PACIFIC REGIONAL OCEANIC AND

COASTAL FISHERIES DEVELOPMENT PROGRAMME

(PROCFish/C/CoFish)

KIRIBATI COUNTRY REPORT:

PROFILES AND RESULTS FROM SURVEY WORK AT ABAIANG, ABEMAMA, KURIA AND KIRITIMATI

(May to November 2004)

by

Ribanataake Awira, Kim Friedman, Samasoni Sauni, Mecki Kronen, Silvia Pinca, Lindsay Chapman, and Franck Magron

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

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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 Kiribati from May to November 2004. Kiribati 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 Kiribati covered three disciplines (finfish, invertebrate and socioeconomic) in each site, with two sites surveyed on each trip by a team of three 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 Kiribati, the four sites selected for the survey were Abaiang, Abemama, Kuria and Kiritimati. 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 Kiribati Department of Fisheries.

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

Results of fieldwork at Abaiang

Abaiang has a land area of ~17.5 km^2, and is located to the north of Tarawa, around four hours travel by boat or 15 minutes by plane. The lagoon is generally shallow but has pools to 25 m depth inside the Bingham channel. Coral on the inside of the lagoon is found in patches and down to 25 m; the inside coastal reefs are subject to algae and silt. Channels and other small openings at the rim of the barrier reef do not appear to flush the whole lagoon, probably because it is so shallow and has reefs with many *motu*, and because the channels are relatively shallow. Water flow in channel locations is strong and the coral and reefs close to the passes are healthy. An extensive sandy zone gently slopes away from the coast, mostly at the southern end of the lagoon, while more patches of coral reef are found along the coast to the north of the lagoon.

Fishing is commonly carried out either in the lagoon or outer-reef slope, especially on the side facing north Tarawa. The windward side of the main island is a fringing reef, which does not extend more than 100 m; fishing by walking (collecting), spear or rod off the edges of the fringing reef is limited to periods of calm weather when the characteristic swell is absent. Accessibility to the windward side is restricted as there is no pass in the immediate vicinity of the main island.

Socioeconomics: Abaiang

A considerable proportion of the Abaiang community engages in fishing, and fisheries are the most important income source for more than half of the island's households. Most (78%) of the finfish, lobsters, sea worms and giant clams caught are exported to Tarawa. Alternative income sources are limited (handicrafts, a few public salaries, very little agricultural potential). Therefore, if there is any future increase in the community's demand for income and nutrition, it is likely that fishing pressure will also increase.

The per capita consumption of fresh finfish is high (88 kg/person/year) if compared to the regional average, and lowest across all Kiribati communities investigated. Neither invertebrates nor canned fish consumption play a major role on Abaiang. Traditional gender roles were found in both finfish and invertebrate fishing; only males dive for lobsters and giant clams, while most of the intertidal and soft-benthos gleaning is done by female fishers.

The highest fisher density occurs in the outer reef (9 fishers/km^2) while, overall, fisher density on the community's total reef area and its total fishing ground is low (3–6 fishers/km^2). If only the subsistence needs of the community are considered, even with the moderate population density, fishing pressure is relatively low (3 t/km^2 of total reef area). However, when we consider that subsistence accounts for only 20% of the total catches on Abaiang, while export catches determine ~80%, fishing pressure is more likely to be moderate-to-high, particularly on the lagoon and outer-reef resources.

Finfish resources: Abaiang

The status of finfish resources in Abaiang is similar to that in Abemama reefs (the only other site with all four habitats present), except for higher biomass in the back-reef and lower biomass in the lagoon and outer reefs. However, size ratio is consistently higher in Abaiang, suggesting a lower level of exploitation. Carnivorous fish, especially Lutjanidae, are highly abundant in all habitats. Biomass is also dominated by carnivores in all reefs, mostly due to the presence of abundant, large Lutjanidae (*Lutjanus fulvus*, *L. gibbus* and *L. ehrenbergii* of size ratio >55%).

These results, combined with the high abundance of carnivorous fish (Lutjanidae especially) in all of the reef systems, suggest that the area's finfish resources are relatively healthy. The reef habitat seems relatively rich and the ecosystem supporting finfish resources healthy. However, Abaiang atoll offers all the available habitats and reefs for a choice of fishing methods and gears and, similarly to Abemama Island, fishing is predominantly done for export reasons, increasing fishing pressure on reefs. The close proximity of the island to the capital is another cause contributing to the low density of commercially important fish stocks. Therefore sustainable limits will soon be exceeded, especially if no monitoring management guidelines are in put in place.

Invertebrate resources: Abaiang

Present densities of elongate clams (*Tridacna maxima*) within Abaiang atoll are not low; however, the size distribution suggests there is heavy fishing pressure on the stock. *T. squamosa* and *Hippopus hippopus*, the two faster-growing, large clam species, are rare in Abaiang to a point where reproductive success and subsequent recruitment may be impaired. *T. gigas* stocks in Abaiang have undergone a catastrophic decline in the last decade and a half, and stocks are severely impacted by fishing.

The commercial topshell (*Trochus niloticus*) has not become well established following translocation from Tarawa. Juvenile trochus were only recently released and therefore it is still too early to judge whether trochus will successfully colonise the reefs of Abaiang. Although the reef systems at Abaiang are extensive, with habitat for both juvenile and adult molluscs, grazing gastropods, such as *Tectus pyramis*, were at low abundance. It is unlikely that this situation is completely the result of overfishing and may indicate less than optimal conditions for grazing gastropods. Wild populations of the pearl oyster *Pinctada margaritifera* are degraded and are considered to be commercially extinct.

Shell beds at Abaiang held a large number of *Anadara holoserica* (*te bun*) at a range of size classes. Density and size-range measures of arc shells describe a resource only marginally impacted by fishing, with excellent recruitment. The smaller mean size of *A. holoserica* found at very high densities might be due to density-dependent growth, i.e. the overall growth in size is limited due to overcrowding within the population. The resource species *Strombus luhuanus* (*te nouo*) and *Gafrarium* spp. (*te koumwara*) were also recorded at reasonable densities. However, based on the information collected on sea cucumber stocks, there is a limited number of species available for bêche-de-mer production, and commercial fishing is not recommended at present stock levels.

Recommendations for Abaiang

- A monitoring programme be implemented for finfish, with any future development of reef finfish fishing focused on the outer reef rather than the lagoon areas, which are currently the most targeted habitats and already showing signs of depletion.

- Catches of drummer, parrotfish and wrasse need to be limited and monitored to avoid overfishing of these species.

- Future expansion of finfish resource harvesting primarily target the relatively untouched deep-bottom fish species to ease pressure on the reef fish stocks.

- Regulations be developed and implemented to control the level of gillnetting and spearfishing in the outer reefs for bumphead parrotfish and napoleon wrasses as spearfishing will seriously deplete these resources in a short time.

- A marine protected area be considered as a primary management tool to ensure the long-term conservation of the coastal reef fisheries on the island.

- Any *Tridacna gigas* found at Abaiang be collected and used in a breeding programme for this species.

- Management measures be introduced for sea cucumbers to allow this species to recover from previous fishing pressure.

Results of fieldwork at Abemama

Abemama is located 153 km to the southeast of Tarawa, just north of the equator. The atoll has a lagoon on its west side, which is relatively silty with poor visibility in some locations. There are two main passages through the reef.

Socioeconomics: Abemama

A considerable proportion of the Abemama community engages in fishing. Most of the finfish are caught for export, while most of the invertebrates are harvested for subsistence purposes. About half of all households surveyed receive income from fisheries, but only 25% depended on fisheries as first income, and another 28% as second income. By comparison, agriculture supplies 56% of all households with first income and another 36% with second income. Remittances do not play an important role on Abemama.

The importance of fisheries is reflected in the high number of fishers per household (2.3) and the fact that 96% of all households are engaged in fishing. Reflecting the important role of fishing in providing subsistence needs, most finfish consumed (92%) are caught by a member of the respective household. However, the percentage of households that sometimes also buy fish locally is surprisingly high.

Traditional gender roles were found to limit females' participation in finfish fisheries, and to prevent females from diving for invertebrates. Females, however, do most of the gleaning in intertidal and other areas.

Overall, fisher density is low. If only the subsistence needs of the community are considered, current fishing pressure is also low. However, 80% of all catches are exported to Tarawa and hence the existing fishing pressure is likely to be relatively high. Because most fishers target the lagoon and outer-reef resources, impact may be detectable here.

Abemama's invertebrate fishery is limited to a few target species. Sea worm collection from intertidal areas is the main fishery (>66% of the total reported annual catch by wet weight), which is for both home consumption and, most importantly, commercial purposes. By comparison, lobster (16.5%) and giant clam (3.4%) catches are of low importance, and so are other bivalves or gastropods collected for home consumption (~14%).

Finfish resources: Abemama

The finfish resource assessment indicates that the status of finfish resources in Abemama is similar to that in Abaiang, the other study site in the country with the same habitats. However, density and biomass are highest in Abemama. The sighting of large aggregations of carnivorous fish, such as snappers, commonly abundant in all four sites but especially in Abemama, as well as the dominance of carnivorous fish among the commercial fish population, suggest that the area's finfish resources are relatively healthy. However, the smallest values of average size and size ratio among the four sites (except for outer reefs in Kuria where these values are lower) are a first indication of heavy exploitation, especially in the lagoon reef.

Overall, Abemama finfish resources appear to be in relatively good condition. The reef habitat seems relatively rich and the ecosystem supporting finfish resources healthy. However, first signs of heavy exploitation are indicated by very low average fish size.

Invertebrate resources: Abemama

The present density and size range of elongate clams, *Tridacna maxima*, in Abemama atoll describe a lightly impacted resource. The lower density measures and average size of clams recorded suggest that stocks of *Hippopus hippopus* and *T. squamosa* are heavily impacted by fishing. The true giant clam, *Tridacna gigas*, has undergone a rapid decline over the last decade and a half.

Trochus has not been relocated to Abemama from Tarawa. Habitats look suitable, but much of the area is sandy and lacking in nutrients. Other grazing gastropods are not present in high densities, which casts doubt on the potential for trochus at Abemama. Data on the presence and recruitment of *Tectus pyramis*, a closely related species, do not suggest that the habitat at Abemama is very suitable for grazing gastropods. *Pinctada margaritifera* populations are low and considered heavily impacted by fishing. *Anadara holoserica* (*te bun*) shell beds were present across the easterly lagoon at Abemama, and the species was found at high density and in a range of size classes. *Strombus luhuanus* (*te nouo*) and other resource species, such as *Gafrarium* spp. (*te koumwara*), were also recorded in the shell beds. *S. luhuanus* was at reasonable density across Abemama.

Based on the information collected on sea cucumber stocks, there is a limited number of species available for commercial fishing, and stock densities for commercial species in Abemama are low. Despite the non-optimal conditions found in Abemama, the resource is considered heavily impacted by fishing.

No edible (*Heterocentrotus mammillatus*, *Tripneustes gratilla*) or non edible urchins were recorded at Abemama. This is a very uncommon result for PROCFish surveys and reflects somewhat the sandy nature of the lagoon system.

Recommendations for Abemama

- A programme to monitor reef finfish resources is required as well as new marine resource management measures for Abemama.

- Any expansion of fishing effort for reef finfish should be directed at the outer-reef areas to alleviate the heavy pressure on the lagoon and primarily target the relatively untouched deep-bottom fish species to ease pressure on the reef fish stocks.

- Considering the high quality of habitat in Abemama, marine protected areas should be considered as a primary management tool to sustain the abundance of commercial and food fish species on a long-term basis.

- If trochus were to be moved to Abemama, it is suggested that the transplanted shells should first be put on both sides of the northwest passage, or along the northern edge of the southwest passage, to give them a chance to get established. The back-reef and front-reef shoal stretching out from the barrier reef southeast of Abatiku Island look suitable for adult and juvenile trochus.

- Management measures should be introduced for sea cucumbers to allow this species to recover from previous fishing pressure.

Results of fieldwork in Kuria

Kuria is located just north of the equator, around 150 km south of Tarawa and around 55 km to the west of Abemama. Kuria is made up of two triangular islands joined by a causeway. There is no lagoon, although there is a fringing reef encircling the islands. To the north of the islands is an extensive reef shoal, which is a common fishing ground for local fishers. A smaller shoal is located to the southwest of the islands near the main passage, with patches of deep submerged reef extending out about 1 km from the fringing reef. Outside the fringing reef on both the windward and leeward sides of the islands, the bottom drops gently to over 2000 m.

Traditional outrigger canoes are used for fishing around Kuria, with gillnets used on sandbanks and intertidal areas, and handlining conducted on the outer-reef slope and drop-offs. Many households are involved in copra production; the price is currently subsidised and now attracts people to this activity for income generation.

Socioeconomics: Kuria

The people of Kuria are dependent on reef fisheries resources as their most important source of nutrition. Finfish are eaten almost every day and the amount eaten is among the highest of the sites investigated. Agriculture is the most important source of income; fisheries providing first income source for only 17% of households, but secondary income for another 39%. Income from fisheries comes from selling fish and sometimes lobsters to Central Pacific Producer Ltd (CPP) to supply local demand and for export to Tarawa.

Invertebrate fisheries are not diverse and far less important than finfish fisheries. People eat invertebrates on average once a fortnight. Fishers target basically four species groups:

lobsters, giant clams, *Coenobita* spp., and *Tellina palatum*. Lobsters are the only invertebrates fished commercially.

Traditional gender roles were found to restrict finfish fisheries and diving for lobsters and giant clams to male fishers only; intertidal gleaning is mostly done by females.

The highest fisher density occurs in the sheltered coastal reef (5 fishers/km^2). Fisher density over the total fishing ground is low (3 fishers/km^2). If only the subsistence needs of the island's population are considered, fishing pressure is low (2.12 t/km^2/year). However, taking into account the frequency of fishing trips, the total number of fishers, and the high catch rate, fishing pressure is assumed to be moderate to high.

Finfish resources: Kuria

The status of finfish resources in Kuria is similar to the average across the four sites surveyed in the country, with relatively high density but low biodiversity, size and biomass. However, the rather high abundance of carnivorous fish (Lutjanidae and Balistidae especially) suggests that the area's finfish resources are relatively healthy. However, detailed assessment at reef level revealed a very low abundance of herbivorous Scaridae, especially Kyphosidae and Siganidae, similarly to at the other sites. This may be due to the fact that these fish species are often easily caught by gillnetting on reef flats during high tide and therefore are specifically targeted by the local community.

Overall, Kuria finfish resources appear to be in average condition compared to the other sites. The reef habitat seems to be in good condition although less rich than the other sites.

Invertebrate resources: Kuria

Clams were not common at Kuria but, noting the shallowness of the pseudo-lagoon and the exposure and limited size of the site, the density of giant clams was moderate. At this density and size-class distribution, giant clams are affected by fishing, but are still spawning and recruiting to local reefs, which means they are only moderately impacted by fishing pressure. The largely unsuitable lagoon and open-reef environment makes recruitment from these broadcast spawners clams more difficult at Kuria, thereby making an already fragile stock more susceptible to overfishing.

Reefs at Kuria would support a population of commercial topshell, *Trochus niloticus*, but conditions are somewhat limited due to the small size of the island and the exposure of most of the reef areas. Data collected on other grazing species suggest that the oceanic influence on the reefs makes them less suited to supporting these species. The blacklip pearl oyster, *Pinctada margaritifera*, was not recorded during the survey and is considered commercially extinct.

Sea cucumber stocks on Kuria are depleted. The limited habitat and low densities recorded suggest that a mix of limited environment and fishing pressure have negatively impacted populations. This preliminary survey suggests that occurrence and density are too low for commercial collection at this time. Noting the sub-optimal conditions found on this low-lying island, the fact that agents would pay a commercial team of divers to target this small island is an indication of high fishing pressure for sea cucumbers within the Central Gilbert group as a whole.

Recommendations for Kuria

- Appropriate monitoring and management measures need to be developed and implemented for finfish resources at Kuria, with an initial focus on parrotfish resources, which are low.

- Any expansion of fishing pressure on finfish resources should be accompanied by appropriate monitoring and management.

- The current activities of fishing deep-water habitats by commercial fishers should be maintained and properly monitored to safeguard the shallower, outer-reef fish population.

- Considering the high quality of habitat in Kuria, marine protected areas (MPAs) should be considered as a primary management tool.

- Management measures should be introduced for sea cucumbers to allow this species to recover from previous fishing pressure.

Results of fieldwork in Kiritimati

Kiritimati Island is located in the Line Islands, just north of the equator and some 2560 km to the east of Tarawa. It is the largest island in Kiribati (388 km^2) and the largest purely coralline island in the world. The major portion of the island, in the northwest, encloses a large lagoon studded with coral patches, which is exposed to easterly winds and currents. The interior of the land area contains more than 100 lakes and ponds, some of which are several kilometres in diameter. Many of the lakes and ponds are used for the culture of milkfish.

Various artisanal fishing methods are widely practised on the island, especially trolling, gillnetting, spearfishing, shallow-water handlining and the collection of lobsters. Fishing craft in use include a variety of skiffs generally powered by outboard motors, a few sailing outrigger canoes and a good many single-man paddling outrigger canoes. A sports fishery has developed on Kiritimati Island, with enthusiasts travelling to the island to fish for bonefish and other species using flyfishing gear.

Socioeconomics: Kiritimati

The people on Kiritimati are highly dependent on reef fisheries resources as their most important source of nutrition. Alternatives are few (coconuts, land crabs, a small number of pigs and chickens, almost no agricultural produce) and any alternative food supply must be imported at high cost. Thus, finfish is consumed frequently and in large amounts (~110 kg/person/year). Fisheries provide the first or second income to most households, although copra production is equally important as first income source, in particular since the government subsidies for copra have increased. Very few households receive remittances.

Finfish fishing in Kiritimati mainly occurs in the lagoon; only a small proportion of reef fish is sourced from the outer reef. Over two-thirds of the total annual reported catch is consumed locally and only ~21% is exported to Tarawa via the company Central Pacific Producer Ltd (CPP). Gillnetting is the main fishing method used in the lagoon but in the outer reef a variety of methods are used, including handlining and spear diving. Traditional gender roles determine that females never engage in any type of fishery. However, they do collect land crabs.

Invertebrate fisheries are far less important than finfish fisheries. People eat invertebrates less than once a week. Fishers target basically four species groups: giant clams, octopus, bêche-de-mer and lobster. Lobsters are sold to CPP at London or to local restaurants and hotels since the lobster export to Hawaii (Honolulu) has stopped due to the lack of air transport. Bêche-de-mer are now sold to a sole agent based at Banana. Overall, fisher density and fishing pressure are low, although higher in the lagoon.

Finfish resource: Kiritimati

Overall, finfish resources in Kiritimati appear to be in relatively good condition. The reef habitat, with more live-coral cover than the other sites, seems relatively rich and the ecosystem supporting finfish resources healthy. In comparison with the other sites surveyed, reef fish stocks on Kiritimati are much better preserved, as shown by the presence of larger fish (68% versus 60% for Abaiang, 45% for Abemama and 41% for Kuria). The presence of large-sized species protected under CITES, such as *Cheilinus undulatus*, and the high numbers of herbivorous fish coupled with large-sized carnivorous fish (Lutjanidae and Serranidae) provide a balanced trophic structure in the island's reef ecosystem. Having larger fish in the coastal marine system ensures genetic diversity and is a good signal to show that resources are healthy. However, this will be short lived as long as the population continues to increase and coastal fisheries resources remain poorly managed, as is currently the case.

Invertebrate resources: Kiritimati

Tridacna maxima giant clams were common at Kiritimati Island, despite the small area within the lagoon where the habitat was most suitable. The densities recorded in this study do not suggest there is heavy fishing pressure on the stocks, although larger clams are noticeably depleted.

Based on the information collected on mother-of-pearl stocks, *Trochus niloticus* does offer some potential if introduced to Kiritimati. Although the reef system is not well suited, the extensive area of coastline may compensate somewhat for the lack of suitable juvenile habitat.

The blacklip pearl oyster, *Pinctada margaritifera*, is present at low abundance and there is no potential for a commercial fishery. Despite once providing a significant income for Kiritimati through sale of pearl shell, pearl production would need to rely on spat collection (or hatchery production) to access stock. In addition to the lack of shells, there is a lack of a protected deep-water lagoon for commercial grow-out of shell and pearls.

Sea cucumber stocks are limited, as shown by the number of species present, distribution of the stock across the lagoon and offshore reefs, and by the densities recorded within aggregated areas. There is indication that, despite the non-optimal environment, fishing has greatly impacted stock availability. Fishing for sea cucumbers is actively pursued in Kiritimati, and commercial aquarium collectors have had SCUBA access for several years.

Recommendations for Kiritimati

- Fisheries management may consider the use of the milkfish breeding project for local (and/or national) consumption rather than for commercial baitfish production. This may provide an alternative fishery and reduce fishing pressure on the natural coastal resources of Kiritimati.

- Management arrangements need to be finalised for the bonefish fishery to protect this species for the tourist or sport fishing industry.

- Appropriate monitoring and management arrangements need to be developed and implemented to sustain the presence of larger-sized fish, and thus conserve the genetic diversity of commercially important species found on the island in the face of an expanding population.

- Commercial fishers should be encouraged to target the seamount fishery, as well as the relatively untouched and high-value deep-bottom fish species, to ease pressure on the reef fish stocks and leave these for subsistence use only.

- Extra care should be taken to protect broodstock of clams, as increased fishing pressure will accelerate negative impacts on stocks on reefs in Kiritimati (which are more susceptible to overfishing).

- Management measures should be introduced for sea cucumbers to allow this species to recover from previous fishing pressure.

RÉSUMÉ

Dans le cadre 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), des études de terrain ont été conduites sur quatre sites de Kiribati, de mai à novembre 2004. Kiribati est l'un des 17 États et Territoires insulaires océaniens dans lesquels des enquêtes ont été menées, sur une période de 5-6 ans, dans le cadre du projet PROCFish ou de son projet associé CoFish (projet régional océanien de développement de la pêche côtière)[3].

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

Les autres résultats escomptés du projet étaient notamment :

- première évaluation exhaustive et comparative des pêcheries récifales (poissons, invertébrés et paramètres socioéconomiques de leur exploitation) jamais entreprise dans plusieurs pays de la région océanienne, suivant une méthode normalisée, appliquée sur chaque site d'étude ;
- diffusion de rapports nationaux comprenant un ensemble de « descriptifs des ressources halieutiques récifales » pour les sites étudiés dans chaque pays, servant de base au développement de la pêche côtière et à la planification de sa gestion ;
- élaboration d'un jeu d'indicateurs (ou points de référence pour l'évaluation de l'état des stocks), qui serviront de guide à l'élaboration de plans de gestion des ressources récifales à l'échelle locale et nationale, et de programmes de suivi ; et
- élaboration de systèmes de gestion des données et des informations, dont des bases de données régionales et nationales.

Les enquêtes conduites à Kiribati couvraient trois disciplines (poissons, invertébrés et facteurs socioéconomiques) sur chaque site ; à chaque mission, deux sites étaient étudiés par une équipe de trois scientifiques chargés du projet et plusieurs agents locaux détachés par le service des pêches. Durant les travaux de terrain, l'équipe a également formé des agents locaux aux méthodes d'enquête et d'inventaire utilisées dans chaque volet des études, notamment la collecte de données et leur saisie dans la base de données du projet.

À Kiribati, les quatre sites retenus pour les enquêtes étaient : Abaiang, Abemama, Kuria et Kiritimati. Ils ont été choisis selon des critères particuliers :

- existence d'une pêcherie récifale active,
- représentativité,
- systèmes relativement fermés (les habitants du site pêchent dans des zones bien définies),
- taille appropriée,
- habitat diversifié,
- absence de gros problème logistique,
- pas d'étude conduite auparavant sur ce site,
- présentant un intérêt particulier pour le Ministère de la pêche de Kiribati.

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

Résultats des études de terrain conduites à Abaiang

La superficie des terres émergées d'Abaiang représente environ 17,5 km². Cette île est située au nord de Tarawa, à quatre heures environ par bateau ou 15 minutes en avion. Le lagon est en général peu profond, mais présente des creux de 25 m de profondeur dans le chenal de Bingham. À l'intérieur du lagon, le corail se trouve sous forme de pâtés coralliens jusqu'à 25 m de fond ; les récifs côtiers intérieurs peuvent être envahis d'algues et de vase. Les chenaux et d'autres petites ouvertures sur le bord du récif-barrière ne semblent pas suffisants pour renouveler l'eau du lagon tout entier, probablement parce que celui-ci est très peu profond et comporte des récifs avec de nombreux *motu*, et que les chenaux sont relativement peu profonds. Le débit d'eau dans les passes étant élevé, le corail et les récifs proches de ces passes sont en bon état. Une vaste zone sablonneuse descend en pente douce depuis la côte, surtout à l'extrémité sud du lagon, tandis que l'on trouve d'autres pâtés de récif corallien le long de la côte vers le nord du lagon.

La pêche se pratique couramment soit dans le lagon, soit sur la pente du récif externe, en particulier du côté qui fait face au nord de Tarawa. Le côté au vent de l'île principale est constitué d'un récif frangeant qui ne dépasse pas 100 m de large. La pêche à pied (ramassage), au harpon ou à la canne à l'extérieur des bords du récif frangeant se limite à des périodes de temps calme, en l'absence de houle caractéristique. L'accès au côté au vent est limité par le fait qu'il n'y a pas de passe à proximité immédiate de l'île principale.

Aspects socioéconomiques : Abaiang

Une proportion considérable de la population d'Abaiang pratique la pêche. Les ressources halieutiques représentent une source très importante de revenus pour plus de la moitié des ménages de l'île. La plupart (78 %) des poissons, langoustes, vers marins et bénitiers capturés sont exportés à Tarawa. Les autres sources de revenus sont limitées (artisanat, quelques emplois salariés dans le secteur public, très peu de potentiel agricole). Si la demande de revenus et de nourriture émanant de la population devait augmenter à l'avenir, il est probable que la pression de pêche croîtrait parallèlement.

La consommation de poisson frais par habitant est élevée (88 kg par personne et par an), par rapport à la moyenne régionale. Parmi toutes les communautés de Kiribati, c'est celle d'Abaiang qui en consomme le moins. Ni les invertébrés ni le poisson en conserve n'occupent une grande place dans la nourriture des habitants d'Abaiang. Les rôles traditionnellement dévolus aux hommes et aux femmes se retrouvent dans la pêche de poissons et celle d'invertébrés : seuls les hommes plongent pour pêcher langoustes et bénitiers, tandis que le ramassage de ressources dans la zone intertidale et sur des fonds meubles est réalisé par des femmes.

C'est sur le récif extérieur que l'on relève la plus forte densité de pêcheurs (9 pêcheurs au kilomètre carré) tandis que, dans l'ensemble, la densité de pêcheurs sur la surface totale de récifs de la communauté et sur sa zone de pêche totale est faible (3 à 6 pêcheurs/km²). Si l'on examine les besoins vivriers de la communauté, même en tenant compte de la densité modérée de la population, la pression de pêche est relativement faible (3 t/km² de surface totale du récif). Toutefois, en considérant que la pêche vivrière ne représente que 20 pour cent des prises totales réalisées à Abaiang, tandis que 80 pour cent des prises sont destinées à l'exportation, la pression de pêche peut probablement être qualifiée de modérée à élevée, en particulier celle qui s'exerce sur les ressources lagonaires et du récif externe.

Poissons : Abaiang

L'état des ressources en poissons d'Abaiang est similaire à celui des récifs d'Abemama (le seul autre site où l'on observe les quatre types d'habitat), à ceci près que la biomasse est plus élevée sur le récif arrière et moindre dans le lagon et sur les récifs extérieurs. Le rapport de taille est toutefois toujours plus élevé à Abaiang, ce qui laisse à penser que le niveau d'exploitation y est moins élevé. Les poissons carnivores, en particulier des Lutjanidés, sont très abondants dans tous les habitats. La biomasse est également dominée par des carnivores dans tous les récifs, ce qui s'explique surtout par la présence en abondance de gros Lutjanidés (*Lutjanus fulvus*, *L. gibbus* et *L. ehrenbergii* d'un rapport de taille > 55 %).

Ces résultats, conjugués à la grande abondance de poissons carnivores (en particulier des Lutjanidés) dans tous les systèmes récifaux, indiquent que les ressources halieutiques de la zone sont en relativement bonne santé. L'habitat récifal semble relativement riche, et l'écosystème accueillant ces ressources, en bon état. Compte tenu de tous les habitats et récifs disponibles, l'atoll d'Abaiang offre cependant le choix entre différentes méthodes et engins de pêche et, de même que sur l'île d'Abemama, la pêche est surtout pratiquée à des fins d'exportation, ce qui accroît la pression de pêche s'exerçant sur les récifs. La proximité de l'île et de la capitale contribue également à la faible densité des stocks de poissons présentant un intérêt commercial. Les limites d'une pêche durable seront donc bientôt franchies, surtout si des règles de surveillance et de gestion ne sont pas appliquées.

Invertébrés : Abaiang

La densité actuelle des bénitiers *Tridacna maxima* dans l'atoll d'Abaiang n'est pas faible, mais la répartition des individus par taille laisse à penser qu'une forte pression de pêche s'exerce sur le stock. *T. squamosa* et *Hippopus hippopus*, les deux espèces de bénitiers à croissance la plus rapide, sont rares à Abaiang, au point que le succès de la reproduction et le recrutement ultérieur pourraient être compromis. Les stocks de *T. gigas* d'Abaiang ont subi un déclin catastrophique au cours des quinze dernières années, et sont gravement touchés par la pêche.

Le troca d'intérêt commercial (*Trochus niloticus*) ne s'est pas établi depuis son transfert de Tarawa. Des juvéniles n'ont être lâchés qu'à une date récente ; il est donc encore trop tôt pour savoir si le troca réussira à coloniser les récifs d'Abaiang. Bien que les systèmes récifaux d'Abaiang soient de grandes dimensions, et offrent un habitat aux mollusques juvéniles et adultes, des gastropodes brouteurs tels que *Tectus pyramis* étaient peu abondants. Il est peu probable que cette situation soit entièrement le résultat d'une surpêche ; elle dénote peut-être des conditions moins qu'optimales pour ces gastropodes brouteurs. Les populations sauvages d'huître perlière *Pinctada margaritifera* sont dégradées et considérées comme éteintes sur le plan commercial.

Les bancs de mollusques d'Abaiang recélaient un grand nombre d'*Anadara holoserica* (*te bun*) de diverses catégories de taille. D'après les mesures de densité et la gamme de tailles des arches, cette ressource n'est que marginalement affectée par la pêche et son recrutement est excellent. La taille moyenne plus petite d'*A. holoserica* observée à de très fortes densités pourrait s'expliquer par une croissance fonction de la densité : la croissance de taille globale est limitée du fait du surpeuplement. Les espèces *Strombus luhuanus* (*te nouo*) et *Gafrarium* spp. (*te koumwara*) ont également été observées à des densités raisonnables. Toutefois, d'après les informations recueillies à propos des stocks d'holothuries, il existe un nombre limité d'espèces se prêtant à la production de bêche-de-mer, et la pêche à des fins commerciales n'est pas recommandée, étant donné le niveau actuel des stocks.

Recommandations applicables à Abaiang

- Un programme de suivi des stocks de poissons devrait être mis en œuvre. Le développement éventuel de la pêche de poissons de récif devrait se limiter au récif extérieur, plutôt qu'aux zones lagonaires, habitats les plus ciblés actuellement et présentant déjà des signes d'appauvrissement.

- Il faut limiter les prises de calicagères, perroquets et napoléons et les surveiller pour éviter la surpêche de ces espèces.

- À l'avenir, le développement de la pêche de poissons devrait principalement cibler les espèces de poissons de grand fond, relativement peu touchées, afin d'atténuer la pression qui s'exerce sur les stocks de poissons de récif.

- Il faudrait élaborer des règlements et les mettre en application, afin de surveiller le niveau de pêche de perroquets à bosse et de napoléons au filet maillant et au harpon sur les récifs : la pêche au harpon épuisera ces ressources à brève échéance.

- Il convient d'envisager l'aménagement d'une aire marine protégées, mesure de gestion essentielle qui permettrait de conserver à long terme les ressources côtières récifales de l'île.

- Tout bénitier *Tridacna gigas* trouvé à Abaiang devrait être récolté et utilisé dans le cadre d'un programme de reproduction de cette espèce.

- Des mesures de gestion devraient être appliquées pour permettre aux stocks d'holothuries de se reconstituer après un épisode de forte pression de pêche.

Résultats des études de terrain conduites à Abemama

Abemama est situé à 153 km au sud-est de Tarawa, juste au nord de l'équateur. Le lagon situé du côté ouest de l'atoll est relativement vaseux, et présente une mauvaise visibilité à certains endroits. Il y a deux passes traversant le récif.

Aspects socioéconomiques : Abemama

Une proportion considérable de la population d'Abemama pratique la pêche. La plupart des poissons sont exportés, tandis que la majorité des invertébrés sont capturés à des fins de subsistance. Près de la moitié des ménages interrogés tirent des revenus de la pêche, mais 25 pour cent seulement en sont tributaires comme première source de revenus, et 28 pour cent comme source secondaire. Par comparaison, 56 pour cent des ménages tirent de l'agriculture des revenus primaires et 36 pour cent des revenus secondaires. Les virements d'argent depuis l'étranger ne jouent pas un rôle important à Abemama.

L'importance des ressources halieutiques se mesure au nombre élevé de pêcheurs par ménage (2,3) et par le fait que 96 pour cent des ménages pratiquent la pêche. La plupart des poissons consommés (92 %) sont capturés par un membre du ménage, ce qui montre le rôle important de la pêche dans la satisfaction des besoins alimentaires. Le pourcentage de ménages qui achètent aussi, parfois, des poissons sur le marché local, est toutefois étonnamment élevé.

Du fait des rôles traditionnellement dévolus aux hommes et aux femmes, la participation des femmes à la pêche de poissons est limitée et les femmes ne peuvent pas plonger pour pêcher des invertébrés. En revanche, ce sont surtout elles qui récoltent ces ressources dans les zones intertidales et autres.

Dans l'ensemble, la densité de pêcheurs est faible. Si l'on examine les seuls besoins alimentaires de la population, la pression de pêche actuelle est également faible. Toutefois, 80 pour cent des prises sont exportées à Tarawa ; la pression de pêche existante est donc sans doute relativement élevée. La plupart des pêcheurs ciblant des ressources du lagon et du récif extérieur, l'impact de la pêche pourrait y être sensible.

La pêche d'invertébrés à Abemama se limite à quelques espèces ciblées. La collecte de vers marins dans les zones intertidales est la principale pêcherie (> 66 % des captures annuelles totales déclarées, par poids humide), destinée à la consommation domestique et surtout, à la vente. Par comparaison, les prises de langoustes (16,5 %) et de bénitiers (3,4 %) n'ont qu'une faible importance, de même que celles d'autres bivalves ou gastropodes destinés à la consommation des ménages (14 % environ).

Poissons : Abemama

L'évaluation des ressources en poisson montre que l'état de ces ressources à Abemama est similaire à celui d'Abaiang, l'autre site étudié du pays présentant les mêmes habitats. C'est toutefois à Abemama que la densité et la biomasse sont les plus élevées. L'observation de grandes concentrations de poissons carnivores, tels que des vivaneaux, couramment abondants sur les quatre sites, mais plus particulièrement à Abemama, ainsi que la prédominance de poissons carnivores parmi les poissons d'intérêt commercial, indiquent que les stocks de poissons de cette zone sont en relativement bon état. Les valeurs de taille moyenne et de rapport de taille, les plus petites des quatre sites (à l'exception des récifs extérieurs de Kuria, où ces valeurs sont encore plus faibles), sont un premier signe de forte exploitation, surtout dans le récif lagonaire.

Dans l'ensemble les stocks de poissons d'Abemama semblent être en relativement bon état. L'habitat récifal semble relativement riche, et l'écosystème abriant ces stocks en bon état. La très faible taille moyenne des poissons constitue toutefois un premier signe de forte exploitation

Invertébrés : Abemama

La densité et la gamme de taille actuelles des bénitiers *Tridacna maxima* dans l'atoll d'Abemama dénotent une ressource légèrement affectée. La faible densité et la taille moyenne des bénitiers observées laissent à penser que les stocks de *Hippopus hippopus* et *T. squamosa* sont fortement affectés par la pêche. Le bénitier *Tridacna gigas* a subi un rapide déclin au cours des quinze dernières années.

Il n'a pas été transféré de troca de Tarawa à Abemama. Les habitats semblent convenir, mais cette zone est en grande partie sablonneuse et manque de nutriments. Il n'y a pas d'autres gastropodes brouteurs en forte densité, ce qui permet de douter du potentiel de la ressource en troca à Abemama. Les données relatives à la présence et au recrutement de *Tectus pyramis*, espèce apparentée, ne suggère pas que l'habitat à Abemama convienne bien à des gastropodes brouteurs. Les populations de *Pinctada margaritifera,* peu abondantes, sont considérées comme fortement affectées par la pêche. Des bancs de mollusques *Anadara holoserica* (*te bun*) sont présents dans l'ensemble du lagon oriental d'Abemama et cette espèce a été observée à une densité élevée et dans diverses classes de taille. *Strombus luhuanus* (*te nouo*) et d'autres espèces telles que *Gafrarium* spp. (*te koumwara*) ont été observés parmi les bancs de mollusques. *S. luhuanus* était présent à une densité raisonnable à Abemama.

D'après les informations recueillies concernant les stocks d'holothuries, un nombre limité d'espèces convient à la pêche commerciale, et la densité des stocks des espèces commerciales à Abemama est faible. Malgré les conditions non optimales constatées à Abemama, cette ressource est considérée comme fortement affectée par la pêche.

On n'a pas observé d'oursin comestible (*Heterocentrotus mammillatus*, *Tripneustes gratilla*) ou non comestible à Abemama. C'est un résultat très inhabituel pour les enquêtes PROCFish, qui traduit la nature sablonneuse du système lagonaire.

Recommandations applicables à Abemama

- Il faut élaborer un programme de suivi des ressources en poissons de récif, et prendre de nouvelles dispositions en vue de la gestion des ressources marines à Abemama.

- Toute expansion de l'effort de pêche de poissons de récif devrait porter sur les zones du récif extérieur, afin d'atténuer la forte pression de pêche s'exerçant sur le lagon, et cibler les espèces de poissons de fond, relativement épargnées, afin d'atténuer celle qui pèse sur les stocks de poissons de récif.

- Compte tenu de la grande qualité d'habitat à Abemama, des aires marines protégées devraient être aménagées à titre d'important outil de gestion, afin de conserver à long terme l'abondance des espèces de poissons d'intérêt commercial et alimentaire.

- En cas de transfert éventuel de trocas à Abemama, il faudrait commencer par disposer les coquillages transplantés des deux côtés de la passe nord-ouest ou le long du bord nord de la passe sud-ouest, afin de les laisser se fixer. L'arrière récif et les hauts fonds de l'avant-récif, s'étendant depuis le récif barrière, au sud-est de l'île d'Abatiku, semblent offrir un habitat approprié pour les trocas adultes et juvéniles.

- Il convient de prendre des mesures de gestion pour les holothuries, de manière à laisser leurs stocks se reconstituer après un épisode de forte pression de pêche.

Résultats des études de terrain conduites à Kuria

Kuria est situé juste au nord de l'équateur, à 150 km environ au sud de Tarawa et à 55 km à l'ouest d'Abemama. Kuria est formé de deux îles triangulaires reliées par un chemin. Il n'y a pas de lagon, mais un récif frangeant qui encercle les îles. Au nord de celles-ci se trouve un vaste haut-fond récifal, zone de pêche habituelle des pêcheurs locaux. Un petit haut-fond se trouve au sud-ouest des îles, près de la passe principale, avec des pâtés de récif profond immergés s'étendant sur 1 km environ depuis le récif frangeant. À l'extérieur de ce dernier, des côtés au vent et sous le vent des îles, le fond descend en pente douce jusqu'à plus de 2000 m.

Les pêcheurs partent à bord de pirogues à balancier traditionnelles pêcher autour de Kuria à l'aide de filets maillants, utilisés sur les bancs de sable et les zones intertidales. La pêche à la palangrotte est pratiquée sur la pente du récif extérieur et les tombants. De nombreux ménages produisent du coprah, dont le prix est actuellement soutenu par des subventions. Cette activité rémunératrice attire maintenant de plus en plus de personnes.

Aspects socioéconomiques : Kuria

Les habitants de Kuria sont surtout tributaires des ressources récifales pour leur nourriture. Ils consomment du poisson pratiquement tous les jours, et la quantité consommée est parmi les plus élevées des sites étudiés. L'agriculture représente la principale source de revenus ; la pêche n'est la première source de revenus que pour 17 pour cent des ménages, et la source secondaire pour 39 pour cent. Les recettes tirées de la pêche proviennent de la vente de poissons, parfois de langoustes, à Central Pacific Producer Ltd (CPP) qui alimente le marché local et assure les exportations à Tarawa.

La pêche d'invertébrés n'est pas diversifiée et beaucoup moins importante que celle de poissons. Les habitants ne consomment des invertébrés qu'une fois par quinzaine en moyenne. Les pêcheurs ciblent essentiellement quatre groupes d'espèces : langoustes, bénitiers, *Coenobita* spp., et *Tellina palatum*. La langouste est le seul invertébré pêché à des fins commerciales.

Du fait du partage traditionnel des tâches entre hommes et femmes, la pêche de poissons et celle de langoustes et bénitiers en plongée sont réservées aux hommes, tandis que ce sont surtout les femmes qui ramassent des ressources dans les zones intertidales.

C'est sur le récif côtier abrité que l'on observe la plus forte densité de pêcheurs (5 pêcheurs au km²). La densité de pêcheurs est faible sur l'ensemble de la zone de pêche (3 pêcheurs/km²). Si l'on ne considère que les besoins de subsistance de la population de l'île, la pression de pêche est faible (2,12 t/km²/an). En revanche, compte tenu de la fréquence des sorties de pêche, du nombre total de pêcheurs et du taux de prises élevé, la pression de pêche peut être considérée comme modérée à élevée.

Poissons : Kuria

L'état des ressources en poissons à Kuria est similaire à la moyenne des quatre sites étudiés dans le pays ; la densité est relativement élevée, mais la biodiversité, la taille et la biomasse faibles. Toutefois, l'abondance assez élevée de poissons carnivores (en particulier Lutjanidés et Balistidés) laisse à penser que les ressources en poissons de la zone sont en relativement bon état. Une évaluation détaillée, au niveau du récif, révèle cependant une très faible abondance de Scaridés herbivores, notamment Kyphosidés et Siganidés, comme sur les autres sites. Cela peut s'expliquer par le fait que ces espèces sont souvent facilement capturées au filet maillant sur les platiers, à marée haute, et sont donc spécialement ciblées par la population locale.

Dans l'ensemble, les ressources en poissons de Kuria semblent dans un état moyen par rapport aux autres sites. L'habitat récifal semble en bon état, bien que moins riche que les autres sites.

Invertébrés : Kuria

Les bénitiers ne sont pas courants à Kuria, mais, compte tenu de la faible profondeur du pseudo-lagon, de l'exposition et de la taille limitée du site, la densité des bénitiers est modérée. À cette densité, et vu la distribution par catégorie de taille, les bénitiers sont affectés par la pêche, mais continuent de se reproduire et le recrutement se poursuit sur les récifs locaux, ce qui signifie qu'ils ne sont que modérément touchés par la pression de pêche. Les conditions environnementales, peu appropriées, dans le lagon et le récif ouvert, rendent le recrutement de ces bénitiers, qui se reproduisent par diffusion de leur semence, plus difficile à Kuria, et fragilise un stock plus affecté par la surpêche.

Les récifs de Kuria pourraient accueillir une population de trocas d'intérêt commercial, *Trochus niloticus*, mais les conditions sont quelque peu limitées du fait de l'exiguité de l'île et de l'exposition de la plupart des zones récifales. Les données recueillies sur d'autres espèces brouteuses laissent à penser que l'influence océanique sur les récifs rend ceux-ci moins aptes à accueillir ces espèces. L'huître perlière à lèvres noires, *Pinctada margaritifera*, n'a pas été observée pendant l'enquête et est considérée comme éteinte sur le plan commercial.

Les stocks d'holothuries sont épuisés à Kuria. L'habitat limité et les faibles densités enregistrées donnent à penser que la conjugaison d'un environnement limité et d'une forte pression de pêche ont eu des retombées négatives sur les populations. Cette enquête préliminaire montre que l'occurrence et la densité sont trop faibles pour une exploitation commerciale pour l'instant. Compte tenu des conditions non optimales observées sur cette île basse, le fait que des négociants rémunèrent une équipe de plongeurs commerciaux pour cibler cette petite île indique qu'une forte pression de pêche s'exerce sur les holothuries dans l'ensemble de l'archipel central des Gilbert.

Recommandations applicables à Kuria

- Il faut prendre des dispositions en matière de suivi et de gestion des ressources en poissons et les appliquer à Kuria, en mettant tout d'abord l'accent sur les perroquets, dont les stocks sont peu abondants.

- Tout accroissement de la pression de pêche sur les ressources en poissons devrait s'accompagner de mesures appropriées de suivi et de gestion.

- La pêche pratiquée dans des habitats profonds par des pêcheurs commerciaux devrait être maintenue à son niveau actuel et surveillée de manière appropriée afin de préserver la population de poissons évoluant à moindre profondeur sur le récif extérieur.

- Compte tenu de l'excellente qualité d'habitat à Kuria, il faudrait envisager d'aménager des aires marines protégées (AMP) à titre de mesure de gestion prioritaire.

- Il conviendrait de prendre des mesures de gestion pour permettre aux stocks d'holothuries de se reconstituer après un épisode de forte pression de pêche.

Résultats des études de terrain conduites à Kiritimati

L'île de Kiritimati fait partie des îles de la Ligne, juste au nord de l'équateur, et à quelque 2 560 km à l'est de Tarawa. C'est la plus grande île de Kiribati (388 km²) et la plus grande île purement corallienne du monde. La majeure partie de l'île, au nord-ouest, comprend un grand lagon parsemé de pâtés coralliens, et exposé aux vents d'est et aux courants marins. L'intérieur des terres comporte plus de 100 lacs et étangs, dont plusieurs ont plusieurs kilomètres de diamètre. L'élevage de chanidés est pratiqué dans de nombreux lacs et étangs.

Diverses méthodes de pêche artisanale sont employées sur l'île, en particulier à la traîne, au filet maillant, au harpon, à la palangrotte dans les eaux peu profondes, ainsi que la collecte de langouste. La pêche se pratique à bord de diverses embarcations, en général équipées d'un moteur hors-bord, quelques pirogues à voile et à balancier, et un grand nombre de pirogues à rames individuelles. La pêche sportive s'est développée à Kiritimati, où des amateurs viennent pêcher à la mouche la banane de mer et d'autres espèces.

Aspects socioéconomiques : Kiritimati

Les habitants de Kiritimati sont fortement tributaires des ressources récifales pour leur alimentation. Les autres sources de nourriture sont rares (noix de coco, crabes de terre, quelques porcs et poulets, pratiquement pas de produits agricoles) et les autres produits alimentaires doivent être importés à un prix élevé. Le poisson est donc consommé souvent et en grandes quantités (110 kg par personne et par an environ). La pêche est la première ou la seconde source de revenus de la plupart des ménages, le coprah étant aussi une source importante de revenus primaires, d'autant que les subventions pour la production de coprah ont été augmentées. Très peu de ménages reçoivent des virements de l'étranger.

À Kiritimati, le poisson est principalement pêché dans le lagon ; une petite proportion seulement de poissons de récifs est pêchée sur le récif extérieur. Plus des deux tiers des prises totales annuelles déclarées sont consommés par la population locale, et 21 pour cent seulement exposés à Tarawa par la Central Pacific Producer Ltd (CPP). La pêche au filet maillant est la principale méthode utilisée dans le lagon, contrairement au récif extérieur, où l'on utilise notamment la pêche à la canne et au harpon sous-marin. Du fait de la répartition traditionnelle des tâches entre hommes et femmes, celles-ci ne pratiquent jamais la pêche, mais elles ramassent des crabes de terre.

La pêche d'invertébrés est beaucoup moins importante que celle de poissons. Les habitants consomment des invertébrés moins d'une fois par semaine. Les pêcheurs ciblent essentiellement quatre groupes d'espèces : bénitiers, poulpes, holothuries et langoustes. Ces dernières sont vendues à CPP à London (Kiribati) ou à des restaurants et hôtels locaux, l'exportation à Hawaii (Honolulu) ayant cessé faute de moyens de transport par avion. Les bêches-de-mer sont maintenant vendues à un représentant exclusif basé à Banana. Dans l'ensemble la densité de pêcheurs et la pression de pêche sont faibles, quoique supérieures dans le lagon.

Poissons : Kiritimati

Les ressources en poissons, à Kiritimati, semblent dans l'ensemble en relativement bon état. L'habitat récifal, dont la couverture de coraux vivants est plus dense que sur les autres sites, semble relativement riche, et l'écosystème qui accueille les ressources en poissons, en bon état. Par rapport aux autres sites étudiés, les stocks de poissons de récifs de Kiritimati sont bien mieux préservés, comme l'indique la présence de gros poissons (68 %, contre 60 % à Abaiang, 45 % à Abemama et 41 % à Kuria). Grâce à la présence d'espèces de grande taille, protégées en vertu de la CITES (*Cheilinus undulatus*, par exemple) et de grandes quantités de poissons herbivores et de poissons carnivores de grande taille (Lutjanidés et Serranidés), l'écosystème récifal de l'île présente une structure trophique équilibrée. La présence de gros poissons dans le système marin côtier est garant de la diversité génétique et dénote la bonne santé des ressources. Cette situation demeurera toutefois précaire tant que la population continue de croître et que la gestion des ressources halieutiques côtières reste médiocre, comme c'est le cas actuellement.

Invertébrés : Kiritimati

Les bénitiers *Tridacna maxima* sont courants à Kiritimati, malgré la superficie restreinte, au sein du lagon, où les conditions d'habitat sont favorables. Les densités enregistrées lors de cette étude ne laissent pas supposer une forte pression de pêche, bien que les bénitiers de grande taille soient visiblement en voie d'appauvrissement.

D'après les informations recueillies concernant les stocks de nacre, *Trochus niloticus* offrirait effectivement un certain potentiel s'il était introduit à Kiritimati. Bien que le système récifal ne convienne pas parfaitement, la longueur du littoral pourrait quelque peu compenser l'absence d'habitat convenant aux juvéniles.

L'huître perlière à lèvres noires, *Pinctada margaritifera*, est présente en faible abondance, et il n'y a pas de possibilité d'exploitation commerciale. Alors que la vente de nacre fournissait jadis des revenus importants à Kiritimati, la production perlière devrait s'appuyer sur la collecte de naissain (ou la production en écloserie) pour disposer d'un stock. Outre l'absence de coquillages, on constate qu'il n'existe pas de lagon protégé suffisamment profond pour un élevage de coquillages et d'huîtres perlières à l'échelle commerciale.

Les stocks d'holothuries sont limités, comme le montrent le nombre d'espèces présentes, la répartition du stock dans le lagon et sur les récifs du large, ainsi que les densités enregistrées dans les zones regroupées. Il semble que, malgré des conditions environnementales peu favorables, la pêche ait eu un impact considérable sur l'existence des stocks. La pêche d'holothuries se pratique à grande échelle à Kiritimati, et les pêcheurs de poissons d'aquariophilie plongent en scaphandre autonome depuis plusieurs années.

Recommandations applicables à Kiritimati

- Les gestionnaires des pêches pourraient envisager de mettre à profit le projet de reproduction de chanidés pour les besoins de la consommation locale (et/ou nationale), plutôt qu'à des fins de production commerciale d'appâts. Cela pourrait constituer une pêcherie supplémentaire tout en atténuant la pression de pêche sur les ressources côtières naturelles de Kiritimati.

- Il faut mettre au point des mesures de gestion pour la pêche de bananes de mer, afin de protéger cette espèce ciblée par les touristes et la pêche sportive.

- Il faut prendre des dispositions appropriées de suivi et de gestion et les appliquer afin de garantir la présence de poissons de grande taille, et conserver ainsi la diversité génétique des espèces d'intérêt commercial que l'on trouve sur l'île, face à l'essor de la population.

- Il faudrait encourager les pêcheurs commerciaux à cibler les poissons évoluant autour de monts sous-marins, ainsi que les espèces de poissons de fond de grande valeur marchande, relativement peu affectés, afin d'atténuer la pression de pêche sur les stocks de poissons de récif et ne cibler ceux-ci qu'à des fins de subsistance.

- Il faut veiller particulièrement à protéger les bénitiers reproducteurs, car la pression de pêche croissante risque d'accentuer les effets négatifs sur les stocks récifaux de Kiritimati (plus vulnérables à la surpêche).

- Il convient de mettre en place des mesures de gestion des holothuries pour permettre à ce stock de se reconstituer après un épisode de forte pression de pêche.

ACRONYMS

ACP	African, Caribbean and Pacific Group of States
AIMS	Australian Institute of Marine Science
AUD	Australian dollar(s)
AusAID	Australian Agency for International Development
BdM	bêche-de-mer (or sea cucumber)
CITES	Convention on International Trade in Endangered Species
CoFish	Pacific Regional Coastal Fisheries Development Programme
CPP	Central Pacific Producers
CPUE	catch per unit effort
Ds	day search
D-UVC	distance-sampling underwater visual census
DWFNs	distant water fishing nations
EDF	European Development Fund
EEZ	exclusive economic zone
EU/EC	European Union/European Commission
FAO	Food and Agricultural Organization (UN)
FL	fork length
GCRMN	Global Coral Reef Monitoring Network
GPS	global positioning system
ha	hectare
HH	household
ICLARM	International Center for Living Aquatic Resources Management
JCU	James Cook University
JICA	Japanese International Cooperation Agency
LRFF	live reef food fish
MCRMP	Millennium Coral Reef Mapping Project
MFMRD	Ministry of Fisheries and Marine Resources Development
MIRAB	Migration, Remittances, Aid and Bureaucracy (model explaining the economies of small island nations)
MOP	mother-of-pearl
MOPt	mother-of-pearl transect
MSA	medium-scale approach
NASA	National Aeronautics and Space Administration (USA)
NCA	nongeniculate coralline algae
Ns	night search
OCT	Overseas Countries and Territories
PICTs	Pacific Island countries and territories
PROCFish	Pacific Regional Oceanic and Coastal Fisheries Development project
PROCFish/C	Pacific Regional Oceanic and Coastal Fisheries Development project (coastal component)

RBt	reef-benthos transect
RFID	Reef Fisheries Integrated Database
RFs	reef-front search
RFs_w	reef-front search by walking
SBq	soft-benthos quadrat
SCUBA	self-contained underwater breathing apparatus
SD	standard deviation
SE	standard error
SPC	Secretariat of the Pacific Community
TAC	total allowable catch
TML	Te Mautari Limited
UNDP	United Nations Development Programme
USD	United States dollar(s)
WHO	World Health Organization

1. INTRODUCTION AND BACKGROUND

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

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

1.1 The PROCFish and CoFish programmes

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

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

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

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

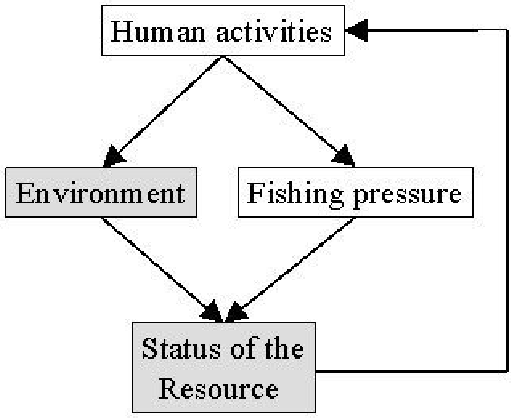

Figure 1.1: Synopsis of the PROCFish/C* multidisciplinary approach.
PROCFish/C conducts coastal fisheries assessment through simultaneous collection of data on the three major components of fishery systems: people, the environment and the resource. This multidisciplinary information should provide the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

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

Expected outputs of the project include:

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

1.2 PROCFish/C and CoFish methodologies

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

1.2.1 Socioeconomic assessment

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

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

Socioeconomic assessments also relied on additional complementary data, including:

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

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

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

1.2.2 Finfish resource assessment

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

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

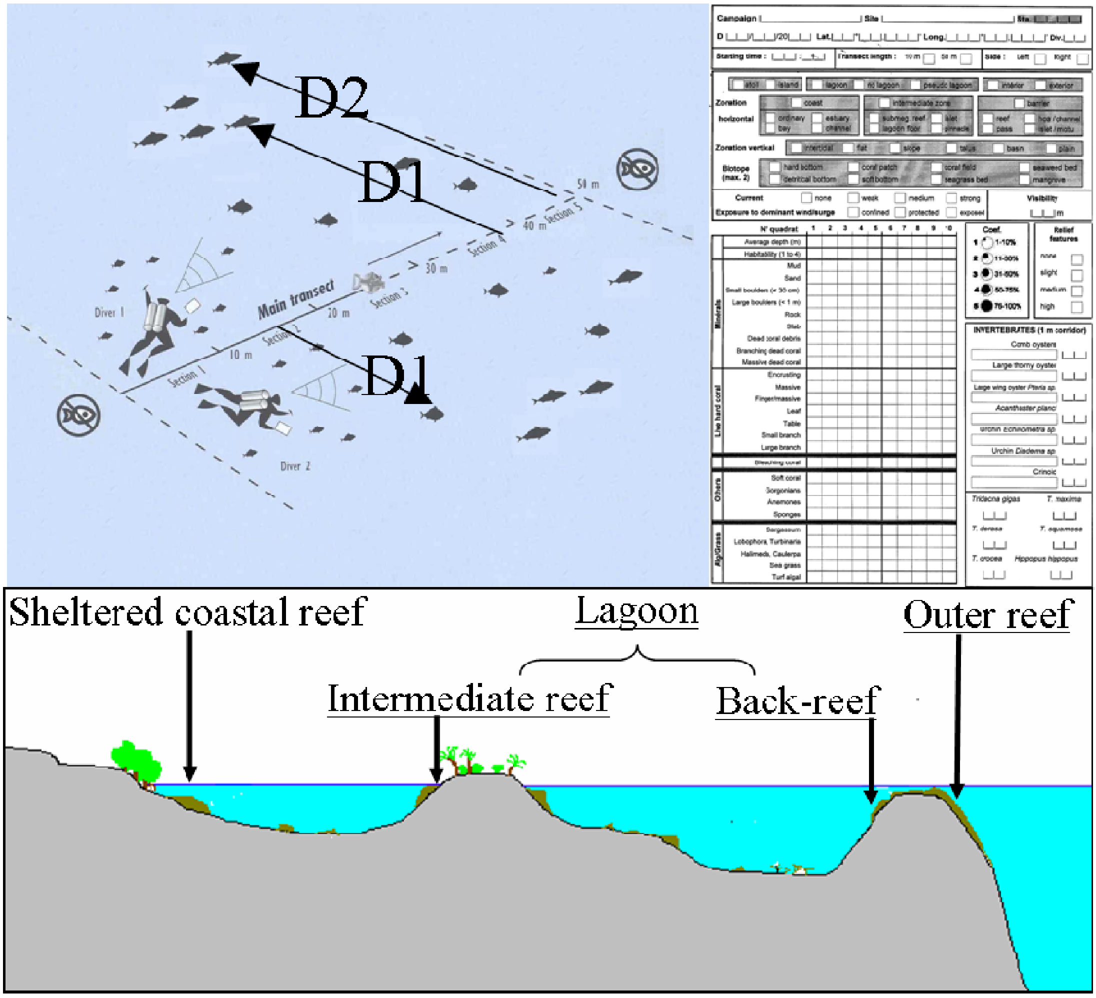

Figure 1.2: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver recorded the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys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

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

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

1.2.3 Invertebrate resource assessment

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

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

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

The main objective of the broad-scale assessment was to describe the large-scale distribution pattern of invertebrates (i.e. their relative rarity and patchiness) and, importantly, to identify target areas for further fine-scale assessment. Broad-scale assessments were used to record large sedentary invertebrates; transects were 300 m long × 2 m wide, across inshore, midshore and more exposed oceanic habitats (See Figure 1.3 (1).).[4]

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

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

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

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

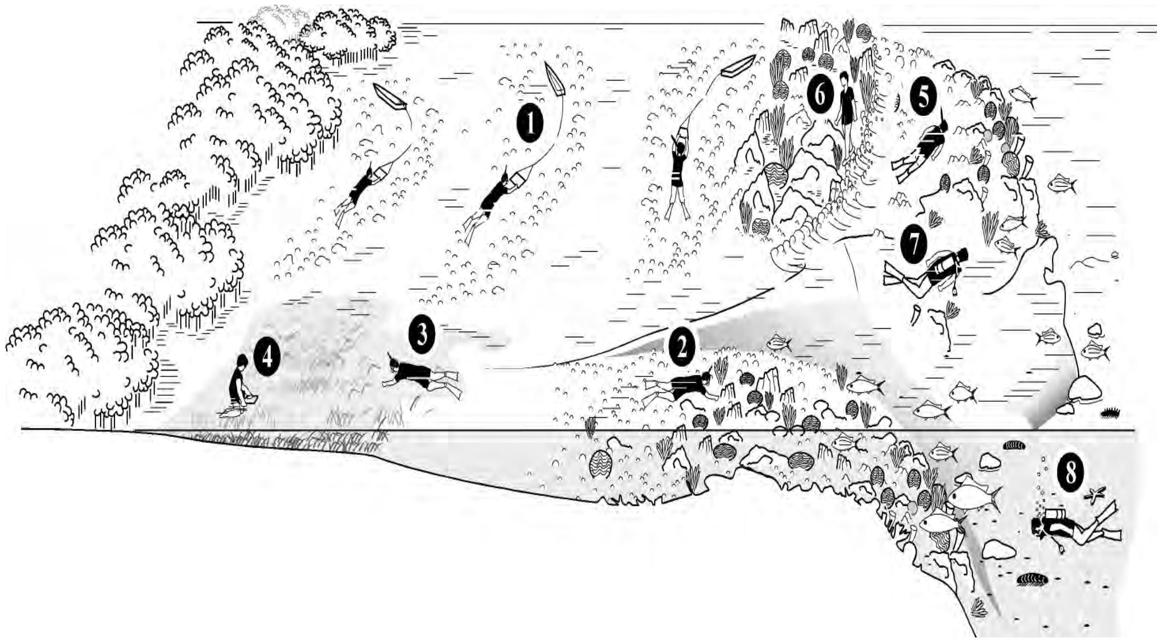

Figure 1.3: Assessment of invertebrate resources and associated environments.
Techniques used include: broad-scale assessments to record large sedentary invertebrates (1); fine-scale assessments to record epi-benthic resources and potential indicator species (2) and (3); quadrats to count targeted infaunal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

1.3 Kiribati

1.3.1 General

Kiribati is an archipelagic nation comprising 33 low lying coral atolls (with the exception of Banaba), widely dispersed over a vast area of the central Pacific Ocean. The country straddles both the Equator and the International Dateline, lying between 174°E and 152°W longitude and between 6°N and 9°S latitude respectively (Figure 1.4). Kiribati has a total land area of 811 km^2 and an Exclusive Economic Zone (EEZ) of almost 3.6 million km^2. Kiribati is divided into three widely separated island groups – the Gilbert Group in the west, the Phoenix Group in the centre, and the Line Islands in the east (Anon. 1994, FAO 2008, SOPAC n.d.). Kiribati has maritime boundaries with Nauru, Marshall Islands, the USA in respect of Jarvis Island, Kingman Reef, Palmyra Atoll and Howland and Baker Islands, New Zealand in respect of Tokelau, Tuvalu, France in respect of French Polynesia, and the Cook Islands (FFA n.d.).

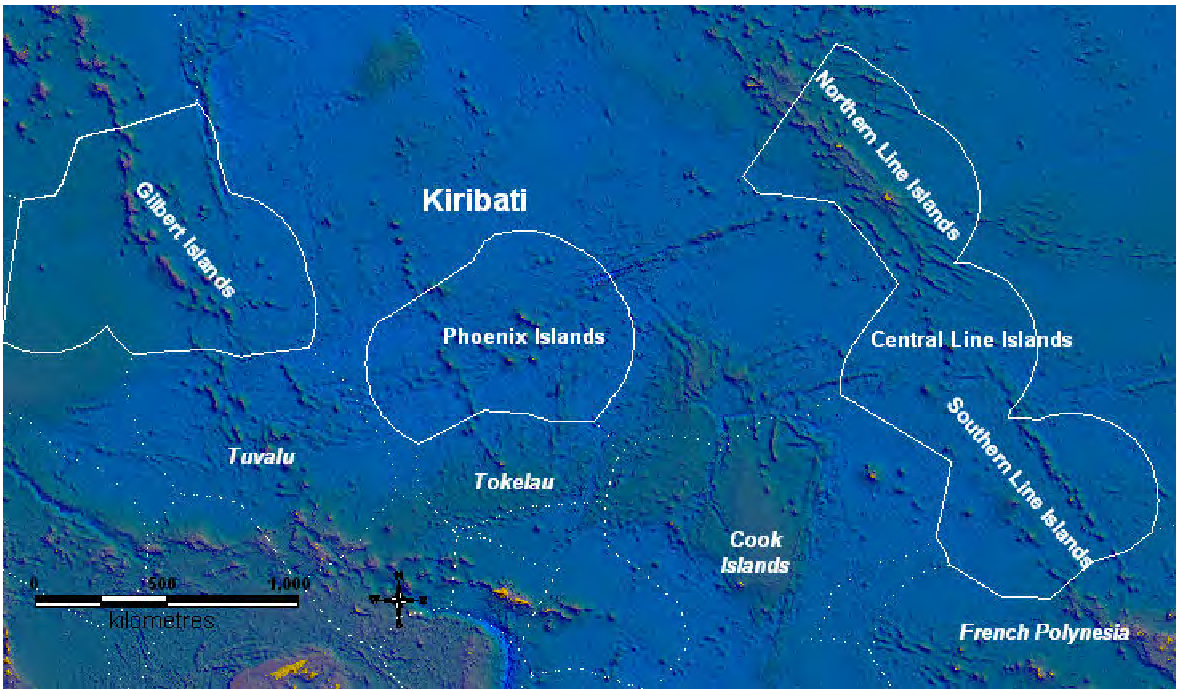

Figure 1.4: Map of Kiribati.

All the islands of Kiribati are of coralline origin and are surrounded by fringing or barrier coral reefs. As coralline structures, they possess few elevations above four metres. Kiribati is, therefore, a nation whose very existence is threatened by a possible rise in sea level due to global warming (Fisheries Division 2003).

The Line Islands, Phoenix Islands and Banaba have a maritime equatorial climate, but the islands further north and south are tropical. Temperature varies between 25 and 33°C. The wet season extends from December to May and rainfall variation is high in most of the islands. Mean annual rainfall ranges from 1250 mm near the equator to 3000 mm in the north. Typhoons are prevalent (November – March), and there are occasional tornadoes (Turner 2007, Kiribati National Statistics Office 2008).

The 2005 population figures show a population of 92,533, a total population density of 127 people per km^2 and a de facto growth rate of 1.8%. The 2005 population figure is an increase of 9.5% or 8039 people from the 2000 figure of 84,494 people. According to the 2005 census, population density varied widely from island to island. For example, Kiritimati had only 13 people/km^2, while South Tarawa had 2558 people/km^2. The increase in the population in North Tarawa was the most noticeable, as well as in the Line Islands, in particular Tabuaeran and Kiritimati. Several islands experienced a population decline, including Kanton, Beru, Tamana, Maiana, Butaritari, Abaiang, and Onotoa. In terms of numbers, the largest increase occurred in South Tarawa, with an increase of 3594 people. South Tarawa's resident population was 40,311, representing 44% of the total Kiribati population. The population of the Outer Islands of the Gilbert Group was 43,372 people, while the population in the Line and Phoenix Group Islands was 8850 people (SPC Statistics and Demography Programme and Kiribati Statistics Office 2007).

The Gilbert Islands were granted self-rule by the United Kingdom in 1971 and complete independence in 1979 under the new name of Kiribati. The United States relinquished all claims to the sparsely inhabited Phoenix and Line Island groups in a 1979 treaty of friendship with Kiribati (CIA 2008). The country is a sovereign democratic state with a 42-member *Maneaba ni Maungatabu* (House of Parliament), elected every four years. The *Beretitenti* (President) is elected from among three or four candidates nominated by the *Maneaba* from its ranks. The *Beretitenti* chooses a twelve-member cabinet from the *Maneaba*. The country is a member of the Commonwealth and adopts the Westminster model of government (Kiribati National Statistics Office 2008).

The country's economy is predominantly subsistence. In 2002, agriculture accounted for 14.2% of the Gross Domestic Product (GDP), industry 10.9% and services 74.9% (Turner 2007). Revenue from the licensing of foreign vessels in the Kiribati EEZ was USD 21 million in 1999 (Gillett and Lightfoot 2001). Tourism plays a fairly modest role in the Gilbert Islands but in the Northern Line Islands, especially Kiritimati Island, tourism has a high priority (Kiribati National Statistics Office 2008). Total imports in 2003 were AUD 79.5 million. The main imports were foodstuffs, machinery and equipment, manufactured goods and fuel. In 2001 the import sources were Australia (26.5%), Poland (15.7%), Fiji Islands (14.8%), and the United States of America (9.5%). The total exports in 2003 were AUD 4.5 million (Turner 2007). The main exports from Kiribati were copra, seaweed, and fish. Export markets in 2001 were Japan (45.8%), Thailand (24.8%), South Korea (10.7%), and Bangladesh (5.5%) (Turner 2007).

A recent study by the Asian Development Bank estimated that the fishing contribution to GDP was about USD 11.7 million (Gillett 2002). This equates to 21.5% of GDP. This appears to be considerably higher than the fishing contribution of any other Pacific Island country. Exports of fishery products were valued at USD 1,485,160 in 1999. This represents 16.9% of the value of all exports from the country in that year (FAO 2008).

1.3.2 The fisheries sector

Kiribati's fisheries comprise the offshore fishery for tuna and other pelagic species, and the reef fishery for a range of fish and invertebrate species.

Subsistence and small-scale artisanal fishing are conducted throughout the Kiribati islands. Surveys by the Fisheries Division indicate that 88% of the households in Kiribati participate in fishing. Of those that do fish, 17% fish commercially full-time, 22% fish commercially part-time, and 61% fish only for subsistence. The 1995 census showed that the main source of cash income for 29% of the 11,920 households in Kiribati was fishing (FAO 2008, Gillett 2002). Fishing techniques include bottom handlining, trolling, pole-and-line fishing, mid-water handlining, spearing, trapping, netting and reef gleaning (Fisheries Division 1995). Fishing craft include traditional canoes driven by sail or paddle, plywood canoes powered by outboard motor, and outboard-powered skiffs. In the outer islands especially, customary obligations relating to the sharing of catch among family and kinship groups are practised. Small-scale commercial fishing is concentrated around Tarawa where there is a large population, ice and cold store facilities, and a cash-oriented economy. The commercial fish catch from the coastal zone is principally made up of reef and deep-slope fish (54%), molluscs (25%), and pelagic species (21%) (FAO 2008, Gillett 2002).

Although they are declining, fisheries resources remain an important part of the Pacific region's wealth. The export of seafood by Kiribati has increased since 1979 during post independence. Early development plans were directed at the offshore fisheries; however, technical and financial problems shifted the focus inshore. This shift took into consideration the accessibility of the inshore resource and the low cost of capital investment involved. More companies now operate in the inshore sector than offshore. In 1999, 18 companies were operating in the inshore sector compared with only six operating offshore. Inevitably, this shift has increased the rate of exploitation of various coastal and reef resources to such an extent that these resources have been reduced to a critical level (Fisheries Division 1999).

Offshore tuna fishery

Foreign fishing vessels

Kiribati is located in the rich tuna fishing grounds of the central Pacific. From 1950 to 1961, the Pacific Ocean Fishery Investigations of the United States Fish and Wildlife Service conducted a range of tuna fishing survey cruises, mainly in the Phoenix Islands and Line Islands, using experimental longlining, trolling, pole-and-line and purse-seine gears (Kleiber and Kearney 1983). Also in the 1950s and 1960s, Japanese distant-water longliners fished in the waters around Kiribati, first fishing in the Gilbert Islands and then extending to the Phoenix Islands and Line Islands (Langley 2003). In the mid-1960s, Korean and Taiwanese longliners also started fishing in Kiribati waters. During the 1970s, Korean fishing effort increased while Japanese and Taiwanese effort dwindled.

The 1970s saw several pole-and-line research cruises undertaken by the Van Camp Sea Food Company, the Japanese International Cooperation Agency (JICA), and the Food and Agricultural Organization/United Nations Development Programme (FAO/UNDP), mainly with mixed results, including poor live-bait catches (Kleiber and Kearney 1983). The SPC's Skipjack Survey and Assessment Programme conducted several tagging cruises in the waters around Kiribati, the first in July 1978 (Kearney and Gillett 1978) and the second in November/December 1979 (Hallier and Kearney 1980).

Kiribati declared its 200 nm EEZ in 1978, which meant that distant-water fishing nations (DWFNs) had to negotiate access agreements to fish in the waters around Kiribati. Japan signed a two-year agreement in mid-1978, and its vessels caught 12,250 t by pole-and-line and 2800 t by longline in 1980 (Chapman 2003). By 1984, Japanese, Korean and US vessels were working in Kiribati waters under access agreements. Catches and access fees increased considerably in the early 1990s as a result of the US purse-seine catch under the Multilateral Treaty, with the catch at 128,000 t in 1992 (access fee of AUD 12.9 million dollars) (Chapman 2003).

The 1990s saw a large increase in the number of foreign fishing vessels and nations wishing to operate in the Kiribati EEZ, with the main nations including Japan, Taiwan, Korea, the United States, and Spain. In 1999 a total of 132,391 t of tuna were caught by DWFNs, using primarily purse-seine gear. By the early 2000s, there were over 350 vessels from a dozen countries, with longline and purse-seine vessels making up over 90% of the vessels (Tumoa 2006). However, in 2005 there was a drop in vessel numbers to 282 compared to 356 in 2004. The drop was mainly in longliners (from 219 in 2004 to 163 in 2005) wishing to fish in the Kiribati EEZ (Tumoa 2006).

Kiribati entered the purse-seine fishery in 1994, when a joint-venture agreement was signed with Kao Fishing Company of Japan. From 1995 to 2000 this vessel caught 3000–6700 t/year of tuna, although little fishing was conducted in the Kiribati EEZ (Chapman 2003). Catches continued around the same level for this vessel during the period 2001 to 2005, with annual catches ranging from 4600 to 7105 t (Tumoa 2006).

The Government of Kiribati has also undertaken negotiations with potential joint-venture partners with the intention of establishing a longline fishing base for the production of fresh tuna for sashimi markets. It is hoped to service such a fishery using shore facilities of the former Te Mautari Limited (TML) (Ribanataake Awira pers. comm. July 2008).

Domestic industrial fishing activities

Domestic industrial fishing activity in Kiribati during the 1980s and early 1990s was dominated by TML, a wholly government-owned company established in 1981 to develop a pole-and-line tuna fishery in Kiribati's EEZ (Chapman 2003). TML started with two pole-and-line vessels, the first donated to Kiribati by the United Kingdom in 1979 and the second donated by Japan in 1980 (Chapman 2003). Two additional pole-and line vessels were acquired in 1983 by TML, with another two vessels constructed under EU funding in 1987, bringing TML's pole-and-line fleet to six vessels (Chapman 2003).

Technical and economic difficulties associated with Kiribati's remoteness, lack of infrastructure and variability in resource abundance, however, plagued TML's operations. Despite landing good catches in some years, the company rarely made a profit, and required continued government support. Since its establishment, TML was provided with assets and technical assistance with a value in excess of AUD 16 million, including six pole-and-line vessels, a refrigerated carrier vessel, cold stores, an ice plant and a wharf (Ribanataake Awira pers. comm. July 2008).

TML's best production was reached in 1989 with a catch of 2272 t. In 1990 TML's fishing vessels were relocated to Solomon Islands but catches there were insufficient to cover operating costs (Chapman 2003). In 1991, following the accumulation of losses totalling ~AUD 8 million, the company's board suspended operations. Since that time four fishing vessels, the carrier vessel and a cold store were refurbished with donor assistance. The fleet operated intermittently in the Gilbert Group and in Solomon Islands. In the late 1990s the refrigerated carrier vessel was leased for operations in other countries and became the sole source of income for TML. The company ceased operations in 2000 (Chapman 2004).

Coupled with the development of the pole-and-line fishing operations were production trials for cultivating milkfish (*Chanos chanos*) as live bait for the fishing operations (Gopalakrishnan 1977, 1978). Problems were encountered with the transporting of the bait from the farms to the vessel used for the fishing trials, although the milkfish were found to be hardy once in the bait wells. During fishing trials from November 1977 to February 1978, 1554 kg of milkfish, 7–17 cm in length, were provided from the farm, with the bait assessed as being successful for pole-and-line fishing operations (Gopalakrishnan 1978). Milkfish cultivation for bait continued during the 1980s and 1990s and ceased for this purpose when the pole-and-line fishing operations stopped (Chapman 2004).

The TML facilities were refurbished in the early 2000s through Japanese aid, and a new company, Central Pacific Producers (CPP), was created for tuna and coastal reef fishing operations, incorporated in May 2001. CPP inherited all of the assets and liabilities of existing government commercial fishing projects, to place them all under one company, and included vessels (including TML's old cargo vessel) and agency services (being agent for crewing foreign vessels and providing stevedores for transshipment of fish), central fish markets (including outer island fisheries projects and fish centres), and the Kiritimati branch (Chapman 2003).

Part of CPP's operations in the early 2000s was to undertake small-scale tuna longline trials using a 12 m twin-hull vessel designed by an FAO naval architect and constructed in 1998/1999. SPC was asked to provide technical assistance with the rigging of this vessel and initial fishing trials (Sokimi *et al*. 2001). This work was undertaken from 1998 to 2000, with 13 fishing trips undertaken, six by the fisheries department and seven with assistance from SPC (Sokimi *et al*. 2001). The trials were encouraging and assessment of the vessel highlighted some faults in design and fitting out that would be corrected in the construction of the next vessel using this design (Chapman 2004). The new vessel was built in 2002 and moved to Kiritimati Island for tuna longline trials in 2003. SPC assisted with the initial fishing trials in late 2003, although only three longline sets were made due to logistical problems and the availability of equipment (Beverly 2004). The fishing operations of the small-scale longliner ceased in 2004 due to a lack of funds to keep the fishing trials going (Tumoa 2006).

Small-scale tuna fishery including fishing around FADs

The small-scale tuna fishery is made up of private fishers using locally built sailing canoes to fish offshore, while other fishers equipped their own 5–6.5 m skiffs with outboard engines and regularly fished for skipjack and yellowfin about 6–8 km offshore. In the late 1970s and early 1980s, these vessels annually caught 700–800 t (Chapman 2003). In support of developing this fishery, in 1983 the fisheries department requested assistance from FAO/UNDP to develop suitable fishing craft for this fishery. During the rest of the 1980s, several outrigger canoes were designed, constructed and trialed, with good success and acceptance by local fishers. Some outrigger canoes were powered by sail, while others were powered by outboard motors (Gulbrandsen and Savins 1987). By 1992, it was estimated that more than 550 outrigger canoes of different FAO designs had been constructed (Chapman 2003).

FADs were first introduced to Kiribati in 1988, with the deployment of 12 FADs around Tarawa and adjacent islands, with further deployments in 1989 and 1990 (Chapman 2003). Fishers quickly learnt the benefits of fishing around the FADs; however, the lifespan of the FADs was limited, with many lost within a year of deployment. The FAD programme was extended to the Line Islands with eight FADs deployed from 1989 to 1993; however, most had a short lifespan (Chapman 2003).

In pursuit of developing small-scale tuna fishing, the fisheries department conducted some small-scale tuna longline trials from the department's 8.5 m skiff. The trials produced 81 fish from 23 sets of a short, 3–6 km line with 70–150 hooks (Chapman 2003). In some cases, one end of the longline was attached to an FAD, and these sets produced the best catches. SPC was asked in 1988 for assistance with these trials, and this was provided from March 1989 to May 1990, with 139 fish caught during 30 fishing trips (Wellington unpubl.).

Vertical longlining was the next small-scale tuna fishing method to be trialed. Initially the trials were to be conducted around FADs; however, no FADs were in the water at the time of the trials. From December 1995 to June 1998, the fisheries department conducted 30 trips to trial vertical longline gear, with encouraging results (Tinga 2002). It was also concluded that catches would have been greater if FADs were available to fish around with this gear. Also in the late 1990s, the fisheries department started exploring options for small-scale longlining, and commenced the construction of a 12 m twin-hull vessel designed by FAO (See section above.).

The troll fishery for skipjack and small yellowfin tuna continues today with over 100 vessels from South Tarawa involved. Awira (2004) reports that, in 2003, there were over 1000 skiffs in the country and the total landings of these vessels was close to 2000 mt in 2003, a decrease of around 4000 mt from the 2002 catch. When looking at the South Tarawa fleet, a value of around AUD 170/trip (Riinga 2005) is estimated for the catch.

There are no charter boats for gamefishing in Kiribati waters, although there are around 15 private sector vessels belonging to the Betio game-fishing club (Whitelaw 2001) and they hold monthly tournaments. There is a well developed sports fishery on Kiritimati Island based on flyfishing for bonefish, as well as other species (Chapman 2004).

Flying fish

Traditionally, a neatly bundled dry coconut frond was set alight and used from paddling outrigger canoes as a light for the night-time catching of flying fish using a scoop net. In the 1970s and 1980s, light was provided by lanterns for this fishing method, although the scoop net remained the same (Chapman 2004). More recently, outboard-powered skiffs were used to catch flyingfish, with lighting provided by battery-powered lights.

In the 1980s, 20–25 mm gillnets were introduced to catch flying fish outside the reef in the late afternoon and early evening (4–7 pm), when the flying fish schooled (Tebano and Tabe 1993). This method is still practised by some male fishers.

Deep-water fisheries – deep-water snapper

Deep-water snapper fishing is not traditional in Kiribati; however, occasionally paddling canoes would drift into deeper water while bottom handlining outside the reef. The first deep-water snapper fishing trials were conducted in 1980 by SPC at the request of the Government of Kiribati. Fishing was centred around Tarawa (14 trips), although survey trips were made to the nearby islands of Maiana (3 trips) and Kuria (6 trips). Many local fishers as well as fisheries department staff were trained in the rigging of deep-water snapper fishing gear and in the fishing technique (Taumaia and Gentle 1983).

Following the success of the first fishing trials, SPC was requested to introduce deep-water fishing techniques to other islands in Kiribati, and assess the suitability of several canoe designs for this fishing method. This work was undertaken in 1984, with trial fishing and training occurring in Tarawa, Abaiang, Abemama, Arorae and Tamana in the Gilbert Group, and Kiritimati Island in the Line Islands (Taumaia and Cusack 1997). The project was successful and most canoe designs were assessed as suitable for this fishing method. The fisheries department continued training activities in this method in the mid-to-late 1980s through their demonstration team, to introduce this method throughout the country (Tinga 2003).

An assessment of the fishing results of SPC's deep-water snapper fishing trials in Kiribati was undertaken by Dalzell and Preston (1992) and it was estimated that, for the Gilbert

Islands, a maximum catch of 55–165 t/year was possible for this fishery. However, today there is basically no consistent targeting of deep-water snappers, although some fishers do this on an *ad hoc* basis when tuna are scarce or weather conditions suit (Chapman 2004).

Deep-water shrimps

A 1985 preliminary stock assessment by SPC identified seven species of deep-water caridean shrimp: smooth nylon shrimp (*Heterocarpus laevigatus*), armed nylon shrimp (*H. ensifer*), humpback nylon shrimp (*H. gibbosus*), an unidentified *H.* sp., golden shrimp (*Plesionika martia*), *P. carinata?*, and an unidentified *P.* sp. *H. laevigatus* and *H. ensifer* together made up about 64% of the stock, and were the only two species likely to have any commercial significance. However, the surveyors in 1985 did not think the low population size would support a commercial fishery (Cruz and Preston 1987).

Aquaculture and mariculture

Although aquaculture has been practised traditionally in Kiribati to culture milkfish, most aquaculture and mariculture have been undertaken to either restock declining populations, provide a food source, or provide a potential means of income generation.

Trochus

Trochus (*Trochus niloticus*) is an exotic species introduced to Kiribati from Fiji. Natural/induced spawning and rearing of these species was undertaken in the fisheries division's hatchery. Approximately 4000 reared juvenile trochus were released in Marakei, Tarawa and Abaiang outer reefs (Fisheries Division 2003). Resture (2001) notes that it has proven difficult to check the survival of animals on the reef. The restocking is aimed at providing income opportunities for islands with limited lagoon systems. Future plans include stocking non-lagoonal islands of Kiribati first before moving on to other islands (Fisheries Division 2003).

Cockles

Growth trials of the cockle (*Anadara* sp.) in some islands has been initiated with assistance from the University of the South Pacific Atoll Research Unit (Anon. 1982).

Milkfish

Milkfish (*Chanos chanos*, *baneawa*) culture has been a tradition in the Gilbert group, practised by private individuals for subsistence purposes. There are no freshwater fisheries in Kiribati. Impoundment of milkfish fry at spring tides occurs in brackish-water lagoons on some islands, and the fish are subsequently harvested after growing to a larger size. No special techniques have been reported, and the main effort has been to collect the fry and introduce them into the ponds (Gopalakrishnan 1977; Gillett 2002). Several projects were conducted on the culture of milkfish to be used as bait and food mainly in Tarawa, Temaiku/Ambo fish farm, and Kiritimati. An 80 ha milkfish farm was established by the government on South Tarawa in the late 1970s to produce bait for the domestic pole-and-line fishery. Currently, Hawaii, Kiribati and Fiji Islands are the only Pacific countries culturing milkfish. Hatchery-reared juveniles in Kiribati are exported to Fiji Islands (SPC 2008). Fish are harvested for local consumption and for export by air to Honolulu (Gillett 2002, Mees *et al*. 1988).

Mojarra

The common *mojarra*, *Gerres argyreus*, is found in the Tarawa lagoon and has been polycultured with milkfish and mullet (SPC 2008).

Mullets

In 1987, mullet was included in the culture programme at the Temaiku fish farm. The initial emphasis was on fingerling collection and transport to the farm (Anon. 1987). In 1989 the culture of the mullet species *Valamugil seheli* and *Liza vaigiensis* was carried out. This involved the collection of mullet fingerlings from the lagoon by seine net, stocking in the rearing pond and feeding with copra cake (Tikai 1989).

Brine shrimps

Brine shrimp (*Artemia salina*) was imported for trials in the ponds of Kiritimati Island in 1971 (Anon. 1974). Several recommendations were put forward by consultants regarding the feasibility of the project. Production was encouraging but constraints attributed to physical and biological parameters, such as the heavy rainfall experienced in 1976, and the management of the culture system, led to a halt of the brine shrimp project in 1978 (SPC 2008).

Prawns

Trials in rearing and breeding of commercially valued species, such as the tiger prawn (*Penaus monodon*), are ongoing at the Ambo hatchery, with results expected in 2007 (SPC 2008).

Bêche-de-mer (sea cucumbers)

Sea cucumbers have been successfully hatchery-reared by Kiribati fisheries division staff. The hatchery's main objective is to maximise the production of two specified species (*Holothuria Microthele nobilis* and *H. fuscogilva*), and to restock the inshore waters of Kiribati as a means of income generation. The scientific findings will be used as baseline information for the development of mariculture research and a sustainable cottage industry. Successful spawning and rearing techniques have been established and attained by local staff. Approximately 140,000 juveniles of sea cucumber *H. fuscogilva* have been reared and released in Tarawa lagoon and in Abaiang in 2003. Plans are underway to reseed or release hatchery-reared sea cucumbers in all islands of Kiribati (Fisheries Division 2003).

Seaweed

Eucheuma seaweed, the source of carrageenan gel, which is used in the food, pharmaceutical and cosmetic industries, was introduced to Kiribati from the Philippines in 1977. Species used were *Eucheuma cottonii* and *E. spinosum*. Commercialisation began in the 1980s following numerous trials on farming methods and marketing (Fisheries Division 1989). Cottonii seaweed (*Kappaphycus alvarezii*) has successfully been produced over 10 years in

12 different atolls within Kiribati, from the far north to the far south of the Gilbert group and in the northern Line Islands (Teitelbaum 2002). Farms have been established in suitable atolls throughout the country's three island groups. The seaweed is harvested after 45–60 days, sun-dried and packed into bales for shipping. Commercial exports commenced in 1990 when the government-operated Atoll Seaweed Company was established to foster this industry, and 100 t were shipped to Denmark. Production increased significantly in 1995 following the establishment of a new programme of technical support by the government. Production in 2000 was 1435 t, of which 1381 t came from the Line Group. In addition to Denmark, the seaweed is exported to other European countries, New Zealand, and the United States (Gillett 2002, Anon. 1984, Why 1985). Total dry weights of seaweed recorded for 2003, 2004 and 2005 were 490, 638, and 304 t respectively. The harvest was mostly from the Line Islands (SPC 2008).

Tilapia

Tilapia (*Oreochromis mossambicus*) was introduced to inland fisheries in 1963. Fingerlings were stocked in existing ponds in Tarawa and the outer islands. The purpose for introducing this species was to cultivate it as bait and food fish. The fish is now considered a pest in Kiribati and, since its introduction, the milkfish population has been greatly reduced (Anon. 1984). Efforts were made to eradicate tilapia as it was not accepted as food by I-Kiribati. Currently, tilapia is being used for alternative purposes, such as livestock feed, a component of fish meal, and fertiliser (SPC 2008).

Reef and reef fisheries (finfish and invertebrates)

Coral reef habitat

Coral reefs play a vital role for inshore fisheries since they provide the necessary habitat for finfish and invertebrates. The main factors that affect coral reefs and related marine resources in Kiribati are pollution from sewage, coastal erosion (sediment), causeway construction, reef blasting to create boat channels, coral mining for seawalls, and shipping/boat and fishing activities (anchorage on coral heads). Aware of the need for baseline data on coral reefs and fisheries resources, the Fisheries Division is currently conducting stock assessment surveys of the coral reef resources, mainly finfish on one or two islands. Extending the surveys to other outer islands is hampered by the lack of finance. Information gathered from these surveys is useful for the proper management of coral reef resources (Anon. n.d.). In 2003 a programme of coral reef monitoring began at Abaokoro, Tarawa to check on coral transplanted to restore the reef after strong wind damage in 2002 (Fisheries Division 2003). The Fisheries Division is focusing on further research work to assess the relative abundance and distribution of coral and finfish resources (Anon. n.d.).

The Environment and Conservation Division (2004) notes that 300–400 species of fish and an unknown number of invertebrates are recorded from Kiribati reefs, lagoons and nearshore coastal waters. Below is a summary of finfish and invertebrate resources.

Milkfish

Chanos chanos is important throughout Kiribati, especially in the atolls. Capture is mainly by netting, often in association with fish drives (Preston 2008). Heavy fishing, environmental degradation and coastal development in Tarawa, Kiritimati and elsewhere have led to declines in milkfish populations and reduced catches. Enforcement of management measures such as a ban on fishing drives, and restriction on harvest within conservation areas (in Kiritimati) has been difficult. The traditional aquaculture of milkfish is practised on a community basis. The government has established milkfish farming operations in Tarawa as discussed under the aquaculture section (Environment and Conservation Division 2004).

Bonefish

Bonefish, *Albula glossodonta*, are of traditional importance in the atolls and captured in nets in the same way as milkfish, and often together with them. Like milkfish, bonefish stocks have declined in some areas, especially in Tarawa, as a result of excessive fishing and coastal development (Preston 2008). Pleasure fishing for bonefish is one of the main tourist attractions in Kiritimati Island. Tourists pay a licence fee of AUD 35, which is valid for the duration of their stay. The catch-and-release technique of fishing is used in designated areas. The sale of bonefish is not encouraged. Despite this, fisheries officers note that significant numbers of bonefish are being caught for food in the lagoon and on reef flats. The Business Licensing Committee of the Ministry of the Line and Phoenix Group plan to completely ban the commercial harvest of bonefish from Kiritimati. To protect bonefish stock, management measures include: a ban on the sale of bonefish; increase in monitoring and surveillance of closed breeding and nursery sites; extension of the catch and release programme to supervised fisheries ponds; the release of bonefish from fisheries ponds to the wild to grow and breed; the inclusion of new breeding sites under fisheries conservation areas; and the inclusion under regulations of lunar closures for areas believed to be spawning sites for bonefish (Kiritimati Fisheries Branch 2001).

Live reef fish fishery

A specialised export operation targeting live reef food fish (LRFF) began operating in Kiribati in 1996. The operation took place from 1996 to 2004, and operated at various times in different locations, including at least four islands (Butaritari, Tabiteuea, Nonouti, Onotoa) in the Gilberts group and three (Tabuaeran, Teraina and Kiritimati) in the Line group. The export figures for the trade from Kiribati for the three companies show an increase in the level of export from 1996 to 1999. The highest ever recorded from the trade was almost 24 t valued at AUD 0.76 million (1999) and 5 t for 1996. As regards the level of catch from each island from 1997 to 1999, there was a dramatic decline in the level of production from one island. As there was no proper monitoring programme in the early stages of the trade, there is no information on how many fish were caught and how many died during captivity. The export composition shows that the major portion of exports (85%) mostly comprised Serranidae (*Epinephelus*, *Cephalopholis* and *Plectropomus* spp.) with wrasses (only *Cheilinus undulatus*) at 15% of the total volume exported from 1996 to 2001 (Awira 2006).

In 2004, the fishery came to an end after a serious outbreak of ciguatera poisoning in Hong Kong caused by fish caught in Kiribati (Preston 2008). While the fishery was active, local fishers and communities on some islands expressed concerns about declining target fish species and voluntarily limited their fishing efforts to reduce fishing pressure (Environment and Conservation Division 2004). Surveys carried out by the Fisheries Division in various islands indicate that the species targeted by the fishery were found to be greatly reduced in number in all harvest locations (Awira 2006). No management action has been contemplated for the fishery. Research has been carried out to establish ciguatera-testing protocols at fish collection sites within Kiribati with the intention of resuming exports (Fisheries Division 2006).

Aquarium fishery (pet fish or ornamental reef fishery)

The aquarium fishery commenced in Kiribati in early 1980. The trade was practised on Tarawa in the Gilbert Group and, in 1989, expanded to include Kiritimati Island in the northern Lines Group. In late 1990 the operation on South Tarawa was closed, leaving Kiritimati Island the only island in the country involved in the trade. The four main pet fish exported from Kiritimati Island are angelfish (Pomacanthidae), tangs and damselfish (Pomacentridae), wrasses (Labridae) and butterflyfish (Chaetodontidae), which are exported to Honolulu (Awira 2006).

Awira (2006) cites 2002 export figures that show that nine fish families were exported from Kiribati with the highest-value family being Chaetodontidae. For the same year a total of 130,479 pieces of fish were exported from the country with a total value of AUD 804,104. Of this total, 87% (114,130 pcs) were of angel fish (Pomacanthidae), valued at AUD 671,883.

There are six pet fish operators with valid export licences on Kiritimati Island. The fisheries sub-division on the island monitors the activities of these operators by collecting data from exporters and routinely checking the harvest techniques of divers. Despite these checks, divers are still harvesting the resource without proper regard for the marine environment and there are numerous reports of pet fish divers wrecking the reef during their operation. The fact that the Fisheries Division has no legal authority to penalise these divers means that no follow-up action is taken (Awira 2006).

Invertebrates

Coastal fisheries in Kiribati exploit a wide range of invertebrates for both subsistence and commercial purposes. Much collection is done by women and children, although men also participate in the fisheries, particularly for commercial or deeper-water species, such as sea cucumbers (Preston 2008).

Bêche-de-mer (sea cucumbers)

Kamatie (1993) states that, of the 14 commercially valuable (tropical Pacific) species of sea cucumber dried to produce bêche-de-mer, Kiribati has eight that are harvested for export markets. The resource exists throughout Kiribati but is more abundant in lagoon islands. Despite consultants' reports that the bêche-de-mer fishery is not feasible (due to low stock populations), the fishery has become one of the most important commercial fisheries for sedentary species in the country. A 1982 South Tarawa stock survey carried out by the Fisheries Division identified four commercial species: the prickly redfish (*Thelenota ananas – te uningauninga*), greenfish (*Stichopus chloronotus – te kirin*), black teatfish (*Holothuria nobilis– te romamma*), and the brown sandfish (*Bohadschia vitiensis – te uninganibakoa*). At the time, the Division was unable to determine whether it would be feasible to set up a cottage industry. In the same year a survey by the USP Atoll Research Unit identified seven commercial species (Kamatie 1993).

Exports began in 1989 and were on average 10 t per company per annum (7 companies). In 1992 this figure increased considerably, raising concerns in the Fisheries Division. A ban on collection by SCUBA diving is one way of restricting overharvesting (Fisheries Division

1995). Surveys conducted in 1999 on black teatfish (*Holothuria nobilis*) and white teatfish (*H. fuscogilva*) on Butaritari, Abaiang, Abemama, Nonouti, Aranuka, Tabiteuea North and Tabiteuea South showed that the density of these species had decreased due to excessive commercial exploitation (Kazu 1998). Monitoring techniques included collecting data on the quantities of bêche-de-mer exported. Kamatie (1993) states that, although bêche-de-mer exporters require a licence, harvesters and processers do not. In order to effectively manage the fishery, Kamatie suggests that there needs to be a control on all who are involved in the fishery. He recommends the establishment of a compliance unit in the research branch of the Fisheries Division; pulse fishing to prevent overfishing in a given area; a ban on SCUBA diving for collection purposes; and special storage cages and sheds.

Pearl oysters

The blacklip pearl oyster (*Pinctada margaritifera*) occurs throughout some of the islands of Kiribati and, from anecdotal information, it is believed to have flourished in the lagoons of Butaritari, Abaiang, Abemama, and Onotoa in the Gilbert group, Canton in the Phoenix group and Tabuaeran, Caroline and Kiritimati in the Line group (Kamatie *et al*. 1995). Stocks have been reduced to low levels due to harvesting for export and local shellcraft, such as fishing lures (Preston 2008). Stock surveys carried out in the 1990s in Abaiang, Butaritari, and Kiritimati showed low populations, an outcome of large-scale pearling expeditions in the 1980s (Sims *et al*. 1990, Preston *et al*. 1992). In Abaiang, Yeeting (1991) noted that there was a current regulation prohibiting the collection of the resource, but little enforcement. He writes that the Island Council can encourage enforcement and discuss the potential for pearl oyster farming and pearl culture. On Butaritari there was no current existing Island Council regulation, which could result in stocks becoming depleted. A moratorium on further harvesting was recommended by the Fisheries Division (Yeeting 1991). The Division has been attempting to establish pearl-farming operations for commercial and restocking purposes. After ten years of planning, research and development, the first pearl harvest at Abaiang atoll occurred in September 2003. The next harvest was expected in 2008 (SPC 2008).

Giant clams

There are four species of giant clams in the Gilberts group of Kiribati: *Tridacna gigas* (*te kima* or *te abuna*), *T. squamosa* (*te wera matai*), *T. maxima* (*te wera*) and *Hippopus hippopus* (*te nei toro*). *T. derasa*, *T. crocea* and *H. porcellanus* have not been reported in Kiribati (Rosewater 1965). A survey of the giant clam stocks of Abaiang, Abemama, Maiana and Tarawa Atolls in the central Gilbert Islands group was undertaken in 1985. The results showed that the clam stocks at Abaiang, Abemama, Tarawa and Maiana were relatively heavily used for domestic consumption and that stock densities at Tarawa were very low. None of the areas investigated were considered able to support any sustained commercial exploitation of the larger species for export (Munro 1988). Tekinaiti (1990) stated that the true giant clam (*T. gigas*) on four islands (Butaritari, Abemama, Nonouti and Tarawa) had been fished beyond its maximum sustainable yield and was already an endangered species (Fisheries Division 2003).

According to SPC (2008), one small-scale exporter of giant clams for the ornamental trade is currently based on Tarawa. The company is expanding its activity to a nearby island in Abaiang where giant clams occur in abundance.

Ark shells (te bun)

The ark shell or blood cockle (*Anadara maculosa – te bun*) inhabits sandy lagoon floors and seagrass beds and supports a fishery of traditional importance in several atolls, including Tarawa (Preston 2008). Harvests in Tarawa in 1992/1993 were 1000 t/year by subsistence collectors and a similar amount by commercial harvesters (PIMRIS 1995). Fay *et al.* (2007) believed that overharvesting led to resource depletion in Tarawa and other areas with catches estimated at 222 t/year in South Tarawa, about 10% less than catches in previous years. Awira (2006) notes unconfirmed reports of a fishery collapse. Fay-Sauni and Robinson (1999) write that, although research on marine resources is carried out, little of the information is reaching the fishers (mainly females) who harvest the resources on a daily basis. In recent years, women who harvest *te bun* have noticed a reduction in the size and number available. Women, therefore, need to be involved in the decision-making process regarding management of stock (sharing data and monitoring stocks) to ensure that harvesting of the ark shell is done in a sustainable manner.

*Peanut worms (*ipo*)*

The fishery for peanut worms (*Siphonosoma austral* and *S. indicus – ipo*) is substantial and is carried out primarily by women in most Kiribati atolls. Fishing occurs at low tide, when the worms are taken from their sand burrows using a slender stick or length of stiff wire. After the sand is expelled, the worms are threaded on a stick and sun-dried for later consumption or sale. Although an important fishery, there is little published information on peanut worms (Preston 2008).

Lobsters

Preston (2008) lists *Panulirus penicillatus* and *P. versicolor* as the two lobster species found in Kiribati. A small-scale lobster fishery supplies the hospitality industry of hotels and guest houses, mainly in Tarawa and Kiritimati. Fishers dive for the lobsters (sometimes using SCUBA), and harvest by hand or spear gun (Preston 2008). SPC surveys conducted in 1977 concluded that the rock lobster resources were under-used. Prescott (1977) suggested that the resource could be exploited by a small-scale, cottage-type industry serving an export market such as Nauru. He recommended regulations to impose minimum size limit on the catch, but noted that a total ban on the collection of females carrying eggs could restrict the developing fishery.

