PACIFIC REGIONAL OCEANIC AND

COASTAL FISHERIES DEVELOPMENT PROGRAMME

(PROCFish/C/CoFish)

NEW CALEDONIA COUNTRY REPORT:

PROFILE AND RESULTS FROM SURVEY WORK AT OUASSÉ, THIO, LUENGONI, OUNDJO AND MOINDOU

(March, April and November 2003; January, February, April, June, August and November 2004; April and May 2005; January to March 2006; and January and February 2007)

by

Mecki Kronen, Pierre Boblin, Kim Friedman, Silvia Pinca, Franck Magron, Ribanataake Awira, Kalo Pakoa, Ferral Lasi, Emmanuel Tardy, Laurent Vigliola, and Lindsay Chapman.

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Secretariat of the Pacific Community
Coastal Fisheries Programme
BP D5, 98848 Noumea Cedex, New Caledonia
Tel: +687 26 00 00
Fax: +687 26 38 18
Email: spc@spc.int; http://www.spc.int/

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

- Lindsay Chapman, Coastal Fisheries Programme Manager
- Kim Friedman, Senior Reef Fisheries Scientist (invertebrates)
- Mecki Kronen, Community Fisheries Scientist
- Franck Magron, Reef Fisheries Information Manager
- Silvia Pinca, Senior Reef Fisheries Scientist (finfish)
- Ribanataake Awira, Reef Fisheries Officer (finfish)
- Kalo Pakoa, Reef Fisheries Officer (invertebrates)
- Pierre Boblin, Reef Fisheries Officer (finfish)
- Emmanuel Tardy, Reef Fisheries Officer (invertebrates)
- Marie-Therese Bui, Project Administrator
- Ferral Lasi, past Reef Fisheries Officer (invertebrates)
- Aliti Vunisea, past Community Fisheries Scientist
- Samasoni Sauni, past Senior Reef Fisheries Scientist (finfish)
- Laurent Vigliola, past Senior Reef Fisheries Scientist (finfish).

[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 five locations around New Caledonia. As New Caledonia was the home base for the PROCFish/C project, fieldwork was conducted site by site between fieldwork activities in other countries. Fieldwork in New Caledonia was undertaken in March, April and November 2003; January, February, April, June, August and November 2004; April and May 2005; January to March 2006; and January and February 2007. New Caledonia 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 New Caledonia covered three disciplines (finfish, invertebrate and socioeconomic) in each site, with sites surveyed on each trip by a team of two to five programme scientists and several local counterparts from the Fisheries Department, Provinces and IRD. 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 New Caledonia, the five sites selected for the survey were Ouassé, Thio, Luengoni, Oundjo and Moindou.

[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.

These sites were selected based on specific criteria, which included:

- having active reef fisheries,
- being representative of the country,
- being relatively closed systems (people from the site fish in well-defined fishing grounds),
- being appropriate in size,
- possessing diverse habitat,
- presenting no major logistical problems,
- having been previously investigated, and
- presenting particular interest for the Service de la Marine Marchande et des Pêches Maritimes and the three Provinces in New Caledonia.

Results of fieldwork in Ouassé

The village of Ouassé is located on the east coast of Grand Terre at the position of 21°28′03″S and 166°02′09″E. Its fishing ground is exclusive and limited. The geomorphology of the lagoon is complex, with at least three separate lines of reef (including a secondary, inshore 'false' barrier reef) forming sectors within the lagoon with differing degrees of land–ocean influence and exposure. In the outer lagoon, there were large, deep-water sections that had unrestricted water exchange with the open ocean and very dynamic water flow. As one moved closer to the shoreline, the parallel lines of reef provided ever-increasing levels of protection from the prevailing winds and swell. The bays along the coast were mainly influenced by land, and were therefore richer, with less oceanic through-flow. Coral habitats were also subjected to outflows from the land, including sediments from the nearby mining operations. The fishing area is mostly exploited for subsistence purposes, but may on rare occasions be commercially fished for the benefit of the community as a whole.

Socioeconomics in Ouassé

Fisheries do not play a major role in generating income in Ouassé; salaries, small business, and retirement and other social revenues are more important. Fresh-fish consumption (21 kg/person/year) is low by regional comparison and also compared to the average of all other PROCFish sites in New Caledonia. Invertebrate consumption is also low (14.3 kg/person/year). The low household expenditure level indicates that the community enjoys a traditional lifestyle and meets much of its subsistence needs with agricultural and fisheries produce. With the isolated location of the community and the difficulties and costs involved in transport and marketing, there are limited opportunities for commercial fishing of species such as trochus or lobsters.

Finfish resources in Ouassé

Overall, Ouassé finfish resources appear to be in relatively good condition and slightly better than the average of the five New Caledonia study sites. This result, combined with the sighting of a large group of very rare and vulnerable bumphead parrotfish, suggests that the area's finfish resources are relatively healthy. However, detailed assessment at reef level also reveals a systematic, lower-than-average abundance for both snappers (Lutjanidae) and emperors (Lethrinidae). First signs of impacts on carnivore species (especially Lethrinidae) are visible as lower biomass and sizes in the coastal and back-reefs, where most fishing is done and gillnets are often used. However, the reef habitat seems relatively rich and the ecosystem supporting finfish resources healthy.

Invertebrates in Ouassé

The range of giant clam species in Ouassé, their occurrence across the site, and the density of aggregations indicate that giant clam stocks are only marginally impacted by fishing. Moderate exploitation is most evident in the lower abundance of the larger species *Tridacna squamosa* and *Hippopus hippopus*. Shell size ranges of *T. maxima* and the larger clam species show that fishing is occurring. However, *T. crocea* are well suited to the embayments at Ouassé and represent a healthy, non-impacted stock.

Data on MOP distribution, density and shell size suggest that trochus (*Trochus niloticus*) are relatively common at Ouassé. However, present densities are too low to support commercial fishing, and stocks should be rested from commercial fishing until densities at the best locations reach ~500 trochus/ha. The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common, while *Tectus pyramis* was less abundant than might be expected.

