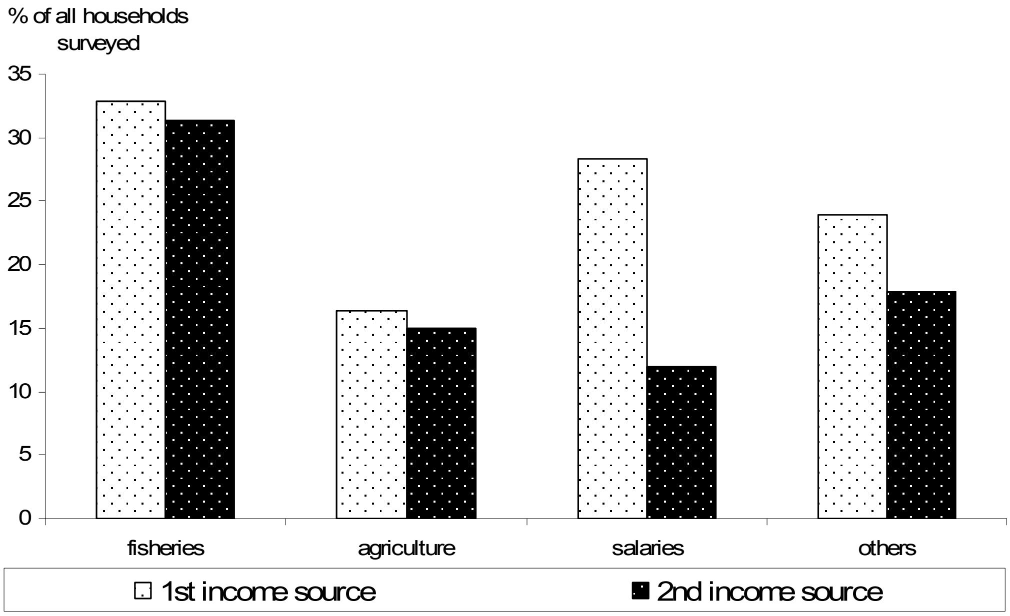

Figure 2.2: Ranked sources of income (%) in Manono-uta.
Total number of households = 67 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small business.

Our results (Table 2.1) show that annual household expenditures are high with an average of USD 3625. Families claimed to spend cash mainly on necessary food and household items including *falavelave. Falavelave* are traditional or religious obligations relating to weddings, births, christening of children, funerals, etc. The household expenditure also includes weekly church donations, which people regard as a basic obligation.

Remittance is an important component of Samoa's household income with 91% of all households surveyed in Manono-uta receiving on average USD 2243 per year. The high number of households that receive remittances and the average amount of USD >2000 per year is consistent throughout all four study areas in Samoa. The many Western Union outlets (offices for transferring money overseas) throughout the two main islands of Samoa are a good indicator of the importance of remittances to the Samoan livelihood. Comparing the average annual household expenditure and the average annual remittances received, it is evident that the basic costs of an average family in the Manono-uta community are met by external donations. Therefore, it is not surprising that most families interviewed described remittances as either the main or one of the major sources from which most of the *falavelave* are met. The frequency of remittances received ranges from once a fortnight to once a month, and most of the foreign currency received is sourced from New Zealand.

Survey results indicate an average of 2–3 fishers per household and, when extrapolated, the total number of fishers in Manono-uta is 516: 418 males and 98 females. Amongst these are 245 fishers who exclusively fish for finfish (227 males, 18 females), 30 fishers who exclusively fish for invertebrates (3 males, 27 females), and 242 fishers who fish for both finfish and invertebrates (188 males, 54 females). About 69% of all households own a boat, and most (~80%) are non-motorised canoes; only ~20% are equipped with an outboard engine.

Table 2.1: Fishery demography, income and seafood consumption patterns in Manono-uta

	Site (n = 67 HH)	Average across sites (n = 207 HH)
Demography		
HH involved in reef fisheries (%)	98.5	91.3
Number of fishers per HH	2.58 (±0.14)	2.03 (±0.09)
Male finfish fishers per HH (%)	43.9	46.6
Female finfish fishers per HH (%)	3.5	2.9
Male invertebrate fishers per HH (%)	0.6	2.1
Female invertebrate fishers per HH (%)	5.2	13.3
Male finfish and invertebrate fishers per HH (%)	36.4	25.9
Female finfish and invertebrate fishers per HH (%)	10.4	9.3
Income		
HH with fisheries as 1st income (%)	32.8	25.1
HH with fisheries as 2nd income (%)	31.3	27.1
HH with agriculture as 1st income (%)	16.4	28.5
HH with agriculture as 2nd income (%)	14.9	27.5
HH with salary as 1st income (%)	28.4	17.9
HH with salary as 2nd income (%)	11.9	11.6
HH with other source as 1st income (%)	23.9	28.5
HH with other source as 2nd income (%)	17.9	8.2
Expenditure (USD/year/HH)	3624.53 (±258.85)	2991.32 (±209.55)
Remittance (USD/year/HH) (1)	2243.05 (±150.96)	2170.81 (±89.23)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	79.37 (±11.90)	61.26 (±4.35)
Frequency fresh fish consumed (times/week)	4.24 (±0.14)	3.92 (±0.10)
Quantity fresh invertebrate consumed (kg/capita/year)	4.09 (±0.67)	9.61 (±4.35)
Frequency fresh invertebrate consumed (times/week)	0.46 (±0.06)	0.49 (±0.04)
Quantity canned fish consumed (kg/capita/year)	21.17 (±4.56)	24.26 (±1.92)
Frequency canned fish consumed (times/week)	2.27 (±0.16)	2.81 (±0.11)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	97.0	83.6
HH eat canned fish (%)	97.0	97.6
HH eat fresh fish they catch (%)	82.1	82.1
HH eat fresh fish they buy (%)	23.9	23.9
HH eat fresh fish they are given (%)	59.7	59.7
HH eat fresh invertebrates they catch (%)	52.2	52.2
HH eat fresh invertebrates they buy (%)	19.4	19.4
HH eat fresh invertebrates they are given (%)	64.2	64.2

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

Fresh fish consumption is high, >79 kg/person/year, which exceeds the average across all four study sites in Samoa, and is more than double the regional average of ~35 kg/person/year (Figure 2.3). By comparison, consumption of invertebrates (edible meat weight only) (Figure 2.4) is relatively low, ~4 kg/person/year. Canned fish (Table 2.1) adds another ~21 kg/person/year to the protein supply from seafood. The pattern of seafood consumption found in Manono-uta highlights the fact that people have access to a variety of agricultural and marine food sources, as well as to commercially available food items. Canned fish, locally named *elegi,* is a regular constituent of *falavelave*, which may explain the large quantity consumed.

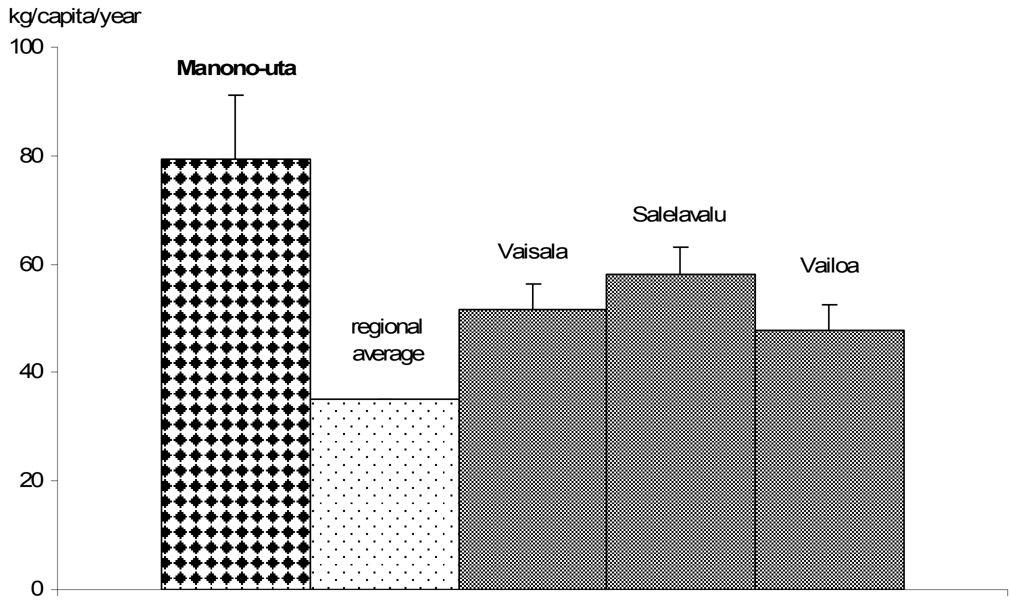

Figure 2.3: Per capita consumption (kg/year) of fresh fish in Manono-uta (n = 67) compared to the regional average (FAO 2002) and the other three PROCFish/C sites in Samoa.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

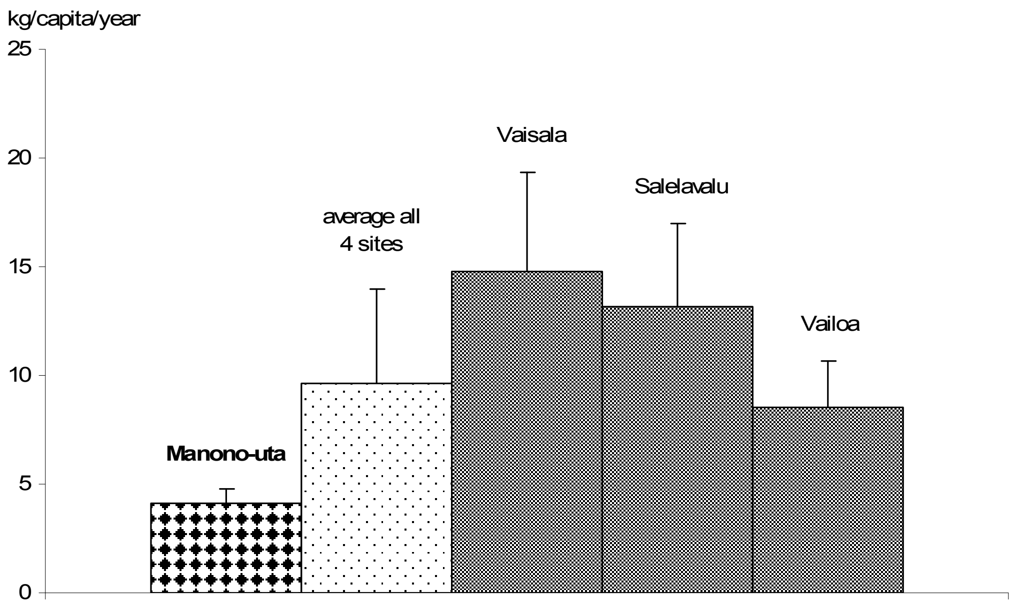

Figure 2.4: Per capita consumption (kg/year) of invertebrates (meat only) in Manono-uta (n = 67) compared to the average of all four sites and the other three PROCFish/C sites in Samoa.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Comparing results obtained for Manono-uta to the average figures across all four study sites surveyed in Samoa, people of the Manono-uta community eat fresh fish, invertebrates and canned fish about as often as found on average. However, the quantity of fresh fish eaten is well above the average, while invertebrates are consumed to a much lesser extent. The canned fish consumption is about the same as the average across all four sites surveyed. The proportion of fish and invertebrates that the Manono-uta community consumes, buys, is given, or is caught by somebody living in the same household, is the same as found in the other sites (Table 2.1). Fishing and salaries play a much greater, and agriculture a lesser role, for income than the average for the four Samoan PROCFish sites. While household expenditure level in Manono-uta is substantially higher than elsewhere, the remittance amount received is similar. By comparison, boat ownership is relatively high, however, as elsewhere, non-motorised canoes are the main type of boats used.

2.2.2 Fishing strategies and gear: Manono-uta

Degree of specialisation in fishing

Most Samoan villages are located along the coast, and the Manono-uta community is no exception. The community occupies a part of the coastal plains and its people depend on fisheries produce for both food and income. Finfish fishing is done by both genders; however, 81% of all fishers are males, of whom about half fish exclusively for finfish, and the other half catch both finfish and invertebrates. Female fishers represent 19% of all fishers; most (~15%) are either exclusive invertebrate collectors or fish for both finfish and invertebrates (Figure 2.5). As shown in Figure 2.5, there are only very few female fishers who exclusively catch finfish. Very few fishers, males or females, specialise in collecting only invertebrates.

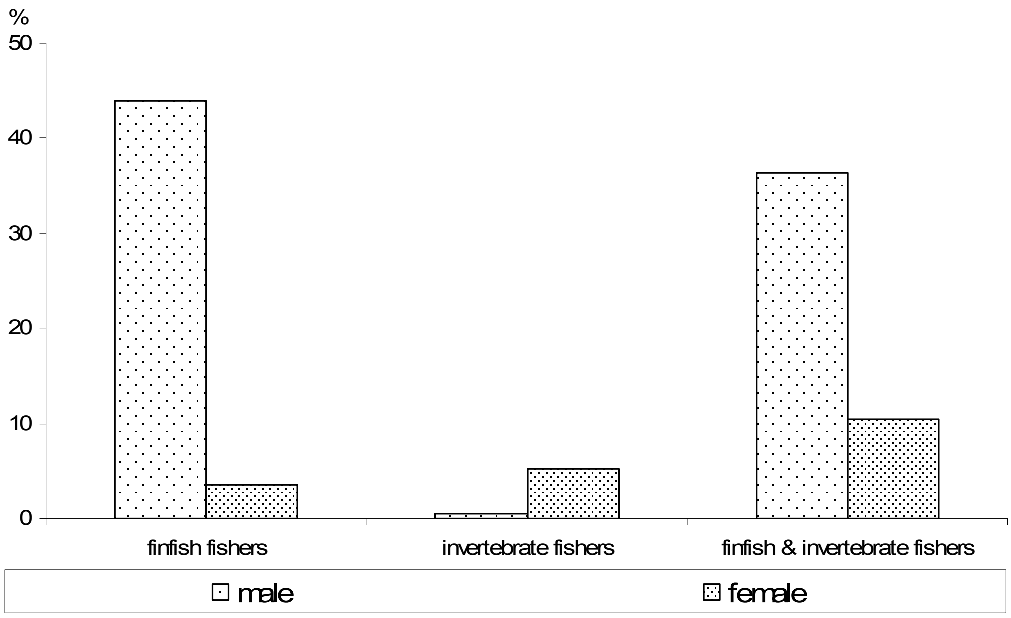

Figure 2.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Manono-uta.
All fishers = 100%.

Targeted stocks/habitat

Considering the limited number of boats, and in particular motorised ones, it is not surprising that Manono-uta's finfish fishers mainly target the easily accessible habitats, namely the sheltered coastal reef and the lagoon. Often, these two habitats are combined in the same trip: 62.5% of the time in the case of male fishers, and 89.5% of the time in the case of females. Outer reef and passages are fished by males only, and trips are much less frequent (Table 2.2). As mentioned above, reeftop and soft-benthos gleaning are the most frequent invertebrate fisheries, with bêche-de-mer collection by females being a specific fishery, which targets mainly soft-benthos habitats. Males dive for other invertebrates, mainly giant clams and lobsters. Some shells, particularly *Anadara* spp., are dug out in the intertidal zones; however this is a much less frequent activity.

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	1.0	0.0
	Sheltered coastal reef & lagoon	62.5	89.5
	Lagoon	1.0	10.5
	Lagoon & outer reef	21.9	0.0
	Outer reef	34.4	0.0
	Outer reef & passage	8.3	0.0
Invertebrates	Reeftop	6.5	0.0
	Reeftop & other	52.2	76.5
	Soft benthos	4.3	5.9
	Soft benthos & other	13.0	11.8
	Intertidal & lobster & other	2.2	0.0
	Bêche-de-mer	4.3	35.3
	Trochus & other	6.5	0.0
	Lobster	6.5	0.0
	Lobster & other	6.5	0.0
	Other	10.9	5.9

'Other' refers to the giant clams, trochus and lobsters fishery.
Finfish fisher interviews, males: n = 96; females: n = 19. Invertebrate fisher interviews, males: n = 46; females, n = 16.

Fishing patterns and strategies

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

Our survey sample suggests that fishers from Manono-uta have a great choice between sheltered coastal reef, lagoon and outer-reef habitats, including passages. However, reeftop (32%) and soft benthos (9%), which also includes the bêche-de-mer fishery (8%), are the main habitats for invertebrate fisheries (Figure 2.6). 'Other', representing 28% of the invertebrate fishery, contains a mixture of all species, mostly associated with reeftop and soft-benthos habitats, and mostly collected by free diving, and includes giant clams, trochus, and lobsters. Females dominate the gleaning fisheries (reeftop, soft benthos including bêche-de-mer) and also glean intertidal areas for certain shells, mainly *Anadara* spp. Females do not engage in any diving, e.g. for giant clams, trochus, lobsters or octopus (Figure 2.7).

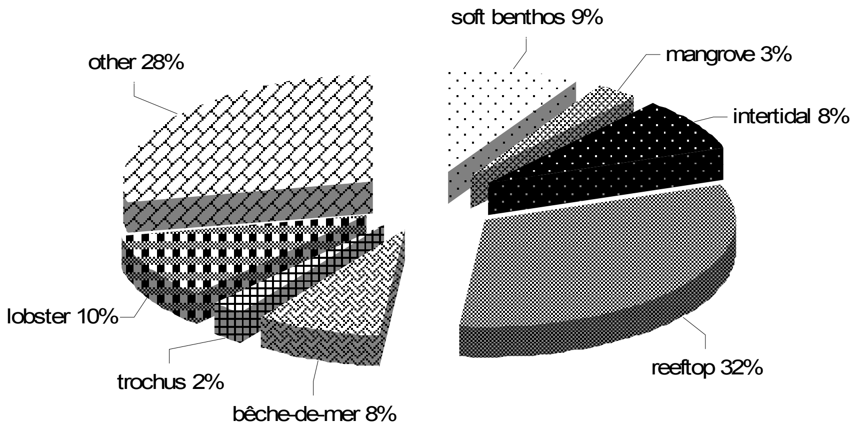

Figure 2.6: Proportion (%) of fishers targeting the four primary invertebrate habitats found in Manono-uta.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the giant clam, trochus and lobster fishery.

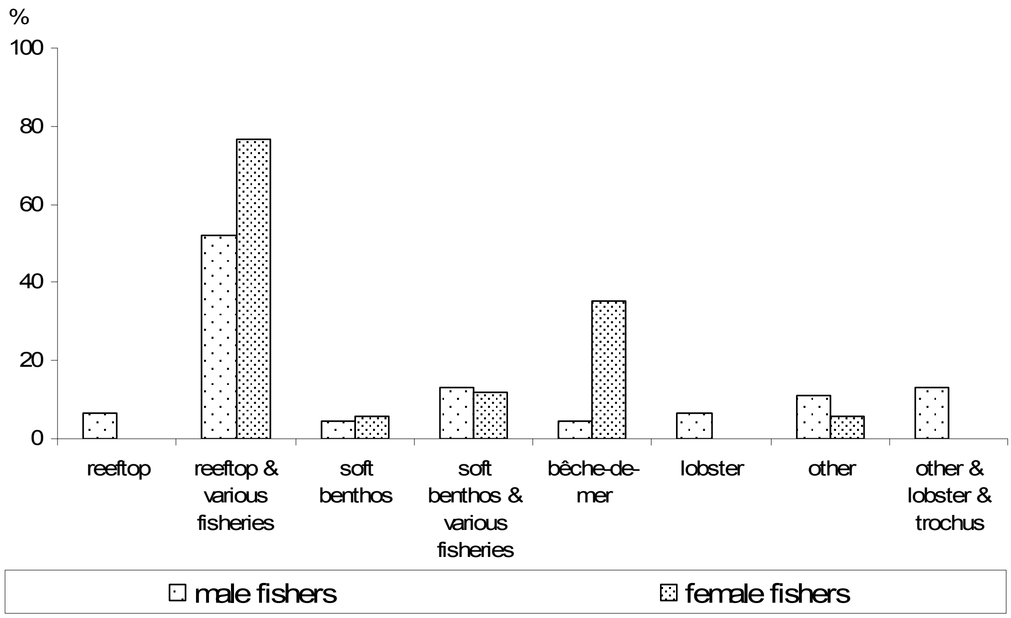

Figure 2.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Manono-uta.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 46 for males, n = 17 for females; 'other' refers to the giant clam, trochus and lobster fishery.

Gear

Figure 2.8 shows that Manono-uta fishers use a variety of different gear and often combine different fishing techniques if catching fish in a particular habitat. In the sheltered coastal reef and lagoon, either fished separately or combined in one fishing trip, a combination of castnetting, gillnetting, handlining, handheld spearing and rod fishing are the main techniques used. If fishers target the outer reef, spear diving becomes the most important technique, complemented by deep-bottom lining, handlining and sometimes others. The fact that fishers combine lagoon and outer reef fishing is because they catch baitfish in the lagoon before venturing out to the outer reef and into the passages. This strategy explains the combined use of castnetting, spear diving and handlining. It must be highlighted that, in the case of spear diving, SCUBA is used, often accompanied by torches at night. However, there is no information available on how often SCUBA and free-diving techniques are used by spear divers in Manono-uta.

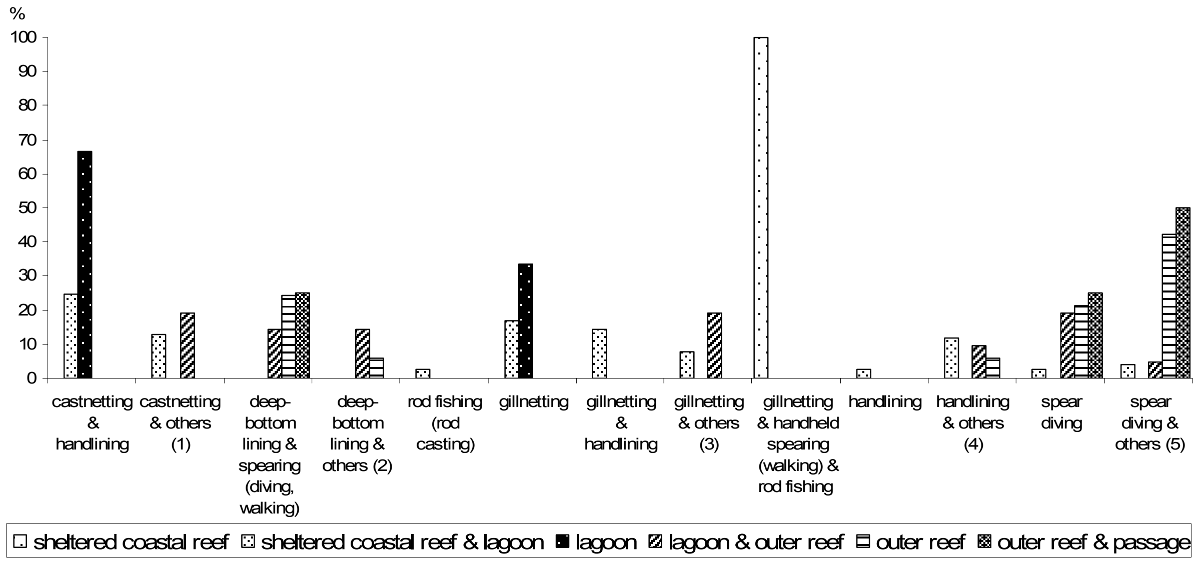

Figure 2.8: Fishing methods commonly used in different habitat types in Manono-uta.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip. (1) fish trapping, gillnetting, rod casting, handheld spearing (walking or from canoe); (2) diving; handlining, spearing, spear diving & trolling, handheld spearing & trolling; (3) spear diving; and/or handheld spearing (walking or from canoe); (4) spear diving, handheld spearing (walking or from canoe), rod fishing; (5) rod fishing; rod casting, handheld spearing (walking or from canoe).

Frequency and duration of fishing trips

Finfish fishers go out around twice per week to any of the habitats. As shown in Table 2.3, there is no difference in the frequency of visits among habitats targeted, or between genders. The average fishing trip lasts 3–5 hours and takes longer if more distant habitats are targeted. Females mainly target the sheltered coastal reef and lagoon areas, and thus spend on average about 3 hours fishing only.

For invertebrates, the frequency of fishing trips depends on the fishery. Reeftop and soft-benthos gleaning may be done between once per fortnight and perhaps twice a week by male and female collectors. Bêche-de-mer harvesting is done more frequently (by both males and females), 2–4 times a week. Diving for lobsters, trochus, giant clams or other species is done by males, and usually once a fortnight only. No great differences were found in the average duration of fishing trips among habitats fished or between genders. It seems that, on average, 3–4 hours are spent gleaning or diving for any of the invertebrates targeted.

Frequency and duration of fishing trips may also be determined by the use of boats, in particular, motorised boats. Most fishers, both males and females, use a boat for finfish fishing. Interestingly, most females (84%) reported using a motorised boat for finfish fishing, while most males (~67%) fish with paddling canoes. Often, fishers borrow boats from other people to go out fishing. Invertebrate collection is mostly done by walking on reeftops, and canoes are used to access soft benthos and mangrove areas. Also, diving trips for bêche-de-mer, giant clams, lobsters, trochus and octopus require boat transport.

Most fishing for finfish is performed according to tidal conditions, i.e. during the day or night. Only 12% of all fishing at the outer reef is exclusively done during the night, and 12.5% of all fishing in the passages is performed only during the day. Invertebrates are either collected during daytime or according to tidal conditions. Only lobsters are targeted mostly at night. Fishers targeting the sheltered coastal reef and lagoon habitats do not use ice on their fishing trips. However, the majority of fishers who target the outer reef (97%), the outer reef and passages (87.5%) and 38–52% of fishers who target the lagoon and outer reef combined in one fishing trip use ice at least for some of their trips. Generally, fishing for both invertebrates and finfish is conducted continuously throughout the year.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male Fishers	Female fishers	Male Fishers	Female fishers
Finfish	Sheltered coastal reef	4.00 (n/a)		3.00 (n/a)	
	Sheltered coastal reef & lagoon	2.32 (±0.09)	2.35 (±0.15)	3.28 (±0.08)	3.29 (±0.14)
	Lagoon	2.00 (n/a)	3.00 (±0.00)	4.00 (n/a)	4.00 (±0.00)
	Lagoon & outer reef	2.10 (±0.16)	0	4.93 (±0.16)	0
	Outer reef	2.00 (±0.12)	0	5.33 (±0.10)	0
	Outer reef & passage	1.88 (±0.23)	0	5.25 (±0.16)	0
Invertebrates	**Reeftop**	**0.63 (±0.06)**	**0**	**3.00 (±0.58)**	**0**
	Reeftop & bêche-de-mer	0	3.00 (n/a)	0	4.00 (n/a)
	Reeftop & bêche-de-mer & other	0	1.00 (n/a)	0	3.00 (n/a)
	Reeftop & lobster & other	2.00 (n/a)	0	3.00 (n/a)	0
	Reeftop & other	0.99 (±0.10)	1.00 (±0.00)	3.05 (±0.11)	2.00 (±0.00)
	Intertidal & lobster & other	0.23 (n/a)	0	3.00 (n/a)	0
	Intertidal & reeftop	0.50 (n/a)	1.26 (±0.26)	4.50 (n/a)	2.78 (±0.15)
	Soft benthos	**1.73 (±1.27)**	**1.00 (n/a)**	**3.00 (±0.00)**	**2.00 (n/a)**
	Soft benthos & bêche-de-mer	0	4.00 (n/a)	0	3.00 (n/a)
	Soft benthos & mangrove	1.00 (±0.00)	0	3.17 (±0.17)	0
	Soft benthos & mangrove & intertidal & reeftop	0	1.00 (n/a)	0	3.00 (n/a)
	Soft benthos & reeftop	1.00 (n/a)	0	3.00 (n/a)	0
	Soft benthos & reeftop & lobster	0.50 (n/a)	0	5.00 (n/a)	0
	Soft benthos & intertidal	2.00 (n/a)	0	3.00 (n/a)	0
	Bêche-de-mer	**2.50 (±0.50)**	**2.50 (±0.34)**	**4.00 (±0.00)**	**3.50 (±0.34)**
	Trochus & other	**0.73 (±0.15)**	**0**	**3.00 (±0.00)**	**0**
	Lobster	**0.49 (±0.01)**	**0**	**4.67 (±0.33)**	**0**
	Lobster & other	0.56 (±0.23)	0	3.17 (±0.17)	0
	Other	**1.01 (±0.26)**	**0.69 (n/a)**	**3.00 (±0.32)**	**3.00 (n/a)**

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam, trochus and lobster fishery. The main invertebrate fisheries are highlighted for the sake of clearness; Manono-uta fishers often combine many habitats in one fishing trip.
Finfish fisher interviews, males: n = 96; females: n = 19. Invertebrate fisher interviews, males: n = 46; females: n = 17.

2.2.3 Catch composition and volume – finfish: Manono-uta

The reported catches from the sheltered coastal reef and mangroves in Manono-uta only contain three major species groups: *Lutjanus bohar*, *Scarus* spp. and *Siganus* spp*.* The parrotfish *Lethrinus variegatus* and *Sargocentron caudimaculatum* are also major species, together with *Naso unicornis* and *Acanthurus* spp. in sheltered coastal reef catches. The combined sheltered coastal reef and lagoon catches are much more diverse with ~70 vernacular names recorded. Here, Acanthuridae (*Acanthurus lineatus, Naso unicornis, Ctenochaetus striatus, Naso* spp., and *Acanthurus* spp*.*), Scaridae, Lutjanidae, Mugilidae, Lethrinidae and Serranidae mainly determine the reported catch composition. If the lagoon is exclusively targeted, *Mugil* spp., *Crenimugil crenilabis, Epinephelides armatus* and *Caranx* spp. are the most reported species groups by weight.

The reported catch composition by fishers who catch at the outer reef and in passages, either in combination with the lagoon to first provide for bait fish, or without fishing in the lagoon first, becomes more diverse, with >50 different vernacular names listed. Scaridae, Acanthuridae, Holocentridae, Lethrinidae and Serranidae are families that were mostly reported. Detailed information on catch composition is reported in Appendix 2.1.1.

Figure 2.9 highlights findings from the socioeconomic survey that were reported earlier, that finfish fishing serves both subsistence and commercial interests. The total annual catch is estimated at ~251.7 t, of which ~133 t are used for subsistence needs (53%) and 118 t are sold externally (47%). The dominance of male fishers shows in the proportion of catch that they account for, i.e. 89% of the total annual catch. Thus, it can be concluded that male fishers are mainly in charge of generating income from finfish fishing, while females occasionally fish for food only. More than half of the total impact is imposed on the sheltered coastal reef and lagoon resources, and less is accounted for by catches from the outer reef and passages.

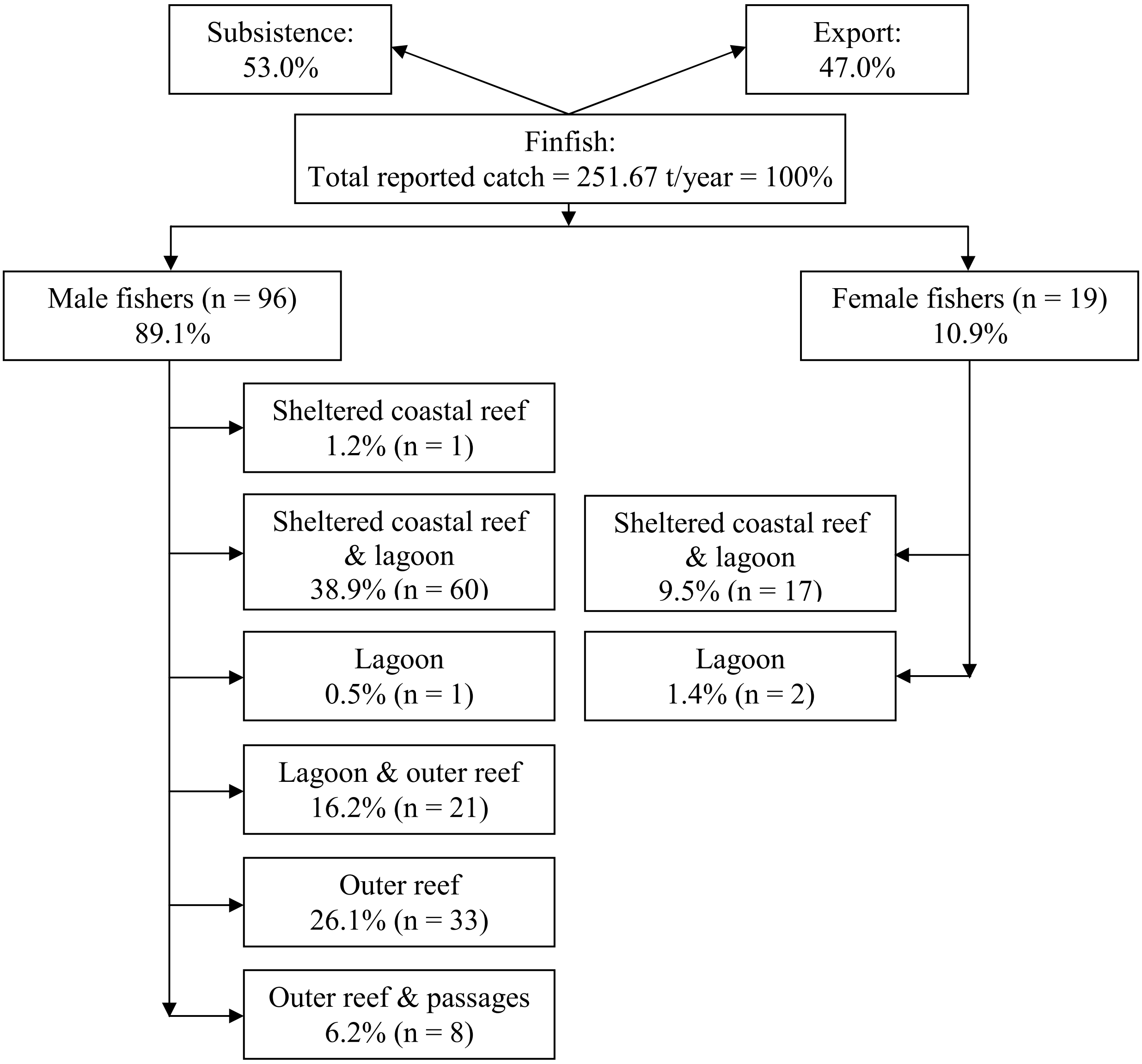

Figure 2.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Manono-uta.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

The distribution of annual catch weight among the more easily accessible sheltered coastal reef, lagoon and further distant outer reef and passages, is a consequence of the number of fishers rather than differences in the annual catch rates. As shown in Figure 2.10, the average annual catch per fisher is similar among the different habitats and combinations of habitats fished, i.e. ranging between 500 and 580 kg/fisher/year. The seemingly much higher annual catch rate at the sheltered coastal reef is misleading due to its very small sample size. Males' and females' annual catch rates are much the same. However, females only fish the sheltered coastal reef and lagoon areas, which makes comparison difficult.

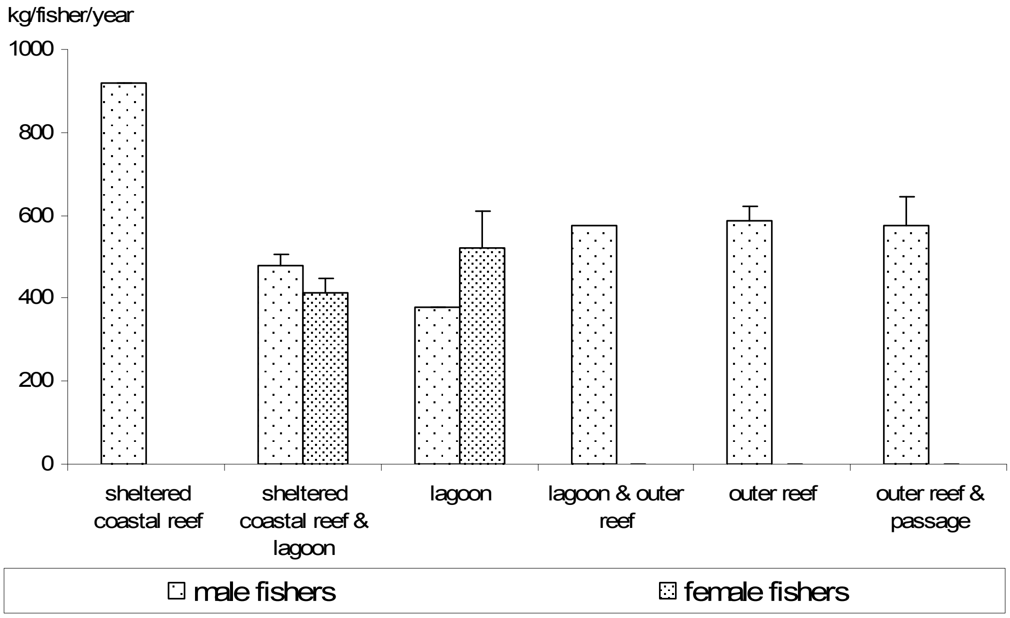

Figure 2.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Manono-uta (based on reported catch only).

Comparing productivity rates between genders and among habitats (Figure 2.11), there are no obvious differences between male and female fishers. However, lagoon fishing alone seems to render lower CPUE rates than fishing at any of the other habitats or combinations of habitats. Overall, CPUEs are rather low, with <1.5 kg of fish caught per hour spent fishing.

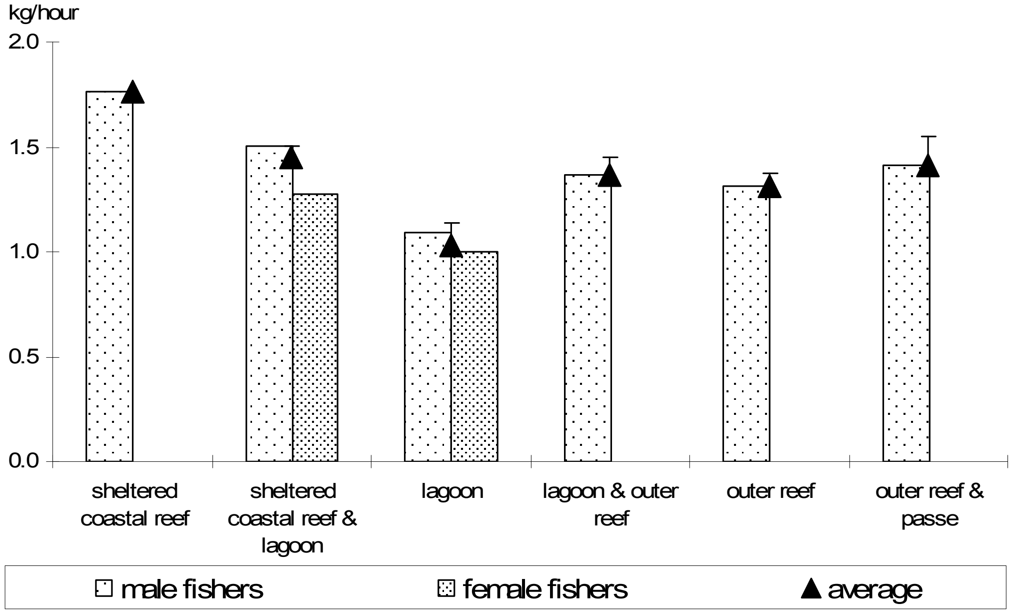

Figure 2.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in Manono-uta.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

The importance of commercial fishing for Manono-uta clearly shows in Figure 2.12. As observed earlier, male fishers targeting the outer reef and passages (first fishing in the lagoon to catch some bait), fish in order to generate income. The combined fishing of the sheltered coastal reef and lagoon system mainly serves subsistence needs and provides catch for non-commercial exchange and, to a much lesser extent, for sale. The high rate of commercial fishing shown for the sheltered coastal reef is misleading due to the small sample size.

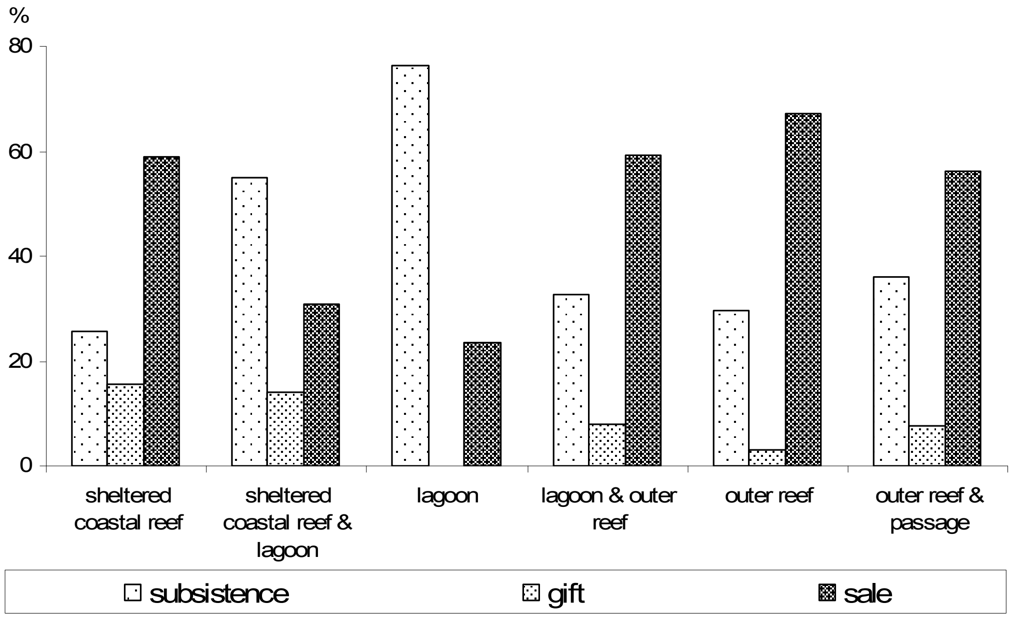

Figure 2.12: The use of finfish catches for subsistence, gift and sale, by habitat in Manono-uta.
Proportions are expressed in % of the total number of trips per habitat.

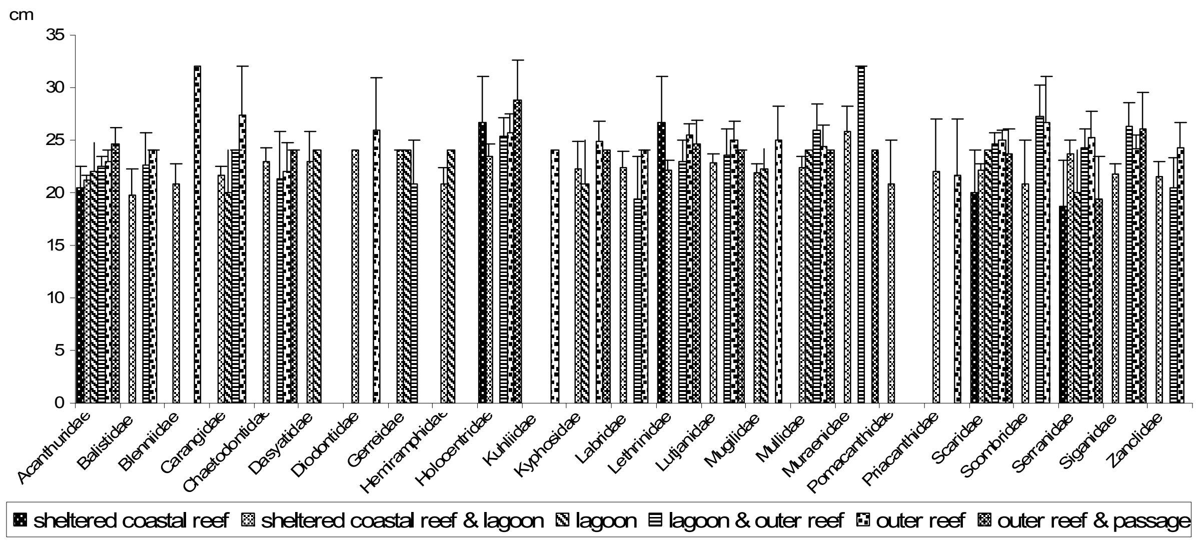

Figure 2.13: Average sizes (cm fork length) of fish caught by family and habitat in Manono-uta. Bars represent standard error (+SE).

The overall productivity of finfish fishing was similar among habitats (Figure 2.11). This observation does not apply if comparing the reported average fish sizes (FL, cm) for the major families caught (Figure 2. 13). As one would expect, there is an increase in fish length for the same species or species groups caught with increasing distance from the shore. This applies for Acanthuridae, Carangidae, Holocentridae, Lethrinidae and Scaridae, where the average reported fish length is greater for the reported outer reef, combined lagoon and outer reef, and combined outer reef and passages catches. However, there are other families, such as Lutjanidae, where differences in the reported average fish length among habitats are small. Also, as observed in the case of Serranidae, the trend that the further from shore the larger the average fish length, may not entirely apply. Nevertheless, in general, average reported fish lengths are small, 20–25 cm only. Small fish lengths, plus relatively low reported CPUEs suggest that stocks are negatively affected by past and presumably current fishing pressure.

The indicators selected to assess current fishing pressure on Manono-uta's reef and lagoon resources are shown in Table 2.4. Due to the available reef surface and total fishing ground, population density, fisher density and catch rates per unit areas of reef and fishing ground are moderate to low. However, it should be borne in mind that more than half of the total annual impact is sourced from the sheltered coastal reef and lagoon areas, habitats that are much more prone to react to fishing than the outer reef and passages, which are in direct exchange with the open ocean. This distribution of fishing effort may aggravate fishing impact.

Table 2.4: Parameters used in assessing fishing pressure on finfish resources in Manono-uta

Parameters	Habitat					
	Sheltered coastal reef	Lagoon	Outer reef	Outer reef & passage	Total reef area	Total fishing ground
Fishing ground area (km^2)	2.71	22.36	12.15		19.61	37.22
Density of fishers (number of fishers/km^2 fishing ground) (1)	1	0.5	9	n/a	25	13
Total number of fishers	3	11	111	27	487	487
Population density (people/km^2) (2)					102	54
Average annual finfish catch (kg/fisher/year) (3)	919.99 (n/a)	474.30 (±70.00)	585.89 (±34.96)	576.84 (±67.79)		
Total fishing pressure of subsistence catches (t/km^2)					6.80	3.58

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; (1) total number of fishers is extrapolated from household surveys; (2) total population = 1997; total number of fishers = 487; total subsistence demand = 133.42 t/year; (3) catch figures are based on recorded data from survey respondents only.
Sheltered coastal reef & lagoon combined fishing trips (average annual catch rate = 465.53 kg/fisher/year ±20.46; total number of fishers = 265), and lagoon & outer reef combined fishing trips (average annual catch rate = 573.92 kg/fisher/year ±37.12; total number of fishers = 70) are excluded in the above table for clarity reasons.

2.2.4 Catch composition and volume – invertebrates: Manono-uta

Calculating reported catches from invertebrate fishers by wet weight shows that only a few species account for the major annual impact expressed in wet weight (Figure 2.14). The combined catches of bêche-de-mer species, including *Stichopus horrens* and *Holothuria* spp. account for most, i.e. an accumulated annual wet weight of 43 t. Bêche-de-mer is considered a delicacy in Samoa, and intestines recovered from collected specimens are either used for home consumption or sold. Marketing of bêche-de-mer is mainly done by females, but also by males. Mostly guts, but sometimes also skins of bêche-de-mer are collected and preserved in coke bottles filled with sea water. It must be noted that, despite the national ban on bêche-de-mer fishing, certain species are still heavily targeted for home consumption and for sale on local markets. Giant clams, shown under three different vernacular names (*pipi*, *faisua*, *li*) account for another 14 t/year (wet weight). Other species, such as octopus, trochus, lobsters and crabs, are of insignificant impact by comparison.

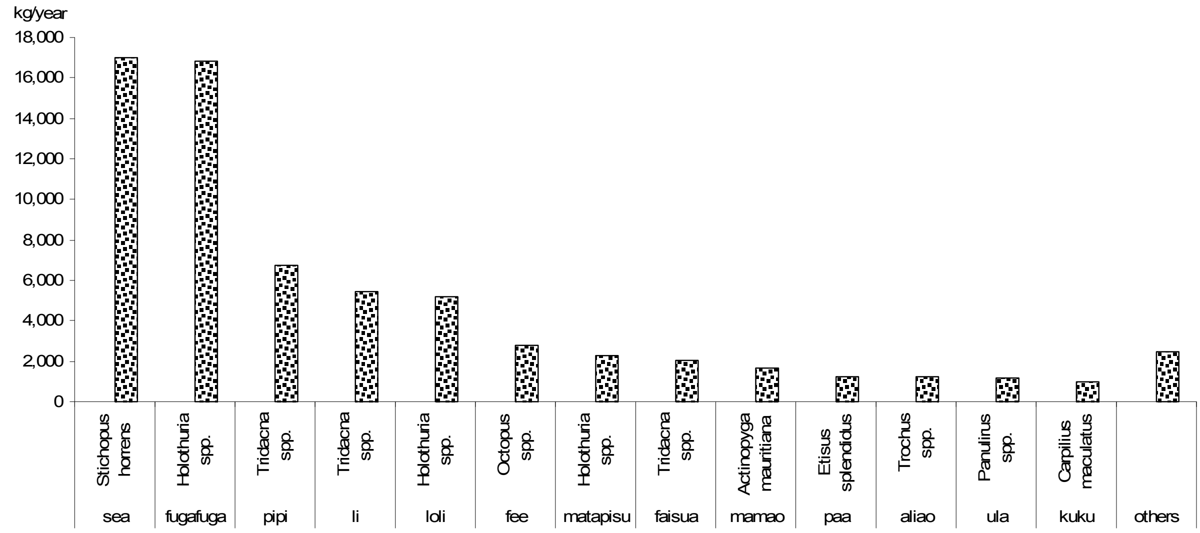

Figure 2.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Manono-uta.
'Others' include: *Pinna bicolor* (*fole*), *Turbo* spp. (*alili*), *Anadara* spp. (*pae*), *Etisus splendidus* (*tutu*), *Cypraea* spp. (*pu*, *pule*), *Scylla serrata* (*paalimago*), *Strombus* spp. (*panae*), *Tripneustes gratilla* (*kuikui*), *Dolabella auricularia* (*gau*), and seaweed (*limu*).

The fact that most impact is due to a few species only also shows in the number of vernacular names that have been registered from respondents. Bêche-de-mer and giant clam fishers reported only three different vernacular names for each species group. Thus, giant clams already represent the major proportion of the five total vernacular names reported for reeftop gleaning or other diving. Figure 2.15 clearly shows that any of the fisheries and combinations thereof is represented by a few vernacular names only.

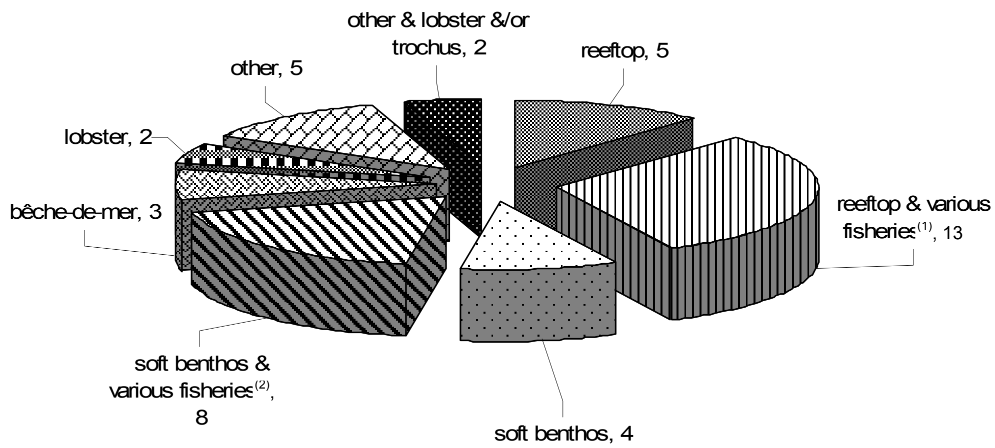

Figure 2.15: Number of vernacular names recorded for each invertebrate fishery in Manono-uta.
Reeftop and soft benthos fisheries labeled '& various fisheries' may include any of the following or a combination thereof: (1) bêche-de-mer, lobster, intertidal, and other; (2) bêche-de-mer, mangroves, lobster, intertidal, and reeftop. 'Other' refers to the giant clam, trochus and lobster fishery.

The average annual catch per fisher by gender and fishery (Figure 2.16) reveals substantial differences. First, males collect more on average per year from any of the habitats targeted, but in particular if bêche-de-mer is collected, or if soft benthos is gleaned. The variation in average annual catches among female fishers targeting the soft benthos is substantial. As observed above, average annual catch rates confirm that the highest pressure is on the soft-benthos and bêche-de-mer resources.

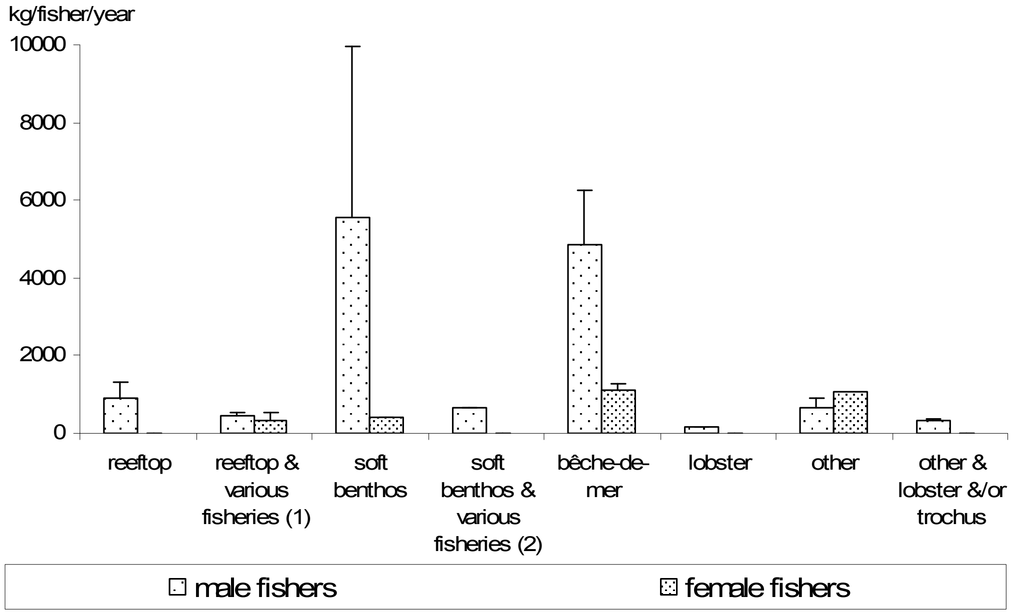

Figure 2.16: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Manono-uta.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 46 for males, n = 17 for females); (1) bêche-de-mer, lobster, intertidal, and other; (2) bêche-de-mer, mangroves, lobster, intertidal, and reeftop. 'Other' refers to the giant clam, trochus and lobster fishery.

The fact that the Manono-uta community is highly dependent on marine resources for subsistence and income, and the proximity to Samoa's capital Apia, also shows in the proportion of invertebrate catches (wet weight) used for home consumption and for sale (Figure 2.17). Assuming that half of the share that may be used for family meals or for sale is eaten by the fisher's family and half is sold, 65% of all invertebrate catches (wet weight) are used by the Manono-uta community for their own meals, and 35% are externally sold.

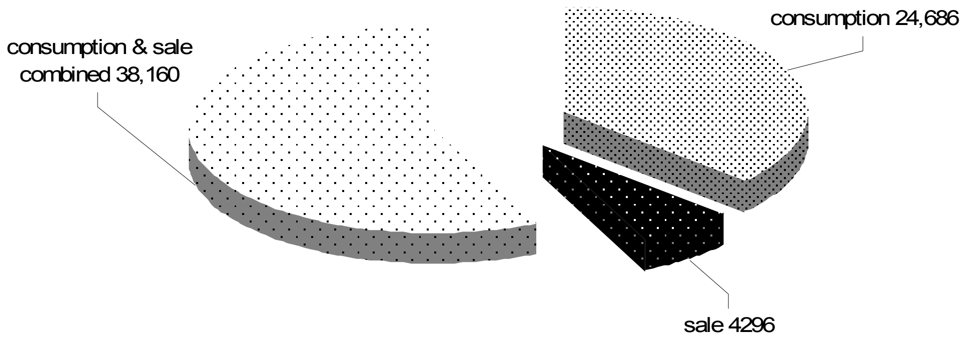

Figure 2.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Manono-uta.

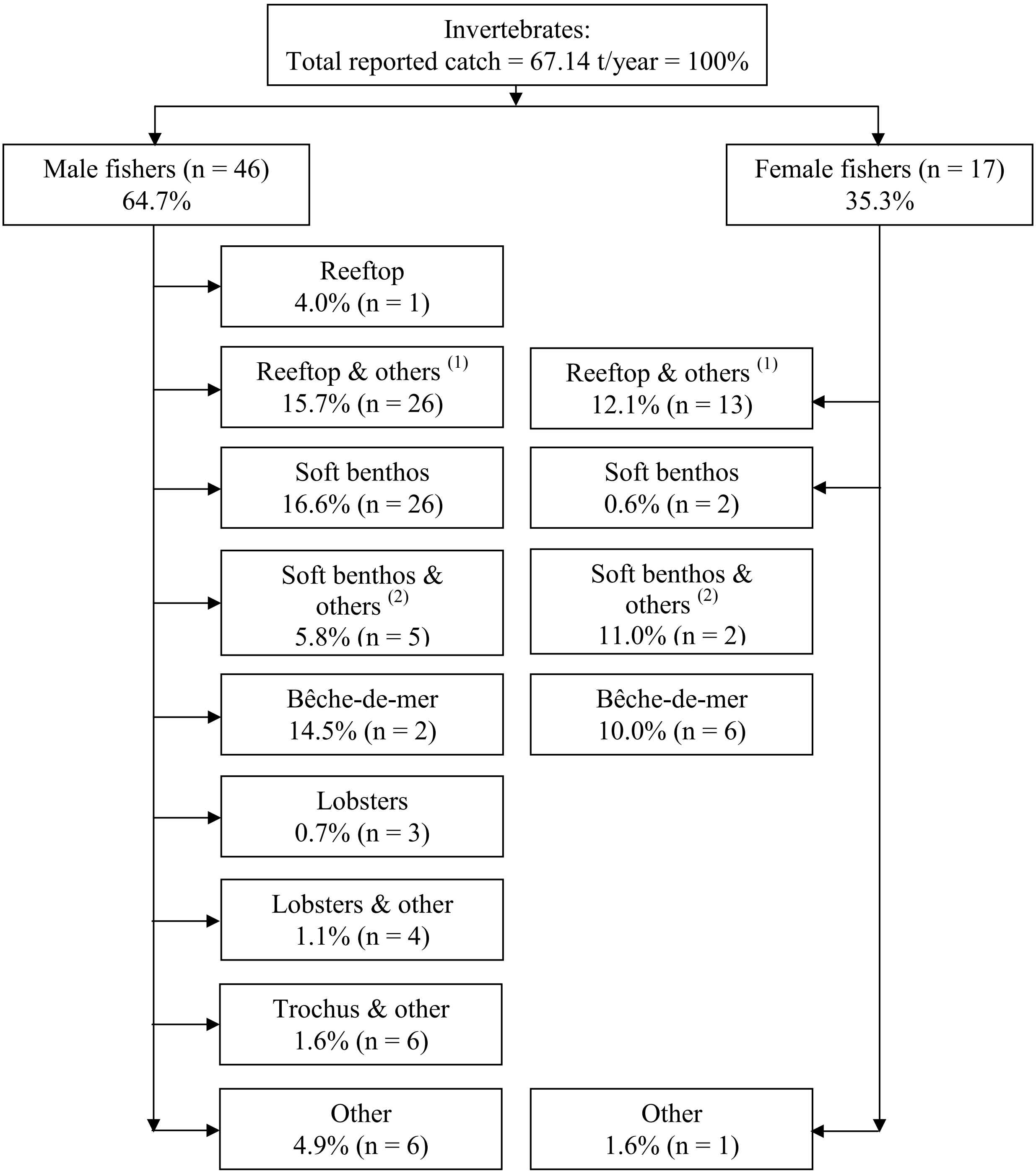

Figure 2.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Manono-uta.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey. Reeftop and soft benthos fisheries labeled '& others' may include any of the following or a combination thereof: (1) bêche-de-mer, lobster, intertidal, and other; (2) bêche-de-mer, mangroves, lobster, intertidal, and reeftop. 'Other' refers to the giant clam, trochus and lobster fishery.

As mentioned earlier, male fishers from Manono-uta are heavily involved in invertebrate fisheries, taking ~65% of the total catch (wet weight) (Figure 2.18). Most male invertebrate fishers target the soft-benthos, reeftop and bêche-de-mer fisheries. Female invertebrate collectors focus mainly on reeftop and soft benthos, each in combination with other habitats, and bêche-de-mer fisheries. Trochus, lobster and other dive fisheries are of negligible importance. There is no exclusive mangrove fishery, but mangroves may be harvested in combination with soft-benthos gleaning. Trochus is the only invertebrate species that is targeted exclusively for sale. All other species serve either only home consumption, or are sold.

Table 2.5: Parameters used in assessing fishing pressure on invertebrate resources in Manono-uta

Parameters	Fishery							
	Reeftop	Reeftop & various fisheries (3)	Soft benthos	Soft benthos & various fisheries (4)	Bêche-de-mer	Lobster	Other	Other & lobster &/or trochus
Fishing ground area (km^2)	13.28	13.28				22.3		14.76
Number of fishers (per fishery) (1)	12	162	13	34	37	12	26	25
Density of fishers (number of fishers/km^2 fishing ground)	1	12	n/a	n/a	n/a	1	n/a	2
Average annual invertebrate catch (kg/fisher/year) (2)	886.19 (±428.03)		3844.68 (±3056.24)		2055.01 (±674.51)	147.34 (±24.12)	720.02 (±213.49)	249.81 (±168.52)

Figures in brackets denote standard error; n/a: no information available or standard error not calculated; (1) total number of fishers is extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; (3) bêche-de-mer, lobster, intertidal, and other; (4) bêche-de-mer, mangroves, lobster, intertidal, and reeftop; 'other' refers to the giant clam, trochus and lobster fishery.

Taking into account available figures on the length of the outer reef that supports lobster dive fisheries, and the inner- and outer-reef surface areas, fisher density is low for any of the fisheries considered to be supported by both areas of reef type. Also, average annual catch rates given for fishers participating in the reeftop, lobster or other fisheries (Table 2.5) are low; however very high annual catch rates accrue for soft-benthos and bêche-de-mer collection. Because the surface areas are unknown for the soft-benthos and bêche-de-mer fisheries, information on the actual status of these fisheries and thus estimation of current and/or future impacts on these resources needs verification with the results from the resource surveys.

2.2.5 Management issues: Manono-uta

Management of marine resources in Samoa occurs at two levels, and so does enforcement: through governmental institutions and traditional village systems. At the national level, regulations mainly refer to size restrictions and harvesting techniques employed. At the community level, community-based reserve areas have been promoted since 1996 and today include about 150 villages. Initially, the programme was assisted by AusAID funding. The programme's success rate, however, varies. One of the major obstacles to assessing impact is the absence of baseline surveys to compare the past and current status and use of reef resources and predict future levels of fishing impact and use.

The Manono-uta community has shown little participation so far in community management, and have only established a small area that is partially closed for giant clam regeneration purposes. Otherwise, the community has not made any other decisions towards managing their reef resources, perhaps due to earlier failures. Five years before this survey was undertaken, some community-based management interventions were tried; however, these were not complied with and were quickly suspended. As in other Samoan villages, the Council of Elders represents traditional leadership and has the power to impose village rules, including regulations and rules for fisheries management. This Council is complemented by the pastors in the village, whose number depends on the number of churches represented; their joint power is equal to that of the village chiefs or *matai*.

Another reason for the lack of interest of Manono-uta's community members in fisheries management may be that they consider such measures as restrictive to their current fishery activities, particular the commercial ones. As stated above, Manono-uta has very good access to markets, including Samoa's main market in Apia. Also, the demand for any kind of seafood is high as the community is located in a highly populated area. Despite the national ban on the bêche-de-mer fishery, certain species are particularly targeted by the Manono-uta community, not only for home consumption but also for selling at the community's roadside, or to the market in Apia.

The well structured and highly organised fishing networks and groups for finfish and invertebrates among males and females of the community also contribute to a considerably high fishing pressure on the community's reef and lagoon resources.

2.2.6 Discussion and conclusions: socioeconomics in Manono-uta

- The Manono-uta community has access to agricultural land and marine resources. However, due to its proximity to the country's main market in Apia, fisheries are the main source of income, followed by salaries and other, private activities. The livelihood of people is highly dependent on their naturally rich reef and lagoon resources, complemented by a high dependency on remittances used to comply with the many traditional and religious obligations. The Manono-uta community has no community-based fisheries management programme in place, except for a small protected area, which aims to restore the population of giant clams.

- Survey results suggest the following:

    - Manono-uta's population is highly dependent on marine resources for home consumption as well as to generate income. The proximity of and easy access to the urban market of Apia fosters fisheries exploitation and may have detrimental effects on the community's reef and lagoon resources.

    - Per capita consumption of fresh fish is high; however, invertebrates are consumed to a much lesser extent. Canned-fish consumption is also high, which may be explained by the frequent use of canned fish for *falavelave* and the high frequency of these events.

    - Consumption and income patterns both suggest that Manono-uta's traditional lifestyle is much influenced by urban and western factors. While traditional gender roles continue, with males being much more involved in finfish fisheries and females mainly focusing on collecting invertebrates, both gender groups are organised in fishing and marketing groups.

- o Finfish are mainly sourced from the lagoon and outer-reef areas, and male fishers also access outer-reef areas outside their own fishing grounds. Due to the highly organised fishing networks, boat transport is not a limiting factor but is provided by middle sellers, and/or fish buyers.

- o Lagoon fishing alone shows the lowest CPUE rates. However, overall, reported CPUEs are generally low, and so is the average catch per individual fisher. The choice of habitat targeted is closely linked with the purpose of the trip, i.e. the outer reef (passages included) and the combined lagoon and outer reef are fished for commercial purposes, while lagoon fishing is mainly subsistence-oriented.

- o A wide range of techniques is used; gillnetting is the main method used in the lagoon, and spearing combined with other techniques is the main method reported for outer-reef fishing. Overall, average reported fish sizes are small. For some families, average reported fish length increases with distance from the shore, for others it does not change between habitats.

- o Results from invertebrate fisher surveys show that the combined catches of bêche-de-mer species account for most of the annual harvest (wet weight). Giant clams are the second most important species group by weight. Bearing in mind that there is a nationwide ban on bêche-de-mer fishing, this figure gives reason for concern. Also, the fact that the community has put aside a small area for the restoration of giant clams but still continues to fish the remaining stocks is alarming.

- o In contrast to finfish fishing, significant differences were found in the average annual catches per fisher by fishery and gender. Again, annual average catches reported for bêche-de-mer and soft-benthos gleaners (most targeting also bêche-de-mer species) are highest. While 65% of all invertebrate catches (wet weight) are used for home consumption, 35% are sold either at the roadside or on the nearby Apia market.

- o The indicators of fishing pressure calculated for finfish and invertebrate fisheries suggest that, due to the available reef and overall fishing ground area, fisher densities and average annual catch rates, as well as catch per unit areas are not alarmingly high. However, the low CPUEs, the small average reported fish sizes, and the fact that fishers are serving the highly demanding urban market of Apia suggest that fishing pressure is high and its effects may be detrimental. The small protected area for the restoration of giant clams suggests that at least one problem has already been recognised by the community. The lack of other community-based fisheries management actions may be due to the conflict between the need for income generation and the need to preserve resource status.

- Final assessment needs comparison between results from the socioeconomic survey and those of the resource surveys. In any case, the Manono-uta site survey results highlight the need for an immediate community fisheries management programme. It is also recommended that a precautionary approach be adopted to using resources to immediately safeguard current stock and thus maintain marine resources for the subsistence and economic livelihood of the people.

- The main legislative fisheries instrument is the Samoa Fisheries Act of 1988, which includes conservation, management and development of marine resources, the promotion of marine scientific research and the protection and preservation of the marine environment. An important provision of the Act is that the Director responsible for fisheries "…may, in consultation with male fishers, industry and village representatives, prepare and promulgate bylaws not inconsistent with the Act for the conservation and management of fisheries…". Using this provision, many villages now have bylaws to assist in managing their fishing grounds. This template is highly recommended for adoption by the Manono-uta community, in close cooperation with the Council of Elders, the pastors, and male and female fishers, to establish as soon as possible the necessary bylaws to protect the community's reef and lagoon resources from further overfishing and to sustain their fisheries for future use. For the future, the Manono-uta community may also need to identify alternative income sources to fisheries to maintain the livelihood of their families and at the same time to preserve their reef and lagoon stocks.

2.3 Finfish resource surveys: Manono-uta

Finfish resources and associated habitats were assessed from a total of 24 transects (6 in each habitat type) from 7 June 2005 to 13 June 2005.

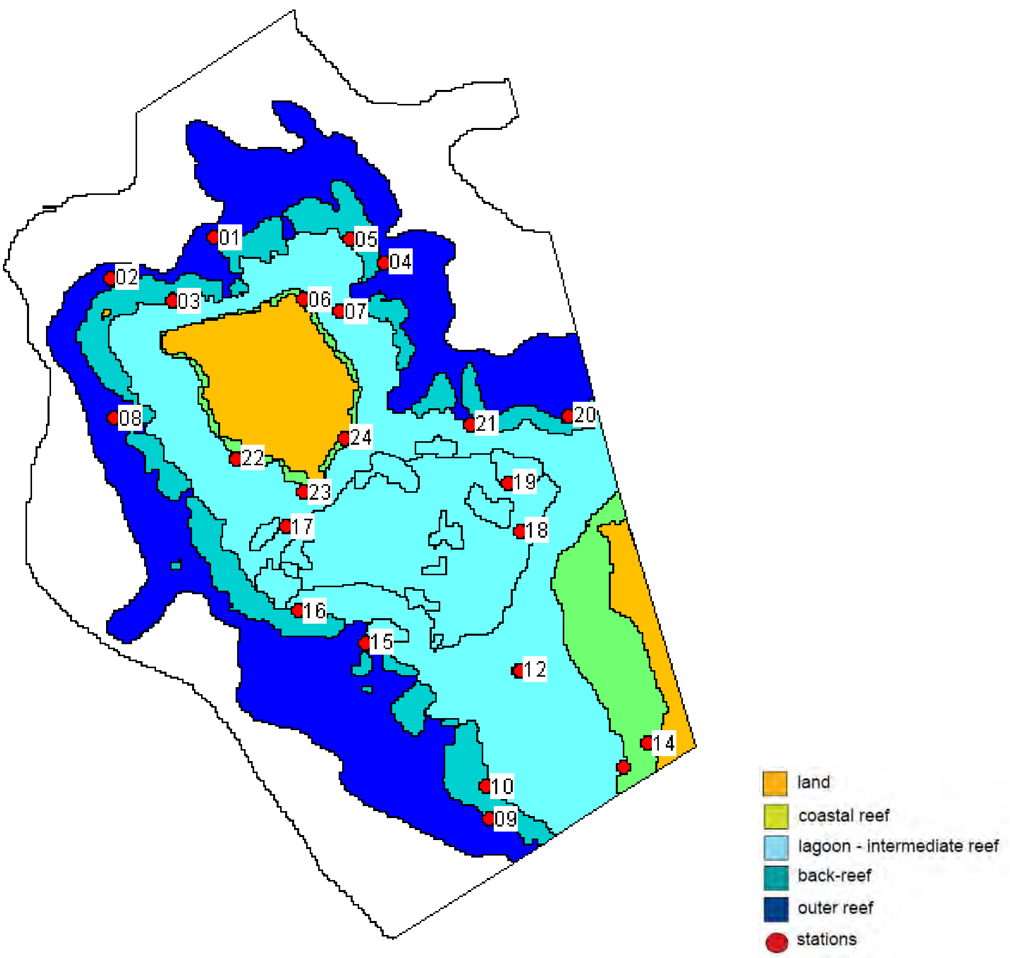

Figure 2.19: Habitat types and transect locations for finfish assessment in Manono-uta.

2.3.1 Finfish assessment results: Manono-uta

A total of 16 families, 43 genera, 122 species and 10,844 fish were recorded in the 24 transects (See Appendix 1.2 for list of species.). Only data on the 14 most dominant families are presented below, representing 40 genera, 118 species and 9765 individuals.

Finfish resources varied greatly among the different habitats, with outer reefs displaying the highest values for the main biological indicators (density, biomass, size and biodiversity, this last particularly high), followed by healthy back-reefs, with high values for density, size and biomass. Back-reefs showed also the highest live-coral percentage cover among all habitats. Sheltered coastal reefs presented the highest average size ratios and second highest mean sizes, even with the lowest biomass values (due to very low density). The substrate is rather uniformly composed throughout the four habitats by 60–80% hard bottom, and by 12–16 % of live coral (Table 2.6).

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

Parameters	Sheltered coastal reef (1)	Lagoon reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	6	6	6	24
Total habitat area (km^2)	2.7	17.6	4.7	12.2	37.2
Depth (m)	1 (1-2) (3)	3 (1-7) (3)	1 (1-3) (3)	9 (4-14) (3)	4 (1-14) (3)
Soft bottom (% cover)	13.3 ±3.9	16.3 ±4.4	12.2 ±5.8	3.2 ±1.6	11.0
Rubble & boulders (% cover)	3.3 ±1.2	6.2 ±4.5	15.7 ±5.3	4.0 ±1.8	6.0
Hard bottom (% cover)	71.0 ±3.1	64.7 ±5.8	55.8 ±6.0	80.0 ±2.0	69.0
Live coral (% cover)	12.5 ±4.4	12.8 ±7.6	16.1 ±4.2	12.4 ±3.0	13.0
Soft coral (% cover)	0.0 ±0.0	0.1 ±0.1	0.1 ±0.1	0.3 ±0.2	0.0
Biodiversity (species/transect)	16 ±3	27 ±4	27 ±3	43 ±3	28 ±3
Density (fish/m^2)	0.3 ±0.1	0.6 ±0.2	0.9 ±0.3	1.3 ±0.1	0.8
Size (cm FL) (4)	14.6 ±0.9	13.7 ±0.7	14.6 ±0.6	17.0 ±0.6	15.0
Size ratio (%)	57.8 ±3.7	53.4 ±2.7	52 ±2.2	57.6 ±2	55.0
Biomass (g/m^2)	26.8 ±10.6	42.7 ±26.2	95.4 ±44.5	201.2 ±30.9	100.0

(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: Manono-uta

The sheltered coastal reef environment of Manono-uta was dominated by four families: the herbivorous Siganidae, Scaridae and Acanthuridae, and the carnivorous Nemipteridae (Figure 2.20). Particularly high abundance and biomass were recorded for the species *Siganus spinus*, *Scolopsis bilineatus*, *Acanthurus triostegus*, *Ctenochaetus striatus*, and *Scarus psittacus* (Table 2.7).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Siganidae	*Siganus spinus*	Scribbled rabbitfish	0.12	17.7
Nemipteridae	*Scolopsis bilineatus*	Bridled monocle bream	0.04	3.12
Scaridae	*Scarus psittacus*	Pale-nose parrotfish	0.02	0.3
Acanthuridae	*Ctenochaetus striatus*	Lined bristle-tooth surgeonfish	0.01	0.6
	Acanthurus triostegus	Convict surgeonfish	0.005	0.7

Biodiversity, density and biomass of all the commercial fish in the sheltered coastal reef habitat were the lowest among the four habitats, but sizes displayed mean high values, and size ratios were the maximum for the area. Compared to the other habitats, the amount of Siganidae was exceptional in this coastal sheltered reef. This family is one of the favourite target species for fishers. Scaridae and Acanthuridae, the two most abundant families in the other three habitats, were found in very low numbers in these sheltered reefs, especially when compared to coastal sheltered reefs of Salelavalu and Vailoa. Their size ratio, the lowest among the four habitats, in addition to their limited number, indicates a high exploitation of these two families in this type of reef. Parrotfish and surgeonfish, along with Lethrinidae and Mullidae – also very rare – are in fact mostly targeted in the coastal reefs. In general and for all families, sizes were smaller in the coastal than in the outer reefs.

When compared to the coastal reefs of all four sites, Manono-uta coastal reefs displayed the highest total biomass, sizes and size ratios, and the second highest density (Table 2.8), as well as the far highest number and biomass of Siganidae. However, Acanthuridae and Scaridae showed the smallest values of biomass and density among the analysed sites, which indicates that these resources are declining.

This reef environment presented a rather poor habitat with a high percentage of hard bottom (70%) but very little live coral (12%). These substrate characteristics may partially explain why there were more herbivorous fish families (especially Siganidae) and fewer carnivorous families as compared to the average across the study sites.

Table 2.7: Comparisons of the sheltered coastal reef biological parameters among the three Samoan sites with sheltered coastal reefs

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	**0.30 (±0.08)**	**26.8 (±10.6)**	**14.6 (±0.9)**	**57.8 (±3.7)**
Salelavalu	0.22 (±0.04)	9.2 (±2.2)	11.0 (±0.7)	36.3 (±2.4)
Vailoa	0.38 (±0.09)	19.6 (±5.1)	11.2 (±0.5)	39.1 (±1.9)

Figures in brackets denote standard error; FL = fork length.

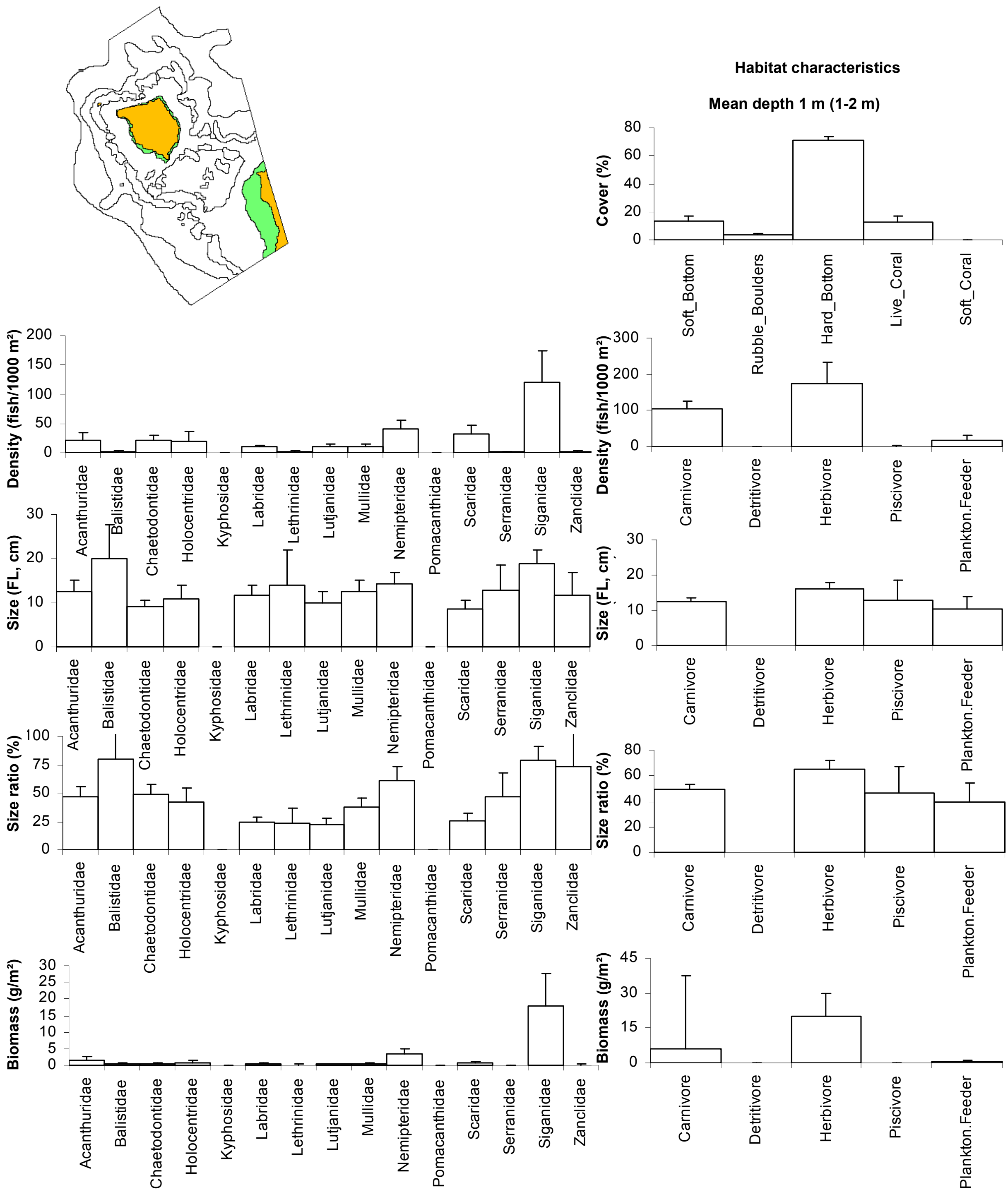

Figure 2.20: Profile of finfish resources in the sheltered coastal reef environment of Manono-uta.
Bars represent standard error (+SE); FL = fork length.

Intermediate-reef environment: Manono-uta

The intermediate-reef environment of Manono-uta was dominated by the carnivorous Lutjanidae, followed by the herbivorous Scaridae and Acanthuridae (Figure 2.21). Predominant high abundance and biomass were recorded for the species *Lutjanus biguttatus* (showing extremely high density and biomass), *L. gibbus, Scarus psittacus, Chlorurus sordidus, Ctenochaetus striatus* and *Acanthurus nigroris* (Table 2.8).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus biguttatus*	Two-spot snapper	0.16	12.5
	Lutjanus gibbus	Humpback snapper	0.04	1.0
Scaridae	*Scarus psittacus*	Pale-nose parrotfish	0.06	0.9
	Chlorurus sordidus	Bullet-head parrotfish	0.04	4.7
Acanthuridae	*Ctenochaetus striatus*	Striped bristle-tooth	0.04	3.3
	Acanthurus nigroris	Blue-lined surgeonfish	0.01	2.3

When compared to the other reef habitats in Manono-uta, biodiversity in the lagoon reef displayed the second highest value, comparable to the back-reef value, and much higher than the coastal-reef value, but lower than density on the outer reefs. Biomass and density values were intermediate between sheltered and back-reefs; however mean sizes were the lowest recorded among the four habitats.

By comparing this site to Salelavalu, the only other site with lagoon habitat, Manono-uta intermediate reefs displayed lower density, biomass and size (Table 2.9). Lutjanidae displayed much higher density and biomass in Manono-uta lagoon, while Acanthuridae and Scaridae were much more important in Salelavalu.

Similarly to the sheltered reef habitat, the substrate was dominated by hard bottom, but had a higher cover of sand and rubble. Live coral cover was rather poor, as everywhere at this site. In this type of substrate are found the typical small invertebrates that Lutjanidae feed on, which could explain the particularly high abundance of this carnivorous family.

Table 2.9: Comparisons of the intermediate-reef biological parameters between Manono-uta and Salelavalu sites

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	**0.56 (±0.24)**	**42.7 (±26.2)**	**13.7 (±0.7)**	**53.4 (±2.7)**
Salelavalu	0.84 (±0.06)	87.7 (±16.0)	14.8 (±0.5)	48.8 (±1.6)

Figures in brackets denote standard error; FL = fork length.

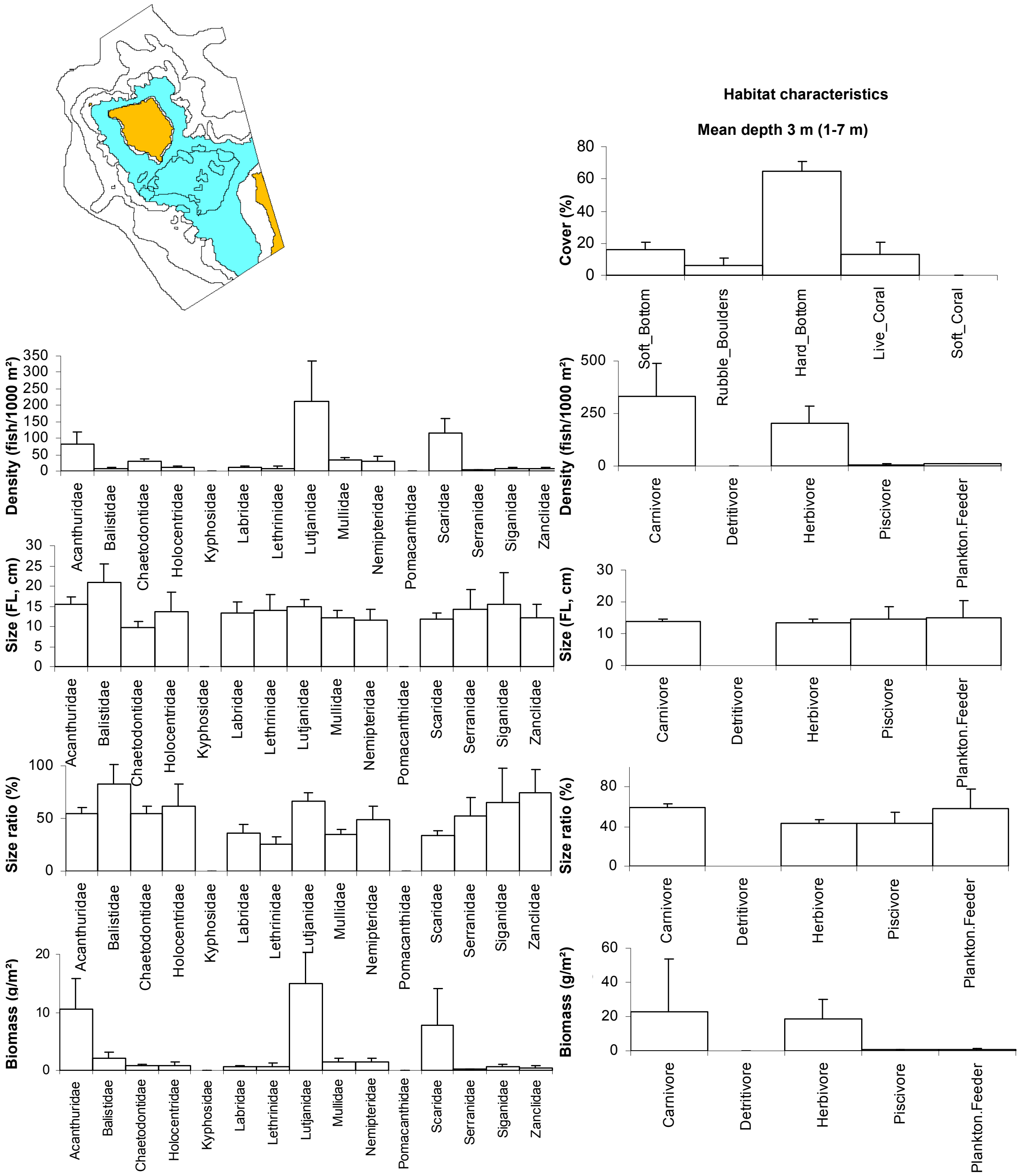

Figure 2.21: Profile of finfish resources in the intermediate-reef environment of Manono-uta. Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Manono-uta

The back-reef environment of Manono-uta was dominated by Acanthuridae, Scaridae and Mullidae. The representative species in these families were *Acanthurus nigroris*, *Ctenochaetus striatus*, *Chlorurus sordidus*, *Scolopsis bilineatus*, *Mulloidichthys flavilineatus*, *Acanthurus triostegus* and *Scarus psittacus*, in order of total biomass (Table 2.10).

Table 2.10: Finfish species contributing most main families in terms of densities and biomass in the back-reef environment of Manono-uta

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striped bristle-tooth	0.19	16.0
	Acanthurus nigroris	Blue-lined surgeonfish	0.08	19.6
	Acanthurus triostegus	Convict tang	0.06	4.7
Scaridae	*Chlorurus sordidus*	Bullet-head parrotfish	0.13	10.1
	Scarus psittacus	Pale-nose parrotfish	0.05	2.5
Mullidae	*Mulloidichthys flavilineatus*	Yellow-striped goatfish	0.12	6.2
	Scolopsis bilineatus	Two-lined spine-cheek	0.05	7.0

Mean biomass and density in the back-reefs were the second highest in Manono-uta, after the outer-reef values. However, mean size ratio was the lowest recorded for Manono-uta and mean size the second lowest and similar to the coastal reef value, indicating a response to heavy fishing. The two most important families, Acanthuridae and Scaridae, were much higher in abundance and biomass than in the coastal and intermediate reefs, where they were replaced by Siganidae and Lutjanidae respectively (Figure 2.22).

Comparisons among the four Samoan sites showed highest density and biomass, as well as size and size ratios in Manono-uta (Table 2.11). Acanthuridae, Siganidae, Mullidae and Nemipteridae at this site displayed the highest biomass and density of all back-reef environments.

The habitat was fairly evenly composed of hard (56%) and mobile substrate (30%) and had the highest cover of live coral for the site.

Table 2.11: Comparisons of the back-reef biological parameters among the four Samoan sites

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	**0.95 (±0.28)**	**95.4 (±44.5)**	**14.6 (±0.6)**	**52.0 (±2.2)**
Salelavalu	0.68 (±0.67)	70.0 (±9.7)	14.6 (±0.6)	49.2 (±2.0)
Vailoa	0.59 (±0.71)	44.5 (±7.5)	12.8 (±0.6)	46.2 (±2.1)
Vaisala	0.77 (±0.11)	64.9 (±14.4)	13.7 (±0.4)	47.4 (±1.3)

Figures in brackets denote standard error; FL = fork length.

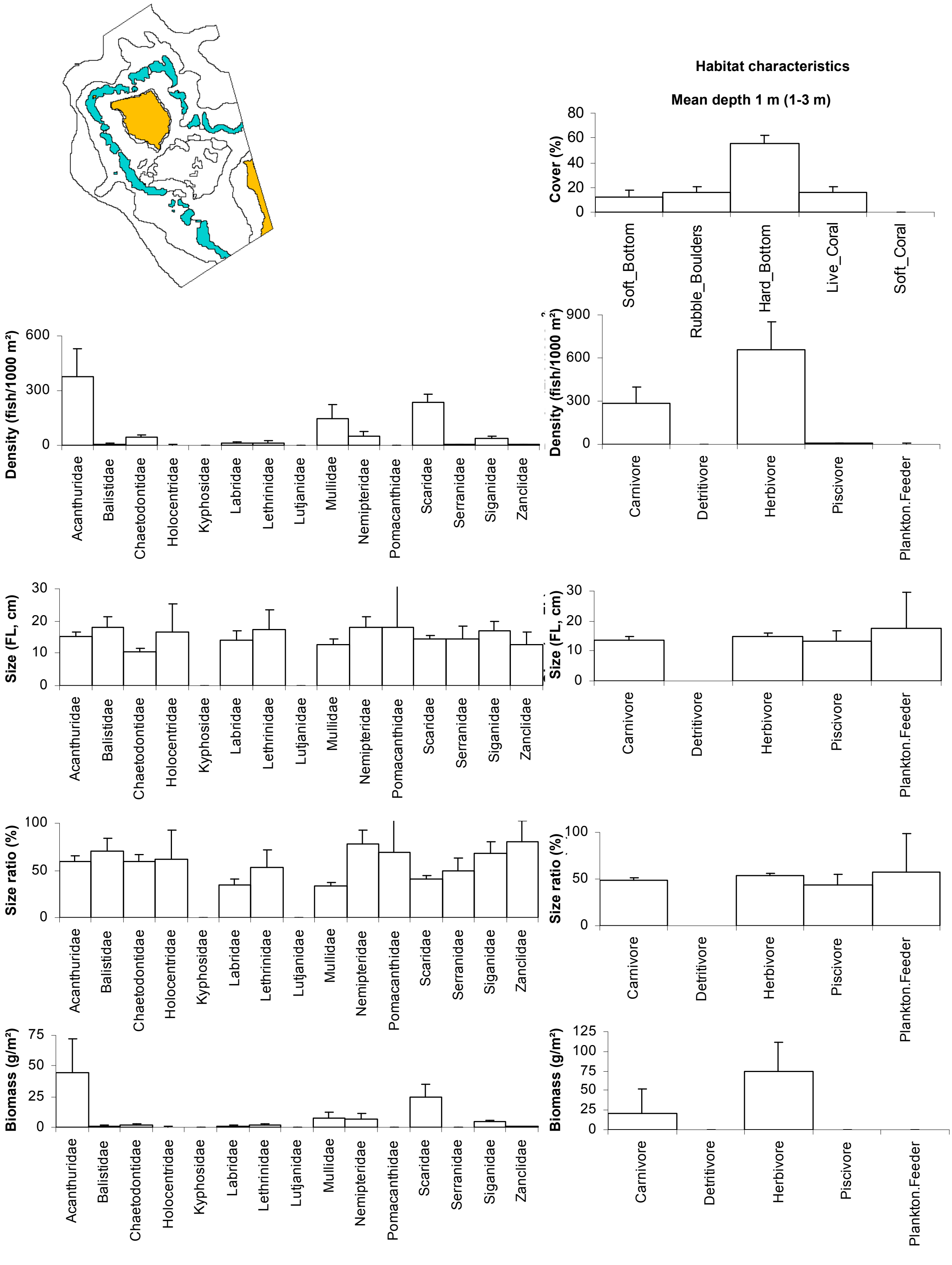

Figure 2.22: Profile of finfish resources in the back-reef environment of Manono-uta.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Manono-uta

The outer reefs were numerically dominated by the herbivores Acanthuridae and Scaridae, and to a much lesser extent by the carnivores Lutjanidae (Figure 2.23). When considering biomass, Lethrinidae was the next important family after these three. Biomass values for Acanthuridae and Scaridae were more than twice as high as the back-reef values. Acanthuridae were present with 8 of the 11 species contributing mostly to biomass. The overall most important species in terms of biomass were: the parrotfish *Chlorurus sordidus*, followed by *Ctenochaetus striatus*, *Acanthurus nigroris*, *Naso lituratus*, *Lutjanus fulvus*, *Scarus oviceps*, *A. blochii*, *A. nigricans*, *A. olivaceus*, *A. nigrofuscus* and *Zebrasoma scopas*, listed by decreasing biomass (Table 2.12), all herbivores except for the invertebrate-eating *Lutjanus fulvus*.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striped bristle-tooth	0.28	26.2
	Zebrasoma scopas	Brushtail tang	0.10	3.3
	Acanthurus nigroris	Blue-lined surgeonfish	0.09	17.4
	Acanthurus nigricans	Whitecheek surgeonfish	0.08	8.2
	Naso lituratus	Orange-spine unicornfish	0.05	16.3
	Acanthurus olivaceus	Orangeband surgeonfish	0.03	6.3
	Acanthurus blochii	Ringtail surgeonfish	0.02	8.6
	Acanthurus nigrofuscus	Dusky surgeonfish	0.02	4.2
Scaridae	*Chlorurus sordidus*	Bullet-head parrotfish	0.20	27.0
	Scarus oviceps	Dark-capped parrotfish	0.06	14.0
Lutjanidae	*Lutjanus fulvus*	Humpback snapper	0.06	14.9

This was by far the richest of all habitats, with density, biomass, biodiversity, size and size ratios the highest of all habitats. Density was ten times higher and biodiversity almost three times higher than in the sheltered coastal reef habitat.

When compared to the outer reefs in the other sites in Samoa, Manono-uta outer reefs displayed the highest total density and biomass but the lowest sizes (Table 2.13). Manono-uta presented also the highest values of density for Acanthuridae, and both highest density and biomass for Scaridae (consistently the two most abundant families at all sites), Lutjanidae, Serranidae and Siganidae.

The substrate was mostly made up of hard bottom (80%, bedrock and dead coral), with the lowest cover of live coral among the four habitats.

Table 2.13: Comparisons of the outer-reef biological parameters among the four Samoan sites

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	**1.31 (±0.13)**	**201.2 (±30.9)**	**17.1 (±0.6)**	**57.6 (±2.0)**
Salelavalu	0.94 (±0.18)	166.0 (±28.9)	18.0 (±0.7)	59.5 (±2.2)
Vailoa	1.03 (±0.13)	179.0 (±32.0)	17.3 (±0.5)	62.0 (±1.7)
Vaisala	0.74 (±0.16)	132.0 (±35.2)	17.9 (±0.7)	62.3 (±2.3)

Figures in brackets denote standard error; FL = fork length.

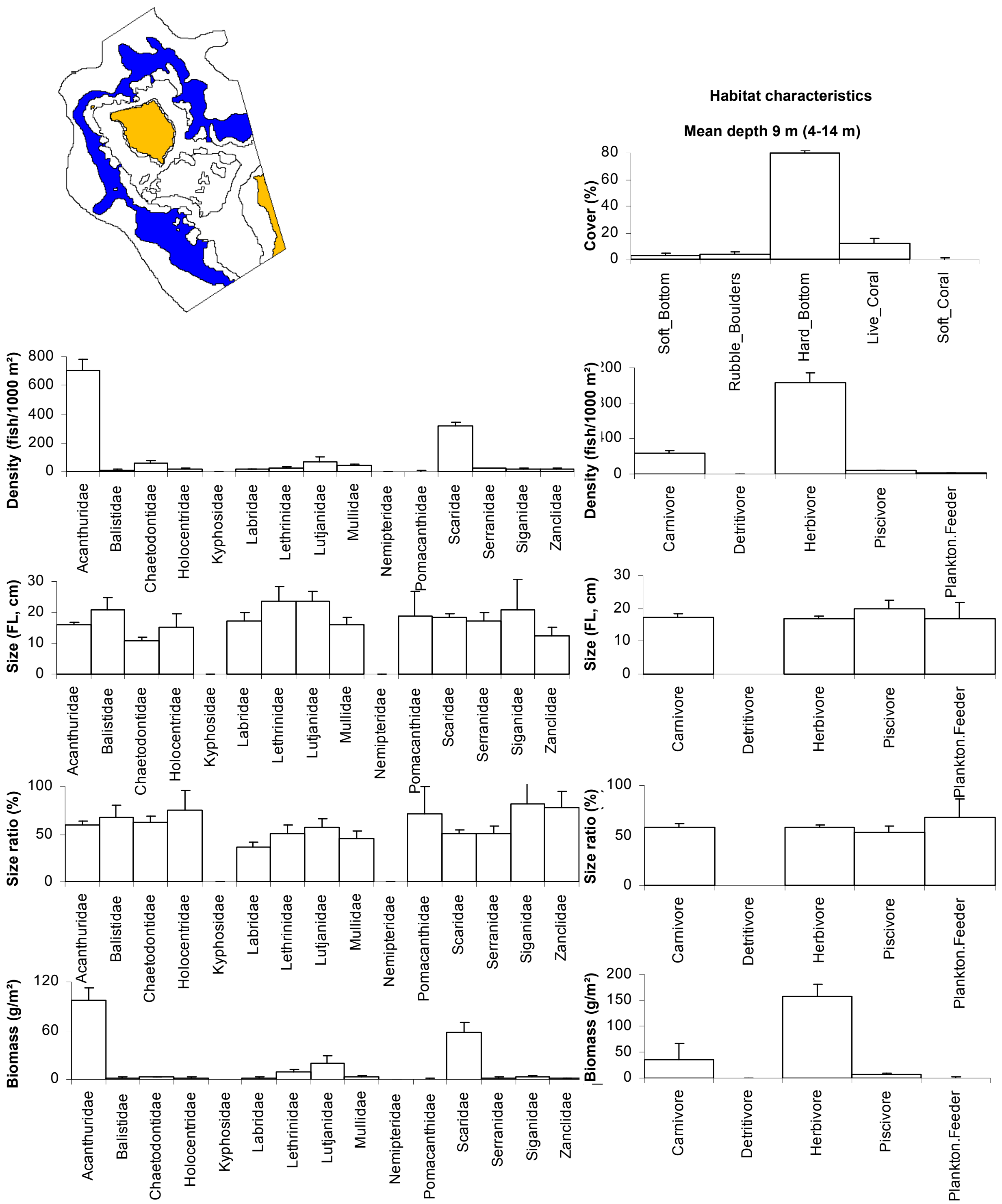

Figure 2.23: Profile of finfish resources in the outer-reef environment of Manono-uta.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Manono-uta

The four habitats considered as a whole are characterised by dominance in abundance and biomass of the herbivore families: Acanthuridae and Scaridae, and the carnivore family Lutjanidae. These families were represented by a total of 48 species of which the most important ones were, in order of decreasing abundance, *Ctenochaetus striatus*, *Chlorurus sordidus*, *Lutjanus biguttatus*, *Acanthurus nigroris*, *A. nigricans*, *Scarus oviceps*, and *L. fulvus* (Table 2.14). The overall community compositions are controlled mostly by the relative abundance and biomass of families encountered in the lagoon reefs, as expected, since this was the largest habitat (47% of total surface area in Manono-uta, Table 2.6).