There are two licensed exporters of lobsters on Kiritimati Island. The existing fisheries regulations on lobster are maintained by inspections to ensure that the lobsters harvested do not carry eggs and are above the minimum size limit of 85 mm carapace length. However, inspectors noted with concern that female lobsters had been cleaned of their eggs. Recommendations for the improvement of management included prosecution of persons who have cleaned eggs from females, and an increase in minimum carapace lengths for both male and female lobsters to allow females to spawn many more times to improve recruitment into the fishery. There is the concern that, if existing management measures continue, the lobster fishery will be adversely affected (Kiritimati Fisheries Branch 2001, 2003).

Sea turtles

There are five species of turtles in Kiribati, including the green turtle (*Chelonia midas – te on*), hawksbill (*Eretmochelys imbricata – te tabakea* or *te borauea*), loggerhead (*Caretta caretta – te on nae*), Pacific ridley (*Lepidochelys olivacea – te on mron*) and, rarely, the leatherback (*Dermochelys coreacea*). Turtle nesting occurs on a number of islands, including some uninhabited islets in North Tarawa (Anon. 1980, Preston 2008). Turtle nesting occurs year round with two seasonal peaks: April – May and October – February (Anon. 1980).

Ciguatera

A survey of the Gilbert Islands was carried out in 1983 by USP Atoll Research and Development Unit to compile the names of the fish species considered ciguatoxic, identify the locations of reefs where the fish are caught, and assess the population density and the distribution of the causative organism (*Gambierdiscus toxicus*) on each island (Anon. 1984, Tikai 1988, Laurent *et al*. 2005). The results identified the following ciguatoxic fish species:

- moray eel (Muraenidae – *rabono*);
- red snapper (*Lutjanus bohar – ingo*);
- surgeonfish (Acanthuridae, notably *Ctenochaetus striatus – riba roro*, and *Acanthurus lineatus – riba tannin*);
- groupers and coral cod (Epinephelidae, notably *Promicrops lanceolatus – bakati*, *Epinephelus fuscoguttatus – maneku*, and *Cephalopholis argus – nimanang*);
- barracuda (*Sphyraena* sp. *– nunua*);
- small snappers (Lutjanidae, notably *Lutjanus monostigma – bawe* and *L. fulvus – tinaemea*);
- parrotfish Scaridae*– inai*, notably *Scarus pectoralis – ika maawa*)**;** and
- triggerfish (Balistidae – *nuonuo*, *bubu*).

The algal survey indicated the general presence of *Gambierdiscus toxicus* throughout the group. As a follow-up, the Fisheries Division is trying to discourage people from eating the suspected species and has produced a booklet to explain the ciguatoxic problem (Tikai 1988).

In 1989, samples of several fish species from each side (east and west) of the blasted channel (Nei Tebaa) on the ocean side of the Dai Nippon Causeway were collected in Tarawa by the Fisheries Division. The causeway links the islet of Betio and Bairiki in South Tarawa. The purpose was to set up a database on fish toxicity levels in the area, in an effort to safeguard the general public from risks associated with ciguatera fish poisoning. Prior to the construction of the causeway, fish in the area were considered safe to eat by fishers. A comparison between toxicity levels of fish collected before and after construction was made. It appears that toxicity levels of fish may have risen after the completion of the causeway, probably due to reef disturbance (Tebano 1992).

1.3.3 Fisheries research activities

The Fisheries Division undertakes fisheries and aquaculture research in Kiribati. The objectives of the Division's Research Unit are to conduct research on marine resources that have potential for development and to coordinate collaborative research activities with regional research organisations. Past and current research activities include: the seaweed growth-monitoring programme, monitoring of the bêche-de-mer fishery, giant clam stock assessment, and the pearl oyster collaborative project. According to Yeeting (1988), a lot of research has been carried out in the absence of a research policy. Past research has included studies of deep-bottom fish, deep-water prawns, tuna baitfish, pelagic fish species in the Line Islands, and other resources, as well as surveys of causeway impacts on fisheries (See Marriott 1984a and b; Mees 1985a and b; Mees and Yeeting 1985; Mees and Yeeting 1986; Yeeting 1986; Mees *et al.* 1988; Tekinaiti 1990; Tebano 1992; Kamatie and Awira 1994; and Kamatie *et al.* 1995.). Other work by the Division is included in their annual reports. The work carried out by other local (Atoll Research Development Unit) or external agencies (International Center for Living Aquatic Resources Management (ICLARM, now WorldFish Center), SPC, USP, James Cook University (JCU) and others) has been documented (See SPC reports by Devambez 1960; Prescott 1977; and Vunisea 2006; ICLARM report by Munro 1988; JCU reports by Kaly and Jones 1983 and 1996; Johannes *et al.* 1979; and Merrick n.d.). Work by others is referred to throughout this report. The Division's Aquaculture Unit is also involved in research aimed at eradicating tilapia from the Tarawa milkfish ponds (FAO 2008). Research in hatchery production and rearing of white teatfish sea cucumber (*Holothuria fuscogilva*), giant clam (*T*ridacna gigas) and trochus (*Trochus niloticus*) is still being carried out. Presently there are difficulties in acquiring suitable broodstock of sea cucumbers necessary for spawning. In addition, the broodstock collected has had a high mortality (SPC 2008). Financial constraints hinder research work on all islands.

Gender research on the tuna industry

Vunisea (2006) carried out a gender and socioeconomic analysis of the Kiribati National Tuna Development and Management Plan. The aim of the study was to gauge the benefits and implications of the tuna industry in Kiribati. The social considerations provided a broader framework for gender discussions. Because Kiribati does not have a well developed domestic tuna industry, Vunisea's (2006) study focused on direct and indirect factors and social impacts of the tuna industry. The report identifies both positive and negative aspects of the tuna industry and suggests vigorous education and training to prepare people for participation in the industry; cooperation between government and private sector stakeholders; and capacity building.

Women in fisheries support

In November 1989, a two-week workshop on women's role in fish processing was organised and conducted by the Ministry of Trade, Industry and Labour. Fisheries staff were involved as resource persons to assist the coordinators. The participants, mostly from Kiribati, were taught how to prepare and make new added-value fish products. The fish products included fish balls, fish sausages, salted tuna, fish cakes, and fish marinated in vinegar (Fisheries Division 1989).

1.3.4 Fisheries management

The Ministry of Fisheries and Marine Resources Development (MFMRD) is the government agency responsible for developing and managing the nation's marine resources. The Fisheries Division is the key agency dealing with marine resource development and management and is charged with undertaking research, data collection, project implementation, project evaluation, and the commercialisation and privatisation of marine resource projects (FAO 2008). Preston (2008) notes that the Fisheries Division has three technical branches: the oceanic fisheries branch (for tuna fishery licensing and access agreements, vessel monitoring system, and deployment of observers), the coastal fisheries branch (for development and management of coastal and inshore fishery resources), and the aquaculture research and development branch (for aquaculture projects). Fisheries management activities include resource assessment, monitoring, regulation and enforcement.

Regulations for specific resources exist only for lobsters and, since February 2008, for bonefish in Kiritimati. There are no size limits set for coastal marine resources other than lobsters, no quotas, no limits on the number of licences issued, no gear restrictions, and only two formal fishery management areas (North Tarawa and Kiritimati). A fisheries management plan for bêche-de-mer is in preparation but will probably be based on a national total allowable catch (TAC), which involves no spatial allocation and may lead to overharvesting in any given island. A management plan for the aquarium (pet fish) fishery is also being developed but using a TAC based on previous export volumes. Management measures used in other Pacific Island countries, such as size limits, closed seasons or protected areas, are not widely used in Kiribati (Preston 2008).

Fisheries legislation

The basic fisheries law is the *Fisheries Act (Cap. 33*). Under this Act, the Minister may take such measures as he may see fit to promote the development of fisheries and fishing in Kiribati to ensure that the fisheries resources of Kiribati are exploited to the full for the benefit of Kiribati. The Minister is empowered to appoint a Chief Fisheries Officer and licensing officers for the purposes of carrying out the provisions of the Act. The Act applies to the licensing of foreign fishing vessels, the conditions to be observed by foreign fishing vessels, the conservation and protection of all species of fish, prohibited fishing gear and methods and the organisation and regulation of marketing, distribution and export from Kiribati of fish and fish products. The *Fisheries Act* creates a regulatory framework for the operation of fish-processing establishments and the *Fisheries (Processing and Export) Regulations 1981* prohibit the export of fish or fish products without a certificate of quality issued by a licensing officer. The *Fisheries Act* contains a provision to protect such rights by prohibiting the taking of fish in any sea or lagoon area or on any reef forming part of the ancient customary fishing ground of any *kainga* (clan) or *utu* (family) or other division or subdivision of the people except by members of the *kainga* or *utu* or under a licence granted by the Minister in his discretion. The *Native Lands Code* also recognises various forms of customary tenure over fish traps, reefs and fish ponds, and there are less formal controls exerted on many of the outer islands by island councils. These controls may include, for example, restrictions on gear types (banning of monofilament gill nets on one island), and prohibitions of fishing for certain species. A licence is required for all local fishing vessels. The *Fisheries Act* prohibits the use of explosives, poisons and noxious substances for the purpose of catching fish, and it is an offence to possess explosives, poisons or other noxious substances in circumstances giving rise to a reasonable suspicion that the substance is intended to be used for fishing. The penalty for breach of this prohibition is a fine of AUD 1000 or imprisonment for five years (FFA n.d.).

There is little formal regulation of inshore fisheries in Kiribati, although, as noted above, traditional fishing rights, which often include traditionally enforced conservation measures, play an important role in Kiribati. Fishing is prohibited in certain areas of Kiritimati and the *Fisheries Conservation and Protection Regulations 1979* introduced minimum size limits throughout Kiribati in respect of rock lobsters (*Panulirus* spp.). Under the *Wildlife Protection Act (Cap. 100*), it is an offence to hunt, kill or capture wild turtles on land and the green turtle (*Chelonia mydas*) is fully protected throughout the Line and Phoenix Islands (FFA n.d.).

Although the *Fisheries Act* places responsibility on the Minister to promote the development of fisheries and fishing in Kiribati for the benefit of Kiribati, it has not, however, stipulated provisions for the conservation and protection of the resource or the need for sustainable development. Conservation has not been one of the primary objectives of the current legislation. There are legal provisions relating to conservation, but these are scattered among several pieces of legislation (Awira 2006).

1.4 Selection of sites in Kiribati

Four PROCFish/C sites were selected in Kiribati, three in the Gilbert Islands (Abaiang, Abemama and Kuria) and one in the Line Islands (Kiritimati Island) (Figure 1.5). These sites were selected for two reasons. First, these sites shared most of the required characteristics for our study: they had active reef fisheries, were representative of the country, were relatively closed systems[5], were appropriate in size, possessed diverse habitats, presented no major logistical limitations that would make fieldwork unfeasible, had been investigated by previous studies, and presented particular interest for Kiribati's Department of Fisheries. Second, there was a mix of marketing arrangements for the non-subsistence catch from road-side sales, to exports to Tarawa, the capital and main urban centre for sale, to export of some species to Hawaii in the case of Kiritimati Island.

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

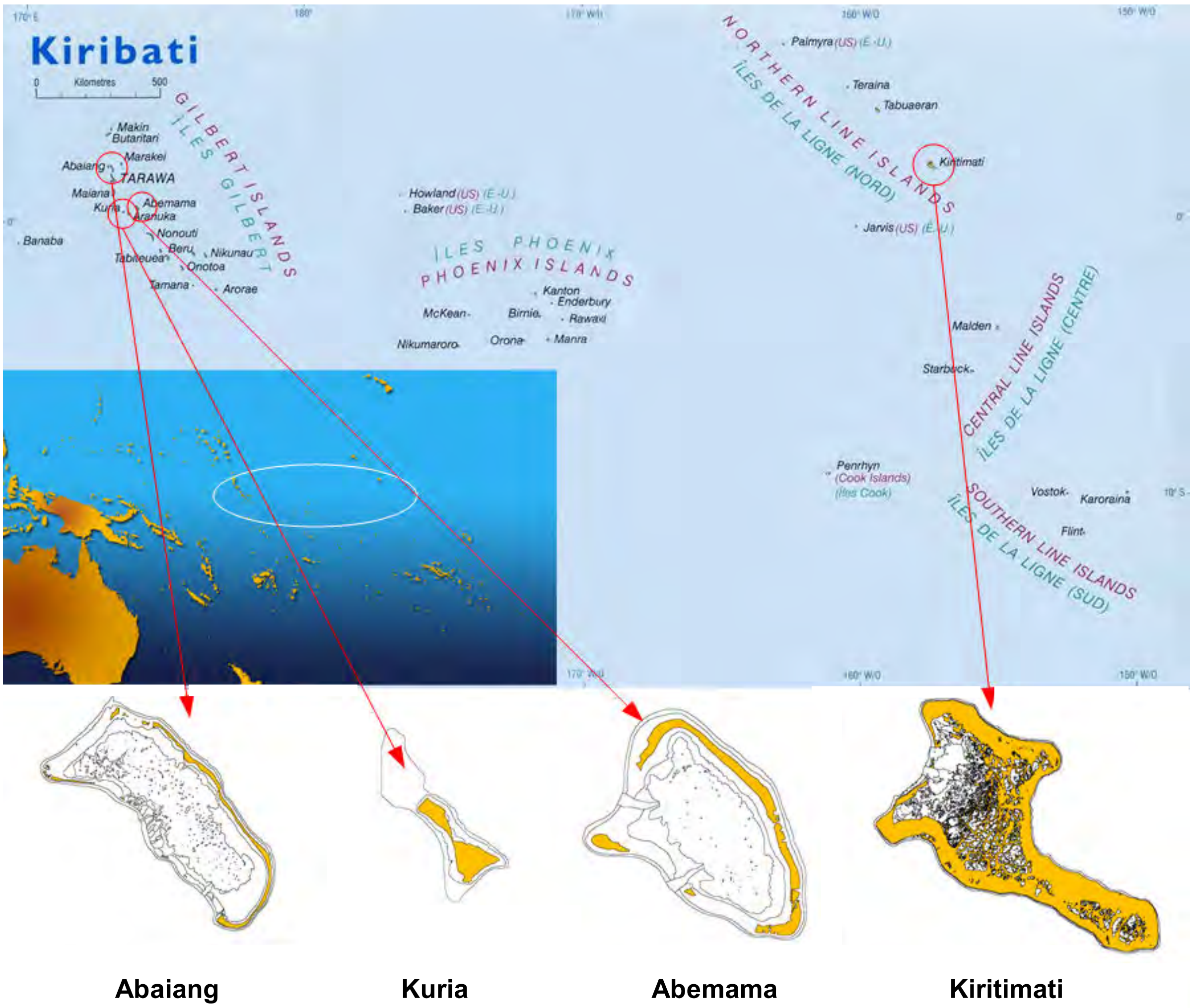

Figure 1.5: Map of the four PROCFish/C sites selected.

2. PROFILE AND RESULTS FOR ABAIANG

2.1 Site characteristics

Abaiang has a land area of ~17.5 km^2, and is located to the north of Tarawa, around four hours travel by boat or 15 minutes by plane (Figure 2.1). The lagoon is generally shallow but has pools to 25 m depth inside of the Bingham channel. Coral on the inside of the lagoon is found in patches and down to 25 m; the inside coastal reefs are subject to algae and silt. Channels and other small openings at the rim of the barrier reef do not appear to flush the whole lagoon, probably because it is so shallow and has reefs with many *motu*, and because the channels are relatively shallow. Water flow in channel locations is strong and the coral and reefs close to the passes are healthy. An extensive sandy zone gently slopes away from the coast, mostly at the southern end of the lagoon, while more patches of coral reef are found along the coast to the north of the lagoon.

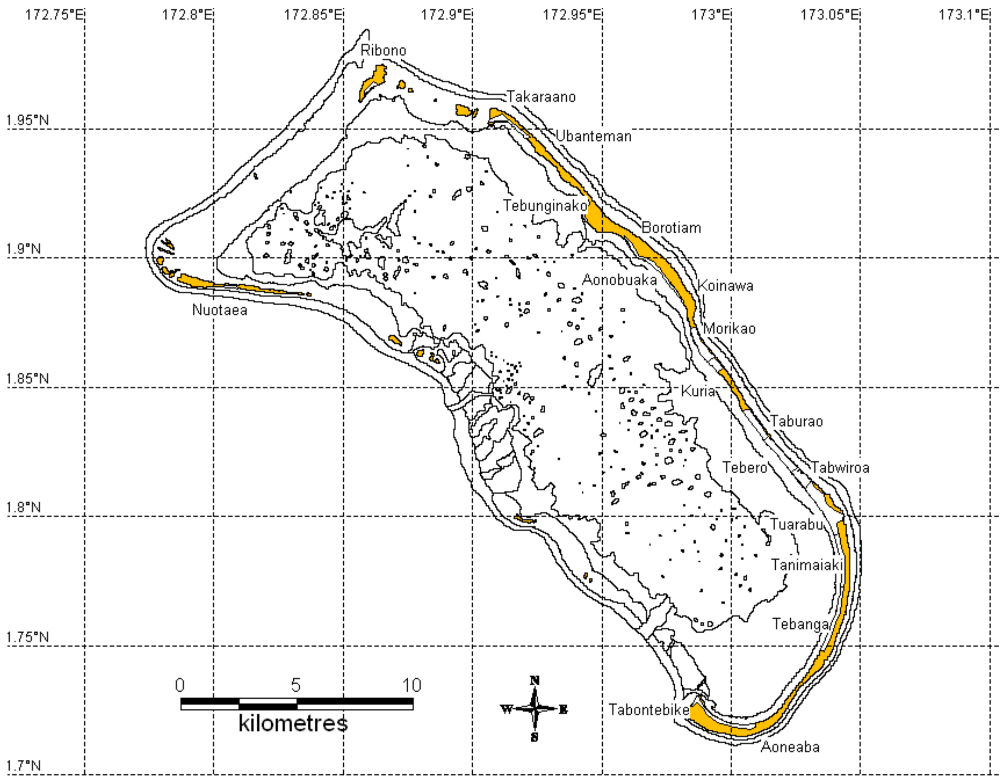

Figure 2.1: Map of Abaiang.

Fishing is commonly carried out either in the lagoon or outer-reef slope, especially on the side facing north Tarawa. The windward side of the main island is a fringing reef, which does not extend more than 100 m; fishing by walking (collecting), spear or rod off the edges of the fringing reef is limited to periods of calm weather when the characteristic swell is absent. Accessibility to the windward side is restricted as there is no pass in the immediate vicinity of the main island.

2.2 Socioeconomic surveys: Abaiang

Socioeconomic fieldwork was carried out on the island of Abaiang in the beginning of October 2004. The survey covered the four villages of Borotiam, Noutaea, Tabonetebike and Taburao. In total, 25 households and 175 people were interviewed. Thus, the survey covered about 3% of the households (~840) and total population (~5900 people).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 23 individual interviews of finfish fishers (males only as females did not seem to be engaged in finfish fisheries) and 22 invertebrate fishers (13 males, 9 females) were conducted. These fishers belonged to one of the 25 households surveyed. Sometimes, the same person was interviewed for both finfish fishing and invertebrate harvesting.

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

Our survey results suggest an average of 2.5 fishers per household, although this number varies among all four villages surveyed (a minimum of 1.9 fishers per household in Noutaea, and a maximum of 3.3 fishers per household in Tabonetebike). If we extrapolate our survey data to the total number of households on Abaiang, we arrive at a total of 1214 male finfish fishers, and 641 male and 843 female invertebrate fishers on Abaiang. About 570 male fishers fish for both finfish and invertebrates.

Our survey suggests that, on average, 44% of all households own a boat. However, the percentage of households owning boats and the type of boats available to the households on Abaiang vary substantially among the communities surveyed. For example, in Tabonetebike 57% of all households own a boat, and most of these (75%) are motorised; the rest are sailing boats. In Borotiam, Taburao and Noutaea 40%, 20% and 50% of the households own a boat respectively. All boats in Borotiam are paddling canoes, while people in Taburao and Noutaea use sailboats.

Fisheries provide the first source of income for more than half of all households surveyed on Abaiang. Salaries supply 24% of households with first income; handicrafts (mat weaving) provide first income for 12% of households. Agriculture (copra production) contributes an important secondary source of income, as do other sources, such as handicrafts and small businesses (Figure 2.1).

On average, 16% of all households surveyed receive remittances. However, this percentage varies substantially and so does the annual amount received. While none of the households surveyed in Noutaea and Taburao receive any remittances, in Borotiam, 60% receive remittances and in Tabonetebike 14%. The annual quantities received are substantial in both cases (USD 1834 and 2735 per year) as they exceed the annual average household expenditures of USD 1173 and 889 per year respectively.

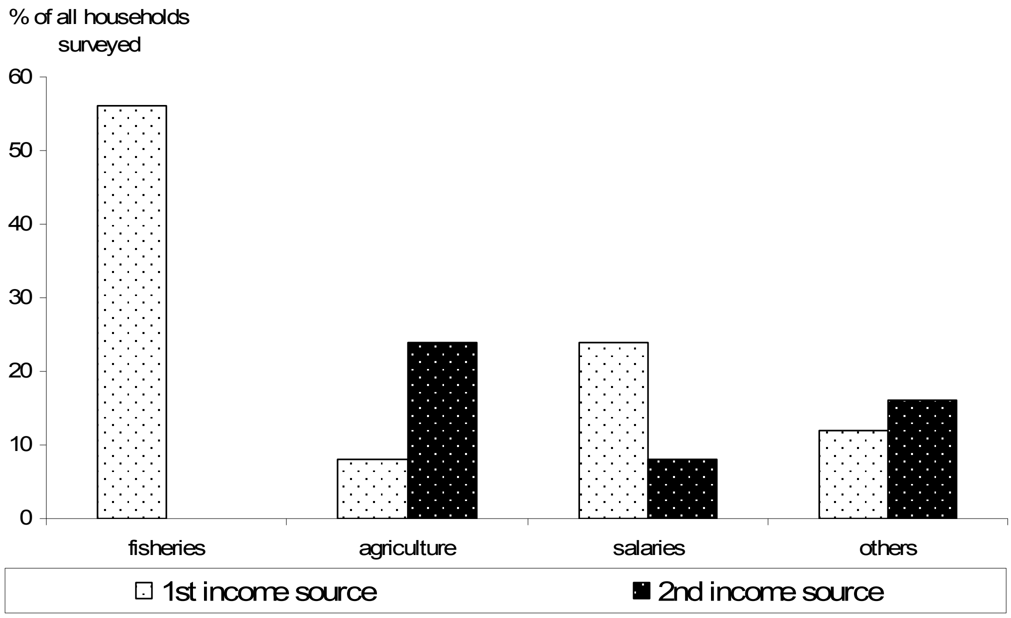

Figure 2.1: Ranked sources of income (%) in Abaiang.
Total number of households = 25 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly handicraft, particularly mat weaving.

The annual per capita fresh fish consumption is high if compared to the regional average (Figure 2.2). However, information published elsewhere suggests a much higher national per capita consumption figure than calculated on the basis of our survey data. As compared to all other PROCFish/C sites in Kiribati, the Abaiang figure represents the lowest per capita consumption.

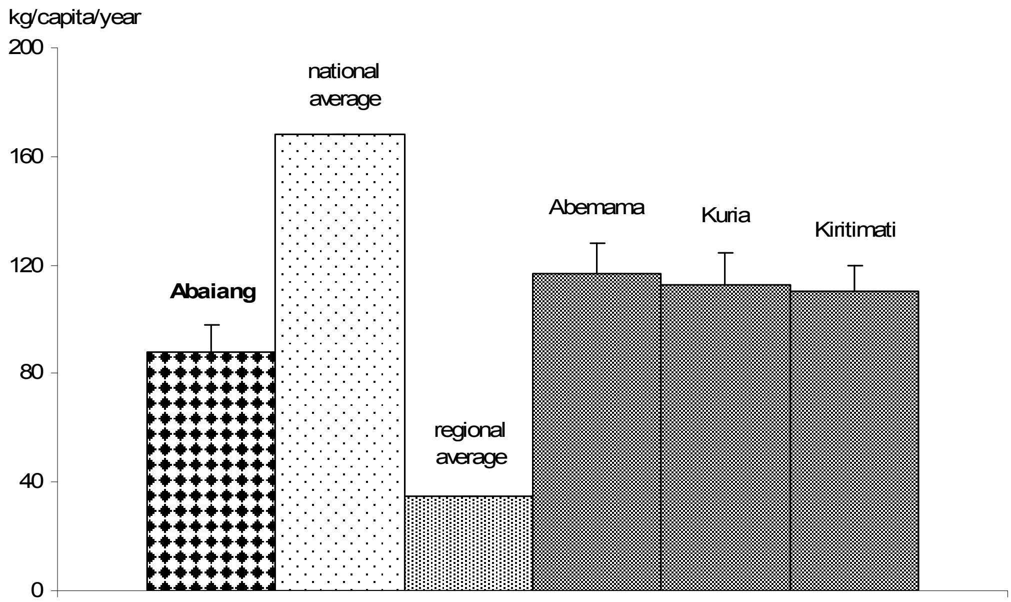

Figure 2.2: Per capita consumption (kg/year) of fresh fish in Abaiang (n = 25) compared to national and regional averages (FAO 2008) and the other three PROCFish/C sites in Kiribati.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

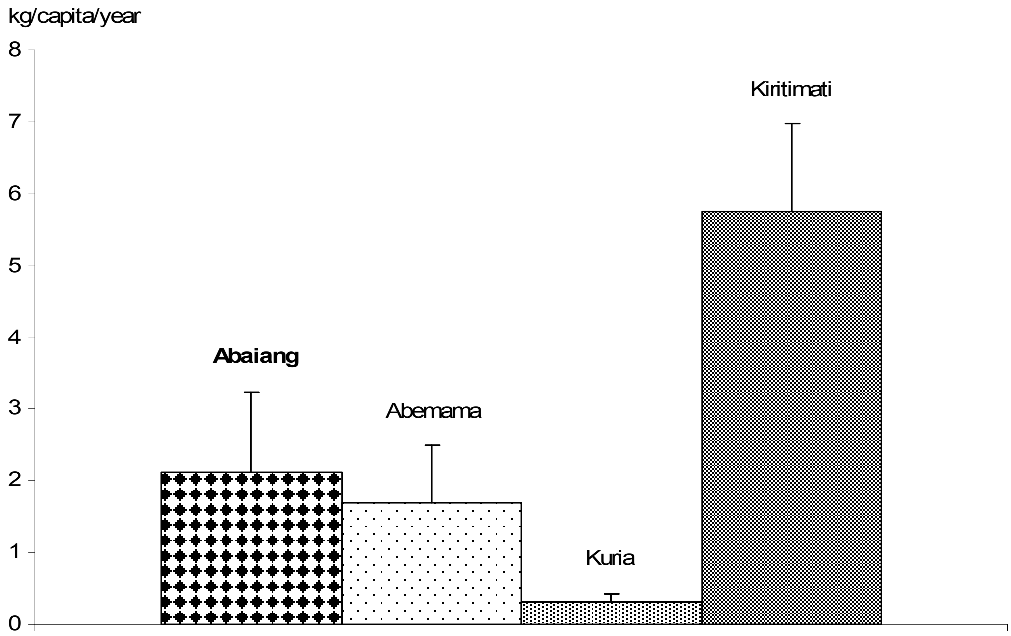

Figure 2.3: Per capita consumption (kg/year) of invertebrates (meat only) in Abaiang (n = 25) compared to the other three PROCFish/C sites in Kiribati.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

Fresh fish is consumed almost every day, on average 5–6 days/week. Invertebrates are less popular and are eaten on average about once per week reaching 2.1 kg/person/year (meat only). The frequency of canned fish consumption is low and negligible by comparison for most of the villages surveyed. For example, the frequency of canned fish consumption is 0–0.3 times/week and the quantity is 0–2.1 kg/person/year for Borotiam, Noutaea and Tabonetebike. People in Taburao are different as they eat canned fish 1.4 times/week and thus, compared to the other PROCFish/C sites, reach a relatively moderate level of 14.7 kg/capita/year.

By comparison with the average for all PROCFish/C sites in Kiribati (Table 2.1), the average household has more fishers and is more dependent on fisheries as first income source than on average across all survey sites. Household expenditures are slightly below average but remittances received are high. The average consumption of fresh fish is well below the average, and less canned fish is consumed than across all sites investigated. A smaller proportion of households than the average reported eating invertebrates and canned fish. As in the other sites, most fresh fish and invertebrates are caught by a household member; however, less are received as a gift, and least purchased. In the case of invertebrates, only small proportions are either bought or given on a non-monetary basis.

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

Survey coverage	Abaiang (n = 25 HH)	Average across sites (n = 98 HH)
Demography		
HH involved in reef fisheries (%)	100	95
Number of fishers per HH	2.52 (±0.25)	1.95 (±0.11)
Male finfish fishers per HH (%)	30.2	41.9
Female finfish fishers per HH (%)	0.0	0.5
Male invertebrate fishers per HH (%)	3.2	6.3
Female invertebrate fishers per HH (%)	39.7	28.3
Male finfish and invertebrate fishers per HH (%)	27.0	20.9
Female finfish and invertebrate fishers per HH (%)	0.0	2.1
Income		
HH with fisheries as 1st income (%)	56	34
HH with fisheries as 2nd income (%)	0	24
HH with agriculture as 1st income (%)	8	43
HH with agriculture as 2nd income (%)	24	27
HH with salary as 1st income (%)	24	18
HH with salary as 2nd income (%)	8	2
HH with other sources as 1st income (%)	12	5
HH with other sources as 2nd income (%)	16	5
Expenditure (USD/year/HH)	1016 (±125.74)	1485 (±128.38)
Remittance (USD/year/HH) (1)	2059 (±683.01)	1486 (±187.22)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	88.0 (±10.00)	106.9 (±5.32)
Frequency fresh fish consumed (times/week)	5.5 (±0.35)	5.6 (±0.18)
Quantity fresh invertebrate consumed (kg/capita/year)	2.12 (±1.12)	2.57 (±5.32)
Frequency fresh invertebrate consumed (times/week)	0.9 (±0.24)	0.7 (±0.09)
Quantity canned fish consumed (kg/capita/year)	4.0 (±2.18)	5.7 (±0.87)
Frequency canned fish consumed (times/week)	0.4 (±0.20)	0.7 (±0.09)
HH eat fresh fish (%)	100	100
HH eat invertebrates (%)	68	74
HH eat canned fish (%)	32	66
HH eat fresh fish they catch (%)	88	88
HH eat fresh fish they buy (%)	28	28
HH eat fresh fish they are given (%)	36	36
HH eat fresh invertebrates they catch (%)	64	64
HH eat fresh invertebrates they buy (%)	8	8
HH eat fresh invertebrates they are given (%)	0	0

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

2.2.2 Fishing strategies and gear: Abaiang

Degree of specialisation in fishing

Fishing on Abaiang is dominated by males: over 60% of all fishers are male, and only about 40% female. Furthermore, we found a gender separation between finfish fishing, which was only performed by males, and invertebrate fishing, which was mainly pursued by females. However, a considerable proportion of males target both finfish and invertebrates (Figure 2.4).

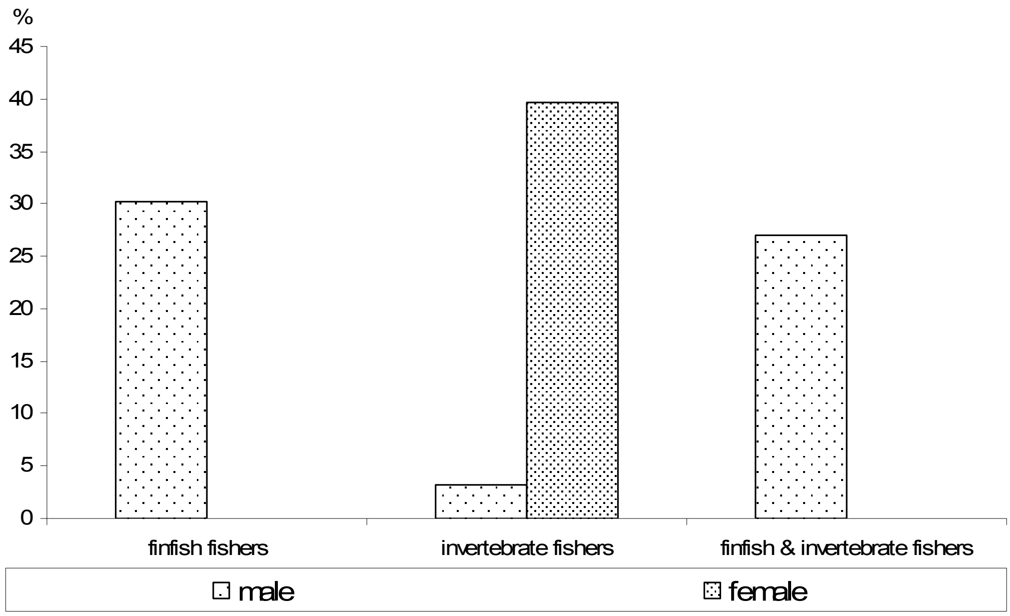

Figure 2.4: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Abaiang.
All fishers = 100%.

Targeted stocks/habitats

Invertebrate fisheries are limited to reef habitats and some intertidal and/or intertidal and soft benthos. Finfish fishers may target the sheltered coastal or outer reef and the lagoon area in between. In addition, fishing in the passages that connect the lagoon with the open ocean is possible (Table 2.2). Information provided by respondents on the areas fished for the different target species is shown in Figure 2.5.

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

Resource	Fishery / Habitat	% male fishers interviewed	% female fishers interviewed
Finfish	Sheltered coastal reef	17.4	0
	Lagoon	65.2	0
	Outer reef	13.0	0
	Outer reef and passages	17.4	0
Invertebrates	Intertidal	0	66.7
	Intertidal and soft benthos	15.4	33.3
	Lobster	30.8	0
	Other	69.2	0

'Other' refers to the giant clam fishery.
Finfish fisher interviews, males: n = 23; females: n = 0. Invertebrate fisher interviews, males: n = 13; females, n = 9.

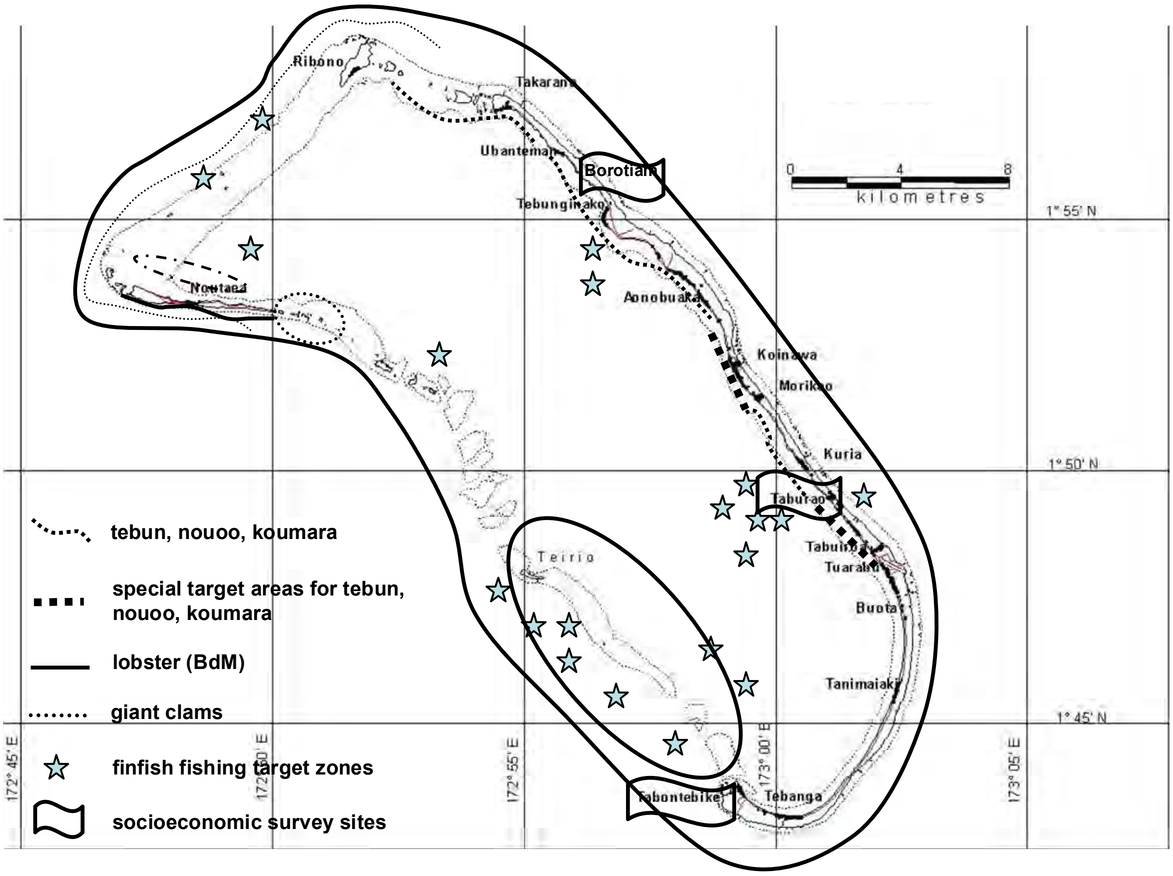

Figure 2.5: Socioeconomic survey sites and habitats fished as indicated by respondents in Abaiang.

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 Abaiang on their fishing grounds.

Our survey sample suggests that most fishers target the lagoon (65%); fewer target the sheltered coastal reef (17%) and the combined outer reef and passages (17%) or the outer reef (13%).

On Abaiang, slightly over half of all invertebrates are collected by gleaning (~55%). The remaining 45% are accounted for by giant clams (31%) and lobsters (14%) (Figure 2.6).

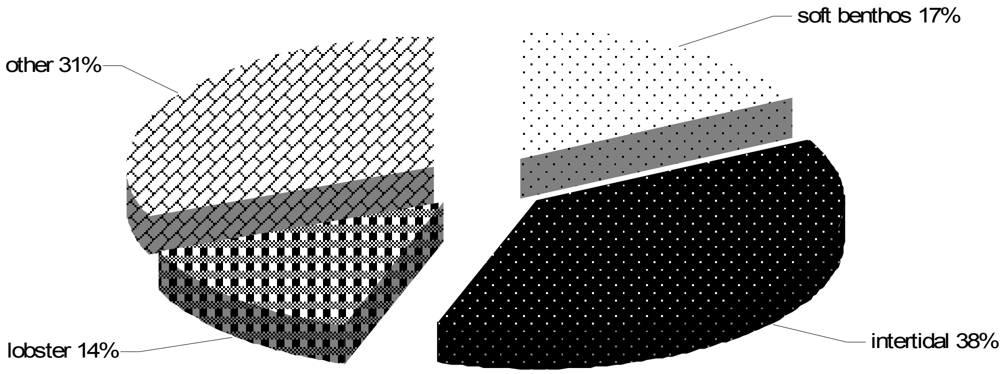

Figure 2.6: Proportion (%) of fishers targeting the four primary invertebrate habitats found in Abaiang.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the giant clam fishery.

There is a clear distinction between genders targeting the four major invertebrate fisheries on Abaiang (Figure 2.7). While lobster and other (giant clams) dive fisheries are exclusively performed by male fishers, females dominate the intertidal and soft-benthos fisheries.

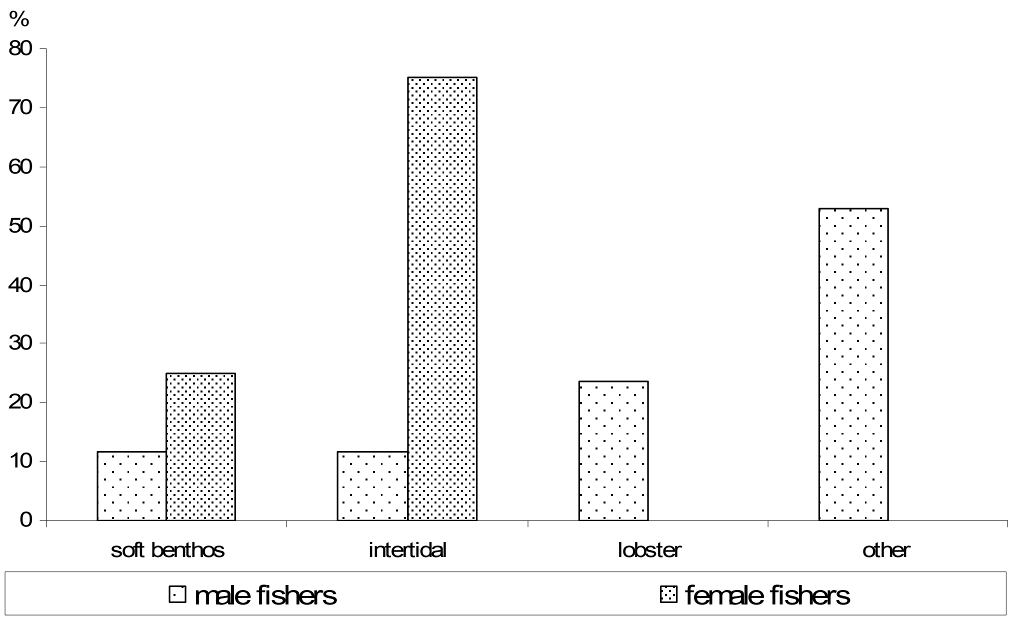

Figure 2.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Abaiang.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 15 for males, n = 9 for females; 'other' refers to the giant clam fishery.

Gear

Figure 2.8 shows that various gears are used for finfish fishing on Abaiang. However, certain techniques are predominantly used in certain habitats. For example, sheltered coastal reef fishing is done using either gillnets or handlines, while lagoon fishing is clearly determined by the use of gillnets. The outer reef is fished with handlines only and, if outer reefs and passages are jointly targeted during one fishing trip, spear diving is the main method used.

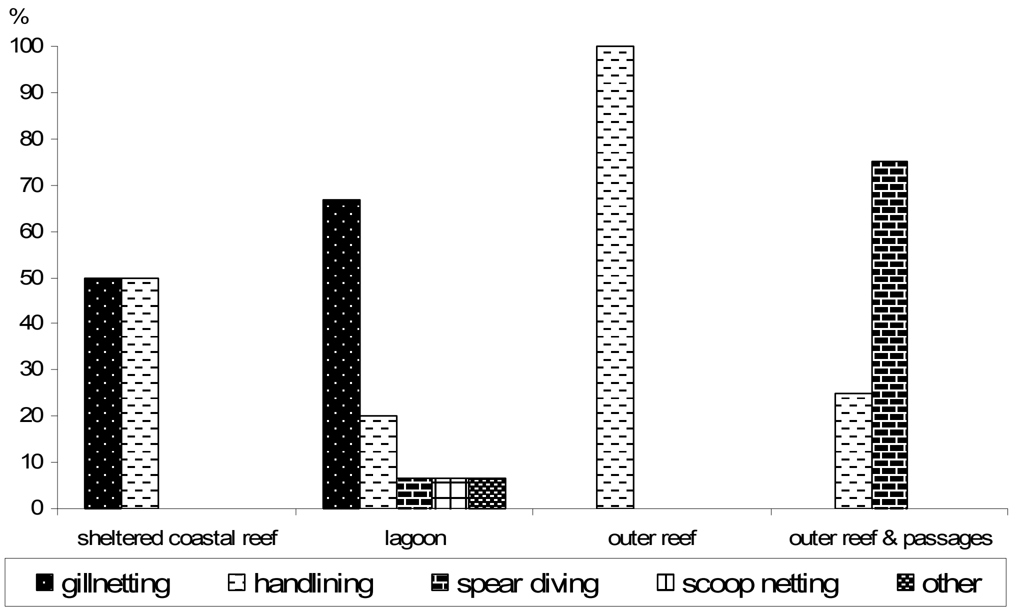

Figure 2.8: Fishing methods commonly used in different habitat types in Abaiang.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Gleaning on Abaiang is mostly done by walking, but sometimes canoes or sail boats are used to reach particular fishing grounds. Collection is done with simple tools. Lobster and giant clam diving often requires motorised boat transport; however, some fishing grounds can also be reached by walking. Lobsters are mostly fished during the day (75%) and only one-quarter of all fishing was reported to be performed during the night. All other invertebrate fisheries are exclusively performed during the day.

In total, 61% of all finfish fishers reported using a boat for fishing; however, half use motorised boats and the other half sailboats. Canoes are hardly ever used (4%) for finfish fishing. Most of the gleaning activities do not require boat transport. However, 50% of the intertidal gleaners use sailboats to reach their fishing grounds. Only 20% of fishers targeting the intertidal and soft-benthos habitats in one fishing trip use canoes to reach the fishing grounds. Most of the dive fisheries require boat transport. 75% of all lobster trips rely on motorised boats and 33% of all 'other' dive fishers (giant clams) use either a motorised boat (22%) or a canoe (11%) to reach the fishing grounds.

Frequency and duration of fishing trips

As shown in Table 2.3, trips to the sheltered coastal reef are on average more frequent (>4 times/week) than those to the lagoon (~3 times/week) or outer reef (~3.5 times/week). However, lagoon fishing trips are of the shortest duration (~3 hours), while outer-reef and sheltered coastal reef fishing trips are usually 1.5–1.6 times longer. Regarding invertebrate fishing, intertidal fishing (~3.5 times/week) and 'other' (giant clam) dive collection (~2.7 times/week) are the most frequently performed activities, and lobster diving is the least frequent. All dive trips take much longer (>4 hours/trip) than any of the gleaning activities (1.5–3.7 hours/trip).

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	4.13 (±0.97)	0	4.38 (±0.59)	0
	Lagoon	3.17 (±0.34)	0	2.93 (±0.42)	0
	Outer reef	3.49 (±1.62)	0	4.83 (±2.13)	0
	Outer reef and passages	3.63 (±0.83)	0	3.88 (±0.75)	0
Invertebrates	Intertidal	0	3.59 (±0.84)	0	3.75 (±0.31)
	Intertidal & soft benthos	0.35 (±0.12)	1.49 (±0.51)	1.50 (±0.00)	1.50 (±0.00)
	Lobster	1.29 (±0.27)	0	4.38 (±0.55)	0
	Other	2.72 (±0.30)	0	4.72 (±0.66)	0

Figures in brackets denote standard error; 'other' refers to the giant clam fishery.
Finfish fisher interviews, males: n = 23; females: n = 0. Invertebrate fisher interviews, males: n = 13; females: n = 9.

2.2.3 Catch composition and volume – finfish: Abaiang

Catches from the sheltered coastal reef are reported to be dominated by *Albula vulpes* (*ikai*) (35%), *Epinephelus merra* (*kuau*, *maneku*) (20%), *Lethrinus miniatus* (*taabou*) (12%) and *Plectropomus areolatus* (*uannati*) (12%). Lagoon catches consist mainly of Lethrinidae (*Lethrinus obsoletus*, *L. miniatus*) (*okaoka*, *taabou*) (24%) and a variety of other reef fish. Far fewer species were reported for outer-reef fishing and catches mainly consist of *Epinephelus merra* (*kuau*) (31%), *Lutjanus gibbus* (*ikanibong*) (28%), and *Aprion virescens* (*awai*) (15%). If passages and the outer reef are fished in one trip, Serranidae (*Epinephelus fuscoguttatus*, *E. merra*) (*bakati*, *kuau*) (27%), *Plectropomus areolatus* (*uannati*) (15%) and *Bolbometopon muricatum* (*kamauti*) (12%) dominate. Further details on the annual catch composition of reported catches in Abaiang are provided in Appendix 2.1.1.

Our survey sample of finfish fishers interviewed represents about 2% of the projected total number of finfish fishers on the island of Abaiang. However, we interviewed most fishers of the commercially oriented fishing communities, i.e. fishers who catch for export, as they have easy access to the island's cooperative centre or a landing point of the privately organised boat transport to Tarawa. Thus, we can assume that our survey data represent a great share of the total annual impact on Abaiang as most of the remaining fishers mainly catch for subsistence needs rather than export. Due to the limited sample size, however, we refrain from extrapolating our data to avoid overestimating the fishing impact on Abaiang's fishing grounds. Thus, we focus on the reported and collected survey data, which is summarised in Figure 2.9.

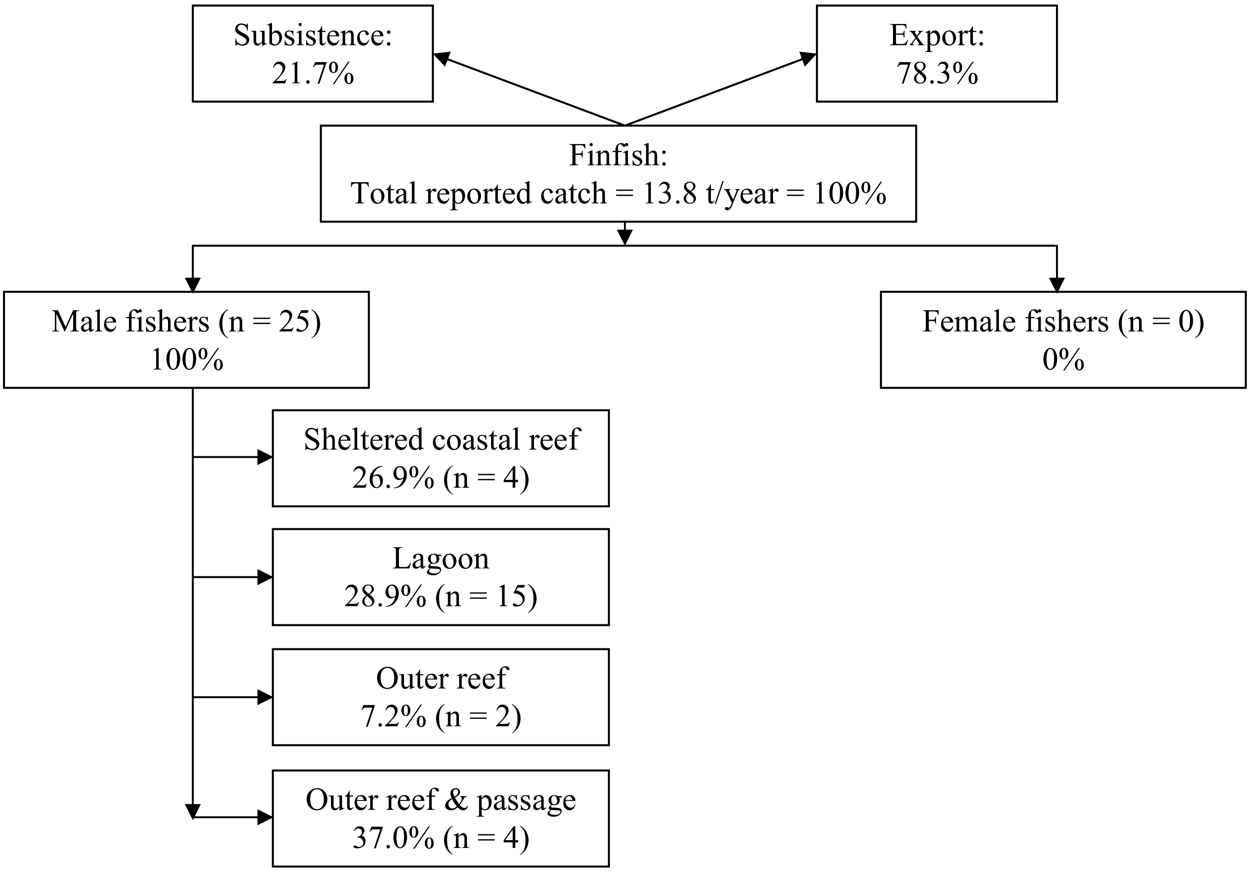

Figure 2.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Abaiang.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and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

Figure 2.9 shows that the major proportion of the reported annual catch is sourced from the combined fishing of the outer reef and passages. Furthermore, substantial shares of the reported annual catch are accounted for by lagoon and sheltered coastal reef fishing. Most of the catch is exported to Tarawa, and less than a quarter is consumed by the community on Abaiang.

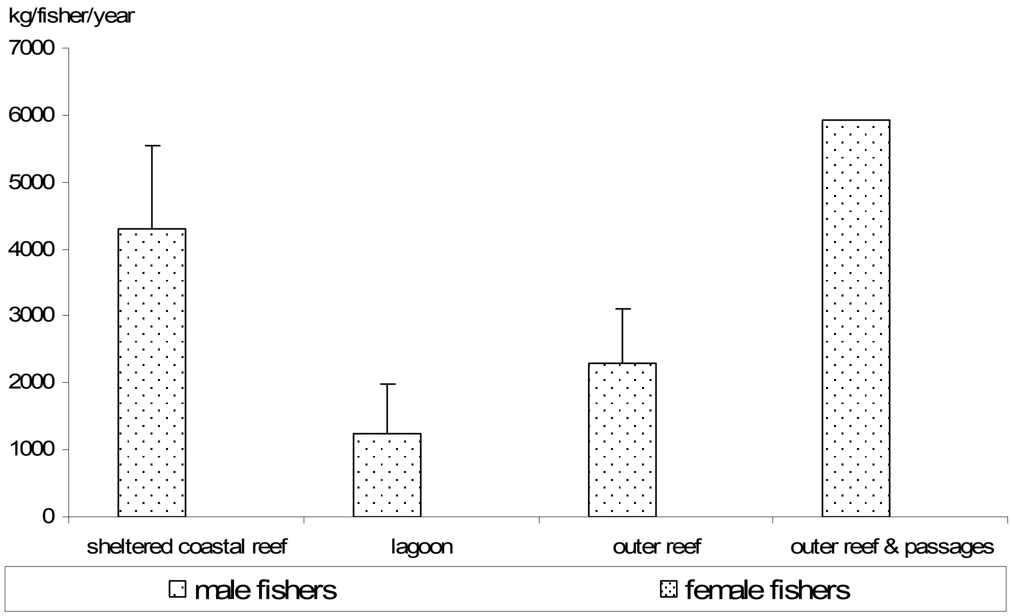

Figure 2.10: Average annual finfish catch (kg/year) per fisher by habitat and gender in Abaiang. Bars represent standard error (+SE).

The large contributions of both the combined targeting of the outer reef and passages, and the sheltered coastal reef to the total annual reported catch is mainly determined by the high average annual catch rates (Figure 2.10) rather than the number of fishers. The opposite argument applies in the case of lagoon fishing. Here the reported average annual catches are about four times lower but, due to the large number of fishers, impact on lagoon resources is high.

Finfish fishing is not performed by females. Thus we can only compare the CPUE of male fishers targeting different habitats. In addition to the differences in average annual catch rates, Figure 2.11 shows slightly higher efficiency (CPUE) if the outer reef and passages are jointly targeted in one trip, or when fishing the sheltered coastal reef as compared to the lagoon. However, fishing the outer reef, although highly variable, also renders a comparatively high productivity.

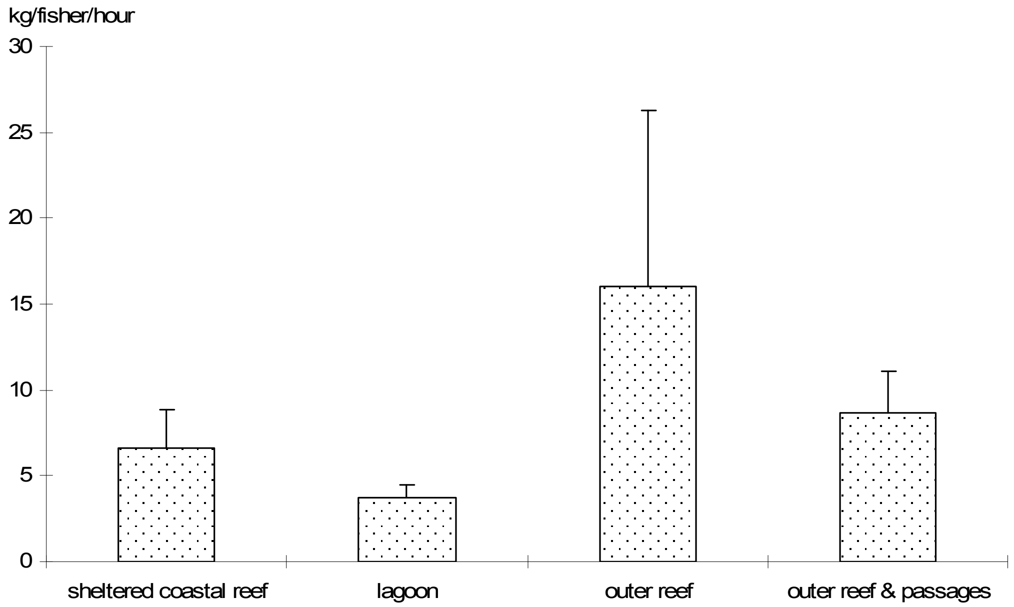

Figure 2.11: Catch per unit effort (kg/hour of total fishing trip) for male fishers by habitat in Abaiang.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Survey data show (Figure 2.12) that most of the catch is used for export. This is true for all habitats except the lagoon. Here, subsistence needs are the major reason for fishing and a possible explanation for the above-mentioned low CPUE.

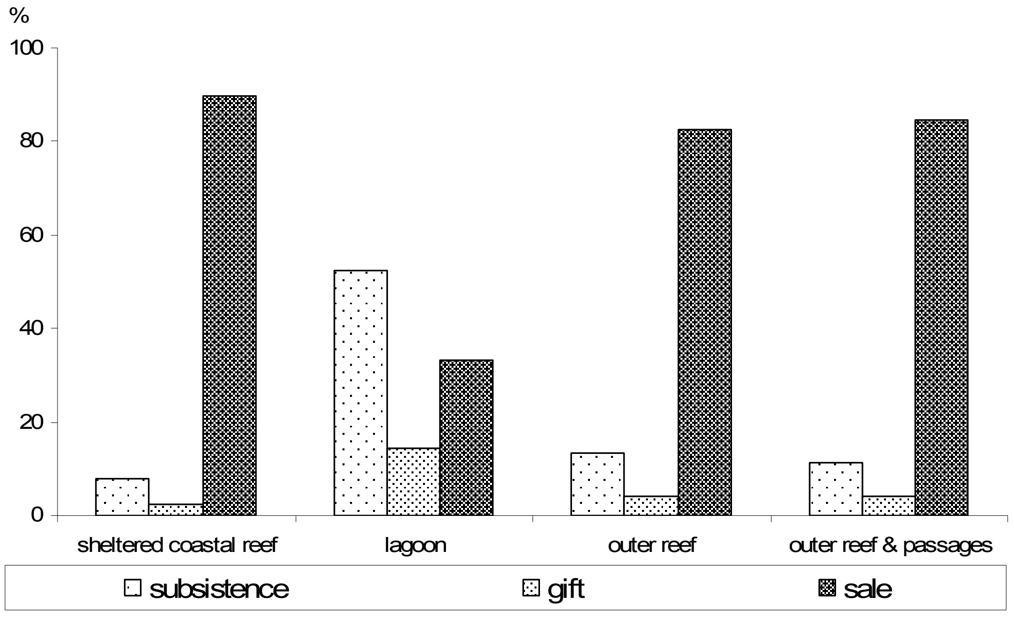

Figure 2.12: The use of finish catches for subsistence, gift and sale, by habitat in Abaiang.
Proportions are expressed in % of the total number of trips per habitat.

Data on the average reported finfish sizes by family and habitat (Figure 2.13) show that, while average fish sizes range from 15 to 65 cm, most sizes are 25–35 cm. There is also a trend that the average fish sizes reported from lagoon catches are the smallest, and that they increase in catches from the sheltered coastal to the outer reef. Average fish sizes reported from catches if the outer reef and passages are jointly fished seem to be the largest.

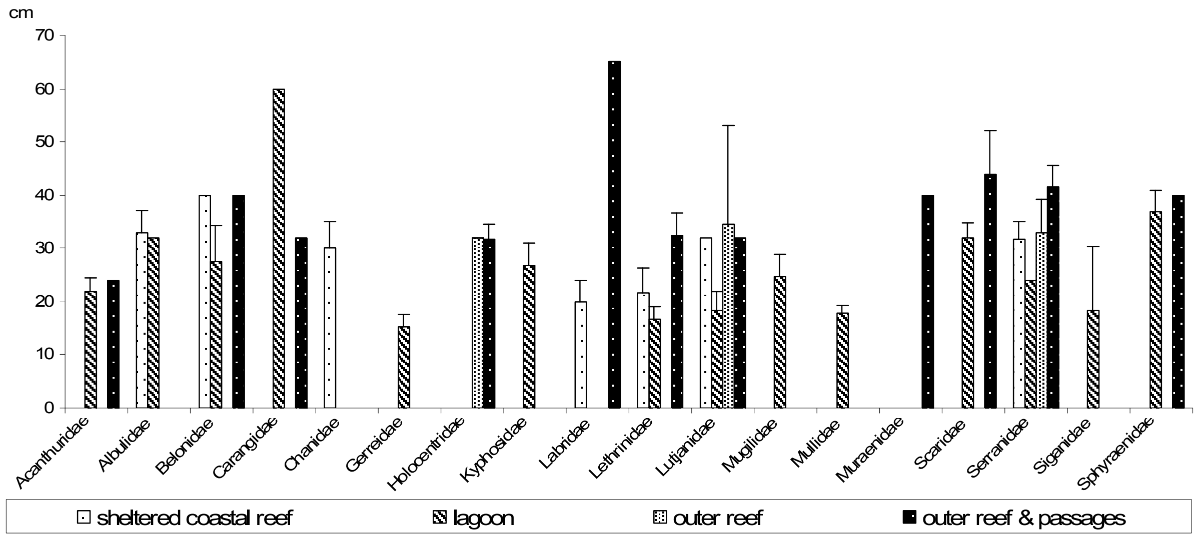

Figure 2.13: Average sizes (cm fork length) of fish caught by family and habitat in Abaiang.
Bars represent standard error (+SE).

Some parameters selected to assess the current fishing pressure on Abaiang's living reef resources are shown in Table 2.4. The comparison of the habitat surfaces that are included in Abaiang's fishing ground shows that the lagoon area is the largest, followed by the sheltered coastal reef. Nevertheless, all habitats are relatively large. The reported average annual catches of fishers vary considerably among the habitats targeted and are highest for the outer-reef and sheltered coastal reef area. Overall, fisher density is low; however, due to the large number of people on the island, population density is moderate (16–30 people/km^2). Considering the subsistence needs of the atoll's population only, a low fishing pressure results (3 t/km^2 of total reef area). However, fishing pressure is presumably moderate, if not high, when considering the fact that export determined about 80% of all fishing in Abaiang. Thus, we can assume that pressure on the lagoon and perhaps outer-reef resources is high due to the high average annual catches.

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

Parameters	Habitat				
	Sheltered coastal reef	Lagoon	Outer reef	Total reef	Total fishing ground
Fishing ground area (km^2)	74.82	260.17	37.22	194.26	372.22
Density of fishers (number of fishers/km^2 fishing ground) (1)	<1	3	9	6	3
Population density (people/km^2) (2)				30	16
Average annual finfish catch (kg/fisher/year) (3)	4303.5 (±1800.7)	1235.2 (±323.4)	5916.6 (±2634.8)		
Total fishing pressure of subsistence catches (t/km^2)				2.7	1.4

Figures in brackets denote standard error; (1) total number of fishers (= 1214) is extrapolated from household surveys; (2) total population = 5901; total subsistence demand = 518.59 t/year; (3) catch figures are based on recorded data from survey respondents only.

2.2.4 Catch composition and volume – invertebrates: Abaiang

Calculations of the annual catch rates per species groups are shown in Figure 2.14. The graph shows that the major impact by wet weight is focused on giant clams (*Tridacna maxima* and *T. squamosa*). In addition, *Sipunculus indicus* and lobster species (*Panulirus versicolor*, *P. penicillatus*) are exploited to some extent. Impact on any of the remaining three species is negligible.

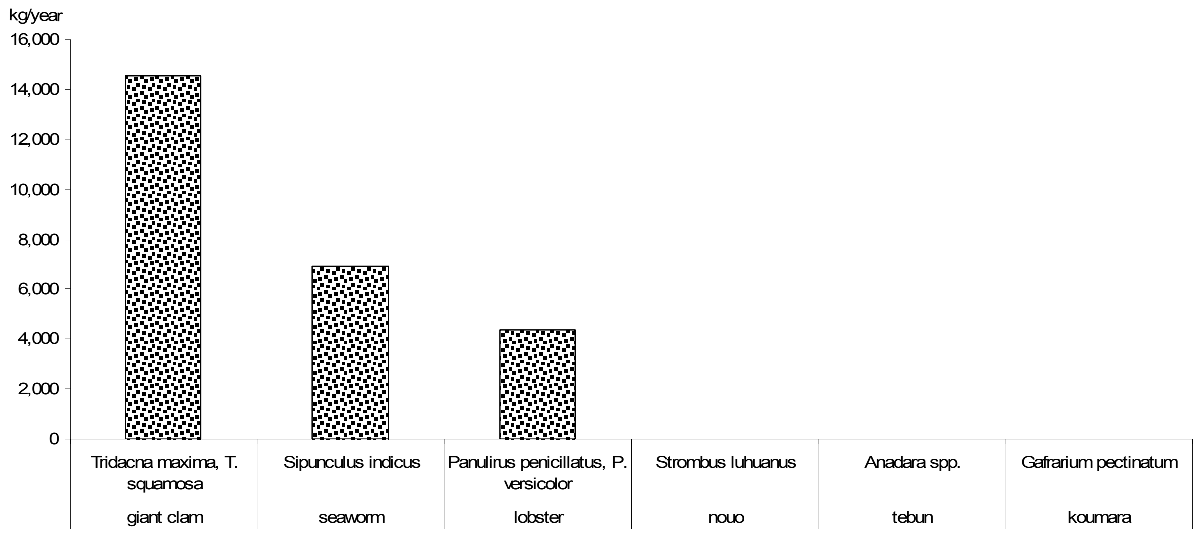

Figure 2.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Abaiang.

Figure 2.15 highlights the limited diversity of Abaiang's invertebrate fisheries, i.e. only 1–3 vernacular names were reported for each fishery.

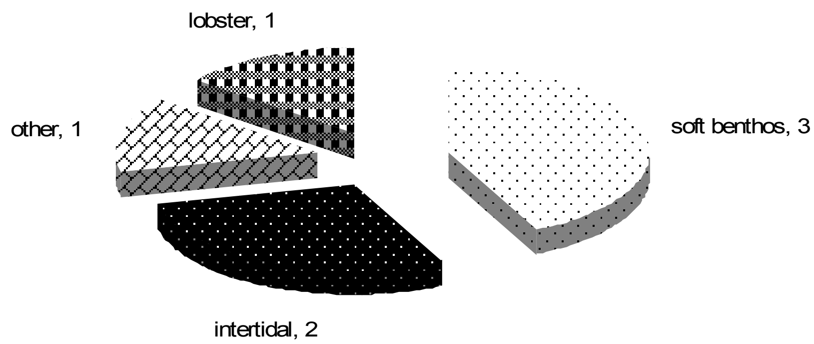

Figure 2.15: Number of vernacular names recorded for each invertebrate fishery in Abaiang.
'Other' refers to the giant clam fishery.

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

Following the trend shown in Figure 2.16, annual recorded catch rates by fisher, gender and fishery are highest for males' catches of giant clams. By comparison, catches from the lobster and intertidal fishery are about 0.5 times less, and the catch from the combined intertidal and soft benthos fisheries is negligible. The latter may be due to the small sample size. Female catch rates, which are exclusive to intertidal collection, are comparative to those of males' lobster catches.

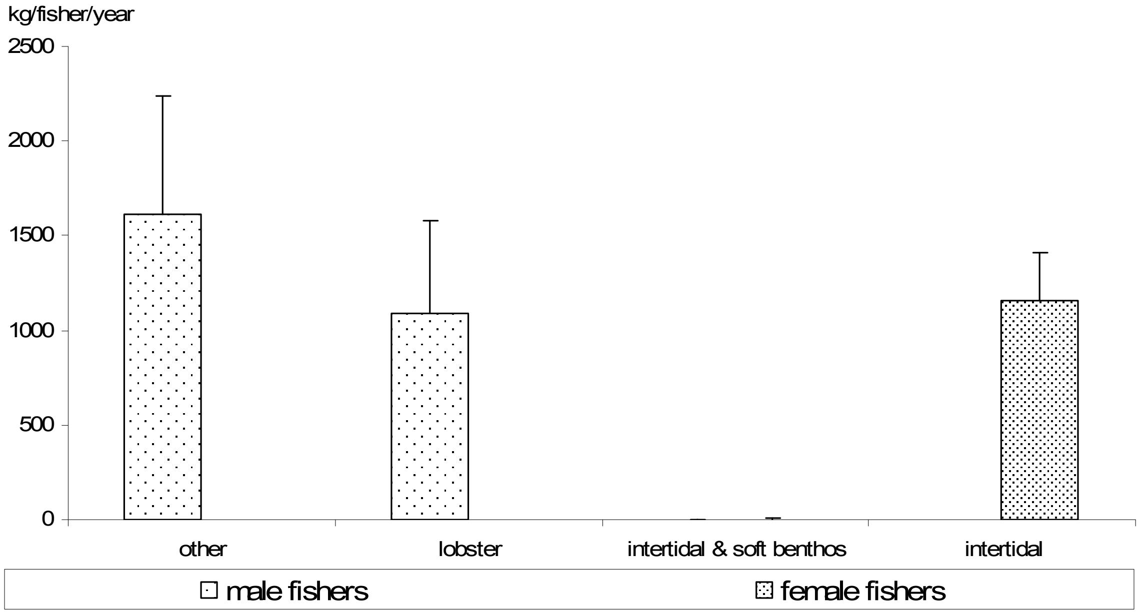

Figure 2.16: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Abaiang.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 15 for males, n = 9 for females). Bars represent standard error (+SE). 'Other' refers to the giant clam fishery.

The ratio between invertebrates caught for subsistence and sale as shown in Figure 2.17 highlights the high orientation of invertebrate fisheries for commercial purposes. Most biomass (wet weight) is caught for sale, i.e. export to Tarawa, and the proportion used for subsistence purposes is low.

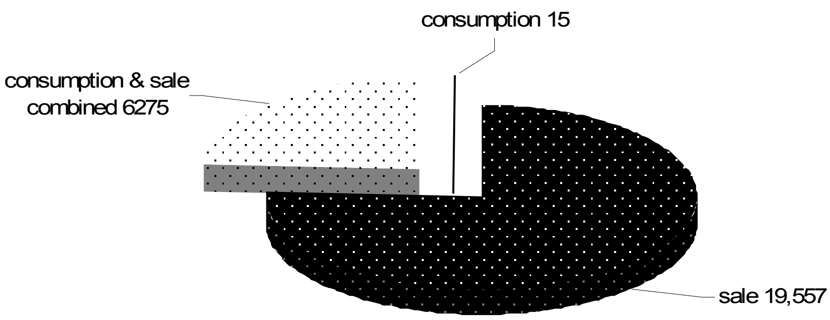

Figure 2.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Abaiang.

Respondents confirmed that certain species, such as *Gafrarium* spp., *Anadara* spp. and *Strombus* spp., are exclusively collected for home consumption, while giant clams, sea worms and lobsters are mainly caught for sale. A smaller proportion of these serves both home consumption and sale purposes (Table 2.5).

Table 2.5: Total annual recorded invertebrate catch by species and purpose of use (kg wet weight/year) in Abaiang

Scientific name	Vernacular name	Total catch (biomass wet weight kg/year)			
		Consumption	Sale	Consumption & sale	Sum
Tridacna maxima, Tridacna squamosa	giant clam	0	10,618	3909	14,527
Gafrarium pectinatum	*koumara*	4	0	0	4
Panulirus penicillatus, Panulirus versicolor	lobster	0	3825	543	4368
Strombus luhuanus	*nouo*	5	0	0	5
Sipunculus indicus	sea worm	1	5114	1824	6939
Anadara spp.	*tebun*	4	0	0	5
Total:		**14**	**19,557**	**6275**	**25,847**

The total annual catch volume (expressed in wet weight based on the recorded data from all respondents interviewed) amounts to 25.8 t/year (Figure 2.18). The data show that the giant clam ('other') fishery accounts for over 56% of the total catch by wet weight. Intertidal gleaning constitutes a bit more than another quarter, and the lobster fishery determines nearly all of the remaining catch. Overall, males account for almost 75% of the total annual catch (biomass wet weight), and females only about 25%.

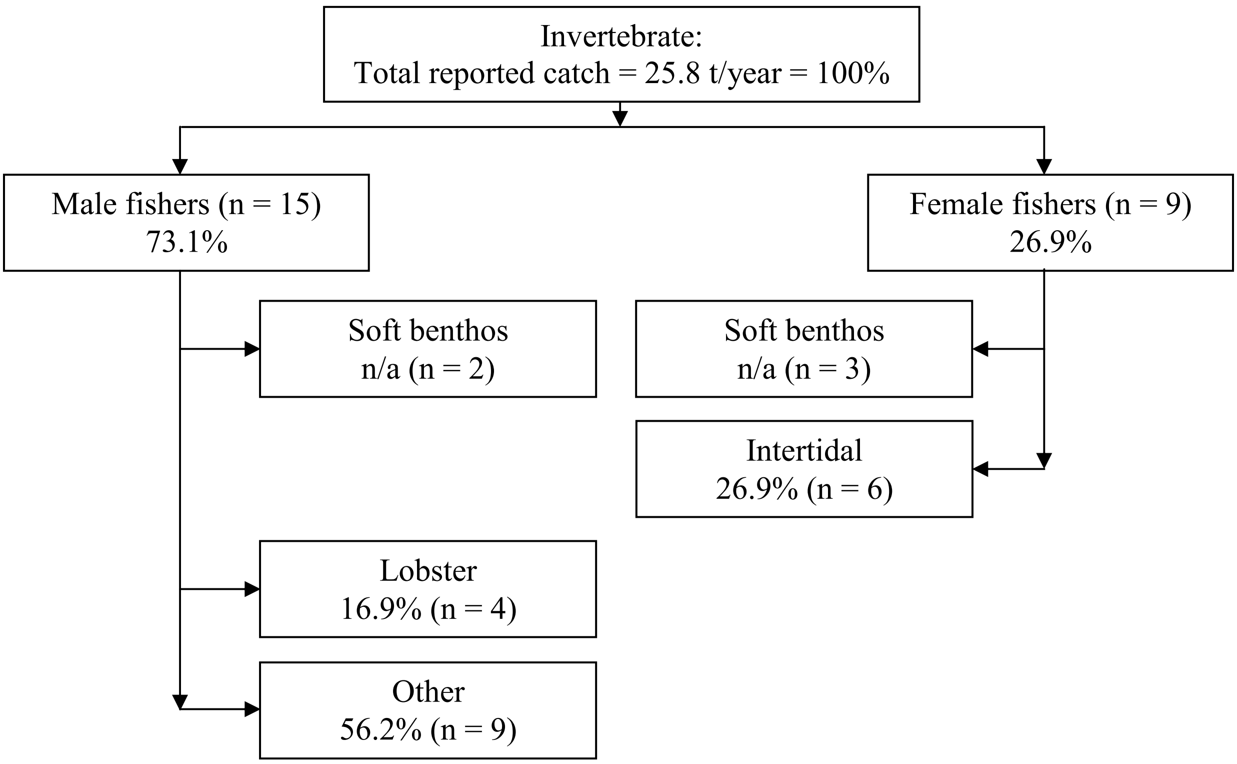

Figure 2.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Abaiang.
n is the total number of interviews conducted per each fishery; n/a = no information available; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey. 'Other' refers to the giant clam fishery.

The parameters presented in Table 2.6 show large fishing grounds for both giant clam and lobster harvesting. Due to the large size of fishing grounds, fisher densities are low, with 5 fishers/km^2 or 2 fishers/km reef length. The average reported annual catch (wet weight) per fisher is outstandingly high for each of the three major fisheries, i.e. intertidal gleaning, lobster and giant clam diving, and is highest for giant clam harvesting. It can be assumed that fishing impact on soft-benthos resources is negligible if taking into account the reported low annual catches.

Table 2.6: Selected parameters (±SE) used to characterise the current level of fishing pressure of invertebrate fisheries in Abaiang

Parameters	Fishery / Habitat			
	Soft benthos	Intertidal	Lobster [3]	Other
Fishing ground area (km^2)	n/a [4]	n/a [4]	88.24	94.24
Number of fishers (per fishery) [1]	380	562	197	444
Density of fishers (number of fishers/km^2 fishing ground)	n/a [4]	n/a [4]	2	5
Average annual invertebrate catch (kg/fisher/year) [2]	2.81 (±1.24)	1156 (±254.61)	1092 (±491.04)	1614 (±627.84)

Figures in brackets denote standard error; n/a = no information available; 'other' refers to the giant clam fishery; [1] number of fishers extrapolated from household surveys; [2] catch figures are based on recorded data from survey respondents only; [3] linear measure km reef length; [4] fishing grounds are presently not determined.

2.2.5 Discussion and conclusions: socioeconomics in Abaiang

- The Abaiang people are dependent on reef fisheries resources. Fisheries are the most important income source for more than half of the island's households. Salaries, mat weaving and, to a lesser extent, remittances are complementary sources of income.

- The per capita consumption of fresh finfish is high if compared to the regional average and lowest across all Kiribati communities investigated. Neither invertebrates nor canned fish consumption play a major role on Abaiang.

- The importance of fisheries is represented in the high number of fishers per households (2.5) and the fact that all households reported to fish. According to the important role fishery plays for income, most finfish (78%) are caught for export to Tarawa and so are most invertebrates, namely lobsters, sea worms and giant clams.

- Traditional gender roles were found in finfish fisheries: only males dive for lobsters and giant clams, while most of the intertidal and soft-benthos gleaning is done by female fishers.

- The highest fisher density occurs for the outer-reef area (9 fishers/km^2) while, overall, fisher density on the community's total reef area and its total fishing ground is low (3–6 fishers/km^2). Also, if only considering the subsistence needs of the atoll's population, although population density is moderate, the resulting fishing pressure is relatively low (3 t/km^2 of total reef area). In total, however, a moderate-to-high fishing pressure can be assumed, in particular on lagoon and outer-reef resources, when we consider that subsistence needs only account for 20%, while export catches determine ~80% of the total catches on Abaiang.

- Abaiang fishers prefer different techniques depending on the habitat they target. For instance, sheltered coastal reef fishing is done using both gillnets and handlines, while lagoon fishing is mainly performed using handlines. At the outer reef, fishers use handlines only but, if the outer reef and passages are combined during one fishing trip, spear diving becomes the first choice.

- The Abaiang invertebrate fishery is limited to a few target species. Giant clams, sea worms and lobsters represent 56%, 27% and 17% of the total annual reported catch respectively (wet weight) and most of these catches are used for sale. By comparison, the proportion of the annual catch of non-commercial species reported by gleaners (mainly *Strombus luhuanus*, *Anadara* spp. and *Gafrarium pectinatum*) is marginal.

- While fisher density for lobster and giant clam fisheries is low, the annual catch per fisher (wet weight) is substantial. This observation is also true for the productivity (CPUE) of intertidal gleaners. Taking into account the total number of possible fishers and the reported average annual catch (wet weight) per fisher, a high fishing pressure may particularly exist for lobster and giant clam species.

Based on the observations that the Abaiang community is highly dependent on fisheries for income generation, that the local fish consumption is high, and that most of the catches are commercially sold to Tarawa, our data suggest the following three conclusions:

1. A considerable proportion of the Abaiang community engage in fishing, and most of the fishing and/or harvesting of lobsters, sea worms and giant clams is done for income purposes.

2. Fishing pressure seems to be high for a number of selected species, in particular lobsters, sea worms and giant clams. Although the reported high annual catch rates suggest good productivity of most species targeted, the reported average sizes caught, especially sizes of giant clams, may indicate the first signs of stress.

3. Alternative income sources are limited (handicrafts, a few public salaries, very little agricultural potential) and give reason to assume that the fishing pressure will not cease but may increase in the future. The latter will depend on any future development concerning the island’s demand for income and nutrition.

2.3 Finfish resource surveys: Abaiang

Finfish resources and associated habitats were assessed between 23 and 30 June 2004 from 24 transects (6 intermediate, 12 back- and 6 outer-reef transects, see Figure 2.19 and Appendix 3.1.1 for transect locations and coordinates respectively.).

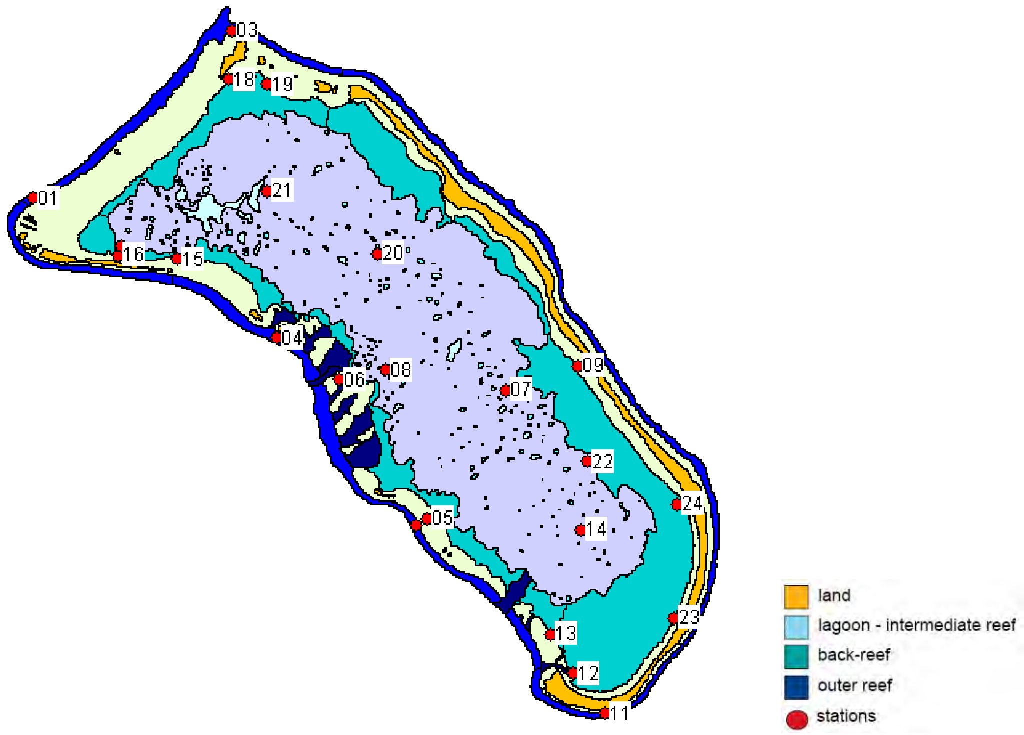

Figure 2.19: Habitat types and transect locations for finfish assessment in Abaiang.

2.3.1 Finfish assessment results: Abaiang

A total of 19 families, 51 genera, 147 species and 7711 fish were recorded in the 24 transects (See Appendix 3.1.2 for list of species.). Only data on the most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 14 families, 44 genera, 137 species and 7397 individuals.

Finfish resources differ greatly among the four reefs found in Abaiang (Table 2.7). The outer reef contains the highest number of fish (0.70 fish/m^2) and species (45 species/transect), and the largest biomass (214 g/m^2). In contrast, the back-reef displays the lowest biomass (156 g/m^2) and biodiversity (23 species/transect) but the largest sized fish (21 cm). Intermediate reef shows intermediate densities (0.60 fish/m^2), biomass (165 g/m^2) and biodiversity (30 species/transect). The high value of biomass in this habitat is largely due to the large numbers of carnivorous Lutjanidae.

Table 2.7: Primary finfish habitat and resource parameters recorded in Abaiang (average values ±SE)

Parameters	Habitat			
	Intermediate reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	12	6	24
Total habitat area (km^2)	3.2	82.2	29.6	115.0
Depth (m)	3 (1-8) (3)	2 (1-5) (3)	7 (4-12) (3)	3 (1-12) (3)
Soft bottom (% cover)	17.1 ±4.7	18.8 ±2.7	4.2 ±1.3	15.0
Rubble & boulders (% cover)	10.7 ±3.6	9.0 ±1.9	2.7 ±1.3	7.0
Hard bottom (% cover)	57.6 ±7.5	52.4 ±2.6	61.6 ±1.7	55.0
Live coral (% cover)	14.1 ±6.7	19.3 ±3.1	31.2 ±2.7	22.0
Soft coral (% cover)	0.17 ±0.17	0.3 ±0.2	0.12 ±0.08	0.00
Biodiversity (species/transect)	30 ±5	23 ±3	45 ±4	39 ±2
Density (fish/m^2)	0.6 ±0.1	0.6 ±0.2	0.7 ±0.07	0.6
Biomass (g/m^2)	165.1 ±48.0	156.4 ±97.9	213.6 ±73.7	171.3
Size (cm FL) (4)	19.4 ±0.9	21.0 ±1.0	20.3 ±0.8	21.0
Size ratio (%)	53 ±2	59 ±2	58 ±2	59

(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.

This trend is also reflected in the status of the benthic community, with outer reefs displaying the highest cover of hard bottom and the highest coral cover (31%). Back- and intermediate reefs show similar bottom composition, with less live coral and more rubble than the outer reef (Table 2.7, Figure 2.20).

Intermediate-reef environment: Abaiang

The intermediate-reef environment of Abaiang is largely dominated by one family of herbivorous Acanthuridae, and two families of carnivorous Lutjanidae and Balistidae (Figure 2.21). These three families were represented by seven major species; particularly high abundance and biomass were recorded for *Acanthurus xanthopterus*, *A. blochii*, *A. olivaceus*, *A. nigricauda*, *Lutjanus gibbus*, *Sufflamen chrysopterus* and *L. kasmira* (Table 2.9).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus xanthopterus*	Yellowfin surgeonfish	0.05	33.1
	Acanthurus blochii	Ringtail surgeonfish	0.0	22.0
	Acanthurus olivaceus	Orangespot surgeonfish	0.05	21.7
	Acanthurus nigricauda	Epaulette surgeonfish	0.02	20.2
Lutjanidae	*Lutjanus gibbus*	Humpback red snapper	0.10	14.4
	Lutjanus kasmira	Common bluelined snapper	0.05	3.3
Balistidae	*Sufflamen chrysopterus*	Halfmoon triggerfish	0.02	3.44

This reef type presents a diverse habitat (Table 2.7 and Figure 2.21), with hard bottom dominating; habitat complexity may partly explain the relative complexity of fish assemblage on this reef, which shows the second-highest biodiversity for the site. The relatively large hard-bottom cover (58%), a suitable environment for algae growth, is accompanied by notable densities of herbivorous fish, such as surgeon fish (Acanthuridae). However, a high abundance of Lutjanidae was also recorded.

Finfish resources in the intermediate reef of Abaiang display the third-highest density, size and biomass among the three reef types on the island (Table 2.7). The substrate is similar to the average (Table 2.7).

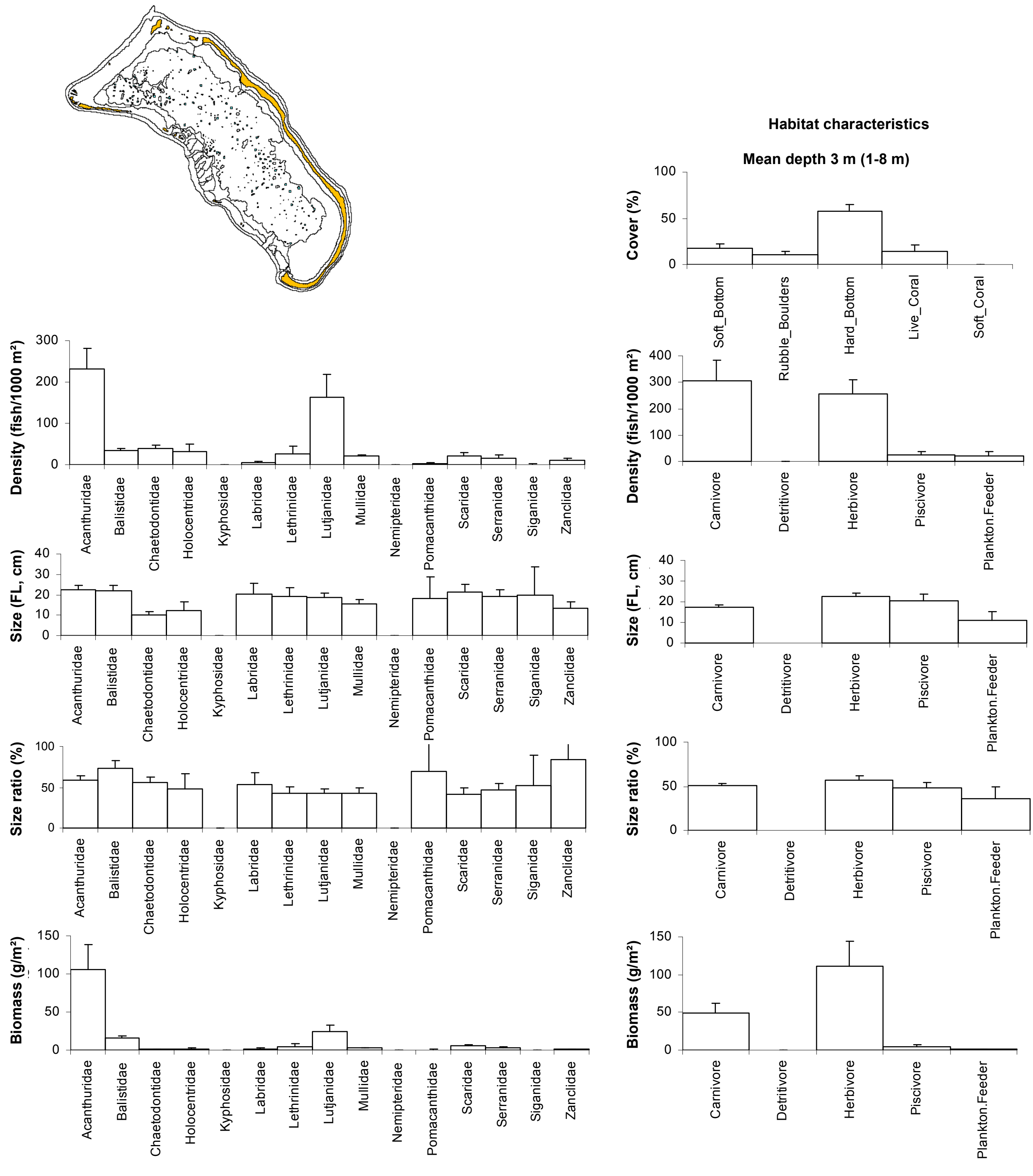

Figure 2.21: Profile of finfish resources in the intermediate-reef environment of Abaiang.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Abaiang

The back-reef environment of Abaiang is largely dominated by two families represented in terms of both density and biomass by carnivorous Lutjanidae and, to a lesser extent, herbivorous Acanthuridae. These two families are represented by 23 species; particularly high abundance and biomass were recorded for *Lutjanus fulvus*, *L. ehrenbergii*, *Ctenochaetus striatus*, *Acanthurus blochii*, *A. olivaceus* and *L. gibbus* (Table 2.10).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus fulvus*	Flametail snapper	0.14	42.0
	Lutjanus ehrenbergii	Blackspot snapper	0.07	32.2
	Lutjanus gibbus	Humpback red snapper	0.01	6.0
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.04	3.1
	Acanthurus olivaceus	Orangespot surgeonfish	0.02	5.2
	Acanthurus blochii	Ringtail surgeonfish	0.02	16.4

Substrate in the back-reef of Abaiang is characterised by a dominance of hard bottom (52% cover) with a very low coral cover (19%). The high percentage cover of hard bottom offers the right environment for algae growth, which in turn attracts herbivorous fish species, which feed on these algae. This trend is clearly reflected in the large presence of herbivorous fish observed, such as Acanthuridae, appearing as high assemblages of *Ctenochaetus striatus*, *Acanthurus olivaceus* and *A. blochii*.

Finfish resources in the back-reef of Abaiang display similar average density, biomass, size, and size ratios relative to the other two reef habitats on the island (Table 2.7).

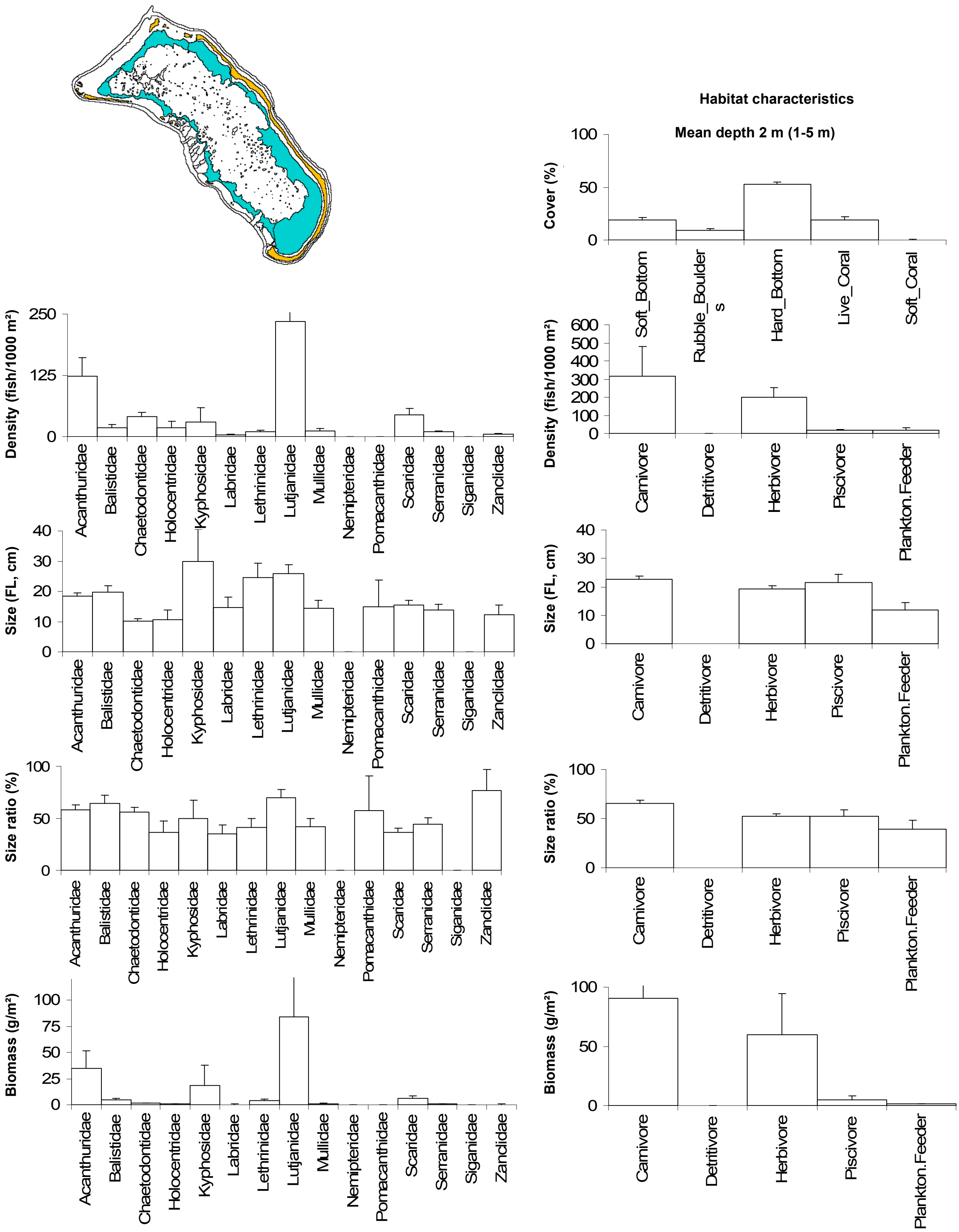

Figure 2.22: Profile of finfish resources in the back-reef environment of Abaiang.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Abaiang

The outer-reef environment of Abaiang is largely dominated by six families represented by two herbivorous fish (Acanthuridae and Scaridae) and, to a much lesser extent numerically, by four carnivorous fish (Lutjanidae, Lethrinidae, Balistidae and Serranidae). In terms of abundance, Acanthuridae have the highest, followed by Lutjanidae, Balistidae, Scaridae, Serranidae, and lastly Lethrinidae while, in terms of biomass, the decreasing order of importance is Lutjanidae, followed by Acanthuridae, Scaridae, Lethrinidae, Balistidae and Serranidae (Figure 2.23). These six families are represented by 13 most important species; particularly high abundance and biomass were recorded for *Lutjanus gibbus*, *Cephalopholis argus*, *Macolor macularis*, *Acanthurus nigricans*, *A. xanthopterus*, *L. bohar*, *Monotaxis grandoculis*, *L. monostigma*, *Ctenochaetus striatus*, *Melichthys vidua* and *Chlorurus sordidus* (Table 2.11).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus gibbus*	Humpback red snapper	0.04	27.9
	Macolor macularis	Midnight snapper	0.01	12.1
	Lutjanus bohar	Two-spot red snapper	0.01	10.7
	Lutjanus monostigma	Onespot snapper	0.01	7.6
Acanthuridae	*Acanthurus nigricans*	Whitecheek surgeonfish	0.10	11.1
	Acanthurus xanthopterus	Yellowfin surgeonfish	0.01	11.0
	Ctenochaetus striatus	Striated surgeonfish	0.12	6.4
Serranidae	*Cephalopholis argus*	Peacock hind	0.04	13.8
Lethrinidae	*Monotaxis grandoculis*	Humpnose big-eye bream	0.02	9.0
Scaridae	*Chlorurus sordidus*	Daisy parrot fish	0.03	5.7
Balistidae	*Melichthys vidua*	Pinktail triggerfish	0.04	4.4

Substrate in the outer reef of Abaiang is characterised by a dominance of hard bottom (62% cover) with relatively high live-coral cover (31%), which is accompanied by the presence of substantial numbers of surgeonfish (Figure 2.23). The prevalence of hard-bottom substrate, in combination with the direct oceanic influence found in the outer-reef environment, may explain the dominance of medium-sized herbivorous fish, such as *Acanthurus nigricans* and *Acanthurus xanthopterus*. The notable presence of large species of carnivorous species, such as *Lutjanus bohar*, *L. gibbus* and *Macolor macularis*, in combination with the presence of large numbers of Serranidae, Lethrinidae and Scaridae (*Cephalopholis argus*, *Monotaxis grandoculis* and *Chlorurus microrhinos* in particular), may be related to the healthy status of the reef.

Finfish resources in the outer reefs of Abaiang display the highest average biodiversity and density among all reef systems on the island (Table 2.7). However, comparing the parameters among the four sites in Kiribati, the outer reef of Abaiang displays the least biodiversity, density and biomass.

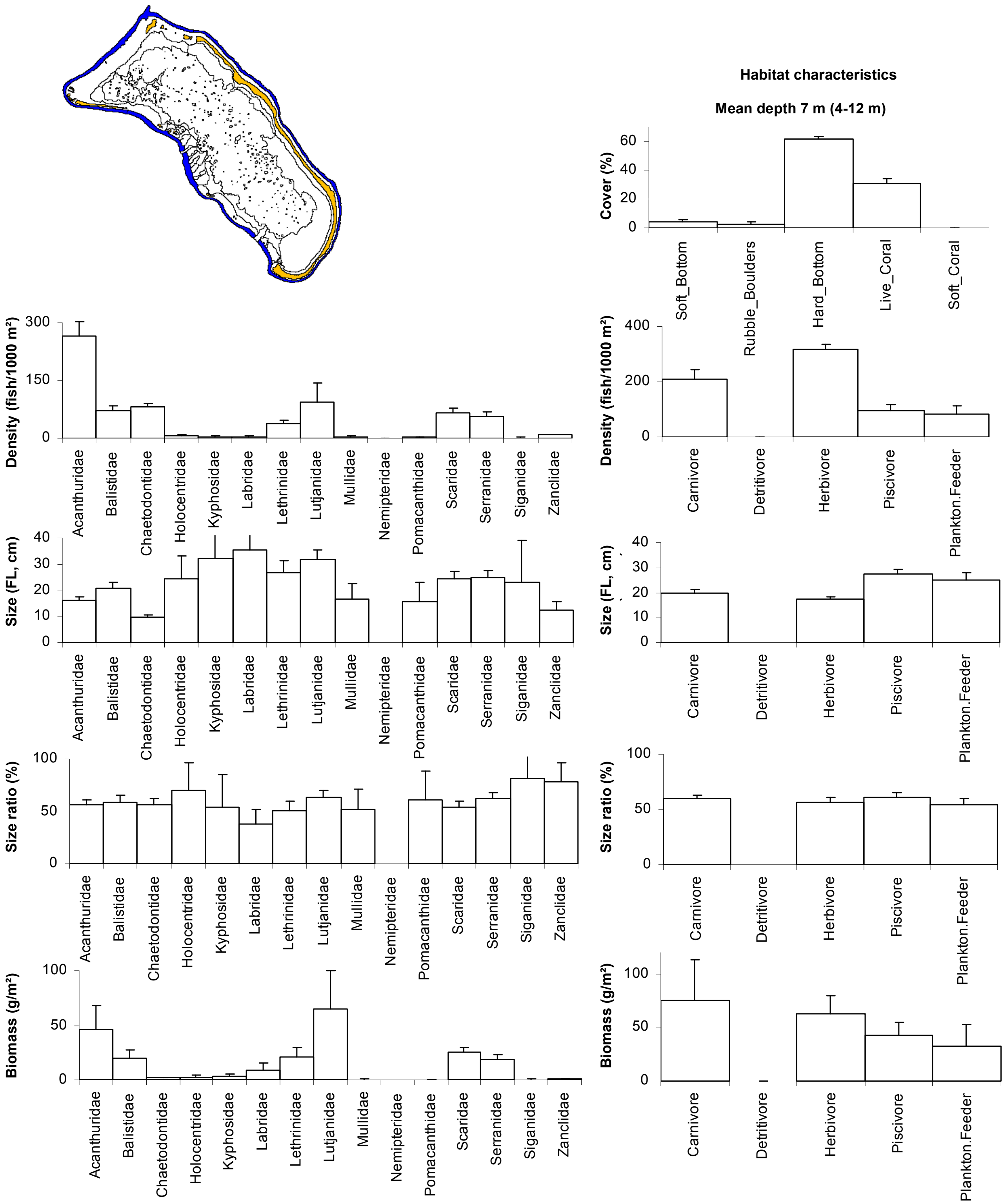

Figure 2.23: Profile of finfish resources in the outer-reef environment of Abaiang.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Abaiang

The overall fish assemblage of Abaiang consists largely of two main families. The most abundant are carnivorous fish, the Lutjanidae, with the highest density and biomass, followed by herbivorous fish Acanthuridae (Figure 2.24). These two major families are represented by 38 most important species; particularly high abundance and biomass were recorded for *Lutjanus fulvus*, *Ctenochaetus striatus*, *L. ehrenbergii*, *Acanthurus nigricans*, *L. gibbus*, *Acanthurus blochii* and *A. olivaceus* (Table 2.12).