The presence of a wide range of sea cucumber stocks reflected the varied environment of the extensive east coast lagoon at Ouassé. Presence and density data collected on commercial sea cucumber species show that there is limited pressure on stocks from commercialisation and that stocks are only marginally impacted by fishing.

Recommendations for Ouassé

- Further studies are needed to find out why snappers (Lutjanidae) and emperors (Lethrinidae) are systematically lower in abundance in Ouassé than the regional average. Until further information is available, a precautionary approach to fisheries management may consist in limiting the catches of snappers and emperors. The efficiency of this trial should then be evaluated by closely monitoring these resources.

- Marine resource management measures and monitoring activities be undertaken to accompany any expansion in finfish fishing to ensure that finfish remain available for subsistence use by future generations.

- Considering the high quality of habitat in Ouassé, marine protected areas be considered as a primary management tool.

- The use of gillnets be controlled in the shallow lagoons and back-reefs, which are the areas under most pressure from fishing.

- Trochus stocks be rested from commercial fishing until densities double at the best locations (until they reach ~500 trochus/ha). The abundance of smaller-sized shells on the reef be monitored to get an indication if there is any upcoming strong recruitment to the fishery. Consideration may be given to protecting the larger size classes of trochus (≥12 cm), which are valuable spawners (produce large numbers of eggs) and are not preferred by industry buyers.

- Further dive assessments be completed both in the more protected inshore lagoon and at more exposed locations to get an indication of the extent and strength of deep-water stocks of high-value white teatfish (*Holothuria fuscogilva*) in Ouassé.

Results of fieldwork in Thio

The survey site called 'Thio' in this report (22 km x 10 km), actually centres on Port Bouquet (21°43′35″S and 166°26′15″E), whose fishing ground includes the bay of Thio and the barrier reef located between Toupeti pass and north Ngoé pass. Here the geomorphology is quite characteristic, with a bay formed by high islands and long intermediate reefs offering 360° protection. Terrigenous (land-based) effects are very important here, in the form of siltation washed from the nearby mines. Each clan owns its own fishing area; however, shared associations among fishers make it difficult to define precise sectors as exclusive to specific clans. To simplify, we can define this area as exclusive to the combined set of clans. The exploitation of the lagoon is for commercial as well as subsistence purposes.

Socioeconomics in Thio

Most fishers in Thio fish for commercial purposes and fishing is the most important source of income for almost 48% of all households. All households in the community eat fresh fish and invertebrates; hence, seafood is marketed outside the community. Canned fish does not play any substantial role. Fresh-fish consumption (~22 kg/person/year) is low compared to the regional average and the average of all five PROCFish sites in New Caledonia (~30 kg/person/year). In contrast, invertebrate consumption in Thio (~35 kg/person/year) exceeds that of fresh fish and is among the highest of all sites surveyed in New Caledonia. The low level of household expenditure and the high dependency on fisheries for income, suggest that the Thio community is rather traditional. Both males and females target finfish and invertebrates, but more males exclusively fish for finfish and more females exclusively collect invertebrates.

Fisheries are diverse: finfish are caught in the sheltered coastal reef, lagoon and outer-reef; invertebrates are gleaned from reeftop, mangrove and soft-bottom areas. In addition, bêche-de-mer, lobsters, trochus, giant clams and octopus are dive fisheries and mainly commercially oriented. Various fishing techniques are used: gillnets, castnets, handlines and a variety of spear techniques, as well as free-diving and simple collection techniques in the case of invertebrate fishing.

Finfish resources in Thio

The status of finfish resources in Thio is similar to the average across PROCFish/C study sites in the country. This result, coupled with the relatively good condition of the substrate and live corals, suggests that the area's finfish resources are relatively healthy. However, detailed assessment at reef level also revealed a systematic lower-than-average abundance for snappers (Lutjanidae), emperors (Lethrinidae) and goatfish (Mullidae). This may be due either to unfavourable environmental conditions for these species or to greater-than-average impact from fishing carnivorous species. Fishing in Thio is mostly carried out for commercial purposes. The impact on fish resources is still light due to the low population and the large reef area available. However, preferentially caught species (*Lethrinus* spp.) appeared to suffer initial depletion.

Invertebrate resources in Thio

Thio has a relatively complete range of giant clam species, some of which are now becoming rare in other parts of the Pacific, even in New Caledonia. However, abundances of the largest species (*Tridacna derasa* and *T. squamosa*) were relatively low and *Hippopus hippopus* was scarce, which suggests fishing pressure is impacting these species. The densities of *T. maxima* and *T. crocea* in Thio were reasonably high, and these species displayed a 'complete' range of size classes, which suggests that these more common clam stocks are only marginally impacted by fishing pressure. The small number of juveniles of *T. derasa*, *H. hippopus* and, to some extent, *T. squamosa*, reflects both the scarcity of recruitment in these species and the cryptic habit of these solitary clam species.

Trochus (*Trochus niloticus*) are relatively common at Thio, as are other grazing gastropods (e.g. *Tectus pyramis*). Aggregations assessed show that there is a good stock of adult trochus of spawning size, but that densities are presently below the level at which commercial fishing is recommended. The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common at Thio but not at sufficient densities to encourage commercial fishing of shell. The scale of shell beds was limited at Thio, but *Anadara* spp. (arc shells) were relatively common and a full complement of shell sizes was found. This result implies that the present shell beds are not significantly impacted by fishing pressure.

Based on the wide range of sea cucumber stocks and the presence and density data collected in survey, stocks are only marginally impacted by fishing. Greenfish (*Stichopus chloronotus*) was widespread across the fishing area in Thio and was recorded at relatively high density.

Recommendations for Thio

- Further studies be conducted to find out why snappers (Lutjanidae), emperors (Lethrinidae) and goatfish (Mullidae) are relatively scarce. Until the cause has been found, a precautionary approach to fisheries management should be taken by limiting the catches of snappers, emperors and goatfish. The efficiency of this trial then be evaluated by monitoring these resources.