Table 2.14: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Manono-uta (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striped bristle-tooth	0.14	12.2
	Acanthurus nigroris	Blue-lined surgeonfish	0.05	9.3
	Acanthurus nigricans	White-cheek surgeonfish	0.03	2.8
Scaridae	*Chlorurus sordidus*	Bullet-head parrotfish	0.10	12.3
	Scarus oviceps	Dark-capped parrotfish	0.02	5.7
Lutjanidae	*Lutjanus biguttatus*	Two-spot snapper	0.07	5.9
	Lutjanus fulvus	Humpback snapper	0.02	5.3

When finfish resource status is considered at site (or village) level, Manono-uta appears to support the second richest resource among the four study sites in Samoa after Vailoa (Table 2.15). Biomass was second to Vailoa (100.0 versus 116.7 g/m^2); size ratio was the highest overall (55%). However, average species diversity was the second lowest value among the four sites, although very similar to the top values of Salelavalu and Vailoa (28 versus 29 species/transect, Table 2.15). This site was characterised by the highest cover of hard substrate and the lowest cover of live coral of all the sites in Samoa.

Table 2.15: Values (average per transects) of descriptive biological parameters for each site

Site	Average number of species	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	**28**	**0.8**	**100.0**	**15**	**55.0**
Salelavalu	29	0.6	67.8	14	46.0
Vailoa	29	0.8	116.7	15	54.0
Vaisala	24	0.8	97.0	15	54.5

FL = fork length.

Manono-uta is very close to the capital of Apia, with easy access to markets. It is subjected to intense fishing to support the demands of Apia's market and local consumption, and there is high reliance on fisheries resources. Despite these pressures, the fish fauna still appeared to be in good condition in the outer- and back-reefs. However, such a high fishing pressure could easily become overexploitation if not regulated. Signs of depletion are already appearing in the stocks of Acanthuridae and Scaridae in the lagoon and coastal habitats, which are the most fished areas for both subsistence and sale requirements.

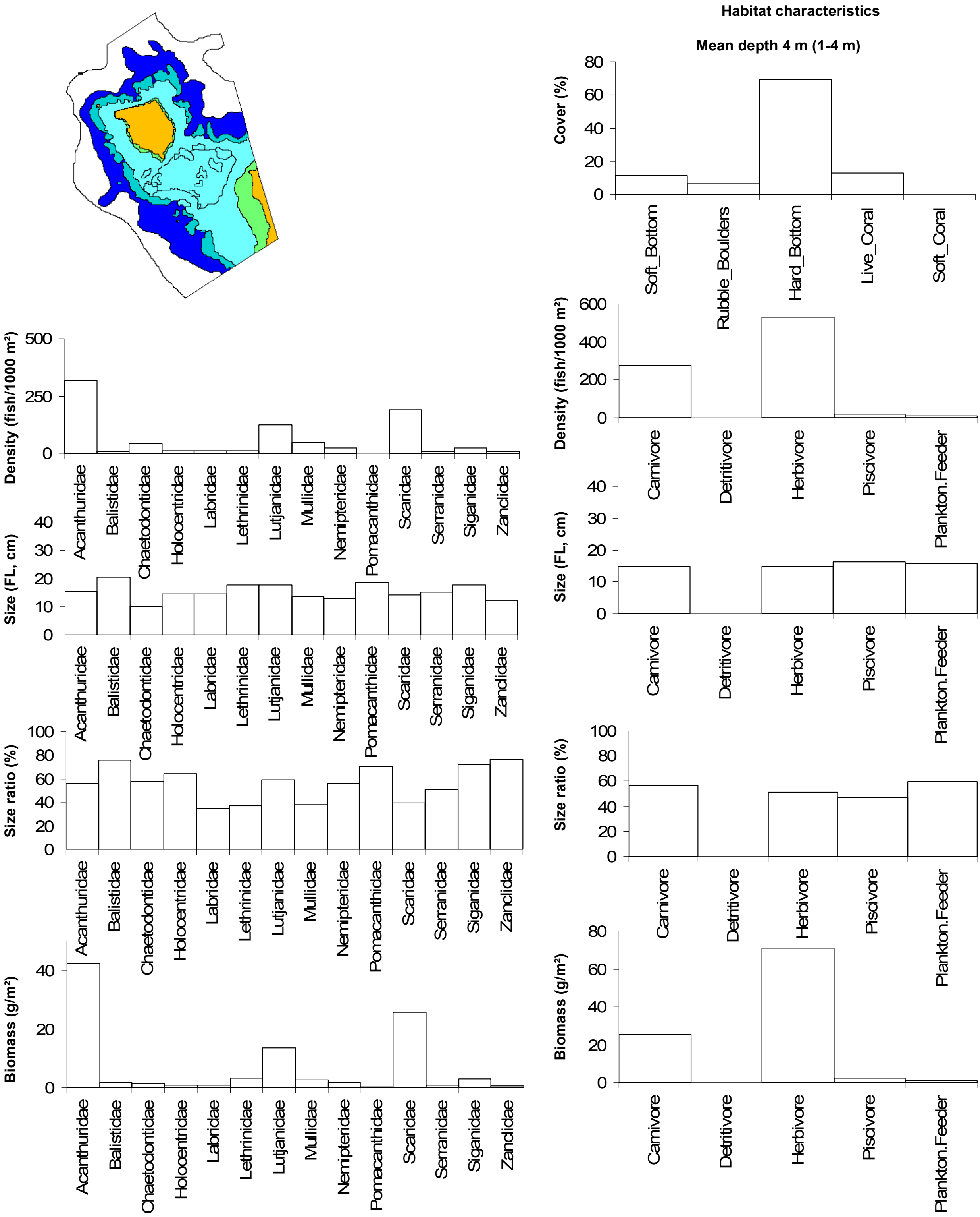

Figure 2.24: Profile of finfish resources in the combined reef habitats of Manono-uta (weighted average).
FL = fork length.

2.3.2 Discussion and conclusions: finfish resources in Manono-uta

In conclusion, finfish resources in Manono-uta appeared to be in good condition, with the second highest biomass and the highest size ratio of fish among the four sampled sites. The richest conditions were found in the outer and back-reefs and this is probably a consequence of the fact that fishing is mostly concentrated in the lagoon habitat. However, Manono-uta has the highest percentage of people involved in fishing for both food and income. Moreover, the market in Apia is close and easily accessible. Consequently, the fishing pressure is rather high and visible in some areas. First signs of impacts are evident as decreased stock of Acanthuridae and Scaridae in the coastal and lagoon habitats.

2.4 Invertebrate resource surveys: Manono-uta

The diversity and abundance of invertebrate species at Manono-uta were independently determined using a range of survey techniques: broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 2.25) and finer-scale assessment of specific reef and benthic habitats (Table 2.16, locations shown in Figures 2.26 and 2.27).

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

Table 2.16: Number of stations and replicate measures completed at Manono-uta

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	72 transects
Reef-benthos transects (RBt)	16	129 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	0	0 transect
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	4	24 search periods
Sea cucumber night searches (Ns)	4	24 search periods
Sea cucumber day searches (Ds)	7	42 search periods

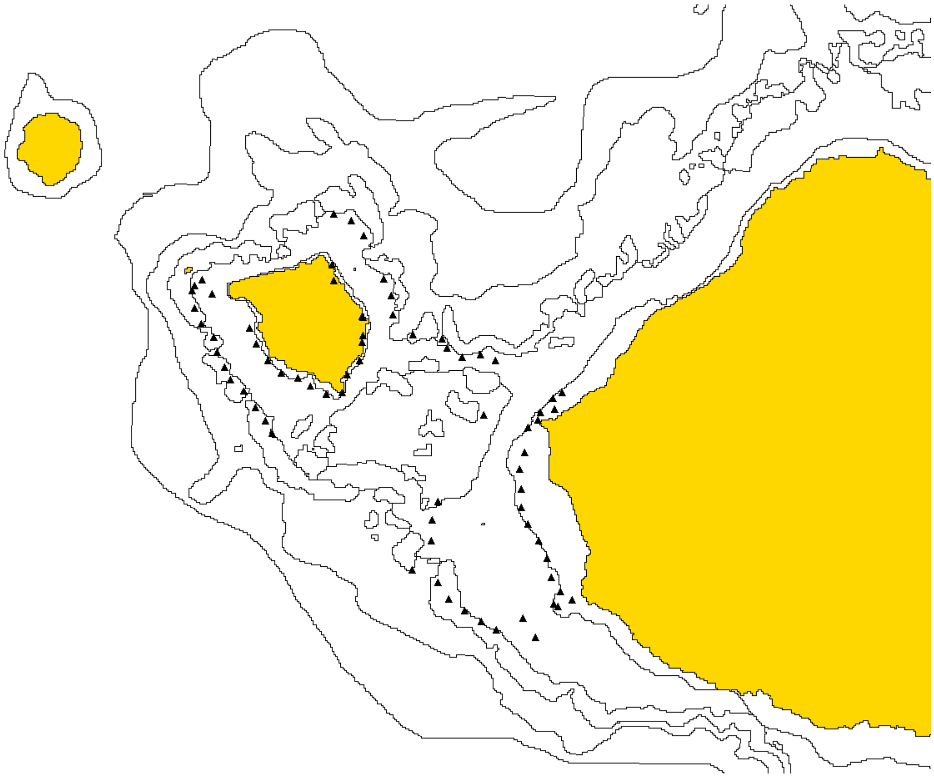

Figure 2.25: Broad-scale survey stations for invertebrates in Manono-uta.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

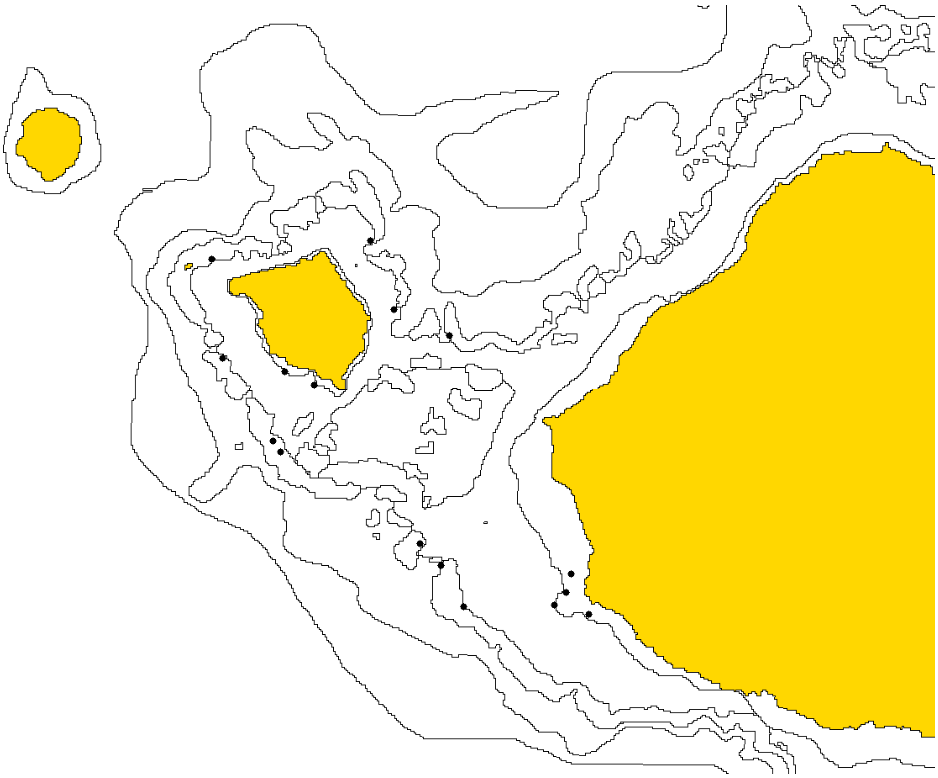

Figure 2.26: Fine-scale reef-benthos transect survey stations for invertebrates in Manono-uta.
Black circles: reef-benthos transect stations (RBt).

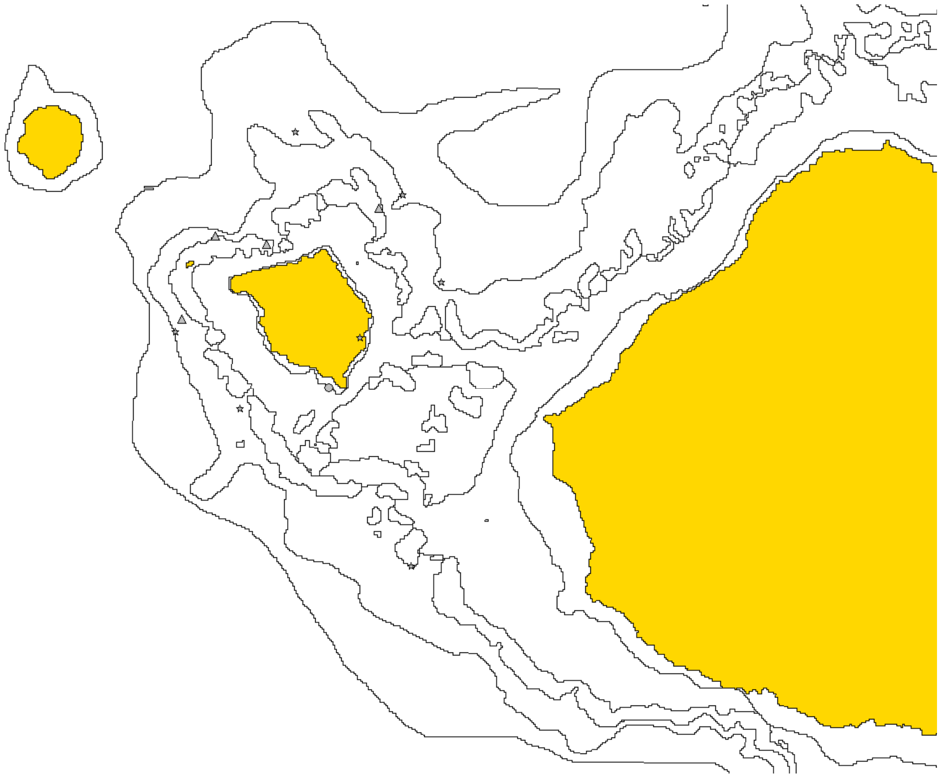

Figure 2.27: Fine-scale survey stations for invertebrates in Manono-uta.
Grey triangles: reef-front search stations (RFs);
grey stars: sea cucumber day search stations (Ds);
grey circles: sea cucumber night search stations (Ns).

Thirty-nine species or species groupings (groups of species within a genus) were recorded in the Manono-uta invertebrate surveys. Among these were: 5 bivalves, 11 gastropods, 11 sea cucumbers, 5 urchins, 3 sea stars, 1 cnidarian and one sand lobster (Appendix 4.1.1). Information on key families and species is detailed below.

2.4.1 Giant clams: Manono-uta

The large land mass of Upolu Island is bordered on the western side by a shallow-water, relatively open lagoon, which has dynamic water flow through numerous deep-water passes to the open ocean. Shallow-reef habitats (suitable for giant clams) were extensive and diverse (28.0 km^2), although only a single naturally occuring species of giant clam, the elongate clam (*Tridacna maxima*) was recorded. The smooth giant clam (*Tridacna derasa*) was also present, but this clam had been introduced and was stockpiled within a 'disputed' marine reserve area close to Manono Island.

Broad-scale sampling provided an overview of giant clam distribution across the Manono-uta study area. *T. maxima* was found at very low density, on reefs in the most exposed locations (found in 1 of 12 stations in a single transect, see Figure 2.28.).

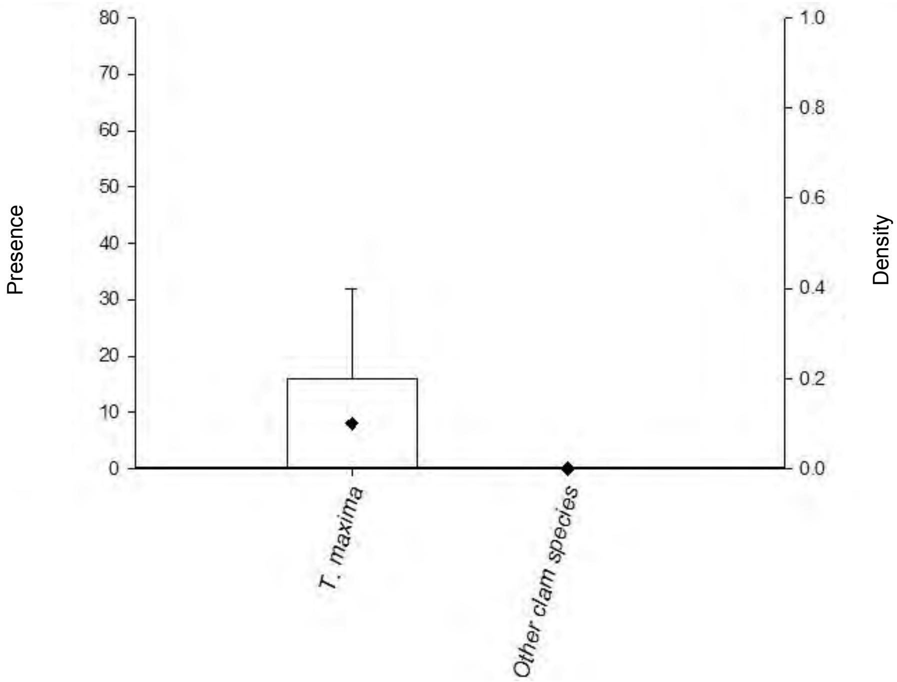

Figure 2.28: Presence and mean density of giant clam species at Manono-uta based on broad-scale assessments.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, fine-scale surveys targeted areas where clam habitat was concentrated. In these reef-benthos transect assessments (RBt), *T. maxima* was present within only 4 of 16 stations (25% of RBt stations, see Figure 2.29.). At these four stations, the mean density was 46.9 ±9.0 individuals/ha.

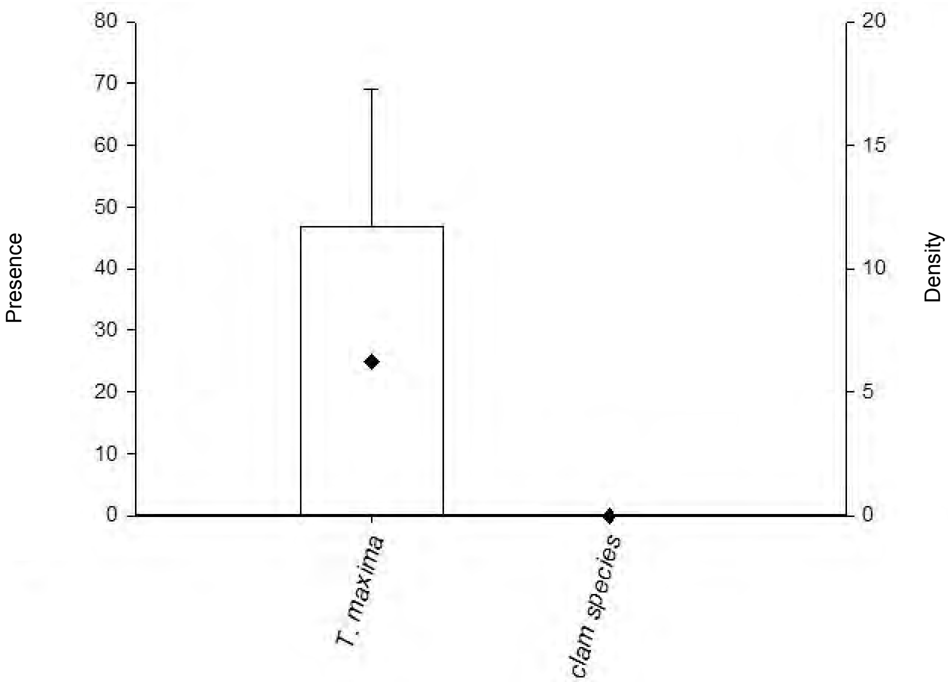

Figure 2.29: Presence and mean density of giant clam species at Manono-uta based on fine-scale reef-benthos survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Clams were uncommon throughout Manono-uta, being virtually absent from the lagoon near the shoreline (apart from the holding area for the smooth clam, *T. derasa*). There was no obvious environmental reason for the absence of clams on these reefs, which implicates overfishing as the main reason. The only other mitigating factor could be water quality, which may have exacerbated the decline of this group of species (The fluted clam, *T. squamosa*, was rare and the horse-hoof or bear's paw clam, *Hippopus hippopus*, extinct.).

There is a limited chance for successful reproduction of clams in the Manono-uta area due to the low number of clams that remain. Individual clams are separated by large distances, which minimise the potential for successful fertilisation of eggs released into the water column. Also, eggs that are viable may be lost from the lagoon system as the prevailing wind pushes water westwards out of the passes (This was noted during the survey, even during incoming tides.). Added to this were water-quality issues (suspension of fine sediment in shallow-water areas, waste metal, plastics, cloth and fishing gear) which were noted in the survey.

T. maxima from reef-benthos stations had an average length of 13.7 cm ±2.1. When clams from deeper water and more exposed locations were included in the calculation (from other assessments), the mean size increased slightly to 15.0 ±1.5, which equates to a *T. maxima* of over 6 years old. As can be seen from the length frequency graph (Figure 2.30), recruitment had not ceased at Manono-uta, but most of the clams present were mature. *T. derasa* stockpiled close to Manono Island were approximately 20–30 cm in length.

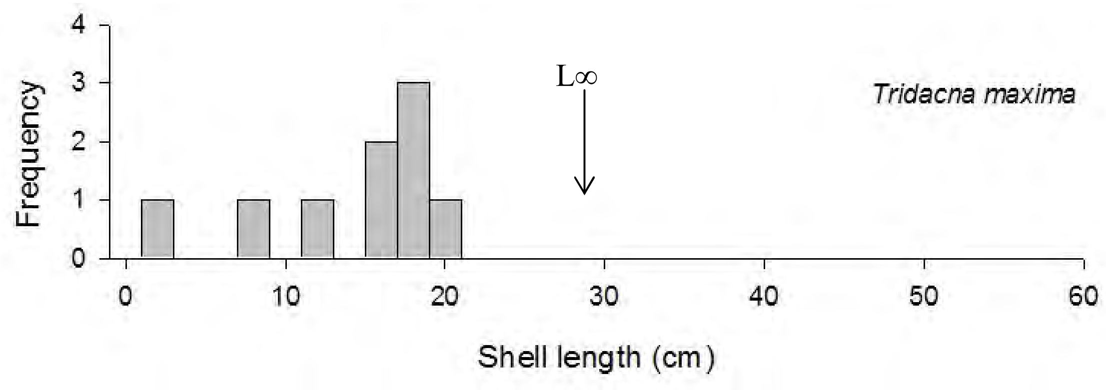

Figure 2.30: Size frequency histogram of *Tridacna maxima* shell length (cm) for Manono-uta.

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

At Manono-uta, there is a large area of reef (22.3 km lineal distance of reef front on the outer barrier reef) suitable for *Trochus niloticus*; this area could potentially support populations of this commercial species. However, Samoa is not within the natural distribution of trochus, and specimens have not been introduced into this area. Despite the apparent suitability of the available reef, numbers of grazing gastropods were not high in general observations.

Tectus pyramis, the green topshell (of low commercial value) is a species with a similar life history to trochus (Table 2.17).

Table 2.17: Presence and mean density of *Tectus pyramis* in Manono-uta
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
Tectus pyramis				
B-S	1.4	0.5	4/12 = 33	6/72 = 8
RBt	21.5	8.9	5/16 = 31	8/129 = 6
RFs	10.9	7.4	2/4 = 50	5/24 = 21

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

Tectus pyramis was only recorded in sparse distribution at low to medium density. The mean size (basal width) of *T. pyramis* (n = 26) was 6.6 cm ±0.4.

The blacklip pearl oyster, *Pinctada margaritifera*, a normally cryptic and sparsely distributed pearl oyster species was not recorded during assessments.

2.4.3 Infaunal species and groups: Manono-uta

The soft benthos of the shallow water lagoon was very sandy and did not hold beds of in-ground resource species such as arc shells, *Anadara* spp. or venus shells, *Gafrarium* spp. Therefore no fine-scale infaunal stations (quadrat surveys) were surveyed in the Manono-uta area.

2.4.4 Other gastropods and bivalves: Manono-uta

Seba's spider conch, *Lambis truncata* (the larger of the two common spider conchs), was detected in broad-scale and reef-benthos surveys at low density. *Strombus luhuanus*, a species often targeted by subsistence fishers in other parts of the Pacific, was uncommon (Appendices 4.1.1 to 4.1.7). Similarly, *Turbo* spp. (*T. argyrostomus*, *T. setosus*) were rare and only recorded in a single reef-front search. Other resource species targeted by fishers (e.g. *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, and *Tectus*) were also recorded during independent surveys (Appendices 4.1.1 to 4.1.8).

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

2.4.5 Lobsters: Manono-uta

There was no dedicated night-time reef-front assessment of lobsters (See Methods.). However, *Lysiosquillina* spp. burrows were recorded in a single reef-benthos transect conducted during the day. No *Panulirus* spp. lobsters were recorded on reef-benthos stations or during night-time lagoon assessments for nocturnal BdM species (Ns).

2.4.6 Sea cucumbers[9]: Manono-uta

The study area at Manono-uta included extensive lagoon areas with shallow-water reef both inshore and outside the barrier reef (30 km² mixed hard- and soft-benthos habitat suitable for sea cucumbers). There was dynamic water movement through the lagoon (generally from east to west), and the area had a high degree of exposure. Allochthonous inputs (river outflows from Manono-uta Island and the extensive mainland) were also noticeable.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 2.18, Appendices 4.1.1 to 4.1.7, also see Methods.). Despite the exposure of some reefs and the relatively sandy lagoon floor, nine commercial species were recorded during in-water assessments (Table 2.18). *Holothuria leucospilota* (Viscera are eaten locally.) and *Synapta* spp. (a potential indicator species) were also recorded.

Within the group of sea cucumber species generally associated with reef, greenfish (*Stichopus chloronotus*), which was relatively common in Samoa, was less common here than at the other three PROCFish/C sites. Conversely, other species associated with reef, such as leopardfish (*Bohadschia argus*) and the high-value black teatfish (*H. nobilis*) were more common. Black teatfish were more common, and recorded at higher densities than in the lagoon facing Manono-uta across the Apolima Strait at Savai'i (Salelavalu), but less common than at the east coast site on Upolu (Vailoa).

Surf redfish (*Actinopyga mauritiana*), which is a species found in well flushed, oceanic-influenced habitats, such as the barrier reef at Manono-uta, were not common at Manono-uta or other Upolu sites. The overall occurrence and densities were unexpectedly poor considering the nature and extent of the reef and surge zone present.

More protected areas of reef and soft benthos in the lagoon held a small range of lower-value species, e.g. brown sandfish (*Bohadschia vitiensis*) and lollyfish (*H. atra*) at reasonably high densities in comparison to other PROCFish/C sites in Samoa. A locally important species collected for subsistence and sale in Samoa was *Stichopus horrens*, locally named *sea*. This species is collected along the mainland shores (Parts of the viscera are bottled along with strips of body wall from lollyfish and brown sandfish.) and was collected during the time of our survey. Night searches for this and other important 'inshore' species were conducted in the lee of Manono-uta Island, which was also well protected (due to logistical constraints), but no *sea* were found.

Deep-dives on SCUBA (25–35m) were conducted to obtain a preliminary assessment of deep-water stocks, such as the high-value white teatfish (*Holothuria fuscogilva*) and the lower-value amberfish (*Thelonata anax*). The presence and density of these commercial species were generally similar to records across the four sites in Samoa, except that the area was more extensive and some lagoon-floor species were more common in Manono-uta. In the deep water, white teatfish (*H. fuscogilva*) and prickly redfish (*T. ananas*) were present, but occurrence was patchy and no high-density aggregations were located.

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

2.4.7 Other echinoderms: Manono-uta

No edible slate urchin *Heterocentrotus mammillatus* or collector urchins *Tripneustes gratilla* were recorded in survey, although *Echinometra mathei* and *Echinothrix* spp. were present.

Starfish (e.g. *Linckia laevigata*, the blue starfish) were very common in assessments (present in 60% of broad-scale transects; see presence and density estimates in Appendices 4.1.1 to 4.1.7). Coralivore (coral eating) starfish, such as *Culcita novaeguineae*, were relatively common (found on 35% of broad-scale transects). Crown of thorns starfish (*Acanthaster planci*) were less common in Manono-uta than in other PROCFish/C sites, despite the northerly offshore reefs showing very little live coral after an event which may have included a COTS outbreak (1990 and 1991 saw cyclones Ofa and Val, but many plate corals in deeper water were intact but dead.). Only three COTS were recorded in Manono-uta assessments.

Table 2.18: Sea cucumber species records for Manono-uta

Species	Common name	Commercial value [5]	B-S transects n = 72			Reef-benthos stations n = 16			Other stations RFs = 4			Other stations Ds = 7; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga mauritiana	Surf redfish	M/H				2.0	31.3	6	4.1	8.3	50			
Bohadschia argus	Leopardfish	M	19.5	42.5	46	29.1	58.2	50	1.5	6.2	25	1.3 24.7	3.1 44.4	43 Ds 75 Ns
Bohadschia vitiensis	Brown sandfish	L	80.1	240.3	33							64.4	64.4	100 Ns
Holothuria atra	Lollyfish	L	2434	2781	88	5209	5556	94	22.6	30.1	75	0.3 26.7	2.4 26.7	14 Ds 100 Ns
Holothuria fuscogilva [4]	White teatfish	H										1.0	7.1	14 Ds
Holothuria fuscopunctata	Elephant trunkfish	M										0.3	2.4	14 Ds
Holothuria leucospilota	Black cucumber	-	0.5	16.2	4									
Holothuria nobilis [4]	Black teatfish	H	0.7	16.2	4	3.9	62.5	6	1.5	6.2	25	0.7	2.4	29 Ds
Stichopus chloronotus	Greenfish	H/M	163.4	356.5	46	212.9	340.6	63	1.5	6.2	25			
Stichopus horrens	Peanutfish	M												
Synapta spp.	-	-	2.9	23.2	13	43.0	137.5	31						
Thelenota ananas	Prickly redfish	H										1.7	4.0	43 Ds
Thelenota anax	Amberfish	L												

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

2.4.8 Discussion and conclusions: invertebrate resources in Manono-uta

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

- The presence, density and size range of clams in Manono-uta indicate that the resource is degraded. Although there were mitigating environmental factors, fishing pressure was the most likely cause for the low density of *T. maxima* and rarity of *T. squamosa* at Manono-uta.

- Present densities of giant clams are so low that they have reached a 'critical threshold' where reproductive success and subsequent recruitment is severely impaired and stocks are likely to decline if action is not taken to protect clams in the lagoon and reintroduce clams to areas which have been cleared completely.

- Data on presence and recruitment of *T. pyramis* indicate that the habitat for grazing gastropods is present, although the density of this species, which is related to the commercial topshell, *Trochus niloticus*, was not high.

- Any consideration for future releases of trochus may consider initially placing transplanted shells on reefs within the lagoon, or on the more protected northern sections of the barrier reef, where epiphytic growth (and potential food sources for trochus) is more developed but crustose coralline algae is still present.

- Taking into account the cryptic nature of *Pinctada margaritifera*, results from the Manono-uta survey describe a low occurrence for the blacklip pearl oyster.

- Based on the information collected on sea cucumber stocks, there is a limited range of species available for commercial fishing; stocks are patchy and *Stichopus horrens* (sea) was not generally abundant at suitable fishing areas in the lagoon.

- Some potential exists for the commercial fishing of brown sandfish (*Bohadschia vitiensis*), and greenfish (*Stichopus chloronotus*) but, before a management plan can be developed for such a fishery, more comprehensive results from Samoa will be needed (A follow-up study has been arranged in collaboration with Uppsala University to sample further sites across Upolu and Savai'I, see Friedman *et al.* 2006.).

- The presence of high-value teatfish and other deep-water stocks are of interest for commercialisation, but stocks look to be insufficient to support regular fishing.

2.5 Overall recommendations for Manono-uta

Based on the survey work undertaken and the assessments made, the following recommendations are made for Manono-uta:

- A community fisheries management programme and the necessary bylaws to protect the community's reef and lagoon resources from further overfishing and to sustain their fisheries for future use be implemented by the Manono-uta community, in close cooperation with the Council of Elders, the pastors, and male and female fishers.

- Marine protected areas be considered as a primary management tool. Measures should be put in place to regulate commercial finfish fishing and these should be accompanied by regular monitoring to ensure that finfish resources remain available for subsistence use by future generations.

- SCUBA diving at night on the outer reef and net fishing in the much poorer coastal and lagoon reefs be regulated to reduce the heavy impact on reef resources.

- Immediate action be taken to protect giant clams in the lagoon and reintroduce clams to areas which have been cleared completely to prevent further decline of these critically depleted stocks.

- The position of the stockpile of *Tridacna derasa*, close to the island of Manono is not optimal, and mortalities seen at this site are likely a result of environmental stresses. At this shallow-water location, boats were moored above the clams and wave movement was too severe. If security issues allow, these clams should be moved to deeper water (2–4 m), in areas which are subject to moderate current and more oceanic influence.

- Some potential exists for the commercial fishing of brown sandfish (*Bohadschia vitiensis*) and greenfish (*Stichopus chloronotus*) but, before a management plan can be developed for such a fishery, more comprehensive results from Samoa will be needed.

- Crown of thorn starfish (COTS) were present in Manono. The population of COTS should be closely monitored by measuring size and abundance of these starfish and the scars they make on coral when feeding, to forewarn of an outbreak.

- Any consideration for future releases of trochus may consider initially placing transplanted shells on reefs within the lagoon, or on the more protected northern sections of the barrier reef, where epiphytic growth (and potential food sources for trochus) is more developed but crustose coralline algae is still present.

3. PROFILE AND RESULTS FOR SALELAVALU

3.1 Site characteristics

Salelavalu is located next to Saleloga, the main urban centre of Savaii, and the island's major port, and administrative and commercial centre. Salelavalu has good access to a major urban market, via the major ferry service that links Savaii with Upolu. Salelavalu is divided into two main areas: Salelavalu-uta, with a population of 571, and Salelavalu-tai with a population of 338 people (Statistical Services Division 2001). The surveys concentrated mainly in the sea areas adjacent to Salelavalu. The reef boundaries adopted during resource surveys stretched from the borders between Saleiloaga and Salelavalu all the way to Lalomalava.

Due to the fact that Salelavalu is close to Salelologa (one of the largest reef areas in Samoa, with a complex structure, habitat diversity and high coral cover), the coral reefs around the Salelavalu area also enjoys a high level of nutrients, supplied by the Apolima Strait upwelling (Zann 1997).

Previous surveys found the coral reefs to be relatively healthy, larger than the reefs at Vaisala and more complex (Zann 1997). There were reports of a crown of thorns outbreak between 1993 and 1995; however, this was not evident during the survey, and the corals affected may have fully recovered since then.

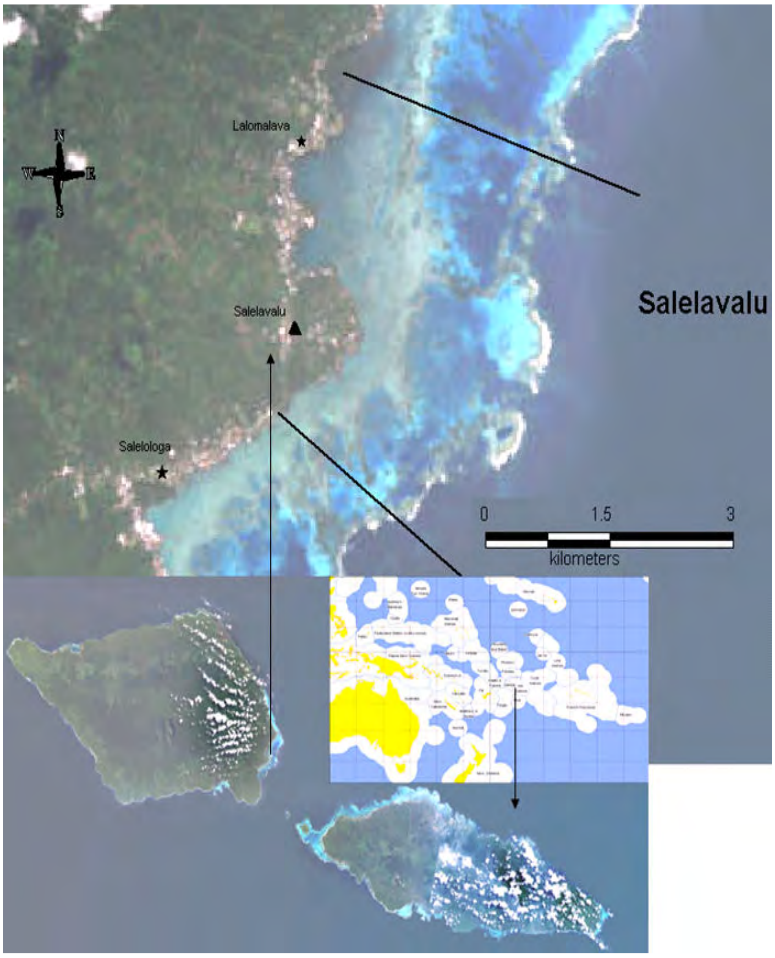

Figure 3.1: Location of Salelavalu.

SALELOGA TO SALELAVALU (FAASALELEAGA I)

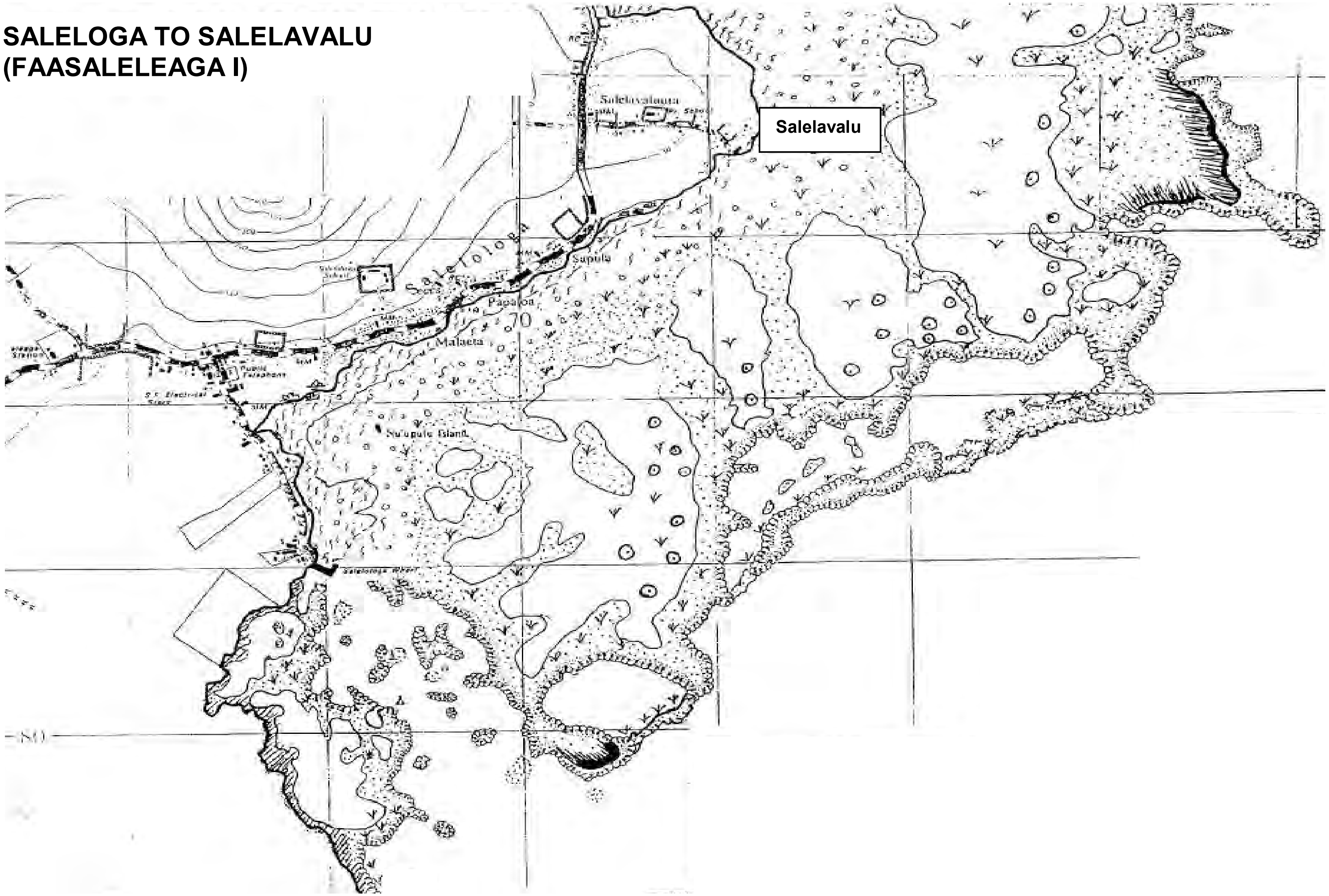

Figure 3.2: Reef system of Salelavalu.

The reef of Salelavalu is a relatively highly complex system. The lagoon reefs in particular are complex, with patch, exposed and submerged reefs covering most of the entire lagoonal area. Water depth in the lagoon ranges from a few meters to over 25 m. The coastal intertidal flat extends from the coastline to over 150 m in some areas; a few 'pools' are scattered along this intertidal flat.

3.2 Socioeconomic surveys: Salelavalu

Socioeconomic fieldwork was carried out in Salelavalu, on the island of Savaii in Samoa on 24–28 August 2005. The fieldwork included household surveys in the three villages of Vaifou, Salelavalu-Tai and Salelavalu-Uta, with 5, 23 and 18 households surveyed respectively. These villages are all referred to as 'Salelavalu' in the following.

The Salelavalu community has a resident population of 1841 and about 180 households. A total of 48 households, which is 27% of total households in the Salelavalu community, were surveyed, with 83% of these households engaged in some form of fishing activities. In addition, a total of 59 finfish fishers (51 males and 8 females) and 22 invertebrate fishers (14 males and 8 females) were interviewed. The household size is large with 10 people on average, due to the practice of living together in extended families (*aiga*). The *aiga* or extended family grouping enables the work to be shared, with everyone designated tasks relating to farming, fishing or general community obligations.

Household interviews focused on the collection of general demographic, socioeconomic and consumption data. General information on sales and distribution of fisheries resources was gathered through interviews with shopkeepers and boat owners. A general survey of shops to establish prices of tinned fish and other food items consumed was also conducted.

Salelavalu has easy access, by walking or using paddling canoes, to its coastal reefs, with small patches of mangroves, a considerable lagoon area, and access to the outer reef and passages. The community is close to the island's major urban market and has easy access to the country's capital market Apia, on Upolu, through the regular ferry services close by. In fact, almost everyday some fishers from Salevalalu market their marine produce at Apia.
Compared to other sites studied in Samoa there is quite a high level of commercial fishing and hence a potential for visible detrimental impact on the community's fishing resources due to catches for external demand.

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

Our results (Figure 3.3) suggest that the primary sector mainly sustains the income needs of Salelavalu's population. Fisheries are the most important source of income, providing ~33% of all households with first income and ~27% with second income. Agricultural produce is not far behind, providing ~29% of all households with first and another ~35% with second income from selling crops or livestock. Salaries and other sources, which mainly include handicrafts and small private business, provide the first source of income for another ~21% and ~17% of all households. The great number of options for generating cash from primary and secondary sector activities is determined by the natural endowment of marine and land resources, and the traditional ownership by the community, as well as its close proximity to the urban centre on Savaii.

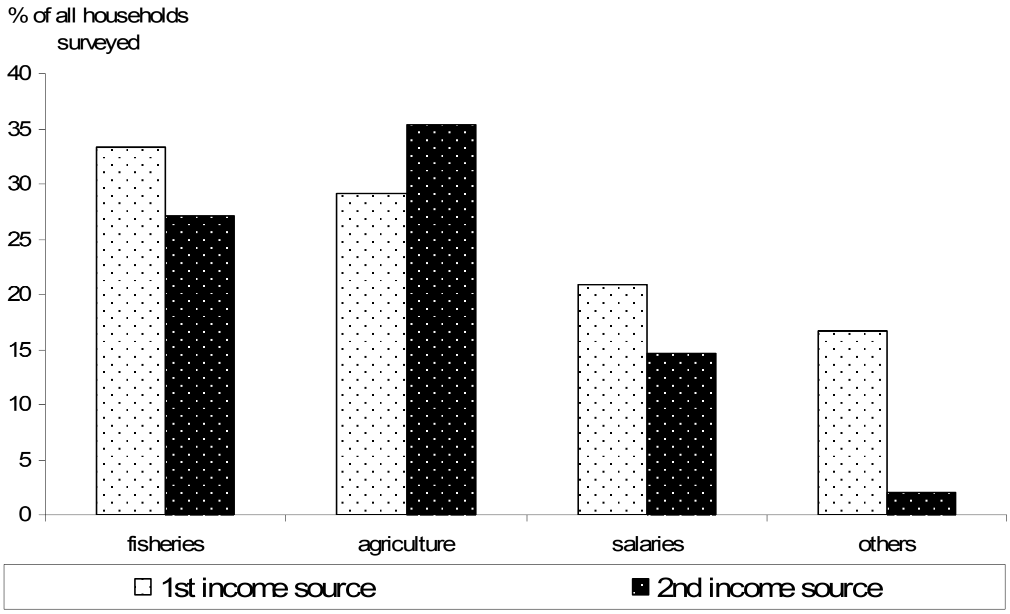

Figure 3.3: Ranked sources of income (%) in Salelavalu.
Total number of households = 48 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses.

Our results (Table 3.1) show that annual household expenditures are lower than the average across all sites surveyed in Samoa, i.e. on average USD 2144. Families claimed to spend cash mainly on necessary food and household items, including *falavelave* (traditional or religious obligations relating to weddings, births, christening of children, funerals, etc.). The household expenditure also includes weekly church donations, which people regarded as a basic obligation. The relatively low household expenditure level is a consequence of the high involvement of almost all households in both agriculture and fisheries, which enables most households in Salelavalu to be very self-sufficient in basic food items.

Table 3.1: Fishery demographics, income and seafood consumption patterns in Salelavalu

Survey coverage	Site (n = 48 HH)	Average across sites (n = 207 HH)
Demography		
HH involved in reef fisheries (%)	83.3	91.3
Number of fishers per HH	1.63 (±0.16)	2.03 (±0.09)
Male finfish fishers per HH (%)	56.4	46.6
Female finfish fishers per HH (%)	1.3	2.9
Male invertebrate fishers per HH (%)	3.8	2.1
Female invertebrate fishers per HH (%)	7.7	13.3
Male finfish and invertebrate fishers per HH (%)	17.9	25.9
Female finfish and invertebrate fishers per HH (%)	12.8	9.3
Income		
HH with fisheries as 1st income (%)	33.3	25.1
HH with fisheries as 2nd income (%)	27.1	27.1
HH with agriculture as 1st income (%)	29.2	28.5
HH with agriculture as 2nd income (%)	35.4	27.5
HH with salary as 1st income (%)	20.8	17.9
HH with salary as 2nd income (%)	14.6	11.6
HH with other source as 1st income (%)	16.7	28.5
HH with other source as 2nd income (%)	2.1	8.2
Expenditure (USD/year/HH)	2144.12 (±157.76)	2991.32 (±209.55)
Remittance (USD/year/HH) (1)	2100.17 (±154.51)	2170.81 (±89.23)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	58.03 (±4.97)	61.26 (±4.35)
Frequency fresh fish consumed (times/week)	4.26 (±0.20)	3.92 (±0.10)
Quantity fresh invertebrate consumed (kg/capita/year)	13.14 (±3.86)	9.61 (±4.35)
Frequency fresh invertebrate consumed (times/week)	0.41 (±0.07)	0.49 (±0.04)
Quantity canned fish consumed (kg/capita/year)	19.00 (±2.55)	24.26 (±1.92)
Frequency canned fish consumed (times/week)	2.89 (±0.23)	2.81 (±0.11)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	66.7	83.6
HH eat canned fish (%)	95.8	97.6
HH eat fresh fish they catch (%)	75.0	82.1
HH eat fresh fish they buy (%)	37.5	23.9
HH eat fresh fish they are given (%)	27.1	59.7
HH eat fresh invertebrates they catch (%)	37.5	52.2
HH eat fresh invertebrates they buy (%)	16.7	19.4
HH eat fresh invertebrates they are given (%)	31.3	64.2

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

Remittance is also an important component of the Salelavalu household income. At least 91% of all households surveyed in Salelavalu receive remittances, and the average amount each household receives is substantial, USD 2100 per year. The large number of households that receive remittances and the average amount of USD >2000 per year is consistent throughout all four study areas in Samoa. The many Western Union outlets (offices for transferring money overseas) throughout the two main islands of Samoa are a good indicator of the importance of remittances to the Samoan livelihood. Comparing the average annual household expenditure and the average annual remittances received, it is evident that the basic costs of an average family in the Salelavalu community are met by external donations. Therefore, it is not surprising that most families interviewed described remittances as either the main or one of the major sources from which most of the *falavelave* are met. The frequency of remittances received ranges from once a fortnight to once a month, and most of the foreign currency received is sourced from New Zealand. However, it should also be noted that remittances also include a return of goods and services to people overseas, usually gifts of food and handicrafts.

Survey results indicate an average of 1–2 fishers per household and, when extrapolated, the total number of fishers in Salelavalu is 293: 229 males and 64 females. These include 169 exclusive finfish fishers (165 males and 4 females), 34 exclusive invertebrate fishers (11 males and 23 females), and 90 fishers that fish for both finfish and invertebrates (53 males and 38 females). The participation of males and females in the various fishing activities reflects the traditional division of labour in the Samoan society, where males are responsible for the more physical activities, including fishing and farming, while females are largely responsible for domestic chores.

More than half of all households (56%) own a boat, and most (79%) are non-motorised canoes; only 21% are equipped with an outboard engine.

Consumption of fresh fish is ~58 kg/person/year. This is below the average across all four study sites in Samoa, yet significantly above the regional average of ~35 kg/person/year (Figure 3.4). By comparison, consumption of invertebrates (edible meat weight only) (Figure 3.5) is relatively high with ~13 kg/person/year. Canned fish (Table 3.1) adds another ~19 kg/person/year to the protein supply from seafood. The pattern of seafood consumption found in Salelavalu highlights the fact that people have access to a variety of agricultural and marine food sources. Also, canned fish, locally named *elegi*, is a regular constituent of *falavelave*, which may explain the large quantity consumed.

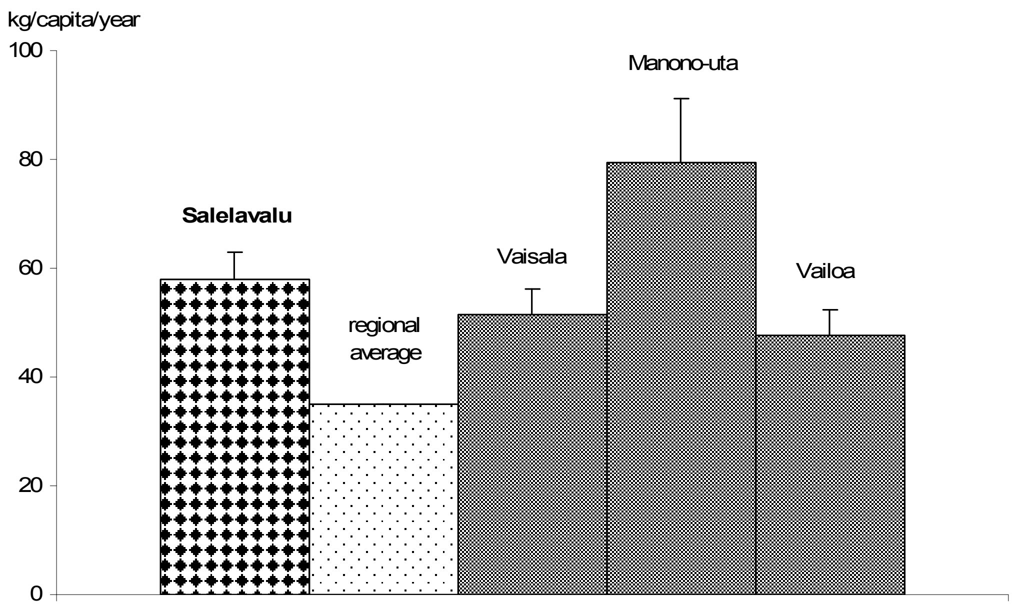

Figure 3.4: Per capita consumption (kg/year) of fresh fish in Salelavalu (n = 48) compared to the regional average (FAO 2002) and the other three PROCFish/C sites in Samoa.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

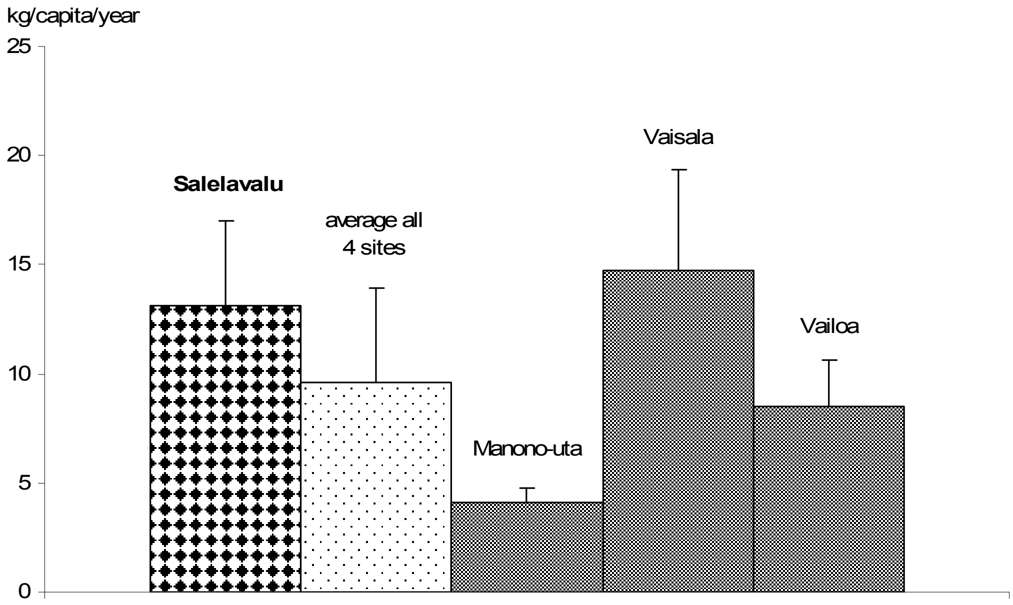

Figure 3.5: Per capita consumption (kg/year) of invertebrates (meat only) in Salelavalu (n = 48) compared to the average of all four sites and the other three PROCFish/C sites in Samoa. Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Comparing results obtained for Salelavalu to the average figures across all four study sites surveyed in Samoa, people of the Salelavalu community eat a bit less fresh and canned fish, but more invertebrates than found on average. Also, Salelavalu people buy more fresh fish than the average amount, and they exchange fresh fish and invertebrates less on a non-commercial basis. The relatively frequent purchase of fresh fish may be explained by the relatively high proportion of households that earn first and second income from salaries and private small business, as well as the proximity to two urban centres, and hence a high level of marketing fishery produce. Fisheries play a much greater role in providing income, agriculture about average and salary a much higher role than the average across all Samoan PROCFish sites. While household expenditure level in Salelavalu is less than elsewhere, the remittance amount received is about the same. By comparison, more households own a boat and most of the boats are non-motorised.

3.2.2 Fishing strategies and gear: Salelavalu

Degree of specialisation in fishing

The Salelavalu villages are located along the seafront, with people depending on fisheries produce to a great extent for both food and income. Both genders fish for finfish, although mostly males (74%), compared to females (14%). Both genders also fish for invertebrates (22% males; 21% females) (Figure 3.6). Some fishers may fish for both finfish and invertebrates, and thus percentages may exceed 100% as these fishers are accounted for twice. As shown in Figure 3.6, the exclusive finfish fishers are mostly males, while females mainly harvest invertebrates. Only a very few fishers exclusively collect invertebrates, nor do many fishers collect both finfish and invertebrates in a single trip or during different fishing trips (Table 3.2).

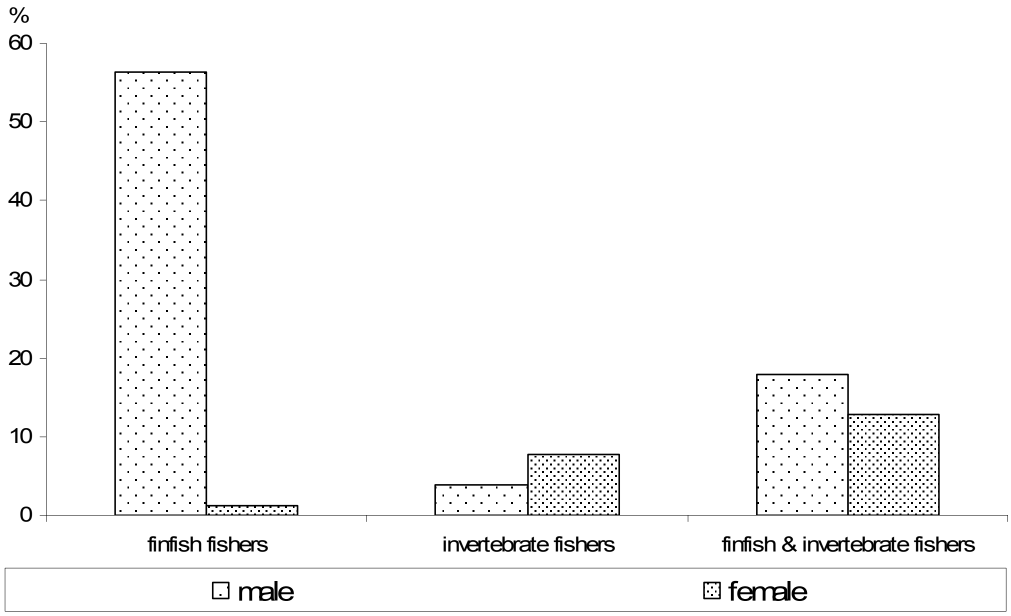

Figure 3.6: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Salelavalu.
All fishers = 100%.

Targeted stocks/habitat

Considering the number of boats and, in particular, motorised boats, it is not surprising that Salelavalu finfish fishers mainly target the easily accessible habitats, namely the sheltered coastal reef and lagoon. Often, these are combined in one trip. Outer reef and passages in combination with the lagoon are fished by male fishers only, and trips are much less frequent (Tables 3.2 and 3.3). Invertebrate collection is distributed over a wide variety of habitats and often includes a combination of different habitats and/or target species. For females, the reeftop is the most frequently visited habitat, followed by soft benthos and mangrove, often combined in one fishing trip. Invertebrate harvesting by males is much more varied and scattered over a large range of fisheries. While most males seem to target the soft-benthos habitat, others prefer to combine intertidal, soft-benthos and reeftop areas for collection, and sometimes dive for lobsters, giant clams, and selected bêche-de-mer species (Table 3.2).

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

Resource	Fishery / Habitat	% male fishers interviewed	% female fishers interviewed
Finfish	Sheltered coastal reef & lagoon	35.3	75.0
	Lagoon	37.3	25.0
	Lagoon & outer reef	27.5	0.0
Invertebrates	Reeftop	0.0	100.0
	Reeftop & other	7.1	0.0
	Intertidal	7.1	12.5
	Intertidal & reeftop	14.3	0.0
	Soft benthos	14.3	12.5
	Soft benthos & mangrove	7.1	50.0
	Soft benthos & intertidal	28.6	25.0
	Soft benthos & intertidal & reeftop	7.1	0.0
	Mangrove	0.0	12.5
	Lobster	7.1	0.0
	Lobster & other	7.1	0.0
	Other	7.1	0.0

'Other' refers to the to the giant clam fishery.
Finfish fisher interviews, males: n = 51; females: n = 8. Invertebrate fisher interviews, males: n = 14; females, n = 8.

Fishing patterns and strategies

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

Our survey sample suggests that fishers from Salelavalu have the choice between sheltered coastal reef, lagoon and outer-reef habitats, including reef passages. However, soft benthos (33%), reeftop (28%), mangroves (13%) and intertidal areas (13%) are the main habitats for invertebrate fisheries (Figure 3.7). Seagrass (soft benthos) is particularly targeted to collect bêche-de-mer by walking. Females dominate the gleaning fisheries (reeftop, soft benthos) and also glean the mangroves. Females do not engage in lobster, giant clam, or bêche-de-mer diving (Figure 3.8).

Boats, mostly non-motorised, are only used in one-third of all fishing trips to the sheltered coastal reef, while another third is performed by walking, and the last third may or may not use boat transport. The use of boats for fishing increases to 80% or even more when the lagoon and the combined lagoon and outer-reef areas are targeted. Most of the finfish fishing in Salelavalu is done according to the tide, either during the day or night. About 30% of all fishing in the sheltered coastal reef and lagoon area is performed only during the day, and mainly by female fishers. The 5% of all male fishers who target the lagoon alone, fish exclusively at night. Ice is hardly ever used on fishing trips (5–14% of all fishing trips to any of the habitats or combinations thereof). Males prefer to fish at night if the catch is to be marketed early next morning.

While most invertebrates are collected during daytime, diving for lobsters and other species is exclusively done at night. Mangrove fishing is mainly done at night, as is 50% of the combined gleaning of intertidal and reeftop habitats. Boats are always used to go diving for lobsters and other species, which is only performed by males. In 40–60% of all trips, motorised boats were used when gleaning the combined areas of soft benthos, mangrove and reeftop.

Finfish and invertebrate fishing are done throughout the year, even for the most important bêche-de-mer fishery, which is banned nationwide.

When fishers use motorised boats, and/or borrow particular fishing gear, they usually pay the boat owner with a share of the catch, or from the money they make from selling the catch, e.g. at the Apia market.

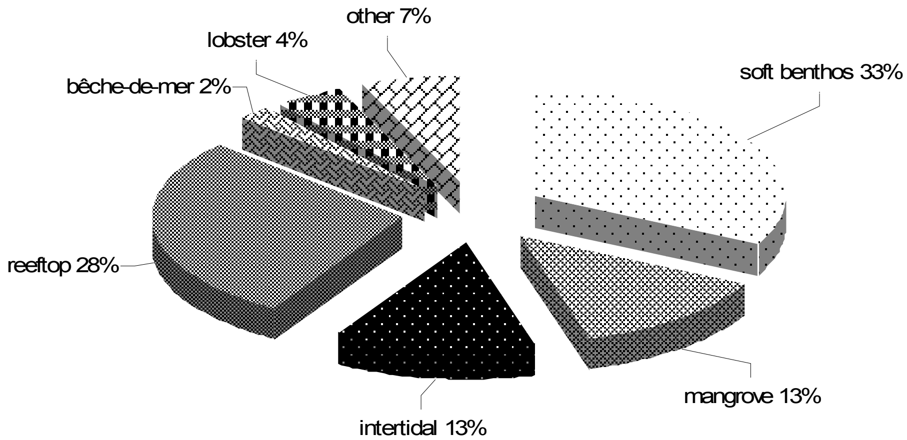

Figure 3.7: Proportion (%) of fishers targeting the five primary invertebrate habitats found in Salelavalu.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the to the giant clam fishery.

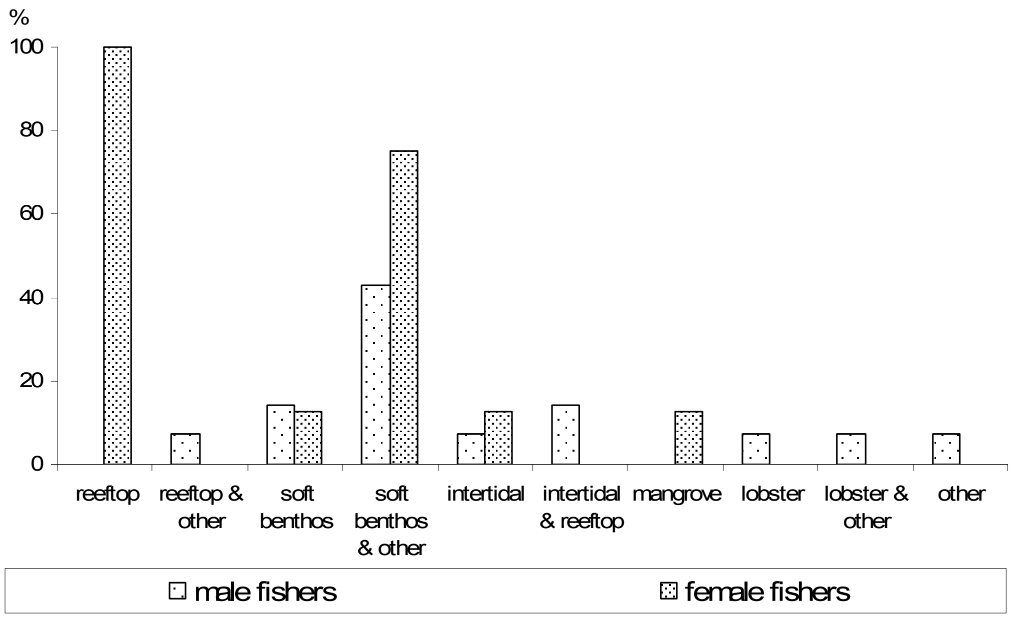

Figure 3.8: Proportion (%) of male and female fishers targeting various invertebrate habitats in Salelavalu.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 14 for males, n = 8 for females; 'other' refers to the to the giant clam fishery.

Gear

Figure 3.9 shows that Salelavalu fishers use a variety of different gear and also often combine different fishing techniques in one particular habitat. For the sheltered coastal reef area, gillnets, followed by castnets, are mostly used; handlines and other techniques are less used. If the lagoon area is targeted, gillnets in combination with other techniques are mainly used; handlines, spear diving or castnetting are less used. Group fishing in lagoon and, on occasions, in the mangrove areas, is one of the fishing activities grouped under 'others' and is performed by females from the community using nets. The combined fishing of lagoon and outer-reef areas, passages included, involves predominantly spear diving, but also some gillnetting. Handlines, deep bottom lines and other techniques are much less frequently used. It is worth mentioning that spear diving is not only done by free-diving, but also on SCUBA, although it is not known how often.

Castnets are used in the lagoon to catch baitfish before fishing on the outer reefs, which explains why the lagoon and outer reef habitats are often combined in one fishing trip.

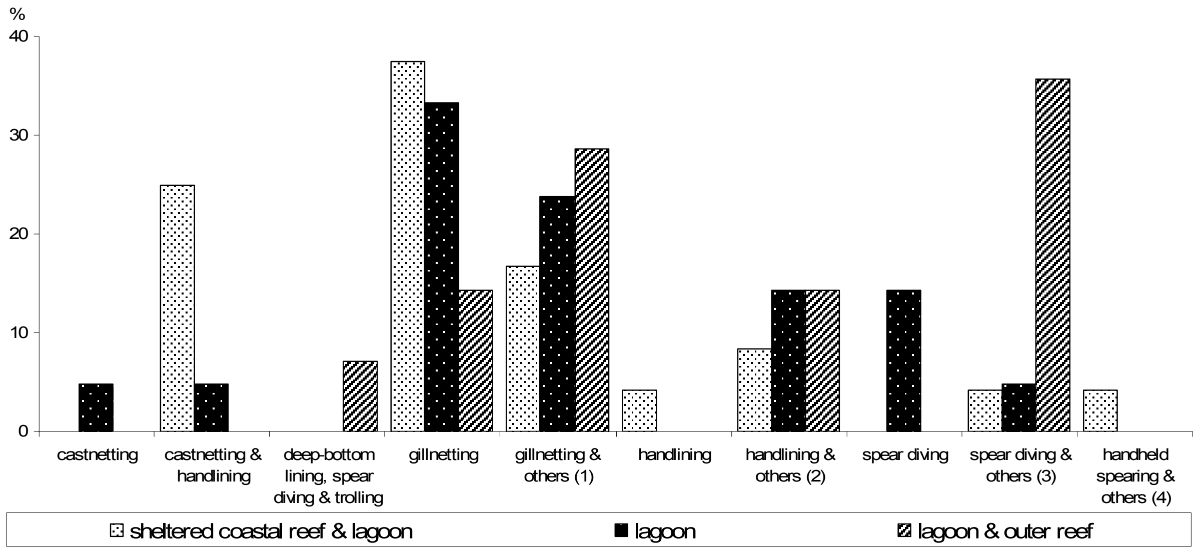

Figure 3.9: Fishing methods commonly used in different habitat types in Salelavalu.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip. (1) handlining, handheld spearing by walking, handheld spearing by canoe, spear diving, rod fishing; (2) spear diving, handheld spearing by walking, handheld spearing by canoe, rod fishing, rod casting, spear diving; (3) handheld spearing by walking, handheld spearing by canoe, rod fishing; (4) handheld spearing by canoe, diving with small rod & line.

Frequency and duration of fishing trips

Finfish fishers go out to any of the habitats 2–3 times/week. As shown in Table 3.3, male fishers who combine lagoon and outer-reef habitats seem to be the most frequent fishers. Females go fishing for finfish at about the same frequency, 2–3 times/week, but target the sheltered coastal reef and lagoon areas only. The average duration of a fishing trip does not vary much among habitats, or combinations of habitats, and is about 3–4 hours. However, fishing trips to the lagoon and outer-reef habitats combined are the longest on average. The average length of trips by female finfish fishers to the sheltered coastal reef and lagoon areas is similar to that of males.

For invertebrates, male fishers go out less frequently, only 1–2 times/week (Table 3.3). Females glean more frequently, depending on the habitats targeted, but on average 2–3 times per week. Again, there is not much difference in length of fishing trips between genders or among habitats. An average fishing trip lasts at least 2 hours; most last 3–4 hours.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	**Sheltered coastal reef & lagoon**	**2.44 (±0.19)**	**1.83 (±0.31)**	**3.33 (±0.14)**	**2.83 (±0.17)**
	Lagoon	**2.29 (±0.17)**	**2.75 (±0.75)**	**3.92 (±0.29)**	**3.00 (±0.00)**
	Lagoon & outer reef	**2.71 (±0.24)**	**0**	**4.14 (±0.20)**	**0**
Invertebrates	**Reeftop**	**0**	**1.59 (±0.28)**	**0**	**2.88 (±0.13)**
	Reeftop & other	1.00 (n/a)	0	3.00 (n/a)	0
	Intertidal	**2.00 (n/a)**	**3.00 (n/a)**	**4.00 (n/a)**	**3.00 (n/a)**
	Intertidal & reeftop	1.00 (±0.00)	0	3.00 (±0.00)	0
	Soft benthos	**1.13 (±0.88)**	**2.00 (n/a)**	**3.50 (±0.50)**	**3.00 (n/a)**
	Soft benthos & mangrove	**2.00 (n/a)**	**1.92 (±0.63)**	**2.00 (n/a)**	**4.50 (±0.29)**
	Soft benthos & intertidal	**2.00 (±0.41)**	**1.00 (±0.00)**	**3.50 (±0.50)**	**3.00 (±0.00)**
	Soft benthos & intertidal & reeftop	2.00 (n/a)	0	3.00 (n/a)	0
	Mangrove	0	1.00 (n/a)	0	3.00 (n/a)
	Lobster	0.50 (n/a)	0	3.00 (n/a)	0
	Lobster & other	1.00 (n/a)	0	5.00 (n/a)	0
	Other	1.00 (n/a)	0	2.00 (n/a)	0

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the to the giant clam fishery; the main invertebrate fisheries are highlighted for clarity; Salelavalu fishers often combine many habitats in one fishing trip.
Finfish fisher interviews, males: n = 51; females: n = 8. Invertebrate fisher interviews, males: n = 14; females: n = 8.

3.2.3 Catch composition and volume – finfish: Salelavalu

The reported catches from the combined fishing of the sheltered coastal reef and the lagoon in Salelavalu are determined by ~50 species or species groups, reported by different vernacular names. Acanthuridae (*Acanthurus lineatus*, *A. triostegus*, *Ctenochaetus striatus* and *Naso unicornis*) represent the most fished groups, followed by Scaridae (*Scarus* spp.), Mugilidae (*Mugil* spp.) and Lethrinidae (*Lethrinus variegatus*, *L.* spp.). If the lagoon is mainly targeted, Scaridae and Lethrinidae become the major species groups, followed by Mugilidae (*Crenimugil crenilabis*, *Mugil* spp.) and Acanthuridae. Reported catches are diverse and are represented by >40 distinguished vernacular names. The number of vernacular names reported for catches from the combined fishing of lagoon and outer reef is smaller as compared to lagoon and sheltered coastal reef catches. *Myripristis* spp., *Scarus* spp., *Acanthurus* spp., *Lethrinus* spp. and *Mugil* spp. are the major species by weight, each making up 6.5–8.7% of the total reported catch. Detailed information on catch composition is reported in Appendix 2.2.1.

Figure 3.10 highlights findings from the socioeconomic survey results reported earlier, that finfish fishing serves both subsistence and commercial interests. The total annual catch is estimated to be ~142 t, of which ~98 t are used for subsistence needs (69%). The remaining 44 t, corresponding to ~31% of the total annual catch, are sold outside the Salelavalu community. The dominance of male fishers shows in the fact that they account for 91% of the total annual catch. Thus, it can be concluded that male fishers are in charge of not only providing the household's finfish needs but also of generating income from finfish fishing. Females fish occasionally and thus are more likely to provide food from their fishing rather than income. More than 32% of the total annual catch is sourced from the sheltered coastal reef, another 37% from the lagoon, and 31% of the impact is from the combined lagoon and outer-reef habitats. Both genders are engaged in marketing finfish.

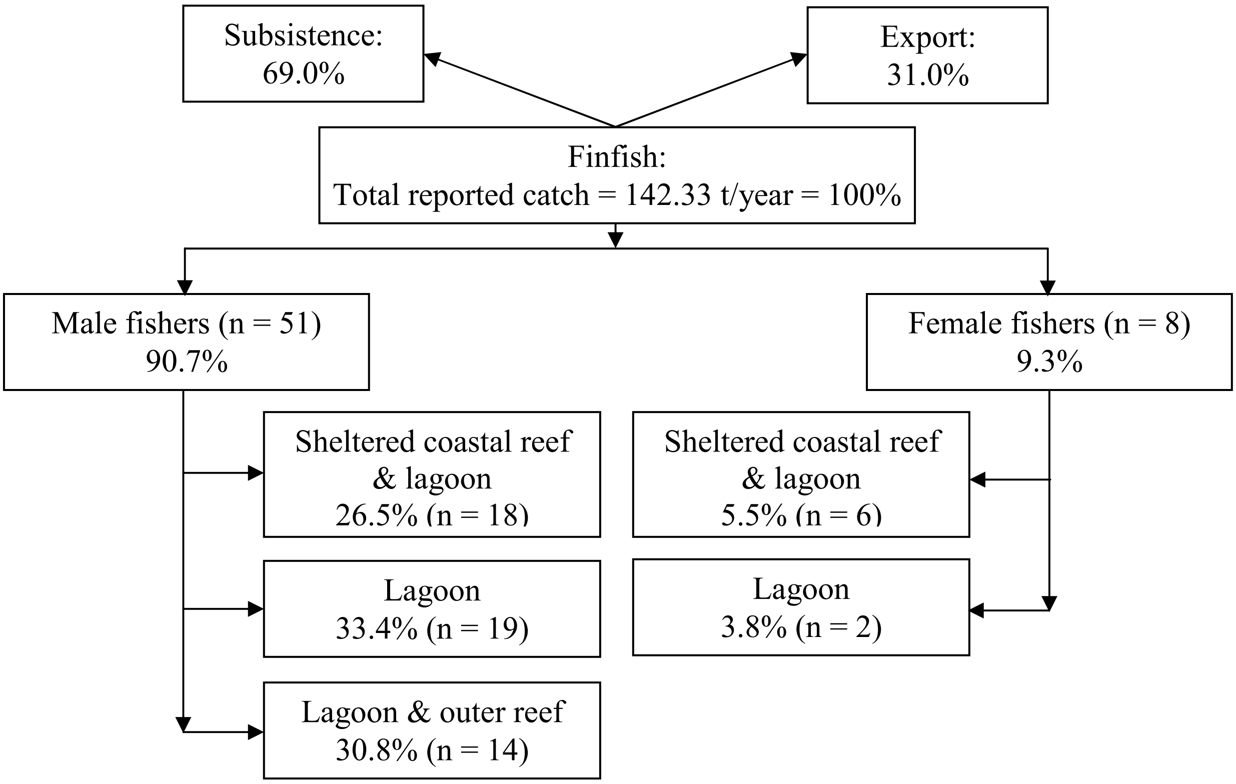

Figure 3.10: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Salelavalu.
N is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The almost even distribution of annual catch weight among the three major habitats accessible by Salelavalu's fishing community is due to the number of fishers targeting each habitat and their annual productivity. As observed earlier, fewer fishers target the combined lagoon and outer reef; most target the more accessible sheltered coastal reef and lagoon. Comparison of the average annual catch (Figure 3.11) reveals that the average annual production increases with distance fished from shore. As far as gender differences are concerned, females seem to fish less than males in the sheltered coastal reef area and about as much in the lagoon. The high variability of females' catches in the lagoon area, however, is also shown by the standard error in Figure 3.11.

Comparing productivity rates between genders and among habitats (Figure 3.12) shows no differences between female and male fishers' efficiency as expressed in catch per hour of fishing trip (CPUE), or among habitats. Figure 3.12 does not suggest an increase in productivity with distance from shore (in contrast to the reported average annual catches). As compared to other sites surveyed in Samoa, overall productivity is similar, and equally as low, with calculated CPUEs around 1.5 kg/hour of fishing trip.

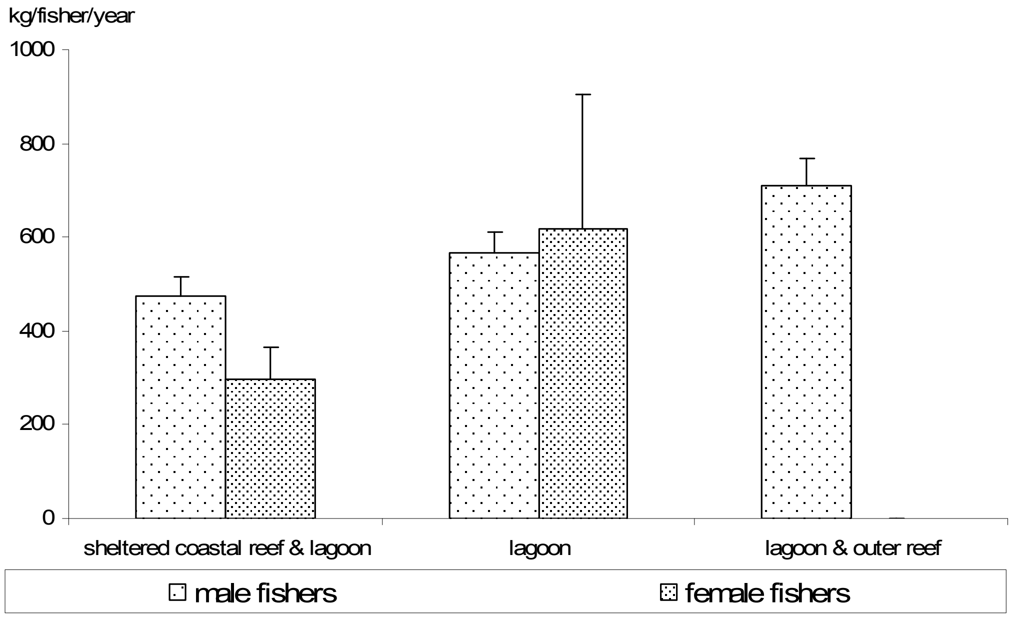

Figure 3.11: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Salelavalu (based on reported catch only).

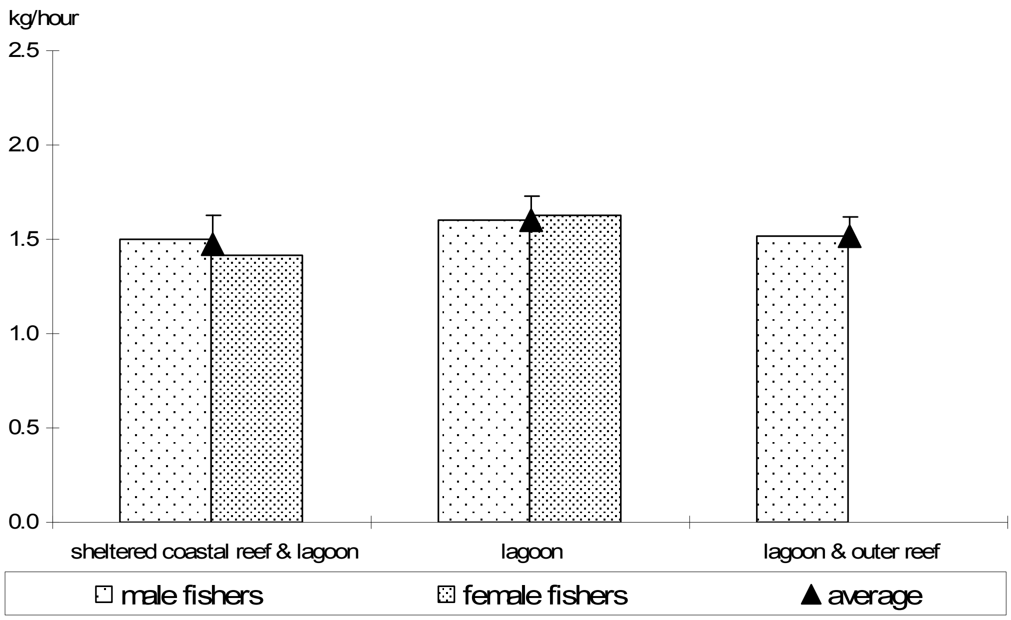

Figure 3.12: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in Salelavalu.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

The predominance of subsistence fishing in the more accessible finfish habitats clearly shows in Figure 3.13. As observed earlier, male fishers targeting the lagoon and the combined lagoon and outer reef and passages fish more for income-generating purposes. However, the proportion of subsistence fishing in these habitats is still prominent. For marketing, there is little organisation among community members. Only a few fishers have formed groups to jointly market their catch at the market on the island or in Apia. The reason for the lack of organised fisher groups may be that access to Apia's market requires land and ferry transport.

The few fishers who fish for regular or occasional selling at the market in Apia or Savaii are those who have formed groups to serve local clients or to target middle sellers from Apia. Overall, the marketing of fisheries produce seems to be less successful than at Manono-uta, for instance.

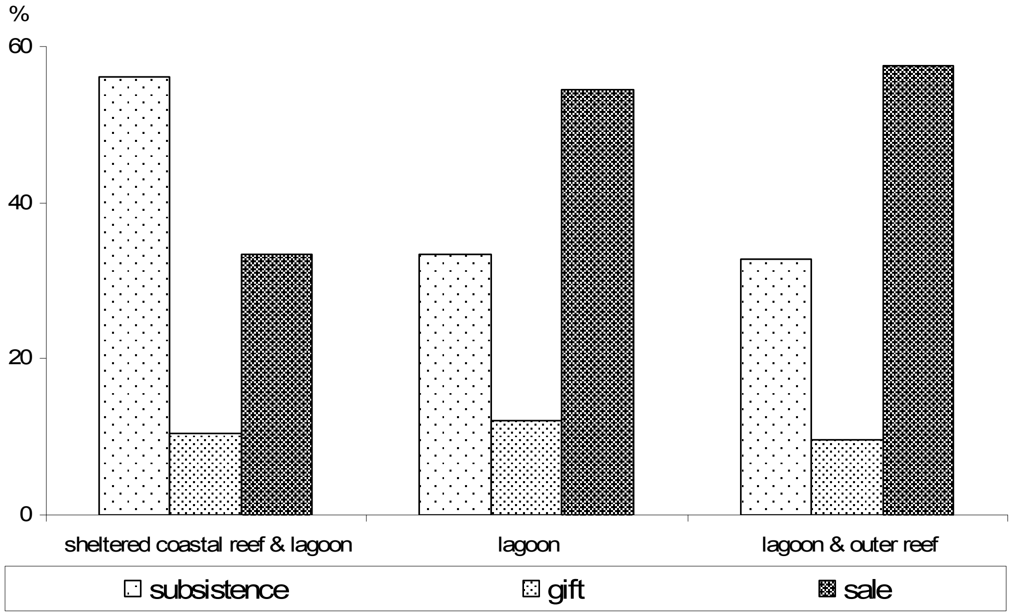

Figure 3.13: The use of finfish catches for subsistence, gift and sale, by habitat in Salelavalu. Proportions are expressed in % of the total number of trips per habitat.

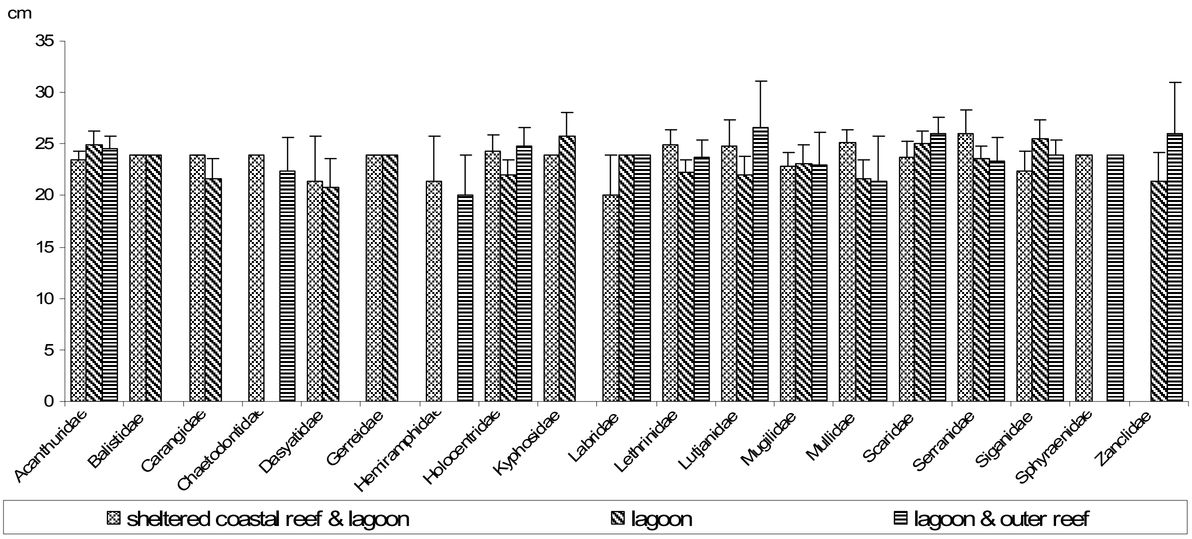

Figure 3.14: Average sizes (cm fork length) of fish caught by family and habitat in Salelavalu. Bars represent standard error (+SE). Diodontidae, Muraenidae and Pomacanthidae were excluded as they were each reported only from one habitat

The overall productivity of finfish fishing was similar among habitats (Figure 3.12). This observation is supported by the reported average fish sizes (cm FL) for the major families caught (Figure 3.14). Usually, one would expect a visible increase in the caught fish length for the same species or species groups with increasing distance from the shore. This expected increase is only visible for Scaridae and Zanclidae. The opposite is true for Serranidae and Hemiramphidae, whose length decreases with distance from shore. Overall, fish lengths were similar among catches from the sheltered coastal reef, lagoon and combined lagoon and outer reef for Acanthuridae, Gerreidea, Holocentridae, Lethrinidae, and Mugilidae.

The indicators selected to assess current fishing pressure on Salelavalu's reef and lagoon resources are shown in Table 3.4. Considering the limited reef surface and total fishing ground, population density, fisher density and catch rates per unit areas of reef and fishing ground are moderate to high. Fisher density is 16–57 fishers/km² of habitat targeted or, if habitats are combined, 26–41 fishers per total reef or total fishing ground area. Again, the population density figures of 163–253 people/km² of total reef and total fishing ground area is moderate, and the extraction of 8.7–13.5 t/km²/year for subsistence purposes is not substantial. In addition, it should be borne in mind that the fishing pressure is actually higher, as the subsistence catch only represents 69% of the total annual catch.

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

Parameters	Habitat				
	Sheltered coastal reef & lagoon [4]	Lagoon	Lagoon & outer reef [5]	Total reef	Total fishing ground
Fishing ground area (km^2)	4.03	5.64	1.66	7.26	11.33
Density of fishers (number of fishers/km^2 fishing ground) [1]	27	16	57	41	26
Total number of fishers	107	93	95	295	295
Population density (people/km^2) [2]				253	163
Average annual finfish catch (kg/fisher/year) [3]	430.18 (±37.30)	572.64 (±43.79)	710.22 (±58.01)		
Total fishing pressure of subsistence catches (t/km^2)				13.5	8.7

Figures in brackets denote standard error; [1] total number of fishers is extrapolated from household surveys; [2] total population = 1841; total subsistence demand = 98.2 t/year; total number of fishers = 295; [3] catch figures are based on recorded data from survey respondents only; [4] area of sheltered coastal reef considered only; [5] area of lagoon considered only.

3.2.4 Catch composition and volume – invertebrates: Salelavalu

Calculating reported catches from invertebrate fishers by wet weight shows that only a few species account for the major annual impact expressed in wet weight (Figure 3.15). The combined catches of bêche-de-mer species, including *Stichopus horrens*, *Holothuria* spp. and *Actinopyga 80auritania* (reported under 'others') account for most, i.e. an accumulated annual wet weight of 33.4 t. Bêche-de-mer is considered a delicacy in Samoa, and intestines from collected specimens are either used for home consumption or sold (by both females and males). Giant clams account for only 1.8 t per year (wet weight), and *Etisus splendidus* (*paa*, *tutu*; reported under 'others') for 1.4 t. Others, such as *Pinna bicolor*, *Panulirus* spp. and *Cypraea* spp., are rather insignificant by wet weight collected.

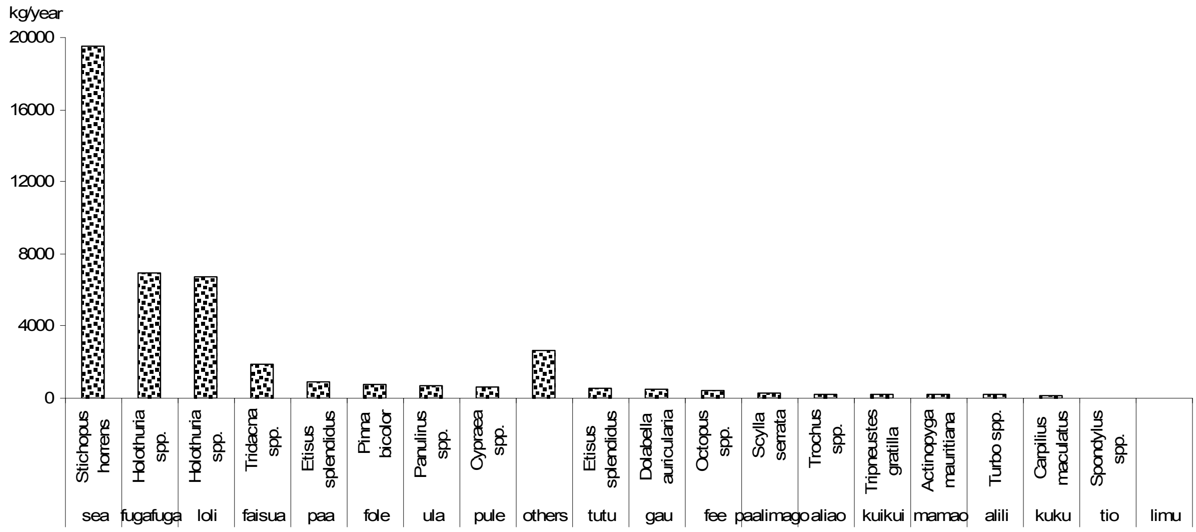

Figure 3.15: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Salelavalu.
'Others' include: *tutu* (*Etisus splendidus*), *gau* (*Dolabella auricularia*), *fee* (*Octopus* spp.), *paalimago* (*Scylla serrata*), *aliao* (*Trochus* spp.), *kuikui* (*Tripneustes gratilla*), *mamao* (*Actinogypa mauritiana*), *alili* (*Turbo* spp.), *kuku* (*Caroilius maculatus*), *tio* (*Spondylus* spp.), and *limu* (seaweed).

The importance of reeftop gleaning also shows in the number of vernacular names reported by respondents. While the reeftop fishery had a total of 11 different names, soft benthos had only four, mangroves two and intertidal only one (Figure 3.16).

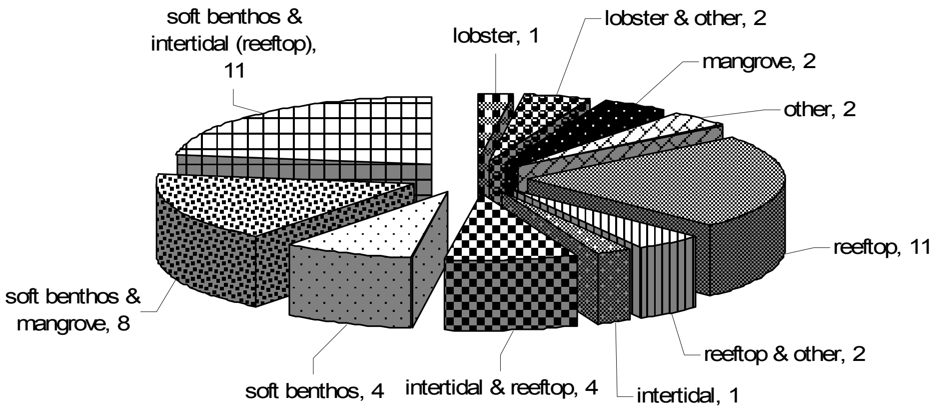

Figure 3.16: Number of vernacular names recorded for each invertebrate fishery in Salelavalu.
'Other' refers to the giant clam fishery.

The average annual catch per fisher by gender and fishery (Figure 3.17) reveals substantial differences. However, the small sample size for each fishery and the combination of fisheries makes conclusive comparison difficult. There is a general trend suggesting that females may collect more than males on an average basis in soft benthos and intertidal areas. Overall, the average annual catch per fisher ranges from as low as ~100 kg (lobster) to up to 4.5 t/year wet weight from soft benthos when combined with mangrove gleaning. The pattern supports the earlier observation that bêche-de-mer are one of the local delicacies that are also sold outside the community. Most bêche-de-mer would be sourced from soft benthos. The fact that males dive for 'others', mostly giant clams, and also collect some of these from reeftops by gleaning, is also revealed in Figure 3.17.

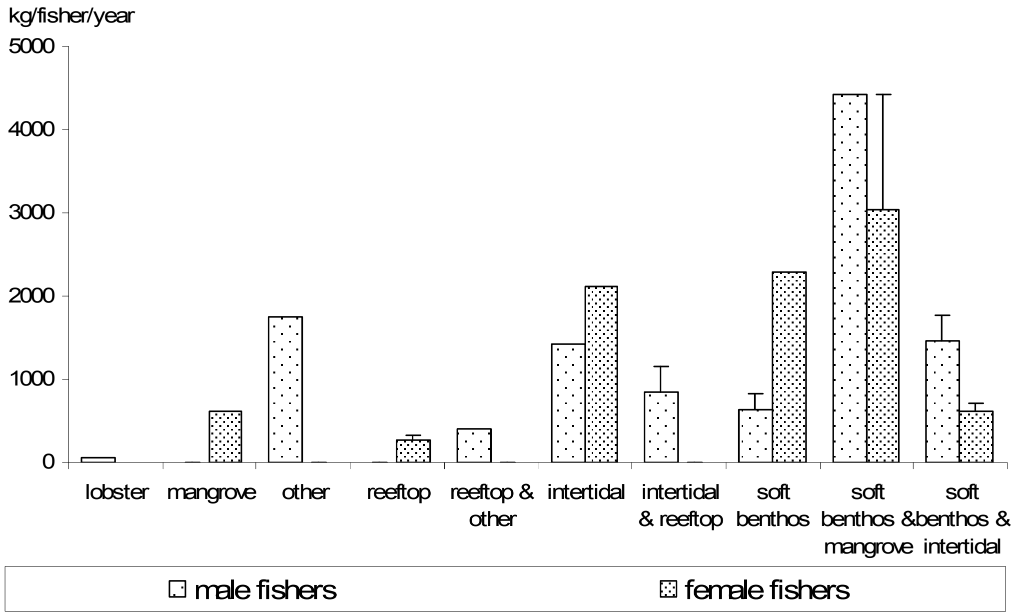

Figure 3.17: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Salelavalu.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 14 for males, n = 8 for females). 'Other' refers to the giant clam fishery.