Table 2.12: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Abaiang (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus fulvus*	Blacktail snapper	0.10	30.1
	Lutjanus ehrenbergii	Blackspot snapper	0.05	23.5
	Lutjanus gibbus	Humpback red snapper	0.02	11.8
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.06	4.0
	Acanthurus blochii	Ringtail surgeonfish	0.01	12.5
	Acanthurus olivaceus	Orangespot surgeonfish	0.02	4.3
	Acanthurus nigricans	Whitecheek surgeonfish	0.03	4.0

The overall fish assemblage in Abaiang more closely resembles that recorded in the back-reef environment (71% of habitat) than that in the outer- and intermediate-lagoon reef environments. The dominance of Lutjanidae and Acanthuridae, as well as the size ratio profile, resemble the condition in the back-reef (Figure 2.24).

Detailed assessment at the reef level suggests that the condition of Abaiang's finfish resources are comparable to Abemama (the only other site with three habitats present); however, with higher biomass in back-reef and lower biomass at lagoon and outer reef. However, size ratio is consistently higher in Abaiang, suggesting a lower level of exploitation.

The overall trend in fish assemblage for Abaiang presents a very high abundance and biomass of carnivorous fish (e.g. Lutjanidae) in all habitats due to the presence of numerous large Lutjanidae (*Lutjanus fulvus*, *L. gibbus* and *L. ehrenbergii* of size ratio >55%).

Abaiang atoll offers all the available habitats and reefs for a choice of fishing methods and gears and, similarly to Abemama Island, fishing is mainly done for export reasons, increasing the fishing pressure on the reefs. The close proximity of the island to the capital island is another cause contributing to the low density of commercially important fish stocks. Therefore, sustainable limits will soon be exceeded, especially if no monitoring management guidelines are in put in place.

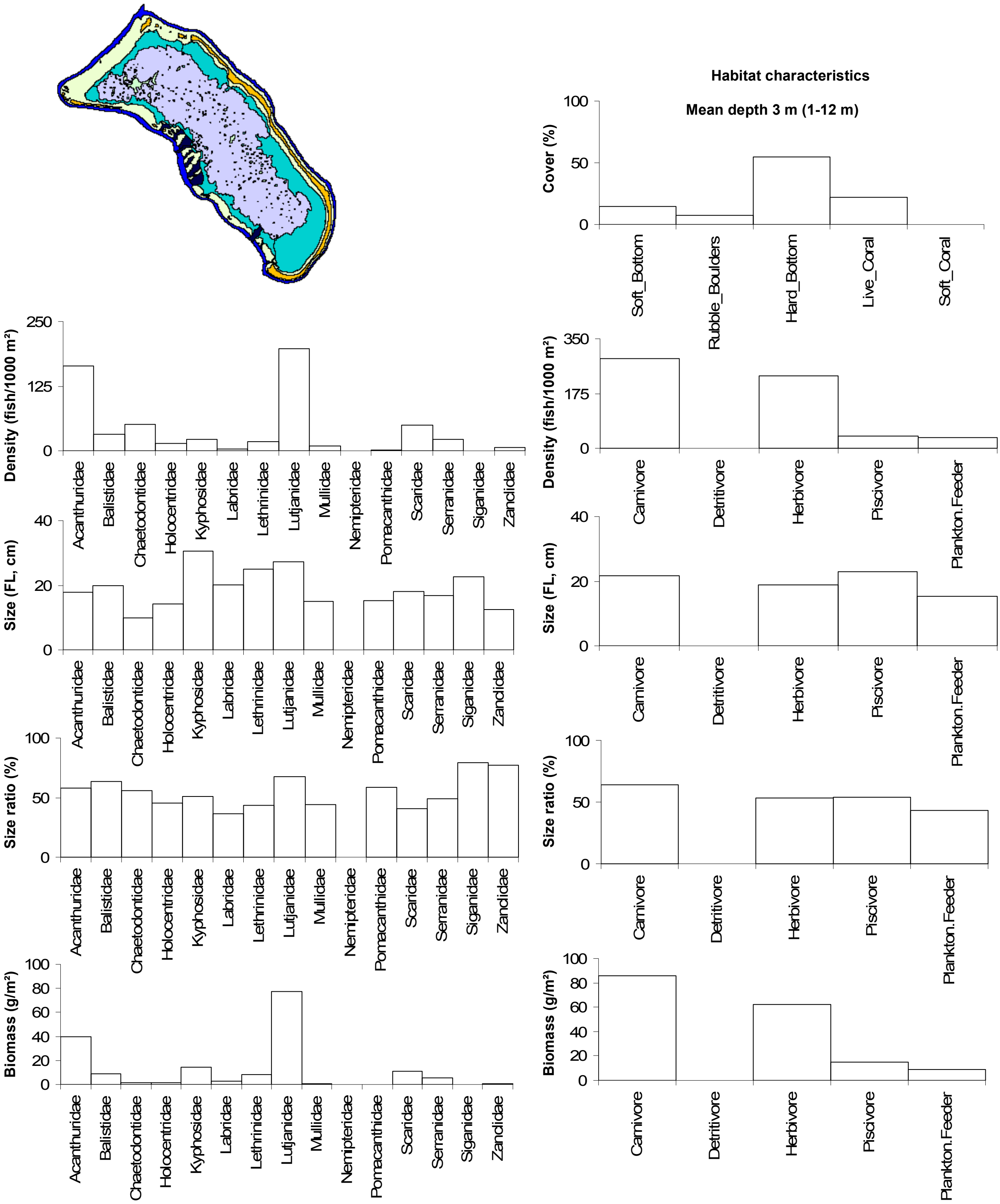

Figure 2.24: Profile of finfish resources in the combined reef habitats of Abaiang (weighted average).
FL = fork length.

2.3.2 Discussion and conclusions: finfish resources in Abaiang

- The status of finfish resources in Abaiang is similar to that in Abemama reefs (the only other site with all four habitats present), except for higher biomass in the back-reef and lower biomass in the lagoon and outer reefs. However, size ratio is consistently higher in Abaiang, suggesting a lower level of exploitation. Carnivorous fish, especially Lutjanidae, are highly abundant in all habitats. Biomass is also dominated by carnivores in all reefs, mostly due to the presence of abundant, large Lutjanidae (*Lutjanus fulvus*, *L. gibbus* and *L. ehrenbergii* of size ratio >55%).

- These results, combined with the high abundance of carnivorous fish (Lutjanidae especially) in all of the reef systems, suggest that the area's finfish resources are relatively healthy. The reef habitat seems relatively rich and the ecosystem supporting finfish resources healthy. However, Abaiang atoll offers all the available habitats and reefs for a choice of fishing methods and gears and, similarly to Abemama Island, fishing is predominantly done for export reasons, increasing fishing pressure on reefs. The close proximity of the island to the capital is another cause contributing to the low density of commercially important fish stocks. Therefore sustainable limits will soon be exceeded, especially if no monitoring management guidelines are in put in place.

2.4 Invertebrate resource survey: Abaiang

The diversity and abundance of invertebrate species at Abaiang were independently determined using a range of survey techniques (Table 2.13): broad-scale assessment (using a 'manta' board; locations shown in Figure 2.25) and finer-scale assessment of specific reef and benthic habitats (Figures 2.26 and 2.27).

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

Table 2.13: Number of stations and replicates completed at Abaiang

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	72 transects
Reef-benthos transects (RBt)	12	72 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	11	88 quadrat groups
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
Reef-front search by walking (RFs_w)	2	12 search periods
Sea cucumber day searches (Ds)	4	24 search periods
Sea cucumber night searches (Ns)	0	0 search period

Figure 2.25: Broad-scale survey stations for invertebrates in Abaiang.
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 in Abaiang.
Black circles: reef-benthos transect stations (RBt).

Figure 2.27: Fine-scale survey stations for invertebrates in Abaiang.
Grey stars: sea cucumber day search stations (Ds);
inverted grey triangles: reef-front search stations (RFs);
grey triangles: reef-front search by walking stations (RFs_w);
black stars: soft-benthos infaunal quadrat stations.

Forty-two species or species groupings (groups of species within a genus) were recorded in the Abaiang invertebrate surveys: 13 bivalves, 10 gastropods, 9 sea cucumbers, 3 urchins, 3 sea stars, 1 cnidarian and 2 lobsters (Appendix 4.1.1). Information on key families and species is detailed below.

2.4.1 Giant clams: Abaiang

Broad-scale sampling provided an overview of giant clam distribution across Abaiang atoll. Shallow-reef habitat, which is suitable for giant clams, was very extensive (94 km^2: 69.5 km^2 within the lagoon and 24.8 km^2 of reef fronts/slopes).

The diverse reef habitat held four giant clam species, the most recorded in PROCFish surveys in Kiribati: elongate clam *Tridacna maxima*, fluted clam *T. squamosa*, giant clam *T. gigas* and the horse hoof or bear's paw clam *Hippopus hippopus*. *T. maxima* had the widest occurrence (found in 8 stations and 48 transects), followed by *H. hippopus* (3 stations and 4 transects), and *T. squamosa* (3 stations and 3 transects). A single, live *T. gigas* was found (Figure 2.28).

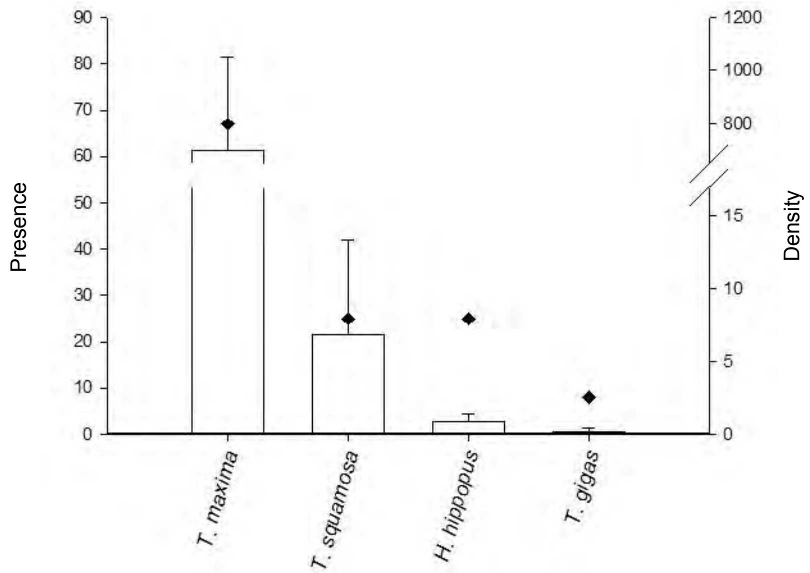

Figure 2.28: Presence and mean density of giant clam species at Abaiang based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat. In these reef-benthos assessments (RBt) *T. maxima* was present within 100% of reef-benthos stations at a mean density of 2472.2 individuals per ha. The other three species were not recorded in reef-benthos transects. Further assessments in deep water (sea cucumber day search) and along the shallows of the lagoon (soft-benthos infaunal quadrats) failed to record any of the larger clam species, although a single recording of *T. squamosa* was made in reef-front searches made on the reef slope. Most clams at Abaiang Atoll were recorded on reef near the southwest passages (subject to water movement); clams were mostly absent from reefs near the populated areas of Abaiang. Although the reef areas on the more enclosed side of the lagoon were less suitable for elongate clams, there was no obvious environmental reason for the absence of this larger clam species in these areas.

The one live *T. gigas* (*te kima*) observed at Abaiang was recorded in the lagoon on deep-water reef (>5m depth) behind the passages. Many empty shells were also seen (locally called *te aubuna*). This survey highlighted the decline in abundance of the true giant clam, *T. gigas*, since a survey in the late 1980s (Munro 1988), which estimated a population density of 4734 *T. gigas* for Abaiang (95% confidence limits were 452–9015 individuals). In that study, *T. gigas* was recorded at a mean density of 1.1 per ha within coral garden areas, 0.4 per ha close to the passages, and 1 per ha in spur-and-groove habitat.

This highlights a rapid decline in abundance of *T. gigas* in the last decade and a half. A survey conducted by GCRMN, the Global Coral Reef Monitoring Network, in early 2005 located a single, live *te kima* in Tarawa lagoon, highlighting the fact that this species is not lost to the central Gilbert Islands group at this time.

The more common, small elongate clam, *T. maxima*, had an average length of 7.4 cm ±0.1 from reef-benthos transects (shallow-water reefs). When clams from deeper water and more exposed locations were included in the calculation (from all assessments), the mean length varied little (7.7 cm ±0.1). The faster-growing *T. squamosa* (which grows to an asymptotic length L_∞ of 400 mm) averaged 18.7 cm ±3.5 in all assessments, and *H. hippopus* averaged 26.8 cm ±2.1. There was only one *T. gigas*, which was measured at over 80 cm. As can be seen from the length frequency graphs (Figure 2.29), there were few recording of large *T. maxima* (around the asymptotic length L_∞ of 30 cm) but recruitment of small *T. maxima* was still strong.

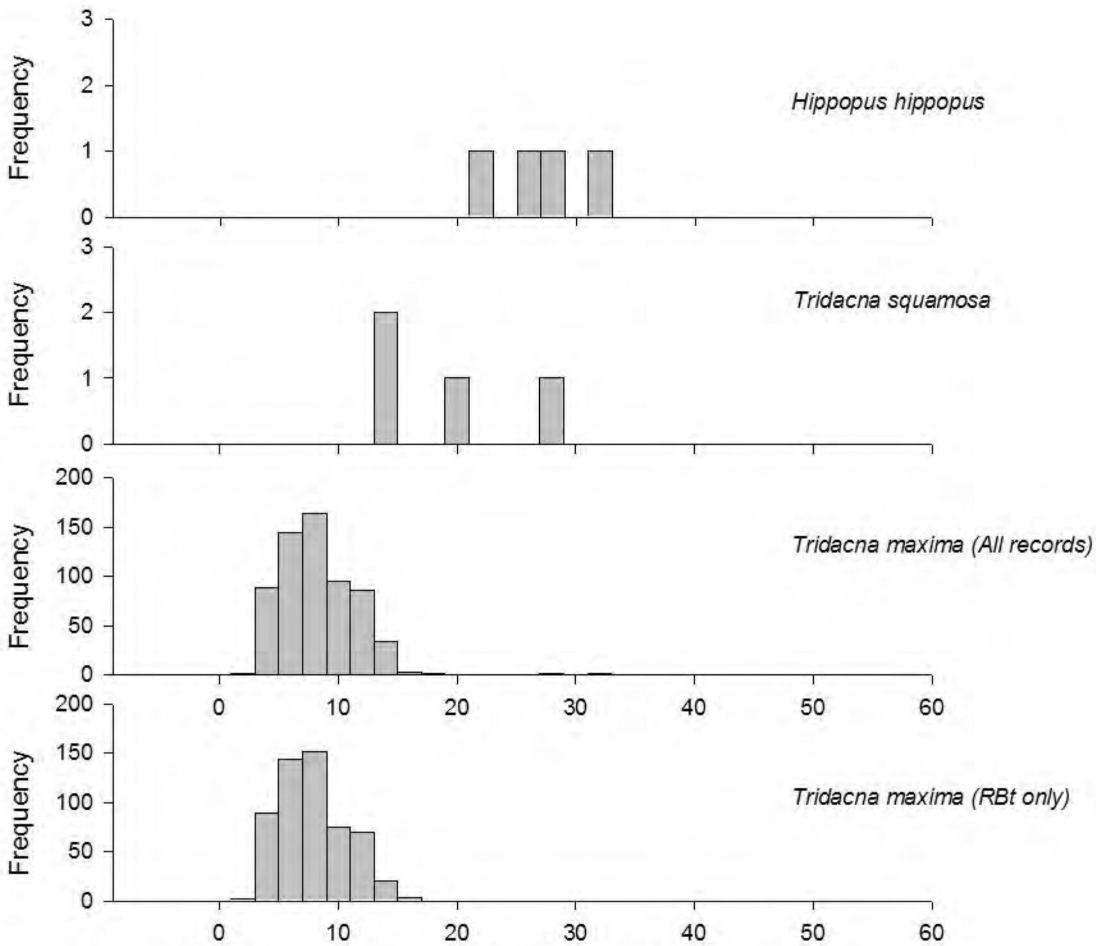

Figure 2.29: Size frequency histograms of giant clam shell length (cm) for Abaiang.

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

Kiribati is not within the natural distribution of the commercial topshell, *Trochus niloticus*. However, in the late 1990s, trochus was transplanted from Fiji to a quarantine facility in Tarawa (FAO 2008, Gillett 2002), and subsequently juvenile trochus (bred in the Tarawa hatchery) were moved to Abaiang. The reefs around Abaiang Atoll constitute an extensive suitable benthos for *T. niloticus* and this area could potentially support significant populations of this commercial species.

Despite searching the release sites for trochus, none were found (nor any dead shells). Although the external reef was extensive (88 km lineal distance of atoll reef perimeter), grazing gastropod numbers were not high in general. The green topshell, *Tectus pyramis* (of low commercial value), which is a closely related species with similar distribution and life history characteristics, was rare. As was the case in Abemama, only a few individuals were recorded during the survey; one on a broad-scale search and one on a reef-benthos transect.

The cryptic and sparsely distributed blacklip pearl oyster, *Pinctada margaritifera*, was not recorded in surveys of Abaiang. This species was, however, noted at the patch reef housing the Kiribati Fisheries – ACIAR experimental pearl farm. More than 50 broodstock and hatchery-reared pearl oysters have been placed out within coral stands at this patch reef, and more are held on nearby mid-water longlines.

2.4.3 Infaunal species and groups: Abaiang

The soft benthos of the coastal margin of the lagoon looked, at first glance, to be slightly more suitable for concentrations of in-ground resources (shell 'beds'), as white sand and stone was colonised by some seagrass but, as in Abemama, there were no obvious inputs of nutrients (rivers absent). Abaiang and other lagoon systems of the Central Gilbert group have renowned *Anadara holoserica* or *te bun* shellfish beds (Tebano 2005). Juvenile *Anadara* settle among seagrass roots, crevices on coral boulders, near or on conspecific adults, and on other suitable hard surfaces. The seagrass present at Abaiang comprised a patchy, narrow strip along the eastern lagoon shoreline. Within these areas, no *Lambis lambis* were found, but other shellfish species of interest were recorded: *Atactodea*, *Cymatium*, *Codakia*, *Gafrarium*, *Onchidium*, *Pinna*, *Spondylus*, *Strombus luhuanus* and *Trachycardium* (Appendix 4.1).

Three fishing areas located along the east coast of the lagoon were sampled for in-ground species (Tebunkinako to the north, Koinawa in the middle, Tuarabu to the south, see Figure 2.27.). Distribution of *te bun* was common (Arc shells were recorded at all stations and 98% of quadrat groups, see Methods.), and generally shells were high in abundance (range of station density 10–83.5 individuals/m^2). The overall mean station density for *A. holoserica* was 41.7 /m^2 ±7.7. This survey found higher densities than a study conducted in July 1994, which recorded only 3 and 6 *te bun* /m^2 for the sampling area of Tuarabu (Tebano 2005).

In the PROCFish study, locations in the middle and north of Abaiang lagoon's eastern shoreline yielded the highest density of *Anadara* (63–83.5 /m^2 at each station). The range of mean length of arc shells for all stations sampled was 3.9–4.7 cm, with the highest density sites holding smaller *te bun* (Figure 2.30). Despite the average shell size being small, 9–43% of all shells sampled were ≥5 cm in length. Interestingly, Tebano (2005) also recorded a small mean shell length at Abaiang (3.8 cm ±8.7 standard deviation (SD) and 2.4 cm ±5.9 SD).

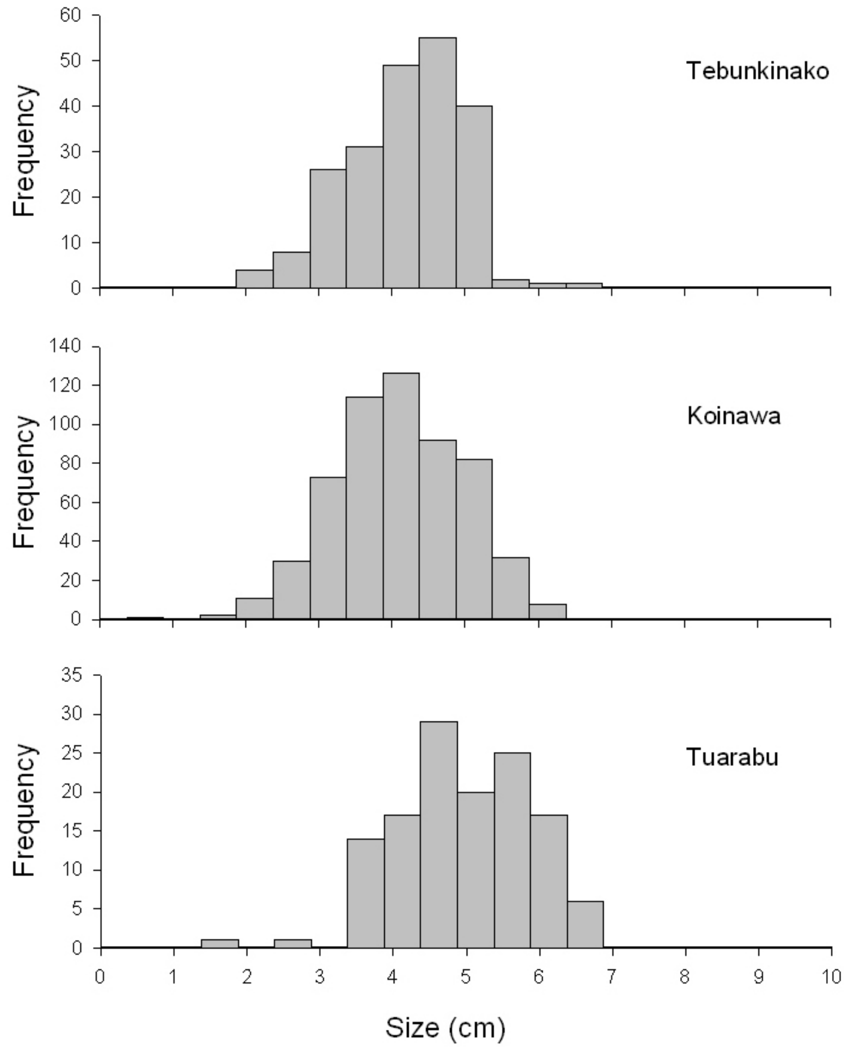

Figure 2.30: Size frequency histograms of arc shell *Anadara* spp. length (cm) for Abaiang.

In addition to the arc shell, another two important resource species were also recorded: the strawberry, or red-lipped, conch *Strombus luhuanus* (*te nouo*), and *Gafrarium pectinatum* (*te koumwara*). Although *S. luhuanus* is not a typical infaunal species (density 454.9 /ha ±448.1 in broad-scale assessments), the conch lies within the upper layers of soft benthos and was found at all infaunal quadrat stations at Abaiang (in 38.6% of quadrat groupings). The mean density of *S. luhuanus* was 2.5 /m^2 ±0.6 and the mean length was 3.7 cm ±0.1.

G. pectinatum (*te koumwara*) were generally small (average size of 2.9 cm ±0.0) but also plentiful (mean station density of 19.4 /m^2 ±8.0, and found in 92% of stations and 75% of quadrat groupings).

2.4.4 Other gastropods and bivalves: Abaiang

Seba's spider conch, *Lambis truncata* (the larger of the two common spider conchs) was detected in 25% of broad-scale surveys, but not in reef-benthos assessments. *Strombus luhuanus* was relatively common throughout the lagoon (found in 33% of broad-scale stations, see Appendices 4.1.1 to 4.1.7). A single *Turbo setosus* was recorded; however, no other *Turbo* spp. were noted. Other species targeted by fishers (resource species, e.g. *Cassis*, *Conus*, *Cymatium*, *Onchidium*, *Tectus*, *Thais* and *Vasum*) were also recorded during independent surveys (Appendices 4.1.1 to 4.1.7). Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Chama*, *Pinna*, *Spondylus* and *Trachycardium* are also in Appendices 4.1.1 to 4.1.7.

No creel survey was conducted at Abaiang atoll, although fishers were collecting *te bun* (both while diving from a canoe and walking), while we were making independent surveys.

2.4.5 Lobsters: Abaiang

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, banded prawn killer *Lysiosquillina* sp. (sand lobster) burrows were noted along the lagoon shoreline, and a single adult *Panulirus* sp. was recorded during broad-scale assessments.

2.4.6 Sea cucumbers[6]: Abaiang

Abaiang atoll has a relatively small land mass (6 islets covering 16 km²) and an extensive lagoon 26 by 8 km that is filled with patch reefs and hard-benthos structure. Reef margins and shallow, mixed hard- and soft-benthos habitat (suitable for sea cucumbers) was extensive in the lagoon and outside the barrier reef. The lagoon was mostly protected (not exposed), but had dynamic water movement in the southwest, near the passages. No rivers are present and allochthonous input (riverine or other inputs from land) seems limited. However, reefs near Abaiang's main settlements (mainly patch reefs) were in poor condition, bleached and overgrown with epiphytes in localised areas. Despite the generally oceanic nature of most of the Abaiang environment, nine commercial species of sea cucumber were recorded during in-water assessments (Table 2.14).

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 2.14, see Methods.). Deep dives on SCUBA (25–35 m) were conducted to obtain a preliminary assessment of deep-water stocks, such as the high-value white teatfish (*Holothuria fuscogilva*), prickly redfish (*Thelenota ananas*) and the lower-value amberfish (*T. anax*).

The presence of valuable commercial species at Abaiang was similar to that at Abemama, the other PROCFish site with a major lagoon system studied in western Kiribati. The profile of the sea cucumber fishery at all sites in Kiribati reflected the oceanic nature of the environment, which impacted on the range and potential densities of these deposit feeders, which eat organic matter in the upper few mm of bottom substrates. Also, there is active fishing for sea cucumbers at Abaiang.

Deep-water assessments (average 27 m depth) could not generally be made within the lagoon (only 1 of 4 assessments) as the lagoon and, more importantly, the passes were relatively shallow (<15 m). White teatfish (*Holothuria fuscogilva*) was not recorded in assessments although collections of white teatfish have been conducted in Abaiang by Fisheries staff

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

when collecting broodstock for the hatchery in Tarawa. Anecdotal reports stated that these collections were difficult, as none could be found until divers reached depths of approximately 70 m (outside the middle passage). In addition, juvenile white teatfish have been released back into Abaiang (Friedman and Tekanene 2005). Prickly redfish (*T. ananas*) and amberfish (*T. anax*) were present in deep-water assessments at medium-to-low densities. Prickly redfish (*T. ananas*) was also recorded in broad-scale assessments of shallow water, although only a single individual was noted.

Other species associated with reef, such as the low-value flowerfish (*Bohadschia graeffei*), medium-value leopardfish (*Bohadschia argus*) and the high-value black teatfish (*Holothuria nobilis*) were present but very rare and at low density (found in 1–4 % of broad-scale transects). Greenfish (*Stichopus chloronotus*) was present but also not at commercial density. Finally, surf redfish (*Actinopyga mauritiana*) was recorded at one reef-front search station, but no moderate or high densities were recorded. The overall occurrence and densities of these reef species were unexpectedly low considering the nature and extent of protected reef and surge zone present at Abaiang.

More protected areas of reef and soft benthos in the lagoon were reported to hold blackfish (*Actinopyga miliaris*; BdM trader reported rare purchases.), but these were not seen in survey. Unfortunately, no night dive was completed in Abaiang. A few lower-value species, e.g. brown sandfish (*Bohadschia vitiensis*) and lollyfish (*Holothuria atra*) were recorded; however, the occurrence and density of *B. vitiensis*, which is more valuable, were low.

The presence and density of medium-value surf redfish (*Actinopyga mauritiana*), high-value white teatfish (*Holothuria fuscogilva*), and prickly redfish (*Thelenota ananas*) in this preliminary survey suggest that stocks are heavily impacted by fishing.

2.4.7 Other echinoderms: Abaiang

A single edible slate urchin (*Heterocentrotus mammillatus*), but no collector urchins (*Tripneustes gratilla*) were recorded at Abaiang. *Echinometra mathaei* and *Echinothrix diadema* were present in survey, but were at low density (≤10 /ha in reef-benthos and reef-front assessments).

The blue starfish (*Linckia laevigata*) was recorded in assessments (17% of broad-scale and reef-benthos stations) but was at low density (3.7 and 6.9 /ha). Coralivore (coral eating) starfish, such as the cushion star (*Culcita novaeguineae*), were also present (in 42% of broad-scale stations) at greater density (8 and 52 /ha, for broad-scale and reef-benthos stations) and a single crown of thorns starfish (*Acanthaster planci*) was recorded on shallow-water reef at the southwest passage (Tabonetebike; see presence and density estimates in Appendices 4.1.1 to 4.1.7.).

Table 2.14: Sea cucumber species records for Abaiang

Species	Common name	Commercial value	B-S transects n = 72			Reef-benthos stations; n = 18			Other stations RFs = 4; RFs_w = 2			Other Stations Ds = 4; SBq = 11		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga mauritiana	Surf redfish	M/H							1.0	3.9	25 RFs			
Actinopyga miliaris	Blackfish	M/H										Anecdotal – small number sold to BDM agent originates from Abaiang		
Bohadschia argus	Leopardfish	M	0.2	16.7	1							0.6	2.4	25 Ds
Bohadschia graeffei	Flowerfish	L	4.2	60.0	7	17.4	69.4	25						
Bohadschia vitiensis	Brown sandfish	L	0.7	16.7	4									
Holothuria atra	Lollyfish	L	662.0	3972	17				1.9	3.7	50 RFs_w	4.1 /m^2	4.1 /m^2	100 SBq
Holothuria edulis	Pinkfish	L												
Holothuria fuscogilva [4]	White teatfish	H										Tarawa hatchery – see text		
Holothuria fuscopunctata	Elephant trunkfish	M												
Holothuria nobilis [4]	Black teatfish	H	0.2	16.7	1									
Stichopus chloronotus	Greenfish	H/M	1.9	22.2	8									
Thelenota ananas	Prickly redfish	H	0.2	16.7	1							6.5	8.7	75 Ds
Thelenota anax	Amberfish	M										14.3	19.0	75 Ds

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

2.4.8 Discussion and conclusions: invertebrate resources in Abaiang

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.

- Present densities of elongate clams within Abaiang atoll are not low; however, the size distribution of clams suggests there is heavy fishing pressure on the stock. *Tridacna squamosa* and *Hippopus hippopus*, the two faster-growing, large clam species, are rare in Abaiang to a point where reproductive success and subsequent recruitment may be impaired. These stocks are likely to decline further if action is not taken to protect these two species. *T. gigas* stocks in Abaiang have undergone a catastrophic decline in the last decade and a half (Munro 1988), and stocks are severely impacted by fishing. The single *T. gigas* clam found in the lagoon is an invaluable resource for Kiribati. Mostly dead shells of this large species remain, and the last remnant live specimens should be fully protected from fishing. In-situ collection of gametes is recommended to allow a breeding programme for the remaining few clams that are found in Abaiang and Tarawa lagoons.

- Based on the survey of mother-of-pearl stocks, *Trochus niloticus* has not become well established following translocation from Tarawa. It has not been a long time since juvenile trochus were released and therefore it is still too early to judge whether trochus will successfully colonise the reefs of Abaiang.

- Although the reef systems at Abaiang are extensive, with habitat for both juvenile and adult molluscs, grazing gastropods, such as *Tectus pyramis*, were at low abundance. It is unlikely that this situation is completely the result of overfishing and may indicate that conditions for grazing gastropods are less than optimal.

- Wild populations of *Pinctada margaritifera* are degraded and are considered to be commercially extinct[7].

- Shell beds at Abaiang held a large number of *Anadara holoserica* (*te bun*) at a range of size classes. Density and size-range measures of arc shells describe a resource only marginally impacted by fishing, with excellent recruitment. The smaller mean size of *A. holoserica* found at very high densities might be due to density-dependent growth, i.e. the overall growth in size is limited due to overcrowding within the population. If there was an area that needed re-seeding with *te bun* some of the smaller shells could be transplanted to other areas in Abaiang.

- The resource species *Strombus luhuanus* (*te nouo*) and *Gafrarium* spp. (*te koumwara*) were also recorded at reasonable densities.

- Based on the information collected on sea cucumber stocks, there is a limited number of species available for bêche-de-mer production, and commercial fishing is not recommended at present stock levels.

[7] Can be seen as being 'commercially extinct' – referring 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

2.5 Overall recommendations for Abaiang

- A monitoring programme be implemented for finfish, with any future development of reef finfish fishing focused on the outer reef rather than the lagoon areas, which are currently the most targeted habitats and already showing signs of depletion.

- Catches of drummer, parrotfish and wrasse be limited and monitored to avoid overfishing of these species.

- Future expansion of finfish resource harvesting primarily target the relatively untouched deep-bottom fish species to ease pressure on the reef fish stocks.

- Regulations be developed and implemented to control the level of gillnetting and spearfishing in the outer reefs for bumphead parrotfish and napoleon wrasses as spearfishing will seriously deplete these resources in a short time.

- A marine protected area be considered as a primary management tool to ensure the long-term conservation of the coastal reef fisheries on the island.

- Any *Tridacna gigas* found at Abaiang be collected and used in a breeding programme for this species.

- Management measures be introduced for sea cucumbers to allow this species to recover from previous fishing pressure.

3. PROFILE AND RESULTS FOR ABEMAMA

3.1 Site characteristics

Abemama is located 153 km to the southeast of Tarawa, just north of the equator (Figure 3.1). The atoll has a lagoon on its west side, which is relatively silty with poor visibility in some locations. There are two main passages through the reef.

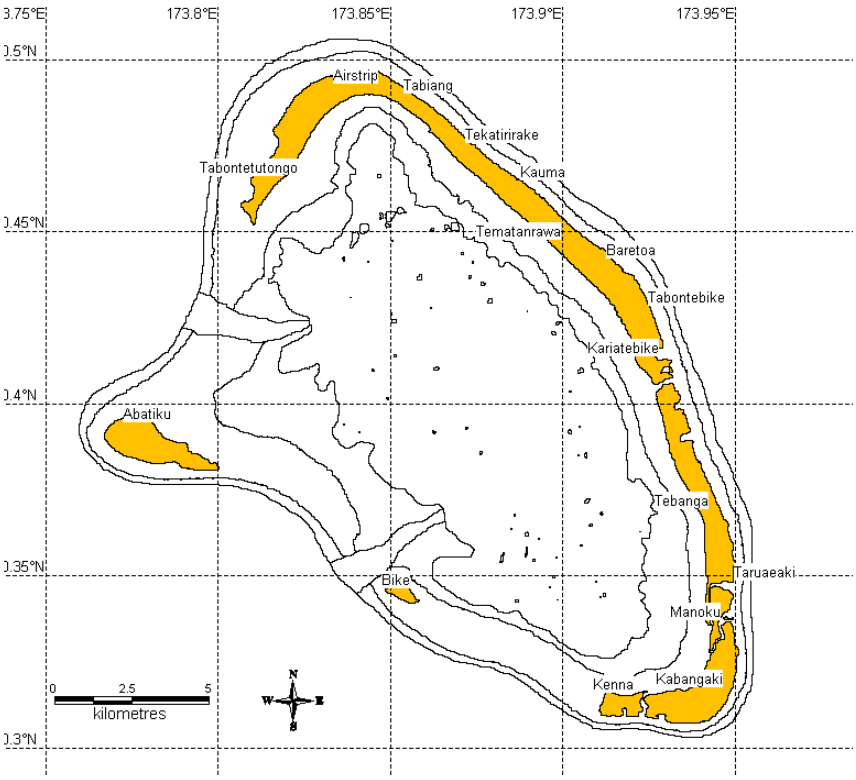

Figure 3.1: Map of Abemama.

3.2 Socioeconomic survey: Abemama

Socioeconomic fieldwork was carried out on the island of Abemama at the end of September 2004. The survey covered two villages on Abemama island: Kariatebike and Tabiang, and several households located on the small island of Abatiku. In total, 25 households, including 160 people were interviewed. Thus, the survey covered >4% of the island's households (~580 in total) and total population (~3725 people).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 16 individual interviews of finfish fishers (15 males and only 1 female, as females are not really engaged in finfish fisheries) and 19 invertebrate fishers (7 males, 12 females) were conducted. These fishers belonged to one of the 25 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing.

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

Our survey results suggest an average of 2.3 fishers per household; although this number varies among the three villages surveyed (i.e. the average number of fishers per household is 2.5, 2.2 and 1.6 for Tabiang, Abatiku Island and Kariatebike respectively). If we extrapolate our survey data to the total number of households on Abemama, we arrive at a total of 535 male finfish fishers, and 70 male and 396 female invertebrate fishers. About 233 male fishers and 93 female fishers fish for both finfish and invertebrates.

Our survey suggests that, on average, 52% of all households own a boat. However the percentage of households and the type of boats available on Abemama vary substantially among the communities surveyed. For example, on Abatiku island, and not surprisingly considering its isolation, 80% of households own a sailboat, while only 47% of households in Tabiang own a boat (mostly sailboats, a few motorised and paddling canoes only). Half of the 40% of Kariatebike households that own a boat have a paddling canoe and the other half a sailboat.

Fisheries provide the first source of income for only one-quarter of all households surveyed on Abemama and second income for 28%. Agriculture is the most important source of revenue and provides first income for 56% of all Abemama households interviewed. Salaries and income from handicrafts (mat weaving) only play a minor role, providing 16% and 4% of all households respectively with their major source of income (Figure 3.2).

On average, 24% of all households surveyed receive remittances. However, this percentage varies substantially (0–40%) and so does the annual amount received. While none of the households surveyed in Kariatebike receive any remittances, 40% in Abatiku and 26% in Tabiang do receive remittances. The annual quantities received are moderate (USD 680 and 817 per year); they cover the annual average household expenditure in Abatiku island (USD 674 per year) and almost reach the level of average household expenditures in the case of Tabiang (USD 1189 per year). Overall, the average household expenditure level on Abemama amounts to USD 1041 per year.

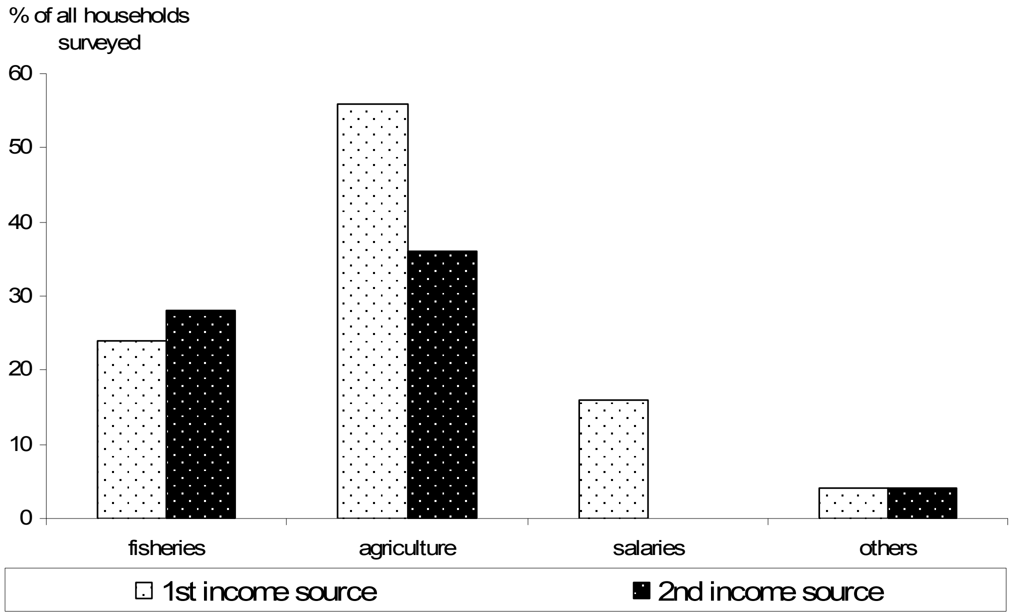

Figure 3.2: Ranked sources of income (%) in Abemama.
Total number of households = 25 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.
'Others' are mostly handicraft, particularly mat weaving.

The annual per capita fresh fish consumption is high if compared to the regional average (Figure 3.3). However, information published elsewhere suggests a much higher national consumption figure than calculated on the basis of our survey data. As compared to all other PROCFish/C sites in Kiribati, fresh fish consumption in Abemama is the highest.

Fresh fish is consumed almost every day, on average 6.3 days per week. Invertebrates are less popular and on average are eaten less than once per week (0.8 times/week). The average invertebrate consumption of 1.7 kg/person/year (meat only) is below the average across all other PROCFish/C sites surveyed in Kiribati. Canned fish is eaten as little as invertebrates. However, the frequency and quantity of canned fish consumption varies considerably more than invertebrate consumption (Figure 3.4), i.e. from 0.7 times/week in Tabiang to 1.2 times/week in Kariatebike, and from 4.1 kg/person/year in Tabiang to 8.8 kg/person/year in Abatiku island.

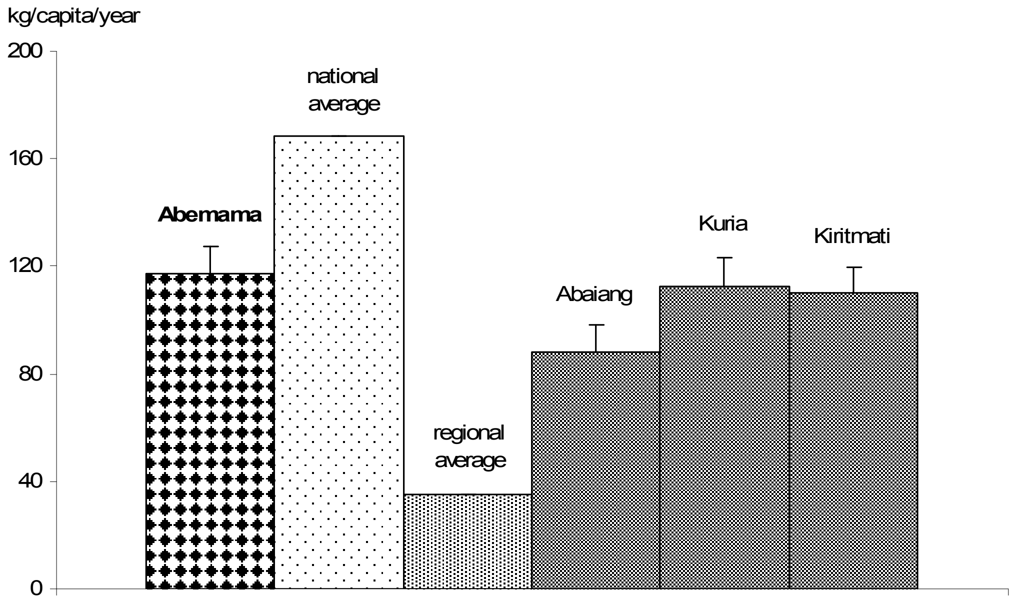

Figure 3.3: Per capita consumption (kg/year) of fresh fish in Abemama (n = 25) compared to national and regional averages (Gillett 2002) and the other three PROCFish/C sites in Kiribati.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

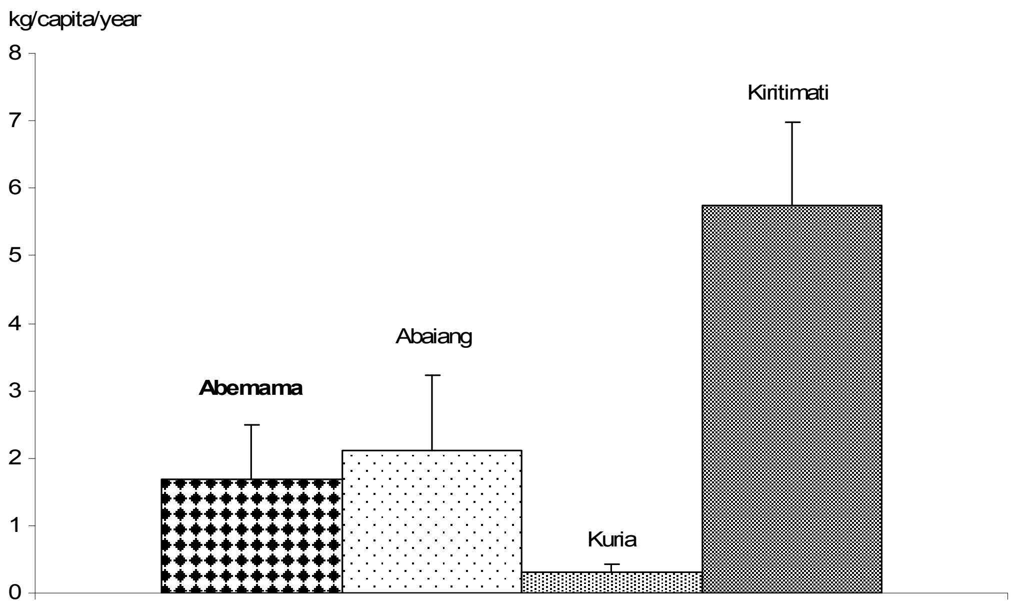

Figure 3.4: Per capita consumption (kg/year) of invertebrates (meat only) in Abemama (n = 25) compared to the other three PROCFish/C sites in Kiribati.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

By comparison with all PROCFish/C sites in Kiribati (Table 3.1), on average, households have slightly more fishers but are less dependent on fishing as first income source than the average of all survey sites. Household expenditures are below average and remittances received are low. Fresh fish consumption is above the average, and canned fish is consumed about the same as average across all sites investigated. While more households than the average eat invertebrates, the proportion of households that eat fresh fish and canned fish is the same as the average figure of all Kiribati PROCFish/C sites. A larger proportion of Abemama's households catch the fish and the invertebrates they eat, and also more households buy the fish they consume. Fewer households consume fresh fish they are given than the average across all sites, and the share of households that receive invertebrates on a non-monetary basis is negligible.

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

Survey coverage	Abemama (n = 25 HH)	Average across sites (n = 98 HH)
Demography		
HH involved in reef fisheries (%)	96	95
Number of fishers per HH	2.28 (±0.23)	1.95 (±0.11)
Male finfish fishers per HH (%)	40.4	41.9
Female finfish fishers per HH (%)	0.0	0.5
Male invertebrate fishers per HH (%)	5.3	6.3
Female invertebrate fishers per HH (%)	29.8	28.3
Male finfish and invertebrate fishers per HH (%)	17.5	20.9
Female finfish and invertebrate fishers per HH (%)	7.0	2.1
Income		
HH with fisheries as 1st income (%)	24	34
HH with fisheries as 2nd income (%)	28	24
HH with agriculture as 1st income (%)	56	43
HH with agriculture as 2nd income (%)	36	27
HH with salary as 1st income (%)	16	18
HH with salary as 2nd income (%)	0	2
HH with other sources as 1st income (%)	4	5
HH with other sources as 2nd income (%)	4	5
Expenditure (USD/year/HH)	1041 (±114.06)	1485 (±128.38)
Remittance (USD/year/HH) (1)	773 (±217.05)	1486 (±187.22)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	117.1(±10.83)	106.9 (±5.32)
Frequency fresh fish consumed (times/week)	6.3 (±0.30)	5.6 (±0.18)
Quantity fresh invertebrate consumed (kg/capita/year)	1.69 (±0.81)	2.57 (±5.32)
Frequency fresh invertebrate consumed (times/week)	0.8 (±0.18)	0.7 (±0.09)
Quantity canned fish consumed (kg/capita/year)	5.5 (±1.08)	5.7 (±0.87)
Frequency canned fish consumed (times/week)	0.8 (±0.16)	0.7 (±0.09)
HH eat fresh fish (%)	100	100
HH eat invertebrates (%)	96	74
HH eat canned fish (%)	68	66
HH eat fresh fish they catch (%)	92	88
HH eat fresh fish they buy (%)	56	28
HH eat fresh fish they are given (%)	24	36
HH eat fresh invertebrates they catch (%)	88	64
HH eat fresh invertebrates they buy (%)	4	8
HH eat fresh invertebrates they are given (%)	4	0

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

3.2.2 Fishing strategies and gear: Abemama

Degree of specialisation in fishing

Finfish fishing on Abemama is dominated by males; about 58% of all fishers are male (~40% finfish fishers only, ~18% fishers for both finfish and invertebrates) and only about 7% of females fish for both finfish and invertebrates. Furthermore, a gender separation exists between males, who focus on finfish fishing, and females who are the main invertebrate fishers (Figure 3.5).

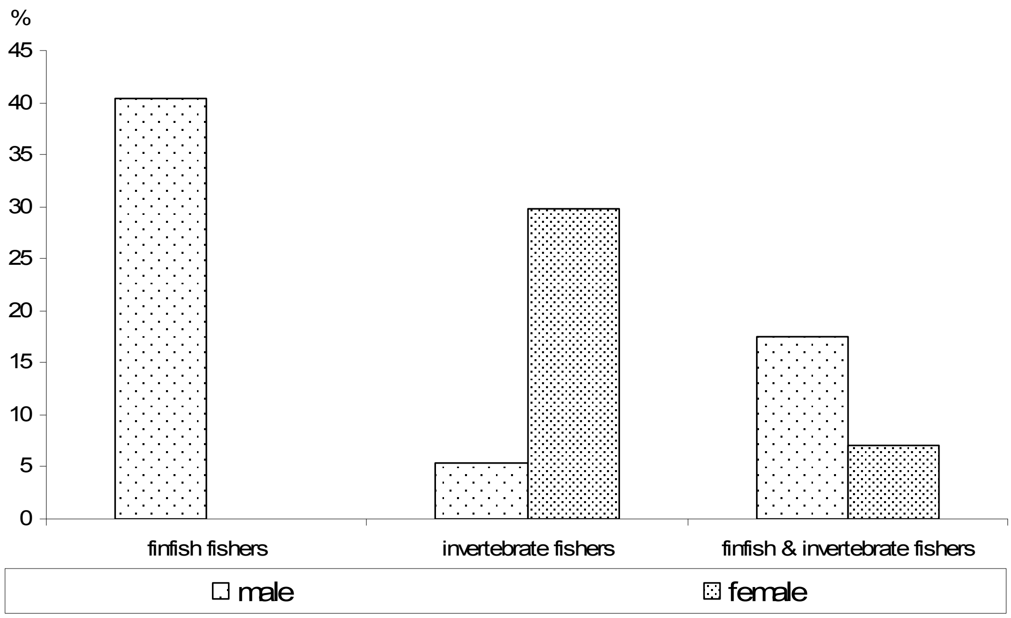

Figure 3.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Abemama.
All fishers = 100%.

Targeted stocks/habitats

Invertebrate fisheries are limited to reef habitats and some intertidal and/or intertidal and soft-benthos habitats. Finfish fishers may target the sheltered coastal or the outer reef, the lagoon area and the passages, which connect the lagoon with the open ocean (Table 3.2). Information provided by respondents on the areas fished for the different target species are shown in Figure 3.6.

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

Resource	Fishery / Habitat	% male fishers interviewed	% female fishers interviewed
Finfish	Sheltered coastal reef	40.0	0
	Lagoon	53.3	100.0
	Sheltered coastal and outer reefs	6.7	0
	Outer reef	6.7	0
	Passage	6.7	0
Invertebrates	Intertidal	42.9	41.7
	Intertidal & soft benthos	28.6	58.3
	Lobster	28.6	0
	Reeftop	0	8.3

Finfish fisher interviews, males: n = 15; females: n = 1. Invertebrate fisher interviews, males: n = 7; females, n = 12.

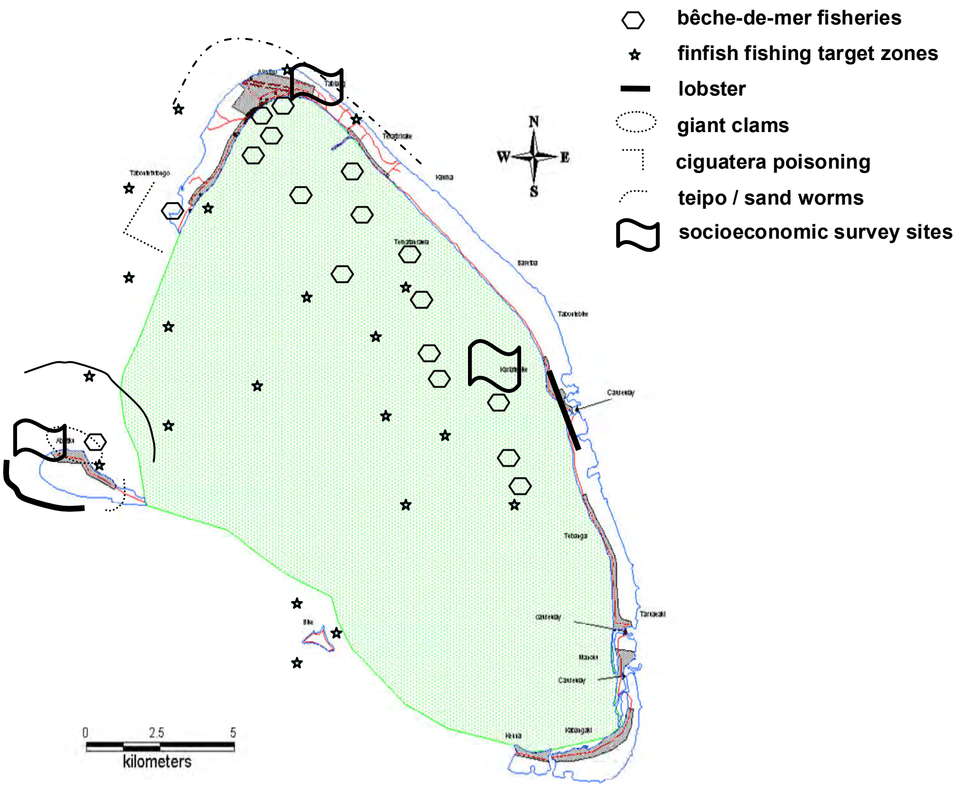

Figure 3.6: Socioeconomic survey sites and habitats fished as indicated by respondents in Abemama.

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 Abemama on their fishing grounds.

Our survey sample suggests that most fishers target the lagoon (56%), and far fewer the sheltered coastal reef (38%), the combined sheltered coastal and outer reef (6%), and the outer reef and passages (6%).

On Abemama, most invertebrate fishers glean (~70% of male and 100% of female fishers) in the intertidal or the combined intertidal and soft-benthos habitats. Only ~29% of all male invertebrate fishers dive for lobsters (Figure 3.7).

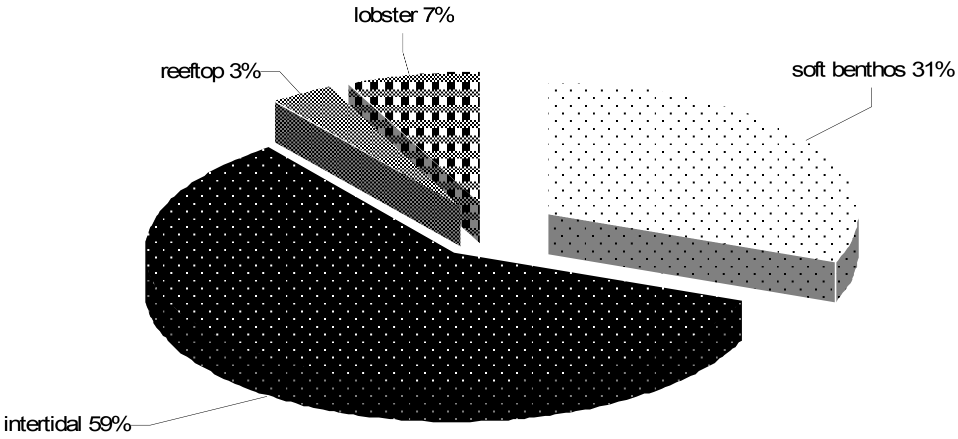

Figure 3.7: Proportion (%) of fishers targeting the four primary invertebrate habitats found in Abemama.
Data based on individual fisher surveys; data for combined fisheries are disaggregated.

There is a clear gender separation between lobster diving and all other gleaning fisheries on Abemama (Figure 3.8). While the lobster dive fishery is exclusively performed by male fishers, only females glean the reeftops; all other gleaning fisheries are performed by both males and females.

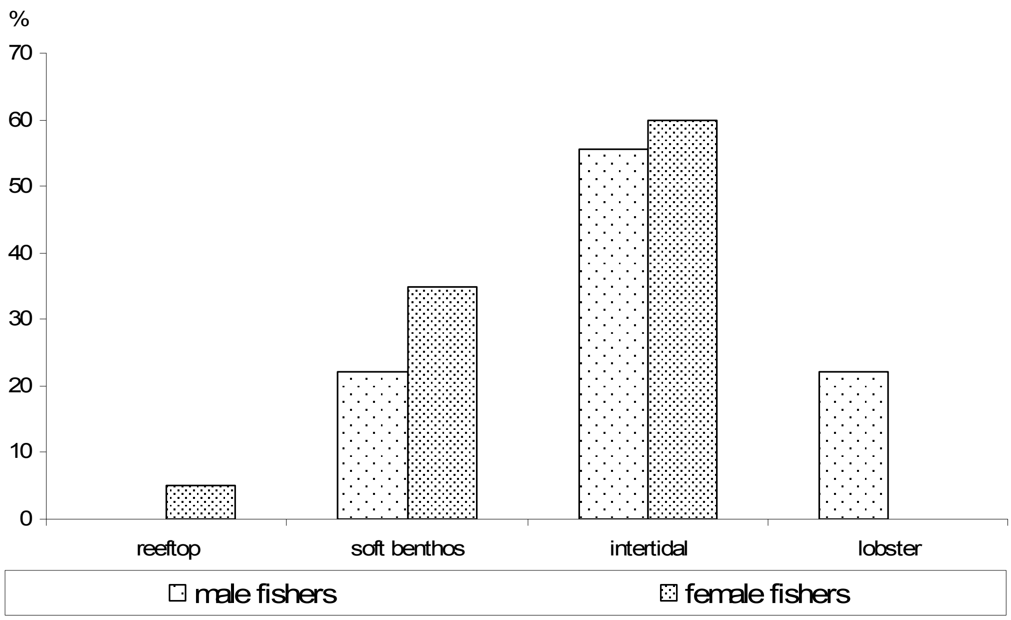

Figure 3.8: Proportion (%) of male and female fishers targeting various invertebrate habitats in Abemama.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 7 for males, n = 13 for females.

Gear

Figure 3.9 shows that, although a variety of fishing gear is used for finfish fishing on Abemama, gillnets are the main method used at the sheltered coastal reef, the sheltered coastal and the outer reef combined, the lagoon, and the passages. However, at the outer reef, castlines are the main gears used. Spear diving, rod and lines and other techniques are generally of low importance.

Figure 3.9: Fishing methods commonly used in different habitat types in Abemama.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Gleaning on Abemama is done by walking only using simple tools. Lobster diving is only performed at night. All other invertebrate fisheries are exclusively performed during the day.

Frequency and duration of fishing trips

As shown in Table 3.3, trips to the lagoon are on average the most frequent (4–5 times/week) while trips to the sheltered coastal reef and the outer reef are less frequently made (3 times/week and 2.4 times/week respectively). The least frequent trips are those to the passages (once a week). The duration of fishing trips regardless of which habitat is targeted are similar, about 3–3.5 hour/trip. Invertebrate gleaning is performed more frequently (1–2 times/week) than lobster diving (once a month). However, dive trips take much longer (~3 hours/trip) than any of the gleaning activities (1–2.2 hours/trip).

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	2.41 (±0.62)		3.25 (±0.28)	
	Sheltered coastal & outer reefs	6.00 (n/a)	0	2.00 (n/a)	0
	Lagoon	4.81 (±0.27)	2.00 (n/a)	3.50 (±0.62)	2.00 (n/a)
	Outer reef	3.00 (n/a)	0	3.00 (n/a)	0
	Passages	1.00 (n/a)	0	3.50 (n/a)	0
Invertebrates	Intertidal	0.58 (±0.23)	1.85 (±0.55)	1.67 (±0.33)	2.20 (±0.34)
	Intertidal and soft benthos	1.12 (±0.88)	1.01 (±0.41)	1.50 (±0.50)	1.57 (±0.17)
	Reeftop	0	1.00 (n/a)	0	1.00 (n/a)
	Lobster	0.23 (±0.00)	0	3.00 (±1.00)	0

Figures in brackets denote standard error; n/a = standard error not calculated.
Finfish fisher interviews, males: n = 15; females: n = 1. Invertebrate fisher interviews, males: n = 7; females: n = 12.

3.2.3 Catch composition and volume – finfish: Abemama

Catches reported from the sheltered coastal reef are dominated by *Mugil* spp. (*aua*) (26%), *Caranx melampygus* (*rereba*) (25%), and *Lutjanus gibbus* (*ikanibong*) (18%). Lagoon catches consist mainly of *Mugil* spp. (*aua*) (34%) and *Albula vulpes* (*ikari*) (28%), while catches from the outer reef are reported to vary more widely and include *Valamugil seheli* (*bana*) (24%), *Acanthurus xanthopterus* (*mako*) (18%), *Gerres oyena* (*ninimai*) (18%), *Lutjanus fulvus* (*bwawe*) (14%), *Lethrinus obsoletus* (*okaoka*) (14%) and *Parupeneus* spp. (*tewe*) (11%). If the sheltered coastal and outer reefs are combined in one fishing trip, catches are dominated by *Caranx melampygus* (*rereba*) (30%), *Naso unicornis* (*bokaboka*) (18%), *Acanthurus xanthopterus* (*mako*) (13%) and *Lethrinus obsoletus* (*okaoka*) (13%). *Mugil* spp. (*aua*) are the only fish reported for catches from passage fishing. Further details on the annual catch composition of reported catches in Abemama are provided in Appendix 2.2.1.

Our survey sample of finfish fishers interviewed represents about 2% of the projected total number of finfish fishers on the island of Abemama. However, we interviewed most fishers in the community of Tabiang, the closest to the island's airport and thus with easiest access for export to Tarawa. We also included fishers from the more administrative community of Kariatebike and the more isolated, offshore island community of Abatiku. Although our sample may well represent the range of fishing activities, it is of limited size. Thus, we refrain from extrapolating our data to avoid over- or underestimating the fishing impact on Abemama's fishing grounds. Thus, we focus on the reported and collected survey data, which are summarised in Figure 3.10.

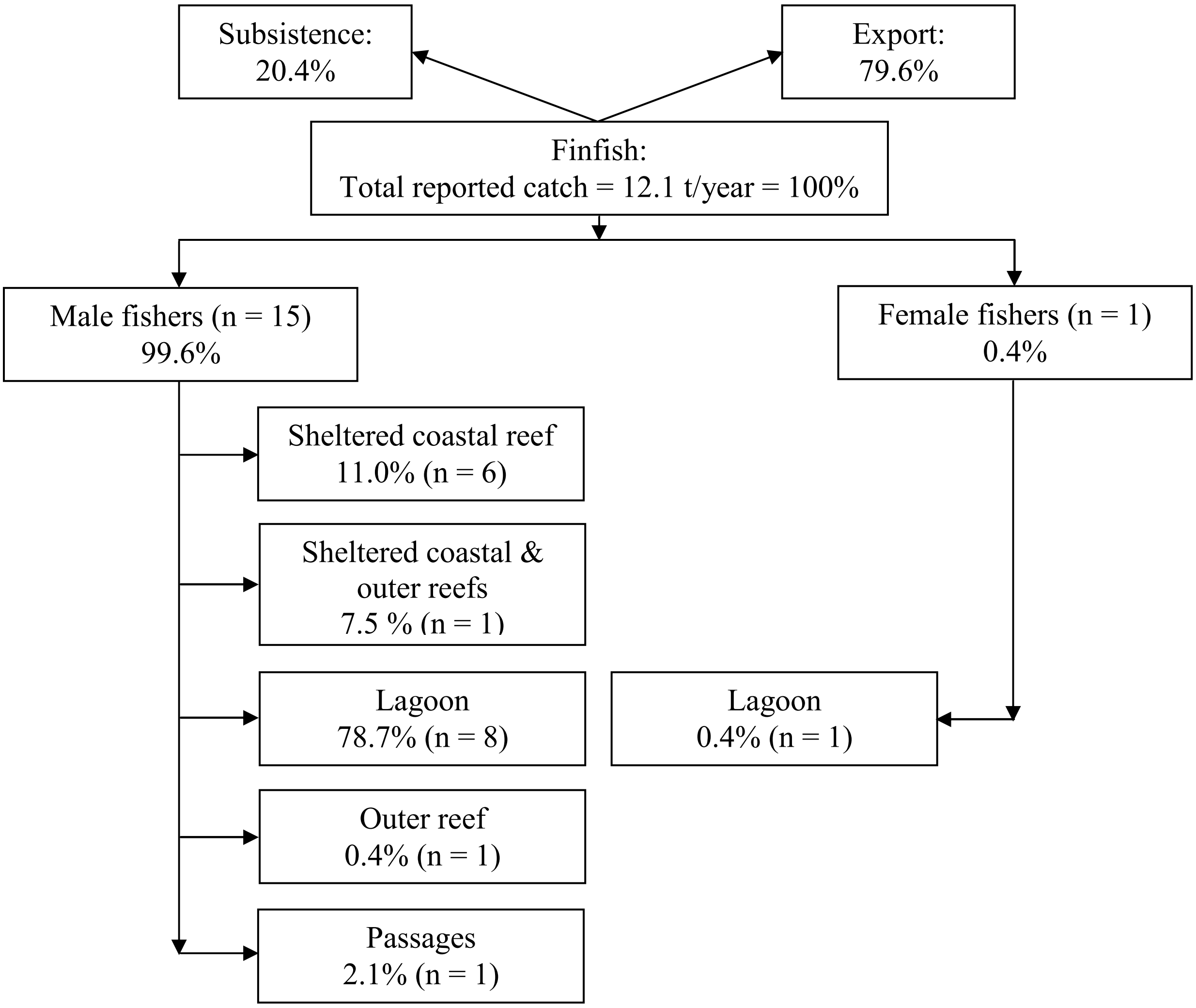

Figure 3.10: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Abemama.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

Figure 3.10 shows that the major proportion of the reported annual catch is from lagoon fishing. Catches from the sheltered coastal reef and from trips that combine both the sheltered coastal and the outer reefs are of minor importance (11 and 7.5% respectively), and all other contributions, such as from the outer reef and passages, are insignificant. Most of the catch is exported to Tarawa, and about 20% is consumed by the community on Abemama.

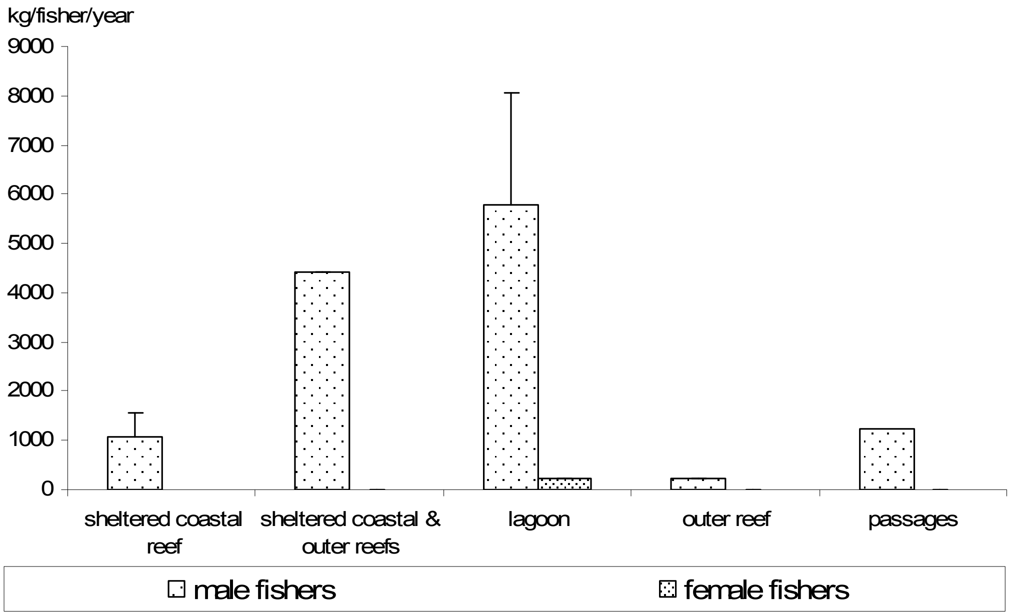

Figure 3.11: Average annual finfish catch (kg/year) per fisher by habitat and gender in Abemama.
Bars represent standard error (+SE).

The high proportion of male fishers (53%) targeting the lagoon and their high annual catch contrast the low annual catches of a yet considerable proportion of male fishers (40%) targeting the sheltered coastal reef (Figure 3.11). Outer-reef and passage fishing also yield very low annual catches. Almost 80% of the total reported annual catch is sourced from lagoon fishing.

Finfish fishing is hardly ever performed by females. Thus we can only compare the CPUEs of male fishers targeting different habitats. In addition to the differences in average annual catch rates, Figure 3.12 shows no major differences in CPUE between fishing the sheltered coastal and outer reefs in the same fishing trip, and fishing in the lagoon. However, CPUE for fishing the outer reef is extremely low; CPUEs are also low for fishing the sheltered coastal reef alone, and for fishing in the passages.

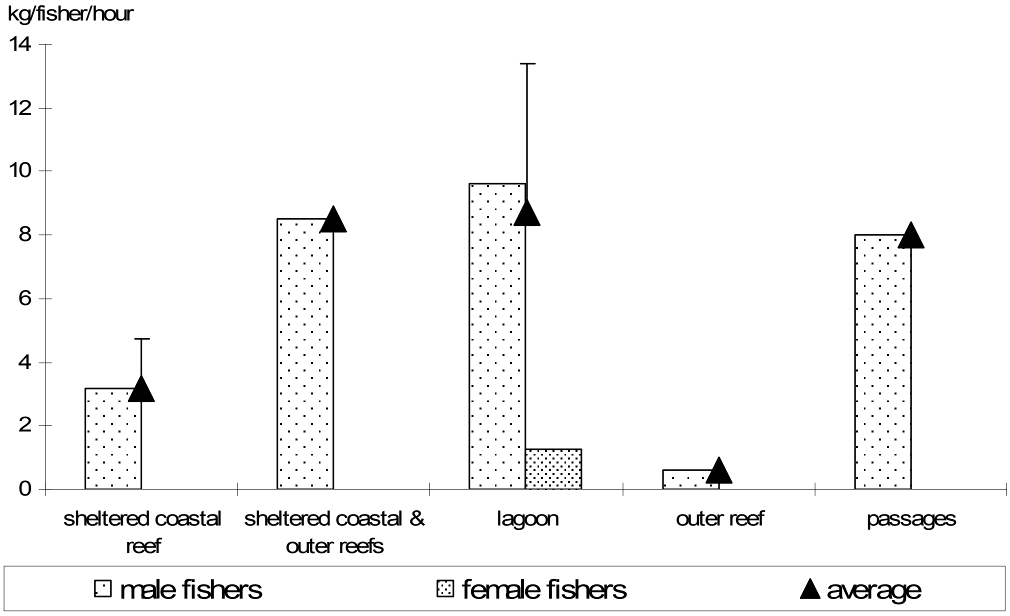

Figure 3.12: Catch per unit effort (kg/hour of total fishing trip) for male fishers by habitat in Abemama.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Survey data show (Figure 3.13) that most of the catch is sold for export. This applies for all habitats except for the sheltered coastal or the outer reefs. Here, subsistence needs are the major if not the only reason for fishing and may possibly explain the comparatively low CPUEs in these two habitats. However, the sample size of fishers targeting the outer reef is low and results may therefore be misleading.

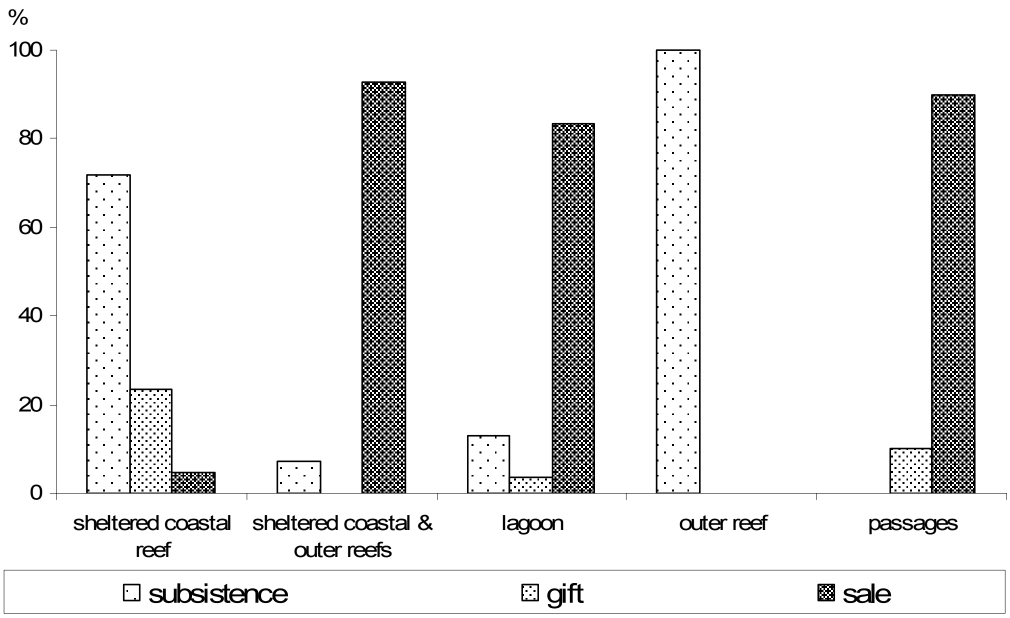

Figure 3.13: The use of finish catches for subsistence, gift and sale, by habitat in Abemama.
Proportions are expressed in % of the total number of trips per habitat.

Data on the average reported finfish sizes by family and habitat (Figure 3.14) show that, while average fish sizes range from 8 to >32 cm, most sizes are 20–30 cm. The reported average sizes per family caught either during trips that combine the sheltered coastal and outer reef, or that target the lagoon area only, do not vary significantly. Data suggest an unexpected decrease in average fish size from the sheltered coastal to the outer reef. However, data may be misleading due to the limited sample size.

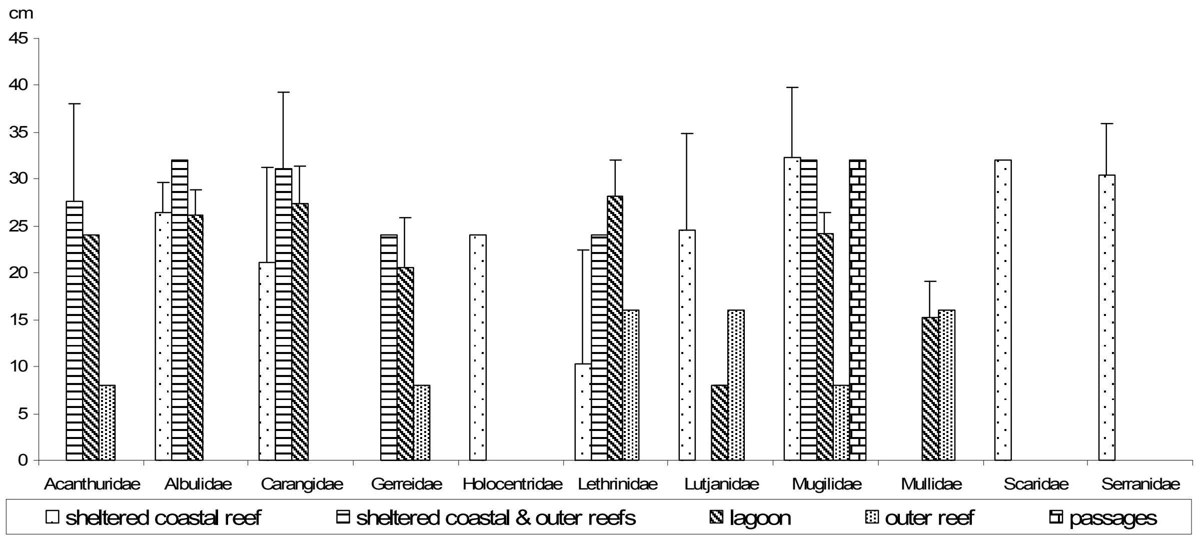

Figure 3.14: Average sizes (cm fork length) of fish caught by family and habitat in Abemama. Bars represent standard error (+SE).

Some parameters selected to assess the current fishing pressure on Abemama's reef resources are shown in Table 3.4. The comparison of habitat surfaces that are included in Abemama's fishing ground shows that the lagoon is the largest area, followed by the sheltered coastal reef. Both habitats dominate the total fishing ground of the atoll's lagoon system. The outer reef and passages are the smallest. Overall, fisher density is low with 6 and 3 fishers/km² of total reef and total fishing ground area respectively. Low fisher density also applies for the sheltered coastal reef, lagoon and outer reef. This is particularly important as far as the lagoon is concerned, where fishers have very high average annual catch rates. If we consider the subsistence needs of the atoll's population alone, fishing pressure is low. Nevertheless, the actual fishing pressure must be much higher when considering that about 80% of all catches are for export to Tarawa.

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

Parameters	Habitat						
	Sheltered coastal reef	Sheltered coastal & outer reefs	Lagoon	Outer reef	Passages	Total reef area	Total fishing ground
Fishing ground area (km^2)	78.84	n/a	150.98	21.38	5.88	150.29	257.07
Density of fishers (number of fishers/km^2 fishing ground) (1)	3		3	4		6	3
Population density (people/km^2) (2)						25	52
Average annual finfish catch (kg/fisher/year) (3)	1079.30 (±488.47)	4425.12 (n/a)	5175.27 (±2089.59)	234.95 (n/a)	1220.34 (n/a)		
Total fishing pressure of subsistence catches (t/km^2)						2.8	1.6

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; (1) total number of fishers (= 861) is extrapolated from household surveys; (2) total population = 3725; total subsistence demand = 413.1 t/year; (3) catch figures are based on recorded data from survey respondents only.

3.2.4 Catch composition and volume – invertebrates: Abemama

Calculations of the recorded annual catch rates per species groups are shown in Figure 3.15. The graph shows that the major impact by wet weight is on sea worms (*Sipunculus indicus*). All other reported catches are much less important. For example, if adding catches of *Panulirus* spp. and *Parribacus* spp. together, the lobster fishery ranks second, with 0.6 t/year of reported catch. All other fisheries are still smaller with 0.2 to 0.4 t/year.

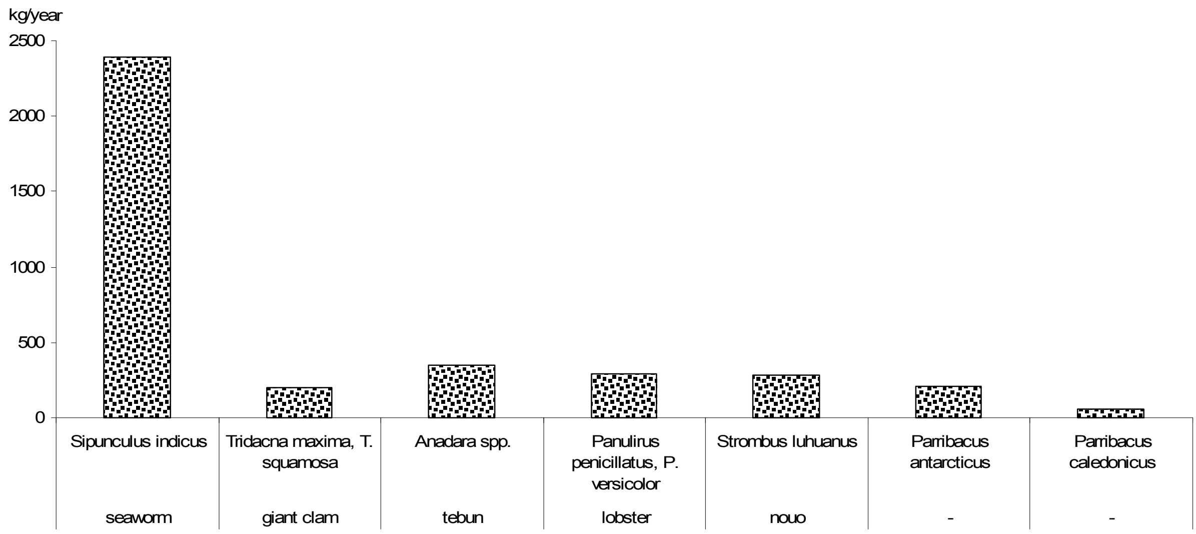

Figure 3.15: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Abemama.

As is already demonstrated in Figure 3.15, Figure 3.16 highlights the limited diversity of Abemama's invertebrate fisheries with a maximum of four different species reported for lobster fishery catches and only one vernacular species (giant clams) reported for reeftop gleaning.

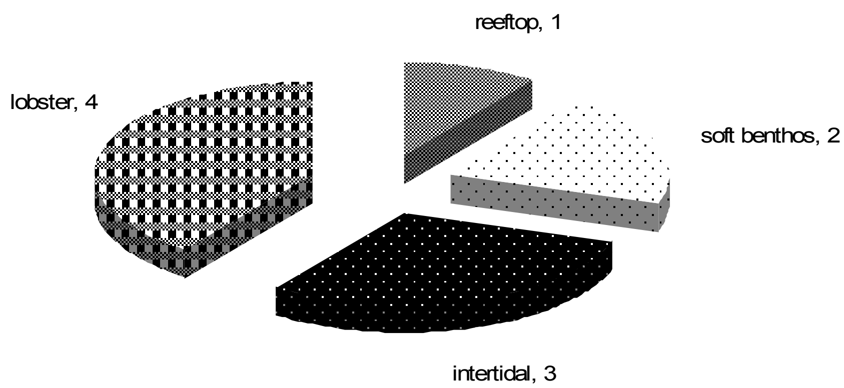

Figure 3.16: Number of vernacular names recorded for each invertebrate fishery in Abemama.

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

Following the trend shown in Figure 3.17, annual recorded catch rates by fisher, gender and fisheries are highest for females fishing intertidal fishery, i.e. sea worm catches. Lobster fishers and all other gleaners have a much lower average annual productivity.

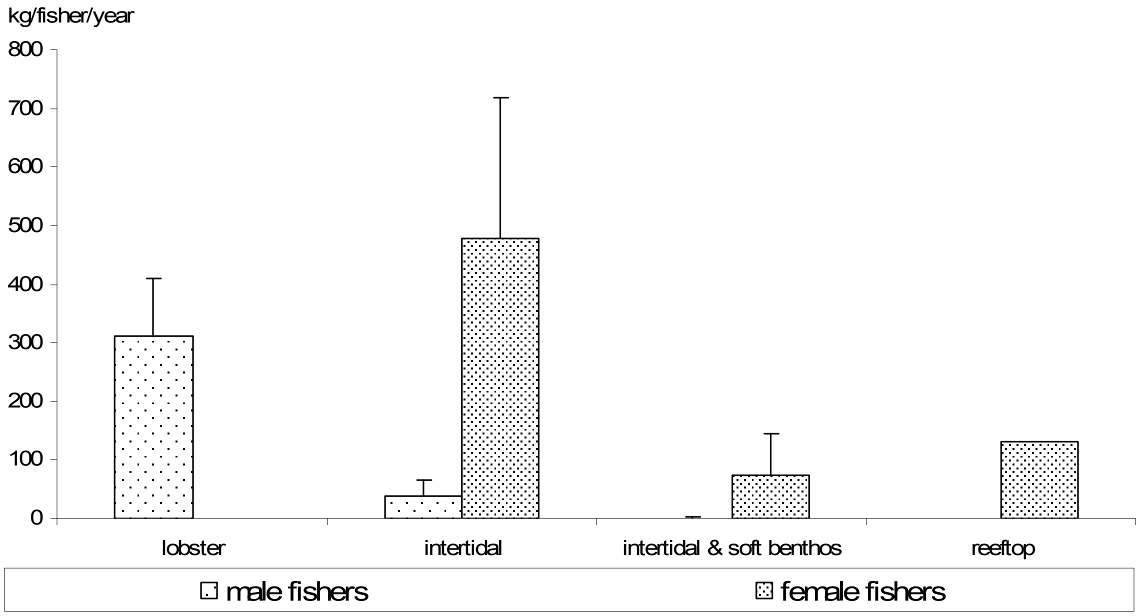

Figure 3.17: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Abemama.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 7 for males, n = 13 for females). Bars represent standard error (+SE).

The ratio between invertebrates caught for subsistence and sale as shown in Figure 3.18 highlights that invertebrates are mostly caught for subsistence purposes. Most biomass (wet weight) is caught for home consumption, and the equivalent of about half of Abemama's consumption is exported to Tarawa. Again, as shown in Table 3.5, most of the invertebrate export fishery is accounted for by sea worms rather than lobsters or giant clams.

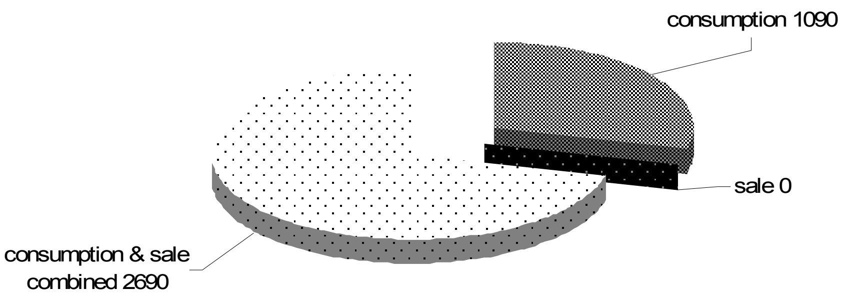

Figure 3.18: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Abemama.

Table 3.5: Total annual recorded invertebrate catch by species and purpose of use (kg wet weight/year) in Abemama

Scientific name	Vernacular name	Total catch (biomass wet weight kg/year)			
		Consumption	Sale	Consumption & sale	Sum
Tridacna maxima, Tridacna squamosa	Giant clam	130	0	70	200
Panulirus penicillatus, Panulirus versicolor	Lobster	100	0	190	290
Strombus luhuanus	Nouo	286	0	0	286
Parribacus antarcticus	-	56	0	150	206
Parribacus caledonicus	-	56	0	0	56
Sipunculus indicus	Sea worm	109	0	2280	2389
Anadara spp.	Tebun	353	0	0	353
Total:		**1090**	**0**	**2690**	**3780**

The total annual catch volume (expressed in wet weight based on the recorded data from all respondents interviewed) is relatively low and amounts to 3.78 t/year (= 100%) (Figure 3.19). The figures underline again the dominant role of the intertidal fishery, which mainly comprises sea worms. This fishery accounts for >66% of the total annual reported catch (wet weight). The lobster fishery (which may also include some giant clams) and the combined intertidal and soft-benthos fishery determine the remaining catch, with a contribution of 16.5% and 13.9% respectively. Overall, the contribution of reeftop gleaning (mostly giant clam collection) is marginal. Due to the distinct gender roles in Abemama's invertebrate fishery, females contribute most of the total reported annual catch (wet weight), i.e. >80%.

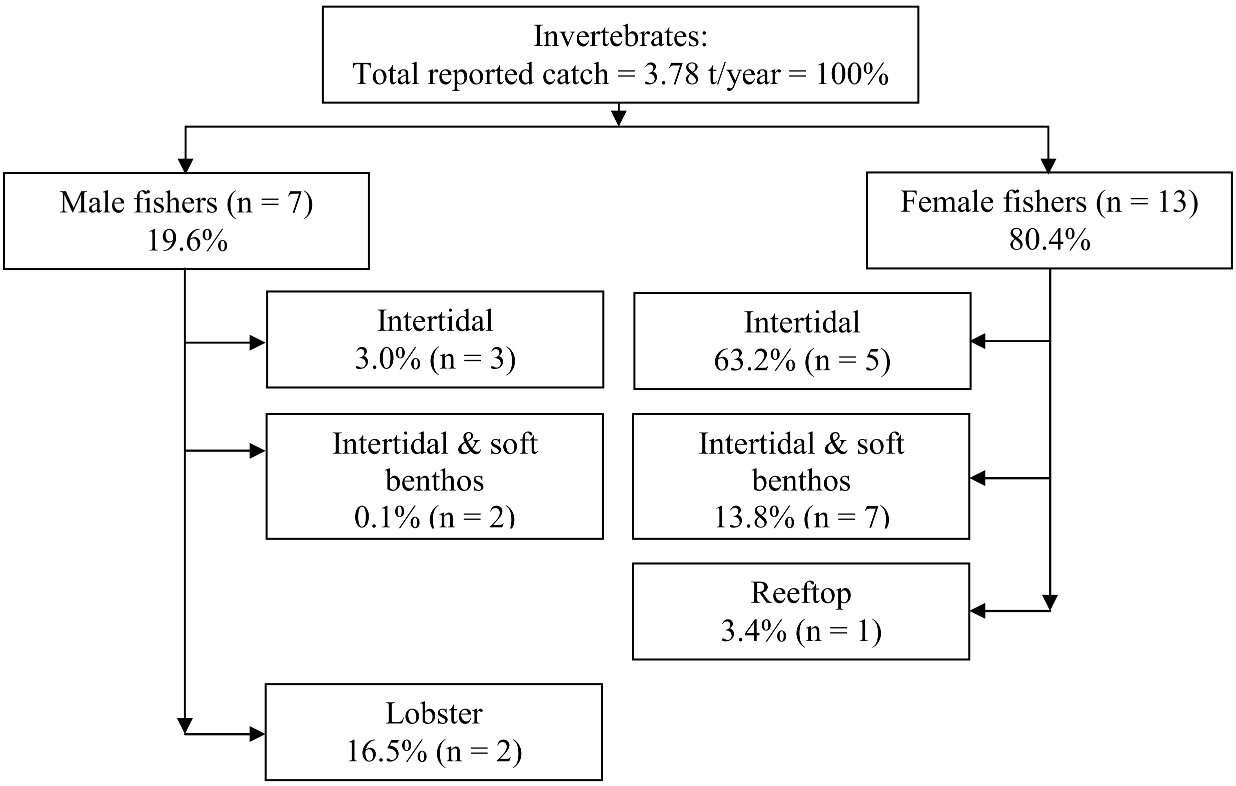

Figure 3.19: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Abemama.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

The parameters presented in Table 3.6 show large fishing grounds for both giant clam (reeftop) harvesting and lobster (and giant clam) diving. As a result and taking into account the total number of fishers engaged in each fishery, fisher densities are very low with 0.7 fishers/km^2 and 1.3 fishers/km reef length. The annual catch (wet weight) reported per fisher is relatively low for each of the three major fisheries, i.e. intertidal gleaning (sea worms), lobster (and giant clam) diving, and reeftop gleaning (giant clams). Because the areas for the intertidal fishery and the combined intertidal and soft-benthos gleaning fishery are not known, it is difficult to assess current fishing impact. However, taking into account the potential shoreline area of Abemama and Abatiku island, the small number of fishers involved, and the low average annual catch rates per fishers, it is assumed that the current fishing pressure is moderate to low.

Table 3.6: Selected parameters (±SE) used to characterise the current level of fishing pressure of invertebrate fisheries in Abemama

Parameters	Fishery / Habitat			
	Intertidal	Intertidal & soft benthos	Reeftop	Lobster [3]
Fishing ground area (km^2)	n/a [4]	n/a [4]	62.40	68.5
Number of fishers (per fishery) [1]	333	372	41	86
Density of fishers (number of fishers/km^2 fishing ground)	n/a [4]	n/a [4]	0.7	1.3
Average annual invertebrate catch (kg/fisher/year) [2]	312.99 (±164.52)	58.20 (±55.18)	130.29 (n/a)	311.08 (±98.70)

Figures in brackets denote standard error; n/a = standard error not calculated; [1] number of fishers extrapolated from household surveys; [2] catch figures are based on recorded data from survey respondents only; [3] linear measure km reef length; [4] fishing grounds are presently not determined.

3.2.5 Discussion and conclusions: socioeconomics in Abemama

- The Abemama people are dependent on reef-fish resources, but more for subsistence rather than income purposes. About half of all households surveyed receive income from fisheries, but only 25% depend on fisheries as first income, and another 28% as second income. By comparison, agriculture supplies 56% of all households with first income and another 36% with second income. Remittances do not play an important role on Abemama.

- The frequency and quantity of fresh fish consumption are the highest across all PROCFish sites investigated in Kiribati. Neither invertebrates nor canned fish are eaten much in Abemama with the exception perhaps of Abatiku island, where people consume 8.8 kg of canned fish/person/year.

- The importance of fisheries is represented in the high number of fishers per households (2.3) and the fact that 96% of all households reported being engaged in fishing. Reflecting the important role fishing plays in providing subsistence needs, most finfish consumed (92%) are caught by a member of the respective household. However, the percentage of households that may sometimes also buy fish locally is surprisingly high.

- Traditional gender roles were found to limit females' participation in finfish fisheries and to restrict females from any invertebrate diving. Females, however, were found to do most of the gleaning in intertidal and other areas.

- Overall, fisher density is low. If we consider only the subsistence needs of the atoll's population and distribute it over the total reef and total fishing ground area available, current fishing pressure is also low (1.6–2.8 t/km² of total reef and total fishing ground). However, 80% of all catches are exported to Tarawa and hence the existing fishing pressure is likely to be relatively high. Because most fishers target the lagoon and outer-reef resources, impact may be detectable here.

- Fishing efficiency (CPUE) is similar in the lagoon, passage, and sheltered coastal and outer reef combined. Outer-reef and sheltered coastal reef fishing showed extremely low CPUEs. However, some of these observations may be a result of small sample sizes.

- Abemama's fishers prefer gillnetting, except at the outer reef, where castnets are mainly used. Handlines, spear diving, rod and line and other techniques are used for fishing the sheltered coastal reef.

- Abemama's invertebrate fishery is limited to a few target species. Sea worm collection from intertidal areas is the main fishery (>66% of the total reported annual catch by wet weight), which is for both home consumption and, most importantly, commercial purposes. By comparison, lobster (16.5%) and giant clam (3.4%) catches are of low importance, and so are other bivalves or gastropods collected for home consumption (~14%).

- Fisher densities and average annual catch rates by fisher for lobster and giant clam fisheries are very low. This observation is also true concerning the productivity of intertidal and reeftop gleaners. Taking into account the total number of possible fishers and the reported average annual catch (wet weight) per fisher, the current pressure on any invertebrate fishery is assumed to be low to moderate.

Based on the observations that the Abemama community is not very dependent on fisheries for income generation, but that fish consumption is high, our data suggest the following four conclusions:

- A considerable proportion of the Abemama community engages in fishing. Most of the finfish are caught for export, while most of the invertebrates are harvested for subsistence purposes.

- Although fisheries are not the most important income source for most households, they nevertheless provide food to all households and income to about half.

- Overall, current fishing pressure seems to be low, considering the low fisher density and the available fishing grounds. However, bearing in mind that most of the commercial fishing focuses on finfish for export to Tarawa, and also on a few selected species, in particular sea worms, high impacts may result locally or on specific species and should not be overlooked.

- Alternative income sources are limited (handicrafts, a few public salaries, very little agricultural potential). Therefore, if there is any future increase in the community's demand for income and nutrition, it is likely that fishing pressure will also increase.

3.3 Finfish resource surveys: Abemama

3.3.1 Finfish assessment results: Abemama

Finfish resources and associated habitats were assessed between 17 and 22 April 2004 from 24 transects (6 intermediate, 12 back- and 6 outer-reef transects, see Figure 3.20 for transect locations and Appendix 3.2.1 for coordinates).

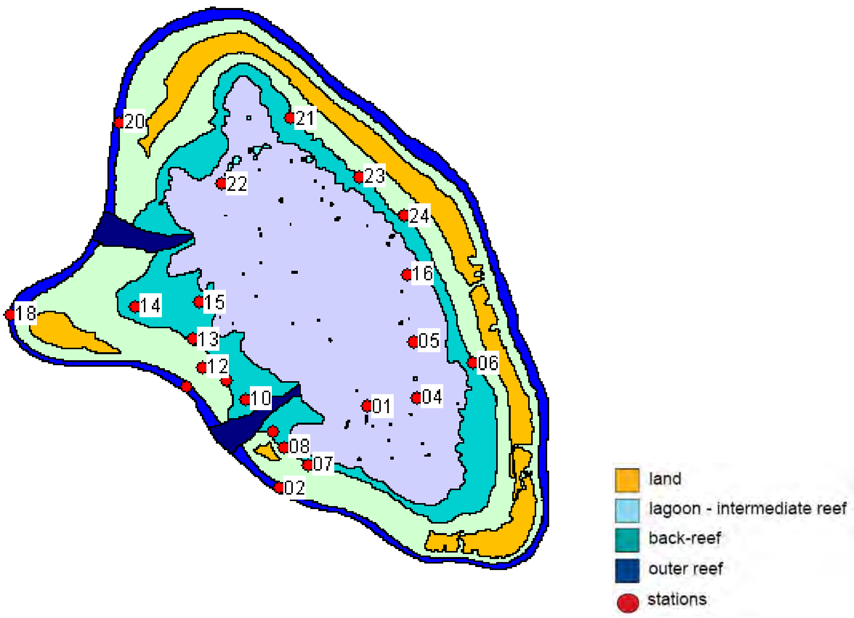

Figure 3.20: Habitat types and transect locations for finfish assessment in Abemama.

A total of 22 families, 58 genera, 180 species and 18,658 fish were recorded in the 24 transects (See Appendix 3.2.2 for list of species.). Only data on the most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 14 families, 45 genera, 160 species and 16,682 fish.

Finfish resources differ greatly among the three reef environments found in Abemama (Table 3.7). Looking at the major parameters of the fish community, fish density is higher in the lagoon reef (2.0 fish/m²) while biomass (485 g/m²) and biodiversity (59 species/transect) are higher in the outer reef compared to the back-reef. Size structure is almost similar across all habitats, with size ratios larger in the outer reefs.

Table 3.7: Primary finfish habitat and resource parameters recorded in Abemama (average values ±SE)

Parameters	Habitat			
	Lagoon reef [1]	Back-reef [1]	Outer reef [1]	All reefs [2]
Number of transects	6	12	6	24
Total habitat area (km^2)	0.7	44.2	21.4	63.3
Depth (m)	5 (2-9) [3]	2 (1-3) [3]	7 (3-13) [3]	4 (1-13) [3]
Soft bottom (% cover)	25.6 ±3.7	29.7 ±2.3	5.4 ±1.9	22
Rubble & boulders (% cover)	17.1 ±1.9	21.7 ±2.6	3.7 ±1.8	16
Hard bottom (% cover)	45.2 ±3.1	35.7 ±2.5	60.2 ±2.6	44
Live coral (% cover)	11.5 ±3.2	12.8 ±2.3	30.4 ±3.1	18
Soft coral (% cover)	0.08 ±0.08	0.1 ±0.1	0.3 ±0.2	0.0
Biodiversity (species/transect)	36 ±5	29 ±4	58 ±6	38 ±4
Density (fish/m^2)	1.95 ±0.46	0.82 ±0.30	1.75 ±0.34	1.1
Biomass (g/m^2)	264.7 ±62.2	105.8 ±33.8	485.8 ±173.9	230.1
Size (cm FL) [4]	15.9 ±0.6	16.4 ±0.5	19.4 ±0.6	17.0
Size ratio (%)	40.3 ±1.5	44.3 ±1.4	48.3 ±1.5	45.0

[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.

Live-coral cover is very limited in the lagoon reef (11%) and much higher in the outer reef (30%) (Table 3.7, Figure 3.21). The lagoon and back-reef substrates are largely dominated by soft bottom substrate (26–30%). As usual, the outer reef is mostly composed of hard substrate (60%).

Intermediate-reef environment: Abemama

The lagoon reef environment of Abemama is largely dominated by two families of carnivorous fish, Balistidae (dominating in numbers but third-lowest for biomass) and Lutjanidae (highest in biomass and second most important in density), and one family of herbivorous fish, Acanthuridae (highest in density and second-largest in biomass) as clearly reflected in Figure 3.21. These three families are represented by 11 species; particularly high abundance and biomass were recorded for *Lutjanus gibbus*, *Acanthurus blochii*, *Lutjanus fulvus*, *Odonus niger*, *Pseudobalistes flavimarginatus*, *L. kasmira*, *A. xanthopterus*, *L. monostigma*, *Naso annulatus*, *A. nigricauda*, *L. bohar* and *Ctenochaetus striatus* (Table 3.8).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Balistidae	*Odonus niger*	Redtooth triggerfish	0.83	22.7
	Pseudobalistes flavimarginatus	Yellowmargin triggerfish	0.02	18.6
Lutjanidae	*Lutjanus gibbus*	Humpback red snapper	0.18	47.4
	Lutjanus fulvus	Blacktail snapper	0.21	34.0
	Lutjanus kasmira	Common bluestripe snapper	0.2	14.9
	Lutjanus monostigma	Onespot snapper	0.02	8.0
	Lutjanus bohar	Two-spot red snapper	0.02	5.0
Acanthuridae	*Acanthurus blochii*	Ringtail surgeonfish	0.06	36.8
	Acanthurus xanthopterus	Yellowfin surgeonfish	0.04	14.9
	Naso annulatus	Whitemargin unicornfish	0.02	6.9
	Ctenochaetus striatus	Striated surgeonfish	0.04	3.9
	Acanthurus nigricauda	Epaulette surgeonfish	0.01	6.6

This reef type presents a diverse habitat (Table 3.7 and Figure 3.21), with hard bottom dominating. The relatively high hard-bottom cover (45% average) is reflected by the high densities of Acanthuridae (fish normally associated with this benthic type). However the carnivorous fish such as Lutjanidae and Balistidae, here the most abundant, are usually associated with soft bottom (Figure 3.21).

Finfish resources in the intermediate reef of Abemama display the highest average density and the second-highest biomass among the four reef types on the island (Table 3.7; Appendix 3.2.2).

In comparison to Abaiang and Kiritimati, the other two sites with intermediate reefs, Abemama displays the highest density and biomass. Its substrate composition is very similar to Kiritimati; therefore, we can say that the biological parameters differ for other reasons than environmental structure.