- Further development of reef finfish fisheries to improve food and financial security of the people of Thio may be sustainable in the intermediate and outer reef areas, provided any expansion of finfish fishing is accompanied by marine resource management and monitoring activities to prevent overfishing.

- Considering the high quality of habitat in Thio, marine protected areas be considered as a primary management tool.

- Trochus (*Trochus niloticus*) stocks be 'rested' until densities increase to approximately 500 individuals per ha in the main aggregations and a larger component of smaller shell sizes are seen on the reef.

- Consideration be given to protecting the larger size classes of trochus (≥12 cm), which are valuable spawners (produce exceptionally large numbers of eggs), and not preferred by industry buyers.

- Further monitoring be conducted, both around the more protected mid-shore reefs and at more exposed locations, to determine the extent and strength of deep-water stocks of the high-value white teatfish (*Holothuria fuscogilva*) in Thio.

Results of fieldwork in Luengoni

The island of Lifou is part of a group of uplifted coral islands, the Loyalty Islands, located to the east of Grand Terre, near the trench of New Hebrides. The PROCFish/C sites on this island, Luengoni and Joj (combined for the purpose of this report as 'Luengoni'), are part of the district of Losi, and are located on the east coast of Lifou, at the central position of 21°02′20″S and 167°25′34″E. The fishing area is contained between the Cape of Pines in the south and the site called 'Hutr' in the north. It is divided into two small lagoons, ~1.5 km x 0.8 km in surface area. The habitats at this site are difficult to classify, especially since the reef system is very small in size. The coastal reefs function as outer reefs, and the intermediate reefs can be classified as back-reefs. Fishing in this pseudo-lagoon is both for commercial and subsistence purposes. Ciguatera is very common among many species. The region is classified 'exclusive', with no *tabu* areas.

Socioeconomics in Luengoni

Fisheries are not an important source of income in Luengoni; salaries, small business and retirement and other social fees provide most income. However, people in Luengoni frequently eat fresh fish and invertebrates and almost all households have someone who fishes for subsistence or leisure. Fishery produce is hardly ever marketed within the Luengoni community and any sales mainly target external markets. Fresh-fish consumption in Luengoni (~36 kg/person/year) is about the same as the regional average and ranks among the highest across all five PROCFish/C sites investigated in New Caledonia. Invertebrate consumption is extremely low (5.5 kg/person/year).

Most fishers are males who fish for finfish; very few females engage in any fisheries. Male fishers target mainly the lagoon and some the sheltered coastal reef. Fishing techniques are varied: mainly gillnets, handlines, castnets and spears. Invertebrate fisheries are marginal; however, the lobster fishery plays a more important role, particularly in generating income.

Finfish resources in Luengoni

The status of finfish resources in Luengoni is similar to that in other New Caledonia study sites but slightly better for some specific families. However, biomass was low in the outer reefs, due to small average fish size and low average density. This could be the direct impact of spearfishing at night, especially manifest in the small size ratio for Scaridae. Overall, Luengoni finfish resources appeared to be in average-to-good condition. The reef habitat seemed relatively rich, with good cover of live coral on the outer reefs, and able to support healthy finfish resources. Populations of emperors (Lethrinidae) in Luengoni were richer than in the other sites, due especially to a large population of *Gnathodentex aureolineatus* (goldlined seabream) in the back-reefs; however other carnivores were rare. Populations of Mullidae were relatively rich in the back-reefs, displaying the highest abundance and biomass in the country, especially of yellowfin goatfish (*Mulloidichthys vanicolensis*).

Invertebrate resources in Luengoni

At Luengoni, sheltered areas of shallow-water lagoon and reef were limited and largely open to ocean influences and swell. The exposed, simple fringing reef and offshore banks were not suitable for the full range of giant clams found in New Caledonia, and only three species were recorded in survey (*Tridacna maxima*, *T. squamosa* and *Hippopus hippopus)*. The elongate clam *T. maxima* had the highest density, but its aggregations were unremarkable. The other species present at Luengoni (*Hippopus hippopus* and *T. squamosa*) were rare and at densities lower than expected. Although *T. maxima* displayed a relatively 'full' range of size classes, including small, young clams, which indicate successful spawning and recruitment, the general low abundance of clams and scarcity of large clams suggest that clams are moderately impacted by fishing at Luengoni.

Habitat for adult trochus (*Trochus niloticus*) is moderately extensive but not ideal for these grazing gastropods. Habitat for juvenile trochus (rubble-covered back-reef) was not extensive, and food was limiting in this mainly oceanic-influenced system. Trochus introduced to this area in 1989 as juveniles do not seem to have become established as a self-maintaining population. The low commercial value green topshell (*Tectus pyramis*) and blacklip pearl oyster (*Pinctada margaritifera*) were also rare at Luengoni, while the green snail (*Turbo marmoratus*) was absent.

Only seven commercial sea cucumber species were recorded at Luengoni, which reflected the geography of the location and the exposed nature of the habitats present. Commercial species were well distributed across the study area: medium- and high-value species, such as leopardfish or tigerfish (*Bohadschia argus*) and black teatfish (*Holothuria nobilis*), were relatively common and under low fishing pressure. Densities of black teatfish (*H. nobilis*) were especially high, similar to those recorded in locations where sea cucumber stocks are protected from commercial fishing. Unfortunately, the area available for any prospective fishery for this valuable species is very limited at Luengoni.

Recommendations for Luengoni

- Any future expansion of finfish fishing be accompanied by marine resource management measures, such as marine protected areas.
- Any future commercial fishing plans for sea cucumber acknowledge the 'natural' limit of stocks in this area (due to the limited environmental conditions) and allow for the fact that stock recovery from fishing is likely to be slower than normal.
- Any future trochus introductions be made using adult trochus, instead of juveniles. Adults can be aggregated and then protected and be allowed to breed and replenish the reefs with young.