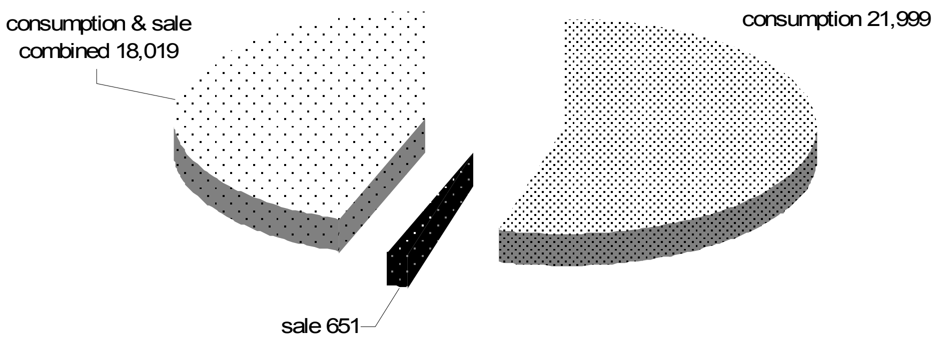

Figure 3.18: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Salelavalu.

The fact that most invertebrate catches are of bêche-de-mer species, which may be locally consumed or sold, explains the high percentage of invertebrate catches in this category (Figure 3.18). About 24% of all invertebrate catches are sold, while the remaining 76% are used for subsistence purposes. These figures are based on the assumption that half of the catch reported as either for subsistence or sale is actually sold. Results suggest that any impact that may be induced by current invertebrate harvesting is basically determined by the subsistence needs of the Salelavalu community. It needs to be considered, however, that most of the catch is accounted for by a few holothurians, used to prepare *sea*, the raw insides of sea cucumbers that are kept in plastic bottles filled with seawater. *Sea* is sold to the local community and the Savaii and Apia urban markets, and is also sent to families and friends living overseas (New Zealand and Australia). *Sea* marketing is mainly done by females. The external demand for this national delicacy adds to the *in-situ* fishing pressure on a few selected species.

A few male fishers specialise in catching octopus, lobsters and giant clams and market their produce, usually on Friday to Sundays at the local market or in their home villages.

As for finfish, only very few fishers have organised themselves into cooperative groups for marketing their catches.

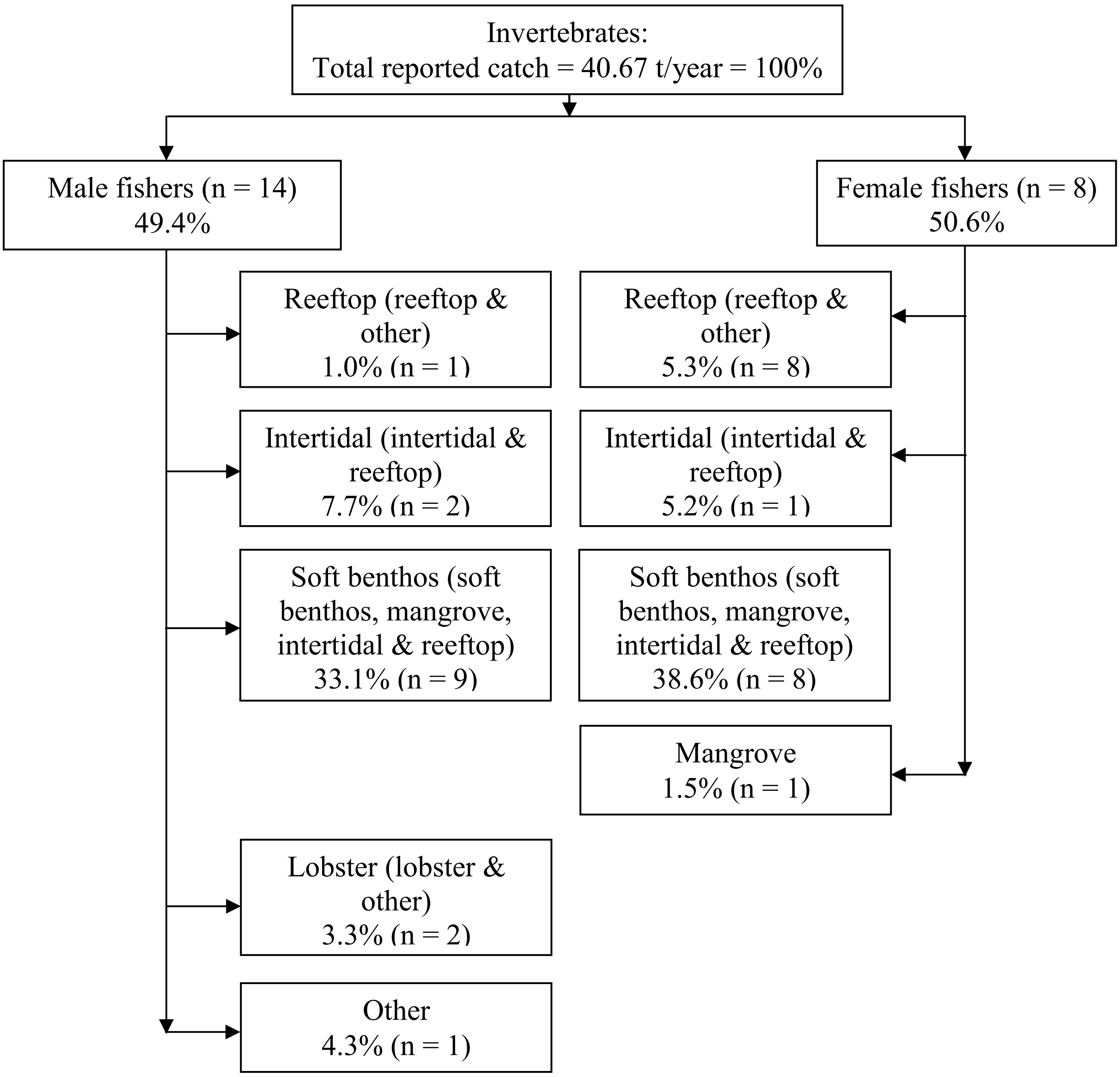

Figure 3.19: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Salelavalu.
N is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one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

As mentioned earlier, females are more involved in fishing for invertebrates than finfish, but males also fully participate in invertebrate collection. These observations are confirmed by Figure 3.19. Male and female fishers each account for about half of the reported annual invertebrate catch (wet weight). Both male and female catches mainly target the habitats close to the village, i.e. the combination of intertidal, soft-benthos, reeftop and mangrove areas. In total, ~72% of the total annual reported invertebrate catch is accounted for by the combined gleaning of these three habitats, with females contributing ~39%, males ~33%.

Females do not engage in any diving; males free-diving for lobsters and giant clams catch 7–8% of the total annual invertebrate catch.

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

Parameters	Fishery					
	Reeftop	Soft benthos & intertidal	Soft benthos & mangrove	Mangrove	Lobster	Lobster & other
Fishing ground area (km^2)	9.06			n/a	6.16	
Number of fishers (per fishery) (1)	60	33	35	8	5	5
Density of fishers (number of fishers/km^2 fishing ground)	7	n/a	n/a	n/a	1	n/a
Average annual invertebrate catch (kg/fisher/year) (2)	266.61 (±51.22)	1175.07 (±270.53)	3316.41 (±1105.83)	623.20 (n/a)	57.90 (n/a)	1302.86 (n/a)

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; (1) total number of fishers is extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only. The following information is excluded in the above table, due to lack of information on possible habitat surface and the number of fishers targeting these fisheries: intertidal, 12 fishers, average annual catch 1768.63 kg (±353.73); intertidal & reeftop, 9 fishers, average annual catch 853.81 kg (±290.97); reeftop & others, 5 fishers, average annual catch 397.37 kg (n/a); soft benthos, 12 fishers, average annual catch 1768.63 (±353.73); soft benthos & intertidal & reeftop, 5 fishers, average annual catch 1966.45 kg (n/a).

Taking into account available figures on the length of the outer reef that is considered to support the lobster fishery and perhaps the combined lobster and giant clam dive fisheries, and the inner-reef surface area, fisher density is low for both lobster and reeftop fisheries. Taking into account that both reeftop and soft-benthos habitats supply the highest annual catches for most fishers, both areas may be prone to detrimental effects of fishing pressure imposed on a very few selected species only. However, the actual status of the resources and thus estimation of any possible future impacts need verification with the results from the resource surveys.

3.2.5 Management issues: Salelavalu

Management of marine resources in Samoa occurs at two levels, and so does enforcement: through governmental institutions and traditional village systems. At the national level, regulations mainly refer to size restrictions and harvesting techniques employed. At the community level, community-based reserve areas have been promoted since 1996 and today include about 150 villages. Initially, the programme was assisted by AusAID funding. The programme's success rate, however, varies. One of the major obstacles to assessing impact is the absence of baseline surveys to enable past and current status and use of reef resources to be compared, and future levels of fishing impact and use to be predicted.

However, Salelavalu has not yet participated in this community-based management project, nor established any alternative management interventions. Some village rules exist that regulate the use of gears, and sometimes also fishing activities. For example, at the time of the field survey, any use of explosives or dynamite for fishing was banned. Village rules also ban fishing on Sundays, making Thursdays to Saturdays the busiest fishing days to serve the local markets. In addition, fishers were aware of the existing national rules and regulations; however, there seems to be no mechanism to control their application and compliance. The Salelavalu fishing ground continues to be a joint fishing ground that is open to access for people from five different villages. In addition, other fishers use this fishing ground under the premises of traditional rights, kinship, or permissions given by village chiefs.

The community expressed concern that selling fish and invertebrates at the Savaii and Apia markets would put a lot of pressure on the marine resources. They also believe that giant clams are declining in numbers.

3.2.6 Discussion and conclusions: socioeconomics in Salelavalu

- Salelavalu is a community that has access to agricultural land, marine resources and income from salaries. Due to its close proximity to Saleloga, Savaii's major urban centre, and also the regular ferry transport services to Apia on mainland Upolu, a substantial proportion of the community relies on fishing for first or second income. Similarly to the other communities surveyed in Samoa, Salelavalu is highly dependent on remittances to meet its many traditional and religious obligations. Additionally, income from agricultural produce is also very important, and salaries provide first income to 21% and second income to 15% of households. The Salelavalu community has not yet participated in the national community-based fisheries management programme, and thus only a few village rules and regulations are in place.

- Survey results suggest the following:

    - Salelavalu's population is dependent on marine resources for both protein and income. The opportunity to generate income from fisheries is supported by the community's proximity to Savaii's major urban centre Saleloga, and the regular and daily ferry services to Samoa's mainland island of Upolu and the capital city, Apia.

    - Per capita consumption of fresh and canned fish is a bit lower than the average across all four sites surveyed in Samoa, but the consumption of invertebrates is much higher. The first may be due to the availability and choice of alternative protein and food items, the frequency of *falavelave,* to which people contribute canned fish, and the involvement of females in collecting invertebrates.

    - Consumption and income patterns both suggest a traditional and remote rural lifestyle that benefits from commercial activities due to access to nearby urban markets and centres. This conclusion is further supported by findings from finfish and invertebrate fisher interviews. Gender roles also confirm a very traditional lifestyle, with females basically responsible for household chores, while males are the main finfish fishers and also fully participate in collecting invertebrates. Females mainly collect invertebrates; they never dive, and mostly focus on gleaning mangroves and harvesting *sea* (bêche-de-mer).

    - Finfish are mainly caught in the easily accessible habitats due to the limited numbers of boats, particularly boats equipped with outboard motors. The wide range of techniques used suggests that investment levels for fishing are not really high; however, compared to other places, more gillnets are used.

    - No major differences were found in finfish productivity (CPUE) by gender and by habitat, suggesting that resource status is similar across all habitats, and generally low.

- Reported average fish sizes by major families caught do not show the expected increase with distance from shore, except in the case of Scaridae. The opposite is true for Serranidae.

- Invertebrates are mainly harvested by gleaning reeftops and soft benthos, with bêche-de-mer and giant clams being the major target species groups for subsistence, and also, to some extent, for commercial purposes.

- In contrast to finfish catches, significant differences were found in the average annual invertebrate catches per fisher by fishery and gender. However, due to the variety gained by combining different habitats in one fishing trip, sample sizes are relatively small and results may mask major commonalities.

- Indicators of fishing pressure calculated for finfish and invertebrate fisheries suggest that, due to the reef and overall fishing ground area, fisher densities and average annual catch rates, as well as catches per unit area, are moderate to high.

3.3 Finfish resource surveys: Salelavalu

Finfish resources and associated habitats were assessed from a total of 24 transects (6 in the coastal-, 7 in the lagoon-, 5 in the back- and 6 in the outer-reef habitats respectively) on 24–30 August 2005.

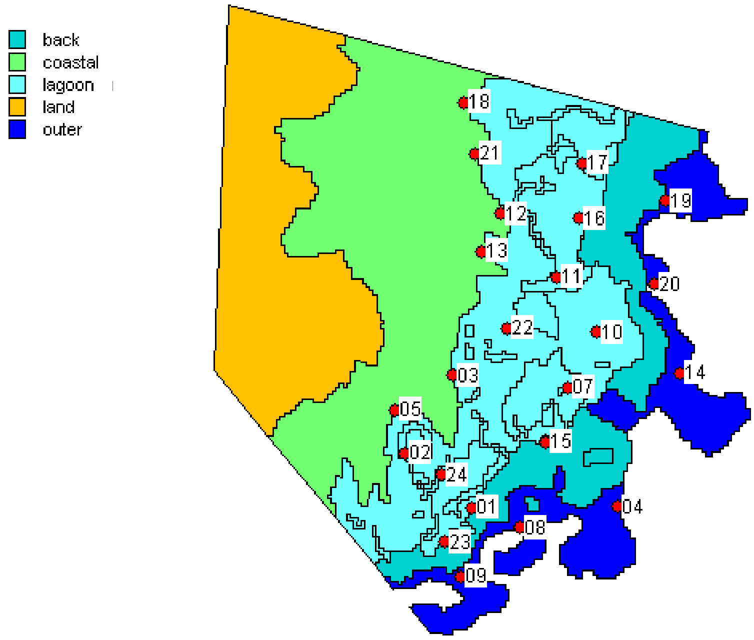

Figure 3.20: Habitat types and transect locations for finfish assessment in Salelavalu.

3.3.1 Finfish assessment results: Salelavalu

A total of 19 families, 46 genera, 120 species and 8715 fish were recorded in the 24 transects (See Appendix 1.2 for list of species.). Only data on the 15 most dominant families are presented and discussed below, representing 41 genera, 112 species and 8599 individuals.

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

Parameters	Habitat				
	Sheltered coastal reef (1)	Lagoon reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	7	5	6	24
Total habitat area (km^2)	4.03	4.06	1.58	1.66	11.33
Depth (m)	1 (1-2) (3)	3 (1-9) (3)	4 (1-9) (3)	7 (2-13) (3)	3 (1-13) (3)
Soft bottom (% cover)	19 ±6	17 ±6	13 ±5	0.1 ±0.1	14
Rubble & boulders (% cover)	12 ±3	7 ±1	5 ±1	0 ±0	7
Hard bottom (% cover)	52 ±5	47 ±4	66 ±7	76 ±7	56
Live coral (% cover)	17 ±4	30 ±6	16 ±3	23 ±8	22
Soft coral (% cover)	0 ±0	0 ±0	0 ±0	1 ±0.5	0
Biodiversity (species/transect)	14 ±2	33 ±3	32 ±4	38 ±2	29 ±2
Density (fish/m^2)	0.22 ±0.04	0.84 ±0.06	0.68 ±0.07	0.94 ±0.18	0.6
Size (cm FL) (4)	11 ±0.7	15 ±0.5	15 ±0.6	18 ±0.7	14
Size ratio (%)	36 ±2	49 ±2	49 ±2	60 ±2	46
Biomass (g/m^2)	9 ±2	87.7 ±16	70 ±10	166 ±29	68

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: Salelavalu

The coastal habitat of Salelavalu was sampled along six transects. This reef environment was widely dominated by Scaridae in very high number and biomass (Figure 3.21). Other families were much less abundant, with Acanthuridae being eight times less abundant and displaying five times less biomass than Scaridae. Herbivorous Mullidae and small, carnivorous Nemipteridae were the third and fourth ranked families in order of abundance. Most of the total density among these four families was determined by one or two major species (Table 3.7). The most important parrotfish were the medium-sized *Scarus psittacus*, displaying the overall maximum biomass, and *Chlorurus sordidus*, while the most representative species of Nemipteridae was *Scolopsis bilineatus* and the most important surgeonfish was the ubiquitous *Ctenochaetus striatus*. Mullidae were mostly represented by *Parupeneus multifasciatus*.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.11	3.1
	Chlorurus sordidus	Bullethead parrotfish	0.04	2.0
Nemipteridae	*Scolopsis bilineatus*	Two lined spinecheek	0.01	0.8
Acanthuridae	*Ctenochaetus striatus*	Striped bristletooth	0.01	0.6
Mullidae	*Parupeneus multifasciatus*	Two-barred goatfish	0.01	0.3

Most commercial families displayed low mean sizes, below 50% of their known maximum size. Scaridae, Acanthuridae, Mullidae but also the carnivores: Labridae, Lethrinidae and Lutjanidae, all presented low mean sizes, suggesting an overexploitation of the biomass.

Fish total abundance, biomass, mean size and diversity displayed the lowest values among the different habitats as well as among the other three coastal reefs analysed in the country (Manono-uta and Vailoa, along with Salelavalu, Table 3.8). The general faunal composition of the fish assemblage was very similar among these three coastal reefs; however, total abundance and biomass of the different families varied strongly. The density and biomass of Scaridae, the dominant family in Salelavalu, displayed intermediate values between Manono-uta and Vailoa, but all other commercial families were much lower than at any other coastal reef studied. Sizes were also much below the average for Acanthuridae and Holocentridae, as well as for the families that displayed low sizes also in Vailoa and Manono-uta (Labridae, Lethrinidae, Lutjanidae, Mullidae, Scaridae and Serranidae).

This reef environment presented a diverse habitat, composed of 50% hard coral, 20% soft bottom and 10% rubble; this habitat complexity may partly explain the relative complexity of the fish assemblage. The relatively good live coral cover (almost 20% average) was accompanied by notable densities of butterflyfish (Chaetodontidae, with average density similar to Nemipteridae, Figure 3.21).

Table 3.8: Comparisons of the sheltered coastal reef biological parameters among the three Samoan sites with sheltered coastal reefs

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Salelavalu	**223.7 (±37.2)**	**9.2 (±2.2)**	**11.0 (±0.7)**	**36.3 (±2.4)**
Manono-uta	296.0 (±80.5)	26.8 (±10.6)	14.6 (±0.9)	57.8 (±3.7)
Vailoa	375.9 (±93.6)	19.6 (±5.1)	11.2 (±0.5)	39.1 (±1.9)

Figures in brackets denote standard error; FL = fork length.

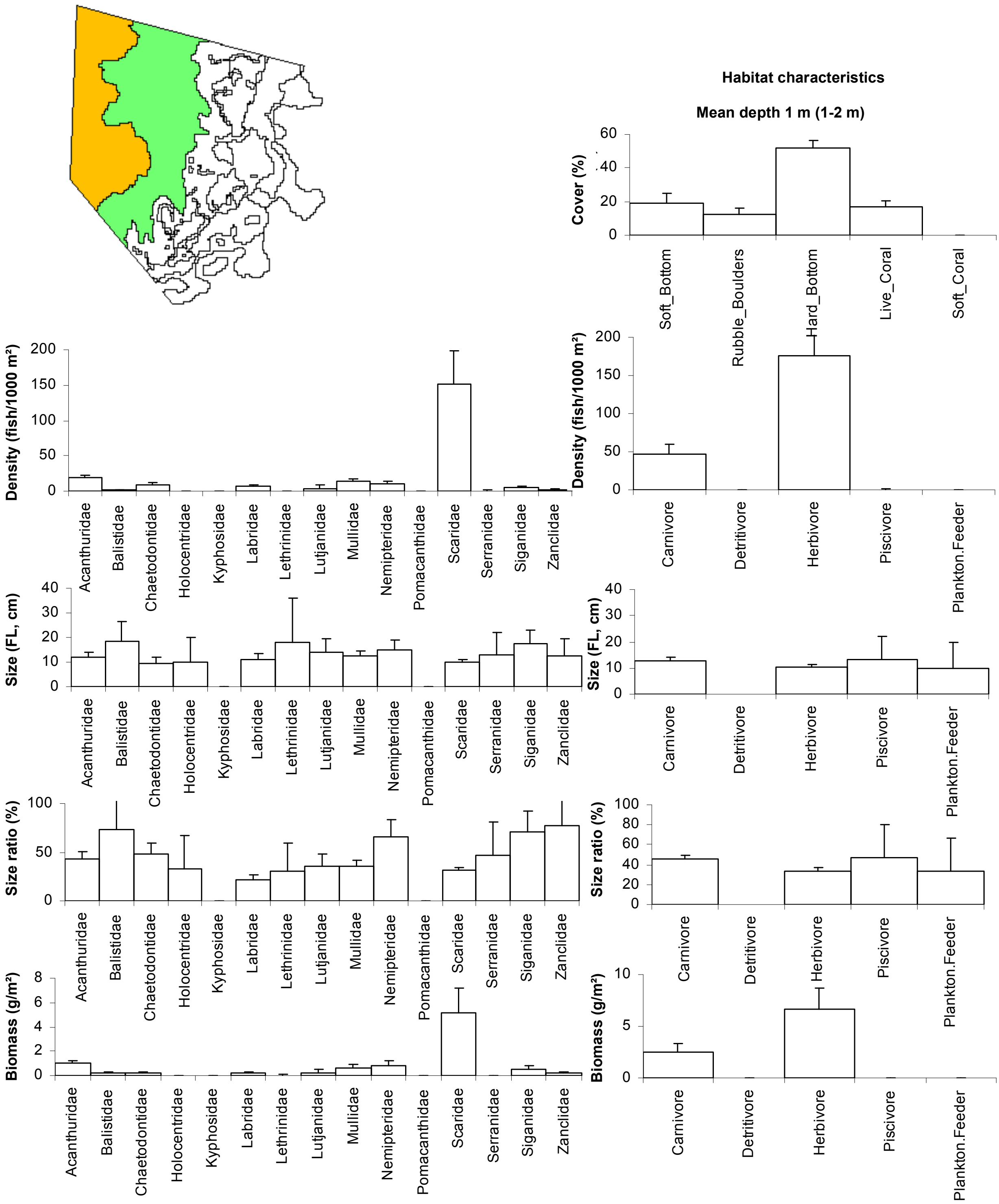

Figure 3.21: Profile of finfish resources in the sheltered coastal reef environment of Salelavalu. Bars represent standard error (+SE); FL = fork length.

Lagoon intermediate-reef environment: Salelavalu

The lagoon intermediate-reef environment was sampled by seven transects. This habitat was numerically dominated by Scaridae, Acanthuridae and Mullidae (Figure 3.22, Table 3.9), followed by Chaetodontidae and Lutjanidae. This last family was the third most important one after Scaridae and Acanthuridae in terms of biomass. The most important species in the total assemblage were, in order of decreasing biomass, *Chlorurus sordidus*, *Lutjanus fulvus*, *Ctenochaetus striatus*, *Scarus dimidiatus*, *S. oviceps*, *S. psittacus*, *Acanthurus triostegus* and *Mulloidichthys flavolineatus*.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.1	3.9
	Chlorurus sordidus	Bullethead parrotfish	0.09	11.4
	Scarus oviceps	Dark-capped parrotfish	0.03	4.1
	Scarus dimidiatus	Turquoise capped parrotfish	0.02	4.2
Acanthuridae	*Ctenochaetus striatus*	Striped bristletooth	0.12	9.5
	Acanthurus triostegus	Convict surgeonfish	0.03	2.9
Lutjanidae	*Lutjanus fulvus*	Flametail snapper	0.04	9.6
Mullidae	*Mulloidychthys flavolineatus*	Yellowstripe goatfish	0.05	1.6

Average values for density, biomass and species diversity were second only to the outer-reef values, and higher than those of the coastal and back-reefs. Size and size ratios were similar to values in the back-reefs, and lower only than outer-reef values.

Other than in Salelavalu, lagoon reefs were only surveyed in Manono-uta. Total density, biomass, mean sizes (Table 3.10) as well as all individual family density and biomass values (except for Lutjanidae) were higher in Salelavalu intermediate reefs.

The substrate was quite diverse, similar to the coastal habitat. However, live coral cover was high and much higher than in Manono-uta lagoon reefs (30%, Table 3.6).

Table 3.10: Comparisons of the intermediate-reef biological parameters between Manono-uta and Salelavalu

Site	Density (fish/m²)	Biomass (g/m²)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	0.56 (±0.24)	42.65 (±26.15)	13.70 (±0.68)	53.39 (±2.67)
Salelavalu	**0.84 (±0.06)**	**87.67 (±15.97)**	**14.80 (±0.48)**	**48.76 (±1.59)**

Figures in brackets denote standard error; FL = fork length.

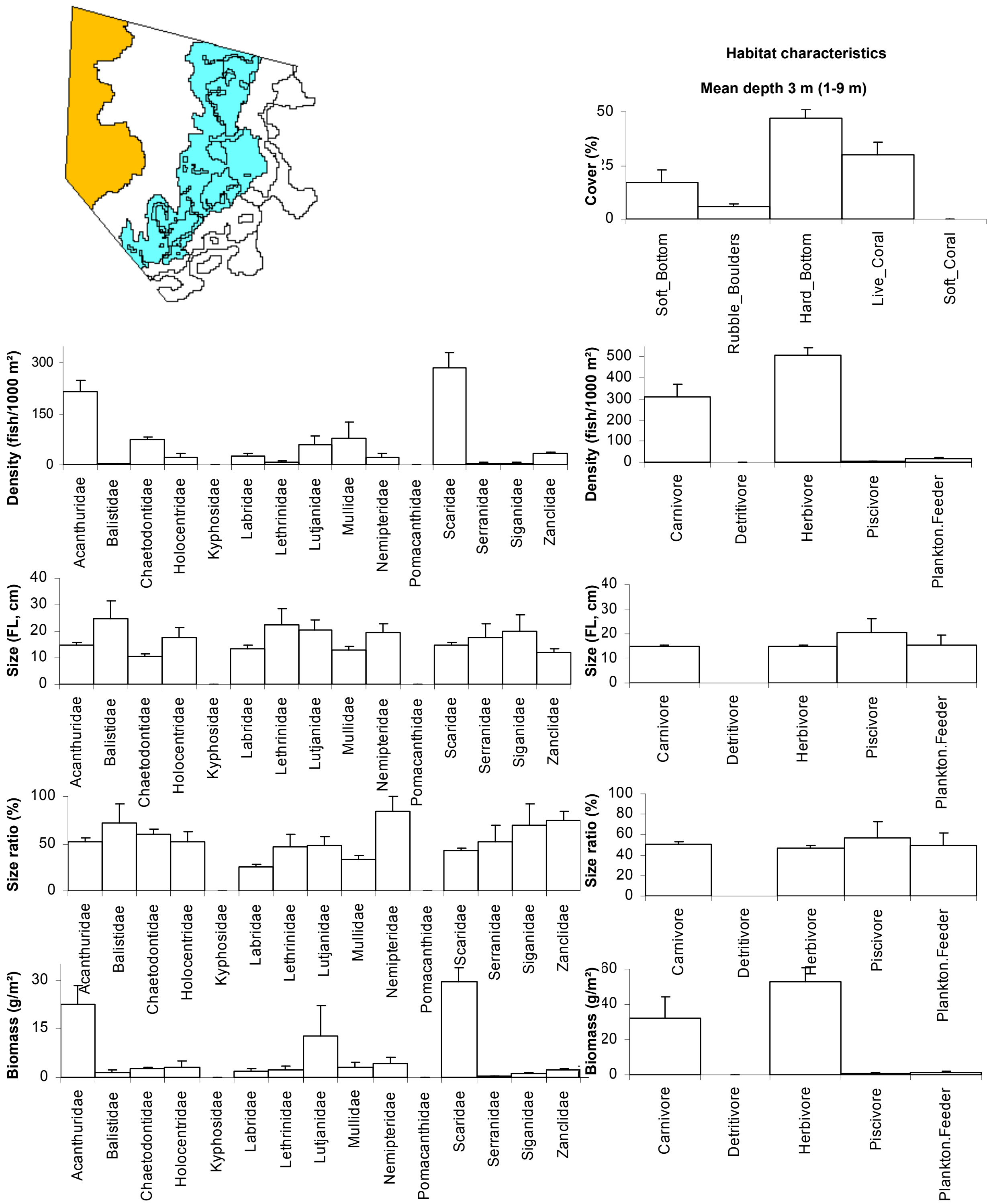

Figure 3.22: Profile of finfish resources in the lagoon intermediate-reef environment of Salelavalu.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Salelavalu

The back-reef of Salelavalu was sampled along five transects. It was largely dominated by Scaridae and Acanthuridae. Other relatively numerically important families were Chaetodontidae, Labridae and Mullidae: in terms of biomass, Lutjanidae and Nemipteridae followed Scaridae and Acanthuridae (Figure 3.23, Table 3.11). The biomass and density was determined by a very highly diverse group of species. The most important species were, in order of decreasing biomass, *Chlorurus sordidus*, *Ctenochaetus striatus*, with the overall highest density, *Scarus psittacus*, *Lutjanus fluvus*, *S. dimidiatus*, *Scolopsis bilineata*, *Scarus oviceps*, *Scarus schlegeli*, *Hemigymnus melapterus*, *Acanthurus triostegus*, and *Parupeneus multifasciatus*.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striped bristletooth	0.15	10.2
	Acanthurus triostegus	Convict surgeonfish	0.01	0.8
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.12	5.1
	Chlorurus sordidus	Bullethead parrotfish	0.08	12.7
	Scarus oviceps	Dark-capped parrotfish	0.02	3.1
	Scarus dimidiatus	Turquoise capped parrotfish	0.02	4.2
	Scarus schlegeli	Schlegel's parrotfish	0.02	1.8
Nemipteridae	*Scolopsis bilineata*	Two-lined spinecheek	0.02	4.0
Labridae	*Hemigymnus melapterus*	Blackedge thicklip wrasse	0.02	1.2
Mullidae	*Parupeneus multifasciatus*	Multibarred goatfish	0.01	0.6
Lutjanidae	*Lutjanus fulvus*	Flametail snapper	0.01	4.3

Mean density, biomass, average size and diversity in the back-reef were relatively low and similar to, but slightly lower than, lagoon values (Table 3.6). Among all four back-reefs studied, Salelavalu displayed the second highest biomass and second lowest density and comparable mean size and size ratios to the highest values of Manono-uta (Table 3.12). Faunal composition for the fish community was very similar to the other back-reefs, but Scaridae, Lutjanidae, Labridae and Lethrinidae displayed the highest biomass in Salelavalu.

Similar to coastal and lagoon habitats, substrate composition is rather diverse, with more than two-thirds composed of hard bottom, 13% soft bottom and 5% rubble. Live coral cover is the lowest recorded among the four habitats (16%, Table 3.6).

Table 3.12: Comparisons of the back-reef biological parameters among the four Samoan sites

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	0.95 (±0.28)	95.4 (±44.5)	14.6 (±0.6)	52.0 (±2.2)
Salelavalu	**0.68 (±0.07)**	**70.0 (±9.7)**	**14.6 (±0.6)**	**49.2 (±2.0)**
Vailoa	0.59 (±0.07)	44.5 (±7.5)	12.8 (±0.6)	46.2 (±2.1)
Vaisala	0.77 (±0.11)	64.9 (±14.4)	13.7 (±0.4)	47.4 (±1.3)

Figures in brackets denote standard error; FL = fork length.

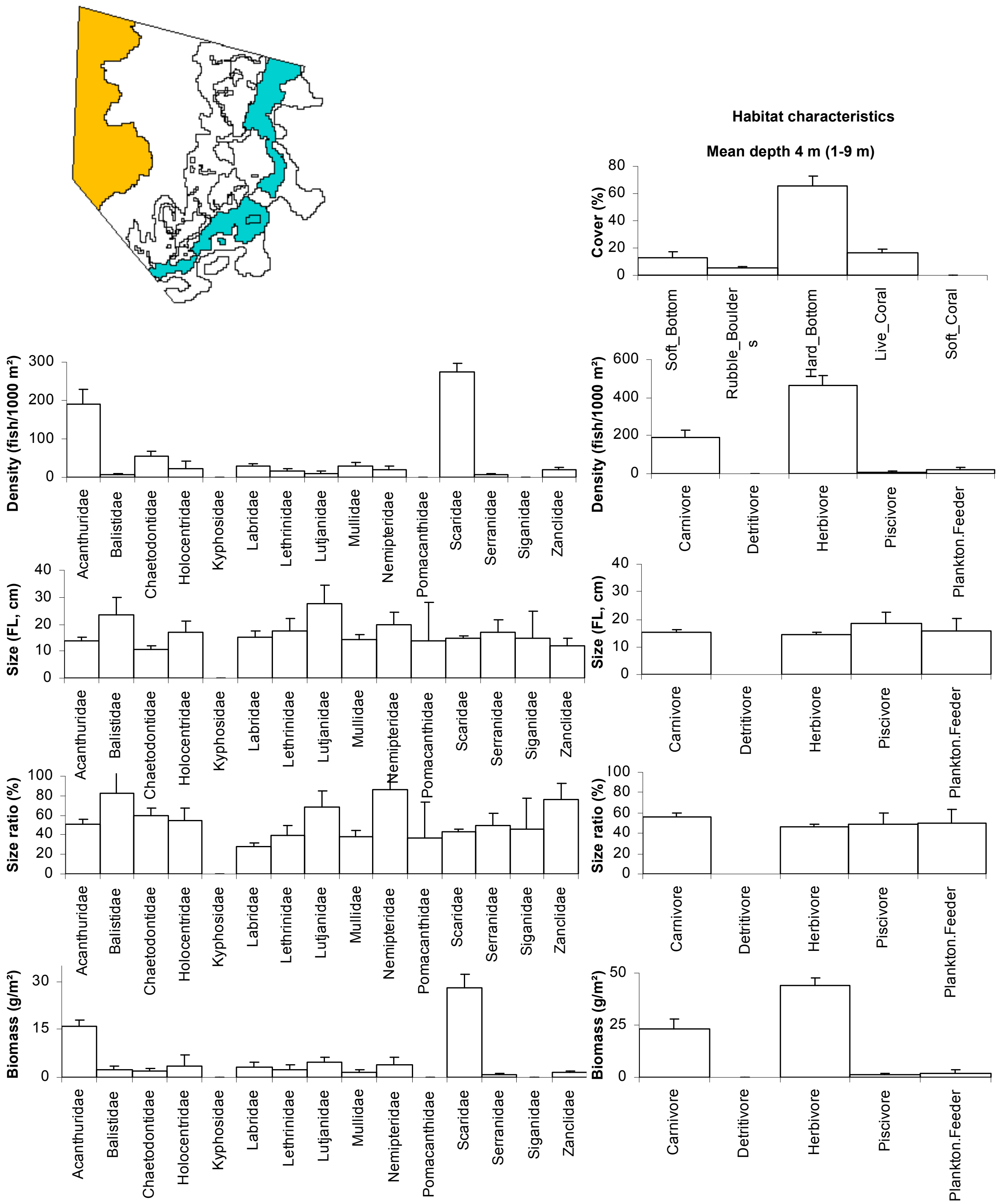

Figure 3.23: Profile of finfish resources in the back-reef environment of Salelavalu.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Salelavalu

The outer reef of Salelavalu (studied at 6 stations) was largely dominated by Acanthuridae, in both high numbers and biomass, followed by Scaridae and then Mullidae, Lethrinidae and Lutjanidae in order of decreasing biomass. The predominant species were *Naso lituratus*, the ubiquitous *Ctenochaetus striatus*, and other herbivorous species: *Mulloidichthys flavolineatus*, *Scarus oviceps*, *Chlorurus sordidus*, *Acanthurus nigricans* and *S. psittacus*.

Table 3.13: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Salelavalu

Family	Species	Common name	Density (fish/m²)	Biomass (g/m²)
Acanthuridae	*Ctenochaetus striatus*	Striped bristletooth	0.20	18.4
	Acanthurus nigricans	White cheek surgeonfish	0.08	8.2
	Naso lituratus	Orangespine unicornfish	0.06	31.9
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.07	6.1
	Chlorurus sordidus	Bullethead parrotfish	0.05	8.8
	Scarus oviceps	Dark-capped parrotfish	0.05	9.9
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.05	17.9

The outer reefs of Salelelavu are undoubtedly the richest among the four habitats in terms of both total density and biomass (twice as high compared to the lagoon, the second highest value). The fish community was also healthy in terms of size and biodiversity.

Among the four outer reefs analysed, Salelavalu displayed the second lowest values for total biomass, density and size ratios, but the largest mean sizes (Table 3.14).

The substrate composition was diverse and dominated by hard bottom and a high percentage of live coral (>20%), the second highest among the four habitats (Table 3.6, Figure 3.24).

Table 3.14: Comparisons of the outer-reef biological parameters among the four Samoan sites

Site	Density (fish/m²)	Biomass (g/m²)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	1.31 (±0.13)	201.2 (±30.9)	17.1 (±0.6)	57.6 (±2.0)
Salelavalu	**0.94 (±0.18)**	**166.0 (±28.9)**	**18.0 (±0.7)**	**59.5 (±2.2)**
Vailoa	1.03 (±0.13)	179.0 (±32.0)	17.3 (±0.5)	62.0 (±1.7)
Vaisala	0.74 (±0.16)	132.0 (±35.2)	17.9 (±0.7)	62.3 (±2.3)

Figures in brackets denote standard error; FL = fork length.

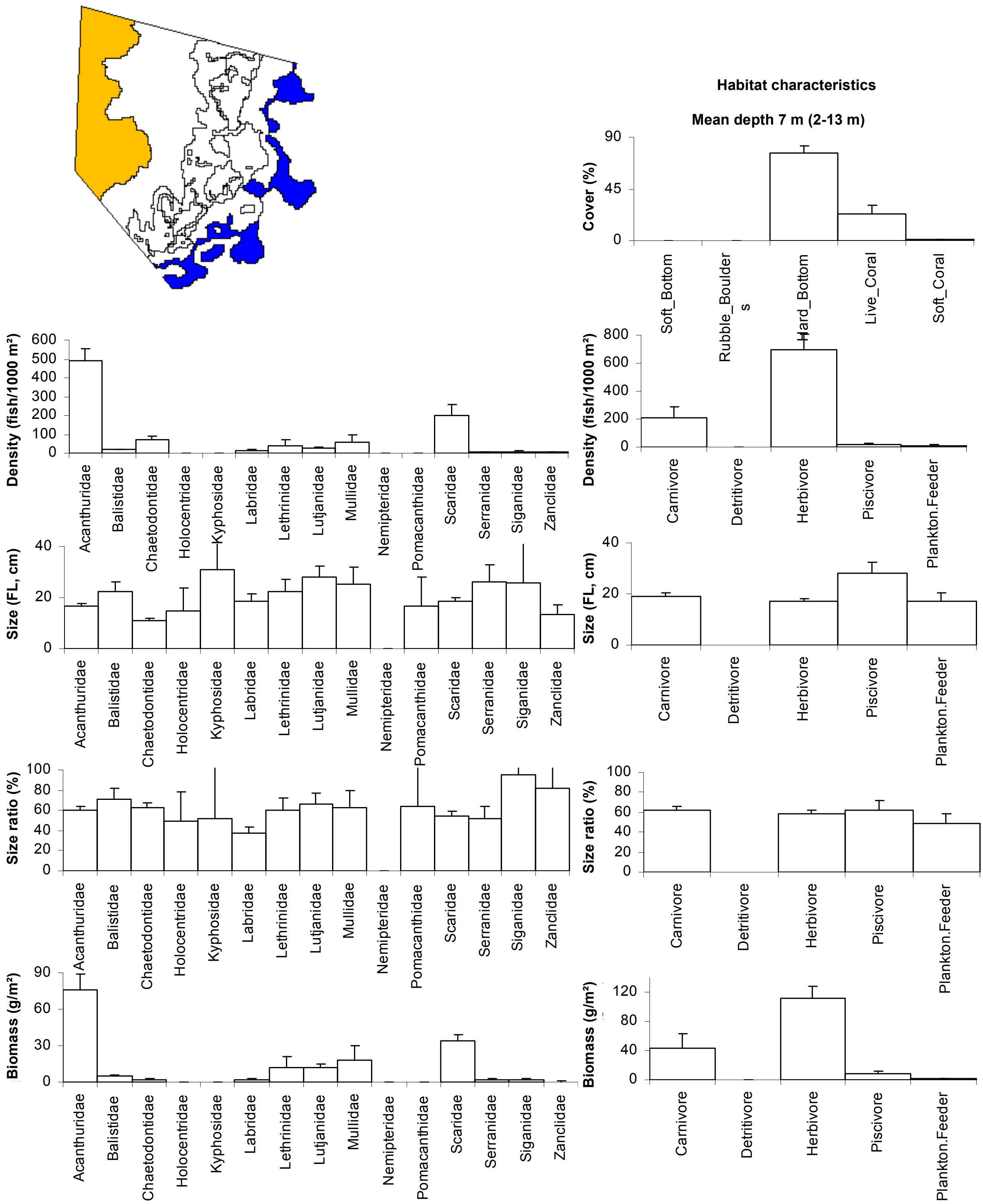

Figure 3.24: Profile of finfish resources in the outer-reef environment of Salelavalu.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Salelavalu

Overall, the fish assemblage of Salelavalu was represented mainly by two families, Scaridae (dominant in coastal, back-reef and lagoon habitats) and Acanthuridae (dominant in outer reefs), with Mullidae and Lutjanidae third and fourth in range for biomass values (Figure 3.25). These four main families were represented by a total of 51 species, dominated (in terms of average density and biomass) by *Scarus psittacus*, *Ctenochaetus striatus*, *Chlorurus sordidus*, *Mulloidichthys flavolineatus*, *Scarus oviceps*, *Acanthurus triostegus* and *Lutjanus fulvus* (Table 3.15). The overall community compositions are controlled mostly by the relative abundance and biomass of families encountered in the lagoon and coastal reefs, as expected, since these were the two largest habitats (36% of total surface area in each, Table 3.6).

Table 3.15: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Salelavalu (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.11	4.2
	Chlorurus sordidus	Bullethead parrotfish	0.06	7.9
	Scarus oviceps	Dark-capped parrotfish	0.02	3.3
Acanthuridae	*Ctenochaetus striatus*	Lined bristletooth	0.10	7.7
	Acanthurus triostegus	Convict tang	0.02	1.5
Mullidae	*Mulloidichthys flavolineatus*	Yellowstripe goatfish	0.03	3.2
Lutjanidae	*Lutjanus fulvus*	Yellow-margined seaperch	0.02	4.3

When compared to the average for Samoa PROCFish/C study sites, Salelavalu displayed the lowest mean values of density, biomass, sizes and size ratios (Table 3.16). According to these observations, the resources in Salelavalu appear to have been exploited to dangerous levels, especially in the lagoon habitat.

The fish community was largely dominated by herbivores. This is another sign of weakening of the fish assemblage. Mean sizes in Salelavalu were below 50% of known maximum values for most commercial families: Holocentridae, Lethrinidae, Lutjanidae, Mullidae, Scaridae and Serranidae, a condition which indicates a more depleted resource compared to all other sites.

Substrate composition is very similar to Manono-uta and Vailoa (Figure 3.25) and cannot by itself explain these differences among sites. Consequently such poor numbers are most probably a sign of an overfished resource.

Table 3.16: Values (average per transects) of descriptive biological parameters for each site

Site	Average number of species	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	28	0.8	100.0	15	55.0
Salelavalu	**29**	**0.6**	**67.8**	**14**	**46.0**
Vailoa	29	0.8	116.7	15	54.0
Vaisala	24	0.8	97.0	15	54.5

FL = fork length.

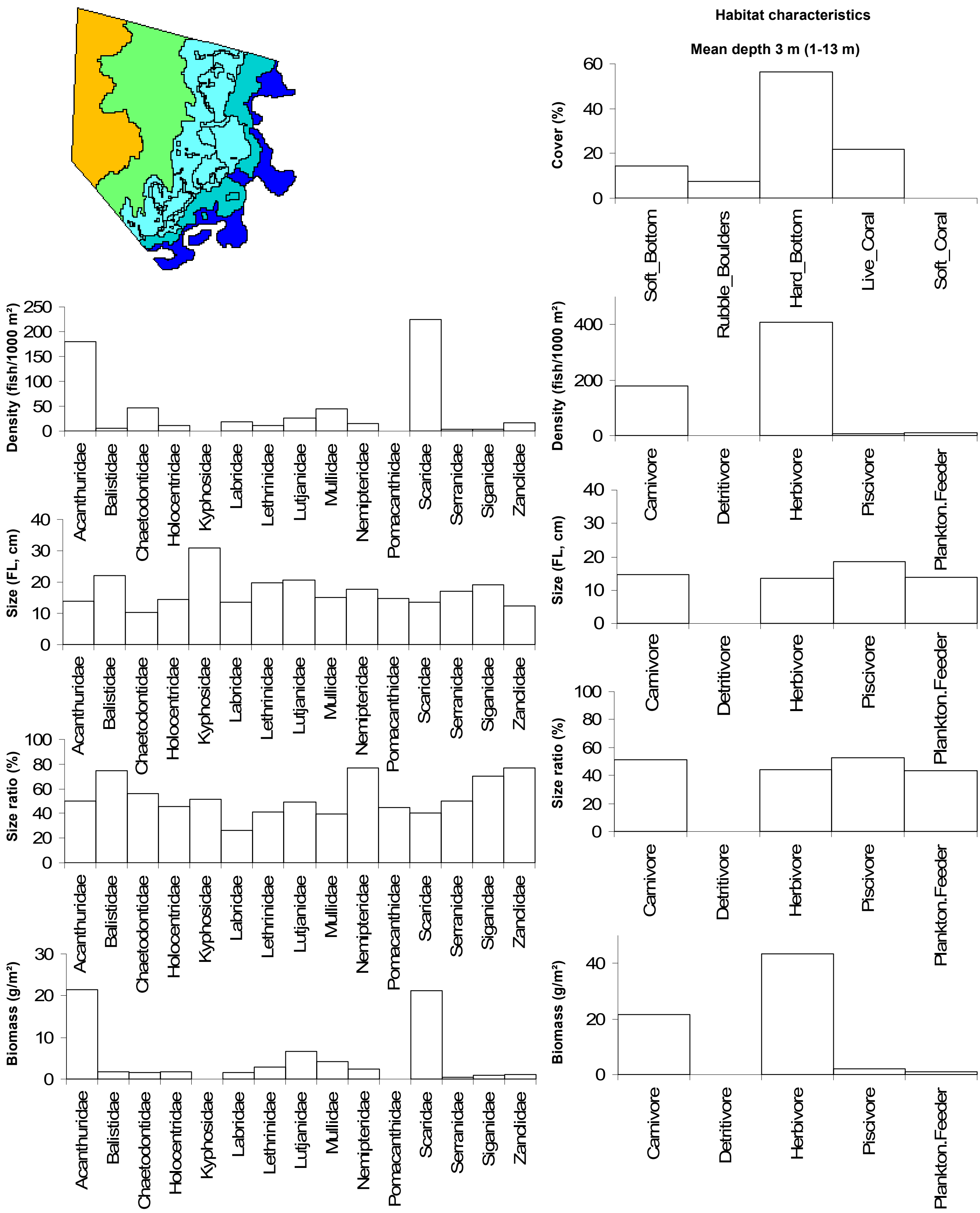

Figure 3.25: Profile of finfish resources in the combined reef habitats of Salelavalu (weighted average).
FL = fork length.

3.3.2 Discussion and conclusions: finfish resources in Salelavalu

In conclusion, finfish resources in Salelavalu appeared to be in poor condition, with the lowest mean values of density, biomass, sizes, size ratios and numbers of fish (Table 3.16) among the four sampled sites. The poorest conditions were found in the coastal and lagoon reefs, where most fishing is concentrated. The signs of impacts from fishing are seen in the decreased stocks of Scaridae, Acanthuridae and Mullidae, as well as all carnivore species, especially in the coastal habitats. Total fish density and biomass in Salelavalu were the lowest among the four sites surveyed in Samoa. Fish sizes, a good indicator of the level of exploitation of the fish community, were also the smallest here.

3.4 Invertebrate resource surveys: Salelavalu

The diversity and abundance of invertebrate species at Salelavalu were independently determined using a range of survey techniques (Table 3.17), broad-scale assessment (using the ‘manta tow’ technique; locations shown in Figure 3.26) and finer-scale assessment of specific reef and benthic habitats (Figures 3.27 and 3.28).

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

Table 3.17: Number of stations and replicate measures completed at Salelavalu

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	13	78 transects
Reef-benthos transects (RBt)	22	132 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	0	0 transect
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	4	24 search periods
Sea cucumber night searches (Ns)	3	18 search periods
Sea cucumber day searches (Ds)	5	30 search period

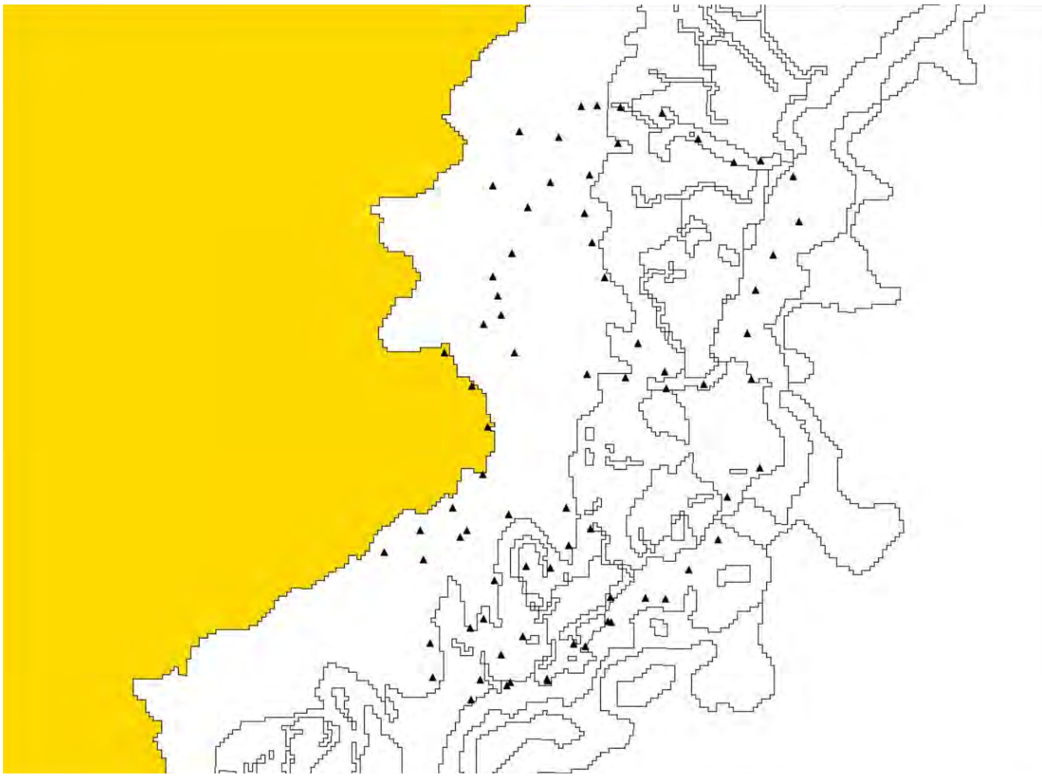

Figure 3.26: Broad-scale survey stations for invertebrates in Salelavalu.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

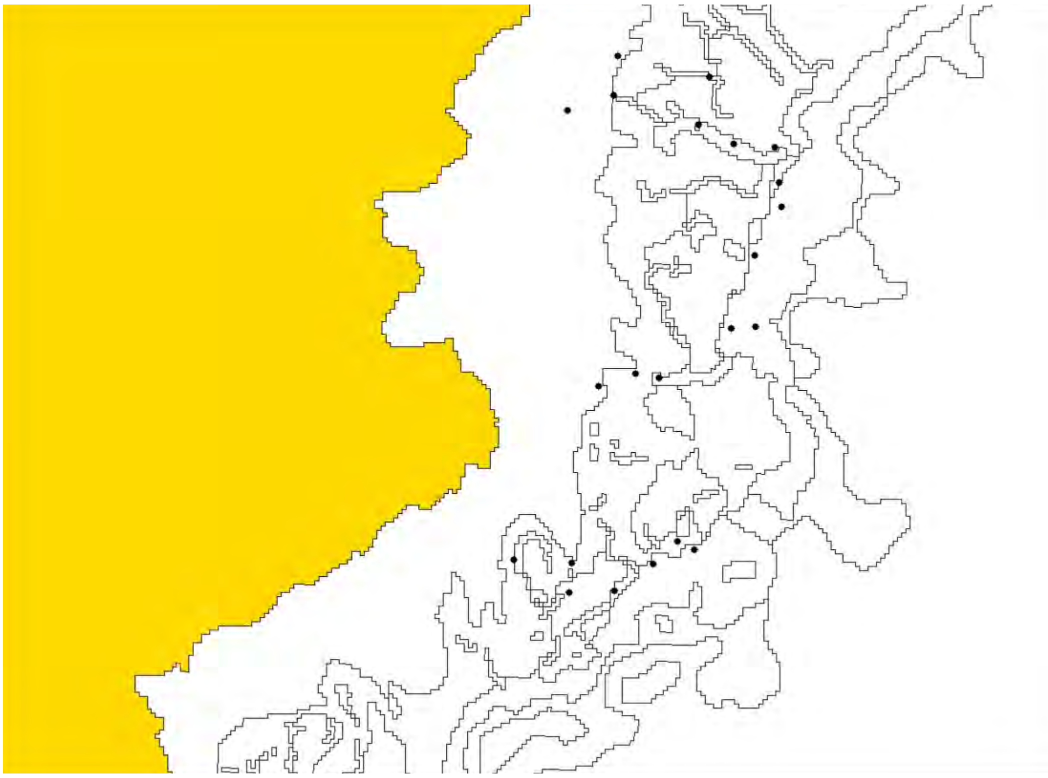

Figure 3.27: Fine-scale reef-benthos transect survey stations for invertebrates in Salelavalu.
Black circles: reef-benthos transect stations (RBt).

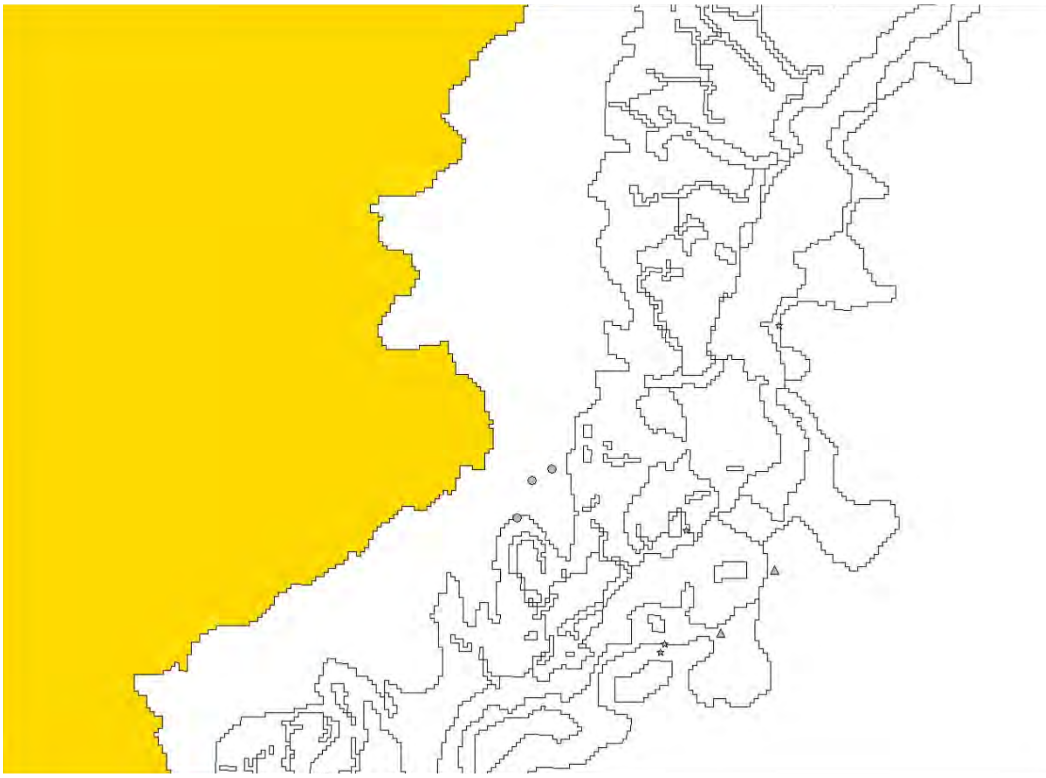

Figure 3.29: Fine-scale survey stations for invertebrates in Salelavalu.
Grey triangles: reef-front search stations (RFs);
grey stars: sea cucumber day search stations (Ds);
grey circles: sea cucumber night search stations (Ns).

Forty species or species groupings (groups of species within a genus) were recorded in the Salelavalu invertebrate surveys. Among these were: 5 bivalves, 10 gastropods, 11 sea cucumbers, 3 urchins, 4 sea stars, and 3 cnidarians (Appendix 4.2.1.). Information on key families and species is detailed below.

3.4.1 Giant clams: Salelavalu

Shallow-reef habitats were relatively extensive (7.7 km²) and very suitable for a range of clam species, but only the elongate clam, *Tridacna maxima*, was recorded in survey. There was no stockpile of introduced giant clam species as was present at the other three PROCFish sites in Samoa.

Broad-scale sampling provided an overview of giant clam distribution across Salelavalu. The elongate clam, *T. maxima*, was recorded in 1 of 13 stations and 2 transects (Figure 3.29).

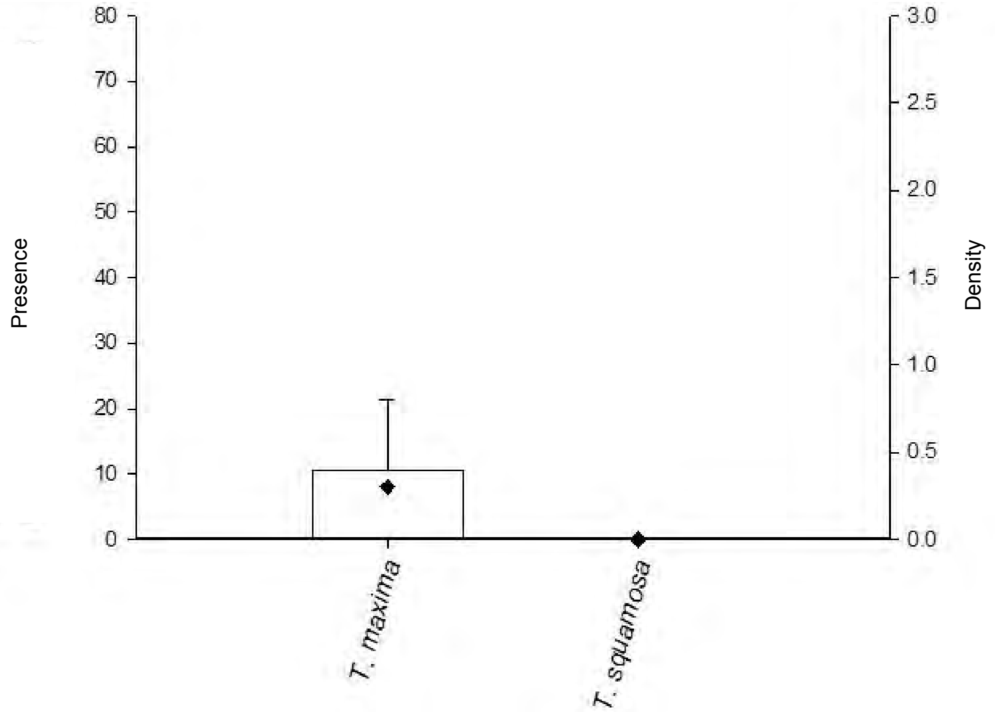

Figure 3.29: Presence and mean density of giant clam species at Salelavalu based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat. In reef-benthos transect assessments (RBt) *T. maxima* was the only species found and this was only recorded in a single station (a single clam was recorded, 5% of stations, see Figure 3.30).

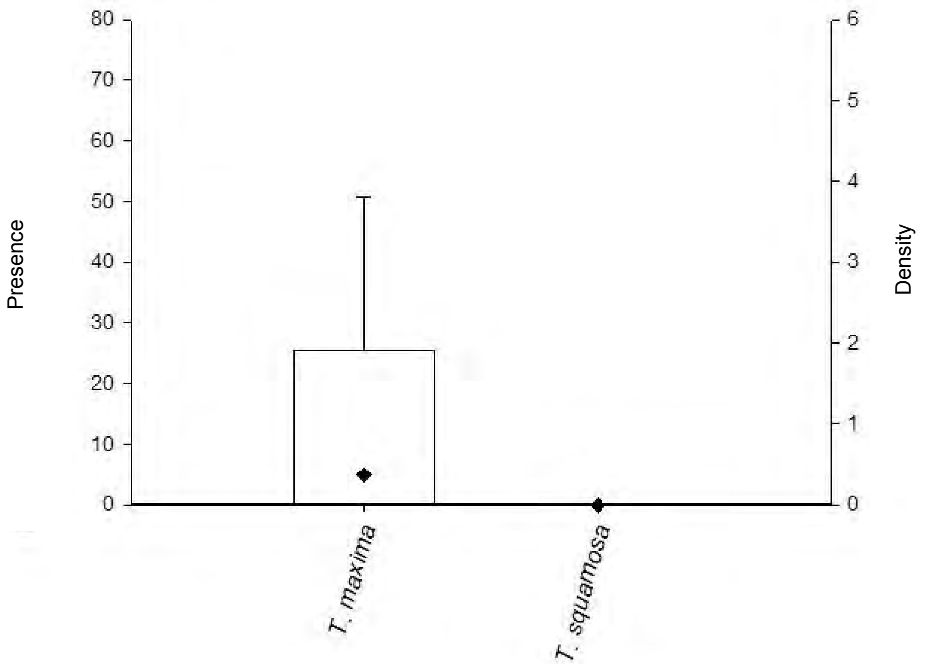

Figure 3.30: Presence and mean density of giant clam species at Salelavalu based on fine-scale reef-benthos survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Although giant clams were very rare throughout the lagoon at Salelavalu, the lagoon system was large and presented varied reef substrate, with adequate depth and water movement for clam species. There were no obvious environmental reasons for the absence of giant clams.

The single *T. maxima* found in the reef-benthos transect was 19 cm in length. When clams from deeper water and more exposed locations were included in the calculation (from other assessments), the average size was 15.3 cm ±4.1, which equates to a *T. maxima* of ~7 years of age. As can be seen from the length frequency graph (Figure 3.31), the few recordings made were generally of large, mature clams.

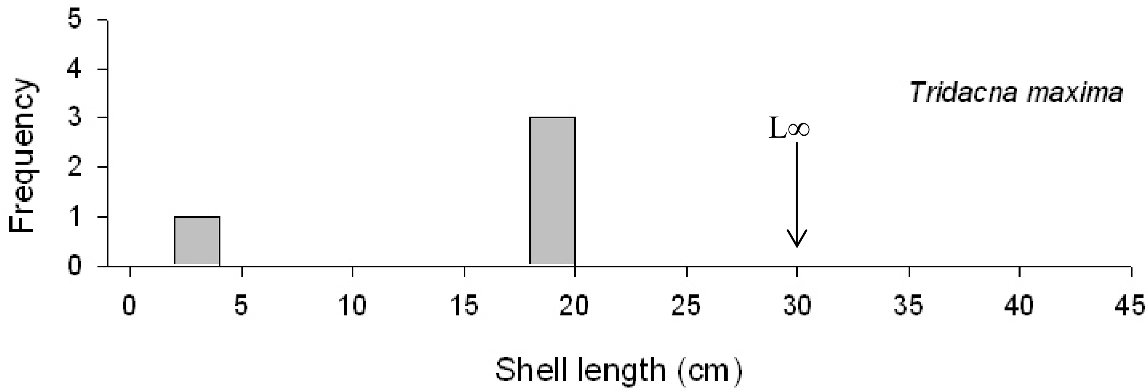

Figure 3.31: Size frequency histogram of *Tridacna maxima* shell length (cm) for Salelavalu.

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

At Salelavalu, there is 6.2 km (lineal distance) of reef front and extensive inshore reef suitable for *Trochus niloticus*; this area could potentially support significant numbers of this commercial species. However, Samoa is not within the natural distribution of trochus, and translocations have not been made to these reefs. The reef-front at Salelavalu generally consists mainly of wave-swept platform leading to a relatively steep drop-off down to sand. This is not optimal trochus habitat, although suitable habitat for nursery and juvenile trochus was extensive in the back-reef.

No commercial topshell, *T. niloticus*, was recorded in Salelavalu, which is not surprising as trochus have not been introduced to nearby reefs during past translocations, and trochus generally recruit close to parent stock (The gametes do not travel far.).

The numbers of other species of grazing gastropods, as measured by the abundance of *Tectus pyramis*, a species with a similar life habit to trochus, were generally low to medium (Table 3.18).

Table 3.18: Presence and mean density of *Tectus pyramis* in Salelavalu
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
Tectus pyramis				
B-S	1.3	0.7	3/13 = 23	5/78 = 6
RBt	18.9	8.6	6/22 = 27	8/132 = 6
RFs	7.3	6.5	2/4 = 50	4/24 = 17

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

Twenty-five *Tectus pyramis* were found; average size (basal width) was 6.0 cm ±0.5. No blacklip pearl oysters, *Pinctada margaritifera* were recorded in survey.

3.4.3 Infaunal species and groups: Salelavalu

The soft benthos of the shallow-water lagoon was very sandy and did not hold shell beds of in-ground resource species, such as arc (*Anadara* spp.) or venus shells, *Gafrarium* spp. Therefore no quadrat stations (infaunal surveys) were required.

3.4.4 Other gastropods and bivalves: Salelavalu

No Seba's spider conch, *Lambis truncata*, or other, smaller conchs, *Lambis* spp. were detected in broad-scale and fine-scale surveys. *Strombus luhuanus* was uncommon throughout the lagoon, but was recorded in broad-scale and reef-benthos surveys (Appendices 4.2.1 to 4.2.8). No *Turbo* spp. were recorded but measures for other species targeted by fishers (resource species, e.g. *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Dollabella*, *Tectus* and *Thais*) can be seen in Appendices 4.2.1 to 4.2.8).

Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Anadara*, *Pinna*, *Spondylus* and *Tellina* are also in Appendices 4.2.1 to 4.2.8. No creel survey was conducted at Salelavalu.

3.4.5 Lobsters: Salelavalu

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, a single recording of a banded prawn killer, *Lysiosquillina maculata* (sand lobster), burrow was made in a RBt station. No lobsters were recorded during night-time lagoon assessments for nocturnal sea cucumber species (Ns).

3.4.6 Sea cucumbers[10]: Salelavalu

Salelavalu has a large lagoon bordering a large high island of Savaii (although most fresh water inflows are spring fed). Reef margin and shallow, mixed hard- and soft-benthos habitat were extensive throughout the system (11 km^2 inside the lagoon, and 3.6 km^2 shallow reef offshore). These habitats suit commercial sea cucumbers, which are predominantly deposit feeders and eat organic matter in the upper few mm of bottom substrates. Near the Salelavalu shoreline, the lagoon was mostly very shallow and water movement was limited, although deeper sections of the lagoon (to 20 m) could be found behind the barrier reef. There were numerous passages across the barrier reef which enabled oceanic and lagoon water to mix.

Nearshore habitats were mostly made of sand, although there was some patchy reef. Most inshore areas were overgrown with epiphytes and algae, but the reef structure radiated out in bars from the coast to the barrier (east–west axis). These structures had good coral cover, but pools in the lagoon were somewhat closed off, limiting exposure and water movement.

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

The presence, size and density of sea cucumber species were determined through broad-scale, fine-scale and dedicated survey methods (Table 3.19, Appendices 4.2.1 to 4.2.7, also see Methods). Within this system, nine commercial species were recorded during in-water assessments. *Holothuria leucospilota* (viscera eaten locally) and *Synapta* spp. (a potential indicator species) were also recorded (Table 3.19).

The presence and density of commercial species in Salevalu were generally similar to records from the other three sites in Samoa, except that the area was more extensive and some lagoon species were more common. Greenfish (*Stichopus chloronotus*), which was not so common across Apolima Straight in Manono-uta, was again common in shallow-water reef areas (similar if not as dense as at the Vailoa site). Other species associated with reef, such as leopardfish (*Bohadschia argus*), were common in relation to the other PROCFish/C sites but at low density considering the size and environment of the lagoon. Similarly, black teatfish (*H. nobilis*) were noted, but were also less common than might be expected considering the extent and presence of a well-flushed and suitable back-reef habitat. Perhaps this area has experienced slower recovery, or was under greater pressure during fishing when the BdM industry was active.

Surf redfish (*Actinopyga mauritiana*) was recorded across different assessment types, but again the occurrence and density of this species were unexpectedly poor (in Salelavalu and Samoa in general), considering the suitable nature and extent of the reef and surge zone present.

More protected areas of reef and soft benthos in the lagoon held a few lower-value species, e.g. brown sandfish (*Bohadschia vitiensis*) and lollyfish (*H. atra*). Lollyfish were especially plentiful on the sandy inshore areas. *Stichopus horrens*, locally named *sea* was actively targeted along the mainland shallows (Parts of the viscera are bottled along with strips of body wall from the larger lollyfish and brown sandfish.) and was fished during the time of our survey. Night searches based in these areas revealed the species to be common, and we recorded densities that were higher than found on Upolu, but low compared to PROCFish records taken in Vanuatu, Tonga and Wallis Island.

Deep dives on SCUBA were conducted to obtain a preliminary assessment of deep-water stocks such as the high-value white teatfish (*Holothuria fuscogilva*) and the lower-value amberfish (*Thelonata anax*). In deep water (25–35 m), white teatfish (*H. fuscogilva*) and prickly redfish (*T. ananas*) were present but again, occurrence was patchy, and densities were low.

3.4.7 Other echinoderms: Salelavalu

No edible slate urchins (*Heterocentrotus mammillatus*) or collector urchins (*Tripneustes gratilla*) were recorded, although *Echinometra mathei* were common in survey and *Echinothrix* spp. were present.

The blue starfish (*Linckia laevigata*) was abundant in Salelavalu (present in 62% of broad-scale and 64% of reef-benthos stations). The cushion star (*Culcita novaeguineae*) and crown of thorns starfish (*Acanthaster planci*, COTS), which are both corallivores (coral eaters), were relatively common. *C. novaeguineae* was present in 46% of broad-scale stations and six COTS were recorded during survey, present in 15% of broad-scale stations (1.1 per ha) and 5% of reef-benthos stations (1.9 per ha). Some fresh scars were noted from their feeding activity, particularly on exposed back-reef in the lagoon.

Table 3.19: Sea cucumber species records for Salelavalu

Species	Common name	Commercial value	B-S transects n = 78			Reef-benthos stations n = 22			Other stations RFs = 4			Other stations Ds = 5; Ns = 3		
			D (1)	DwP (2)	PP (3)	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga mauritiana	Surf redfish	M/H	1.1	20.8	5	1.9	41.7	5	1.1	4.4	25			
Bohadschia argus	Leopardfish	M	10.7	43.9	17	11.4	62.5	18				1.4	3.6	40 Ds
Bohadschia vitiensis	Brown sandfish	L	0.9	33.3	3									
Holothuria atra	Lollyfish	L	2132	3779	56	549.2	1343	41						
Holothuria fuscogilva (4)	White teatfish	H										0.5	2.4	20 Ds
Holothuria fuscopunctata	Elephant trunkfish	M												
Holothuria leucospilota	Black cucumber	L	0.2	16.7	1									
Holothuria nobilis (4)	Black teatfish	H	0.2	16.7	1									
Stichopus chloronotus	Greenfish	H/M	119.2	265.7	45	937.5	1375	68						
Stichopus horrens	Peanutfish	M										80	80	100 Ns
Synapta spp.	-	-												
Thelenota ananas	Prickly redfish	H	0.2	16.7	1							1.0	2.4	40 Ds
Thelenota anax	Amberfish	L												

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

3.4.8 Discussion and conclusions: invertebrate resources in Salelavalu

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

- The presence, density and size range of giant clams in Salelavalu indicates that the resource is degraded, most probably due to fishing pressure. Present densities are so low that they have passed the 'critical threshold' where reproductive success and subsequent recruitment is severely impaired. Stocks are likely to decline if action is not taken to protect and re-introduce clams.

- Mother-of-pearl stocks, *Trochus niloticus* and *Pinctada margaritifera*, were absent from Salelavalu, whilst *Tectus pyramis*, a species of similar life history to trochus, was only found at low-to-medium density.

- Reefs in Salelavalu are suitable for trochus, although there is little habitat for adult trochus on the ocean side of the reef, as it drops off steeply onto a sandy bottom.

- Based on the information collected on sea cucumber stocks, there is a limited number of species available for commercial fishing, stocks are patchy and *Stichopus horrens* (sea) is under significant fishing pressure at suitable fishing locations.

- The presence of high-value teatfish and other deep-water stocks are of interest for commercialisation, but stocks in this section of Savaii are insufficient to support fishing at present.

3.5 Overall recommendations for Salelavalu

Based on the survey work undertaken and the assessments made, the following recommendations are made for Salelavalu:

- Salelavalu should delay no further in participating in the national community-based fisheries management programme. A community management scheme should be set up in cooperation between the five villages and the Fisheries Department, with additional help from non-governmental organisations if possible. Traditional village or community leadership and social institutions are still well defined and respected in Salelavalu and will therefore serve well to effectively develop a community fisheries management programme. Certain reef and lagoon areas could be identified and declared as marine protected areas to allow stocks to recover because of the large size of the community's reef and lagoon resources.

- New marine resource management measures for finfish and invertebrate resources need to be put in place. Commercial fishing needs to be regulated and a monitoring programme established to ensure that resources remain available for subsistence use by future generations.

- The use of SCUBA for spear diving and spear fishing activities undertaken at night may need to be restricted. The use of gillnets may need to be regulated. Instead, handlining, rod-fishing and deep-water line fishing, which are still of minor impact, should be encouraged.

- Urgent action is needed to protect declining giant clam stocks and re-introduce new stocks. The giant clam *Tridacna derasa* (which has been introduced to other PROCFish sites) should be introduced to Salelavalu, which has an extensive lagoon system with suitable reef habitat and better environmental conditions than the other sites.

- Some potential exists for commercially fishing greenfish (*Stichopus chloronotus*) but, before a management plan can be developed for such a fishery, more comprehensive results from Samoa are needed.

- Crown of thorns starfish (COTS) were present in Salelavalu and their deleterious effect on live coral was noticeable in some locations. The population of COTS should be closely managed by encouraging the removal of individuals, and their size and abundance need to be closely monitored to forewarn of an outbreak.

4 PROFILE AND RESULTS FOR VAILOA

4.1 Site characteristics

Vailoa is part of the Aleipata District, about 60 km southeast of Apia (Figure 4.1). Southern Aleipata consists of a narrow coastal plain backed by volcanic slopes and cliffs, with two offshore islands, Nu'utele and Nu'ulua. Nu'utele Island is a sanctuary for birds, where fishing is prohibited; it has a narrow fringing reef to the north, and a very steep reef slope with high coral cover dropping off to a sand/rubble bottom at about 27 m (Zann 1989). Most of the offshore finfish fishing is conducted in the areas surrounding Nu'utele and Nu'ulua. The inner lagoon is mainly of fine sand, dominated by seagrass communities with mixed coral assemblages around Lolamanu.

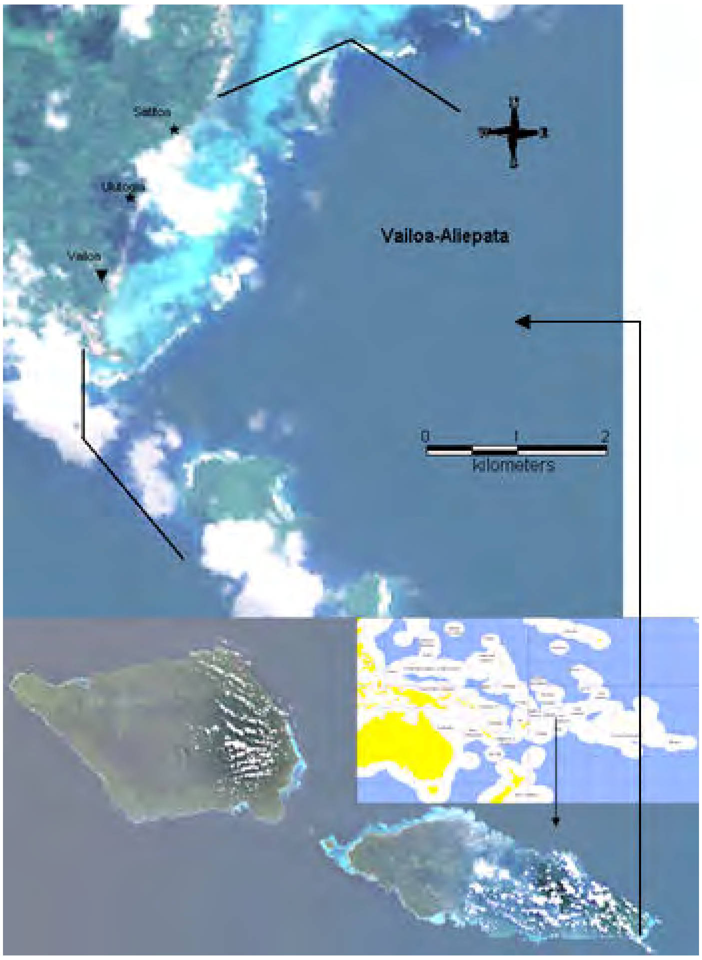

Figure 4.1: Location of Vailoa.

Resource surveys concentrated mainly in the sea areas adjacent to Vailoa, Ulutogia and Satitoa villages on the eastern side of Upolu Island. Vailoa (population: 335; households: 36) and Ulutogia (population: 194; households: 21) villages are in the District of Aleipata Itupa I Luga, while Satitoa village (population: 520; households: 71) is located in Aleipata Itupa I Lalo District (Statistical Services Division 2001). The 13 villages in Aleipata (i.e. 3 in Aleipata Itupa I Luga and 10 in Aleipata Itup I Lalo) have a combined population of 4614, with the majority of houses located along the coastal area of Aleipata. With about the same ratio of males and females, the village populations of Vailoa, Ulutogia and Satitoa represent 27%, 16% and 15% respectively of the district population.

Samoa has an open-access system for its inshore areas which makes demarcation of actual fishing grounds by village extremely difficult. This problem is further complicated by the close proximity of villages, located a few metres apart. The reef boundaries adopted during resource surveys were agreed to cover inshore areas that encompass several villages in Aleipata, therefore stretching from Nu'utele Island (including Cape of Tapaga) in the south to Namua Island (NE direction). Habitats are generally similar across the entire Aleipata sea area, though oceanic or terrestrial influence may slightly vary in certain areas. The Aleipata study area has MPAs adjacent to the villages of Vaiola, Ulutogia and Satitoa. These small and localised MPAs extend from the coastline to about mid-lagoon.

In rural Samoa, a distance of 60 km limits market access of fishery produce. Thus, catch is mainly sold to the four tourist resorts in the area, or along the roadside. Compared to Manono-uta and Salelavalu, commercialisation of catch in Vailoa is low and therefore fishing pressure is not as intense.

4.2 Socioeconomic surveys: Vailoa

Socioeconomic fieldwork was carried out in Vailoa, Samoa on 20–27 June 2005. The fieldwork included household surveys in four villages: Satitoa, Ulutogia, Vailoa, and some additional households in Lolamanu. Survey results are referred to as representing 'Vailoa' in the following.

The 'Vailoa' community has a resident population of 1756 with a total of 200 households. A total of 44 households (22% of total households in the community) were surveyed, with all (100%) of these households being engaged in some form of fishing activities. In addition, a total of 59 finfish fishers (54 males, 5 females) and 45 invertebrate fishers (21 males, 24 females) were interviewed. The average household size is large, with 11 people on average, due to the practice of living together in extended families (*aiga*).

Household interviews focused on the collection of general demographic, socioeconomic and consumption data. General information on sales and distribution of fisheries resources was conducted through interviews with shopkeepers and boat owners. A general survey of shops to establish prices of tinned fish and other food items consumed was also conducted.

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

Our results (Figure 4.2) suggest that agriculture is by far the most important source of household income with >65% of households stating agriculture as their primary (~36%) or secondary (~30%) source of income. This is followed by other sources, mainly small businesses and handicrafts (~32%), and fisheries, which provides ~16% of all households with first income and 25% with second income. The role of salaries is minor; providing only ~14% of households with primary, and another 9% with secondary income. Pigs and chickens are popularly reared for *falavelave* and for selling. Distribution of fish and seafood produce on a non-monetary basis is a very important and traditional practice all over Samoa and thus also in Vailoa.

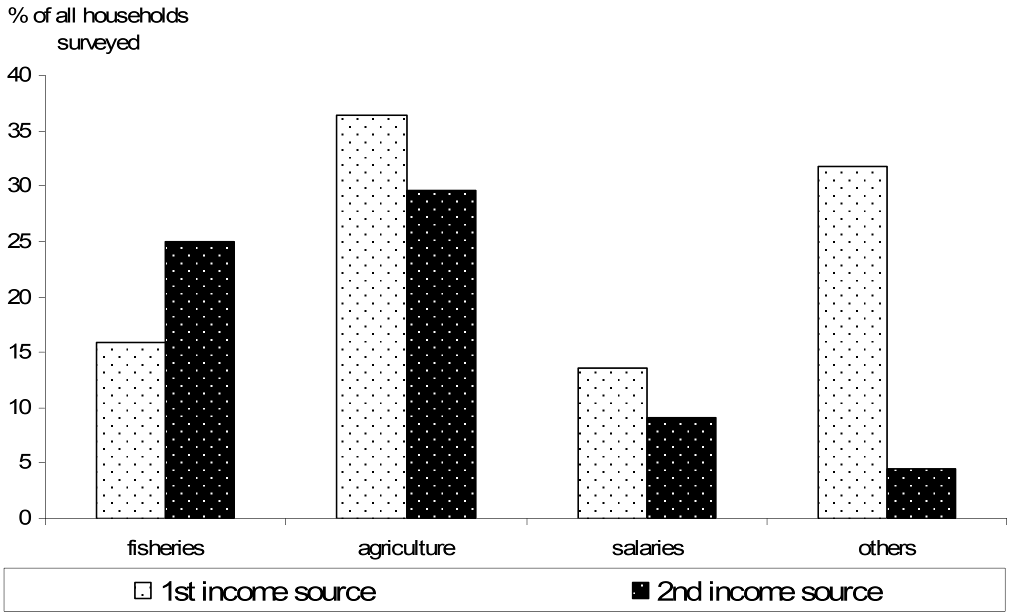

Figure 4.2: Ranked sources of income (%) in Vailoa.
Total number of households = 44 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1^{st} and 2^{nd} incomes are possible. 'Others' are mostly home-based small businesses.

Our results (Table 4.1) show that annual household expenditures are high with an average of USD 3610. Families claimed to spend cash mainly on necessary food and household items including *falavelave.* The household expenditure also included weekly church donations, which people regarded as a basic obligation.

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

	Site (n = 44 HH)	Average across sites (n = 207 HH)
Demography		
HH involved in reef fisheries (%)	100.0	91.3
Number of fishers per HH	2.20 (±0.19)	2.03 (±0.09)
Male finfish fishers per HH (%)	45.4	46.6
Female finfish fishers per HH (%)	1.0	2.9
Male invertebrate fishers per HH (%)	1.0	2.1
Female invertebrate fishers per HH (%)	25.8	13.3
Male finfish and invertebrate fishers per HH (%)	21.6	25.9
Female finfish and invertebrate fishers per HH (%)	5.2	9.3
Income		
HH with fisheries as 1st income (%)	15.9	25.1
HH with fisheries as 2nd income (%)	25.0	27.1
HH with agriculture as 1st income (%)	36.4	28.5
HH with agriculture as 2nd income (%)	29.5	27.5
HH with salary as 1st income (%)	13.6	17.9
HH with salary as 2nd income (%)	9.1	11.6
HH with other source as 1st income (%)	31.8	28.5
HH with other source as 2nd income (%)	4.5	8.2
Expenditure (USD/year/HH)	3610.88 (±840.38)	2991.32 (±209.55)
Remittance (USD/year/HH) (1)	1855.11 (±148.32)	2170.81 (±89.23)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	47.73 (±4.69)	61.26 (±4.35)
Frequency fresh fish consumed (times/week)	3.32 (±0.23)	3.92 (±0.10)
Quantity fresh invertebrate consumed (kg/capita/year)	8.52 (±2.13)	9.61 (±4.35)
Frequency fresh invertebrate consumed (times/week)	0.61 (±0.11)	0.49 (±0.04)
Quantity canned fish consumed (kg/capita/year)	28.32 (±2.81)	24.26 (±1.92)
Frequency canned fish consumed (times/week)	3.37 (±0.23)	2.81 (±0.11)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	86.4	83.6
HH eat canned fish (%)	97.7	97.6
HH eat fresh fish they catch (%)	88.6	82.1
HH eat fresh fish they buy (%)	27.3	23.9
HH eat fresh fish they are given (%)	50.0	59.7
HH eat fresh invertebrates they catch (%)	56.8	52.2
HH eat fresh invertebrates they buy (%)	22.7	19.4
HH eat fresh invertebrates they are given (%)	36.4	64.2

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

Remittance is an important component of Samoa's household income with 93% of all households surveyed in Vailoa receiving on average USD 1855 per year. The high number of households that receive remittances and the average amount of USD >2000 per year is consistent throughout all four study areas in Samoa. Comparing the average annual household expenditure and the average annual remittances received, it is evident that the basic costs of an average family in the Vailoa community are met by external donations. Therefore, it not surprising that most families interviewed described remittances as either the main or one of the major sources from which most of the *falavelave* are met. The frequency of remittances received ranges from once a fortnight to once a month, and most of the foreign currency received is sourced from New Zealand.

Survey results indicate an average of two fishers per household and, when extrapolated, the total number of fishers in Vailoa is 331: 225 males, 106 females. Amongst these are 153 exclusive finfish fishers (150 males, 3 females), 88 exclusive invertebrate fishers (3 males, 85 5 females), and 89 fishers who fish for both finfish and invertebrates (72 males, 17 females). About half of all households own a boat, most (~83%) of which are non-motorised canoes; only ~17% are equipped with an outboard engine.

Consumption of fresh fish is relatively low, ~48 kg/person/year, much less than the average across all four study sites in Samoa, but significantly higher than the regional average of ~35 kg/person/year (Figure 4.3). By comparison, consumption of invertebrates (edible meat weight only) (Figure 4.4) is moderately high with 8.5 kg/person/year. Canned fish (Table 4.1) adds another ~28 kg/person/year to the protein supply from seafood. The pattern of seafood consumption found in Vailoa highlights the fact that people have access to a variety of agricultural and marine food sources, as well as to commercially available food items. Canned fish, locally named *elegi*, is a regular constituent of *falavelave*, which may explain the large quantity consumed.

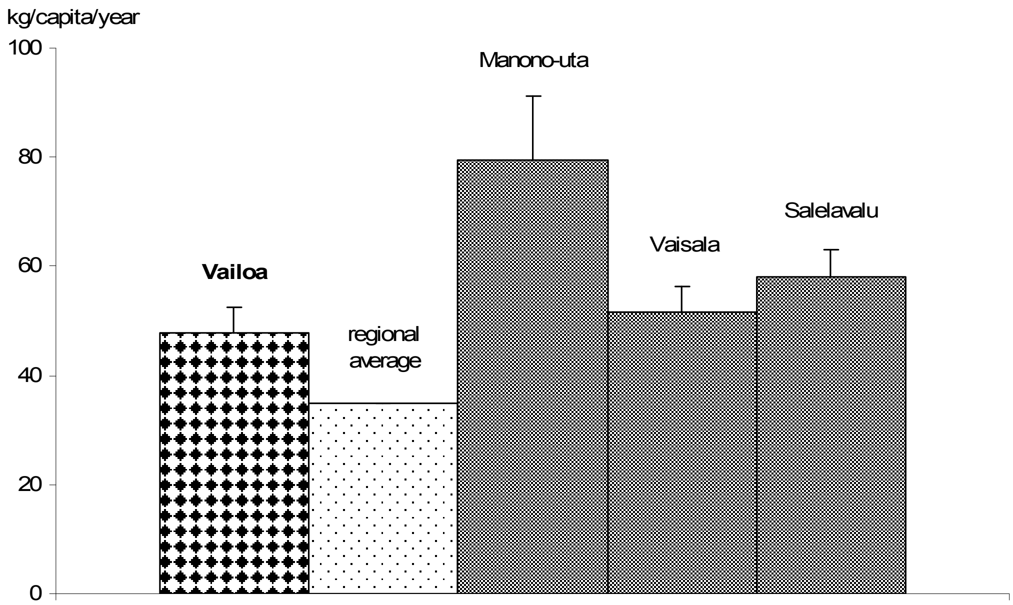

Figure 4.3: Per capita consumption (kg/year) of fresh fish in Vailoa (n = 44) compared to the regional average (FAO 2002) and the other three PROCFish/C sites in Samoa.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

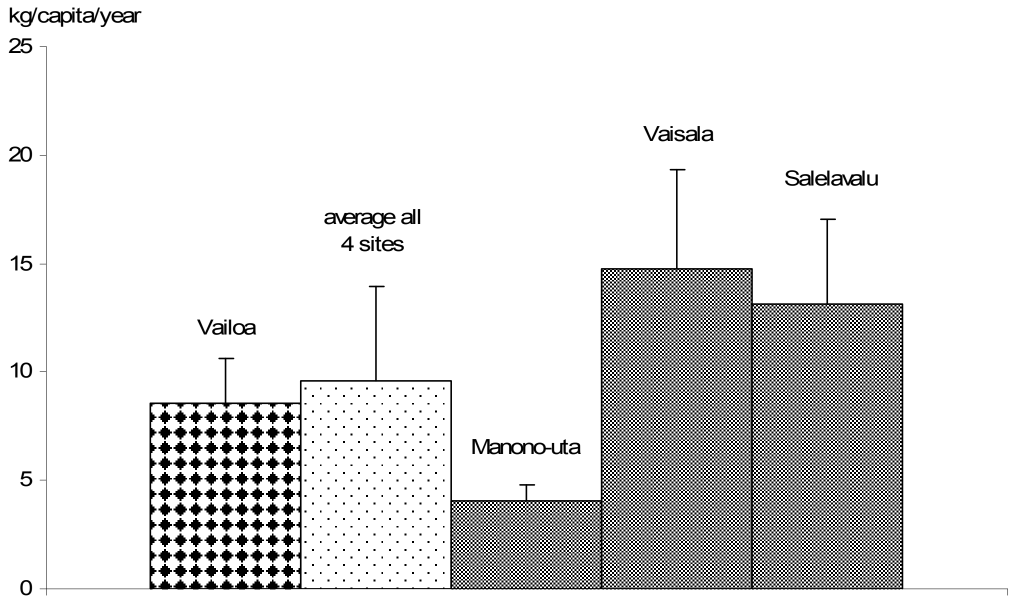

Figure 4.4: Per capita consumption (kg/year) of invertebrates (meat only) in Vailoa (n = 44) compared to the average of all four sites and the other three PROCFish/C sites in Samoa. Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

Comparing results obtained for Vailoa to the average figures across all four study sites surveyed in Samoa, people of the Vailoa community eat fresh fish, invertebrates and canned fish about as often as average. However, the quantity of fresh fish eaten is well below the average, while the quantity of invertebrates is average. The amount of canned fish eaten is slightly higher than average. The proportion of fish and invertebrates that the people in Vailoa consume and buy, or that is caught by somebody living in the household, is the same as the average across the study sites. However seafood is gifted among the community less often as compared to other sites. Agriculture and small businesses including handicrafts, play a much greater, and fisheries and salaries a lesser role in providing income than across all Samoan PROCFish sites. While household expenditure in Vailoa is substantially more than elsewhere, the amount of remittance received is less. Fewer than average households own boats; however, as elsewhere, most are non-motorised canoes.

4.2.2 Fishing strategies and gear: Vailoa

Vailoa has one of the best co-managed fisheries reserves in Samoa. The Fisheries Department, non-governmental organisations and the community are working hand-in-hand to implement fisheries management strategies that all partners have agreed upon. The Vailoa community is well aware of the need to manage their limited reef and lagoon resources to ensure their long-term benefits for food and income. Fishing is a day-to-day activity, and some fishers may venture out on a daily basis, particularly if generating income from fisheries. Traditional roles still show in the low participation of females in finfish fishing. While more males fish exclusively for finfish, more females exclusively collect invertebrates (Figure 4.5). More than 20% of all male fishers but only a very few female fishers (~5%) fish for both finfish and invertebrates.

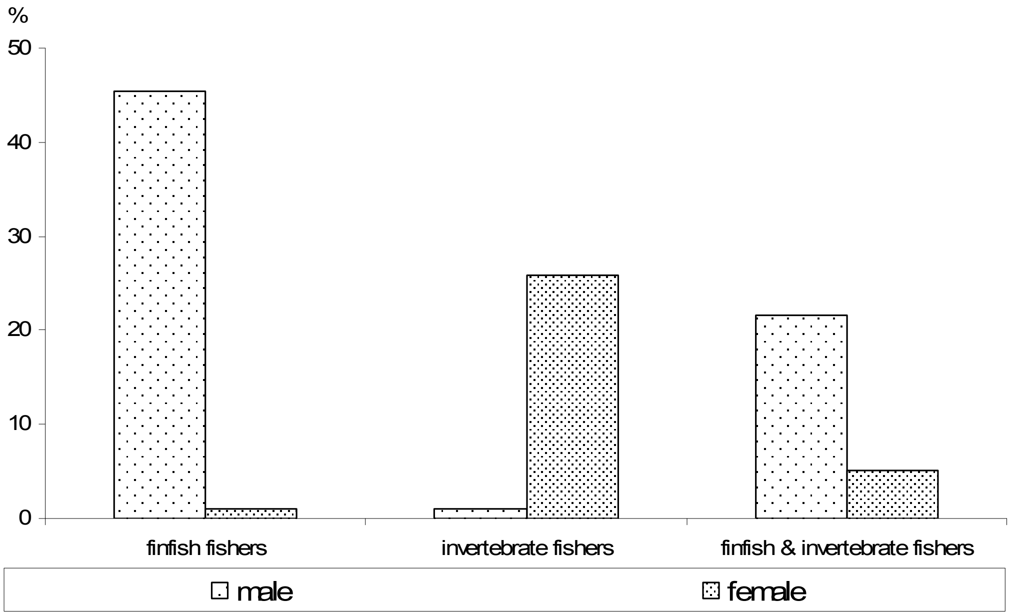

Figure 4.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Vailoa.
All fishers = 100%.

Targeted stocks/habitat

Considering that only half of all households own a boat, and that most (>80%) of these are paddling canoes, it is not surprising that most female fishers only target the easily accessible and close-by areas, including the sheltered coastal reef and the lagoon. This observation is only partially true for males, as most target the lagoon (43%) or the combined lagoon and outer reef (37%). Another 15% catch fish at the outer reef and passages. The reason for combining the lagoon and outer reef is usually to catch baitfish in the lagoon and in response to weather and sea conditions (Table 4.2). While most fishers target the reeftop for invertebrate collection, a considerable proportion of male fishers also dive for giant clams, certain bêche-de-mer, and other species (Table 4.2). A great number of female fishers also visit soft-benthos and mangrove areas, in particular to target preferred bêche-de-mer species and crustaceans. Some shells, particularly *Anadara* spp., are dug out in the intertidal zones; however this is a much less frequent activity.

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	0.0	20.0
	Sheltered coastal reef & lagoon	16.7	60.0
	Lagoon	42.6	20.0
	Lagoon & outer reef	37.0	0.0
	Outer reef	3.7	0.0
	Outer reef & passage	11.1	0.0
Invertebrates	Reeftop	38.1	54.2
	Reeftop & other	9.5	4.2
	Reeftop & trochus	4.8	0.0
	Intertidal	0.0	4.2
	Intertidal & reeftop	0.0	16.7
	Soft benthos	4.8	8.3
	Soft benthos & mangrove	4.8	29.2
	Soft benthos & intertidal & reeftop	0.0	8.3
	Mangrove	0.0	16.7
	Lobster	4.8	0.0
	Other	42.9	0.0

'Other' refers to the giant clam, octopus and bêche-de-mer fisheries.
Finfish fisher interviews, males: n = 54; females: n = 5. Invertebrate fisher interviews, males: n = 23; females, n = 34.

Fishing patterns and strategies

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

Our survey sample suggests that fishers from Vailoa have a great choice of fishing grounds: sheltered coastal reef, lagoon, outer reef, and passages. However, reeftop (38%), soft benthos (19%) and mangrove (12%), which also includes some bêche-de-mer collection, are the main habitats for invertebrate fisheries (Figure 4.6). The group of 'other', representing 17% of the invertebrate fishery, contains a mixture of species that male fishers dive for, mostly associated with reeftop and soft-benthos habitats, i.e. giant clams and certain bêche-de-mer species. Gender participation shows that females dominate the gleaning fisheries (reeftop and soft benthos, particularly bêche-de-mer) and also collect certain shells, mainly *Anadara* spp., in the intertidal areas (11%). No females dive for giant clams, lobsters ('other'), or trochus (Figure 4.7).

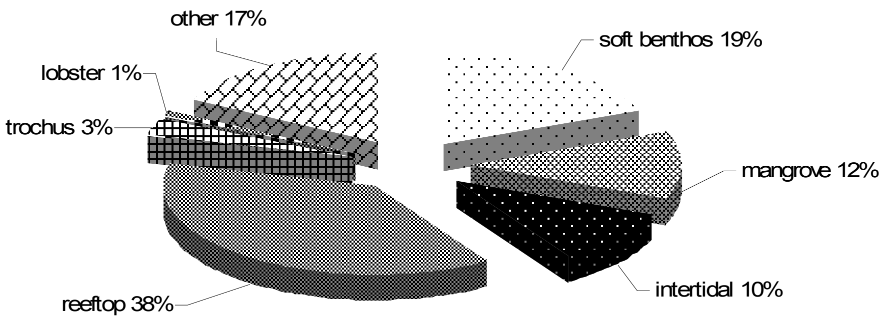

Figure 4.6: Proportion (%) of fishers targeting the seven primary invertebrate habitats found in Vailoa.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the giant clam, octopus and bêche-de-mer fisheries.