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

Back-reef environment: Abemama

The back-reef of Abemama is largely dominated by Lutjanidae and, to a much lower extent, Balistidae and Acanthuridae in terms of both density and biomass. These three families were represented by 33 species. The most important ones in order of decreasing density are *Lutjanus kasmira*, *L. fulvus*, *Odonus niger*, *L. gibbus*, *Ctenochaetus striatus* and *Acanthurus blochii* (Table 3.9).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus kasmira*	Common bluestripe snapper	0.17	16.9
	Lutjanus fulvus	Blacktail snapper	0.11	13.7
	Lutjanus gibbus	Humpback red snapper	0.08	12.1
Balistidae	*Odonus niger*	Redtooth triggerfish	0.10	2.6
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.03	2.3
	Acanthurus blochii	Ringtail surgeonfish	0.02	7.0

Substrate in the back-reef of Abemama is characterised by a dominance of hard bottom (36% cover) over soft bottom (30%) with very low coral cover (13%).

Finfish resources in the back-reef of Abemama display the lowest density, biomass and biodiversity among the three reef types on the island (Table 3.7 and Appendix 3.2.2). However, size ratios are the largest.

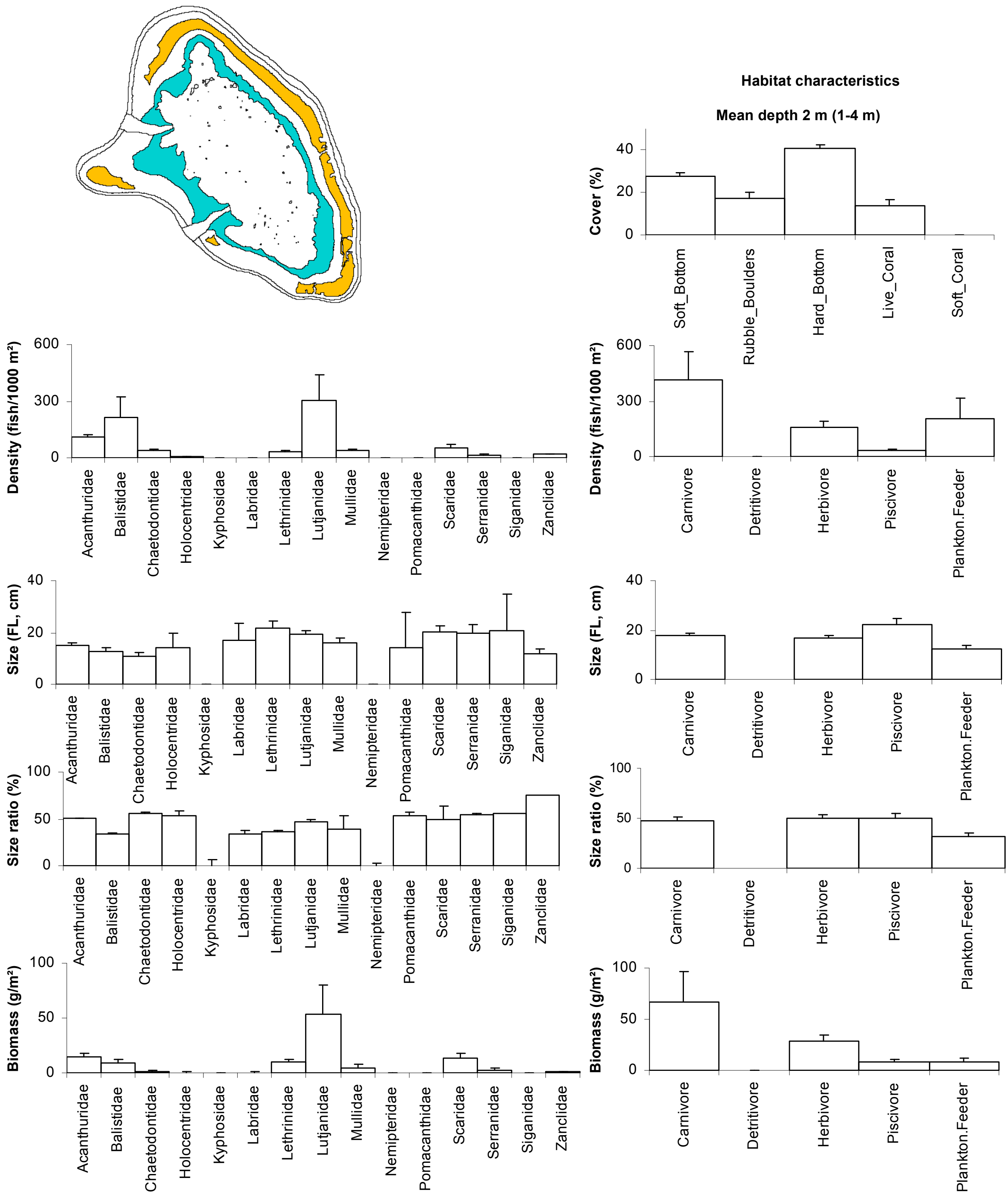

Figure 3.22: Profile of finfish resources in the back-reef environment of Abemama.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Abemama

The outer-reef environment of Abemama is largely dominated by four families: three carnivorous families, Balistidae, Lutjanidae and Lethrinidae and one herbivorous family, Acanthuridae. Balistidae and Lutjanidae display the highest density, followed by Acanthuridae and Lethrinidae. Biomass is largely dominated by Lutjanidae, followed by Lethrinidae, Balistidae and Acanthuridae (Figure 3.23). These four families were represented by 10 major species; particularly high abundance and biomass were recorded for *Lutjanus gibbus*, *Lethrinus xanthochilus*, *Pseudobalistes flavimarginatus*, *Lethrinus olivaceus*, *Lutjanus bohar*, *Ctenochaetus striatus*, *Naso vlamingii*, *Acanthurus nigricans*, *Melichthys vidua* and *Odonus niger* (highest density) (Table 3.10).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus gibbus*	Humpback red snapper	0.38	190.4
	Lutjanus bohar	Two-spot red snapper	0.04	15.0
Lethrinidae	*Lethrinus xanthochilus*	Yellow lip emperor	0.04	27.5
	Lethrinus olivaceus	Long nose emperor	0.02	17.0
Balistidae	*Pseudobalistes flavimarginatus*	Yellow margin triggerfish	0.01	23.1
	Melichthys vidua	Pink tail triggerfish	0.10	8.6
	Odonus niger	Redtooth triggerfish	0.40	3.7
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.05	11.0
	Acanthurus nigricans	White cheek surgeonfish	0.08	8.7
	Naso vlamingii	Big nose unicorn fish	0.02	9.1

Substrate in the outer reef of Abemama is characterised by a dominance of hard bottom (60% cover) and good live-coral cover (30%), both in much higher percentage compared to the other three sites. The prevalence of hard-bottom substrate, in combination with the direct oceanic influence found in the outer-reef environment, may explain the dominance of large species of carnivorous species, such as *Lutjanus bohar* and *L. gibbus*. The presence of significant numbers of Serranidae, Lethrinidae, Carangidae and Carcharhinidae (*Cephalopholis argus*, *Lethrinus xanthochilus*, *Caranx melampygus*, *C. ignobilis* and *Triaenodon obesus* in particular) may also be related to the healthy status of the reef, harbouring these top predators as well as both juvenile and adult fish of all types. Finfish resources in the outer reefs of Abemama display the second-highest average biodiversity and density, and the highest biomass among all four reefs surveyed on the island (Table 3.7 Appendix 3.2.2).

Abemama outer reef shows very similar substrate composition to Abaiang, with the highest amount of live-coral cover compared to the rest of the survey sites. Abemama displays the highest biodiversity as well as the highest biomass of all the four outer reefs, a result of both large average fish size and high density of fish.

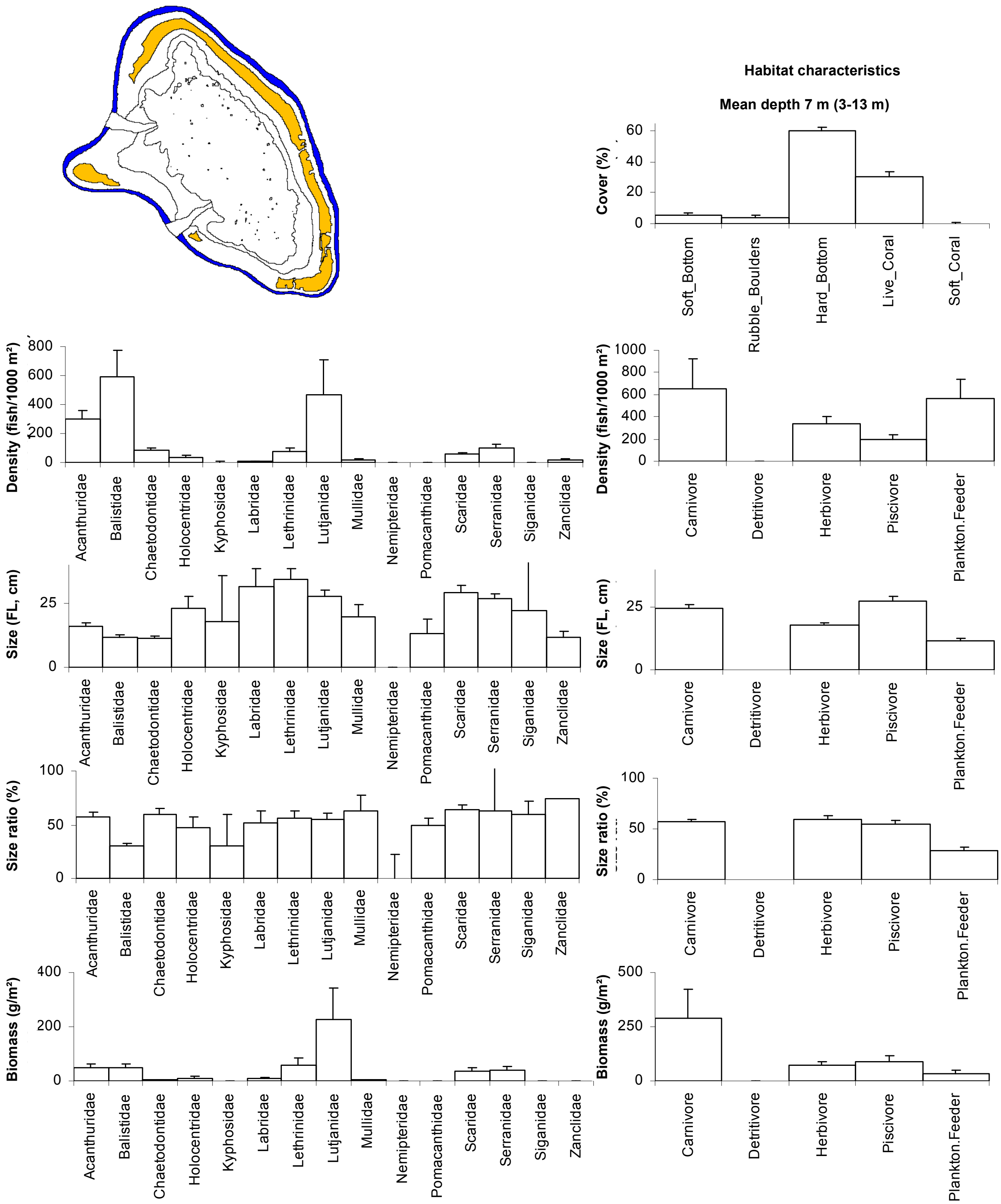

Figure 3.23: Profile of finfish resources in the outer-reef environment of Abemama.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Abemama

The overall fish assemblage of Abemama is largely composed of three families. The highest in density and biomass are the carnivorous fish: Lutjanidae, followed by Balistidae, and the herbivorous: Acanthuridae (Figure 3.24, Table 3.11). These major families are represented by 53 species. The main species in terms of both density and biomass are, in order of decreasing density, *Odonus niger*, *Lutjanus gibbus*, *L. kasmira*, *L. fulvus*, *Ctenochaetus striatus*, *Melichthys vidua* and *Acanthurus blochii* (Table 3.11).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus gibbus*	Humpback red snapper	0.18	70.0
	Lutjanus kasmira	Common blue stripe snapper	0.11	11.5
	Lutjanus fulvus	Black tail snapper	0.07	9.5
Balistidae	*Odonus niger*	Red toothed triggerfish	0.21	3.2
	Melichthys vidua	Pink tail triggerfish	0.04	4.3
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.05	5.1
	Acanthurus blochii	Ringtail surgeonfish	0.02	5.5

Detailed assessment at the reef level suggests that the condition of finfish resources in Abemama is healthier than in Abaiang, the only other site with the three reef habitats: density and biomass are higher in Abemama, although back-reefs are healthier in Abaiang (higher size and biomass). Like Abaiang, Abemama atoll offers all the available habitats and reefs for a choice of fishing methods and gears. Therefore, the level of fishing impact in the windward and distant areas is relatively lower.

Dominance of carnivores is common to the three habitats with high Lutjanidae and Balistidae in the lagoon, outer and back-reefs. Habitat is similar between back-reef and intermediate reefs, and soft substrate, a type of substrate favoured by Balistidae as well as Lethrinidae, is much less important in the outer reefs. This observation leads to the conclusion that the high abundance of Lutjanidae and Balistidae is not simply driven by habitat.

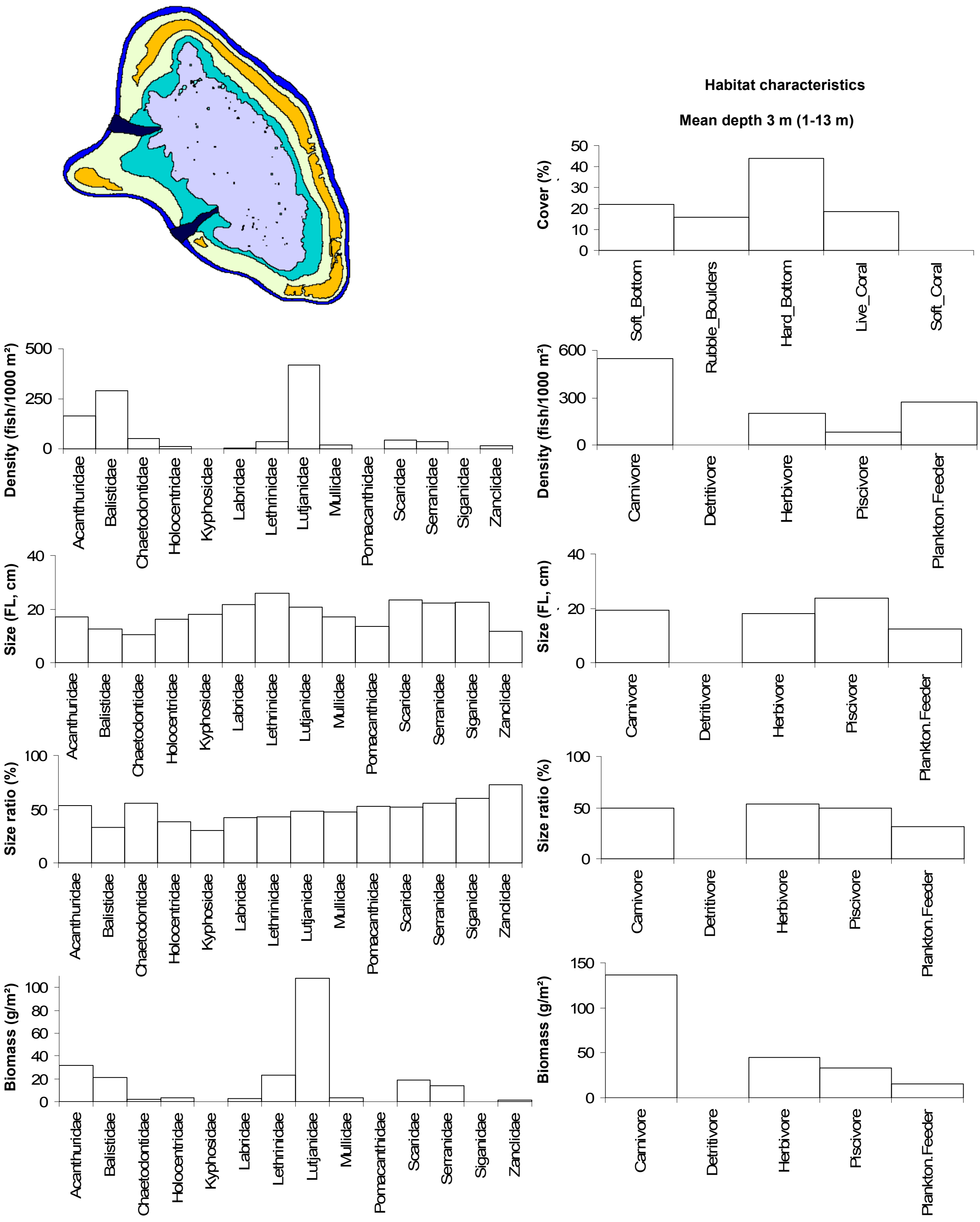

Figure 3.24: Profile of finfish resources in the combined reef habitats of Abemama (weighted average).
FL = fork length.

3.3.2 Discussion and conclusions: finfish resources in Abemama

- The finfish resource assessment indicates that the status of finfish resources in Abemama is similar to that in Abaiang, the other study site in the country with the same habitats. However, density and biomass have the highest values in Abemama. The sighting of large aggregations of carnivorous fish, such as snappers, commonly abundant in all four sites but especially in Abemama, as well as the dominance of carnivorous fish among the commercial fish population, suggest that the area's finfish resources are relatively healthy. However, the smallest values of average size and size ratio among the four sites (except for outer reefs, for which Kuria's show lower values) are a first indication of heavy exploitation, especially in the lagoon reef.

- Overall, Abemama finfish resources appear to be in relatively good condition. The reef habitat seems relatively rich and the ecosystem supporting finfish resources healthy. However, first signs of heavy exploitation in the lagoon are indicated by very low average fish size.

- Future expansion of finfish resource harvesting should primarily target the relatively untouched deep-bottom fish species to ease pressure on the reef fish stocks. Similarly, outer reefs are presently not heavily fished and could be targeted to alleviate the heavy pressure on the lagoon.

- Future expansion of finfish resource harvesting should also be accompanied by monitoring activities as well as by new marine resource management measures.

- Considering the high quality of habitat in Abemama, marine protected areas should be considered as a primary management tool to sustain the abundance of commercial and food fish species on a long-term basis.

3.4 Invertebrate resource survey: Abemama

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

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

Table 3.12: Number of stations and replicates completed at Abemama

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	73 transects
Reef-benthos transects (RBt)	12	72 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	16	128 quadrat groups
Mother-of-pearl transects (MOPt)	0	0 transect
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	3	18 search periods
Reef-front search by walking (RFs_w)	0	0 search period
Sea cucumber day searches (Ds)	2	12 search periods
Sea cucumber night searches (Ns)	0	0 search period

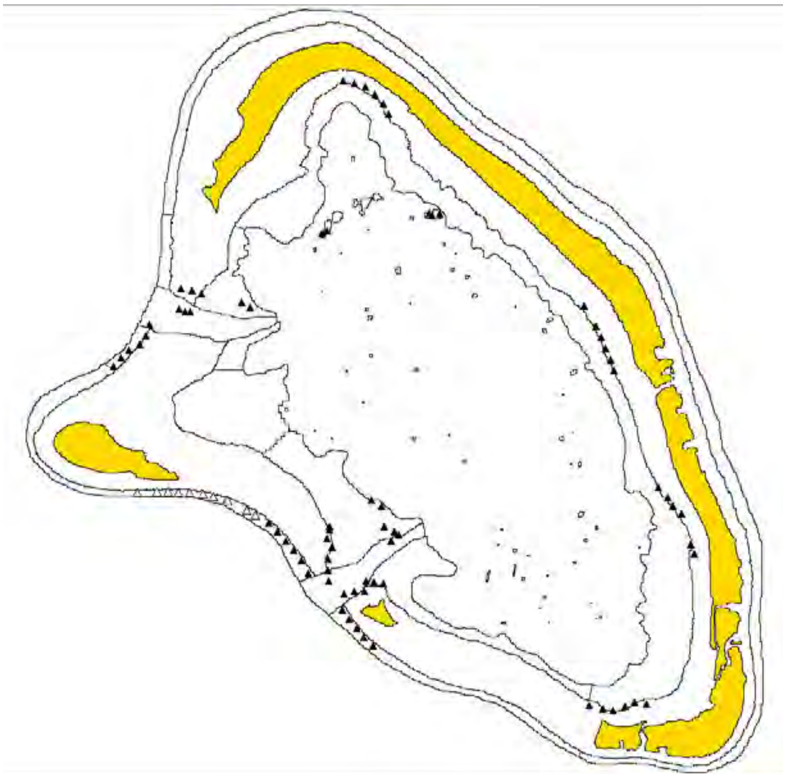

Figure 3.25: Broad-scale survey stations for invertebrates in Abemama.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

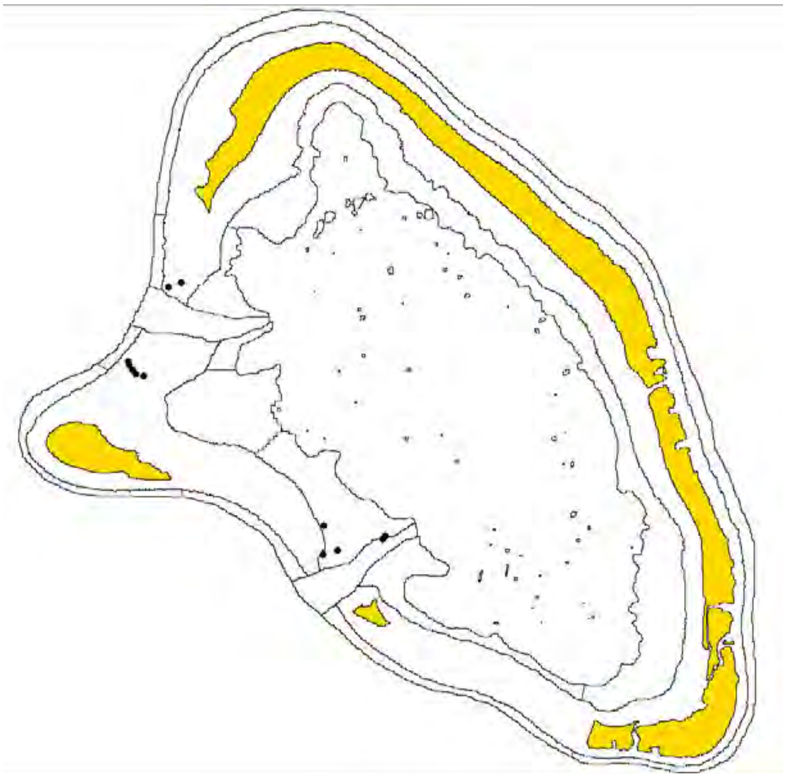

Figure 3.26: Fine-scale reef-benthos transect survey stations in Abemama.
Black circles: reef-benthos transect stations (RBt).

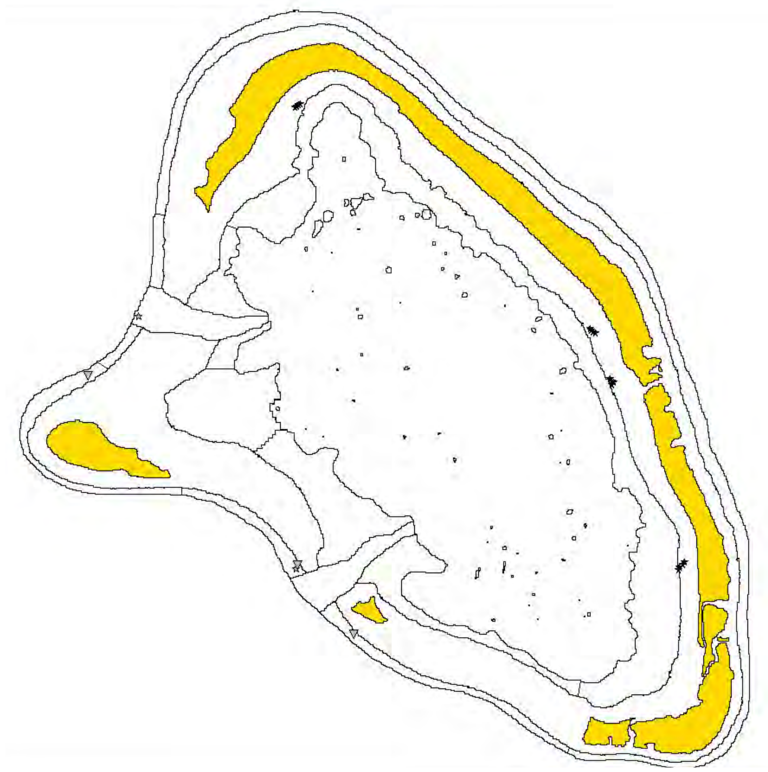

Figure 3.27: Fine-scale survey stations for invertebrates in Abemama.
Inverted grey triangles: reef-front search stations (RFs);
grey stars: sea cucumber day search stations (Ds);
black stars: soft-benthos infaunal quadrat stations.

Thirty-two species or species groupings (groups of species within a genus) were recorded in the Abemama invertebrate surveys: 9 bivalves, 8 gastropods, 10 sea cucumbers, 2 sea stars and 2 lobsters (Appendix 4.2.1). Information on key families and species is detailed below.

3.4.1 Giant clams: Abemama

Broad-scale sampling provided an overview of giant clam distribution across the Abemama Atoll. Reef habitat that is suitable for giant clams was extensive within the lagoon (41 km^2), although a large part of the available reef was relatively deep (>6 m depth), and the south and east of lagoon benthos comprised mainly sand. Outside the lagoon approximately 21 km^2 of exposed reef slope was present (total reef area: 62 km^2). Similarly to in Abaiang, there was a mixture of characteristics; the lagoon was quite enclosed around the eastern edges, but the northern and western passages allowed significant flows and mixing between ocean and lagoon water.

Three giant clam species were recorded in survey: the elongate clam *Tridacna maxima*, the fluted clam *T. squamosa*, and the horse-hoof or bear's paw clam *Hippopus hippopus*. Dead *T. gigas* shells (true giant clams) were also seen in the lagoon but no live individuals were recorded. The most suitable reef habitat for giant clams within the lagoon was concentrated along the southwestern edge of the north passage and just within the southeastern passage, where reef was shallow and water movement was dynamic. Fringing reef within the lagoon on its eastern edge was limited. This more enclosed and protected part of the lagoon was still relatively oceanic in nature, but only supported small patches of reef.

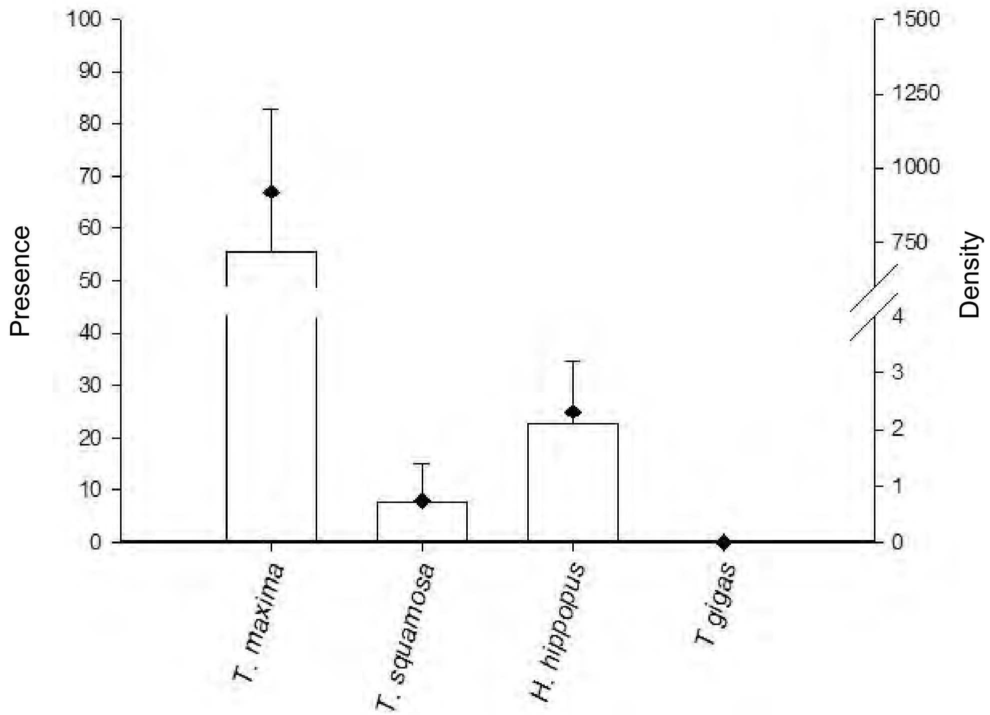

Figure 3.28: Presence and mean density of giant clam species at Abemama based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Broad-scale sampling stations revealed *T. maxima* to have the widest occurrence (found in 8 stations and 40 transects), followed by *H. hippopus* (3 stations and 6 transects) and *T. squamosa* (1 station and 3 transects; see Figure 3.28.).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat. In these reef-benthos assessments (RBt), *T. maxima* was present within 92% of stations (Figure 3.29). At these stations (11 stations where clams were recorded), the mean density for *T. maxima* was 7541.7 ±1469.5 individuals/ha. Only 11 *H. hippopus* and 5 *T. squamosa* were recorded in broad-scale and reef-benthos stations (Both these larger species are normally found at lower density than *T. maxima*.).

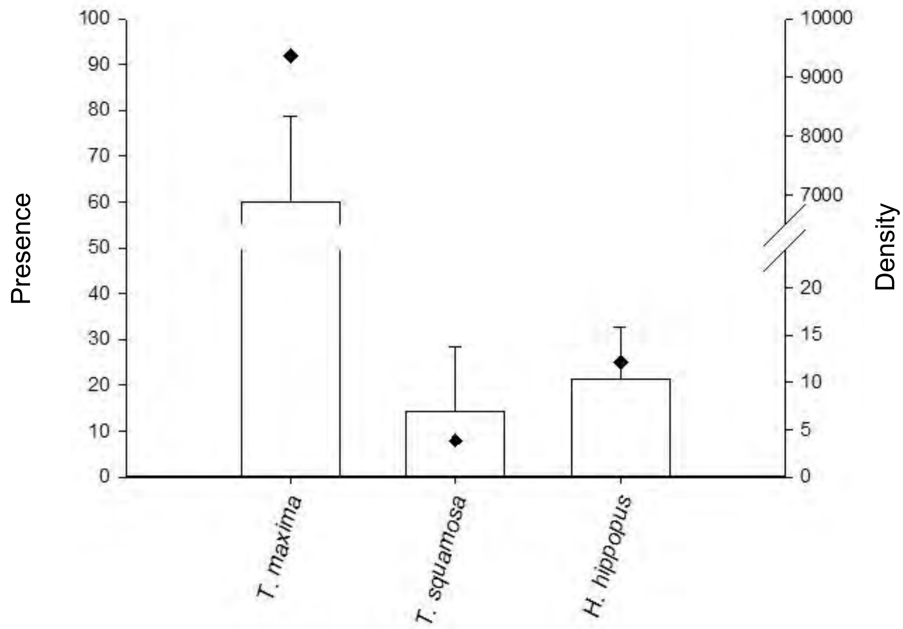

Figure 3.29: Presence and mean density of giant clam species at Abemama based on all reef-benthos transect assessments.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Clams were not distributed evenly on reefs in Abemama atoll. *T. maxima* were common around the passages, but not found in abundance along the eastern edge of the lagoon near the populated areas of Abemama, where habitat was limited. The larger two species, which are characteristically found at lower density than *T. maxima*, were still considered rare at Abemama. *H. hippopus* clams were found at less exposed sites, whereas *T. squamosa* were observed in areas with greater oceanic influence (especially outside the barrier on shoals in the west of Abemama). Day searches for sea cucumbers in deeper water on the reef slope were limited in number (only 2 stations); no *T. squamosa* were recorded during these assessments of potential refuge habitat.

There was a report from a fisher that a single live *Tridacna gigas* could still be found in Abemama but, despite an extra two hours of broad-scale searches (in addition to 73 x 300 m transects) at the location suggested (the shelf outside the barrier reef west of Abatiku Island), only empty, dead shells of *T. gigas* were observed (called *te aubuna*). This highlighted a decline in abundance of the true giant clam *T. gigas* (*te kima*) in Abemama, as a previous survey from the late 1980s (Munro 1988), stated that Abemama held one of the most abundant sources of *te kima* within the Central Gilbert group (survey of Abaiang, Abemama, Maina and Tarawa). In Munro's 1988 study, *T. gigas* was recorded at a mean density of 4.8 per ha in patch reefs, 1.3 per ha within coral garden areas, and 3.0 per ha close to the passages. 'Newly' dead shells were also noted at that time, allowing a survival rate to be estimated (between 0.38 and 0.55 per year). This reflects a far higher death rate than is documented for the natural mortality of *T. gigas* (<10% per year; Munro and Heslinga 1983; Heslinga and Watson 1985), and highlights the fishing pressure these large clams were subjected to almost two decades ago.

The common, small elongate clam *T. maxima* from reef-benthos transects (shallow-water reefs) had an average length of 10.7 cm ±0.1. When *T. maxima* from deeper water and more exposed locations were included in the calculation (from other assessments), the mean length increased slightly to 11.4 cm ±0.1, which equates to a *T. maxima* clam of ~5–6 years old. Both *H. hippopus* and *T. squamosa* are faster growing and can reach 20 cm shell length in 4–5 years. The small number of *H. hippopus* (n = 11) had a mean length of 29.5 cm ±2.4, whereas *T. squamosa* (n = 6) averaged 36.8 cm ±1.4 in all assessments. As can be seen from the length frequency graphs (Figure 3.30), the few recordings of *H. hippopus* and *T. squamosa* were mainly of clams near their asymptotic length, but a full range of *T. maxima* lengths were seen.

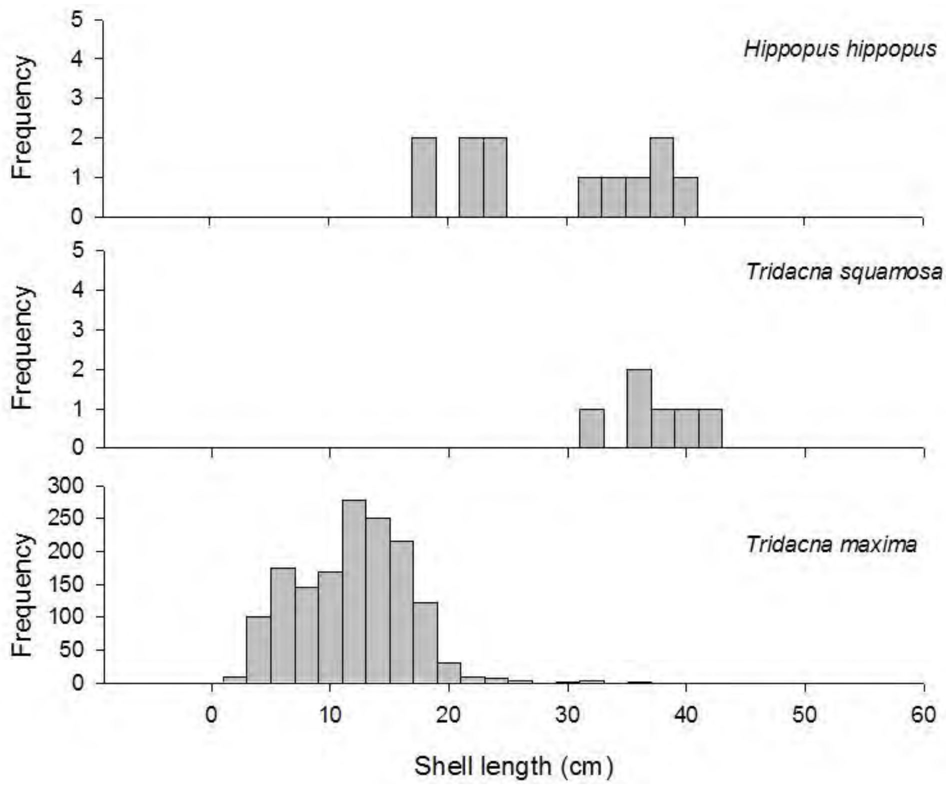

Figure 3.30: Size frequency histograms of giant clam shell length (cm) for Abemama.

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

Kiribati is not within the natural distribution of the commercial topshell, *Trochus niloticus*; however, in the late 1990s, trochus was transplanted from Fiji to a quarantine facility in Tarawa (FAO 2008, Gillett 2002). Although some movements were made to outer islands (e.g. Abaiang), none were moved to Abemama. Although no trochus could be assessed, the green topshell, *Tectus pyramis* (of low commercial value), a closely related species with similar distribution and life history characteristics, was recorded. However, this grazing gastropod was rare, only being recorded once on a reef-front search outside the lagoon (basal width 5.8 cm). It must be remembered that this is a preliminary investigation, and not all areas were examined. One potential area missed was the exposed eastern reef slope, where the presence of grazing gastropods or habitat potential was not assessed due to lack of access (due to swell conditions and distance). The paucity of gastropods with similar life histories to trochus partially reflects the oceanic nature of the environment found at Abemama.

Pinctada margaritifera, a normally cryptic and sparsely distributed pearl oyster species, was rare at Abemama. Only a single shell was found (during deep-water assessments for sea cucumbers on the outer-reef slope, depth 32 m).

3.4.3 Infaunal species and groups: Abemama

The soft benthos of the coastal margin of the lagoon looked at first glance to be unsuitable for concentrations of in-ground resources (shell 'beds'), as white sand predominated and there were no obvious inputs of nutrients (because there were no rivers). However, this and other lagoon systems of the Central Gilbert group are renowned for *Anadara holoserica* or *te bun* shell beds (Tebano 2005). Juvenile *Anadara* settle among seagrass roots, crevices on coral boulders, on conspecific adults and other suitable hard surfaces. Seagrass was present at Abemama but was isolated to the more sheltered northern portion of the lagoon, along the spring low-tide mark. At the other shell-bed areas, soft benthos had rubble and dead coral mixed as a proportion of the benthos. No *Lambis* spp. were found, but other shellfish of interest were recorded: *Cerithium*, *Gafrarium*, *Oliva*, *Pinna*, *Polinices* and *Strombus luhuanus* (Appendices 4.2.2 to 4.2.6).

Four locations were sampled for in-ground species, starting from the northeast to the southeast of the lagoon. These were: Tabiang in the north (seagrass), Tabonetebike and Binoinano/Kariatebike in the east, and Tebanga/Manoku in the southeast (Figures 3.26 and 3.27). Arc shells were recorded at all stations at a range of densities (1.5–51.5 individuals/m^2), with a mean station density of 14.9 /m^2 ±3.8. This density suggests there has been no major decline in density since the mid-1990s, as Tebano (2005) reported shell densities of 12 /m^2 ±4.1SD and 18 /m^2 ±5.7SD for two locations in Tabiang and 4 /m^2 ±6.1SD for Tebanga (recorded May – July 1994).

Shell presence was not very patchy, shells being recorded across all the areas sampled (Arc shells were recorded at 73% of quadrat groupings; see Methods.). Shell beds with the greatest density of *Anadara* were not isolated to areas of seagrass. In fact, the three stations with the highest density were found north of the causeway opposite Tabonetebike over an area without seagrass. Mean length of arc shells ranged from 4.7–5.1 cm for the four locations sampled, and significantly more small arc shells were recorded in the location of the seagrass (Figure 3.31). Tebano (2005) recorded similar mean shell lengths at Abaiang in his 1994 study (54.6 mm ±6.1SD, 48.6 mm ±5.7SD, and 50.1 mm ±4.1SD).

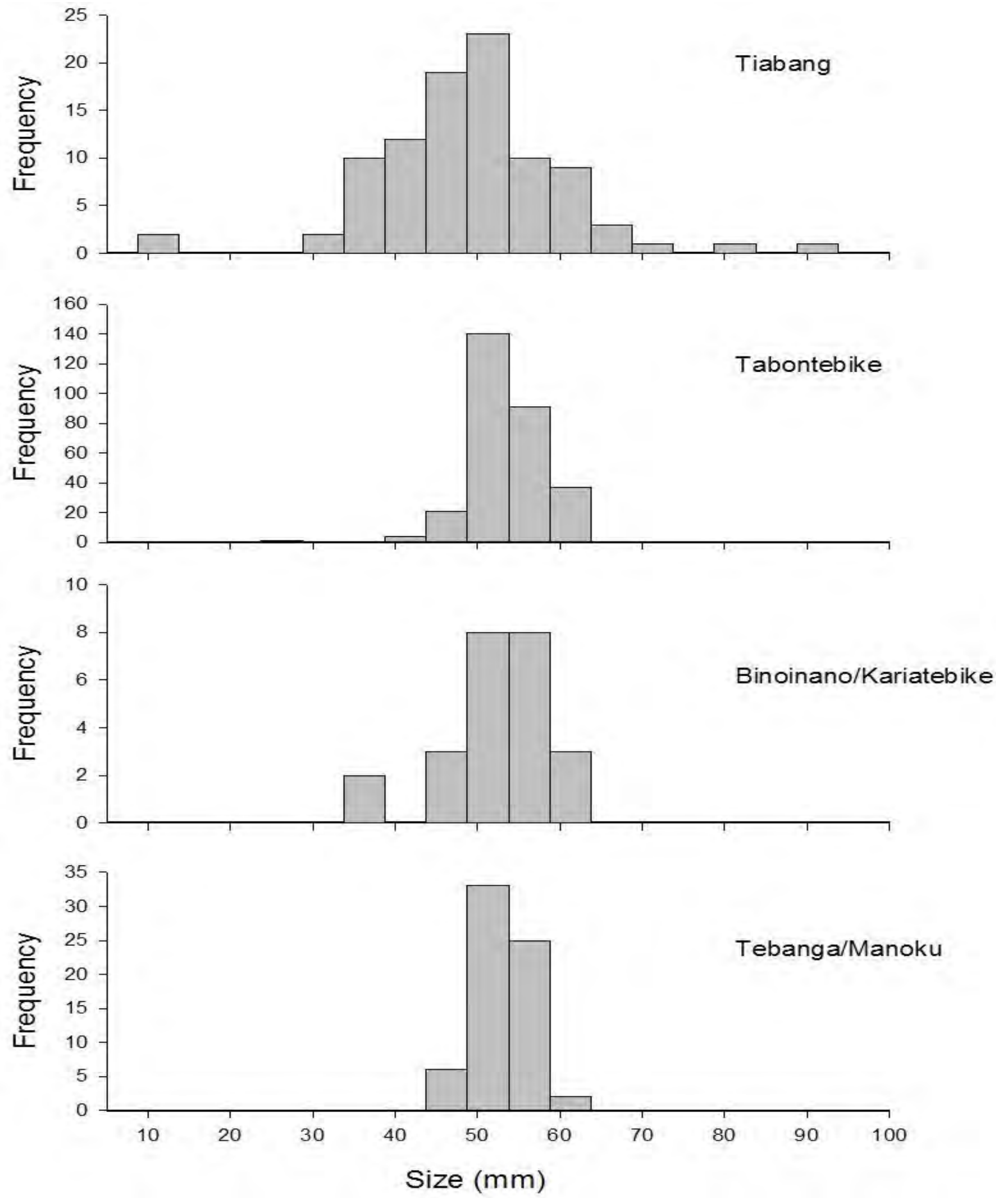

Figure 3.31: Size frequency histograms of arc shell *Anadara* spp. length (cm) for Abemama.

Fishers actively targeted the *te bun* beds at Abemama, and in the two days we monitored catches (n = 4), fishers took an average of 292 ±80 shells/hour (a total of 154–428 /trip). Fishing in these surveys lasted for 45 minutes to an hour, and small numbers of other species were also collected (*Strombus luhuanus*, *Pitar prora*, *Gafrarium* spp.). *S. luhuanus* was the most common of the other species and, in these limited surveys, this species was collected at a rate of 44 /hour in non-targeted fishing. The sizes of all the shells collected reflected the general pattern of the shells available, with fishers not seeming to select specific sizes (Figure 3.32).

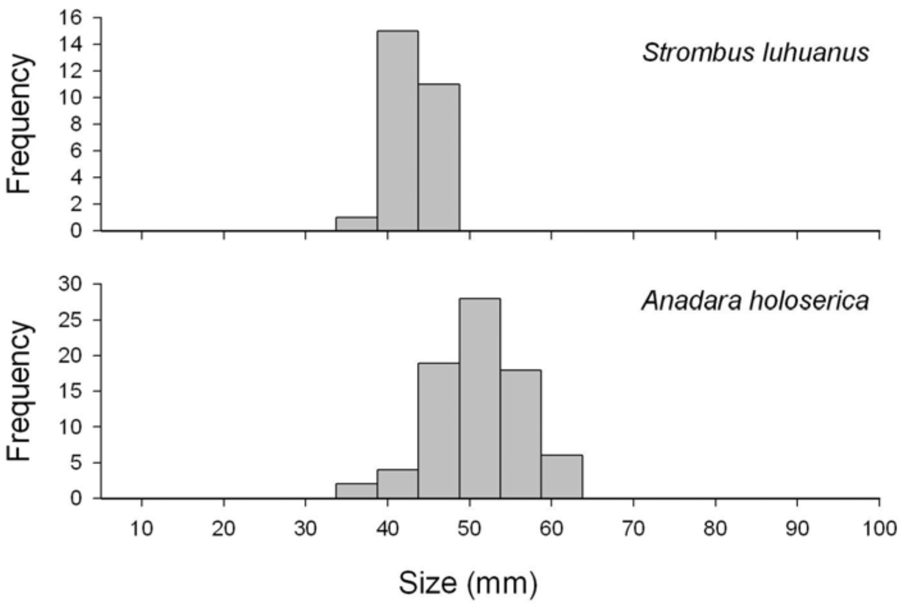

Figure 3.32: Size frequency histograms of arc shell, *Anadara holoserica*, and strawberry conch, *Strombus luhuanus*, from creel survey catches in Abemama.

In addition to arc shells, another important resource species, the strawberry or red-lipped conch *Strombus luhuanus* (*te nouo*) was also recorded. Although not a typical infaunal species (also recorded over open bottom in broad-scale assessments, at density 473.3 /ha ±272.5), the conch was found at a mean density of 2.1 /m^2 ±0.7 at quadrat stations. *S. luhuanus* was plentiful at Tabonetebike (recorded in 10 of 16 stations and 23% of quadrat groups) but not found in Tebanga/Manoku. The mean length of *S. luhuanus* was 4.1 cm ±0.1.

3.4.4 Other gastropods and bivalves: Abemama

Seba's spider conch, *Lambis truncata*, and the common spider conch, *Lambis lambis*, were not detected in broad-scale or reef-benthos surveys. *Strombus luhuanus* was quite common throughout the lagoon and was recorded in broad-scale and soft-infaunal quadrat assessments (Appendices 4.2.2 to 4.2.4). No *Turbo* spp. were recorded during broad- or fine-scale assessments (nor during reef-front searches; see Methods). Other species targeted by fishers (e.g. *Cerithium*, *Conus*, *Oliva*, *Polinices* and *Vasum*) were also recorded during independent survey (Appendices 4.2.1 to 4.2.7). Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Chama*, *Pinna* and *Spondylus*, are also in Appendices 4.2.1 to 4.2.7.

A creel survey was conducted on arc shell catches at Abemama Atoll (See section *Infaunal species and groups: Abemama*).

3.4.5 Lobsters: Abemama

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, one *Panulirus* sp. lobster was recorded during a reef-front search on the reef slope in front of Biike Island on the southwestern side of the lagoon. In addition, burrows for the banded prawn killer *Lysiosquillina* sp. (sand lobster) were common along the eastern shoreline of the lagoon. These species were regularly fished by children.

3.4.6 Sea cucumbers[8]: Abemama

Abemama atoll has a small land mass (30.5 km^2) relative to the size of the lagoon (190 km^2). Reef margins and shallow, mixed hard- and soft-benthos habitat (suitable for sea cucumbers) were relatively small in area within the lagoon (41 km^2), as the lagoon was characterised by sandy areas and generally oceanic in nature. There was a high degree of exposure and reef was generally concentrated in dynamic water conditions near the passes. Outside the barrier reef a further 21 km^2 of reef was located. Despite the lack of significant nutrient inputs into the lagoon (due to the land mass being low lying) and the sandy, oceanic nature of the lagoon, ten commercial species were recorded during in-water assessments (Table 3.13).

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 3.13; also see Methods). Deep dives on SCUBA (generally 25–35 m in depth) were conducted to obtain a preliminary assessment of deep-water stocks, such as the high-value white teatfish (*Holothuria fuscogilva*), prickly redfish (*Thelenota ananas*) and the lower-value amberfish (*T. anax*).

The profile of the sea cucumber fishery at all sites in Kiribati reflected the oceanic nature of the environment, which impacted on the range and potential densities of these deposit feeders (which eat organic matter in the upper few mm of bottom substrates). Also there has been active fishing for sea cucumbers in the recent past. In deep-water assessments (average 22.6 m in depth), white teatfish (*H. fuscogilva*) were not found, despite checking suitable areas for this species. The shallow water in the passes (<25 m) enabled any white teatfish that were living in these locations to be easily fished by snorkel divers. Prickly redfish (*T. ananas*) and amberfish (*T. anax*) were present but at low density.

Other species associated with reef, such as leopardfish (*Bohadschia argus*) and the high-value black teatfish (*Holothuria nobilis*) were present (found in 1–8% of broad-scale transects) but not at high density. The low-value flowerfish (*B. graeffei*) was somewhat more common, but is not fished commercially. Surf redfish (*Actinopyga mauritiana*) a higher-value species, was uncommon, and no high-density aggregations were recorded, despite the suitable nature and extent of the reef and surge zone present at Abemama.

More protected areas of reef and soft benthos in the lagoon held no blackfish (*Actinopyga miliaris*), but the lower-value species, e.g. brown sandfish (*B. vitiensis*), lollyfish (*H. atra*) and pinkfish (*H. edulis*) were present. The occurrence and density of all these species were generally low and do not offer a large potential for commercial fishing.

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

Table 3.13: Sea cucumber species records for Abemama

Species	Common name	Commercial value [5]	B-S transects n = 73			Reef-benthos stations n = 12			Other stations RFs = 3; SBq = 16			Other stations Ds = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga mauritiana	Surf redfish	M/H	0.5	16.7	3				2.6	7.8	33 RFs			
Actinopyga miliaris	Blackfish	M/H												
Bohadschia argus	Leopardfish	M				3.5	41.7	8						
Bohadschia graeffei	Flowerfish	L	2.1	30.0	7	45.1	135.4	33	1.3	3.9	33 RFs			
Bohadschia vitiensis	Brown sandfish	L	89.3	2172.0	4									
Holothuria atra	Lollyfish	L	3286	8568	38				2.8 /m²	7.5 /m²	38 SBq			
Holothuria edulis	Pinkfish	L	0.7	48.4	1	3.5	41.7	8				1.2	2.4	50
Holothuria fuscogilva [4]	White teatfish	H												
Holothuria fuscopunctata	Elephant trunkfish	M												
Holothuria nobilis [4]	Black teatfish	H	0.2	16.7	1				1.3	3.9	33 RFs			
Stichopus chloronotus	Greenfish	H/M	1.4	50.0	3	17.4	104.2	17						
Thelenota ananas	Prickly redfish	H	0.2	16.7	1	3.5	41.7	8				28.6	57.1	50
Thelenota anax	Amberfish	M	0.2	16.7	1									

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

3.4.7 Other echinoderms: Abemama

No edible urchins (*Heterocentrotus mammillatus*, *Tripneustes gratilla*) or non-edible urchins were recorded at Abemama. This is a very uncommon result for PROCFish surveys and reflects somewhat the sandy nature of the lagoon system.

Starfish were also rare. No blue starfish (*Linckia laevigata*) were recorded, while corallivorous (coral eating) stars, such as the pincushion star (*Culcita novaeguineae*) were not common (recorded in 18% of broad-scale transects; see presence and density estimates in Appendices 4.2.2 to 4.2.6). A single crown of thorns starfish (*Acanthaster planci*) was recorded.

3.4.8 Discussion and conclusions: invertebrate resources in Abemama

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 present density and size range of elongate clams, *Tridacna maxima*, in Abemama atoll describe a lightly impacted resource, although larger clam sizes would make up a larger proportion of the size frequency in an unfished stock. *Hippopus hippopus* and *Tridacna squamosa* are generally found at higher density in locations that are less exposed to fishing. The lower density measures and large size of the clams recorded suggest that stocks of *H. hippopus* and *T. squamosa* are heavily impacted by fishing. The true giant clam, *T. gigas*, has undergone a rapid decline over the last decade and a half. The population was estimated (at 95% confidence levels) to be 4025–9788 in 1988 (Munro 1988), but today is commercially extinct[9].

- Trochus has not been relocated to Abemama from Tarawa. Habitats look suitable, but much of the area is sandy and lacking in nutrients. Other grazing gastropods are not present in high densities, which puts some doubt on the potential for trochus at Abemama.

- Data on the presence and recruitment of *Tectus pyramis*, a closely related species with similar distribution and life history characteristics to trochus, do not suggest that the habitat at Abemama is very suitable for grazing gastropods.

- If trochus were to be moved to Abemama, it is suggested that, first, transplants should be put on both sides of the northwest passage, or along the northern edge of the southwest passage, to give them a chance to get established. The back-reef and front-reef shoal stretching out from the barrier reef southeast of Abatiku Island look suitable for adult and juvenile trochus.

- Based on the information collected, *Pinctada margaritifera* populations are low, and considered heavily impacted by fishing.

- *Anadara holoserica* (*te bun*) shell beds were present across the eastern lagoon at Abemama, and the species was found at high density and in a range of size classes. This

[9] 'Commercially extinct' refers to 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.

distribution, density and size range describe a resource that is responding well to current levels of fishing pressure. Local fishers suggested that alterations to the two causeways may have negatively affected the health of the *te bun* fishery on the eastern side of the lagoon.

- *Strombus luhuanus* (*te nouo*) and other resource species, such as *Gafrarium* (*te koumwara*), were also recorded in the shell beds. *S. luhuanus* was at reasonable density across Abemama.

- Based on the information collected on sea cucumber stocks, there is a limited number of species available for commercial fishing, and stock densities for commercial species in Abemama are low. Despite the non-optimal conditions found in Abemama, the resource is considered heavily impacted by fishing.

- No edible (*Heterocentrotus mammillatus*, *Tripneustes gratilla*) or non-edible urchins were recorded at Abemama. This is a very uncommon result for PROCFish surveys and reflects somewhat the sandy nature of the lagoon system.

3.5 Overall recommendations for Abemama

- A programme to monitor reef finfish resources is required as well as new marine resource management measures for Abemama.

- Any expansion of fishing effort for reef finfish should be directed at the outer-reef areas to alleviate the heavy pressure on the lagoon and primarily target the relatively untouched deep-bottom fish species to ease pressure on the reef fish stocks.

- Considering the high quality of habitat in Abemama, marine protected areas should be considered as a primary management tool to sustain the abundance of commercial and food fish species on a long-term basis.

- If trochus were to be moved to Abemama, it is suggested that the transplanted shells should first be put on both sides of the northwest passage, or along the northern edge of the southwest passage, to give them a chance to get established. The back-reef and front-reef shoal stretching out from the barrier reef southeast of Abatiku Island look suitable for adult and juvenile trochus.

- Management measures should be introduced for sea cucumbers to allow this species to recover from previous fishing pressure.

4. PROFILE AND RESULTS FOR KURIA

4.1 Site characteristics

Kuria is located just north of the equator, around 150 km south of Tarawa and around 55 km to the west of Abemama (Figure 4.1). Kuria is made up of two triangular islands joined by a causeway. There is no lagoon, although there is a fringing reef encircling the islands. To the north of the islands is an extensive reef shoal, which is a common fishing ground for local fishers. A smaller shoal is located to the southwest of the islands near the main passage, with patches of deep submerged reef extending out about 1 km from the fringing reef. Outside the fringing reef, on both the windward and leeward sides of the islands, the bottom drops gently to over 2000 m.

Traditional outrigger canoes are used for fishing around Kuria, with gillnets used on sandbanks and intertidal areas, and handlining conducted on the outer reef slope and drop-offs. Many households are involved in copra production; the price is currently subsidised and now attracts people to this activity for income generation.

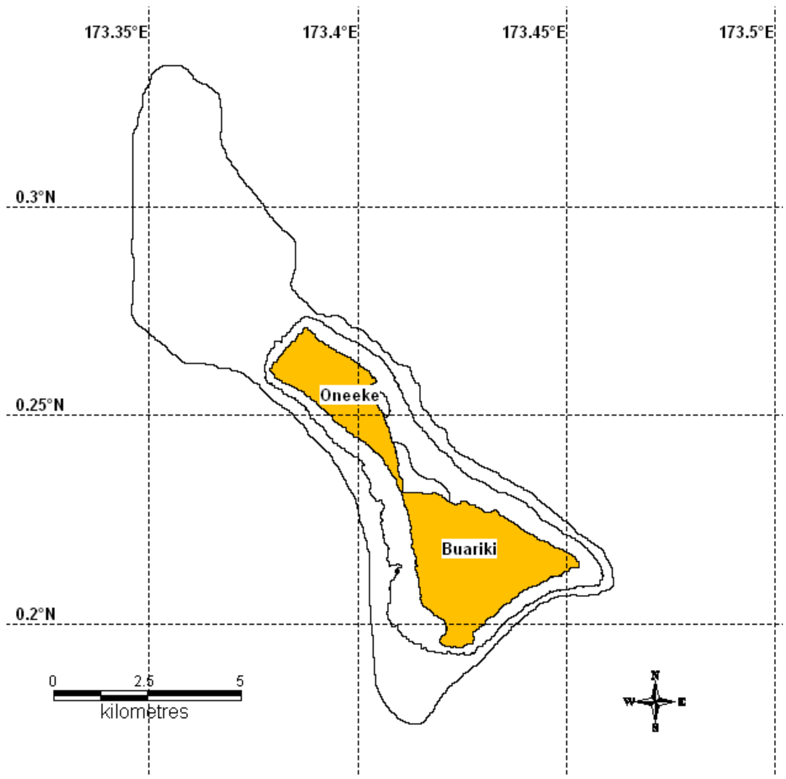

Figure 4.1: Map of Kuria.

4.2 Socioeconomic surveys: Kuria

Socioeconomic fieldwork was carried out on the island of Kuria in September – October 2004. The survey covered the two villages of Buariki and Oneeke. In total, 23 households were interviewed including 139 people. Thus, the survey covered almost 13% of the island's households (~180 in total) and total population (~1100 people).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 19 individual interviews of finfish fishers (18 males, 1 female) and 12 invertebrate fishers (6 males, 6 females) were conducted. These fishers belonged to one of the 23 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing.

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

Our survey results suggest an average of 1.7 fishers/household (1.5 fishers/household in Buariki; ~2 fishers/household in Oneeke). If we extrapolate our survey data to the total number of households in Kuria, we arrive at a total of 119 male and 8 female finfish fishers, as well as 55 male and 95 female invertebrate fishers. About 32 male fishers fish for both finfish and invertebrates.

Our survey suggests that, on average, 13% of households own a boat. However, the percentage of households and the type of boats available to the households on Kuria vary substantially between the two communities surveyed. In Buariki, only 7% of households own a boat, and these are all motorised. The 25% of households in Oneeke that own a boat all have sailboats only.

Fisheries provide ~17% of all households with first income and another 39% with second income. Agriculture is the most important source of income, providing first income for 74% and second income for another 22% of all households surveyed. Salaries are not significant for income generation (Figure 4.2). No other sources of income exist on Kuria.

On average, 34% of all households surveyed receive remittances, with no great variation between the two communities surveyed. The annual quantities received are substantial, USD 1710 /household/year, which is 1.5 times the household expenditure of USD 1137 /household/year.

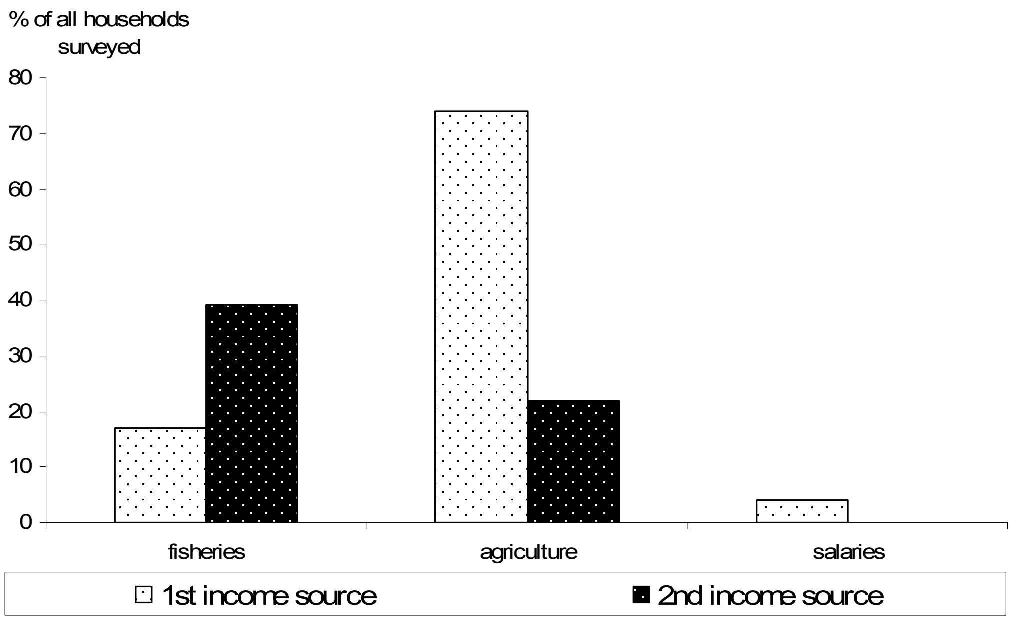

Figure 4.2: Ranked sources of income (%) in Kuria.
Total number of households = 23 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.

The annual per capita consumption of fresh fish is high if compared to the regional average (Figure 4.3). However, information published elsewhere suggests a much higher national consumption than calculated on the basis of our survey data. As compared to all other PROCFish/C sites in Kiribati, the Kuria community eats the second-largest amount of fish.

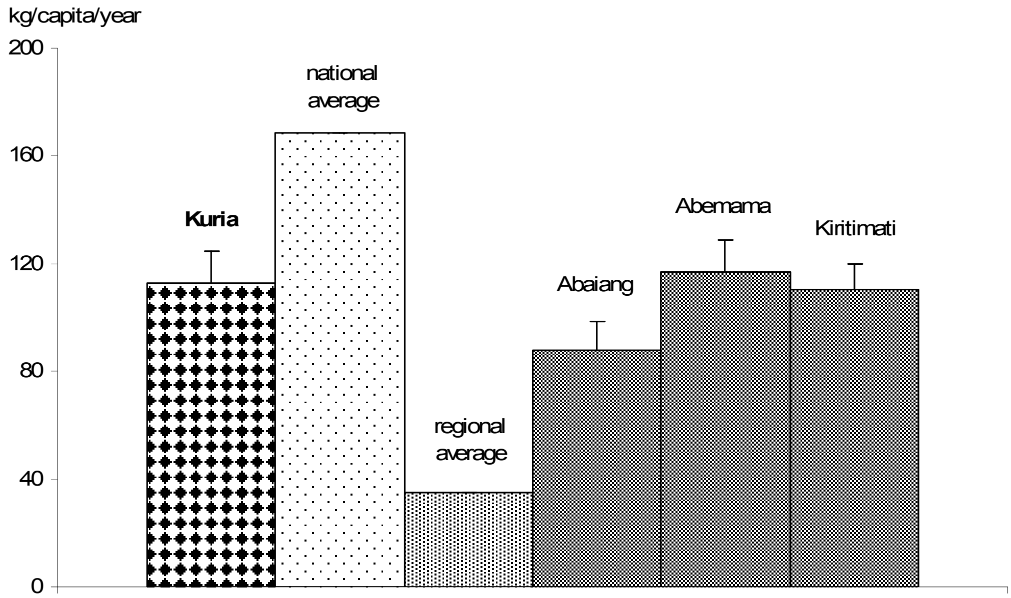

Figure 4.3: Per capita consumption (kg/year) of fresh fish in Kuria (n = 23) compared to national and regional averages (FAO 2008) and the other three PROCFish/C sites in Kiribati. Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

Fresh fish is consumed almost everyday, on average 5–6 days per week. Invertebrates and canned fish are less popular; invertebrates are eaten on average about once per fortnight and canned fish once per week. In fact, invertebrate consumption is very low (0.3 kg/person/year) and the lowest among all Kiribati PROCFish/C sites investigated (Figure 4.4). Although the frequency of canned fish consumption on Kuria corresponds well to the regional average, the consumption figure of 7.8 kg/person/year is slightly above the average of all Kiribati sites investigated.

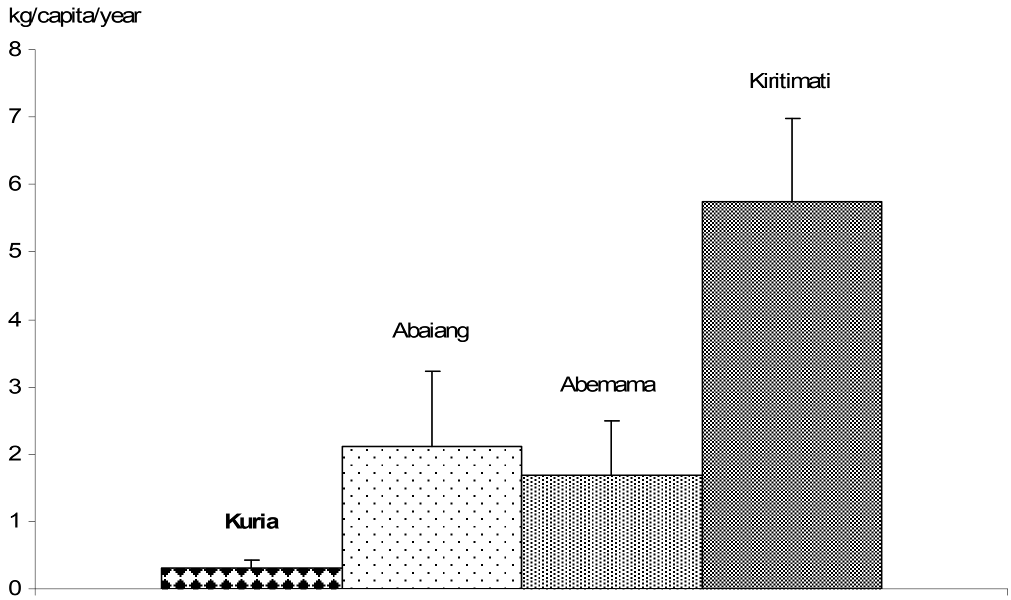

Figure 4.4: Per capita consumption (kg/year) of invertebrates (meat only) in Kuria (n = 23) compared to the other three PROCFish/C sites in Kiribati.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

By comparison with the average of all PROCFish/C sites in Kiribati (Table 4.1) the average household in Kuria has a lower number of fishers and is considerably less dependent on fisheries for first income. Household expenditures are below average but remittances received are higher. Fresh fish consumption is well above the average, and canned fish consumption is also higher than average. A smaller proportion of households than the average eats invertebrates, and fewer households catch or are given fresh fish or invertebrates that they consume. On the other hand, a much larger proportion of households purchase fresh fish than the average of PROCFish/C sites in Kiribati.

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

Survey coverage	Kuria (n = 23 HH)	Average across sites (n = 98 HH)
Demography		
HH involved in reef fisheries (%)	91	95
Number of fishers per HH	1.7 (±0.17)	1.9 (±0.11)
Male finfish fishers per HH (%)	38.5	41.9
Female finfish fishers per HH (%)	2.6	0.5
Male invertebrate fishers per HH (%)	17.9	6.3
Female invertebrate fishers per HH (%)	30.8	28.3
Male finfish and invertebrate fishers per HH (%)	10.3	20.9
Female finfish and invertebrate fishers per HH (%)	0.0	2.1
Income		
HH with fisheries as 1st income (%)	17	34
HH with fisheries as 2nd income (%)	39	24
HH with agriculture as 1st income (%)	74	43
HH with agriculture as 2nd income (%)	22	27
HH with salary as 1st income (%)	4	18
HH with salary as 2nd income (%)	0	2
HH with other sources as 1st income (%)	0	5
HH with other sources as 2nd income (%)	0	5
Expenditure (USD/year/HH)	1136.86 (±163.43)	1485.00 (±128.38)
Remittance (USD/year/HH) [(1)]	1709.53 (±187.76)	1486.00 (±187.22)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	112.62 (±11.89)	106.9 (±5.3)
Frequency fresh fish consumed (times/week)	5.7 (±0.4)	5.6 (±0.2)
Quantity fresh invertebrate consumed (kg/capita/year)	0.32 (±0.10)	0.67 (±0.09)
Frequency fresh invertebrate consumed (times/week)	0.3 (±0.1)	0.7 (±0.1)
Quantity canned fish consumed (kg/capita/year)	7.8 (±2.1)	5.7 (±0.9)
Frequency canned fish consumed (times/week)	0.8 (±0.2)	0.7 (±0.1)
HH eat fresh fish (%)	100	100
HH eat invertebrates (%)	65	74
HH eat canned fish (%)	83	66
HH eat fresh fish they catch (%)	83	88
HH eat fresh fish they buy (%)	44	28
HH eat fresh fish they are given (%)	22	36
HH eat fresh invertebrates they catch (%)	61	64
HH eat fresh invertebrates they buy (%)	0	8
HH eat fresh invertebrates they are given (%)	4	0

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

4.2.2 Fishing strategies and gear: Kuria

Degree of specialisation in fishing

Fishing on Kuria is dominated by males; almost 67% of all fishers are males, and only ~33% are females. Furthermore, most finfish fishers were males, and most invertebrate fishers were females. However, 10% of male fishers target both finfish and invertebrates (Figure 4.5).

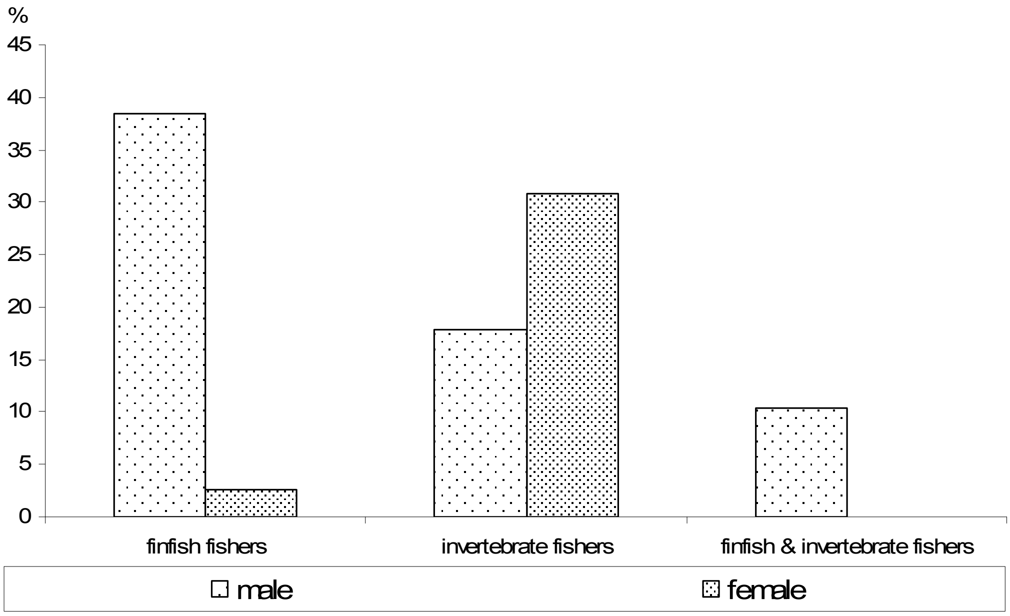

Figure 4.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Kuria.
All fishers = 100%.

Targeted stocks/habitats

Invertebrate fisheries are limited to reef and intertidal habitats. Finfish fishers may target the sheltered coastal or outer reef, or may fish in the narrow but steep passage between the two island parts of Kuria (Table 4.2). Information provided by respondents on the areas fished for the different target species is included in Figure 4.6.

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	66.7	100.0
	Outer reef	72.2	0
	Passages	11.1	0
Invertebrates	Intertidal	16.7	100.0
	Reeftop	16.7	0
	Lobster	50.0	0
	Other	33.3	0

'Other' refers to the giant clam and lobster fisheries.
Finfish fisher interviews, males: n = 18; females: n = 1. Invertebrate fisher interviews, males: n = 6; females, n = 6.

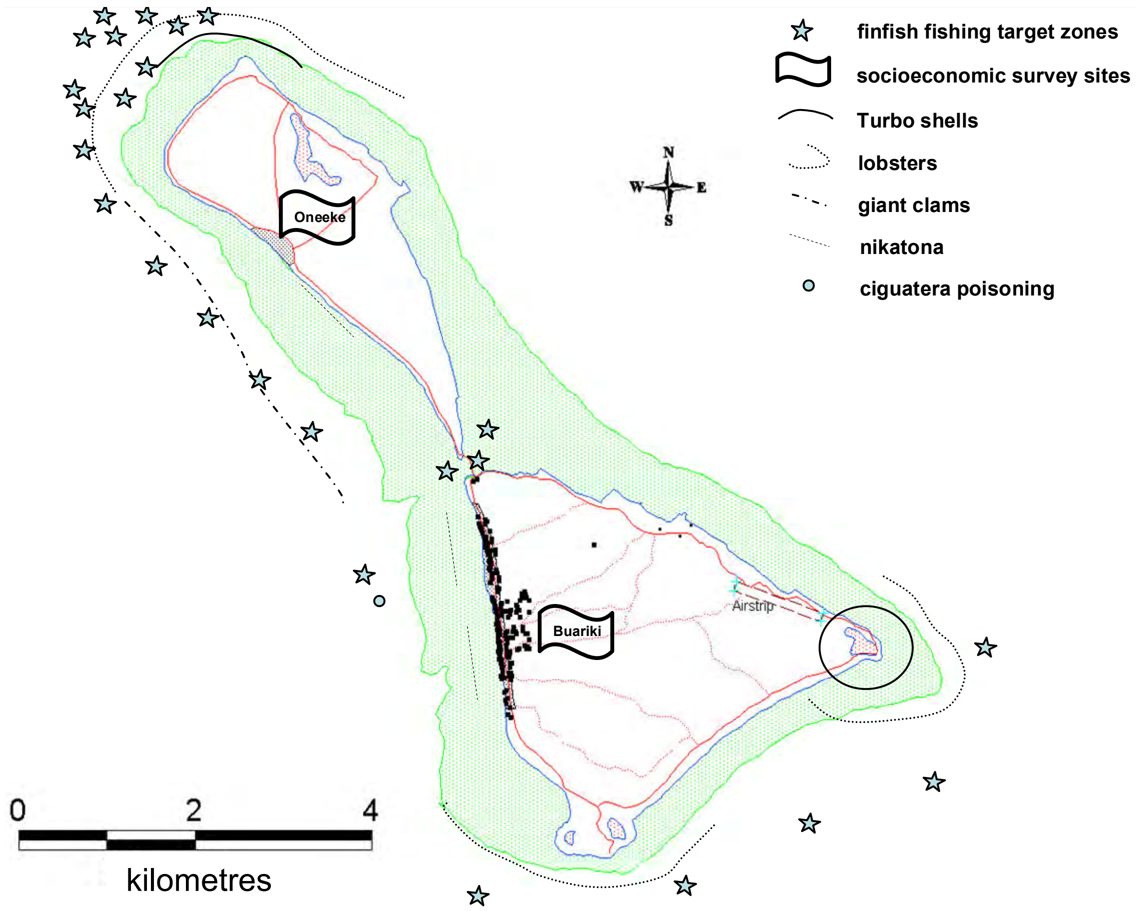

Figure 4.6: Socioeconomic survey sites and habitats fished as indicated by respondents in Kuria.

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 Kuria on their fishing grounds.

Our survey sample suggests that most fishers target equally the sheltered coastal and the outer reefs (~68% each), while passages are much less targeted (~10%). More than half of all invertebrate fishers glean the intertidal areas (~54%) and the reeftop (~8%). The remaining 38% fish for lobsters (~23%) and giant clams (15%) (Figure 4.7).

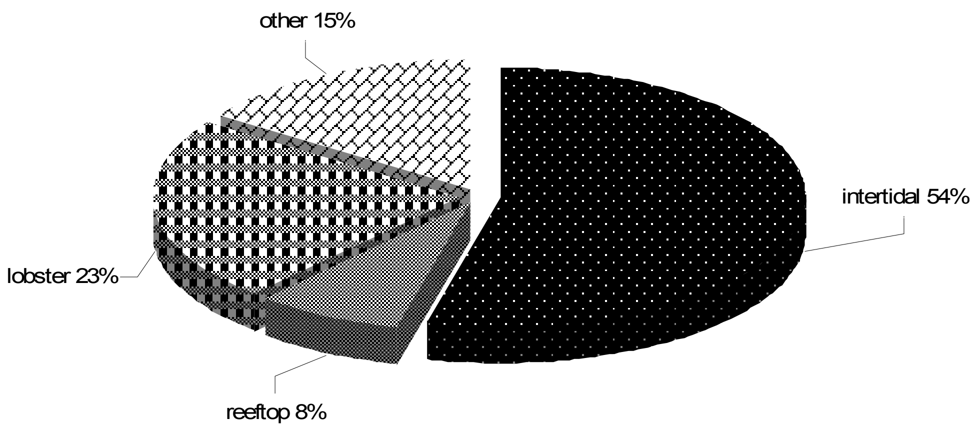

Figure 4.7: Proportion (%) of fishers targeting the four primary invertebrate habitats found in Kuria.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; 'other' refers to the giant clam and lobster fisheries.

There is a clear gender distinction among the major invertebrate fisheries on Kuria (Figure 4.8). Female fishers only glean the intertidal areas; all other fisheries, including reeftop gleaning and diving for lobsters and giant clams, are exclusively performed by males.

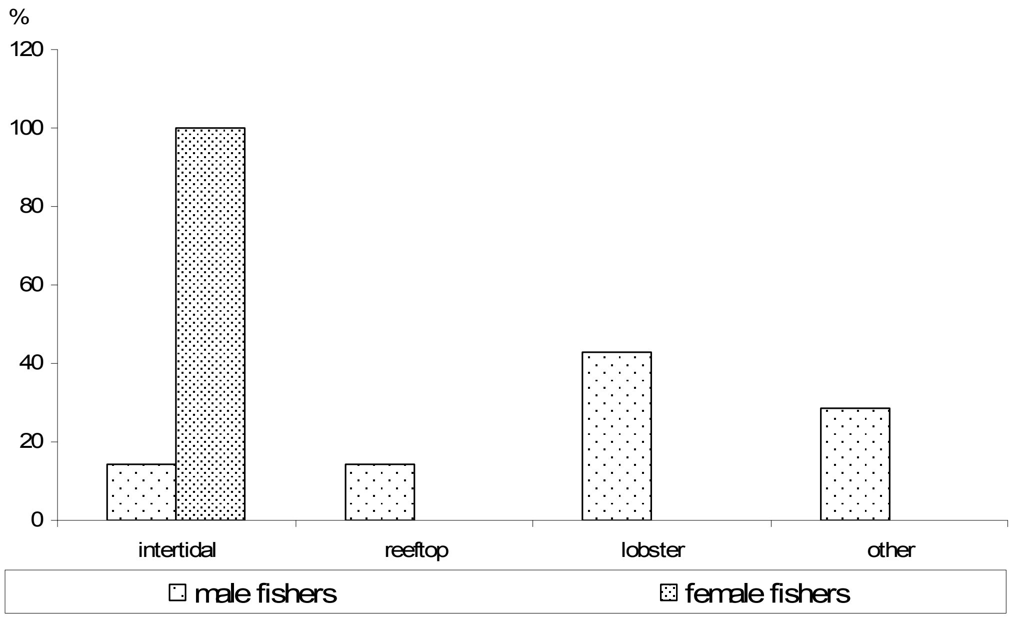

Figure 4.8: Proportion (%) of male and female fishers targeting various invertebrate habitats in Kuria.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; 'other' refers to the giant clam and lobster fisheries; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 6 for males, n = 6 for females.

Gear

Figure 4.9 shows that various fishing gear is used for finfish on Kuria. For example, although a great variety of gears is used in the sheltered coastal reef, gillnets, handlines and perhaps spear diving are the main methods used. On the outer reef, handlines are the main method used and, to a lesser extent, deep-bottom lines. Handlines or rod-and-lines are used at the passages.

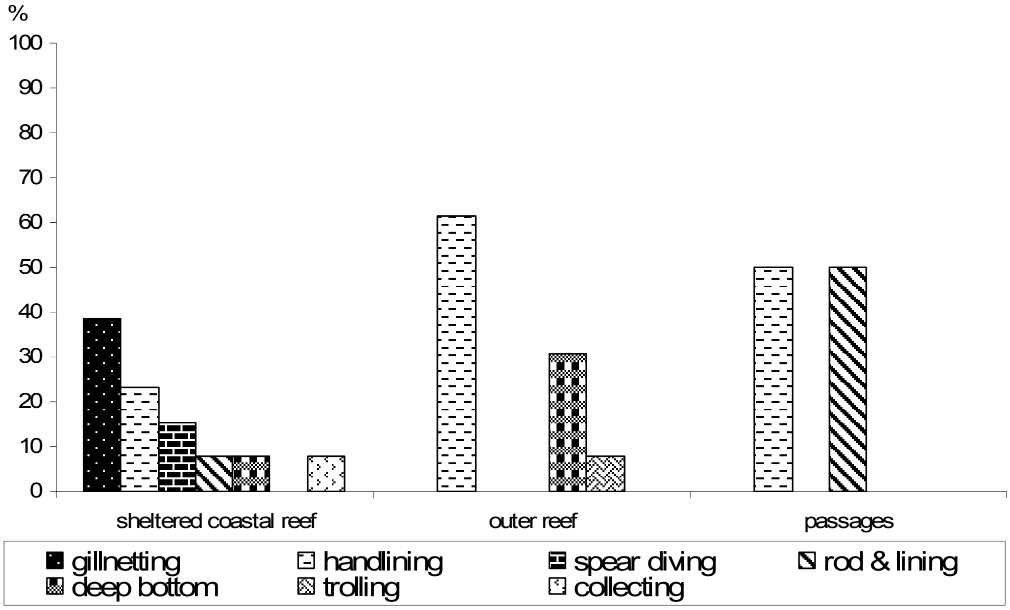

Figure 4.9: Fishing methods commonly used in different habitat types in Kuria.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Most males use a motorised boat (>66%) or a sailboat (65%) to catch finfish. Boats are not used to fish the passage, as it is fished from the bridge that connects both parts of the island.

Gleaning and diving grounds for invertebrates on Kuria are reached by walking only. Collection is done with simple tools. Diving for lobsters and giant clams is often performed using mask, snorkel and fins only. All giant clams are collected during the day and all lobster trips are performed only at night. Gleaning is only performed during the day.

Frequency and duration of fishing trips

As shown in Table 4.3, on average, trips to the sheltered coastal reef and to the passages are more frequent (3 times/week) than those to the outer reef (~1.7 times/week). However, fishing trips to the passages are the shortest (~1.25 hours/trip); trips to the sheltered coastal reef are also relatively short (2.5 hours/trip); and trips to the outer reef are the longest (5–6 hours/trip). Regarding invertebrate fishing, reeftop and intertidal gleaning, as well as giant clam collection are the most frequently performed fisheries (1–2 times/week). Diving for lobsters happens less often (0.13 times/week). The average trips for gleaning and diving fisheries do not vary much; however, diving trips for lobsters and giant clams last the longest (>2 hours/trip), and gleaning, either in the intertidal areas or the reeftop, lasts the shortest (1.5–2 hours/trip).

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

Resource	Fishery	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	3.00 (±0.31)	2.00 (n/a)	2.25 (±0.28)	6.00 (n/a)
	Outer reef	1.69 (±0.38)	0	5.88 (±0.55)	0
	Passages	3.00 (±0.50)	0	1.25 (±0.25)	0
Invertebrates	Lobster	0.13 (±0.05)	0	2.33 (±0.17)	0
	Other	0.46 (±0.00)	0	2.25 (±0.25)	0
	Reeftop	0.50 (n/a)	0	1.50 (n/a)	0
	Sand	0.23 (n/a)	0.45 (±0.14)	2.00 (n/a)	1.67 (±0.33)

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam and lobster fisheries.
Finfish fisher interviews, males: n = 18; females: n = 1. Invertebrate fisher interviews, males: n = 6; females: n = 6.

4.2.3 Catch composition and volume – finfish: Kuria

Catches reported from the sheltered coastal reef are dominated by *Mugil* spp. (*aua*) (18.3%), *Gerres oyena* (*ninimai*, *amori*) (17.9%) and *Caranx melampygus* (*rereba*) (15.7%). At the outer reef, *Aprion virescens* (*awai*) (28.1%), *Elagatis bipinnulata* (*kaama*) (24.6%) and *Caranx melampygus* (*rereba*) (10.6%) dominate the catches. Catches from passage fishing are much less diverse than those from the sheltered coastal or outer reefs, and consist of four main species: *Caranx melampygus* (*rereba*) (58.9%), *Lutjanus fulvus* (*bwawe*) (23.0%), *Lethrinus obsoletus* (*okaoka*) (14.5%) and *Lutjanus monostigma* (*tinaemia*) (3.6%). Further details on catch composition are provided in Appendix 2.3.1.

Our survey sample of finfish fishers interviewed represents about 12% of the projected total number of finfish fishers on the island of Kuria. Although this sample size is assumed to represent most of the total annual impact on Kuria, as we have tried to capture both commercial and subsistence fishers, we refrain from extrapolating our data to avoid overestimation of the fishing impact on Kuria's fishing grounds. Thus, we focus on the reported and collected survey data, which are summarised in Figure 4.10.

Figure 4.10 shows that over half of the reported annual catch is sourced from the outer reef and another 43% from the sheltered coastal reef. Catches from passages contribute little. Most of the catch is exported to Tarawa, and about 40% of the catch is consumed locally.

Due to the small sample size of female fishers on Kuria (n = 1), we refrain from interpreting any data on this group of fishers. However, for the sake of convenience, data on female fishers are presented in the following figures and tables.

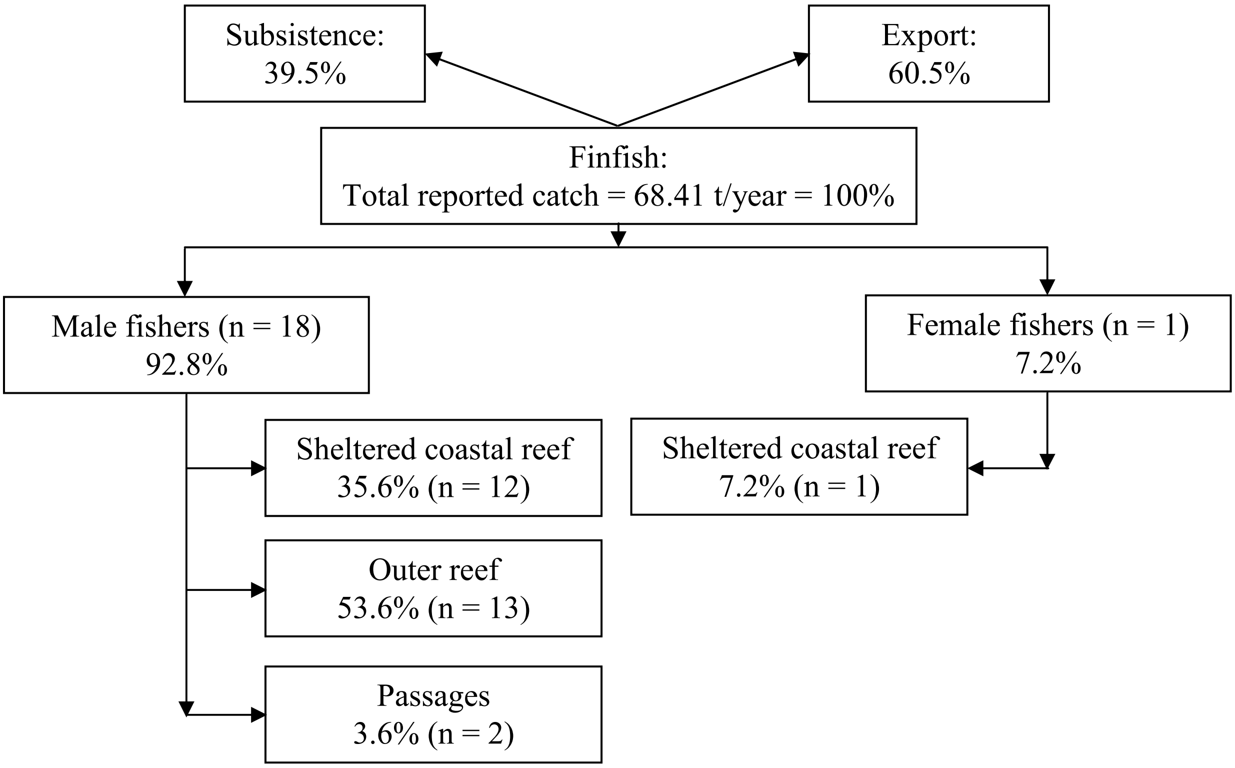

Figure 4.10: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Kuria.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The average annual catch of fishers targeting the outer reef is by far the highest. Passage fishers have the lowest annual catch on average (Figure 4.11). The higher annual catches at the outer reef explain the fact that impact there is highest (>50% of all reported annual catches, Figure 4.10) although the numbers of fishers targeting the sheltered coastal and the outer reefs are similar.

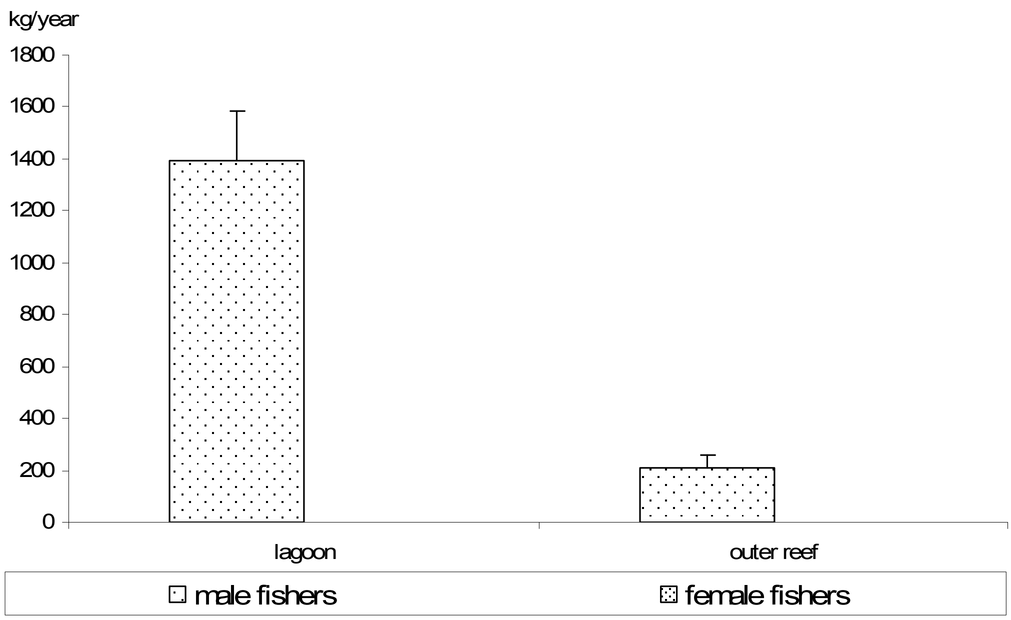

Figure 4.11: Average annual finfish catch (kg/year) per fisher by habitat and gender in Kuria.
Bars represent standard error (+SE).

Hardly any females fish for finfish, which explains our small sample size (female fisher n = 1) (Figure 4.10). Therefore, we compare only the CPUEs of male fishers targeting different habitats. Figure 4.12 shows that the efficiency of fishing is similar among all three habitats targeted, i.e. about 6.5 kg fish/hour of fishing trip.

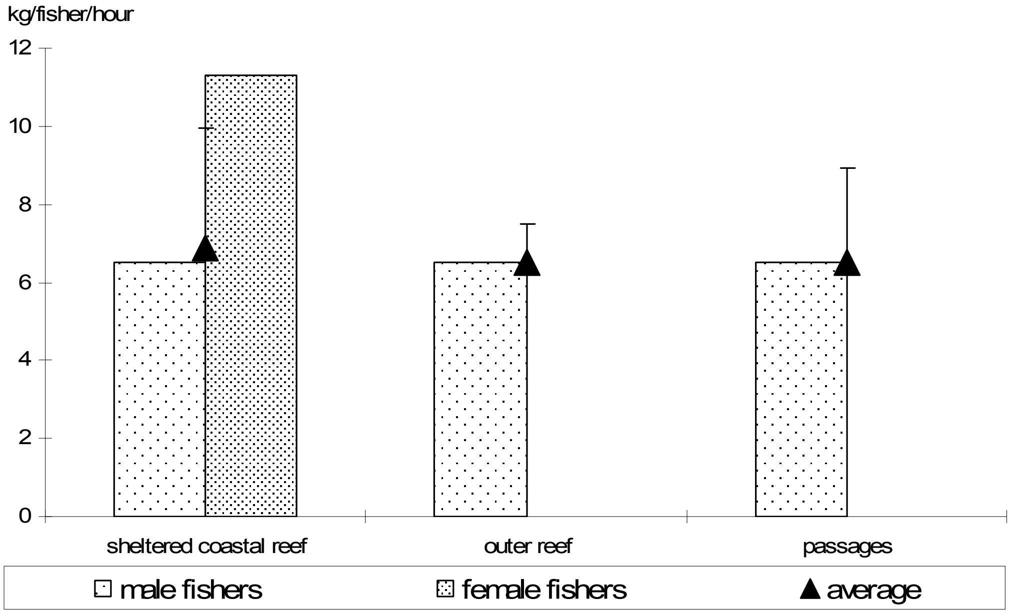

Figure 4.12: Catch per unit effort (kg/hour of total fishing trip) for male fishers by habitat in Kuria.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Survey data show (Figure 4.13) that most of the catch is used for export. This applies in particular for the outer-reef catches, and for about half of all catches from the sheltered coastal reef. The passage is exclusively fished for subsistence purposes. On Kuria, the passage is a special case, as fishers cast rods or handlines from a small bridge into the narrow but deep passage between the two island parts of Kuria. This bridge is easily accessible by road (reached by walking, bicycle, or car) and the passage is a promising fishing ground as it is connected to the open ocean but offers shelter at the same time.

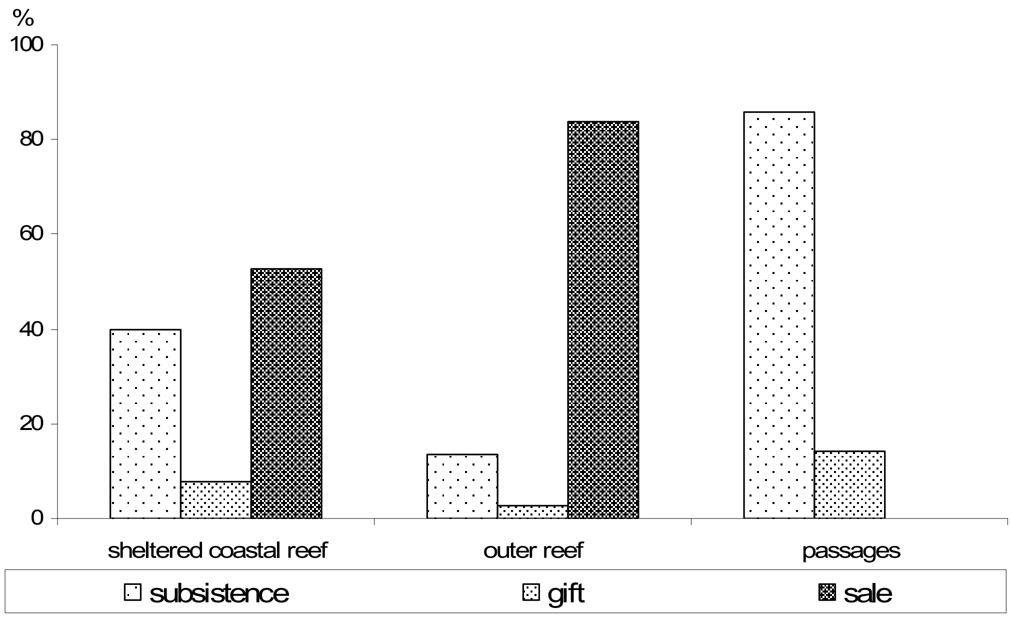

Figure 4.13: The use of finish catches for subsistence, gift and sale, by habitat in Kuria.
Proportions are expressed in % of the total number of trips per habitat.

Data on the average reported finfish sizes by family and habitat (Figure 4.14) show a high variability. Fish caught at the small passage are 24–31 cm on average. While the average fish caught at the sheltered coastal reef are ~25 cm, average lengths reported for the various families range from 16 cm (Holocentridae) to 40 cm (Muraenidae). Similarly the average fish length of 32 cm reported for catches from the outer reef includes a minimum average length of 24 cm (Balistidae) and a maximum average size of 41 cm (Carangidae). As expected, on average, fish sizes reported for catches from the outer reef are larger than those from the sheltered coastal reef.

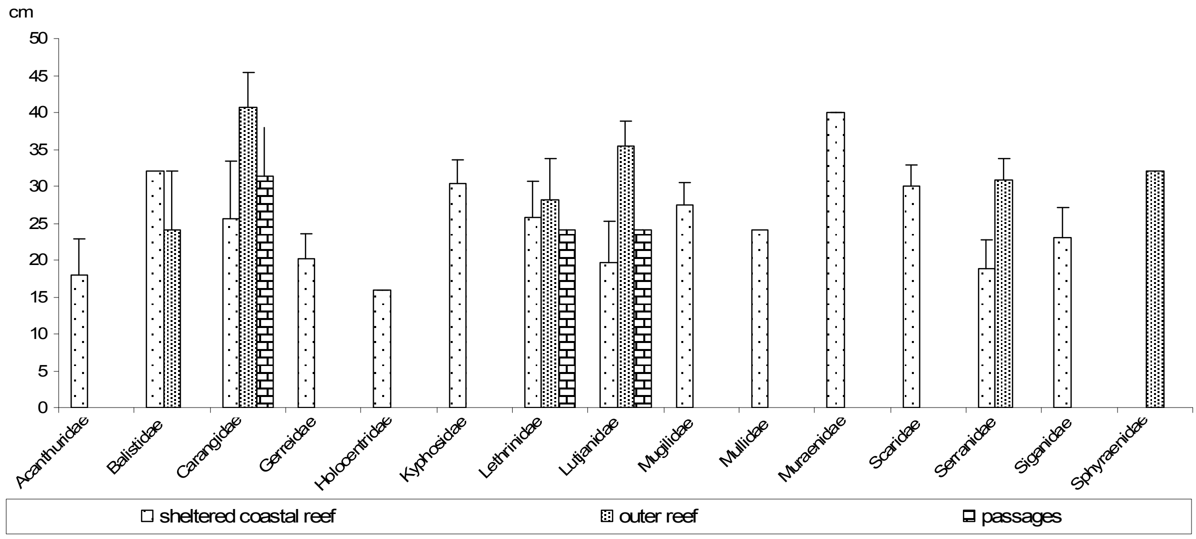

Figure 4.14: Average sizes (cm fork length) of fish caught by family and habitat in Kuria.
Bars represent standard error (+SE).

Some selected parameters to assess the current fishing pressure on Kuria's living reef resources are shown in Table 4.4. The comparison of the habitat surfaces that are included in

Kuria's fishing ground shows that the sheltered coastal reef area is about one-third of the outer-reef area in size. Size variations and number of fishers targeting the two major habitats result in differences of fisher density, which is highest in the sheltered coastal reef and otherwise rather small (2–5 fishers/km^2). The average annual catch per fisher is very high and may be explained by the fact that the cooperative system on Kuria is working very well, and that most fishers are also commercially oriented. Overall, population density is moderate but fishing pressure imposed on Kuria's reef habitat by the subsistence needs of the island's population alone is low. However, it should be borne in mind that most fishing is done for export to Tarawa and, hence, a much higher current fishing pressure must be assumed.

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

Parameters	Habitat			
	Sheltered coastal reef	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	14.38	37.92	52.30	52.30
Density of fishers (number of fishers/km^2 fishing ground) [(1)]	5	2	3	3
Population density (people/km^2) [(2)]			21	21
Average annual finfish catch (kg/fisher/year) [(3)]	2252.59 (±1139.82)	2818.78 (±738.42)		
Total fishing pressure of subsistence catches (t/km^2)			2.1	2.1

Figures in brackets denote standard error; [(1)] total number of fishers (= 158) is extrapolated from household surveys; [(2)] total population = 1100; total subsistence demand = 110.62 t/year; [(3)] catch figures are based on recorded data from survey respondents only.

4.2.4 Catch composition and volume – invertebrates: Kuria

Calculations of the recorded annual catch rates per species groups are shown in Figure 4.15. The graph shows that, although annual catches are generally low, the highest impact by wet weight is on lobsters (*Panulirus penicillatus*, *P. versicolor*), followed by giant clams (*Tridacna maxima*, *T. squamosa*), and *Coenobita* spp. (*makauro*). Impact on *Tellina palatum* (*nikatona*) appears to be negligible.