Results of fieldwork at Oundjo

Located on the west coast of Grand Terre, at 21°02′30″S and 164°41′47″E, Oundjo is a coastal village surrounded by mangroves. Its fishing area is limited by the Gatope pass in the north and the Goyeta pass in the south, with a surface area of 23 km x 4.5 km. Only a very poorly defined zone in the north within a radius of about 7 km from the village can be considered as exclusive to Oundjo; the southern sector is not under the control of the village. This zone, which is shared with the Gatope clan, includes a *tabu* area, the 'blue hole', located on the barrier reef at the position 21°03′12″S and 164°41′47″E. The lagoon is very shallow and a large part is sandy. Here, rivers discharge their siltation from the land during the rainy season in larger amounts than found elsewhere. The fishers of Oundjo exploit the lagoon and the mangroves both commercially and for subsistence purposes.

Socioeconomics in Oundjo

Fisheries are the most important source of income in Oundjo; however, salaries and income from small business and retirement and other social fees also play a role. All households eat fresh fish and most also invertebrates regularly. Fresh-fish consumption (~34 kg/person/year) is about average for the region and among the highest values of the five PROCFish/C sites surveyed in New Caledonia. Invertebrate consumption (46 kg/person/year) is outstandingly high and exceeds that of fresh fish by 35%.

Most male fishers target only finfish and most female fishers collect invertebrates. Finfish fishers mainly target the sheltered coastal reefs and lagoon and much less the outer reef. Invertebrate fisheries are mainly commercial, with collection mainly from mangroves and on reeftops, while some male fishers also collect bêche-de-mer, lobsters and trochus for commercial purposes. Finfish are caught using a combination of castnets, gillnets, handlines and spears. Invertebrate fisheries mainly involve the use of simple tools and sometimes motorised boat transport to reach certain fishing areas.

The Oundjo community is one of the major suppliers of fish to agents for the greater Noumea market and fisheries play an important role for income generation. Given the limited local alternatives for other income sources for people in Oundjo, it can be assumed that fisheries will continue to play an important role in the future. Depending on transport and marketing cost and market demand in Noumea, it is possible that fishing pressure on certain species, e.g. mud crabs, lobsters, trochus and selected finfish species will increase. Although the fishing grounds in Oundjo are large, stocks of these selectively targeted species may need to be monitored in the future.

Finfish resources in Oundjo

The status of finfish resources in Oundjo is much poorer than the average across New Caledonia study sites and is relatively overfished. The reef habitat seemed relatively rich but the biomass and abundance of fish were low. Detailed assessment at reef level also revealed a systematic, lower-than-average abundance of all families except Acanthuridae and Scaridae in the outer reefs (the richest environments at this site) and the back-reefs, and Chaetodontidae, which, in the coastal, intermediate and outer reefs, have the highest abundance of all sites. Preliminary results, together with the lack of carnivores observed, suggest that this trend is probably due to intense fishing. Only coastal reefs displayed relatively high density of snappers; in the other habitats, populations of snappers (Lutjanidae) and emperors (Lethrinidae) were systematically lower than the regional average. Further development of reef finfish fisheries to improve food and financial security of the people of Oundjo may not be sustainable at this point. Oundjo has a traditional *tabu* area but the fishing pressure on resources has reached too precarious a level to show any advantage from such a traditional management measure.

Invertebrate resources in Oundjo

Oundjo has a relatively complete range of giant clam species, some of which are now becoming rare in other parts of the Pacific. The shallow-water lagoon was very suitable for the elongate clam *Tridacna maxima* and inshore sites were suitable for *Hippopus hippopus*, which was relatively common at Oundjo compared to other PROCFish/C sites in New Caledonia. Giant clam density in Oundjo was reasonably high for *T. maxima*; most species groups displayed a 'complete' range of size classes, which supports the assumption that clam stocks are only marginally impacted by fishing pressure. However, abundances of the largest species (*T. derasa* and *T. squamosa*) were relatively low. These two species are usually the first to decline through fishing pressure, and are already depleted at Oundjo.

Trochus (*Trochus niloticus*) at Oundjo is relatively common, as are other grazing gastropods (e.g. *Tectus pyramis*). Densities of the aggregations assessed are presently below the level at which commercial fishing is recommended. Small trochus were noted (shells < 8cm), which is promising for future growth of the stock. The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common at Oundjo, but not sufficient to encourage commercial fishing of shell. Shell beds at Oundjo were richer further away from the village, where *Anadara* spp. were relatively common. A full complement of shell sizes was recorded, which implies that the shell beds distant from the village are not significantly impacted by fishing pressure.

Based on the wide range of sea cucumber species and the presence and density data collected in survey, it is concluded that there is only moderate pressure on stocks from commercialisation, and that fishing pressure is being successfully managed. The premium-value sandfish (*Holothuria scabra*) was found at reasonable density at two locations.

Recommendations for Oundjo

- Further studies to elucidate the cause of the relative scarcity of snappers (Lutjanidae) and emperors (Lethrinidae) be initiated. Until the cause has been found, a precautionary approach to fisheries management be taken by limiting the catches of snappers and emperors, which were systematically lower in abundance than the regional average, except at coastal reefs. The efficiency of this trial then needs to be evaluated by closely monitoring these resources.

- There be no further development of reef finfish fisheries to improve food and financial security of the people of Oundjo as this is considered not to be sustainable at this point.

- Marine resource management and monitoring activities be developed and implemented to protect the remaining finfish resources.

- Before commercial fishing is re-considered, stocks of trochus (*Trochus niloticus*) at Oundjo be 'rested' until densities increase to approximately 500/ha in the main aggregations.

- Consideration be given to protecting the larger size classes of trochus (≥12 cm), which are valuable spawners and not preferred by industry buyers.

- Further assessment be undertaken to determine the availability of the white teatfish (*Holothuria fuscogilva)* and other deep-water sea cucumber stocks. Effort should preferably be concentrated along the northerly and two southerly passages.