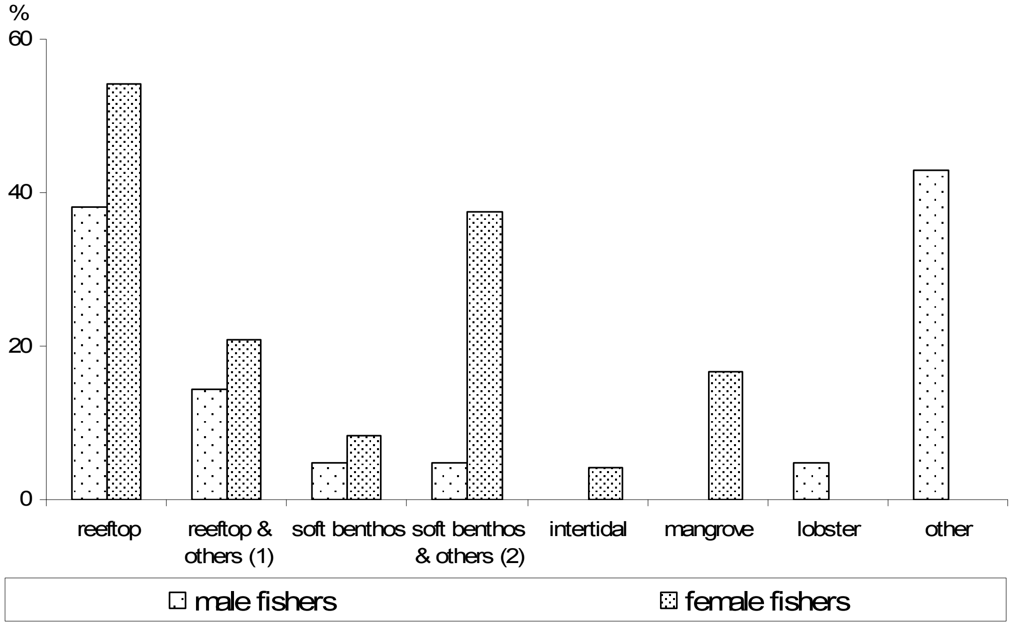

Figure 4.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Vailoa.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 23 for males, n = 34 for females; 'other' refers to the giant clam, octopus and bêche-de-mer fisheries; (1) other, trochus and intertidal; (2) mangrove, intertidal and reeftop.

Gear

Figure 4.8 shows that Vailoa fishers use a variety of different gears and often combine different fishing techniques if catching fish in a particular habitat. In the sheltered coastal reefs mostly castnets in combination with other gear, including gillnets, handlines and spear diving are employed. Spear diving is performed in all habitats but is the main method used in the outer reef and passages. Often, spear diving is also combined with the use of handheld spears, either when walking on the reef or from the canoe, and the use of knives while diving at night with torch lights. Spear diving is also sometimes done on SCUBA at night. However, no information was available on the rate and time of day at which SCUBA diving is performed compared to free-diving. Gillnets and handlines are not frequently or exclusively used in any of the habitats fished (Figure 4.8).

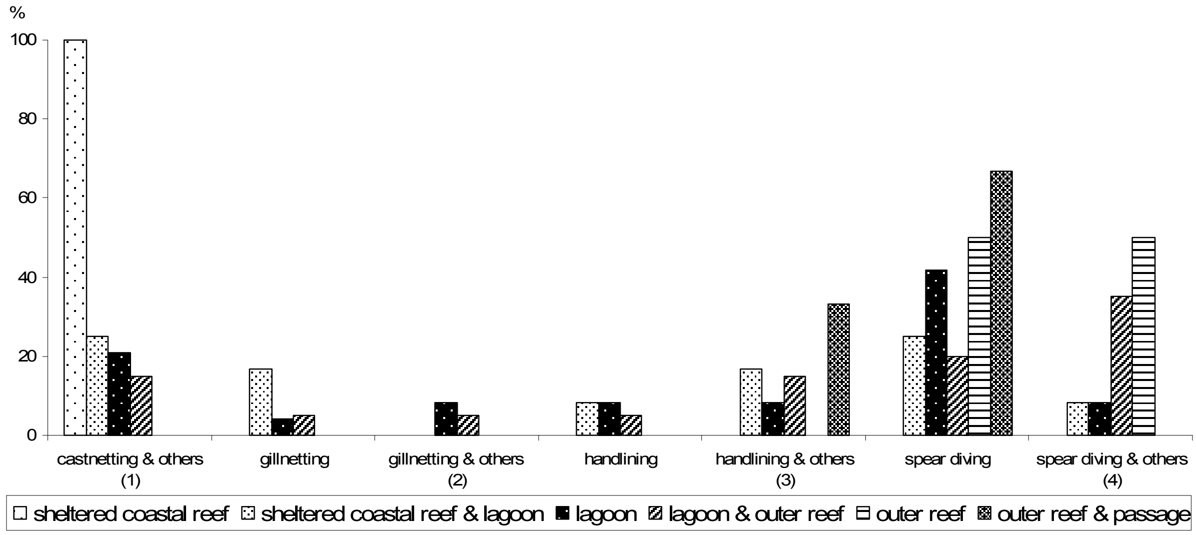

Figure 4.8: Fishing methods commonly used in different habitat types in Vailoa.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip; (1) gillnetting, handlining, spear diving; (2) spear diving, handheld spearing by walking, handheld spearing by canoe; (3) diving with hook and line, spear diving, handheld spearing by walking, handheld spearing by canoe, rod fishing; (4) handheld spearing by walking, handheld spearing by canoe, night fishing with torch and knife.

Frequency and duration of fishing trips

Male finfish fishers go fishing about twice per week; females a bit less often (1–2 times/week). As shown in Table 4.3, the major difference between genders shows in the duration of an average fishing trip, and this may be due to the different habitats targeted. For instance, an average fishing trip for male fishers takes ~3–5 hours, and is longer if the outer reef and passages are targeted. Females, who stay closer to shore, fish on average 3 hours/trip.

For invertebrates, the frequency of fishing trips depends on the fishery. The most frequently targeted reeftops are visited less than once per week by males and ~1.5 times/week by female fishers. Females go more frequently (twice per week) to soft-benthos areas, and less frequently (~ once per week) to soft benthos and mangroves. An average trip takes 2–3 hours (Table 4.3).

The frequency and duration of fishing trips may also be determined by the use of boats, in particular, motorised boats. Most fishers (almost all males and ~80% of females) use boats for fishing, at least sometimes, and these are mostly non-motorised canoes. Often, fishers borrow boats from other people to go out fishing. Invertebrate collection is mostly done when walking, but ~20% of all reeftop gleaning, and 67% of diving for species such as giant clams and certain bêche-de-mer, as well as all lobster harvesting, is done from canoes and, in rare cases, motorised boats.

Most finfish fishing is performed according to the tide, i.e. either during the day or at night. Female fishers mostly prefer to fish during the day. Invertebrates are either collected during the day or according to the tide. Respondents reported that 25% of all trips to collect invertebrates in mangroves are done at night. All lobster fishers, 33% of the soft-benthos gatherers and a small proportion of fishers who harvest invertebrates from combined habitats in one fishing trip, reported doing so at night and during the day. Most (95%) reeftop harvesting is done only during the day. Only a very small proportion of all fishers use ice, at least during some fishing trips. Mostly, no ice is used, regardless of which habitat is targeted, and by whom. Generally, all fishers fish all year around for both finfish and invertebrates.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef		1.00 (n/a)		3.00 (n/a)
	Sheltered coastal reef & lagoon	2.33 (±0.24)	2.33 (±0.67)	3.67 (±0.17)	3.00 (±0.00)
	Lagoon	2.54 (±0.22)	3.00 (n/a)	4.22 (±0.37)	4.00 (n/a)
	Lagoon & outer reef	2.43 (±0.26)	0	3.95 (±0.14)	0
	Outer reef	2.00 (±1.00)	0	4.00 (±1.00)	0
	Outer reef & passage	1.67 (±0.21)	0	4.83 (±0.17)	0
Invertebrates	**Reeftop**	**0.87 (±0.09)**	**1.38 (±0.17)**	**3.00 (±0.00)**	**2.69 (±0.13)**
	Reeftop & other	0.62 (±0.38)	1.00 (n/a)	3.00 (±0.00)	3.00 (n/a)
	Reeftop & trochus	1.00 (n/a)	0	2.00 (n/a)	0
	Intertidal	0	2.00 (n/a)	0	3.00 (n/a)
	Intertidal & reeftop	0	1.24 (±0.60)	0	2.75 (±0.48)
	Soft benthos	**0.50 (n/a)**	**2.00 (±0.00)**	**2.00 (n/a)**	**3.00 (±0.00)**
	Soft benthos & mangrove	**3.00 (n/a)**	**1.35 (±0.24)**	**4.00 (n/a)**	**2.86 (±0.26)**
	Soft benthos & intertidal & reeftop	0	1.50 (±0.50)	0	3.00 (±0.00)
	Mangrove	**0**	**0.79 (±0.41)**	**0**	**2.50 (±0.29)**
	Lobster	0.46 (n/a)	0	3.00 (n/a)	0
	Other	**0.83 (±0.08)**	**0**	**2.78 (±0.15)**	**0**

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam, octopus and bêche-de-mer fisheries. The main invertebrate fisheries are highlighted for the sake of clearness; Vailoa fishers often combine many habitats in one fishing trip.
Finfish fisher interviews, males: n = 54; females: n = 5. Invertebrate fisher interviews, males: n = 21; females: n = 24.

4.2.3 Catch composition and volume – finfish: Vailoa

Reported catches from the sheltered coastal reef in Vailoa only contain four major species groups: *Scarus* spp., *Siganus argenteus*, *Caranx* spp. *and Naso* spp. The most prominent species are *Mugil* spp., *Cheilinus chlorurus*, *Scarus* spp., *Acanthurus lineatus*, *Caranx* spp. and *Lethrinus variegatus*, each representing 6–9% of the total reported catches from the combined fishing in the sheltered coastal reef and lagoon. Lagoon catches are not significantly different in their composition, and they mainly comprise five species groups: *Lethrinus variegatus* (~11%), *Epinephelus* spp. (~10%), *Acanthurus lineatus* (~9%), *Siganus* spp. (~9%), and *Scarus* spp. (~9%). Acanthuridae, Scaridae and Lethrinidae together determine over 50% of the combined lagoon and outer-reef catches. At the outer reef and passages, Scaridae, Acanthuridae, Lethrinidae and Lutjanidae dominate. Detailed information on catch composition is reported in Appendix 2.3.1.

Figure 4.9 highlights findings from the socioeconomic survey reported earlier, that finfish fishing serves both subsistence and commercial interests. The total annual catch is estimated to amount to ~127.4 t, of which ~75 t (~58%) are used for subsistence needs, while ~53 t (~42%) are sold externally. The dominance of male fishers also shows in the large proportion (>93%) of the total annual catch that they take. Thus, it can be concluded that male fishers are the main ones responsible for supplying fish for home consumption and for generating income. Females fish occasionally, and are more likely to contribute to the family food rather than income from their fishing. Most of the reported catch is sourced from areas close-by, i.e. the sheltered coastal reef and lagoon. Up to 28% of the total annual catch comes from the outer reef and passages if half of the catches from combined habitats are allocated to the total catch of each of the two habitats concerned.

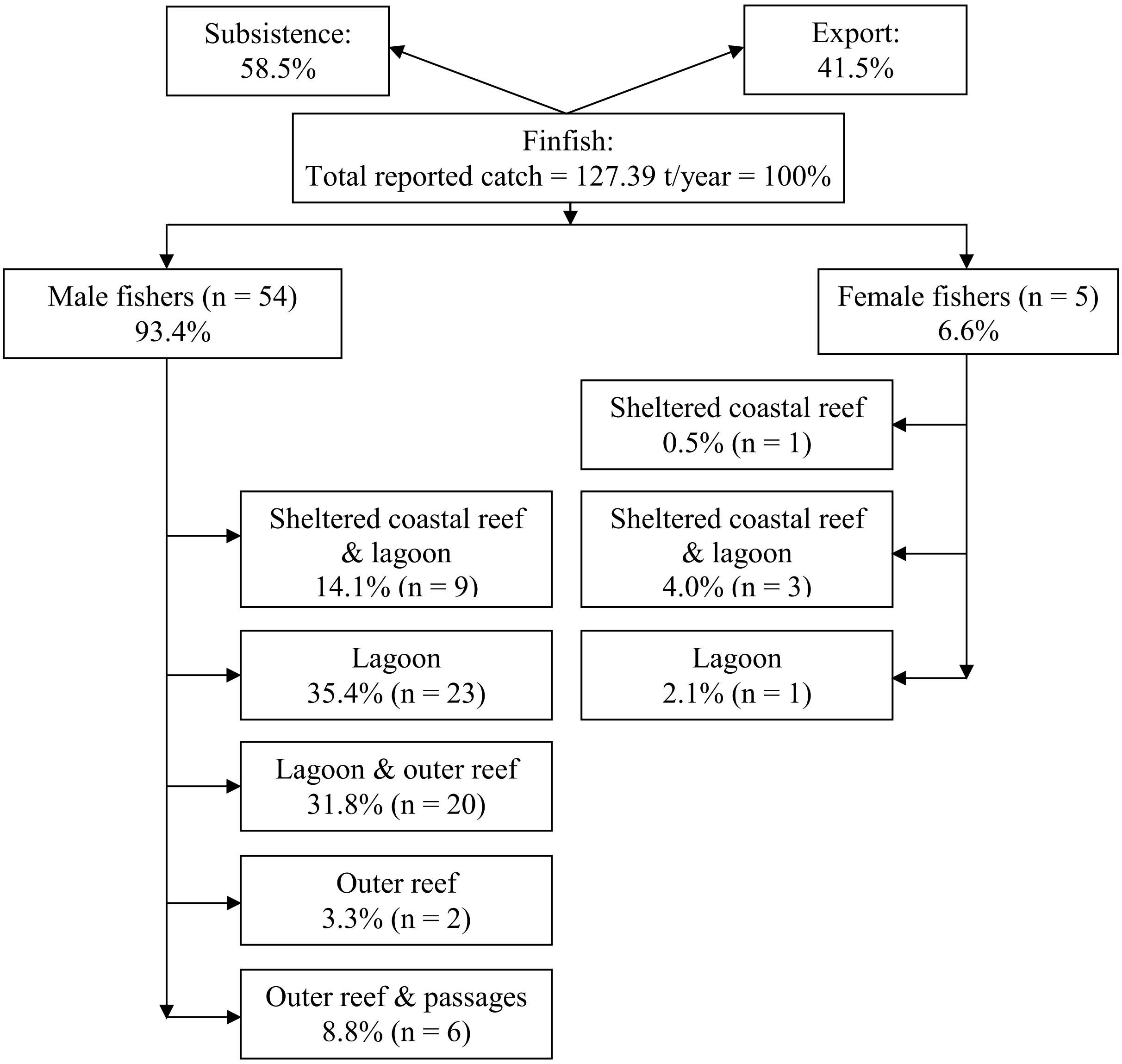

Figure 4.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Vailoa.
N is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and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

The distribution of annual catch (weight) between the more easily accessible sheltered coastal reef and lagoon, and the more distant outer reef and passages, is a result of the number of fishers rather than differences in the annual catch rates. As shown in Figure 4.10, the average annual catch per fisher is similar among the different habitats and combinations of habitats fished, and it oscillates around 500 kg/fisher/year. Due to the small sample size and also the low general participation by female fishers, the catches by female fishers targeting the lagoon are not included in this observation. If comparing males' and females' annual catch rates for fishing in the sheltered coastal reef and lagoon habitats combined, there is no significant difference if we take into account the variations (SE).

Comparing productivity rates between genders and among habitats (Figure 4.11), there are no obvious differences between male and female fishers. However, overall, CPUEs are low and hardly exceed 1.5 kg/hour of fishing trip. Outer-reef fishers are slightly more efficient on average, reporting about 2 kg/hour of fishing trip. As mentioned earlier, outer reef and passages are only targeted by male fishers.

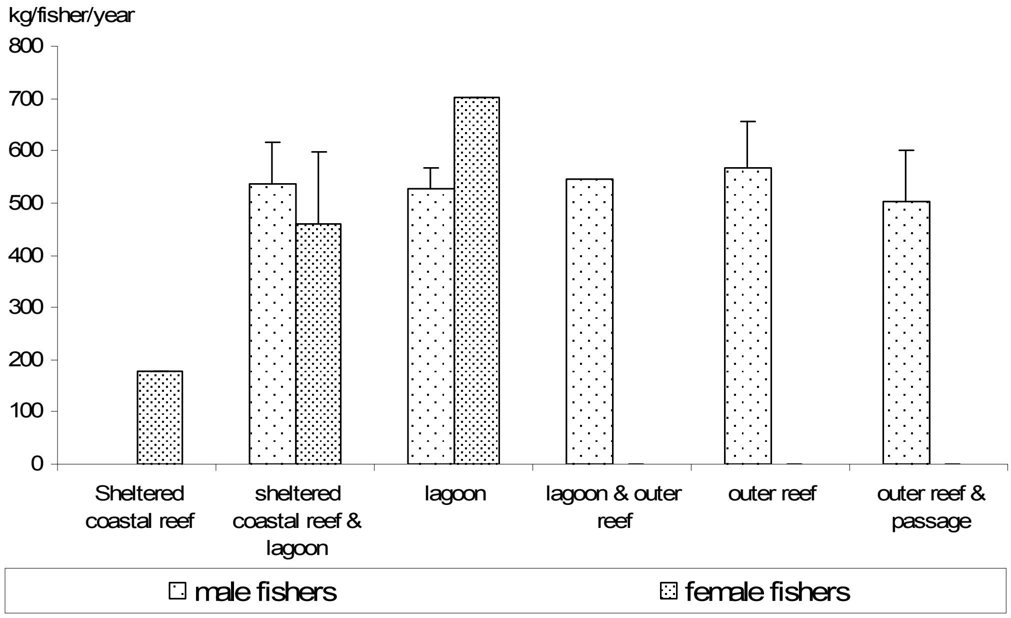

Figure 4.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Vailoa (based on reported catch only).

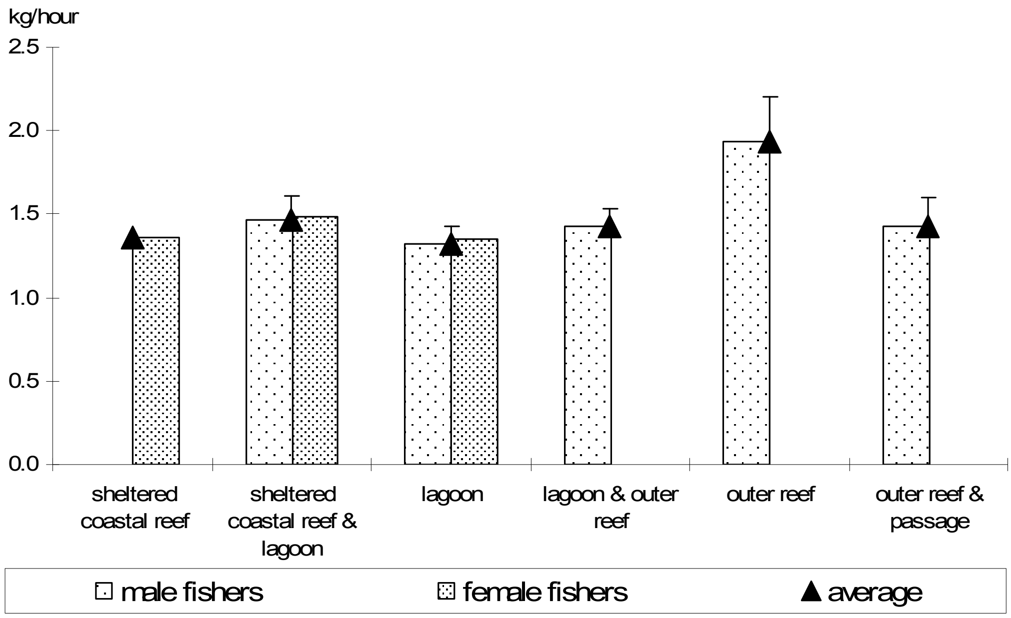

Figure 4.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in Vailoa.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

The greater importance of subsistence than commercial fishing for Vailoa's people clearly shows in Figure 4.12. As observed earlier, male fishers targeting the outer reef and passages (first catching bait in the lagoon) fish more for income-generating purposes. However, fishing in the sheltered coastal reef and lagoon, either separately or combined in the same trip, mainly serves subsistence needs and the provision of non-commercial exchange, and is to a much lesser extent for sale. The earlier conclusion that female fishers mainly target subsistence needs is confirmed as they only target the sheltered coastal reef, sometimes combined with the lagoon, where commercial purposes are of no, or very low, interest.

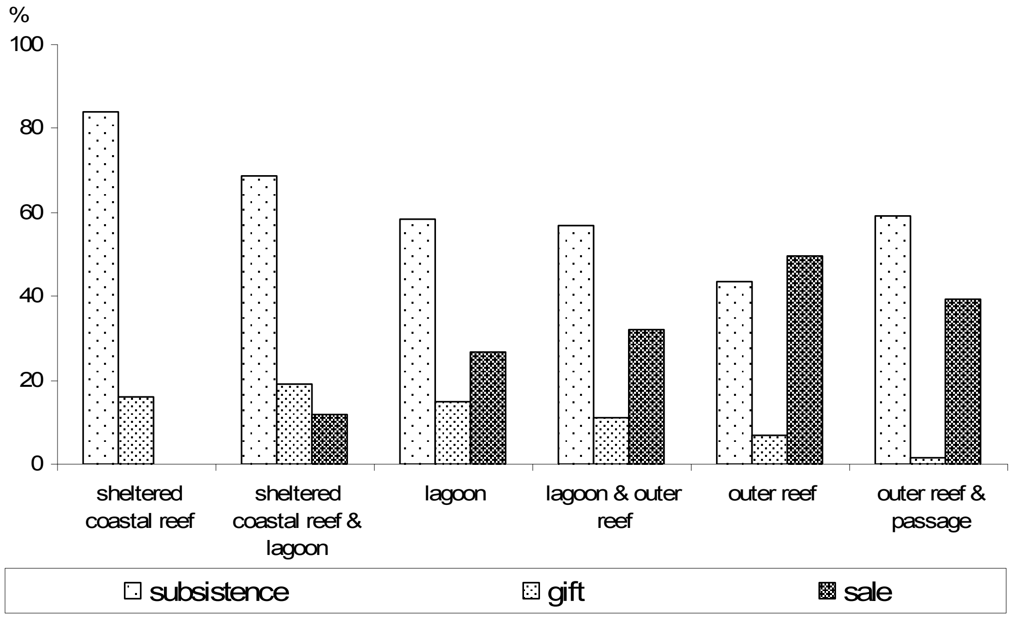

Figure 4.12: The use of finfish catches for subsistence, gift and sale, by habitat in Vailoa. Proportions are expressed in % of the total number of trips per habitat.

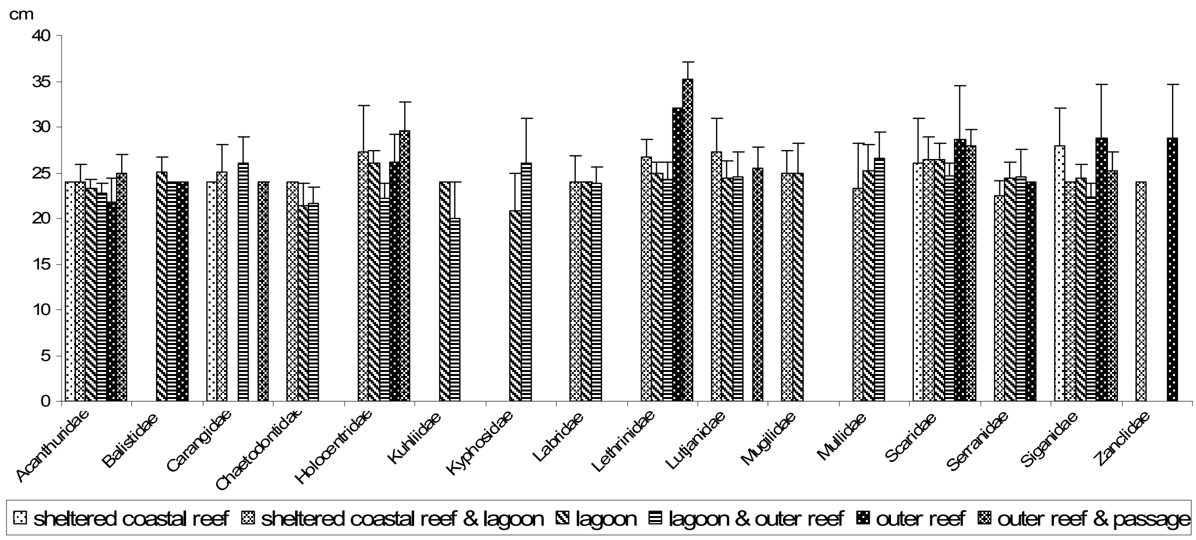

Figure 4.13: Average sizes (cm fork length) of fish caught by family and habitat in Vailoa. Bars represent standard error (+SE). The families Blennidae, Diodontidae, Gerreidae, Hemiramphidae, Pomacanthidae and Scombridae are excluded because they each occur in only one habitat.

Comparison of the overall finfishing productivity among habitats suggests that CPUE was slightly higher from fishing the outer reef and passages rather than the sheltered coastal reef and lagoon (Figure 4.11). This observation does not apply if comparing the reported average fish sizes (fork length) for the major families caught (Figure 4.13). One would expect an increase in fish length for the same species or species groups with increasing distance from shore. However, none of the main families reported: Acanthuridae, Scaridae, and Lutjanidae, followed this trend, except Lethrinidae. The other families, such as Serranidae and Siganidae, also do not follow this expected trend. In general, average reported fish lengths are small to moderate, 20–25 cm only, although Lutjanidae, Holocentridae and Scaridae may reach greater average sizes. The small sizes, the lack of expected increase in size with distance from shore, and the relatively low CPUEs, all suggest that stocks are detrimentally affected by past and presumably current fishing pressure.

The indicators selected to assess current fishing pressure on Vailoa's reef and lagoon resources are shown in Table 4.4. Due to the available reef surface and total fishing ground, population density, fisher density and catch rates per unit areas of reef and fishing ground are moderate to high. By comparison, the highest fisher density occurs for the lagoon, which, together with the sheltered coastal reef, accounts for >70% of the total annual catch. Lagoon and sheltered coastal reef resources are much more vulnerable to fishing than the outer reef and passages, which are in direct exchange with the open ocean. This distribution of fishing effort may aggravate fishing impact.

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

Parameters	Habitat					
	Sheltered coastal reef	Sheltered coastal reef & lagoon	Lagoon	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	2.62		2.54	3.18	7.02	8.34
Density of fishers (number of fishers/km^2 fishing ground) (1)	2	n/a	35	2	34	29
Total number of fishers	4	46	89	7	242	242
Population density (people/km^2) (2)					250	210
Average annual finfish catch (kg/fisher/year) (3)	177.80 (n/a)	517.60 (±65.34)	533.93 (±38.84)	566.74 (±89.38)		
Total fishing pressure of subsistence catches (t/km^2)					10.6	8.9

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) total population = 1756; total number of fishers = 242; total subsistence demand = 74.51 t/year; (3) catch figures are based on recorded data from survey respondents only. The fishing trips to the lagoon & outer reef combined (average annual catch rate = 545.08 kg/fisher/year ±46.94; total fishers = 74), and outer reef & passages (average annual catch rate = 501.81 kg/fisher/year ±99.93, total fishers = 22) are excluded in the above table for clarity reasons.

4.2.4 Catch composition and volume – invertebrates: Vailoa

Calculating reported catches from invertebrate fishers by wet weight shows that only a few species account for the major annual impact expressed in wet weight (Figure 4.14). The combined catches of bêche-de-mer species, including *Holothuria* spp., *Stichopus horrens* and *Actinogypa 123lanktivor*, account for most, i.e. an accumulated annual wet weight of ~31 t. Bêche-de-mer is considered a delicacy in Samoa, and intestines recovered from collected specimens are either used for the family meal or sold by females, and also males. Mostly guts, but sometimes also skins of bêche-de-mer are collected and preserved in coke bottles filled with sea water. It must be noted that despite the national ban on bêche-de-mer fishery, certain species are still heavily targeted for home consumption and for sale on local markets. Giant clams, shown under two different vernacular names (*pipi*, *faisua*) account for another ~9 t/year (wet weight). Other species, such as lobsters, crabs, and octopus, are of insignificant impact by comparison.

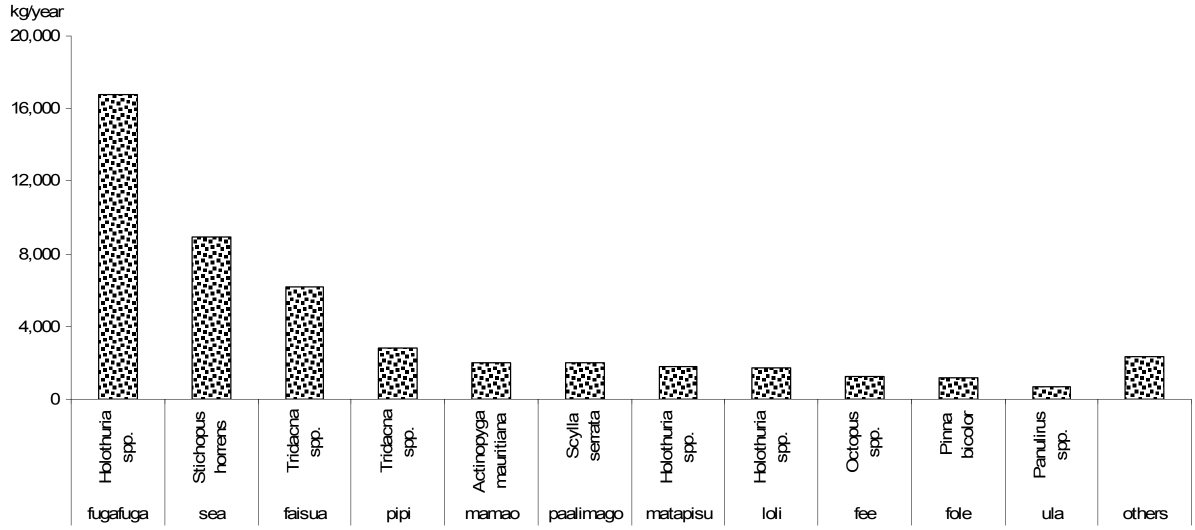

Figure 4.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Vailoa.
'Others' include: *kuku* (*Caroilius maculatus*), *alili* (*Turbo* spp.), *kuikui* (*Tripneustes gratilla*), *paa* and *tutu* (*Etisus splendidus*), *li* (*Tridacna* spp.), *pae* (*Anadara* spp.), *pu* and *pule* (*Cypraea* spp.), *tio* (*Spondylus* spp.), *panaea* (*Strombus* spp.), *gau* (*Dolabella auricularia*), *limu* (seaweed).

The fact that most impact is due to a few species only also shows in the number of vernacular names that have been registered from respondents. Reeftop fishing shows the highest variety, with 16 different vernacular names reported. Comparison to other fisheries is difficult as Vailoa invertebrate collectors often combine a variety of different habitats (Figure 4.15).

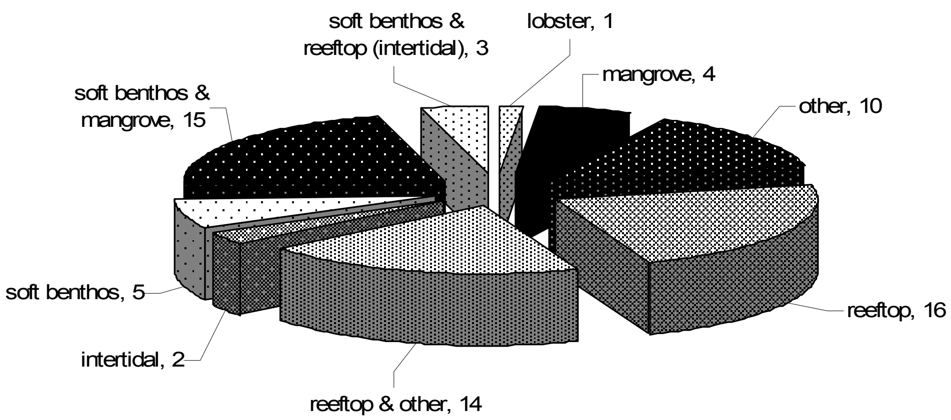

Figure 4.15: Number of vernacular names recorded for each invertebrate fishery in Vailoa.
'Other' refers to the giant clam, octopus and bêche-de-mer fisheries.

The average annual catch per fisher by gender and fishery (Figure 4.16) reveals substantial differences. First, females collect more on average per year from any of the habitats targeted. In particular the diverse combination of reeftop, soft-benthos and intertidal habitats renders the highest annual average catches of ~4.5 t per female fisher. All other average catches as shown in Figure 4.16, are substantially lower (~100 kg – 2 t/fisher/year). These results suggest two conclusions: First, invertebrate fishing in Vailoa mainly serves subsistence needs and, second, it is best represented by a set of species that occur across the intertidal to the reeftop areas.

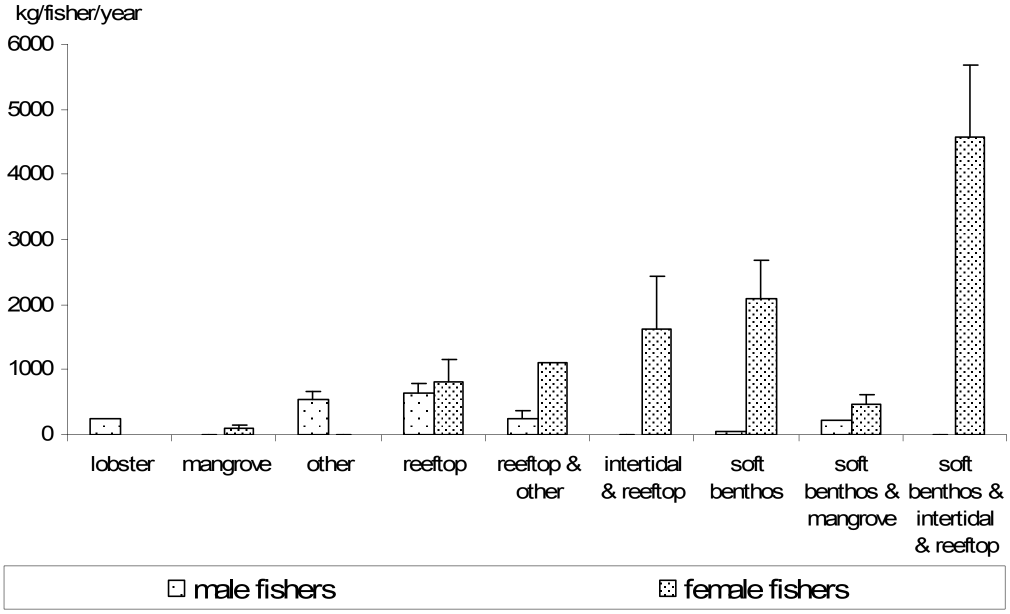

Figure 4.16: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Vailoa.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 23 for males, n = 34 for females). 'Other' refers to the giant clam, octopus and bêche-de-mer fisheries.

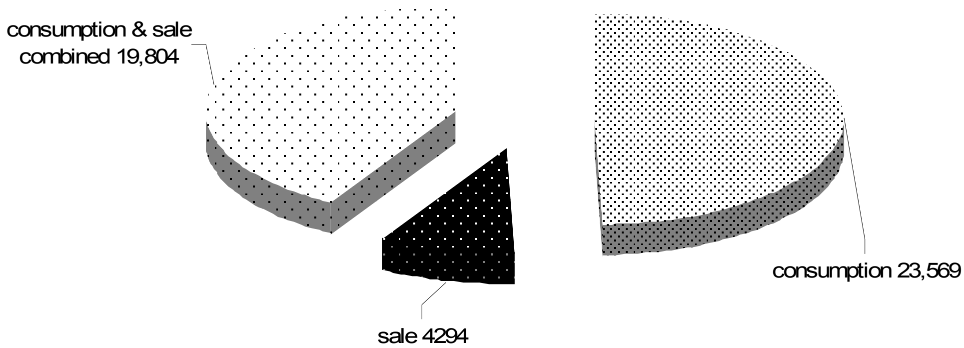

Figure 4.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Vailoa.

The above observation that invertebrate collection mainly serves subsistence needs in Vailoa is confirmed by results shown in Figure 4.17. The proportion that is sold on the local markets may not exceed 30% if we assume that half of the share that may be consumed or sold is, indeed, sold.

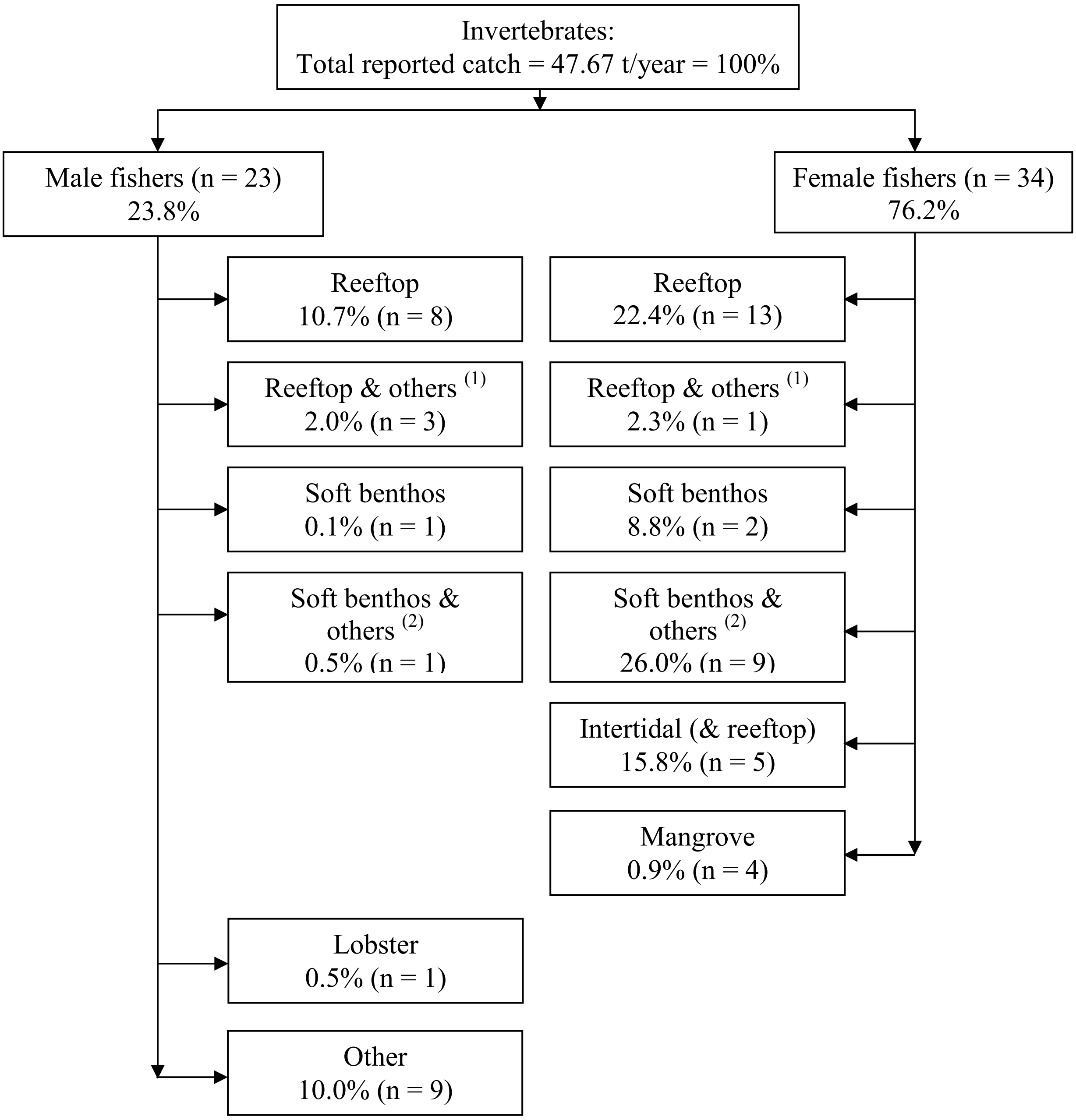

Figure 4.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Vailoa.
'Other' refers to the giant clam, octopus and bêche-de-mer fisheries; n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey. Reeftop and soft benthos fisheries 126lanktiv '& others' may include any of the following or a combination thereof: (1) bêche-de-mer, lobster, intertidal, other; (2) bêche-de-mer, mangroves, lobster, intertidal, reeftop.

As mentioned earlier, male fishers from Vailoa are much less engaged in invertebrate fisheries than females. While males account for ~24% of the total catch (wet weight) only, females are responsible for ~76% (Figure 4.18). Most male invertebrate fishers glean the reeftop and dive for 'other' species: giant clams, octopus and some bêche-de-mer species. Female invertebrate collectors focus on soft-benthos species, combined with other, mainly reef-associated species, reeftop gleaning, and the combined intertidal and reeftop collection. The lobster and mangrove fisheries are of very little importance if expressed in per cent of total annual wet weight collected. Diving for invertebrates or finfish is exclusively done by males.

Table 4.5: Parameters selected (±SE) to characterise the current level of fishing pressure of invertebrate fisheries in Vailoa

Parameters	Fishery							
	Reeftop	Reeftop & others (3)	Intertidal & reeftop	Soft benthos	Soft benthos & others (4)	Mangrove	Lobster	Other
Fishing ground area (km^2)	2.09					n/a	11.20	2.04
Number of fishers (per fishery) (1)	84	15	21	12	42	17	4	32
Density of fishers (number of fishers/km^2 fishing ground)	40	n/a	n/a	n/a	n/a	n/a	0.3	16
Average annual invertebrate catch (kg/fisher/year) (2)	751.86 (±211.99)	533.92 (±291.06)	1011.89 (n/a)	1407.45 (±762.52)	432.74 (±145.52)	103.33 (±39.59)	239.87 (n/a)	531.93 (±128.27)

Figures in brackets denote standard error; n/a: no information available or standard error not calculated; (1) total number of fishers is extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; 'Other' refers to the giant clam, octopus and bêche-de-mer fisheries.

Taking into account available figures on the length of outer reef that is considered to support lobster dive fisheries, fishing pressure for lobster fishing alone is low. This conclusion is based on the low fisher density, and also the low average annual catch of lobsters. Using the inside shallow-reef areas as the habitat available for reeftop gleaning, fisher density is moderate to high. Reeftop gleaners also take substantial average catches by wet weight. Both factors suggest that this fishery in Vailoa may be under relatively high pressure, and that possible past and current detrimental effects may already be evident. There is not yet any further data available to allow assessment of current fishing pressure for the other fisheries, or a combination of all invertebrate harvesting activities (Table 4.5). Results from the resource surveys need to be considered before final assessment is made.

4.2.5 Management issues: Vailoa

Management of marine resources in Samoa occurs at two levels, and so does enforcement: through governmental institutions and traditional village systems. At the national level, regulations mainly refer to size restrictions and harvesting techniques employed. At the community level, community-based reserve areas have been promoted since 1996 and today include about 150 villages. Initially, the programme was assisted by AusAID funding. The programme's success rate, however, varies. One of the major obstacles to assessing impact is the absence of baseline surveys to compare the past and current status and use of reef resources and predict future levels of fishing impact and use.

Marine tenure is legally established under customary owners, and thus resource owners have been empowered to have a greater role in decision making and monitoring of marine resource management. Although fishing access and marine tenure are both well defined and areas are demarcated, traditional practice allows members of the *aiga* (extended family), as well as any other person who has gained permission from chiefs to fish in these areas as well. Thus, a much higher, and often unknown, number of people access the fishing ground and exploit its resources than just the community.

Vailoa is considered to have one of the best examples of community-based management initiatives as several interventions have been identified and shared among the Fisheries Department, the community, and non-governmental organisations. Among these interventions are small ‘no-fishing areas’ within the lagoon and sheltered coastal reefs, which are easily accessible. These ‘no-fishing areas’ have been in operation for the last six years. A major coral reef reserve has been established directly opposite Vailoa village. A village committee, assisted by the village chiefs in the area and external project staff, monitors the managed areas. Both village and national rules and regulations are employed to ensure compliance, particularly as far as the major coral reef fisheries reserve is concerned. Choosing close-by habitats as the managed areas is sensible because, due to the limited number of motorised boats, most fishing occurs within the lagoon or in the closest outer reefs and passages.

Because of the good cooperation in monitoring, the level of compliance is high and enforcement measures respected when necessary. The Vailoa community is very well aware of the need to adequately manage their limited reef and lagoon resources to ensure they are sustainable over time.

4.2.6 Discussion and conclusions: socioeconomics in Vailoa

The Vailoa community has access to agricultural land and marine resources. However, due to its distance from major markets, in particular Apia, the commercialisation of marine resources is limited to the occasional visit and to roadside selling. As a result, about 60% of all finfish catches and about 70% of all invertebrate catches serve the community’s own subsistence needs. The livelihood of people is therefore less dependent on marine resources compared to other sites surveyed in Samoa, but highly dependent on agricultural production. This shows in the lower amounts of finfish and invertebrates eaten than the average across all four sites surveyed in Samoa, and the fact that over 65% of all households depend on agriculture to provide first or second income. Remittances are as important as the community’s own cash-earning activities, and handicrafts as well as small private businesses are important. The community, however, is well aware of the necessity to maintain their marine resources for long-term benefit and is considered as having one of the best community-based management projects in place. Several no-fishing areas and an important coral reef fishing reserve opposite Vailoa village have been established, monitored and respected over the past six years.

In summary, survey results suggest that:

- Vailoa’s population is very dependent upon their marine resources for home consumption, but to a lesser degree for income generation. The distance to the urban market of Apia hinders regular and larger-scale marketing of fisheries produce.

- Per capita consumption of fresh fish is moderate and that of invertebrates rather low. Both figures are lower than the average across all four sites surveyed in Samoa. However, the canned fish consumption level is high, which may be explained by the frequent use of canned fish for *falavelave* and the high frequency of these events.

- Consumption and income patterns both suggest that Vailoa's people still enjoy a rather traditional lifestyle. Traditional gender roles also show in the different fisheries engaged in by females and males. While males are mainly responsible for finfish fishing, and much less for invertebrate diving (or collection), females are the main collectors of invertebrates, including bêche-de-mer, which they sell on a small scale.

- Finfish is mainly sourced from the lagoon and sheltered coastal reef areas as the community has limited access to boats, especially motorised boats. Consequently, only the closest passages and outer reefs are fished when male fishers venture further out.

- Overall, CPUEs are low, oscillating around 1.5 kg fish/hour of fishing trip. Only fishing at the outer reef renders slightly higher productivity with on average 2 kg catch/hour of fishing trip. CPUEs are similar between male and female fishers.

- A wide range of techniques is used, and several techniques are often combined if targeting one of the habitats or a combination of two habitats. Castnets and others dominate in the sheltered coastal reef. Spear diving is used everywhere, but is the main fishing method used at the outer reef and passages. Gillnets and handlines are not much used in Vailoa. Overall, average reported fish sizes are on the smaller side, with an average length of 25 cm. Only certain families, in particular Lethrinidae, are larger than average, and follow the expected trend of increasing size from sheltered coastal reef to the outer reef.

- Results from invertebrate fisher interviews show that catches of bêche-de-mer species account for most of the annual harvest (wet weight). Giant clams are the second most important species group by weight. Bearing in mind that there is a nationwide ban on bêche-de-mer fishing, this figure gives reason for concern.

- In contrast to finfish fishing, significant differences were found in the average annual catches by invertebrate fishery. Annual average catches reported for the combined gleaning of reeftops, soft benthos and intertidal areas, thus including all bêche-de-mer species, giant clams, *Anadara* spp., and 'others', are significantly higher than average catches from all other fisheries.

- The indicators of fishing pressure calculated for finfish fisheries suggest that, due to the available reef and overall fishing ground area, fisher densities and average annual catch rates, as well as catch per unit areas, are moderate to high. The low CPUEs, the rather small average reported fish sizes, the lack of increased average fish length with distance from shore and the fact that Vailoa's fishing ground is also accessible by presumably a much larger number of fishers due to extended family and cultural obligations, all suggest that fishing pressure may have reached a high level that requires more than just monitoring. The small, protected no-fish areas that were established by the community six years ago, as well as the major, protected coral-reef area opposite Vailoa village, may be appropriate means to restore or maintain stocks and to reduce impacts of past and current high fishing pressure.

- Final assessment needs comparison between results from the socioeconomic survey and the resource surveys. In any case, the Vailoa site underpins the need to continue and to improve community fisheries management programmes.

4.3 Finfish resource surveys: Vailoa

Finfish resource surveys concentrated mainly in the sea areas adjacent to Vailoa, Ulutogia and Satitoa villages on the eastern side of Upolu Island. The reef boundaries adopted during resource surveys covered inshore areas that encompass several villages in Aleipata, therefore stretching from Nu'utele Island (including Cape of Tapaga) in the south, to Namua Island (NE direction) (Figures 4.1 and 4.19).

Figure 4.19: The fishing ground of Vailoa-Aleipata.

Aleipata coastal fringing reef is made up of a shallow area of sand, rubble, seagrass beds and mixed coral assemblages (maximum depth ~4 m). A shallow reef platform and algal ridge characterise the reef edge. The exposed outer reef consists of a pavement of coralline algae with well-developed spur-and-groove system and several passes, the largest of which is close to Namua Island. The reef slope is generally low in coral cover except for a few areas. The outer lagoon and back-reef are dominated by branching and tabulate *Acropora* and massive Porites corals.

4.3.1 Finfish assessment results: Vailoa

A total of 22 families, 52 genera, 140 species and 12,322 fish were recorded in the 28 transects: 10 sheltered coastal, 6 back- and 13 outer-reef transects. Lagoon patch reefs were not surveyed (Appendix 3.3.1 gives location.).

Data on the 15 commercial families (See Appendix 3.3.2 for species list.) are presented below, representing 41 genera, 126 species and 11,361 individuals.

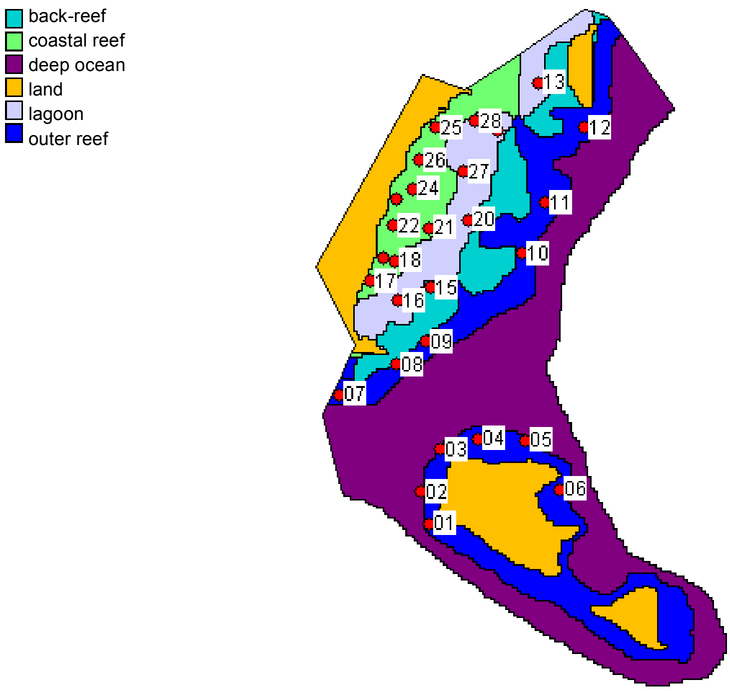

Figure 4.20: Habitat types and transect locations for finfish assessment in Vailoa.

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

Parameters	Habitat			
	Sheltered coastal reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	10	6	12	28
Total habitat area (km^2)	1.12	1.22	3.18	5.52
Depth (m)	1 (1-2) (3)	2 (1-2) (3)	9 (2-15) (3)	6 (1-15) (3)
Soft bottom (% cover)	23 ±3	18 ±5	0.51 ±0.5	9
Rubble & boulders (% cover)	10 ±3	8 ±2.5	3 ±2.6	5
Hard bottom (% cover)	43 ±4	59 ±4	77 ±5	66
Live coral (% cover)	24 ±3	15 ±3	16 ±3	17
Soft coral (% cover)	0 ±0	0.13 ±0.13	2 ±1	1
Biodiversity (species/transect)	17 ±3	26 ±4	42 ±3	29 ±3
Density (fish/m^2)	0.38 ±0.1	0.6 ±0.1	1 ±0.13	0.8
Size (cm FL) (4)	11 ±0.5	12.8 ±0.6	17.3 ±0.5	15
Size ratio (%)	39 ±1.9	46 ±2.2	62 ±1.7	54
Biomass (g/m^2)	19.6 ±5.1	44.5 ±7.5	179.0 ±32.0	116.7

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: Vailoa

The sheltered coastal reef environment of Vailoa was dominated by Scaridae, followed by Acanthuridae and Siganidae (Figure 4.21). These five families were characterised by few species with highest abundance and biomass: *Scarus psittacus*, *Siganus spinus*, *Ctenochaetus striatus*, *Scarus oviceps*, *Chlorurus sordidus*, and *Acanthurus triostegus* as listed in order of decreasing biomass (Table 4.7).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Chlorurus sordidus*	Bullethead parrotfish	0.03	1.03
	Scarus psittacus	Palenose parrotfish	0.21	5.14
	Scarus oviceps	Dark-capped parrotfish	0.004	1.10
Siganidae	*Siganus spinus*	Scribbled rabbitfish	0.03	2.54
Acanthuridae	*Ctenochaetus striatus*	Lined bristletooth	0.03	2.18
	Acanthurus triostegus	Convict tang	0.007	0.39

The total biomass and density in the sheltered coastal reef were the lowest recorded among the different habitats in Vailoa. Similarly, sizes and size ratios were the lowest for the site and also particularly low compared to Manono-uta (Tables 4.6 and 4.8). However, total density was higher than at both Manono-uta and Salelavalu coastal reefs, mainly due to the high concentration of Scaridae.

This reef environment presented a diverse habitat (Table 4.6 and Figure 4.21), with hard bottom predominating (>40%), and soft bottom (>20%) and rubbles (>10%) covering the remaining substrate; the highest live-coral cover (>20%) among the three habitats, as well as among the three coastal reefs, was recorded here. The relatively good live-coral cover was accompanied by notable densities of butterflyfish (Chaetodontidae).

Table 4.8: Comparisons of the sheltered coastal reef biological parameters among the three Samoan sites with sheltered coastal reefs

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	0.30 (±0.08)	26.8 (±10.6)	14.6 (±0.9)	57.8 (±3.7)
Salelavalu	0.22 (±0.04)	9.2 (±2.2)	11.0 (±0.7)	36.3 (±2.4)
Vailoa	**0.38 (±0.09)**	**19.6 (±5.1)**	**11.2 (±0.5)**	**39.1 (±1.9)**

Figures in brackets denote standard error; FL = fork length.

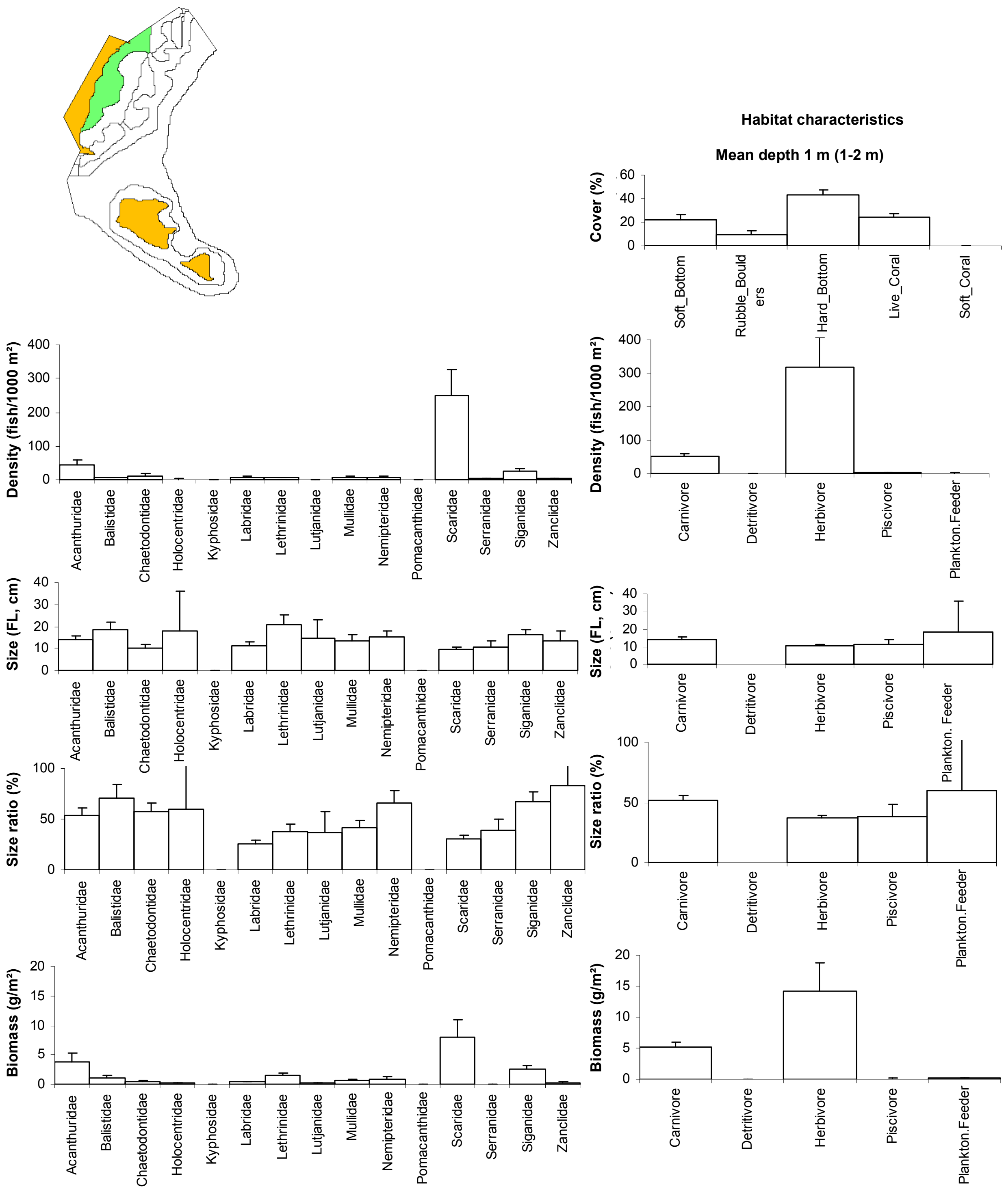

Figure 4.21: Profile of finfish resources in the sheltered coastal reef environment of Vailoa.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Vailoa

The back-reef of Vailoa was largely dominated by herbivorous Scaridae and Acanthuridae and, to some extent, by Siganidae (Figure 4.22). Chaetodontidae were the third most important family in order of density. The three herbivore families were mostly represented by *Ctenochaetus striatus*, *Scarus psittacus*, *Chlorurus sordidus*, (together making up the bulk of the biomass) *Siganus spinus*, *Acanthurus nigricans* and *Acanthurus triostegus* (Table 4.9).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.16	7.5
	Chlorurus sordidus	Bullethead parrotfish	0.08	5.3
Acanthuridae	*Ctenochaetus striatus*	Lined bristle-tooth	0.12	8.6
	Acanthurus nigricans	White-cheek surgeonfish	0.01	0.9
	Acanthurus triostegus	Convict surgeonfish	0.02	0.8
Siganidae	*Siganus spinus*	Scribbled rabbitfish	0.03	2.1

Finfish resources in the back-reefs of Vailoa displayed middle values of biodiversity, density, biomass and size among the three types of reefs (Table 4.6). However, total density, biomass and size were the lowest recorded in all back-reefs (Table 4.10). Both Acanthuridae and Scaridae were less important in Vailoa compared to the other survey sites.

Substrate in the back-reef of the Vailoa was characterised by a dominance of hard bottom (59% cover) with very low live-coral cover (15%). This type of habitat, also dominant at the other sites, is well suited to herbivorous fish, particularly Acanthuridae and Scaridae, which dominate the back-reef communities.

Table 4.10: Comparisons of the back-reef biological parameters among the four Samoan sites

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	0.95 (±0.28)	95.4 (±44.5)	14.6 (±0.6)	52.0 (±2.2)
Salelavalu	0.68 (±0.07)	70.0 (±9.7)	14.6 (±0.6)	49.2 (±2.0)
Vailoa	**0.59 (±0.07)**	**44.5 (±7.5)**	**12.8 (±0.6)**	**46.2 (±2.1)**
Vaisala	0.77 (±0.11)	64.9 (±14.4)	13.7 (±0.4)	47.4 (±1.3)

Figures in brackets denote standard error; FL = fork length.

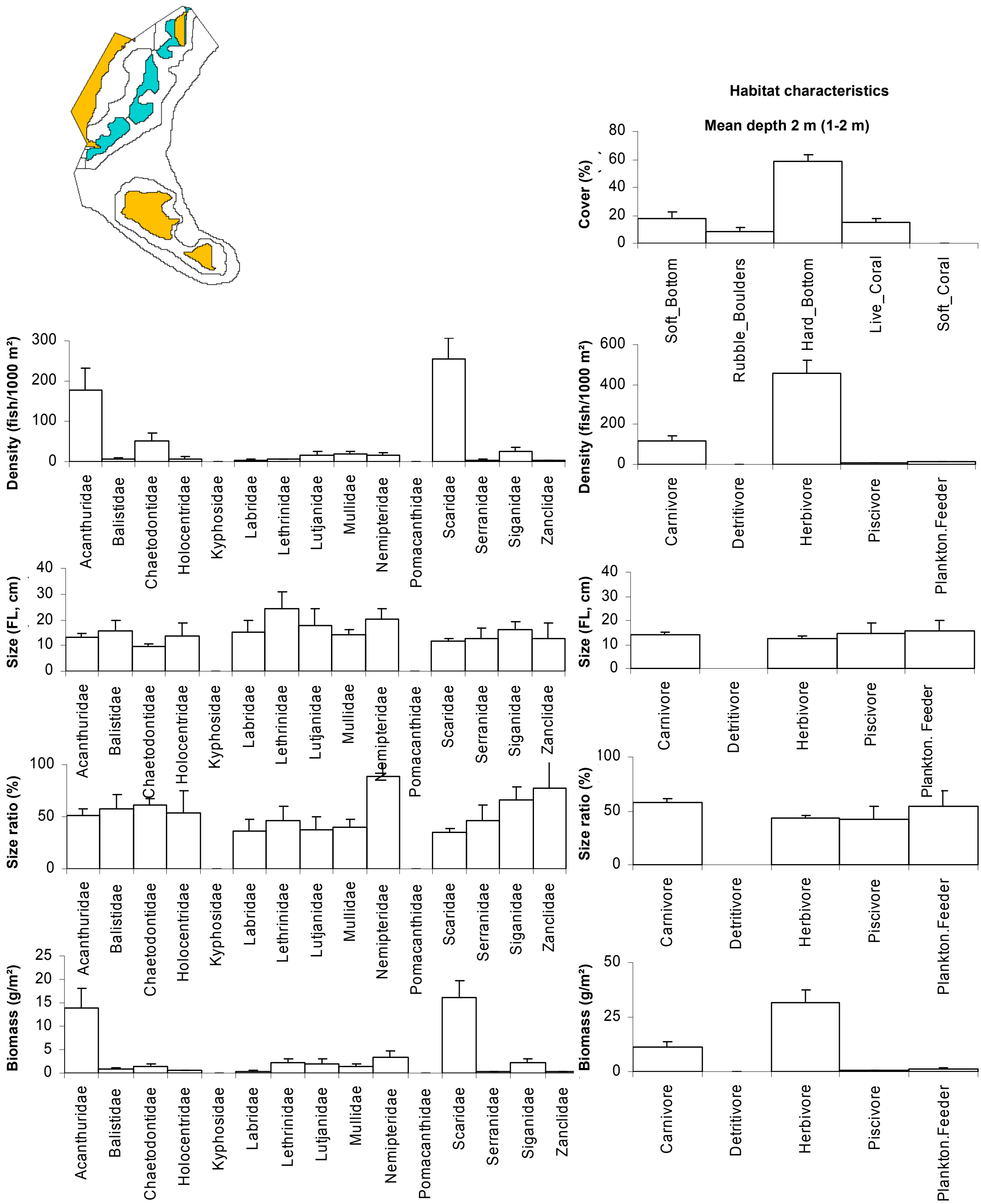

Figure 4.22: Profile of finfish resources in the back-reef environment of Vailoa.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Vailoa

The outer reef of Vailoa was heavily dominated by herbivorous Acanthuridae, followed by much less abundant Scaridae, and then Balistidae (Figure 4.23). The density of Acanthuridae was almost four times higher than at the back-reef, with an average of 0.6 fish/m². The species making up most of the fish assemblage of Acanthuridae were: *Ctenochaetus striatus* (with overall maximum biomass), *Acanthurus nigroris*, *A. nigricans*, *A. nigrofuscus*, and *A. lineatus*, all of which are herbivores feeding on the algal film in hard bottom, as well as the 136lanktivores *A. albipectoralis*. The most representative species of the Scaridae were *Chlorurus sordidus* and *Scarus oviceps*. Balistidae were mainly composed of *Melichthys vidua* and *Balistapus undulatus*, which feed on small invertebrates (Table 4.11).

Table 4.11: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Vailoa

Family	Species	Common name	Density (fish/m²)	Biomass (g/m²)
Acanthuridae	*Ctenochaetus striatus*	Lined bristle-tooth	0.27	23.1
	Acanthurus nigrincans	White-cheek surgeonfish	0.13	14.4
	Acanthurus nigroris	Blue-lined surgeonfish	0.07	20.4
	Acanthurus nigrofuscus	Dusky surgeonfish	0.05	11.4
	Acanthurus lineatus	Striped surgeonfish	0.04	9.2
	Acanthurus albipectoralis	White-fin surgeonfish	0.02	6.8
Scaridae	*Chlorurus sordidus*	Bullet-head parrotfish	0.08	13.7
	Scarus oviceps	Dark-capped parrotfish	0.02	7.5
Balistidae	*Melichthys vidua*	Pink-tail triggerfish	0.05	5.4
	Balistapus undulatus	Orange-striped triggerfish	0.02	2.3

All the values of the biological community descriptors (biodiversity, density, biomass, mean size and size ratio) were the highest recorded at the Vailoa site. Biomass in the outer reef was four times higher than at the back-reef and nine times higher than in the lagoon. Density and biomass were also similar to Salelavalu and Manono-uta outer reefs (Table 4.12). The substrate composition was predominantly made of hard bottom, with low live coral (16%, Table 4.6).

Table 4.12: Comparisons of the outer-reef biological parameters among the four Samoan sites

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	1.31 (±0.13)	201.2 (±30.9)	17.1 (±0.6)	57.6 (±2.0)
Salelavalu	0.94 (±0.18)	166.0 (±28.9)	18.0 (±0.7)	59.5 (±2.2)
Vailoa	**1.03 (±0.13)**	**179.0 (±32.0)**	**17.3 (±0.5)**	**62.0 (±1.7)**
Vaisala	0.74 (±0.16)	132.0 (±35.2)	17.9 (±0.7)	62.3 (±2.3)

Figures in brackets denote standard error; FL = fork length.

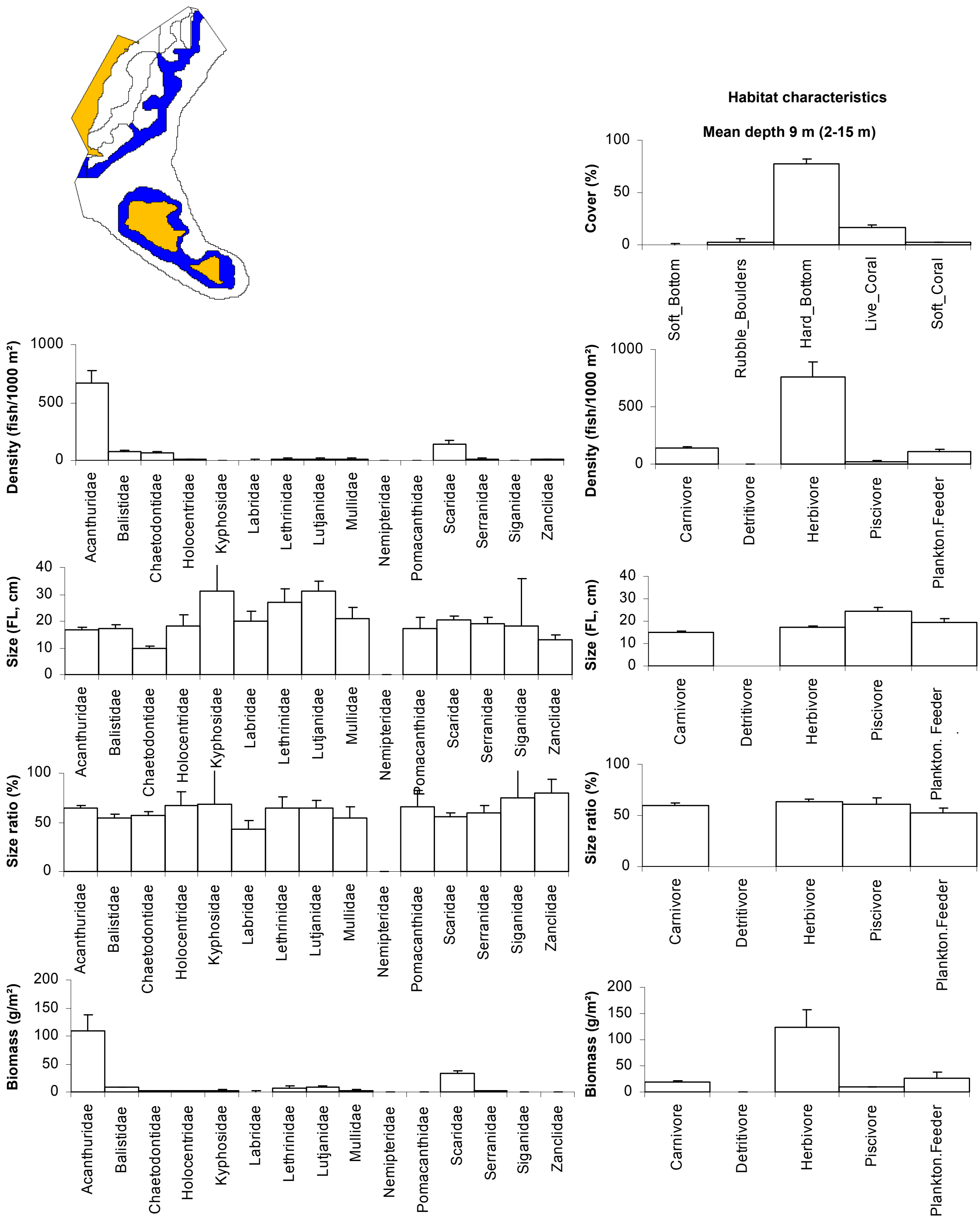

Figure 4.23: Profile of finfish resources in the outer-reef environment of Vailoa.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Vailoa

The overall fish composition was dominated by Acanthuridae and, to a lesser extent, by Scaridae, in both abundance and biomass values with a total of 44 species. Other relatively important families were Chaetodontidae and Balistidae (Figure 4.24). The list of major species (Table 4.13) resembles the list of dominant species in the outer reef. The overall most abundant species was the small Acanthuridae *Ctenochaetus striatus*, with the highest density and biomass of all the commercial species counted. This was followed in order of decreasing density by *Scarus psittacus*, *Acanthurus nigricans*, *Chlorurus sordidus*, *A. nigroris*, *A. nigrofuscus*, *A. lineatus, Scarus oviceps* and *A. albipectoralis*.

Table 4.13: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Vailoa (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Lined bristle-tooth	0.19	15.6
	Acanthurus nigroris	Blue-lined surgeonfish	0.04	11.8
	Acanthurus nigricans	White-cheek surgeonfish	0.07	8.5
	Acanthurus nigrofuscus	Dusky surgeonfish	0.03	6.6
	Acanthurus lineatus	Striped surgeonfish	0.02	5.3
	Acanthurus albipectoralis	Whitefin surgeonfish	0.01	4.1
Scaridae	*Chlorurus sordidus*	Bullet-head parrotfish	0.07	9.3
	Scarus oviceps	Dark-capped parrotfish	0.02	4.9
	Scarus psittacus	Pale-nose parrotfish	0.08	3.7

As expected, the overall fish assemblage in Vailoa more closely resembled that recorded in the outer-reef environment than in the other habitats, since the outer reef represents 58% of the total habitat.

Herbivores dominated the fish community in Vailoa, with high predominance of Acanthuridae and Scaridae. Parrotfish were mostly dominant in the coastal and back-reefs. Mean size ratios of fish were below the 50% known maximum values in the back- and coastal reefs for the large carnivores: Lethrinidae, Lutjanidae, Serranidae and Labridae, and for the herbivores: Mullidae, Scaridae and Serranidae; these were larger than the 50% value in the outer reefs for all families, except for Labridae. This result suggests a heavy exploitation of fish in the two internal reefs and much less exploitation in the outer reefs.

Overall, the reefs of Vailoa appeared to be in fairly good condition, with stocks comparable to those of Manono-uta. Density, biomass and biodiversity showed the highest values for the country, after Manono-uta (Table 4.14).

Table 4.14: Values (average per transects) of descriptive biological parameters for each site

Sites	Average number of species	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	28	0.8	100.0	15	55.0
Salelavalu	29	0.6	67.8	14	46.0
Vailoa	**29**	**0.8**	**116.7**	**15**	**54.0**
Vaisala	24	0.8	97.0	15	54.5

FL = fork length.

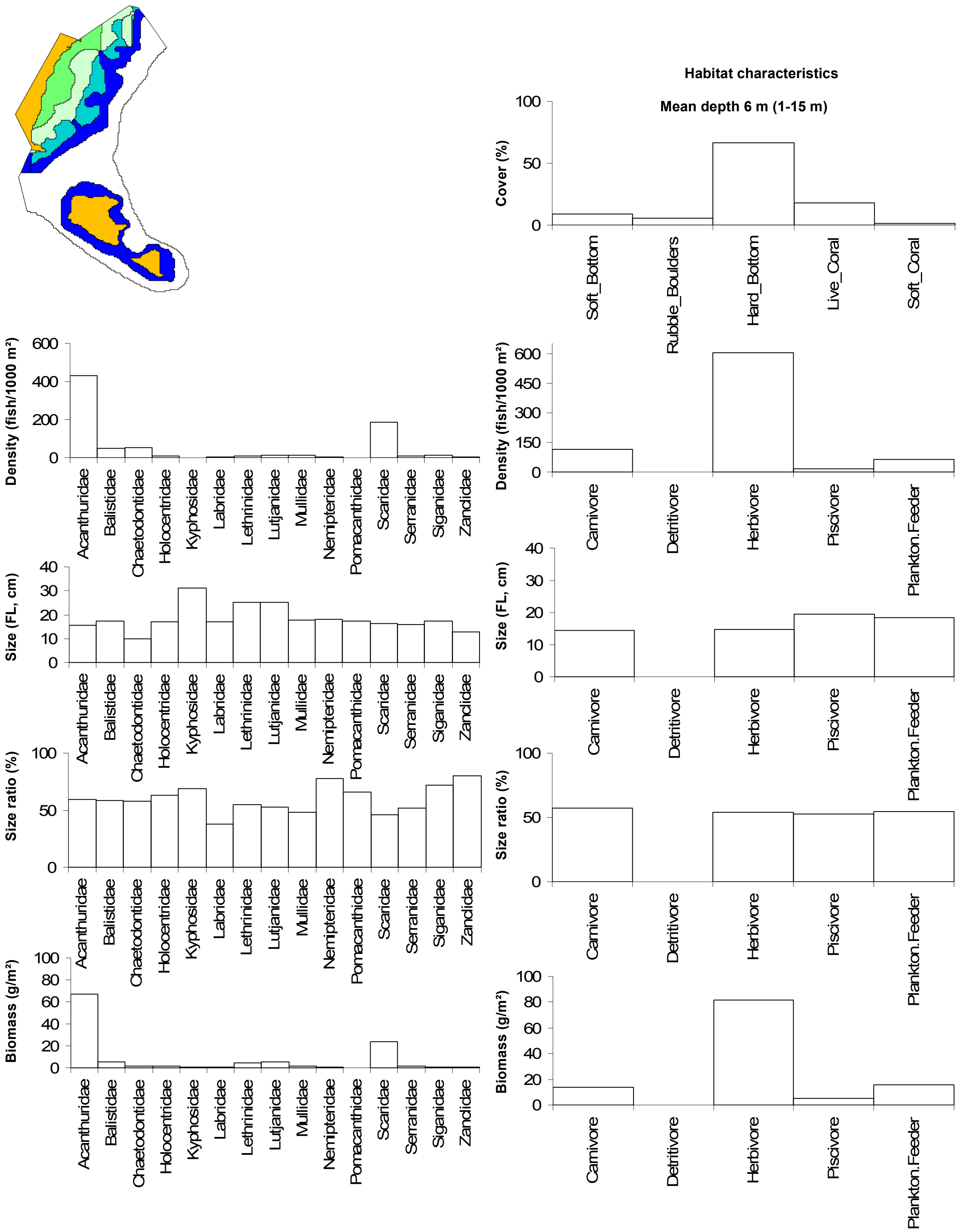

Figure 4.24: Profile of finfish resources in the combined reef habitats of Vailoa (weighted average).
FL = fork length.

4.3.2 Discussion and conclusions: finfish resources in Vailoa

- Overall, the finfish resources in the reefs surveyed in Vailoa-Aleipata appeared to be generally healthy, with a high abundance of fish and species diversity, and especially biomass, displaying higher values compared to all the other sites. However, reef fish resources were healthier in the outer-reef slope and offshore-island habitats, while resources in the reef shallows and lagoon were poor. The outer reefs showed the highest fish density, particularly of Acanthuridae.

- No differences were observed between fish resources inside and outside of the MPAs adjacent to the villages of Vaiola, Ulutogia and Satitoa, probably due to the fact that there was poor policing of the MPAs (Fishing activities were observed during the time of surveys.).

- Nu'utele Island is a sanctuary for birds, where fishing is prohibited. With a narrow fringing reef that drops off to over 1000 m depth, fish resources are still in good abundance in the outer-reef slope. The present observations were consistent with what was recorded some 10 years back by Samoilys and Carlos (1991). They recorded the highest fish diversity and biomass off the offshore islands and the highest records observed by sports divers in the country. In particular, diversity, abundance and biomass were very high on the rarely fished offshore islands; comparatively high on the moderately fished reef slopes of the main island; and low on the heavily fished reef shallows and lagoon. This indicates that the deeper reef slopes act as a population reservoir for the heavily fished lagoons.

- Coral cover was generally good (15–24%), mainly at the outer-reef crest (0–5 m) and back-reef behind the breakers. Also, good coral cover was recorded along the sheltered coastal reef (within 15 m of the shore) of Lalomanu, Vailoa and Ulutogia villages. Massive and sub-massive *Porites* corals were predominant in reef areas close to shore, while branching and tabulate *Acropora* corals dominated coral cover at the back-reef. Coral cover mid-lagoon was low and the substrate there was mainly composed of fine sand.

4.4 Invertebrate resource surveys: Vailoa

The diversity and abundance of invertebrate species at Vailoa were independently determined using a range of survey techniques (Table 4.15): broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 4.25) and finer-scale assessment of specific reef and benthic habitats (Figures 4.26 and 4.27).

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

Table 4.15: Number of stations and replicate measures completed at Vailoa

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	71 transects
Reef-benthos transects (RBt)	22	143 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	0	0 transect
Mother-of-pearl searches (MOPs)	3	18 search periods
Reef-front searches (RFs)	4	24 search periods
Sea cucumber night searches (Ns)	4	24 search period
Sea cucumber day searches (Ds)	5	30 search periods

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

Figure 4.26: Fine-scale reef-benthos transect survey stations for invertebrates in Vailoa.
Black circles: reef-benthos transect stations (RBt).
Marine protected areas (MPAs) are marked in red (total 2600m^2).

Figure 4.27: Fine-scale survey stations for invertebrates in Vailoa.
Grey triangles: reef-front search stations (RFs);
grey squares: mother-of-pearl search stations (MOPs);
grey stars: sea cucumber day searches stations (Ds);
grey circles: sea cucumber night searches stations (Ns).

Thirty-nine species or species groupings (groups of species within a genus) were recorded in the Vailoa invertebrate surveys. Among these were: 5 bivalves, 11 gastropods, 10 sea cucumbers, 6 urchins, 3 sea stars, and 1 cnidarian (Appendix 4.3.1). Information on key families and species is detailed below.

4.4.1 Giant clams: Vailoa

Shallow-reef habitat that is suitable for giant clams was not extensive at Vailoa (4.1 km², of which approximately 2600 m² was protected from fishing), and the shallow lagoon system was relatively open, with a major pass and dynamic water flow across the barrier reef allowing exchange of lagoon and oceanic water. Much of the lagoon floor behind the back-reef had scattered areas of branching *Acropora* corals on sand, with more substantial hard benthos only found to be abundant near the shoreline.

Broad-scale sampling provided an overview of giant clam distribution across the Vailoa area. Although there was diverse reef habitat that was suitable for a range of giant clams (fringing, intermediate and barrier reef), only the elongate clam *Tridacna maxima* was recorded in survey. The smooth clam, *Tridacna derasa*, which had been introduced, was also present, stockpiled within marine protected areas (MPAs). Most *T. maxima* were recorded near the barrier reef (found in 4 stations and 10 transects, Figure 4.28).

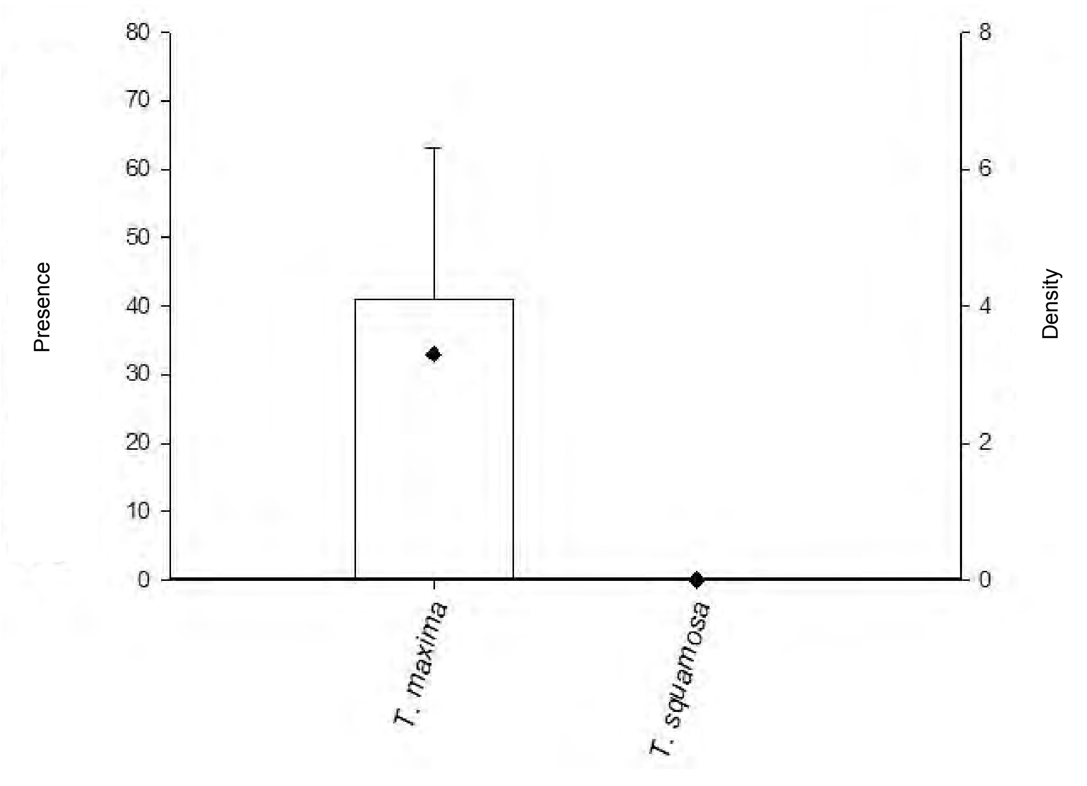

Figure 4.28: Presence and mean density of giant clam species at Vailoa based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat. In these reef-benthos transect assessments (RBt), *T. maxima* was present within 18% of stations (Figure 4.29, Table 4.16). At these stations (4 stations where clams were recorded), the mean density was 67.7 ±19.7 individuals/ha.

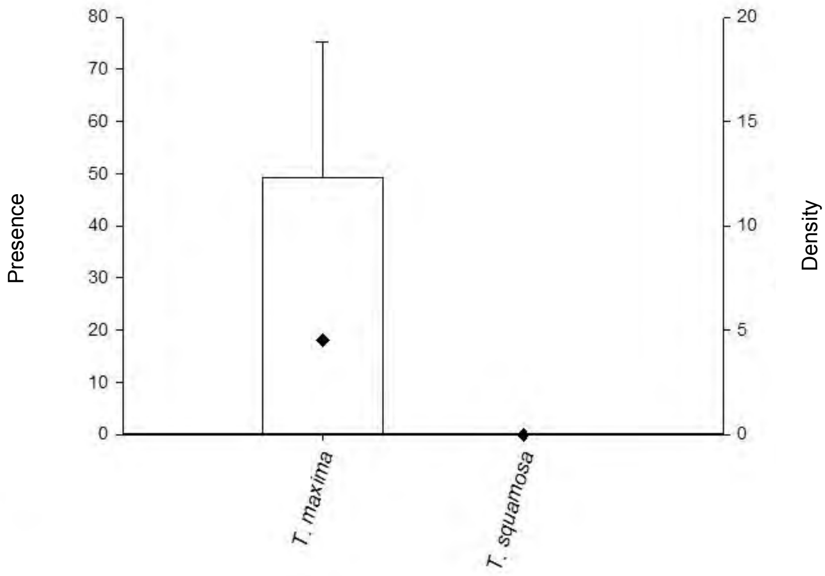

Figure 4.29: Presence and mean density of giant clam species at Vailoa based on fine-scale reef-benthos survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Table 4.16: Presence and mean density of *Tridacna maxima* in Vailoa
Based on reef-benthos transect assessment technique; mean density measured in numbers per ha (±SE). Comparisons of results from similar environments are listed for stations both inside and outside the Marine Protected Areas (MPAs).

	Density	SE	% of stations with species	% of transects or search periods with species
Tridacna maxima				
All stations	12.3	6.5		6/143 = 4
MPA Inner RBt stations	0	0		0/49 = 0
Inner and mid RBt stations ouside MPA	0	0		0/56 = 0
Outer-reef stations outside MPA	45.1	19.0		6/38 = 16

Despite there being no obvious environmental reasons for their absence, clams were scarce throughout Vailoa. An earlier assessment (Fisk 2002) also recorded few clams. In this study clams were not seen on reefs near the shoreline, neither within nor outside the MPAs (apart from in the *T. derasa* holding area). Reasons for this result (other than overfishing), may be the shallowness of the lagoon, freshwater seeps and the high number of urchins present in these locations (Urchins bioerode limestone substrates, and may negatively impact the recruitment of young clams.). In addition to these factors, there was noticeable disturbance of the bottom, presumably by fishers looking for the cryptic sea cucumber, *sea* (*Stichopus horrens*).

T. maxima from reef-benthos transects had an average length of 10.1 cm ±0.3. When clams from deeper water and more exposed locations were included in the calculation (from other assessments), the mean size decreased slightly to 11.4 cm ±0.8. *T. maxima* of this size are approximately 5–6 years old. As can be seen from the length frequency graph (Figure 4.30), a range of size classes was found, including small clams (which show new recruitment). Few large clams were found.

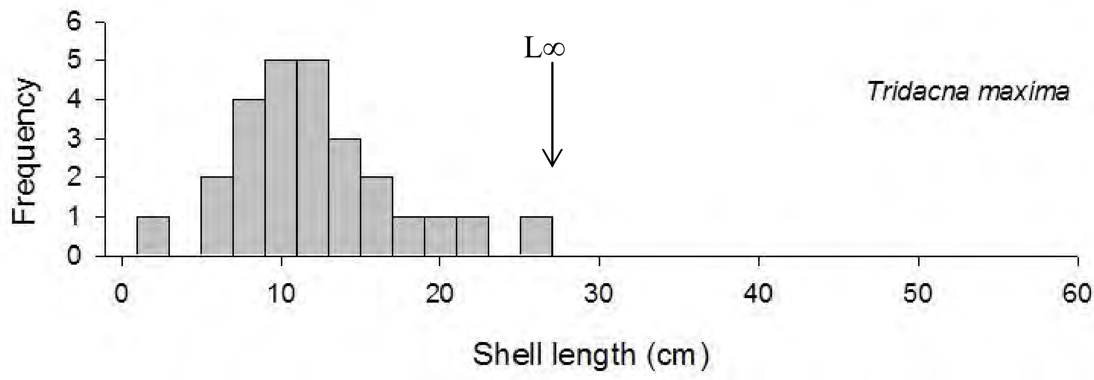

Figure 4.30: Size frequency histogram of *Tridacna maxima* shell length (cm) for Vailoa.

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

Samoa is not within the natural distribution of the commercial topshell, *Trochus niloticus*; however, specimens were introduced to Vailoa. The reefs around Vailoa constitute a suitable benthos for trochus (11.2 km lineal distance of reef front at the barrier reef, and approximately 4.1 km² of shallow water reef); this area could potentially support this commercial species.

The relief and complexity of the substrate covered by mother-of-pearl searches (MOPs) was medium with a mean crustose coralline algae (CCA) cover of 43%. Nursery habitat that is most suitable for juvenile trochus was present, and consisted of a wave-swept reef platform and extensive areas of submerged rubble and coral flats; rubble and boulder substrate made up 18% of the benthos of shallow reef-benthos stations. Despite the apparent suitability of the habitat, numbers of other grazing gastropods were not high in general observations and were mainly found within the channels of the barrier and in the lagoon reef system, where food availability seemed more able to support these species.

The survey concentrated effort on both places where trochus had previously been released, general oceanic-influenced reef slopes and inshore shallow reefs; however, *T. niloticus* was not found (Figure 4.27). A species with a similar life history to trochus, the green topshell *Tectus pyramis* (of low commercial value) was recorded, but was rare (Table 4.17). This species was predominantly found on back-reefs within the lagoon. No *T. pyramis* was found on inshore reefs, either within or outside the MPAs. The mean size (basal width) of *T. pyramis* (n = 6) was 5.4 cm ±1.0.

Table 4.17: Presence and mean density of mother-of-pearl species in Vailoa
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
Tectus pyramis				
B-S	0.5	0.3	1/12 = 8	2/71 = 3
RBt	7.6	4.5	3/22 = 14	4/143 = 3
RFs	0	0	0/4 = 0	0/24 = 0
MOPs	0	0	0/3 = 0	0/18 = 0

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

The blacklip pearl oyster, *Pinctada margaritifera*, a normally cryptic and sparsely distributed species, was not recorded during assessments at Vailoa. A single adult specimen of *P. margaritifera* was collected during an exploratory dive on an offshore reef in front of Tapaga (GPS position: 188.558466–14.060047).

The survey results suggest that trochus have not become established following their introduction to Vailoa. The reported release method and site selected were not optimal. Any future releases of trochus may consider initially placing transplanted shells on reefs within the lagoon, where epiphytic growth (a potential food source for trochus) is more developed. Use of more staged-release methods may also assist translocated shells to acclimatise to local conditions before they are released to areas where there is no protection from predators.

4.4.3 Infaunal species and groups: Vailoa

The soft benthos of the shallow-water lagoon was very sandy and did not hold shell beds of in-ground resource species, such as arc shells *Anadara* spp. or venus shells *Gafrarium* spp. Therefore no fine-scale assessments or infaunal stations (quadrat surveys) were made.

4.4.4 Other gastropods and bivalves: Vailoa

Seba's spider conch *Lambis truncata*, the smaller spider conch *Lambis lambis* and *Lambis crocata* were not detected in broad-scale or reef-benthos surveys, although two individuals of *Lambis scorpius* were recorded. *Strombus luhuanus* was detected but was uncommon in the lagoon. Similarly, *Turbo* spp. (*T. argyrostomus*, *T. setosus*) were rare, not being recorded in reef-front searches or other surveys. Results from other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Conus*, *Cypraea*, *Pleuroploca*, *Tectus*), also recorded during independent survey, can be seen in Appendices 4.3.1 to 4.3.7). Andrews and Holthus (1989) reported that the green sea hare, *Dollabella auricularia*, was collected; however, none were found in this survey.

Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Anadara*, *Chama*, *Spondylus* and *Pinna*, are also in Appendices 4.3.1 to 4.3.8. No creel survey was conducted at Vailoa (Some data exist in Andrews and Holthus 1989.).

4.4.5 Lobsters: Vailoa

There was no dedicated night reef-front assessment of lobsters (See Methods.), and no lobsters were recorded on reef-benthos stations or during night lagoon assessments (Ns) for nocturnal BdM species.

4.4.6 Sea cucumbers[11]: Vailoa

The varied hard- and soft-benthos habitats found at Vailoa generally suited commercial sea cucumbers, as they are predominantly deposit feeders (which eat organic matter in the upper few mm of bottom substrates). However, the lagoon was generally very shallow and limited in scale (just over 2 km²). The high degree of exposure and dynamic water movement

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

through the lagoon, with freshwater seeps from land, may have negatively affected overall habitability. The large number of urchins recorded on hard substrates in the lagoon may also have played a role in limiting the range of species that were found.

Species presence, size and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 4.18, Appendices 4.3.1 to 4.3.8; also see Methods.). Despite the limited scale of the area and exposure of some reefs, nine commercial species were recorded during in-water assessments (Table 4.18).

The presence and density of commercial species in Vailoa were generally similar to records across the four survey sites in Samoa. Within the group of species generally associated with reef, greenfish (*Stichopus chloronotus*) was notable for its high density close to shore. The densities recorded for this species were some of the highest recorded for PROCFish/C sites in the Pacific, and the second highest across sites in Samoa. There was a notable difference in the density of greenfish inside and outside of the MPAs sites (Figure 4.31). This difference may stem indirectly from *sea* (*Stichopus horrens*) fishing, which disturbed the substrate outside the MPAs more regularly.

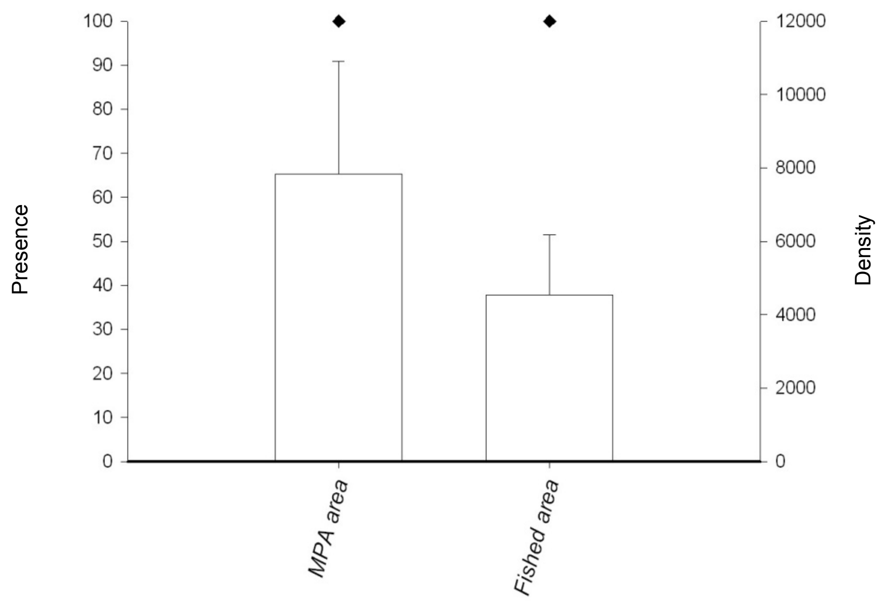

Figure 4.31: Presence and mean density of *Stichopus chloronotus* at Vailoa within and outside the marine protected areas, based on reef-benthos transect survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Other species associated with reef, such as leopardfish (*Bohadschia argus*), were not common in relation to the other PROCFish/C sites, but black teatfish (*Holothuria nobilis*) were noted in relatively high numbers on outer reefs. Fifteen black teatfish were recorded in survey, and as this species is a valuable, shallow-water species and relatively slow growing, it was promising to see a good recovery of this stock from past fishing. Fisk (2002) also noted this species on reefs in Vailoa and stated that their presence was more common in this part of the lagoon than further north.

Surf redfish, *Actinopyga mauritiana*, was not common on the exposed reef front (recorded during 8% of reef-front search periods). This result was disappointing considering the suitable nature and extent of the reef and surge zone at Vailoa.
More protected areas of reef and soft benthos held a few lower-value species, e.g. brown sandfish (*Bohadschia vitiensis*) and lollyfish (*H. atra*) at reasonable densities. *Stichopus horrens*, locally named as *sea* was collected daily (Parts of the viscera are bottled along with strips of the body wall from lollyfish and brown sandfish.). The densities of this subsistence species were very low compared to PROCFish records taken in Vanuatu, Tonga and Wallis. In Samoa anecdotal catches of 15–200 per harvest were reported by Andrews and Holthus (1989).

Deep dives on SCUBA were conducted to obtain a preliminary assessment of deep-water stocks, such as the high-value white teatfish (*H. fuscogilva*), prickly redfish (*Thelonata ananas*) and the lower-value amberfish (*T. anax*). In deep water (25–35 m), white teatfish (*H. fuscogilva*) and prickly redfish (*T. ananas*) were present, but presence was patchy and no high-density aggregations were located.

4.4.7 Other echinoderms: Vailoa

No edible slate urchins *Heterocentrotus mammillatus* or collector urchins *Tripneustes gratilla* were recorded. Very high densities of *Echinometra mathei* were recorded (found in 100% of reef-benthos transect stations). *Echinothrix diadema* was also common (32% of reef-benthos transect stations for *E. diadema*; see presence and density estimates in Appendices 4.3.1 to 4.3.8).

Starfish, such as *Linckia laevigata* the blue starfish, were common (found in 32% of broad-scale transects and 54% of reef-benthos transect stations), as were coralivore species, such as *Culcita novaeguineae*. Another coral-eating species, the crown of thorns (COTS), *Acanthaster planci*, was of concern in past surveys (Andrews and Holthus 1988, Fisk 2002, Green 2002), and was still present in reasonable numbers in this survey (recorded on two broad-scale and one reef transect station, Appendices 4.3.1 to 4.3.8).

Table 4.18: Sea cucumber species records for Vailoa

Species	Common name	Commercial value [5]	B-S transects n = 70			Reef-benthos stations n = 22			Other stations RFs = 4 MOPs = 3			Other stations Ns = 2 Ds = 5		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga mauritiana	Surf redfish	M/H	0.2	16.4	1				3.1	6.3	50 RFs			
Bohadschia argus	Leopardfish	M	1.9	26.7	7	7.1	39.1	18						
Bohadschia vitiensis	Brown sandfish	L	4.7	33.0	14	7.1	78.1	9				8.9	17.8	50 Ns
Holothuria atra	Lollyfish	L	4821	8348	58	13,499	16,499							
Holothuria fuscogilva [4]	White teatfish	H										1.0	4.8	20 Ds
Holothuria fuscopunctata	Elephant trunkfish	M												
Holothuria leucospilota	Black cucumber	L												
Holothuria nobilis [4]	Black teatfish	H	2.6	20.4	13	1.4	31.3	5	2.3	9.0	25 RFs	0.5	2.4	20 Ds
Stichopus chloronotus	Greenfish	H/M	1061	1537	69	4587	4743	95						
Stichopus horrens	Peanutfish	M	15.9	375.3	4	30.8	225.7	14				226.7	226.7	100 Ns
Synapta spp.	-	-	3.0	21.6	14	27.5	86.3	32						
Thelenota ananas	Prickly redfish	H	0.2	16.7	1							1.0	2.4	40 Ds
Thelenota anax	Amberfish	L												

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

4.4.8 Discussion and conclusions: invertebrate resources in Vailoa

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

- The density and size range of giant clams in Vailoa indicate that the clam resource is degraded. As the conditions within the lagoon and offshore reefs were suitable for giant clams, fishing pressure was the most likely cause for the low density of the only species found in natural distribution at Vailoa (*T. maxima*).