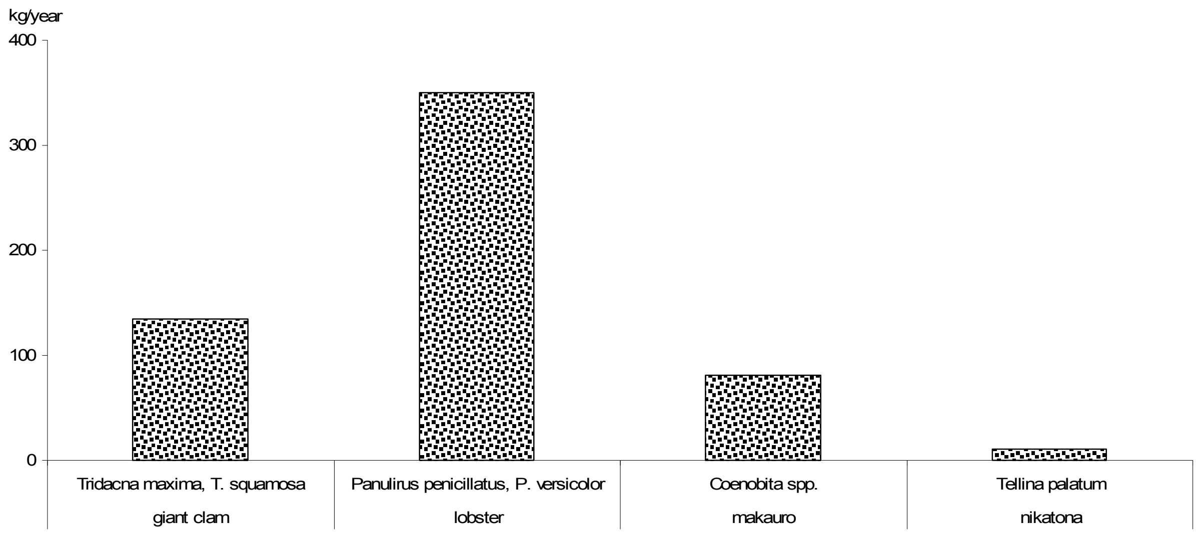

Figure 4.15: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Kuria.

The diversity of Kuria's invertebrate fisheries is limited, i.e. only one or two vernacular names were reported for each fishery (Figures 4.15 and 4.16).

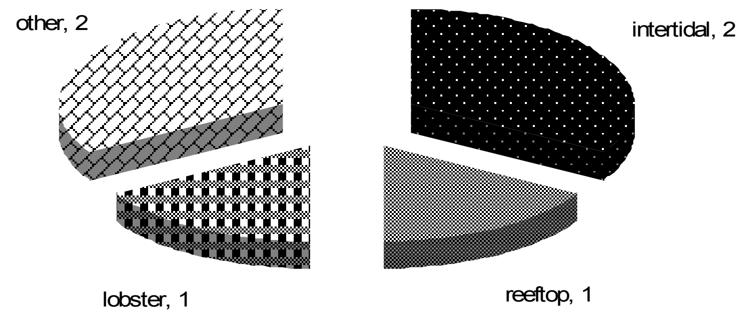

Figure 4.16: Number of vernacular names recorded for each invertebrate fishery in Kuria.

Details on species distribution per habitat and size distribution by species are provided in Appendices 4.3.2 and 4.3.3 respectively.

Following the trend shown in Figure 4.17, annual recorded catch rates by fisher, gender and fisheries are highest for male fishers' catches targeting lobsters. By comparison, average annual catches from 'other' fisheries (giant clams and lobsters) and reeftop gleaning are 40–50% less. However, considering that reeftop collection almost exclusively comprises giant clams, giant clam fishers may reach similar average annual catches (by wet weight) to lobster fishers. The average annual catches by female fishers from the intertidal fishery are negligible.

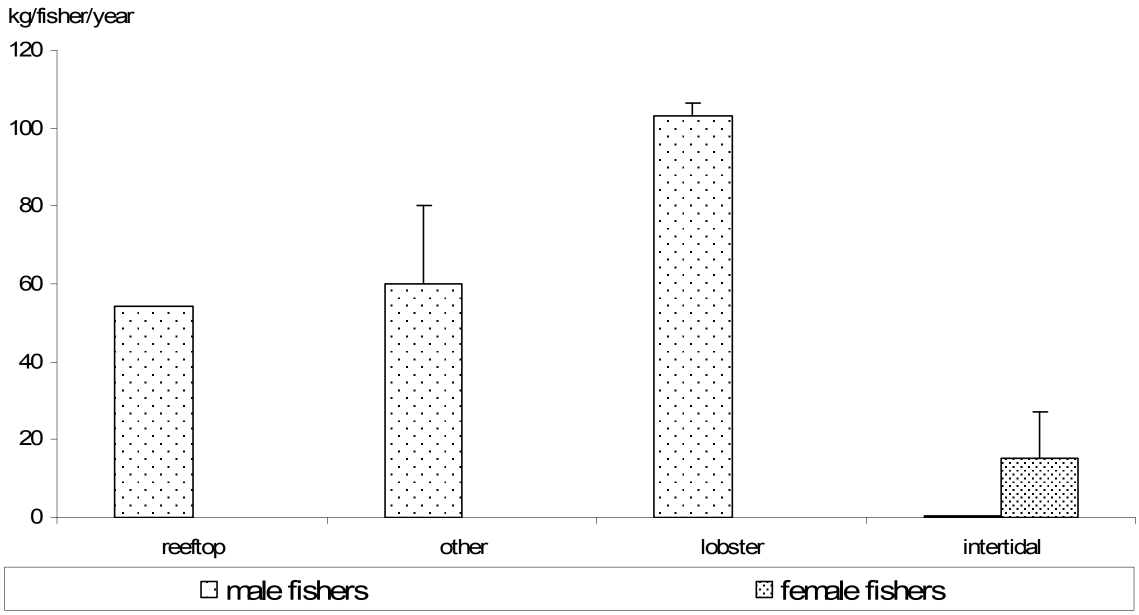

Figure 4.17: Average annual invertebrate catch (kg wet weight/year) by fisher, gender and fishery in Kuria.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 6 for males, n = 6 for females). Bars represent standard error (+SE). 'Other' refers to the giant clam and lobster fisheries.

The fact that most invertebrates are collected for subsistence rather than commercial purposes may explain why, overall, annual average catches are low. As shown in Figure 4.18 most invertebrates are consumed locally, and about 17% of the reported total annual catch may be used either for home consumption or sold. Only lobsters are fished commercially, sometimes bought by the local cooperative or shipped to Tarawa for private sale (See also Table 4.5.).

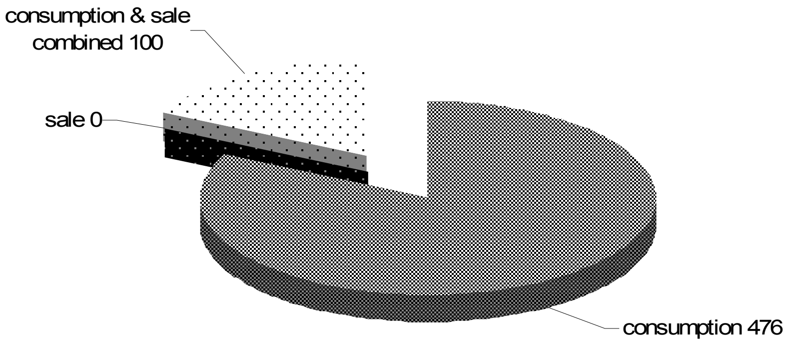

Figure 4.18: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Kuria.

Table 4.5: Total annual recorded invertebrate catch by species and purpose of use (kg wet weight/year) in Kuria

Scientific name	Vernacular name	Total catch (biomass wet weight kg/year)			
		Consumption	Sale	Consumption & sale	Sum
Tridacna maxima, Tridacna squamosa	giant clam	134	0	0	134
Panulirus penicillatus, Panulirus versicolor	lobster	250	0	100	350
Coenobita spp.	*makauro*	81	0	0	81
Tellina palatum	*nikatona*	11	0	0	11
Total:		**476**	**0**	**100**	**576**

The total annual catch volume (expressed in wet weight based on the recorded data from all respondents interviewed) amounts to 0.58 t/year (= 100%) (Figure 4.19). The data show that the lobster fishery accounts for the highest proportion of the total reported annual catch (54%). The 'other' fishery (mostly giant clams, with some lobster catches), together with the reeftop fishery, (mostly giant clams), determine another 30%. Catches from intertidal areas (mainly *Coenobita* spp. and *Tellina palatum*) only account for 16% of the total annual reported catch.

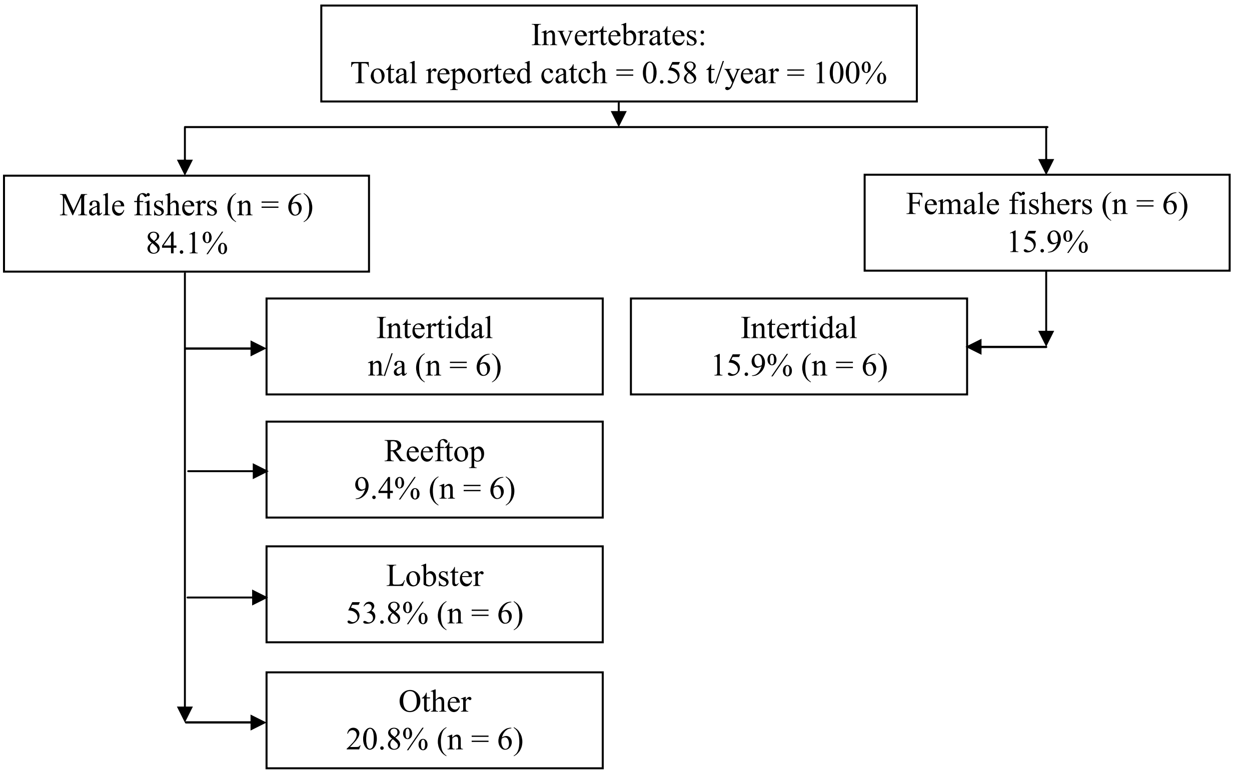

Figure 4.19: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Kuria.
n is the total number of interviews conducted per each fishery; n/a = no information available; 'other' refers to the giant clam and lobster fisheries; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

The parameters presented in Table 4.6 show large fishing grounds, especially for giant clams collected from the reeftop by gleaners and free-divers. There is also a considerable length of reef that supports the lobster fishery. As a result, taking into account the total number of fishers engaged in each fishery, fisher densities are very low, 0.7–1.5 fishers/km^2 reef surface or km reef length. Unfortunately, the total surface area available for the intertidal fishery was not known and therefore no fisher density was calculated for this fishery. We may, however, speculate that the fishing pressure on the intertidal fishery is low as the relatively large number of fishers targeting this fishery may be balanced by the low catch rate/fisher/year.

Table 4.6: Selected parameters (±SE) used to characterise the current level of fishing pressure of invertebrate fisheries in Kuria

Parameters	Fishery / Habitat			
	Intertidal	Reeftop	Lobster (3)	Other
Fishing ground area (km^2)	n/a (4)	21.81	28.64	21.81
Number of fishers (per fishery) (1)	109	15	44	29
Density of fishers (number of fishers/km^2 fishing ground)	n/a (4)	0.7	1.5	1.3
Average annual invertebrate catch (kg/fisher/year) (2)	13.09 (±10.38)	54.29 (n/a)	103.28 (±3.33)	59.97 (±19.99)

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; (1) number of fishers extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; (3) linear measure km reef length; (4) fishing grounds are presently not determined.

4.2.5 Discussion and conclusions: socioeconomics in Kuria

- The people of Kuria are dependent on reef fisheries resources as their most important source of protein and nutrition. This applies in particular to finfish, which is consumed almost everyday; the annual average amount eaten is among the highest across all Kiribati PROCFish/C sites investigated.

- Finfish fisheries on Kuria include reef, deep-bottom, and pelagic fisheries. For commercial purposes, deep-bottom fishing is particularly popular. Handlines and fishing rods are the main methods used at the easily accessible passage between the two island parts; this fishing is performed exclusively for subsistence purposes.

- Revenues are mainly derived from agriculture. In addition, 34% of all households receive remittances that exceed the average household expenditures by 1.5 times. However, while fisheries provide the first income source for only a few households (17%), it nevertheless provides another 39% with secondary income. Income generation from fisheries on Kuria is supported by Central Pacific Producer Ltd. (CPP, formerly known as Kirimati Marine Export Ltd., KMEL), which buys fish and sometimes lobsters to supply local demand and for export to Tarawa.

- The fact that fishing is important for subsistence needs and still also plays a certain role in generating income may explain why the proportion of households that engage in fishing and the average number of fishers per household are slightly below the average across all Kiribati PROCFish/C sites.

- Invertebrate fisheries are not diverse and play a much lesser role than finfish fisheries. People eat invertebrates on average once a fortnight. Fishers target basically four species groups: lobsters, giant clams, *Coenobita* spp., and *Tellina palatum*. Lobsters are the only invertebrates fished commercially.

- Traditional gender roles were found to restrict finfish fisheries and diving for lobsters and giant clams diving to male fishers only; intertidal gleaning is mostly done by females.

- Our survey data show that the highest fisher density occurs for the sheltered coastal reef area (5 fishers/km^2). Overall, fisher density on the community's total reef area and its total fishing ground is low (3 fishers/km^2). However, taking into account the frequency of fishing trips, the total number of fishers, and the high average annual catch per fisher, a moderate-to-high fishing pressure (total annual catch) can be assumed for both areas. If only the subsistence needs of the island's population are considered, fishing pressure is low (2.12 t/km^2/year).

- Kuria fishers use different fishing techniques when targeting different habitats. In the sheltered coastal reef, gillnets, handlines, and perhaps spear diving are the main methods used. In the outer reef, handlines and deep-bottom lines are used; the passages are fished with handlines or rods and lines.

- Fisher densities for the giant clam and lobster fisheries are low, as are annual catch rates per fisher (wet weight) for both species groups, corresponding to the earlier finding that invertebrates are less important for both subsistence and sale. The lowest catch rates were those of the intertidal gleaners, who are mostly female fishers and who fish exclusively for home consumption.

- The low fisher density for giant clams and lobster and the relatively low average annual catch rates per fisher, as well as the low productivity of intertidal gleaners give reason to assume that the current fishing pressure on invertebrate resources at Kuria is relatively low.

Based on the observations that the Kuria community is highly dependent on fisheries for income generation; fish consumption is high; and most of the catches are commercially sold to Tarawa; our data suggest the following three conclusions:

- A considerable proportion of the Kuria community fish and, although fisheries are not the most important income source, most finfish, lobsters and giant clams are fished to provide income.

- Fishing pressure does not seem high if only subsistence needs are considered. However, the overall commercial fishing of finfish, and the fact that invertebrate fishing focuses on a few species, such as lobsters and giant clams only, may impose considerable pressure on selected resources. Thus, sizes, most importantly for giant clams, need to be monitored, in order to detect early signs of stress due to fishing pressure.

- Alternative income sources are limited (handicrafts, a few public salaries, very little agricultural potential) and the give reason to assume that the fishing pressure will not cease but may increase to meet future demands of the island's growing community for income and nutrition.

4.3 Finfish resource surveys: Kuria

4.3.1 Finfish assessment results: Kuria

Surveys were conducted in 24 transects sites randomly selected across the 38 km^2 reef area around Kuria April 10–15 2004. Kuria is an atoll without a lagoon and therefore there is only one reef type surrounding the island, the outer fringing reef (See Figure 4.20 for transect locations and Appendix 3.3.1 for coordinates.).

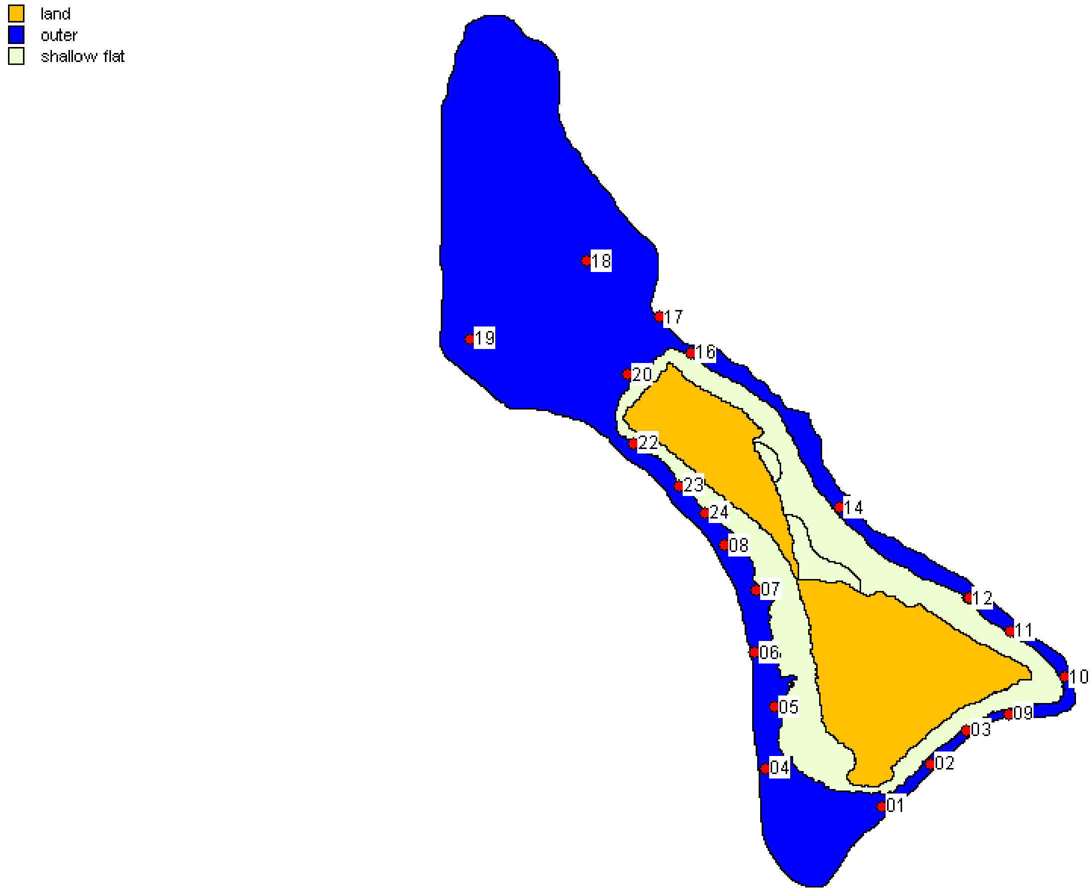

Figure 4.20: Habitat types and transect locations for finfish assessment in Kuria.

A total of 20 families, 59 genera, 186 species and 28,207 fish were recorded in the 24 transects (See Appendix 3.3.2 for list of species). Only data on the most dominant families in our regional database are presented below, representing 14 families, 48 genera, 166 species and 27,266 individuals.

Table 4.7: Primary finfish habitat and resource parameters recorded in Kuria (average values ±SE)

Parameters	Habitat
	Outer reef [(1)]
Number of transects	24
Total habitat area (km^2)	37.92
Depth (m)	8 (3-14) [(2)]
Soft bottom (% cover)	5.1 ±1.0
Rubble & boulders (% cover)	4.2 ±0.8
Hard bottom (% cover)	67.5 ±1.4
Live coral (% cover)	22.5 ±1.8
Soft coral (% cover)	0.3 ±0.3
Biodiversity (species/transect)	52.9 ±2.8
Density (fish/m^2)	1.9 ±0.2
Biomass (g/m^2)	275.9 ±65.5
Size (cm FL) [(3)]	15.2 ±0.3
Size ratio (%)	41.2 ±0.7

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

Outer-reef environment: Kuria

The outer-reef environment of Kuria is largely dominated by two families of carnivorous fish: Lutjanidae, with the overall highest biomass, and Balistidae with the overall highest density; and one family of herbivorous fish, the Acanthuridae (Figure 4.21). These three families are mostly represented by 11 species; particularly high abundance and biomass were recorded for *Lutjanus gibbus*, *L. kasmira*, *L. fulvus*, *Acanthurus lineatus*, *Odonus niger*, L. bohar, *A. nigricans*, *Ctenochaetus striatus* and *Melichthys vidua* (Table 4.8).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.11	55.0
	Lutjanus kasmira	Common bluelined snapper	0.12	13.7
	Lutjanus fulvus	Flametail snapper	0.05	13.1
	Lutjanus bohar	Twospot red snapper	0.03	10.1
Balistidae	*Odonus niger*	Redtooth triggerfish	0.79	10.4
	Melichthys vidua	Pinktail triggerfish	0.09	6.5
Acanthuridae	*Acanthurus lineatus*	Lined surgeonfish	0.04	10.8
	Acanthurus nigricans	Whitecheek surgeonfish	0.08	9.9
	Ctenochaetus striatus	Striped bristletooth	0.08	6.6

The reef around Kuria resembles a concrete slab, in most parts. It is strongly dominated by hard bottom (68% cover) and live coral (23%), while soft-bottom and rubble substrates are in low cover. This type of environment generally favours herbivorous fish that graze on small algae growing on bare rocks; however, this is not truly reflected in the density and biomass of fish found on this island, where the community is dominated by carnivores (Figure 4.21).

Detailed assessment at the reef level among the four outer-reef sites surveyed in Kiribati suggests that finfish resources in Kuria display the highest density and second-highest biodiversity but the smallest size ratio and second-smallest biomass.

As stated above, Kuria Island is an atoll with no lagoon and therefore only one habitat (outer reef) is available for any fishing activity, whether commercial or subsistence. Fishing impact on the outer reef is the same as the average between Abemama and Abaiang, despite the existence of a Fisheries cold storage centre on the island, which enables reef and pelagic fish to be exported to the capital. This commercial fishery adds to the level of fishing impact on local reef-fish stocks.

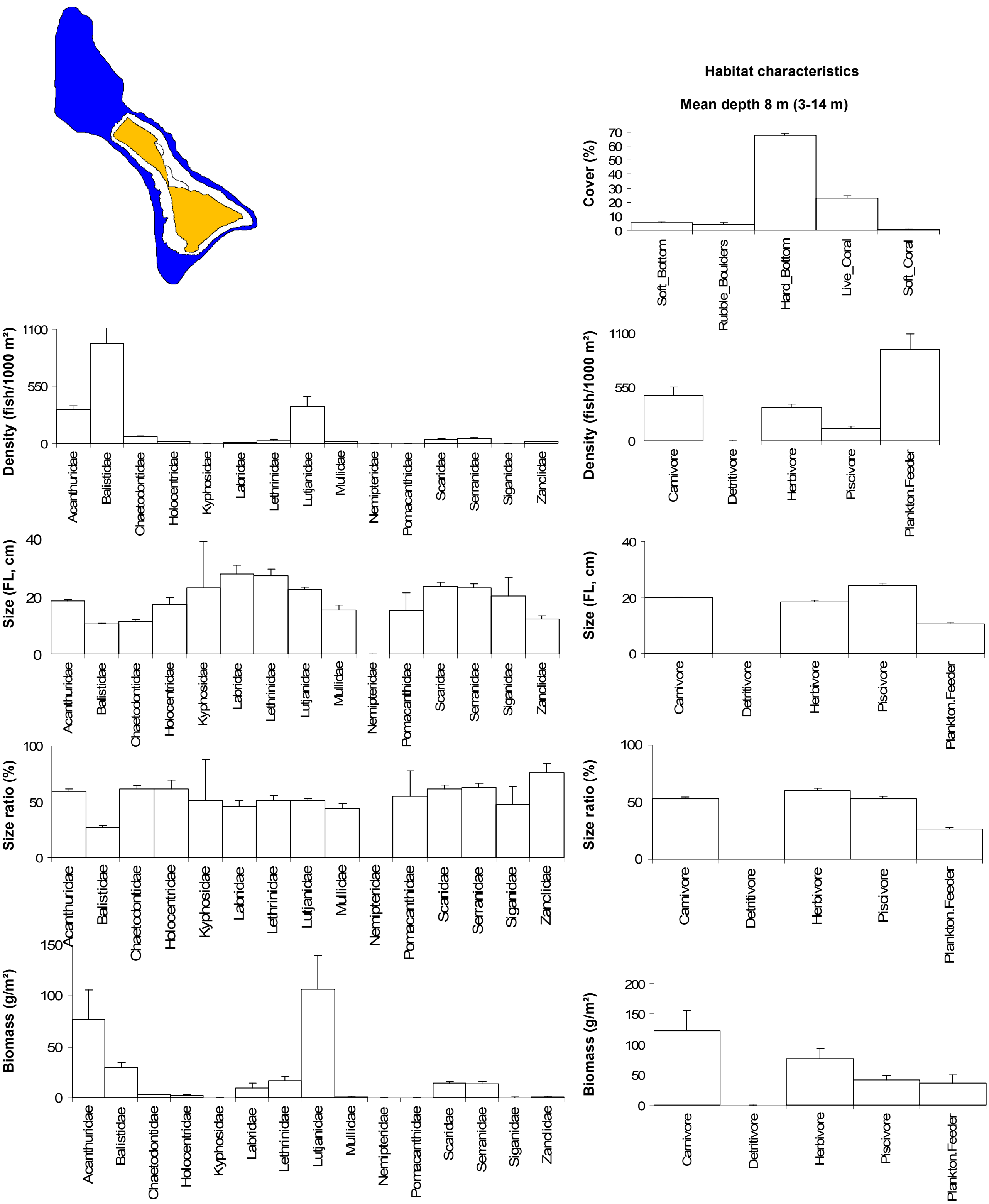

Figure 4.21: Profile of finfish resources in the outer-reef environment of Kuria.
Bars represent standard error (+SE); FL = fork length.

4.3.2 Discussion and conclusions: finfish resources in Kuria

- The assessment indicates that the status of finfish resources in Kuria is average across the four sites surveyed in the country, with relatively high density but low biodiversity, size and biomass. However, the rather high abundance of carnivorous fish (Lutjanidae and Balistidae especially) suggests that the area's finfish resources are relatively healthy for this high trophic level of fish. However, detailed assessment at reef level revealed a very low abundance of herbivorous Scaridae, especially Kyphosidae and Siganidae, similarly to the other sites. This may be due to the fact that these fish species are often easily caught by gillnetting on reef flats during high tide and therefore are specifically targeted by the local community.

- Overall, Kuria finfish resources appear to be in average condition compared to the other sites. The reef habitat seems to be in good condition although less rich than the other sites.

- The quality and quantity of finfish resources in Kuria should allow sustainable subsistence use of this resource, with possibly some controlled commercial use as well.

4.4 Invertebrate resource surveys: Kuria

The diversity and abundance of invertebrate species at Kuria were independently determined using a range of survey techniques (Table 4.9): broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 4.22) and finer-scale assessment of specific reef and benthic habitats (Figures 4.23 and 4.24).

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

Table 4.9: Number of stations and replicates completed at Kuria

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	10	57 transects
Reef-benthos transects (RBt)	12	72 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
Reef-front search by walking (RFs_w)	0	0 search period
Sea cucumber day searches (Ds)	4	24 search periods
Sea cucumber night searches (Ns)	2	12 search periods

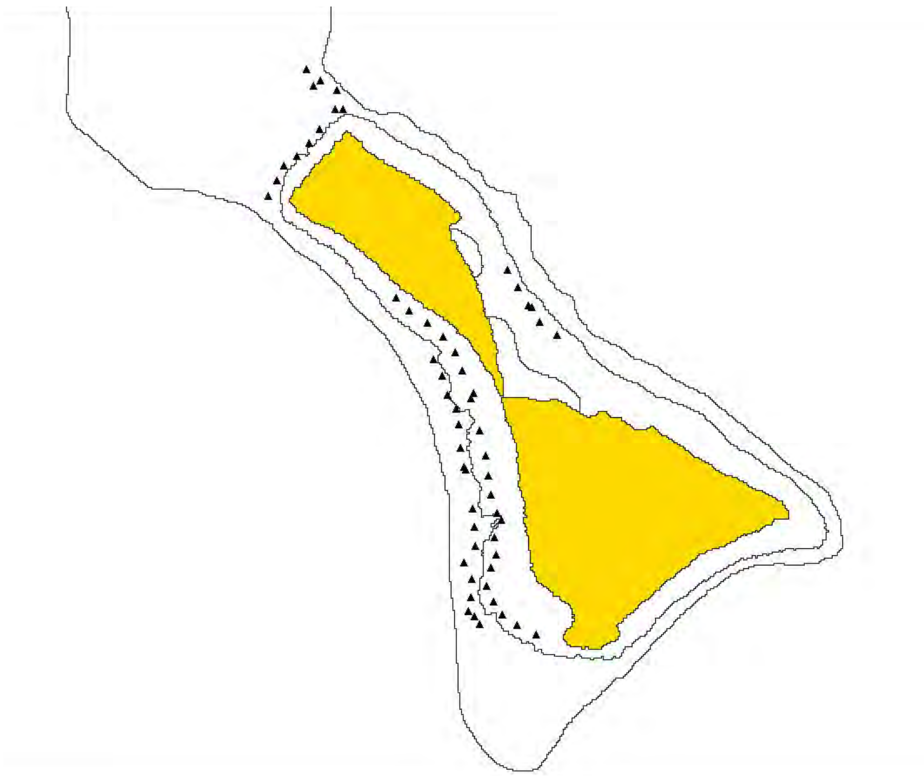

Figure 4.22: Broad-scale survey stations for invertebrates in Kuria.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

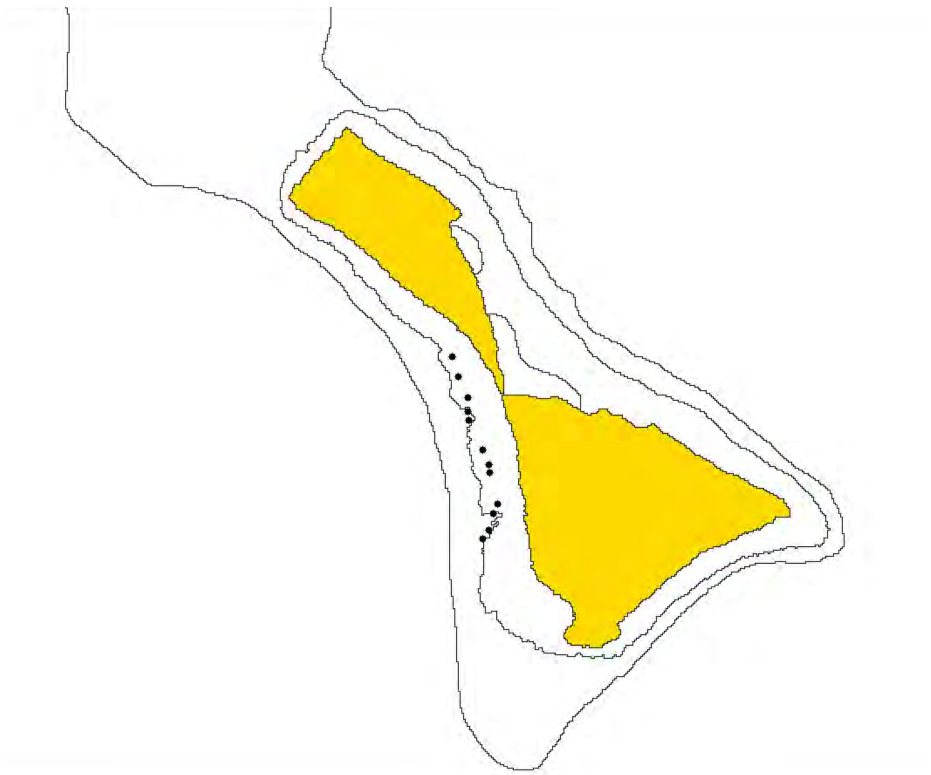

Figure 4.23: Fine-scale reef-benthos transect survey stations in Kuria.
Black circles: reef-benthos transect stations (RBt).

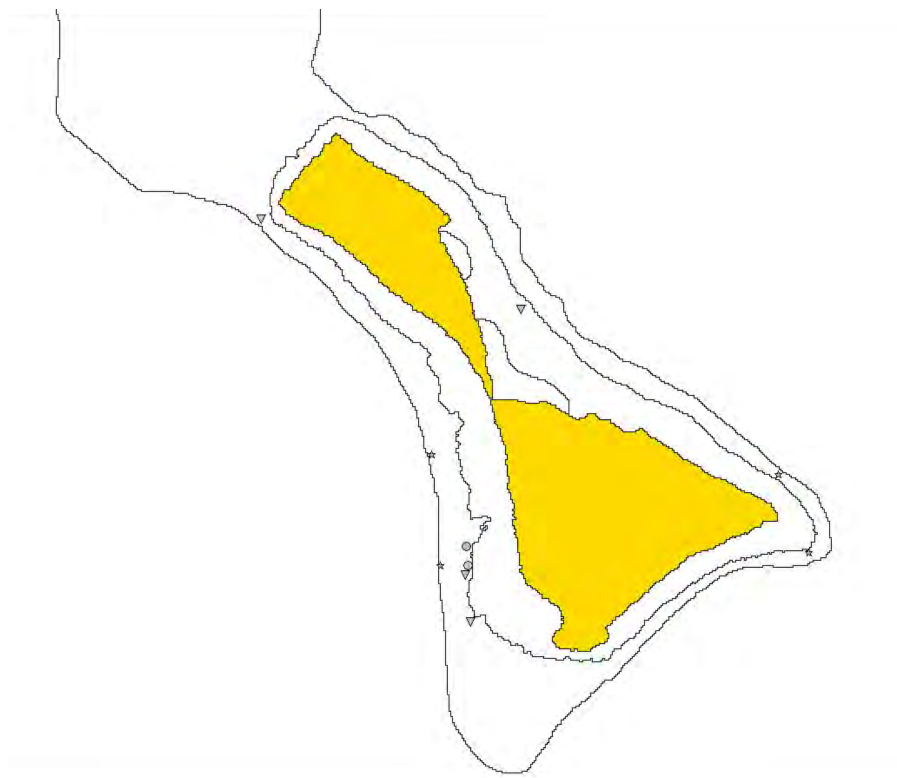

Figure 4.24: Fine-scale survey stations for invertebrates in Kuria.
Inverted grey triangles: reef-front search stations (RFs);
grey stars: sea cucumber day search stations (Ds).

Twenty-three species or species groupings (groups of species within a genus) were recorded in the Kuria invertebrate surveys: 2 bivalves, 8 gastropods, 9 sea cucumbers, 2 urchins and 1 lobster (Appendix 4.3.1). Information on key families and species is detailed below.

4.4.1 Giant clams: Kuria

Broad-scale sampling provided an overview of giant clam distribution around Kuria Island. Reef habitat that is suitable for giant clams was relatively limited compared to other PROCFish sites in Kiribati. Such reef habitat was found within areas of the pseudo lagoon (11 km^2), although most of the available reef was very shallow (depth <2 m). Outside the lagoon, approximately 10.8 km^2 of exposed reef slope and shoal habitat was present (Lineal distance around Kuria was 28.6 km.).

There was no deep-water lagoon reef; most suitable protected lagoon reef habitat for giant clams was restricted to submerged reef flats in the west and south of Kuria. Outside the 'barrier' reef, reef habitat was mainly steep-sloped, only shoaling at its northerly and southerly points or forming offshore bommies in the lee (west) of the island. The elongate clam *Tridacna maxima* was the only live clam recorded in survey (found in 9 broad-scale stations and 39 transects, see Figure 4.25).

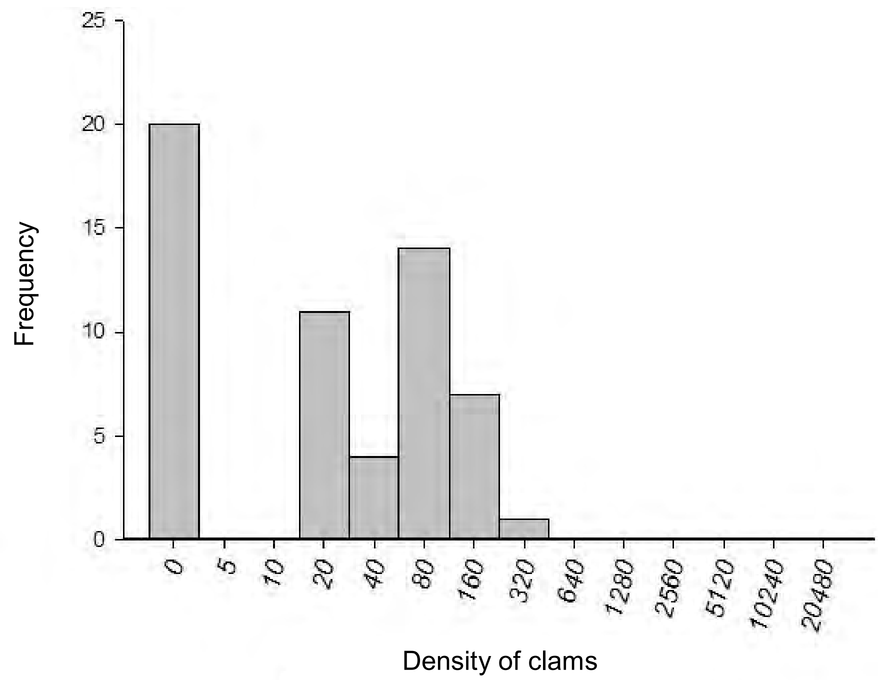

Figure 4.25: Frequency plot of density per 300 m transect measures (per ha) for *Tridacna maxima* clam at Kuria, based on all broad-scale assessment stations.
Density = numbers/ha, recorded on a geometric progression with common ratio 2, i.e. each interval is double the value of the previous.

Finer-scale surveys targeting clam habitat for a closer inspection were conducted using reef-benthos assessments (RBt; see Figure 4.23.). *T. maxima* was well distributed in this area (found in 83% of reef-benthos stations), but not abundant (only in 19 of 72 transects; see Figure 4.26.).

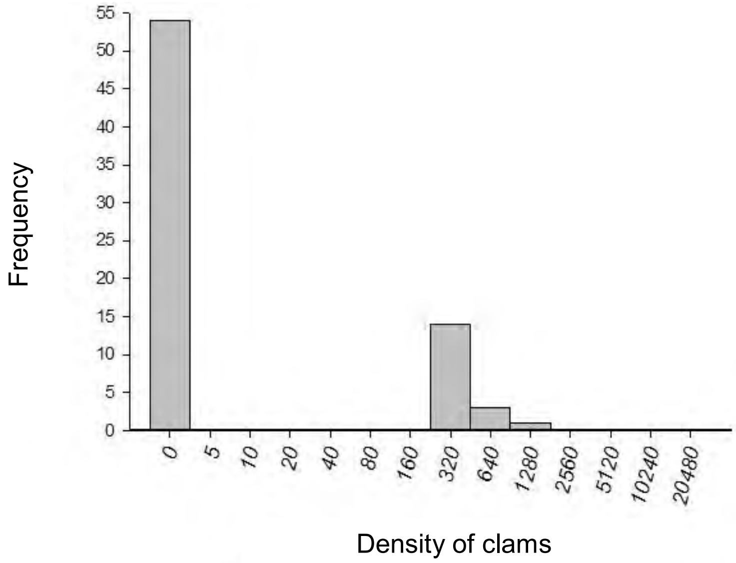

Figure 4.26: Frequency plot of density per 40 m transect measures (per ha) for *Tridacna maxima* clam at Kuria, based on all fine-scale reef-benthos transect assessment stations.
Density = numbers/ha, recorded on a geometric progression with common ratio 2, i.e. each interval is double the value of the previous.

T. maxima found in these reef-benthos stations had a mean density of 86.8 per ha ±23.8. *T. squamosa*, a species that is normally found at lower density than *T. maxima*, and which naturally occurs in Kiribati, was not found. This species can often be found at refuge in deeper water, but was absent from all survey records in Kuria (See above and Appendices 4.3.2 to 4.3.6.).

T. maxima from reef-benthos stations had an average length of 12.7 cm ±1.4. When clams from other assessments were included in the calculation (from all assessments), the mean length increased a little to 13.4 cm ±0.4). As can be seen from the length frequency graphs (Figure 4.27), there were relatively few clams above 20 cm in length (asymptotic length L∞ is 30 cm), but recruitment of small *T. maxima* can still be seen.

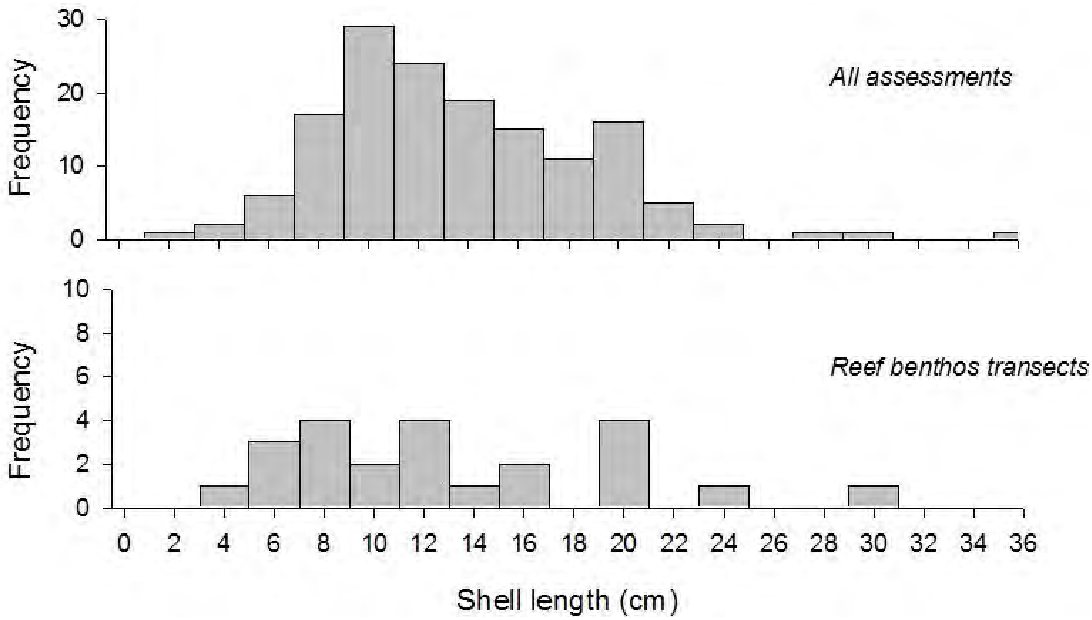

Figure 4.27: Size frequency histograms of giant clam shell length (cm) for Kuria.

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

Kuria is moderate to small in size, with an outer perimeter of approximately 28.6 km. The reefs around Kuria Island, especially in the south and west, have some of the elements required for commercial topshell, *Trochus niloticus*. There is exposed reef and submerged shoal habitat for adult shells, and linked back-reef boulder habitat for juvenile settlement and growth. However, the exposed reef is subject to large swells and the complexity of the bottom is not always suitable for cryptic gastropods that like to hide in complex reef.

Kiribati is outside the natural distribution of trochus and, unlike in Abemama and Abaiang, no trochus have been introduced following the rearing of juveniles in Tarawa from trochus originating in Fiji. Another influencing factor is the fact that, in general, the numbers of grazing gastropods was not high in survey. No green topshell, *Tectus pyramis* (of low commercial value), a species closely related to trochus, with similar distribution and life-history characteristics, was recorded.

The blacklip pearl oyster, *Pinctada margaritifera*, a normally cryptic and sparsely distributed pearl oyster species, was not recorded during the survey and is considered commercially extinct[10].

4.4.3 Infaunal species and groups: Kuria

The soft benthos found within the pseudo lagoon was sandy, without seagrass or muddy areas that characteristically hold concentrations of in-ground resources (shell 'beds'). No shell beds of *Anadara holoserica* or other species were located in soft benthos at Kuria, and therefore no fine-scale assessments or infaunal stations (quadrat surveys) were made for this type of resource.

However, a creel survey was conducted with *Sipunculus* sp. fishers. The *ipo* or *Sipunculus* sp. 'worm' (which is not an Annelid, but belongs to a separate Phylum of unsegmented, protostomate marine 'worms') is a popular food source in Kuria, and fishing is conducted at areas where *ipo* are aggregated. In this case, the fished area was in shallow water (0.5 m deep), about 200 m west of the causeway between Kuria and Oneaka (a strip approximately 20 m long and 5 m wide). The benthos was pure, fine, white sand and *ipo* were taken from their burrows at a rate of approximately one every two minutes (They can be fished faster if there is less wind, allowing better visibility.). To fish these *ipo*, fishers search for the twin holes that indicate a Sipunculidae is present, and then stab in a sharpened piece of coconut frond midrib at a specific angle to the hole. The *ipo* is dug out by hand and then held in the teeth while the thumb and forefinger run down its length to expel the sand from its viscera. *Ipo* are eaten both raw and smoke-dried, but can cause allergic reactions in some people. The two fishers on this occasion collected more than 45 *ipo*, with a mean live length and 'stripped' weight of 37.0 cm ± 2.4 and 18.1 g ±1.0.

[10] 'Commercially extinct' refers to 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.

4.4.4 Other gastropods and bivalves: Kuria

A single Seba's spider conch, *Lambis truncata* (the larger of the two common spider conchs), and two rugose spider conchs, *Lambis chiragra*, were noted in broad-scale and reef-benthos stations. *Strombus luhuanus* was present, but no high-density patches were located (Appendices 4.3.2 to 4.3.6). *Turbo* spp., which are commonly collected along exposed reef fronts in the Pacific, were not recorded during the survey. Other species targeted by fishers (e.g. *Cassis*, *Cerithium*, *Conus*, *Thais* and *Vasum*) were recorded during independent surveys. Data on these and other bivalves found in broad-scale and fine-scale benthos surveys are also in Appendices 4.3.2 to 4.3.6.

No creel survey was conducted for shell collection at Kuria Island.

4.4.5 Lobsters: Kuria

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, two adult lobsters were recorded during broad-scale surveys and three adult lobsters were recorded on one reef-benthos station at the edge of the western lagoon. Lastly, the night assessments (Ns) for sea cucumbers could only be completed in reefs at the edge of the lagoon (on the seaward side, west of Kuria), as the lagoon reef was very shallow and exposed and therefore unsuitable for blackfish, *Actinopyga miliaris*, and related sea cucumber species. We took this opportunity to record lobsters and, in the hour of searching, six adult lobsters were recorded. During the survey at Kuria, no burrows of the banded prawn killer, *Lysiosquillina* sp. (sand lobster) were recorded.

4.4.6 Sea cucumbers[11]: Kuria

Kuria island is a relatively small, low-lying island (15.4 km^2) without rivers, and with only a shallow, exposed pseudo-lagoon, which was not very suitable for commercial sea cucumbers (which are deposit feeders that eat organic matter in the upper few mm of bottom substrates). The lagoon contained a restricted area of shallow-water reef (<11 km^2), much of which was sandy rubble in water <2 m deep. Reef margins and mixed hard- and soft-benthos habitat in sheltered areas were not common, except for a small area in the lee (west) of the island. Generally, most reefs were subject to a high degree of wave action on exposed reef fronts, apart from shoals off the north and south points of the island, and patch bommies on sand in the west. In the east, the exposed reef slopes fell off quickly into deep water.

During the survey in Kuria, a group of commercial divers brought in by an affiliate of the main bêche-de-mer agent in Tarawa was collecting sea cucumbers by night and setting nets for sharks, which were cleared and moved during the day. They had obtained a licence to fish from the Kuria Island Council. Despite the limited habitat and active fishing, nine species of sea cucumbers were recorded during in-water assessments (Table 4.10).

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 4.10, Appendix 4.3.2 to 4.3.5; see also Methods). Sea cucumber day searches were also conducted on SCUBA (at 25–35 m depth) to obtain a preliminary

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

assessment of deep-water stocks, such as the high-value white teatfish (*Holothuria fuscogilva*), prickly redfish (*Thelenota ananas*) and the lower-value amberfish (*T. anax*). In deep-water assessments (average depth 27 m), *H. fuscogilva*, *T. ananas* and *T. anax* were recorded, although mean density for these three species was low to medium.

Other species associated with reef, such as the medium-value leopardfish (*Bohadschia argus*) and high-value black teatfish (*H. nobilis*) were rare. *B. argus* were found in <5% of broad-scale transects; <10% of RBt, while *H. nobilis* was not recorded in broad-scale surveys, but found at <10% of RBt. The medium/high-value greenfish (*Stichopus chloronotus*) was absent. The exposed, oceanic nature of the site suited surf redfish, *Actinopyga mauritiana*, which were relatively common across Kuria, but always at low density.

More protected areas of reef and soft benthos were not common on Kuria and elephant trunkfish, *Holothuria fuscopunctata*, and blackfish, *Actinopyga miliaris*, were only recorded in deeper water in the lee of the island (again not common and at low density). Lollyfish (*H. atra*) were present within the lagoon at low density.

4.4.7 Other echinoderms: Kuria

No edible slate urchins *Heterocentrotus mammillatus* or collector urchins *Tripneustes gratilla* were found at Kuria. *Echinometra mathaei* was found at low density, whereas *E. diadema* was recorded at high density during night searches at the lee of the lagoon (mean density of 791.1 per ha ±35.6 at two stations).

No blue starfish, *Linckia laevigata*, or coralivore (coral eating) starfish, such as the cushion star, *Culcita novaeguineae*, and crown-of-thorns starfish, *Acanthaster planci*, were recorded during assessments in Kuria (Appendices 4.3.2 to 4.3.6).

Table 4.10: Sea cucumber species records for Kuria

Species	Common name	Commercial value [5]	B-S transects n = 57			Reef-benthos stations n = 12			Other stations RFs = 4			Other stations Ds = 4; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga mauritiana	Surf redfish	M/H	0.3	16.7	2	6.9	83.3	8	4.9	9.8	50	13.3	26.7	50 Ns
Actinopyga miliaris	Blackfish	M/H										0.6	2.4	24 Ds
Bohadschia argus	Leopardfish	M	0.6	16.7	4	3.5	41.7	8						
Bohadschia graeffei	Flowerfish	L												
Bohadschia vitiensis	Brown sandfish	L												
Holothuria atra	Lollyfish	L	0.3	16.7	2									
Holothuria edulis	Pinkfish	L												
Holothuria fuscogilva [4]	White teatfish	H										4.2	16.7	25 Ds
Holothuria fuscopunctata	Elephant trunkfish	M										1.2	4.8	25 Ds
Holothuria nobilis [4]	Black teatfish	H				3.5	41.7	8						
Stichopus chloronotus	Greenfish	H/M												
Thelenota ananas	Prickly redfish	H										3.6	4.8	75 Ds
Thelenota anax	Amberfish	M										1.2	2.4	50 Ds

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

4.4.8 Discussion and conclusions: invertebrate resources in Kuria

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.

- Clams were not common at Kuria but, noting the shallowness of the pseudo-lagoon and the exposure and limited size of the site, the density of giant clams represents a moderate abundance of clams. At this density and size-class distribution, giant clams are affected by fishing, but are still spawning and recruiting to local reefs, which means they are only moderately impacted by fishing pressure. The largely unsuitable lagoon and open reef environment makes recruitment from these broadcast spawners clams more difficult at Kuria, thereby making an already fragile stock more susceptible to overfishing.

- Reefs at Kuria would support a population of commercial topshell, *Trochus niloticus*, but conditions are somewhat limited due to the small size of the island and the exposure of most of the reef areas. In addition to this, data collected on other grazing species tend to suggest that the oceanic influence on the reefs makes them less suited to supporting these species.

- The blacklip pearl oyster, *Pinctada margaritifera*, a normally cryptic and sparsely distributed pearl oyster species, was not recorded during the survey and is considered commercially extinct[12].

- Sea cucumber stocks on Kuria are depleted. The limited habitat and low densities recorded on Kuria suggest that a mix of limited environment and fishing pressure have negatively impacted populations. This preliminary survey suggests that occurrence and density are too low for commercial collection at this time. Noting the sub-optimal conditions found on this low-lying island, the fact that agents would pay a commercial team of divers to target this small island is an indication of high fishing pressure for sea cucumbers within the Central Gilbert group as a whole.

4.5 Overall recommendations for Kuria

- Appropriate monitoring and management measures need to be developed and implemented for finfish resources at Kuria, with an initial focus on parrotfish resources, which are low.

- Any expansion of fishing pressure on finfish resources should be accompanied by appropriate monitoring and management.

- The current activities of fishing deep-water habitats by commercial fishers should be maintained and properly monitored to safeguard the shallower, outer-reef fish population.

- Considering the high quality of habitat in Kuria, marine protected areas (MPAs) should be considered as a primary management tool.

- Management measures should be introduced for sea cucumbers to allow this species to recover from previous fishing pressure.

[12] 'Commercially extinct' refers to 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.

5. PROFILE AND RESULTS FOR KIRITIMATI

5.1 Site characteristics

Kiritimati Island is located in the Line Islands, just north of the equator and some 2560 km to the east of Tarawa (Figure 5.1). It is the largest island in Kiribati (388 km^2) and the largest purely coralline island in the world. The major portion of the island, in the northwest, encloses a large lagoon studded with coral patches, which is exposed to easterly winds and currents. The interior of the land area contains more than 100 lakes and ponds, some of which are several kilometres in diameter. Many of the lakes and ponds are used for the culture of milkfish.

A variety of artisanal fishing methods are widely practised on the island, especially trolling, gillnetting, spearfishing, shallow-water handlining and the collection of lobsters. Fishing craft in use include a variety of skiffs generally powered by outboard motors, a few sailing outrigger canoes and a good many single-man paddling outrigger canoes. A sports fishery has developed on Kiritimati Island, with enthusiasts travelling to the island to fish for bonefish and other species using flyfishing gear.

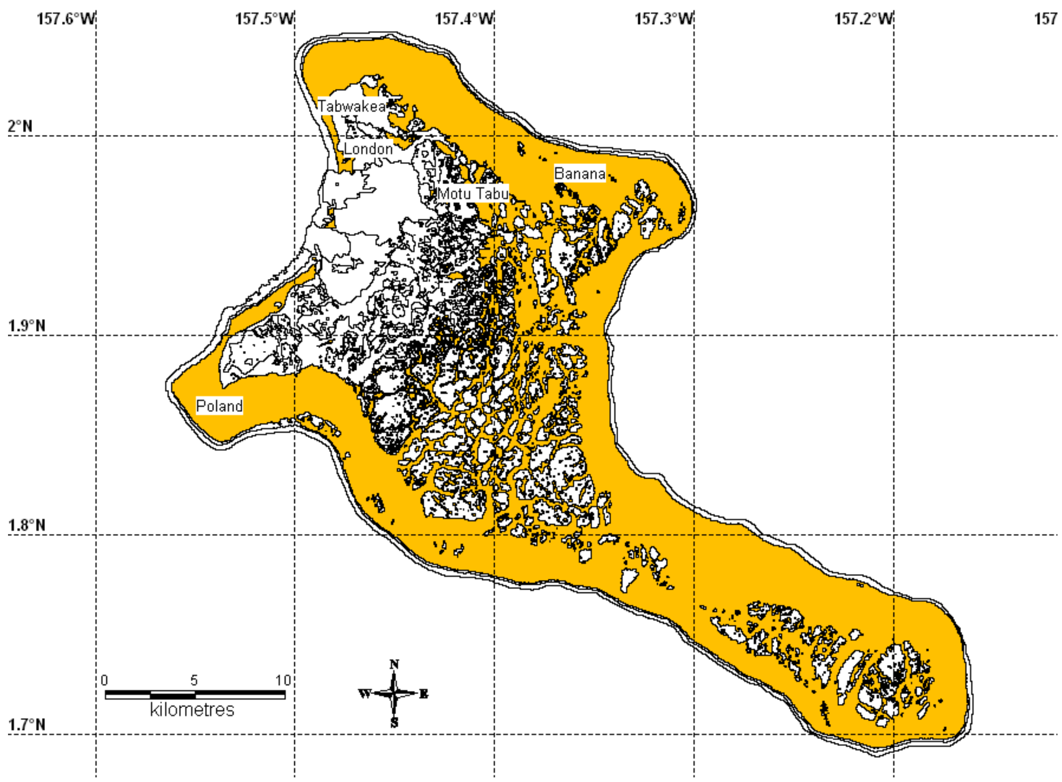

Figure 5.1: Map of Kiritimati.

5.2 Socioeconomic surveys: Kiritimati

Socioeconomic fieldwork was carried out on the island of Kiritimati on 9–17 August 2004. The survey focused mainly on Tabakea, the second largest of the four villages on the island. The other three villages are London, the largest; Banana, located close to the international airport; and Poland, the most isolated and smallest community. In total 25 households were interviewed including 181 people. Thus, the survey covered 12% of the island's total households (209 households) and total population (1513 people).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. Individual interviews were conducted with a total of 21 finfish fishers and 13 invertebrate fishers. Females on Kiritimati do not fish at all. All male fishers interviewed belonged to one of the 25 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing.

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

Our survey results suggest an average of 1.3 fishers per household. If we extrapolate our survey data to the total number of households on Kiritimati, we arrive at a total of 268 fishers (all males). Of these fishers, 193 fish only for finfish and the remaining 75 fish for both finfish and for invertebrates.

Our survey suggests that, on average, 32% of all households own a boat. Most households (60%) own a motorised boat; fewer (40%) have a paddling canoe.

Both fisheries and agriculture are equally important, each providing first income to 36% of all households. However, fisheries provide more households (32%) with a secondary income. Salaries are also important, providing first income to 28% of all households. By comparison, the role of 'other' income sources, such as small businesses or handicrafts is marginal (Figure 5.2).

On average, only 16% of all households surveyed receive remittances. Although this percentage is small, the average annual amount received is high compared to other communities surveyed in Kiribati. However, due to the outstanding, high living costs on Kiritimati, which amount on average to USD 2718 /household/year, the average annual remittances only cover about 57% of expenditure.

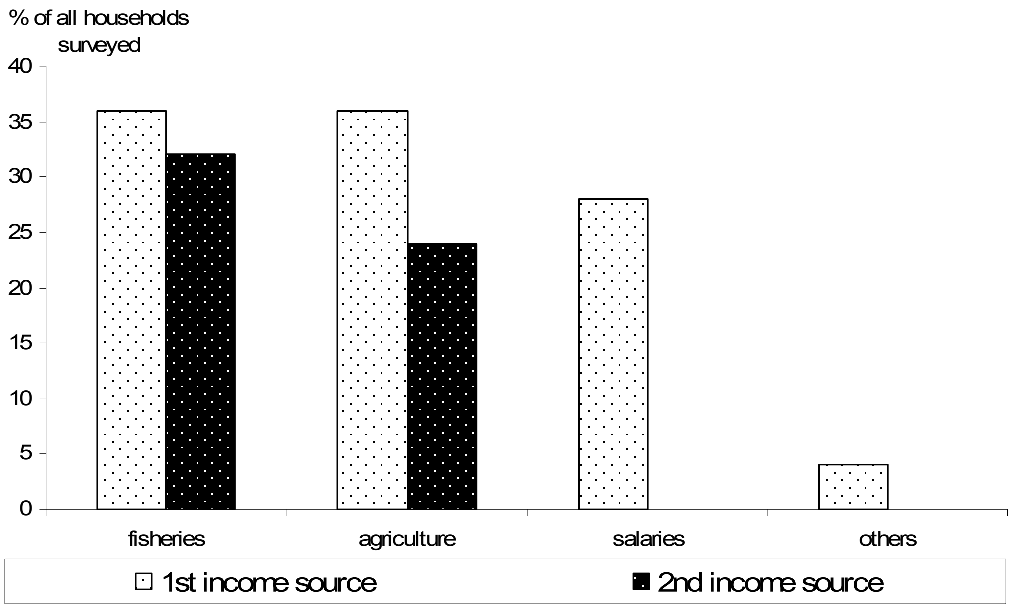

Figure 5.2: Ranked sources of income (%) in Kiritimati.
Total number of households = 25 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.

Average fresh fish consumption (110.2 kg/person/year) is high compared to the regional average (Figure 5.3). However, Gillett (2002) suggests a much higher national consumption figure than calculated on the basis of our survey data. Compared to all other PROCFish/C sites in Kiribati, the Kiritimati figure ranks third and is slightly above the average calculated across all four Kiribati sites.

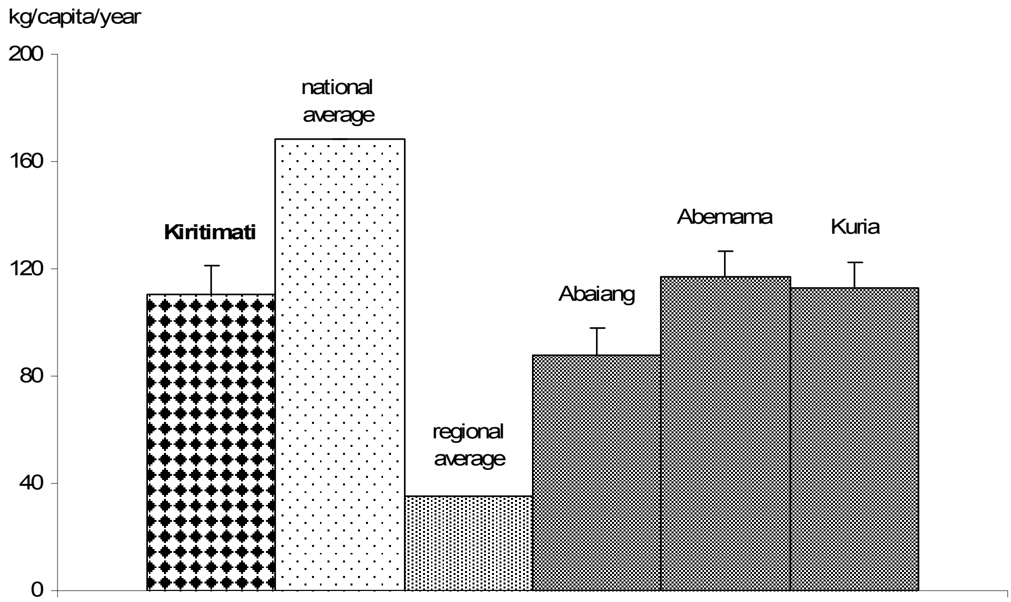

Figure 5.3: Per capita consumption (kg/year) of fresh fish in Kiritimati (n = 25) compared to national and regional averages (FAO 2008) and the other three PROCFish/C sites in Kiribati. Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

Fresh fish is consumed almost 5 days per week. Invertebrates and canned fish are less popular. On average, invertebrates are eaten 0.7 times/week; canned fish 0.9 times/week. Only 6–7 kg of invertebrates (meat only) are eaten per person per year, which is, however, the largest amount of invertebrates eaten in any of the PROCFish/C sites in Kiribati (Figure 5.4). The low frequency of canned fish consumption on Kiritimati corresponds well to the regional average, as does the amount (5.8 kg/year).

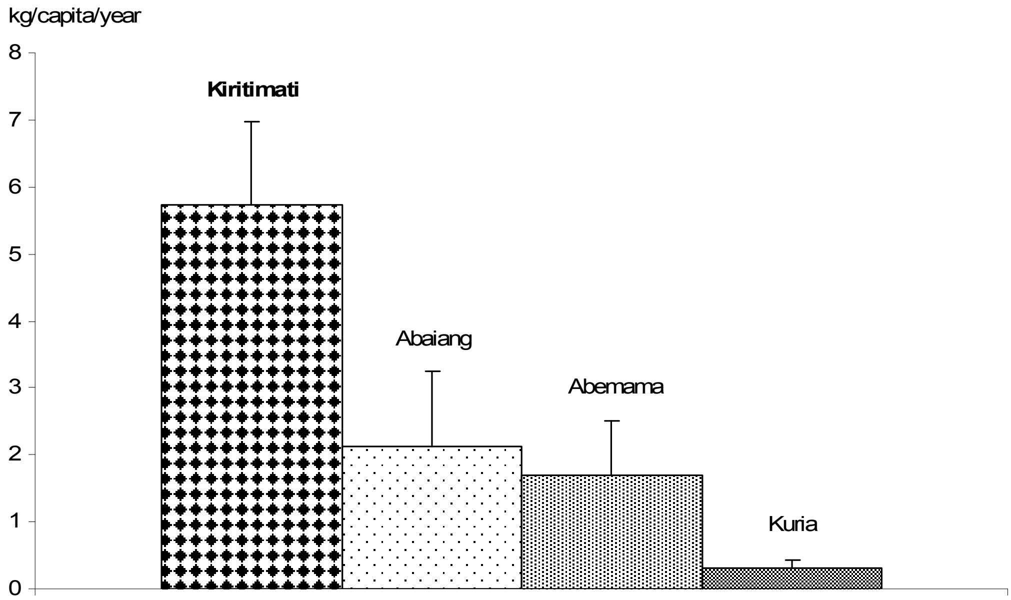

Figure 5.4: Per capita consumption (kg/year) of invertebrates (meat only) in Kiritimati (n = 25) compared to the other three PROCFish/C sites in Kiribati.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

By comparison with all PROCFish/C sites in Kiribati (Table 5.1) the average household has a considerably lower number of fishers, but is more dependent on fisheries if the percentages of households that depend on fisheries for first income and second income are combined. Household expenditures are far above average (i.e. 83% higher) but remittances received are about average. Fresh fish consumption is slightly above the average, and canned fish consumption meets the average of all sites investigated. Fewer than average households eat invertebrates, but more households catch or are given the fresh fish or invertebrates that they consume. On the other hand, fewer households purchase fresh fish than the average across all PROCFish/C sites in Kiribati.

Table 5.1: Fishery demography, income and seafood consumption patterns in Kiritimati

Survey coverage	Kiritimati (n = 25 HH)	Average across sites (n = 98 HH)
Demography		
HH involved in reef fisheries (%)	92	95
Number of fishers per HH	1.3 (±0.2)	1.9 (±0.1)
Male finfish fishers per HH (%)	71.9	41.9
Female finfish fishers per HH (%)	0.0	0.5
Male invertebrate fishers per HH (%)	0.0	6.3
Female invertebrate fishers per HH (%)	0.0	28.3
Male finfish and invertebrate fishers per HH (%)	28.1	20.9
Female finfish and invertebrate fishers per HH (%)	0.0	2.1
Income		
HH with fisheries as 1st income (%)	36	34
HH with fisheries as 2nd income (%)	32	25
HH with agriculture as 1st income (%)	36	43
HH with agriculture as 2nd income (%)	24	27
HH with salary as 1st income (%)	28	18
HH with salary as 2nd income (%)	0	2
HH with other sources as 1st income (%)	4	5
HH with other sources as 2nd income (%)	0	5
Expenditure (USD/year/HH)	2718 (±353)	1485 (±128)
Remittance (USD/year/HH) (1)	1539 (±450)	1486 (±187)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	110.2 (±9.6)	106.9 (±5.3)
Frequency fresh fish consumed (times/week)	4.9 (±0.3)	5.6 (±0.2)
Quantity fresh invertebrate consumed (kg/capita/year)	5.74 (±1.23)	2.57 (±5.32)
Frequency fresh invertebrate consumed (times/week)	0.7 (±0.1)	0.7 (±0.1)
Quantity canned fish consumed (kg/capita/year)	5.8 (±1.4)	5.7 (±0.9)
Frequency canned fish consumed (times/week)	0.9 (±0.2)	0.7 (±0.1)
HH eat fresh fish (%)	100	100
HH eat invertebrates (%)	68	75
HH eat canned fish (%)	84	66
HH eat fresh fish they catch (%)	92	89
HH eat fresh fish they buy (%)	16	36
HH eat fresh fish they are given (%)	44	32
HH eat fresh invertebrates they catch (%)	60	68
HH eat fresh invertebrates they buy (%)	4	4
HH eat fresh invertebrates they are given (%)	12	5

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

5.2.2 Fishing strategies and gear: Kiritimati

Degree of specialisation in fishing

Only males go fishing in Kiritimati. With the decline of the bêche-de-mer fishery and the lack of air transport to supply the Hawaiian market with fresh lobster tails, no fishers reported exclusively targeting invertebrates. However, our survey results showed that 28% of all male fishers target both finfish and invertebrates (Figure 5.5).

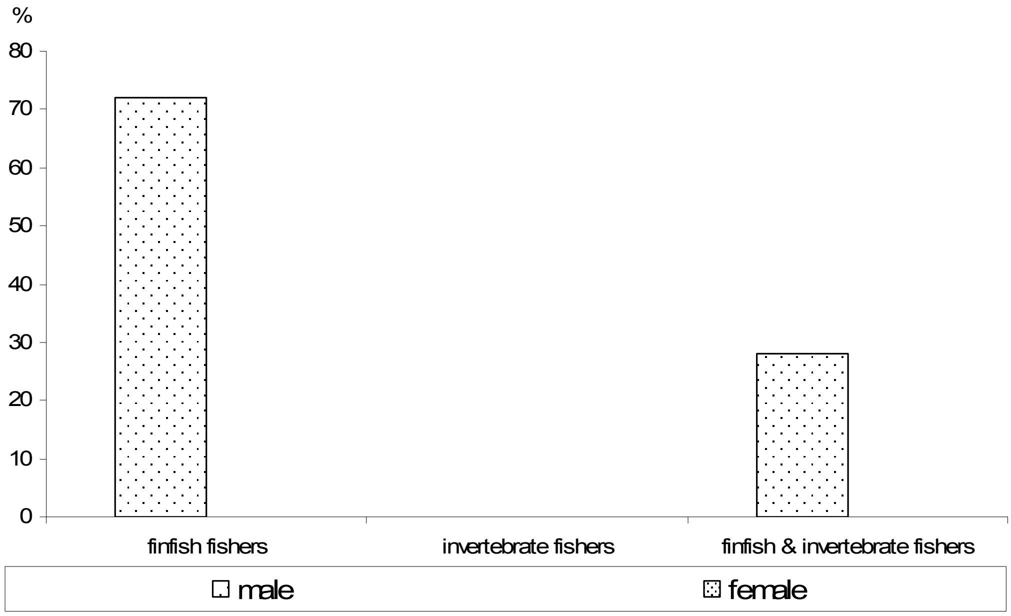

Figure 5.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Kiritimati.
All fishers = 100%.

Targeted stocks/habitats

Invertebrate fishers target only the accessible reef, while finfish fishers may choose between the lagoon and the outer reef (Table 5.2). Information provided by respondents on the areas fished for the different target species is shown in Figure 5.6.

Table 12: Proportion (%) of male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Kiritimati

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Lagoon	76.2	0.0
	Outer reef	33.3	0.0
Invertebrates	Bêche-de-mer	7.7	0.0
	Lobster	7.7	0.0
	Other	100.0	0.0

Finfish fisher interviews, males: n = 21; females: n = 0. Invertebrate fisher interviews, males: n = 13; females, n = 0.

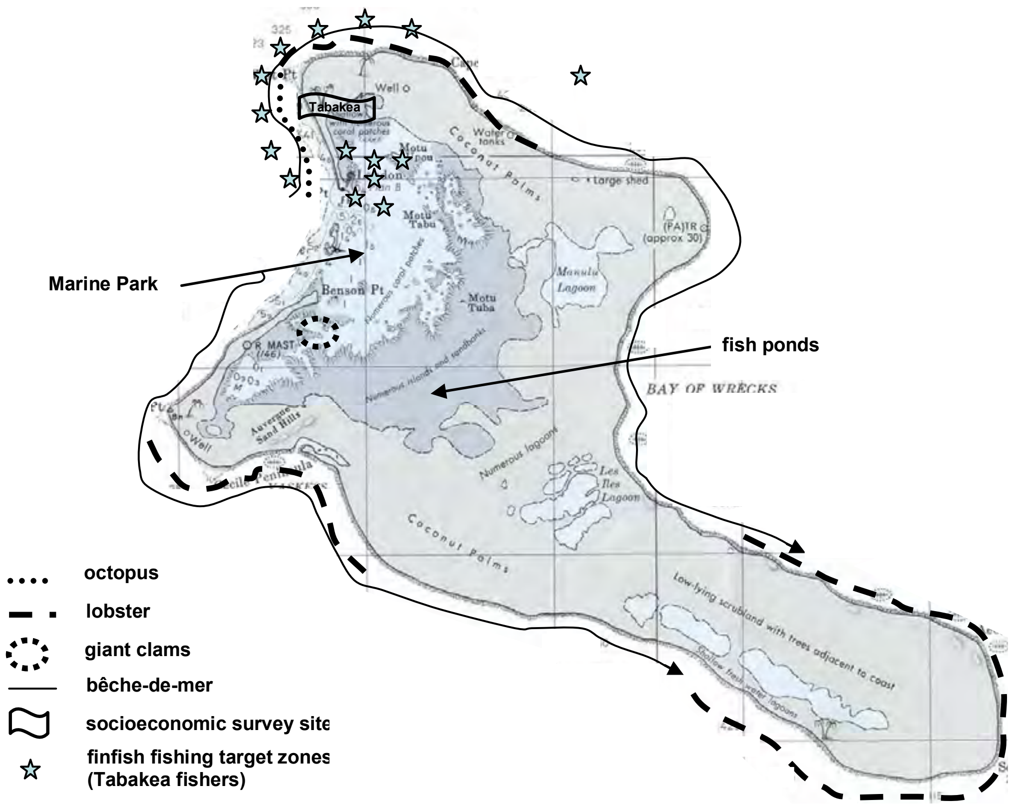

Figure 5.6: Socioeconomic survey sites and habitats fished as indicated by respondents in Kiritimati.

Fishing patterns and strategies

The combined information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip is used to estimate the fishing pressure imposed by people from Kiritimati on their fishing grounds.

Our survey sample suggests that most fishers target the shallow lagoon area (76%) rather than the outer reef (33%) (Table 5.2).

On Kiritimati more than two-thirds of all invertebrate fishers free-dive for 'other' invertebrates, i.e. giant clams and octopus (87%), while only 7% of fishers participate in specialised fisheries, such as bêche-de-mer and lobster diving (Figure 5.7).

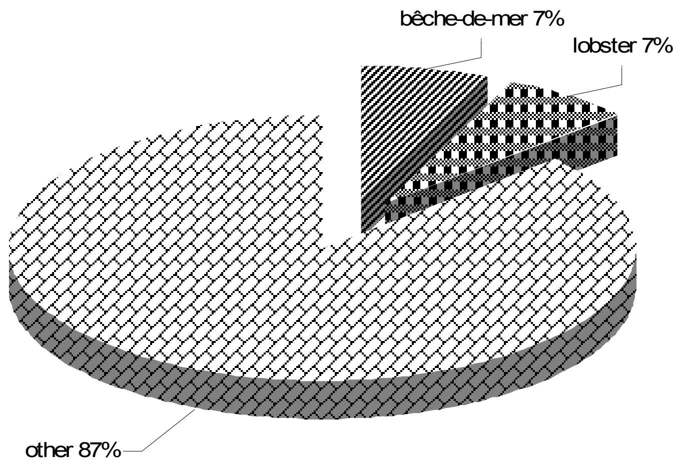

Figure 5.7: Proportion (%) of fishers targeting the three primary invertebrate habitats found in Kiritimati.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; 'other' refers to the octopus and giant clam fisheries.

Gear

Figure 5.8 shows that various gear is used to catch finfish on Kiritimati. Gillnets are almost the only method used in the shallow lagoon, while fishing techniques used at the outer reef are varied and include handlines, fishing rods, spear diving and the combined use of gillnets and handlines.

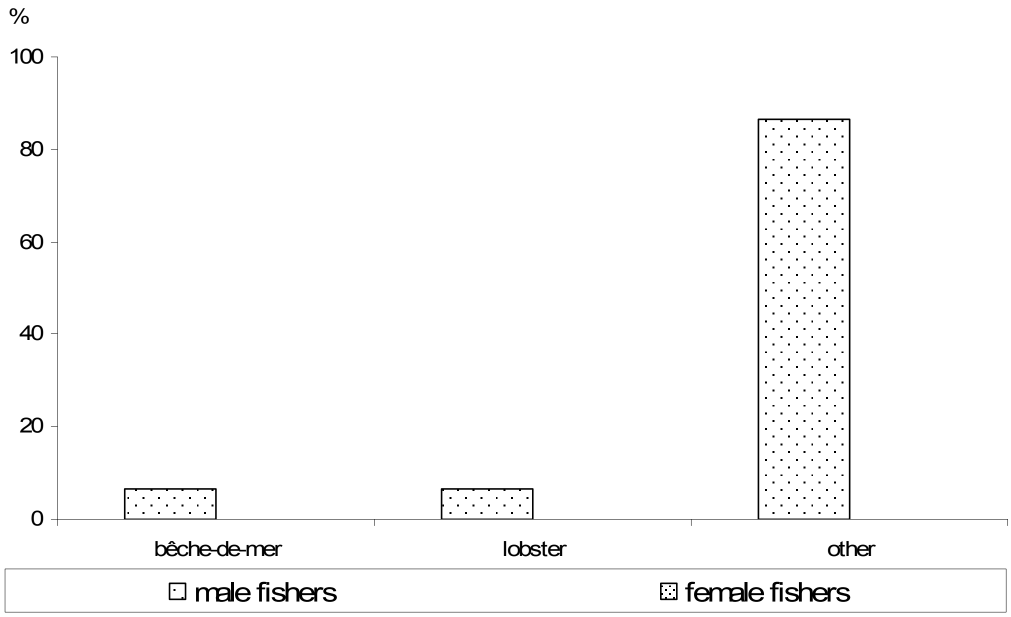

Figure 5.8: Proportion (%) of male and female fishers targeting various invertebrate habitats in Kiritimati.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 13 for males, n = 0 for females; 'other' refers to the octopus and giant clam fisheries.

Invertebrates on Kiritimati are exclusively collected by free-diving, with mask, snorkel and fins only. Fishing for giant clams and octopus is done during the day; only 15% of all fishers use boats to do this. Lobster fishers do not use boats; however, all bêche-de-mer fishers rely on motorised boats to reach their fishing grounds, and dive during the day and also at night. Diving for lobsters is exclusively performed at night using a torch.

Frequency and duration of fishing trips

As shown in Table 5.3, trips to the lagoon and the outer reef are similar in terms of frequency and average duration. Fishers go slightly more often to the lagoon (2.7 times/week) than to the outer reef (2.2 times/week). However, the average fishing trip to either location takes about four hours. Bêche-de-mer fishers are the most active invertebrate fishers, making two trips per week on average. Fishers diving for lobsters and for octopus and giant clams (‘others’) go out about once a week. On average, the longest trips are those targeting lobsters (5 hours/trip) and the shortest are those collecting octopus and giant clams (3.4 hours/trip). The fact that bêche-de-mer diving (and, to some extent, the lobster fishery) is only done for commercial purposes, may explain why these fishing trips are longer than the ‘other’ dive fishery, which mainly serves subsistence needs.

Table 5.3: Average frequency and duration of fishing trips reported by fishers in Kiritimati (males only)

Resource	Fishery / Habitat	Trip frequency (trips/week)	Trip duration (hours/trip)
Finfish	Lagoon	2.72 (±0.19)	4.13 (±0.50)
	Outer reef	2.19 (±0.27)	4.21 (±0.67)
Invertebrates	Bêche-de-mer	2.00 (n/a)	4.50 (n/a)
	Lobster	1.00 (n/a)	5.00 (n/a)
	Other	1.28 (±0.32)	3.35 (±0.40)

Figures in brackets denote standard error; n/a = standard error not calculated; ‘other’ refers to the octopus and giant clam fisheries; only males fish in Kiritimati.
Finfish fisher interviews, males: n = 21; females: n = 0. Invertebrate fisher interviews, males: n = 13; females: n = 0.

5.2.3 Catch composition and volume – finfish: Kiritimati

About 20 vernacular names were frequently reported for catches from the lagoon. However, *Chanos chanos* (*awatai*, *baneawa*) accounts for 65% of the reported lagoon catches and *Albula vulpes* (*ikai*) another 17%. In addition, reef fish, such as *Epinephelus merra* (*kuau*), *Mugil* spp. (*aua*) and *Acanthurus xanthopterus* (*mako*), contribute with 7, 5 and 3% respectively. At the outer reef, *Lutjanus* spp. (*takabe*, 21%), *Myripristis kuntee* (*mon*, 16%), *A. xanthopterus* (*mako*, 16%) and *E. merra* (*kuau*, 12%) dominate the reported catches. Further details on the annual catch composition of reported catches in Kiritimati are provided in Appendix 2.4.1.

Our survey sample of finfish fishers interviewed represents about 8% of the projected total number of finfish fishers on Kiritimati. Although this sample size is assumed to be representative of the community of Tabakea, as it includes both commercial and subsistence fishers, we refrain from extrapolating our data as it may overestimate the fishing impact on Kiritimati fishing grounds. Thus, we focus on the reported and collected survey data, which are summarised in Figure 5.9.

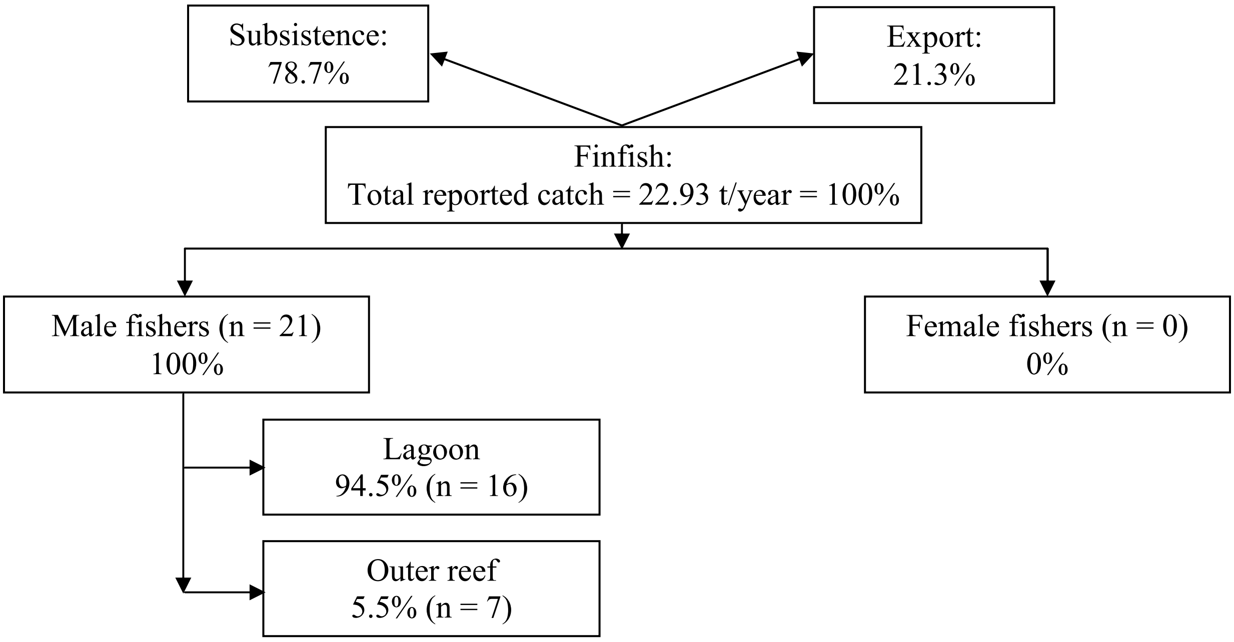

Figure 5.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Kiritimati.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

Figure 5.9 shows that most of the reported annual catch is sourced from the lagoon and only 5.5% is harvested from the outer reef. Most of the catch is used for local consumption; only 21% of catches are exported to Tarawa.

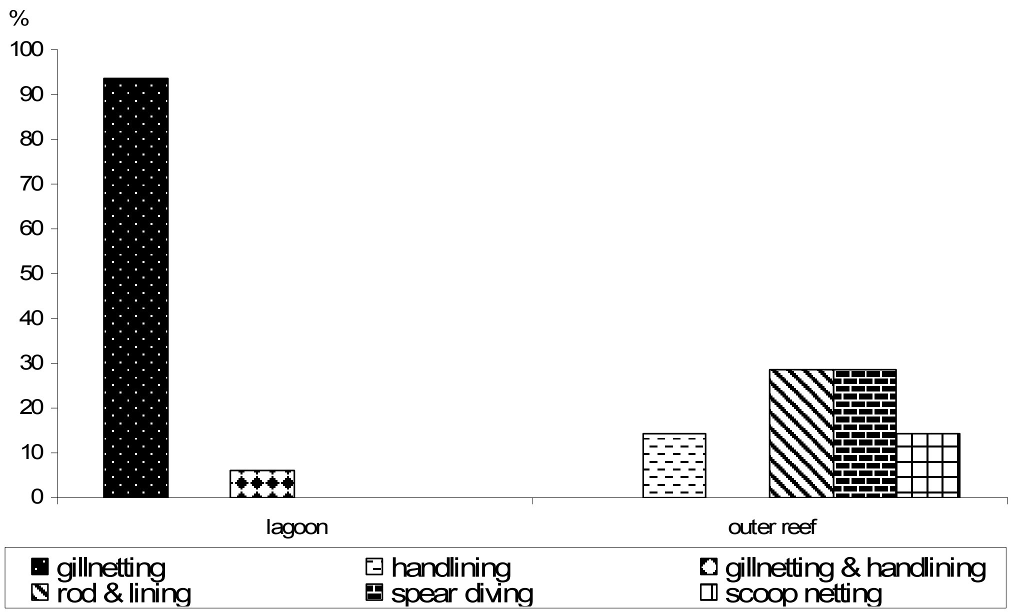

Figure 5.10: Fishing methods commonly used in different habitat types in Kiritimati.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Figure 5.11 shows that the average annual catch from the lagoon is much higher than the catch from the outer reef. In addition, fishing in the lagoon is much more efficient (~3.3 kg/hour of fishing trip) than fishing the outer reef (<1 kg/hour of fishing trip) (Figure 5.11).

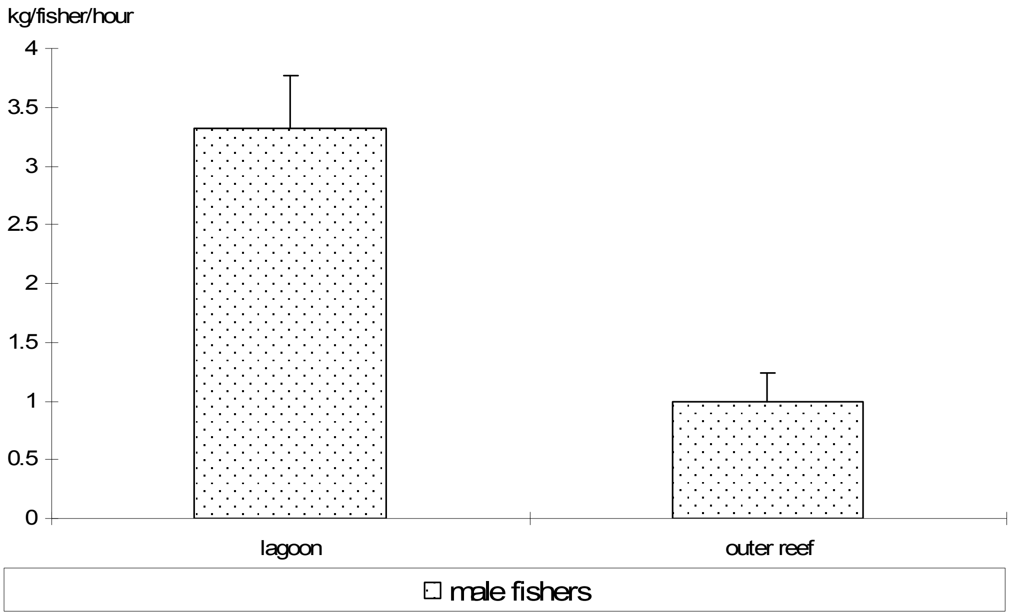

Figure 5.11: Catch per unit effort (kg/hour of total fishing trip) for male fishers by habitat in Kiritimati.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Most catches are used for subsistence purposes (Figure 5.12), especially catches from the outer reef, and about half of all catches from the lagoon (including catches that are shared among the community on a non-monetary basis). About half of the fishing trips to the lagoon and only 25% of fishing trips to the outer-reef serve commercial purposes.

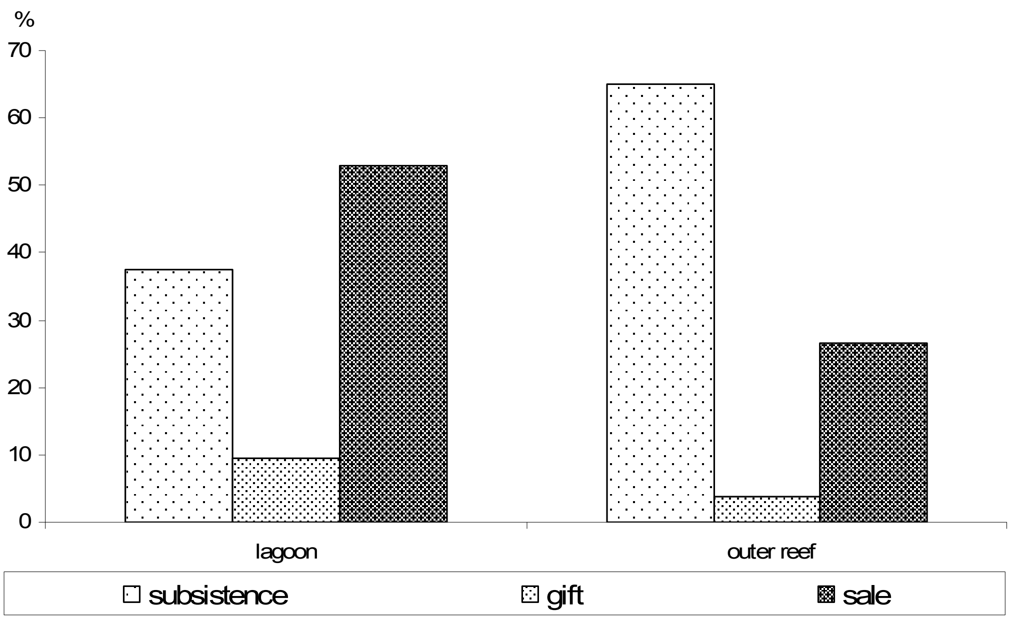

Figure 5.12: The use of finish catches for subsistence, gift and sale, by habitat in Kiritimati.
Proportions are expressed in % of the total number of trips per habitat.

Data on reported average finfish sizes by family and habitat (Figure 5.13) show that most fish in lagoon catches are ~30 cm in length (FL). Average fish sizes in catches from the outer reef are smaller, except for Acanthuridae.

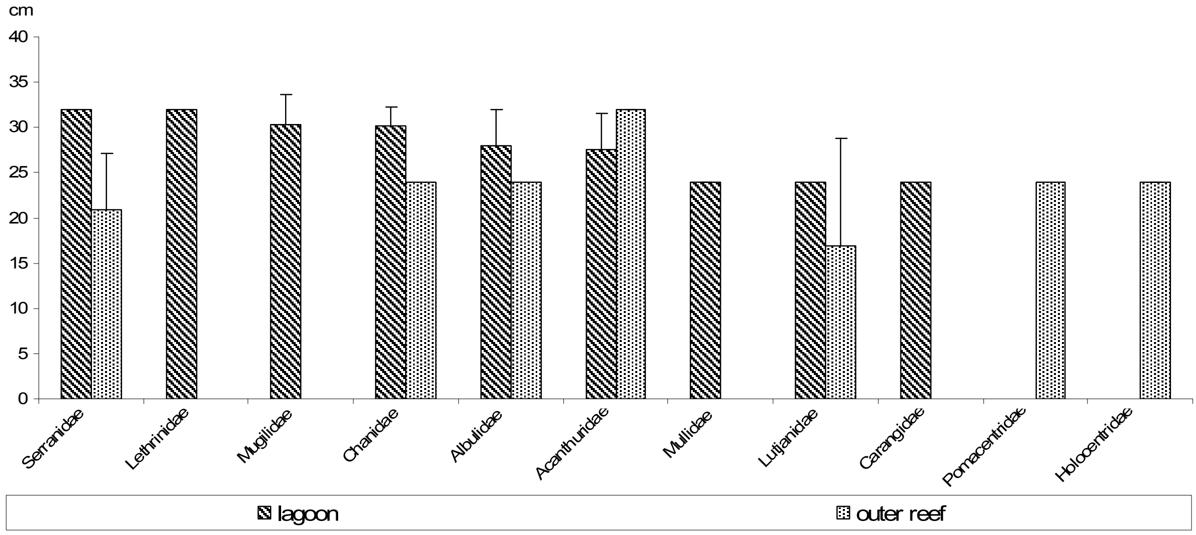

Figure 5.13: Average sizes (cm fork length) of fish caught by family and habitat in Kiritimati. Bars represent standard error (+SE).

Some parameters selected to assess the current fishing pressure on Christmas's living reef resources are shown in Table 5.4. The data suggest a considerable difference in fish size between the two habitats targeted. Because of the size of the lagoon, fisher density remains low. However, lagoon fishers have the highest annual catch rates. The much smaller outer reef is under lower pressure because fewer fishers target this area and annual catch per fisher is low. If the catches are calculated per total reef and total available fishing ground areas, the impact imposed by the Kiritimati community is low. While fisher density is low, population density is low to moderate. Subsistence needs, if equally distributed over the two habitat areas result in a low fishing pressure, i.e. 0.6–3 t/km² of total reef and total fishing ground.

Table 5.4: Parameters used in assessing fishing pressure on finfish resources in Kiritimati

Parameters	Habitat			
	Lagoon	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	240.86	44.23	56.46	297.32
Density of fishers (number of fishers/km^2 fishing ground) [(1)]	1	2	5	1
Population density (people/km^2) [(2)]			27	5
Average annual finfish catch (kg/fisher/year) [(3)]	1345.29 (±185.54)	209.56 (±50.22)		
Total fishing pressure of subsistence catches (t/km^2)			3	0.6

Figures in brackets denote standard error; [(1)] total number of fishers (= 268) is extrapolated from household surveys; [(2)] total population = 1513; total subsistence demand = 169.76 t/year; [(3)] catch figures are based on recorded data from survey respondents only. Sheltered coastal reef area is 12.23 km² and is included in total reef area, although not targeted by fishers.

5.2.4 Catch composition and volume – invertebrates: Kiritimati

Calculations of the recorded annual catch rates per species groups are shown in Figure 5.14. The graph shows that the major impact by wet weight is on giant clams (*Tridacna maxima*, *T. squamosa*). By comparison, impact on octopus, several bêche-de-mer species (*Thelenota ananas*, *Stichopus chloronotus*) and lobsters (*Panulirus penicillatus*, *P. versicolor*) is low. Impact on *Bohadschia argus* (leopardfish), *B. vitiensis* (*kanimim*) and *Actinopyga mauritania* (surf redfish) appears to be negligible.

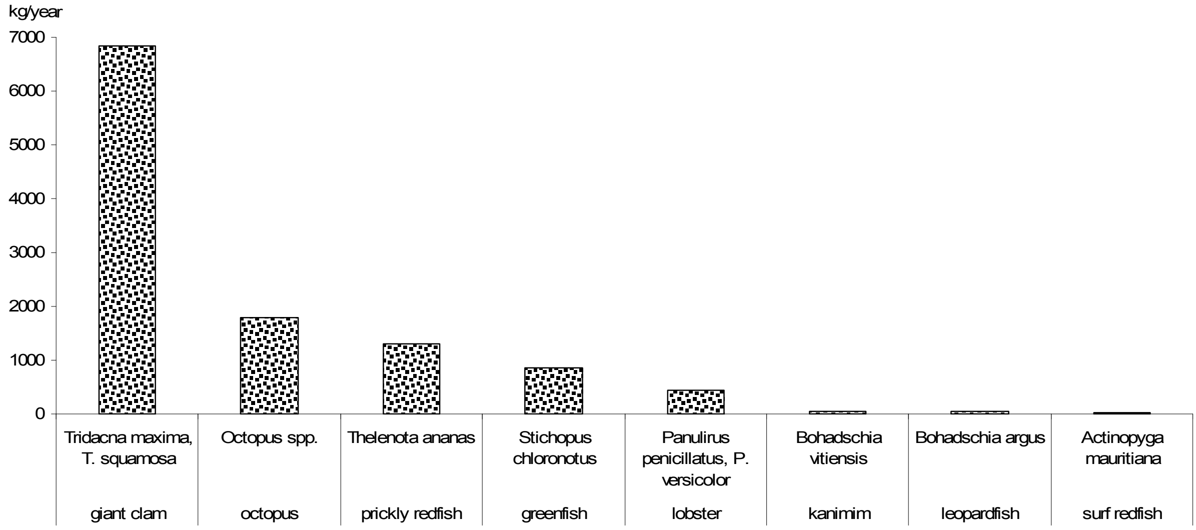

Figure 5.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Kiritimati.

Figure 5.15 highlights the limited diversity of the invertebrate fisheries on Kiritimati, i.e. only one or two vernacular names were reported for each fishery, except the bêche-de-mer fishery, which currently targets five major species.

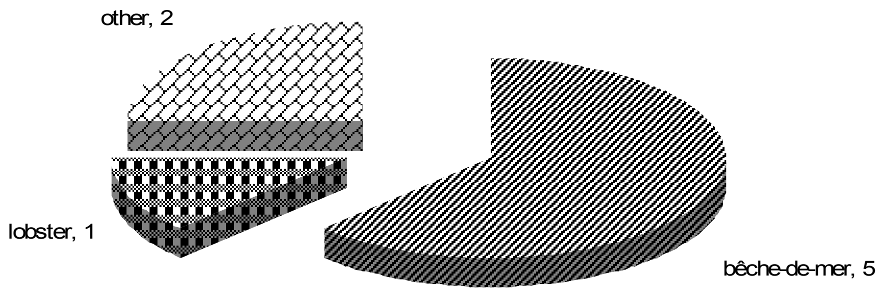

Figure 5.15: Number of vernacular names recorded for each invertebrate fishery in Kiritimati.
'Other' refers to the octopus and giant clam fisheries.

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

Figure 5.16 shows the annual reported catch rates per fisher and highlights the outstanding catch rates for bêche-de-mer fishers. By comparison, average annual catches from the lobster or 'other' fishery (giant clams and octopus) are 70–80% less.

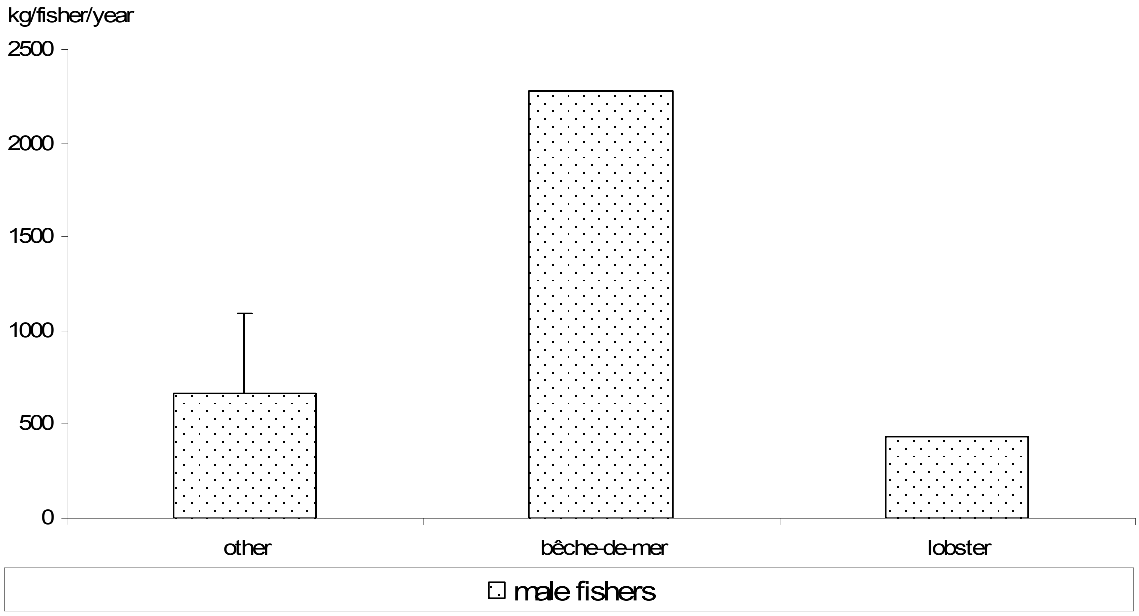

Figure 5.16: Average annual invertebrate catch (kg wet weight/year) by fisher and fishery in Kiritimati.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat (n = 13 for males). Bars represent standard error (+SE). 'Other' refers to the octopus and giant clam fisheries.

The high proportion of invertebrates collected for commercial purposes (Figure 5.17) applies only to bêche-de-mer species. Lobsters, giant clams and octopus are caught for subsistence and occasionally for local sale. Lobsters are no longer commercially fished for sale to Hawaii because air transport is no longer available. However, lobsters may be sold to the few restaurants and hotels on the island and among community members. Octopus and giant clams are only sold within the community.

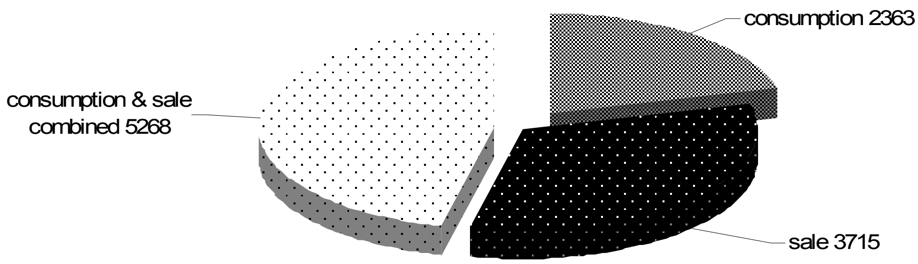

Figure 5.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Kiritimati.