Results of fieldwork in Moindou

Moindou village is located on the west coast of Grande Terre, at the position 21°41′31″S and 165°40′38″E. The village is located inland, near the mangroves. The fishing area is limited by Ouarai pass in the south and by the point 21°41'S and 165°30′E in the north, with a surface area of 25 km x 7 km. This is an 'open-access' area and subject to strong fishing pressure for commercial, recreational and sustenance purposes. The Moindou sector is characterised by very large areas of shallow sandy bottom and by large seagrass meadows. The coastal habitats were very difficult to explore with diving gear due to the elevated turbidity of the water. Mangroves occupy large areas and their exploitation causes problems regarding the management of mangrove crab stocks. There are no reserves protected from fishing, nor any *tabu* areas.

Socioeconomics in Moindou

Salaries and small business are the most important income sources for households in Moindou. Only 30% of all households rely on fisheries for income generation but most (17.5%) only as secondary income. However, all households eat fresh fish and invertebrates. Fresh-fish consumption (33 kg/person/year) is about average for the region and among the higher values of the five PROCFish/C sites surveyed in New Caledonia. Invertebrate consumption (23.5 kg/person/year) is about average compared to the country sites surveyed. The average household expenditure level in Moindou is well above the country average and no remittances are received, suggesting that the people in Moindou have adopted a rather urbanised lifestyle.

Most fishers target both finfish and invertebrates. A few male fishers target exclusively finfish and about half of female fishers collect only invertebrates. Most fishers are male, and they account for most of the reported impact. Main impact by fisher and catch is imposed on the sheltered coastal reefs and lagoon and very little on the outer reef. Invertebrates are mostly collected from the mangroves; much less impact is reported for reeftop and soft-benthos gleaning. Finfish are caught using a combination of gillnets, castnets, handlines and spears. Gleaning for invertebrates is done using very simple tools only. Mud crabs are caught by hand, using sticks and iron bars, or baited cages and the number of external fishers give the community, fishery services and other administrative authorities cause for concern.

Finfish resources in Moindou

The status of finfish resources in Moindou was similar to or slightly poorer than the average across the New Caledonia study sites. However, the reef habitat seemed relatively rich and the ecosystem supporting finfish resources quite healthy. The populations of Lutjanidae, Lethrinidae and Mullidae were in the low-value ranges for the country, but similar to those in Ouassé, Thio and Oundjo. A lack of suitable habitats for these carnivores (who prefer soft bottom) could possibly explain this low abundance. Biomass was comparable to values in Luengoni and Oundjo, while density was similar to the averages in Oundjo and Thio. Moindou reefs displayed some of the lowest values of density for Acanthuridae, Siganidae and Labridae, low values of density and biomass for Lutjanidae, Lethrinidae and Mullidae, but the highest abundance of Scaridae (due to a very high density of small parrotfish in the intermediate reefs). Siganidae (rabbitfish) displayed some of the lowest densities, particularly in the coastal, back- and outer reefs, possibly related to the high consumption of rabbitfish, especially of those caught in coastal reefs. The fishing pressure may already have impacted the fish population, and the lack of large-sized fish, especially among carnivorous families, is a response to heavy fishing.

Invertebrate resources in Moindou

Reef habitat at Moindou provided ample refuge areas with sufficient depth and water flow for all the species of clams, including the larger species *T. derasa* and *T. squamosa*. In general, the current densities and the range of size classes suggest that giant clam stocks are less impacted by fishing pressure than at other sites in New Caledonia. *Tridacna crocea* was not recorded but may be present on inshore reefs. *T. gigas* was missing from the site and is generally not found around Grande Terre, New Caledonia. *T. maxima* and the larger *T. derasa* were located at the 'false' barrier reef and back-reefs at relatively high densities. *Hippopus hippopus* was also relatively common compared to in the other PROCFish sites in New Caledonia, which is a promising indication of stock condition. However, overall, abundances of the largest species *T. derasa* and *T. squamosa* were low and survey results suggest that these species are heavily impacted from fishing. *T. derasa* and *T. squamosa* clam meat is still regularly marketed at the main fish market in Noumea.

Trochus (*Trochus niloticus*) at Moindou are moderately common, as are other grazing gastropods (e.g. *Tectus pyramis*). Densities of the main aggregations assessed are presently at levels at which commercial fishing is not recommended. Even though some stations had densities >500–600 /ha, these were limited to a small number of stations in difficult-to-reach locations outside the barrier reef. All sizes of trochus were noted (including shells <8 cm), which indicates that recruitment is still occurring, which is promising for future growth of the stock. The blacklip pearl oyster (*Pinctada margaritifera*) and silver-mouthed turban (*Turbo argyrostomus*) were relatively common at Moindou, but not in sufficient amounts to encourage commercial fishing of shell.

Moindou has a diverse range of environments suitable for sea cucumbers and the range of sea cucumber species recorded here was large, partially reflecting the varied environment, but also the fact that the export fishery is controlled. Presence and density data suggest that there has been moderate-to-high pressure on stocks from commercialisation. The presence of reasonable numbers of black teatfish (*Holothuria nobilis*) suggests that fishing is now less active, although many species are only found at moderate densities. The high-value sandfish (*H. scabra*) was found, but in low amounts, despite reported exceptionally high abundances in previous years. The premium-value white teatfish (*H. fuscogilva*) was noted in deep-water assessments at reasonable densities.

Recommendations for Moindou

- Careful monitoring and management of the mud crab resource and fishing practices be implemented, including limiting the total annual catch, the catching methods, and the number of external fishers who target mud crabs in the Moindou fishing ground.

- Further studies be conducted to find out if the cause of the relative scarcity of snappers (Lutjanidae), emperors (Lethrinidae) and goatfish (Mullidae) is related to fishing practice. Until the cause has been found, a precautionary approach to fisheries management may be taken by limiting the catches of snappers, emperors and goatfish. The efficiency of this trial can then be evaluated by monitoring these resources.

- Any further development of reef fish fisheries to improve food and financial security of the people of Moindou be carefully managed and accompanied by monitoring activities. Considering the high quality of habitat in Moindou, marine protected areas can be considered as a primary management tool.

- Commercial trochus (*Trochus niloticus*) fishing not begin until densities reach >500 trochus/ha) in all main aggregations. Protection needs to be given to trochus ≥12 cm, which are valuable spawners and are not preferred by industry buyers.