- *Hippopus hippopus* is already extinct and *T. squamosa*, reported as having a 'very low' abundance in a recent biodiversity assessment (Fisk 2002) was not detected in this survey[12].

- It is encouraging to note that recruitment is still occurring and the clams transplanted to the MPA (*Tridacna derasa*) are nearing a mature size at which they can hopefully produce second-generation stock.

- Based on the information collected, *Trochus niloticus* has not been successfully introduced to Vailao. Presence and recruitment of *Tectus pyramis* was poor to moderate, but habitat was available for grazing gastropods and recruitment in the dynamic lagoon was occurring. The blacklip pearl oyster, *Pinctada margaritifera*, is considered overfished. The general scarcity of these three mother-of-pearl species is considered a result of poor release strategies for the introduction of trochus, the limited reef area available, and overfishing.

- Based on the information collected on sea cucumber stocks, there is a limited number of species available for commercial fishing, stocks are patchy and the regularly fished *Stichopus horrens* (*sea*) is currently at low densities in comparison to other areas of the Pacific.

- Recovery of greenfish, *S. chloronotus*, presents an option for redeveloping a limited fishery for sea cucumbers in Samoa, but developing a management plan for such a fishery will need to wait for more comprehensive results (Uppsala University and Samoa Fisheries study underway in 2006).

- The presence of high-value teatfish and other deep-water sea cucumber stocks are of interest for commercialisation, but habitat and stocks are insufficient to support a regular fishery.

[12] Can be seen as being 'commercially extinct' – refering to a scarcity such that collection is not possible to service commercial or subsistence fishing, but species is or may still be present at very low densities.

4.5 Overall recommendations for Vailoa

Based on the survey work undertaken and the assessments made, the following recommendations are made for Vailoa:

- Risk zones, i.e. areas within Vailoa's fishing ground that are potentially the most vulnerable to over-harvesting, need to be mapped to complement current management practices, and indicators found to assist in monitoring resources and determining which invertebrates and finfish species need closer surveillance.

- Existing community fisheries management programmes need to be continued and improved. More involvement of female fishers in the community's management work is needed as they are the main harvesters of bêche-de-mer for subsistence and small-scale sales, and the main subsistence gleaners.

- A cautionary approach to using resources is required to immediately safeguard current stocks and thus maintain marine resources for the subsistence and economic livelihoods of the people.

- The resource management plans already in place for the Aleipata area should be implemented to allow restoration of resources in the lagoon. Even though the long-term ecological benefits of MPAs have not been fully realised, fishing activities such as spearfishing and netting should be banned inside the MPAs and these conservation sites regularly patrolled.

- Fishing in the outer-reef slope, although difficult during adverse sea conditions, should be encouraged to relieve pressure on resources in the lagoon.

- Immediate action is required to protect and reintroduce giant clams, as present densities are so low that they have reached a 'critical threshold', where reproductive success and subsequent recruitment are impaired and stocks are likely to decline. The present MPA arrangement does not protect any broodstock of clams naturally occurring in Vailoa.

- Recovery of greenfish, *S. chloronotus*, presents an option for redeveloping a limited fishery for sea cucumbers in Samoa, but developing a management plan for such a fishery will need to wait for more comprehensive results.

- Present densities of crown of thorns starfish (COTS) at Vailoa are not critical but, to prevent an outbreak, adult COTS should be periodically removed from the small lagoon, and their numbers closely monitored.

5. PROFILE AND RESULTS FOR VAISALA

5.1 Site characteristics

Vaisala is located close to the northwest end of Savaii Island, about three hours' drive from the main town of Saleloga (Figure 5.1). The population of Vaisala at the time of the survey was 611, constituting 24.1% of the entire district. Most of the 86 households were located along the narrow margin of the coastal area (Statistical Services Division 2001). The average household contained seven people.

Vaisala has a narrow coastal strip composed of older lava flows with some topsoil development. The Vaisala bay area (our survey site) has a distinct fringing and barrier reef. Underground tunnels discharge freshwater directly into the lagoon. The intermediate lagoon area is quite narrow, 2–4 m deep, with pools of slightly deeper water. The substrate is mainly sand, with scattered coral patches with high live-coral cover. Coral reefs are better developed here than on the south and east areas of Savaii (Zann 1997) and are relatively healthy, with more cover of live corals in the sheltered lagoon than on the outer-reef slope.

The fishing ground of Vaisala is relatively small, with no legal demarcation of its boundary. Fishing is predominantly restricted to reef areas next to the village, although there is free access to fishing areas elsewhere. In addition to fishing activities, several natural disasters have affected the reef system, including repeated cyclones in the 1990s and more recent ones. Also, there were signs of a previous crown of thorns starfish (COTS) outbreak, with a handful of COTS sighted during the surveys. The area is well-suited to development of a near-shore fishery as the coastline is protected during the prevailing summer tradewinds. The preferred fishing spots on the outer-reef slope for spearfishing and deep sea fishing are relatively close to shore. Vaisala has one localised *tabu* area/MPA, which was established some five years ago with assistance from an AusAID project.

ASAU TO VAISALA (VAISIGANO)

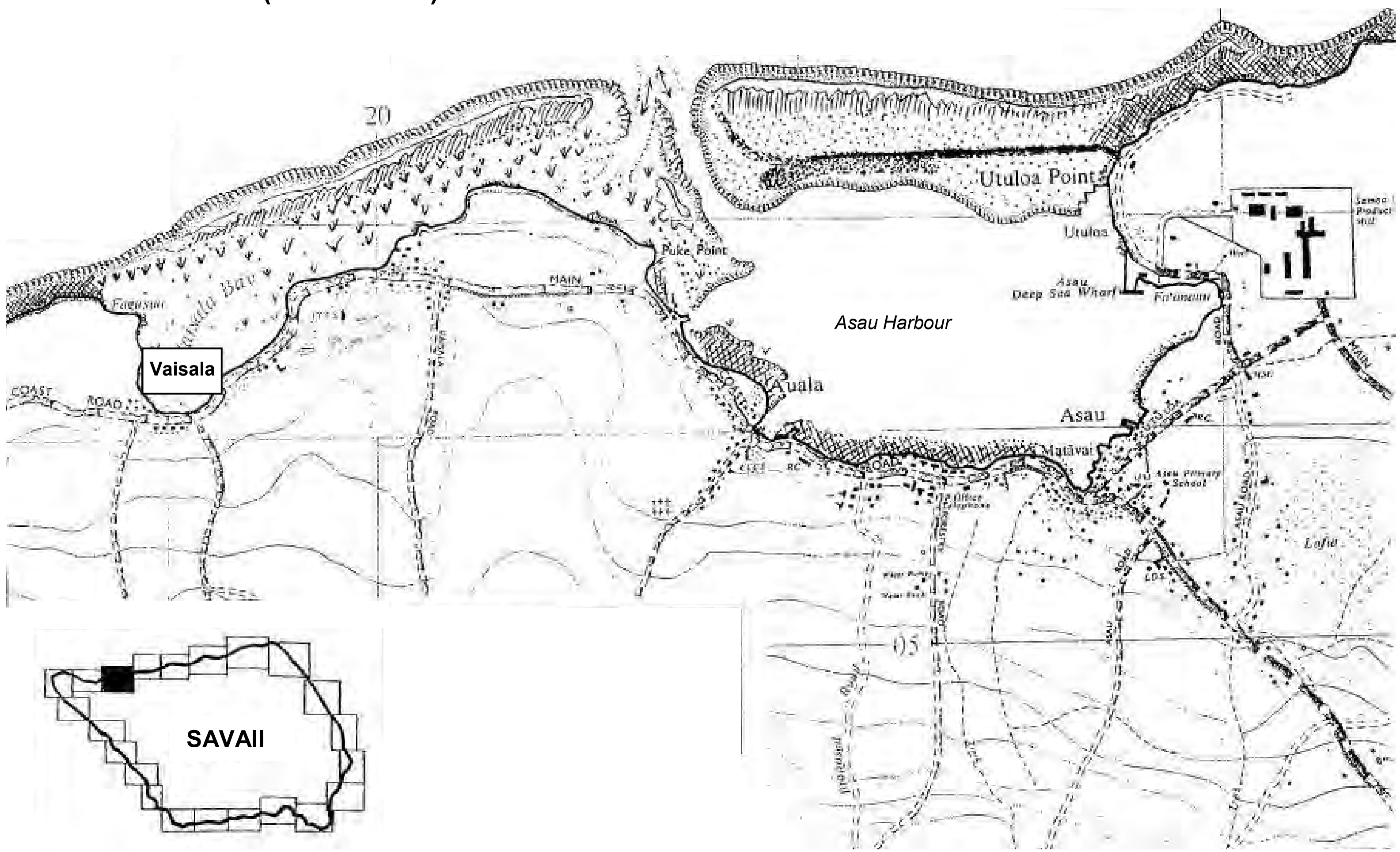

Figure 5.1: Reef system of Vaisala.

5.2 Socioeconomic surveys: Vaisala

Vaisala is the centre of the district, approximately 15 km distant from the Saleloga market in Salelavalu, the urban centre in Savaii. Vaisala is a rural coastal community with people primarily dependent on fisheries resources for subsistence food needs. Socioeconomic fieldwork was carried out in Vaisala on 20–27 June 2005. Household surveys were conducted in three out of the five villages in the district: Auala, Fagasa and Vaisala, with 9, 10 and 29 households surveyed respectively. The results were combined and are referred to as 'Vaisala' in the following.

The 'Vaisala' community (3 villages combined) had a resident population of 1502 and about 170 households. A total of 48 households, which is 28% of the total households in the Vaisala community, were surveyed, with 81% of these households engaged in some form of fishing activities. In addition, a total of 41 finfish fishers (33 males, 8 females) and 27 invertebrate fishers (13 males, 14 females) were interviewed. Household interviews focused on collecting general demographic, socioeconomic and consumption data. General information on sales and distribution of fisheries resources was gathered through interviews with shopkeepers and boat owners. A general survey of shops to establish prices of tinned fish and other food items consumed was also conducted. The average household size was large with 8–9 people on average, due to the practice of living together in extended families (*aiga*).

Vaisala has coastal reefs, a wide lagoon area, and a narrow fringe of mangrove areas and sand and mud flats in nearshore areas. There is limited access to larger markets; thus fish is sold mostly within the community or at Saleloga, and sometimes to the single tourist resort in the area. Compared to other sites studied in Samoa there was less commercialisation of fisheries products and hence less impact on the community's fishing resources caused by external demand.

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

Our results (Figure 5.2) suggest that agriculture is the main source of income. Almost 73% of households stated that agriculture was their primary or secondary source of income. This was followed by other forms of home-based ventures, which provided income for 47% of households. Fisheries were the third most important income source, providing first or second income for 36% of households. Salaries were the least important income source. The isolated location of Vaisala from the main centre explains the limited opportunities for formal employment. Pigs and chickens are popularly reared for *falavelave* and for selling.

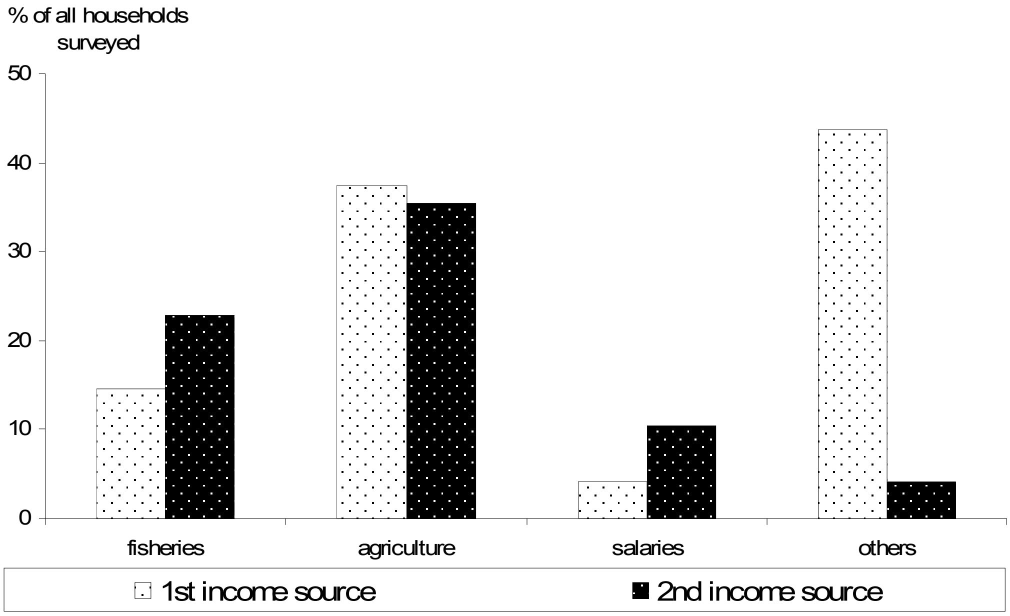

Figure 5.2: Ranked sources of income (%) in Vaisala.
Total number of households = 48 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses.

Our results (Table 5.1) show that household expenditures were relatively high with an average of USD 2256 per year. Families spend cash mainly on necessary food and household items including *falavelave* (traditional or religious obligations relating to weddings, births, christening of children, funerals, etc.). Household expenditure also includes weekly church donations, which people regard as a basic obligation.

Remittance is an important component of Samoa's household income, with 95% of all households receiving on average USD 2242 per year. The high number of households that receive remittances (~90%) and the average amount of USD >2000 per year is consistent throughout all four study sites in Samoa. Comparing the average annual household expenditure and the average annual remittances received, it is evident that the basic costs of an average family in the Vaisala community are met by external donations. Therefore, it is not surprising that most families interviewed described remittances as either the main or one of the major sources from which most of the *falavelave* are met. Remittances are received on average between once a fortnight to once a month, and most of the foreign currency received is sourced from New Zealand.

Table 5.1: Fishery demographics, income and seafood consumption patterns in Vaisala

Survey coverage	Site (n = 48 HH)	Average across sites (n = 207 HH)
Demography		
HH involved in reef fisheries (%)	81.3	91.3
Number of fishers per HH	1.52 (±0.18)	2.03 (±0.09)
Male finfish fishers per HH (%)	43.8	46.6
Female finfish fishers per HH (%)	5.5	2.9
Male invertebrate fishers per HH (%)	5.5	2.1
Female invertebrate fishers per HH (%)	21.9	13.3
Male finfish and invertebrate fishers per HH (%)	15.1	25.9
Female finfish and invertebrate fishers per HH (%)	8.2	9.3
Income		
HH with fisheries as 1st income (%)	14.6	25.1
HH with fisheries as 2nd income (%)	22.9	27.1
HH with agriculture as 1st income (%)	37.5	28.5
HH with agriculture as 2nd income (%)	35.4	27.5
HH with salary as 1st income (%)	4.2	17.9
HH with salary as 2nd income (%)	10.4	11.6
HH with other source as 1st income (%)	43.8	28.5
HH with other source as 2nd income (%)	4.2	8.2
Expenditure (USD/year/HH)	2256.27 (±144.95)	2991.32 (±209.55)
Remittance (USD/year/HH) (1)	2422.42 (±240.84)	2170.81 (±89.23)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	51.62 (±4.60)	61.26 (±4.35)
Frequency fresh fish consumed (times/week)	3.68 (±0.24)	3.92 (±0.10)
Quantity fresh invertebrate consumed (kg/capita/year)	14.76 (±4.58)	9.61 (±4.35)
Frequency fresh invertebrate consumed (times/week)	0.50 (±0.07)	0.49 (±0.04)
Quantity canned fish consumed (kg/capita/year)	30.10 (±3.73)	24.26 (±1.92)
Frequency canned fish consumed (times/week)	3.00 (±0.24)	2.81 (±0.11)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	79.2	83.6
HH eat canned fish (%)	100.0	97.6
HH eat fresh fish they catch (%)	66.7	82.1
HH eat fresh fish they buy (%)	39.6	23.9
HH eat fresh fish they are given (%)	29.2	59.7
HH eat fresh invertebrates they catch (%)	54.2	52.2
HH eat fresh invertebrates they buy (%)	12.5	19.4
HH eat fresh invertebrates they are given (%)	31.3	64.2

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

Survey results indicate an average of 1–2 fishers per household. When extrapolated, the total number of fishers in Vaisala is 259: 167 males and 92 females. Among these are 128 fishers who only fish for finfish (114 males, 14 females), 71 fishers who only fish for invertebrates (14 males, 57 females), and 60 fishers who fish for both finfish and invertebrates (39 males, 21 females). Only 46% of all households own a boat; most (90%) are non-motorised canoes, and only 10% are equipped with an outboard engine.

Consumption of fresh fish is ~52 kg/person/year and this is less than the average across all four study sites in Samoa, and well below the regional average of ~35 kg/person/year (Figure 5.3). By comparison, consumption of invertebrates (15 kg/year edible meat weight only) is relatively high (Figure 5.4). Canned fish (Table 5.1) adds another ~30 kg/person/year to the protein supply from seafood. The consumption pattern of seafood found in Vaisala highlights the fact that people have access to a variety of agricultural and marine food sources. Also, canned fish, locally named *elegi*, is a regular constituent of *falavelave*, which may explain the large quantity consumed.

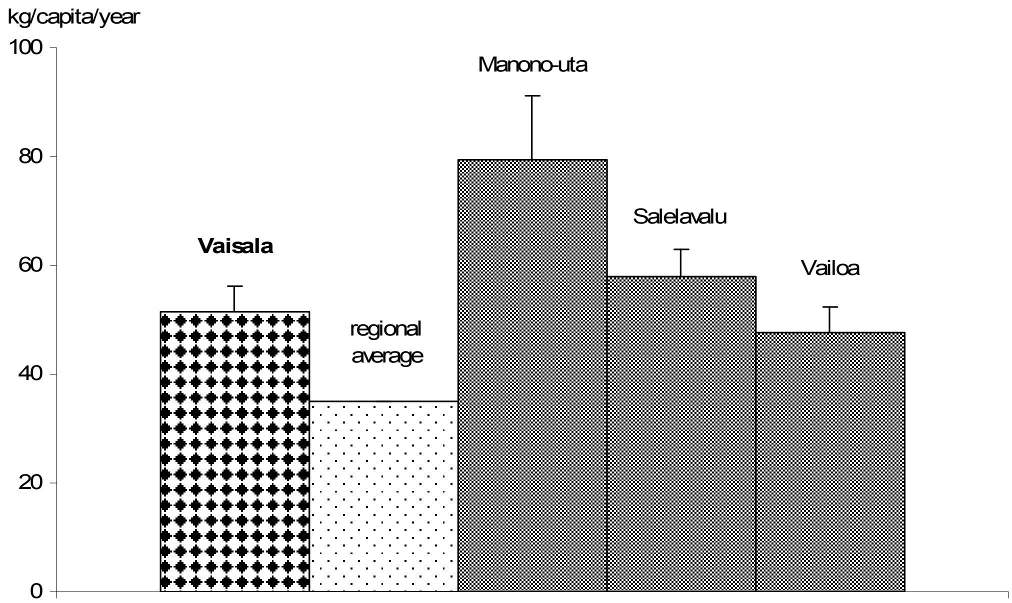

Figure 5.3: Per capita consumption (kg/year) of fresh fish in Vaisala (n = 48) compared to the regional average (FAO 2002) and the other three PROCFish/C sites in Samoa.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

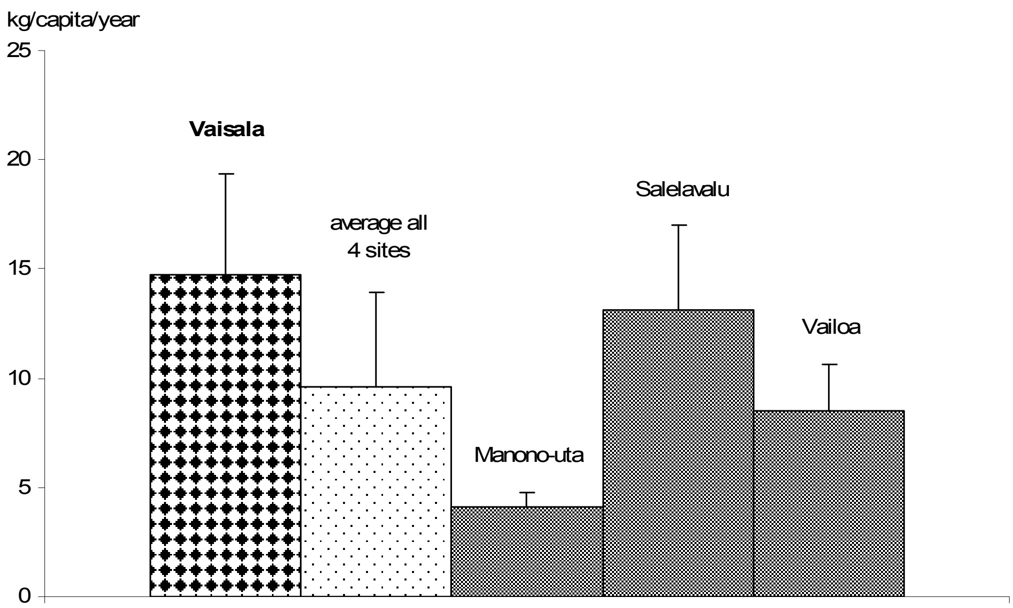

Figure 5.4: Per capita consumption (kg/year) of invertebrates (meat only) in Vaisala (n = 48) compared to the other three PROCFish/C sites in Samoa.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Comparing results obtained for Vaisala to the average figures across all four study sites surveyed in Samoa, people of the Vaisala community eat fresh fish, invertebrates and canned fish about as often as the average for all sites. However, the quantity of fresh fish eaten is well below the average, while the quantities of invertebrates and canned fish consumed are above average (Table 4.1). Overall, Vaisala people buy fresh fish more often, and exchange fresh fish and invertebrates on a non-commercial basis much less often than in other sites. The relatively frequent purchase of fresh fish may be explained by the presence of local middle sellers, who regularly sell tuna and other pelagic fish. Agriculture plays a much greater, and fishing a much smaller role in providing income than the average across all Samoan PROCFish sites. While average household expenditure in Vaisala is less than elsewhere, the remittance amount received is higher. By comparison, few people own boats and these are mainly canoes.

5.2.2 Fishing strategies and gear: Vaisala

Degree of specialisation in fishing

The Vaisala villages are located along the sea front, with people depending on fisheries produce for both food and income. Both males and females fish for finfish; however, 59% of all finfish fishers are males, and they also contribute substantially to invertebrate fisheries (21% of all fishers). Female finfish fishers represent 14% and female invertebrate fishers 30% of all fishers (Figure 5.5). Some fishers, both males and females, fish for both finfish and invertebrates; and these are counted twice, thus making the total more than 100%. As shown in Figure 5.5, males are the main fishers who only fish for finfish, while females mainly harvest invertebrates. Only a few male and female fishers fish for both finfish and invertebrates, either in a single fishing trip or during different trips.

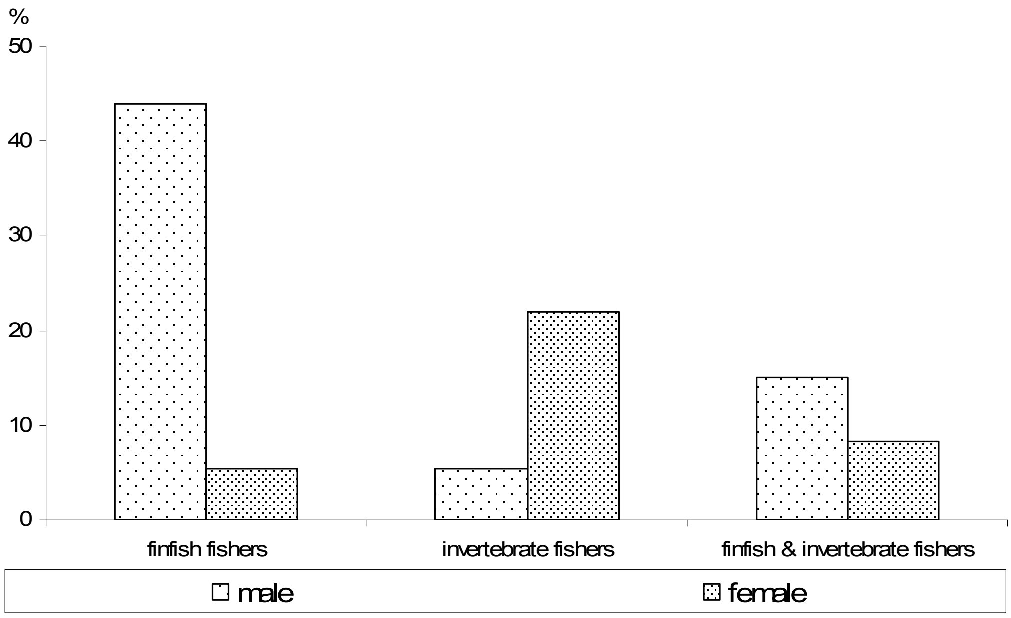

Figure 5.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Vaisala.
All fishers = 100%.

Targeted stocks/habitat

Considering the limited number of boats, particularly motorised boats, it is not surprising that Vaisala's finfish fishers mainly target the easily accessible habitats, namely the sheltered coastal reef, mangroves and lagoon. Often, a trip combines two habitats. The outer reef and passages are fished by male fishers only, and much less often (Table 5.2). Reeftop and soft-benthos gleaning are the most frequent invertebrate fisheries, particularly reeftop gleaning done by females. Males also dive for other invertebrates, such as trochus, giant clams, lobsters and bêche-de-mer. Mangroves are visited by both genders, however much less often than the other habitats.

Table 5.2: Proportion (%) of male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Vaisala

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef & lagoon	30.3	62.5
	Sheltered coastal reef & mangrove	0.0	12.5
	Lagoon	18.2	25.0
	Lagoon & outer reef	33.3	0.0
	Pelagic	3.0	0.0
	Outer reef	15.2	0.0
	Outer reef & passage	9.1	0.0
Invertebrates	Reeftop	46.2	100.0
	Soft benthos	0.0	28.6
	Soft benthos & reeftop	23.1	0.0
	Mangrove	7.7	7.1
	Lobster	7.7	0.0
	Other	15.4	0.0

'Other' refers to the trochus, giant clam, lobster and bêche-de-mer fishery.
Finfish fisher interviews, males: n = 33; females: n = 8. Invertebrate fisher interviews, males: n = 13; females, n = 14.

Fishing patterns and strategies

The combined information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip are the basic factors used to estimate the fishing pressure imposed by people from Vaisala on their fishing ground (Tables 5.2 and 5.3).

Our survey sample suggests that fishers from Vaisala have the choice between fishing the sheltered coastal reef, lagoon and outer reef, including the passages. However, reeftop (65%) and soft benthos, i.e. seagrass (20%), are the main habitats for invertebrate fisheries (Figure 5.6). Seagrass is particularly targeted to collect bêche-de-mer by walking. Females are the main fishers who glean the reeftop and soft benthos, and they also glean the mangroves. Females do not dive for trochus, giant clams, bêche-de-mer or lobsters (Figure 5.7).

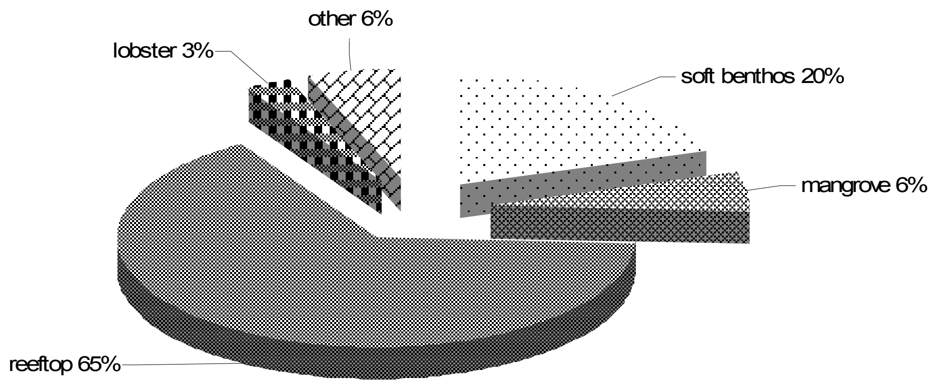

Figure 5.6: Proportion (%) of fishers targeting the five primary invertebrate habitats found in Vaisala.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the trochus, giant clam, lobster and bêche-de-mer fishery.

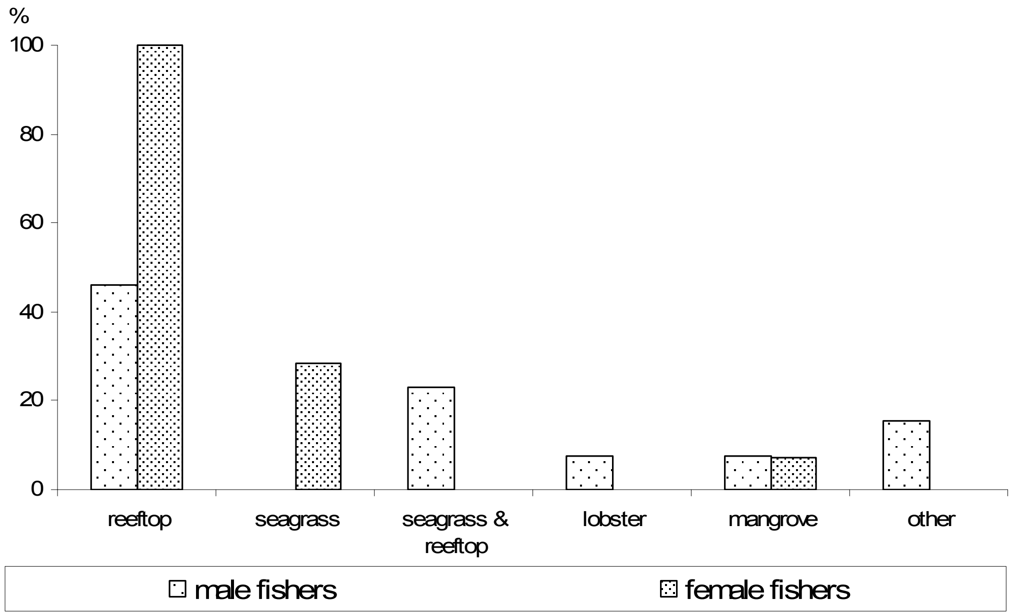

Figure 5.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Vaisala.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 13 for males, n = 14 for females; 'other' refers to the trochus, giant clam, lobster and bêche-de-mer fishery.

Gear

Figure 5.8 shows that Vaisala fishers use a variety of different gears and often combine different fishing techniques when catching fish in a particular habitat. In the sheltered coastal reef and lagoon, handlines, gillnets and spears are all equally and frequently used. Castnets, however, seem to only be used in the lagoon. As fishers (males) move further offshore, targeting the outer reef, passages and more distant lagoon areas, spear diving and handlines become more important. This pattern may be explained by the fact that fishers targeting the outer reef and adjacent habitats mainly use motorised boats, which cost more, so they are fishing more for income purposes. The use of castnets in the lagoon is mainly explained by the need for fishers to catch bait fish in the lagoon areas before moving out to the outer reefs. This strategy also explains why the lagoon and outer reef are often combined in a single fishing trip.

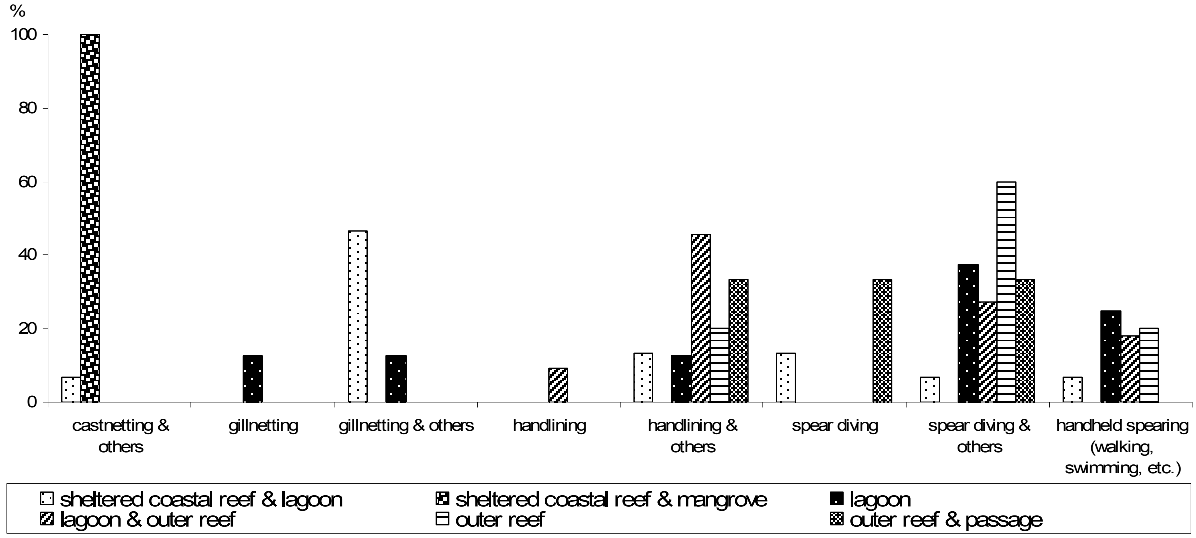

Figure 5.8: Fishing methods commonly used in different habitat types in Vaisala.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Frequency and duration of fishing trips

Male finfish fishers go out about 2–3 times/week to any of the habitats. As shown in Table 5.3, the further the habitat, i.e. outer reef and passages, the less frequent the trips. Females go fishing for finfish about once or twice a week only. The average duration of a fishing trip does not vary substantially among habitats, and lasts about 3–4 hours. Females spend less time fishing, about 3 hours/trip.

For invertebrates, fishing trips are less frequent for males, 0.5–1 times/week only, and last on average about 2 hours, particularly if gleaning is performed. However, when males go diving for invertebrates (lobsters, trochus, giant clams, or bêche-de-mer) and use boats, invertebrate fishing trips take as long as finfish trips, i.e. 3–4 hours. Females go gleaning about once a week and their trips usually last 3 hours.

Table 5.3: Average frequency and duration of fishing trips reported by male and female fishers in Vaisala

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef & lagoon	2.10 (±0.23)	1.80 (±0.49)	3.15 (±0.37)	2.80 (±0.20)
	Sheltered coastal reef & mangrove	0	1.00 (n/a)	0	3.00 (n/a)
	Lagoon	2.33 (±0.33)	1.50 (±0.50)	4.17 (±0.80)	3.00 (±0.00)
	Lagoon & outer reef	2.50 (±0.22)	0	3.86 (±0.17)	0
	Outer reef	2.00 (±0.00)	0	4.50 (±0.32)	0
	Outer reef & passage	1.83 (±0.17)	0	4.67 (±0.33)	0
Invertebrates	Reeftop	0.75 (±0.11)	0.96 (±0.17)	3.00 (±0.22)	2.68 (±0.12)
	Soft benthos	0	1.00 (±0.00)	0	3.13 (±0.52)
	Soft benthos & reeftop	1.17 (±0.44)	0	2.17 (±0.44)	0
	Mangrove	0.50 (n/a)	3.00 (n/a)	1.50 (n/a)	4.00 (n/a)
	Lobster	1.00 (n/a)	0	3.00 (n/a)	0
	Other	1.00 (±0.00)	0	4.00 (±0.00)	0

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the trochus, giant clam, lobster and bêche-de-mer fishery.
Finfish fisher interviews, males: n = 33; females: n = 8. Invertebrate fisher interviews, males: n = 13; females: n = 14.

5.2.3 Catch composition and volume – finfish: Vaisala

The reported catches from the combined fishing of the sheltered coastal reef and the lagoon in Vaisala are determined by eight species groups: two Acanthuridae (*Acanthurus lineatus*, *Ctenochaetus striatus*), Scaridae (*Scarus* spp.), Serranidae (*Epinephelides armatus*), Mullidae (*Mullus* spp.), Holocentridae (*Myripristis* spp.), Mureanidae (*Echidna nebulosa*) and Lethrinidae (*Lethrinus* spp.). If the sheltered coastal reef and mangrove areas are jointly targeted, catches are composed of three major species groups: *Lutjanus bohar*, *Scarus* spp. and *Siganus* spp. Also, lagoon catches were reported to be less diverse than those from the sheltered coastal reef, but again mainly determined by six species or species groups, including *Scarus* spp., the Acanthuridae *Ctenochaetus striatus* and *A. lineatus*, *Epinephelus* spp., *Myripristis* spp. and *Lethrinus* spp. These major species groups also make up most of the reported catches from the lagoon and outer reef combined, with Acanthuridae and Scaridae being increasingly more important, possibly because spear diving and handlining are more important at the outer reef than in the habitats closer to shore. Scaridae and Acanthuridae, families that are mainly targeted by spear divers, dominate catches reported from the outer reef. Here, *Scarus* spp. make up ~30% of the total reported catches, *Acanthurus* spp. another 16% and Myripristis spp. ~9%. Detailed information on catch compositions by species, species groups and habitats is reported in Appendix 2.4.1.

Figure 5.9 highlights the above findings from the socioeconomic survey, that finfish are caught mainly for subsistence rather than commercial interests. The total annual catch is estimated to be ~90 t, of which ~76 t (84.1%) are used for subsistence needs. The remaining 14 t (~16% of the total annual catch) are sold outside the Vaisala community. The dominance of male fishers shows in the proportion of catch that they take: 87% of the total annual catch. Thus, it can be concluded that males are the main fishers responsible for fishing both to supply their family consumption needs and to generate income. Females fish occasionally, mainly for home consumption rather than for income. About one-third of the total impact is imposed on each of the major habitats: the sheltered coastal reef including mangroves, the lagoon, and the outer reef, including passages.

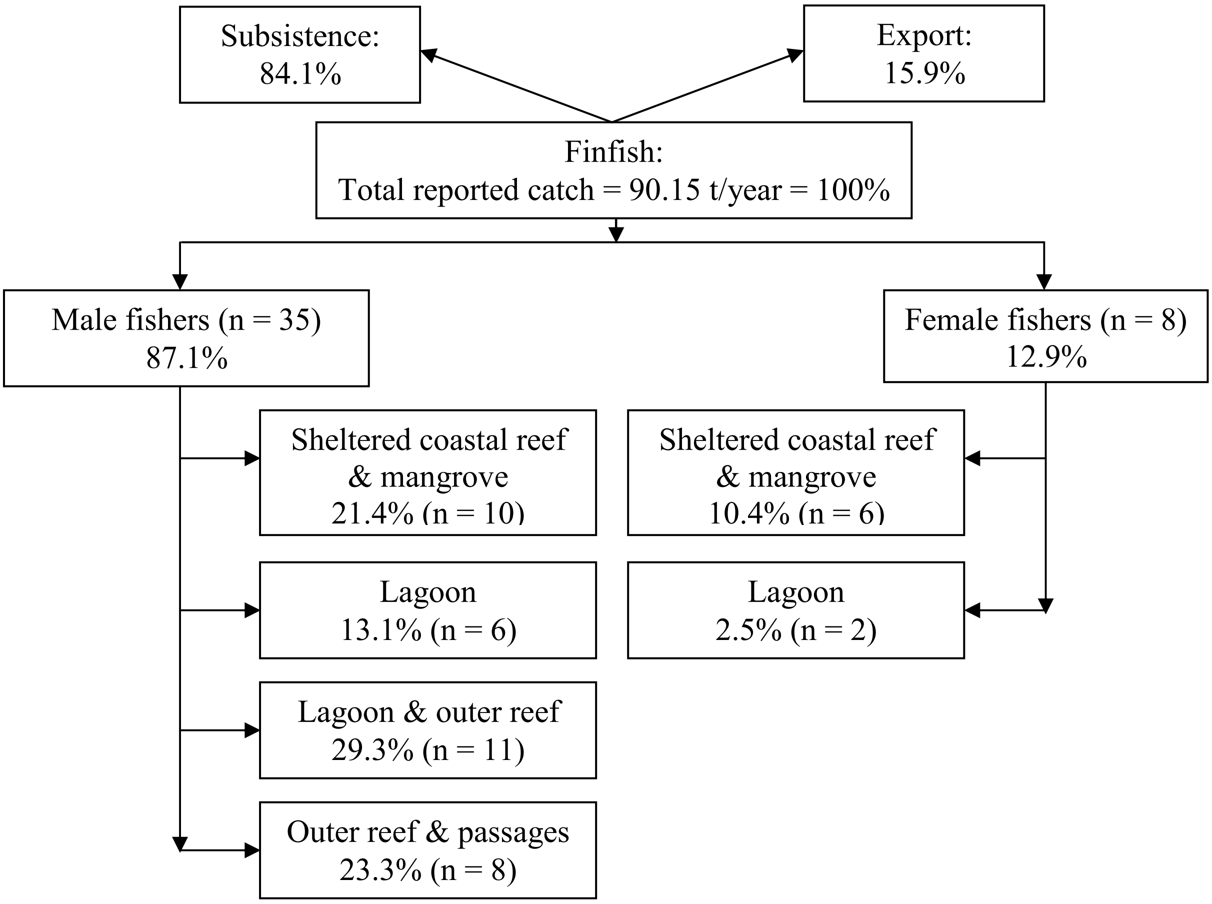

Figure 5.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Vaisala.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The almost equal distribution of annual catch weight among the sheltered coastal reef, lagoon and mangrove habitats, and outer reef and passages, is a consequence of higher annual catch rates at the outer reef, including passages. These proportions are determined by dedicating half of the catch from trips to combined habitats to each of the two habitats concerned. As observed earlier, there are fewer fishers who fish the outer reef, and they do so less often; however, each fisher catches on average about 600 kg/year. By comparison, the numerous fishers who target the closer habitats catch only about 400–450 kg/year on average. Figure 5.10 demonstrates that the average annual catch rate for females is below that for males in lagoon fishing. This does not, however, apply for catches from the sheltered coastal reef and lagoon habitats combined, where males' and females' catch rates are similar.

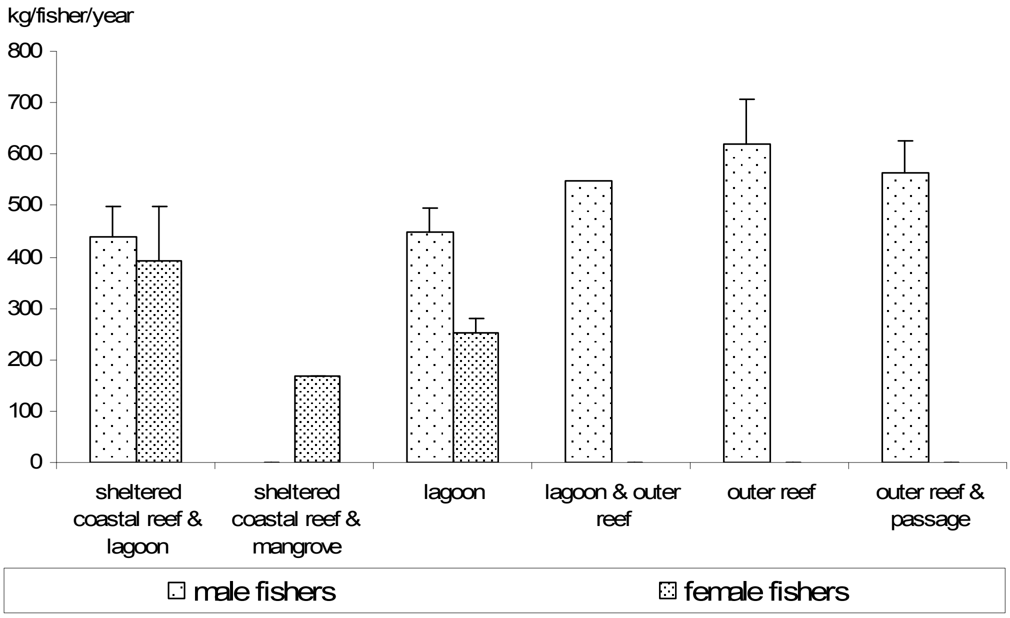

Figure 5.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Vaisala (based on reported catch only).

Comparing productivity rates between genders and among habitats (Figure 5.11), there are no obvious differences between male and female fishers, or among CPUEs calculated for any of the different habitats or combinations of habitats that were reported. Overall, CPUEs are low, around 1.5 kg/hour of fishing trip.

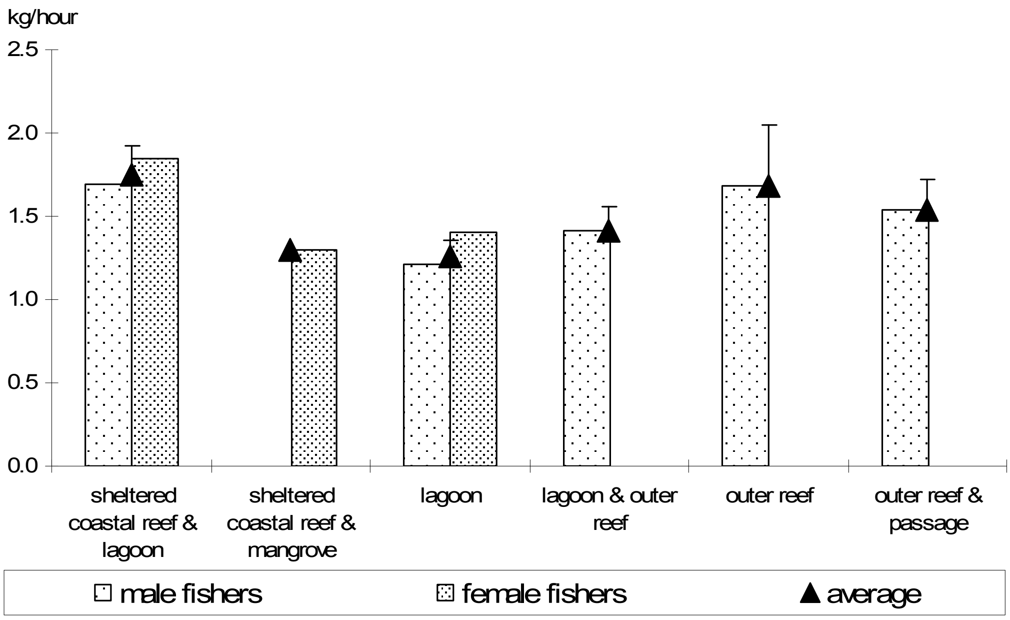

Figure 5.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in Vaisala.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Figure 5.12 clearly shows that finfish fishing in Vaisala is mostly to supply subsistence needs. Male fishers targeting the outer reef and passages mainly fish for income-generating purposes; however, even in these habitats a considerable proportion of fishing is still for subsistence needs.

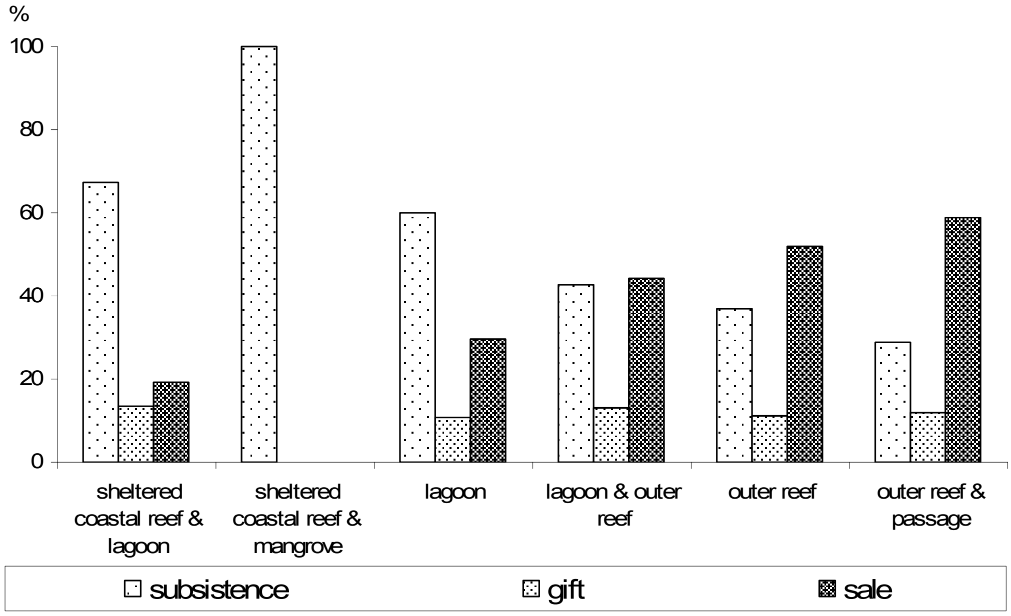

Figure 5.12: The use of finfish catches for subsistence, gift and sale, by habitat in Vaisala. Proportions are expressed in % of the total number of trips per habitat.

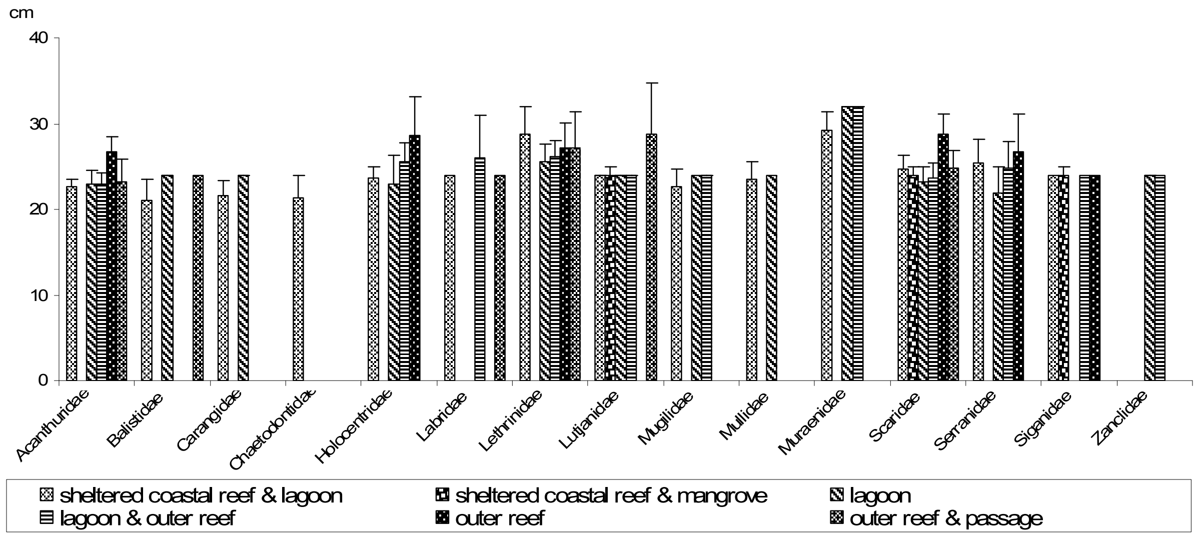

Figure 5.13: Average sizes (cm fork length) of fish caught by family and habitat in Vaisala. Bars represent standard error (+SE).

The overall productivity of finfish fishing was similar among habitats (Figure 5.11). This observation is supported by the average fish sizes (fork length) reported for the major families caught (Figure 5.13). Usually, one would expect an increase in the size for the same species or species groups caught with increasing distance from the shore. However, in the case of reported catches in Vaisala, this general assumption was not observed. Acanthuridae and Scaridae are usually sensitive to fishing impact; both these families are major targets for spear diving, which is used in all habitats but more often at the outer reef. The slightly larger sizes of both families at the outer reef may confirm this general assumption; however, if we take into account standard errors and variations in the collected information, these differences may not be significant.

The indicators selected to assess current fishing pressure on Vaisala's reef and lagoon resources are shown in Table 5.4. Due to the limited reef surface and total fishing ground, population density, fisher density and catch rates per unit areas of reef and fishing ground are all high. However, it should be borne in mind that one-third of the total annual impact is sourced from the outer reef and passages, habitats that have a high level of interaction with adjacent reef areas and the open ocean. This effect may dilute actual fishing impact, at least on the outer-reef habitats.

Table 5.4: Parameters used in assessing fishing pressure on finfish resources in Vaisala

Parameters	Habitat					
	Sheltered coastal reef & lagoon	Lagoon	Outer reef	Outer reef & passages	Total reef area	Total fishing ground
Fishing ground area (km^2)	n/a	1.94	0.10	1.67	3.38	3.60
Density of fishers (number of fishers/km^2 fishing ground) [(1)]	n/a	18	210	8	56	52
Total number of fishers	15	34	21	13	188	188
Population density (people/km^2) [(2)]					444	417
Average annual finfish catch (kg/fisher/year) [(3)]	424.02 (±50.73)	398.84 (±46.65)	619.99 (±87.84)	563.49 (±62.48)		
Total fishing pressure of subsistence catches (t/km^2)					22	21

Figures in brackets denote standard error; n/a = no information available; [(1)] total number of fishers is extrapolated from household surveys; [(2)] total population = 1502; total number of fishers = 188; total subsistence demand = 75.81 t/year; [(3)] catch figures are based on recorded data from survey respondents only. Sheltered coastal reef and mangrove combined fishing trips (average annual catch rate = 168.85 kg/fisher/year (n/a), total fishers = 4), and lagoon and outer reef combined fishing trips (average annual catch rate = 547.35 kg/fisher/year (±50.05), total fishers = 51) are excluded in the above table for clarity reasons.

5.2.4 Catch composition and volume – invertebrates: Vaisala

Calculating reported catches from invertebrate fishers by wet weight shows that only a few species account for the major annual impact expressed in wet weight (Figure 5.14). The combined catches of bêche-de-mer species, including *Stichopus horrens* and *Holothuria* spp., account for most, i.e. an accumulated annual wet weight of 27.8 t. Bêche-de-mer is considered a delicacy in Samoa, and intestines recovered from collected specimens are either used for home consumption or sold by both males and females. Giant clams, shown under two different vernacular names (*pipi* and *faisua*) account for another 22.4 t/year (wet weight). Catches of other species, such as *Chama* spp. (*fee*), octopus, lobsters and other shellfish, are insignificant by comparison.

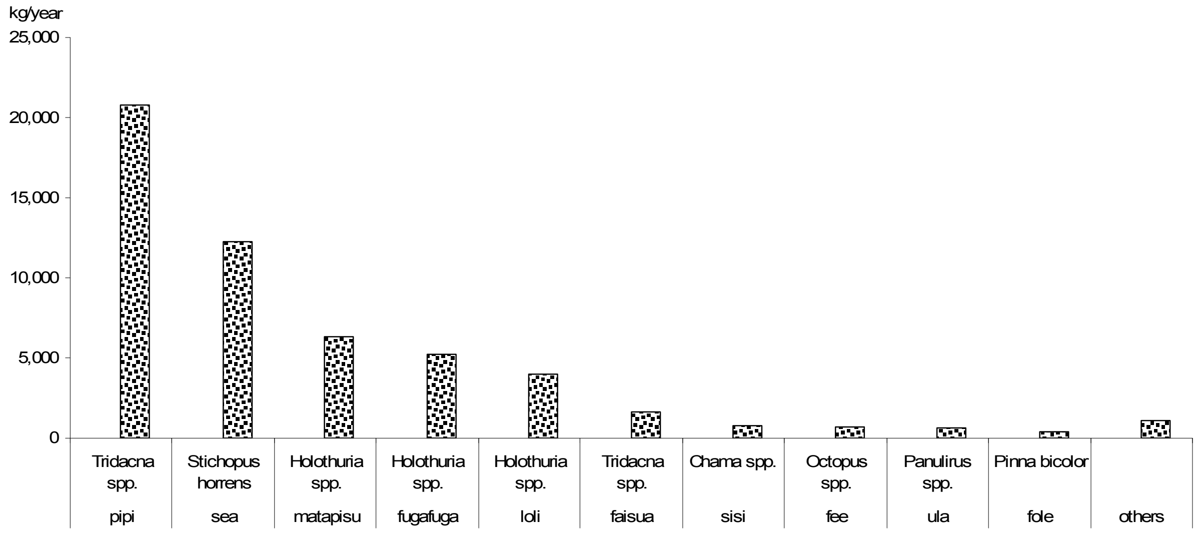

Figure 5.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Vaisala.

The predominance of reeftop and soft-benthos gleaning also shows in the number of vernacular names reported by respondents. While the reeftop fishery is represented by 16 different vernacular names, soft benthos had only five names, and these mainly refer to bêche-de-mer species. All other fisheries are represented by only a few vernacular names representing target species (Figure 5.15).

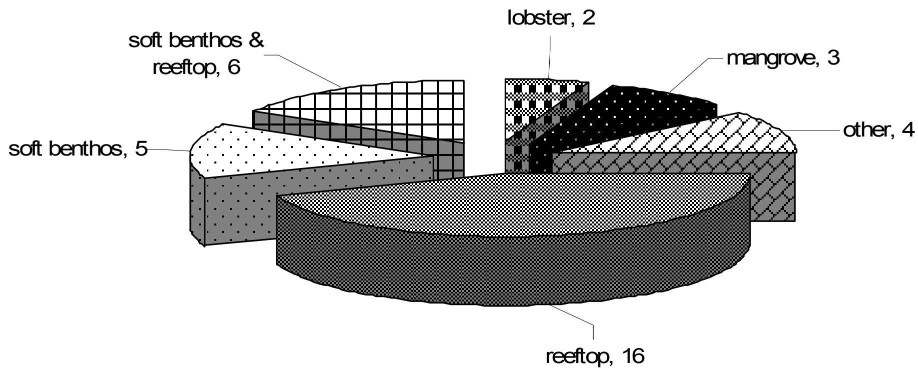

Figure 5.15: Number of vernacular names recorded for each invertebrate fishery in Vaisala.
'Other' refers to trochus, giant clam, lobster and bêche-de-mer fishery.

The average annual catch per fisher by gender and fishery (Figure 5.16) reveals substantial differences. First, females collect more than males on average per year from reeftops, but less from mangroves. Secondly, the highest annual catches are from the soft-benthos fisheries; however, these catches also show the greatest variation (SE) among female fishers. If we take standard errors into account, average annual catches from the soft benthos (performed by females) and the combined soft benthos and reeftop fisheries (performed by males), are similar in quantities, and the highest compared to all other fisheries. Accordingly, catch rates can be as low as 100 kg/fisher/year (lobsters) and as high as 3.8 t/fisher/year (soft-benthos gleaning by female fishers). The pattern supports the earlier observation, that bêche-de-mer are one of the local delicacies that are also sold outside the community. The same may apply for giant clams, which are mostly collected by males.

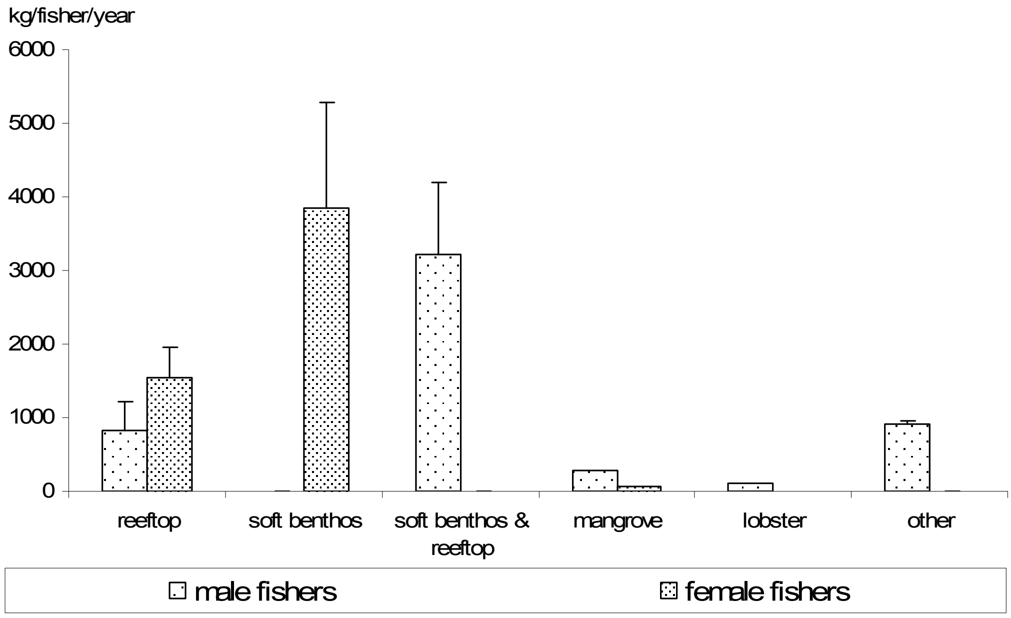

Figure 5.16: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Vaisala.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 13 for males, n = 19 for females).

The fact that most invertebrate catches serve home consumption needs is highlighted by Figure 5.17. Less than 6% of the total reported annual catch by wet weight is sold. This figure is based on the assumption that half of the reported catch used for either subsistence or sale is actually sold. Results suggest that any impact imposed by invertebrate harvesting is basically determined by the subsistence needs of the Vaisala community.

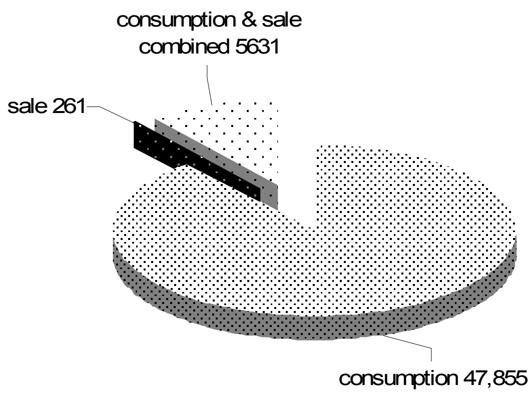

Figure 5.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Vaisala.

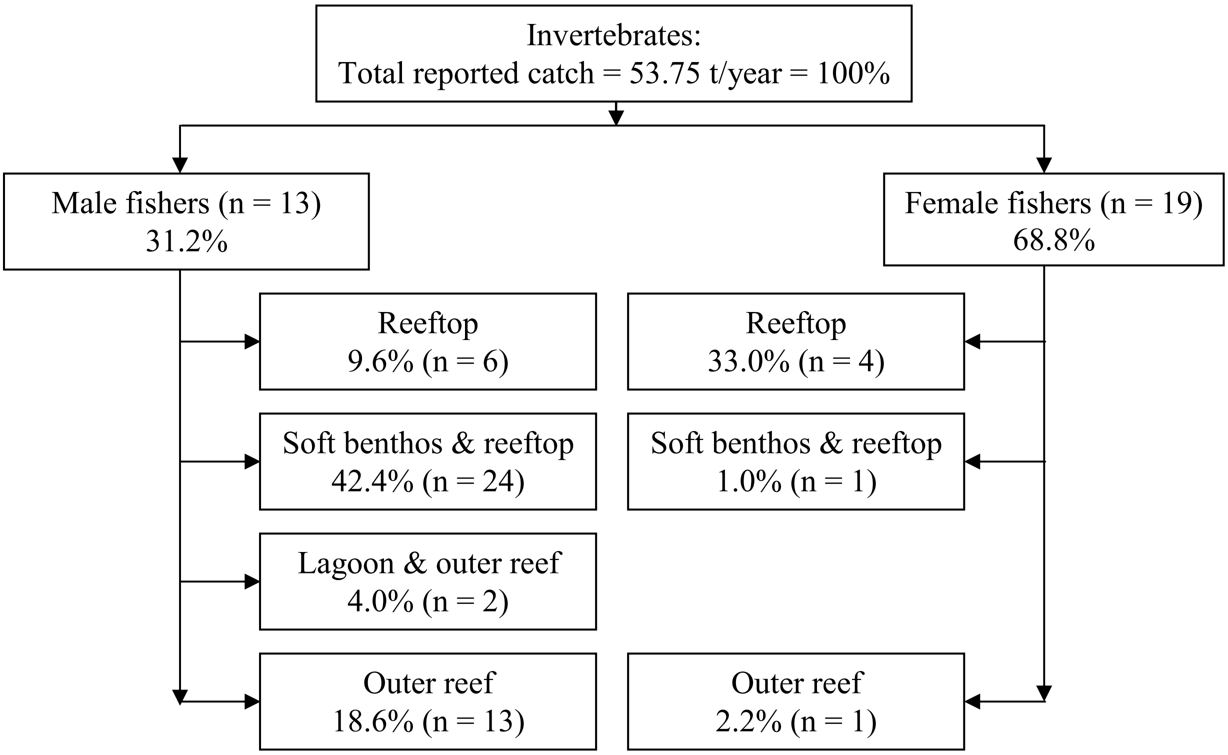

Figure 5.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Vaisala.
'Other' refers to the trochus, giant clam, lobster and bêche-de-mer fishery; n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

As mentioned earlier, females are more involved in invertebrate fishing than males and this observation is confirmed by Figure 5.18. While females account for ~69% of the total annual catch (wet weight), males contribute only ~31%. Both female and male fishers' catches mainly target reeftops and the combined reeftop and soft-benthos areas, with a total of ~43% of total annual catches from reeftops alone and another ~46% from the combination of reeftops and soft benthos. Only males dive for lobsters, trochus, giant clams and bêche-de-mer, but overall, impacts from these catches are negligible. The same applies for impacts from mangrove catches (0.6% of total annual catch in wet weight), either taken by males or females.

Table 5.5: Parameters used in assessing fishing pressure on invertebrate resources in Vaisala

Parameters	Fishery / Habitat					
	Lobster [3]	Mangrove	Other	Reeftop	Soft benthos	Soft benthos & reeftop
Fishing ground area (km^2)	3.91	n/a	1.96	1.63	n/a	n/a
Number of fishers (per fishery) [1]	4	10	8	102	22	12
Density of fishers (number of fishers/km^2 fishing ground)	1		4	63		
Average annual invertebrate catch (kg/fisher/year) [2]	98.44 (n/a)	168.29 (±109.66)	914.90 (±46.32)	1324.58 (±325.21)	3841.33 (±1434.88)	3208.41 (±987.20)

Figures in brackets denote standard error; n/a: no information available or standard error not calculated; [1] total number of fishers is extrapolated from household surveys; [2] catch figures are based on recorded data from survey respondents only; [3] linear measure km reef length; 'Other' refers to the trochus, giant clam, lobster and bêche-de-mer fishery.

Taking into account available figures on the length of the outer reef that is considered to support lobster dive fisheries, and the inner-reef surface area, fisher density is low for the lobster fishery and moderate to high for reeftop collection. Taking into account that both reeftop and soft-benthos habitats supply the highest annual catches for most fishers, both areas may be considered potentially impacted. However, the actual status and estimation of possible future impacts on these resources need to be verified by results from the resource surveys.

5.2.5 Management issues: Vaisala

Management of marine resources in Samoa occurs at two levels, and so does enforcement: through governmental institutions and traditional village systems. At the national level, regulations mainly refer to size restrictions and harvesting techniques employed. At the community level, community-based reserve areas have been promoted since 1996 and today include about 150 villages. Initially, the programme was assisted by AusAID funding. The programme's success rate, however, varies. One of the major obstacles to assessing impact is the absence of baseline surveys to compare the past and current and status and use of reef resources and predict future levels of fishing impact and use.

Vaisala is one of the 150 villages participating in the community-based reserve programme. Vaisala's community-based reserve area was established in 1997 with the assistance of the Fisheries Department. Under the programme, fishing is banned in certain parts of the lagoon and coastal reef. A committee formed by people from all villages in the Vaisala district monitors, ensures compliance, enforces regulations if necessary, and imposes punishment for misconduct. The existing regulations, however, allow the ban to be periodically lifted if requested by the village chiefs. These requests are usually to meet obligations for special religious or traditional functions. Survey respondents confirmed that catches have improved since the ban was in place. However, it should also be noted that people from Vaisala have started to explore new areas, as the ban has reduced access to their traditional fishing grounds. This was particularly the case in Fagasa, one of the villages within the Vaisala district, which established a fishing ban on the major part of their reef area and also imposed a fishing ban within 100 m of the protected reef area. Fishers found it difficult to cope with the limited access and, as a result, requested permission from neighbouring communities to fish in their fishing grounds. Expanding fishing activities to other areas needs permission from village elders, as fishing access and marine tenure is well demarcated. Because management measures have already been set in place, any scientific study, e.g. the PROCFish survey, should assist in further strengthening Vaisala's community fisheries management scheme.

5.2.6 Discussion and conclusions: socioeconomics in Vaisala

- Vaisala is a community that has access to agricultural land and marine resources. However, due to its geographical isolation and distance from Samoa's main centre, opportunities to earn income from salaries are limited. As a consequence, people are highly dependent on remittances to meet their many traditional and religious obligations. Additionally, agricultural produce provides more income than do fisheries, as it is less sensitive to storage and transportation time. The Vaisala community has participated in the national community-based fisheries management programme at an early stage and thus has established a reserve area, where fishing is banned within their demarcated reef and lagoon fishing grounds.

- Survey results obtained suggest the following:

  - Vaisala's population is highly dependent on marine resources as a source of food and protein but only to a small extent to generate income, mainly due to the lack of market access and storage capacities.

  - Fresh-fish consumption is not as high as expected, presumably due to the availability of alternative protein sources. However, invertebrate and canned fish consumption levels are both high, due to the fact that females gather invertebrates as easily available food items, and because canned fish is used for *falavelave*, which occur very often.

  - Consumption and income patterns both suggest a highly traditional and remote, rural lifestyle. This conclusion is supported by information from interviews with fishers. Gender roles also suggest a very traditional lifestyle, with females collecting invertebrates, while males fish for finfish and do all the diving.

  - Finfish fishing is limited to easily accessible habitats due to the limited numbers of boats, especially boats equipped with outboard motors. The wide range of techniques used suggests that investment levels for fishing are low and thus fishers use techniques for which tools are readily available.

  - No major differences were found in CPUE for finfish by gender or by habitat, suggesting that resource status is similar across all habitats.

  - Reported average fish sizes by major families caught do not show the expected increase with distance from shore. This observation also applies to families (Acanthuridae, Scaridae) mainly targeted by spear divers at the outer reef.

  - Invertebrates are mainly harvested by gleaning reeftops and soft benthos. Bêche-de-mer and giant clams are the major target species groups for subsistence and, to a lesser extent, commercial purposes. In contrast to finfish fishing, significant differences were found in the average annual invertebrate catches per fisher by fishery and gender.

- Indicators of fishing pressure calculated for finfish and invertebrate fisheries suggest that, due to the limited reef and overall fishing ground area, fisher densities and average annual catch rates, as well as catch per unit areas, are high. The fact that Vaisala was one of the first communities to participate in the nationwide community-based fisheries management programme may hint that there was a potential problem that was already known in the past. On the other hand, the fact that most impact is caused by the subsistence demand of the local community only, and that results do not reveal any major differences in finfish fisheries (average fish lengths, CPUEs) by habitat, does not suggest any such problem.

- Final assessment needs comparison between the results of the socioeconomic survey and those of the resource surveys. In any case, results from the Vaisala site underline the need for proper indicators to assess future stocks and use development against measured baselines. The fact that the community has established protected reef areas where fishing is banned does not necessarily solve the problem of unsustained resource use. The fact that fishers seek permission to catch fish in other communities' fishing grounds may just shift the problem geographically. The Vaisala site study also highlights the need to adopt a precautionary approach to resource use to immediately safeguard current stocks and thus to maintain marine resources for subsistence and economic livelihoods of the people.

5.3 Finfish resource surveys: Vaisala

The fishing ground of Vaisala is relatively small and fishing is mainly restricted to reef areas next to the village. The coral reefs are relatively healthy with a higher cover of live corals in the sheltered lagoon than on the outer-reef slope. The lagoon is relatively shallow, with pools of slightly deeper water. Underground tunnels discharge freshwater directly into the lagoon, which made survey work difficult in some locations because visibility was distorted within the top one metre of the water column. Natural disasters, e.g. cyclones and COTS outbreaks have affected the reef system. A handful of COTS were sighted during the surveys. Vaisala has one localised tabu area/MPA, which had been established about five years at the time of the survey.

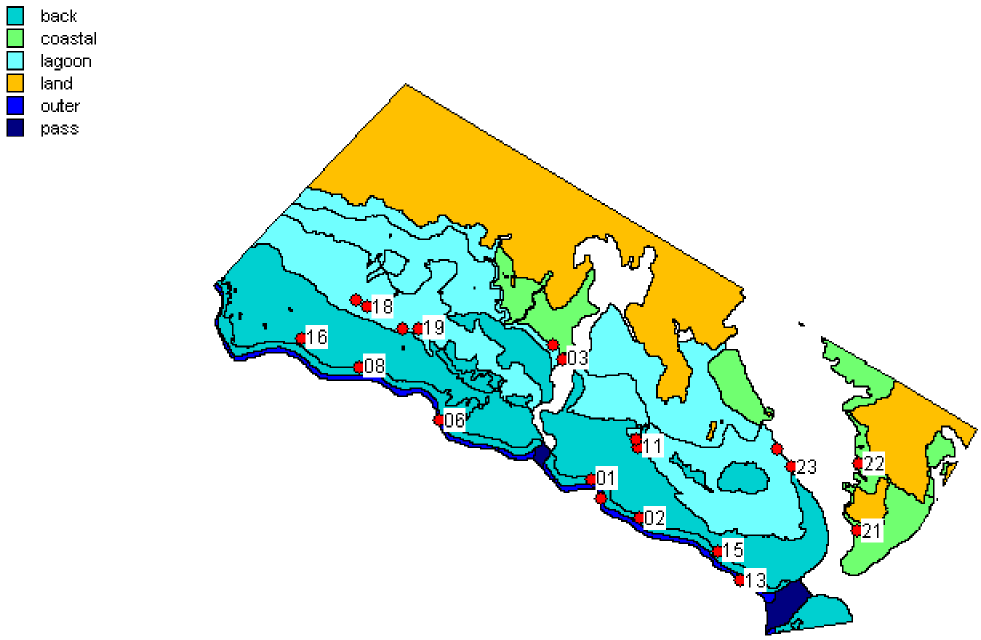

Figure 5.19: Habitat types and transect locations for finfish assessment in Vaisala.

5.3.1 Finfish assessment results: Vaisala

A total of 25 sites were sampled in two reef habitats, back-reef (17 sites) and outer reef (8 sites, see Figure 5.19 and Appendix 3.4.1 for transect locations.). A total of 22 families, 46 genera, 114 species and 10,027 fish were recorded in the 25 transects (See Appendix 3.4.2 for list of species.). Only data on the 14 dominant commercial families are presented below, representing 37 genera, 104 species and 9856 fish.

Table 5.6: Primary finfish habitat and resource parameters recorded in Vaisala (average values ±SE)

Parameters	Habitat		
	Back-reef (1)	**Outer reef (1)**	**All reefs (2)**
Number of transects	17	8	25
Total habitat area (km^2)	1.71	1.57	3.28
Depth (m)	2 (1-4) (3)	7 (4-12) (3)	3 (1-12) (3)
Soft bottom (% cover)	12.4 ±2.2	1.6 ±0.8	7.3
Rubble & boulders (% cover)	10.5 ±2.8	8.2 ±4.2	9.4
Hard bottom (% cover)	55.4 ±5.0	84 ±5	69.1
Live coral (% cover)	21.7 ±4.4	6.2 ±1.6	14.3
Soft coral (% cover)	0.02 ±0.02	0.00 ±0.00	0.01
Biodiversity (species/transect)	23 ±2	27 ±4	24 ±4
Density (fish/m^2)	0.77 ±0.11	0.74 ±0.16	0.76
Size (cm FL) (4)	13.7 ±0.4	17.9 ±0.7	15.7
Size ratio (%)	47.3 ±1.3	62.3 ±2.3	54.5
Biomass (g/m^2)	64.9 ±14.4	132.0 ±35.2	97

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

Back-reef environment: Vaisala

The back-reef of Vaisala was largely dominated by the herbivore families: Scaridae and Acanthuridae, followed by the carnivore families: Holocentridae and Lutjanidae, with much lower density and biomass. Chaetodontidae were relatively important in density. The main species were, in order of decreasing biomass: *Ctenochaetus striatus* (with the highest biomass overall), *Scarus psittacus*, displaying the highest density, *S. oviceps*, *Chlorurus sordidus*, *Acanthurus triostegus*, *Lutjanus fulvus* and *Neoniphon sammara* (Table 5.7).

Table 5.7: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Vaisala

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.22	8.4
	Chlorurus sordidus	Bullethead parrotfish	0.08	6.4
	Scarus oviceps	Dark-capped parrotfish	0.05	7.1
Acanthuridae	*Ctenochaetus striatus*	Striped bristletooth	0.13	10.8
	Acanthurus triostegus	Convict tang	0.08	6.2
Lutjanidae	*Lutjanus fulvus*	Flametail snapper	0.01	2.2
Holocentridae	*Neoniphon sammara*	Bloodspot squirrelfish	0.01	0.8

The back-reef habitat displayed higher density but much lower biomass (half as much) than the outer reef (Table 5.6), due to smaller fish in this habitat. In fact, sizes and size ratios were much smaller in the back-reefs. Species diversity was also lower.

Compared to the other back-reef environments surveyed at the other sites in Samoa, Vaisala displayed the second highest values of density, but the second lowest biomass and size (Table 5.8). Densities and biomass of Acanthuridae and Scaridae, the two most important families overall, were similar to values in Salelvalu and Vaisala, and much lower than in Manono-uta.

The substrate was composed of more than 10% soft bottom and there was much less hard bottom compared to the outer reef, but live-coral cover was much higher (20%) than at the other habitats (6%).

Table 5.8: Comparisons of the back-reef biological parameters among the four Samoan sites

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	0.95 (±0.28)	95.4 (±44.5)	14.6 (±0.6)	52.0 (±2.2)
Salelavalu	0.68 (±0.07)	70.0± (9.7)	14.6 (±0.6)	49.2 (±2.0)
Vailoa	0.59 (±0.07)	44.5± (7.5)	12.8 (±0.6)	46.2 (±2.1)
Vaisala	**0.77 (±0.11)**	**64.9 (±14.4)**	**13.7 (±0.4)**	**47.4 (±1.3)**

Figures in brackets denote standard error; FL = fork length.

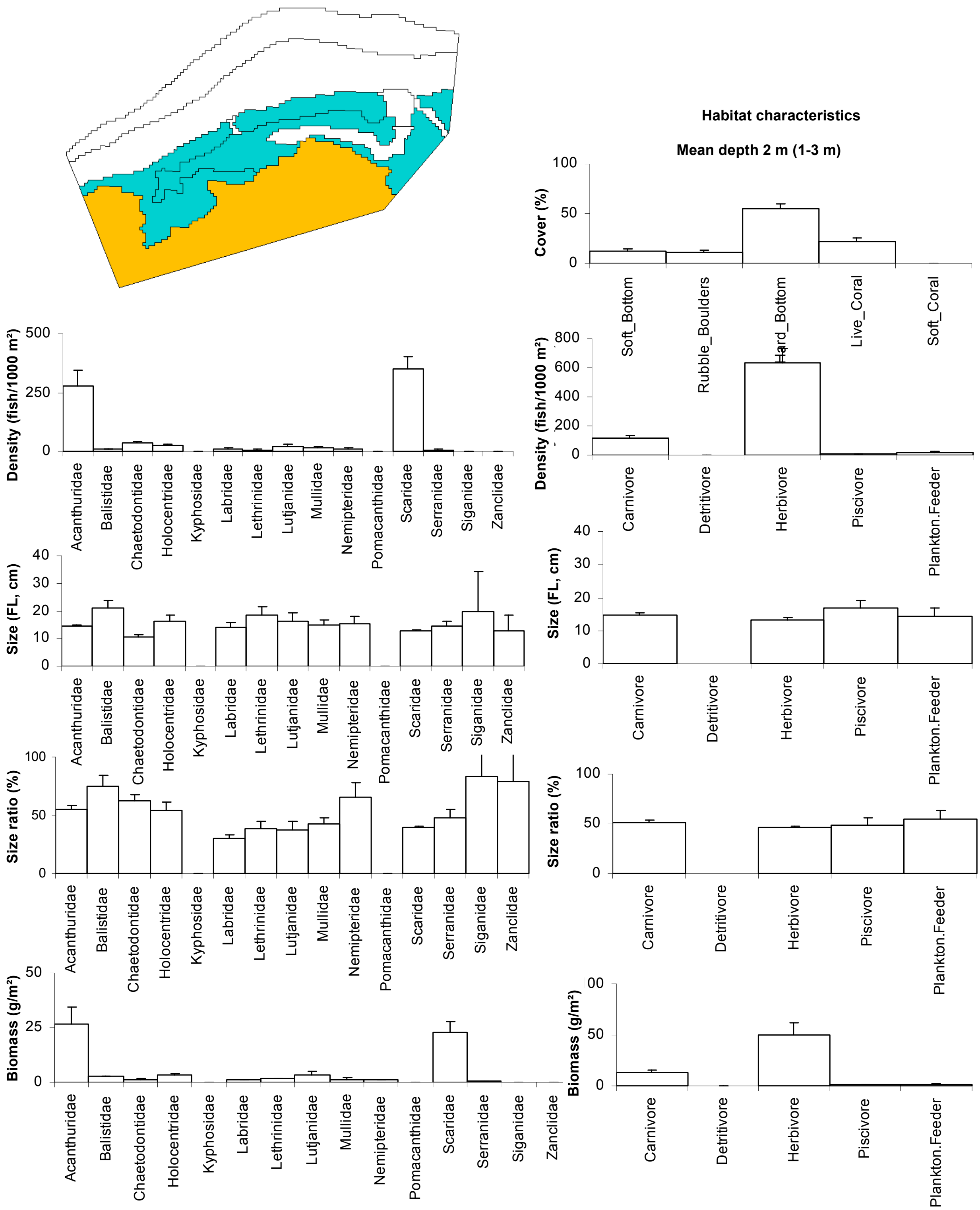

Figure 5.20: Profile of finfish resources in the back-reef environment of Vaisala.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Vaisala

The outer reef of Vaisala was largely dominated by the herbivore family Acanthuridae, followed by Scaridae, and the carnivore families: Balistidae and Lutjanidae, both in terms of density and biomass. The species composition was very diverse, with six species of surgeonfish most abundant: *Ctenochaetus striatus* (highest density and biomass), *Acanthurus nigricans*, *A. lineatus*, *A. nigricauda*, *Naso lituratus* and *C. strigosus* (in order of decreasing biomass); three species of parrotfish: *Chlorurus sordidus* (highest biomass of all the parrotfish), *Scarus psittacus*, and *Scarus oviceps*; four species of triggerfish: *Melichthys vidua*, *Balistapus undulatus*, *Rinecanthus rectangulus* and *Sufflamen chrysopterus*; and two main species of Lutjanidae: *Lutjanus kasmira* and *Aphareus furca* (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 Vaisala

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striped bristletooth	0.20	18.4
	Acanthurus nigricans	Whitecheek surgeonfish	0.08	13.6
	Acanthurus lineatus	Striped surgeonfish	0.07	13.6
	Acanthurus nigricauda	Blackstreaked surgeonfish	0.02	11.2
	Ctenochaetus strigosus	Goldring bristletooth	0.02	3.7
	Naso lituratus	Orangespine unicornfish	0.01	6.8
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.06	7.4
	Chlorurus sordidus	Bullethead parrotfish	0.04	13.4
	Scarus oviceps	Darkcapped parrotfish	0.02	5.6
Balistidae	*Melichthys vidua*	Pinktail triggerfish	0.04	10.0
	Balistapus undulatus	Orangestriped triggerfish	0.02	3.2
	Rinecanthus rectangulus	Wedge picassofish	0.01	2.2
	Sufflamen chrysopterus	Halfmoon triggerfish	0.01	1.9
Lutjanidae	*Lutjanus kasmira*	Bluelined snapper	0.02	2.8
	Aphareus furca	Smalltooth jobfish	0.01	3.4

Biomass, size and species diversity were higher than in the back-reef habitat, while density was lower. Among the four country sites surveyed, the outer reefs of Vaisala displayed the lowest values of density and biomass, but the highest sizes and size ratios (Table 5.10). Acanthuridae and Scaridae were the main fish families but displayed the lowest biomass over the four sites.

Most of the substrate was composed of hard bottom (84%); live-coral cover was very low.

Table 5.10: Comparisons of the outer-reef biological parameters among the four Samoan sites

Site	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	1.31 (±0.13)	201.2 (±30.9)	17.1 (±0.6)	57.6 (±2.0)
Salelavalu	0.94 (±0.18)	166.0 (±28.9)	18.0 (±0.7)	59.5 (±2.2)
Vailoa	1.03 (±0.13)	179.0 (±32.0)	17.3 (±0.5)	62.0 (±1.7)
Vaisala	**0.74 (±0.16)**	**132.0 (±35.2)**	**17.9 (±0.7)**	**62.3 (±2.3)**

Figures in brackets denote standard error; FL = fork length.

Figure 5.21: Profile of finfish resources in the outer-reef environment of Vaisala.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Vaisala

The total reef area sampled (outer reef plus back-reef) was numerically dominated by Acanthuridae, Scaridae and Balistidae. In addition, Lutjanidae were an important component of total biomass. The most relevant species were numerous, showing a high diversity in the fish community. *Ctenochaetus striatus*, *Chlorurus sordidus*, *Scarus psittacus*, *Acanthurus lineatus*, *Scarus oviceps*, *A. nigricans*, *A. nigricauda*, *Melichthys vidua*, *Naso lituratus*, *A. triostegus*, *Balistapus undulatus* and *Lutjanus kasmira* were the most important species listed in order of decreasing biomass (Table 5.11).

Table 5.11: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Vaisala (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striped bristletooth	0.16	14.5
	Acanthurus triostegus	Convict tang	0.05	3.5
	Acanthurus nigricans	Whitecheek surgeonfish	0.04	5.6
	Acanthurus lineatus	Striped surgeonfish	0.04	7.4
	Acanthurus nigricauda	Blackstreaked surgeonfish	0.01	5.5
	Naso lituratus	Orangespine unicornfish	0.01	4.5
Scaridae	*Scarus psittacus*	Palenose parrotfish	0.14	7.9
	Chlorurus sordidus	Bullethead parrotfish	0.06	9.8
	Scarus oviceps	Darkcapped parrotfish	0.03	6.4
Balistidae	*Melichthys vidua*	Pinktail triggerfish	0.02	4.8
	Balistapus undulatus	Orangestriped triggerfish	0.01	2.5
Lutjanidae	*Lutjanus kasmira*	Bluelined snapper	0.01	1.4

Vaisala site displayed the second lowest values of density and biomass among the four samples sites in Samoa, higher only than Salelavalu, and the same as Vailoa. Mean fish sizes were, however, the second highest after Manono-uta. Species diversity was the lowest in the country (Table 5.12).

Table 5.12: Values (average per transects) of descriptive biological parameters for each site

	Average number of species	Average number of fish	Density (fish/m^2)	Biomass (g/m^2)	Mean size (FL, cm)	Size ratio (%)
Manono-uta	28	451	1.0	144.4	15.9	56.1
Salelavalu	29	363	0.5	59.6	13.4	44.6
Vailoa	30	440	0.8	103.0	14.6	52.4
Vaisala	**24**	**401**	**0.8**	**97.0**	**15.7**	**54.5**

Figures in brackets denote standard error; FL = fork length.

Most of the species dominating the fish assemblage of Vaisala were herbivores, as shown in Figure 5.22.

This site was mostly covered by hard bottom and had the second lowest cover of live coral among the country sites.

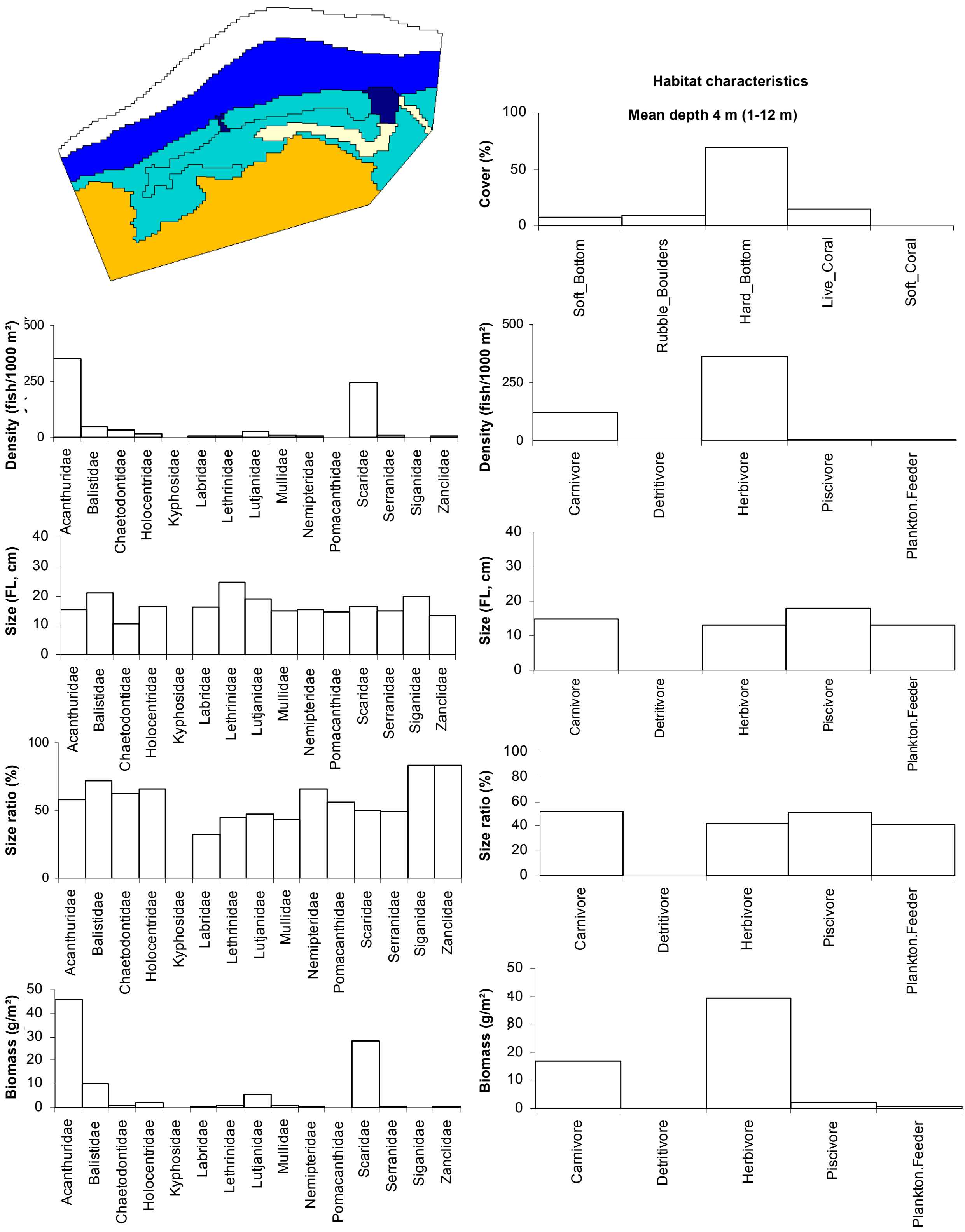

Figure 5.22: Profile of finfish resources in the combined reef habitats of Vaisala (weighted average).
FL = fork length.

5.3.2 Discussion and conclusions: finfish resources in Vaisala

- In conclusion, finfish resources in Vaisala appeared rather poor, with low values of density, biomass and species number. Total biomass was the second lowest after Salelavalu. Only two habitats were surveyed at this site; the outer-reef habitat was richer than the back-reef, displaying higher stock, due to the presence of larger fish.

- Fishing activities at Vaisala are intense and fishing pressure is especially concentrated in the outer reefs. Spearfishing is the most common fishing method used, in both the outer reef and back-reef. This fishing technique could hasten the overfishing of specific targeted resources. In fact Scaridae, which, along with Acanthuridae are the most fished family at this site and the main target of spearfishing, appear to be decreasing in abundance in the outer reefs. This impact from targeted fishing is evident when comparing densities among the outer-reef habitats of the other survey sites.

5.4 Invertebrate resource surveys: Vaisala

The diversity and abundance of invertebrate species at Vaisala were independently determined using a range of survey techniques: broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 5.23) and finer-scale assessment of specific reef and benthic habitats (Table 5.13, locations shown in Figures 5.24 and 5.25).

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

Table 5.13: Number of stations and replicate measures completed at Vaisala

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	74 transects
Reef-benthos transects (RBt)	21	126 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	0	0 transect
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	5	30 search periods
Sea cucumber night searches (Ns)	3	18 search periods
Sea cucumber day searches (Ds)	6	36 search period

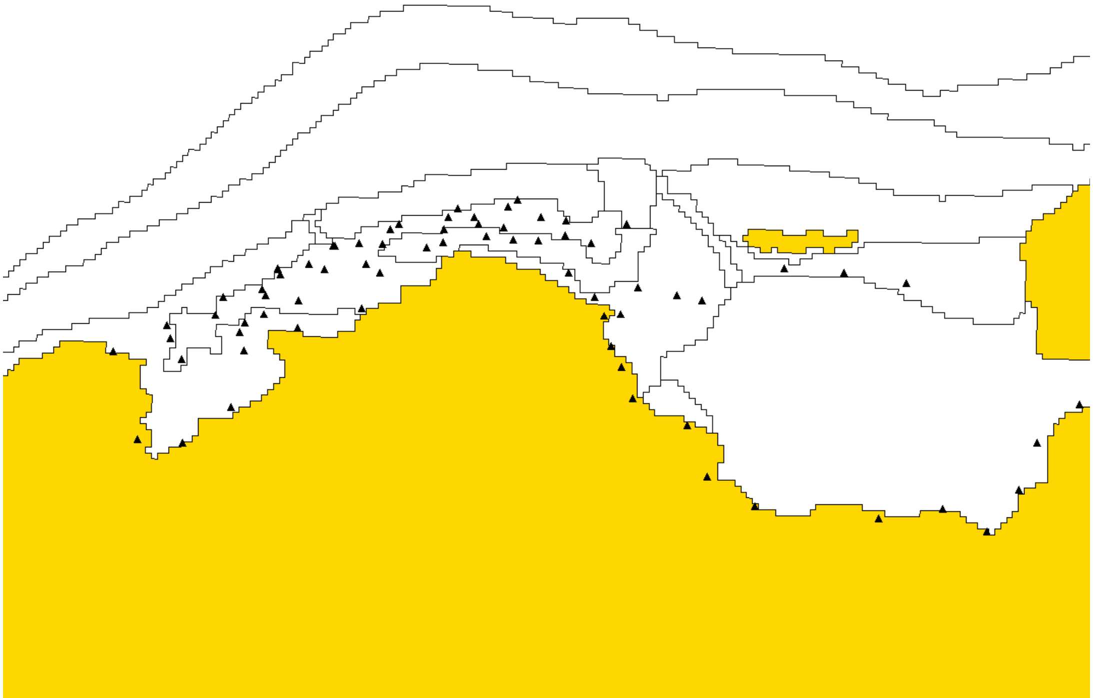

Figure 5.23: Broad-scale survey stations for invertebrates in Vaisala.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

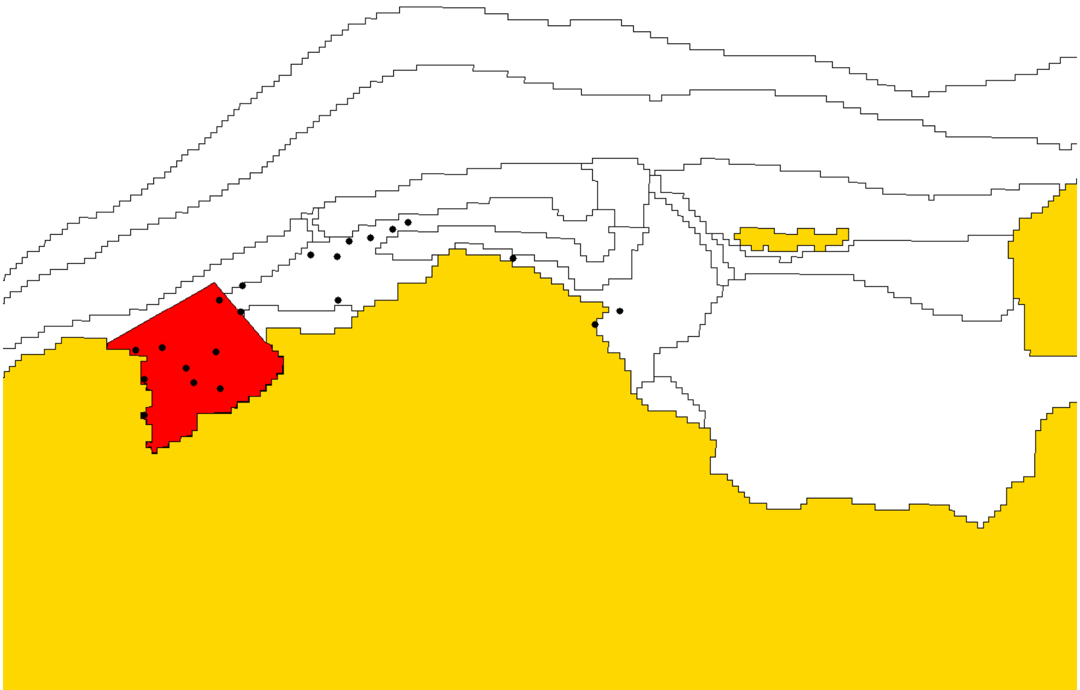

Figure 5.24: Fine-scale reef-benthos transect survey stations for invertebrates in Vaisala.
Black circles: reef-benthos transect stations (RBt). Marine protected area (0.4 km²) is marked in red.