The total annual catch volume expressed in wet weight based on the recorded data from all respondents interviewed amounts to 11.35 t/year (= 100%) (Figure 5.18, Table 5.5). The data show that the 'other' fishery (giant clams, octopus) accounts for the highest proportion of the total reported annual catch (76%). Comparison between catch rates and total annual catch (wet weight) shows the difference between the commercially oriented bêche-de-mer fishery and the mainly subsistence-oriented 'other' dive fishery. The bêche-de-mer fishery is characterised by high catch rates but less total annual catch due to the limited number of fishers involved, while the opposite is true for the 'other' dive fishery (giant clams and octopus).

Table 5.5: Total annual recorded invertebrate catch by species and purpose of use (kg wet weight/year) in Kiritimati

Scientific name	Vernacular name	Total catch (biomass wet weight kg/year)			
		Consumption	Consumption & sale	Sale	Sum
Tridacna maxima, Tridacna squamosa	giant clam	521	1433	4886	6840
Stichopus chloronotus	greenfish	0	869	0	869
Bohadschia vitiensis	*kanimim*	0	40	0	40
Panulirus penicillatus, Panulirus versicolor	lobster	434	0	0	434
Octopus spp.	octopus	1408	0	382	1790
Thelenota ananas	prickly redfish	0	1303	0	1303
Actinopyga mauritiana	surf redfish	0	30	0	30
Bohadschia argus	leopardfish	0	40	0	40
Total:		**2363**	**3715**	**5268**	**11,347**

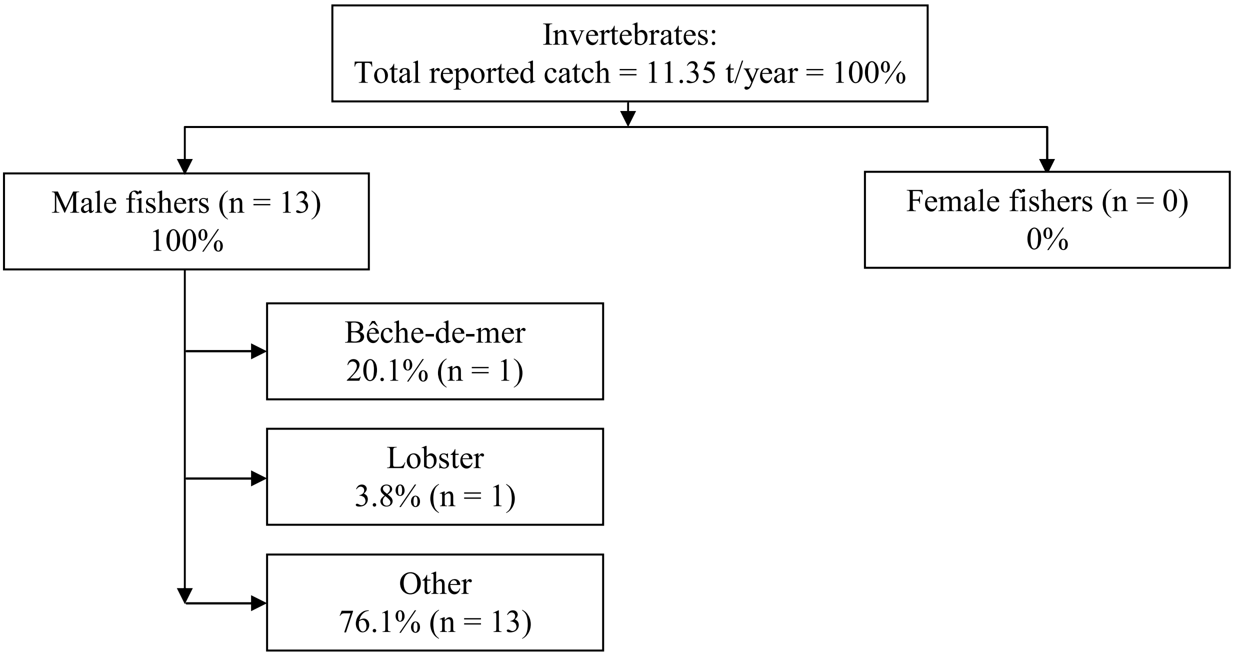

Figure 5.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Kiritimati.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey; 'Other' refers to the octopus and giant clam fisheries.

The parameters presented in Table 5.6 show large fishing grounds, in particular for lobsters, giant clams and octopus. Unfortunately, the total fishing ground area potentially available to the bêche-de-mer fishery could not be determined. The parameters presented here, in particular the total number of fishers per fishery, highlight the fact already mentioned that most invertebrate collection targets giant clam and octopus. However, in this context, it is important to note that the reported sizes for giant clams are small (Appendix 2.4.3) with 73% of clams reported to be only 12–16 cm in size, 20% <12 cm and another 6% 14–18 cm. The fisher density for lobster harvesting is extremely low, and also for giant clams and octopus

(~1 fisher/2 km reef length) although this fishery ('other') is targeted by most fishers. These figures support the conclusion that current fishing pressure for all invertebrate fisheries on Kiritimati is low.

Table 5.6: Selected parameters (±SE) used to characterise the current level of fishing pressure of invertebrate fisheries in Kiritimati

Parameters	Fishery		
	Bêche-de-mer	Lobster [3]	Other [3]
Fishing ground area (km^2)	n/a [4]	145.5	145.45
Number of fishers (per fishery) [1]	6	6	75
Density of fishers (number of fishers/km^2 fishing ground)	n/a [4]	0.04	0.52
Average annual invertebrate catch (kg/fisher/year) [2]	2282.17 (n/a)	434.29 (n/a)	663.86 (±425.54)

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; [1] number of fishers extrapolated from household surveys; [2] catch figures are based on recorded data from survey respondents only; [3] linear measure km reef length; [4] fishing grounds are presently not determined.

There are a number of factors reported by respondents during the field survey that are responsible for the decline in fisheries on Kiritimati:

1. Since the increase in government subsidies for copra from AUD 0.40 to 0.60 per kg in 2004, copra production is considered much more lucrative than fisheries.

2. The lack of motorised boat transport to bring fishers to the most promising fishing grounds and the 1–2 week delay in payments to fishers are believed to have negatively impacted the bêche-de-mer fishery. The delay in payment occurs because processed bêche-de-mer has to be shipped from Kiritimati to Tarawa (to the buyer, Marine Protect Kiribati, MPK) before the payment for the catches can be transferred back to Kiritimati. The reduced participation of fishers in the bêche-de-mer fishery on Kiritimati has resulted in a drastic decline of shipments. From September 2000 to December 2002, 80–130 bags (40 kg each) were shipped 1–2 times/month; however, from January 2003 onwards only 4–8 bags were exported 1–2 times/month. While at the beginning of the fishery almost every young fisher was involved, today fewer than 10 divers from Tabakea, 3–4 divers from London, and 2–3 divers from Banana are still involved. However, the sole agent based on Banana believes that high-value species are still abundant at the outer-reef drop-off between Tabakea and London. He also believes that night diving would still yield substantial catches. However, fishers prefer to go out during the day and some do not have transport to get to the harvesting areas at night. He also thought that stocks may be recovering in the lagoon and other protected areas.

3. The lack of air cargo space from Kiritimati to Honolulu has brought the export of fresh lobster tails to an end. The price paid for lobsters shipped to Tarawa by Central Pacific Producer Ltd. (CPP, formerly known as Kiritimati Marine Export Ltd., KMEL), is less attractive.

4. The local prices for dried and salted octopus and fresh giant clam meat are relatively low and serve only to generate occasional and complementary income.

5. CPP operates a longline boat, and buys and sells reef and pelagic fish. The company also operates an ice machine and intends to upgrade cooling facilities to increase its annual turnover and to better meet export standards. While reef fish is exclusively sold to

Tarawa, pelagic fish is exported overseas. Alternative and commercial fisheries also include shark fins, an ongoing seaweed project and aquarium fish.

5.2.5 Discussion and conclusions: socioeconomics in Kiritimati

- The people on Kiritimati are highly dependent on reef fisheries resources as their most important protein and nutrition source. There are very few alternatives as the island has almost no agricultural potential apart from the established coconut plantations. Land crabs may constitute another significant protein source. The number of pigs and chickens is rather limited. As a result, any alternative food supply must be imported at high cost. Thus, it is not surprising that finfish is consumed about 5 times per week and the annual average amount eaten is high.

- Finfish fishing in Kiritimati mainly occurs in the lagoon; only a small proportion of reef fish is sourced from the outer reef. Over two-thirds of the total annual reported catch is consumed locally and only ~21% is exported to Tarawa via the company Central Pacific Producer Ltd (CPP). Gillnetting is the main fishing method used in the lagoon but in the outer reef a variety of methods are used, including handlining and spear diving.

- Revenues are mainly derived from fishery if the percentages of households that depend on fishery for first and second income are combined. However, copra production (agriculture) is equally important as first income source, in particular since the government subsidies for copra have increased. Salaries also provide an alternative income for some households, although other income sources are rare. Very few households receive remittances. As a consequence of the community's high dependency on imports and isolated location, living costs are extremely high.

- Invertebrate fisheries are not diverse and play a much lesser role than finfish fisheries. People eat invertebrates less than once a week. Fishers target basically four species groups: giant clams, octopus, bêche-de-mer and lobsters. Lobsters are sold to the CPP at London or to local restaurants and hotels since the lobster export to Hawaii (Honolulu) has stopped due to the lack of air transport. Bêche-de-mer are now sold to a sole agent based at Banana.

- Traditional gender roles determine that females never engage in any type of fishery. However, they do collect land crabs.

- Overall, fisher density is low. Lagoon fishers have higher annual catch rates than outer-reef fishers. If the subsistence demand of the community for fresh fish is equally distributed between the two habitats, the total fishing pressure is low, regardless of whether calculated for the reef habitat alone, or for the total fishing ground area (including the lagoon).

- The fisher density for invertebrate fisheries is low considering the available and accessible reef area and the total number of fishers engaged. However, this observation excludes the bêche-de-mer fishery, as the area available for harvesting was not determined at the time of the survey. The reported annual catch rate per fisher (wet weight) reflects the commercial character of the bêche-de-mer fishery, as it represents the highest rate. Catch rates for giant clams, octopus and lobster fisheries, which mainly serve subsistence and, to a lesser extent, commercial purposes, were average.

- The low fisher density for giant clams, lobster and octopus fisheries and the reported average annual catch rates do not give any reason to assume that current fishing pressure on invertebrate resources in Kiritimati is detrimental. However, this conclusion may be challenged by the reported average catch sizes for giant clams, which are relatively low (most ranging from 12 to 16 cm only).

- However, there are indications that the island's bêche-de-mer resources are significantly reduced. Although payment and other logistical difficulties may have reduced the level of bêche-de-mer exploitation, it also seems that a considerable decline in the resource makes harvesting less productive and less effective. This argument is supported by the information provided by the remaining sole agent, i.e. a reduction in number of bags shipped (once or twice per month) from 80–130 bags between September 2000 and December 2002, to 4–8 bags from January 2003 onwards.

Based on the observations that the Kiritimati community is highly dependent on fisheries for protein and nutritional purposes as well as for income generation, our data suggest the following conclusions:

- Most of the coastal fisheries target the lagoon area, in particular, its sheltered zone. Lagoon fish, mainly milkfish and bonefish, are targeted by gillnets. Additional impact imposed by the aquarium-fish and shark-fin fisheries may add to the fishing pressure in the lagoon.

- At the time of survey, the Kiribati government, in order to reduce the population in overcrowded Tarawa, was promoting a potential annual influx of >1000 people from the Gilbert group. This could result in an alarming population increase: assuming an average fish consumption of 110.2 kg/person/year, this would increase fishing pressure from local demand by 110.2 t/year, i.e. an annual increase of >50% of the currently calculated total consumption of 208.5 t/year. In addition, the demand for reef fish export to the Gilbert group is likely to increase considering the population dynamics and the need to generate income for the Kiritimati population. Thus, the current fishing pressure is likely to increase considerably.

- Concerning fisheries management, it is assumed that the marine protected areas in the lagoon will help to counteract at least some of the existing and future fishing pressure. Also the fact that people from Banana have limited access to the lagoon, and the high cost and/or lack of motorised boat transport may help to limit any future increase in fishing pressure.

- The octopus and giant clam fishery is mainly subsistence oriented, with limited local commercial sales. At present, fishing pressure on these resources is assumed to be low, but future development may largely depend on the population dynamics, in particular the immigration rate. This also applies, to some extent, to the lobster fishery.

- The bêche-de-mer fishery shows all signs of exhaustion, i.e. a steep drop in the number of fishers, the catches, and the export amounts from the end of 2000 until the beginning of 2003. The fishery, however, is believed to be still lucrative. The problems reported, such as delay in payment, and transport support, may divert attention from the fact that resources are not sufficiently abundant to provide as good an income as the aquarium-fish fishery or copra production.

5.3 Finfish resource surveys: Kiritimati

5.3.1 Finfish assessment results: Kiritimati

Finfish resources and associated habitats were assessed between 15 and 21 September 2004 from 25 transects in the two habitats (13 lagoon intermediate and 12 outer-reef transects; see Figure 5.19 for transect locations and Appendix 3.4.1 for coordinates).

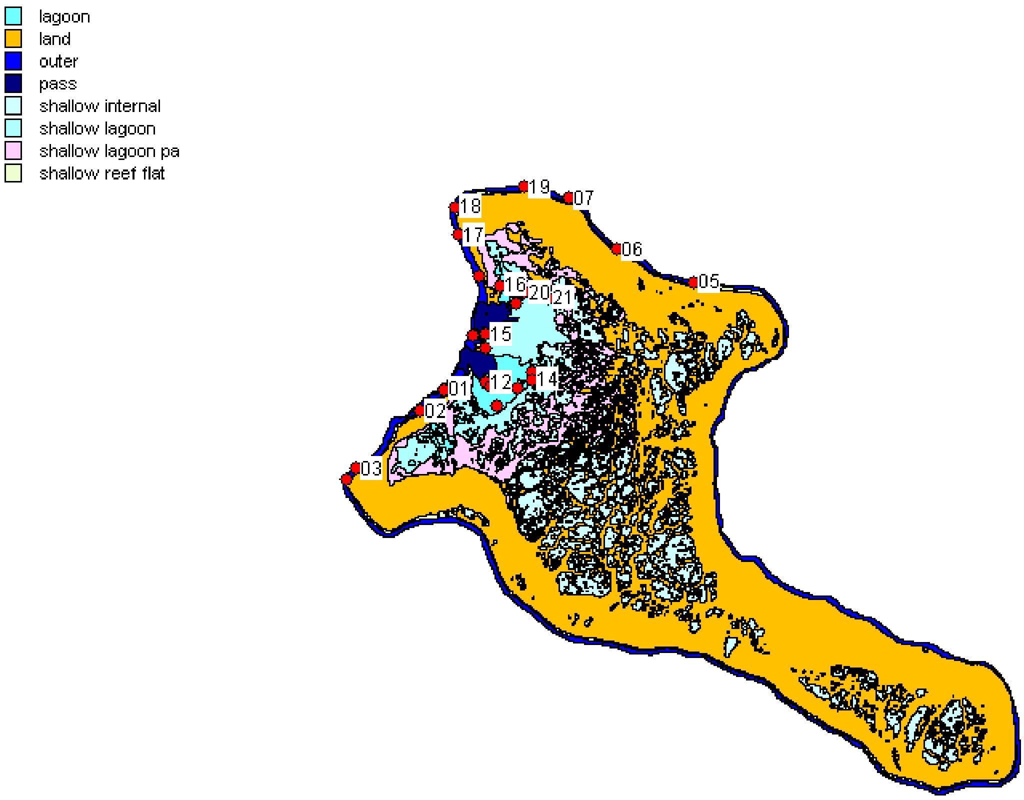

Figure 5.19: Habitat types and transect locations for finfish assessment in Kiritimati.

A total of 17 families, 51 genera, 148 species and 11,001 fish were recorded in the 25 transects (See Appendix 4.4.2 for list of species.). Only data on the 11 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 43 genera, 136 species and 10,462 individuals.

Finfish resources differed greatly between the two reef types found in Kiritimati (Table 5.7). The outer reef contained the highest average density of fish (1.0 fish/m^2), biodiversity (50 species/transect), biomass (437 g/m^2) and mean fish size (24 cm FL). The lagoon reef, on the other hand, has average density of 0.6 fish/m^2, biodiversity of 27 species/transect, biomass of 226 g/m^2 and mean fish size of 23 cm FL. The high biomass observed in the outer reef is largely contributed to by a large school of herbivorous Labridae, *Cheilinus undulatus*, displaying the highest biomass of 43.8 g/m^2 for the outer reef.

Table 5.7: Primary finfish habitat and resource parameters recorded in Kiritimati (average values ±SE)

Parameters	Habitat		
	Intermediate reef [1]	Outer reef [1]	All reefs [2]
Number of transects	13	12	25
Total habitat area (km^2)	16.3	36.8	53.1
Depth (m)	2 (1-11) [3]	8 (3-12) [3]	6 (1-12) [3]
Soft bottom (% cover)	24.5 ±2.5	8.8 ±1.7	14.0
Rubble & boulders (% cover)	14.5 ±2.4	5.9 ±2.0	9.0
Hard bottom (% cover)	42.4 ±3.1	60.7 ±3.4	55.0
Live coral (% cover)	18.4 ±3.4	22.8 ±1.8	21.0
Soft coral (% cover)	0.02 ±0.02	1.7 ±0.6	1.0
Biodiversity (species/transect)	26.9 ±4.1	50 ±3	37±3
Density (fish/m^2)	0.59 ±0.12	1.03 ±0.08	0.9
Biomass (g/m^2)	225.7 ±68.9	436.5 ±37.4	364.7
Size (cm FL) [4]	22.5 ±0.7	23.5 ±0.5	23.0
Size ratio (%)	64 ±2	70 ±2	67.0

[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.

There is much greater cover of soft bottom (24%) in the intermediate-reef substrate in comparison to that of the outer reef (9%). Live corals are more abundant in the outer reef (23%) compared to the intermediate reef (18%, Table 5.7). The predominance of hard-bottom substrate and the good coverage of live coral in the outer reef is clearly reflected in the higher abundance, density and biomass of fish.

Intermediate-reef environment: Kiritimati

The lagoon reef of Kiritimati is largely dominated by three families: one family of herbivorous Acanthuridae and two carnivorous families, Lutjanidae and Balistidae. These families are represented by 10 main species; particularly high abundance and biomass were recorded for *Acanthurus xanthopterus*, *Lutjanus gibbus*, *L. fulvus*, *A. nigricauda*, *A. triostegus*, *Rhinecanthus aculeatus*, *Ctenochaetus marginatus*, *A. blochii*, *C. striatus* and *Odonus niger* (Table 5.8).

Table 5.8: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Kiritimati

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus xanthopterus*	Yellow fin surgeon fish	0.06	57.7
	Acanthurus nigricauda	Epaulette surgeon fish	0.02	18.5
	Acanthurus triostegus	Convict surgeon fish	0.09	13.3
	Ctenochaetus marginatus	Blue-spotted bristletooth	0.01	5.7
	Acanthurus blochii	Ringtail surgeon fish	0.01	5.7
	Ctenochaetus striatus	Striped bristletooth	0.02	3.2
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.07	44.8
	Lutjanus fulvus	Flametail snapper	0.05	23.6
Balistidae	*Rhinecanthus aculeatus*	Blackbar triggerfish	0.03	6.5
	Odonus niger	Red-toothed triggerfish	0.02	3.1

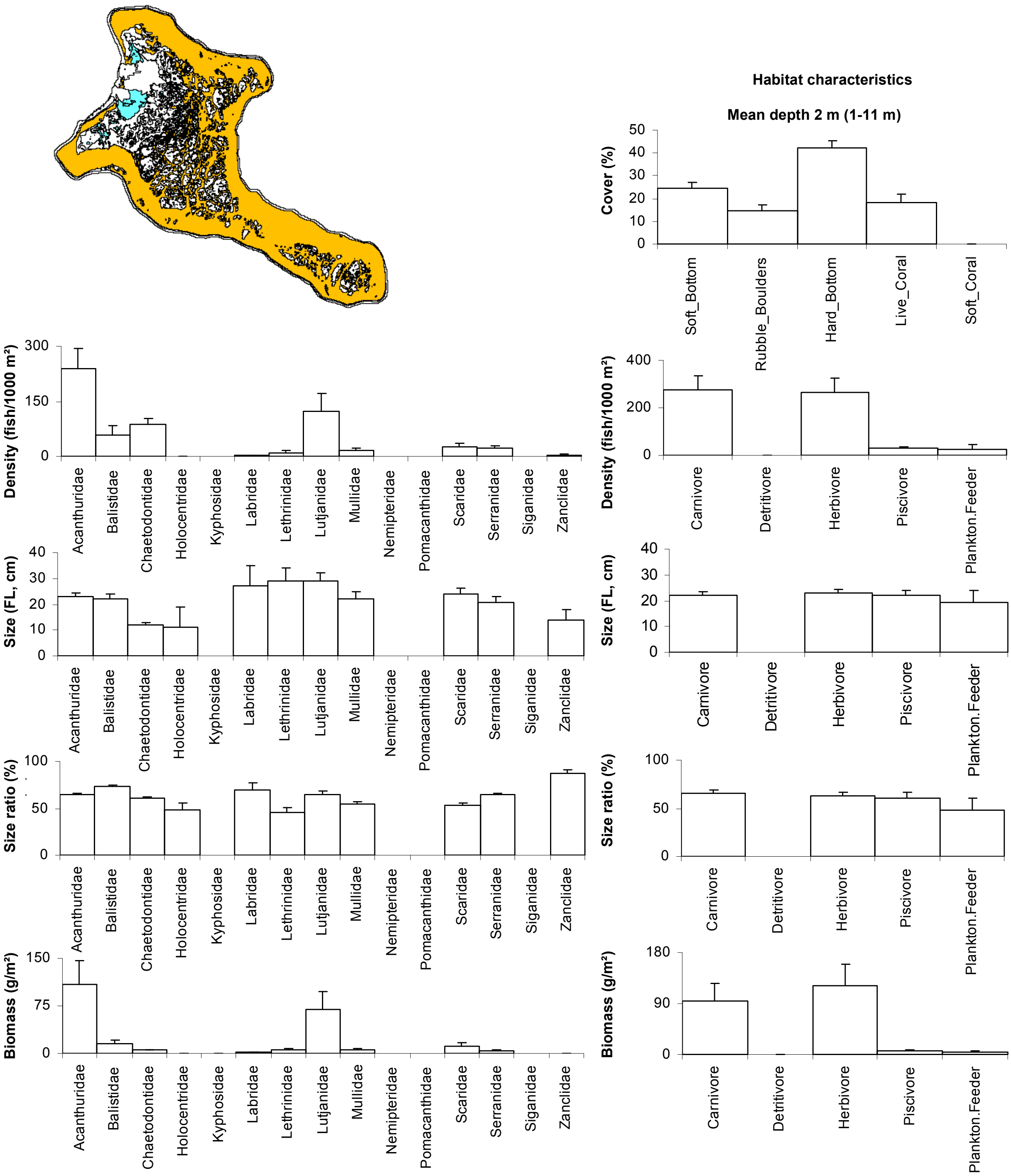

Figure 5.20: Profile of finfish resources in the intermediate-reef environment of Kiritimati.
Bars represent standard error (+SE); FL = fork length.

This reef presents a rather diverse habitat (Table 5.7 and Figure 5.20), with hard bottom predominating; habitat complexity may partly explain the relative complexity of the fish assemblage on this reef. The relatively low live-coral cover (18%), and the high coverage of soft bottom (25%) and rubble and boulders (14%) in comparison to the outer reef are accompanied by notable densities of Lutjanidae.

Finfish resources of the intermediate lagoon reef of Kiritimati show relatively low species diversity and density when compared to the other two islands with this type of habitat (Abaiang and Abemama). However, mean size and size ratio of fish in the intermediate-reef environment on Kiritimati are much higher than at the other two sites (22.5 cm FL and 64% versus 19.4 cm and 53% for Abaiang and 16.0 cm and 40% for Abemama). As a consequence of large average fish size, Kiritimati displays the second-highest biomass after Abemama.

Outer-reef environment: Kiritimati

The outer reef of Kiritimati is largely dominated by four families: two herbivorous families, Acanthuridae and Labridae (high biomass only) and two carnivorous families, Balistidae and Lutjanidae (Figure 5.21). These families are mostly represented by 11 species; particularly high abundance and biomass were recorded for *Cheilinus undulatus*, *Ctenochaetus marginatus*, *Lutjanus gibbus*, *Acanthurus lineatus*, *A. nigricauda*, *A. leucocheilus*, *Ctenochaetus striatus*, *Melichthys niger*, *Acanthurus nigricans*, *L. bohar* and *M. vidua* (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 Kiritimati

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus marginatus*	Blue-spotted bristletooth	0.09	33.5
	Acanthurus lineatus	Lined surgeonfish	0.05	25.5
	Acanthurus nigricauda	Blackstreaked surgeonfish	0.03	21.7
	Acanthurus leucocheilus	Pale-lipped surgeonfish	0.04	20.8
	Ctenochaetus striatus	Striped bristletooth	0.08	16.5
	Acanthurus nigricans	White-cheek surgeonfish	0.07	12.1
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.05	32.5
	Lutjanus bohar	Twospot red snapper	0.02	11.7
Balistidae	*Melichthys vidua*	Pink-tail triggerfish	0.03	10.6
	Melichthys niger	Black triggerfish	0.03	16.1
Labridae	*Cheilinus undulatus*	Humphead wrasse	0.001	43.8

Substrate in the outer reef of Kiritimati is characterised by a dominance of hard bottom (61% cover). Relatively high live-coral cover (23%) is accompanied by the presence of substantial numbers of surgeon and butterflyfish (Figure 5.21). Soft-coral coverage (1.7%) is higher than in the intermediate reef (0.02%); however, rubble, boulders and soft bottom are lower than the intermediate reef (Table 5.7).

Like the resources of the intermediate reef, finfish resources of the outer-reef environment in Kiritimati are similar to those in the outer reefs of the three other survey sites. As the biological parameters show, Kiritimati outer reef has the second-lowest biodiversity (50 species/transect versus 59 for Abemama, 53 for Kuria and 45 for Abaiang), and second-lowest density (1.0 fish/m^2 versus 1.9 in Kuria, 1.8 in Abemama and 0.7 in Abaiang).

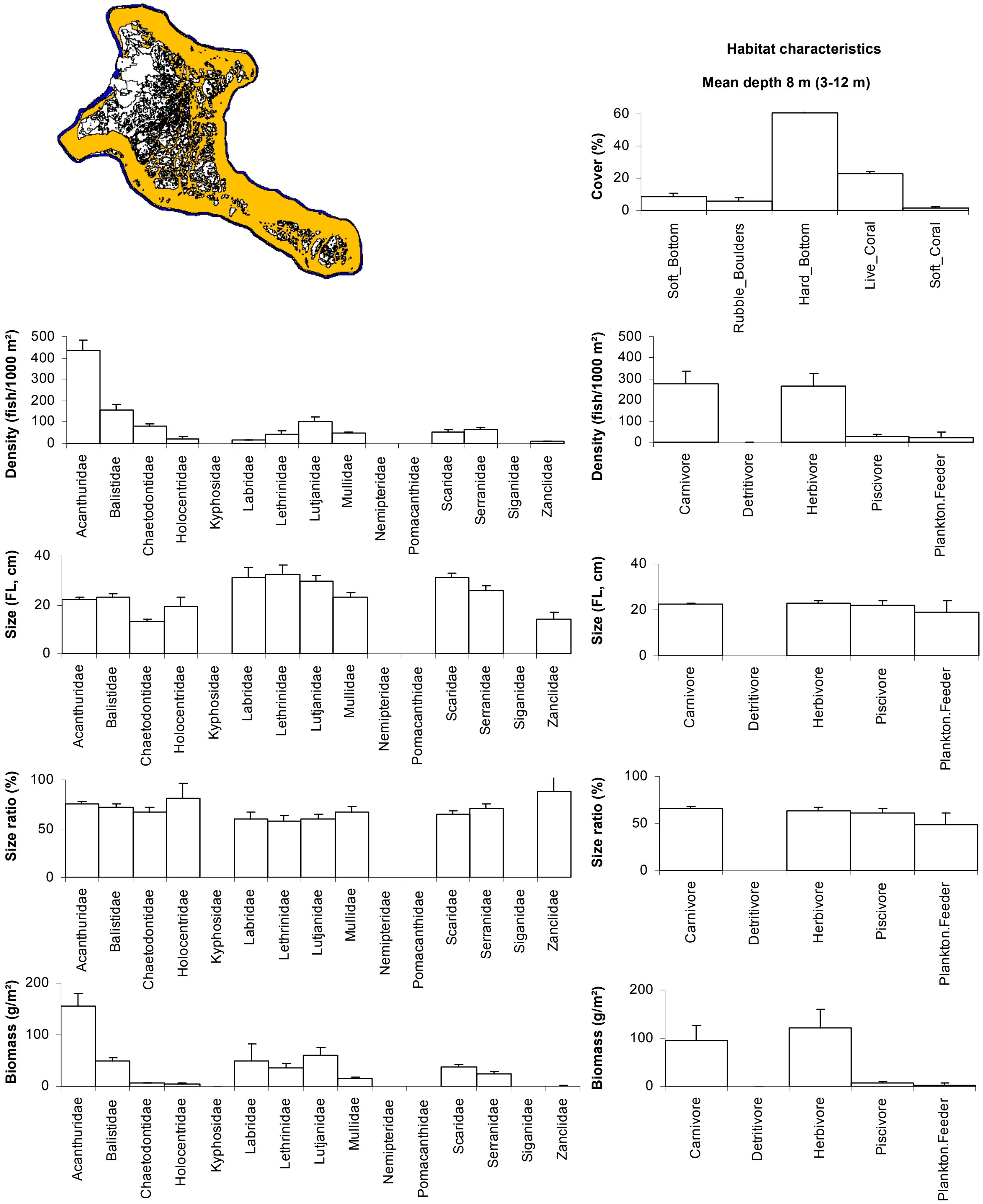

Figure 5.21: Profile of finfish resources in the outer-reef environment of Kiritimati.
Bars represent standard error (+SE); FL = fork length.

However, Kiritimati outer reefs display the highest average sizes (24 cm FL versus 20 in Abaiang, 19 in Abemama and 15 in Kuria) and the highest size ratio (70% versus 57% in Abaiang, 48% in Abemama and 41% in Kuria) and, as a consequence, the second-highest biomass (437 g/m^2 versus 486 in Abemama, 276 in Kuria and 214 in Abaiang) among the four sites. The prevalence of hard-bottom substrate in combination with the direct oceanic influence found in the outer-reef environment may explain the dominance of medium-sized herbivorous fish, such as *Ctenochaetus marginatus*, *C. striatus* and *Acanthurus nigricans.* However, the notable presence of large carnivorous species, such as *Lutjanus bohar* and *L. gibbus*, in combination with the presence of large *Cheilinus undulatus*, may be related to the healthy status of the reef.

Overall reef environment: Kiritimati

Overall, fish assemblage on Kiritimati is largely dominated by herbivorous fish. By looking at the specific fish assemblage of the island in terms of density and biomass, there are three main fish families: one herbivorous family, Acanthuridae and two carnivorous families, Lutjanidae and Balistidae (Figure 5.22). These three families are represented by 41 species. The most important ones in terms of density and biomass are *Ctenochaetus striatus*, *C. marginatus*, *Lutjanus gibbus*, *Acanthurus nigricans*, *A. lineatus*, *A. nigricauda*, *A. leucocheilus*, *Lutjanus fulvus* and *Melichthys vidua* (Table 5.10).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striped bristletooth	0.06	12.4
	Ctenochaetus marginatus	Blue-spotted bristletooth	0.06	25.0
	Acanthurus nigricans	White-cheek surgeonfish	0.04	8.4
	Acanthurus lineatus	Lined surgeonfish	0.03	17.9
	Acanthurus nigricauda	Blackstreaked surgeonfish	0.03	20.7
	Acanthurus leucocheilus	Palelipped surgeonfish	0.03	15.1
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.06	36.2
	Lutjanus fulvus	Flametail snapper	0.02	11.7
Balistidae	*Melichthys vidua*	Pink tail triggerfish	0.02	7.4

Covering a depth range of 1 to 12 metres, the average bottom coverage in Kiritimati is dominated by hard bottom (55%) with an average cover of live coral (21%).

In comparison with the other sites surveyed, reef fish stocks on Kiritimati are much better preserved, as shown by the presence of larger fish (67% versus 60% for Abaiang, 45% for Abemama and 41% for Kuria). Having larger fish in the coastal marine system ensures a genetic diversity of the single species and is a good signal to show that resources are healthy. However, this will be short-lived as the population continues to increase and coastal fisheries resources remain poorly managed, as is currently the case.

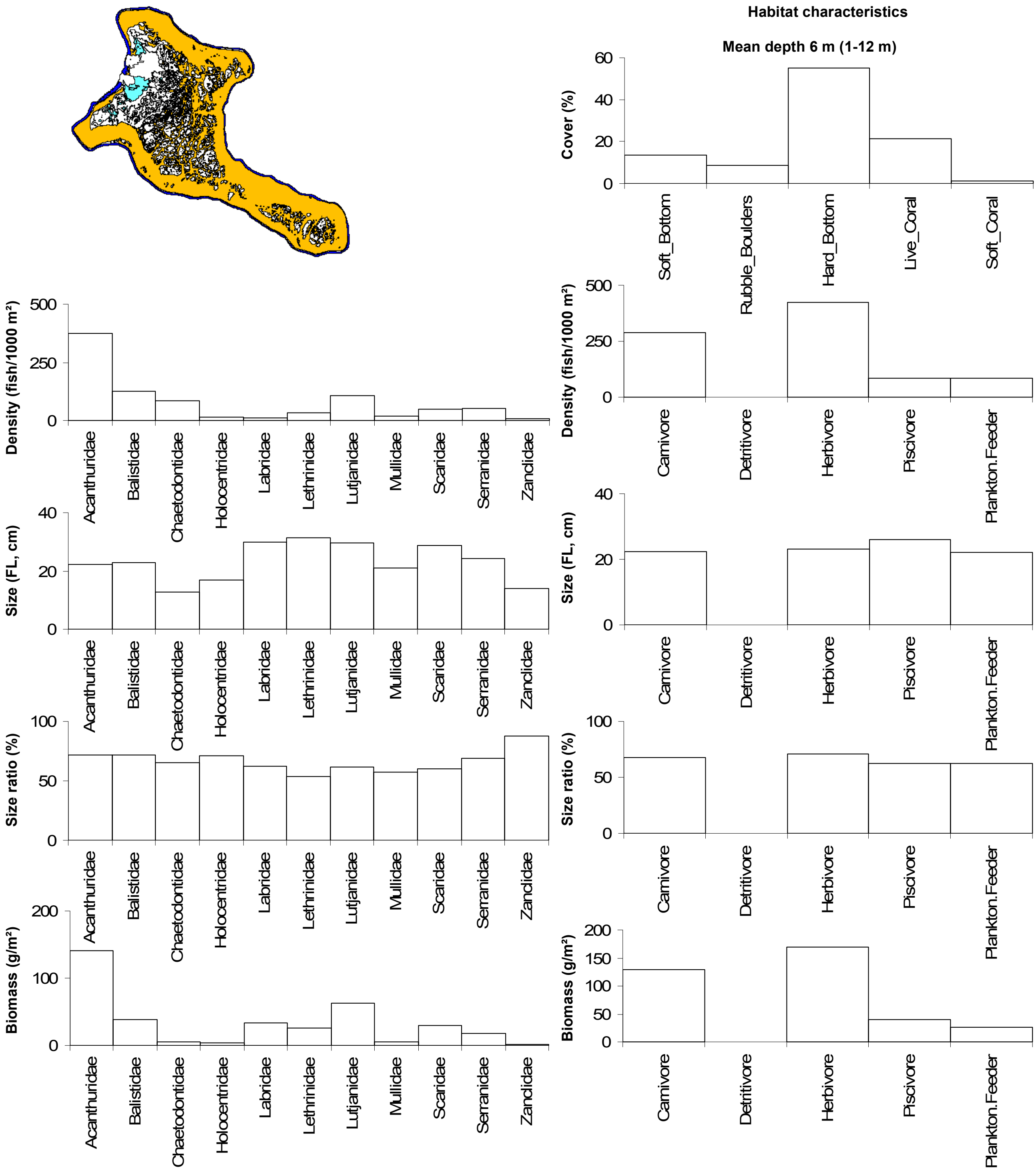

Figure 5.22: Profile of finfish resources in the combined reef habitats of Kiritimati (weighted average).
FL = fork length.

5.3.2 Discussion and conclusions: finfish resources in Kiritimati

- The assessment indicates that the status of finfish resources in Kiritimati is slightly better than the other three sites surveyed in the country. The presence of large-sized species protected under CITES, such as *Cheilinus undulatus*, and the high numbers of herbivorous fish, coupled with large-sized carnivorous fish (Lutjanidae and Serranidae), provide a balanced trophic structure in the island's reef ecosystem.

- Overall, Kiritimati finfish resources appear to be in relatively good condition. The reef habitat seems relatively rich and the ecosystem supporting finfish resources healthy.

5.4 Invertebrate resource surveys: Kiritimati

The diversity and abundance of invertebrate species at Kiritimati Island were independently determined using a range of survey techniques (Table 5.11): broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 5.23) and finer-scale assessment of specific reef and benthic habitats (Figures 5.24 and 5.25).

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

Table 5.11: Number of stations and replicates completed at Kiritimati

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	14	84 transects
Reef-benthos transects (RBt)	12	72 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	16	128 quadrat groups
Mother-of-pearl transects (MOPt)	0	0 transect
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	6	36 search periods
Reef-front search by walking (RFs_w)	4	24 search periods
Sea cucumber day searches (Ds)	4	24 search periods
Sea cucumber night searches (Ns)	2	12 search periods

Figure 5.23: Broad-scale survey stations for invertebrates in Kiritimati.
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 in Kiritimati.
Black circles: reef-benthos transect stations (RBt).

Figure 5.25: Fine-scale survey stations for invertebrates in Kiritimati.
Inverted grey triangles: reef-front search stations (RFs);
grey triangles: reef-front search stations by walking (RFs_w);
grey stars: sea cucumber day search stations (Ds);
grey circles: sea cucumber night search stations (Ns);

Twenty-two species or species groupings (groups of species within a genus) were recorded in the Kiritimati invertebrate surveys: 4 bivalves, 4 gastropods, 7 sea cucumbers, 3 urchins, 1 sea star and 2 lobsters (Appendix 6.4.1). Information on key families and species is detailed below.

5.4.1 Giant clams: Kiritimati

Broad-scale sampling provided an overview of giant clam distribution around Kiritimati Island. Shallow-reef habitat that is suitable for giant clams was moderately limited within the lagoon (18.6 km^2) but more extensive on the exposed reef slope (30.5 km^2). Despite the main lagoon covering over 150 km^2, and the total extent of all lagoons on Kiritimati being greatly larger, most are shallow, saline ponds that are unsuitable for giant clams. Within the main lagoon, suitable reef habitat was mostly restricted to areas near the pass south of Cook Island (west). The northern sector of the main lagoon (near London) and the westerly reaches were generally unsuitable for clams as the water was cloudy and influenced by discharges from the more enclosed inland pools found throughout Kiritimati.

Reefs outside the island, along the barrier reef, sloped relatively quickly into deep water, except in the west, where there was more habitat, and a sand shelf >25 m deep. Only one species of giant clam was recorded in broad-scale survey at Kiritimati: the elongate clam *Tridacna maxima* (recorded in 11 of 14 stations, 63% of transects, see Figure 5.26).

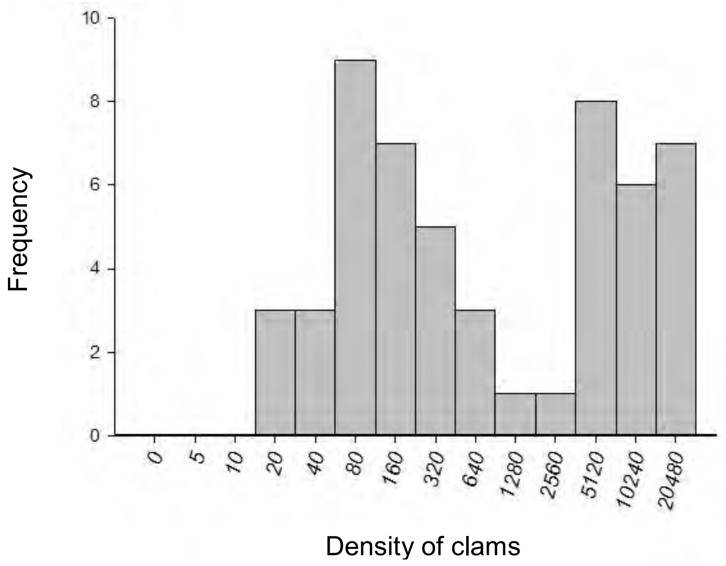

Figure 5.26: Frequency plot of density per 300 m transect measures (per ha) for *Tridacna maxima* clam at Kiritimati, based on all broad-scale assessment stations.
Density = numbers/ha, recorded on a geometric progression with common ratio 2, i.e. each interval is double the value of the previous.

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 5.27). In these reef-benthos assessments (RBt), *T. maxima* was present within 100% of stations at a mean density of 13,187.5 per ha ± 3153.4. The larger fluted clam *Tridacna squamosa* was not recorded, and no dead shells of this or other clams were seen. A previous environmental impact assessment report by NASDA (Japan's National Space Development Agency) for a wharf project had mentioned that *T. squamosa* was present, but contact with the authors through Stanford University (Don Barclay and Bill Gilly at Hopkins Marine Lab) revealed that no definite finding was made for this species. The absence of other species was also confirmed by Sims *et al*. (1989).

Most clams at Kiritimati Island were recorded on reef near the southwest passage (subject to strong water movement) and clams were mostly absent from the populated areas of London and the more enclosed side of the lagoon, which was overgrown with epiphytes and less suitable for *T. maxima*.

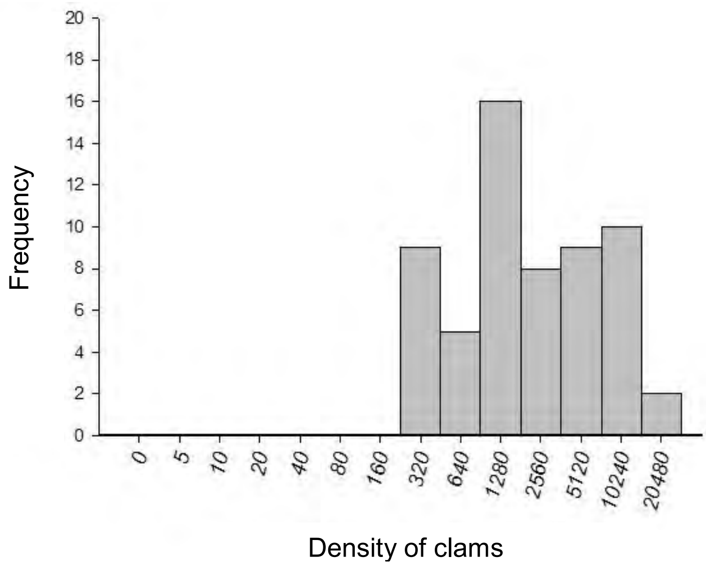

Figure 5.27: Frequency plot of density per 40 m transect measures (per ha) for *Tridacna maxima* clam at Kiritimati, based on all fine-scale reef-benthos transect assessment stations. Density = numbers/ha, recorded on a geometric progression with common ratio 2, i.e. each interval is double the value of the previous.

T. maxima from reef-benthos transects (RBt, shallow-water reefs) had an average length of 10.0 cm ±0.1. When clams from deeper water or more exposed locations were included (from all assessments), the mean length varied little (10.2 cm ±0.1). As can be seen from the length frequency graphs (Figure 5.28), there were relatively few clams larger than 20 cm in length (asymptotic length L∞ of 30 cm), but recruitment of small *T. maxima* was still strong. Anecdotal evidence from an assessment in the late 1980s (Sims *et al*. 1989) suggests that 15 years ago the size frequency distribution showed a predominance of larger clams; however, as can be seen on the graphs presented below, this is not the case today (Figure 5.28).

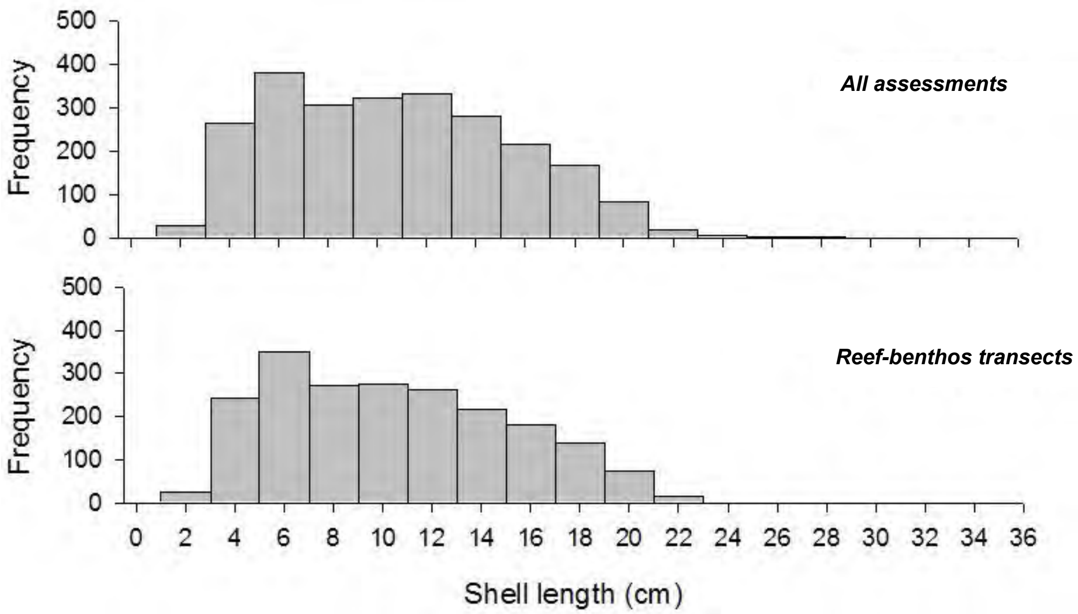

Figure 5.28: Size frequency histograms of giant clam shell length (cm) for Kiritimati.

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

Kiritimati is a large island with an outer perimeter of approximately 145 km (lineal measure). The reefs around Kiritimati Island do not constitute a particularly suitable benthos for the commercial topshell, *Trochus niloticus.* The outer-reef slopes quickly into deeper water around most of the island and there is very little habitat for juveniles except for the section around Cook Island and in the southwest of the south passage (near Wood Island). *T. niloticus* does not naturally occur in Kiribati and, although there have been translocations of adult shells from Fiji to Tarawa, trochus has never been introduced to Kiritimati. The area would probably support a population of this commercial species if it was introduced. However, the numbers of other grazing gastropods, which may indicate the suitability of Kiritimati, were not found to be high. *Tectus pyramis*, the green topshell, (of low commercial value), which has a similar life history to trochus, was not present (possibly also not naturally occurring here).

Pinctada margaritifera, a normally cryptic and sparsely distributed pearl oyster species, was recorded in both broad-scale and fine-scale surveys (Table 5.12). In the late 1800s, >250 t of pearl shell were removed from Kiritimati and, despite no significant commercial fishing this century, there is still no recovery of pearl shell to this level of abundance. In the early 1900s, the goldlip pearl shell, *Pinctada maxima*, was introduced into Kiritimati (from Torres Strait) without apparent success.

There are some reports of a limited fishery for *P. margaritifera* from the last few decades; in the late 1980s, some 100 individual shells were collected from the lagoon, along with ongoing incidental collection of shells to make fishing lures (infrequent shipments to Tarawa). A previous assessment of pearl oyster stocks (Sims *et al.* 1989) recorded a low abundance of *P. margaritifera* from two weeks of dedicated, in-water assessment (total n = 34, average density in good areas was 22 /ha ±31SD, mean size 18.8 cm ±3.6SD).

Table 5.12: Presence and mean density of *Pinctada margaritifera* in Kiritimati
Based on various assessment techniques; mean density measured in numbers/ha (±SE).

	Density	SE	% of stations with species	% of transects or search periods with species
Pinctada margaritifera				
B-S	2.2	0.8	6/14 = 43	10/84 = 12
RBt	3.5	3.5	1/12 = 8	2/72 = 3
RFs	0	0	0/4 = 0	0/24 = 0
Ds	1.8	1.1	2/4 = 50	2/24 = 8

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

5.4.3 Infaunal species and groups: Kiritimati

The soft benthos of the shallow-water lagoon was generally present without seagrass or muddy areas and did not hold beds of in-ground shell 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. There were, however, many *Atrina* sp. present within the lagoon, especially towards the more enclosed easterly edges of the main lagoon. They were half buried in the sediment and their distribution would not lend themselves to quadrat measures (best noted by broad-scale surveys at mean density 67.3 per ha ±39.7).

5.4.4 Other gastropods and bivalves: Kiritimati

Seba's spider conch, *Lambis truncata* (the larger of the two common spider conchs) was detected in broad-scale and deep-water sea cucumber day searches at low density (Appendices 4.4.2 to 4.4.7). *Turbo* spp., which are commonly collected along exposed reef fronts in the Pacific, were recorded at low density during reef-front searches (<5 /ha). Other gastropod species targeted by fishers (e.g. *Conus* and *Thais*) were also recorded during independent surveys (Appendices 4.4.2 to 4.4.7). Data on other bivalves found in broad-scale and fine-scale benthos surveys, such as *Atrina* and *Chama*, are also in Appendices 4.4.2 to 4.4.7.

No creel survey was conducted at Kiritimati Island.

5.4.5 Lobsters: Kiritimati

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, one adult lobster was recorded during broad-scale surveys on the south of Cook Island, and four juvenile lobsters were recorded on a broad-scale station east of London. The banded prawn killer, *Lysiosquillina* sp. (sand lobster), was also recorded at this station. Lastly, following night assessments for sea cucumbers, we took the opportunity to do a 30–40 min search for lobsters on the seaward side (west) of Cook Island. No lobsters were found.

5.4.6 Sea cucumbers[13]: Kiritimati

The land mass of Kiritimati Island (approximately 400 km^2) was large compared to the scale of the main lagoon (150 km^2), but low lying and generally saline. The extensive reef and soft-benthos areas within the lagoon were mainly very shallow, exposed (to wind), and subjected to tidal outflows from inland saline ponds. This provided limited habitat, which did not generally favour deposit feeders (which eat organic matter in the upper few mm of bottom substrates). The outer-reef slope was steep but extensive, Kiritimati Island having a perimeter of 145 km lineal measure. In this survey, seven commercial species of sea cucumbers were recorded during in-water assessments (Table 5.13).

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 5.13, Appendices 4.4.2 to 4.4.7; see also Methods.). Deep dives on SCUBA, sea cucumber day searches (25–35 m in depth), were also conducted to obtain a preliminary assessment of deep-water stocks, such as the high-value white teatfish (*Holothuria fuscogilva*), prickly redfish (*Thelenota ananas*) and the lower-value amberfish (*T. anax*). In deep-water assessments (average depth 27.3 m) *H. fuscogilva* and *T. anax* were not recorded, although *T. ananas* was found at low-to-medium density.

Other species associated with reef, such as the high-value black teatfish (*Holothuria nobilis*) and greenfish (*Stichopus chloronotus*), were present but rare (found in <10% of broad-scale transects). The lower-value leopardfish (*Bohadschia argus*) was more common (in 24% of broad-scale transects). An earlier assessment (Sims *et al*. 1989), recorded greater numbers of

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

leopardfish and also greenfish, but also highlighted that suitable habitat was limited within the lagoon.

Unfortunately, the oceanic, exposed reeftops and surge zone present at Kiritimati did not hold a significant resource of commercial sea cucumbers. These reefs covered an extensive area and were not comprehensively surveyed during this study. However, initial findings indicate a low abundance (presence and density) of surf redfish, *Actinopyga mauritiana*. Sims *et al*. (1989) also noted that surf redfish were not common during in-water surveys of the lagoon.

More protected areas of reef and soft benthos within the lagoon at Kiritimati held limited numbers of lower-value species. Brown sandfish (*Bohadschia vitiensis*) and lollyfish (*Holothuria atra*) were present; however densities were generally low. Blackfish, (*Actinopyga miliaris*) was not recorded in our survey, despite night work and a comprehensive search of the main lagoon. This species was present (if uncommon) in the late 1980s (Sims *et al*. 1989).

5.4.7 Other echinoderms: Kiritimati

Neither the edible slate urchin, *Heterocentrotus mammillatus*, nor the collector urchin, *Tripneustes gratilla* were found in survey, despite the collector urchin being recorded as common in the past (Sims *et al*. 1989). *Echinometra mathaei* and *Echinothrix diadema* were recorded in 36% of broad-scale stations, but presence and densities were higher at reef-benthos stations (mean density 150–180 per ha for each species).

No blue starfish, *Linckia laevigata*, were recorded in survey. Coralivore (coral eating) starfish, such as the cushion star, *Culcita novaeguineae*, were present (in 50% of broad-scale stations), but only at moderate-to-low density (13.1 and 59.0 per ha, for broad-scale and reef-benthos stations respectively). No crown of thorns starfish, *Acanthaster planci*, were recorded (Appendices 4.4.2 to 4.4.7).

Table 5.13: Sea cucumber species records for Kiritimati Island

Species	Common name	Commercial value (5)	B-S transects n = 84			Reef-benthos stations n = 12			Other stations RFs = 6; RFs_w = 4			Other stations Ds = 4; Ns = 2		
			D (1)	DwP (2)	PP (3)	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga mauritiana	Surf redfish	M/H	0.6	16.7	4									
Actinopyga miliaris	Blackfish	M/H												
Bohadschia argus	Leopardfish	M	11.3	50.0	23	10.4	125.0	8				1.8 106.7	7.1 106.7	25 Ds 100 Ns
Bohadschia graeffei	Flowerfish	L												
Bohadschia vitiensis	Brown sandfish	L	0.8	16.7	5							4.2 48.9	8.3 48.9	50 Ds 100 Ns
Holothuria atra	Lollyfish	L	1.2	16.7	7	3.5	41.7	8	1.3 36.1	7.8 36.1	17 RFs 100 RFs_w			
Holothuria edulis	Pinkfish	L												
Holothuria fuscogilva (4)	White teatfish	H												
Holothuria fuscopunctata	Elephant trunkfish	M												
Holothuria nobilis (4)	Black teatfish	H	0.4	16.7	2									
Stichopus chloronotus	Greenfish	H/M	4.8	57.1	8	17.4	52.1	33				17.8	35.6	50 Ns
Thelenota ananas	Prickly redfish	H	0.6	16.7	4							11.3	22.6	50 Ds
Thelenota anax	Amberfish	M												

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

5.4.8 Discussion and conclusions: invertebrate resources in Kiritimati

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.

- *Tridacna maxima* were common at Kiritimati Island, despite the small area within the lagoon where the habitat was most suitable. The densities recorded in this study do not suggest there is a heavy fishing pressure on the stocks, although the larger clams are noticeably depleted.

- Based on the information collected on mother-of-pearl stocks, *Trochus niloticus* does offer some potential if introduced to Kiritimati. Although the reef system is not well suited, the extensive area of coastline may compensate somewhat for deficiency of juvenile habitat.

- The blacklip pearl oyster, *Pinctada margaritifera*, is presently at low abundance and there is no potential for a commercial fishery. Despite once providing a significant income for Kiritimati through sale of pearl shell, pearl production would need to rely on spat collection (or hatchery production) to access stock. In addition to the lack of shells, there is a lack of a protected deep-water lagoon for commercial grow-out of shell and pearls.

- Sea cucumber stocks are limited, as shown by the number of species present, distribution of the stock across the lagoon and offshore reefs, and by the densities recorded within aggregated areas. There is indication that, despite the non-optimal environment, fishing has greatly impacted stock availability. Fishing for sea cucumbers is actively pursued in Kiritimati, and commercial aquarium collectors have had SCUBA access for several years.

5.5 Overall recommendations for Kiritimati

- Fisheries management may consider the use of the milkfish breeding project for local (and/or national) consumption rather than for commercial baitfish production. This may provide an alternative fishery and reduce fishing pressure on the natural coastal resources of Kiritimati.

- Management arrangements need to be finalised for the bonefish fishery to protect this species for the tourist or sport fishing industry.

- Appropriate monitoring and management arrangements need to be developed and implemented to sustain the presence of larger-sized fish, and thus conserve the genetic diversity of commercially important species found on the island in the face of an expanding population.

- Commercial fishers should be encouraged to target the seamount fishery, as well as the relatively untouched and high-value deep-bottom fish species, to ease pressure on the reef fish stocks and leave these for subsistence use only.

- Extra care should be taken to protect broodstock of clams, as increased fishing pressure will have accelerated negative impacts on stocks on reefs in Kiritimati (which are more susceptible to overfishing).

- Management measures should be introduced for sea cucumbers to allow this species to recover from previous fishing pressure.

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APPENDIX 1: SURVEY METHODS

1.1 Socioeconomic surveys, questionnaires and average invertebrate wet weights

1.1.1 Socioeconomic survey methods

Preparation

The PROCFish/C socioeconomic survey is planned in close cooperation with local counterparts from national fisheries authorities. It makes use of information gathered during the selection process for the four sites chosen for each of the PROCFish/C participating countries and territories, as well as any information obtained by resource assessments, if these precede the survey.

Information is gathered regarding the target communities, with preparatory work for a particular socioeconomic field survey carried out by the local fisheries counterparts, the project's attachment, or another person charged with facilitating and/or participating in the socioeconomic survey. In the process of carrying out the surveys, training opportunities are provided for local fisheries staff in the PROCFish/C socioeconomic field survey methodology.

Staff are careful to respect local cultural and traditional practices, and follow any local protocols while implementing the field surveys. The aim is to cause minimal disturbance to community life, and surveys have consequently been modified to suit local habits, with both the time interviews are held and the length of the interviews adjusted in various communities. In addition, an effort is made to hold community meetings to inform and brief community members in conjunction with each socioeconomic field survey.

Approach

The design of the socioeconomic survey stems from the project focus, which is on rural coastal communities in which traditional social structures are to some degree intact. Consequently, survey questions assume that the primary sectors (and fisheries in particular) are of importance to communities, and that communities currently depend on coastal marine resources for their subsistence needs. As urbanisation increases, other factors gain in importance, such as migration, as well as external influences that work in opposition to a subsistence-based socioeconomic system in the Pacific (e.g. the drive to maximise income, changes in lifestyle and diet, and increased dependence on imported foods). The latter are not considered in this survey.

The project utilises a 'snapshot approach' that provides 5–7 working days per site (with four sites per country). This timeframe generally allows about 25 households (and a corresponding number of associated finfish and invertebrate fishers) to be covered by the survey. The total number of finfish and invertebrate fishers interviewed also depends on the complexity of the fisheries practised by a particular community, the degree to which both sexes are engaged in finfish and invertebrate fisheries, and the size of the total target population. Data from finfish and invertebrate fisher interviews are grouped by habitat and fishery, respectively. Thus, the project's time and budget and the complexity of a particular site's fisheries are what determine the level of data representation: the larger the population and the number of fishers, and the more diversified the finfish and invertebrate fisheries, the lower the level of representation that can be achieved. It is crucial that this limitation be taken into consideration, because the data gathered through each survey and the emerging distribution patterns are extrapolated to estimate the total annual impact of all fishing activity reported for the entire community at each site.

If possible, people involved in marketing (at local, regional or international scale) who operate in targeted communities are also surveyed (e.g. agents, middlemen, shop owners).

Key informants are targeted in each community to collect general information on the nature of local fisheries and to learn about the major players in each of the fisheries that is of concern, and about fishing rights and local problems. The number of key informants interviewed depends on the complexity and heterogeneity of the community's socioeconomic system and its fisheries.

At each site the extent of the community to be covered by the socioeconomic survey is determined by the size, nature and use of the fishing grounds. This selection process is highly dependent on local marine tenure rights. For example, in the case of community-owned fishing rights, a fishing community includes all villages that have access to a particular fishing ground. If the fisheries of all the villages concerned are comparable, one or two villages may be selected as representative samples, and consequently surveyed. Results will then be extrapolated to include all villages accessing the same fishing grounds under the same marine tenure system.

In an open access system, geographical distance may be used to determine which fishing communities realistically have access to a certain area. Alternatively, in the case of smaller islands, the entire island and its adjacent fishing grounds may be considered as one site. In this case a large number of villages may have access to the fishing ground, and representative villages, or a cross-section of the population of all villages, are selected to be included in the survey.

In addition, fishers (particularly invertebrate fishers) are regularly asked how many people external to the surveyed community also harvest from the same fishing grounds and/or are engaged in the same fisheries. If responses provide a concise pattern, the magnitude of additional impact possibly imposed by these external fishers is determined and discussed.

Sampling

Most of the households included in the survey are chosen by simple random selection, as are the finfish and invertebrate fishers associated with any of these households. In addition, important participants in one or several particular fisheries may be selected for complementary surveying. Random sampling is used to provide an average and representative picture of the fishery situation in each community, including those who do not fish, those engaged in finfish and/or invertebrate fishing for subsistence, and those engaged in fishing activities on a small-scale artisanal basis. This assumption applies provided that selected communities are mostly traditional, relatively small (~100–300 households) and (from a socioeconomic point of view) largely homogenous. Similarly, gender and participation patterns (types of fishers by gender and fishery) revealed through the surveys are assumed to be representative of the entire community. Accordingly, harvest figures reported by male and female fishers participating in a community's various fisheries may be extrapolated to assess the impacts resulting from the entire community, sample size permitting (at least 25–30% of all households).

Data collection and analysis

Data collection is performed using a standard set of questionnaires developed by PROCFish/C's socioeconomic component, which include a household survey (key socioeconomic parameters and consumption patterns), finfish fisheries survey, invertebrate fisheries survey, marketing of finfish survey, marketing of invertebrates survey, and general information questionnaire (for key informants). In addition, further observations and relevant details are noted and recorded in a non-standardised format. The complete set of questionnaires used is attached as Appendix 1.1.2.

Most of the data are collected in the context of face-to-face interviews. Names of people interviewed are recorded on each questionnaire to facilitate cross-identification of fishers and households during data collection and to ensure that each fisher interview is complemented by a household interview. Linking data from household and fishery surveys is essential to permit joint data analysis. However, all names are suppressed once the data entry has been finalised, and thus the information provided by respondents remains anonymous.

Questionnaires are fully structured and closed, although open questions may be added on a case-to-case situation. If translation is required, each interview is conducted jointly by the leader of the project's socioeconomic team and the local counterpart. In cases where no translation is needed, the project's socioeconomist may work individually. Selected interviews may be conducted by trainees receiving advanced field training, but trainees are monitored by project staff in case clarification or support is needed.

The questionnaires are designed to allow a minimum dataset to be developed for each site, one that allows:

- the community's dependency on marine resources to be characterised;
- assessment of the community's engagement in and the possible impact of finfish and invertebrate harvesting; and
- comparison of socioeconomic information with data collected through PROCFish/C resource surveys.

Household survey

The major objectives of the household survey are to:

- **collect recent demographic information** (needed to calculate seafood consumption);
- **determine the number of fishers per household, by gender and type of fishing activity** (needed to assess a community's total fishing impact); and
- **assess the community's relative dependency on marine resources** (in terms of ranked source(s) of income, household expenditure level, agricultural alternatives for subsistence and income (e.g. land, livestock), external financial input (i.e. remittances), assets related to fishing (number and type of boat(s)), and seafood consumption patterns by frequency, quantity and type).

The demographic assessment focuses only on permanent residents, and excludes any family members who are absent more often than they are present, who do not normally share the household's meals or who only join on a short-term visitor basis (for example, students during school holidays, or emigrant workers returning for home leave).

The number of fishers per household distinguishes three categories of adult (≥ 15 years) fishers for each gender: (1) exclusive finfish fishers, (2) exclusive invertebrate fishers, and (3) fishers who pursue both finfish and invertebrate fisheries. This question also establishes the percentage of households that do not fish at all. We use this pattern (i.e. the total number of fishers by type and gender) to determine the number of female and male fishers, and the percentage of these who practise either finfish or invertebrate fisheries exclusively, or who practise both. The share of adult men and women pursuing each of the three fishery categories is presented as a percentage of all fishers. Figures for the total number of people in each fishery category, by gender, are also used to calculate total fishing impact (see below).

The role of fisheries as a source of income in a community is established by a ranking system. Generally, rural coastal communities represent a combined system of traditional (subsistence) and cash-generating activities. The latter are often diversified, mostly involving the primary sector, and are closely associated with traditional subsistence activities. Cash flow is often irregular, tailored to meet seasonal or occasional needs (school and church fees, funerals, weddings, etc.). Ranking of different sources of income by order of importance is therefore a better way to render useful information than trying to quantify total cash income over a certain time period. Depending on the degree of diversification, multiple entries are common. It is also possible for one household to record two different activities (such as fisheries and agriculture) as equally important (i.e. both are ranked as a first source of income, as they equally and importantly contribute to acquisition of cash within the household). In order to demonstrate the degree of diversification and allow for multiple entries, the role that each sector plays is presented as a percentage of the total number of households surveyed. Consequently, the sum of all figures may exceed 100%. Income sources include fisheries, agriculture, salaries, and 'others', with the latter including primarily handicrafts, but sometimes also small private businesses such as shops or kava bars.

Cash income is often generated in parallel by various members of one household and may also be administered by many, making it difficult to establish the overall expenditure level. On the other hand, the head of the household and/or the woman in charge of managing and organising the household are typically aware and in control of a certain amount of money that is needed to ensure basic and common household needs are met. We therefore ask for the level of average household expenditure only, on a weekly, bi-weekly or monthly basis, depending on the payment interval common in a particular community. Expenditures quoted in local currency are converted into US dollars (USD) to enable regional comparison. Conversion factors used are indicated.

Geomorphologic differences between low and high islands influence the role that agriculture plays in a community, but differences in land tenure systems and the particulars of each site are also important, and the latter factors are used in determining the percentage of households that have access to gardens and agricultural land, the average size of these areas, and the type (and if possible number) of livestock that are at the disposal of an average household. A community whose members are equally engaged in agriculture and fisheries will either show distinct groups of fishers and farmers/gardeners, or reveal active and non-active fishing seasons in response to the agricultural calendar.

The frequency and amount of remittances received from family members working elsewhere in the country or overseas enable us to assess the degree to which principles of the MIRAB economy apply. MIRAB was coined to characterise an economy dependent on migration, remittances, foreign aid and government bureaucracy as its major sources of revenue (Small and Dixon 2004; Bertram 1999; Bertram and Watters 1985). A high influx of foreign financing, and in particular remittances, is considered to yield flexible and stable economic conditions at the community level (Evans 2001), and may also substitute for or reduce the need for local income-generating activities, such as fishing.

The number of boats per household is indicative of the level of isolation, and is generally higher for communities that are located on small islands and far from the nearest regional centre and market. The nature of the boats (e.g. non-motorised, handmade dugout canoes, dugouts equipped with sails, and the number and size of any motorised boats) provides insights into the level of investment, and usually relates to the household expenditure level. Having access to boats that are less sensitive to sea conditions and equipped with outboard engines provides greater choice of which fishing grounds to target, decreases isolation and increases independence in terms of transport, and hence provides fishing and marketing advantages. Larger and more powerful boats may also have a multiplication factor, as they accommodate bigger fishing parties. In this context it should be noted that information on boats is usually complemented by a separate boat inventory performed by interviewing key informants and senior members of the community. If possible, we prefer to use the information from the complementary boat inventory surveys rather than extrapolating data from household surveys, in order to minimise extrapolation errors.

A variety of data are collected to characterise the seafood consumption of each community. We distinguish between fresh fish (with an emphasis on reef and lagoon fish species), invertebrates and canned fish. Because meals are usually prepared for and shared by all household members, and certain dishes may be prepared in the morning but consumed throughout the day, we ask for the average quantity prepared for one day's consumption. In the case of fresh fish we ask for the number of fish per size class, or the total weight, usually consumed. However, the weight is rarely known, as most communities are largely self-sufficient in fresh fish supply and local, non-metric units are used for marketing of fish (heap, string, bag, etc.). Information on the number of size classes consumed allows calculation of weight using length–weight relationships, which are known for most finfish species (FishBase 2000, refer to Letourneur *et al.* 1998; Kulbicki pers. com.). Size classes (using fork length) are identified using size charts (Figure A1.1.1).

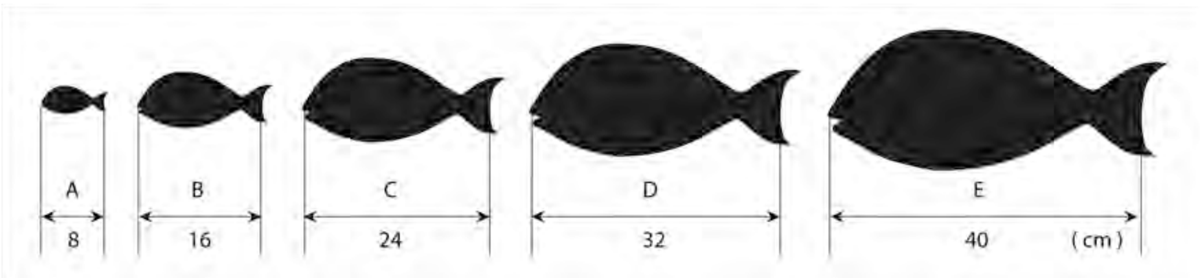

Figure A1.1.1: Finfish size field survey chart for estimating average length of reef and lagoon fish (including five size classes from A = 8 cm to E = 40 cm, in 8 cm intervals).

The frequency of all consumption data is adjusted downwards by 17% (a factor of 0.83 determined on the basis that about two months of the year are not used for fishing due to festivities, funerals and bad weather conditions) to take into account exceptional periods throughout the year when the supply of fresh fish is limited or when usual fish eating patterns are interrupted.

Equation for fresh finfish:

$$F_{wj} = \sum_{i=1}^{n} (N_{ij} \bullet W_i) \bullet 0.8 \bullet F_{dj} \bullet 52 \bullet 0.83$$

F_{wj} = finfish net weight consumption (kg edible meat/household/year) for household$_j$
n = number of size classes
N_{ij} = number of fish of size class$_i$ for household$_j$
W_i = weight (kg) of size class$_i$
0.8 = correction factor for non-edible fish parts
F_{dj} = frequency of finfish consumption (days/week) of household$_j$
52 = total number of weeks/year
0.83 = correction factor for frequency of consumption

For invertebrates, respondents provide numbers and sizes or weight (kg) per species or species groups usually consumed. Our calculation automatically transfers these data entries per species/species group into wet weight using an index of average wet weight per unit and species/species group (Appendix 1.1.3).[1] The total wet weight is then automatically further broken down into edible and non-edible proportions. Because edible and non-edible proportions may vary considerably, this calculation is done for each species/species group individually (e.g. compare an octopus that consists almost entirely of edible parts with a giant clam that has most of its wet weight captured in its non-edible shell).

Equation for invertebrates:

$$Inv_{wj} = \sum_{i=1}^{n} E_{p\,i} \bullet (N_{ij} \bullet W_{wi}) \bullet F_{dj} \bullet 52 \bullet 0.83$$

Inv_{wj} = invertebrate weight consumption (kg edible meat/household/year) of household$_j$
E_{pi} = percentage edible (1 = 100%) for species/species group$_i$ (Appendix 1.1.3)
N_{ij} = number of invertebrates for species/species group$_i$ for household$_j$
n = number of species/species group consumed by household$_j$
W_{wi} = wet weight (kg) of unit (piece) for invertebrate species/species group$_i$
1000 = to convert g invertebrate weight into kg
F_{dj} = frequency of invertebrate consumption (days/week) for household$_j$
52 = total number of weeks/year
0.83 = correction factor for consumption frequency

[1] The index used here mainly consists of estimated average wet weights and ratios of edible and non-edible parts per species/species group. At present, SPC's Reef Fishery Observatory is making efforts to improve this index so as to allow further specification of wet weight and edible proportion as a function of size per species/species group. The software will be updated and users informed about changes once input data are available.

Equation for canned fish:

Canned fish data are entered as total number of cans per can size consumed by the household at a daily meal, i.e.:

$$CF_{wj} = \sum_{i=1}^{n} (N_{cij} \bullet W_{ci}) \bullet F_{dcj} \bullet 52$$

CF_{wj} = canned fish net weight consumption (kg meat/household/year) of household$_j$
N_{cij} = number of cans of can size$_i$ for household$_j$
n = number and size of cans consumed by household$_j$
W_{ci} = average net weight (kg)/can size$_i$
F_{dcj} = frequency of canned fish consumption (days/week) for household$_j$
52 = total number of weeks/year

Age-gender correction factors are used because simply dividing total household consumption by the number of people in the household will result in underestimating per head consumption. For example, imagine the difference in consumption levels between a 40-year-old man as compared to a five-year-old child. We use simplified gender-age correction factors following the system established and used by the World Health Organization (WHO; Becker and Helsing 1991), i.e. (Kronen *et al.* 2006):

Age (years)	Gender	Factor
≤5	All	0.3
6–11	All	0.6
12–13	Male	0.8
≥12	Female	0.8
14–59	Male	1.0
≥60	Male	0.8

The per capita finfish, invertebrate and canned fish consumptions are then calculated by selecting the relevant formula from the three provided below:

Finfish per capita consumption:

$$F_{pcj} = \frac{F_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

F_{pcj} = Finfish net weight consumption (kg/capita/year) for household$_j$
F_{wj} = Finfish net weight consumption (kg/household/year) for household$_j$
n = number of age-gender classes
AC_{ij} = number of people for age class i and household j
C_i = correction factor of age-gender class$_i$

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Invertebrate per capita consumption:

$$Inv_{pcj} = \frac{Inv_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

Inv_{pcj} = Invertebrate weight consumption (kg edible meat/capita/year) for $household_j$
Inv_{wj} = Invertebrate weight consumption (kg edible meat/household/year) for $household_j$
n = number of age-gender classes
AC_{ij} = number of people for age class i and household j
C_i = correction factor of age-gender $class_i$

Canned fish per capita consumption:

$$CF_{pcj} = \frac{CF_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) for $household_j$
CF_{wj} = canned fish net weight consumption (kg/household/year) for $household_j$
n = number of age-gender classes
AC_{ij} = number of people for age $class_i$ and $household_j$
C_i = correction factor of age-gender $class_i$

The total finfish, invertebrate and canned fish consumption of a known population is calculated by extrapolating the average per capita consumption for finfish, invertebrates and canned fish of the sample size to the entire population.

Total finfish consumption:

$$F_{tot} = \frac{\sum_{j=1}^{n} F_{pcj}}{n_{ss}} \bullet n_{pop}$$

F_{pcj} = finfish net weight consumption (kg/capita/year) for $household_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

Total invertebrate consumption:

$$Inv_{tot} = \frac{\sum_{j=1}^{n} Inv_{pcj}}{n_{ss}} \bullet n_{pop}$$

Inv_{pcj} = invertebrate weight consumption (kg edible meat/capita/year) for household$_j$

n_{ss} = number of people in sample size

n_{pop} = number of people in total population

Total canned fish consumption:

$$CF_{tot} = \frac{\sum_{j=1}^{n} CF_{pcj}}{n_{ss}} \bullet n_{pop}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) of household$_j$

n_{ss} = number of people in sample size

n_{pop} = number of people in total population

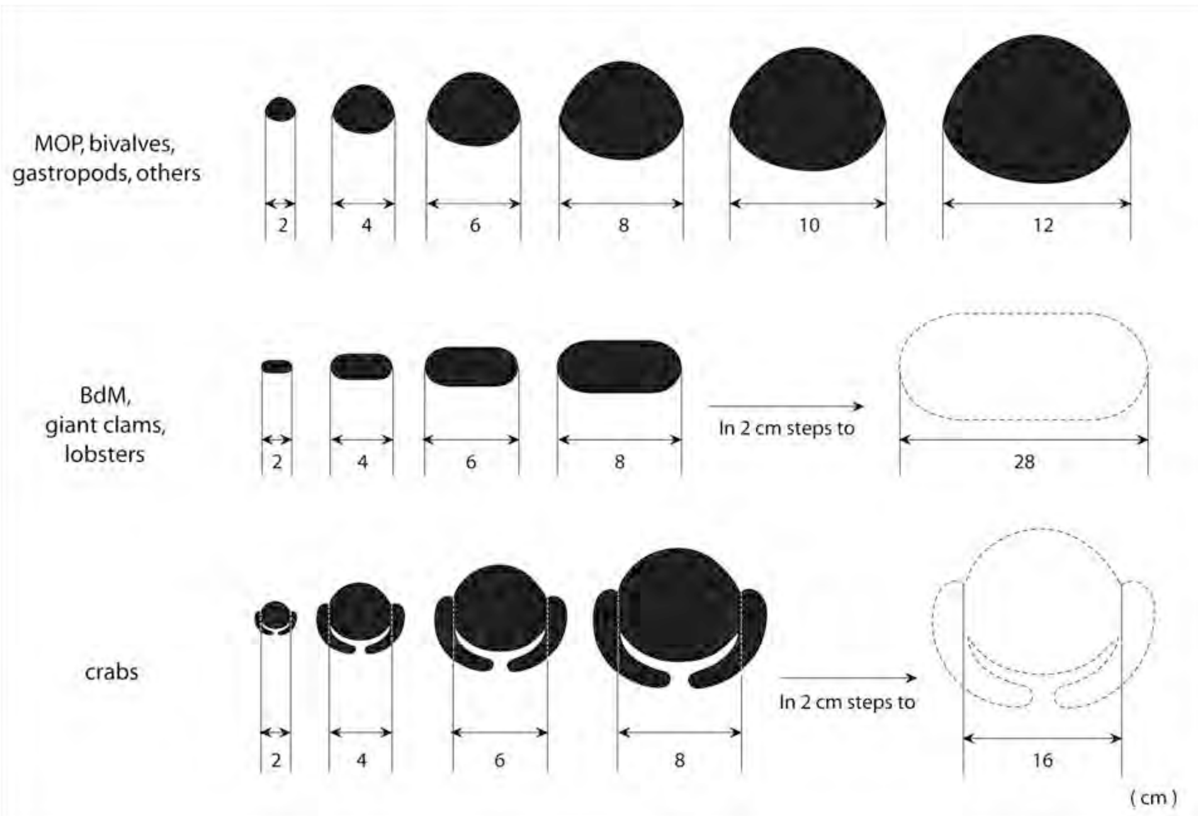

Figure A1.1.2: Invertebrate size field survey chart for estimating average length of different species groups (2 cm size intervals).

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Finfish fisher survey

The finfish fisher survey primarily aims to collect the data needed to understand finfish fisheries strategies, patterns and dimensions, and thus possible impacts on the resource. Data collection faces the challenge of retrieving information from local people that needs to match resource survey parameters, in order to make joint data analysis possible. This challenge is highlighted by the following three major issues:

(i) Fishing grounds are classified by habitat, with the latter defined using geomorphologic characteristics. Local people's perceptions of and hence distinctions between fishing grounds often differ substantially from the classifications developed by the project. Also, fishers do not target particular areas according to their geomorphologic characteristics, but instead due to a combination of different factors including time and transport availability, testing of preferred fishing spots, and preferences of members of the fishing party. As a result, fishers may shift between various habitats during one fishing trip. Fishers also target lagoon and mangrove areas, as well as passages if these are available, all of which cannot be included in the resource surveys. It should be noted that a different terminology for reef and other areas fished is needed to communicate with fishers.

    These problems are dealt with by asking fishers to indicate the areas they refer to as coastal reef, lagoon, outer-reef and pelagic fishing on hydrologic charts, maps or aerial photographs. In this way we can often further refine the commonly used terms of coastal or outer reef to better match the geomorphologic classification. The proportion of fishers targeting each habitat is provided as a percentage of all fishers surveyed; the socioeconomic analysis refers to habitats by the commonly used descriptive terms for these habitats, rather than the ecological or geomorphologic classifications.

    Fishers may travel between various habitats during a single fishing trip, with differing amounts of time spent in each of the combined habitats; the catch that is retrieved from each combined habitat may potentially vary from one trip to the next. If targeting combined habitats is a common strategy practised by most fishers, the resource data for individual geomorphologic habitats need to be lumped to enable comparison of results.

(ii) People usually provide information on fish by vernacular or common names, which are far less specific than (and thus not compatible with) scientific nomenclature. Vernacular name systems are often very localised, changing with local languages, and thus may differ significantly between the sites surveyed in one country alone. As a result, one fish species may be associated with a number of vernacular names, but each vernacular name may also apply to more than one species.

    This issue is addressed, as much as possible, through indexing the vernacular names recorded during a survey to the scientific names for those species. However, this is not always possible due to inconsistencies between informants. The use of photographic indices is helpful but can also trigger misleading information, due to the variety of photos presented and the limitations of species recognition using photos alone. In this respect, collaboration with local counterparts from fisheries departments is crucial.

(iii) The assessment of possible fishing impacts is based on the collection of average data. Accordingly, fishers are requested to provide information on a catch that is neither exceptionally good nor exceptionally bad. They are also requested to provide this information concerning the most commonly caught species. This average information suffers from two major shortcomings. Firstly, some fish species are seasonal and may be dominant during a short period of the year but do not necessarily appear frequently in the average catch. Depending on the time of survey implementation this may result in over- or under-representation of these species. Secondly, fishers usually employ more than one technique. Average catches may vary substantially by quantity and quality depending on which technique they use.

We address these problems by recording any fish that plays a seasonal role. This information may be added and helpful for joint interpretation of resource and socioeconomic data. Average catch records are complemented by information on the technique used, and fishers are encouraged to provide the average catch information for the technique that they employ most often.

The design of the finfish fisher survey allows the collection of details on fishing strategies, and quantitative and qualitative data on average catches for each habitat. Targeting men and women fishers allows differences between genders to be established.

Determination of fishing strategies includes:

- frequency of fishing trips
- mode and frequency of transport used for fishing
- size of fishing parties
- duration of the fishing trip
- time of fishing
- months fished
- techniques used
- ice used
- use of catch
- additional involvement in invertebrate fisheries.

The frequency of fishing trips is determined by the number of weekly (or monthly) trips that are regularly made. The average figure resulting from data for all fishers surveyed, per habitat targeted, provides a first impression of the community's engagement in finfish fisheries and shows whether or not different habitats are fished with the same frequency.

Information on the utilisation of non-motorised or motorised boat transport for fishing helps to assess accessibility, availability and choice of fishing grounds. Motorised boats may also represent a multiplication factor as they may accommodate larger fishing parties.

We ask about the size of the fishing party that the interviewee usually joins to learn whether there are particularly active or regular fisher groups, whether these are linked to fishing in certain habitats, and whether there is an association between the size of a fishing party and fishing for subsistence or sale. We also use this information to determine whether information regarding an average catch applies to one or to several fishers.

The duration of a fishing trip is defined as the time spent from any preparatory work through the landing of the catch. This definition takes into account the fact that fishing in a Pacific Island context does not follow a western economic approach of benefit maximisation, but is a more integral component of people's lifestyles. Preparatory time may include up to several hours spent reaching the targeted fishing ground. Fishing time may also include any time spent on the water, regardless of whether there was active fishing going on. The average trip duration is calculated for each habitat fished, and is usually compared to the average frequency of trips to these habitats (see discussion above).

Temporal fishing patterns – the times when most people go fishing – may reveal whether the timing of fishing activities depends primarily on individual time preferences or on the tides. There are often distinct differences between different fisher groups (e.g. those that fish mostly for food or mostly for sale, men and women, and fishers using different techniques). Results are provided in percentage of fishers interviewed for each habitat fished.

To calculate total annual fishing impact, we determine the total number of months that each interviewee fishes. As mentioned earlier, the seasonality of complementary activities (e.g. agriculture), seasonal closing of fishing areas, etc. may result in distinct fishing patterns. To take into account exceptional periods throughout the year when fishing is not possible or not pursued, we apply a correction factor of 0.83 to the total provided by people interviewed (this factor is determined on the basis that about two months of every year – specifically, 304/365 days – are not used for fishing due to festivals, funerals and bad weather conditions).

Knowing the range of techniques used and learning which technique(s) is/are predominantly used helps to identify the possible causes of detrimental impacts on the resource. For example, the predominant use of gillnets, combined with particular mesh sizes, may help to assess the impact on a certain number of possible target species, and on the size classes that would be caught. Similarly, spearfishing targets particular species, and the impacts of spearfishing on the abundance of these species in the habitats concerned may become evident. To reveal the degree to which fishers use a variety of different techniques, the percentage of techniques used refers to the proportion of all fishers who use that technique. Percentages show which techniques are used by most or even all fishers, and which are used by smaller groups. In addition, the data are presented by habitat (what percentage of fishers targeting a habitat use a particular technique, where n = the total number of fishers interviewed by habitat).

The use of ice (whether it is used at all, used infrequently or used regularly) hints at the degree of commercialisation, available infrastructure and investment level. Usually, communities targeted by our project are remote and rather isolated, and infrastructure is rudimentary. Thus, ice needs to be purchased and is often obtained from distant sources, with attendant costs in terms of transport and time. On the other hand, ice may be the decisive input that allows marketing at a regional or urban centre. The availability of ice may also be a decisive factor in determining the frequency of fishing trips.

Determining the use of the catch or shares thereof for various purposes (subsistence, non-monetary exchange and sale) is a necessary prerequisite to providing fishery management advice. Fishing pressure is relatively stable if determined predominantly by the community's subsistence demand. Fishing is limited by the quantity that the community can consume, and changes occur in response to population growth and/or changes in eating habits. In contrast, if fishing is performed mainly for external sale, fishing pressure varies according to outside market demand (which may be dynamic) and the cost-benefit (to fishers) of fishing. Fishing strategies may vary accordingly and significantly. The recorded purposes of fishing are presented as the percentage of all fishers interviewed per habitat fished. We distinguish these figures by habitat so as to allow for the fact that one fisher may fish several habitats but do so for different purposes.

Information on the additional involvement of interviewed fishers in invertebrate fisheries, for either subsistence or commercial purposes, helps us to understand the subsistence and/or commercial importance of various coastal resources. The percentage of finfish fishers who also harvest invertebrates is calculated, with the share of these who do so for subsistence and/or for commercial purposes presented in percentage (the sum of the latter percentages may exceed 100, because fishers may harvest invertebrates for both subsistence and sale).

The average catch per habitat (technique and transport used) is recorded, including:

- a list of species, usually by vernacular names; and
- the kg or number per size class for each species.

These data are used to calculate total weight per species and size class, using a weight–length conversion factor (FishBase 2000, refer to Letourneur *et al.* 1998; Kulbicki pers. com.). This requires using the vernacular/scientific name index to relate (as far as possible) local names to their scientific counterparts. Fish length is reported by using size charts that comprise five major size classes in 8 cm intervals, i.e. 8 cm, 16 cm, 24 cm, 32 cm and 40 cm. The length of any fish that exceeds the largest size class (40 cm) presented in the chart is individually estimated using a tape measure. The length–weight relationship is calculated for each site using a regression on catch records from finfish fishers' interviews weighted by the annual catch. Data used from the catch records consist of scientific names correlated to the vernacular names given by fishers, number of fish, size class (or measured size) and/or weight. In other words, we use the known length–weight relationship for the corresponding species to vernacular names recorded.

Once we have established the average and total weight per species and size class recorded, we provide an overview of the average size for each family. The resulting pattern allows analysis of the degree to which average and relative sizes of species within the various families present at a particular site are homogeneous. The same average distribution pattern is calculated for all families, per habitat, in order to reveal major differences due to the locations where the fish were caught. Finally, we combine all fish records caught, per habitat and site, to determine what proportion of the extrapolated total annual catch is composed of each of the various size classes. This comparison helps to establish the most dominant size class caught overall, and also reveals major differences between the habitats present at a site.

Catch data are further used to calculate the total weight for each family (includes all species reported) and habitat. We then convert these figures into the percentage distribution of the total annual catch, by family and habitat. Comparison of relative catch composition helps to identify commonalities and major differences, by habitat and between those fish families that are most frequently caught.

A number of parameters from the household and fisher surveys are used to calculate the total annual catch volume per site, habitat, gender, and use of the catch (for subsistence and/or commercial purposes).

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Data from the household survey regarding the number of fishers (by gender and type of fishery) in each household interviewed are extrapolated to determine the total number of men and women that target finfish, invertebrates, or both.

Data from the fisher survey are used to determine what proportion of men and women fishers target various habitats or combinations of habitats. These figures are assumed to be representative of the community as a whole, and hence are applied to the total number of fishers (as determined by the household survey). The total number of finfish fishers is the sum of all fishers who solely target finfish, and those who target both finfish and invertebrates; the same system is applied for invertebrate fishers (i.e. it includes those who collect only invertebrates and those who target both invertebrates and finfish. These numbers are also disaggregated by gender.

The total annual catch per fisher interviewed is calculated, and the average total annual catch reported for each type of fishing activity/fishery (including finfish and invertebrates) by gender is then multiplied by the total number of fishers (calculated as detailed above, for each type of fishing activity/fishery and both genders). More details on the calculation applied to invertebrate fisheries are provided below.

Total annual catch (t/year):

$$\mathrm{TAC} = \sum_{h=1}^{N_h} \frac{Fif_h \bullet Acf_h + Fim_h \bullet Acm_h}{1000}$$

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:

$$\mathrm{Acf_h} = \frac{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cfi}{If_h} \bullet \frac{\sum_{k=1}^{Rf_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

If_h = number of interviews of female fishers for habitat_h (total number of interviews where female fishers provided detailed information for habitat_h)
f_i = frequency of fishing trips (trips/week) as reported on interview_i
Fm_i = number of months fished (reported in interview_i)
Cf_i = average catch reported in interview_i (all species)
Rf_h = number of targeted habitats as reported by female fishers for habitat_h (total numbers of interviews where female fishers reported targeting habitat_h but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat_k
Fm_k = number of months fished for reported habitat_k (fishers = sum of finfish fishers and mixed fishers, i.e. people pursuing both finfish and invertebrate fishing)

Thus, we obtain the total annual catch by habitat and gender group. The sum of all catches from all habitats and both genders equals the total annual impact of the community on its fishing ground.

The accuracy of this calculation is determined by reliability of the data provided by interviewees, and the extrapolation procedure. The variability of the data obtained through fisher surveys is illuminated by providing standard errors for the calculated average total annual catches. The size of any error stemming from our extrapolation procedure will vary according to the total population at each site. As mentioned above, this approach is best suited to assess small and predominantly traditional coastal communities. Thus, the risk of over- or underestimating fishing impact increases in larger communities, and those with greater urban influences. We provide both the total annual catch by interviewees (as determined from fisher records) and the extrapolated total impact of the community, so as to allow comparison between recorded and extrapolated data.

The total annual finfish consumption of the surveyed community is used to determine the share of the total annual catch that is used for subsistence, with the remainder being the proportion of the catch that is exported (sold externally).

<u>Total annual finfish export:</u>

$$E = TAC - \left(\frac{F_{tot}}{1000} \bullet \frac{1}{0.8}\right)$$

Where:

E = total annual export (t)
TAC = total annual catch (t)
F_{tot} = total annual finfish consumption (net weight kg)
$\frac{1}{0.8}$ = to calculate total biomass/weight, i.e. compensate for the earlier deduction by 0.8 to determine edible weight parts only

In order to establish <u>fishing pressure</u>, we use the habitat areas as determined by satellite interpretation. However, as already mentioned, resource surveys and satellite interpretation do not include lagoon areas. Thus, we determine the missing areas by calculating the smallest possible polygon (Figure A1.1.3) that encompasses the total fishing ground determined with fishers and local people during the fieldwork. In cases where fishing grounds are gazetted, owned and managed by the community surveyed, the missing areas are determined using the community's fishing ground limits.

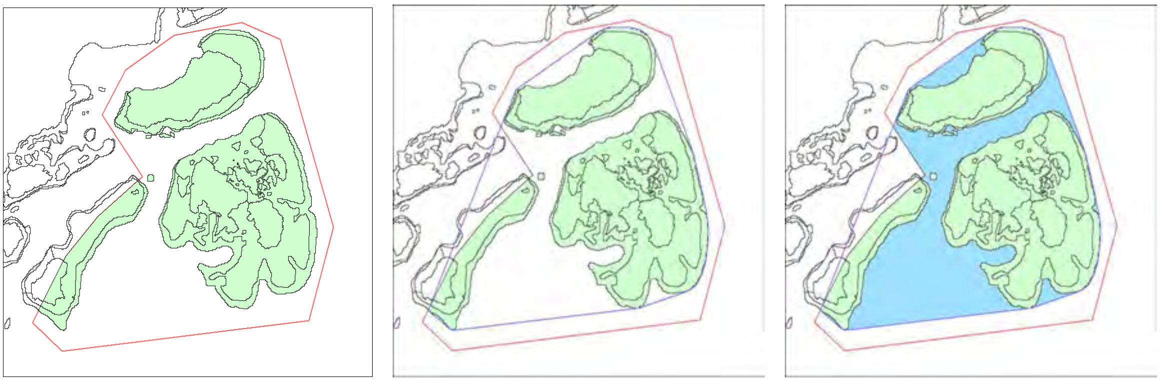

Figure A1.1.3: Determination of lagoon area.
The fishing ground (in red) is initially delineated using information from fishers. Reef areas within the fishing area (in green; interpreted from satellite data) are then identified. The remaining non-reef areas within the fishing grounds are labelled as lagoon (in blue) (Developed using MapInfo).

We use the calculated total annual impact and fishing ground areas to determine relative fishing pressure. Fishing pressure indicators include the following:

- annual catch per habitat
- annual catch per total reef area
- annual catch per total fishing ground area.

Fisher density includes the total number of fishers per km^2 of reef and total fishing ground area, and productivity is the annual catch per fisher. Due to the lack of baseline data, we compare selected indicators, such as fisher density, productivity (catch per fisher and year) and total annual catch (per reef and total fishing ground area), across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The catch per unit effort (CPUE) is generally acknowledged as an indicator of the status of a resource. If an increasing amount of time is required to obtain a certain catch, degradation of the resource is assumed. However, taking into account that our project is based on a snapshot approach, CPUE is used on a comparative basis between sites within a country, and will be employed later on a regional scale. Its application and interpretation must also take into account the fact that fishing in the Pacific Islands does not necessarily follow efficiency or productivity maximisation strategies, but is often an integral component of people's lifestyles. As a result, CPUE has limited applicability.

In order to capture comparative data, in calculating CPUE we use the entire time spent on a fishing trip, including travel, fishing and landing. Thus, we divide the total average catch per fisher by the total average time spent per fishing trip. CPUE is determined as an overall average figure, by gender and habitat fished.

Invertebrate fisher survey

The objective, purpose and design of the invertebrate fisher survey largely follow those of the finfish fisher survey. Thus, the primary aim of the invertebrate fisher survey is to collect data needed to understand the strategies, patterns and dimensions of invertebrate fisheries, and hence the possible impacts on invertebrate resources. Invertebrate data collection faces several challenges, as retrieval of information from local people needs to match the resource survey parameters in order to enable joint data analysis. Some of the major issues are:

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(i) The invertebrate resource survey defines invertebrate fisheries using differing parameters (several are primarily determined by habitat, others by target species). However, these fisheries classifications do not necessarily coincide with the perceptions and fishing strategies of local people. In general, there are two major types of invertebrate fishers: those who walk and collect with simple tools, and those who free-dive using masks, fins, snorkel, hands, simple tools or spears. The latter group is often more commercially oriented, targeting species that are exploited for export (trochus, BdM, lobster, etc.). However, some of the divers may harvest invertebrates as a by-product of spearfishing for finfish. Fishers who primarily walk (some may or may not use non-motorised or even motorised transport to reach fishing grounds) are mainly gleaners targeting available habitats (or a combination of habitats, if convenient). While gleaning is often performed for subsistence needs, it may also be used as a source of income, albeit mostly serving national rather than export markets. While gleaning is an activity that may be performed by both genders, diving is usually men's domain.

We have addressed the problem of collecting information according to fisheries as defined by the resource survey by asking people to report according to the major habitats they target and/or species-specific dive fisheries they engage in. Very often this results in the grouping of various fisheries, as they are jointly targeted or performed on one fishing trip. Where possible, we have disaggregated data for these groups and allocated individuals to specific fisheries. Examples of such data disaggregation are the proportion of all fishers and fishers by gender targeting each of the possible fisheries at one site.

We have also disaggregated some of the catch data, because certain species are always or mostly associated with a particular fishery. However, the disagreement between people's perception and the resource classification becomes visible when comparing species composition per fishery (or combination of fisheries) as reported by interviewed fishers, and the species and total annual wet weight harvested allocated individually by fishery, as defined by the resource survey.

(ii) As is true for finfish, people usually provide information on invertebrate species by vernacular or common names, which are far less specific and thus not directly compatible with scientific nomenclature. Vernacular name systems are often very localised, changing with local languages, and thus may differ significantly between the sites surveyed in one country. Differing from finfish, vernacular names for invertebrates usually combine a group (often a family) of species, and are rarely species specific.

Similar to finfish, the issue of vernacular versus scientific names is addressed by trying to index as many scientific names as possible for any vernacular name recorded during the ongoing survey. Inconsistencies between informants are a limiting factor. The use of photographic indices is very useful, but may trigger misleading information; in addition, some reported species may not be depicted. Again, collaboration with local counterparts from fisheries departments is crucial.

The lack of specificity in the vernacular names used for invertebrates is an issue that cannot be resolved, and specific information regarding particular species that are included with others under one vernacular name cannot be accurately provided.

(iii) The assessment of possible fishing impacts is based on the collection of average data. This means that fishers are requested to provide information on a catch that is neither exceptionally good nor exceptionally bad. They are also requested to provide this information concerning the most commonly caught species. In the case of invertebrate fisheries this results in underestimation of the total number of species caught, and often greater attention is given to commercial species than to rare species that are used mainly for consumption. Seasonality of invertebrate species appears to be a less important issue than when compared to finfish.

We address these problems by encouraging people to also share with us the names of species they may only rarely catch.

(iv) Assessment of possible fishing impact requires knowledge of the size–weight relationship of (at least) the major species groups harvested. Unfortunately, a comparative tool (such as FishBase and others that are used for finfish) is not available for invertebrates. In addition, the proportion of edible and non-edible parts varies considerably among different groups of invertebrates. Further, non-edible parts may still be of value, as for instance in the case of trochus. However, these ratios are also not readily available and hence limit current data analysis.

We have dealt with this limitation by applying average weights (drawn from the literature or field measurements) for certain invertebrate groups. The applied wet weights are listed in Appendix 1.1.3. We used this approach to estimate total biomass (wet weight) removed; we have also listed approximations of the ratio between edible and non-edible biomass for each species.

Information on <u>invertebrate fishing strategies</u> 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 <u>species composition of an average catch</u> is listed, and the average catch for each fishery is specified by number, size and/or total weight. If local units such as bags (plastic bags, flour bags), cups, bottles or buckets are used, the approximate weight of each unit is estimated and/or weighed during the field survey and average weight applied accordingly. For size classes, size charts for different species groups are used (Figure A1.1.2).

The proportion of fishers targeting each fishery (as defined by the resource survey) is presented as a percentage of all fishers. Records of fisheries that are combined in one trip are disaggregated by counting each fishery as a single data entry. The same process is applied to determine the share of women and men fishers per fishery (as defined by the resource survey).

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The number of different vernacular names recorded for each fishery is useful to distinguish between opportunistic and specialised harvesting strategies. This distribution is particularly interesting when comparing gleaning fisheries, while commercial dive fisheries are species specific by definition.

The calculation of 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:

$$\text{Ac}_{\text{inv}}\text{f}_{\text{hj}} = \frac{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cf_{ij}}{I_{inv}f_h} \bullet \frac{\sum_{k=1}^{R_{inv}f_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

$I_{inv}f_h$ = number of interviews of female invertebrate fishers for habitat_h (total numbers of interviews where female invertebrate fishers provided detailed information for habitat_h)

f_i = frequency of fishing trips (trips/week) as reported in interview_i

Fm_i = number of months fished as reported in interview$_i$
Cf_{ij} = average catch reported for species$_j$ as reported in interview$_i$
$R_{inv}f_h$ = number of targeted habitats reported by female invertebrate fishers for habitat$_h$ (total numbers of interviews where female invertebrate fishers reported targeting habitat$_h$ but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat$_k$
Fm_k = number of months fished for reported habitat$_k$

The total annual biomass (t/year) removed is also calculated and presented by species after transferring vernacular names to scientific nomenclature. Size frequency distributions are provided for the most important species, by total annual weight removed, expressed in percentage of each size group of the total annual weight harvested. The size frequency distribution may reveal the impact of fishing pressure for species that are represented by a wide size range (from juvenile to adult state). It may also be a useful parameter to compare the status of a particular species or species group across various sites at the national or even regional level.

To further determine fishing strategies, we also inquire about the purpose of harvesting each species (as recorded by vernacular name). Results are depicted as the proportion (in kg/year) of the total annual biomass (net weight) removed for each purpose: consumption, sale or both. We also provide an index of all species recorded through fisher interviews and their use (in percentage of total annual weight) for any of the three categories.

In order to gain an idea of the productivity of and differences between the fisheries practices used in each site we calculate the average annual catch per fisher, by gender and fishery. This calculation is based on the total biomass (net weight) removed from each fishery and the total number of fishers by gender group.

For invertebrate species that are marketed, detailed information is collected on total numbers (weight and/or combination of number and size), processing level, location of sale or client, frequency of sales and price received per unit sold. At this stage of our project we do not fully analyse this marketing information. However, prices received for major commercial species, as well as an approximation of sale volumes by fishery and fisher, help to assess what role invertebrate fisheries (or a particular fishery) play(s) in terms of income generation for the surveyed community, and in comparison to the possible earnings from finfish fisheries.

We use the calculated total annual impact in combination with the fishing ground area to determine relative fishing pressure. Fishing pressure indicators are calculated as the annual catch per km^2 for each area that is considered to support any of the fisheries present at each study site. In some instances (e.g. intertidal fisheries), areas are replaced by linear km; accordingly, fishing pressure is then related to the length (in km) of the supporting habitat. Due to the lack of baseline data, we compare selected indicators, such as the fisher density (number of fishers per km^2 – or linear km – of fishing ground, for each fishery), productivity (catch per fisher and year) and total annual catch per fishery, across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The differing nature of invertebrate species that may be caught during one fishing trip, and hence the great variability between edible and non-edible, useful and non-useful parts of species caught, make the determination of CPUE difficult. Substantial differences in the economic value of species add another challenge. We have therefore refrained from calculating CPUE values at this stage of the project.