- Protective measures be taken to allow the sandfish (*Holothuria scabra*) to recover, as the habitat looked very suitable for this high-value species.

- Further assessment of the premium-value white teatfish (*Holothuria fuscogilva*) be undertaken to determine the full condition of this stock and availability for commercial fishing.

RÉSUMÉ

Les agents chargés de la composante côtière du Programme régional de développement des pêches océaniques et côtières (PROCFish/C) ont réalisé des enquêtes de terrain, sur cinq sites dispersés autour de la Nouvelle-Calédonie. Étant donné que le programme PROCFish/C était géré depuis la Nouvelle-Calédonie, les travaux de terrain ont été conduits site par site, entre ceux menés dans les autres pays. En Nouvelle-Calédonie, les enquêtes de terrain ont été réalisées en mars, avril et novembre 2003, en janvier, février, avril, juin, août et novembre 2004, aux mois d'avril et de mai 2005, de janvier à mars 2006 et en janvier et février 2007. La Nouvelle-Calédonie est l'un des dix-sept États et Territoires insulaires océaniens ayant fait l'objet d'une évaluation sur une période de cinq à six ans, dans le cadre de PROCFish ou de son programme connexe, CoFish (Programme régional de développement de la pêche côtière)[3].

Les enquêtes réalisées visaient à recueillir des données de référence sur l'état des ressources récifales, afin de combler l'énorme déficit d'informations qui fait obstacle à la bonne gestion de ces ressources.

Les autres résultats attendus du programme étaient notamment :

- la réalisation, pour la toute première fois en Océanie, d'une évaluation exhaustive et comparative des ressources récifales de plusieurs pays (poissons, invertébrés et aspects socioéconomiques), grâce à une méthode normalisée, appliquée à chaque site d'étude ;
- la diffusion de rapports de pays comprenant un ensemble de « profils des ressources récifales » des différents sites étudiés dans chaque pays, afin de transmettre les informations nécessaires à la planification de la gestion et du développement de la pêche côtière ;
- l'élaboration d'une série d'indicateurs (ou de points de référence sur l'état des ressources) afin de guider l'établissement de plans de gestion des ressources récifales et de programmes de suivi aux échelons local et national ; et
- la mise en place de systèmes de gestion des données et de l'information, notamment des bases de données régionales et nationales.

Les enquêtes conduites en Nouvelle-Calédonie sur chacun des sites s'articulaient autour de trois volets (les poissons, les invertébrés et les aspects socioéconomiques). À chaque mission, une équipe composée de deux à cinq scientifiques du programme et de plusieurs agents locaux du service des pêches, des provinces et de l'IRD, se chargeait d'étudier les sites. Au cours des travaux de terrain, l'équipe a formé ses homologues locaux aux méthodes d'enquête et de comptage employées dans chacun des trois volets, notamment à la collecte de données et à leur saisie dans la base de données du programme.

En Nouvelle-Calédonie, les cinq sites retenus pour le travail d'enquêtes étaient : Ouassé, Thio, Luengoni, Oundjo et Moindou.

[3] CoFish et PROCFish/C sont les deux composantes d'un même programme, 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). Les termes CoFish et PROCFish/C sont, par conséquent, employés indifféremment dans tous les rapports de pays.

Ces sites ont été sélectionnés selon des critères précis et devaient notamment :

- être le siège d'une pêche récifale active ;
- être représentatifs du pays ;
- constituer des systèmes relativement fermés (les populations environnantes pêchent dans des zones bien définies) ;
- couvrir une superficie appropriée ;
- présenter une grande diversité d'habitats ;
- ne pas poser de problèmes logistiques majeurs ;
- avoir été étudiés auparavant ; et
- présenter un intérêt particulier pour le Service de la marine marchande et des pêches maritimes (SMMPM) et les trois provinces de la Nouvelle-Calédonie.

Résultats des travaux de terrain effectués à Ouassé

La tribu de Ouassé est située sur la côte est de la Grande Terre, par 21° 28′ 03″ de latitude sud et 166° 02′ 09″ de longitude est. Sa zone de pêche est exclusive et limitée. La géomorphologie du lagon est complexe : on relève au moins trois récifs distincts, notamment un « pseudo » récif-barrière côtier secondaire, qui, au sein du lagon, délimitent des secteurs différemment exposés aux influences océaniques et continentales. À l'extérieur du lagon, on note de vastes zones profondes où se produisent des échanges d'eaux libres avec le large et un fort hydrodynamisme. Lorsque l'on se rapproche du littoral, la succession de récifs offre une protection contre les vents dominants et la houle. Les baies du littoral sont principalement influencées par les terres et, par conséquent, plus riches, tandis que les échanges avec l'océan sont moindres. Les habitats coralliens sont également exposés aux écoulements en provenance des terres, qui contiennent notamment des sédiments originaires des exploitations minières avoisinantes. La zone de pêche est principalement exploitée à des fins de subsistance, mais il arrive, à de rares occasions, que les poissons soient vendus au profit de toute la communauté.

Enquêtes socioéconomiques : Ouassé

À Ouassé, la pêche ne joue pas un rôle majeur en matière de génération de revenus ; les salaires, les petites entreprises, les pensions de retraite et d'autres prestations sociales occupent une place plus importante. La consommation de poisson frais (21 kg par personne et par an) est faible par rapport au reste de la région et à la moyenne de tous les autres sites PROCFish de Nouvelle-Calédonie. La consommation d'invertébrés est, elle aussi, peu élevée (14,3 kg par personne et par an). Par ailleurs, le niveau peu élevé des dépenses des ménages montre que la communauté conserve un mode de vie traditionnel et que ses membres satisfont une grande partie de leurs besoins alimentaires grâce à l'agriculture et à la pêche. De plus, compte tenu de l'isolement géographique de la communauté, ainsi que des difficultés et des frais résultant du transport et de la commercialisation des produits, la pêche commerciale d'espèces comme le troca ou la langouste ne présente qu'un intérêt limité.