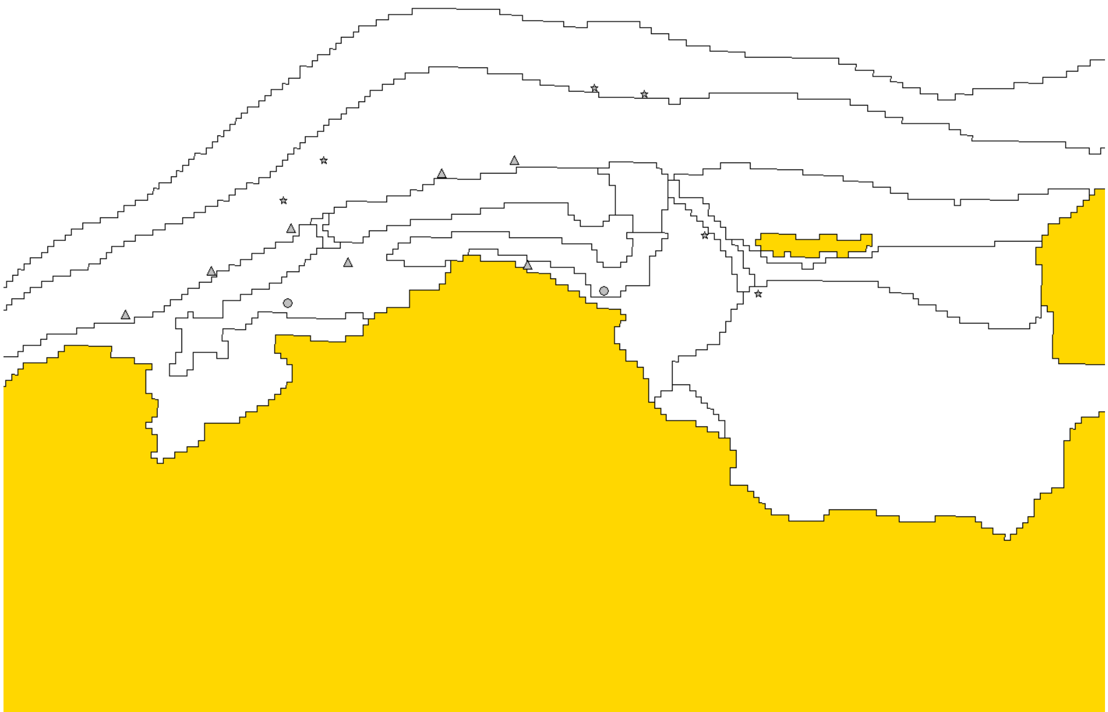

Figure 5.25: Fine-scale survey stations for invertebrates in Vaisala.
Grey triangles: reef-front search stations;
grey stars: sea cucumber day search stations;
grey circles: sea cucumber night search stations (Ns).

Forty-seven species or species groupings (groups of species within a genus) were recorded in the Vaisala invertebrate surveys. Among these were: 7 bivalves, 13 gastropods, 12 sea cucumbers, 4 urchins, 3 sea stars, 2 cnidarians and 1 sand lobster (Appendix 4.4.1). Information on key families and species is detailed below.

5.4.1 Giant clams: Vaisala

Although generally shallow, the lagoon at Vaisala was well flushed with oceanic water, through numerous passes in the barrier reef. Offshore shoals of shallow-water reef were also present and, in general, shallow reef habitats within the surveyed area were suitable for a range of giant clams. One of the limiting factors was the small scale of the suitable reef area, which covered only 3.6 km².

In Vaisala, two species of giant clams were recorded: the elongate clam, *Tridacna maxima*, and the fluted clam, *Tridacna squamosa*. A single dead *Hippopus hippopus* shell was found onshore but this species has long been considered extinct in Samoa. Lastly, *Tridacna derasa* had been introduced and was stockpiled within the marine protected area close to the main village.

Broad-scale sampling provided a good overview of giant clam distribution across Vaisala. *T. maxima* was the most common species recorded (found in 9 stations and 13 transects), followed by *T. squamosa* (in 1 station and 1 transect, Figure 5.26).

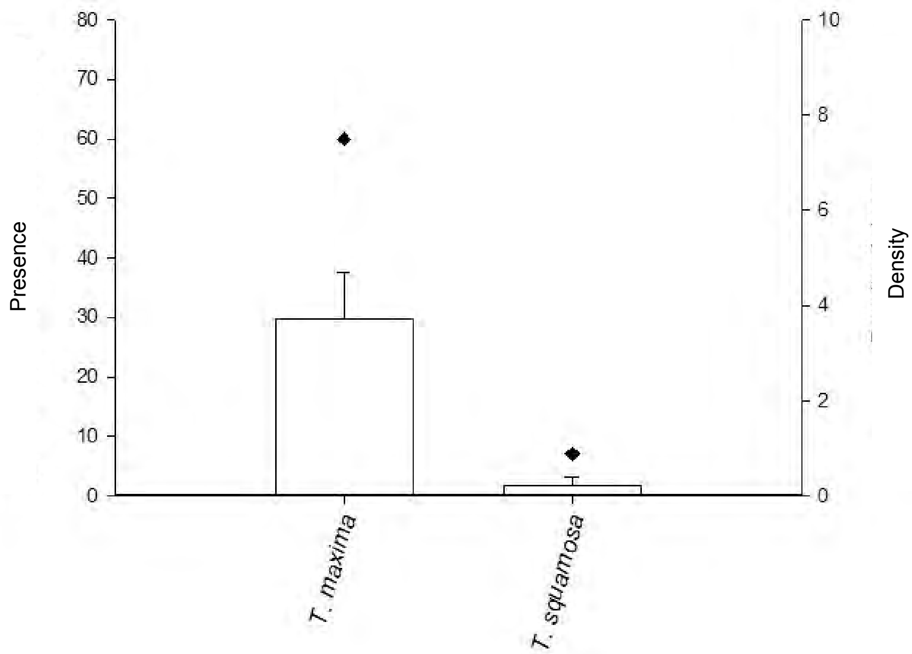

Figure 5.26: Presence and mean density of giant clam species in Vaisala based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, fine-scale surveys targeted specific areas of clam habitat. Only *T. maxima* were recorded in these reef-benthos transect assessments (RBt), and records were taken from 10% of stations (Figure 5.27). At these stations (2 stations where clams were recorded), the mean density of *T. maxima* was 83.3 ±41.7 individuals per ha.

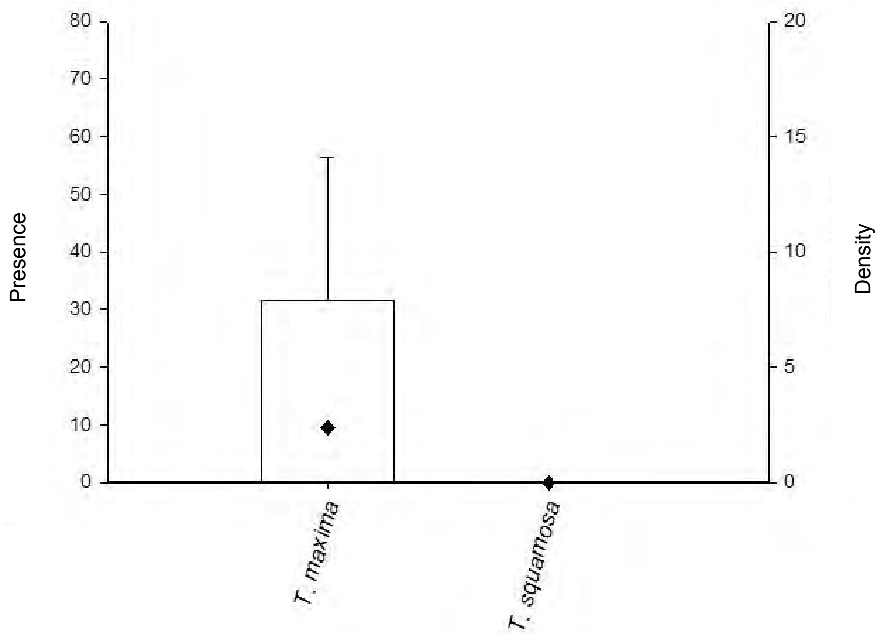

Figure 5.27: Presence and mean density of giant clam species in Vaisala based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Giant clams were uncommon throughout Vaisala and rarely recorded on reefs situated near the shoreline (apart from in the *T. derasa* holding area). The lagoon system was relatively small and shallow, but there was no obvious environmental reason for the general absence of clams.

Tridacna maxima from reef-benthos transects (shallow-water reefs) had an average length of 11.8 cm ±2.7. When clams from deeper water and more exposed locations were included in the calculation (from other assessments), the mean size increased slightly to 12.6 cm ±0.7, which equates to a *T. maxima* of approximately 5–6 years old. The faster-growing *T. squamosa* (which grows to an asymptotic length L∞ of 40 cm) had a mean of 30.3 cm ±2.6 shell length (>6 years old at mean length). As can be seen from the length frequency graphs (Figure 5.28), recruitment was apparent for *T. maxima* but there were few recordings of large clams (around the asymptotic length). For *T. squamosa*, only three large individuals were recorded. Lastly, the stockpiled *T. derasa*, close to the village (n = 104 individuals) had an average shell length of 27.2 cm ±0.6.

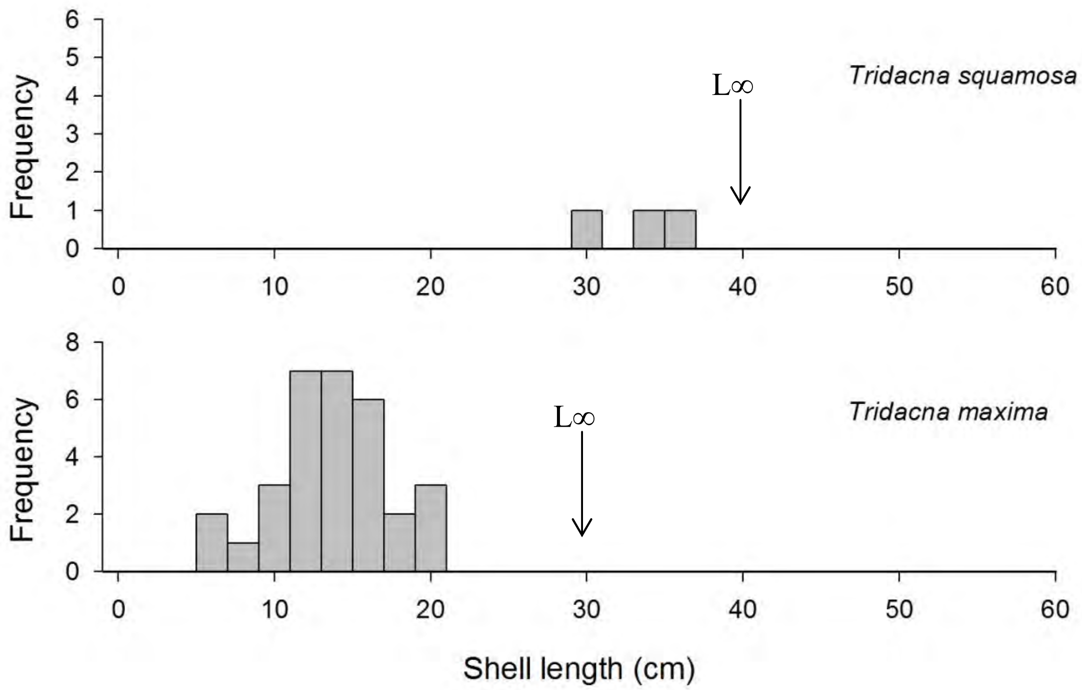

Figure 5.28: Size frequency histograms of giant clams shell length (cm) for Vaisala.

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

Samoa is not within the natural distribution of the commercial topshell *Trochus niloticus*, and translocations have not been made to reefs at Vaisala. Reefs that could be suitable for trochus were generally limited in scale and therefore the reef front (3.9 km lineal distance) and inshore areas could potentially only support a small population of this commercial species. The reef front at Vaisala was also predominantly wave-swept reef platform, without extensive areas of submerged boulder or coral habitat that would be suitable for adult trochus. However, there was suitable nursery habitat for juvenile trochus in the back-reef. The abundance of other grazing gastropods, as measured by the number of *Tectus pyramis* (a species with similar life/habit requirements to trochus), was generally low (Table 5.14).

Table 5.14: Presence and mean density of *Tectus pyramis* in Vaisala
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
Tectus pyramis				
B-S	0.4	0.3	2/12 = 17	2/74 = 3
RBt	0	0	0/21 = 0	0/126 = 0
RFs	1.3	1.3	1/5 = 20	1/30 = 3

B-S = broad-scale transect; RBt = reef-benthos transect; RFs = reef-front search station.

As trochus has not been introduced locally, and juveniles tend to recruit close to parent stock (Fertilised gametes of *T. niloticus* do not travel far from adults.), it was not surprising that no *T. niloticus* were recorded at Vaisala.

Only five *Tectus pyramis* were found; the single individual measured was 7.8 cm (basal width). The blacklip pearl oysters, *Pinctada margaritifera* were also rare, with none recorded in the survey period.

5.4.3 Infaunal species and groups: Vaisala

The soft benthos of the shallow-water lagoon had limited areas of sand and seagrass that could potentially hold beds of in-ground resource species such as arc shells, *Anadara* spp. or venus shells, *Gafrarium* spp. Therefore no infaunal surveys (quadrat stations) were made.

5.4.4 Other gastropods and bivalves: Vaisala

No Seba's spider conch, *Lambis truncata*, or other, smaller *Lambis* spp. were detected. *Strombus luhuanus* was found in the lagoon, and was also recorded in broad-scale and reef-benthos surveys, but generally at medium-to-low density (Appendices 4.4.1 to 4.4.7). *Turbo* spp. (*T. argyrostomus* and *T. setosus*) were recorded at low densities in reef-front searches, but not in reef-benthos assessments. Other resource species targeted by fishers (e.g. *Cerithium, Charonia, Conus, Cypraea, Pleuroploca, Tectus, Thais* and *Vasum*) were also recorded during independent surveys (Appendices 4.4.1 to 4.4.7). A trumpet triton, *Charonia tritonis,* recorded within the lagoon, represents a rare find considering that the lagoon is small and actively fished, but may be explained by the general presence of crown of thorns starfish (See 'Other echinoderms: Vaisala', below.).

Data on other bivalves found in broad-scale and fine-scale benthos surveys, such as *Anadara, Chama, Periglypta,* and *Spondylus*, are also in Appendices 4.4.1 to 4.4.7. No creel survey was conducted at Vaisala.

5.4.5 Lobsters: Vaisala

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, *Lysiosquillina* spp. burrows were recorded in a single reef-benthos station. No lobsters were recorded at reef-benthos stations or during night-time assessments for nocturnal sea cucumbers (Ns).

5.4.6 Sea cucumbers[13]: Vaisala

Although sea cucumber habitat was varied at Vaisala (reef, mixed hard and soft benthos), the lagoon was shallow and limited in scale (just over 1.6 km^2). There was less exposure and greater depth at the eastern edge of the lagoon, but the lagoon edges were sandy on the outside or covered with boulders, overgrown with epiphytes, on the coastal fringing reefs. Water exchange was more limited at the eastern edge of the lagoon.

The presence, size and density of sea cucumber species were determined through broad-scale, fine-scale and dedicated survey methods (Table 5.15, Appendices 4.4.1 to 4.4.7**,** also see Methods.). Despite the shallowness of the lagoon and its limited scale, eleven commercial species were recorded during in-water assessments (Table 5.15).

Within the group of sea cucumber species generally associated with reef, greenfish (*Stichopus chloronotus*) was notable for its high density close to shore, especially on boulder habitat (volcanic stone). The densities recorded for this species were the highest recorded for all PROCFish/C sites in the Pacific, and were especially high on back-reefs at the most easterly survey areas. Other species associated with reef, such as leopardfish (*Bohadschia argus*) were common in relation to the other PROCFish/C sites, and black teatfish (*Holothuria nobilis*) were noted at moderate numbers (15 individuals) along the back-reef. As this species is found in shallow water, is valuable and relatively slow growing, it is promising to see such a good number of this stock, which must have recovered from past fishing.

Surf redfish, *Actinopyga mauritiana*, was uncommon on the exposed reef front, and only recorded once in a night search. This result was unexpected and disappointing considering the suitable nature and extent of the reef and surge zone at Vaisala.

More protected areas of reef and soft benthos held a few lower-value species, e.g. brown sandfish (*Bohadschia vitiensis*) and lollyfish (*H. atra*) at medium density in comparison to other PROCFish/C sites in Samoa. *Stichopus horrens*, locally named *sea* was collected regularly (Parts of the viscera of lollyfish and brown sandfish are bottled, along with strips of the body wall.), and *sea* fishers were noted during the survey. The average size of *sea* at Vaisala was significantly larger than in Vailoa, where fishers were more active; however, densities of this species were low in Samoa compared to PROCFish records taken in Vanuatu, Tonga and Wallis Island.

Deep dives on SCUBA were conducted to obtain a preliminary assessment of deep-water stocks, such as the high-value white teatfish (*Holothuria fuscogilva*), prickly redfish (*Thelonata ananas*) and the lower-value amberfish (*T. anax*). The presence and density of commercial species in Vaisala were generally similar to records across the four sites in Samoa. In deep water (25–35 m), white teatfish (*H. fuscogilva*) and prickly redfish (*T. ananas*) were present, but occurrence was patchy and no high-density areas were located.

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

5.4.7 Other echinoderms: Vaisala

No edible slate urchins *Heterocentrotus mammillatus* or collector urchins *Tripneustes gratilla* were recorded, although *Echinometra mathei* and *Echinothrix* spp. were common in survey (Presence and density estimates are given in Appendices 4.4.1 to 4.4.7).

The blue starfish, *Linckia laevigata*, was moderately abundant in Vaisala (present in 87% of broad-scale and 57% of RBt stations). The cushion star (*Culcita novaeguineae*) and crown of thorns starfish (*Acanthaster planci,* COTS), which are both corallivores (coral eaters) were also common in Vaisala. *C. novaeguineae* was present in 42% of broad-scale stations and 17 COTS were recorded during survey. This is a relatively high number for PROCFish assessments in general. COTS were present in 25% of broad-scale stations (mean density of 1.2 per ha) and 14% of reef-benthos stations (mean density of 11.9 per ha), and scars caused by their feeding were seen on live-coral colonies throughout the lagoon. Major outbreaks of COTS have been reported in Samoa and American Samoa in the 1970s (Andrews and Holthus 1988, Fisk 2002, Green 2002). Due to the small size of the available reef habitat, the population of COTS should be closely managed by periodically removing adults, and their abundance needs to be monitored to forewarn of an outbreak.

Table 5.15: Sea cucumber species records for Vaisala

Species	Common name	Commercial value	B-S transects n = 82			Reef-benthos stations n = 21			Other stations RFs = 3			Other Stations Ds = 3; Ns = 3		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga mauritiana	Surf redfish	M/H										5.9	17.8	33 Ns
Bohadschia argus	Leopardfish	M	52.3	84.2	62	111.1	233.3	48				136.3	136.3	100 Ns
Bohadschia vitiensis	Brown sandfish	L	5.9	48.1	12	31.7	166.7	19				130.4	130.4	100 Ns
Holothuria atra	Lollyfish	L	110.3	247.3	45	256.0	358.3	71				5.9	17.8	33 Ns
Holothuria fuscogilva [4]	White teatfish	H										1.2	3.6	33 Ds
Holothuria fuscopunctata	Elephant trunkfish	M	0.7	25.0	3									
Holothuria leucospilota	Black cucumber	L												
Holothuria nobilis [4]	Black teatfish	H	2.4	22.3	11	6.0	62.5	10						
Stichopus chloronotus	Greenfish	H/M	4268	10,189	42	5639	11,842	48				0.4 163.0	2.4 244.4	17 Ds 66 Ns
Stichopus horrens	Peanutfish	M										3.0	8.9	33 Ns
Synapta spp.	-	-	4.3	57.2	8	6.0	62.5	10						
Thelenota ananas	Prickly redfish	H	0.6	22.8	3							3.6	21.4	17 Ds
Thelenota anax	Amberfish	L										0.4	2.4	17 Ds

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

5.4.8 Discussion and conclusions: invertebrate resources in Vaisala

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

- The presence, density and size range of giant clams in Vaisala indicate that the resource is degraded; *T. maxima* abundance was low, and *T. squamosa* was rare in the limited area of reef available to fishers. Fishing pressure is the most likely cause for the depleted stock.

- Mother-of-pearl stocks *T. niloticus* and *P. margaritifera* were absent from survey records taken in Vaisala, whilst *T. pyramis*, a species with a similar life history to trochus, was rare.

- Reefs in Vaisala are suitable for trochus stocks, although the limited scale of the reef and inshore areas, plus the small number of other gastropod grazers suggest that Vaisala does not offer much potential for future translocations.

- Based on the information collected on sea cucumber stocks, stocks are patchy, and there is a limited number of species available for commercial fishing.

- The regularly fished *sea* (*Stichopus horrens*) is currently found at low densities in comparison to other areas of the Pacific. Sizes of *S. horrens* in Vaisala were larger than those found Salelavalu and Vailoa.

- The presence of high-value teatfish and other deep-water stocks is of interest for commercialisation, but these resources appear from preliminary assessment to be insufficient for regular fishing.

5.5 Overall recommendations for Vaisala

Based on the survey work undertaken and the assessments made, the following recommendations are made for Vaisala:

- A precautionary approach to resource use needs to be immediately adopted and ongoing monitoring is needed in order to properly manage marine resources to protect current stocks and thus provide for the future subsistence needs and economic livelihoods of the people.

- Any commercial fishing (of finfish and invertebrates) should be accompanied by monitoring activities, to ensure that resources remain available for subsistence use by future generations.

- SCUBA diving at night on the outer reef should be regulated to limit the heavy impact on reef resources, especially Scaridae.

- The marine protected area in front of the village of Vaisala needs to be regularly patrolled and monitored in order to make this reserve profitable as a management tool.

- To sustain healthy populations of giant clams, urgent action is required to protect existing clams, including larger, older individuals, and to reintroduce clams.

- The stocks of the smooth clam, *Tridacna derasa*, that are stockpiled inshore, are held in sub-optimal locations (too silty with too little water flow), and no recruitment (second-generation settlement) was detected from this resource. If security issues allow, these clams should be moved to deeper water (2–4 m), where water temperatures are less variable and there is greater oceanic influence.

- Excellent recovery of greenfish, *Stichopus chloronotus*, presents an option for redeveloping a limited fishery for sea cucumbers. There is also a possibility of fishing the ubiquitous brown sandfish (*Bohadschia vitiensis*).

- Crown of thorns starfish were common in Vaisala and their deleterious effect on live corals was noticeable. Due to the small size of the lagoon, populations of COTS can be closely managed by removing individuals and monitoring their size and abundance to forewarn of an outbreak.

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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).

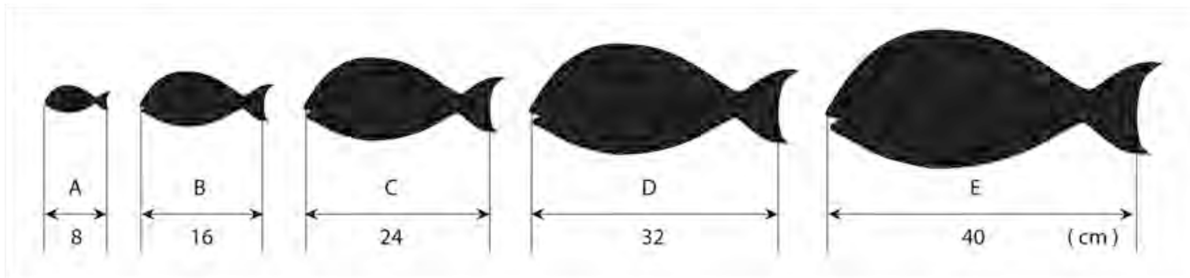

Figure A1.1.1: Finfish size field survey chart for estimating average length of reef and lagoon fish (including five size classes from A = 8 cm to E = 40 cm, in 8 cm intervals).

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$_i$

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Invertebrate per capita consumption:

$$Inv_{pcj} = \frac{Inv_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

Inv_{pcj} = Invertebrate weight consumption (kg edible meat/capita/year) for $household_j$
Inv_{wj} = Invertebrate weight consumption (kg edible meat/household/year) for $household_j$
n = number of age-gender classes
AC_{ij} = number of people for age class i and household j
C_i = correction factor of age-gender $class_i$

Canned fish per capita consumption:

$$CF_{pcj} = \frac{CF_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) for $household_j$
CF_{wj} = canned fish net weight consumption (kg/household/year) for $household_j$
n = number of age-gender classes
AC_{ij} = number of people for age $class_i$ and $household_j$
C_i = correction factor of age-gender $class_i$

The total finfish, invertebrate and canned fish consumption of a known population is calculated by extrapolating the average per capita consumption for finfish, invertebrates and canned fish of the sample size to the entire population.

Total finfish consumption:

$$F_{tot} = \frac{\sum_{j=1}^{n} F_{pcj}}{n_{ss}} \bullet n_{pop}$$

F_{pcj} = finfish net weight consumption (kg/capita/year) for $household_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

Total invertebrate consumption:

$$Inv_{tot} = \frac{\sum_{j=1}^{n} Inv_{pcj}}{n_{ss}} \bullet n_{pop}$$

Inv_{pcj} = invertebrate weight consumption (kg edible meat/capita/year) for household$_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

Total canned fish consumption:

$$CF_{tot} = \frac{\sum_{j=1}^{n} CF_{pcj}}{n_{ss}} \bullet n_{pop}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) of household$_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

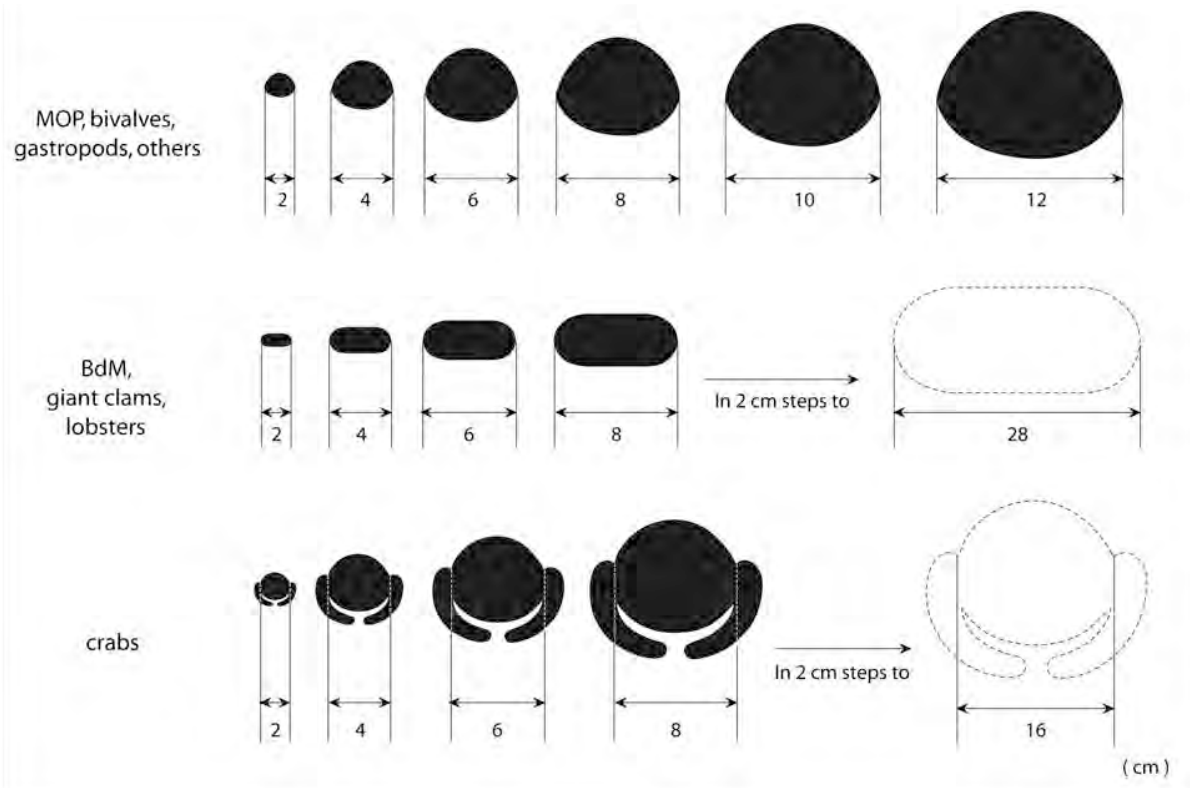

Figure A1.1.2: Invertebrate size field survey chart for estimating average length of different species groups (2 cm size intervals).

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Finfish fisher survey

The finfish fisher survey primarily aims to collect the data needed to understand finfish fisheries strategies, patterns and dimensions, and thus possible impacts on the resource. Data collection faces the challenge of retrieving information from local people that needs to match resource survey parameters, in order to make joint data analysis possible. This challenge is highlighted by the following three major issues:

(i) Fishing grounds are classified by habitat, with the latter defined using geomorphologic characteristics. Local people's perceptions of and hence distinctions between fishing grounds often differ substantially from the classifications developed by the project. Also, fishers do not target particular areas according to their geomorphologic characteristics, but instead due to a combination of different factors including time and transport availability, testing of preferred fishing spots, and preferences of members of the fishing party. As a result, fishers may shift between various habitats during one fishing trip. Fishers also target lagoon and mangrove areas, as well as passages if these are available, all of which cannot be included in the resource surveys. It should be noted that a different terminology for reef and other areas fished is needed to communicate with fishers.

    These problems are dealt with by asking fishers to indicate the areas they refer to as coastal reef, lagoon, outer-reef and pelagic fishing on hydrologic charts, maps or aerial photographs. In this way we can often further refine the commonly used terms of coastal or outer reef to better match the geomorphologic classification. The proportion of fishers targeting each habitat is provided as a percentage of all fishers surveyed; the socioeconomic analysis refers to habitats by the commonly used descriptive terms for these habitats, rather than the ecological or geomorphologic classifications.

    Fishers may travel between various habitats during a single fishing trip, with differing amounts of time spent in each of the combined habitats; the catch that is retrieved from each combined habitat may potentially vary from one trip to the next. If targeting combined habitats is a common strategy practised by most fishers, the resource data for individual geomorphologic habitats need to be lumped to enable comparison of results.

(ii) People usually provide information on fish by vernacular or common names, which are far less specific than (and thus not compatible with) scientific nomenclature. Vernacular name systems are often very localised, changing with local languages, and thus may differ significantly between the sites surveyed in one country alone. As a result, one fish species may be associated with a number of vernacular names, but each vernacular name may also apply to more than one species.

    This issue is addressed, as much as possible, through indexing the vernacular names recorded during a survey to the scientific names for those species. However, this is not always possible due to inconsistencies between informants. The use of photographic indices is helpful but can also trigger misleading information, due to the variety of photos presented and the limitations of species recognition using photos alone. In this respect, collaboration with local counterparts from fisheries departments is crucial.

(iii) The assessment of possible fishing impacts is based on the collection of average data. Accordingly, fishers are requested to provide information on a catch that is neither exceptionally good nor exceptionally bad. They are also requested to provide this information concerning the most commonly caught species. This average information suffers from two major shortcomings. Firstly, some fish species are seasonal and may be dominant during a short period of the year but do not necessarily appear frequently in the average catch. Depending on the time of survey implementation this may result in over- or under-representation of these species. Secondly, fishers usually employ more than one technique. Average catches may vary substantially by quantity and quality depending on which technique they use.

We address these problems by recording any fish that plays a seasonal role. This information may be added and helpful for joint interpretation of resource and socioeconomic data. Average catch records are complemented by information on the technique used, and fishers are encouraged to provide the average catch information for the technique that they employ most often.

The design of the finfish fisher survey allows the collection of details on fishing strategies, and quantitative and qualitative data on average catches for each habitat. Targeting men and women fishers allows differences between genders to be established.

Determination of fishing strategies includes:

- frequency of fishing trips
- mode and frequency of transport used for fishing
- size of fishing parties
- duration of the fishing trip
- time of fishing
- months fished
- techniques used
- ice used
- use of catch
- additional involvement in invertebrate fisheries.

The frequency of fishing trips is determined by the number of weekly (or monthly) trips that are regularly made. The average figure resulting from data for all fishers surveyed, per habitat targeted, provides a first impression of the community's engagement in finfish fisheries and shows whether or not different habitats are fished with the same frequency.

Information on the utilisation of non-motorised or motorised boat transport for fishing helps to assess accessibility, availability and choice of fishing grounds. Motorised boats may also represent a multiplication factor as they may accommodate larger fishing parties.

We ask about the size of the fishing party that the interviewee usually joins to learn whether there are particularly active or regular fisher groups, whether these are linked to fishing in certain habitats, and whether there is an association between the size of a fishing party and fishing for subsistence or sale. We also use this information to determine whether information regarding an average catch applies to one or to several fishers.

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The duration of a fishing trip is defined as the time spent from any preparatory work through the landing of the catch. This definition takes into account the fact that fishing in a Pacific Island context does not follow a western economic approach of benefit maximisation, but is a more integral component of people's lifestyles. Preparatory time may include up to several hours spent reaching the targeted fishing ground. Fishing time may also include any time spent on the water, regardless of whether there was active fishing going on. The average trip duration is calculated for each habitat fished, and is usually compared to the average frequency of trips to these habitats (see discussion above).

Temporal fishing patterns – the times when most people go fishing – may reveal whether the timing of fishing activities depends primarily on individual time preferences or on the tides. There are often distinct differences between different fisher groups (e.g. those that fish mostly for food or mostly for sale, men and women, and fishers using different techniques). Results are provided in percentage of fishers interviewed for each habitat fished.

To calculate total annual fishing impact, we determine the total number of months that each interviewee fishes. As mentioned earlier, the seasonality of complementary activities (e.g. agriculture), seasonal closing of fishing areas, etc. may result in distinct fishing patterns. To take into account exceptional periods throughout the year when fishing is not possible or not pursued, we apply a correction factor of 0.83 to the total provided by people interviewed (this factor is determined on the basis that about two months of every year – specifically, 304/365 days – are not used for fishing due to festivals, funerals and bad weather conditions).

Knowing the range of techniques used and learning which technique(s) is/are predominantly used helps to identify the possible causes of detrimental impacts on the resource. For example, the predominant use of gillnets, combined with particular mesh sizes, may help to assess the impact on a certain number of possible target species, and on the size classes that would be caught. Similarly, spearfishing targets particular species, and the impacts of spearfishing on the abundance of these species in the habitats concerned may become evident. To reveal the degree to which fishers use a variety of different techniques, the percentage of techniques used refers to the proportion of all fishers who use that technique. Percentages show which techniques are used by most or even all fishers, and which are used by smaller groups. In addition, the data are presented by habitat (what percentage of fishers targeting a habitat use a particular technique, where n = the total number of fishers interviewed by habitat).

The use of ice (whether it is used at all, used infrequently or used regularly) hints at the degree of commercialisation, available infrastructure and investment level. Usually, communities targeted by our project are remote and rather isolated, and infrastructure is rudimentary. Thus, ice needs to be purchased and is often obtained from distant sources, with attendant costs in terms of transport and time. On the other hand, ice may be the decisive input that allows marketing at a regional or urban centre. The availability of ice may also be a decisive factor in determining the frequency of fishing trips.

Determining the use of the catch or shares thereof for various purposes (subsistence, non-monetary exchange and sale) is a necessary prerequisite to providing fishery management advice. Fishing pressure is relatively stable if determined predominantly by the community's subsistence demand. Fishing is limited by the quantity that the community can consume, and changes occur in response to population growth and/or changes in eating habits. In contrast, if fishing is performed mainly for external sale, fishing pressure varies according to outside market demand (which may be dynamic) and the cost-benefit (to fishers) of fishing. Fishing strategies may vary accordingly and significantly. The recorded purposes of fishing are presented as the percentage of all fishers interviewed per habitat fished. We distinguish these figures by habitat so as to allow for the fact that one fisher may fish several habitats but do so for different purposes.

Information on the additional involvement of interviewed fishers in invertebrate fisheries, for either subsistence or commercial purposes, helps us to understand the subsistence and/or commercial importance of various coastal resources. The percentage of finfish fishers who also harvest invertebrates is calculated, with the share of these who do so for subsistence and/or for commercial purposes presented in percentage (the sum of the latter percentages may exceed 100, because fishers may harvest invertebrates for both subsistence and sale).

The average catch per habitat (technique and transport used) is recorded, including:

- a list of species, usually by vernacular names; and
- the kg or number per size class for each species.

These data are used to calculate total weight per species and size class, using a weight–length conversion factor (FishBase 2000, refer to Letourneur *et al.* 1998; Kulbicki pers. com.). This requires using the vernacular/scientific name index to relate (as far as possible) local names to their scientific counterparts. Fish length is reported by using size charts that comprise five major size classes in 8 cm intervals, i.e. 8 cm, 16 cm, 24 cm, 32 cm and 40 cm. The length of any fish that exceeds the largest size class (40 cm) presented in the chart is individually estimated using a tape measure. The length–weight relationship is calculated for each site using a regression on catch records from finfish fishers' interviews weighted by the annual catch. Data used from the catch records consist of scientific names correlated to the vernacular names given by fishers, number of fish, size class (or measured size) and/or weight. In other words, we use the known length–weight relationship for the corresponding species to vernacular names recorded.

Once we have established the average and total weight per species and size class recorded, we provide an overview of the average size for each family. The resulting pattern allows analysis of the degree to which average and relative sizes of species within the various families present at a particular site are homogeneous. The same average distribution pattern is calculated for all families, per habitat, in order to reveal major differences due to the locations where the fish were caught. Finally, we combine all fish records caught, per habitat and site, to determine what proportion of the extrapolated total annual catch is composed of each of the various size classes. This comparison helps to establish the most dominant size class caught overall, and also reveals major differences between the habitats present at a site.

Catch data are further used to calculate the total weight for each family (includes all species reported) and habitat. We then convert these figures into the percentage distribution of the total annual catch, by family and habitat. Comparison of relative catch composition helps to identify commonalities and major differences, by habitat and between those fish families that are most frequently caught.

A number of parameters from the household and fisher surveys are used to calculate the total annual catch volume per site, habitat, gender, and use of the catch (for subsistence and/or commercial purposes).

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Socioeconomics

Data from the household survey regarding the number of fishers (by gender and type of fishery) in each household interviewed are extrapolated to determine the total number of men and women that target finfish, invertebrates, or both.

Data from the fisher survey are used to determine what proportion of men and women fishers target various habitats or combinations of habitats. These figures are assumed to be representative of the community as a whole, and hence are applied to the total number of fishers (as determined by the household survey). The total number of finfish fishers is the sum of all fishers who solely target finfish, and those who target both finfish and invertebrates; the same system is applied for invertebrate fishers (i.e. it includes those who collect only invertebrates and those who target both invertebrates and finfish. These numbers are also disaggregated by gender.

The total annual catch per fisher interviewed is calculated, and the average total annual catch reported for each type of fishing activity/fishery (including finfish and invertebrates) by gender is then multiplied by the total number of fishers (calculated as detailed above, for each type of fishing activity/fishery and both genders). More details on the calculation applied to invertebrate fisheries are provided below.

<u>Total annual catch (t/year):</u>

$$\text{TAC} = \sum_{h=1}^{N_h} \frac{Fif_h \bullet Acf_h + Fim_h \bullet Acm_h}{1000}$$

TAC = total annual catch t/year
Fif_h = total number of female fishers for habitat_h
Acf_h = average annual catch of female fishers (kg/year) for habitat_h
Fim_h = total number of male fishers for habitat_h
Acm_h = average annual catch of male fishers (kg/year) for habitat_h
N_h = number of habitats

Where:

$$\text{Acf}_h = \frac{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cfi}{If_h} \bullet \frac{\sum_{k=1}^{Rf_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

If_h = number of interviews of female fishers for habitat_h (total number of interviews where female fishers provided detailed information for habitat_h)
f_i = frequency of fishing trips (trips/week) as reported on interview_i
Fm_i = number of months fished (reported in interview_i)
Cf_i = average catch reported in interview_i (all species)
Rf_h = number of targeted habitats as reported by female fishers for habitat_h (total numbers of interviews where female fishers reported targeting habitat_h but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat_k
Fm_k = number of months fished for reported habitat_k (fishers = sum of finfish fishers and mixed fishers, i.e. people pursuing both finfish and invertebrate fishing)

Thus, we obtain the total annual catch by habitat and gender group. The sum of all catches from all habitats and both genders equals the total annual impact of the community on its fishing ground.

The accuracy of this calculation is determined by reliability of the data provided by interviewees, and the extrapolation procedure. The variability of the data obtained through fisher surveys is illuminated by providing standard errors for the calculated average total annual catches. The size of any error stemming from our extrapolation procedure will vary according to the total population at each site. As mentioned above, this approach is best suited to assess small and predominantly traditional coastal communities. Thus, the risk of over- or underestimating fishing impact increases in larger communities, and those with greater urban influences. We provide both the total annual catch by interviewees (as determined from fisher records) and the extrapolated total impact of the community, so as to allow comparison between recorded and extrapolated data.

The total annual finfish consumption of the surveyed community is used to determine the share of the total annual catch that is used for subsistence, with the remainder being the proportion of the catch that is exported (sold externally).

Total annual finfish export:

$$E = TAC - \left(\frac{F_{tot}}{1000} \bullet \frac{1}{0.8}\right)$$

Where:

E = total annual export (t)
TAC = total annual catch (t)
F_{tot} = total annual finfish consumption (net weight kg)
$\frac{1}{0.8}$ = to calculate total biomass/weight, i.e. compensate for the earlier deduction by 0.8 to determine edible weight parts only

In order to establish fishing pressure, we use the habitat areas as determined by satellite interpretation. However, as already mentioned, resource surveys and satellite interpretation do not include lagoon areas. Thus, we determine the missing areas by calculating the smallest possible polygon (Figure A1.1.3) that encompasses the total fishing ground determined with fishers and local people during the fieldwork. In cases where fishing grounds are gazetted, owned and managed by the community surveyed, the missing areas are determined using the community's fishing ground limits.

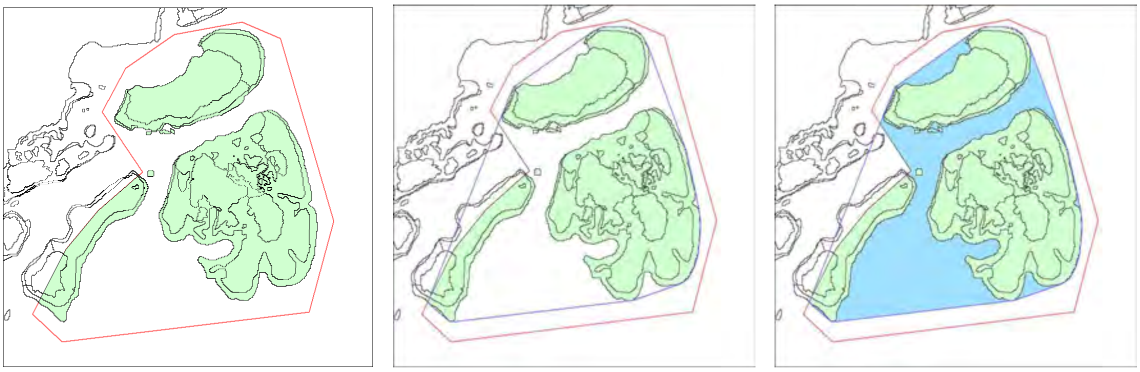


Figure A1.1.3: Determination of lagoon area.
The fishing ground (in red) is initially delineated using information from fishers. Reef areas within the fishing area (in green; interpreted from satellite data) are then identified. The remaining non-reef areas within the fishing grounds are labelled as lagoon (in blue) (Developed using MapInfo).

We use the calculated total annual impact and fishing ground areas to determine relative fishing pressure. Fishing pressure indicators include the following:

- annual catch per habitat
- annual catch per total reef area
- annual catch per total fishing ground area.

Fisher density includes the total number of fishers per km^2 of reef and total fishing ground area, and productivity is the annual catch per fisher. Due to the lack of baseline data, we compare selected indicators, such as fisher density, productivity (catch per fisher and year) and total annual catch (per reef and total fishing ground area), across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The catch per unit effort (CPUE) is generally acknowledged as an indicator of the status of a resource. If an increasing amount of time is required to obtain a certain catch, degradation of the resource is assumed. However, taking into account that our project is based on a snapshot approach, CPUE is used on a comparative basis between sites within a country, and will be employed later on a regional scale. Its application and interpretation must also take into account the fact that fishing in the Pacific Islands does not necessarily follow efficiency or productivity maximisation strategies, but is often an integral component of people's lifestyles. As a result, CPUE has limited applicability.

In order to capture comparative data, in calculating CPUE we use the entire time spent on a fishing trip, including travel, fishing and landing. Thus, we divide the total average catch per fisher by the total average time spent per fishing trip. CPUE is determined as an overall average figure, by gender and habitat fished.

Invertebrate fisher survey

The objective, purpose and design of the invertebrate fisher survey largely follow those of the finfish fisher survey. Thus, the primary aim of the invertebrate fisher survey is to collect data needed to understand the strategies, patterns and dimensions of invertebrate fisheries, and hence the possible impacts on invertebrate resources. Invertebrate data collection faces several challenges, as retrieval of information from local people needs to match the resource survey parameters in order to enable joint data analysis. Some of the major issues are:

Appendix 1: Survey methods
Socioeconomics

(i) The invertebrate resource survey defines invertebrate fisheries using differing parameters (several are primarily determined by habitat, others by target species). However, these fisheries classifications do not necessarily coincide with the perceptions and fishing strategies of local people. In general, there are two major types of invertebrate fishers: those who walk and collect with simple tools, and those who free-dive using masks, fins, snorkel, hands, simple tools or spears. The latter group is often more commercially oriented, targeting species that are exploited for export (trochus, BdM, lobster, etc.). However, some of the divers may harvest invertebrates as a by-product of spearfishing for finfish. Fishers who primarily walk (some may or may not use non-motorised or even motorised transport to reach fishing grounds) are mainly gleaners targeting available habitats (or a combination of habitats, if convenient). While gleaning is often performed for subsistence needs, it may also be used as a source of income, albeit mostly serving national rather than export markets. While gleaning is an activity that may be performed by both genders, diving is usually men's domain.

We have addressed the problem of collecting information according to fisheries as defined by the resource survey by asking people to report according to the major habitats they target and/or species-specific dive fisheries they engage in. Very often this results in the grouping of various fisheries, as they are jointly targeted or performed on one fishing trip. Where possible, we have disaggregated data for these groups and allocated individuals to specific fisheries. Examples of such data disaggregation are the proportion of all fishers and fishers by gender targeting each of the possible fisheries at one site.

We have also disaggregated some of the catch data, because certain species are always or mostly associated with a particular fishery. However, the disagreement between people's perception and the resource classification becomes visible when comparing species composition per fishery (or combination of fisheries) as reported by interviewed fishers, and the species and total annual wet weight harvested allocated individually by fishery, as defined by the resource survey.

(ii) As is true for finfish, people usually provide information on invertebrate species by vernacular or common names, which are far less specific and thus not directly compatible with scientific nomenclature. Vernacular name systems are often very localised, changing with local languages, and thus may differ significantly between the sites surveyed in one country. Differing from finfish, vernacular names for invertebrates usually combine a group (often a family) of species, and are rarely species specific.

Similar to finfish, the issue of vernacular versus scientific names is addressed by trying to index as many scientific names as possible for any vernacular name recorded during the ongoing survey. Inconsistencies between informants are a limiting factor. The use of photographic indices is very useful, but may trigger misleading information; in addition, some reported species may not be depicted. Again, collaboration with local counterparts from fisheries departments is crucial.

The lack of specificity in the vernacular names used for invertebrates is an issue that cannot be resolved, and specific information regarding particular species that are included with others under one vernacular name cannot be accurately provided.

(iii) The assessment of possible fishing impacts is based on the collection of average data. This means that fishers are requested to provide information on a catch that is neither exceptionally good nor exceptionally bad. They are also requested to provide this information concerning the most commonly caught species. In the case of invertebrate fisheries this results in underestimation of the total number of species caught, and often greater attention is given to commercial species than to rare species that are used mainly for consumption. Seasonality of invertebrate species appears to be a less important issue than when compared to finfish.

We address these problems by encouraging people to also share with us the names of species they may only rarely catch.

(iv) Assessment of possible fishing impact requires knowledge of the size–weight relationship of (at least) the major species groups harvested. Unfortunately, a comparative tool (such as FishBase and others that are used for finfish) is not available for invertebrates. In addition, the proportion of edible and non-edible parts varies considerably among different groups of invertebrates. Further, non-edible parts may still be of value, as for instance in the case of trochus. However, these ratios are also not readily available and hence limit current data analysis.

We have dealt with this limitation by applying average weights (drawn from the literature or field measurements) for certain invertebrate groups. The applied wet weights are listed in Appendix 1.1.3. We used this approach to estimate total biomass (wet weight) removed; we have also listed approximations of the ratio between edible and non-edible biomass for each species.

Information on invertebrate fishing strategies by fishery and gender includes:

- frequency of fishing trips
- duration of an average fishing trip
- time when fishing
- total number of months fished per year
- mode of transport used
- size of fishing parties
- fishing external to the community's fishing grounds
- purpose of the fisheries
- whether or not the fisher also targets finfish.

In addition, for each fishery (or combination of fisheries) the species composition of an average catch is listed, and the average catch for each fishery is specified by number, size and/or total weight. If local units such as bags (plastic bags, flour bags), cups, bottles or buckets are used, the approximate weight of each unit is estimated and/or weighed during the field survey and average weight applied accordingly. For size classes, size charts for different species groups are used (Figure A1.1.2).

The proportion of fishers targeting each fishery (as defined by the resource survey) is presented as a percentage of all fishers. Records of fisheries that are combined in one trip are disaggregated by counting each fishery as a single data entry. The same process is applied to determine the share of women and men fishers per fishery (as defined by the resource survey).

The number of different vernacular names recorded for each fishery is useful to distinguish between opportunistic and specialised harvesting strategies. This distribution is particularly interesting when comparing gleaning fisheries, while commercial dive fisheries are species specific by definition.

The calculation of catch volumes is based on the determination of the total number of invertebrate fishers and fishers targeting both finfish and invertebrates, by gender group and by fishery, as described above.

The average invertebrate catch composition by number, size and species (with vernacular names transferred to scientific nomenclature), and by fishery and gender group, is extrapolated to include all fishers concerned. Conversion of numbers and species by average weight factors (Appendix 1.1.3) results in a determination of total biomass (wet weight) removed, by fishery and by gender. The sum of all weights determines the total annual impact, in terms of biomass removed.

To calculate total annual impact, we determine the total numbers of months fished by each interviewee. As mentioned above, seasonality of complementary activities, seasonal closing of fishing areas, etc. may result in distinct fishing patterns. Based on data provided by interviewees, we apply – as for finfish – a correction factor of 0.83 to take into account exceptional periods throughout the year when fishing is not possible or not pursued (this is determined on the basis that about two months (304/365 days) of each year are not used for fishing due to festivals, funerals and bad weather conditions).

Total annual catch:

$$\text{TACj} = \sum_{h=1}^{N_h} \frac{F_{inv} f_h \bullet Ac_{inv} f_{hj} + F_{inv} m_h \bullet Ac_{inv} m_{hj}}{1000}$$

TACj = total annual catch t/year for species$_j$

$F_{inv}f_h$ = total number of female invertebrate fishers for habitat$_h$

$Ac_{inv}f_{hj}$ = average annual catch by female invertebrate fishers (kg/year) for habitat$_h$ and species$_j$

$F_{inv}m_h$ = total number of male invertebrate fishers for habitat$_h$

$Ac_{inv}m_{hj}$ = average annual catch by male invertebrate fishers (kg/year) for habitat$_h$ and species$_j$

N_h = number of habitats

Where:

$$Ac_{inv}f_{hj} = \frac{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cf_{ij}}{I_{inv} f_h} \bullet \frac{\sum_{k=1}^{R_{inv}f_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

$I_{inv}f_h$ = number of interviews of female invertebrate fishers for habitat$_h$ (total numbers of interviews where female invertebrate fishers provided detailed information for habitat$_h$)

f_i = frequency of fishing trips (trips/week) as reported in interview$_i$

Fm_i = number of months fished as reported in interview$_i$
Cf_{ij} = average catch reported for species$_j$ as reported in interview$_i$
$R_{inv}f_h$ = number of targeted habitats reported by female invertebrate fishers for habitat$_h$ (total numbers of interviews where female invertebrate fishers reported targeting habitat$_h$ but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat$_k$
Fm_k = number of months fished for reported habitat$_k$

The total annual biomass (t/year) removed is also calculated and presented by species after transferring vernacular names to scientific nomenclature. Size frequency distributions are provided for the most important species, by total annual weight removed, expressed in percentage of each size group of the total annual weight harvested. The size frequency distribution may reveal the impact of fishing pressure for species that are represented by a wide size range (from juvenile to adult state). It may also be a useful parameter to compare the status of a particular species or species group across various sites at the national or even regional level.

To further determine fishing strategies, we also inquire about the purpose of harvesting each species (as recorded by vernacular name). Results are depicted as the proportion (in kg/year) of the total annual biomass (net weight) removed for each purpose: consumption, sale or both. We also provide an index of all species recorded through fisher interviews and their use (in percentage of total annual weight) for any of the three categories.

In order to gain an idea of the productivity of and differences between the fisheries practices used in each site we calculate the average annual catch per fisher, by gender and fishery. This calculation is based on the total biomass (net weight) removed from each fishery and the total number of fishers by gender group.

For invertebrate species that are marketed, detailed information is collected on total numbers (weight and/or combination of number and size), processing level, location of sale or client, frequency of sales and price received per unit sold. At this stage of our project we do not fully analyse this marketing information. However, prices received for major commercial species, as well as an approximation of sale volumes by fishery and fisher, help to assess what role invertebrate fisheries (or a particular fishery) play(s) in terms of income generation for the surveyed community, and in comparison to the possible earnings from finfish fisheries.

We use the calculated total annual impact in combination with the fishing ground area to determine relative fishing pressure. Fishing pressure indicators are calculated as the annual catch per km^2 for each area that is considered to support any of the fisheries present at each study site. In some instances (e.g. intertidal fisheries), areas are replaced by linear km; accordingly, fishing pressure is then related to the length (in km) of the supporting habitat. Due to the lack of baseline data, we compare selected indicators, such as the fisher density (number of fishers per km^2 – or linear km – of fishing ground, for each fishery), productivity (catch per fisher and year) and total annual catch per fishery, across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The differing nature of invertebrate species that may be caught during one fishing trip, and hence the great variability between edible and non-edible, useful and non-useful parts of species caught, make the determination of CPUE difficult. Substantial differences in the economic value of species add another challenge. We have therefore refrained from calculating CPUE values at this stage of the project.

Data entry and analysis

Data from all questionnaire forms are entered in the Reef Fisheries Integrated Database (RFID) system. All data entered are first verified and 'cleaned' prior to analysis. In the process of data entry, a comprehensive list of vernacular and corresponding scientific names for finfish and invertebrate species is developed.

Database queries have been defined and established that allow automatic retrieval of the descriptive statistics used when summarising results at the site and national levels.

1.1.2 Socioeconomic survey questionnaires

- Household census and consumption survey
- Finfish fishing and marketing survey (for fishers)
- Invertebrate fishing and marketing survey (for fishers)
- Fisheries (finfish and invertebrate and socioeconomics) general information survey

HOUSEHOLD CENSUS AND CONSUMPTION SURVEY

HH NO. ☐

Name of head of household: ________________ Village: _________________

Name of person asked: _____________________ Date: __________________

Surveyor's ID: __________________

1. Who is the head of your household? 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?

(if the fisher can't specify, tick the box)

		times/week	duration in hours <2	2–4	4–6	>6	glean/dive at D	N	D&N	fish no. of months/year
☐ seagrass gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ mangrove & mud gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ sand & beach gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ reeftop gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ bêche-de-mer diving	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ lobster diving	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ mother-of-pearl diving trochus, pearl shell, etc.	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ other diving (clams, octopus)	☐	____	☐	☐	☐	☐	☐	☐	☐	________

D = day, N = night, D&N = day and night (no preference but fish with tide)

4. Do you sometimes go gleaning/fishing for invertebrates outside your village fishing grounds?

yes ☐ no ☐

If yes, where? ____

5. Do you finfish? yes ☐ no ☐

for: ☐ consumption? ☐ sale?

at the same time? yes ☐ no ☐

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐

SHEET 1: EACH FISHERY PER FISHER INTERVIEWED: ☐ **HH NO. __Name of fisher: ____________** **gender: F** ☐ **M** ☐

What transport do you mainly use? ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

How many fishers are usually on a trip? (total no.) ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit 1	3/4	1/2	1/4				

Appendix 1: Survey methods
Socioeconomics

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit							
			1	3/4	1/2	1/4				

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐ other (clams, octopus) ☐

SHEET 2: SPECIES SOLD PER FISHER INTERVIEWED: **HH NO**. ☐ **Name of fisher:** ________________________

Copy all species that have been named for 'SALE' in previous sheet

Who markets your products? ☐ you ☐ your wife ☐ your husband ☐ a group of fishers ☐ other __________________

Species for sale – copy from sheet 2 (for each fishery per fisher) above	Processing level of product sold (see list)	Where do you sell? (see list)	How often? Days/week?	How much each time? Quantity/unit	Price

FISHERIES (FINFISH AND INVERTEBRATE AND SOCIOECONOMICS) GENERAL INFORMATION SURVEY

Target group: key people, groups of fishers, fisheries officers, etc.

1. Are there management rules that apply to your fisheries? Do they specifically target finfish or invertebrates, or do they target both sectors?

a) legal/Ministry of Fisheries

b) traditional/community/village determined:

2. What do you think – do people obey:

traditional/village management rules?

mostly ☐ sometimes ☐ hardly ☐

legal/Ministry of Fisheries management rules?

mostly ☐ sometimes ☐ hardly ☐

3. Are there any particular rules that you know people do not respect or follow at all? And do you know why?

4. What are the main techniques used by the community for:

a) finfishing

gillnets – most-used mesh sizes:

What is usually used for bait? And is it bought or caught?

b) invertebrate fishing → ***see end!***

5. Please give a quick inventory and characteristics of boats used in the community (length, material, motors, etc.).

Seasonality of species

What are the **FINFISH** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

Seasonality of species

What are the **INVERTEBRATE** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

How many people carry out the invertebrate fisheries below, from inside and from outside the community?

GLEANING	no. from this village	no.	from village	no.	from village
☐ seagrass gleaning	☐	☐	______	☐	______
☐ mangrove & mud gleaning	☐	☐	______	☐	______
☐ sand & beach gleaning	☐	☐	______	☐	______
☐ reeftop gleaning	☐	☐	______	☐	______
DIVING					
☐ bêche-de-mer diving	☐	☐	______	☐	______
☐ lobster diving	☐	☐	______	☐	______
☐ mother-of-pearl diving trochus, pearl shell, etc.	☐	☐	______	☐	______
☐ other (clams, octopus)	☐	☐	______	☐	______

What gear do invertebrate fishers use? *(tick box of technique per fishery)*

GLEANING (soft bottom = seagrass)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other ________		

GLEANING (soft bottom = mangrove & mud)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other ________		

GLEANING (soft bottom = sand & beach)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

GLEANING (hard bottom = reeftop)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (bêche-de-mer)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (lobster)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (mother-of-pearl, trochus, pearl shell, etc.)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (other, such as clams, octopus)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

Any traditional/customary/village fisheries?

Name:

Season/occasion:

Frequency:

Quantification of marine resources caught:

Species name	Size	Quantity (unit?)

1.1.3 Average wet weight applied for selected invertebrate species groups

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Acanthopleura gemmata	29	35	65	10.15	Chiton
Actinopyga lecanora	300	10	90	30	BdM (1)
Actinopyga mauritiana	350	10	90	35	BdM (1)
Actinopyga miliaris	300	10	90	30	BdM (1)
Anadara spp.	21	35	65	7.35	Bivalves
Asaphis violascens	15	35	65	5.25	Bivalves
Astralium spp.	20	25	75	5	Gastropods
Atactodea striata, *Donax cuneatus,* *Donax cuneatus*	2.75	35	65	0.96	Bivalves
Atrina vexillum, *Pinctada margaritifera*	225	35	65	78.75	Bivalves
Birgus latro	1000	35	65	350	Crustacean
Bohadschia argus	462.5	10	90	46.25	BdM (1)
Bohadschia spp.	462.5	10	90	46.25	BdM (1)
Bohadschia vitiensis	462.5	10	90	46.25	BdM (1)
Cardisoma carnifex	227.8	35	65	79.74	Crustacean
Carpilius maculatus	350	35	65	122.5	Crustacean
Cassis cornuta, *Thais aculeata,* *Thais aculeata*	20	25	75	5	Gastropods
Cerithium nodulosum, *Cerithium nodulosum*	240	25	75	60	Gastropods
Chama spp.	25	35	65	8.75	Bivalves
Codakia punctata	20	35	65	7	Bivalves
Coenobita spp.	50	35	65	17.5	Crustacean
Conus miles, *Strombus gibberulus gibbosus*	240	25	75	60	Gastropods
Conus spp.	240	25	75	60	Gastropods
Cypraea annulus, *Cypraea moneta*	10	25	75	2.5	Gastropods
Cypraea caputserpensis	15	25	75	3.75	Gastropods
Cypraea mauritiana	20	25	75	5	Gastropods
Cypraea spp.	95	25	75	23.75	Gastropods
Cypraea tigris	95	25	75	23.75	Gastropods
Dardanus spp.	10	35	65	3.5	Crustacean
Dendropoma maximum	15	25	75	3.75	Gastropods
Diadema spp.	50	48	52	24	Echinoderm
Dolabella auricularia	35	50	50	17.5	Others
Donax cuneatus	15	35	65	5.25	Bivalves
Drupa spp.	20	25	75	5	Gastropods
Echinometra mathaei	50	48	52	24	Echinoderm
Echinothrix spp.	100	48	52	48	Echinoderm
Eriphia sebana	35	35	65	12.25	Crustacean
Gafrarium pectinatum	21	35	65	7.35	Bivalves
Gafrarium tumidum	21	35	65	7.35	Bivalves
Grapsus albolineatus	35	35	65	12.25	Crustacean
Hippopus hippopus	500	19	81	95	Giant clams
Holothuria atra	100	10	90	10	BdM (1)
Holothuria coluber	100	10	90	10	BdM (1)

1.1.3 Average wet weight applied for selected invertebrate species groups (continued)

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Holothuria fuscogilva	2000	10	90	200	BdM (1)
Holothuria fuscopunctata	1800	10	90	180	BdM (1)
Holothuria nobilis	2000	10	90	200	BdM (1)
Holothuria scabra	2000	10	90	200	BdM (1)
Holothuria spp.	2000	10	90	200	BdM (1)
Lambis lambis	25	25	75	6.25	Gastropods
Lambis spp.	25	25	75	6.25	Gastropods
Lambis truncata	500	25	75	125	Gastropods
Mammilla melanostoma, *Polinices mammilla*	10	25	75	2.5	Gastropods
Modiolus auriculatus	21	35	65	7.35	Bivalves
Nerita albicilla, *Nerita polita*	5	25	75	1.25	Gastropods
Nerita plicata	5	25	75	1.25	Gastropods
Nerita polita	5	25	75	1.25	Gastropods
Octopus spp.	550	90	10	495	Octopus
Panulirus ornatus	1000	35	65	350	Crustacean
Panulirus penicillatus	1000	35	65	350	Crustacean
Panulirus spp.	1000	35	65	350	Crustacean
Panulirus versicolor	1000	35	65	350	Crustacean
Parribacus antarcticus	750	35	65	262.5	Crustacean
Parribacus caledonicus	750	35	65	262.5	Crustacean
Patella flexuosa	15	35	65	5.25	Limpet
Periglypta puerpera, *Periglypta reticulate*	15	35	65	5.25	Bivalves
Periglypta spp., *Periglypta* spp., *Spondylus* spp., *Spondylus* spp.,	15	35	65	5.25	Bivalves
Pinctada margaritifera	200	35	65	70	Bivalves
Pitar proha	15	35	65	5.25	Bivalves
Planaxis sulcatus	15	25	75	3.75	Gastropods
Pleuroploca filamentosa	150	25	75	37.5	Gastropods
Pleuroploca trapezium	150	25	75	37.5	Gastropods
Portunus pelagicus	227.83	35	65	79.74	Crustacean
Saccostrea cuccullata	35	35	65	12.25	Bivalves
Saccostrea spp.	35	35	65	12.25	Bivalves
Scylla serrata	700	35	65	245	Crustacean
Serpulorbis spp.	5	25	75	1.25	Gastropods
Sipunculus indicus	50	10	90	5	Seaworm
Spondylus squamosus	40	35	65	14	Bivalves
Stichopus chloronotus	100	10	90	10	BdM (1)
Stichopus spp.	543	10	90	54.3	BdM (1)
Strombus gibberulus gibbosus	25	25	75	6.25	Gastropods
Strombus luhuanus	25	25	75	6.25	Gastropods
Tapes literatus	20	35	65	7	Bivalves
Tectus pyramis, *Trochus niloticus*	300	25	75	75	Gastropods
Tellina palatum	21	35	65	7.35	Bivalves
Tellina spp.	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 spp.	37.5	25	75	9.39	Gastropods
Thais armigera	20	25	75	5	Gastropods
Thais spp.	20	25	75	5	Gastropods
Thelenota ananas	2500	10	90	250	BdM (1)
Thelenota anax	2000	10	90	200	BdM (1)
Tridacna maxima	500	19	81	95	Giant clams
Tridacna spp.	500	19	81	95	Giant clams
Trochus niloticus	200	25	75	50	Gastropods
Turbo crassus	80	25	75	20	Gastropods
Turbo marmoratus	20	25	75	5	Gastropods
Turbo setosus	20	25	75	5	Gastropods
Turbo spp.	20	25	75	5	Gastropods

BdM = Bêche-de-mer; (1) edible part of dried Bêche-de-mer, i.e. drying process consumes about 90% of total wet weight; hence 10% are considered as the edible part only.

1.2 Methods used to assess the status of finfish resources

Fish counts

In order to count and size fish in selected sites, we use the **distance-sampling underwater visual census (D-UVC)** method (Kulbicki and Sarramegna 1999, Kulbicki *et al.* 2000), fully described in Labrosse *et al.* (2002). Briefly, the method consists of recording the species name, abundance, body length and the distance to the transect line for each fish or group of fish observed; the transect consists of a 50 m line, represented on the seafloor by an underwater tape (Figure A1.2.1). For security reasons, two divers are required to conduct a survey, each diver counting fish on a different side of the transect. Mathematical models are then used to estimate fish density (number of fish per unit area) and biomass (weight of fish per unit area) from the counts.

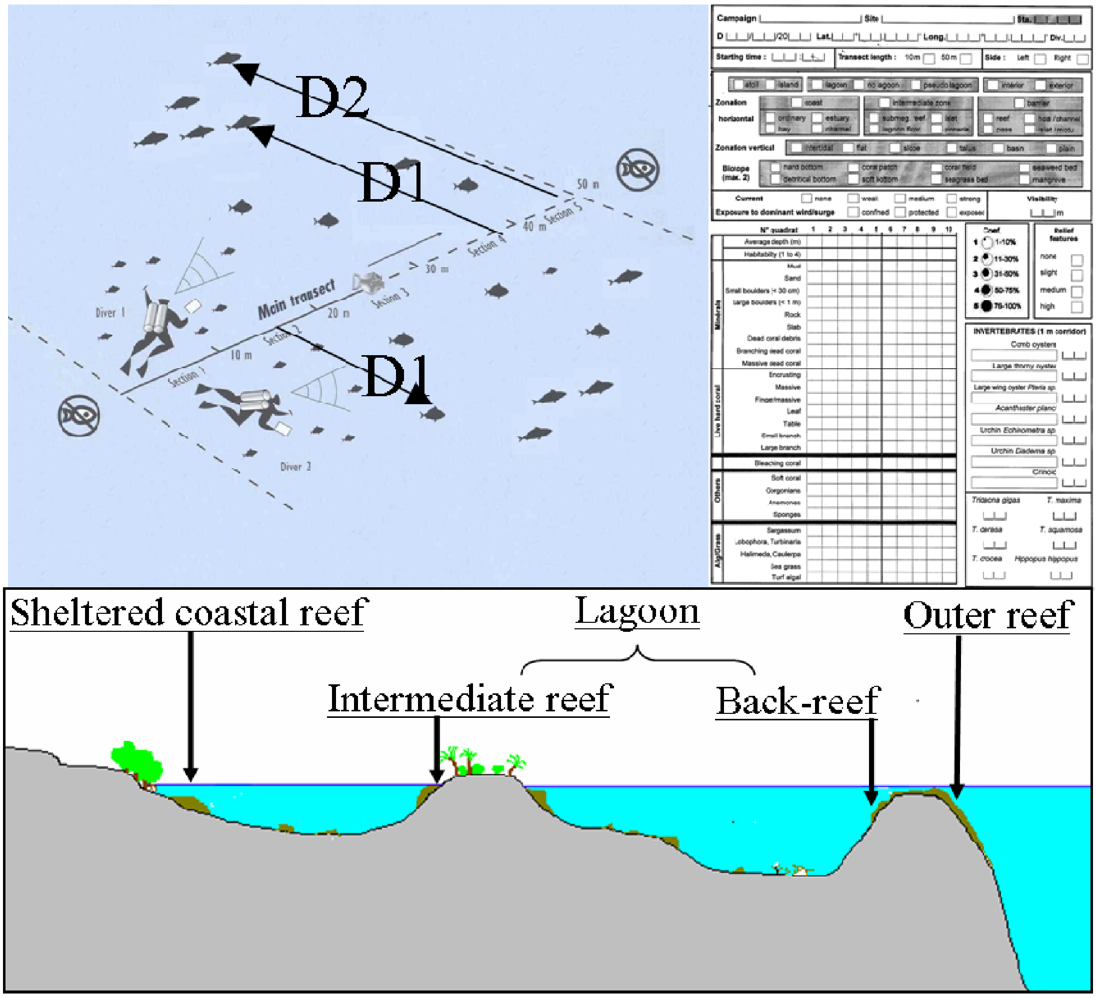


Figure A1.2.1: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver records the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys are conducted along 24 transects, with six transects in each of the four main geomorphologic coral reef structures: sheltered coastal reefs, intermediate reefs and back-reefs (lumped into the 'lagoon reef' category of socioeconomic assessment), and outer reefs. D1 is the distance of an observed fish from the transect line. If a school of fish is observed, D1 is the distance from the transect line to the closest fish; D2 the distance to the furthest fish.

Species selection

Only reef fish of interest for consumption or sale and species that could potentially serve as indicators of coral reef health are surveyed (see Table A1.2.1; Appendix 3.2 provides a full list of counted species and abundance for each site surveyed).

Table A1.2.1: List of finfish species surveyed by distance sampling underwater visual census (D-UVC)
Most frequently observed families on which reports are based are highlighted in yellow.

Family	Selected species
Acanthuridae	All species
Aulostomidae	*Aulostomus chinensis*
Balistidae	All species
Belonidae	All species
Caesionidae	All species
Carangidae	All species
Carcharhinidae	All species
Chaetodontidae	All species
Chanidae	All species
Dasyatidae	All species
Diodontidae	All species
Echeneidae	All species
Ephippidae	All species
Fistulariidae	All species
Gerreidae	*Gerres* spp.
Haemulidae	All species
Holocentridae	All species
Kyphosidae	All species
Labridae	*Bodianus axillaris, Bodianus loxozonus, Bodianus perditio, Bodianus* spp., *Cheilinus:* all species, *Choerodon:* all species, *Coris aygula, Coris gaimard, Epibulus insidiator, Hemigymnus:* all species, *Oxycheilinus diagrammus, Oxycheilinus* spp.
Lethrinidae	All species
Lutjanidae	All species
Monacanthidae	*Aluterus scriptus*
Mugilidae	All species
Mullidae	All species
Muraenidae	All species
Myliobatidae	All species
Nemipteridae	All species
Pomacanthidae	*Pomacanthus semicirculatus, Pygoplites diacanthus*
Priacanthidae	All species
Scaridae	All species
Scombridae	All species
Serranidae	Epinephelinae: all species
Siganidae	All species
Sphyraenidae	All species
Tetraodontidae	*Arothron*: all species
Zanclidae	All species

Analysis of percentage occurrence in surveys at both regional and national levels indicates that of the initial 36 surveyed families, only 15 families are frequently seen in country counts.

Appendix 1: Survey methods
Finfish

Since low percentage occurrence could either be due to rarity (which is of interest) or low detectability (representing a methodological bias), we decided to restrict our analysis to the 15 most frequently observed families, for which we can guarantee that D-UVC is an efficient resource assessment method.

These are:

- Acanthuridae (surgeonfish)
- Balistidae (triggerfish)
- Chaetodontidae (butterflyfish)
- Holocentridae (squirrelfish)
- Kyphosidae (drummer and seachubs)
- Labridae (wrasse)
- Lethrinidae (sea bream and emperor)
- Lutjanidae (snapper and seaperch)
- Mullidae (goatfish)
- Nemipteridae (coral bream and butterfish)
- Pomacanthidae (angelfish)
- Scaridae (parrotfish)
- Serranidae (grouper, rockcod, seabass)
- Siganidae (rabbitfish)
- Zanclidae (moorish idol).

Substrate

We used the **medium-scale approach** (MSA) to record substrate characteristics along transects where finfish were counted by D-UVC. MSA has been developed by Clua *et al.* (2006) to specifically complement D-UVC surveys. Briefly, the method consists of recording depth, habitat complexity, and 23 substrate parameters within ten 5 m x 5 m quadrats located on each side of a 50 m transect, for a total of 20 quadrats per transect (Figure A1.2.1). The transect's habitat characteristics are then calculated by averaging substrate records over the 20 quadrats.

Parameters of interest

In this report, the status of finfish resources has been characterised using the following seven parameters:

- **biodiversity** – the number of families, genera and species counted in D-UVC transects;
- **density** (fish/m^2) – estimated from fish abundance in D-UVC;
- **size** (cm fork length) – direct record of fish size by D-UVC;
- **size ratio** (%) – the ratio between fish size and maximum reported size of the species. This ratio can range from nearly zero when fish are very small to nearly 100 when a given fish has reached the greatest size reported for the species. Maximum reported size (and source of reference) for each species are stored in our database;
- **biomass** (g/m^2) – obtained by combining densities, size, and weight–size ratios (Weight–size ratio coefficients are stored in our database and were provided by Mr Michel Kulbicki, IRD Noumea, Coreus research unit);
- **community structure** – density, size and biomass compared among families; and

- **trophic structure –** density, size and biomass compared among trophic groups. Trophic groups are stored in our database and were provided by Mr Michel Kulbicki, IRD Noumea, Coreus research unit. Each species was classified into one of five broad trophic groups: 1) carnivore (feed predominantly on zoobenthos), 2) detritivore (feed predominantly on detritus), 3) herbivore (feed predominantly on plants), 4) piscivore (feed predominantly on nekton, other fish and cephalopods) and 5) plankton feeder (feed predominantly on zooplankton). More details on fish diet can be found online at: http://www.fishbase.org/manual/english/FishbaseThe_FOOD_ITEMS_Table.htm.

The relationship between environment quality and resource status has not been fully explored at this stage of the project, as this task requires complex statistical analyses on the regional dataset. Rather, the living resources assessed at all sites in each country are placed in an environmental context via the description of several crucial habitat parameters. These are obtained by grouping the original 23 substrate parameters recorded by divers into the following six parameters:

- **depth** (m)
- **soft bottom** (% cover) – sum of substrate components:
  (1) mud (sediment particles <0.1 mm), and
  (2) sand and gravel (0.1 mm <hard particles <30 mm)
- **rubble and boulders** (% cover) – sum of substrate components:
  (3) dead coral debris (carbonated structures of heterogeneous size, broken and removed from their original locations),
  (4) small boulders (diameter <30 cm), and
  (5) large boulders (diameter <1 m)
- **hard bottom** (% cover) – sum of substrate components:
  (6) slab and pavement (flat hard substratum with no relief), rock (massive minerals) and eroded dead coral (carbonated edifices that have lost their coral colony shape),
  (7) dead coral (dead carbonated edifices that are still in place and retain a general coral shape), and
  (8) bleaching coral
- **live coral** (% cover) – sum of substrate components:
  (9) encrusting live coral,
  (10) massive and sub-massive live corals,
  (11) digitate live coral,
  (12) branching live coral,
  (13) foliose live coral,
  (14) tabulate live coral, and
  (15) *Millepora* spp.
- **soft coral** (% cover) – substrate component:
  (16) soft coral.

Sampling design

Coral reef ecosystems are complex and diverse. The NASA Millennium Coral Reef Mapping Project (MCRMP) has identified and classified coral reefs of the world in about 1000 categories. These very detailed categories can be used directly to try to explain the status of living resources or be lumped into more general categories to fit a study's particular needs. For the needs of the finfish resource assessment, MCRMP reef types were grouped into the four main coralline geomorphologic structures found in the Pacific (Figure A1.2.2):

- **sheltered coastal reef**: reef that fringes the land but is located inside a lagoon or a pseudo-lagoon
- **lagoon reef**:
  - **intermediate reef** – patch reef that is located inside a lagoon or a pseudo-lagoon, and
  - **back-reef** – inner/lagoon side of outer reef
- **outer reef**: ocean side of fringing or barrier reefs.

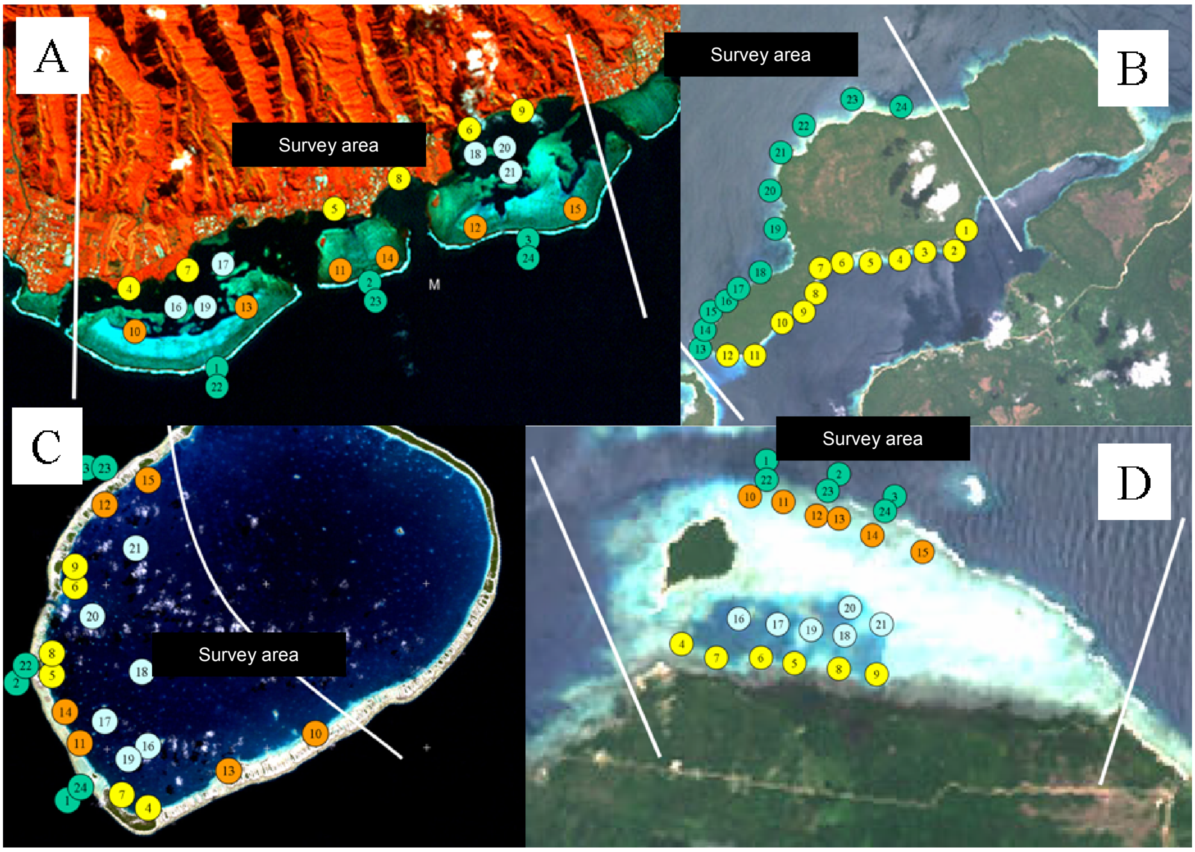


Figure A1.2.2: Position of the 24 D-UVC transects surveyed in A) an island with a lagoon, B) an island with a pseudo-lagoon C) an atoll and D) an island with an extensive reef enclosing a small lagoon pool.
Sheltered coastal reef transects are in yellow, lagoon intermediate-reef transects in blue, lagoon back-reef transects in orange and outer-reef transects in green. Transect locations are determined using satellite imagery prior to going into the field, which greatly enhances fieldwork efficiency. The white lines delimit the borders of the survey area.

Fish and associated habitat parameters are recorded along 24 transects per site, with a balanced design among the main geomorphologic structures present at a given site (Figure A1.2.2). For example, our design results in at least six transects in each of the sheltered coastal, lagoon intermediate, lagoon back-reef, and outer reefs of islands with lagoons (Figure A1.2.2A) or 12 transects in each of the sheltered coastal and outer reefs of islands with pseudo-lagoons (Figure A1.2.2B). This balanced, stratified and yet flexible sampling design was chosen to optimise the quality of the assessment, given the logistical and time constraints that stem from the number and diversity of sites that have to be covered over the life of the project. The exact position of transects is determined in advance using satellite imagery, to assist in locating the exact positions in the field; this maximises accuracy and allows replication for monitoring purposes (Figure A1.2.2).

Appendix 1: Survey methods
Finfish

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 |__|__|__|

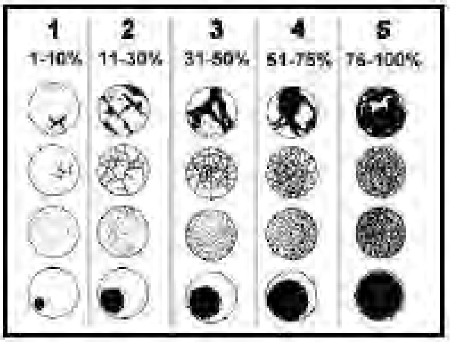
Starting time : |__|__| :|__|__| — Visibility |__|__| m — Side : Left ☐ Right ☐

☐ 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

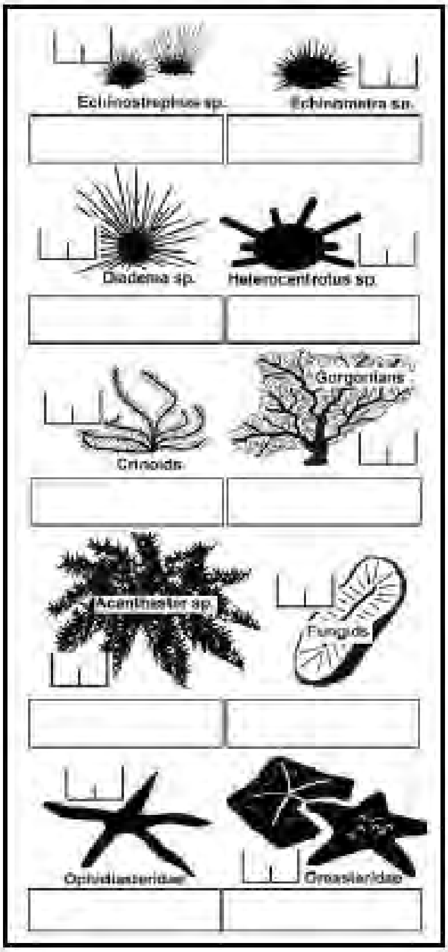
☐ intertidal ☐ flat ☐ gentle slope ☐ steep slope ☐ talus ☐ basin ☐ lagoon plain

☐ hard bottom ☐ detritical bottom ☐ large coral patches ☐ soft bottom ☐ small coral patches ☐ coral field ☐ seagrass bed ☐ seaweed bed ☐ mangrove

	current	relief features	exposure to dominant wind	oceanic influence	terrigenous influence
none	☐	☐	☐	☐	☐
medium	☐	☐	☐	☐	☐
strong	☐	☐	☐	☐	☐



Quadrat limits	0	5	10	15	20	25	30	35	40	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 :											



Finfish

Campaign |____________________| Site |______________________________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|,|__|__|__|’ Long.|__|__|__|°|__|__|,|__|__|__|’ Left ☐ Right ☐

ST	SCIENTIFIC NAME	NBER	LGT	D1	D2	COMMENTS

1.3 Invertebrate resource survey methods

1.3.1 Methods used to assess the status of invertebrate resources

Introduction

Coastal communities in the Pacific access a range of invertebrate resources. Within the PROCFish/C study, a range of survey methods were used to provide information on key invertebrate species commonly targeted. These provide information on the status of resources at scales relevant to species (or species groups) and the fishing grounds being studied that can be compared across sites, countries and the region, in order to assess relative status.

Species data resulting from the resource survey are combined with results from the socioeconomic survey of fishing activity to describe invertebrate fishing activity within specific 'fisheries'. Whereas descriptions of commercially orientated fisheries are generally recognisable in the literature (e.g. the sea cucumber fishery), results from non-commercial stocks and subsistence-orientated fishing activities (e.g. general reef gleaning) will also be presented as part of the results, so as to give managers a general picture of invertebrate fishery status at study sites.

Field methods

We examined invertebrate stocks (and fisheries) for approximately seven days at each site, with at least two research officers (SPC Invertebrate Biologist and Fisheries Officer) plus officers from the local fisheries department. The work completed at each site was determined by the availability of local habitats and access to fishing activity.

Two types of survey were conducted: fishery-dependent surveys and fishery independent surveys.

- Fishery-dependent surveys rely on information from those engaged in the fishery, e.g. catch data;
- Fishery-independent surveys are conducted by the researchers independently of the activity of the fisheries sector.

Fishery-dependent surveys were completed whenever the opportunity arose. This involved accompanying fishers to target areas for the collection of invertebrate resources (e.g. reef-benthos, soft-benthos, trochus habitat). The location of the fishing activity was marked (using a GPS) and the catch composition and catch per unit effort (CPUE) recorded (kg/hour).

This record was useful in helping to determine the species complement targeted by fishers, particularly in less well-defined 'gleaning' fisheries. A CPUE record, with related information on individual animal sizes and weights, provided an additional dataset to expand records from reported catches (as recorded by the socioeconomic survey). In addition, size and weight measures collected through fishery-dependent surveys were compared with records from fishery-independent surveys, in order to assess which sizes fishers were targeting.

For a number of reasons, not all fisheries lend themselves to independent snapshot assessments: density measures may be difficult to obtain (e.g. crab fisheries in mangrove systems) or searches may be greatly influenced by conditions (e.g. weather, tide and lunar conditions influence lobster fishing). In the case of crab or shoreline fisheries, searches are very subjective and weather and tidal conditions affect the outcome. In such cases, observed and reported catch records were used to determine the status of species and fisheries.

A further reason for accompanying groups of fishers was to gain a first-hand insight into local fishing activities and facilitate the informal exchange of ideas and information. By talking to fishers in the fishing grounds, information useful for guiding independent resource assessment was generally more forthcoming than when trying to gather information using maps and aerial photographs while in the village. Fishery-independent surveys were not conducted randomly over a defined site 'study' area. Therefore assistance from knowledgeable fishers in locating areas where fishing was common was helpful in selecting areas for fishery-independent surveys.

A series of fishery-independent surveys (direct, in-water resource assessments) were conducted to determine the status of targeted invertebrate stocks. These surveys needed to be wide ranging within sites to overcome the fact that distribution patterns of target invertebrate species can be strongly influenced by habitat, and well replicated as invertebrates are often highly aggregated (even within a single habitat type).

PROCFish/C assessments do not aim to determine the size of invertebrate populations at study sites. Instead, these assessments aim to determine the status of invertebrates within the main fishing grounds or areas of naturally higher abundance. The implications of this approach are important, as the haphazard measures taken in main fishing grounds are indicative of stock health in these locations only and should not be extrapolated across all habitats within a study site to gain population estimates.

This approach was adopted due to the limited time allocated for surveys and the study's goal of 'assessing the status of invertebrate resources' (as opposed to estimating the standing stock). Making judgements on the status of stocks from such data relies on the assumption that the state of these estimates of 'unit stock'[2] reflects the health of the fishery. For example, an overexploited trochus fishery would be unlikely to have high-density 'patches' of trochus, just as a depleted shallow-reef gleaning fishery would not hold high densities of large clams. Conversely, a fishery under no stress would be unlikely to be depleted or show skewed size ratios that reflected losses of the adult component of the stock.

In addition to examining the density of species, information on spatial distribution and size/weight was collected, to add confidence to the study's inferences.

The basic assumption that looking at a unit stock will give a reliable picture of the status of that stock is not without weaknesses. Resource stocks may appear healthy within a much-restricted range following stress from fishing or environmental disturbance (e.g. a cyclone), and historical information on stock status is not usually available for such remote locations. The lack of historical datasets also precludes speculation on 'missing' species, which may be 'fished-out' or still remain in remnant populations at isolated locations within study sites.

[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).

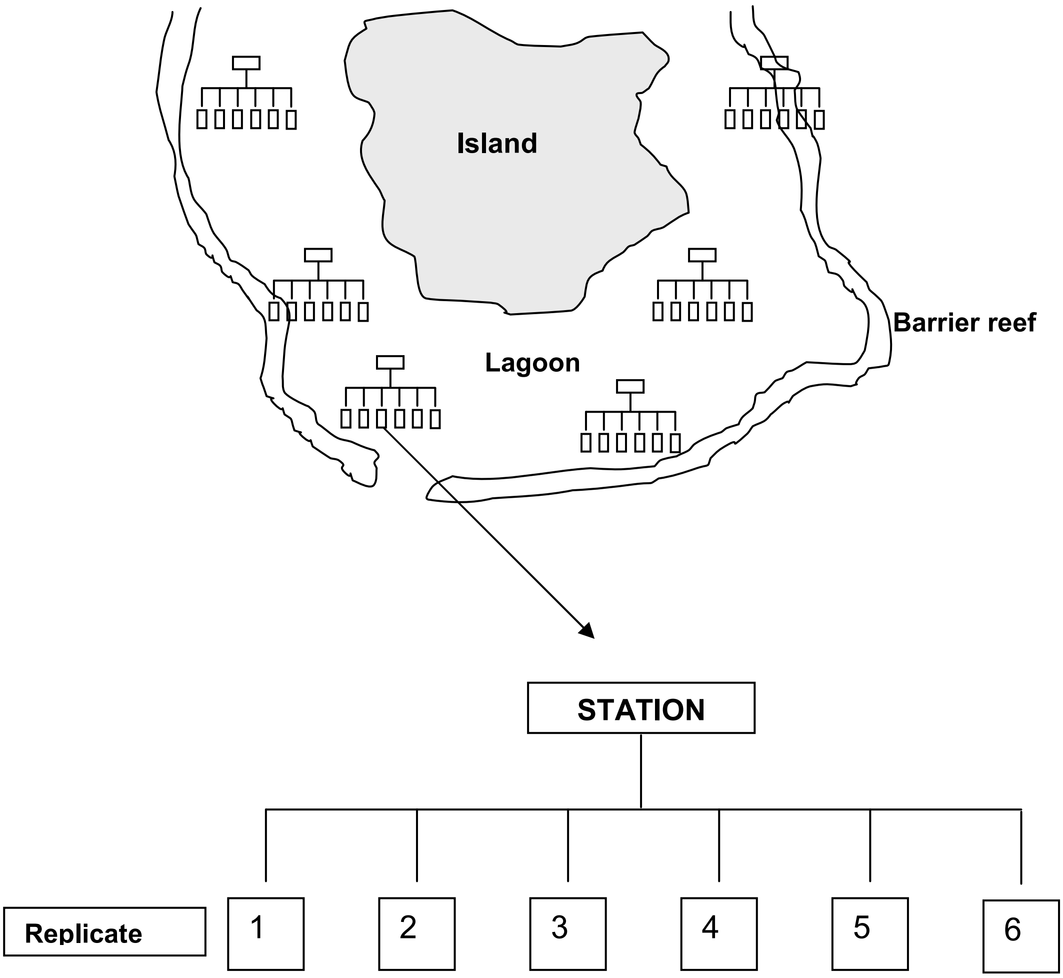


Figure A1.3.1: Stations and replicate measures at a given site.
A replicate measure could be a transect, search period or quadrat group.

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).

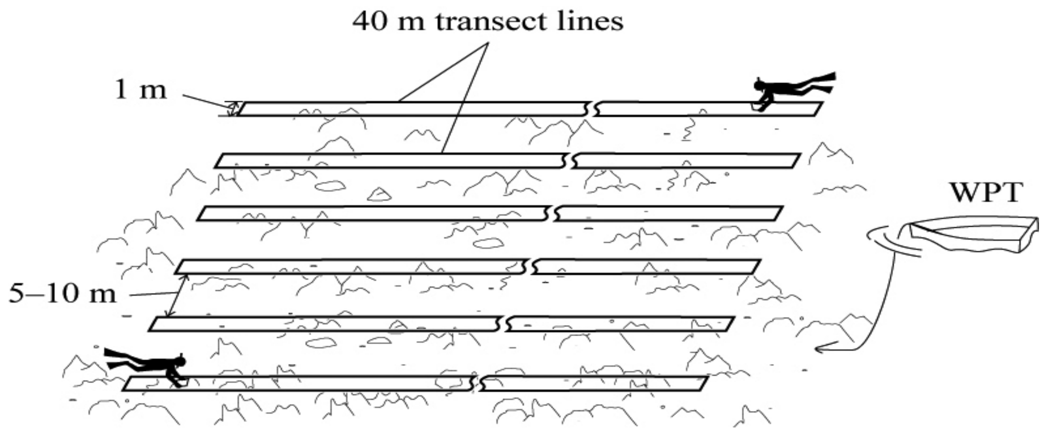


Figure A1.3.2: Example of a reef-benthos transect station (RBt).

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.

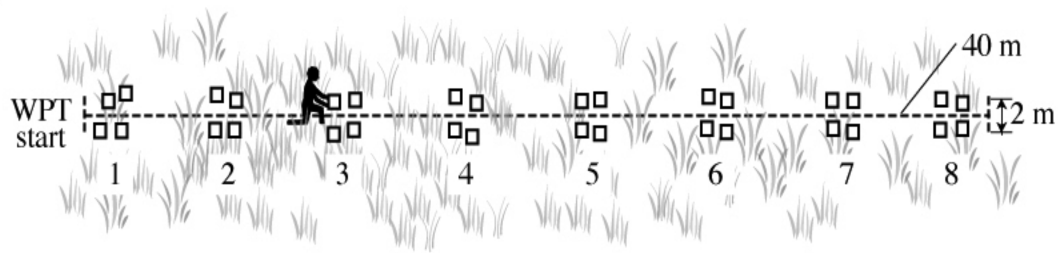


Figure A1.3.3: Soft-benthos (infaunal) quadrat station (SBq).
Single quadrats are 25 cm x 25 cm in size and four make up one 'quadrat group'.

<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).

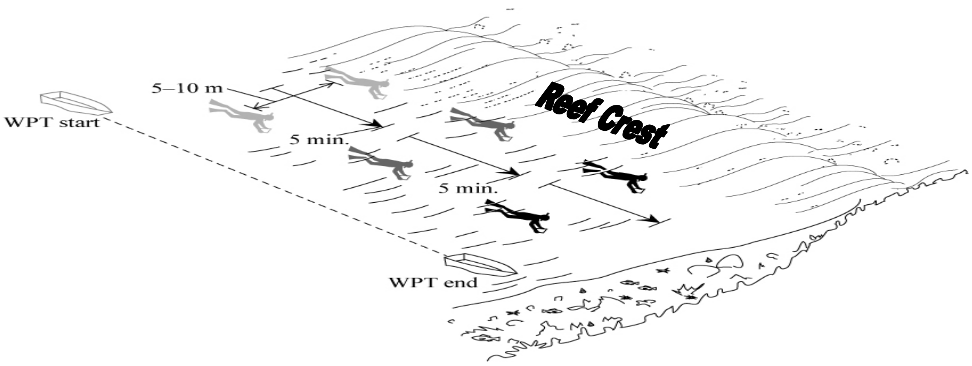


Figure A1.3.4: Reef-front search (RFs) station.

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.

<u>Mother-of-pearl search (MOPs)</u>

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).

<u>Mother-of-pearl transects (MOPt)</u>

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.

Appendix 1: Survey methods
Invertebrates

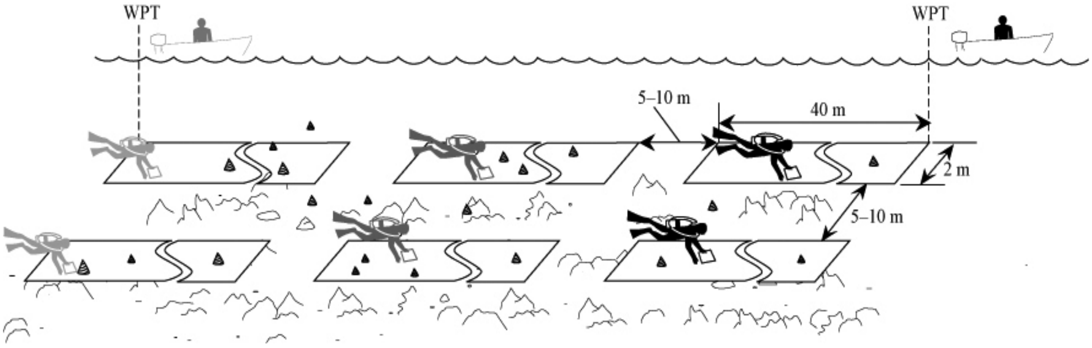


Figure A1.3.5: Mother-of-pearl transect station (MOPt).

Sea cucumber day search (Ds)

When possible, dives to 25–35 m were made to establish if white teatfish (*Holothuria (Microthele) fuscogilva*) populations were present and give an indication of abundance. In these searches two divers recorded the number and sizes of valuable deep-water sea cucumber species within three 5-min search periods (30 min total). This assessment from deep water does not yield sufficient presence/absence data for a very reliable inference on the status (i.e. 'health') of this and other deeper-water species.

Sea cucumber night search (Ns)

In the case of sea cucumber fisheries, dedicated night searches (Ns) for sea cucumbers and other echinoderms were conducted using snorkel for predominantly nocturnal species (blackfish *Actinopyga miliaris*, *A. lecanora*, and *Stichopus horrens*). Sea cucumbers were collected for three 5-min search periods by two snorkellers (30 min total), and if possible weighed (length and width measures for *A. miliaris* and *A. lecanora* are more dependent on the condition than the age of an individual).

Reporting style

For country site reports, results highlight the presence and distribution of species of interest, and their density at scales that yield a representative picture. Generally speaking, mean densities (average of all records) are presented, although on occasion mean densities for areas of aggregation ('patches') are also given. The later density figure is taken from records (stations or transects, as stated) where the species of interest is present (with an abundance >zero). Presentation of the relative occurrence and densities (without the inclusion of zero records) can be useful when assessing the status of aggregations within some invertebrate stocks.

An example and explanation of the reporting style adopted for invertebrate results follows.

1. The mean density range of *Tridacna* spp. on broad-scale stations (n = 8) was 10–120 per ha.

Density range includes results from all stations. In this case, replicates in each station are added and divided by the number of replicates for that station to give a mean. The lowest and highest station averages (here 10 and 120) are presented for the range. The number in brackets (n = 8) highlights the number of stations examined.

2. The mean density (per ha, ±SE) of all *Tridacna* clam species observed in broad-scale transects (n = 48) was 127.8 ±21.8 (occurrence in 29% of transects).

Mean density is the arithmetic mean, or average of measures across all replicates taken (in this case broad-scale transects). On occasion mean densities are reported for stations or transects where the species of interest is found at an abundance greater than zero. In this case the arithmetic mean would only include stations (or replicates) where the species of interest was found (excluding zero replicates). If this was presented for stations, even stations with a single clam from six transects would be included. (Note: a full breakdown of data is presented in the appendices.)