Data entry and analysis

Data from all questionnaire forms are entered in the Reef Fisheries Integrated Database (RFID) system. All data entered are first verified and 'cleaned' prior to analysis. In the process of data entry, a comprehensive list of vernacular and corresponding scientific names for finfish and invertebrate species is developed.

Database queries have been defined and established that allow automatic retrieval of the descriptive statistics used when summarising results at the site and national levels.

1.1.2 Socioeconomic survey questionnaires

- Household census and consumption survey
- Finfish fishing and marketing survey (for fishers)
- Invertebrate fishing and marketing survey (for fishers)
- Fisheries (finfish and invertebrate and socioeconomics) general information survey

HOUSEHOLD CENSUS AND CONSUMPTION SURVEY

HH NO. ☐

Name of head of household: ________________ Village: _________________

Name of person asked: _____________________ Date: __________________

Surveyor's ID: __________________

1. Who is the head of your household? *(must be living there; tick box)* — male ☐ female ☐

2. How old is the head of household? *(enter year of birth)* ☐

3. How many people ALWAYS live in your household? *(enter number)* ☐

4. How many are male and how many are female? (*tick box and enter age in years or year of birth)*

male	age	female	age
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐

5. Does this household have any agricultural land?

yes ☐ no ☐

6. How much (*for this household only*)?

for permanent/regular cultivation ☐ (unit)

for permanent/regular livestock ☐ (unit)

type of animals__________ no. ☐

7. How many fishers live in your household?
(*enter number of people who go fishing/collecting regularly)*

invertebrate fishers		finfish fishers		invertebrate & finfish fishers	
M	F	M	F	M	F

8. Does this household own a boat? yes no

9a. Canoe		length?		metres/feet	
Sailboat		length?		metres/feet	
Boat with outboard engine		length?		metres/feet	HP
9b. Canoe		length?		metres/feet	
Sailboat		length?		metres/feet	
Boat with outboard engine		length?		metres/feet	HP
9c. Canoe		length?		metres/feet	
Sailboat		length?		metres/feet	
Boat with outboard engine		length?		metres/feet	HP

10. Where does the CASH money in this household come from? (*rank options, 1 = most money, 2 = second important income source, 3 = 3rd important income source, 4 = 4th important income source*)

Fishing/seafood collection

Agriculture (crops & livestock)

Salary

Others (handicrafts, etc.) specify: ____________________

11. Do you get remittances? yes no

12. How often? 1 per month 1 per 3 months 1 per 6 months other *(specify)*

13. How much? *(enter amount)* Every time? (currency) ☐

14. How much CASH money do you use on average for household expenditures (food, fuel for cooking, school bus, etc.)?

(currency) ☐ per week/2-weekly/month (or? specify_______)

15. What is the educational level of your household members?

no. of people	having achieved:
☐	elementary/primary education
☐	secondary education
☐	tertiary education (college, university, special schools, etc.)

CONSUMPTION SURVEY

16. During an average/normal week, on how many days do you prepare fish, other seafood and canned fish for your family? *(tick box)*

	7 days	6 days	5 days	4 days	3 days	2 days	1 day	other, specify
Fresh fish	☐	☐	☐	☐	☐	☐	☐	☐
Other seafood	☐	☐	☐	☐	☐	☐	☐	☐
Canned fish	☐	☐	☐	☐	☐	☐	☐	☐

17. Mainly at	breakfast	lunch	supper
Fresh fish	☐	☐	☐
Other seafood	☐	☐	☐
Canned fish	☐	☐	☐

18. How much do you cook on average per day for your household? *(tick box)*

	number	kg	size: A	B	C	D	E	>E (cm)
Fresh fish	☐	☐	☐	☐	☐	☐	☐	☐

Other seafood

name:	no.	size	kg	plastic bag ¼	½	¾	1
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐

19. Canned fish   No. of cans: ☐   Size of can: ☐ small
☐ medium
☐ big

20. Where do you normally get your fish and seafood from?

Fish:

☐ caught by myself/member of this household
☐ get it from somebody in the family/village (no money paid)
☐ buy it at ______________________

Which is the most important source? ☐ caught ☐ given ☐ bought

Invertebrates:

☐ caught by myself/member of this household
☐ get it from somebody in the family/village (no money paid)
☐ buy it at ______________________

Which is the most important source? ☐ caught ☐ given ☐ bought

21. Which is the last day you had fish? ______________________

22. Which is the last day you had other seafood? ______________________

–THANK YOU–

FISHING (FINFISH) AND MARKETING SURVEY

Name: ____________________ F ☐ M ☐ **HH NO.** ☐

Name of head of household: ________________________ Village: _______________

Surveyor's name: ______________________ Date: _______________

1. Which areas do you fish?

coastal reef ☐ lagoon ☐ outer reef ☐ mangrove ☐ pelagic ☐

2. Do you go to only one habitat per trip?

Yes ☐ no ☐

3. If no, how many and which habitats do you visit during an average trip?

total no. ☐ habitats: coastal reef ☐ lagoon ☐ mangrove ☐ outer reef ☐

4. How often (days/week) do you fish in each of the habitats visited?

coastal reef	lagoon	mangrove	outer reef	
☐	☐	☐	☐	___________/times per week/month
☐	☐	☐	☐	___________/times per week/month
☐	☐	☐	☐	___________/times per week/month

5. Do you use a boat for fishing?

	Always	sometimes	never
coastal reef	☐	☐	☐
lagoon	☐	☐	☐
mangrove	☐	☐	☐
outer reef	☐	☐	☐

6. If you use a boat, which one?

1 canoe (paddle) ☐ sailing ☐

motorised ☐ HP outboard ☐ 4-stroke engine ☐

coastal reef ☐ lagoon ☐ outer reef ☐

2	canoe (paddle)	☐					sailing	☐
	motorised	☐		HP outboard	☐		4-stroke engine	☐
	coastal reef	☐	lagoon ☐			outer reef ☐		
3	canoe (paddle)	☐					sailing	☐
	motorised	☐		HP outboard	☐		4-stroke engine	☐
	coastal reef	☐	lagoon ☐			outer reef ☐		

7. How many fishers ALWAYS go fishing with you?

Names:____
____
____
____

Appendix 1: Survey methods
Socioeconomics

INFORMATION BY FISHERY **Name of fisher:** ______________ **HH NO.** ☐

coastal reef ☐ lagoon ☐ mangrove ☐ outer reef ☐

1. HOW OFTEN do you normally go out FISHING for this habitat? *(tick box)*

Every Day	5 days/ week	4 days/ week	3 days/ week	2 days/ week	1 day/ week	other, specify:
☐	☐	☐	☐	☐	☐	____________________

2. What time do you spend fishing this habitat per average trip? ____________________
(if the fisher can't specify, tick a box)

<2 hrs	2–6 hrs	6–12 hrs	>12 hrs
☐	☐	☐	☐

3. WHEN do you go fishing? *(tick box)* day ☐ night ☐ day & night ☐

4. Do you go all year?

Yes ☐ no ☐

5. If no, which months <u>don't</u> you fish?

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6. Which fishing techniques do you use (*in the habitat referred to here*)?

☐ handline

☐ castnet ☐ gillnet

☐ spear (dive) ☐ longline

☐ trolling ☐ spear (handheld) walking ☐ canoe ☐

☐ deep bottom line ☐ poison: which one? ______________

☐ other, specify: ____

7. Do you use more than one technique per trip for this habitat? If yes, which ones usually?

☐ one technique/trip ☐ more than one technique/trip:

____

8. Do you use ice on your fishing trips?

☐ always ☐ sometimes ☐ never

☐ is it homemade? ☐ or bought?

9. What is your average catch (kg) per trip? ☐ Kg <u>OR:</u>

size class:	A	B	C	D	E	>E (cm)
number:	☐	☐	☐	☐	☐	☐

10. Do you sell fish? yes ☐ no ☐

11. Do you give fish as a gift (for no money)? yes ☐ no ☐

12. Do you use your catch for family consumption? yes ☐ no ☐

13. How much of your usual catch do you keep for family consumption?

kg ☐ <u>OR:</u>

size class	A	B	C	D	E	>E (cm)
no	☐	☐	☐	☐	☐	☐

and the rest you gift? yes ☐

how much? kg ☐ <u>OR:</u>

size class	A	B	C	D	E	>E (cm)
no.	☐	☐	☐	☐	☐	☐

and/or sell? yes ☐

how much? kg ☐ <u>OR</u>:

size class	A	B	C	D	E	>E (cm)
no.	☐	☐	☐	☐	☐	☐

14. What sizes of fish do you use for your family consumption, what for sale and what do you give away without getting any money?

size classes:	all	A	B	C	D	E	and larger (no. and cm)
consumption	☐	☐	☐	☐	☐	☐	☐
sale	☐	☐	☐	☐	☐	☐	☐
give away	☐	☐	☐	☐	☐	☐	☐

15. You sell where?

☐ inside village ☐ outside village where? ___________________________

and to whom?

market ☐ agents/middlemen ☐ shop owners ☐ others ☐ ___________

16. In an average catch what fish do you catch, and how much of each species? *(write down the species in the table)*

technique usually used:____________________ boat type usually used:_______________
habitat usually fished: ____

Specify the number by size

Name of fish	kg	A	B	C	D	E	>E cm

20. Do you also fish invertebrates?

Yes ☐ no ☐ <u>if yes</u> for consumption? ☐ sale? ☐

–THANK YOU–

INVERTEBRATE FISHING AND MARKETING SURVEY
FISHERS

HH NO. ☐

Name: ____________________________________

Gender: ☐ female ☐ male Age: ☐

Village: ____________________________________

Date: ________________ Surveyor's name: ____________________

Invertebrates = everything that is not a fish with fins!

1. Which type of fisheries do you do?

☐ seagrass gleaning ☐ mangrove & mud gleaning

☐ sand & beach gleaning ☐ reeftop gleaning

☐ bêche-de mer diving ☐ mother-of-pearl diving trochus, pearl shell, etc.

☐ lobster diving ☐ other, such as clams, octopus

2. *(if more than one fishery in question 1):* Do you usually go fishing at only one of the fisheries or do you visit several during one fishing trip?

☐ one only ☐ several

If several fisheries at a time, which ones do you combine?

----

3. How often do you go gleaning/diving (*tick as from questions 1 and 2 above and watch for combinations*) and for how long, and do you also finfish at the same time?

	times/week		duration in hours <2	2–4	4–6	>6	glean/dive at D	N	D&N	fish no. of months/year
			(if the fisher can't specify, tick the box)							
☐ seagrass gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ mangrove & mud gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ sand & beach gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ reeftop gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ bêche-de-mer diving	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ lobster diving	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ mother-of-pearl diving trochus, pearl shell, etc.	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ other diving (clams, octopus)	☐	____	☐	☐	☐	☐	☐	☐	☐	________

D = day, N = night, D&N = day and night (no preference but fish with tide)

4. Do you sometimes go gleaning/fishing for invertebrates outside your village fishing grounds?

yes ☐ no ☐

If yes, where? ____

5. Do you finfish? yes ☐ no ☐

for: ☐ consumption? ☐ sale?

at the same time? yes ☐ no ☐

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐ other (clams, octopus) ☐

SHEET 1: EACH FISHERY PER FISHER INTERVIEWED: ☐ **HH NO. __Name of fisher: ______________** **gender: F** ☐ **M** ☐

What transport do you mainly use? ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

How many fishers are usually on a trip? (total no.) ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit							
			1	3/4	1/2	1/4				

Appendix 1: Survey methods
Socioeconomics

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit							
			1	3/4	1/2	1/4				

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐ other (clams, octopus) ☐

SHEET 2: SPECIES SOLD PER FISHER INTERVIEWED: **HH NO**. ☐ **Name of fisher:** ______________________

Copy all species that have been named for 'SALE' in previous sheet

Who markets your products? ☐ you ☐ your wife ☐ your husband ☐ a group of fishers ☐ other ________________

Species for sale – copy from sheet 2 (for each fishery per fisher) above	Processing level of product sold (see list)	Where do you sell? (see list)	How often? Days/week?	How much each time? Quantity/unit	Price

FISHERIES (FINFISH AND INVERTEBRATE AND SOCIOECONOMICS) GENERAL INFORMATION SURVEY

Target group: key people, groups of fishers, fisheries officers, etc.

1. Are there management rules that apply to your fisheries? Do they specifically target finfish or invertebrates, or do they target both sectors?

a) legal/Ministry of Fisheries

b) traditional/community/village determined:

2. What do you think – do people obey:

traditional/village management rules?

mostly ☐ sometimes ☐ hardly ☐

legal/Ministry of Fisheries management rules?

mostly ☐ sometimes ☐ hardly ☐

3. Are there any particular rules that you know people do not respect or follow at all? And do you know why?

4. What are the main techniques used by the community for:

a) finfishing

gillnets – most-used mesh sizes:

What is usually used for bait? And is it bought or caught?

b) invertebrate fishing → ***see end!***

5. Please give a quick inventory and characteristics of boats used in the community (length, material, motors, etc.).

Seasonality of species

What are the **<u>FINFISH</u>** species that you do not catch during the total year? Can you specify the particular months that they are **<u>NOT</u>** fished?

Vernacular name	Scientific name(s)	Months NOT fished

Seasonality of species

What are the **INVERTEBRATE** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

How many people carry out the invertebrate fisheries below, from inside and from outside the community?

GLEANING	**no. from this village**	**no.**	**from village**	**no.**	**from village**
☐ seagrass gleaning	☐	☐	______	☐	______
☐ mangrove & mud gleaning	☐	☐	______	☐	______
☐ sand & beach gleaning	☐	☐	______	☐	______
☐ reeftop gleaning	☐	☐	______	☐	______
DIVING					
☐ bêche-de-mer diving	☐	☐	______	☐	______
☐ lobster diving	☐	☐	______	☐	______
☐ mother-of-pearl diving trochus, pearl shell, etc.	☐	☐	______	☐	______
☐ other (clams, octopus)	☐	☐	______	☐	______

What gear do invertebrate fishers use? *(tick box of technique per fishery)*

GLEANING (soft bottom = seagrass)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other __________		

GLEANING (soft bottom = mangrove & mud)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other __________		

GLEANING (soft bottom = sand & beach)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other __________		

GLEANING (hard bottom = reeftop)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other __________		

DIVING (bêche-de-mer)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other __________		

DIVING (lobster)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ goggles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ other __________		

DIVING (mother-of-pearl, trochus, pearl shell, etc.)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other ___________

DIVING (other, such as clams, octopus)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other ___________

Any traditional/customary/village fisheries?

Name:

Season/occasion:

Frequency:

Quantification of marine resources caught:

Species name	Size	Quantity (unit?)

1.1.3 Average wet weight applied for selected invertebrate species groups

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Acanthopleura gemmata	29	35	65	10.15	Chiton
Actinopyga lecanora	300	10	90	30	BdM (1)
Actinopyga mauritiana	350	10	90	35	BdM (1)
Actinopyga miliaris	300	10	90	30	BdM (1)
Anadara spp.	21	35	65	7.35	Bivalves
Asaphis violascens	15	35	65	5.25	Bivalves
Astralium spp.	20	25	75	5	Gastropods
Atactodea striata, *Donax cuneatus,* *Donax cuneatus*	2.75	35	65	0.96	Bivalves
Atrina vexillum, *Pinctada margaritifera*	225	35	65	78.75	Bivalves
Birgus latro	1000	35	65	350	Crustacean
Bohadschia argus	462.5	10	90	46.25	BdM (1)
Bohadschia spp.	462.5	10	90	46.25	BdM (1)
Bohadschia vitiensis	462.5	10	90	46.25	BdM (1)
Cardisoma carnifex	227.8	35	65	79.74	Crustacean
Carpilius maculatus	350	35	65	122.5	Crustacean
Cassis cornuta, *Thais aculeata,* *Thais aculeata*	20	25	75	5	Gastropods
Cerithium nodulosum, *Cerithium nodulosum*	240	25	75	60	Gastropods
Chama spp.	25	35	65	8.75	Bivalves
Codakia punctata	20	35	65	7	Bivalves
Coenobita spp.	50	35	65	17.5	Crustacean
Conus miles, *Strombus gibberulus gibbosus*	240	25	75	60	Gastropods
Conus spp.	240	25	75	60	Gastropods
Cypraea annulus, *Cypraea moneta*	10	25	75	2.5	Gastropods
Cypraea caputserpensis	15	25	75	3.75	Gastropods
Cypraea mauritiana	20	25	75	5	Gastropods
Cypraea spp.	95	25	75	23.75	Gastropods
Cypraea tigris	95	25	75	23.75	Gastropods
Dardanus spp.	10	35	65	3.5	Crustacean
Dendropoma maximum	15	25	75	3.75	Gastropods
Diadema spp.	50	48	52	24	Echinoderm
Dolabella auricularia	35	50	50	17.5	Others
Donax cuneatus	15	35	65	5.25	Bivalves
Drupa spp.	20	25	75	5	Gastropods
Echinometra mathaei	50	48	52	24	Echinoderm
Echinothrix spp.	100	48	52	48	Echinoderm
Eriphia sebana	35	35	65	12.25	Crustacean
Gafrarium pectinatum	21	35	65	7.35	Bivalves
Gafrarium tumidum	21	35	65	7.35	Bivalves
Grapsus albolineatus	35	35	65	12.25	Crustacean
Hippopus hippopus	500	19	81	95	Giant clams
Holothuria atra	100	10	90	10	BdM (1)
Holothuria coluber	100	10	90	10	BdM (1)

1.1.3 Average wet weight applied for selected invertebrate species groups (continued)

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Holothuria fuscogilva	2000	10	90	200	BdM (1)
Holothuria fuscopunctata	1800	10	90	180	BdM (1)
Holothuria nobilis	2000	10	90	200	BdM (1)
Holothuria scabra	2000	10	90	200	BdM (1)
Holothuria spp.	2000	10	90	200	BdM (1)
Lambis lambis	25	25	75	6.25	Gastropods
Lambis spp.	25	25	75	6.25	Gastropods
Lambis truncata	500	25	75	125	Gastropods
Mammilla melanostoma, *Polinices mammilla*	10	25	75	2.5	Gastropods
Modiolus auriculatus	21	35	65	7.35	Bivalves
Nerita albicilla, *Nerita polita*	5	25	75	1.25	Gastropods
Nerita plicata	5	25	75	1.25	Gastropods
Nerita polita	5	25	75	1.25	Gastropods
Octopus spp.	550	90	10	495	Octopus
Panulirus ornatus	1000	35	65	350	Crustacean
Panulirus penicillatus	1000	35	65	350	Crustacean
Panulirus spp.	1000	35	65	350	Crustacean
Panulirus versicolor	1000	35	65	350	Crustacean
Parribacus antarcticus	750	35	65	262.5	Crustacean
Parribacus caledonicus	750	35	65	262.5	Crustacean
Patella flexuosa	15	35	65	5.25	Limpet
Periglypta puerpera, *Periglypta reticulate*	15	35	65	5.25	Bivalves
Periglypta spp., *Periglypta* spp., *Spondylus* spp., *Spondylus* spp.,	15	35	65	5.25	Bivalves
Pinctada margaritifera	200	35	65	70	Bivalves
Pitar proha	15	35	65	5.25	Bivalves
Planaxis sulcatus	15	25	75	3.75	Gastropods
Pleuroploca filamentosa	150	25	75	37.5	Gastropods
Pleuroploca trapezium	150	25	75	37.5	Gastropods
Portunus pelagicus	227.83	35	65	79.74	Crustacean
Saccostrea cucullata	35	35	65	12.25	Bivalves
Saccostrea spp.	35	35	65	12.25	Bivalves
Scylla serrata	700	35	65	245	Crustacean
Serpulorbis spp.	5	25	75	1.25	Gastropods
Sipunculus indicus	50	10	90	5	Seaworm
Spondylus squamosus	40	35	65	14	Bivalves
Stichopus chloronotus	100	10	90	10	BdM (1)
Stichopus spp.	543	10	90	54.3	BdM (1)
Strombus gibberulus gibbosus	25	25	75	6.25	Gastropods
Strombus luhuanus	25	25	75	6.25	Gastropods
Tapes literatus	20	35	65	7	Bivalves
Tectus pyramis, *Trochus niloticus*	300	25	75	75	Gastropods
Tellina palatum	21	35	65	7.35	Bivalves

1.1.3 Average wet weight applied for selected invertebrate species groups (continued)

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Tellina spp.	20	35	65	7	Bivalves
Terebra spp.	37.5	25	75	9.39	Gastropods
Thais armigera	20	25	75	5	Gastropods
Thais spp.	20	25	75	5	Gastropods
Thelenota ananas	2500	10	90	250	BdM [(1)]
Thelenota anax	2000	10	90	200	BdM [(1)]
Tridacna maxima	500	19	81	95	Giant clams
Tridacna spp.	500	19	81	95	Giant clams
Trochus niloticus	200	25	75	50	Gastropods
Turbo crassus	80	25	75	20	Gastropods
Turbo marmoratus	20	25	75	5	Gastropods
Turbo setosus	20	25	75	5	Gastropods
Turbo spp.	20	25	75	5	Gastropods

BdM = Bêche-de-mer; [(1)] edible part of dried Bêche-de-mer, i.e. drying process consumes about 90% of total wet weight; hence 10% are considered as the edible part only.

1.2 Methods used to assess the status of finfish resources

Fish counts

In order to count and size fish in selected sites, we use the **distance-sampling underwater visual census (D-UVC)** method (Kulbicki and Sarramegna 1999, Kulbicki *et al.* 2000), fully described in Labrosse *et al.* (2002). Briefly, the method consists of recording the species name, abundance, body length and the distance to the transect line for each fish or group of fish observed; the transect consists of a 50 m line, represented on the seafloor by an underwater tape (Figure A1.2.1). For security reasons, two divers are required to conduct a survey, each diver counting fish on a different side of the transect. Mathematical models are then used to estimate fish density (number of fish per unit area) and biomass (weight of fish per unit area) from the counts.

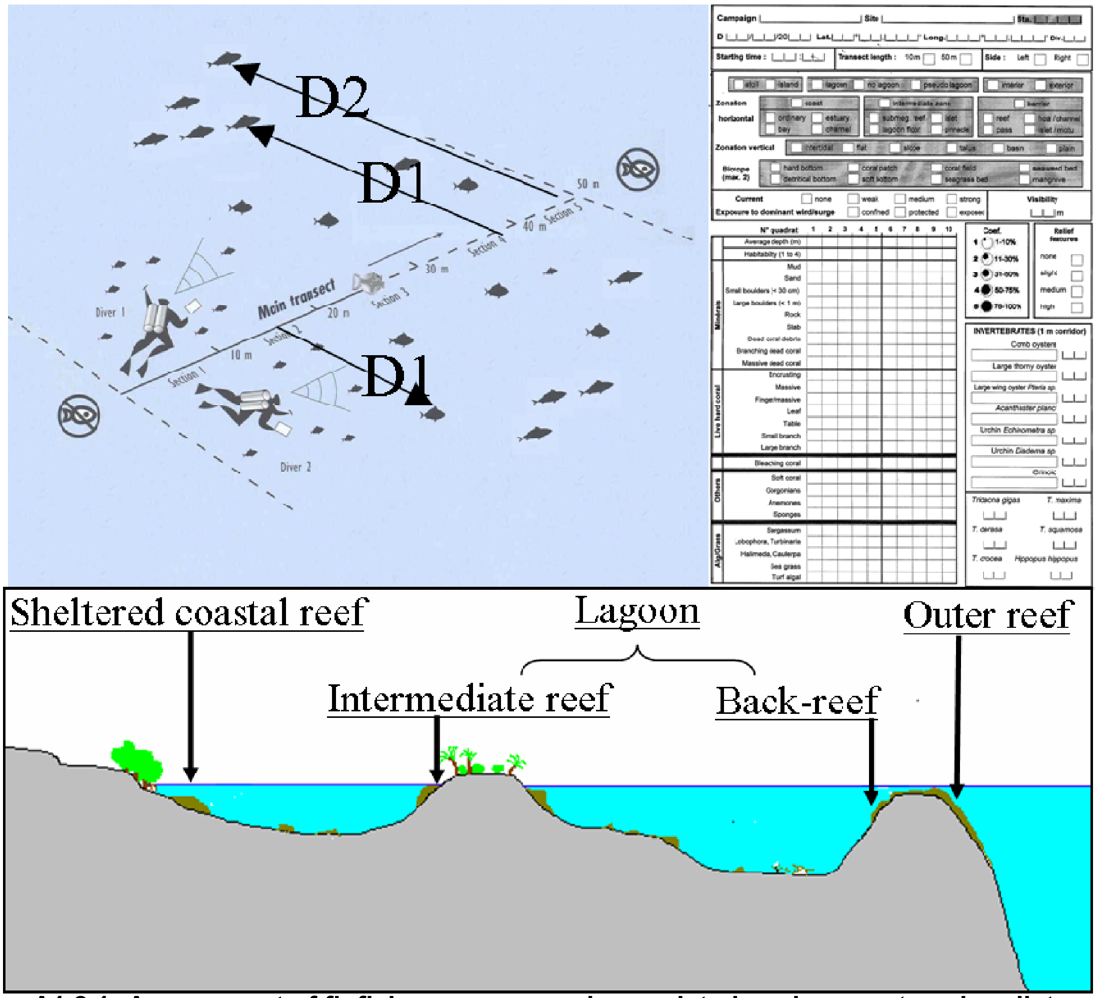


Figure A1.2.1: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver records the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys are conducted along 24 transects, with six transects in each of the four main geomorphologic coral reef structures: sheltered coastal reefs, intermediate reefs and back-reefs (lumped into the 'lagoon reef' category of socioeconomic assessment), and outer reefs. D1 is the distance of an observed fish from the transect line. If a school of fish is observed, D1 is the distance from the transect line to the closest fish; D2 the distance to the furthest fish.

Appendix 1: Survey methods
Finfish

Species selection

Only reef fish of interest for consumption or sale and species that could potentially serve as indicators of coral reef health are surveyed (see Table A1.2.1; Appendix 3.2 provides a full list of counted species and abundance for each site surveyed).

Table A1.2.1: List of finfish species surveyed by distance sampling underwater visual census (D-UVC)
Most frequently observed families on which reports are based are highlighted in yellow.

Family	Selected species
Acanthuridae	All species
Aulostomidae	*Aulostomus chinensis*
Balistidae	All species
Belonidae	All species
Caesionidae	All species
Carangidae	All species
Carcharhinidae	All species
Chaetodontidae	All species
Chanidae	All species
Dasyatidae	All species
Diodontidae	All species
Echeneidae	All species
Ephippidae	All species
Fistulariidae	All species
Gerreidae	*Gerres* spp.
Haemulidae	All species
Holocentridae	All species
Kyphosidae	All species
Labridae	*Bodianus axillaris, Bodianus loxozonus, Bodianus perditio, Bodianus* spp.*, Cheilinus:* all species*, Choerodon:* all species*, Coris aygula, Coris gaimard, Epibulus insidiator, Hemigymnus:* all species*, Oxycheilinus diagrammus, Oxycheilinus* spp.
Lethrinidae	All species
Lutjanidae	All species
Monacanthidae	*Aluterus scriptus*
Mugilidae	All species
Mullidae	All species
Muraenidae	All species
Myliobatidae	All species
Nemipteridae	All species
Pomacanthidae	*Pomacanthus semicirculatus, Pygoplites diacanthus*
Priacanthidae	All species
Scaridae	All species
Scombridae	All species
Serranidae	Epinephelinae: all species
Siganidae	All species
Sphyraenidae	All species
Tetraodontidae	*Arothron*: all species
Zanclidae	All species

Appendix 1: Survey methods
Finfish

Analysis of percentage occurrence in surveys at both regional and national levels indicates that of the initial 36 surveyed families, only 15 families are frequently seen in country counts. Since low percentage occurrence could either be due to rarity (which is of interest) or low detectability (representing a methodological bias), we decided to restrict our analysis to the 15 most frequently observed families, for which we can guarantee that D-UVC is an efficient resource assessment method.

These are:

- Acanthuridae (surgeonfish)
- Balistidae (triggerfish)
- Chaetodontidae (butterflyfish)
- Holocentridae (squirrelfish)
- Kyphosidae (drummer and seachubs)
- Labridae (wrasse)
- Lethrinidae (sea bream and emperor)
- Lutjanidae (snapper and seaperch)
- Mullidae (goatfish)
- Nemipteridae (coral bream and butterfish)
- Pomacanthidae (angelfish)
- Scaridae (parrotfish)
- Serranidae (grouper, rockcod, seabass)
- Siganidae (rabbitfish)
- Zanclidae (moorish idol).

Substrate

We used the **medium-scale approach** (MSA) to record substrate characteristics along transects where finfish were counted by D-UVC. MSA has been developed by Clua *et al.* (2006) to specifically complement D-UVC surveys. Briefly, the method consists of recording depth, habitat complexity, and 23 substrate parameters within ten 5 x 5 m quadrats located on each side of a 50 m transect, for a total of 20 quadrats per transect (Figure A1.2.1). The transect's habitat characteristics are then calculated by averaging substrate records over the 20 quadrats.

Parameters of interest

In this report, the status of finfish resources has been characterised using the following seven parameters:

- **biodiversity –** the number of families, genera and species counted in D-UVC transects;
- **density** (fish/m^2) – estimated from fish abundance in D-UVC;
- **size** (cm fork length) – direct record of fish size by D-UVC;
- **size ratio** (%) – the ratio between fish size and maximum reported size of the species. This ratio can range from nearly zero when fish are very small to nearly 100 when a given fish has reached the greatest size reported for the species. Maximum reported size (and source of reference) for each species are stored in our database;

- **biomass** (g/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 1,000 categories. These very detailed categories can be used directly to try to explain the status of living resources or be lumped into more general categories to fit a study's particular needs. For the needs of the finfish resource assessment, MCRMP reef types were grouped into the four main coralline geomorphologic structures found in the Pacific (Figure A1.2.2):

- **sheltered coastal reef**: reef that fringes the land but is located inside a lagoon or a pseudo-lagoon
- **lagoon reef**:
  - **intermediate reef** – patch reef that is located inside a lagoon or a pseudo-lagoon, and
  - **back-reef** – inner/lagoon side of outer reef
- **outer reef**: ocean side of fringing or barrier reefs.

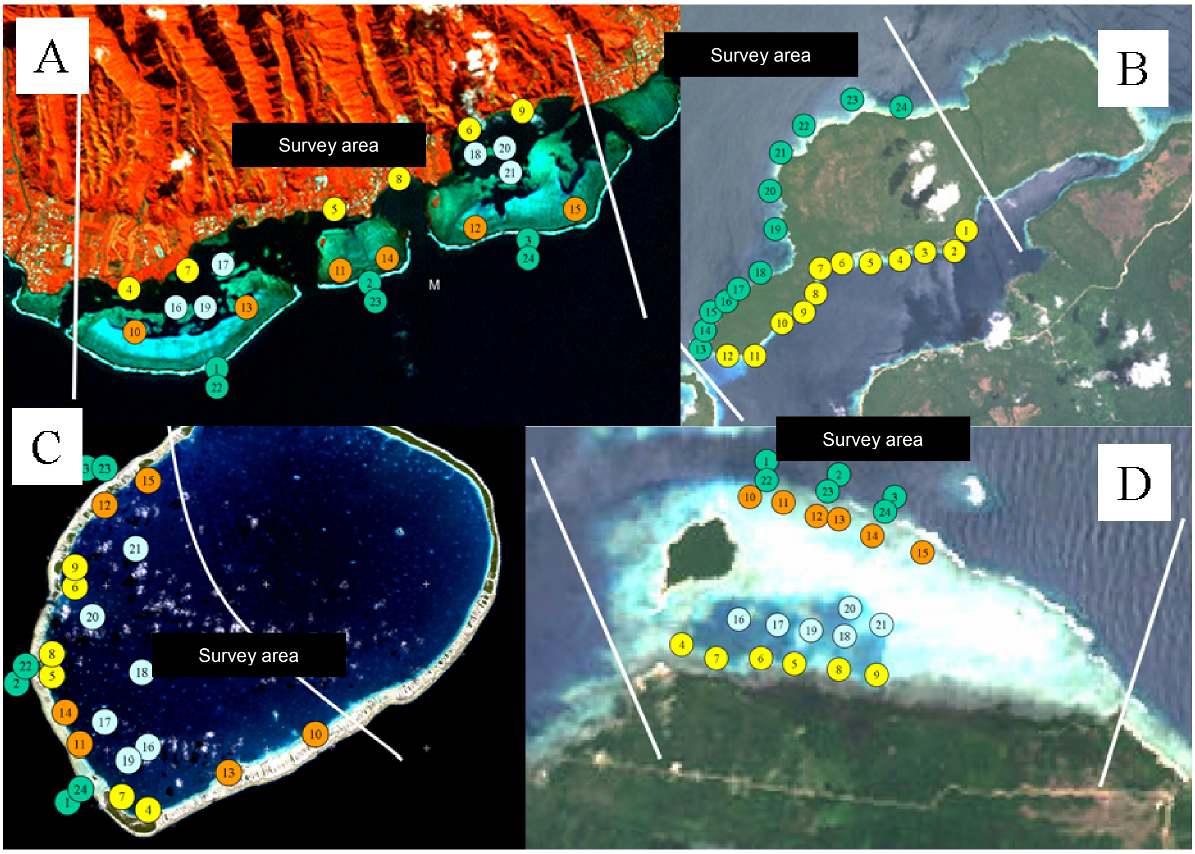


Figure A1.2.2: Position of the 24 D-UVC transects surveyed in A) an island with a lagoon, B) an island with a pseudo-lagoon C) an atoll and D) an island with an extensive reef enclosing a small lagoon pool.
Sheltered coastal reef transects are in yellow, lagoon intermediate-reef transects in blue, lagoon back-reef transects in orange and outer-reef transects in green. Transect locations are determined using satellite imagery prior to going into the field, which greatly enhances fieldwork efficiency. The white lines delimit the borders of the survey area.

Fish and associated habitat parameters are recorded along 24 transects per site, with a balanced design among the main geomorphologic structures present at a given site (Figure A1.2.2). For example, our design results in at least six transects in each of the sheltered coastal, lagoon intermediate, lagoon back-reef, and outer reefs of islands with lagoons (Figure A1.2.2A) or 12 transects in each of the sheltered coastal and outer reefs of islands with pseudo-lagoons (Figure A1.2.2B). This balanced, stratified and yet flexible sampling design was chosen to optimise the quality of the assessment, given the logistical and time constraints that stem from the number and diversity of sites that have to be covered over the life of the project. The exact position of transects is determined in advance using satellite imagery, to assist in locating the exact positions in the field; this maximises accuracy and allows replication for monitoring purposes (Figure A1.2.2).

Scaling

Maps from the Millennium Project allow the calculation of reef areas in each studied site, and those areas can be used to scale (using weighted averages) the resource assessment at any spatial level. For example, the average biomass (or density) of finfish at site (i.e. village) level would be calculated by relating the biomass (or density) recorded in each of the habitats sampled at the site ('the data') to the proportion of surface of each type of reef over the total reef present in the site ('the weights'), by using a weighted average formula. The result is a village-level figure for finfish biomass that is representative of both the intrinsic characteristics of the resource and its spatial distribution. Technically, the weight given to the average biomass (or density) of each habitat corresponds to the ratio between the total area of that reef habitat (e.g. the area of sheltered coastal reef) and the total area of reef present (e.g. the area of sheltered coastal reef + the area of intermediate reef, etc.). Thus the calculated weighted biomass value for the site would be:

$$\mathrm{B}_{\mathrm{Vk}} = \sum j_l \, [B_{Hj} \bullet S_{Hj}] \, / \sum_j S_{Hj}$$

Where:

B_{Vk} = computed biomass or fish stock for village k
B_{Hj} = average biomass in habitat 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.

Appendix 1: Survey methods
Finfish

Campaign |________| Site |________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|.|__|__|__|' Long.|__|__|__|°|__|__|.|__|__|__|' WT |__|__|__|

Starting time : |__|__|:|__|__| Visibility |__|__| m Side : Left ☐ Right ☐

☐ coast
- ☐ linear ☐ cape
- ☐ bay mouth ☐ back of bay
- ☐ estuary ☐ channel

☐ intermediate zone
- ☐ submerg. reef ☐ pinnacle
- ☐ near surf. reef ☐ islet lagoon
- ☐ lagoon floor ☐ islet fringing reef

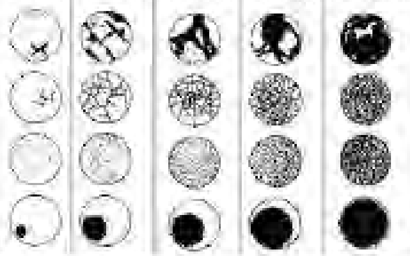
☐ barrier
- ☐ outer slope ☐ pass
- ☐ reef crest ☐ hoa/channel
- ☐ back reef ☐ motu

☐ intertidal ☐ flat ☐ gentle slope ☐ steep slope ☐ talus ☐ basin ☐ lagoon plain

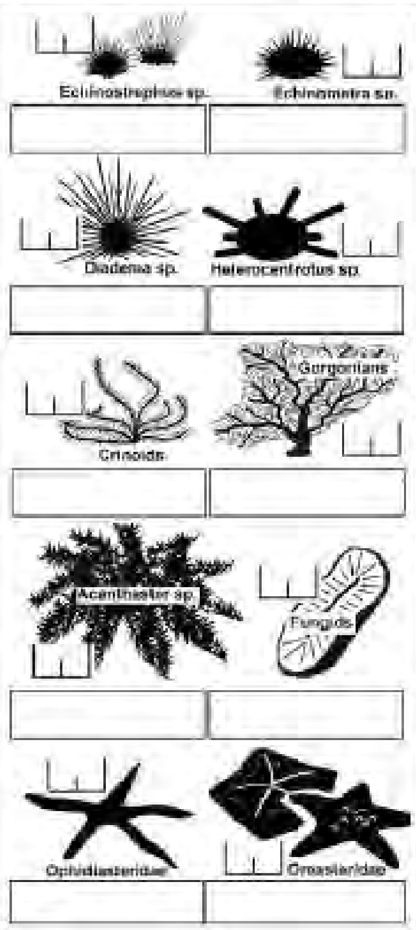
☐ hard bottom ☐ large coral patches ☐ small coral patches ☐ coral field ☐ seaweed bed
☐ detritical bottom ☐ soft bottom ☐ seagrass bed ☐ mangrove

	current	relief features	exposure to dominant wind	oceanic influence	terrigenous influence
none	☐	☐	☐	☐	☐
medium	☐	☐	☐	☐	☐
strong	☐	☐	☐	☐	☐

1	2	3	4	5
1-10%	11-30%	31-50%	51-75%	76-100%



Quadrat limits	0	5	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 :											



Appendix 1: Survey methods
Finfish

Campaign |___________________| Site |_____________________________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|,|__|__|__|' Long.|__|__|__|°|__|__|,|__|__|__|' Left ☐ Right ☐

ST	SCIENTIFIC NAME	NBER	LGT	D1	D2	COMMENTS

1.3 Invertebrate resource survey methods

1.3.1 Methods used to assess the status of invertebrate resources

Introduction

Coastal communities in the Pacific access a range of invertebrate resources. Within the PROCFish/C study, a range of survey methods were used to provide information on key invertebrate species commonly targeted. These provide information on the status of resources at scales relevant to species (or species groups) and the fishing grounds being studied that can be compared across sites, countries and the region, in order to assess relative status.

Species data resulting from the resource survey are combined with results from the socioeconomic survey of fishing activity to describe invertebrate fishing activity within specific 'fisheries'. Whereas descriptions of commercially orientated fisheries are generally recognisable in the literature (e.g. the sea cucumber fishery), results from non-commercial stocks and subsistence-orientated fishing activities (e.g. general reef gleaning) will also be presented as part of the results, so as to give managers a general picture of invertebrate fishery status at study sites.

Field methods

We examined invertebrate stocks (and fisheries) for approximately seven days at each site, with at least two research officers (SPC Invertebrate Biologist and Fisheries Officer) plus officers from the local fisheries department. The work completed at each site was determined by the availability of local habitats and access to fishing activity.

Two types of survey were conducted: fishery-dependent surveys and fishery independent surveys.

- Fishery-dependent surveys rely on information from those engaged in the fishery, e.g. catch data;
- Fishery-independent surveys are conducted by the researchers independently of the activity of the fisheries sector.

Fishery-dependent surveys were completed whenever the opportunity arose. This involved accompanying fishers to target areas for the collection of invertebrate resources (e.g. reef-benthos, soft-benthos, trochus habitat). The location of the fishing activity was marked (using a GPS) and the catch composition and catch per unit effort (CPUE) recorded (kg/hour).

This record was useful in helping to determine the species complement targeted by fishers, particularly in less well-defined 'gleaning' fisheries. A CPUE record, with related information on individual animal sizes and weights, provided an additional dataset to expand records from reported catches (as recorded by the socioeconomic survey). In addition, size and weight measures collected through fishery-dependent surveys were compared with records from fishery-independent surveys, in order to assess which sizes fishers were targeting.

For a number of reasons, not all fisheries lend themselves to independent snapshot assessments: density measures may be difficult to obtain (e.g. crab fisheries in mangrove systems) or searches may be greatly influenced by conditions (e.g. weather, tide and lunar conditions influence lobster fishing). In the case of crab or shoreline fisheries, searches are very subjective and weather and tidal conditions affect the outcome. In such cases, observed and reported catch records were used to determine the status of species and fisheries.

A further reason for accompanying groups of fishers was to gain a first-hand insight into local fishing activities and facilitate the informal exchange of ideas and information. By talking to fishers in the fishing grounds, information useful for guiding independent resource assessment was generally more forthcoming than when trying to gather information using maps and aerial photographs while in the village. Fishery-independent surveys were not conducted randomly over a defined site 'study' area. Therefore assistance from knowledgeable fishers in locating areas where fishing was common was helpful in selecting areas for fishery-independent surveys.

A series of fishery-independent surveys (direct, in-water resource assessments) were conducted to determine the status of targeted invertebrate stocks. These surveys needed to be wide ranging within sites to overcome the fact that distribution patterns of target invertebrate species can be strongly influenced by habitat, and well replicated as invertebrates are often highly aggregated (even within a single habitat type).

PROCFish/C assessments do not aim to determine the size of invertebrate populations at study sites. Instead, these assessments aim to determine the status of invertebrates within the main fishing grounds or areas of naturally higher abundance. The implications of this approach are important, as the haphazard measures taken in main fishing grounds are indicative of stock health in these locations only and should not be extrapolated across all habitats within a study site to gain population estimates.

This approach was adopted due to the limited time allocated for surveys and the study's goal of 'assessing the status of invertebrate resources' (as opposed to estimating the standing stock). Making judgements on the status of stocks from such data relies on the assumption that the state of these estimates of 'unit stock'[2] reflects the health of the fishery. For example, an overexploited trochus fishery would be unlikely to have high-density 'patches' of trochus, just as a depleted shallow-reef gleaning fishery would not hold high densities of large clams. Conversely, a fishery under no stress would be unlikely to be depleted or show skewed size ratios that reflected losses of the adult component of the stock.

In addition to examining the density of species, information on spatial distribution and size/weight was collected, to add confidence to the study's inferences.

The basic assumption that looking at a unit stock will give a reliable picture of the status of that stock is not without weaknesses. Resource stocks may appear healthy within a much-restricted range following stress from fishing or environmental disturbance (e.g. a cyclone), and historical information on stock status is not usually available for such remote locations. The lack of historical datasets also precludes speculation on 'missing' species, which may be 'fished-out' or still remain in remnant populations at isolated locations within study sites.

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[2] As used here, 'unit stock' refers to the biomass and cohorts of adults of a species in a given area that is subject to a well-defined fishery, and is believed to be distinct and have limited interchange of adults from biomasses or cohorts of the same species in adjacent areas (Gulland 1983).

As mentioned, specific independent assessments were not conducted for mud crab and shore crabs (mangrove fishery), lobster or shoreline stocks (e.g. nerites, surf clams and crabs), as limited access or the variability of snapshot assessments would have limited relevance for comparative assessments.

Generic terminology used for surveys: site, station and replicates

Various methods were used to conduct fishery-independent assessments. At each site, surveys were generally made within specific areas (termed 'stations'). At least six replicate measures were made at each station (termed 'transects', 'searches' or 'quadrats', depending on the resource and method) (Figure A1.3.1).

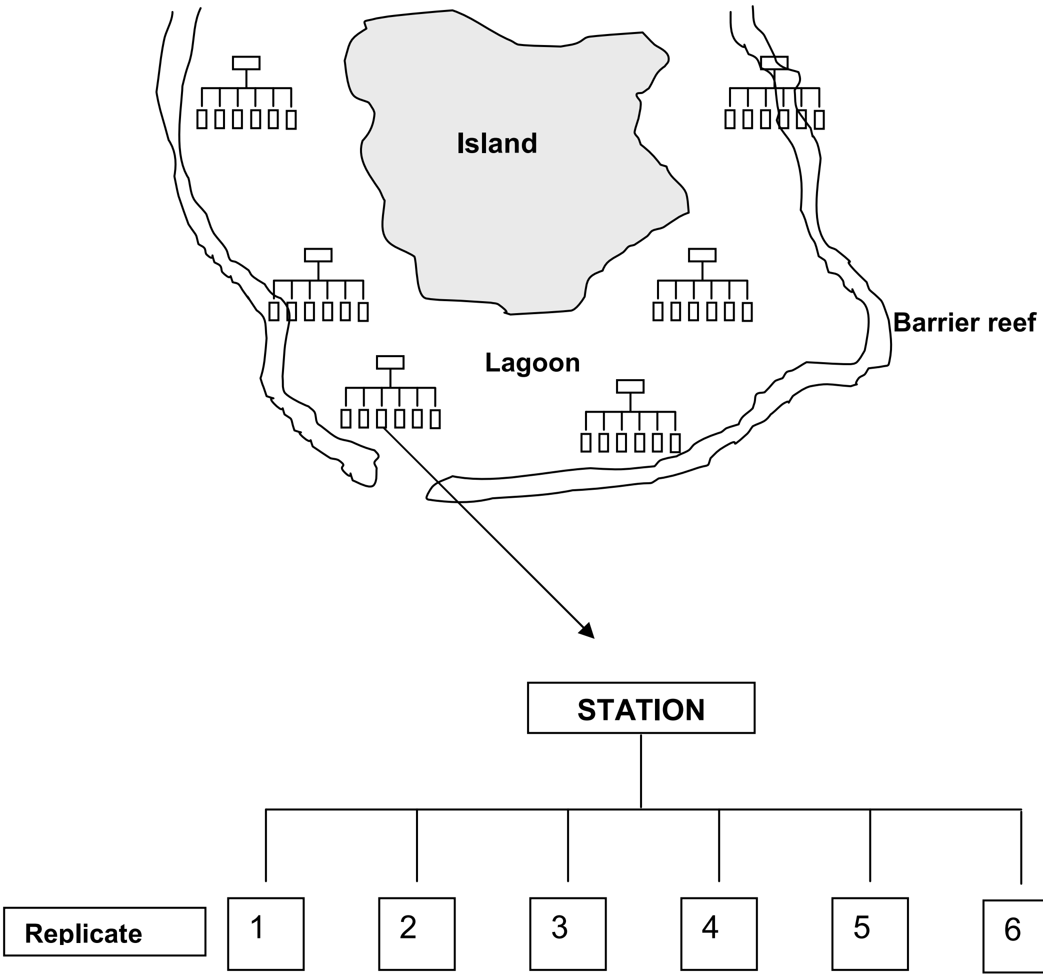


Figure A1.3.1: Stations and replicate measures at a given site.
Note: a replicate measure could be a transect, search period or quadrat group.

Invertebrate species diversity, spatial distribution and abundance were determined using fishery-independent surveys at stations over broad-scale and more targeted surveys. Broad-scale surveys aimed to record a range of macro invertebrates across sites, whereas more targeted surveys concentrated on specific habitats and groups of important resource species.

Recordings of habitat are generally taken for all replicates within stations (see Appendix 1.3.3). Comparison of species complements and densities among stations and sites does not factor in fundamental differences in macro and micro habitat, as there is presently no established method that can be used to make allowances for these variations. The complete dataset from PROCFish/C will be a valuable resource to assess such habitat effects, and by identifying salient habitat factors that reliably affect resource abundance, we may be able to account for these habitat differences when inferring 'status' of important species groups. This will be examined once the full Pacific dataset has been collected.

More detailed explanations of the various survey methods are given below.

Broad-scale survey

Manta 'tow-board' transect surveys

A general assessment of large sedentary invertebrates and habitat was conducted using a tow-board technique adapted from English *et al.* (1997), with a snorkeller towed at low speed (<2.5 km/hour). This is a slower speed than is generally used for manta transects, and is less than half the normal walking pace of a pedestrian.

Where possible, manta surveys were completed at 12 stations per site. Stations were positioned near land masses on fringing reefs (inner stations), within the lagoon system (middle stations) and in areas most influenced by oceanic conditions (outer stations). Replicate measures within stations (called transects) were conducted at depths between 1 m and <10 m of water (mostly 1.5–6 m), covering broken ground (coral stone and sand) and at the edges of reefs. Transects were not conducted in areas that were too shallow for an outboard-powered boat (<1 m) or adjacent to wave-impacted reef.

Each transect covered a distance of ~300 m (thus the total of six transects covered a linear distance of ~2 km). This distance was calibrated using the odometer function within the trip computer option of a Garmin 76Map® GPS. Waypoints were recorded at the start and end of each transect to an accuracy of ≤10 m. The abundance and size estimations for large sedentary invertebrates were taken within a 2 m swathe of benthos for each transect. Broad-based assessments at each station took approximately one hour to complete (7–8 minutes per transect × 6, plus recording and moving time between transects). Hand tally counters and board-mounted bank counters (three tally units) were used to assist with enumerating common species.

The tow-board surveys differed from traditional manta surveys by utilising a lower speed and concentrating on a smaller swathe on the benthos. The slower speed, reduced swathe and greater length of tows used within PROCFish/C protocols were adopted to maximise efficiency when spotting and identifying cryptic invertebrates, while covering areas that were large enough to make representative measures.

Targeted surveys

Reef- and soft-benthos transect surveys (RBt and SBt), and soft-benthos quadrats (SBq)

To assess the range, abundance, size and condition of invertebrate species and their habitat with greater accuracy at smaller scales, reef- and soft-benthos assessments were conducted within fishing areas and suitable habitat. Reef benthos and soft benthos are not mutually exclusive, in that coral reefs generally have patches of sand, while soft-benthos seagrass areas can be strewn with rubble or contain patches of coral. However, these survey stations (each covering approximately 5000 m^2) were selected in areas representative of the habitat (those generally accessed by fishers, although MPAs were examined on occasion). Six 40 m transects (1 m swathe) were examined per station to record most epi-benthic invertebrate resources and some sea stars and urchin species (as potential indicators of habitat condition). Transects were randomly positioned but laid across environmental gradients where possible (e.g. across reefs and not along reef edges). A single waypoint was recorded for each station (to an accuracy of ≤10 m) and habitat recordings were made for each transect (see Figure A1.3.2 and Appendix 1.3.2).

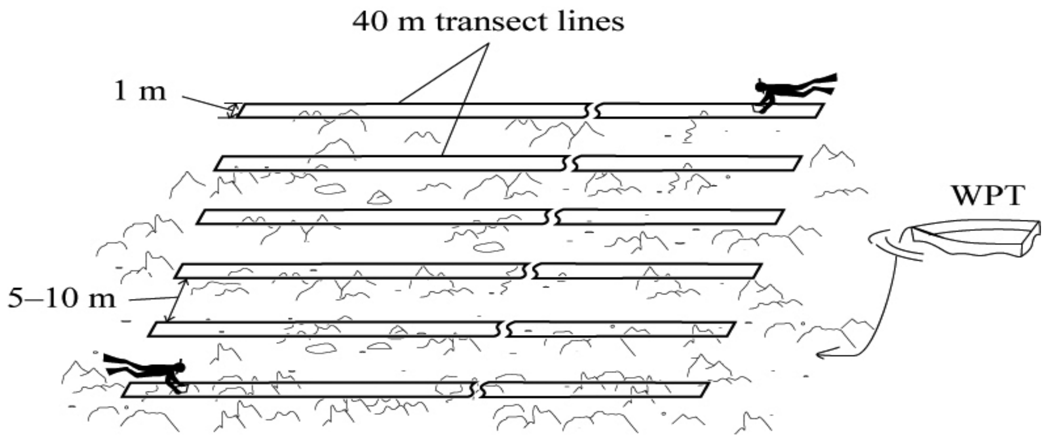


Figure A1.3.2: Example of a reef-benthos transect station (RBt).

To record infaunal resources, quadrats (SBq) were used within a 40 m × 2 m strip transect to measure densities of molluscs (mainly bivalves) in soft-benthos 'shell bed' areas. Four 25 cm^2 quadrats (one quadrat group) were dug to approximately 5–8 cm to retrieve and measure infaunal target species and potential indicator species. Eight randomly spaced quadrat groups were sampled along the 40 m transect line (Figure A1.3.3). A single waypoint and habitat recording was taken for each infaunal station.

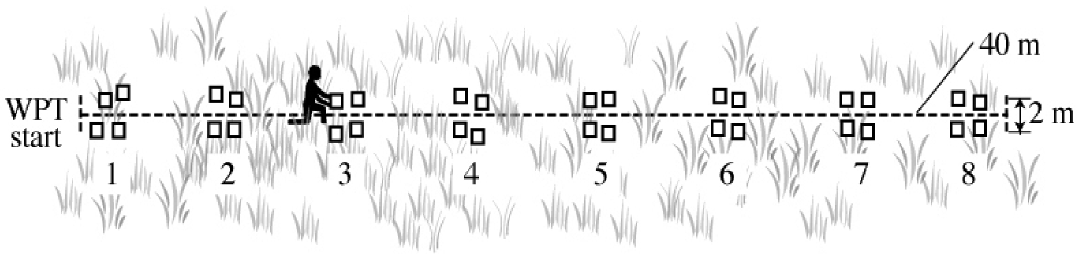


Figure A1.3.3: Soft-benthos (infaunal) quadrat station (SBq).
Single quadrats are 25 cm x 25 cm in size and four make up one 'quadrat group'.

<u>Mother-of-pearl (MOP) or sea cucumber (BdM) fisheries</u>

To assess fisheries such as those for trochus or sea cucumbers, results from broad-scale, reef- and soft-benthos assessments were used. However, other specific surveys were incorporated into the work programme, to more closely target species or species groups not well represented in the primary assessments.

<u>Reef-front searches (RFs and RFs_w)</u>

If swell conditions allowed, three 5-min search periods (30 min total) were conducted along exposed reef edges (RFs) where trochus (*Trochus niloticus*) and surf redfish (*Actinopyga* *mauritiana*) generally aggregate (Figure A1.3.4). Due to the dynamic conditions of the reef front, it was not generally possible to lay transects, but the start and end waypoints of reef-front searches were recorded, and two snorkellers recorded the abundance (generally not size measures) of large sedentary species (concentrating on trochus, surf redfish, gastropods and clams).

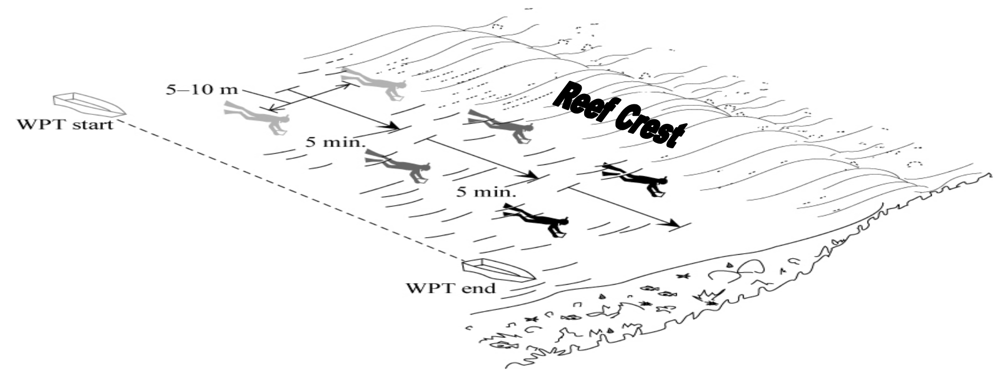


Figure A1.3.4: Reef-front search (RFs) station.

On occasions when it was too dangerous to conduct in-water reef-front searches (due to swell conditions or limited access) and the reeftop was accessible, searches were conducted on foot along the top of the reef front (RFs_w). In this case, two officers walked side by side (5–10 m apart) in the pools and cuts parallel to the reef front. This search was conducted at low tide, as close as was safe to the wave zone. In this style of assessment, reef-front counts of sea cucumbers, gastropod shells, urchins and clams were made during three 5-min search periods (total of 30 minutes search per station).

In the case of *Trochus niloticus*, reef-benthos transects, reef-front searches and local advice (trochus areas identified by local fishers) led us to reef-slope and shoal areas that were surveyed using SCUBA. Initially, searches were undertaken using SCUBA, although SCUBA transects (greater recording accuracy for density) were adopted if trochus were shown to be present at reasonable densities.

Mother-of-pearl search (MOPs)

Initially, two divers (using SCUBA) actively searched for trochus for three 5-min search periods (30 min total). Distance searched was estimated from marked GPS start and end waypoints. If more than three individual shells were found on these searches, the stock was considered dense enough to proceed with the more defined area assessment technique (MOPt).

Mother-of-pearl transects (MOPt)

Also on SCUBA, this method used six 40-m transects (2 m swathe) run perpendicular to the reef edge and not exceeding 15 m in depth (Figure A1.3.5). In most cases the depth ranged between 2 and 6 m, although dives could reach 12 m at some sites where more shallow-water habitat or stocks could not be found. In cases where the reef dropped off steeply, more oblique transect lines were followed. On MOP transect stations, a hip-mounted (or handheld) Chainman® measurement system (thread release) was used to measure out the 40 m. This allowed a hands-free mode of survey and saved time and energy in the often dynamic conditions where *Trochus niloticus* are found.

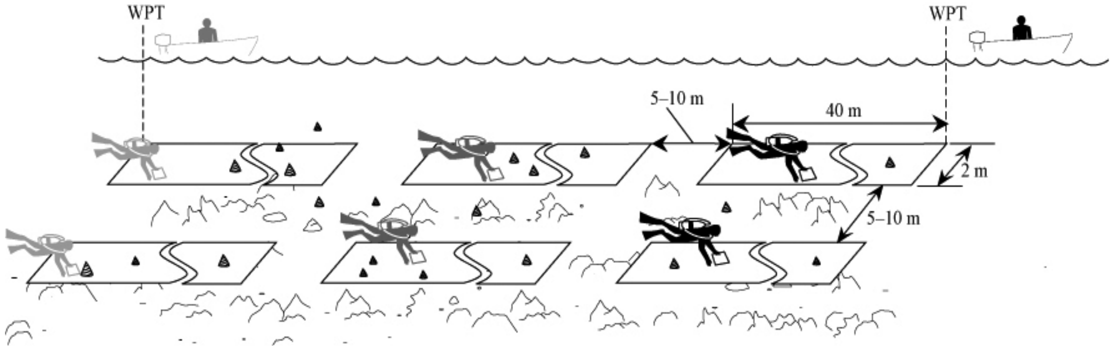


Figure A1.3.5: Mother-of-pearl transect station (MOPt).

Sea cucumber day search (Ds)

When possible, dives to 25–35 m were made to establish if white teatfish (*Holothuria (Microthele) fuscogilva*) populations were present and give an indication of abundance. In these searches two divers recorded the number and sizes of valuable deep-water sea cucumber species within three 5-min search periods (30 min total). This assessment from deep water does not yield sufficient presence/absence data for a very reliable inference on the status (i.e. 'health') of this and other deeper-water species.

Sea cucumber night search (Ns)

In the case of sea cucumber fisheries, dedicated night searches (Ns) for sea cucumbers and other echinoderms were conducted (using snorkel) for predominantly nocturnal species (blackfish *Actinopyga miliaris*, *A. lecanora*, and *Stichopus horrens*). Sea cucumbers were collected for three 5-min search periods by two snorkellers (30 min total), and if possible weighed (length and width measures for *A. miliaris* and *A. lecanora* are more dependent on the condition than the age of an individual).

Reporting style

For country site reports, results highlight the presence and distribution of species of interest, and their density at scales that yield a representative picture. Generally speaking, mean densities (average of all records) are presented, although on occasion mean densities for areas of aggregation ('patches') are also given. The later density figure is taken from records (stations or transects, as stated) where the species of interest is present (with an abundance >zero). Presentation of the relative occurrence and densities (without the inclusion of zero records) can be useful when assessing the status of aggregations within some invertebrate stocks.

An example and explanation of the reporting style adopted for invertebrate results follows.

1. The mean density range of *Tridacna* spp. on broad-scale stations (n = 8) was 10–120 per ha.

Density range includes results from all stations. In this case, replicates in each station are added and divided by the number of replicates for that station to give a mean. The lowest and highest station averages (here 10 and 120) are presented for the range. The number in brackets (n = 8) highlights the number of stations examined.

2. The mean density (per ha, ±SE) of all *Tridacna* clam species observed in broad-scale transects (n = 48) was 127.8 ±21.8 (occurrence in 29% of transects).

Mean density is the arithmetic mean, or average of measures across all replicates taken (in this case broad-scale transects). On occasion mean densities are reported for stations or transects where the species of interest is found at an abundance greater than zero. In this case the arithmetic mean would only include stations (or replicates) where the species of interest was found (excluding zero replicates). If this was presented for stations, even stations with a single clam from six transects would be included. (Note: a full breakdown of data is presented in the appendices.)

Written after the mean density figure is a descriptor that highlights variability in the figures used to calculate the mean. Standard error[3] (SE) is used in this example to highlight variability in the records that generated the mean density (SE = (standard deviation of records)/√n). This figure provides an indication of the dispersion of the data when trying to estimate a population mean (the larger the standard error, the greater variation of data points around the mean presented).

Following the variability descriptor is a presence/absence indicator for the total dataset of measures. The presence/absence figure describes the percentage of stations or replicates with a recording >0 in the total dataset; in this case 29% of all transects held *Tridacna* spp., which equated to 14 of a possible 48 transects (14/48*100 = 29%).

3. The mean length (cm, ±SE) of *T. maxima* was 12.4 ±1.1 (n = 114).

The number of units used in the calculation is indicated by *n*. In the last case, 114 clams were measured.

[3] In order to derive confidence limits around the mean, a transformation (usually y = log (x+1)) needs to be applied to data, as samples are generally non-normally distributed. Confidence limits of 95% can be generated through other methods (bootstrapping methods) and will be presented in the final report where appropriate.

1.3.2 General fauna invertebrate recording sheet with instructions to users

DATE		RECORDER		Pg No	

STATION NAME																		
WPT - WIDTH																		
RELIEF / COMPLEXITY **1–5**																		
OCEAN INFLUENCE **1–5**																		
DEPTH (M)																		
% SOFT SED (M – S – CS)																		
% RUBBLE / BOULDERS																		
% CONSOL RUBBLE / PAVE																		
% CORAL *LIVE*																		
% CORAL *DEAD*																		
SOFT / SPONGE / FUNGIDS																		
ALGAE *CCA*																		
CORALLINE																		
OTHER																		
GRASS																		
EPIPHYTES **1–5** / SILT **1–5**																		
bleaching: % of																		
entered /	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/

Figure A1.3.6: Sample of the invertebrate fauna survey sheet.

The sheet above (Figure A1.3.6) has been modified to fit on this page (the original has more line space (rows) for entering species data). When recording abundance or length data against species names, columns are used for individual transects or 5-min search replicates. If more space is needed, more than a single column can be used for a single replicate.

A separate sheet is used by a recorder in the boat to note information from handheld GPS equipment. In addition to the positional information, this boat sheet has space for manta transect distance (from GPS odometer function) and for sketches and comments.

1.3.3 Habitat section of invertebrate recording sheet with instructions to users

Figure A1.3.7 depicts the habitat part of the form used during invertebrate surveys; it is split into seven broad categories.

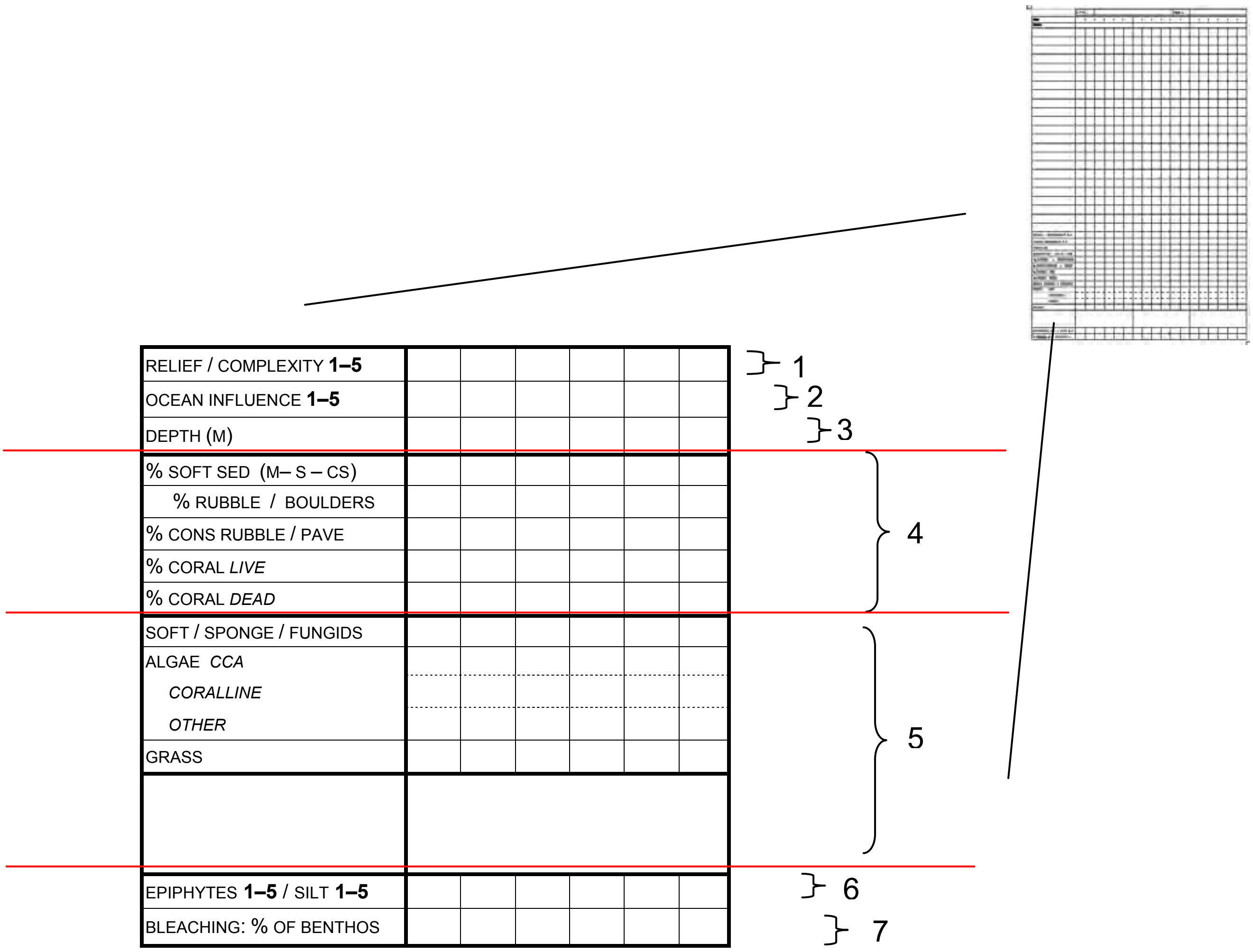


Figure A1.3.7: Sample of the invertebrate habitat part of survey form.

Relief and complexity (section 1 of form)

Each is on a scale of 1 to 5. If a record is written as 1/5, relief is 1 and complexity is 5, with the following explanation.

Relief describes average height variation for hard (and soft) benthos transects:

1 = flat (to ankle height)
2 = ankle up to knee height
3 = knee to hip height
4 = hip to shoulder/head height
5 = over head height

Complexity describes average surface variation for substrates (relative to places for animals to find shelter) for hard (and soft) benthos transects:

1 = smooth – no holes or irregularities in substrate
2 = some complexity to the surfaces but generally little

3 = generally complex surface structure
4 = strong complexity in surface structure, with cracks, spaces, holes, etc.
5 = very complex surfaces with lots of spaces, nooks, crannies, under-hangs and caves

Ocean influence (section 2 of form)

1 = riverine, or land-influenced seawater with lots of allochthonous input
2 = seawater with some land influence
3 = ocean and land-influenced seawater
4 = water mostly influenced by oceanic water
5 = oceanic water without land influence

Depth (section 3 of form)

Average depth in metres

Substrate – bird's-eye view of what's there (section 4 of form)

All of section 4 must make up 100%. Percentage substrate is estimated in units of 5% so, e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Soft substrate	Soft sediment – mud
Soft substrate	Soft sediment – mud and sand
Soft substrate	Soft sediment – sand
Soft substrate	Soft sediment – coarse sand
Hard substrate	Rubble
Hard substrate	Boulders
Hard substrate	Consolidated rubble
Hard substrate	Pavement
Hard substrate	Coral live
Hard substrate	Coral dead

Mud, sand, coarse sand: The sand is not sieved – it is estimated visually and manually. Surveyors can use the 'drop test', where sand drops through the water column and mud stays in suspension. Patchy settled areas of silt/clay/mud in very thin layers on top of coral, pavement, etc. are not listed as soft substrate unless the layer is significant (>a couple of cm).

Rubble is small (<25–30 cm) fragments of coral (reef), pieces of coral stone and limestone debris. AIMS' definition is very similar to that for Reefcheck (found on the 'C-nav' interactive CD): 'pieces of coral (reef) between 0.5 and 15 cm. If smaller, it is sand; if larger, then rock or whatever organism is growing upon it'.

Boulders are detached, big pieces (>30 cm) of stone, coral stone and limestone debris.

Consolidated rubble is attached, cemented pieces of coral stone and limestone debris. We tend to use 'rubble' for pieces or piles loose in the sediment of seagrass, etc., and 'consolidated rubble' for areas that are not flat pavement but concreted rubble on reeftops and cemented talus slopes.

Pavement is solid, substantial, fixed, flat stone (generally limestone) benthos.

Coral live is any live hard coral.

Coral dead is coral that is recognisable as coral even if it is long dead. Note that long-dead and *eroded* coral that is found in flat pavements is called 'pavement' and when it is found in loose pieces or blocks it is termed 'rubble' or 'boulders' (depending on size).

Cover – what is on top of the substrate (section 5 of form)

This cannot exceed 100%, but can be anything from 0 to 100%. Surveyors give scores in blocks of 5%, so e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Cover	Soft coral
Cover	Sponge
Cover	Fungids
Cover	Crustose-nongeniculate coralline algae
Cover	Coralline algae
Cover	Other (algae like sargassum, caulerpa and padina)
Cover	Seagrass

Soft coral is all soft corals but not Zoanthids or anemones.

Sponge includes half-buried sponges in seagrass beds – only sections seen on the surface are noted.

Fungids are fungids.

Crustose – nongeniculate coralline algae are pink rock. Crustose or nongeniculate coralline algae (NCA) are red algae that deposit calcium carbonate in their cell walls. Generally they are members of the division Rhodophyta.

Coralline algae – halimeda are red coralline algae (often seen in balls – *Galaxaura*). (Note: AIMS lists *halimeda* and other coralline algae as macro algae along with fleshy algae not having $CaCo_3$ deposits.)

Other algae include fleshy algae such as *Turbinaria*, *Padina* and *Dictyota*. Surveyors describe coverage by taking a bird's-eye view of what is covered, not by delineating the spatial area of the algae colony within the transect (i.e. differences in very low or high density are accounted for). The large space on the form is used to write species information if known.

Seagrass includes seagrass such as *Halodule*, *Thalassia*, *Halophila* and *Syringodium*. Surveyors note types by species if possible or by structure (i.e. flat versus reed grass), and describe coverage by taking a bird's-eye view of what benthos is covered, not by delineating the spatial area of the grass meadow within the transect (i.e. differences in very low or high density are accounted for).

Cover continued – epiphytes and silt (section 6 of form)

Epiphytes 1–5 grade are mainly turf algae – turf that grows on hard and soft substrates, but also on algae and grasses. The growth is usually fine-stranded filamentous algae that have few noticeable distinguishing features (more like fuzz).

1 = none
2 = small areas or light coverage
3 = patchy, medium coverage
4 = large areas or heavier coverage
5 = very strong coverage, long and thick almost choking epiphytes – normally including strands of blue-green algae as well

Silt 1–5 grade (or a similar fine-structured material sometimes termed 'marine snow') consists of fine particles that slowly settle out from the water but are easily re-suspended. When re-suspended, silt tends to make the water murky and does not settle quickly like sand does. Sand particles are not silt and should not be included here when seen on outer-reef platforms that are wave affected.

1 = clear surfaces
2 = little silt seen
3 = medium amount of silt-covered surfaces
4 = large areas covered in silt
5 = surfaces heavily covered in silt

Bleaching (section 7 of form)

The percentage of bleached live coral is recorded in numbers from 1 to 100% (Not 5% blocks). This is the percentage of benthos that is dying hard coral (just-bleached) or very recently dead hard coral showing obvious signs of recent bleaching.

APPENDIX 2: SOCIOECONOMIC SURVEY DATA

2.1 Abaiang socioeconomic survey data

2.1.1 Annual catch (kg) of fish groups per habitat – Abaiang

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Ikari	Albulidae	*Albula vulpes*	5876	35
Maneku	Serranidae	*Epinephelus merra*	2021	12
Taabou	Lethrinidae	*Lethrinus miniatus*	2021	12
Uannati	Serranidae	*Plectropomus areolatus*	2021	12
Kuau	Serranidae	*Epinephelus merra*	1386	8
Baneawa	Chanidae	*Chanos chanos*	865	5
Ikanibong	Lutjanidae	*Lutjanus gibbus*	693	4
Ikauraura	Serranidae	*Cephalopholis sonnerati*	693	4
Tau	Belonidae	*Strongylura incisa*	483	3
Karon	Labridae	*Cheilinus undulatus*	427	3
Okaoka	Lethrinidae	*Lethrinus obsoletus*	378	2
Nrekereke	Serranidae	*Cephalopholis cyanostigma*	100	1
Morikoi	Lethrinidae	*Lethrinus nebulosus*	65	0
Total:				**100**
Lagoon				
Taabou	Lethrinidae	*Lethrinus miniatus*	1950	12
Okaoka	Lethrinidae	*Lethrinus obsoletus*	1909	12
Morikoi	Lethrinidae	*Lethrinus nebulosus*	1210	8
Ikanibong	Lutjanidae	*Lutjanus gibbus*	1135	7
Maebo	Mullidae	*Upeneus taeniopterus*	1107	7
Tau	Belonidae	*Strongylura incisa*	1058	7
Ninimai	Gerreidae	*Gerres oyena*	996	6
Urua	Carangidae	*Caranx ignobilis*	866	5
Aua	Mugilidae	*Mugil* spp.	761	5
Ikabwauea	Sphyraenidae	*Sphyraena forsteri*	586	4
Ikamawa	Scaridae	*Bolbometopon muricatum*	538	3
Tewe	Mullidae	*Parupeneus* spp.	478	3
Inonikai	Kyphosidae	*Kyphosus cinerascens*	470	3
Kuau	Serranidae	*Epinephelus merra*	425	3
Mako	Acanthuridae	*Acanthurus xanthopterus*	393	2
Amori	Gerreidae	*Gerres oyena*	356	2
Inai	Scaridae	*Scarus ghobban*	296	2
Ikamatoa	Lethrinidae	*Lethrinus miniatus*	252	2
Ikari	Albulidae	*Albula vulpes*	252	2
Ribauri	Lethrinidae	*Lethrinus rubrioperculatus*	214	1
Mawa	Mullidae	*Parupeneus cyclostomus*, *Parupeneus barberinus*	201	1
Imnai	Siganidae	*Siganus argenteus*	184	1
Riba	Acanthuridae	*Acanthurus gahhm*	131	1
Baneriki	Mugilidae	*Valamugil seheli*	67	0
Anatababa	Lutjanidae	*Etelis carbunculus*	65	0
Total:				**100**

2.1.1 Annual catch (kg) of fish groups per habitat – Abaiang (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef				
Kuau	Serranidae	*Epinephelus merra*	1231	31
Ikanibong	Lutjanidae	*Lutjanus gibbus*	1119	28
Awai	Lutjanidae	*Aprion virescens*	577	15
Kungkung	Holocentridae	*Myripristis kuntee*	504	13
Taa	Holocentridae	*Sargocentron spiniferum*	504	13
Total:				**100**
Outer reef & passage fishing during one trip				
Bakati	Serranidae	*Epinephelus fuscoguttatus*	4111	17
Uannati	Serranidae	*Plectropomus areolatus*	3567	15
Kamauti, Ikamawa	Scaridae	*Bolbometopon muricatum*	3268	14
Kuau	Serranidae	*Epinephelus merra*	2262	9
Karon	Labridae	*Cheilinus undulatus*	2087	9
Taabou	Lethrinidae	*Lethrinus miniatus*	1724	7
Kungkung	Holocentridae	*Myripristis kuntee*	1701	7
Ikanibong	Lutjanidae	*Lutjanus gibbus*	1512	6
Ikabwauea	Sphyraenidae	*Sphyraena forsteri*	1449	6
Tau	Belonidae	*Strongylura incisa*	869	4
Taa	Holocentridae	*Sargocentron spiniferum*	811	3
Inai	Scaridae	*Scarus ghobban*	189	1
Rereba	Carangidae	*Caranx melampygus*	126	1
Rabono-mai	Muraenidae	*Gymnothorax fimbriatus*	121	1
Riba	Acanthuridae	*Acanthurus gahhm*	54	0
Total:				**100**

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Abaiang

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded data		Extrapolated data	
				no/year	kg/year	no/year	kg/year
Lobster	Lobster	*Panulirus penicillatus, Panulirus versicolor*	100.0	4368	4368	215,246	215,246
Other	Giant clam	*Tridacna maxima, Tridacna squamosa*	100.0	145,269	14,527	7,159,282	715,928
Sand	Seaworm	*Sipunculus indicus*	100.0	138,771	6939	12,998,211	649,911
	Tebun	*Anadara* spp.	0.0	2	0	156	3
Soft benthos & sand	Nouo	*Strombus luhuanus*	36.2	204	5	17,749	444
	Tebun	*Anadara* spp.	33.4	224	5	19,621	412
	Koumara	*Gafrarium pectinatum*	30.4	204	4	17,749	373

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Abaiang

Vernacular name	Scientific name	Size class	Annual catch total number	% of total catch by species (number)
Giant clam	*Tridacna maxima, Tridacna squamosa*	6 cm	60,800	41.85
		8 cm	22,583	15.55
		12 cm	6514	4.48
		14 cm	29,314	20.18
		16 cm	26,057	17.94
Total:			**145,269**	**100.00**
Lobster	*Panulirus penicillatus, Panulirus versicolor*	22 cm	2399	54.92
		24 cm	543	12.43
		26 cm	167	3.81
		28 cm	1259	28.84
Total:			**4368**	**100.00**
Tebun	*Anadara* spp.	4 cm	52	22.91
		6 cm	174	77.09
Total:			**225**	**100.00**
Koumara	*Gafrarium pectinatum*	2 cm	30	14.72
		4 cm	174	85.28
Total:			**204**	**100.00**
Nouo	*Strombus luhuanus*	2 cm	20	9.81
		4 cm	10	4.91
		6 cm	174	85.28
Total:			**204**	**100.00**
Seaworm	*Sipunculus indicus*	28 cm	138,771	100.00
Total:			**138,771**	**100.00**

2.2 Abemama socioeconomic survey data

2.2.1 Annual catch (kg) of fish groups per habitat – Abemama

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Aua	Mugilidae	*Mugil* spp.	1688	26
Rereba	Carangidae	*Caranx melampygus*	1627	25
Ikanibong	Lutjanidae	*Lutjanus gibbus*	1182	18
Bwawe	Lutjanidae	*Lutjanus fulvus*	623	10
Kuau	Serranidae	*Epinephelus merra*	619	9
Ikamawa	Scaridae	*Bolbometopon muricatum*	421	6
Ikari	Albulidae	*Albula vulpes*	244	4
Mon	Holocentridae	*Myripristis kuntee*	64	1
Nimanang	Serranidae	*Cephalopholis argus*	64	1
Morikoi	Lethrinidae	*Lethrinus nebulosus*	12	0
Okaoka	Lethrinidae	*Lethrinus obsoletus*	3	0
Total:			**6549**	**100**
Lagoon				
Aua	Mugilidae	*Mugil* spp.	15,765	34
Ikari	Albulidae	*Albula vulpes*	13,181	28
Maebo	Mullidae	*Upeneus taeniopterus*	3317	7
Rereba	Carangidae	*Caranx melampygus*	2943	6
Morikoi	Lethrinidae	*Lethrinus nebulosus*	2934	6
Kobe	Gerreidae	*Gerres argyreus*	2687	6
Okaoka	Lethrinidae	*Lethrinus obsoletus*	1846	4
Tewe	Mullidae	*Parupeneus* spp.	1330	3
Ninimai	Gerreidae	*Gerres oyena*	988	2
Amori	Gerreidae	*Gerres oyena*	888	2
Urua	Carangidae	*Caranx ignobilis*	474	1
Bwawe	Lutjanidae	*Lutjanus fulvus*	206	0
Mako	Acanthuridae	*Acanthurus xanthopterus*	43	0
Total:			**46,602**	**100**
Sheltered coastal reef and outer reef in one trip				
Rereba	Carangidae	*Caranx melampygus*	1459	30
Bokaboka	Acanthuridae	*Naso unicornis*	852	18
Okaoka	Lethrinidae	*Lethrinus obsoletus*	645	13
Mako	Acanthuridae	*Acanthurus xanthopterus*	645	13
Aua	Mugilidae	*Mugil* spp.	446	9
Ikari	Albulidae	*Albula vulpes*	446	9
Amori	Gerreidae	*Gerres oyena*	322	7
Total:			**4816**	**100**
Passage				
Aua	Mugilidae	*Mugil* spp.	1239	100
Total:			**1239**	**100**

2.2.1 Annual catch (kg) of fish groups per habitat – Abemama (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef				
Bana	Mugilidae	*Valamugil seheli*	53	24
Ninimai	Gerreidae	*Gerres oyena*	40	18
Mako	Acanthuridae	*Acanthurus xanthopterus*	40	18
Okaoka	Lethrinidae	*Lethrinus obsoletus*	30	14
Bwawe	Lutjanidae	*Lutjanus fulvus*	30	14
Tewe	Mullidae	*Parupeneus* spp.	25	11
Total:			**217**	**100**

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Abemama

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded data		Extrapolated data	
				no/year	kg/year	no/year	kg/year
Lobster	Lobster	*Panulirus penicillatus, Panulirus versicolor*	46.6	290	290	12,531	12,531
	-	*Parribacus antarcticus*	33.1	275	206	11,883	8912
	Giant clam	*Tridacna maxima, Tridacna squamosa*	11.2	700	70	30,247	3025
	-	*Parribacus caledonicus*	9.0	75	56	3241	2431
Reeftop	Giant clam	*Tridacna maxima, Tridacna squamosa*	100.0	1303	130	53,078	5308
Sand	Seaworm	*Sipunculus indicus*	95.4	47,771	2389	1,946,208	97,310
	Tebun	*Anadara* spp.	4.1	4896	103	211,650	4445
	Nouo	*Strombus luhuanus*	0.5	500	12	21,605	540
Soft benthos & sand	Nouo	*Strombus luhuanus*	52.2	10,946	274	445,946	11,149
	Tebun	*Anadara* spp.	47.8	11,912	250	485,548	10,197

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Abemama

Vernacular name	Scientific name	Size class	Annual catch total number	% of total catch by species (number)
Giant clam	*Tridacna maxima, Tridacna squamosa*	10-12 cm	1303	65.1
		20 cm	700	34.9
Total:				**100.0**
Lobster	*Panulirus penicillatus, Panulirus versicolor*	05 cm	50	17.2
		22 cm	50	17.2
		28 cm	190	65.5
Total:				**100.0**
Nouo	*Strombus luhuanus*	04 cm	510	4.5
		04-06 cm	10,916	95.4
		06 cm	20	0.2
Total:				**100.0**
-	*Parribacus antarcticus*	12-14 cm	200	72.7
		14 cm	75	27.3
Total:				**100.0**
-	*Parribacus caledonicus*	14 cm	75	100.0
Total:				**100.0**
Seaworm	*Sipunculus indicus*	14 cm	5211	10.9
		28 cm	42,560	89.1
Total:				**100.0**
Tebun	*Anadara* spp.	04 cm	4896	29.1
		04-06 cm	10,901	64.9
		06 cm	247	1.5
		06-08 cm	765	4.5
Total:				**100.0**

2.3 Kuria socioeconomic survey data

2.3.1 Annual catch (kg) of fish groups per habitat – Kuria
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Aua	Mugilidae	*Mugil* spp.	4154	18
Rereba	Carangidae	*Caranx melampygus*	3583	16
Ninimai	Gerreidae	*Gerres oyena*	2727	12
Amori	Gerreidae	*Gerres oyena*	1345	6
Tewe	Mullidae	*Parupeneus* spp.	1328	6
Ikanibong	Lutjanidae	*Lutjanus gibbus*	968	4
Taabou	Lethrinidae	*Lethrinus miniatus*	962	4
Takabe	Lutjanidae	*Lutjanus* spp.	924	4
Rabono-mai	Muraenidae	*Gymnothorax fimbriatus*	851	4
Koinawa	Acanthuridae	*Acanthurus triostegus*	831	4
Imnai	Siganidae	*Siganus argenteus*	816	4
Kaama	Carangidae	*Elagatis bipinnulata*	774	3
Mako	Acanthuridae	*Acanthurus xanthopterus*	772	3
Bwawe	Lutjanidae	*Lutjanus fulvus*	691	3
Okaoka	Lethrinidae	*Lethrinus obsoletus*	507	2
Bubu	Balistidae	*Rhinecanthus aculeatus*	336	1
Inonikai	Kyphosidae	*Kyphosus cinerascens*	263	1
Mon	Holocentridae	*Myripristis kuntee*	176	1
Ikamatoa	Lethrinidae	*Lethrinus miniatus*	150	1
Bureinawa	Holocentridae	*Sargocentron violaceum*	117	1
Inai	Scaridae	*Scarus ghobban*	108	0
Kuau	Serranidae	*Epinephelus merra*	107	0
Ikamawa	Scaridae	*Bolbometopon muricatum*	78	0
Riba	Acanthuridae	*Acanthurus gahhm*	72	0
Tinaemia	Lutjanidae	*Lutjanus monostigma*	59	0
Nimanang	Serranidae	*Cephalopholis argus*	48	0
Total:			**22,748**	**100**

2.3.1 Annual catch (kg) of fish groups per habitat – Kuria
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Outer reef				
Awai	Lutjanidae	*Aprion virescens*	10,376	28
Kaama	Carangidae	*Elagatis bipinnulata*	9080	25
Rereba	Carangidae	*Caranx melampygus*	3931	11
Bukinirin	Lutjanidae	*Aphareus rutilans*	3176	9
Kuau	Serranidae	*Epinephelus merra*	2739	7
Okaoka	Lethrinidae	*Lethrinus obsoletus*	2100	6
Ikanibong	Lutjanidae	*Lutjanus gibbus*	2055	6
Urua	Carangidae	*Caranx ignobilis*	595	2
Taabou	Lethrinidae	*Lethrinus miniatus*	526	1
Nimanang	Serranidae	*Cephalopholis argus*	504	1
Morikoi	Lethrinidae	*Lethrinus nebulosus*	475	1
Koa	Carangidae	*Carangoides ferdau*	432	1
Kaama	Carangidae	*Elagatis bipinnulata*	290	1
Ikauraura	Serranidae	*Cephalopholis sonnerati*	235	1
Ikabwauea	Sphyraenidae	*Sphyraena forsteri*	161	0
Maneku	Serranidae	*Epinephelus merra*	125	0
Aonga	Carangidae	*Caranx lugubris*	100	0
Bubu	Balistidae	*Rhinecanthus aculeatus*	35	0
Total:			**36,936**	**100**
Passages				
Rereba	Carangidae	*Caranx melampygus*	1473	59
Bwawe	Lutjanidae	*Lutjanus fulvus*	573	23
Okaoka	Lethrinidae	*Lethrinus obsoletus*	362	14
Tinaemia	Lutjanidae	*Lutjanus monostigma*	91	4
Total:			**2499**	**100**

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Kuria

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded data		Extrapolated data	
				no/year	kg/year	no/year	kg/year
Lobster	Lobster	*Panulirus penicillatus, Panulirus versicolor*	100.0	310	310	4495	4495
Total:			**100.0**				
Other	Giant clam	*Tridacna maxima, Tridacna squamosa*	66.7	800	80	11,599	1160
	Lobster	*Panulirus penicillatus, Panulirus versicolor*	33.3	40	40	580	580
Total:			**100.0**				
Reeftop	Giant Clam	*Tridacna maxima, Tridacna squamosa*	100.0	543	54	7875	788
Total:			**100.0**				
Intertidal	Makauro	*Coenobita* spp.	88.2	1616	81	25,569	1278
	Nikatona	*Tellina palatum*	11.8	516	11	8149	171
Total:			**100.0**				

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Kuria

Vernacular name	Scientific name	Size class	Annual catch total number	% of total catch by species (number)
Giant clam	*Tridacna maxima, Tridacna squamosa*	6 cm	60,800	41.85
		8 cm	22,583	15.55
		12 cm	6514	4.48
		14 cm	29,314	20.18
		16 cm	26,057	17.94
Total:			**145,269**	**100.00**
Lobster	*Panulirus penicillatus, Panulirus versicolor*	22 cm	2399	54.92
		24 cm	543	12.43
		26 cm	167	3.81
		28 cm	1259	28.84
Total:			**4368**	**100.00**
Tebun	*Anadara* spp.	4 cm	52	22.91
		6 cm	174	77.09
Total:			**225**	**100.00**
Koumara	*Gafrarium pectinatum*	2 cm	30	14.72
		4 cm	174	85.28
Total:			**204**	**100.00**
Nouo	*Strombus luhuanus*	2 cm	20	9.81
		4 cm	10	4.91
		6 cm	174	85.28
Total:			**204**	**100.00**
Seaworm	*Sipunculus indicus*	28 cm	138,771	100.00

2.4 Kiritimati socioeconomic survey data

2.4.1 Annual catch (kg) of fish groups per habitat – Kiritimati
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon				
Awatai	Chanidae	*Chanos chanos*	7199	33
Baneawa	Chanidae	*Chanos chanos*	6920	32
Ikari	Albulidae	*Albula vulpes*	3731	17
Kuau	Serranidae	*Epinephelus merra*	1512	7
Aua	Mugilidae	*Mugil* spp.	1009	5
Mako	Acanthuridae	*Acanthurus xanthopterus*	636	3
Tewe	Mullidae	*Parupeneus* spp.	329	2
Nari	Carangidae	*Scomberoides lysan*	228	1
Taabou	Lethrinidae	*Lethrinus miniatus*	101	0
Bwawe	Lutjanidae	*Lutjanus fulvus*	20	0
Takabe	Lutjanidae	*Lutjanus* spp.	0	0
Mon	Holocentridae	*Myripristis kuntee*	0	0
Ikanibong	Lutjanidae	*Lutjanus gibbus*	0	0
Nikoro	Serranidae	*Cephalopholis miniata*	0	0
Onauti	Exocoetidae	*Cypselurus* spp.	0	0
Ingo	Lutjanidae	*Lutjanus argentimaculatus*	0	0
Reiati	Serranidae	*Epinephelus polyphekadion*	0	0
Bukibuki	Pomacentridae	*Abudefduf septemfasciatus*	0	0
Bureinawa	Holocentridae	*Sargocentron violaceum*	0	0
Total:			**21,684**	**100**
Outer reef				
Takabe	Lutjanidae	*Lutjanus* spp.	264	21
Mon	Holocentridae	*Myripristis kuntee*	203	16
Mako	Acanthuridae	*Acanthurus xanthopterus*	202	16
Kuau	Serranidae	*Epinephelus merra*	152	12
Bwawe	Lutjanidae	*Lutjanus fulvus*	93	7
Ikanibong	Lutjanidae	*Lutjanus gibbus*	56	5
Nikoro	Serranidae	*Cephalopholis miniata*	54	4
Baneawa	Chanidae	*Chanos chanos*	41	3
Ikari	Albulidae	*Albula vulpes*	41	3
Onauti	Exocoetidae	*Cypselurus* spp.	41	3
Ingo	Lutjanidae	*Lutjanus argentimaculatus*	26	2
Reiati	Serranidae	*Epinephelus polyphekadion*	25	2
Bukibuki	Pomacentridae	*Abudefduf septemfasciatus*	25	2
Bureinawa	Holocentridae	*Sargocentron violaceum*	23	2
Awatai	Chanidae	*Chanos chanos*	0	0
Aua	Mugilidae	*Mugil* spp.	0	0
Tewe	Mullidae	*Parupeneus* spp.	0	0
Nari	Carangidae	*Scomberoides lysan*	0	0
Taabou	Lethrinidae	*Lethrinus miniatus*	0	0
Total:			**1244**	**100**

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Kiritimati

Fishery	Vernacular name	Scientific name	% annual catch (weight)	Recorded data		Extrapolated data	
				no/year	kg/year	no/year	kg/year
Bêche-de-mer	Prickly	*Thelenota ananas*	57.1	521	1303	3016	7541
	Green	*Stichopus chloronotus*	38.1	8686	869	50,270	5027
	Tiger skin	*Bohadschia argus*	1.8	87	40	503	232
	Kanimim	*Bohadschia vitiensis*	1.8	87	40	503	232
	Red sand	*Actinopyga mauritiana*	1.3	87	30	503	176
Lobster	Lobster	*Panulirus penicillatus, Panulirus versicolor*	100.0	434	434	2514	2514
Other	Giant clam	*Tridacna maxima, Tridacna squamosa*	79.3	68,400	6840	395,878	39,588
	Octopus	*Octopus* spp.	20.7	3255	1790	18,838	10,361

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Kiritimati

Vernacular name	Scientific name	Size class	Annual catch total number	% of total catch by species (number)
Giant clam	*Tridacna maxima, Tridacna squamosa*	10 cm	869	1.3
		10-14 cm	13,029	19.0
		12-16 cm	50,160	73.3
		14-18 cm	4343	6.3
Total:				**100.0**
Green	*Stichopus chloronotus*	18 cm	8686	100.0
Kanimim	*Bohadschia vitiensis*	20 cm	87	100.0
Prickly	*Thelenota ananas*	28 cm	521	100.0
Red sand	*Actinopyga mauritiana*	24 cm	87	100.0
Tiger skin	*Bohadschia argus*	26 cm	87	100.0
Lobster	*Panulirus penicillatus, Panulirus versicolor*	16 cm	434	100.0
Octopus	*Octopus* spp.	04 cm	70	2.1
		06 cm	217	6.7
		06-08 cm	100	3.1
		06-10 cm	130	4.0
		08 cm	217	6.7
		08-12 cm	174	5.3
		10 cm	239	7.3
		10-12 cm	2063	63.4
		12 cm	45	1.4
Total:				**100.0**

2.4.4 Total annual recorded biomass (wet weight kg/year) by species & category of use – Kiritimati

Scientific name	Vernacular name	Total catch (biomass wet weight kg/year)			
		Consumption	Sale	Consumption & sale	Sum
Tridacna maxima, Tridacna squamosa	Giant clam	521	1433	4886	6840
Stichopus chloronotus	Green	0	869	0	869
Bohadschia vitiensis	Kanimim	0	40	0	40
Panulirus penicillatus, Panulirus versicolor	Lobster	434	0	0	434
Octopus spp.	Octopus	1408	0	382	1790
Thelenota ananas	Prickly	0	1303	0	1303
Actinopyga mauritiana	Red sand	0	30	0	30
Bohadschia argus	Tiger skin	0	40	0	40
Total:		**2363**	**3715**	**5268**	**11347**

APPENDIX 3: FINFISH SURVEY DATA

3.1 Abaiang finfish survey data

3.1.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Abaiang

Station name	Habitat	Latitude	Longitude
TRA01	Outer reef	1°54'37.8612" N	172°47'09.8412" E
TRA02	Outer reef	1°58'32.2788" N	172°51'46.3212" E
TRA03	Outer reef	1°58'32.34" N	172°51'46.1988" E
TRA04	Outer reef	1°51'22.14" N	172°52'50.8188" E
TRA05	Back-reef	1°47'10.0788" N	172°56'21.3" E
TRA06	Back-reef	1°50'23.8812" N	172°54'16.74" E
TRA07	Lagoon	1°50'08.9988" N	172°58'11.28" E
TRA08	Lagoon	1°50'37.4388" N	172°55'23.4588" E
TRA09	Coastal reef	1°50'42.54" N	172°59'51.9" E
TRA10	Outer reef	1°47'01.0788" N	172°56'06.2988" E
TRA11	Outer reef	1°42'36.9" N	173°00'31.14" E
TRA12	Coastal reef	1°43'33.78" N	172°59'44.8188" E
TRA13	Back-reef	1°44'28.7412" N	172°59'13.2" E
TRA14	Lagoon	1°46'54.4188" N	172°59'56.4" E
TRA15	Back-reef	1°53'12.5412" N	172°50'31.92" E
TRA16	Coastal reef	1°53'17.6388" N	172°49'08.5188" E
TRA17	Coastal reef	1°53'31.0812" N	172°49'11.3412" E
TRA18	Back	1°57'23.94" N	172°51'43.6788" E
TRA19	Back	1°57'16.74" N	172°52'35.94" E
TRA20	Lagoon	1°53'20.1012" N	172°55'11.5788" E
TRA21	Lagoon	1°54'48.1212" N	172°52'37.38" E
TRA22	Lagoon	1°48'29.5812" N	173°00'06.0012" E
TRA23	Coastal reef	1°44'51.1188" N	173°02'06.6012" E
TRA24	Coastal reef	1°47'29.8212" N	173°02'12.12" E

Appendix 3: Finfish survey data
Abaiang

3.1.2 Weighted average density and biomass of all finfish species recorded in Abaiang
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	0.0328	25.600
Acanthuridae	*Acanthurus leucocheilus*	0.0093	2.090
Acanthuridae	*Acanthurus lineatus*	0.0110	2.940
Acanthuridae	*Acanthurus maculiceps*	0.0020	0.093
Acanthuridae	*Acanthurus nigricans*	0.0500	5.850
Acanthuridae	*Acanthurus nigricauda*	0.0274	27.400
Acanthuridae	*Acanthurus nigrofuscus*	0.0100	0.707
Acanthuridae	*Acanthurus nigroris*	0.0047	0.450
Acanthuridae	*Acanthurus olivaceus*	0.0917	32.200
Acanthuridae	*Acanthurus pyroferus*	0.0020	0.054
Acanthuridae	*Acanthurus triostegus*	0.0311	1.350
Acanthuridae	*Acanthurus xanthopterus*	0.0293	18.900
Acanthuridae	*Aethaloperca rogaa*	0.0090	1.180
Acanthuridae	*Anyperodon leucogrammicus*	0.0020	0.504
Acanthuridae	*Ctenochaetus binotatus*	0.0053	0.138
Acanthuridae	*Ctenochaetus flavicauda*	0.0180	0.649
Acanthuridae	*Ctenochaetus striatus*	0.0634	4.160
Acanthuridae	*Naso annulatus*	0.0153	5.950
Acanthuridae	*Naso brachycentron*	0.0050	3.360
Acanthuridae	*Naso brevirostris*	0.0160	4.220
Acanthuridae	*Naso caesius*	0.0110	8.620
Acanthuridae	*Naso hexacanthus*	0.0320	26.900
Acanthuridae	*Naso lituratus*	0.0060	2.520
Acanthuridae	*Naso* spp.	0.0020	0.055
Acanthuridae	*Naso unicornis*	0.0033	0.592
Acanthuridae	*Naso vlamingii*	0.0160	9.530
Acanthuridae	*Zebrasoma rostratum*	0.0020	0.054
Acanthuridae	*Zebrasoma scopas*	0.0123	0.427
Acanthuridae	*Zebrasoma veliferum*	0.0033	0.204
Balistidae	*Balistapus undulatus*	0.0179	3.170
Balistidae	*Balistoides conspicillum*	0.0020	1.970
Balistidae	*Balistoides viridescens*	0.0080	14.200
Balistidae	*Melichthys niger*	0.0064	2.310
Balistidae	*Melichthys vidua*	0.0318	4.010
Balistidae	*Pseudobalistes flavimarginatus*	0.0095	15.900
Balistidae	*Rhinecanthus aculeatus*	0.0076	1.100
Balistidae	*Sufflamen chrysopterus*	0.0161	2.660
Balistidae	*Sufflamen fraenatus*	0.0020	0.012
Chaetodontidae	*Chaetodon auriga*	0.0130	0.493
Chaetodontidae	*Chaetodon bennetti*	0.0100	0.427
Chaetodontidae	*Chaetodon citrinellus*	0.0078	0.084
Chaetodontidae	*Chaetodon ephippium*	0.0060	0.155
Chaetodontidae	*Chaetodon flavirostris*	0.0040	0.230
Chaetodontidae	*Chaetodon kleinii*	0.0090	0.151
Chaetodontidae	*Chaetodon lunula*	0.0089	0.314
Chaetodontidae	*Chaetodon lunulatus*	0.0109	0.306
Chaetodontidae	*Chaetodon meyeri*	0.0169	0.604
Chaetodontidae	*Chaetodon reticulatus*	0.0080	0.289