Ressources en poissons : Ouassé

Dans l'ensemble, l'état des ressources en poissons de Ouassé semble plutôt bon, voire légèrement meilleur que la moyenne relevée sur les cinq sites d'étude de Nouvelle-Calédonie. Associé à l'observation d'une concentration de perroquets à bosse très rares et vulnérables, ce résultat laisse à penser que les ressources en poissons de la zone sont relativement en bon état. Toutefois, une évaluation détaillée à l'échelle du récif a également mis en évidence une abondance des vivaneaux (lutjanidés) et des empereurs (lethrinidés) systématiquement inférieure à la moyenne. Les premiers signes des effets sur les espèces carnivores, en particulier les lethrinidés, sont visibles : on relève une biomasse et des tailles inférieures sur le récif côtier et l'arrière-récif, où se déroule la majeure partie des activités de pêche et où sont fréquemment utilisés des filets maillants. Toutefois, l'habitat récifal paraît relativement riche et l'écosystème, qui garantit les ressources en poissons, en bonne santé.

Ressources en invertébrés : Ouassé

La diversité des espèces de bénitiers, leur présence sur le site et la densité de leurs concentrations indiquent qu'à Ouassé, la pression de pêche qui s'exerce sur les stocks de bénitiers est faible. La preuve la plus évidente de cette exploitation modérée est la faible abondance des espèces de grande taille *Tridacna squamosa* et *Hippopus hippopus*. La diversité de la taille des coquilles de *T. maxima* et des espèces de grande taille signale l'existence d'une activité de pêche. Toutefois, les spécimens de *T. crocea* s'adaptent parfaitement aux baies de Ouassé et forment un stock sain, sur lequel la pêche n'a pas d'effet néfaste.

Les informations relatives à la répartition, la densité et la taille de la coquille des espèces nacrières donnent à penser que le troca (*Trochus niloticus*) est relativement commun à Ouassé. Toutefois, les densités actuelles de trocas ne permettent pas l'exploitation commerciale de ceux-ci, et il faut s'abstenir de toute pêche commerciale tant que la densité des sites les plus fournis n'avoisine pas 500 trocas par hectare. L'huître perlière à lèvres noires (*Pinctada margaritifera*) est relativement commune, tandis que *Tectus pyramis* l'est moins que ce à quoi on aurait pu s'attendre.

La grande diversité d'holothuries reflète l'environnement varié du vaste lagon de Ouassé, situé sur la côte est du Territoire. Les informations relatives à la présence et à la densité d'espèces commerciales d'holothuries collectées dans le cadre de l'enquête dénotent une pression limitée de l'exploitation commerciale sur les stocks. De plus, elles montrent que les populations ne sont que faiblement affectées par la pêche.

Recommandations pour Ouassé

- Il convient de conduire d'autres enquêtes afin de déterminer pour quelles raisons, à Ouassé, l'abondance de vivaneaux et d'empereurs, appartenant respectivement à la famille des lutjanidés et des lethrinidés, est systématiquement inférieure à la moyenne régionale. Jusqu'à ce que de nouvelles informations soient disponibles, il faut adopter le principe de précaution dans la gestion des pêches, ce qui pourrait se traduire par la limitation des prises de ces deux espèces. Un suivi constant de l'état de ces ressources permettra ensuite de jauger l'efficacité des mesures appliquées.

- L'expansion de la pêche des poissons doit s'accompagner de mesures de gestion des ressources marines et d'activités de suivi, afin de faire en sorte que les générations futures puissent continuer d'exploiter les ressources halieutiques à des fins de subsistance.

- Compte tenu de la qualité de l'habitat à Ouassé, des aires marines protégées doivent être envisagées comme principal outil de gestion.

- L'utilisation de filets maillants doit être contrôlée dans les eaux peu profondes du lagon et sur les arrière-récifs, où la pression de pêche est la plus forte.

- Il faut s'abstenir de pratiquer la pêche commerciale du troca jusqu'à ce que sa densité double sur les sites les plus fournis (objectif : près de 500 trocas/ha). L'abondance des coquillages de petite taille sur le récif doit être surveillée et servir d'indicateur au cas où le nombre de pêcheurs venait à augmenter fortement. Il faudra peut-être envisager de protéger les trocas appartenant aux classes de taille supérieure (≥12 cm de diamètre), précieux géniteurs qui pondent de nombreux œufs et ne sont pas particulièrement recherchés par les acheteurs.

- D'autres évaluations réalisées en plongée doivent être conduites à Ouassé, tant dans le lagon intérieur protégé, que sur les sites davantage exposés, afin d'évaluer la taille et l'état des stocks d'holothuries blanches à mamelles (*H. fuscogilva*.), espèce des eaux profondes à forte valeur commerciale.

Résultats des travaux de terrain effectués à Thio

Le site d'enquête appelé « Thio » dans le présent rapport (qui s'étend sur 22 km de long et 10 km de large), se trouve en réalité à Port Bouquet (à 21° 43′ 35″ de latitude sud et 166° 26′ 15″ de longitude est), dont la zone de pêche comprend la baie de Thio et le récif-barrière situé entre la passe de Toupeti et la passe nord de Ngoé. La géomorphologie de ce site est tout à fait caractéristique. Il s'agit d'une baie composée d'îles hautes et de récifs intermédiaires offrant une protection à 360 degrés. Les apports terrigènes (d'origine continentale) y sont considérables : on observe un envasement provoqué par un ruissellement provenant des mines environnantes. Chaque clan dispose d'une zone de pêche qui lui est propre. Il est toutefois difficile de savoir précisément quels secteurs sont réservés à tels ou tels clans, étant donné que les pêcheurs s'associent entre eux pour se partager les zones de pêche. Pour simplifier, on peut dire que cette zone appartient à un groupe composé de plusieurs clans. Les ressources du lagon sont exploitées à des fins commerciales et de subsistance.