Written after the mean density figure is a descriptor that highlights variability in the figures used to calculate the mean. Standard error[3] (SE) is used in this example to highlight variability in the records that generated the mean density (SE = (standard deviation of records)/√n). This figure provides an indication of the dispersion of the data when trying to estimate a population mean (the larger the standard error, the greater variation of data points around the mean presented).

Following the variability descriptor is a presence/absence indicator for the total dataset of measures. The presence/absence figure describes the percentage of stations or replicates with a recording >0 in the total dataset; in this case 29% of all transects held *Tridacna* spp., which equated to 14 of a possible 48 transects (14/48*100 = 29%).

3. The mean length (cm, ±SE) of *T. maxima* was 12.4 ±1.1 (n = 114).

The number of units used in the calculation is indicated by *n*. In the last case, 114 clams were measured.

[3] In order to derive confidence limits around the mean, a transformation (usually y = log (x+1)) needs to be applied to data, as samples are generally non-normally distributed. Confidence limits of 95% can be generated through other methods (bootstrapping methods) and will be presented in the final report where appropriate.

1.3.2 General fauna invertebrate recording sheet with instructions to users

DATE		RECORDER		Pg No	

STATION NAME																		
WPT - WIDTH																		
RELIEF / COMPLEXITY **1–5**																		
OCEAN INFLUENCE **1–5**																		
DEPTH (M)																		
% SOFT SED (M – S – CS)																		
% RUBBLE / BOULDERS																		
% CONSOL RUBBLE / PAVE																		
% CORAL *LIVE*																		
% CORAL *DEAD*																		
SOFT / SPONGE / FUNGIDS																		
ALGAE *CCA*																		
CORALLINE																		
OTHER																		
GRASS																		
EPIPHYTES **1–5** / SILT **1–5**																		
bleaching: % of benthos																		
entered / checked																		

Figure A1.3.6: Sample of the invertebrate fauna survey sheet.

The sheet above (Figure A1.3.6) has been modified to fit on this page (the original has more line space (rows) for entering species data). When recording abundance or length data against species names, columns are used for individual transects or 5-min search replicates. If more space is needed, more than a single column can be used for a single replicate.

A separate sheet is used by a recorder in the boat to note information from handheld GPS equipment. In addition to the positional information, this boat sheet has space for manta transect distance (from GPS odometer function) and for sketches and comments.

1.3.3 Habitat section of invertebrate recording sheet with instructions to users

Figure A1.3.7 depicts the habitat part of the form used during invertebrate surveys; it is split into seven broad categories.

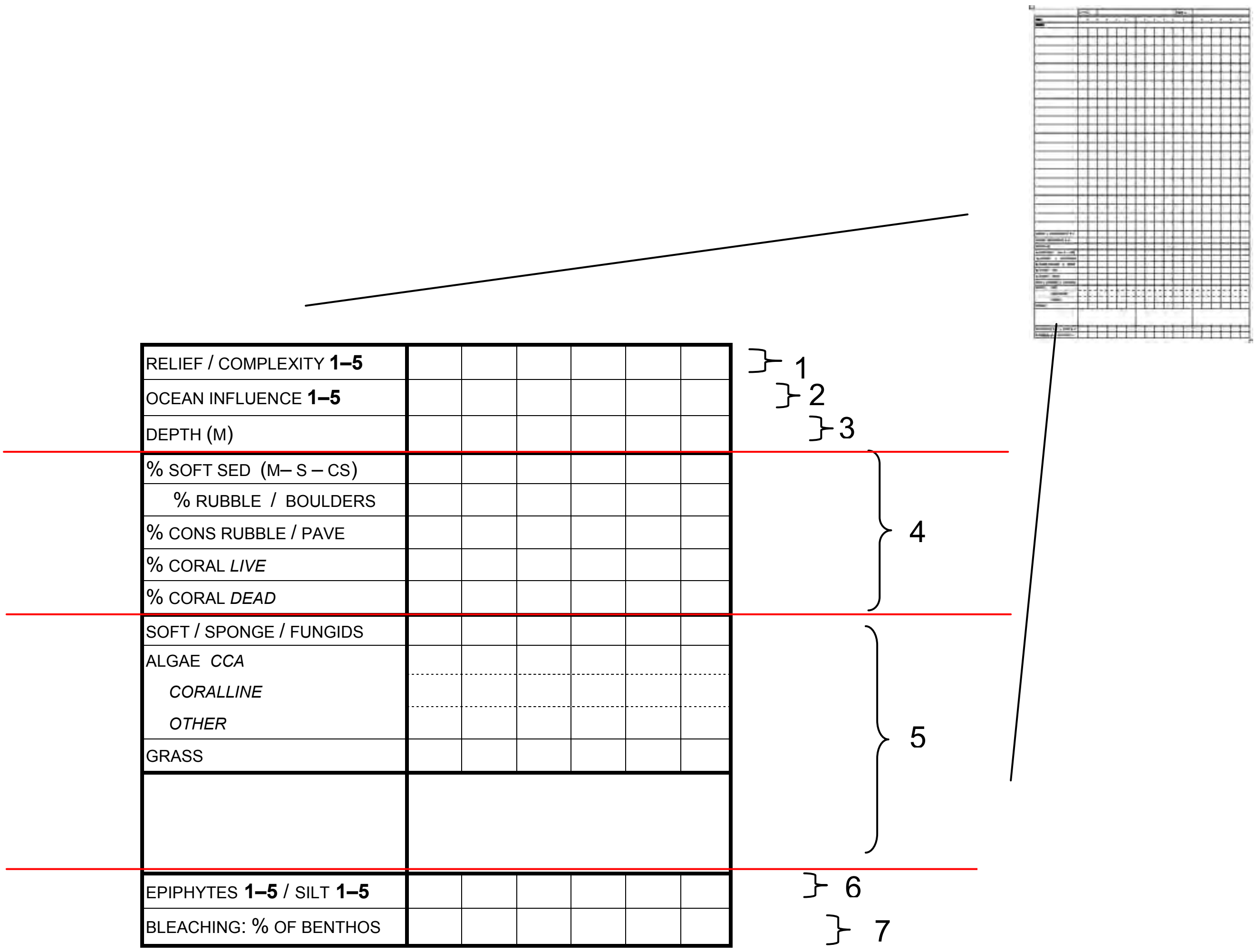


Figure A1.3.7: Sample of the invertebrate habitat part of survey form.

Relief and complexity (section 1 of form)

Each is on a scale of 1 to 5. If a record is written as 1/5, relief is 1 and complexity is 5, with the following explanation.

Relief describes average height variation for hard (and soft) benthos transects:

1 = flat (to ankle height)
2 = ankle up to knee height
3 = knee to hip height
4 = hip to shoulder/head height
5 = over head height

Complexity describes average surface variation for substrates (relative to places for animals to find shelter) for hard (and soft) benthos transects:

1 = smooth – no holes or irregularities in substrate
2 = some complexity to the surfaces but generally little

3 = generally complex surface structure
4 = strong complexity in surface structure, with cracks, spaces, holes, etc.
5 = very complex surfaces with lots of spaces, nooks, crannies, under-hangs and caves

Ocean influence (section 2 of form)

1 = riverine, or land-influenced seawater with lots of allochthonous input
2 = seawater with some land influence
3 = ocean and land-influenced seawater
4 = water mostly influenced by oceanic water
5 = oceanic water without land influence

Depth (section 3 of form)

Average depth in metres

Substrate – bird's-eye view of what's there (section 4 of form)

All of section 4 must make up 100%. Percentage substrate is estimated in units of 5% so, e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Soft substrate	Soft sediment – mud
Soft substrate	Soft sediment – mud and sand
Soft substrate	Soft sediment – sand
Soft substrate	Soft sediment – coarse sand
Hard substrate	Rubble
Hard substrate	Boulders
Hard substrate	Consolidated rubble
Hard substrate	Pavement
Hard substrate	Coral live
Hard substrate	Coral dead

Mud, sand, coarse sand: The sand is not sieved – it is estimated visually and manually. Surveyors can use the 'drop test', where sand drops through the water column and mud stays in suspension. Patchy settled areas of silt/clay/mud in very thin layers on top of coral, pavement, etc. are not listed as soft substrate unless the layer is significant (>a couple of cm).

Rubble is small (<25–30 cm) fragments of coral (reef), pieces of coral stone and limestone debris. AIMS' definition is very similar to that for Reefcheck (found on the 'C-nav' interactive CD): 'pieces of coral (reef) between 0.5 and 15 cm. If smaller, it is sand; if larger, then rock or whatever organism is growing upon it'.

Boulders are detached, big pieces (>30 cm) of stone, coral stone and limestone debris.

Consolidated rubble is attached, cemented pieces of coral stone and limestone debris. We tend to use 'rubble' for pieces or piles loose in the sediment of seagrass, etc., and 'consolidated rubble' for areas that are not flat pavement but concreted rubble on reeftops and cemented talus slopes.

Appendix 1: Survey methods
Invertebrates

Pavement is solid, substantial, fixed, flat stone (generally limestone) benthos.

Coral live is any live hard coral.

Coral dead is coral that is recognisable as coral even if it is long dead. Note that long-dead and *eroded* coral that is found in flat pavements is called 'pavement' and when it is found in loose pieces or blocks it is termed 'rubble' or 'boulders' (depending on size).

Cover – what is on top of the substrate (section 5 of form)

This cannot exceed 100%, but can be anything from 0 to 100%. Surveyors give scores in blocks of 5%, so e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Cover	Soft coral
Cover	Sponge
Cover	Fungids
Cover	Crustose-nongeniculate coralline algae
Cover	Coralline algae
Cover	Other (algae like *Sargassum*, *Caulerpa* and *Padina* spp.)
Cover	Seagrass

Soft coral is all soft corals but not Zoanthids or anemones.

Sponge includes half-buried sponges in seagrass beds – only sections seen on the surface are noted.

Fungids are fungids.

Crustose – nongeniculate coralline algae are pink rock. Crustose or nongeniculate coralline algae (NCA) are red algae that deposit calcium carbonate in their cell walls. Generally they are members of the division Rhodophyta.

Coralline algae – halimeda are red coralline algae (often seen in balls – *Galaxaura*). (Note: AIMS lists *halimeda* and other coralline algae as macro algae along with fleshy algae not having $CaCo_3$ deposits.)

Other algae include fleshy algae such as *Turbinaria*, *Padina* and *Dictyota*. Surveyors describe coverage by taking a bird's-eye view of what is covered, not by delineating the spatial area of the algae colony within the transect (i.e. differences in very low or high density are accounted for). The large space on the form is used to write species information if known.

Seagrass includes seagrass spp. such as *Halodule*, *Thalassia*, *Halophila* and *Syringodium*. Surveyors note types by species if possible or by structure (i.e. flat versus reed grass), and describe coverage by taking a bird's-eye view of what benthos is covered, not by delineating the spatial area of the grass meadow within the transect (i.e. differences in very low or high density are accounted for).

Cover continued – epiphytes and silt (section 6 of form)

Epiphytes 1–5 grade are mainly turf algae – turf that grows on hard and soft substrates, but also on algae and grasses. The growth is usually fine-stranded filamentous algae that have few noticeable distinguishing features (more like fuzz).

1 = none
2 = small areas or light coverage
3 = patchy, medium coverage
4 = large areas or heavier coverage
5 = very strong coverage, long and thick almost choking epiphytes – normally including strands of blue-green algae as well

Silt 1–5 grade (or a similar fine-structured material sometimes termed 'marine snow') consists of fine particles that slowly settle out from the water but are easily re-suspended. When re-suspended, silt tends to make the water murky and does not settle quickly like sand does. Sand particles are not silt and should not be included here when seen on outer-reef platforms that are wave affected.

1 = clear surfaces
2 = little silt seen
3 = medium amount of silt-covered surfaces
4 = large areas covered in silt
5 = surfaces heavily covered in silt

Bleaching (section 7 of form)

The percentage of bleached live coral is recorded in numbers from 1 to 100% (Not 5% blocks). This is the percentage of benthos that is dying hard coral (just-bleached) or very recently dead hard coral showing obvious signs of recent bleaching.

APPENDIX 2: SOCIOECONOMIC SURVEY DATA

2.1 Manono-uta socioeconomic survey data

2.1.1 Annual catch (kg) of fish groups per habitat – Manono-uta

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Sheltered coastal reef & mangrove				
Kivi	Lutjanidae	*Lutjanus bohar*	56	44.36
Fuga	Scaridae	*Scarus* spp.	42	33.27
Lo	Siganidae	*Siganus* spp.	28	22.18
Total:			**127**	**99.81**
Sheltered coastal reef				
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	240	23.1
Malau iusina	Holocentridae	*Sargocentron caudimaculatum*	240	23.1
Fuga	Scaridae	*Scarus* spp.	140	13.5
Ume	Acanthuridae	*Naso unicornis*	140	13.5
Palagi	Acanthuridae	*Acanthurus* spp.	108	10.4
Pone	Acanthuridae	*Ctenochaetus striatus*	85	8.2
Gatala	Serranidae	*Epinephelus* spp.	85	8.2
Total:			**1038**	**100.0**
Sheltered coastal reef & lagoon				
Alogo	Acanthuridae	*Acanthurus lineatus*	2847	7.1
Fuga	Scaridae	*Scarus* spp.	2523	6.3
Ume	Acanthuridae	*Naso unicornis*	2220	5.5
Pone	Acanthuridae	*Ctenochaetus striatus*	1856	4.6
Fagamea	Lutjanidae	*Lutjanus* spp.	1825	4.5
Fugausi	Scaridae	*Cetoscarus bicolor*	1762	4.4
Anae	Mugilidae	*Mugil* spp.	1716	4.3
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	1398	3.5
Iliilia	Acanthuridae	*Naso lituratus*	1166	2.9
Matamu	Lethrinidae	*Monotaxis grandoculis*	1072	2.7
Gatala	Serranidae	*Epinephelus* spp.	1024	2.5
Afulu	Mullidae	*Mullus* spp.	1021	2.5
Filoa	Lethrinidae	*Lethrinus* spp.	1014	2.5
Lo	Siganidae	*Siganus* spp.	996	2.5
Atule	Carangidae	*Caranx* spp.	862	2.1
Ulaoa	Mullidae	*Upeneus vittatus*	838	2.1
Loloa	Siganidae	*Siganus argenteus*	837	2.1
Pusi	Muraenidae	*Gymnothorax fimbriatus*	826	2.1
Fuafua	Mugilidae	*Crenimugil crenilabis*	814	2.0
Galafa	Zanclidae	*Zanclus* spp.	732	1.8
Fuga a'au	Scaridae	*Scarus spinus*	717	1.8
Bulelei	Carangidae	*Caranx* spp.	688	1.7
Lalafi	Labridae	*Cheilinus undulatus*	639	1.6
Palagi	Acanthuridae	*Acanthurus* spp.	612	1.5
Tifitifi	Chaetodontidae	*Chaetodon* spp.	552	1.4
Kauliuli	Lutjanidae	*Lutjanus* spp.	550	1.4
Laea	Scaridae	*Chlorurus microrhinos*	525	1.3

2.1.1 Annual catch (kg) of fish groups per habitat – Manono-uta (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Sheltered coastal reef & lagoon (continued)				
Anaana	Mugilidae	*Mugil* spp.	472	1.2
Umelei	Acanthuridae	*Naso* spp.	442	1.1
Malau	Holocentridae	*Myripristis* spp.	439	1.1
Ganue	Kyphosidae	*Kyphosus cinerascens*	430	1.1
Ise	Hemiramphidae	*Hemiramphus* spp.	401	1.0
Kauleea	Lutjanidae	*Lutjanus* spp.	393	1.0
Kivi	Lutjanidae	*Lutjanus bohar*	391	1.0
Magigi	Holocentridae	*Holocentrus* spp.	368	0.9
Kagapa	Blenniidae	*Omobranchus elongatus*	353	0.9
Lailai	Mullidae	*Pseudupeneus* spp.	343	0.9
Manini	Acanthuridae	*Acanthurus triostegus*	331	0.8
Molemole	Labridae	*Novaculichthys taeniourus*	302	0.8
Malava	Siganidae	*Siganus argenteus*	267	0.7
Matu	Gerreidae	*Gerres oyena*	257	0.6
Lalafutu	Carangidae	*Trachinotus blochii*	248	0.6
Fae	Dasyatidae	*Taeniura* spp.	217	0.5
Melei	Scaridae	*Bolbometopon muricatum*	190	0.5
Paumalo	Monacanthidae	*Monacanthus* spp.	178	0.4
Matulau	Mullidae	*Upeneus* spp.	174	0.4
Galo	Scaridae	*Scarus* spp.	172	0.4
Utu	Lutjanidae	*Aprion virescens*	157	0.4
Taiva	Lutjanidae	*Lutjanus* spp.	145	0.4
Tuuu	Pomacanthidae	*Holacanthus* spp.	145	0.4
Sumu	Balistidae	*Balistes* spp.	143	0.4
Matapula	Priacanthidae	*Priacanthus* spp.	134	0.3
Mataloa	Lutjanidae	*Macolor niger*	122	0.3
Malau uli	Holocentridae	*Sargocentron violaceum*	122	0.3
Maila	Lethrinidae	*Lethrinus* spp.	122	0.3
Sugale	Labridae	*Thalassoma* spp.	122	0.3
Mumu	Lutjanidae	*Lutjanus bohar*	122	0.3
Ulapo	Scaridae	*Scarus* spp.	116	0.3
Papa	Serranidae	*Variola louti*	98	0.2
Mala	Scombridae	*Acanthocybium solandri*	97	0.2
Tauleia	Mullidae	*Parupeneus indicus*	87	0.2
Malauli	Holocentridae	*Sargocentron violaceum*	81	0.2
Lupota	Carangidae	*Caranx* spp.	81	0.2
Malau iusina	Holocentridae	*Sargocentron caudimaculatum*	81	0.2
Malie	Odontaspididae	*Carcharias* spp.	54	0.1
Oleole	Siganidae	*Siganus* spp.	41	0.1
Tautu	Diodontidae	*Diodon hystrix*	41	0.1
Pauulu	Siganidae	*Siganus spinus*	39	0.1
Magau	Holocentridae	*Holocentrus* spp.	27	0.1
Total:			**40,177**	**100.0**

2.1.1 Annual catch (kg) of fish groups per habitat – Manono-uta (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Lagoon				
Anae	Mugilidae	*Mugil* spp.	377	22.8
Fuafua	Mugilidae	*Crenimugil crenilabis*	231	13.9
Gatala	Serranidae	*Epinephelus* spp.	157	9.5
Atule	Scombridae Carangidae	*Katsuwonus pelamis* *Selar crumenophthalmus*	157	9.5
Fuga a'au	Scaridae	*Scarus spinus*	122	7.4
Manini	Acanthuridae	*Acanthurus triostegus*	97	5.8
Lufi	Kyphosidae	*Kyphosus* spp.	97	5.8
Anaana	Mugilidae	*Mugil* spp.	81	4.9
Iliilia	Acanthuridae	*Naso lituratus*	81	4.9
Lailai	Mullidae	*Pseudupeneus* spp.	81	4.9
Fae	Dasyatidae	*Taeniura* spp.	81	4.9
Matu	Gerreidae	*Gerres* spp.	54	3.3
Ise	Hemiramphidae	*Hemiramphus* spp.	41	2.5
Total:			**1658**	**100.0**
Lagoon & outer reef				
Fuga	Scaridae	*Scarus* spp.	1517	11.0
Laea	Scaridae	*Chlorurus microrhinos*	1207	8.7
Alogo	Acanthuridae	*Acanthurus lineatus*	1154	8.3
Ume	Acanthuridae	*Naso unicornis*	1052	7.6
Malau	Holocentridae	*Myripristis* spp.	871	6.3
Filoa	Lethrinidae	*Lethrinus* spp.	814	5.9
Gatala	Serranidae	*Epinephelus* spp.	705	5.1
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	561	4.1
Lo	Siganidae	*Siganus* spp.	470	3.4
Pone	Acanthuridae	*Ctenochaetus striatus*	456	3.3
Fugausi	Scaridae	*Cetoscarus bicolor*	399	2.9
Tauleia	Mullidae	*Parupeneus indicus*	378	2.7
Malauli	Holocentridae	*Sargocentron violaceum*	342	2.5
Fagamea	Lutjanidae	*Lutjanus* spp.	317	2.3
Palagi	Acanthuridae	*Acanthurus* spp.	285	2.1
Pusi	Muraenidae	*Gymnothorax fimbriatus*	263	1.9
Galafa	Zanclidae	*Zanclus* spp.	250	1.8
Bulelei	Carangidae	*Caranx* spp.	244	1.8
Mala	Scombridae	*Acanthocybium solandri*	240	1.7
Manini	Acanthuridae	*Acanthurus triostegus*	220	1.6
Melei	Scaridae	*Bolbometopon muricatum*	201	1.5
Mataloa	Lutjanidae	*Macolor niger*	163	1.2
Malau uli	Holocentridae	*Sargocentron violaceum*	149	1.1
Loloa	Siganidae	*Siganus argenteus*	147	1.1
Papa	Serranidae	*Variola louti*	147	1.1
Sumu	Balistidae	*Balistes* spp.	143	1.0
Atu	Scombridae	*Thunnus* spp.	139	1.0
Magau	Holocentridae	*Holocentrus* spp.	122	0.9
Lalafi	Labridae	*Cheilinus undulatus*	112	0.8
Ulaoa	Mullidae	*Upeneus vittatus*	106	0.8

2.1.1 Annual catch (kg) of fish groups per habitat – Manono-uta (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Lagoon & outer reef (continued)				
Atule	Scombridae Carangidae	*Katsuwonus pelamis* *Selar crumenophthalmus*	81	0.6
Oleole	Siganidae	*Siganus* spp.	81	0.6
Matu	Gerreidae	*Gerres* spp.	73	0.5
Umelei	Acanthuridae	*Naso* spp.	70	0.5
Tifitifi	Chaetodontidae	*Chaetodon* spp.	62	0.4
Palu malau	Lutjanidae	*Etelis carbunculus*	60	0.4
Malie	Odontaspididae	*Carcharias* spp.	60	0.4
Iliilia	Acanthuridae	*Naso lituratus*	54	0.4
Mumu	Lutjanidae	*Lutjanus bohar*	54	0.4
Matulau	Mullidae	*Upeneus* spp.	41	0.3
Utu	Lutjanidae	*Aprion virescens*	27	0.2
Total:			**13,837**	**100.0**
Outer reef				
Filoa	Lethrinidae	*Lethrinus* spp.	3703	16.9
Laea	Scaridae	*Chlorurus microrhinos*	1896	8.7
Fuga	Scaridae	*Scarus* spp.	1824	8.3
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	1622	7.4
Malau	Holocentridae	*Myripristis* spp.	1216	5.6
Palagi	Acanthuridae	*Acanthurus* spp.	918	4.2
Afulu	Mullidae	*Mullus* spp.	834	3.8
Ume	Acanthuridae	*Naso unicornis*	755	3.5
Galafa	Zanclidae	*Zanclus* spp.	747	3.4
Alogo	Acanthuridae	*Acanthurus lineatus*	619	2.8
Lo	Siganidae	*Siganus* spp.	596	2.7
Fagamea	Lutjanidae	*Lutjanus* spp.	568	2.6
Gatala	Serranidae	*Epinephelus* spp.	530	2.4
Mataloa	Lutjanidae	*Macolor niger*	466	2.1
Ganue	Kyphosidae	*Kyphosus cinerascens*	397	1.8
Manini	Acanthuridae	*Acanthurus triostegus*	356	1.6
Melei	Scaridae	*Bolbometopon muricatum*	283	1.3
Bulelei	Carangidae	*Caranx* spp.	277	1.3
Fuafua	Mugilidae	*Crenimugil crenilabis*	269	1.2
Matapula	Priacanthidae	*Priacanthus* spp.	255	1.2
Ulaoa	Mullidae	*Upeneus vittatus*	244	1.1
Oleole	Siganidae	*Siganus* spp.	240	1.1
Tautu	Diodontidae	*Diodon hystrix*	220	1.0
Pone	Acanthuridae	*Ctenochaetus striatus*	213	1.0
Magigi	Holocentridae	*Holocentrus* spp.	197	0.9
Tifitifi	Chaetodontidae	*Chaetodon* spp.	178	0.8
Maila	Lethrinidae	*Lethrinus* spp.	174	0.8
Fugausi	Scaridae	*Cetoscarus bicolor*	170	0.8
Lalafi	Labridae	*Cheilinus undulatus*	163	0.7
Sumu	Balistidae	*Balistes* spp.	149	0.7
Matamu	Lethrinidae	*Monotaxis grandoculis*	147	0.7
Umelei	Acanthuridae	*Naso* spp.	145	0.7
Ulapo	Scaridae	*Scarus* spp.	145	0.7

2.1.1 Annual catch (kg) of fish groups per habitat – Manono-uta (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Outer reef (continued)				
Magau	Holocentridae	*Holocentrus* spp.	122	0.6
Atu	Scombridae	*Thunnus* spp.	120	0.5
Kagapa	Blenniidae	*Omobranchus elongatus*	98	0.4
Iliilia	Acanthuridae	*Naso lituratus*	81	0.4
Utu	Lutjanidae	*Aprion virescens*	81	0.4
Savane	Lutjanidae	*Lutjanus* spp.	81	0.4
Galo	Scaridae	*Scarus* spp.	81	0.4
Mumu	Lutjanidae	*Lutjanus bohar*	81	0.4
Matulau	Mullidae	*Upeneus* spp.	73	0.3
Malauli	Holocentridae	*Sargocentron violaceum*	66	0.3
Pala	Cyprinidae	*Acanthobrama* spp.	62	0.3
Kauliuli	Lutjanidae	*Lutjanus* spp.	54	0.2
Tauleia	Mullidae	*Parupeneus indicus*	54	0.2
Lupota	Carangidae	*Caranx* spp.	54	0.2
Malava	Siganidae	*Siganus argenteus*	41	0.2
Lufi	Kyphosidae	*Kyphosus* spp.	41	0.2
Sumulaolao	Balistidae	*Balistes* spp.	41	0.2
Safole	Kuhliidae	*Kuhlia taeniura*	41	0.2
Pauulu	Siganidae	*Siganus spinus*	41	0.2
Lailai	Mullidae	*Pseudupeneus* spp.	35	0.2
Kivi	Lutjanidae	*Lutjanus bohar*	27	0.1
Total:			**21,894**	**100.0**
Outer reef & passage				
Filoa	Lethrinidae	*Lethrinus* spp.	769	17.6
Alogo	Acanthuridae	*Acanthurus lineatus*	478	10.9
Lo	Siganidae	*Siganus* spp.	416	9.5
Pone	Acanthuridae	*Ctenochaetus striatus*	397	9.1
Malau uli	Holocentridae	*Sargocentron violaceum*	397	9.1
Malau	Holocentridae	*Myripristis* spp.	375	8.6
Ume	Acanthuridae	*Naso unicornis*	360	8.2
Loloa	Siganidae	*Siganus argenteus*	328	7.5
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	238	5.5
Fugausi	Scaridae	*Cetoscarus bicolor*	228	5.2
Umelei	Acanthuridae	*Naso* spp.	190	4.3
Palagi	Acanthuridae	*Acanthurus* spp.	178	4.1
Laea	Scaridae	*Chlorurus microrhinos*	155	3.5
Tifitifi	Chaetodontidae	*Chaetodon* spp.	108	2.5
Fuga	Scaridae	*Scarus* spp.	85	1.9
Iliilia	Acanthuridae	*Naso lituratus*	81	1.9
Ulaoa	Mullidae	*Upeneus vittatus*	81	1.9
Gatala	Serranidae	*Epinephelus* spp.	56	1.3
Pusi	Muraenidae	*Gymnothorax fimbriatus*	54	1.2
Utu	Lutjanidae	*Aprion virescens*	54	1.2
Mataloa	Lutjanidae	*Macolor niger*	41	0.9
Ganue	Kyphosidae	*Kyphosus cinerascens*	41	0.9
Matamu	Lethrinidae	*Monotaxis grandoculis*	27	0.6
Total:			**4370**	**100.0**

2.1.2 Invertebrate species caught by fishery and percentage of total annual catch wet weight – Manono-uta

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Reeftop	Matapisu	*Holothuria* spp.	85.7
	Faisua	*Tridacna* spp.	10.2
	Fee	*Octopus* spp.	2.5
	Gau	*Dolabella auricularia*	1.1
	Paa	*Etisus splendidus*	0.6
Reeftop & bêche-de-mer	Sea	*Stichopus horrens*	93.9
	Alili	*Turbo* spp.	6.1
Reeftop & bêche-de-mer & other	Fee	*Octopus* spp.	59.9
	Alili	*Turbo* spp.	21.8
	Pae	*Anadara* spp.	18.3
Reeftop & lobster & other	Faisua	*Tridacna* spp.	72.8
	Tutu	*Etisus splendidus*	27.2
Reeftop & other	Pipi	*Tridacna* spp.	30.1
	Li	*Tridacna* spp.	23.7
	Fee	*Octopus* spp.	20.0
	Paa	*Etisus splendidus*	7.6
	Aliao	*Trochus* spp.	6.1
	Kuku	*Carpilius maculatus*	4.3
	Ula	*Panulirus* spp.	2.2
	Fole	*Pinna bicolor*	2.1
	Pae	*Anadara* spp.	1.2
	Alili	*Turbo* spp.	1.1
	Kuikui	*Tripneustes gratilla*	1.0
	Panea	*Strombus* spp.	0.4
	Pu	*Cypraea* spp.	0.1
Intertidal & lobster & other	Ula	*Panulirus* spp.	58.8
	Paa	*Etisus splendidus*	41.2
Reeftop & intertidal	Fugafuga	*Holothuria* spp.	30.5
	Sea	*Stichopus horrens*	26.5
	Li	*Tridacna* spp.	8.8
	Pipi	*Tridacna* spp.	7.4
	Fole	*Pinna bicolor*	5.2
	Pu	*Cypraea* spp.	4.8
	Fee	*Octopus* spp.	4.5
	Faisua	*Tridacna* spp.	3.7
	Panea	*Strombus* spp.	2.9
	Kuku	*Carpilius maculatus*	2.6
	Alili	*Turbo* spp.	1.8
	Pae	*Anadara* spp.	1.0
	Paa	*Etisus splendidus*	0.4
	Limu		
Soft benthos	Fugafuga	*Holothuria* spp.	78.2
	Sea	*Stichopus horrens*	18.4
	Kuku	*Carpilius maculatus*	3.2
	Alili	*Turbo* spp.	0.3
Soft benthos & bêche-de-mer	Loli	*Holothuria* spp.	73.4
	Sea	*Stichopus horrens*	26.6

2.1.2 Invertebrate species caught by fishery and percentage of total annual catch wet weight – Manono-uta (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Soft benthos & mangrove	Pipi	*Tridacna* spp.	64.9
	Paa	*Etisus splendidus*	15.2
	Sea	*Stichopus horrens*	9.8
	Fee	*Octopus* spp.	3.0
	Faisua	*Tridacna* spp.	2.7
	Tutu	*Etisus splendidus*	2.5
	Kuku	*Carpilius maculatus*	1.9
	Limu		
Soft benthos & mangrove & intertidal & reeftop	Paalimago	*Scylla serrata*	91.4
	Pae	*Anadara* spp.	8.6
Soft benthos & reeftop	Sea	*Stichopus horrens*	86.1
	Paa	*Etisus splendidus*	13.9
Soft benthos reeftop & lobster	Fee	*Octopus* spp.	84.6
	Paa	*Etisus splendidus*	15.4
	Limu		
Soft benthos & intertidal	Pipi	*Tridacna* spp.	69.7
	Sea	*Stichopus horrens*	30.3
Bêche-de-mer	Sea	*Stichopus horrens*	55.2
	Fugafuga	*Holothuria* spp.	36.5
	Mamao	*Actinopyga mauritiana*	8.3
Trochus & other	Aliao	*Trochus* spp.	57.4
	Fee	*Octopus* spp.	20.5
	Faisua	*Tridacna* spp.	14.3
	Ula	*Panulirus* spp.	6.2
	Pae	*Anadara* spp.	1.6
Lobster	Ula	*Panulirus* spp.	88.5
	Paa	*Etisus splendidus*	11.5
Lobster & other	Ula	*Panulirus* spp.	62.7
	Mamao	*Actinopyga mauritiana*	37.3
Other	Li	*Tridacna* spp.	57.2
	Pipi	*Tridacna* spp.	23.9
	Faisua	*Tridacna* spp.	15.6
	Pule	*Cypraea* spp.	2.2
	Pae	*Anadara* spp.	1.1

2.1.3 Average length-frequency distribution for invertebrates and percentage of total annual catch weight – Manono-uta

Vernacular name	Scientific name	Size class	% of total catch (weight)
Aliao	*Trochus* spp.	08-12 cm	100.0
Alili	*Turbo* spp.	06-08 cm	57.2
		06-10 cm	34.5
		08-10 cm	5.8
		12-14 cm	2.4
Faisua	*Tridacna* spp.	10-12 cm	13.4
		12-14 cm	65.7
		12-16 cm	18.2
		12-18 cm	2.7
Fee	*Octopus* spp.	04-08 cm	9.0
		08-12 cm	47.0
		10-14 cm	2.6
		12-14 cm	11.6
		12-16 cm	21.1
		12-18 cm	8.7
Fole	*Pinna bicolor*	08-10 cm	53.4
		08-12 cm	46.6
Fugafuga	*Holothuria* spp.	08-14 cm	46.5
		12-14 cm	53.5
Gau	*Dolabella auricularia*	10-12 cm	100.0
Kuikui	*Tripneustes gratilla*	06-08 cm	100.0
Kuku	*Carpilius maculatus*	08-12 cm	27.3
		10-12 cm	36.4
		10-13 cm	8.4
		12-14 cm	24.2
		14-16 cm	3.8
Li	*Tridacna* spp.	08-12 cm	72.2
		10-12 cm	10.0
		12-14 cm	17.8
Limu		01 cm	
Loli	*Holothuria* spp.	12-14 cm	100.0
Mamao	*Actinopyga mauritiana*	08-12 cm	27.7
		12-14 cm	55.3
		12-40 cm	17.0
Matapisu	*Holothuria* spp.	06-10 cm	52.6
		10-12 cm	47.4
Paa	*Etisus splendidus*	08-12 cm	13.2
		10-12 cm	29.9
		10-14 cm	24.1
		14-16 cm	12.4
		14-18 cm	20.4
Paalimago	*Scylla serrata*	12-16 cm	100.0
Pae	*Anadara* spp.	06-08 cm	12.4
		06-10 cm	15.3
		08-10 cm	7.4
		08-12 cm	36.4
		10-12 cm	28.5

2.1.3 Average length-frequency distribution for invertebrates and percentage of total annual catch weight – Manono-uta (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Panea	*Strombus* spp.	06-08 cm	14.3
		06-10 cm	18.1
		08-12 cm	67.6
Pipi	*Tridacna* spp.	06-08 cm	32.1
		08-10 cm	6.4
		08-12 cm	16.6
		10-12 cm	30.4
		12-14 cm	14.5
Pu	*Cypraea* spp.	06-10 cm	97.1
		14-18 cm	2.9
Pule	*Cypraea* spp.	10-12 cm	100.0
Sea	*Stichopus horrens*	08-12 cm	1.3
		08-14 cm	12.5
		10-12 cm	5.5
		10-14 cm	25.6
		12-14 cm	55.1
Tutu	*Etisus splendidus*	10-12 cm	82.8
		14-16 cm	17.2
Ula	*Panulirus* spp.	18-24 cm	10.2
		18-26 cm	5.5
		20-22 cm	8.5
		20-26 cm	61.3
		24-26 cm	14.4

2.2 Salelavalu socioeconomic survey data

2.2.1 Annual catch (kg) of fish groups per habitat – Salelavalu
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Species	Total weight (kg)	Total weight (%)
Sheltered coastal reef & lagoon				
Anae	Mugilidae	*Mugil* spp.	1102	9.9
Fuga	Scaridae	*Scarus* spp.	986	8.8
Alogo	Acanthuridae	*Acanthurus lineatus*	964	8.6
Manini	Acanthuridae	*Acanthurus triostegus*	623	5.6
Gatala	Serranidae	*Epinephelus* spp.	609	5.4
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	594	5.3
Pone	Acanthuridae	*Ctenochaetus striatus*	583	5.2
Malauli	Holocentridae	*Sargocentron violaceum*	553	4.9
Filoa	Lethrinidae	*Lethrinus* spp.	441	3.9
Afulu	Mullidae	*Mullus* spp.	398	3.6
Fagamea	Lutjanidae	*Lutjanus* spp.	396	3.5
Matamu	Lethrinidae	*Monotaxis grandoculis*	340	3.0
Fugausi	Scaridae	*Cetoscarus bicolor*	293	2.6
Pusi	Muraenidae	*Gymnothorax fimbriatus*	267	2.4
Mataloa	Lutjanidae	*Macolor niger*	213	1.9
Malau	Holocentridae	*Myripristis* spp.	208	1.9
Lo	Siganidae	*Siganus* spp.	206	1.8
Matu	Gerreidae	*Gerres oyena*	198	1.8
Ulaoa	Mullidae	*Upeneus vittatus*	168	1.5
Lailai	Mullidae	*Pseudupeneus* spp.	145	1.3
Sapatu	Sphyraenidae	*Sphyraena barracuda*	132	1.2
Oleole	Siganidae	*Siganus* spp.	131	1.2
Ume	Acanthuridae	*Naso unicornis*	121	1.1
Tifitifi	Chaetodontidae	*Chaetodon* spp.	119	1.1
Melei	Scaridae	*Bolbometopon muricatum*	119	1.1
Anaana	Mugilidae	*Mugil* spp.	106	1.0
Lalafutu	Carangidae	*Trachinotus blochii*	106	0.9
Palagi	Acanthuridae	*Acanthurus* spp.	97	0.9
Fae	Dasyatidae	*Taeniura* spp.	91	0.8
Ise	Hemiramphidae	*Hemiramphus* spp.	91	0.8
Kivi	Lutjanidae	*Lutjanus bohar*	91	0.8
Laea	Scaridae	*Chlorurus microrhinos*	79	0.7
Umelei	Acanthuridae	*Naso* spp.	79	0.7
Ulapo	Scaridae	*Scarus* spp.	79	0.7
Sumu	Balistidae	*Balistes* spp.	79	0.7
Sumulaolao	Balistidae	*Balistes* spp.	79	0.7
Malau uli	Holocentridae	*Sargocentron violaceum*	61	0.5
Fuafua	Mugilidae	*Crenimugil crenilabis*	53	0.5
Magau	Holocentridae	*Holocentrus* spp.	51	0.5
Iliilia	Acanthuridae	*Naso lituratus*	34	0.3
Sinapiki	Labridae	*Cheilinus* spp.	34	0.3
Ganue	Kyphosidae	*Kyphosus cinerascens*	26	0.2
Tauleia	Mullidae	*Parupeneus indicus*	26	0.2
Mumu	Lutjanidae	*Lutjanus bohar*	13	0.1
Total:			**11,187**	**100.0**

2.2.1 Annual catch (kg) of fish groups per habitat – Salelavalu (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Species	Total weight (kg)	Total weight (%)
Lagoon				
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	1615	12.4
Fuafua	Mugilidae	*Crenimugil crenilabis*	1452	11.1
Fuga	Scaridae	*Scarus* spp.	932	7.2
Lo	Siganidae	*Siganus* spp.	907	7.0
Laea	Scaridae	*Chlorurus microrhinos*	837	6.4
Filoa	Lethrinidae	*Lethrinus* spp.	622	4.8
Palagi	Acanthuridae	*Acanthurus* spp.	577	4.4
Gatala	Serranidae	*Epinephelus* spp.	484	3.7
Ume	Acanthuridae	*Naso unicornis*	473	3.6
Pone	Acanthuridae	*Ctenochaetus striatus*	471	3.6
Malau	Holocentridae	*Myripristis* spp.	372	2.9
Alogo	Acanthuridae	*Acanthurus lineatus*	313	2.4
Lupota	Carangidae	*Caranx* spp.	310	2.4
Malau uli	Holocentridae	*Sargocentron violaceum*	299	2.3
Kauleea	Lutjanidae	*Lutjanus* spp.	271	2.1
Ganue	Kyphosidae	*Kyphosus cinerascens*	268	2.1
Magigi	Holocentridae	*Holocentrus* spp.	227	1.7
Malava	Siganidae	*Siganus argenteus*	221	1.7
Galafa	Zanclidae	*Zanclus* spp.	219	1.7
Matamu	Lethrinidae	*Monotaxis grandoculis*	210	1.6
Loloa	Siganidae	*Siganus argenteus*	178	1.4
Fugausi	Scaridae	*Cetoscarus bicolor*	172	1.3
Lalafutu	Carangidae	*Trachinotus blochii*	172	1.3
Fae	Dasyatidae	*Taeniura* spp.	166	1.3
Manini	Acanthuridae	*Acanthurus triostegus*	153	1.2
Iliilia	Acanthuridae	*Naso lituratus*	132	1.0
Uiva	Lutjanidae	*Lutjanus* spp.	121	0.9
Malauli	Holocentridae	*Sargocentron violaceum*	103	0.8
Magau	Holocentridae	*Holocentrus* spp.	93	0.7
Kauliuli	Lutjanidae	*Lutjanus* spp.	91	0.7
Anae	Mugilidae	*Mugil* spp.	86	0.7
Tafauli	Carangidae	*Caranx lugubris*	77	0.6
Tauleia	Mullidae	*Parupeneus indicus*	66	0.5
Ulaoa	Mullidae	*Upeneus vittatus*	53	0.4
Melei	Scaridae	*Bolbometopon muricatum*	53	0.4
Sumulaolao	Balistidae	*Balistes* spp.	53	0.4
Sugale	Labridae	*Thalassoma* spp.	53	0.4
Afulu	Mullidae	*Mullus* spp.	42	0.3
Matu	Gerreidae	*Gerres* spp.	40	0.3
Tuuu	Pomacanthidae	*Holacanthus* spp.	40	0.3
Total:			**13,025**	**100.0**

2.2.1 Annual catch (kg) of fish groups per habitat – Salelavalu (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Species	Total weight (kg)	Total weight (%)
Lagoon & outer reef				
Malau	Holocentridae	*Myripristis* spp.	940	8.7
Laea	Scaridae	*Chlorurus microrhinos*	904	8.4
Palagi	Acanthuridae	*Acanthurus* spp.	832	7.7
Filoa	Lethrinidae	*Lethrinus* spp.	757	7.0
Anae	Mugilidae	*Mugil* spp.	707	6.5
Gatala	Serranidae	*Epinephelus* spp.	655	6.1
Fuga	Scaridae	*Scarus* spp.	616	5.7
Alogo	Acanthuridae	*Acanthurus lineatus*	490	4.5
Ume	Acanthuridae	*Naso unicornis*	478	4.4
Tautu	Diodontidae	*Diodon hystrix*	467	4.3
Lo	Siganidae	*Siganus* spp.	383	3.5
Fugausi	Scaridae	*Cetoscarus bicolor*	327	3.0
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	308	2.8
Manini	Acanthuridae	*Acanthurus triostegus*	300	2.8
Malau uli	Holocentridae	*Sargocentron violaceum*	274	2.5
Fuafua	Mugilidae	*Crenimugil crenilabis*	259	2.4
Pone	Acanthuridae	*Ctenochaetus striatus*	250	2.3
Tifitifi	Chaetodontidae	*Chaetodon* spp.	227	2.1
Galafa	Zanclidae	*Zanclus* spp.	213	2.0
Fagamea	Lutjanidae	*Lutjanus* spp.	173	1.6
Matamu	Lethrinidae	*Monotaxis grandoculis*	159	1.5
Pauulu	Siganidae	*Siganus spinus*	159	1.5
Lalafi	Labridae	*Cheilinus undulatus*	159	1.5
Ise	Hemiramphidae	*Hemiramphus* spp.	137	1.3
Umelei	Acanthuridae	*Naso* spp.	119	1.1
Paumalo	Monacanthidae	*Monacanthus* spp.	115	1.1
Iliilia	Acanthuridae	*Naso lituratus*	106	1.0
Afulu	Mullidae	*Mullus* spp.	91	0.8
Ulapo	Scaridae	*Scarus* spp.	91	0.8
Malava	Siganidae	*Siganus argenteus*	53	0.5
Sapatu	Sphyraenidae	*Sphyraena barracuda*	53	0.5
Total:			**10,800**	**100.0**

2.2.2 Invertebrate species caught by fishery and percentage of total annual catch wet weight – Salelavalu

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Lobster	Ula	*Panulirus* spp.	100.0
Lobster & other	Faisua	*Tridacna* spp.	50.0
	Ula	*Panulirus* spp.	50.0
Mangrove	Paa	*Etisus splendidus*	61.0
	Paalimago	*Scylla serrata*	39.0
Other	Loli	*Holothuria* spp.	99.3
	Alili	*Turbo* spp.	0.7
Reeftop	Faisua	*Tridacna* spp.	20.4
	Fole	*Pinna bicolor*	12.2
	Tutu	*Etisus splendidus*	11.4
	Kuikui	*Tripneustes gratilla*	10.2
	Aliao	*Trochus* spp.	10.2
	Fee	*Octopus* spp.	9.0
	Pule	*Cypraea* spp.	8.7
	Paa	*Etisus splendidus*	6.9
	Alili	*Turbo* spp.	6.7
	Gau	*Dolabella auricularia*	4.3
	Limu		
Reeftop & other	Faisua	*Tridacna* spp.	82.0
	Fee	*Octopus* spp.	18.0
Intertidal	Sea	*Stichopus horrens*	100.0
Intertidal & reeftop	Sea	*Stichopus horrens*	55.2
	Loli	*Holothuria* spp.	30.5
	Paa	*Etisus splendidus*	14.2
	Limu		
Soft benthos	Sea	*Stichopus horrens*	66.2
	Loli	*Holothuria* spp.	28.7
	Mamao	*Actinopyga mauritiana*	5.1
	Limu		
Soft benthos & mangrove	Fugafuga	*Holothuria* spp.	41.9
	Sea	*Stichopus horrens*	32.6
	Loli	*Holothuria* spp.	21.0
	Fole	*Pinna bicolor*	3.1
	Kuku	*Carpilius maculatus*	0.8
	Gau	*Dolabella auricularia*	0.5
	Tio	*Spondylus* spp.	0.1
	Limu		
Soft benthos & intertidal	Sea	*Stichopus horrens*	83.1
	Pule	*Cypraea* spp.	5.9
	Tutu	*Etisus splendidus*	4.3
	Gau	*Dolabella auricularia*	3.0
	Fee	*Octopus* spp.	2.0
	Paa	*Etisus splendidus*	1.7
	Limu		
Soft benthos & intertidal & reeftop	Sea	*Stichopus horrens*	72.0
	Faisua	*Tridacna* spp.	22.1
	Gau	*Dolabella auricularia*	4.6
	Alili	*Turbo* spp.	1.3

2.2.3 Average length-frequency distribution for invertebrates and percentage of total annual catch weight – Salelavalu

Vernacular name	Scientific name	Size class	% of total catch (weight)
Aliao	*Trochus* spp.	06-10 cm	100.0
Alili	*Turbo* spp.	06-08 cm	14.4
		06-10 cm	30.1
		06-12 cm	8.6
		08-10 cm	46.9
Faisua	*Tridacna* spp.	10-14 cm	16.5
		12-14 cm	7.1
		14-18 cm	76.5
Fee	*Octopus* spp.	12-14 cm	47.3
		12-18 cm	17.6
		16-18 cm	35.1
Fole	*Pinna bicolor*	08-10 cm	50.6
		08-12 cm	15.7
		10-12 cm	33.7
Fugafuga	*Holothuria* spp.	08-14 cm	25.0
		12-14 cm	75.0
Gau	*Dolabella auricularia*	08-12 cm	11.2
		10-14 cm	62.3
		10-16 cm	9.3
		12-14 cm	17.1
Kuikui	*Tripneustes gratilla*	08-12 cm	40.0
		10-12 cm	60.0
Kuku	*Carpilius maculatus*	08-10 cm	100.0
Limu		01 cm	
Loli	*Holothuria* spp.	12-16 cm	95.2
		14-16 cm	4.8
Mamao	*Actinopyga mauritiana*	12-16 cm	100.0
Paa	*Etisus splendidus*	08-10 cm	16.5
		08-14 cm	42.6
		14-18 cm	40.9
Paalimago	*Scylla serrata*	12-14 cm	100.0
Pule	*Cypraea* spp.	02-05 cm	69.0
		06-08 cm	13.8
		08-10 cm	17.2
Sea	*Stichopus horrens*	08-14 cm	2.4
		10-16 cm	10.9
		12-14 cm	7.2
		12-16 cm	60.7
		14-16 cm	15.1
		14-18 cm	3.6
Tio	*Spondylus* spp.	08-10 cm	100.0
Tutu	*Etisus splendidus*	08-14 cm	55.6
		10-14 cm	44.4
Ula	*Panulirus* spp.	18-20 cm	8.2
		20-26 cm	91.8

2.3 Vailoa socioeconomic survey data

2.3.1 Annual catch (kg) of fish groups per habitat – Vailoa
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Sheltered coastal reef				
Fugausi	Scaridae	*Cetoscarus bicolor*	69	36.40167
Loloa	Siganidae	*Siganus argenteus*	43	22.80333
Atule	Scombridae Carangidae	*Katsuwonus pelamis* *Selar crumenophthalmus*	39	20.3975
Iliilia	Acanthuridae	*Naso lituratus*	39	20.3975
Total:			**190**	**100**
Sheltered coastal reef & lagoon				
Anae	Mugilidae	*Mugil* spp.	605	8.897923
Lalafi	Labridae	*Cheilinus undulatus*	554	8.150714
Fugausi	Scaridae	*Cetoscarus bicolor*	543	7.989888
Alogo	Acanthuridae	*Acanthurus lineatus*	518	7.628726
Atule	Scombridae Carangidae	*Katsuwonus pelamis* *Selar crumenophthalmus*	411	6.049233
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	410	6.033376
Gatala	Serranidae	*Epinephelus* spp.	346	5.088742
Magigi	Holocentridae	*Holocentrus* spp.	268	3.946207
Tauleia	Mullidae	*Parupeneus indicus*	242	3.561675
Bulelei	Carangidae	*Caranx* spp.	232	3.418428
Fuga	Scaridae	*Scarus* spp.	230	3.390456
Fuafua	Mugilidae	*Crenimugil crenilabis*	194	2.84869
Mataloa	Lutjanidae	*Macolor niger*	177	2.605134
Galo	Scaridae	*Scarus* spp.	168	2.468865
Malauli	Holocentridae	*Sargocentron violaceum*	155	2.278952
Matamu	Lethrinidae	*Monotaxis grandoculis*	152	2.235123
Melei	Scaridae	*Bolbometopon muricatum*	144	2.116581
Atu	Scombridae	*Thunnus* spp.	138	2.033525
Iliilia	Acanthuridae	*Naso lituratus*	138	2.033525
Malava	Siganidae	*Siganus argenteus*	116	1.709214
Lailai	Mullidae	*Pseudupeneus* spp.	116	1.709214
Ise	Hemiramphidae	*Hemiramphus* spp.	116	1.709214
Kauliuli	Lutjanidae	*Lutjanus* spp.	116	1.709214
Filoa	Lethrinidae	*Lethrinus* spp.	112	1.6537
Mumu	Lutjanidae	*Lutjanus bohar*	91	1.341074
Ulaoa	Mullidae	*Upeneus vittatus*	89	1.315402
Pone	Acanthuridae	*Ctenochaetus striatus*	77	1.139476
Galafa	Zanclidae	*Zanclus* spp.	77	1.139476
Lalafutu	Carangidae	*Trachinotus blochii*	52	0.759651
Kauleea	Lutjanidae	*Lutjanus* spp.	52	0.759651
Magau	Holocentridae	*Holocentrus* spp.	52	0.759651
Tifitifi	Chaetodontidae	*Chaetodon* spp.	39	0.569738
Kivi	Lutjanidae	*Lutjanus bohar*	39	0.569738
Umelei	Acanthuridae	*Naso* spp.	26	0.379825
Total:			**6795**	**100**

2.3.1 Annual catch (kg) of fish groups per habitat – Vailoa (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Lagoon				
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	1502	11.00081
Gatala	Serranidae	*Epinephelus* spp.	1390	10.18201
Alogo	Acanthuridae	*Acanthurus lineatus*	1257	9.208408
Lo	Siganidae	*Siganus* spp.	1211	8.870357
Fuga	Scaridae	*Scarus* spp.	1202	8.803053
Pone	Acanthuridae	*Ctenochaetus striatus*	750	5.491737
Filoa	Lethrinidae	*Lethrinus* spp.	684	5.012707
Ume	Acanthuridae	*Naso unicornis*	441	3.228689
Laea	Scaridae	*Chlorurus microrhinos*	409	2.992854
Malauli	Holocentridae	*Sargocentron violaceum*	363	2.658195
Fagamea	Lutjanidae	*Lutjanus* spp.	362	2.647864
Sugale	Labridae	*Thalassoma* spp.	361	2.646564
Loloa	Siganidae	*Siganus argenteus*	305	2.230523
Lalafi	Labridae	*Cheilinus undulatus*	271	1.984923
Tauleia	Mullidae	*Parupeneus indicus*	259	1.896218
Tifitifi	Chaetodontidae	*Chaetodon* spp.	244	1.785822
Sapatu	Sphyraenidae	*Sphyraena barracuda*	241	1.768253
Malau	Holocentridae	*Myripristis* spp.	233	1.707178
Manini	Acanthuridae	*Acanthurus triostegus*	221	1.616412
Sumu	Balistidae	*Balistes* spp.	190	1.390172
Ulaoa	Mullidae	*Upeneus vittatus*	175	1.282876
Fugausi	Scaridae	*Cetoscarus bicolor*	170	1.244915
Matamu	Lethrinidae	*Monotaxis grandoculis*	163	1.190801
Anae	Mugilidae	*Mugil* spp.	138	1.012092
Iliilia	Acanthuridae	*Naso lituratus*	134	0.9824
Malava	Siganidae	*Siganus argenteus*	119	0.869281
Taiva	Lutjanidae	*Lutjanus* spp.	116	0.850681
Lailai	Mullidae	*Pseudupeneus* spp.	116	0.850681
Galo	Scaridae	*Scarus* spp.	116	0.850681
Anaana	Mugilidae	*Mugil* spp.	103	0.756161
Tautu	Diodontidae	*Diodon hystrix*	77	0.567121
Kauliuli	Lutjanidae	*Lutjanus* spp.	77	0.567121
Safole	Kuhliidae	*Kuhlia taeniura*	52	0.378081
Matu	Gerreidae	*Gerres oyena*	52	0.378081
Ganue	Kyphosidae	*Kyphosus cinerascens*	46	0.34012
Sumulaolao	Balistidae	*Balistes* spp.	39	0.28356
Mataloa	Lutjanidae	*Macolor niger*	39	0.28356
Magigi	Holocentridae	*Holocentrus* spp.	26	0.18904
Total:			**13,654**	**100**

2.3.1 Annual catch (kg) of fish groups per habitat – Vailoa (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Lagoon & outer reef				
Ume	Acanthuridae	*Naso unicornis*	1100	9.19
Fuga	Scaridae	*Scarus* spp.	904	7.56
Alogo	Acanthuridae	*Acanthurus lineatus*	844	7.05
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	816	6.82
Filoa	Lethrinidae	*Lethrinus* spp.	809	6.76
Pone	Acanthuridae	*Ctenochaetus striatus*	800	6.69
Fugausi	Scaridae	*Cetoscarus bicolor*	687	5.74
Laea	Scaridae	*Chlorurus microrhinos*	635	5.31
Gatala	Serranidae	*Epinephelus* spp.	533	4.46
Fagamea	Lutjanidae	*Lutjanus* spp.	463	3.87
Palagi	Acanthuridae	*Acanthurus* spp.	405	3.39
Tifitifi	Chaetodontidae	*Chaetodon* spp.	342	2.86
Loloa	Siganidae	*Siganus argenteus*	310	2.59
Lalafi	Labridae	*Cheilinus undulatus*	298	2.49
Malau	Holocentridae	*Myripristis* spp.	261	2.18
Malau uli	Holocentridae	*Sargocentron violaceum*	246	2.05
Ulaoa	Mullidae	*Upeneus vittatus*	242	2.02
Malau iusina	Holocentridae	*Sargocentron caudimaculatum*	207	1.73
Lalafutu	Carangidae	*Trachinotus blochii*	207	1.73
Lufi	Kyphosidae	*Kyphosus* spp.	207	1.73
Magigi	Holocentridae	*Holocentrus* spp.	194	1.62
Tuuu	Pomacanthidae	*Holacanthus* spp.	192	1.60
Lo	Siganidae	*Siganus* spp.	162	1.35
Bulelei	Carangidae	*Caranx* spp.	138	1.16
Taiva	Lutjanidae	*Lutjanus* spp.	136	1.13
Iliilia	Acanthuridae	*Naso lituratus*	116	0.97
Malava	Siganidae	*Siganus argenteus*	116	0.97
Matulau	Mullidae	*Parupeneus indicus*	91	0.76
Sumu	Balistidae	*Balistes* spp.	90	0.76
Kivi	Lutjanidae	*Lutjanus bohar*	67	0.56
Kauliuli	Lutjanidae	*Lutjanus* spp.	59	0.50
Molemole	Labridae	*Novaculichthys taeniourus*	59	0.50
Sugale	Labridae	*Thalassoma* spp.	45	0.37
Tauleia	Mullidae	*Upeneus* spp.	39	0.32
Safole	Kuhliidae	*Kuhlia taeniura*	34	0.28
Kagapa	Blenniidae	*Omobranchus elongatus*	34	0.28
Ulapo	Scaridae	*Scarus* spp.	26	0.22
Umelei	Acanthuridae	*Naso* spp.	26	0.22
Maila	Lethrinidae	*Lethrinus* spp.	13	0.11
Oleole	Siganidae	*Siganus* spp.	12	0.10
Total:			**11,962**	**100.00**

2.3.1 Annual catch (kg) of fish groups per habitat – Vailoa (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Outer reef				
Fuga	Scaridae	*Scarus* spp.	171	14.14174
Ume	Acanthuridae	*Naso unicornis*	169	13.90888
Malau	Holocentridae	*Myripristis* spp.	169	13.90888
Lo	Siganidae	*Siganus* spp.	128	10.57032
Galafa	Zanclidae	*Zanclus* spp.	128	10.57032
Alogo	Acanthuridae	*Acanthurus lineatus*	101	8.300872
Pone	Acanthuridae	*Ctenochaetus striatus*	101	8.300872
Filoa	Lethrinidae	*Lethrinus* spp.	91	7.519637
Gatala	Serranidae	*Epinephelus* spp.	77	6.389244
Sumu	Balistidae	*Balistes* spp.	52	4.259496
Magau	Holocentridae	*Holocentrus* spp.	26	2.129748
Total:			**1212**	**100**
Outer reef & passage				
Laea	Scaridae	*Chlorurus microrhinos*	488	15.29458
Filoa	Lethrinidae	*Lethrinus* spp.	418	13.10087
Fagamea	Lutjanidae	*Lutjanus* spp.	394	12.35204
Fugausi	Scaridae	*Cetoscarus bicolor*	276	8.65576
Malau	Holocentridae	*Myripristis* spp.	205	6.407419
Kauleea	Lutjanidae	*Lutjanus* spp.	181	5.658583
Galo	Scaridae	*Scarus* spp.	179	5.59905
Pauulu	Siganidae	*Siganus spinus*	164	5.136249
Alogo	Acanthuridae	*Acanthurus lineatus*	138	4.32788
Iliilia	Acanthuridae	*Naso lituratus*	129	4.041845
Fuga	Scaridae	*Scarus* spp.	121	3.780678
Lalafutu	Carangidae	*Trachinotus blochii*	103	3.233476
Loloa	Siganidae	*Siganus argenteus*	82	2.568125
Lo	Siganidae	*Siganus* spp.	77	2.425107
Savane	Lutjanidae	*Lutjanus* spp.	77	2.425107
Malau iusina	Holocentridae	*Sargocentron caudimaculatum*	69	2.16394
Kivi	Lutjanidae	*Lutjanus bohar*	52	1.616738
Bulelei	Carangidae	*Caranx* spp.	39	1.212553
Total:			**3193**	**100**

2.3.2 Invertebrate species caught by fishery and percentage of total annual catch wet weight – Vailoa

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Lobster	Ula	*Panulirus* spp.	100.0
Mangrove	Kuikui	*Tripneustes gratilla*	33.6
	Paa	*Etisus splendidus*	30.5
	Paalimago	*Scylla serrata*	27.1
	Pae	*Anadara* spp.	8.8
Other	Faisua	*Tridacna* spp.	48.8
	Loli	*Holothuria* spp.	18.1
	Sea	*Stichopus horrens*	9.9
	Mamao	*Actinopyga mauritiana*	9.5
	Fee	*Octopus* spp.	8.2
	Fole	*Pinna bicolor*	3.6
	Kuku	*Carpilius maculatus*	1.0
	Alili	*Turbo* spp.	0.7
	Tutu	*Etisus splendidus*	0.2
	Limu		
Reeftop	Fugafuga	*Holothuria* spp.	33.7
	Sea	*Stichopus horrens*	17.9
	Matapisu	*Holothuria* spp.	11.2
	Faisua	*Tridacna* spp.	9.3
	Paalimago	*Scylla serrata*	6.0
	Mamao	*Actinopyga mauritiana*	5.4
	Fee	*Octopus* spp.	3.9
	Fole	*Pinna bicolor*	3.4
	Ula	*Panulirus* spp.	2.8
	Alili	*Turbo* spp.	1.7
	Tutu	*Etisus splendidus*	1.4
	Li	*Tridacna* spp.	1.4
	Paa	*Etisus splendidus*	1.2
	Kuku	*Carpilius maculatus*	0.6
	Panea	*Strombus* spp.	0.3
	Limu		
Reeftop & other	Loli	*Holothuria* spp.	54.2
	Faisua	*Tridacna* spp.	33.9
	Paalimago	*Scylla serrata*	7.9
	Fee	*Octopus* spp.	3.0
	Alili	*Turbo* spp.	1.0
Reeftop & trochus	Pipi	*Tridacna* spp.	96.0
	Pae	*Anadara* spp.	4.0
Intertidal	Faisua	*Tridacna* spp.	85.8
	Fee	*Octopus* spp.	14.2
Intertidal & reeftop	Sea	*Stichopus horrens*	50.6
	Fugafuga	*Holothuria* spp.	26.6
	Faisua	*Tridacna* spp.	15.0
	Paalimago	*Scylla serrata*	7.0
	Pu	*Cypraea* spp.	0.7
	Panea	*Strombus* spp.	0.2
	Limu		

2.3.2 Invertebrate species caught by fishery and percentage of total annual catch wet weight – Vailoa (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Soft benthos	Fugafuga	*Holothuria* spp.	65.8
	Sea	*Stichopus horrens*	22.3
	Mamao	*Actinopyga mauritiana*	10.8
	Fee	*Octopus* spp.	0.8
	Alili	*Turbo* spp.	0.2
Soft benthos & mangrove	Sea	*Stichopus horrens*	27.2
	Pipi	*Tridacna* spp.	18.8
	Fole	*Pinna bicolor*	12.5
	Paalimago	*Scylla serrata*	9.7
	Mamao	*Actinopyga mauritiana*	7.0
	Kuku	*Carpilius maculatus*	6.6
	Kuikui	*Tripneustes gratilla*	5.3
	Tio	*Spondylus* spp.	3.0
	Pae	*Anadara* spp.	2.6
	Pu	*Cypraea* spp.	2.4
	Pule	*Cypraea* spp.	2.1
	Gau	*Dolabella auricularia*	1.4
	Alili	*Turbo* spp.	1.0
	Panea	*Strombus* spp.	0.3
	Limu		
Soft benthos & intertidal & reeftop	Fugafuga	*Holothuria* spp.	75.9
	Pipi	*Tridacna* spp.	19.0
	Sea	*Stichopus horrens*	5.2

2.3.3 Average length-frequency distribution for invertebrates and percentage of total annual catch weight – Vailoa

Vernacular name	Scientific name	Size class	% of total catch (weight)
Alili	*Turbo* spp.	05-08 cm	3.6
		06-08 cm	36.4
		06-10 cm	58.2
		08-12 cm	1.8
Faisua	*Tridacna* spp.	10-14 cm	14.0
		12-16 cm	5.3
		12-18 cm	28.1
		14-16 cm	8.8
		14-18 cm	43.9
Fee	*Octopus* spp.	10-16 cm	7.7
		12-14 cm	15.4
		12-18 cm	48.1
		14-18 cm	1.9
		16-18 cm	26.9
Fole	*Pinna bicolor*	08-10 cm	84.8
		08-12 cm	15.2
Fugafuga	*Holothuria* spp.	12-14 cm	5.2
		12-16 cm	84.5
		12-18 cm	10.4
Gau	*Dolabella auricularia*	10-14 cm	100.0
Kuikui	*Tripneustes gratilla*	06-08 cm	43.2
		06-10 cm	56.8
Kuku	*Carpilius maculatus*	08-10 cm	63.1
		08-12 cm	11.6
		10-14 cm	12.6
		12-14 cm	12.6
Li	*Tridacna* spp.	08-12 cm	100.0
Limu		01 cm	100.0
Loli	*Holothuria* spp.	12-14 cm	50.0
		12-18 cm	50.0
Mamao	*Actinopyga mauritiana*	12-14 cm	42.5
		12-16 cm	52.6
		12-18 cm	4.9
Matapisu	*Holothuria* spp.	12-16 cm	100.0
Paa	*Etisus splendidus*	14-18 cm	100.0
Paalimago	*Scylla serrata*	12-16 cm	17.0
		12-18 cm	77.3
		14-18 cm	2.1
		16-20 cm	3.5
Pae	*Anadara* spp.	06-08 cm	44.3
		08-10 cm	30.4
		12-16 cm	25.3
Panea	*Strombus* spp.	08-10 cm	85.1
		08-12 cm	14.9
Pipi	*Tridacna* spp.	02-04 cm	61.5
		04-06 cm	23.1
		04-08 cm	15.4

2.3.3 Average length-frequency distribution for invertebrates and percentage of total annual catch weight – Vailoa (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Pu	*Cypraea* spp.	06-10 cm	100.0
Pule	*Cypraea* spp.	06-12 cm	100.0
Sea	*Stichopus horrens*	12-14 cm	10.5
		12-16 cm	84.2
		14-16 cm	5.3
Tio	*Spondylus* spp.	04-06 cm	100.0
Tutu	*Etisus splendidus*	08-10 cm	95.5
		12-14 cm	4.5
Ula	*Panulirus* spp.	18-22 cm	35.6
		20-26 cm	64.4

2.4 Vaisala socioeconomic survey data

2.4.1 Annual catch (kg) of fish groups per habitat – Vaisala

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Sheltered coastal reef & lagoon				
Alogo	Acanthuridae	*Acanthurus lineatus*	1117	14.73
Fuga	Scaridae	*Scarus* spp.	1066	14.06
Pone	Acanthuridae	*Ctenochaetus striatus*	626	8.26
Gatala	Serranidae	*Epinephelus* spp.	494	6.52
Afulu	Mullidae	*Mullus* spp.	474	6.25
Malau	Holocentridae	*Myripristis* spp.	443	5.84
Pusi	Muraenidae	*Gymnothorax fimbriatus*	441	5.81
Filoa	Lethrinidae	*Lethrinus* spp.	412	5.44
Fugausi	Scaridae	*Cetoscarus bicolor*	280	3.70
Anae	Mugilidae	*Mugil* spp.	230	3.03
Sumu	Balistidae	*Balistes* spp.	199	2.63
Tifitifi	Chaetodontidae	*Chaetodon* spp.	195	2.57
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	180	2.37
Malau uli	Holocentridae	*Sargocentron violaceum*	149	1.97
Iliilia	Acanthuridae	*Naso lituratus*	140	1.84
Lailai	Mullidae	*Pseudupeneus* spp.	127	1.67
Ise	Hemiramphidae	*Hemiramphus* spp.	127	1.67
Fangamea	Lutjanidae	*Lutjanus* spp.	113	1.49
Atule	Scombridae Carangidae	*Katsuwonus pelamis* *Selar crumenophthalmus*	113	1.49
Anaana	Mugilidae	*Mugil* spp.	111	1.46
Bulelei	Carangidae	*Caranx* spp.	111	1.46
Fae	Dasyatidae	*Taeniura* spp.	85	1.11
Kivi	Lutjanidae	*Lutjanus bohar*	56	0.74
Loloa	Siganidae	*Siganus argenteus*	56	0.74
Tauleia	Mullidae	*Parupeneus indicus*	55	0.73
Lalafi	Labridae	*Cheilinus undulatus*	42	0.56
Galo	Scaridae	*Scarus* spp.	42	0.56
Fuafua	Mugilidae	*Crenimugil crenilabis*	42	0.56
Magigi	Holocentridae	*Holocentrus* spp.	28	0.37
Tuuu	Pomacanthidae	*Holacanthus* spp.	28	0.37
Total:			**7582**	**100.00**
Sheltered coastal reef & mangrove				
Kivi	Lutjanidae	*Lutjanus bohar*	56	44.36
Fuga	Scaridae	*Scarus* spp.	42	33.27
Lo	Siganidae	*Siganus* spp.	28	22.18
Total:			**127**	**99.81**

2.4.1 Annual catch (kg) of fish groups per habitat – Vaisala (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Lagoon				
Fuga	Scaridae	*Scarus* spp.	686	19.19
Pone	Acanthuridae	*Ctenochaetus striatus*	460	12.87
Alogo	Acanthuridae	*Acanthurus lineatus*	357	9.99
Gatala	Serranidae	*Epinephelus* spp.	312	8.73
Malau	Holocentridae	*Myripristis* spp.	292	8.17
Filoa	Lethrinidae	*Lethrinus* spp.	238	6.66
Laea	Scaridae	*Chlorurus microrhinos*	167	4.66
Atule	Scombridae Carangidae	*Katsuwonus pelamis* *Selar crumenophthalmus*	141	3.94
Pusi	Muraenidae	*Echidna nebulosa*	130	3.62
Fangamea	Lutjanidae	*Lutjanus* spp.	127	3.54
Galafa	Zanclidae	*Zanclus* spp.	113	3.15
Fugausi	Scaridae	*Cetoscarus bicolor*	99	2.76
Anaana	Mugilidae	*Mugil* spp.	85	2.36
Maila	Lethrinidae	*Lethrinus* spp.	75	2.09
Ume	Acanthuridae	*Naso unicornis*	56	1.58
Afulu	Mullidae	*Mullus* spp.	42	1.18
Sumu	Balistidae	*Balistes* spp.	42	1.18
Matamu	Lethrinidae	*Monotaxis grandoculis*	42	1.18
Kivi	Lutjanidae	*Lutjanus bohar*	42	1.18
Kagapa	Blenniidae	*Omobranchus elongatus*	42	1.18
Sumulaolao	Balistidae	*Balistes* spp.	28	0.79
Total:			**3576**	**100.00**
Lagoon & outer reef				
Alogo	Acanthuridae	*Acanthurus lineatus*	1211	16.18
Pone	Acanthuridae	*Ctenochaetus striatus*	800	10.68
Malau	Holocentridae	*Myripristis* spp.	782	10.45
Filoa	Lethrinidae	*Lethrinus* spp.	761	10.16
Pusi	Muraenidae	*Gymnothorax fimbriatus*	680	9.08
Fuga	Scaridae	*Scarus* spp.	652	8.70
Fugausi	Scaridae	*Cetoscarus bicolor*	510	6.81
Gatala	Serranidae	*Epinephelus* spp.	352	4.70
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	314	4.20
Magau	Holocentridae	*Holocentrus* spp.	253	3.38
Lalafi	Labridae	*Cheilinus undulatus*	149	1.99
Taiva	Lutjanidae	*Lutjanus* spp.	148	1.97
Mataloa	Lutjanidae	*Macolor niger*	148	1.97
Tautu	Diodontidae	*Diodon hystrix*	127	1.69
Galafa	Zanclidae	*Zanclus* spp.	127	1.69
Laea	Scaridae	*Chlorurus microrhinos*	85	1.13
Ume	Acanthuridae	*Naso unicornis*	85	1.13
Matapula	Priacanthidae	*Priacanthus* spp.	74	0.98
Iliilia	Acanthuridae	*Naso lituratus*	65	0.87
Anaana	Mugilidae	*Mugil* spp.	56	0.75
Manini	Acanthuridae	*Acanthurus triostegus*	46	0.61
Malau uli	Holocentridae	*Sargocentron violaceum*	37	0.49
Paumalo	Monacanthidae	*Monacanthus* spp.	14	0.19
Pauulu	Siganidae	*Siganus spinus*	14	0.19
Total:			**7489**	**100.00**

2.4.1 Annual catch (kg) of fish groups per habitat – Vaisala (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	Total weight (%)
Outer reef				
Fuga	Scaridae	*Scarus* spp.	667	19.50
Palagi	Acanthuridae	*Acanthurus* spp.	546	15.96
Laea	Scaridae	*Chlorurus microrhinos*	368	10.77
Malau	Holocentridae	*Myripristis* spp.	303	8.88
Mataeleele	Lethrinidae	*Lethrinus amboinensis*	270	7.91
Alogo	Acanthuridae	*Acanthurus lineatus*	262	7.66
Matamu	Lethrinidae	*Monotaxis grandoculis*	180	5.26
Pone	Acanthuridae	*Ctenochaetus striatus*	177	5.19
Ume	Acanthuridae	*Naso unicornis*	149	4.37
Paumalo	Monacanthidae	*Monacanthus* spp.	149	4.37
Gatala	Serranidae	*Epinephelus* spp.	121	3.54
Magigi	Holocentridae	*Holocentrus* spp.	85	2.47
Lo	Siganidae	*Siganus* spp.	85	2.47
Fugausi	Scaridae	*Cetoscarus bicolor*	56	1.65
Total:			**3419**	**100.00**
Outer reef & passage				
Laea	Scaridae	*Chlorurus microrhinos*	450	24.24
Fangamea	Lutjanidae	*Lutjanus* spp.	273	14.71
Alogo	Acanthuridae	*Acanthurus lineatus*	211	11.37
Ulapo	Scaridae	*Scarus* spp.	181	9.78
Fugausi	Scaridae	*Cetoscarus bicolor*	140	7.54
Filoa	Lethrinidae	*Lethrinus* spp.	130	6.98
Matamu	Lethrinidae	*Monotaxis grandoculis*	85	4.56
Galo	Scaridae	*Scarus* spp.	85	4.56
Molemole	Labridae	*Novaculichthys taeniourus*	85	4.56
Pone	Acanthuridae	*Ctenochaetus striatus*	76	4.12
Fuga	Scaridae	*Scarus* spp.	56	3.04
Palagi	Acanthuridae	*Acanthurus* spp.	56	3.04
Sumu	Balistidae	*Balistes* spp.	28	1.52
Total:			**1855**	**100.00**

2.4.2 Invertebrate species caught by fishery and percentage of total annual catch wet weight – Vaisala

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Lobster	Ula	*Panulirus* spp.	58.8
	Paa	*Etisus splendidus*	41.2
Mangrove	Paalimago	*Scylla serrata*	72.3
	Panea	*Strombus* spp.	17.4
	Kuikui	*Tripneustes gratilla*	10.3
Other	Faisua	*Tridacna* spp.	47.5
	Loli	*Holothuria* spp.	38.0
	Ula	*Panulirus* spp.	11.1
	Fee	*Octopus* spp.	3.5
Reeftop	Pipi	*Tridacna* spp.	35.8
	Sea	*Stichopus horrens*	25.8
	Fugafuga	*Holothuria* spp.	16.4
	Loli	*Holothuria* spp.	9.8
	Faisua	*Tridacna* spp.	2.9
	Fee	*Octopus* spp.	2.5
	Fole	*Pinna bicolor*	1.4
	Ula	*Panulirus* spp.	1.2
	Matapisu	*Holothuria* spp.	1.1
	Kuikui	*Tripneustes gratilla*	0.8
	Paa	*Etisus splendidus*	0.7
	Sisi	*Chama* spp.	0.6
	Alili	*Turbo* spp.	0.5
	Aliao	*Trochus* spp.	0.2
	Gau	*Dolabella auricularia*	0.2
	Limu		
Soft benthos	Matapisu	*Holothuria* spp.	39.6
	Pipi	*Tridacna* spp.	35.8
	Sea	*Stichopus horrens*	22.5
	Sisi	*Chama* spp.	2.0
	Alili	*Turbo* spp.	0.1
Soft benthos & reeftop	Pipi	*Tridacna* spp.	60.2
	Sea	*Stichopus horrens*	20.4
	Fugafuga	*Holothuria* spp.	9.0
	Loli	*Holothuria* spp.	6.8
	Sisi	*Chama* spp.	3.3
	Alili	*Turbo* spp.	0.4

2.4.3 Average length-frequency distribution for invertebrates and percentage of total annual total catch weight – Vaisala

Vernacular name	Scientific name	Size class	% of total catch (weight)
Aliao	*Trochus* spp.	06-10 cm	100.0
Alili	*Turbo* spp.	06-08 cm	12.4
		06-10 cm	33.5
		08-10 cm	54.1
Faisua	*Tridacna* spp.	14-18 cm	88.5
		14-20 cm	11.5
Fee	*Octopus* spp.	12-14 cm	13.4
		12-16 cm	20.1
		12-18 cm	8.9
		14-18 cm	6.7
		16-18 cm	50.9
Fole	*Pinna bicolor*	10-12 cm	100.0
Fugafuga	*Holothuria* spp.	10-14 cm	83.3
		12-14 cm	16.7
Gau	*Dolabella auricularia*	10-12 cm	100.0
Kuikui	*Tripneustes gratilla*	04-06 cm	11.5
		06-08 cm	14.7
		12-14 cm	73.7
Limu		01 cm	
Loli	*Holothuria* spp.	12-14 cm	34.1
		12-16 cm	65.9
Matapisu	*Holothuria* spp.	08-12 cm	95.6
		10-12 cm	4.4
Paa	*Etisus splendidus*	14-18 cm	82.7
		16-18 cm	17.3
Paalimago	*Scylla serrata*	10-13 cm	50.0
		12-14 cm	50.0
Panea	*Strombus* spp.	06-10 cm	100.0
Pipi	*Tridacna* spp.	02-04 cm	7.0
		04-06 cm	10.5
		04-08 cm	13.9
		06-08 cm	66.6
		06-12 cm	2.1
Sea	*Stichopus horrens*	12-14 cm	38.5
		12-16 cm	53.8
		16-18 cm	7.7
Sisi	*Chama* spp.	02-04 cm	16.4
		03-05 cm	22.4
		04-06 cm	61.2
Ula	*Panulirus* spp.	20-26 cm	65.4
		22-24 cm	34.6

APPENDIX 3: FINFISH SURVEY DATA

3.1 Manono-uta finfish survey data

3.1.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Manono-uta

Transect	Habitat	Latitude	Longitude
TRA01	Outer reef	13°50'01.9788"S	172°06'59.8788" W
TRA02	Outer reef	13°50'17.88" S	172°07'41.5812" W
TRA03	Back-reef	13°50'26.9988" S	172°07'16.5" W
TRA04	Outer reef	13°50'11.8212" S	172°05'49.8588" W
TRA05	Back-reef	13°50'02.58" S	172°06'04.32" W
TRA06	Coastal reef	13°50'26.4588" S	172°06'22.86" W
TRA07	Lagoon	13°50'31.2" S	172°06'08.7012" W
TRA08	Outer reef	13°51'13.3812" S	172°07'40.3788" W
TRA09	Outer reef	13°53'51.9" S	172°05'07.44" W
TRA10	Back-reef	13°53'39.1812" S	172°05'08.7612" W
TRA11	Coastal reef	13°53'31.02" S	172°04'12.36" W
TRA12	Lagoon	13°52'53.1588" S	172°04'55.74" W
TRA13	Lagoon	13°52'53.04" S	172°04'54.7212" W
TRA14	Coastal reef	13°53'21.84" S	172°04'02.9388" W
TRA15	Back-reef	13°52'42.3012" S	172°05'58.0812" W
TRA16	Back-reef	13°52'29.64" S	172°06'25.1388" W
TRA17	Lagoon	13°51'56.0988" S	172°06'29.9988" W
TRA18	Lagoon	13°51'58.0212" S	172°04'54.7788" W
TRA19	Lagoon	13°51'38.7612" S	172°04'59.88" W
TRA20	Outer reef	13°51'12.42" S	172°04'34.9788" W
TRA21	Back-reef	13°51'15.7788" S	172°05'14.9388" W
TRA22	Coastal reef	13°51'29.16" S	172°06'50.58" W
TRA23	Coastal reef	13°51'42.5988" S	172°06'23.22" W
TRA24	Coastal reef	13°51'21.06" S	172°06'05.94" W

3.1.2 Weighted average density and biomass of all finfish species recorded in Manono-uta
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus achilles*	0.0100	0.47
Acanthuridae	*Acanthurus blochii*	0.0120	5.13
Acanthuridae	*Acanthurus guttatus*	0.0057	1.22
Acanthuridae	*Acanthurus lineatus*	0.0073	1.74
Acanthuridae	*Acanthurus maculiceps*	0.0004	0.03
Acanthuridae	*Acanthurus nigricans*	0.0469	4.92
Acanthuridae	*Acanthurus nigricauda*	0.0004	0.05
Acanthuridae	*Acanthurus nigrofuscus*	0.0104	2.45
Acanthuridae	*Acanthurus nigroris*	0.0685	14.70
Acanthuridae	*Acanthurus olivaceus*	0.0167	3.70
Acanthuridae	*Acanthurus triostegus*	0.0156	1.20
Acanthuridae	*Ctenochaetus striatus*	0.2110	19.10
Acanthuridae	*Naso annulatus*	0.0001	0.01
Acanthuridae	*Naso brachycentron*	0.0002	0.02

3.1.2 Weighted average density and biomass of all finfish species recorded in Manono-uta (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Naso lituratus*	0.0290	9.52
Acanthuridae	*Naso unicornis*	0.0002	0.00
Acanthuridae	*Zebrasoma scopas*	0.0652	2.50
Acanthuridae	*Zebrasoma veliferum*	0.0022	0.10
Balistidae	*Balistapus undulatus*	0.0062	1.12
Balistidae	*Melichthys vidua*	0.0008	0.11
Balistidae	*Pseudobalistes flavimarginatus*	0.0000	0.03
Balistidae	*Rhinecanthus aculeatus*	0.0021	0.33
Balistidae	*Rhinecanthus rectangulus*	0.0002	0.00
Balistidae	*Sufflamen chrysopterum*	0.0004	0.06
Caesionidae	*Caesio caerulaurea*	0.0452	8.14
Caesionidae	*Caesio teres*	0.0143	1.93
Caesionidae	*Pterocaesio trilineata*	0.0101	0.18
Chaetodontidae	*Chaetodon auriga*	0.0031	0.16
Chaetodontidae	*Chaetodon citrinellus*	0.0070	0.11
Chaetodontidae	*Chaetodon ephippium*	0.0040	0.19
Chaetodontidae	*Chaetodon kleinii*	0.0000	0.00
Chaetodontidae	*Chaetodon lunula*	0.0015	0.06
Chaetodontidae	*Chaetodon lunulatus*	0.0067	0.24
Chaetodontidae	*Chaetodon melannotus*	0.0004	0.01
Chaetodontidae	*Chaetodon rafflesii*	0.0002	0.00
Chaetodontidae	*Chaetodon reticulatus*	0.0052	0.20
Chaetodontidae	*Chaetodon trifascialis*	0.0047	0.12
Chaetodontidae	*Chaetodon ulietensis*	0.0009	0.03
Chaetodontidae	*Chaetodon unimaculatus*	0.0014	0.08
Chaetodontidae	*Chaetodon vagabundus*	0.0066	0.24
Chaetodontidae	*Forcipiger flavissimus*	0.0017	0.05
Chaetodontidae	*Forcipiger longirostris*	0.0006	0.04
Chaetodontidae	*Heniochus acuminatus*	0.0000	0.00
Chaetodontidae	*Heniochus chrysostomus*	0.0027	0.21
Chaetodontidae	*Heniochus monoceros*	0.0004	0.02
Chaetodontidae	*Heniochus varius*	0.0034	0.33
Cirrhitidae	*Paracirrhites hemistictus*	0.0008	0.01
Diodontidae	*Diodon* spp.	0.0000	0.00
Holocentridae	*Myripristis berndti*	0.0010	0.07
Holocentridae	*Myripristis kuntee*	0.0009	0.10
Holocentridae	*Myripristis murdjan*	0.0004	0.05
Holocentridae	*Myripristis pralinia*	0.0020	0.24
Holocentridae	*Myripristis violacea*	0.0002	0.03
Holocentridae	*Neoniphon argenteus*	0.0011	0.04
Holocentridae	*Neoniphon sammara*	0.0014	0.07
Holocentridae	*Sargocentron caudimaculatum*	0.0032	0.18
Holocentridae	*Sargocentron diadema*	0.0034	0.34
Holocentridae	*Sargocentron microstoma*	0.0001	0.00
Holocentridae	*Sargocentron spiniferum*	0.0009	0.12
Labridae	*Cheilinus chlorourus*	0.0041	0.35
Labridae	*Cheilinus fasciatus*	0.0003	0.08

3.1.2 Weighted average density and biomass of all finfish species recorded in Manono-uta (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Labridae	*Cheilinus trilobatus*	0.0002	0.10
Labridae	*Cheilinus undulatus*	0.0002	0.04
Labridae	*Hemigymnus fasciatus*	0.0028	0.28
Labridae	*Hemigymnus melapterus*	0.0043	0.47
Labridae	*Oxycheilinus digramma*	0.0007	0.02
Lethrinidae	*Gnathodentex aureolineatus*	0.0059	1.59
Lethrinidae	*Lethrinus genivittatus*	0.0002	0.04
Lethrinidae	*Lethrinus harak*	0.0001	0.01
Lethrinidae	*Monotaxis grandoculis*	0.0110	3.74
Lutjanidae	*Aphareus furca*	0.0050	2.42
Lutjanidae	*Lutjanus biguttatus*	0.0102	0.82
Lutjanidae	*Lutjanus bohar*	0.0015	0.32
Lutjanidae	*Lutjanus fulvus*	0.0340	8.69
Lutjanidae	*Lutjanus gibbus*	0.0037	0.21
Lutjanidae	*Lutjanus kasmira*	0.0005	0.01
Lutjanidae	*Lutjanus monostigma*	0.0002	0.01
Lutjanidae	*Lutjanus vitta*	0.0000	0.00
Lutjanidae	*Macolor niger*	0.0006	0.09
Mullidae	*Mulloidichthys flavolineatus*	0.0336	2.02
Mullidae	*Mulloidichthys vanicolensis*	0.0058	0.55
Mullidae	*Parupeneus barberinoides*	0.0011	0.07
Mullidae	*Parupeneus barberinus*	0.0023	0.13
Mullidae	*Parupeneus cyclostomus*	0.0007	0.04
Mullidae	*Parupeneus indicus*	0.0002	0.01
Mullidae	*Parupeneus multifasciatus*	0.0150	0.90
Mullidae	*Parupeneus spilurus*	0.0004	0.02
Mullidae	*Parupeneus trifasciatus*	0.0004	0.07
Nemipteridae	*Scolopsis bilineata*	0.0181	2.09
Nemipteridae	*Scolopsis trilineata*	0.0004	0.03
Pomacanthidae	*Centropyge bicolor*	0.0006	0.02
Pomacanthidae	*Centropyge flavissima*	0.0006	0.01
Pomacanthidae	*Centropyge loricula*	0.0000	0.00
Pomacanthidae	*Pomacanthus imperator*	0.0002	0.02
Pomacanthidae	*Pygoplites diacanthus*	0.0016	0.36
Scaridae	*Cetoscarus bicolor*	0.0004	0.49
Scaridae	*Chlorurus bleekeri*	0.0079	1.45
Scaridae	*Chlorurus japanensis*	0.0012	0.22
Scaridae	*Chlorurus microrhinos*	0.0002	0.06
Scaridae	*Chlorurus sordidus*	0.1500	18.23
Scaridae	*Hipposcarus longiceps*	0.0004	0.11
Scaridae	*Scarus altipinnis*	0.0046	0.92
Scaridae	*Scarus dimidiatus*	0.0048	1.54
Scaridae	*Scarus flavipectoralis*	0.0004	0.21
Scaridae	*Scarus forsteni*	0.0002	0.17
Scaridae	*Scarus frenatus*	0.0004	0.22
Scaridae	*Scarus ghobban*	0.0015	0.26
Scaridae	*Scarus globiceps*	0.0000	0.01

3.1.2 Weighted average density and biomass of all finfish species recorded in Manono-uta (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus niger*	0.0027	2.07
Scaridae	*Scarus oviceps*	0.0391	9.98
Scaridae	*Scarus psittacus*	0.0239	1.24
Scaridae	*Scarus rubroviolaceus*	0.0010	0.54
Scaridae	*Scarus schlegeli*	0.0075	1.05
Scaridae	*Scarus* spp.	0.0003	0.20
Scaridae	*Scarus spinus*	0.0015	0.67
Scaridae	*Scarus tricolor*	0.0004	0.21
Scorpaenidae	*Pterois volitans*	0.0000	0.00
Serranidae	*Aethaloperca rogaa*	0.0031	0.30
Serranidae	*Cephalopholis argus*	0.0002	0.02
Serranidae	*Cephalopholis urodeta*	0.0090	0.70
Serranidae	*Epinephelus merra*	0.0013	0.05
Serranidae	*Epinephelus spilotoceps*	0.0002	0.01
Serranidae	*Plectropomus* spp.	0.0004	0.04
Serranidae	*Variola louti*	0.0004	0.18
Siganidae	*Siganus argenteus*	0.0016	0.47
Siganidae	*Siganus spinus*	0.0324	4.42
Zanclidae	*Zanclus cornutus*	0.0111	0.86

3.2 Salelavalu finfish survey data

3.2.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Salelavalu

Transect	Habitat	Latitude	Longitude
TRA01	Back-reef	13°43'57" S	172°11'19.32" W
TRA02	Lagoon	13°43'42.8412" S	172°11'37.5" W
TRA03	Coastal reef	13°43'22.3212" S	172°11'24.4788" W
TRA04	Outer reef	13°43'56.9388" S	172°10'39.9612" W
TRA05	Coastal reef	13°43'31.3788" S	172°11'40.02" W
TRA06	Back-reef	13°43'39.9" S	172°10'59.4012" W
TRA07	Lagoon	13°43'25.6188" S	172°10'53.4612" W
TRA08	Outer reef	13°44'02.22" S	172°11'06.1188" W
TRA09	Outer reef	13°44'15.0612" S	172°11'22.2" W
TRA10	Lagoon	13°43'11.1" S	172°10'45.7212" W
TRA11	Lagoon	13°42'56.52" S	172°10'56.2188" W
TRA12	Coastal reef	13°42'39.96" S	172°11'11.3388" W
TRA13	Coastal reef	13°42'49.9212" S	172°11'16.5588" W
TRA14	Outer reef	13°43'21.72" S	172°10'23.2788" W
TRA15	Back-reef	13°43'39.6588" S	172°10'59.4588" W
TRA16	Back-reef	13°42'41.3388" S	172°10'50.16" W
TRA17	Lagoon	13°42'26.7588" S	172°10'49.44" W
TRA18	Coastal reef	13°42'10.8612" S	172°11'21.3" W
TRA19	Outer reef	13°42'36.6012" S	172°10'27.0012" W
TRA20	Outer reef	13°42'58.5" S	172°10'29.9388" W
TRA21	Coastal reef	13°42'24.2388" S	172°11'18.6" W
TRA22	Lagoon	13°43'10.0812" S	172°11'09.8988" W
TRA23	Back-reef	13°44'06.0612" S	172°11'26.7" W
TRA24	Lagoon	13°43'48.36" S	172°11'27.6" W

3.2.2 Weighted average density and biomass of all finfish species recorded in Salelavalu (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus achilles*	0.0026	0.40
Acanthuridae	*Acanthurus blochii*	0.0004	0.11
Acanthuridae	*Acanthurus guttatus*	0.0030	0.49
Acanthuridae	*Acanthurus lineatus*	0.0065	1.37
Acanthuridae	*Acanthurus nigricans*	0.0199	1.84
Acanthuridae	*Acanthurus nigricauda*	0.0022	0.76
Acanthuridae	*Acanthurus nigrofuscus*	0.0007	0.17
Acanthuridae	*Acanthurus nigroris*	0.0003	0.03
Acanthuridae	*Acanthurus pyroferus*	0.0001	0.00
Acanthuridae	*Acanthurus thompsoni*	0.0003	0.01
Acanthuridae	*Acanthurus triostegus*	0.0156	1.01
Acanthuridae	*Acanthurus xanthopterus*	0.0002	0.05
Acanthuridae	*Ctenochaetus striatus*	0.0848	6.86
Acanthuridae	*Naso annulatus*	0.0004	0.04
Acanthuridae	*Naso brevirostris*	0.0001	0.05
Acanthuridae	*Naso lituratus*	0.0151	7.39
Acanthuridae	*Naso unicornis*	0.0003	0.14

3.2.2 Weighted average density and biomass of all finfish species recorded in Salelavalu *(continued)*

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Zebrasoma scopas*	0.0098	0.42
Acanthuridae	*Zebrasoma veliferum*	0.0041	0.16
Balistidae	*Balistapus undulatus*	0.0027	1.03
Balistidae	*Melichthys vidua*	0.0017	0.25
Balistidae	*Pseudobalistes flavimarginatus*	0.0001	0.17
Balistidae	*Rhinecanthus aculeatus*	0.0014	0.26
Balistidae	*Rhinecanthus rectangulus*	0.0003	0.03
Caesionidae	*Pterocaesio marri*	0.0004	0.12
Caesionidae	*Pterocaesio tile*	0.0022	0.23
Caesionidae	*Pterocaesio trilineata*	0.0043	0.25
Carangidae	*Carangoides orthogrammus*	0.0001	0.08
Carangidae	*Caranx melampygus*	0.0003	0.23
Chaetodontidae	*Chaetodon auriga*	0.0006	0.02
Chaetodontidae	*Chaetodon bennetti*	0.0000	0.00
Chaetodontidae	*Chaetodon citrinellus*	0.0011	0.02
Chaetodontidae	*Chaetodon ephippium*	0.0040	0.14
Chaetodontidae	*Chaetodon lunula*	0.0004	0.01
Chaetodontidae	*Chaetodon lunulatus*	0.0073	0.21
Chaetodontidae	*Chaetodon melannotus*	0.0003	0.02
Chaetodontidae	*Chaetodon ornatissimus*	0.0005	0.02
Chaetodontidae	*Chaetodon pelewensis*	0.0001	0.00
Chaetodontidae	*Chaetodon rafflesii*	0.0002	0.01
Chaetodontidae	*Chaetodon reticulatus*	0.0044	0.19
Chaetodontidae	*Chaetodon semeion*	0.0004	0.02
Chaetodontidae	*Chaetodon speculum*	0.0003	0.01
Chaetodontidae	*Chaetodon trifascialis*	0.0077	0.20
Chaetodontidae	*Chaetodon unimaculatus*	0.0003	0.01
Chaetodontidae	*Chaetodon vagabundus*	0.0043	0.14
Chaetodontidae	*Forcipiger longirostris*	0.0002	0.01
Chaetodontidae	*Heniochus acuminatus*	0.0005	0.03
Chaetodontidae	*Heniochus chrysostomus*	0.0001	0.00
Chaetodontidae	*Heniochus varius*	0.0023	0.14
Diodontidae	*Diodon hystrix*	0.0002	0.15
Diodontidae	*Diodon* spp.	0.0001	0.02
Haemulidae	*Plectorhinchus orientalis*	0.0002	0.09
Holocentridae	*Myripristis adusta*	0.0006	0.05
Holocentridae	*Myripristis berndti*	0.0014	0.17
Holocentridae	*Myripristis kuntee*	0.0000	0.00
Holocentridae	*Myripristis murdjan*	0.0005	0.06
Holocentridae	*Neoniphon sammara*	0.0020	0.16
Holocentridae	*Sargocentron cornutum*	0.0005	0.01
Holocentridae	*Sargocentron spiniferum*	0.0011	0.47
Kyphosidae	*Kyphosus vaigiensis*	0.0001	0.05
Labridae	*Cheilinus chlorourus*	0.0032	0.34
Labridae	*Cheilinus fasciatus*	0.0001	0.04
Labridae	*Cheilinus trilobatus*	0.0001	0.01
Labridae	*Cheilinus undulatus*	0.0007	0.26

3.2.2 Weighted average density and biomass of all finfish species recorded in Salelavalu *(continued)*

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Labridae	*Hemigymnus fasciatus*	0.0010	0.19
Labridae	*Hemigymnus melapterus*	0.0086	0.52
Labridae	*Oxycheilinus digramma*	0.0000	0.00
Lethrinidae	*Gnathodentex aureolineatus*	0.0068	1.46
Lethrinidae	*Lethrinus harak*	0.0003	0.06
Lethrinidae	*Monotaxis grandoculis*	0.0052	1.63
Lutjanidae	*Aphareus furca*	0.0021	1.27
Lutjanidae	*Lutjanus bohar*	0.0004	0.22
Lutjanidae	*Lutjanus fulviflamma*	0.0001	0.11
Lutjanidae	*Lutjanus fulvus*	0.0080	2.11
Lutjanidae	*Lutjanus gibbus*	0.0014	0.32
Lutjanidae	*Lutjanus monostigma*	0.0002	0.14
Lutjanidae	*Macolor niger*	0.0002	0.05
Mullidae	*Mulloidichthys flavolineatus*	0.0177	4.10
Mullidae	*Mulloidichthys vanicolensis*	0.0002	0.02
Mullidae	*Parupeneus barberinoides*	0.0000	0.00
Mullidae	*Parupeneus barberinus*	0.0033	0.21
Mullidae	*Parupeneus cyclostomus*	0.0007	0.05
Mullidae	*Parupeneus multifasciatus*	0.0074	0.38
Mullidae	*Parupeneus pleurostigma*	0.0000	0.00
Mullidae	*Parupeneus spilurus*	0.0002	0.01
Mullidae	*Parupeneus trifasciatus*	0.0001	0.01
Nemipteridae	*Scolopsis bilineata*	0.0105	1.47
Pomacanthidae	*Centropyge bispinosa*	0.0005	0.01
Pomacanthidae	*Centropyge flavissima*	0.0013	0.02
Pomacanthidae	*Pomacanthus imperator*	0.0001	0.01
Pomacanthidae	*Pygoplites diacanthus*	0.0001	0.02
Scaridae	*Cetoscarus bicolor*	0.0003	0.11
Scaridae	*Chlorurus japanensis*	0.0001	0.08
Scaridae	*Chlorurus microrhinos*	0.0001	0.03
Scaridae	*Chlorurus sordidus*	0.0530	6.15
Scaridae	*Hipposcarus longiceps*	0.0005	0.10
Scaridae	*Scarus chameleon*	0.0001	0.06
Scaridae	*Scarus dimidiatus*	0.0052	1.08
Scaridae	*Scarus frenatus*	0.0005	0.20
Scaridae	*Scarus ghobban*	0.0015	0.31
Scaridae	*Scarus globiceps*	0.0004	0.12
Scaridae	*Scarus niger*	0.0016	0.80
Scaridae	*Scarus oviceps*	0.0177	3.00
Scaridae	*Scarus psittacus*	0.1050	4.23
Scaridae	*Scarus rubroviolaceus*	0.0001	0.07
Scaridae	*Scarus schlegeli*	0.0075	0.80
Scaridae	*Scarus spinus*	0.0013	0.23
Scaridae	*Scarus tricolor*	0.0001	0.04
Serranidae	*Aethaloperca rogaa*	0.0007	0.16
Serranidae	*Cephalopholis argus*	0.0004	0.16
Serranidae	*Cephalopholis urodeta*	0.0001	0.00