3.1.2 Weighted average density and biomass of all finfish species recorded in Abaiang (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Chaetodon trifascialis*	0.0068	0.185
Chaetodontidae	*Chaetodon ulietensis*	0.0067	0.186
Chaetodontidae	*Chaetodon vagabundus*	0.0074	0.211
Chaetodontidae	*Forcipiger flavissimus*	0.0080	0.255
Chaetodontidae	*Forcipiger longirostris*	0.0040	0.040
Chaetodontidae	*Heniochus acuminatus*	0.0035	0.275
Chaetodontidae	*Heniochus chrysostomus*	0.0070	0.489
Chaetodontidae	*Heniochus* spp.	0.0020	0.107
Chaetodontidae	*Heniochus varius*	0.0053	0.258
Holocentridae	*Myripristis adusta*	0.0130	3.230
Holocentridae	*Myripristis berndti*	0.0040	0.652
Holocentridae	*Myripristis violacea*	0.0060	1.070
Holocentridae	*Neoniphon sammara*	0.0755	2.260
Holocentridae	*Sargocentron caudimaculatum*	0.0020	0.025
Holocentridae	*Sargocentron microstoma*	0.0600	4.090
Holocentridae	*Sargocentron spiniferum*	0.0080	5.250
Kyphosidae	*Kyphosus vaigiensis*	0.1900	121.000
Labridae	*Cheilinus chlorourus*	0.0036	0.446
Labridae	*Cheilinus fasciatus*	0.0087	2.270
Labridae	*Cheilinus trilobatus*	0.0020	2.210
Labridae	*Cheilinus undulatus*	0.0033	16.000
Labridae	*Coris aygula*	0.0040	0.048
Labridae	*Epibulus insidiator*	0.0020	0.383
Labridae	*Hemigymnus melapterus*	0.0036	0.230
Lethrinidae	*Gnathodentex aureolineatus*	0.0273	6.630
Lethrinidae	*Lethrinus amboinensis*	0.0020	1.510
Lethrinidae	*Lethrinus genivittatus*	0.0020	0.511
Lethrinidae	*Lethrinus harak*	0.0074	3.200
Lethrinidae	*Lethrinus obsoletus*	0.0020	1.020
Lethrinidae	*Lethrinus olivaceus*	0.0045	3.060
Lethrinidae	*Lethrinus ornatus*	0.0020	1.510
Lethrinidae	*Lethrinus xanthochilus*	0.0093	10.300
Lethrinidae	*Monotaxis grandoculis*	0.0197	6.340
Lutjanidae	*Aphareus furca*	0.0074	3.360
Lutjanidae	*Aprion virescens*	0.0020	1.830
Lutjanidae	*Lutjanus bohar*	0.0168	13.800
Lutjanidae	*Lutjanus ehrenbergii*	0.1770	81.400
Lutjanidae	*Lutjanus fulvus*	0.2200	64.600
Lutjanidae	*Lutjanus gibbus*	0.0991	32.600
Lutjanidae	*Lutjanus kasmira*	0.0700	4.890
Lutjanidae	*Lutjanus monostigma*	0.0211	12.700
Lutjanidae	*Lutjanus semicinctus*	0.0060	0.940
Lutjanidae	*Macolor macularis*	0.0400	36.300
Lutjanidae	*Macolor niger*	0.0020	0.562
Mullidae	*Mulloidichthys flavolineatus*	0.0200	2.800
Mullidae	*Mulloidichthys vanicolensis*	0.0120	3.110
Mullidae	*Parupeneus barberinus*	0.0042	0.572

3.1.2 Weighted average density and biomass of all finfish species recorded in Abaiang (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Mullidae	*Parupeneus bifasciatus*	0.0027	0.103
Mullidae	*Parupeneus cyclostomus*	0.0020	0.291
Mullidae	*Parupeneus multifasciatus*	0.0140	0.911
Mullidae	*Parupeneus pleurostigma*	0.0040	0.239
Pomacanthidae	*Pygoplites diacanthus*	0.0038	0.480
Scaridae	*Cetoscarus bicolor*	0.0040	3.080
Scaridae	*Chlorurus sordidus*	0.0416	5.110
Scaridae	*Hipposcarus longiceps*	0.0075	3.620
Scaridae	*Scarus altipinnis*	0.0080	2.760
Scaridae	*Scarus dimidiatus*	0.0020	0.435
Scaridae	*Scarus flavipectoralis*	0.0040	1.630
Scaridae	*Scarus frenatus*	0.0033	0.646
Scaridae	*Scarus ghobban*	0.0071	2.700
Scaridae	*Scarus globiceps*	0.0040	0.321
Scaridae	*Scarus longipinnis*	0.0040	1.510
Scaridae	*Scarus oviceps*	0.0035	0.996
Scaridae	*Scarus psittacus*	0.0057	1.500
Scaridae	*Scarus rivulatus*	0.0040	0.697
Scaridae	*Scarus rubroviolaceus*	0.0030	1.260
Scaridae	*Scarus schlegeli*	0.0030	0.483
Scaridae	*Scarus spinus*	0.0030	0.755
Scaridae	*Scarus tricolor*	0.0030	1.500
Serranidae	*Cephalopholis argus*	0.0228	7.570
Serranidae	*Cephalopholis urodeta*	0.0104	0.775
Serranidae	*Epinephelus coeruleopunctatus*	0.0020	0.084
Serranidae	*Epinephelus hexagonatus*	0.0036	0.107
Serranidae	*Epinephelus macrospilos*	0.0020	0.962
Serranidae	*Epinephelus maculatus*	0.0020	0.788
Serranidae	*Epinephelus merra*	0.0038	0.136
Serranidae	*Epinephelus spilotoceps*	0.0020	0.409
Serranidae	*Gracila albomarginata*	0.0040	2.050
Serranidae	*Plectropomus areolatus*	0.0024	1.600
Serranidae	*Plectropomus laevis*	0.0030	2.300
Serranidae	*Plectropomus maculatus*	0.0060	2.320
Serranidae	*Variola louti*	0.0020	1.930
Siganidae	*Siganus argenteus*	0.0040	0.748
Siganidae	*Siganus corallinus*	0.0080	3.110
Siganidae	*Siganus punctatus*	0.0020	0.135
Zanclidae	*Zanclus cornutus*	0.0106	0.876

3.2 Abemama finfish survey data

3.2.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Abemama

Station name	Habitat	Latitude	Longitude
TRA01	Lagoon	0°21'33.3612" N	173°53'00.3012" E
TRA02	Outer reef	0°19'46.6212" N	173°51'06.48" E
TRA03	Outer reef	0°19'46.4412" N	173°51'06.4188" E
TRA04	Lagoon	0°21'44.7012" N	173°54'06.4188" E
TRA05	Lagoon	0°22'57.8388" N	173°54'00.7812" E
TRA06	Coastal reef	0°22'29.3412" N	173°55'19.4988" E
TRA07	Back-reef	0°20'16.98" N	173°51'44.28" E
TRA08	Back-reef	0°20'39.5988" N	173°51'12.3012" E
TRA09	Back-reef	0°20'59.7012" N	173°50'56.94" E
TRA10	Back-reef	0°21'42.48" N	173°50'22.4988" E
TRA11	Back-reef	0°22'07.32" N	173°49'57.6012" E
TRA12	Back-reef	0°22'24.5388" N	173°49'25.0212" E
TRA13	Back-reef	0°23'00.4812" N	173°49'13.26" E
TRA14	Coastal reef	0°23'43.6812" N	173°47'57.5988" E
TRA15	Lagoon	0°23'48.3612" N	173°49'22.1988" E
TRA16	Lagoon	0°24'25.2612" N	173°53'53.9988" E
TRA17	Outer reef	0°21'58.0212" N	173°49'05.2788" E
TRA18	Outer reef	0°23'33.2412" N	173°45'15.2388" E
TRA19	Outer reef	0°23'33" N	173°45'15.0588" E
TRA20	Outer reef	0°27'43.8012" N	173°47'36.1788" E
TRA21	Coastal reef	0°27'48.42" N	173°51'20.52" E
TRA22	Lagoon	0°26'23.2188" N	173°49'49.8" E
TRA23	Coastal reef	0°26'32.3412" N	173°52'50.6388" E
TRA24	Coastal reef	0°25'41.0988" N	173°53'49.4988" E

3.2.2 Weighted average density and biomass of all finfish species recorded in Abemama (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus albipectoralis*	0.0080	4.650
Acanthuridae	*Acanthurus blochii*	0.0408	19.500
Acanthuridae	*Acanthurus guttatus*	0.0040	0.622
Acanthuridae	*Acanthurus leucocheilus*	0.0020	0.369
Acanthuridae	*Acanthurus lineatus*	0.0213	4.520
Acanthuridae	*Acanthurus maculiceps*	0.0020	0.181
Acanthuridae	*Acanthurus nigricans*	0.0423	4.240
Acanthuridae	*Acanthurus nigricauda*	0.0114	5.900
Acanthuridae	*Acanthurus nigroris*	0.0100	1.100
Acanthuridae	*Acanthurus olivaceus*	0.0046	1.080
Acanthuridae	*Acanthurus pyroferus*	0.0080	0.583
Acanthuridae	*Acanthurus* spp.	0.0260	12.100
Acanthuridae	*Acanthurus triostegus*	0.0405	1.760
Acanthuridae	*Acanthurus xanthopterus*	0.0245	12.600
Acanthuridae	*Aethaloperca rogaa*	0.0053	1.890
Acanthuridae	*Anyperodon leucogrammicus*	0.0060	1.470
Acanthuridae	*Ctenochaetus marginatus*	0.0100	2.360
Acanthuridae	*Ctenochaetus striatus*	0.0602	6.190
Acanthuridae	*Ctenochaetus strigosus*	0.0110	0.230
Acanthuridae	*Naso annulatus*	0.0219	6.600
Acanthuridae	*Naso caesius*	0.0220	9.740
Acanthuridae	*Naso hexacanthus*	0.0040	5.120
Acanthuridae	*Naso lituratus*	0.0180	9.900
Acanthuridae	*Naso lopezi*	0.0040	5.450
Acanthuridae	*Naso* spp.	0.0030	1.940
Acanthuridae	*Naso unicornis*	0.0112	5.450
Acanthuridae	*Naso vlamingii*	0.0940	54.400
Acanthuridae	*Zebrasoma flavescens*	0.0020	0.040
Acanthuridae	*Zebrasoma rostratum*	0.0090	0.262
Acanthuridae	*Zebrasoma scopas*	0.0210	0.681
Acanthuridae	*Zebrasoma veliferum*	0.0043	0.244
Balistidae	*Abalistes stellaris*	0.0120	0.985
Balistidae	*Balistapus undulatus*	0.0189	2.780
Balistidae	*Balistoides conspicillum*	0.0060	4.830
Balistidae	*Balistoides viridescens*	0.0040	6.090
Balistidae	*Melichthys niger*	0.0217	3.500
Balistidae	*Melichthys vidua*	0.0564	5.300
Balistidae	*Odonus niger*	0.5750	12.600
Balistidae	*Pseudobalistes flavimarginatus*	0.0165	19.300
Balistidae	*Rhinecanthus aculeatus*	0.0113	1.080
Balistidae	*Rhinecanthus verrucosus*	0.0020	0.139
Balistidae	*Sufflamen bursa*	0.0100	0.254
Balistidae	*Sufflamen chrysopterus*	0.0083	1.430
Chaetodontidae	*Chaetodon auriga*	0.0098	0.366
Chaetodontidae	*Chaetodon bennetti*	0.0060	0.214
Chaetodontidae	*Chaetodon citrinellus*	0.0080	0.143
Chaetodontidae	*Chaetodon ephippium*	0.0082	0.386
Chaetodontidae	*Chaetodon kleinii*	0.0085	0.202

3.2.2 Weighted average density and biomass of all finfish species recorded in Abemama (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Chaetodon lunula*	0.0091	0.347
Chaetodontidae	*Chaetodon lunulatus*	0.0111	0.340
Chaetodontidae	*Chaetodon mertensii*	0.0020	0.008
Chaetodontidae	*Chaetodon meyeri*	0.0297	1.490
Chaetodontidae	*Chaetodon ornatissimus*	0.0060	0.412
Chaetodontidae	*Chaetodon reticulatus*	0.0080	0.349
Chaetodontidae	*Chaetodon speculum*	0.0020	0.036
Chaetodontidae	*Chaetodon trifascialis*	0.0052	0.137
Chaetodontidae	*Chaetodon ulietensis*	0.0065	0.186
Chaetodontidae	*Chaetodon vagabundus*	0.0130	0.398
Chaetodontidae	*Forcipiger flavissimus*	0.0060	0.171
Chaetodontidae	*Forcipiger longirostris*	0.0063	0.133
Chaetodontidae	*Heniochus acuminatus*	0.0096	0.660
Chaetodontidae	*Heniochus chrysostomus*	0.0080	0.455
Chaetodontidae	*Heniochus varius*	0.0080	0.486
Holocentridae	*Myripristis adusta*	0.0330	9.560
Holocentridae	*Myripristis berndti*	0.0030	1.130
Holocentridae	*Myripristis botche*	0.0020	0.170
Holocentridae	*Myripristis* spp.	0.0120	0.560
Holocentridae	*Myripristis violacea*	0.0020	0.487
Holocentridae	*Neoniphon sammara*	0.0160	0.747
Holocentridae	*Neoniphon* spp.	0.0540	17.400
Holocentridae	*Sargocentron caudimaculatum*	0.0108	0.790
Holocentridae	*Sargocentron* spp.	0.0080	8.140
Holocentridae	*Sargocentron spiniferum*	0.0036	2.050
Kyphosidae	*Kyphosus vaigiensis*	0.0200	2.590
Labridae	*Cheilinus chlorourus*	0.0047	1.160
Labridae	*Cheilinus trilobatus*	0.0020	0.502
Labridae	*Cheilinus undulatus*	0.0080	31.100
Labridae	*Coris aygula*	0.0028	0.686
Labridae	*Hemigymnus fasciatus*	0.0020	1.030
Labridae	*Hemigymnus melapterus*	0.0030	0.847
Lethrinidae	*Gnathodentex aureolineatus*	0.0360	17.600
Lethrinidae	*Gymnocranius euanus*	0.0080	11.600
Lethrinidae	*Lethrinus amboinensis*	0.0020	1.260
Lethrinidae	*Lethrinus atkinsoni*	0.0030	2.210
Lethrinidae	*Lethrinus erythropterus*	0.0020	1.030
Lethrinidae	*Lethrinus harak*	0.0055	2.120
Lethrinidae	*Lethrinus miniatus*	0.0040	2.250
Lethrinidae	*Lethrinus obsoletus*	0.0060	2.470
Lethrinidae	*Lethrinus olivaceus*	0.0204	21.300
Lethrinidae	*Lethrinus* spp.	0.0020	0.767
Lethrinidae	*Lethrinus variegatus*	0.0020	0.139
Lethrinidae	*Lethrinus xanthochilus*	0.0226	15.500
Lethrinidae	*Monotaxis grandoculis*	0.0228	7.280
Lutjanidae	*Aphareus furca*	0.0107	3.470
Lutjanidae	*Aphareus rutilans*	0.0027	0.520

3.2.2 Weighted average density and biomass of all finfish species recorded in Abemama (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Aprion virescens*	0.0040	3.950
Lutjanidae	*Lutjanus bohar*	0.0311	8.750
Lutjanidae	*Lutjanus ehrenbergii*	0.0494	13.900
Lutjanidae	*Lutjanus fulviflamma*	0.0060	0.638
Lutjanidae	*Lutjanus fulvus*	0.2590	36.900
Lutjanidae	*Lutjanus gibbus*	0.1980	71.500
Lutjanidae	*Lutjanus kasmira*	0.4600	41.800
Lutjanidae	*Lutjanus monostigma*	0.0220	8.930
Lutjanidae	*Lutjanus quinquelineatus*	0.0160	3.280
Lutjanidae	*Lutjanus semicinctus*	0.0095	3.310
Mullidae	*Mulloidichthys flavolineatus*	0.0280	0.844
Mullidae	*Mulloidichthys vanicolensis*	0.0080	0.591
Mullidae	*Parupeneus barberinus*	0.0136	2.110
Mullidae	*Parupeneus bifasciatus*	0.0027	0.107
Mullidae	*Parupeneus cyclostomus*	0.0065	0.858
Mullidae	*Parupeneus indicus*	0.0070	2.880
Mullidae	*Parupeneus multifasciatus*	0.0140	1.550
Mullidae	*Parupeneus spilurus*	0.0020	0.070
Pomacanthidae	*Pygoplites diacanthus*	0.0024	0.157
Scaridae	*Cetoscarus bicolor*	0.0033	2.970
Scaridae	*Chlorurus sordidus*	0.0244	4.740
Scaridae	*Hipposcarus longiceps*	0.0086	5.420
Scaridae	*Scarus altipinnis*	0.0040	2.750
Scaridae	*Scarus chameleon*	0.0020	0.755
Scaridae	*Scarus flavipectoralis*	0.0038	1.290
Scaridae	*Scarus forsteni*	0.0020	2.360
Scaridae	*Scarus frenatus*	0.0059	2.020
Scaridae	*Scarus ghobban*	0.0066	3.810
Scaridae	*Scarus globiceps*	0.0030	0.847
Scaridae	*Scarus niger*	0.0045	2.850
Scaridae	*Scarus oviceps*	0.0069	2.230
Scaridae	*Scarus psittacus*	0.0043	0.706
Scaridae	*Scarus rivulatus*	0.0020	1.950
Scaridae	*Scarus rubroviolaceus*	0.0030	3.310
Scaridae	*Scarus schlegeli*	0.0060	3.000
Scaridae	*Scarus* spp.	0.0090	2.280
Scaridae	*Scarus tricolor*	0.0020	1.020
Serranidae	*Cephalopholis argus*	0.0326	15.600
Serranidae	*Cephalopholis miniata*	0.0020	1.040
Serranidae	*Cephalopholis sexmaculata*	0.0020	1.720
Serranidae	*Cephalopholis urodeta*	0.0136	0.672
Serranidae	*Epinephelus coeruleopunctatus*	0.0040	0.137
Serranidae	*Epinephelus coioides*	0.0020	0.130
Serranidae	*Epinephelus fuscoguttatus*	0.0020	3.120
Serranidae	*Epinephelus hexagonatus*	0.0020	0.166
Serranidae	*Epinephelus howlandi*	0.0090	1.930
Serranidae	*Epinephelus maculatus*	0.0036	1.500

3.2.2 Weighted average density and biomass of all finfish species recorded in Abemama (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Serranidae	*Epinephelus merra*	0.0048	0.236
Serranidae	*Epinephelus polyphekadion*	0.0030	2.610
Serranidae	*Epinephelus* spp.	0.0040	1.840
Serranidae	*Epinephelus spilotoceps*	0.0040	0.613
Serranidae	*Epinephelus tauvina*	0.0020	0.713
Serranidae	*Gracila albomarginata*	0.0140	8.050
Serranidae	*Plectropomus areolatus*	0.0095	7.400
Serranidae	*Plectropomus laevis*	0.0120	0.338
Serranidae	*Plectropomus leopardus*	0.0020	1.480
Serranidae	*Plectropomus maculatus*	0.0020	1.530
Serranidae	*Variola albimarginata*	0.0080	4.500
Serranidae	*Variola louti*	0.0040	3.170
Siganidae	*Siganus argenteus*	0.0040	0.786
Siganidae	*Siganus puellus*	0.0040	0.614
Siganidae	*Siganus punctatus*	0.0040	2.090
Zanclidae	*Zanclus cornutus*	0.0207	1.290

3.3 Kuria finfish survey data

3.3.1 Coordinates (WGS 84) of the 24 D-UVC transects used to assess finfish resource status in Kuria

Station name	Habitat	Latitude	Longitude
TRA01	Outer reef	0°11'26.4012" N	173°25'33.6" E
TRA02	Outer reef	0°11'53.88" N	173°26'04.56" E
TRA03	Outer reef	0°12'15.7788" N	173°26'28.9212" E
TRA04	Outer reef	0°11'51" N	173°24'17.2188" E
TRA05	Outer reef	0°12'31.0788" N	173°24'23.4" E
TRA06	Outer reef	0°13'06.24" N	173°24'10.26" E
TRA07	Outer reef	0°13'47.3412" N	173°24'10.8612" E
TRA08	Outer reef	0°14'16.44" N	173°23'50.9388" E
TRA09	Outer reef	0°12'26.5212" N	173°26'55.86" E
TRA10	Outer reef	0°12'50.4612" N	173°27'32.4612" E
TRA11	Outer reef	0°13'20.82" N	173°26'57.5412" E
TRA12	Outer reef	0°13'42.1212" N	173°26'29.94" E
TRA13	Outer reef	0°13'42.1212" N	173°26'30.0012" E
TRA14	Outer reef	0°14'41.3988" N	173°25'05.9988" E
TRA15	Outer reef	0°14'41.3412" N	173°25'05.88" E
TRA16	Outer reef	0°16'22.5012" N	173°23'29.22" E
TRA17	Outer reef	0°16'45.5988" N	173°23'07.5588" E
TRA18	Outer reef	0°17'22.2" N	173°22'20.7012" E
TRA19	Outer reef	0°16'31.62" N	173°21'04.3812" E
TRA20	Outer reef	0°16'08.04" N	173°22'47.1" E
TRA21	Outer reef	0°16'08.04" N	173°22'47.0388" E
TRA22	Outer reef	0°15'23.1588" N	173°22'50.9988" E
TRA23	Outer reef	0°14'55.3812" N	173°23'20.4612" E
TRA24	Outer reef	°14'37.86" N	0 173°23'37.68" E

Appendix 3: Finfish survey data
Kuria

3.3.2 Weighted average density and biomass of all finfish species recorded in Kuria
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus albipectoralis*	0.0240	1.410
Acanthuridae	*Acanthurus blochii*	0.0148	4.130
Acanthuridae	*Acanthurus dussumieri*	0.0112	6.130
Acanthuridae	*Acanthurus guttatus*	0.0090	1.060
Acanthuridae	*Acanthurus leucocheilus*	0.0066	1.350
Acanthuridae	*Acanthurus lineatus*	0.0620	18.600
Acanthuridae	*Acanthurus maculiceps*	0.0069	1.120
Acanthuridae	*Acanthurus nigricans*	0.0844	10.300
Acanthuridae	*Acanthurus nigricauda*	0.0135	8.360
Acanthuridae	*Acanthurus nigroris*	0.0540	4.200
Acanthuridae	*Acanthurus olivaceus*	0.0388	5.800
Acanthuridae	*Acanthurus pyroferus*	0.0048	0.874
Acanthuridae	*Acanthurus* spp.	0.0400	34.600
Acanthuridae	*Acanthurus triostegus*	0.0698	6.970
Acanthuridae	*Acanthurus xanthopterus*	0.0488	40.800
Acanthuridae	*Aethaloperca rogaa*	0.0026	1.340
Acanthuridae	*Anyperodon leucogrammicus*	0.0020	0.555
Acanthuridae	*Ctenochaetus binotatus*	0.0020	0.060
Acanthuridae	*Ctenochaetus marginatus*	0.0129	3.160
Acanthuridae	*Ctenochaetus striatus*	0.0767	6.590
Acanthuridae	*Ctenochaetus strigosus*	0.0030	0.101
Acanthuridae	*Naso annulatus*	0.0377	17.500
Acanthuridae	*Naso brachycentron*	0.0160	19.300
Acanthuridae	*Naso brevirostris*	0.0080	2.070
Acanthuridae	*Naso caesius*	0.1300	122.000
Acanthuridae	*Naso hexacanthus*	0.0360	28.800
Acanthuridae	*Naso lituratus*	0.0077	4.070
Acanthuridae	*Naso lopezi*	0.0510	54.900
Acanthuridae	*Naso thynnoides*	0.0300	3.050
Acanthuridae	*Naso tuberosus*	0.0040	3.870
Acanthuridae	*Naso unicornis*	0.0080	5.490
Acanthuridae	*Paracanthurus hepatus*	0.0100	0.535
Acanthuridae	*Zebrasoma rostratum*	0.0047	0.139
Acanthuridae	*Zebrasoma scopas*	0.0113	0.531
Acanthuridae	*Zebrasoma veliferum*	0.0175	1.090
Balistidae	*Abalistes stellaris*	0.0213	1.750
Balistidae	*Balistapus undulatus*	0.0269	3.650
Balistidae	*Balistoides conspicillum*	0.0027	1.880
Balistidae	*Balistoides viridescens*	0.0028	3.370
Balistidae	*Melichthys niger*	0.0465	2.840
Balistidae	*Melichthys vidua*	0.0858	6.500
Balistidae	*Odonus niger*	0.9440	12.500
Balistidae	*Pseudobalistes flavimarginatus*	0.0046	9.890
Balistidae	*Rhinecanthus aculeatus*	0.0020	0.111
Balistidae	*Rhinecanthus lunula*	0.0050	0.098
Balistidae	*Rhinecanthus rectangulus*	0.0043	0.556
Balistidae	*Rhinecanthus verrucosus*	0.0050	0.770
Balistidae	*Sufflamen bursa*	0.0069	0.304

3.3.2 Weighted average density and biomass of all finfish species recorded in Kuria (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Balistidae	*Sufflamen chrysopterus*	0.0065	0.697
Balistidae	*Sufflamen fraenatus*	0.0020	0.303
Chaetodontidae	*Chaetodon auriga*	0.0055	0.256
Chaetodontidae	*Chaetodon bennetti*	0.0076	0.307
Chaetodontidae	*Chaetodon ephippium*	0.0073	0.330
Chaetodontidae	*Chaetodon flavirostris*	0.0080	0.921
Chaetodontidae	*Chaetodon kleinii*	0.0063	0.180
Chaetodontidae	*Chaetodon lineolatus*	0.0040	0.811
Chaetodontidae	*Chaetodon lunula*	0.0059	0.328
Chaetodontidae	*Chaetodon lunulatus*	0.0071	0.289
Chaetodontidae	*Chaetodon melannotus*	0.0020	0.030
Chaetodontidae	*Chaetodon mertensii*	0.0040	0.028
Chaetodontidae	*Chaetodon meyeri*	0.0252	1.270
Chaetodontidae	*Chaetodon ornatissimus*	0.0040	0.305
Chaetodontidae	*Chaetodon pelewensis*	0.0030	0.026
Chaetodontidae	*Chaetodon reticulatus*	0.0080	0.356
Chaetodontidae	*Chaetodon speculum*	0.0040	0.265
Chaetodontidae	*Chaetodon trifascialis*	0.0040	0.127
Chaetodontidae	*Chaetodon ulietensis*	0.0064	0.198
Chaetodontidae	*Chaetodon unimaculatus*	0.0030	0.141
Chaetodontidae	*Chaetodon vagabundus*	0.0065	0.239
Chaetodontidae	*Forcipiger flavissimus*	0.0069	0.244
Chaetodontidae	*Forcipiger longirostris*	0.0065	0.213
Chaetodontidae	*Heniochus acuminatus*	0.0077	0.571
Chaetodontidae	*Heniochus chrysostomus*	0.0030	0.073
Chaetodontidae	*Heniochus monoceros*	0.0037	0.156
Chaetodontidae	*Heniochus singularius*	0.0040	0.424
Chaetodontidae	*Heniochus varius*	0.0050	0.394
Holocentridae	*Myripristis adusta*	0.0103	2.270
Holocentridae	*Myripristis berndti*	0.0093	1.880
Holocentridae	*Myripristis murdjan*	0.0050	0.368
Holocentridae	*Myripristis* spp.	0.0020	0.141
Holocentridae	*Myripristis violacea*	0.0100	1.380
Holocentridae	*Neoniphon sammara*	0.0060	0.413
Holocentridae	*Sargocentron caudimaculatum*	0.0055	0.428
Holocentridae	*Sargocentron spiniferum*	0.0033	1.340
Kyphosidae	*Kyphosus cinerascens*	0.0020	0.502
Labridae	*Cheilinus chlorourus*	0.0053	0.963
Labridae	*Cheilinus fasciatus*	0.0030	0.702
Labridae	*Cheilinus trilobatus*	0.0026	1.340
Labridae	*Cheilinus undulatus*	0.0065	47.300
Labridae	*Choerodon anchorago*	0.0020	0.251
Labridae	*Coris aygula*	0.0048	0.885
Labridae	*Hemigymnus fasciatus*	0.0042	1.010
Labridae	*Hemigymnus melapterus*	0.0045	1.630
Lethrinidae	*Gnathodentex aureolineatus*	0.0323	8.920
Lethrinidae	*Gymnocranius* spp.	0.0280	9.860

Appendix 3: Finfish survey data
Kuria

3.3.2 Weighted average density and biomass of all finfish species recorded in Kuria (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Lethrinidae	*Lethrinus atkinsoni*	0.0040	2.130
Lethrinidae	*Lethrinus harak*	0.0076	2.460
Lethrinidae	*Lethrinus obsoletus*	0.0033	1.080
Lethrinidae	*Lethrinus olivaceus*	0.0091	6.960
Lethrinidae	*Lethrinus xanthochilus*	0.0159	11.800
Lethrinidae	*Monotaxis grandoculis*	0.0211	9.910
Lutjanidae	*Aphareus furca*	0.0349	7.830
Lutjanidae	*Aphareus rutilans*	0.0030	0.663
Lutjanidae	*Aprion virescens*	0.0192	16.700
Lutjanidae	*Lutjanus bohar*	0.0338	11.600
Lutjanidae	*Lutjanus fulvus*	0.0716	18.500
Lutjanidae	*Lutjanus gibbus*	0.1280	66.000
Lutjanidae	*Lutjanus kasmira*	0.2590	30.000
Lutjanidae	*Lutjanus monostigma*	0.0204	8.030
Lutjanidae	*Lutjanus quinquelineatus*	0.0080	1.690
Lutjanidae	*Lutjanus semicinctus*	0.0085	2.340
Lutjanidae	*Macolor niger*	0.0025	0.202
Mullidae	*Mulloidichthys flavolineatus*	0.0140	0.583
Mullidae	*Mulloidichthys vanicolensis*	0.0060	0.533
Mullidae	*Parupeneus barberinus*	0.0054	0.544
Mullidae	*Parupeneus bifasciatus*	0.0094	1.130
Mullidae	*Parupeneus cyclostomus*	0.0040	0.270
Mullidae	*Parupeneus multifasciatus*	0.0086	0.647
Pomacanthidae	*Pomacanthus imperator*	0.0020	0.254
Pomacanthidae	*Pygoplites diacanthus*	0.0025	0.285
Scaridae	*Cetoscarus bicolor*	0.0028	1.570
Scaridae	*Chlorurus bleekeri*	0.0040	1.180
Scaridae	*Chlorurus sordidus*	0.0216	5.680
Scaridae	*Hipposcarus longiceps*	0.0056	2.270
Scaridae	*Scarus altipinnis*	0.0060	6.360
Scaridae	*Scarus chameleon*	0.0028	0.915
Scaridae	*Scarus flavipectoralis*	0.0053	2.160
Scaridae	*Scarus forsteni*	0.0040	0.716
Scaridae	*Scarus frenatus*	0.0034	1.800
Scaridae	*Scarus ghobban*	0.0040	1.220
Scaridae	*Scarus globiceps*	0.0051	1.030
Scaridae	*Scarus longipinnis*	0.0020	0.282
Scaridae	*Scarus niger*	0.0049	3.160
Scaridae	*Scarus oviceps*	0.0135	2.580
Scaridae	*Scarus psittacus*	0.0032	1.160
Scaridae	*Scarus rivulatus*	0.0035	1.660
Scaridae	*Scarus rubroviolaceus*	0.0028	2.140
Scaridae	*Scarus schlegeli*	0.0040	0.544
Scaridae	*Scarus* spp.	0.0020	0.333
Scaridae	*Scarus spinus*	0.0053	1.700
Scaridae	*Scarus tricolor*	0.0020	0.635
Serranidae	*Cephalopholis argus*	0.0304	11.900

3.3.2 Weighted average density and biomass of all finfish species recorded in Kuria (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Serranidae	*Cephalopholis miniata*	0.0020	1.040
Serranidae	*Cephalopholis urodeta*	0.0193	1.350
Serranidae	*Epinephelus fasciatus*	0.0040	1.040
Serranidae	*Epinephelus hexagonatus*	0.0047	0.346
Serranidae	*Epinephelus howlandi*	0.0040	0.487
Serranidae	*Epinephelus maculatus*	0.0020	0.475
Serranidae	*Epinephelus merra*	0.0030	0.315
Serranidae	*Epinephelus polyphekadion*	0.0030	1.160
Serranidae	*Epinephelus spilotoceps*	0.0035	0.545
Serranidae	*Variola albimarginata*	0.0020	0.857
Serranidae	*Variola louti*	0.0020	2.430
Siganidae	*Siganus argenteus*	0.0040	0.984
Siganidae	*Siganus punctatus*	0.0044	1.040
Siganidae	*Siganus* spp.	0.0080	0.665
Siganidae	*Siganus spinus*	0.0020	0.369
Siganidae	*Siganus vulpinus*	0.0040	0.480
Zanclidae	*Zanclus cornutus*	0.0162	1.160

3.4 Kiritimati finfish survey data

3.4.1 Coordinates (WGS 84) of the 25 D-UVC transects used to assess finfish resource status in Kiritimati

Station name	Habitat	Latitude	Longitude
TRA01	Outer reef	1°55'49.8" N	157°30'13.9212" W
TRA02	Outer reef	1°55'03.6012" N	157°31'07.4388" W
TRA03	Outer reef	1°52'59.88" N	157°33'23.4612" W
TRA04	Outer reef	1°52'37.8012" N	157°33'45.18" W
TRA05	Outer reef	1°59'40.4988" N	157°21'17.82" W
TRA06	Outer reef	2°00'50.76" N	157°24'02.7612" W
TRA07	Outer reef	2°02'40.4988" N	157°25'46.74" W
TRA08	Lagoon	1°56'29.1012" N	157°27'05.1012" W
TRA09	Lagoon	1°55'52.9788" N	157°27'38.16" W
TRA10	Lagoon	1°55'15.8412" N	157°28'20.3988" W
TRA11	Lagoon	1°55'55.9812" N	157°28'36.0588" W
TRA12	Lagoon	1°56'05.82" N	157°28'46.6788" W
TRA13	Lagoon	1°56'09.8988" N	157°28'06.1212" W
TRA14	Lagoon	1°56'10.32" N	157°27'06.3612" W
TRA15	Lagoon	1°57'49.5" N	157°28'46.2612" W
TRA16	Lagoon	1°59'33.4788" N	157°28'16.2588" W
TRA17	Outer reef	2°01'22.1412" N	157°29'44.8188" W
TRA18	Outer reef	2°02'22.2" N	157°29'50.8812" W
TRA19	Outer reef	2°03'05.22" N	157°27'24.4188" W
TRA20	Lagoon	1°59'18.3588" N	157°27'22.0788" W
TRA21	Lagoon	1°59'06.9612" N	157°26'33.4788" W
TRA22	Outer reef	1°59'52.1412" N	157°28'59.8188" W
TRA23	Lagoon	1°58'56.1" N	157°27'40.2012" W
TRA24	Lagoon	1°57'17.46" N	157°28'47.46" W
TRA25	Outer reef	1°57'46.5012" N	157°29'14.9388" W

3.4.2 Weighted average density and biomass of all finfish species recorded in Kiritimati (using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus achilles*	0.0021	0.527
Acanthuridae	*Acanthurus blochii*	0.0098	5.040
Acanthuridae	*Acanthurus guttatus*	0.0000	0.000
Acanthuridae	*Acanthurus leucocheilus*	0.0209	11.200
Acanthuridae	*Acanthurus lineatus*	0.0240	12.700
Acanthuridae	*Acanthurus maculiceps*	0.0038	0.871
Acanthuridae	*Acanthurus nigricans*	0.0316	5.820
Acanthuridae	*Acanthurus nigricauda*	0.0274	20.000
Acanthuridae	*Acanthurus nigrofuscus*	0.0002	0.029
Acanthuridae	*Acanthurus nigroris*	0.0030	0.131
Acanthuridae	*Acanthurus olivaceus*	0.0131	5.470
Acanthuridae	*Acanthurus pyroferus*	0.0000	0.000
Acanthuridae	*Acanthurus* spp.	0.0000	0.000
Acanthuridae	*Acanthurus thompsoni*	0.0000	0.000
Acanthuridae	*Acanthurus triostegus*	0.0513	7.200
Acanthuridae	*Acanthurus xanthopterus*	0.0318	31.600
Acanthuridae	*Aethaloperca rogaa*	0.0001	0.016
Acanthuridae	*Anyperodon leucogrammicus*	0.0000	0.000
Acanthuridae	*Ctenochaetus binotatus*	0.0000	0.000
Acanthuridae	*Ctenochaetus hawaiiensis*	0.0079	1.170
Acanthuridae	*Ctenochaetus marginatus*	0.0481	19.100
Acanthuridae	*Ctenochaetus* spp.	0.0000	0.000
Acanthuridae	*Ctenochaetus striatus*	0.0521	9.580
Acanthuridae	*Ctenochaetus strigosus*	0.0047	0.121
Acanthuridae	*Naso annulatus*	0.0000	0.000
Acanthuridae	*Naso brevirostris*	0.0000	0.000
Acanthuridae	*Naso caesius*	0.0002	0.170
Acanthuridae	*Naso lituratus*	0.0004	0.340
Acanthuridae	*Naso* spp.	0.0001	0.005
Acanthuridae	*Naso thynnoides*	0.0000	0.000
Acanthuridae	*Naso tuberosus*	0.0000	0.000
Acanthuridae	*Naso unicornis*	0.0000	0.000
Acanthuridae	*Naso vlamingii*	0.0000	0.000
Acanthuridae	*Paracanthurus hepatus*	0.0003	0.015
Acanthuridae	*Zebrasoma scopas*	0.0000	0.000
Acanthuridae	*Zebrasoma veliferum*	0.0010	0.105
Balistidae	*Balistapus undulatus*	0.0151	3.890
Balistidae	*Balistoides conspicillum*	0.0002	0.061
Balistidae	*Balistoides viridescens*	0.0004	0.781
Balistidae	*Melichthys niger*	0.0157	7.740
Balistidae	*Melichthys vidua*	0.0172	5.260
Balistidae	*Odonus niger*	0.0241	3.500
Balistidae	*Pseudobalistes flavimarginatus*	0.0015	3.110
Balistidae	*Rhinecanthus aculeatus*	0.0142	3.410
Balistidae	*Rhinecanthus rectangulus*	0.0041	0.802
Balistidae	*Sufflamen bursa*	0.0070	1.320
Balistidae	*Sufflamen chrysopterus*	0.0057	1.140
Balistidae	*Xanthichthys auromarginatus*	0.0002	0.024

3.4.2 Weighted average density and biomass of all finfish species recorded in Kiritimati (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Chaetodontidae	*Chaetodon auriga*	0.0252	1.470
Chaetodontidae	*Chaetodon bennetti*	0.0008	0.038
Chaetodontidae	*Chaetodon citrinellus*	0.0006	0.019
Chaetodontidae	*Chaetodon ephippium*	0.0130	0.773
Chaetodontidae	*Chaetodon kleinii*	0.0022	0.070
Chaetodontidae	*Chaetodon lineolatus*	0.0002	0.017
Chaetodontidae	*Chaetodon lunula*	0.0124	0.878
Chaetodontidae	*Chaetodon lunulatus*	0.0026	0.101
Chaetodontidae	*Chaetodon melannotus*	0.0000	0.000
Chaetodontidae	*Chaetodon mertensii*	0.0000	0.000
Chaetodontidae	*Chaetodon meyeri*	0.0053	0.395
Chaetodontidae	*Chaetodon ornatissimus*	0.0085	0.628
Chaetodontidae	*Chaetodon pelewensis*	0.0000	0.000
Chaetodontidae	*Chaetodon quadrimaculatus*	0.0005	0.028
Chaetodontidae	*Chaetodon rafflesii*	0.0000	0.000
Chaetodontidae	*Chaetodon reticulatus*	0.0002	0.018
Chaetodontidae	*Chaetodon semeion*	0.0002	0.006
Chaetodontidae	*Chaetodon* spp.	0.0001	0.001
Chaetodontidae	*Chaetodon speculum*	0.0000	0.000
Chaetodontidae	*Chaetodon trifascialis*	0.0002	0.004
Chaetodontidae	*Chaetodon ulietensis*	0.0040	0.166
Chaetodontidae	*Chaetodon unimaculatus*	0.0010	0.167
Chaetodontidae	*Chaetodon vagabundus*	0.0026	0.135
Chaetodontidae	*Forcipiger flavissimus*	0.0000	0.000
Chaetodontidae	*Forcipiger longirostris*	0.0019	0.089
Chaetodontidae	*Heniochus acuminatus*	0.0037	0.236
Chaetodontidae	*Heniochus chrysostomus*	0.0000	0.000
Chaetodontidae	*Heniochus varius*	0.0000	0.000
Holocentridae	*Myripristis adusta*	0.0008	0.381
Holocentridae	*Myripristis berndti*	0.0017	0.629
Holocentridae	*Myripristis botche*	0.0000	0.000
Holocentridae	*Myripristis kuntee*	0.0000	0.000
Holocentridae	*Myripristis murdjan*	0.0010	0.516
Holocentridae	*Myripristis pralinia*	0.0000	0.000
Holocentridae	*Myripristis* spp.	0.0000	0.000
Holocentridae	*Myripristis violacea*	0.0000	0.000
Holocentridae	*Myripristis vittata*	0.0050	0.640
Holocentridae	*Neoniphon sammara*	0.0002	0.001
Holocentridae	*Neoniphon* spp.	0.0000	0.000
Holocentridae	*Sargocentron caudimaculatum*	0.0010	0.137
Holocentridae	*Sargocentron cornutum*	0.0000	0.000
Holocentridae	*Sargocentron diadema*	0.0002	0.015
Holocentridae	*Sargocentron* spp.	0.0000	0.000
Holocentridae	*Sargocentron spiniferum*	0.0002	0.110
Holocentridae	*Sargocentron tiere*	0.0001	0.036
Labridae	*Bodianus loxozonus*	0.0006	0.230
Labridae	*Cheilinus chlorourus*	0.0023	0.860

3.4.2 Weighted average density and biomass of all finfish species recorded in Kiritimati (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Labridae	*Cheilinus fasciatus*	0.0000	0.000
Labridae	*Cheilinus trilobatus*	0.0005	0.276
Labridae	*Cheilinus undulatus*	0.0005	21.000
Labridae	*Choerodon anchorago*	0.0002	0.080
Labridae	*Coris aygula*	0.0008	0.295
Labridae	*Hemigymnus fasciatus*	0.0024	0.813
Labridae	*Hemigymnus melapterus*	0.0000	0.000
Labridae	*Oxycheilinus digrammus*	0.0010	0.264
Lethrinidae	*Gnathodentex aureolineatus*	0.0036	1.660
Lethrinidae	*Lethrinus atkinsoni*	0.0002	0.076
Lethrinidae	*Lethrinus erythracanthus*	0.0001	0.066
Lethrinidae	*Lethrinus genivittatus*	0.0001	0.001
Lethrinidae	*Lethrinus harak*	0.0001	0.068
Lethrinidae	*Lethrinus lentjan*	0.0004	0.153
Lethrinidae	*Lethrinus olivaceus*	0.0052	4.410
Lethrinidae	*Lethrinus xanthochilus*	0.0066	5.880
Lethrinidae	*Monotaxis grandoculis*	0.0105	7.280
Lutjanidae	*Aphareus furca*	0.0042	2.490
Lutjanidae	*Aphareus rutilans*	0.0002	0.086
Lutjanidae	*Aprion virescens*	0.0007	0.670
Lutjanidae	*Lutjanus bohar*	0.0084	5.620
Lutjanidae	*Lutjanus fulviflammus*	0.0000	0.000
Lutjanidae	*Lutjanus fulvus*	0.0323	15.300
Lutjanidae	*Lutjanus gibbus*	0.0604	38.900
Lutjanidae	*Lutjanus kasmira*	0.0056	0.994
Lutjanidae	*Lutjanus monostigma*	0.0017	0.953
Lutjanidae	*Lutjanus semicinctus*	0.0000	0.000
Lutjanidae	*Macolor macularis*	0.0000	0.000
Lutjanidae	*Macolor niger*	0.0000	0.000
Mullidae	*Mulloidichthys flavolineatus*	0.0003	0.056
Mullidae	*Mulloidichthys vanicolensis*	0.0000	0.000
Mullidae	*Parupeneus barberinoides*	0.0002	0.020
Mullidae	*Parupeneus barberinus*	0.0049	1.790
Mullidae	*Parupeneus bifasciatus*	0.0142	5.390
Mullidae	*Parupeneus cyclostomus*	0.0020	1.260
Mullidae	*Parupeneus indicus*	0.0005	0.055
Mullidae	*Parupeneus multifasciatus*	0.0094	1.840
Mullidae	*Parupeneus pleurostigma*	0.0000	0.000
Mullidae	*Parupeneus spilurus*	0.0001	0.018
Nemipteridae	*Scolopsis bilineata*	0.0000	0.000
Scaridae	*Cetoscarus bicolor*	0.0015	1.310
Scaridae	*Chlorurus bleekeri*	0.0003	0.125
Scaridae	*Chlorurus frontalis*	0.0002	0.105
Scaridae	*Chlorurus japanensis*	0.0000	0.000
Scaridae	*Chlorurus microrhinos*	0.0011	1.450
Scaridae	*Chlorurus sordidus*	0.0137	5.580
Scaridae	*Hipposcarus longiceps*	0.0003	0.310

3.4.2 Weighted average density and biomass of all finfish species recorded in Kiritimati (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus altipinnis*	0.0000	0.000
Scaridae	*Scarus chameleon*	0.0002	0.066
Scaridae	*Scarus dimidiatus*	0.0000	0.000
Scaridae	*Scarus flavipectoralis*	0.0026	1.050
Scaridae	*Scarus forsteni*	0.0001	0.053
Scaridae	*Scarus frenatus*	0.0030	2.240
Scaridae	*Scarus ghobban*	0.0063	3.840
Scaridae	*Scarus globiceps*	0.0015	0.430
Scaridae	*Scarus niger*	0.0000	0.000
Scaridae	*Scarus oviceps*	0.0018	0.617
Scaridae	*Scarus psittacus*	0.0005	0.181
Scaridae	*Scarus rivulatus*	0.0003	0.194
Scaridae	*Scarus rubroviolaceus*	0.0043	4.190
Scaridae	*Scarus schlegeli*	0.0000	0.000
Scaridae	*Scarus* spp.	0.0002	0.096
Scaridae	*Scarus spinus*	0.0005	0.184
Scaridae	*Scarus tricolor*	0.0020	1.510
Scaridae	*Scarus xanthopleura*	0.0004	0.203
Serranidae	*Cephalopholis argus*	0.0135	7.960
Serranidae	*Cephalopholis leopardus*	0.0000	0.000
Serranidae	*Cephalopholis miniata*	0.0012	0.383
Serranidae	*Cephalopholis sexmaculata*	0.0000	0.000
Serranidae	*Cephalopholis* spp.	0.0000	0.000
Serranidae	*Cephalopholis urodeta*	0.0134	1.190
Serranidae	*Epinephelus areolatus*	0.0011	0.317
Serranidae	*Epinephelus corallicola*	0.0001	0.009
Serranidae	*Epinephelus fasciatus*	0.0046	1.310
Serranidae	*Epinephelus fuscoguttatus*	0.0001	0.105
Serranidae	*Epinephelus hexagonatus*	0.0006	0.056
Serranidae	*Epinephelus howlandi*	0.0001	0.017
Serranidae	*Epinephelus merra*	0.0054	0.499
Serranidae	*Epinephelus polyphekadion*	0.0002	0.191
Serranidae	*Epinephelus rivulatus*	0.0006	0.157
Serranidae	*Epinephelus sexfasciatus*	0.0000	0.000
Serranidae	*Epinephelus spilotoceps*	0.0009	0.194
Serranidae	*Epinephelus tauvina*	0.0001	0.011
Serranidae	*Gracila albomarginata*	0.0002	0.154
Serranidae	*Plectropomus areolatus*	0.0000	0.000
Serranidae	*Variola albimarginata*	0.0004	0.356
Serranidae	*Variola louti*	0.0006	0.771
Siganidae	*Siganus argenteus*	0.0000	0.000
Siganidae	*Siganus punctatus*	0.0000	0.000
Siganidae	*Siganus spinus*	0.0000	0.000
Zanclidae	*Zanclus cornutus*	0.0062	0.715

APPENDIX 4: INVERTEBRATE SURVEY DATA

4.1 Abaiang invertebrate survey data

4.1.1 Invertebrate species recorded in different assessments in Abaiang

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*				+
Bêche-de-mer	*Bohadschia argus*	+			+
Bêche-de-mer	*Bohadschia graeffei*	+	+		
Bêche-de-mer	*Bohadschia vitiensis*	+			
Bêche-de-mer	*Holothuria atra*	+		+	+
Bêche-de-mer	*Holothuria nobilis*	+			
Bêche-de-mer	*Stichopus chloronotus*	+			
Bêche-de-mer	*Thelenota ananas*	+			+
Bêche-de-mer	*Thelenota anax*				+
Bivalve	*Anadara holoserica*			+	
Bivalve	*Atactodea striata*			+	
Bivalve	*Chama* spp.	+	+		
Bivalve	*Dosinia* spp.			+	
Bivalve	*Gafrarium* spp.			+	
Bivalve	*Hippopus hippopus*	+			
Bivalve	*Pinctada margaritifera*	+			
Bivalve	*Pinna* spp.			+	
Bivalve	*Spondylus* spp.	+	+	+	
Bivalve	*Trachycardium* spp.			+	
Bivalve	*Tridacna gigas*	+			
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+			+
Cnidarian	*Stichodactyla* spp.	+			
Crustacean	*Lysiosquillina* spp.	+			
Crustacean	*Panulirus* spp.	+			
Gastropod	*Cassis cornuta*				+
Gastropod	*Conus leopardus*		+		
Gastropod	*Conus* spp.	+	+		
Gastropod	*Cymatium* spp.			+	
Gastropod	*Lambis truncata*	+			
Gastropod	*Onchidium* spp.			+	
Gastropod	*Strombus luhuanus*	+		+	
Gastropod	*Tectus pyramis*	+	+		
Gastropod	*Thais* spp.				+
Gastropod	*Turbo setosus*				+
Gastropod	*Vasum ceramicum*				+
Gastropod	*Vasum* spp.		+		+
Octopus	*Octopus* spp.	+			
Star	*Acanthaster planci*		+		
Star	*Culcita novaeguineae*	+	+		
Star	*Linckia laevigata*	+	+		
Urchin	*Echinometra mathaei*		+		+
Urchin	*Echinothrix diadema*				+
Urchin	*Heterocentrotus mammillatus*				+

+ = presence of the species.

4.1.2 Abaiang 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	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Bohadschia graeffei	4.2	2.1	72	60.0	15.5	5	4.2	2.6	12	12.5	6.3	4
Bohadschia vitiensis	0.7	0.4	72	16.7	0.0	3	0.7	0.5	12	4.2	1.4	2
Chama spp.	3.5	2.0	72	50.0	21.7	5	3.5	1.9	12	8.3	3.6	5
Conus spp.	2.8	0.9	72	19.9	2.2	10	2.8	1.0	12	4.8	1.2	7
Culcita novaeguineae	8.6	2.4	72	41.1	6.9	15	8.6	5.3	12	20.6	11.1	5
Hippopus hippopus	0.9	0.5	72	16.7	0.0	4	0.9	0.5	12	3.7	0.9	3
Holothuria atra	662.0	350.3	72	3972.2	1886.3	12	662.0	643.6	12	3972.2	3766.7	2
Holothuria nobilis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Lambis truncata	3.9	3.5	72	94.4	77.8	3	3.9	3.4	12	15.7	13.0	3
Linckia laevigata	3.7	1.6	72	44.4	7.0	6	3.7	2.7	12	22.2	8.3	2
Lysiosquillina spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Octopus spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Panulirus spp.	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Pinctada margaritifera	10.9	10.9	72	781.3		1	11.4	11.4	12	137.4		1
Spondylus spp.	2.1	0.9	72	25.0	3.7	6	2.1	1.4	12	8.3	4.2	3
Stichodactyla spp.	0.9	0.4	72	16.4	0.3	4	0.9	0.5	12	3.7	0.9	3
Stichopus chloronotus	1.9	0.8	72	22.2	5.6	6	1.9	1.2	12	7.4	3.3	3
Strombus luhuanus	454.9	274.6	72	2977.3	1659.6	11	454.9	448.1	12	1364.6	1339.7	4
Tectus pyramis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Thelenota ananas	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna gigas	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Tridacna maxima	700.5	157.1	72	1050.7	219.4	48	700.5	350.8	12	1050.7	487.4	8
Tridacna squamosa	0.7	0.4	72	16.7	0.0	3	0.7	0.4	12	2.8	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.

4.1.3 Abaiang 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	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Bohadschia graeffei	17.4	7.5	72	250.0	0.0	5	17.4	10.8	12	69.4	27.8	3
Chama spp.	104.2	33.4	72	468.8	111.5	16	104.2	38.2	12	178.6	48.7	7
Conus leopardus	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Conus spp.	13.9	8.4	72	333.3	83.3	3	13.9	7.8	12	55.6	13.9	3
Culcita novaeguineae	59.0	17.5	72	354.2	48.2	12	59.0	23.8	12	141.7	28.3	5
Echinometra mathaei	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Linckia laevigata	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Spondylus spp.	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Tectus pyramis	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Tridacna maxima	2472.2	400.7	72	3016.9	459.9	59	2472.2	794.0	12	2472.2	794.0	12
Vasum spp.	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	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.

4.1.4 Abaiang soft-benthos quadrat (SBq) assessment data review

Station: 8 quadrat groups (4 quadrats/group).

Species	Quadrat group			Quadrat group _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Anadara holoserica	41.7	3.1	88	42.7	3.1	86	41.7	7.7	11	41.7	7.7	11
Atactodea striata	0.0	0.0	88	4.0		1	0.0	0.0	11	0.5		1
Cymatium spp.	0.2	0.1	88	5.3	1.3	3	0.2	0.1	11	1.0	0.5	2
Dosinia spp.	1.2	0.4	88	6.9	1.4	15	1.2	0.4	11	1.6	0.4	8
Gafrarium spp.	19.4	3.1	88	25.8	3.8	66	19.4	8.0	11	21.3	8.6	10
Holothuria atra	4.1	0.4	88	6.5	0.4	56	4.1	0.5	11	4.1	0.5	11
Onchidium spp.	0.0	0.0	88	4.0		1	0.0	0.0	11	0.5		1
Pinna spp.	0.3	0.1	88	4.0	0.0	6	0.3	0.2	11	1.0	0.3	3
Spondylus spp.	0.1	0.1	88	6.0	2.0	2	0.1	0.1	11	0.8	0.3	2
Strombus luhuanus	2.5	0.4	88	6.5	0.7	34	2.5	0.6	11	2.5	0.6	11
Trachycardium spp.	0.1	0.1	88	4.0	0.0	2	0.1	0.1	11	0.5	0.0	2

Mean = mean density (numbers/m²); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.5 Abaiang 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	1.0	1.0	24	23.5		1.0	1.0	1.0	4	3.9		1
Echinometra mathaei	3.9	2.3	24	31.4	7.8	3.0	3.9	2.8	4	7.8	3.9	2
Echinothrix diadema	10.8	6.3	24	86.3	20.8	3.0	10.8	10.8	4	43.1		1
Heterocentrotus mammillatus	1.0	1.0	24	23.5		1.0	1.0	1.0	4	3.9		1
Tridacna maxima	193.1	30.9	24	220.7	30.9	21.0	193.1	65.3	4	193.1	65.3	4
Tridacna squamosa	1.0	1.0	24	23.5		1.0	1.0	1.0	4	3.9		1
Vasum ceramicum	2.9	2.2	24	35.3	11.8	2	2.9	2.9	4	11.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.6 *Abaiang reef-front search by walking (RFs_w) assessment data review*

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Echinothrix diadema	0.9	0.9	12	11.1		1	0.9	0.9	2	1.9		1
Holothuria atra	1.9	1.2	12	11.1	0.0	2	1.9	1.9	2	3.7		1
Thais spp.	5.6	3.7	12	33.3	0.0	2	5.6	0.0	2	5.6	0.0	2
Tridacna maxima	2.8	2.8	12	33.3		1	2.8	2.8	2	5.6		1
Turbo setosus	0.9	0.9	12	11.1		1	0.9	0.9	2	1.9		1
Vasum spp.	15.7	4.4	12	27.0	3.3	7	15.7	10.2	2	15.7	10.2	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.1.7 *Abaiang sea cucumber day search (Ds) assessment data review*

Station: Six 5-min search periods.

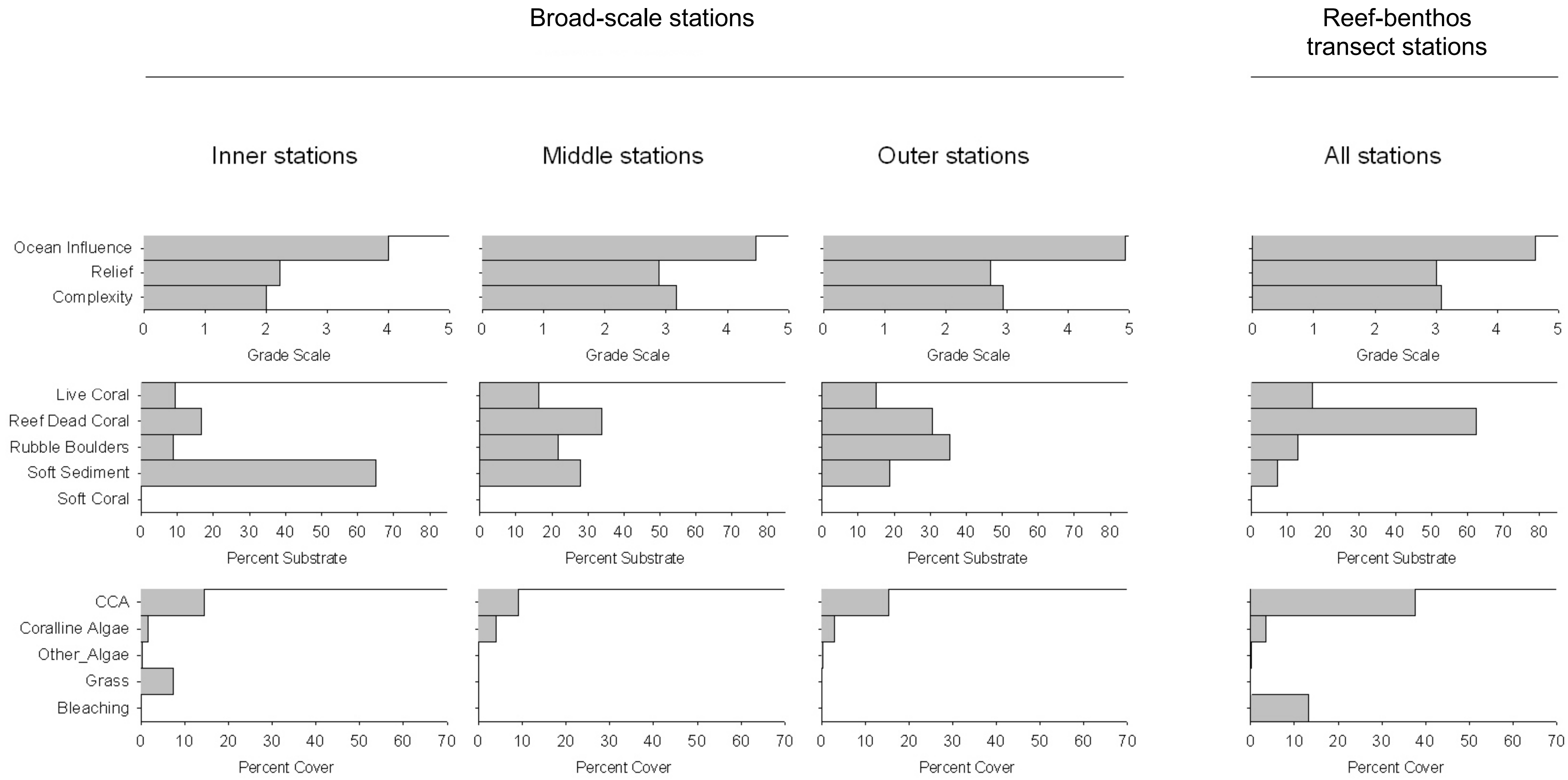
Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Bohadschia argus	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Cassis cornuta	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Thelenota ananas	6.5	2.4	24	22.4	4.2	7	6.5	3.0	4	8.7	2.9	3
Thelenota anax	14.3	6.5	24	42.9	15.7	8	14.3	6.1	4	19.0	5.5	3

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

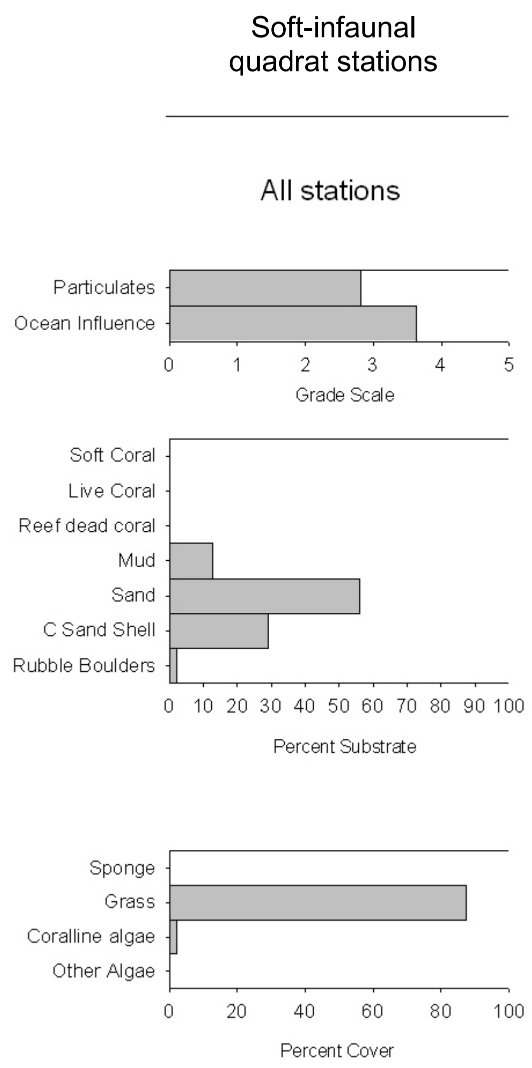
4.1.8 Abaiang species size review – all survey methods

Species	Mean length (cm)	SE	n
Tridacna maxima	7.7	0.1	3938
Holothuria atra	10.4	0.5	2953
Strombus luhuanus	3.7	0.1	2020
Anadara holoserica	4.0	0.0	918
Gafrarium spp.	2.9	0.0	426
Dosinia spp.	3.6	0.0	26
Thelenota anax	58.4	2.0	24
Bohadschia graeffei	34.0	2.8	23
Vasum spp.	6.4	0.7	20
Lambis truncata	11.8	8.2	17
Conus spp.	8.1	0.1	16
Spondylus spp.	4.5	1.3	14
Thelenota ananas	56.1	1.8	12
Stichopus chloronotus	31.6	0.8	8
Cymatium spp.	3.4	0.2	4
Tridacna squamosa	18.8	3.4	4
Hippopus hippopus	26.8	2.1	4
Conus leopardus	11.0	0.6	3
Bohadschia vitiensis	32.0	2.0	3
Bohadschia argus	35.5	0.5	2
Pinna spp.	5.6		6
Trachycardium spp.	2.8		2
Tectus pyramis	6.8		2
Tridacna gigas	80.0		1
Onchidium spp.	7.8		1
Atactodea striata	2.5		1
Cassis cornuta	28.0		1
Holothuria nobilis	28.0		1
Culcita novaeguineae			54
Pinctada margaritifera			50
Chama spp.			45
Linckia laevigata			18
Echinothrix diadema			12
Thais spp.			6
Echinometra mathaei			6
Stichodactyla spp.			4
Vasum ceramicum			3
Acanthaster planci			1
Octopus spp.			1
Panulirus spp.			1
Lysiosquillina spp.			1
Actinopyga mauritiana			1
Heterocentrotus mammillatus			1
Turbo setosus			1

4.1.9 Habitat descriptors for independent assessment – Abaiang



4.1.9 Habitat descriptors for independent assessments – Abaiang (continued)



4.2 Abemama invertebrate survey data

4.2.1 Invertebrate species recorded in different assessments in Abemama

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*	+			+
Bêche-de-mer	*Bohadschia argus*		+		
Bêche-de-mer	*Bohadschia graeffei*	+	+		+
Bêche-de-mer	*Bohadschia vitiensis*	+			
Bêche-de-mer	*Holothuria atra*	+		+	
Bêche-de-mer	*Holothuria edulis*	+	+		+
Bêche-de-mer	*Holothuria nobilis*	+			+
Bêche-de-mer	*Stichopus chloronotus*	+	+		
Bêche-de-mer	*Thelenota ananas*	+	+		+
Bêche-de-mer	*Thelenota anax*	+			
Bivalve	*Anadara holoserica*			+	
Bivalve	*Anadara* spp.	+			
Bivalve	*Chama* spp.		+		
Bivalve	*Gafrarium* spp.			+	
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Pinctada margaritifera*				+
Bivalve	*Pinna bicolor*			+	
Bivalve	*Spondylus* spp.	+			
Bivalve	*Spondylus squamosus*	+			
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+	+		+
Cnidarian	*Stichodactyla* spp.	+	+		
Crustacean	*Panulirus* spp.				+
Gastropod	*Cerithium nodulosum*	+			
Gastropod	*Cerithium* spp.			+	
Gastropod	*Conus* spp.	+	+		
Gastropod	*Oliva* spp.			+	
Gastropod	*Polinices* spp.			+	
Gastropod	*Strombus luhuanus*	+		+	
Gastropod	*Tectus pyramis*				+
Gastropod	*Vasum turbinellum*	+			
Octopus	*Octopus cyanea*	+			+
Star	*Acanthaster planci*				+
Star	*Culcita novaeguineae*	+	+		

+ = presence of the species.

4.2.2 Abemama broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	0.5	0.3	73	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2
Anadara spp.	25.3	7.4	73	123.3	22.8	15	25.7	15.2	12	102.7	33.3	3
Bohadschia graeffei	2.1	1.0	73	30.0	6.2	5	2.1	1.0	12	6.3	1.7	4
Bohadschia vitiensis	89.3	63.0	73	2172.0	1104.6	3	90.5	90.3	12	542.8	540.5	2
Cerithium nodulosum	0.9	0.4	73	16.7	0.0	4	0.9	0.7	12	5.3	3.0	2
Conus spp.	0.9	0.4	73	16.5	0.2	4	0.9	0.5	12	3.5	1.0	3
Culcita novaeguineae	5.4	1.6	73	30.6	5.0	13	5.4	1.9	12	10.8	2.0	6
Hippopus hippopus	1.8	0.8	73	22.2	3.5	6	1.9	1.1	12	7.4	2.4	3
Holothuria atra	3285.2	939.7	73	8565.0	2112.8	28	3287.7	2169.5	12	7890.5	4688.7	5
Holothuria edulis	0.7	0.7	73	47.6		1	0.6	0.6	12	7.0		1
Holothuria nobilis	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1
Octopus cyanea	0.9	0.4	73	16.7	0.0	4	0.9	0.4	12	2.8	0.0	4
Spondylus spp.	11.8	5.1	73	108.1	31.2	8	12.0	8.1	12	48.1	23.8	3
Spondylus squamosus	2.5	1.1	73	30.6	5.1	6	2.5	2.3	12	15.3	12.5	2
Stichodactyla spp.	0.9	0.4	73	16.5	0.2	4	0.8	0.5	12	3.4	0.6	3
Stichopus chloronotus	1.4	1.2	73	50.0	33.3	2	1.4	1.2	12	8.3	5.6	2
Strombus luhuanus	466.2	205.4	73	2127.0	829.6	16	473.3	272.5	12	946.7	486.9	6
Thelenota ananas	0.2	0.2	73	16.7		1	0.2	0.2	12	2.7		1
Thelenota anax	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1
Tridacna maxima	720.1	238.1	73	1314.1	413.4	40	729.9	481.7	12	1094.8	699.9	8
Tridacna squamosa	0.7	0.4	73	16.7	0.0	3	0.7	0.7	12	8.3		1
Vasum turbinellum	0.2	0.2	73	16.7		1	0.2	0.2	12	2.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.2.3 Abemama 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
Bohadschia argus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Bohadschia graeffei	45.1	18.1	72	406.3	93.8	8	45.1	31.0	12	135.4	80.5	4
Chama spp.	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Conus spp.	17.4	9.0	72	312.5	62.5	4	17.4	12.0	12	104.2	20.8	2
Culcita novaeguineae	24.3	10.1	72	291.7	41.7	6	24.3	10.8	12	58.3	16.7	5
Hippopus hippopus	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Holothuria edulis	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Stichodactyla spp.	17.4	9.0	72	312.5	62.5	4	17.4	10.8	12	69.4	27.8	3
Stichopus chloronotus	17.4	9.0	72	312.5	62.5	4	17.4	14.0	12	104.2	62.5	2
Thelenota ananas	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Tridacna maxima	6913.2	695.8	72	8028.2	712.5	62	6913.2	1481.4	12	7541.7	1469.5	11
Tridacna squamosa	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.2.4 Abemama soft-benthos quadrats (SBq) assessment data review

Station: 8 quadrat groups (4 quadrats/group).

Species	Quadrat group			Quadrat group _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Anadara holoserica	14.9	1.7	128	5.4	0.6	93	14.9	3.8	16	14.9	3.8	16
Cerithium spp.	0.1	0.0	128	1.0	0.0	2	0.1	0.0	16	0.5	0.0	2
Gafrarium spp.	0.8	0.2	128	1.7	0.2	16	0.8	0.4	16	3.4	1.1	4
Holothuria atra	2.8	0.6	128	3.5	0.5	26	2.8	1.5	16	7.5	3.3	6
Oliva spp.	0.0	0.0	128	1.0		1	0.0	0.0	16	0.5		1
Pinna bicolor	0.0	0.0	128	1.0		1	0.0	0.0	16	0.5		1
Polinices spp.	0.1	0.0	128	1.0	0.0	2	0.1	0.0	16	0.5	0.0	2
Strombus luhuanus	2.1	0.5	128	2.3	0.3	30	2.1	0.7	16	3.4	0.8	10

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 Abemama 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	2.6	1.8	18	23.5	0.0	2	2.6	2.6	3	7.8		1
Bohadschia graeffei	1.3	1.3	18	23.5		1	1.3	1.3	3	3.9		1
Holothuria nobilis	1.3	1.3	18	23.5		1	1.3	1.3	3	3.9		1
Octopus cyanea	1.3	1.3	18	23.5		1	1.3	1.3	3	3.9		1
Panulirus spp.	1.3	1.3	18	23.5		1	1.3	1.3	3	3.9		1
Tectus pyramis	1.3	1.3	18	23.5		1	1.3	1.3	3	3.9		1
Tridacna maxima	275.8	77.2	18	275.8	77.2	18	275.8	205.5	3	275.8	205.5	3
Tridacna squamosa	1.3	1.3	18	23.5		1	1.3	1.3	3	3.9		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 Abemama sea cucumber day search (Ds) assessment data review
Station: Six 5-min search periods.

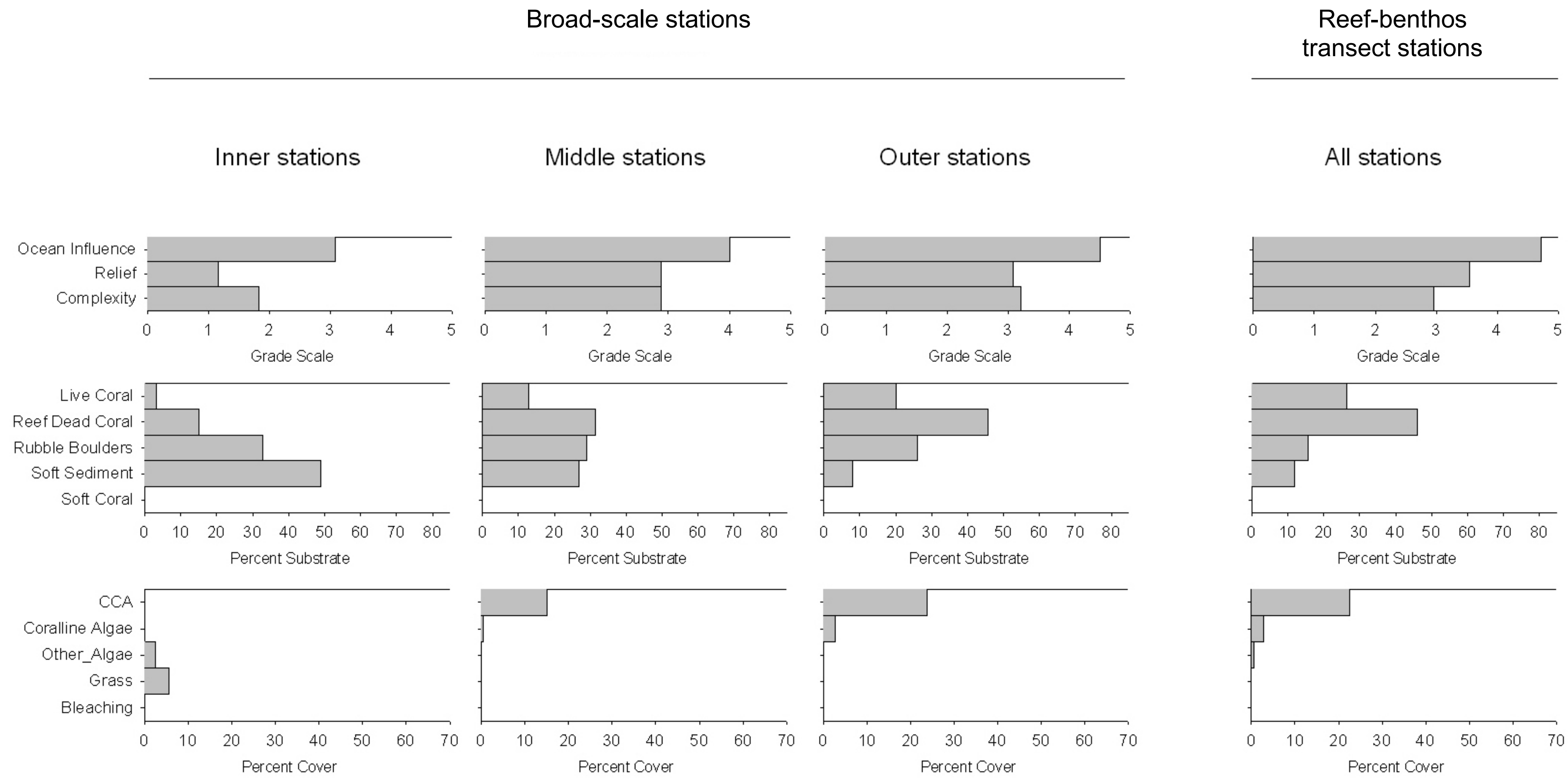
Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	1.2	1.2	12	14.3		1	1.2	1.2	2	2.4		1
Holothuria edulis	1.2	1.2	12	14.3		1	1.2	1.2	2	2.4		1
Pinctada margaritifera	1.2	1.2	12	14.3		1	1.2	1.2	2	2.4		1
Thelenota ananas	28.6	11.4	12	68.6	13.1	5	28.6	28.6	2	57.1		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

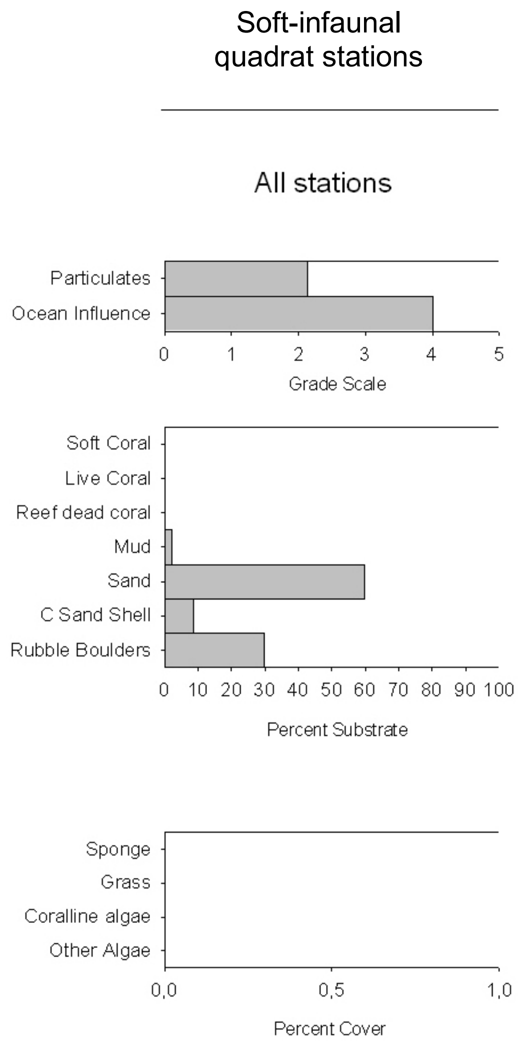
4.2.7 Abemama species size review – all survey methods

Species	Mean length (cm)	SE	n
Holothuria atra	9.4	0.3	14,498
Tridacna maxima	11.4	0.1	5356
Strombus luhuanus	4.1	0.1	2116
Anadara holoserica	5.0	0.0	477
Spondylus spp.	17.7	0.9	52
Gafrarium spp.	3.2	0.1	28
Thelenota ananas	46.1	1.7	27
Bohadschia graeffei	33.0	2.1	23
Hippopus hippopus	29.5	2.4	11
Stichopus chloronotus	21.0	1.0	11
Tridacna squamosa	36.8	1.4	10
Conus spp.	8.5	0.8	9
Cerithium spp.	3.5	0.0	2
Polinices spp.	2.6	0.4	2
Holothuria nobilis	24.0	1.0	2
Spondylus squamosus	35.0		11
Holothuria edulis	20.0		5
Oliva spp.	2.6		1
Pinna bicolor	8.5		1
Bohadschia argus	28.0		1
Tectus pyramis	5.8		1
Thelenota anax	55.0		1
Pinctada margaritifera	18.0		1
Bohadschia vitiensis			391
Anadara spp.			111
Culcita novaeguineae			31
Stichodactyla spp.			9
Octopus cyanea			5
Cerithium nodulosum			4
Actinopyga mauritiana			4
Chama spp.			2
Acanthaster planci			1
Vasum turbinellum			1
Panulirus spp.			1

4.2.8 Habitat descriptors for independent assessments – Abemama



4.2.8 Habitat descriptors for independent assessments – Abemama (continued)



4.3 Kuria invertebrate survey data

4.3.1 Invertebrate species recorded in different assessments in Kuria

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*	+	+		+
Bêche-de-mer	*Actinopyga miliaris*				+
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Holothuria atra*	+			
Bêche-de-mer	*Holothuria fuscogilva*				+
Bêche-de-mer	*Holothuria fuscopunctata*				+
Bêche-de-mer	*Holothuria nobilis*		+		
Bêche-de-mer	*Thelenota ananas*				+
Bêche-de-mer	*Thelenota anax*				+
Bivalve	*Spondylus* spp.	+			
Bivalve	*Tridacna maxima*	+	+		+
Cnidarian	*Stichodactyla* spp.	+			
Crustacean	*Panulirus* spp.	+	+		+
Gastropod	*Cassis cornuta*				+
Gastropod	*Cerithium nodulosum*	+			
Gastropod	*Conus flavidus*		+		
Gastropod	*Conus leopardus*		+		
Gastropod	*Conus miles*		+		
Gastropod	*Conus* spp.	+	+		
Gastropod	*Conus virgo*		+		
Gastropod	*Drupa morum*		+		
Gastropod	*Lambis chiragra*	+	+		
Gastropod	*Lambis truncata*	+			
Gastropod	*Strombus luhuanus*	+			
Gastropod	*Thais* spp.		+		
Gastropod	*Vasum turbinellum*		+		
Urchin	*Echinometra mathaei*		+		+
Urchin	*Echinothrix diadema*	+	+		+
Urchin	*Echinothrix* spp.		+		

+ = presence of the species.

4.3.2 Kuria broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	**SE**	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**
Actinopyga mauritiana	0.3	0.3	57	16.7		1	0.3	0.3	10	2.8		1
Bohadschia argus	0.6	0.4	57	16.7	0.0	2	0.6	0.4	10	2.8	0.0	2
Cerithium nodulosum	0.3	0.3	57	16.1		1	0.3	0.3	10	2.8		1
Conus spp.	1.5	0.8	57	20.8	4.2	4	1.4	0.6	10	3.5	0.7	4
Echinothrix diadema	0.9	0.9	57	50.0		1	0.8	0.8	10	8.3		1
Holothuria atra	0.3	0.3	57	16.7		1	0.3	0.3	10	2.8		1
Lambis chiragra	0.6	0.4	57	16.7	0.0	2	0.6	0.4	10	2.8	0.0	2
Lambis truncata	0.3	0.3	57	16.7		1	0.3	0.3	10	2.8		1
Panulirus spp.	0.6	0.4	57	16.7	0.0	2	0.6	0.6	10	5.6		1
Spondylus spp.	0.3	0.3	57	16.7		1	0.3	0.3	10	2.8		1
Stichodactyla spp.	0.6	0.4	57	16.7	0.0	2	0.6	0.4	10	2.8	0.0	2
Strombus luhuanus	0.3	0.3	57	16.7		1	0.3	0.3	10	2.8		1
Tridacna maxima	39.1	5.7	57	57.2	6.6	39	38.0	7.9	10	42.2	7.5	9

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 Kuria reef-benthos transect (RBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	**Transect**			**Transect _P**			**Station**			**Station _P**		
	Mean	**SE**	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**
Actinopyga mauritiana	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Bohadschia argus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus flavidus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus leopardus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus miles	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus spp.	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Conus virgo	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Drupa morum	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Echinometra mathaei	17.4	9.0	72	312.5	62.5	4	17.4	8.0	12	52.1	10.4	4
Echinothrix diadema	17.4	9.0	72	312.5	62.5	4	17.4	14.0	12	104.2	62.5	2
Echinothrix spp.	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Holothuria nobilis	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Lambis chiragra	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Panulirus spp.	10.4	10.4	72	750.0		1	10.4	10.4	12	125.0		1
Thais spp.	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Tridacna maxima	86.8	20.5	72	328.9	43.0	19	86.8	23.8	12	104.2	25.0	10
Vasum turbinellum	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	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.

4.3.4 Kuria 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	4.9	2.8	24	39.2	7.8	3	4.9	3.7	4	9.8	5.9	2
Echinometra mathaei	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Tridacna maxima	33.3	10.2	24	66.7	15.3	12	33.3	12.2	4	33.3	12.2	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.3.5 Kuria sea cucumber night search (Ns) assessment data review
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	13.3	7.0	12	53.3	0.0	3.0	13.3	13.3	2	26.7		1
Bohadschia argus	4.4	4.4	12	53.3		1.0	4.4	4.4	2	8.9		1
Echinothrix diadema	791.1	155.3	12	791.1	155.3	12.0	791.1	35.6	2	791.1	35.6	2
Panulirus spp.	22.2	10.3	12	66.7	13.3	4	22.2	4.4	2	22.2	4.4	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.3.6 Kuria sea cucumber day search (Ds) assessment data review
Station: Six 5-min search periods.

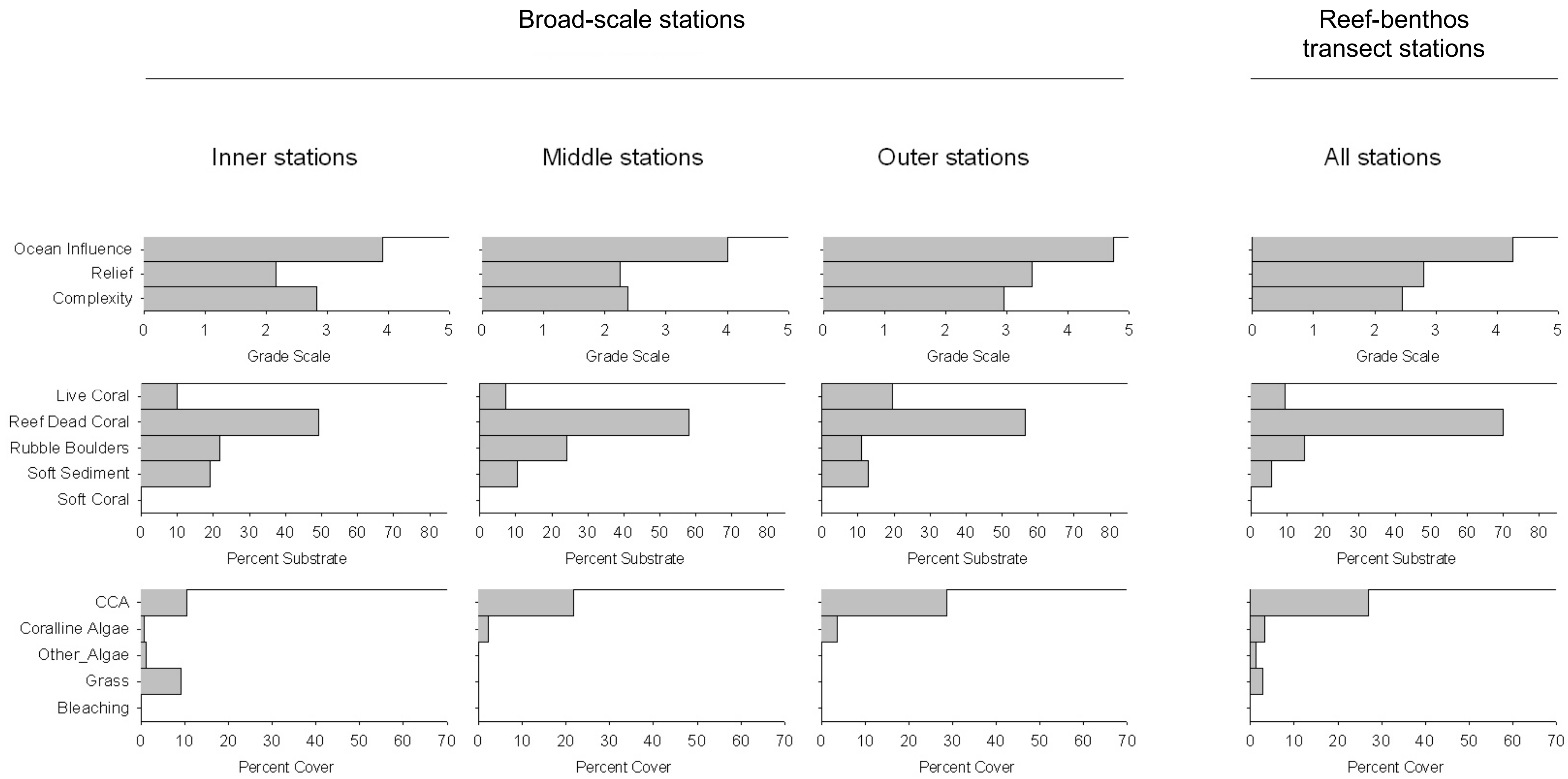
Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga miliaris	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Cassis cornuta	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Holothuria fuscogilva	4.2	1.8	24	20.0	3.5	5	4.2	4.2	4	16.7		1
Holothuria fuscopunctata	1.2	0.8	24	14.3	0.0	2	1.2	1.2	4	4.8		1
Thelenota ananas	3.6	1.3	24	14.3	0.0	6	3.6	1.5	4	4.8	1.4	3
Thelenota anax	1.2	0.8	24	14.3	0.0	2	1.2	0.7	4	2.4	0.0	2
Tridacna maxima	1.2	1.2	24	28.6		1	1.2	1.2	4	4.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.3.7 Kuria species size review — all survey methods

Species	Mean length (cm)	SE	n
Tridacna maxima	13.4	0.4	195
Panulirus spp.	20.0	0.0	10
Conus spp.	8.3	1.3	8
Holothuria fuscogilva	39.8	0.6	7
Thelenota ananas	56.3	1.5	6
Bohadschia argus	23.0	1.0	4
Thais spp.	6.2	0.2	3
Lambis chiragra	17.5	0.0	3
Thelenota anax	46.5	13.5	2
Vasum turbinellum	4.5	0.0	2
Holothuria fuscopunctata	26.0	0.0	2
Actinopyga miliaris	24.0		1
Holothuria nobilis	22.0		1
Lambis truncata	20.0		1
Conus leopardus	11.5		1
Conus virgo	7.5		1
Conus flavidus	6.2		1
Drupa morum	3.4		1
Conus miles	3.2		1
Echinothrix diadema			186
Actinopyga mauritiana			11
Echinometra mathaei			6
Stichodactyla spp.			2
Echinothrix spp.			2
Holothuria atra			1
Strombus luhuanus			1
Cerithium nodulosum			1
Cassis cornuta			1
Spondylus spp.			1

4.3.8 Habitat descriptors for independent assessments – Kuria



4.4 Kiritimati invertebrate survey data

4.4.1 Invertebrate species recorded in different assessments in Kiritimati

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 nobilis*	+			
Bêche-de-mer	*Stichopus chloronotus*	+	+		+
Bêche-de-mer	*Thelenota ananas*	+			+
Bivalve	*Atrina* spp.	+	+		
Bivalve	*Atrina vexillum*	+			
Bivalve	*Chama* spp.	+	+		
Bivalve	*Pinctada margaritifera*	+	+		+
Bivalve	*Tridacna maxima*	+	+		+
Crustacean	*Lysiosquillina* spp.	+			
Crustacean	*Panulirus* spp.	+			
Gastropod	*Conus* spp.		+		
Gastropod	*Lambis truncata*	+			+
Gastropod	*Thais* spp.				+
Gastropod	*Turbo argyrostomus*				+
Gastropod	*Turbo* spp.				+
Octopus	*Octopus cyanea*	+	+		
Star	*Culcita novaeguineae*	+	+		+
Urchin	*Diadema* spp.		+		
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix diadema*	+	+		+
Urchin	*Echinothrix* spp.				+

+ = presence of the species.

4.4.2 Kiritimati broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	0.6	0.3	84	16.7	0.0	3	0.6	0.3	14	2.8	0.0	3
Atrina spp.	67.7	18.9	84	177.6	43.4	32	67.7	39.6	14	105.2	58.9	9
Atrina vexillum	0.2	0.2	84	16.7		1	0.2	0.2	14	2.8		1
Bohadschia argus	11.5	2.9	84	48.3	7.6	20	11.5	5.2	14	32.2	8.9	5
Bohadschia vitiensis	0.8	0.4	84	16.7	0.0	4	0.8	0.5	14	3.7	0.9	3
Chama spp.	0.4	0.3	84	16.7	0.0	2	0.4	0.3	14	2.8	0.0	2
Culcita novaeguineae	13.1	4.0	84	45.8	11.6	24	13.1	5.4	14	26.2	8.3	7
Echinometra mathaei	4.6	1.4	84	29.5	5.4	13	4.6	1.9	14	12.8	2.9	5
Echinothrix diadema	12.3	3.5	84	57.4	11.5	18	12.3	6.5	14	34.4	14.1	5
Holothuria atra	1.2	0.5	84	16.7	0.0	6	1.2	0.4	14	2.8	0.0	6
Holothuria nobilis	0.4	0.3	84	16.7	0.0	2	0.4	0.3	14	2.8	0.0	2
Lambis truncata	0.4	0.3	84	16.7	0.0	2	0.4	0.3	14	2.8	0.0	2
Lysiosquillina spp.	0.2	0.2	84	16.7		1	0.2	0.2	14	2.8		1
Octopus cyanea	0.2	0.2	84	16.7		1	0.2	0.2	14	2.8		1
Panulirus spp.	1.0	0.5	84	20.8	4.2	4	1.0	0.8	14	6.9	4.2	2
Pinctada margaritifera	2.2	0.7	84	18.3	1.7	10	2.2	0.8	14	5.1	1.1	6
Stichopus chloronotus	4.8	2.7	84	57.1	27.4	7	4.8	4.1	14	22.2	18.1	3
Thelenota ananas	0.6	0.3	84	16.7	0.0	3	0.6	0.3	14	2.8	0.0	3
Tridacna maxima	2181.0	490.9	84	3456.6	724.5	53	2181.0	1084.8	14	2775.8	1334.9	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.

4.4.3 Kiritimati 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
Atrina spp.	104.2	29.1	72	468.8	81.9	16	104.2	46.6	12	208.3	72.2	6
Bohadschia argus	17.4	9.0	72	312.5	62.5	4	17.4	10.8	12	69.4	27.8	3
Chama spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Culcita novaeguineae	59.0	16.0	72	326.9	33.3	13	59.0	25.4	12	141.7	36.3	5
Diadema spp.	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Echinometra mathaei	149.3	29.5	72	447.9	47.5	24	149.3	34.2	12	162.9	34.4	11
Echinothrix diadema	180.6	31.7	72	448.3	45.4	29	180.6	43.3	12	180.6	43.3	12
Holothuria atra	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Octopus cyanea	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Pinctada margaritifera	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Stichopus chloronotus	17.4	7.5	72	250.0	0.0	5	17.4	8.0	12	52.1	10.4	4
Tridacna maxima	13,187.5	1329.9	72	13,564.3	1340.8	70	13,187.5	3153.4	12	13,187.5	3153.4	12

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 Kiritimati 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
Echinometra mathaei	18.3	6.2	36	82.4	10.9	8.0	18.3	8.6	6	36.6	5.7	3
Echinothrix diadema	113.7	19.6	36	178.0	20.9	23.0	113.7	46.1	6	170.6	45.7	4
Echinothrix spp.	38.6	13.6	36	138.8	32.4	10.0	38.6	24.4	6	115.7	5.9	2
Holothuria atra	1.3	0.9	36	23.5	0.0	2.0	1.3	1.3	6	7.8		1
Thais spp.	0.7	0.7	36	23.5		1.0	0.7	0.7	6	3.9		1
Tridacna maxima	43.8	11.0	36	83.0	16.3	19.0	43.8	21.4	6	43.8	21.4	6
Turbo argyrostomus	2.6	1.6	36	31.4	7.8	3.0	2.6	2.6	6	15.7		1
Turbo spp.	0.7	0.7	36	23.5		1	0.7	0.7	6	3.9		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.

4.4.5 Kiritimati reef-front search by walking (RFs_w) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Echinothrix diadema	340.3	225.1	24	583.3	377.8	14	340.3	231.6	4	340.3	231.6	4
Holothuria atra	36.1	9.5	24	43.3	10.7	20	36.1	15.1	4	36.1	15.1	4
Thais spp.	0.5	0.5	24	11.1		1	0.5	0.5	4	1.9		1
Tridacna maxima	15.3	2.7	24	20.4	2.6	18	15.3	2.3	4	15.3	2.3	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.

4.4.6 Kiritimati sea cucumber night search (Ns) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Bohadschia argus	142.2	25.1	9	142.2	25.1	9	106.7	62.2	2	106.7	62.2	2
Bohadschia vitiensis	195.6	77.5	3	195.6	77.5	3	48.9	40.0	2	48.9	40.0	2
Culcita novaeguineae	53.3		1	53.3		1	4.4	4.4	2	8.9		1
Echinothrix diadema	868.6	223.8	7	868.6	223.8	7	506.7	488.9	2	506.7	488.9	2
Stichopus chloronotus	106.7	0.0	2	106.7	0.0	2	17.8	17.8	2	35.6		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number of individuals; SE = standard error.

4.4.7 Kiritimati sea cucumber day search (Ds) assessment data review

Station: Six 5-min search periods.

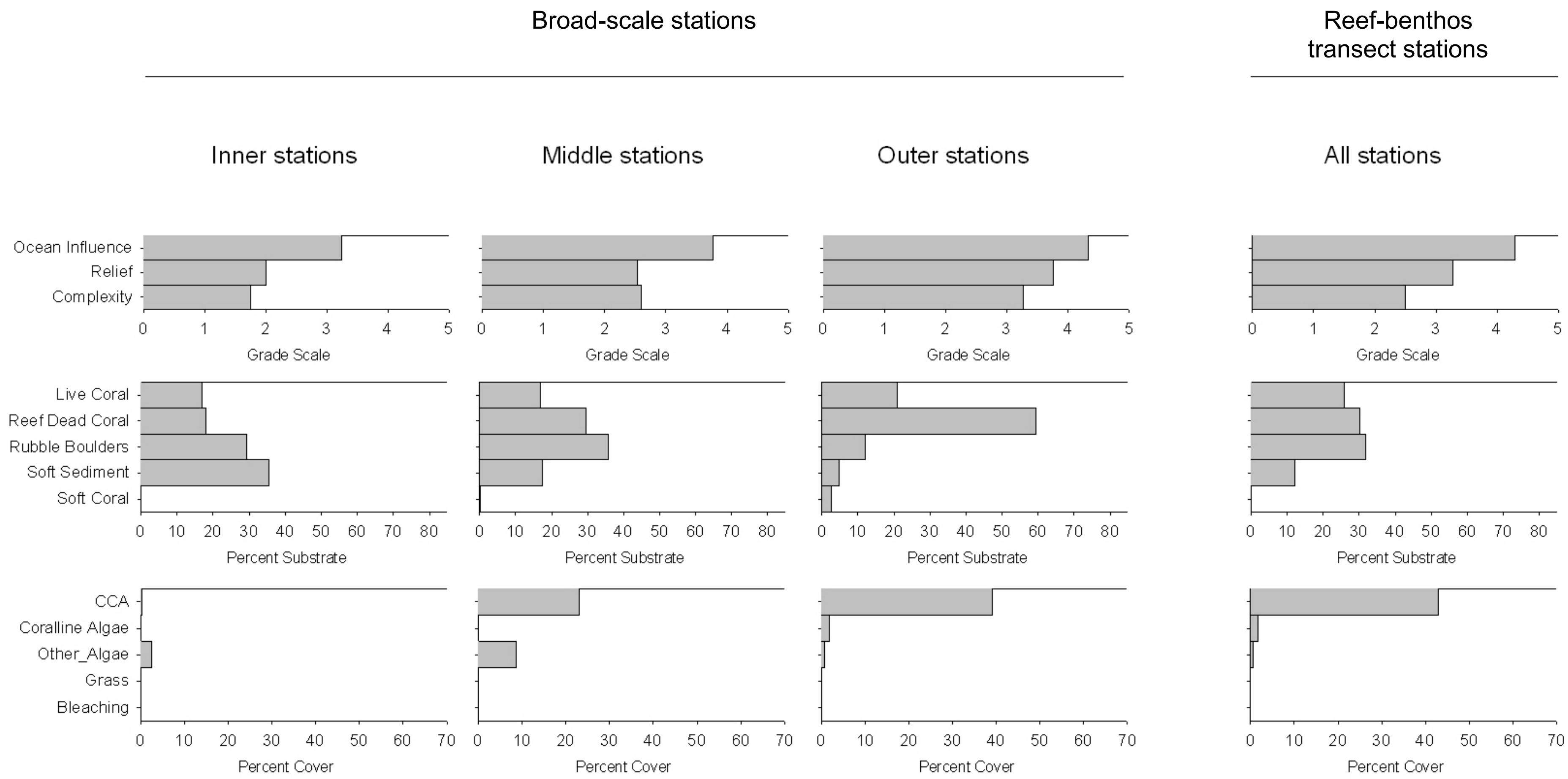
Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Bohadschia argus	1.8	1.0	24	14.3	0.0	3	1.8	1.8	4	7.1		1
Bohadschia vitiensis	4.2	1.4	24	14.3	0.0	7	4.2	2.5	4	8.3	1.2	2
Culcita novaeguineae	0.6	0.6	24	14.3		1	0.6	0.6	4	2.4		1
Lambis truncata	4.2	4.2	24	100.0		1	4.2	4.2	4	16.7		1
Pinctada margaritifera	1.8	1.3	24	21.4	7.1	2	1.8	1.1	4	3.6	1.2	2
Thelenota ananas	9.5	3.7	24	32.7	7.5	7	9.5	8.0	4	19.0	14.3	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.

4.4.8 Kiritimati species size review — all survey methods

Species	Mean length (cm)	SE	n
Tridacna maxima	10.2	0.1	14,890
Bohadschia argus	28.4	1.1	90
Holothuria atra	29.7	5.3	87
Stichopus chloronotus	22.5	2.5	33
Bohadschia vitiensis	30.0	2.0	23
Thelenota ananas	50.1	2.7	19
Pinctada margaritifera	15.4	0.5	15
Lambis truncata	24.0	4.2	9
Panulirus spp.	5.0	0.0	5
Holothuria nobilis	30.0	0.0	2
Conus spp.	3.2		1
Echinothrix diadema			1137
Atrina spp.			371
Echinometra mathaei			94
Culcita novaeguineae			85
Echinothrix spp.			59
Turbo argyrostomus			4
Actinopyga mauritiana			3
Chama spp.			3
Octopus cyanea			2
Thais spp.			2
Diadema spp.			2
Atrina vexillum			1
Lysiosquillina spp.			1
Turbo spp.			1

4.4.9 Habitat descriptors for independent assessments – Kiritimati



APPENDIX 5: MILLENNIUM CORAL REEF MAPPING PROJECT, KIRIBATI

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
Kiribati

(January 2009)

Map of Gilbert Islands, Kiribati

The Institute for Marine Remote Sensing (IMaRS) of University of South Florida (USF) was funded in 2002 by the Oceanography Program of the National Aeronautics and Space Administration (NASA) to characterize, map and estimate the extent of shallow coral reef ecosystems worldwide using high-resolution satellite imagery (Landsat 7 images at 30 meters resolution). Since mid-2003, the project is a partnership between Institut de Recherche Pour le Développement (IRD, France) and USF. The program aims to highlight similarities and differences between reef structures at a scale never considered so far by traditional work based on field studies. It provides a reliable, spatially well constrained data set for biogeochemical budgets, biodiversity assessment, coral reef conservation programs and fisheries. The PROCFish/Coastal project has been using Kiribati Millennium products in the last four years to optimize sampling strategy, access reliable reef maps, and further help in fishery data interpretation for all targeted countries. PROCFish/C is using Millennium maps only for the fishery grounds surveyed for the project.

For further inquiries regarding the status of the coral reef mapping of Kiribati and data availability, please contact:

Dr Serge Andréfouët
IRD, Research Unit COREUS 128, BP A5, Nouméa Cedex,
98848 New Caledonia;
E-mail: andrefouet@noumea.ird.nc

For further information on the project: http://imars.marine.usf.edu/corals.

Reference: Andréfouët S, *et al.* (2006), Global assessment of modern coral reef extent and diversity for regional science and management applications: a view from space. Proc 10th Int. Coral Reef Symposium, Okinawa 2004, Japan: pp. 1732-1745.