3.2.2 Weighted average density and biomass of all finfish species recorded in Salelavalu *(continued)*

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Serranidae	*Epinephelus merra*	0.0015	0.06
Serranidae	*Plectropomus areolatus*	0.0001	0.06
Serranidae	*Variola albimarginata*	0.0001	0.10
Serranidae	*Variola louti*	0.0001	0.06
Siganidae	*Siganus argenteus*	0.0004	0.18
Siganidae	*Siganus punctatus*	0.0003	0.07
Siganidae	*Siganus spinus*	0.0037	0.55
Zanclidae	*Zanclus cornutus*	0.0081	0.58

3.3 Vailoa finfish survey data

3.3.1 Coordinates (WGS84) of the 28 D-UVC transects used to assess finfish resource status in Vailoa

Transect	Habitat	Latitude	Longitude
TRA01	Outer reef	14°03'53.5212" S	171°25'47.5212" W
TRA02	Outer reef	14°03'42.9588" S	171°25'50.5812" W
TRA03	Outer reef	14°03'28.9188" S	171°25'43.9212" W
TRA04	Outer reef	14°03'25.3188" S	171°25'31.08" W
TRA05	Outer reef	14°03'25.8012" S	171°25'14.8188" W
TRA06	Outer reef	14°03'42.12" S	171°25'03.2988" W
TRA07	Outer reef	14°03'10.6812" S	171°26'18.1212" W
TRA08	Outer reef	14°03'00.6588" S	171°25'58.6812" W
TRA09	Outer reef	14°02'53.2212" S	171°25'48.6588" W
TRA10	Outer reef	14°02'24.0612" S	171°25'16.2012" W
TRA11	Outer reef	14°02'07.08" S	171°25'07.9212" W
TRA12	Outer reef	14°01'42.3588" S	171°24'54.54" W
TRA13	Back-reef	14°01'27.5412" S	171°25'10.6788" W
TRA14	Back-reef	14°01'43.0788" S	171°25'24.24" W
TRA15	Back-reef	14°02'35.4012" S	171°25'47.28" W
TRA16	Back-reef	14°02'39.66" S	171°25'58.5012" W
TRA17	Coastal reef	14°02'33.18" S	171°26'07.5588" W
TRA18	Coastal reef	14°02'26.4012" S	171°25'59.7" W
TRA19	Coastal reef	14°02'25.5588" S	171°26'03.0588" W
TRA20	Back-reef	14°02'13.02" S	171°25'34.14" W
TRA21	Back-reef	14°02'15.6588" S	171°25'47.64" W
TRA22	Coastal reef	14°02'14.7588" S	171°26'00.1212" W
TRA23	Coastal reef	14°02'05.8812" S	171°25'58.98" W
TRA24	Coastal reef	14°02'02.58" S	171°25'53.5188" W
TRA25	Coastal reef	14°01'42.4812" S	171°25'45.66" W
TRA26	Coastal reef	14°01'53.04" S	171°25'51.06" W
TRA27	Coastal reef	14°01'56.9388" S	171°25'35.8788" W
TRA28	Coastal reef	14°01'40.3212" S	171°25'32.2788" W

3.3.2 Weighted average density and biomass of all finfish species recorded in Vailoa (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus achilles*	0.0017	0.18
Acanthuridae	*Acanthurus albipectoralis*	0.0124	3.46
Acanthuridae	*Acanthurus blochii*	0.0021	0.60
Acanthuridae	*Acanthurus guttatus*	0.0016	0.20
Acanthuridae	*Acanthurus lineatus*	0.0172	4.38
Acanthuridae	*Acanthurus nigricans*	0.0616	7.02
Acanthuridae	*Acanthurus nigricauda*	0.0017	1.29
Acanthuridae	*Acanthurus nigrofuscus*	0.0223	5.37
Acanthuridae	*Acanthurus nigroris*	0.0332	9.51
Acanthuridae	*Acanthurus olivaceus*	0.0014	0.22
Acanthuridae	*Acanthurus pyroferus*	0.0002	0.01
Acanthuridae	*Acanthurus thompsoni*	0.0061	0.27
Acanthuridae	*Acanthurus triostegus*	0.0111	0.64

3.3.2 Weighted average density and biomass of all finfish species recorded in Vailoa (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus xanthopterus*	0.0002	0.22
Acanthuridae	*Ctenochaetus flavicauda*	0.0015	0.04
Acanthuridae	*Ctenochaetus striatus*	0.1750	14.30
Acanthuridae	*Naso caesius*	0.0029	3.63
Acanthuridae	*Naso hexacanthus*	0.0011	1.02
Acanthuridae	*Naso lituratus*	0.0046	2.20
Acanthuridae	*Naso* spp.	0.0009	0.75
Acanthuridae	*Naso tuberosus*	0.0006	0.70
Acanthuridae	*Naso unicornis*	0.0033	0.14
Acanthuridae	*Zebrasoma scopas*	0.0181	0.71
Acanthuridae	*Zebrasoma veliferum*	0.0003	0.03
Balistidae	*Balistapus* spp.	0.0000	0.00
Balistidae	*Balistapus undulatus*	0.0087	1.16
Balistidae	*Melichthys niger*	0.0016	0.09
Balistidae	*Melichthys vidua*	0.0219	2.54
Balistidae	*Rhinecanthus aculeatus*	0.0017	0.34
Balistidae	*Rhinecanthus rectangulus*	0.0017	0.11
Balistidae	*Sufflamen bursa*	0.0037	0.26
Balistidae	*Sufflamen chrysopterum*	0.0006	0.07
Balistidae	*Sufflamen fraenatum*	0.0001	0.02
Caesionidae	*Caesio caerulaurea*	0.0408	7.91
Caesionidae	*Caesio cuning*	0.0030	0.96
Caesionidae	*Caesio teres*	0.0027	0.94
Caesionidae	*Pterocaesio marri*	0.0060	2.79
Caesionidae	*Pterocaesio tile*	0.0013	0.38
Carangidae	*Caranx melampygus*	0.0000	0.00
Carangidae	*Elagatis bipinnulata*	0.0001	0.33
Carangidae	*Scomberoides lysan*	0.0001	0.02
Chaetodontidae	*Chaetodon auriga*	0.0007	0.02
Chaetodontidae	*Chaetodon bennetti*	0.0002	0.01
Chaetodontidae	*Chaetodon citrinellus*	0.0071	0.11
Chaetodontidae	*Chaetodon ephippium*	0.0020	0.07
Chaetodontidae	*Chaetodon lunula*	0.0009	0.02
Chaetodontidae	*Chaetodon lunulatus*	0.0072	0.19
Chaetodontidae	*Chaetodon melannotus*	0.0001	0.00
Chaetodontidae	*Chaetodon ornatissimus*	0.0021	0.06
Chaetodontidae	*Chaetodon pelewensis*	0.0008	0.01
Chaetodontidae	*Chaetodon reticulatus*	0.0111	0.35
Chaetodontidae	*Chaetodon semeion*	0.0002	0.01
Chaetodontidae	*Chaetodon speculum*	0.0002	0.00
Chaetodontidae	*Chaetodon trifascialis*	0.0069	0.13
Chaetodontidae	*Chaetodon ulietensis*	0.0003	0.01
Chaetodontidae	*Chaetodon unimaculatus*	0.0021	0.08
Chaetodontidae	*Chaetodon vagabundus*	0.0039	0.12
Chaetodontidae	*Forcipiger longirostris*	0.0024	0.08
Chaetodontidae	*Heniochus chrysostomus*	0.0019	0.13
Chaetodontidae	*Heniochus varius*	0.0024	0.22

3.3.2 Weighted average density and biomass of all finfish species recorded in Vailoa (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Cirrhitidae	*Paracirrhites hemistictus*	0.0004	0.02
Diodontidae	*Diodon hystrix*	0.0001	0.11
Haemulidae	*Diagramma pictum*	0.0004	0.27
Haemulidae	*Plectorhinchus orientalis*	0.0003	0.10
Holocentridae	*Myripristis adusta*	0.0003	0.14
Holocentridae	*Myripristis berndti*	0.0019	0.24
Holocentridae	*Myripristis hexagona*	0.0007	0.04
Holocentridae	*Myripristis kuntee*	0.0004	0.04
Holocentridae	*Myripristis violacea*	0.0005	0.08
Holocentridae	*Neoniphon sammara*	0.0033	0.37
Holocentridae	*Sargocentron cornutum*	0.0002	0.01
Holocentridae	*Sargocentron diadema*	0.0004	0.03
Holocentridae	*Sargocentron spiniferum*	0.0002	0.09
Kyphosidae	*Kyphosus cinerascens*	0.0012	0.80
Labridae	*Cheilinus chlorourus*	0.0021	0.22
Labridae	*Cheilinus undulatus*	0.0001	0.09
Labridae	*Hemigymnus fasciatus*	0.0016	0.21
Labridae	*Hemigymnus melapterus*	0.0013	0.06
Labridae	*Oxycheilinus digramma*	0.0002	0.02
Lethrinidae	*Gnathodentex aureolineatus*	0.0033	1.22
Lethrinidae	*Lethrinus atkinsoni*	0.0000	0.00
Lethrinidae	*Lethrinus harak*	0.0018	0.83
Lethrinidae	*Monotaxis grandoculis*	0.0040	2.15
Lutjanidae	*Aphareus furca*	0.0028	1.60
Lutjanidae	*Aprion virescens*	0.0001	0.06
Lutjanidae	*Lutjanus bohar*	0.0015	1.33
Lutjanidae	*Lutjanus fulvus*	0.0012	0.31
Lutjanidae	*Lutjanus gibbus*	0.0055	0.97
Lutjanidae	*Lutjanus kasmira*	0.0004	0.06
Lutjanidae	*Lutjanus monostigma*	0.0001	0.06
Lutjanidae	*Macolor macularis*	0.0002	0.15
Lutjanidae	*Macolor niger*	0.0005	0.35
Mugilidae	*Valamugil seheli*	0.0008	0.30
Mullidae	*Mulloidichthys flavolineatus*	0.0039	0.75
Mullidae	*Mulloidichthys vanicolensis*	0.0004	0.01
Mullidae	*Parupeneus barberinus*	0.0012	0.07
Mullidae	*Parupeneus cyclostomus*	0.0013	0.17
Mullidae	*Parupeneus indicus*	0.0000	0.00
Mullidae	*Parupeneus multifasciatus*	0.0064	0.46
Mullidae	*Parupeneus pleurostigma*	0.0001	0.01
Mullidae	*Parupeneus spilurus*	0.0001	0.01
Mullidae	*Parupeneus trifasciatus*	0.0009	0.19
Nemipteridae	*Scolopsis bilineata*	0.0071	1.36
Pomacanthidae	*Apolemichthys trimaculatus*	0.0112	0.10
Pomacanthidae	*Centropyge bicolor*	0.0001	0.00
Pomacanthidae	*Centropyge bispinosa*	0.0005	0.00
Pomacanthidae	*Centropyge loricula*	0.0004	0.00

3.3.2 Weighted average density and biomass of all finfish species recorded in Vailoa (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Pomacanthidae	*Pygoplites diacanthus*	0.0015	0.20
Scaridae	*Chlorurus bleekeri*	0.0001	0.04
Scaridae	*Chlorurus japanensis*	0.0059	1.21
Scaridae	*Chlorurus microrhinos*	0.0013	1.02
Scaridae	*Chlorurus sordidus*	0.0720	8.50
Scaridae	*Scarus altipinnis*	0.0005	0.18
Scaridae	*Scarus chameleon*	0.0002	0.06
Scaridae	*Scarus dimidiatus*	0.0005	0.28
Scaridae	*Scarus flavipectoralis*	0.0027	0.44
Scaridae	*Scarus forsteni*	0.0001	0.01
Scaridae	*Scarus frenatus*	0.0002	0.15
Scaridae	*Scarus ghobban*	0.0007	0.50
Scaridae	*Scarus globiceps*	0.0006	0.13
Scaridae	*Scarus longipinnis*	0.0001	0.08
Scaridae	*Scarus niger*	0.0004	0.04
Scaridae	*Scarus oviceps*	0.0138	4.21
Scaridae	*Scarus psittacus*	0.0996	4.41
Scaridae	*Scarus rubroviolaceus*	0.0004	0.30
Scaridae	*Scarus schlegeli*	0.0007	0.31
Scaridae	*Scarus spinus*	0.0009	0.26
Scaridae	*Scarus tricolor*	0.0006	0.25
Scombridae	*Gymnosarda unicolor*	0.0001	0.21
Serranidae	*Aethaloperca rogaa*	0.0008	0.10
Serranidae	*Cephalopholis argus*	0.0016	0.40
Serranidae	*Cephalopholis urodeta*	0.0040	0.40
Serranidae	*Epinephelus merra*	0.0021	0.09
Siganidae	*Siganus argenteus*	0.0001	0.08
Siganidae	*Siganus puellus*	0.0001	0.01
Siganidae	*Siganus spinus*	0.0137	1.22
Zanclidae	*Zanclus cornutus*	0.0054	0.47

3.4 Vaisala finfish survey data

3.4.1 Coordinates (WGS 84) of the 25 D-UVC transects used to assess finfish resource status in Vaisala

Transect	Habitat	Latitude	Longitude
TRA01	Outer reef	13°30'25.2612" S	172°40'56.46" W
TRA02	Outer reef	13°30'24.5988" S	172°40'38.2188" W
TRA03	Outer reef	13°30'17.3412" S	172°40'21.9612" W
TRA04	Back-reef	13°30'25.4988" S	172°40'23.4012" W
TRA05	Outer reef	13°30'01.98" S	172°39'54.0612" W
TRA06	Outer reef	13°30'02.9988" S	172°39'34.74" W
TRA07	Back-reef	13°30'12.8412" S	172°39'33.0012" W
TRA08	Back-reef	13°30'12.1212" S	172°39'44.1" W
TRA09	Back-reef	13°30'32.6412" S	172°40'41.2212" W
TRA10	Back-reef	13°30'38.8188" S	172°40'36.7788" W
TRA11	Back-reef	13°30'27.1188" S	172°40'14.0412" W
TRA12	Back-reef	13°30'25.02" S	172°40'06.06" W
TRA13	Outer reef	13°29'59.7012" S	172°39'04.3812" W
TRA14	Back-reef	13°30'17.7012" S	172°40'07.7988" W
TRA15	Back-reef	13°30'18.7812" S	172°39'55.8612" W
TRA16	Back-reef	13°30'12.78" S	172°39'52.56" W
TRA17	Back-reef	13°30'19.0188" S	172°39'43.9812" W
TRA18	Back-reef	13°30'20.34" S	172°39'34.0812" W
TRA19	Back-reef	13°30'25.2" S	172°39'06.1812" W
TRA20	Back-reef	13°30'39.3588" S	172°40'28.92" W
TRA21	Back-reef	13°30'29.2788" S	172°40'31.26" W
TRA22	Outer reef	13°29'58.8012" S	172°39'41.6988" W
TRA23	Back-reef	13°30'25.4988" S	172°39'23.5188" W
TRA24	Back-reef	13°30'31.2012" S	172°39'19.3788" W
TRA25	Outer reef	13°30'05.04" S	172°38'59.3988" W

3.4.2 Weighted average density and biomass of all finfish species recorded in Vaisala (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus achilles*	0.0006	0.06
Acanthuridae	*Acanthurus blochii*	0.0005	0.32
Acanthuridae	*Acanthurus guttatus*	0.0011	0.25
Acanthuridae	*Acanthurus lineatus*	0.0385	7.37
Acanthuridae	*Acanthurus nigricans*	0.0430	5.58
Acanthuridae	*Acanthurus nigricauda*	0.0125	5.54
Acanthuridae	*Acanthurus nigrofuscus*	0.0066	0.75
Acanthuridae	*Acanthurus nigroris*	0.0004	0.02
Acanthuridae	*Acanthurus olivaceus*	0.0005	0.05
Acanthuridae	*Acanthurus pyroferus*	0.0001	0.01
Acanthuridae	*Acanthurus triostegus*	0.0451	3.47
Acanthuridae	*Acanthurus xanthopterus*	0.0009	0.73
Acanthuridae	*Ctenochaetus striatus*	0.1640	14.46
Acanthuridae	*Ctenochaetus strigosus*	0.0114	1.85
Acanthuridae	*Naso lituratus*	0.0098	4.50
Acanthuridae	*Naso tuberosus*	0.0002	0.10

3.4.2 Weighted average density and biomass of all finfish species recorded in Vaisala (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Zebrasoma scopas*	0.0167	0.86
Acanthuridae	*Zebrasoma veliferum*	0.0007	0.05
Aulostomidae	*Aulostomus chinensis*	0.0001	0.01
Balistidae	*Balistapus undulatus*	0.0115	2.46
Balistidae	*Melichthys vidua*	0.0218	4.85
Balistidae	*Rhinecanthus aculeatus*	0.0014	0.24
Balistidae	*Rhinecanthus rectangulus*	0.0055	1.09
Balistidae	*Sufflamen bursa*	0.0024	0.23
Balistidae	*Sufflamen chrysopterum*	0.0055	0.99
Belonidae	*Tylosurus crocodilus*	0.0015	0.13
Caesionidae	*Caesio caerulaurea*	0.0019	1.22
Caesionidae	*Pterocaesio tile*	0.0093	0.99
Carangidae	*Scomberoides lysan*	0.0006	0.11
Carangidae	*Scomberoides* spp.	0.0002	0.11
Chaetodontidae	*Chaetodon auriga*	0.0002	0.01
Chaetodontidae	*Chaetodon citrinellus*	0.0078	0.15
Chaetodontidae	*Chaetodon ephippium*	0.0016	0.06
Chaetodontidae	*Chaetodon lunula*	0.0011	0.04
Chaetodontidae	*Chaetodon lunulatus*	0.0045	0.15
Chaetodontidae	*Chaetodon ornatissimus*	0.0005	0.01
Chaetodontidae	*Chaetodon pelewensis*	0.0001	0.00
Chaetodontidae	*Chaetodon rafflesii*	0.0004	0.01
Chaetodontidae	*Chaetodon reticulatus*	0.0026	0.09
Chaetodontidae	*Chaetodon semeion*	0.0003	0.01
Chaetodontidae	*Chaetodon* spp.	0.0001	0.00
Chaetodontidae	*Chaetodon trifascialis*	0.0026	0.10
Chaetodontidae	*Chaetodon ulietensis*	0.0001	0.00
Chaetodontidae	*Chaetodon vagabundus*	0.0060	0.23
Chaetodontidae	*Forcipiger longirostris*	0.0001	0.00
Chaetodontidae	*Heniochus acuminatus*	0.0004	0.04
Chaetodontidae	*Heniochus chrysostomus*	0.0004	0.05
Chaetodontidae	*Heniochus varius*	0.0010	0.09
Holocentridae	*Myripristis berndti*	0.0003	0.03
Holocentridae	*Myripristis kuntee*	0.0009	0.03
Holocentridae	*Myripristis violacea*	0.0001	0.01
Holocentridae	*Myripristis vittata*	0.0021	0.18
Holocentridae	*Neoniphon sammara*	0.0060	0.42
Holocentridae	*Sargocentron caudimaculatum*	0.0029	0.33
Holocentridae	*Sargocentron cornutum*	0.0002	0.01
Holocentridae	*Sargocentron diadema*	0.0001	0.01
Holocentridae	*Sargocentron spiniferum*	0.0034	0.89
Labridae	*Cheilinus chlorourus*	0.0027	0.19
Labridae	*Cheilinus trilobatus*	0.0001	0.02
Labridae	*Coris aygula*	0.0001	0.02
Labridae	*Hemigymnus fasciatus*	0.0006	0.07
Labridae	*Hemigymnus melapterus*	0.0042	0.38
Labridae	*Oxycheilinus digramma*	0.0001	0.00

3.4.2 Weighted average density and biomass of all finfish species recorded in Vaisala (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Lethrinidae	*Gnathodentex aureolineatus*	0.0010	0.12
Lethrinidae	*Lethrinus harak*	0.0011	0.59
Lethrinidae	*Monotaxis grandoculis*	0.0023	0.45
Lutjanidae	*Aphareus furca*	0.0035	1.66
Lutjanidae	*Aprion virescens*	0.0001	0.58
Lutjanidae	*Lutjanus fulviflamma*	0.0004	0.17
Lutjanidae	*Lutjanus fulvus*	0.0029	1.13
Lutjanidae	*Lutjanus gibbus*	0.0062	0.22
Lutjanidae	*Lutjanus kasmira*	0.0102	1.40
Lutjanidae	*Lutjanus monostigma*	0.0006	0.21
Lutjanidae	*Macolor macularis*	0.0001	0.12
Mugilidae	*Mugil* spp.	0.0012	1.27
Mullidae	*Mulloidichthys flavolineatus*	0.0025	0.34
Mullidae	*Mulloidichthys vanicolensis*	0.0003	0.04
Mullidae	*Parupeneus barberinus*	0.0007	0.00
Mullidae	*Parupeneus cyclostomus*	0.0012	0.21
Mullidae	*Parupeneus multifasciatus*	0.0066	0.38
Mullidae	*Parupeneus spilurus*	0.0002	0.03
Mullidae	*Parupeneus trifasciatus*	0.0005	0.01
Nemipteridae	*Scolopsis bilineata*	0.0043	0.45
Pempheridae	*Pempheris vanicolensis*	0.0002	0.00
Pomacanthidae	*Apolemichthys trimaculatus*	0.0023	0.72
Pomacanthidae	*Centropyge bispinosa*	0.0001	0.00
Pomacanthidae	*Centropyge flavissima*	0.0048	0.08
Pomacanthidae	*Pygoplites diacanthus*	0.0006	0.06
Scaridae	*Cetoscarus bicolor*	0.0007	0.34
Scaridae	*Chlorurus microrhinos*	0.0002	0.30
Scaridae	*Chlorurus sordidus*	0.0587	9.77
Scaridae	*Scarus altipinnis*	0.0008	0.96
Scaridae	*Scarus chameleon*	0.0002	0.12
Scaridae	*Scarus dimidiatus*	0.0021	0.23
Scaridae	*Scarus flavipectoralis*	0.0028	0.98
Scaridae	*Scarus forsteni*	0.0002	0.17
Scaridae	*Scarus frenatus*	0.0002	0.06
Scaridae	*Scarus globiceps*	0.0012	0.48
Scaridae	*Scarus oviceps*	0.0340	6.38
Scaridae	*Scarus psittacus*	0.1410	7.89
Scaridae	*Scarus rivulatus*	0.0001	0.02
Scaridae	*Scarus schlegeli*	0.0010	0.13
Scaridae	*Scarus spinus*	0.0010	0.38
Serranidae	*Aethaloperca rogaa*	0.0010	0.09
Serranidae	*Cephalopholis argus*	0.0002	0.12
Serranidae	*Cephalopholis urodeta*	0.0041	0.27
Serranidae	*Epinephelus fasciatus*	0.0008	0.09
Serranidae	*Epinephelus hexagonatus*	0.0002	0.01
Serranidae	*Epinephelus merra*	0.0028	0.12
Siganidae	*Siganus spinus*	0.0005	0.08
Tetraodontidae	*Arothron nigropunctatus*	0.0001	0.04
Zanclidae	*Zanclus cornutus*	0.0034	0.36

APPENDIX 4: INVERTEBRATE SURVEY DATA

4.1 Manono-uta invertebrate survey data

4.1.1 Invertebrate species recorded in different assessments in Manono-uta

Group	Species	Broad scale	Reef benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*	+	+	
Bêche-de-mer	*Bohadschia argus*	+	+	
Bêche-de-mer	*Bohadschia vitiensis*	+	+	
Bêche-de-mer	*Holothuria atra*	+	+	
Bêche-de-mer	*Holothuria fuscogilva*			
Bêche-de-mer	*Holothuria leucospilota*	+		
Bêche-de-mer	*Holothuria nobilis*	+		
Bêche-de-mer	*Stichopus chloronotus*	+	+	
Bêche-de-mer	*Stichopus horrens*	+		
Bêche-de-mer	*Synapta sp.*	+	+	
Bêche-de-mer	*Thelenota ananas*	+		
Bivalve	*Anadara antiquata*	+	+	
Bivalve	*Pinna bicolor*	+	+	
Bivalve	*Pinna sp.*	+	+	
Bivalve	*Spondylus sp.*	+	+	
Bivalve	*Tellina scobinata*	+		
Bivalve	*Tridacna maxima*	+	+	
Cnidarians	*Cassiopea sp.*	+		
Cnidarians	*Stichodactyla sp.*	+	+	
Crustacean	*Coenobita sp.*		+	
Crustacean	*Dardanus sp.*		+	
Crustacean	*Lysiosquillina sp.*		+	
Gastropod	*Cerithium aluco*	+		
Gastropod	*Cerithium nodulosum*	+		
Gastropod	*Chicoreus sp.*		+	
Gastropod	*Conus flavidus*		+	
Gastropod	*Conus sp.*	+	+	
Gastropod	*Cypraea annulus*		+	
Gastropod	*Cypraea lynx*		+	
Gastropod	*Cypraea moneta*	+	+	
Gastropod	*Cypraea sp.*		+	
Gastropod	*Cypraea tigris*	+	+	
Gastropod	*Dolabella sp.*	+		
Gastropod	*Drupa sp.*		+	
Gastropod	*Strombus gibberulus gibbosus*	+		
Gastropod	*Strombus labiatus*		+	
Gastropod	*Strombus luhuanus*	+	+	
Gastropod	*Strombus sp.*	+		
Gastropod	*Tectus pyramis*	+	+	
Gastropod	*Tectus sp.*		+	
Gastropod	*Thais sp.*		+	
Octopus	*Octopus sp.*	+		
Star	*Acanthaster planci*	+	+	

+ = presence of the species.

4.1.1 Invertebrate species recorded in different assessments in Manono-uta (continued)

Group	Species	Broad scale	Reef benthos	Others
Star	*Linckia laevigata*	+	+	
Urchin	*Echinometra mathaei*	+	+	
Urchin	*Echinothrix diadema*	+	+	
Urchin	*Echinothrix sp.*	+		
Urchin	*Mespilia globulus*	+	+	

+ = presence of the species.

Appendix 4: Invertebrate survey data
Manono-uta

4.1.2 Manono-uta 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
Bohadschia argus	19.5	3.8	72	42.5	6.3	33	19.5	5.4	12	21.2	5.6	11
Bohadschia vitiensis	80.1	27.6	72	240.3	73.3	24	80.6	35.9	12	161.3	55.4	6
Conus sp.	2.0	0.7	72	18.3	1.9	8	2.0	0.8	12	4.9	1.0	5
Culcita novaeguineae	11.2	2.8	72	32.3	6.4	25	11.2	2.9	12	13.4	3.0	10
Cypraea moneta	0.2	0.2	72	16.5		1	0.2	0.2	12	2.7		1
Cypraea tigris	0.9	0.4	72	16.3	0.2	4	0.9	0.4	12	2.7	0.0	4
Diadema sp.	2.5	1.0	72	29.8	5.0	6	2.5	1.3	12	7.5	2.3	4
Echinometra mathaei	102.5	26.5	72	238.1	52.8	31	102.5	33.7	12	123.0	37.3	10
Echinothrix diadema	0.9	0.6	72	32.2	0.6	2	0.9	0.6	12	5.4	0.0	2
Echinothrix sp.	12.3	3.0	72	42.1	7.0	21	12.2	4.7	12	18.4	5.9	8
Holothuria atra	2433.6	640.9	72	2781.2	722.5	63	2405.6	1391.1	12	2405.6	1391.1	12
Holothuria leucospilota	0.5	0.3	72	16.2	0.2	2	0.5	0.3	12	2.7	0.0	2
Holothuria nobilis	0.7	0.4	72	16.2	0.2	3	0.7	0.4	12	2.7	0.0	3
Lambis truncata	0.2	0.2	72	16.6		1	0.2	0.2	12	2.8		1
Linckia laevigata	78.3	21.4	72	131.2	33.6	43	78.3	49.0	12	104.4	63.7	9
Spondylus sp.	1.8	0.7	72	18.8	2.3	7	1.8	0.6	12	3.6	0.6	6
Stichodactyla sp.	1.4	0.6	72	19.7	3.3	5	1.4	0.5	12	3.3	0.5	5
Stichopus chloronotus	163.4	147.7	72	356.5	321.7	33	167.3	150.5	12	200.8	180.3	10
Synapta sp.	2.9	1.0	72	23.2	2.7	9	2.9	1.3	12	7.0	1.8	5
Tectus pyramis	1.4	0.5	72	16.3	0.1	6	1.4	0.7	12	4.1	1.4	4
Toxopneustes sp.	0.2	0.2	72	16.2		1	0.2	0.2	12	2.7		1
Tridacna maxima	0.2	0.2	72	16.7		1	0.2	0.2	12	2.7		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.

4.1.3 Manono-uta 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	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Acanthaster sp.	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Actinopyga mauritiana	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Bohadschia argus	29.1	8.1	129	288.5	26.0	13	29.1	9.7	16	58.2	12.6	8
Cerithium nodulosum	5.8	3.3	129	250.0	0.0	3	5.9	4.2	16	46.9	15.6	2
Chama sp.	3.9	2.7	129	250.0	0.0	2	3.9	2.7	16	31.3	0.0	2
Chicoreus ramosus	1.9	1.9	129	250.0		1	1.7	1.7	16	27.8		1
Conus flavidus	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Conus leopardus	3.9	2.7	129	250.0	0.0	2	3.9	2.7	16	31.3	0.0	2
Conus litteratus	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Conus sp.	19.4	6.5	129	277.8	27.8	9	19.5	6.9	16	44.6	9.3	7
Culcita novaeguineae	19.4	6.5	129	277.8	27.8	9	19.5	8.5	16	62.5	14.0	5
Cypraea annulus	17.4	7.4	129	375.0	55.9	6	17.6	7.5	16	56.3	11.7	5
Cypraea lynx	9.7	5.8	129	416.7	83.3	3	9.8	6.8	16	78.1	15.6	2
Cypraea moneta	3.9	2.7	129	250.0	0.0	2	3.9	2.7	16	31.3	0.0	2
Cypraea sp.	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Cypraea tigris	7.8	3.8	129	250.0	0.0	4	7.8	4.5	16	41.7	10.4	3
Dardanus sp.	13.6	7.4	129	437.5	119.7	4	13.7	7.0	16	54.7	15.0	4
Diadema sp.	31.0	11.3	129	444.4	81.0	9	31.3	13.7	16	100.0	23.0	5
Echinometra mathaei	3418.6	542.0	129	4900.0	723.8	90	3431.2	1183.8	16	3431.2	1183.8	16
Echinothrix diadema	102.7	34.3	129	1019.2	216.4	13	103.5	53.8	16	276.0	116.8	6
Echinothrix sp.	73.6	25.0	129	730.8	161.3	13	74.2	25.7	16	148.4	35.3	8
Holothuria atra	5275.2	908.8	129	7317.2	1196.4	93	5209.2	2408.7	16	5556.5	2548.1	15
Holothuria nobilis	3.9	3.9	129	500.0		1	3.9	3.9	16	62.5		1
Lambis lambis	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Lambis sp.	3.9	2.7	129	250.0	0.0	2	3.9	3.9	16	62.5		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.

4.1.3 Manono-uta reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Latirolagena smaragdula	15.5	7.1	129	400.0	61.2	5	15.6	8.6	16	62.5	22.1	4
Linckia laevigata	137.6	23.2	129	467.1	46.4	38	138.7	53.0	16	246.5	77.7	9
Lysiosquillina sp.	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Pinctada sp.	3.9	3.9	129	500.0		1	3.9	3.9	16	62.5		1
Pinna sp.	3.9	2.7	129	250.0	0.0	2	3.7	2.5	16	29.5	1.7	2
Stichopus chloronotus	211.2	37.1	129	736.5	79.3	37	212.9	89.0	16	340.6	127.7	10
Strombus luhuanus	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Strombus sp.	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Synapta sp.	42.6	13.8	129	458.3	80.4	12	43.0	24.2	16	137.5	61.4	5
Tectus pyramis	21.3	8.3	129	343.8	65.8	8	21.5	8.9	16	68.8	11.7	5
Toxopneustes sp.	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		1
Tridacna maxima	11.6	4.7	129	250.0	0.0	6	11.7	5.6	16	46.9	9.0	4
Trochus sp.	1.9	1.9	129	250.0		1	2.0	2.0	16	31.3		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.

4.1.4 Manono-uta reef-front search (RFs) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	1.2	1.2	24	28.0		1	1.2	1.2	4	4.7		1
Actinopyga mauritiana	4.1	2.3	24	33.1	2.0	3	4.1	2.5	4	8.3	2.1	2
Bohadschia argus	1.5	1.5	24	37.1		1	1.5	1.5	4	6.2		1
Cypraea tigris	1.5	1.5	24	37.1		1	1.5	1.5	4	6.2		1
Echinometra mathaei	96.9	62.2	24	465.0	252.7	5	96.9	96.9	4	387.5		1
Echinothrix sp.	1.2	1.2	24	28.0		1	1.2	1.2	4	4.7		1
Holothuria atra	22.6	12.8	24	108.3	46.7	5	22.6	19.3	4	30.1	25.2	3
Holothuria nobilis	1.5	1.5	24	37.1		1	1.5	1.5	4	6.2		1
Linckia laevigata	33.8	14.5	24	115.9	34.6	7	33.8	23.3	4	67.6	31.3	2
Stichopus chloronotus	1.5	1.5	24	37.1		1	1.5	1.5	4	6.2		1
Tectus pyramis	10.9	4.9	24	52.2	11.6	5	10.9	7.4	4	21.8	9.4	2
Tridacna maxima	1.5	1.5	24	37.1		1	1.5	1.5	4	6.2		1
Turbo sp.	1.3	1.3	24	31.1		1	1.3	1.3	4	5.2		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.

4.1.5 Manono-uta 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
Bohadschia argus	33.3	11.0	24	100.0	15.7	8	33.3	24.7	4	44.4	31.2	3
Bohadschia vitiensis	64.4	19.5	24	128.9	29.0	12	64.4	23.6	4	64.4	23.6	4
Calappa sp.	4.4	4.4	24	106.7		1	4.4	4.4	4	17.8		1
Culcita novaeguineae	2.2	2.2	24	53.3		1	2.2	2.2	4	8.9		1
Echinothrix calamaris	2.2	2.2	24	53.3		1	2.2	2.2	4	8.9		1
Echinothrix diadema	6.7	4.9	24	80.0	26.7	2	6.7	6.7	4	26.7		1
Holothuria atra	26.7	10.2	24	80.0	20.2	8	26.7	3.6	4	26.7	3.6	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.

4.1.6 Manono-uta sea cucumber day search (Ds) assessment data review

Station: Six 5-min search periods/station.

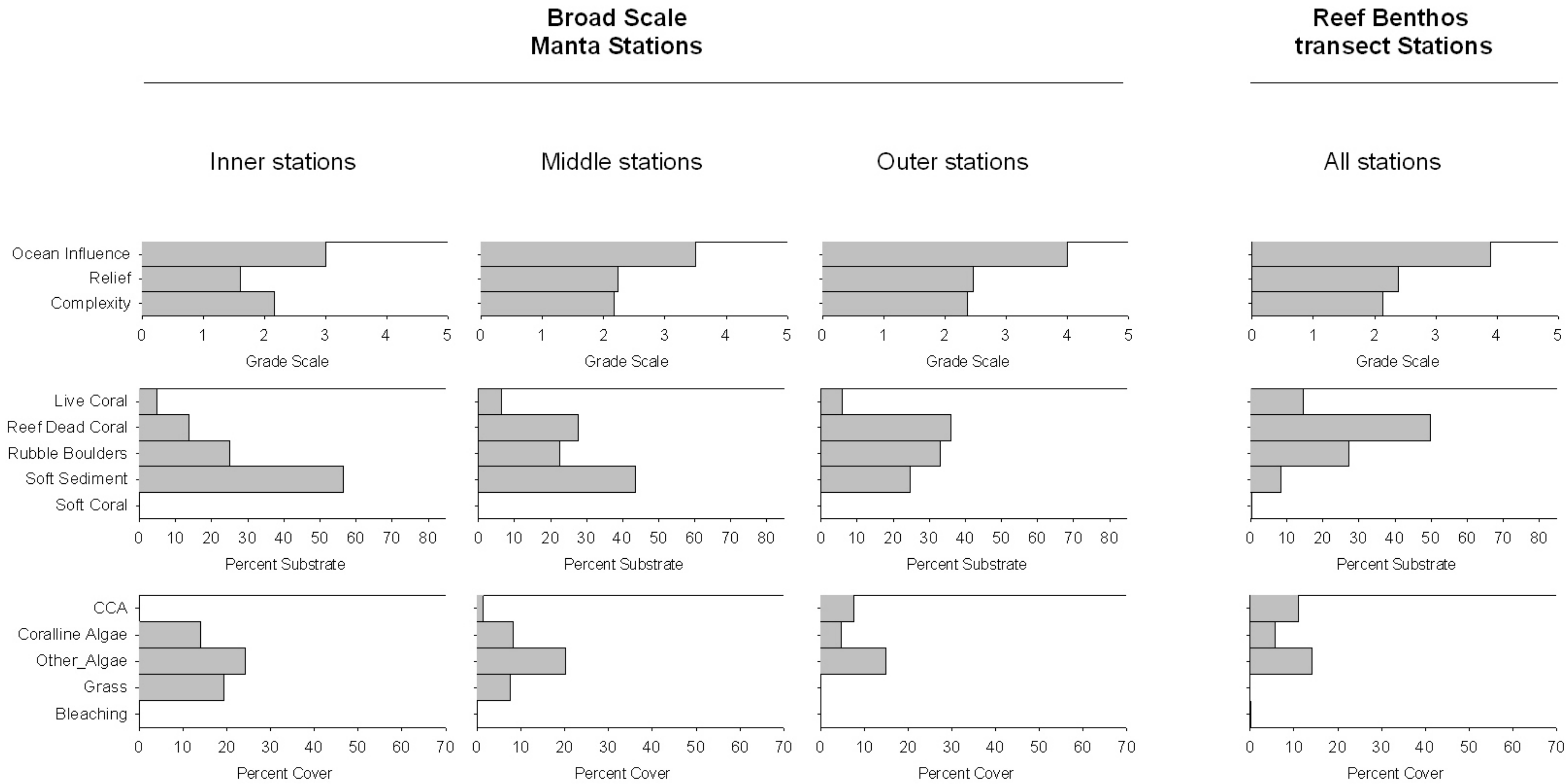
Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Bohadschia argus	1.4	0.8	42	19.0	4.8	3	1.3	0.7	7	3.1	0.9	3
Conus leopardus	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Culcita novaeguineae	4.8	2.0	42	25.0	7.0	8	4.8	3.2	7	8.3	5.2	4
Holothuria atra	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Holothuria fuscogilva	1.0	0.6	42	14.3	0.0	3	1.0	1.0	7	7.1		1
Holothuria fuscopunctata	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Holothuria nobilis	0.7	0.5	42	14.3	0.0	2	0.7	0.4	7	2.4	0.0	2
Lambis truncata	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Stichodactyla sp.	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Tectus pyramis	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		1
Thelenota ananas	1.7	0.9	42	17.9	3.6	4	1.7	0.9	7	4.0	0.8	3
Tridacna maxima	0.3	0.3	42	14.3		1	0.3	0.3	7	2.4		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.

4.1.7 Manono-uta species size review – all survey methods

Species	Mean length (cm)	SE	n
Holothuria atra	10.9	0.2	13,416
Stichopus chloronotus	13.3	0.4	851
Bohadschia vitiensis	20.7	1.2	387
Bohadschia argus	31.0	0.7	121
Tectus pyramis	6.6	0.4	26
Conus sp.	5.2	1.1	19
Tridacna maxima	15.0	1.5	9
Cypraea tigris	7.9	0.4	9
Holothuria nobilis	27.0	1.0	8
Cypraea lynx	4.2	0.6	5
Thelenota ananas	44.4	2.4	5
Actinopyga mauritiana	16.8	1.1	4
Cerithium nodulosum	8.7	0.4	3
Holothuria fuscogilva	31.7	1.3	3
Conus leopardus	9.5	0.5	3
Pinctada sp.	4.0	0.0	2
Lambis truncata	26.0	0.0	2
Lambis sp.	14.5	4.5	2
Synapta sp.	15.0		35
Latirolagena smaragdula	5.6		8
Cypraea moneta	2.5		3
Pinna sp.	7.0		2
Strombus sp.	22.0		1
Strombus luhuanus	4.0		1
Conus litteratus	8.0		1
Turbo sp.	6.0		1
Lambis lambis	22.0		1
Conus flavidus	3.0		1
Chicoreus ramosus	3.8		1
Trochus sp.	3.1		1
Holothuria fuscopunctata	32.0		1
Echinometra mathaei			2301
Linckia laevigata			437
Echinothrix sp.			93
Culcita novaeguineae			74
Echinothrix diadema			60
Diadema sp.			27
Cypraea annulus			9
Spondylus sp.			8
Stichodactyla sp.			7
Dardanus sp.			7
Acanthaster planci			3
Holothuria leucospilota			2
Toxopneustes sp.			2
Chama sp.			2
Calappa sp.			2
Lysiosquillina sp.			1
Echinothrix calamaris			1
Acanthaster sp.			1
Cypraea sp.			1

4.1.8 Habitat descriptors for independent assessment – Manono-uta



4.2 Salelavalu invertebrate survey data

4.2.1 Invertebrate species recorded in different assessments in Salelavalu

Group	Species	Broad scale	Reef benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*	+	+	
Bêche-de-mer	*Bohadschia argus*	+	+	
Bêche-de-mer	*Bohadschia vitiensis*	+	+	
Bêche-de-mer	*Holothuria atra*	+	+	
Bêche-de-mer	*Holothuria fuscogilva*			
Bêche-de-mer	*Holothuria leucospilota*	+		
Bêche-de-mer	*Holothuria nobilis*	+		
Bêche-de-mer	*Stichopus chloronotus*	+	+	
Bêche-de-mer	*Stichopus horrens*	+		
Bêche-de-mer	*Synapta sp.*	+	+	
Bêche-de-mer	*Thelenota ananas*	+		
Bivalve	*Anadara antiquata*	+	+	
Bivalve	*Pinna bicolor*	+	+	
Bivalve	*Pinna sp.*	+	+	
Bivalve	*Spondylus sp.*	+	+	
Bivalve	*Tellina scobinata*	+		
Bivalve	*Tridacna maxima*	+	+	
Cnidarians	*Cassiopea sp.*	+		
Cnidarians	*Stichodactyla sp.*	+	+	
Crustacean	*Coenobita sp.*		+	
Crustacean	*Dardanus sp.*		+	
Crustacean	*Lysiosquillina sp.*		+	
Gastropod	*Cerithium aluco*	+		
Gastropod	*Cerithium nodulosum*	+		
Gastropod	*Chicoreus sp.*		+	
Gastropod	*Conus flavidus*		+	
Gastropod	*Conus sp.*	+	+	
Gastropod	*Cypraea annulus*		+	
Gastropod	*Cypraea lynx*		+	
Gastropod	*Cypraea moneta*	+	+	
Gastropod	*Cypraea sp.*		+	
Gastropod	*Cypraea tigris*	+	+	
Gastropod	*Dolabella sp.*	+		
Gastropod	*Drupa sp.*		+	
Gastropod	*Strombus gibberulus gibbosus*	+		
Gastropod	*Strombus labiatus*		+	
Gastropod	*Strombus luhuanus*	+	+	
Gastropod	*Strombus sp.*	+		
Gastropod	*Tectus pyramis*	+	+	
Gastropod	*Tectus sp.*		+	
Gastropod	*Thais sp.*		+	
Octopus	*Octopus sp.*	+		
Star	*Acanthaster planci*	+	+	
Star	*Archaster typicus*	+		
Star	*Culcita novaeguineae*	+	+	
Star	*Fromia sp.*		+	

+ = presence of the species.

4.2.1 Invertebrate species recorded in different assessments in Salelavalu (continued)

Group	Species	Broad scale	Reef benthos	Others
Star	*Linckia laevigata*	+	+	
Urchin	*Echinometra mathaei*	+	+	
Urchin	*Echinothrix diadema*	+	+	
Urchin	*Echinothrix sp.*	+		
Urchin	*Mespilia globulus*	+	+	

+ = presence of the species.

4.2.2 Salelavalu 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	1.1	0.6	78	27.8	5.6	3	1.1	0.7	13	6.9	1.4	2
Actinopyga mauritiana	1.1	0.6	78	20.8	4.2	4	1.1	0.7	13	4.6	1.8	3
Anadara antiquata	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Archaster typicus	532.1	162.6	78	3192.3	556.6	13	532.1	356.0	13	2305.6	1118.1	3
Bohadschia argus	10.7	2.9	78	43.9	8.0	19	10.7	4.5	13	23.1	6.8	6
Bohadschia vitiensis	0.9	0.6	78	33.3	0.0	2	0.9	0.6	13	5.6	0.0	2
Cassiopea sp.	1.7	1.2	78	66.7	16.7	2	1.7	1.7	13	22.2		1
Cerithium aluco	0.4	0.4	78	33.3		1	0.4	0.4	13	5.6		1
Cerithium nodulosum	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Conus sp.	0.2	0.2	78	16.6		1	0.2	0.2	13	2.8		1
Culcita novaeguineae	4.7	1.4	78	24.4	4.8	15	4.7	2.4	13	10.2	4.4	6
Cypraea moneta	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Cypraea tigris	1.9	0.7	78	18.8	2.1	8	1.9	0.7	13	4.2	0.6	6
Dolabella sp.	0.4	0.3	78	16.7	0.0	2	0.4	0.3	13	2.8	0.0	2
Echinometra mathaei	865.8	298.8	78	1436.8	479.7	47	865.1	276.8	13	865.1	276.8	13
Echinothrix diadema	4.3	4.3	78	333.3		1	4.3	4.3	13	55.6		1
Echinothrix sp.	1.1	0.9	78	41.7	25.0	2	1.1	0.9	13	6.9	4.2	2
Holothuria atra	2131.6	802.0	78	3778.8	1377.3	44	2131.6	1593.9	13	2131.6	1593.9	13
Holothuria leucospilota	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Holothuria nobilis	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Linckia laevigata	29.7	5.0	78	62.6	7.3	37	29.7	8.2	13	48.2	7.7	8
Mespilia globulus	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Octopus sp.	0.4	0.3	78	16.6	0.1	2	0.4	0.3	13	2.8	0.0	2
Pinna bicolor	51.7	24.4	78	672.2	189.1	6	51.7	38.4	13	336.1	138.9	2
Pinna sp.	55.8	35.1	78	1087.5	492.2	4	55.8	55.8	13	725.0		1
Spondylus sp.	3.2	0.8	78	17.9	1.2	14	3.2	1.2	13	5.9	1.7	7
Stichodactyla sp.	1.3	0.7	78	25.0	8.3	4	1.3	0.9	13	5.6	2.8	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.

4.2.2 Salelavalu 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 chloronotus	119.2	30.1	78	265.7	58.6	35	119.2	36.5	13	140.9	39.8	11
Stichopus horrens	0.4	0.4	78	33.3		1	0.4	0.4	13	5.6		1
Strombus gibberulus gibbosus	1.1	1.1	78	83.3		1	1.1	1.1	13	13.9		1
Strombus luhuanus	1.9	1.1	78	37.5	12.5	4	1.9	1.2	13	8.3	3.2	3
Strombus sp.	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Synapta sp.	3.0	0.9	78	23.3	2.7	10	3.0	1.4	13	7.8	2.4	5
Tectus pyramis	1.3	0.6	78	19.9	3.3	5	1.3	0.7	13	5.5	1.6	3
Tellina scobinata	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Thelenota ananas	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Tridacna maxima	0.4	0.3	78	16.7	0.0	2	0.4	0.4	13	5.6		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.

4.2.3 Salelavalu 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	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Actinopyga mauritiana	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Anadara antiquata	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Bohadschia argus	11.4	5.3	132	300.0	50.0	5	11.4	5.6	22	62.5	12.0	4
Bohadschia vitiensis	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Chicoreus sp.	7.6	3.7	132	250.0	0.0	4	7.6	3.5	22	41.7	0.0	4
Coenobita sp.	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Conus flavidus	3.8	3.8	132	500.0		1	3.8	3.8	22	83.3		1
Conus sp.	3.8	2.7	132	250.0	0.0	2	3.8	2.6	22	41.7	0.0	2
Culcita novaeguineae	81.4	19.5	132	447.9	68.9	24	81.4	29.7	22	162.9	48.8	11

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 Salelavalu reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Cypraea annulus	3.8	2.7	132	250.0	0.0	2	3.8	2.6	22	41.7	0.0	2
Spondylus sp.	155.3	143.9	132	3416.7	3116.9	6	155.3	143.5	22	683.3	620.9	5
Stichodactyla sp.	11.4	9.6	132	750.0	500.0	2	11.4	11.4	22	250.0		1
Stichopus chloronotus	937.5	232.5	132	2426.5	542.6	51	937.5	554.2	22	1375.0	795.5	15
Strombus labiatus	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Strombus luhuanus	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Synapta sp.	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Tectus pyramis	18.9	6.9	132	312.5	40.9	8	18.9	8.6	22	69.4	20.6	6
Tectus sp.	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Thais sp.	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Tridacna maxima	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Cypraea lynx	3.8	2.7	132	250.0	0.0	2	3.8	2.6	22	41.7	0.0	2
Cypraea moneta	9.5	5.6	132	416.7	83.3	3	9.5	5.4	22	69.4	13.9	3
Cypraea sp.	9.5	4.2	132	250.0	0.0	5	9.5	3.8	22	41.7	0.0	5
Cypraea tigris	43.6	9.9	132	302.6	24.0	19	43.6	11.8	22	79.9	14.9	12
Dardanus sp.	17.0	7.7	132	375.0	85.4	6	17.0	7.1	22	62.5	14.2	6
Drupa sp.	9.5	5.6	132	416.7	83.3	3	9.5	5.4	22	69.4	13.9	3
Echinometra mathaei	5299.2	677.7	132	7859.6	886.3	89	5299.2	1525.6	22	6136.0	1690.9	19
Echinothrix diadema	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Fromia sp.	11.4	6.5	132	375.0	125.0	4	11.4	6.2	22	62.5	20.8	4
Holothuria atra	549.2	182.7	132	2900.0	823.4	25	549.2	443.2	22	1342.6	1061.8	9
Linckia laevigata	119.3	27.1	132	477.3	81.7	33	119.3	35.7	22	187.5	47.4	14
Lysiosquillina sp.	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Mespilia globulus	3.8	2.7	132	250.0	0.0	2	3.8	2.6	22	41.7	0.0	2
Pinna bicolor	1.9	1.9	132	250.0		1	1.9	1.9	22	41.7		1
Pinna sp.	5.7	3.3	132	250.0	0.0	3	5.7	3.1	22	41.7	0.0	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.

4.2.4 Salelavalu 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	1.1	1.1	24	26.7		1	1.1	1.1	4	4.4		1
Echinothrix diadema	3.3	2.4	24	40.0	13.3	2	3.3	3.3	4	13.3		1
Tectus pyramis	7.3	4.0	24	43.8	14.5	4	7.3	6.5	4	14.6	12.1	2
Tridacna maxima	0.8	0.8	24	18.9		1	0.8	0.8	4	3.2		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.

4.2.5 Salelavalu 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
Cypraea tigris	8.9	6.5	18	80.0	26.7	2	8.9	5.1	3	13.3	4.4	2
Dolabella sp.	14.8	8.4	18	88.9	17.8	3	14.8	3.0	3	14.8	3.0	3
Echinometra mathaei	2823.7	545.8	18	3909.7	480.2	13	2823.7	143.9	3	2823.7	143.9	3
Holothuria atra	1001.5	473.3	18	2575.2	978.0	7	1001.5	846.5	3	1502.2	1182.2	2
Stichopus chloronotus	1128.9	471.2	18	2540.0	837.3	8	1128.9	833.5	3	1693.3	1062.2	2
Stichopus horrens	80.0	21.2	18	120.0	24.7	12	80.0	53.3	3	80.0	53.3	3
Strombus luhuanus	3.0	3.0	18	53.3		1	3.0	3.0	3	8.9		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.

4.2.6 Salelavalu sea cucumber day search (Ds) 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
Bohadschia argus	1.4	1.1	30	21.4	7.1	2	1.4	1.0	5	3.6	1.2	2
Conus sp.	1.4	0.8	30	14.3	0.0	3	1.4	0.6	5	2.4	0.0	3
Holothuria fuscogilva	0.5	0.5	30	14.3		1	0.5	0.5	5	2.4		1
Linckia laevigata	1.0	1.0	30	28.6		1	1.0	1.0	5	4.8		1
Stichodactyla sp.	0.5	0.5	30	14.3		1	0.5	0.5	5	2.4		1
Stichopus chloronotus	0.5	0.5	30	14.3		1	0.5	0.5	5	2.4		1
Synapta sp.	0.5	0.5	30	14.3		1	0.5	0.5	5	2.4		1
Thelenota ananas	1.0	0.7	30	14.3	0.0	2	1.0	0.6	5	2.4	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.

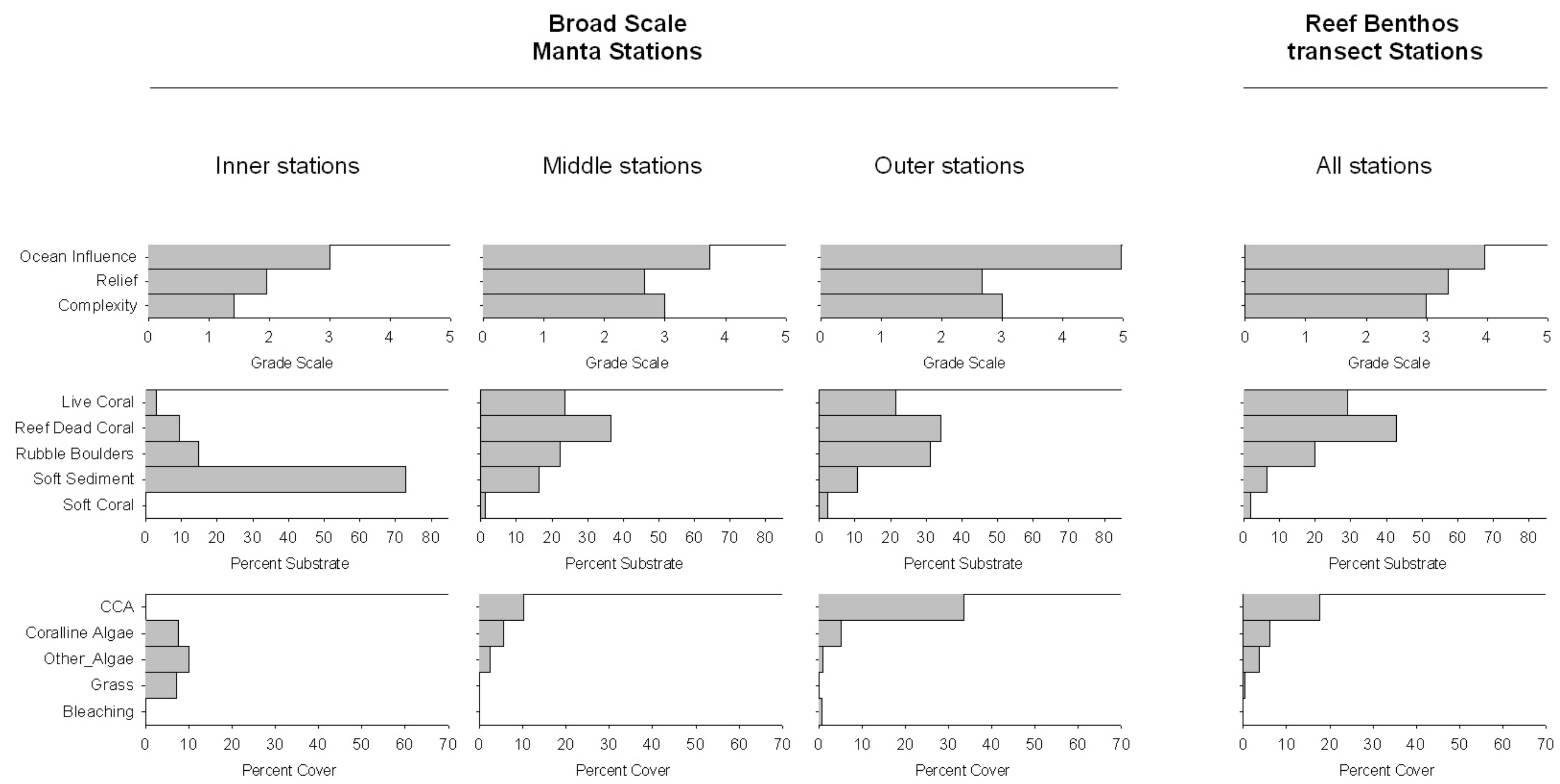
4.2.7 Salelavalu species size review – all survey methods

Species	Mean length (cm)	SE	n
Holothuria atra	15.3	0.7	10,604
Stichopus chloronotus	15.8	0.3	1435
Spondylus sp.	8.9	0.1	97
Bohadschia argus	30.2	0.6	59
Cypraea tigris	7.6	0.2	35
Stichopus horrens	11.0	0.4	29
Tectus pyramis	6.0	0.5	23
Strombus luhuanus	8.0	2.0	11
Actinopyga mauritiana	18.0	2.0	7
Dolabella sp.	17.0	0.0	7
Conus sp.	6.5	1.4	6
Bohadschia vitiensis	24.3	3.5	5
Tridacna maxima	15.3	4.1	4
Chicoreus sp.	3.9	0.3	4
Thelenota ananas	48.3	3.2	3
Conus flavidus	3.0	0.0	2
Mespilia globulus	6.0	0.0	3
Cypraea lynx	3.6	0.0	2
Anadara antiquata	6.0	0.0	2
Holothuria fuscogilva	44.0		1
Holothuria nobilis	30.0		1
Tectus sp.	2.0		1
Thais sp.	3.9		1
Echinometra mathaei			7803
Archaster typicus			2490
Pinna sp.			264
Pinna bicolor			243
Linckia laevigata			204
Culcita novaeguineae			65
Echinothrix diadema			24
Synapta sp.			16
Stichodactyla sp.			13
Dardanus sp.			9
Cassiopea sp.			8
Fromia sp.			6
Cypraea moneta			6
Acanthaster planci			6
Cypraea sp.			5
Strombus gibberulus gibbosus			5
Drupa sp.			5
Echinothrix sp.			5
Octopus sp.			2
Cypraea annulus			2
Cerithium aluco			2
Cerithium nodulosum			1
Lysiosquillina sp.			1
Holothuria leucospilota			1

4.2.7 Salelavalu species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Strombus sp.			1
Coenobita sp.			1
Tellina scobinata			1
Strombus labiatus			1

4.2.8 Habitat descriptors for independent assessment – Salelavalu



4.3 Vailoa invertebrate survey data

4.3.1 Invertebrate species recorded in different assessments in Vailoa

Group	Species	Broad scale	Reef benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*	+		
Bêche-de-mer	*Bohadschia argus*	+	+	
Bêche-de-mer	*Bohadschia vitiensis*	+	+	
Bêche-de-mer	*Holothuria atra*	+	+	
Bêche-de-mer	*Holothuria fuscogilva*			
Bêche-de-mer	*Holothuria nobilis*	+	+	
Bêche-de-mer	*Stichopus chloronotus*	+	+	
Bêche-de-mer	*Stichopus horrens*	+	+	
Bêche-de-mer	*Synapta sp.*	+	+	
Bêche-de-mer	*Thelenota ananas*	+		
Bivalve	*Anadara sp.*		+	
Bivalve	*Pinctada sp.*		+	
Bivalve	*Pinna bicolor*		+	
Bivalve	*Pinna sp.*		+	
Bivalve	*Spondylus sp.*	+		
Bivalve	*Tellina palatum*		+	
Bivalve	*Tridacna maxima*	+	+	
Cnidarians	*Stichodactyla sp.*	+		
Crustacean	*Dardanus sp.*		+	
Crustacean	*Etisus splendidus*			
Gastropod	*Astralium sp.*	+		
Gastropod	*Cerithium aluco*		+	
Gastropod	*Cerithium nodulosum*		+	
Gastropod	*Cerithium sp.*		+	
Gastropod	*Conus frigidus*		+	
Gastropod	*Conus litteratus*		+	
Gastropod	*Conus sp.*	+	+	
Gastropod	*Cypraea annulus*		+	
Gastropod	*Cypraea sp.*		+	
Gastropod	*Cypraea tigris*	+	+	
Gastropod	*Drupella sp.*		+	
Gastropod	*Lambis scorpius*		+	
Gastropod	*Pleuroploca filamentosa*	+		
Gastropod	*Strombus luhuanus*	+		
Gastropod	*Strombus sp.*		+	
Gastropod	*Tectus pyramis*	+	+	
Gastropod	*Trochus sp.*		+	
Star	*Acanthaster planci*	+	+	
Star	*Culcita novaeguineae*	+	+	
Star	*Linckia laevigata*	+	+	
Star	*Linckia sp*		+	
Urchin	*Diadema sp.*		+	
Urchin	*Echinometra mathaei*	+	+	
Urchin	*Echinothrix calamaris*		+	
Urchin	*Echinothrix diadema*	+	+	
Urchin	*Echinothrix sp.*		+	
Urchin	*Mespilia globulus*	+	+	
Urchin	*Toxopneustes sp.*	+		

+ = presence of the species.

4.3.2 Vailoa broad-scale assessment data review
Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	0.5	0.3	71	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Actinopyga mauritiana	0.2	0.2	71	16.4		1	0.2	0.2	12	2.7		1
Astralium sp.	0.2	0.2	71	16.7		1	0.2	0.2	12	2.8		1
Bohadschia argus	1.9	0.9	71	26.7	6.7	5	1.9	1.2	12	7.4	3.3	3
Bohadschia vitiensis	4.7	1.8	71	33.0	8.7	10	4.4	2.7	12	10.6	5.8	5
Conus sp.	1.5	0.8	71	27.1	4.0	4	1.2	1.0	12	7.4	4.5	2
Culcita novaeguineae	1.9	0.6	71	16.7	0.0	8	1.8	0.7	12	3.7	0.9	6
Cypraea tigris	6.3	1.5	71	22.3	3.1	20	6.2	1.8	12	8.3	2.0	9
Echinometra mathaei	2989.5	897.5	71	5442.4	1532.9	39	2912.2	1074.8	12	3494.6	1211.7	10
Echinothrix diadema	14.1	6.3	71	100.0	35.0	10	13.9	9.3	12	41.6	23.9	4
Holothuria atra	4820.8	1090.1	71	8348.2	1692.6	41	4762.5	1823.6	12	6350.0	2199.3	9
Holothuria nobilis	2.6	0.9	71	20.4	2.4	9	2.5	1.7	12	10.2	4.9	3
Linckia laevigata	19.6	4.9	71	60.6	11.2	23	19.7	9.1	12	26.2	11.4	9
Mespilia globulus	0.2	0.2	71	16.7		1	0.2	0.2	12	2.8		1
Pleuroploca filamentosa	0.4	0.3	71	15.2	1.3	2	0.4	0.3	12	2.7	0.0	2
Spondylus sp.	0.2	0.2	71	16.7		1	0.2	0.2	12	2.4		1
Stichodactyla sp.	0.9	0.6	71	22.2	5.6	3	0.9	0.6	12	5.6	0.0	2
Stichopus chloronotus	1060.9	261.3	71	1537.2	359.2	49	1019.2	380.3	12	1223.0	429.4	10
Stichopus horrens	15.9	12.4	71	375.3	243.3	3	16.1	13.9	12	96.3	71.3	2
Strombus luhuanus	0.7	0.4	71	16.7	0.0	3	0.7	0.5	12	4.2	1.3	2
Synapta sp.	3.0	1.0	71	21.6	2.6	10	3.1	0.6	12	4.2	0.5	9
Tectus pyramis	0.5	0.3	71	16.7	0.0	2	0.5	0.5	12	5.6		1
Thelenota ananas	0.2	0.2	71	16.7		1	0.2	0.2	12	2.8		1
Toxopneustes sp.	0.2	0.2	71	16.7		1	0.2	0.2	12	2.4		1
Tridacna maxima	4.2	1.4	71	29.7	4.7	10	4.1	2.1	12	12.2	4.1	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.

4.3.3 Vailoa 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	12.2	8.0	143	583.3	220.5	3	13.3	13.3	22	291.7		1
Anadara sp.	1.7	1.7	143	250.0		1	1.9	1.9	22	41.7		1
Bohadschia argus	7.0	3.5	143	250.0	0.0	4	7.1	3.3	22	39.1	2.6	4
Bohadschia vitiensis	8.7	4.6	143	312.5	62.5	4	7.1	5.0	22	78.1	15.6	2
Cerithium aluco	3.5	2.5	143	250.0	0.0	2	3.3	2.3	22	36.5	5.2	2
Cerithium nodulosum	8.7	4.6	143	312.5	62.5	4	8.5	4.0	22	46.9	5.2	4
Cerithium sp.	3.5	2.5	143	250.0	0.0	2	3.8	2.6	22	41.7	0.0	2
Conus frigidus	1.7	1.7	143	250.0		1	1.9	1.9	22	41.7		1
Conus litteratus	3.5	2.5	143	250.0	0.0	2	3.3	2.3	22	36.5	5.2	2
Conus sp.	5.2	3.0	143	250.0	0.0	3	5.7	4.2	22	62.5	20.8	2
Culcita novaeguineae	49.0	10.0	143	304.3	22.0	23	50.7	13.0	22	85.7	15.7	13
Cypraea annulus	17.5	6.4	143	312.5	40.9	8	18.9	8.6	22	69.4	20.6	6
Cypraea sp.	1.7	1.7	143	250.0		1	1.9	1.9	22	41.7		1
Cypraea tigris	29.7	8.4	143	303.6	38.7	14	31.3	13.7	22	98.2	31.0	7
Dardanus sp.	10.5	5.5	143	375.0	72.2	4	9.9	4.7	22	54.3	7.5	4
Diadema sp.	1.7	1.7	143	250.0		1	1.4	1.4	22	31.3		1
Drupella sp.	35.0	19.0	143	714.3	305.8	7	37.9	21.4	22	138.9	65.1	6
Echinometra mathaei	9674.8	1383.2	143	12,810.2	1728.1	108	8513.0	2865.9	22	8513.0	2865.9	22
Echinothrix calamaris	3.5	2.5	143	250.0	0.0	2	3.8	3.8	22	83.3		1
Echinothrix diadema	87.4	28.0	143	694.4	164.9	18	87.1	46.6	22	273.8	124.0	7
Echinothrix sp.	3.5	2.5	143	250.0	0.0	2	3.8	3.8	22	83.3		1
Holothuria atra	13,547.2	1615.6	143	18,992.6	2030.0	102	13,499.3	3662.4	22	16,499.1	4164.1	18
Holothuria nobilis	1.7	1.7	143	250.0		1	1.4	1.4	22	31.3		1
Lambis scorpius	3.5	3.5	143	500.0		1	3.8	3.8	22	83.3		1
Linckia laevigata	69.9	13.9	143	344.8	38.1	29	72.0	24.6	22	131.9	37.4	12
Linckia sp	1.7	1.7	143	250.0		1	1.9	1.9	22	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.

4.3.3 Vailoa 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
Mespilia globulus	1.7	1.7	143	250.0		1	1.4	1.4	22	31.3		1
Pinctada sp.	1.7	1.7	143	250.0		1	1.6	1.6	22	35.7		1
Pinna bicolor	15.7	5.1	143	250.0	0.0	9	16.6	7.5	22	72.9	16.8	5
Pinna sp.	3.5	2.5	143	250.0	0.0	2	3.8	2.6	22	41.7	0.0	2
Stichopus chloronotus	4507.0	598.6	143	6445.0	780.3	100	4527.0	1386.1	22	4742.6	1436.1	21
Stichopus horrens	31.5	19.8	143	1125.0	505.2	4	30.8	20.9	22	225.7	108.3	3
Strombus sp.	1.7	1.7	143	250.0		1	1.9	1.9	22	41.7		1
Synapta sp.	28.0	8.3	143	333.3	35.5	12	27.5	10.2	22	86.3	17.3	7
Tectus pyramis	7.0	3.5	143	250.0	0.0	4	7.6	4.5	22	55.6	13.9	3
Tellina palatum	1.7	1.7	143	250.0		1	1.9	1.9	22	41.7		1
Tridacna maxima	12.2	5.2	143	291.7	41.7	6	12.3	6.5	22	67.7	19.7	4
Trochus sp.	1.7	1.7	143	250.0		1	1.4	1.4	22	31.3		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.

4.3.4 Vailoa 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	3.1	2.3	24	37.7	10.7	2	3.1	2.0	4	6.3	1.8	2
Cypraea annulus	1.1	1.1	24	27.0		1	1.1	1.1	4	4.5		1
Echinothrix sp.	1.1	1.1	24	27.0		1	1.1	1.1	4	4.5		1
Holothuria nobilis	2.3	2.3	24	54.1		1	2.3	2.3	4	9.0		1
Tridacna maxima	1.1	1.1	24	27.0		1	1.1	1.1	4	4.5		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 Vailoa 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
Tridacna maxima	5.1	3.5	18	45.5	0.0	2	5.1	5.1	3	15.2		1
Trochus maculata	2.5	2.5	18	45.5		1	2.5	2.5	3	7.6		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.

4.3.6 Vailoa 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
Acanthaster planci	2.2	2.2	24	53.3		1	2.2	2.2	4	8.9		1
Bohadschia vitiensis	8.9	5.2	24	71.1	17.8	3	8.9	6.3	4	17.8	8.9	2
Cypraea tigris	2.2	2.2	24	53.3		1	2.2	2.2	4	8.9		1
Etisus splendidus	6.7	6.7	24	160.0		1	6.7	6.7	4	26.7		1
Stichopus horrens	226.7	63.1	24	418.5	86.0	13	226.7	47.7	4	226.7	47.7	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.

4.3.7 Vailoa sea cucumber day search (Ds) assessment data review

Station: Six 5-min search periods/station.

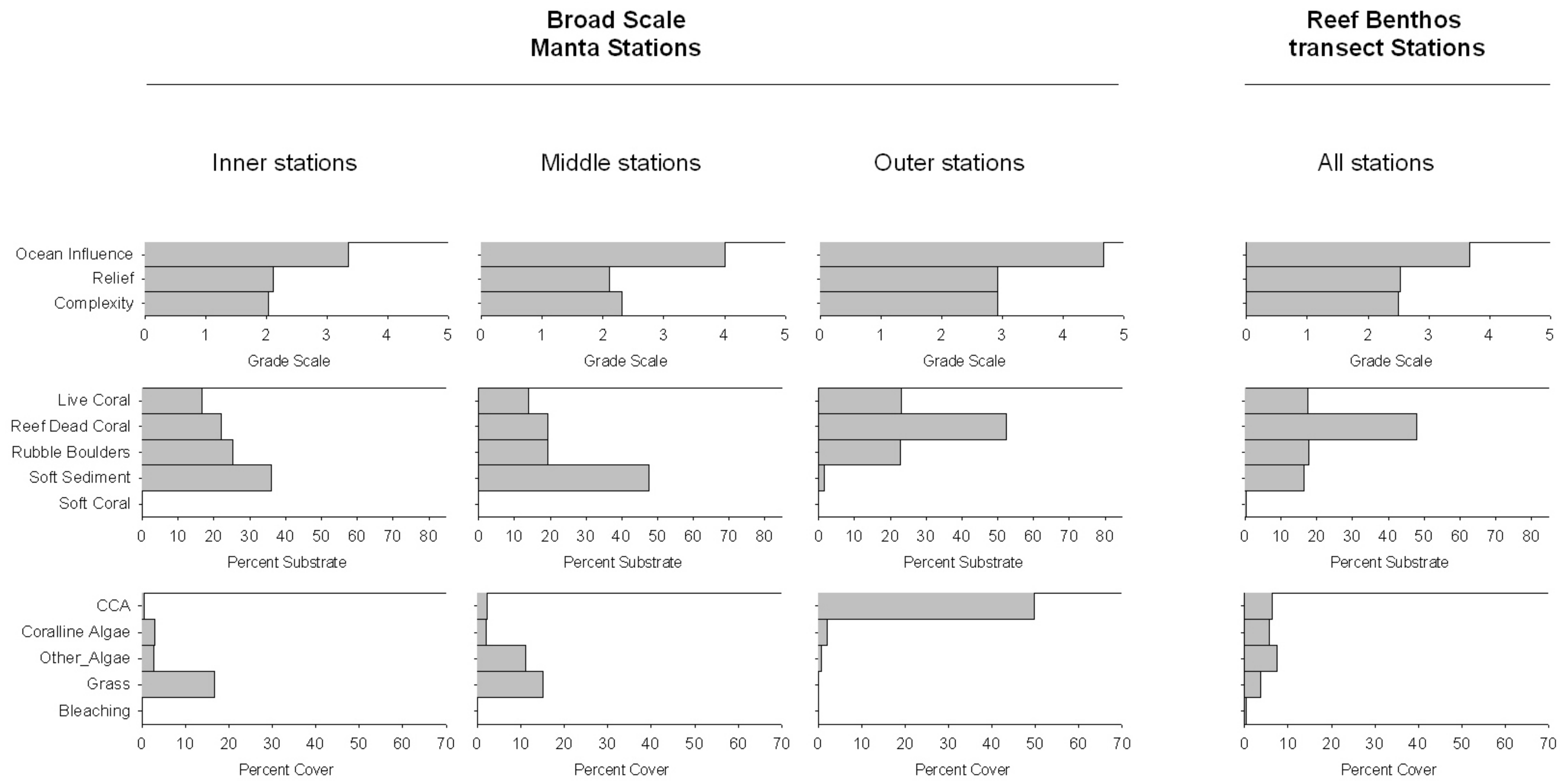
Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Culcita novaeguineae	0.5	0.5	30	14.3		1	0.5	0.5	5	2.4		1
Holothuria fuscogilva	1.0	0.7	30	14.3	0.0	2	1.0	1.0	5	4.8		1
Holothuria nobilis	0.5	0.5	30	14.3		1	0.5	0.5	5	2.4		1
Stichodactyla sp.	1.0	0.7	30	14.3	0.0	2	1.0	0.6	5	2.4	0.0	2
Thelenota ananas	1.0	0.7	30	14.3	0.0	2	1.0	0.6	5	2.4	0.0	2
Tridacna maxima	0.5	0.5	30	14.3		1	0.5	0.5	5	2.4		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.

4.3.8 Vailoa species size review - all survey methods

Species	Mean length (cm)	SE	n
Holothuria atra	11.5	0.2	28,083
Stichopus chloronotus	15.1	0.2	6836
Stichopus horrens	10.0	0.5	175
Cypraea tigris	7.1	0.2	43
Bohadschia vitiensis	20.8	2.6	33
Tridacna maxima	11.4	0.8	29
Holothuria nobilis	28.9	1.6	15
Bohadschia argus	28.2	2.0	12
Conus sp.	3.5	0.3	9
Tectus pyramis	5.4	1.0	6
Thelenota ananas	44.7	2.9	3
Etisus splendidus	10.0	0.0	3
Cerithium aluco	5.6	1.5	2
Holothuria fuscogilva	24.5	1.5	2
Lambis scorpius	13.8	0.8	2
Conus litteratus	8.0	1.0	2
Cerithium sp.	4.1	1.1	2
Cerithium nodulosum	5.6	0.0	5
Trochus sp.	2.3	0.0	2
Cypraea sp.	4.0	0.0	1
Anadara sp.	6.1	0.0	1
Conus frigidus	4.0	0.0	1
Strombus sp.	4.0	0.0	1
Echinometra mathaei			17,632
Linckia laevigata			123
Echinothrix diadema			110
Culcita novaeguineae			37
Synapta sp.			29
Drupella sp.			20
Cypraea annulus			11
Acanthaster planci			10
Pinna bicolor			9
Dardanus sp.			6
Stichodactyla sp.			6
Actinopyga mauritiana			4
Strombus luhuanus			3
Echinothrix sp.			3
Mespilia globulus			2
Echinothrix calamaris			2
Pinna sp.			2
Pleuroploca filamentosa			2
Spondylus sp.			1
Astralium sp.			1
Diadema sp.			1
linckia sp			1
Tellina palatum			1
Pinctada sp.			1
Toxopneustes sp.			1

4.3.9 Habitat descriptors for independent assessment – Vailoa



4.4 Vaisala invertebrate survey data

4.4.1 Invertebrate species recorded in different assessments in Vaisala

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*				+
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Bohadschia vitiensis*	+	+		+
Bêche-de-mer	*Holothuria atra*	+	+		+
Bêche-de-mer	*Holothuria fuscogilva*				+
Bêche-de-mer	*Holothuria fuscopunctata*	+			
Bêche-de-mer	*Holothuria nobilis*	+	+		
Bêche-de-mer	*Stichopus chloronotus*	+	+		+
Bêche-de-mer	*Stichopus horrens*		+		+
Bêche-de-mer	*Synapta sp.*	+	+		
Bêche-de-mer	*Thelenota ananas*	+			+
Bêche-de-mer	*Thelenota anax*				+
Bivalve	*Anadara antiquata*	+			
Bivalve	*Anadara sp.*	+			
Bivalve	*Periglypta puerpera*	+			
Bivalve	*Pinna sp.*		+		
Bivalve	*Spondylus sp.*	+	+		+
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+			+
Cnidarians	*Cassiopea sp.*				+
Cnidarians	*Stichodactyla sp.*		+		+
Crustacean	*Carpilius maculatus*		+		
Crustacean	*Dardanus sp.*		+		+
Crustacean	*Eriphia sebana*				+
Crustacean	*Lysiosquillina sp.*		+		
Gastropod	*Cerithium sp.*				+
Gastropod	*Charonia tritonis*	+			
Gastropod	*Conus leopardus*		+		
Gastropod	*Conus litteratus*		+		+
Gastropod	*Conus marmoreus*		+		
Gastropod	*Conus miles*				+
Gastropod	*Conus sp.*	+	+		+
Gastropod	*Conus virgo*		+		
Gastropod	*Cypraea annulus*		+		
Gastropod	*Cypraea caputserpensis*		+		+
Gastropod	*Cypraea moneta*		+		
Gastropod	*Cypraea sp.*	+	+		+
Gastropod	*Cypraea tigris*	+	+		+
Gastropod	*Drupa sp.*		+		
Gastropod	*Latirolagena smaragdula*				+
Gastropod	*Nassarius sp.*				+
Gastropod	*Pleuroploca filamentosa*	+			
Gastropod	*Strombus luhuanus*	+	+		
Gastropod	*Strombus sp.*		+		
Gastropod	*Tectus pyramis*	+			+

+ = presence of the species.

4.4.1 Invertebrate species recorded in different assessments in Vaisala (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Thais sp.*		+		+
Gastropod	*Trochus sp.*		+		
Gastropod	*Turbo argyrostomus*				+
Gastropod	*Turbo crassus*	+			
Gastropod	*Turbo setosus*				+
Gastropod	*Vasum sp.*				+
Octopus	*Octopus sp.*	+	+		+
Star	*Acanthaster planci*	+	+		+
Star	*Culcita novaeguineae*	+	+		+
Star	*Fromia sp.*		+		
Star	*Linckia laevigata*	+	+		+
Urchin	*Diadema sp.*	+	+		+
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix calamaris*		+		+
Urchin	*Echinothrix diadema*	+	+		+
Urchin	*Echinothrix sp.*	+	+		+

+ = presence of the species.

4.4.2 *Vaisala 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	1.1	0.5	74	16.6	0.1	5	1.2	0.6	12	4.6	0.9	3
Anadara antiquata	0.2	0.2	74	16.7		1	0.2	0.2	12	2.8		1
Anadara sp.	0.2	0.2	74	16.5		1	0.2	0.2	12	2.8		1
Bohadschia argus	52.3	9.0	74	84.2	12.3	46	50.5	13.7	12	55.1	14.2	11
Bohadschia vitiensis	5.9	3.3	74	48.1	23.8	9	6.0	4.4	12	24.1	14.4	3
Charonia tritonis	0.2	0.2	74	16.2		1	0.2	0.2	12	2.6		1
Conus sp.	2.3	0.7	74	18.5	1.9	9	2.2	0.8	12	4.5	1.0	6
Culcita novaeguineae	1.8	0.8	74	22.2	3.5	6	1.8	0.9	12	4.3	1.7	5
Cypraea sp.	0.2	0.2	74	16.7		1	0.2	0.2	12	2.8		1
Cypraea tigris	2.7	0.8	74	18.1	1.5	11	2.8	1.0	12	5.5	1.0	6
Diadema sp.	10.4	10.1	74	383.3	366.7	2	10.0	9.7	12	59.9	57.1	2
Echinometra mathaei	167.8	37.7	74	302.9	60.4	41	161.1	54.4	12	175.7	57.3	11
Echinothrix diadema	2.7	1.8	74	66.2	25.6	3	2.7	1.7	12	10.9	4.3	3
Echinothrix sp.	32.7	12.1	74	201.7	54.2	12	33.7	16.8	12	80.8	30.2	5
Holothuria atra	110.3	54.0	74	247.3	117.6	33	109.8	51.6	12	119.8	55.4	11
Holothuria fuscopunctata	0.7	0.5	74	25.0	8.3	2	0.7	0.5	12	4.2	1.4	2
Holothuria nobilis	2.4	0.9	74	22.3	4.5	8	2.5	1.2	12	6.0	2.0	5
Linckia laevigata	32.4	4.7	74	46.2	5.7	52	32.8	5.1	12	35.7	4.5	11
Octopus sp.	0.2	0.2	74	16.7		1	0.2	0.2	12	2.8		1
Periglypta puerpera	0.2	0.2	74	16.7		1	0.2	0.2	12	2.8		1
Pleuroploca filamentosa	0.2	0.2	74	16.7		1	0.2	0.2	12	2.8		1
Spondylus sp.	2.7	1.0	74	22.2	3.9	9	2.7	1.0	12	5.3	1.4	6
Stichopus chloronotus	4268.4	1107.7	74	10,189.1	2262.0	31	4384.4	1921.1	12	5261.3	2213.7	10
Strombus luhuanus	91.5	38.2	74	376.3	139.5	18	94.1	75.4	12	141.1	111.5	8
Synapta sp.	4.3	2.2	74	52.7	18.0	6	4.4	3.9	12	26.3	20.8	2
Tectus pyramis	0.4	0.3	74	16.4	0.1	2	0.4	0.3	12	2.7	0.1	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.

4.4.2 Vaisala broad-scale manta 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	0.6	0.5	74	22.8	10.5	2	0.6	0.4	12	3.4	0.8	2
Tridacna maxima	5.9	2.9	74	33.7	14.8	13	6.1	3.3	12	10.4	5.2	7
Tridacna squamosa	0.2	0.2	74	16.7		1	0.2	0.2	12	2.8		1
Turbo crassus	0.2	0.2	74	12.3		1	0.2	0.2	12	2.6		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.

4.4.3 Vaisala 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	5.5	126	300.0	50.0	5	11.9	8.2	21	83.3	41.7	3
Bohadschia argus	111.1	28.7	126	518.5	101.6	27	111.1	54.1	21	233.3	102.5	10
Bohadschia vitiensis	31.7	24.1	126	800.0	550.0	5	31.7	23.9	21	166.7	111.5	4
Carpilius maculatus	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Conus leopardus	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Conus litteratus	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	41.7	0.0	2
Conus marmoreus	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Conus sp.	21.8	10.5	126	458.3	135.7	6	21.8	10.2	21	91.7	24.3	5
Conus virgo	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	41.7	0.0	2
Culcita novaeguineae	9.9	5.2	126	312.5	62.5	4	9.9	7.0	21	104.2	20.8	2
Cypraea annulus	19.8	10.4	126	500.0	158.1	5	19.8	10.2	21	104.2	26.9	4
Cypraea caputserpensis	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Cypraea moneta	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	41.7	0.0	2
Cypraea sp.	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	41.7	0.0	2
Cypraea tigris	17.9	6.4	126	281.3	31.3	8	17.9	8.9	21	75.0	24.3	5
Dardanus sp.	6.0	4.4	126	375.0	125.0	2	6.0	4.3	21	62.5	20.8	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.3 Vaisala 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
Diadema sp.	13.9	7.6	126	437.5	119.7	4	13.9	10.5	21	145.8	62.5	2
Drupa sp.	11.9	4.8	126	250.0	0.0	6	11.9	4.2	21	41.7	0.0	6
Echinometra mathaei	3686.5	643.6	126	6277.0	992.5	74	3686.5	1212.6	21	4300.9	1364.8	18
Echinothrix calamaris	53.6	35.9	126	1350.0	760.8	5	53.6	49.5	21	375.0	333.3	3
Echinothrix diadema	69.4	21.9	126	625.0	122.2	14	69.4	34.3	21	208.3	83.3	7
Echinothrix sp.	71.4	36.7	126	1000.0	422.9	9	71.4	50.1	21	250.0	161.7	6
Fromia sp.	19.8	18.0	126	1250.0	1000.0	2	19.8	17.9	21	208.3	166.7	2
Holothuria atra	256.0	37.7	126	632.4	63.5	51	256.0	60.9	21	358.3	69.3	15
Holothuria nobilis	6.0	3.4	126	250.0	0.0	3	6.0	4.3	21	62.5	20.8	2
Linckia laevigata	113.1	21.8	126	445.3	52.3	32	113.1	39.4	21	197.9	58.5	12
Lysiosquillina sp.	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Octopus sp.	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Pinna sp.	6.0	3.4	126	250.0	0.0	3	6.0	4.3	21	62.5	20.8	2
Spondylus sp.	9.9	4.4	126	250.0	0.0	5	9.9	4.9	21	52.1	10.4	4
Stichodactyla sp.	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	41.7	0.0	2
Stichopus chloronotus	5638.9	2381.4	126	28,420.0	11,040.1	25	5638.9	5351.5	21	11,841.7	11,202.0	10
Stichopus horrens	11.9	6.2	126	375.0	72.2	4	11.9	10.0	21	125.0	83.3	2
Strombus luhuanus	9.9	8.2	126	625.0	375.0	2	9.9	8.1	21	104.2	62.5	2
Strombus sp.	2.0	2.0	126	250.0		1	2.0	2.0	21	41.7		1
Synapta sp.	6.0	4.4	126	375.0	125.0	2	6.0	4.3	21	62.5	20.8	2
Thais sp.	6.0	3.4	126	250.0	0.0	3	6.0	6.0	21	125.0		1
Tridacna maxima	7.9	4.8	126	333.3	83.3	3	7.9	6.2	21	83.3	41.7	2
Trochus sp.	4.0	2.8	126	250.0	0.0	2	4.0	2.7	21	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.

4.4.4 Vaisala 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
Cerithium sp.	0.6	0.6	30	19.0		1	0.6	0.6	5	3.2		1
Conus litteratus	0.9	0.9	30	26.1		1	0.9	0.9	5	4.3		1
Conus miles	0.7	0.7	30	19.7		1	0.7	0.7	5	3.3		1
Conus sp.	1.3	0.9	30	19.4	0.3	2	1.3	0.8	5	3.2	0.1	2
Cypraea caputserpensis	4.1	1.8	30	24.4	3.5	5	4.1	1.9	5	6.8	1.8	3
Cypraea sp.	0.6	0.6	30	19.0		1	0.6	0.6	5	3.2		1
Dardanus sp.	0.6	0.6	30	19.0		1	0.6	0.6	5	3.2		1
Diadema sp.	0.9	0.9	30	26.1		1	0.9	0.9	5	4.3		1
Echinometra mathaei	9.6	2.9	30	31.8	4.0	9	9.6	2.8	5	11.9	1.8	4
Echinothrix calamaris	0.9	0.9	30	26.1		1	0.9	0.9	5	4.3		1
Echinothrix diadema	0.9	0.9	30	26.1		1	0.9	0.9	5	4.3		1
Echinothrix sp.	17.0	6.8	30	73.1	16.9	7	17.0	9.8	5	28.4	12.5	3
Eriphia sebana	0.9	0.9	30	26.1		1	0.9	0.9	5	4.3		1
Latirolagena smaragdula	2.4	1.3	30	23.7	2.3	3	2.4	1.7	5	5.9	2.8	2
Nassarius sp.	0.6	0.6	30	19.0		1	0.6	0.6	5	3.2		1
Spondylus sp.	0.7	0.7	30	19.7		1	0.7	0.7	5	3.3		1
Tectus pyramis	1.3	1.3	30	38.1		1	1.3	1.3	5	6.3		1
Thais sp.	28.6	7.6	30	53.7	11.0	16	28.6	9.9	5	28.6	9.9	5
Tridacna maxima	10.1	5.1	30	50.7	18.6	6	10.1	5.0	5	16.9	5.0	3
Turbo argyrostomus	4.7	2.4	30	35.6	6.2	4	4.7	3.4	5	11.9	5.5	2
Turbo setosus	4.3	1.6	30	21.5	1.1	6	4.3	1.3	5	5.4	0.9	4
Vasum sp.	1.4	1.0	30	21.4	0.6	2	1.4	0.9	5	3.6	0.1	2
Stichodactyla sp.	0.7	0.7	30	19.7		1	0.7	0.7	5	3.3		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.

4.4.5 Vaisala 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
Acanthaster planci	17.8	10.6	18	106.7	30.8	3	17.8	8.9	3	26.7	0.0	2
Actinopyga mauritiana	5.9	5.9	18	106.7		1	5.9	5.9	3	17.8		1
Bohadschia argus	136.3	28.0	18	188.7	26.7	13	136.3	62.7	3	136.3	62.7	3
Bohadschia vitiensis	130.4	47.3	18	180.5	60.2	13	130.4	39.9	3	130.4	39.9	3
Cypraea tigris	3.0	3.0	18	53.3		1	3.0	3.0	3	8.9		1
Echinometra mathaei	26.7	10.8	18	96.0	10.7	5	26.7	8.9	3	26.7	8.9	3
Holothuria atra	5.9	4.1	18	53.3	0.0	2	5.9	5.9	3	17.8		1
Linckia laevigata	11.9	9.2	18	106.7	53.3	2	11.9	7.8	3	17.8	8.9	2
Octopus sp.	5.9	5.9	18	106.7		1	5.9	5.9	3	17.8		1
Stichopus chloronotus	163.0	150.5	18	586.7	533.3	5	163.0	154.2	3	244.4	226.7	2
Stichopus horrens	3.0	3.0	18	53.3		1	3.0	3.0	3	8.9		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 Vaisala sea cucumber day search (Ds) 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
Bohadschia argus	12.3	3.2	36	31.6	5.0	14	12.3	7.5	6	18.5	10.1	4
Cassiopea sp.	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Conus sp.	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Culcita novaeguineae	2.4	1.1	36	17.1	2.9	5	2.4	1.2	6	4.8	1.4	3
Holothuria fuscogilva	1.2	0.7	36	14.3	0.0	3	1.2	0.8	6	3.6	1.2	2
Linckia laevigata	1.6	1.2	36	28.6	14.3	2	1.6	1.6	6	9.5		1
Stichodactyla sp.	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Stichopus chloronotus	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Tectus pyramis	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Thelenota ananas	3.6	1.8	36	32.1	6.8	4	3.6	3.6	6	21.4		1
Thelenota anax	0.4	0.4	36	14.3		1	0.4	0.4	6	2.4		1
Tridacna maxima	3.2	1.3	36	19.0	3.0	6	3.2	1.2	6	4.8	1.0	4
Tridacna squamosa	0.8	0.6	36	14.3	0.0	2	0.8	0.5	6	2.4	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.

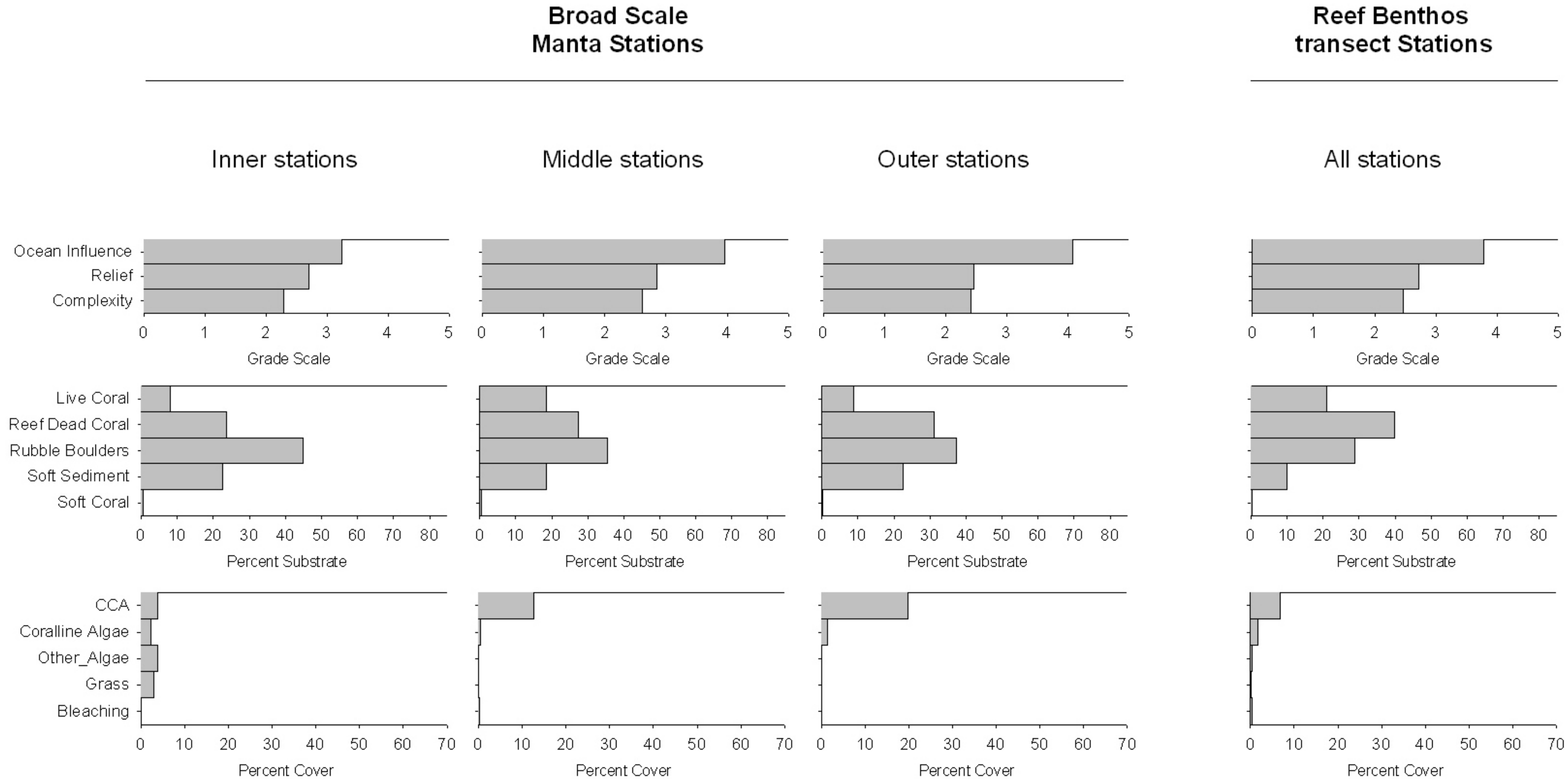
4.4.7 Vaisala species size review – all survey methods

Species	Mean length (cm)	SE	n
Stichopus chloronotus	15.2	0.4	21,860
Holothuria atra	17.2	0.9	621
Strombus luhuanus	3.9	0.8	413
Bohadschia argus	32.2	0.4	366
Bohadschia vitiensis	21.3	1.6	71
Tridacna maxima	12.6	0.7	52
Conus sp.	5.7	1.8	24
Cypraea tigris	7.6	0.4	22
Spondylus sp.	5.6	0.5	18
Holothuria nobilis	29.9	1.0	14
Thelenota ananas	54.9	2.2	12
Stichopus horrens	12.5	3.0	7
Turbo argyrostomus	5.5	0.5	6
Cypraea sp.	5.7	0.5	4
Conus litteratus	9.4	1.3	3
Holothuria fuscopunctata	32.3	3.8	3
Tridacna squamosa	30.3	2.6	3
Holothuria fuscogilva	30.0	6.5	3
Actinopyga mauritiana	20.5	3.5	2
Conus virgo	8.1	0.0	2
Thais sp.	4.8	0.0	43
Drupa sp.	7.5	0.0	6
Tectus pyramis	7.8	0.0	5
Trochus sp.	2.2	0.0	2
Conus leopardus	9.9	0.0	1
Charonia tritonis	30.0	0.0	1
Thelenota anax	45.0	0.0	1
Conus miles	5.0	0.0	1
Conus marmoreus	3.6	0.0	1
Echinometra mathaei			2627
Linckia laevigata			210
Echinothrix sp.			205
Diadema sp.			54
Echinothrix diadema			48
Echinothrix calamaris			28
Synapta sp.			22
Culcita novaeguineae			19
Acanthaster planci			17
Fromia sp.			10
Cypraea annulus			10
Cypraea caputserpensis			7
Turbo setosus			6
Stichodactyla sp.			4
Dardanus sp.			4
Octopus sp.			4
Pinna sp.			3
Latirolagena smaragdula			3
Cypraea moneta			2
Vasum sp.			2

4.4.7 Vaisala species size review – all survey methods

Species	Mean length (cm)	SE	n
Pleuroploca filamentosa			1
Anadara sp.			1
Lysiosquillina sp.			1
Anadara antiquata			1
Cassiopea sp.			1
Nassarius sp.			1
Strombus sp.			1
Carpilius maculatus			1
Cerithium sp.			1
Periglypta puerpera			1
Eriphia sebana			1
Turbo crassus			1

4.4.8 Habitat descriptors for independent assessment – Vaisala



APPENDIX 5: MILLENNIUM CORAL REEF MAPPING PROJECT – SAMOA

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
Samoa

(October 2008)

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, Samoa coral reefs are systematically mapped. The figure on the top left shows the mapping status as in October 2008, with mapped reefs in red. Reefs are mapped at geomorphological level, the result of a compromise between richness of information and accuracy when no ground-truthing is available. A preview is provided on the bottom left, for Savai'i Island.

The PROCFish/Coastal project who is reporting in this document on Samoa 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 fishery grounds surveyed for the project.

For further inquiries regarding the status of the coral reef mapping of Samoa and data availability (satellite images and Geographical Information Systems mapped products), please contact:

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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.