Enquêtes socioéconomiques : Thio

À Thio, la plupart des pêcheurs pratiquent cette activité à des fins commerciales et la pêche constitue la première source de revenus pour près de 48 pour cent des familles. Dans tous les foyers du village, on mange du poisson frais et des invertébrés ; les produits de la mer sont, par conséquent, commercialisés en dehors de la communauté. Le poisson en conserve ne joue pas un rôle prédominant. La consommation de poisson frais (environ 22 kg par personne et par an) est faible par rapport à la moyenne régionale et à celle estimée pour les cinq sites PROCFish de Nouvelle-Calédonie (environ 30 kg par personne et par an). À Thio, la quantité d'invertébrés consommés (environ 35 kg par personne et par an) est en revanche supérieure à la quantité de poisson frais consommé par la population et compte parmi les plus élevées de tous les sites étudiés en Nouvelle-Calédonie. Étant donné que les dépenses des ménages sont minimes et que les habitants de Thio tirent l'essentiel de leurs revenus de la pêche, on considère que cette communauté a un mode de vie plutôt traditionnel. Aussi bien les hommes que les femmes ciblent les poissons et les invertébrés, mais davantage d'hommes pêchent exclusivement du poisson, tandis que les femmes sont plus nombreuses à se consacrer uniquement à la collecte d'invertébrés.

Les zones de pêche sont multiples : les poissons sont capturés sur le récif côtier protégé, dans le lagon et sur le tombant récifal externe, et les invertébrés sont prélevés sur le platier récifal, dans la mangrove et les zones de fonds meubles. On note par ailleurs que les holothuries, les langoustes, les trocas, les bénitiers et les poulpes sont pêchés en plongée, le plus souvent à des fins commerciales. Divers engins sont utilisés pour capturer le poisson : filets maillants, éperviers, palangrottes et fusils à harpon. Enfin, les invertébrés sont prélevés en plongée libre ou à pied.

Ressources en poissons : Thio

À Thio, l'état des ressources en poissons est comparable à la moyenne calculée pour l'ensemble des sites PROCFish étudiés en Nouvelle-Calédonie. Ce résultat, associé au fait que le substrat et les coraux vivants sont relativement sains, semble indiquer que les ressources en poissons de la zone se portent plutôt bien. Une évaluation détaillée à l'échelle du récif a toutefois révélé une abondance des vivaneaux (lutjanidés), des empereurs (lethrinidés) et des rougets (mullidés) systématiquement inférieure à la moyenne. Cela peut être dû à des conditions environnementales peu favorables au développement de ces espèces ou à une surpêche des carnivores. À Thio, la pêche est surtout pratiquée à des fins commerciales. L'impact de cette activité sur les ressources en poissons reste limité, en raison de la faible densité de population et de l'étendue de la zone récifale. Néanmoins, les espèces les plus pêchées (*Lethrinus* spp.) semblent être en voie d'épuisement.

Ressources en invertébrés : Thio

Le site de Thio abrite toute une variété d'espèces de bénitiers, dont certaines tendent à disparaître dans d'autres régions du Pacifique, y compris en Nouvelle-Calédonie. Les plus grands bénitiers (*Tridacna derasa* et *T. squamosa*) sont toutefois relativement peu abondants et *Hippopus hippopus* est rare. Il semble donc que ces espèces soient soumises à une forte pression de pêche. À Thio, les densités de *T. maxima* et de *T. crocea* sont assez élevées et toutes les classes de taille sont représentées, ce qui permet de penser que la pression de pêche qui s'exerce sur ces stocks de bénitiers plus communs est moindre. Le petit nombre de juvéniles de *T. derasa*, de *H. hippopus* et, dans une certaine mesure, de *T. squamosa* montre que le recrutement de ces espèces est insuffisant et que ces bénitiers solitaires ont un comportement cryptique.

Le troca (*Trochus niloticus*) est, au même titre que d'autres gastéropodes brouteurs (tels que *Tectus pyramis*), relativement commun sur le site de Thio. Les concentrations de trocas observées durant l'enquête montrent qu'il existe un important stock d'adultes ayant atteint une taille suffisante pour se reproduire, mais que les densités sont actuellement à un niveau nettement inférieur au minimum recommandé pour la pêche commerciale. Si l'huître perlière à lèvres noires (*Pinctada margaritifera*) est relativement commune à Thio, sa densité est trop insuffisante pour encourager la pêche de cette espèce à des fins commerciales. L'étendue des gisements de coquillages est limitée sur le site de Thio ; les arches (*Anadara* spp.) sont toutefois relativement communes et des spécimens de toutes les tailles sont présents. Ces résultats tendent à indiquer que la pression de pêche qui s'exerce sur les gisements de coquillages existants est faible.

La grande diversité des stocks d'holothuries et les données relatives à leur présence et à leur densité, recueillies dans le cadre de l'enquête, montrent que les ressources sont soumises à une pression de pêche relativement faible. Le trépang vert (*Stichopus chloronotus*), surnommé « ananas vert » en Nouvelle-Calédonie, est très présent dans la zone de pêche de Thio et sa densité est relativement élevée.

Recommandations pour Thio

- Des études complémentaires doivent être menées afin de comprendre pourquoi les vivaneaux (lutjanidés), les empereurs (lethrinidés) et les rougets (mullidés) sont relativement rares. Tant qu'aucune explication n'est trouvée, il faut adopter une stratégie de gestion des ressources halieutiques fondée sur le principe de précaution et limiter les prises de ces espèces. Le suivi de l'état de ces ressources permettra ensuite d'évaluer l'efficacité des mesures prises.

- Le développement de la pêche de poissons de récif en vue d'améliorer la sécurité alimentaire et financière des habitants de Thio pourra se poursuivre sur le récif intermédiaire et le tombant récifal externe, à condition que celui-ci s'accompagne de mesures de gestion des ressources marines et d'activités de suivi, afin de prévenir la surpêche.

- Compte tenu de la qualité de l'habitat sur le site de Thio, les aires marines protégées doivent être considérées comme un outil de gestion particulièrement important.

- Les stocks de trocas (*Trochus niloticus*) ne doivent plus être exploités jusqu'à ce que leur densité atteigne environ 500 individus par hectare dans les principales concentrations et que des coquilles de plus petite taille soient observées sur le récif.

- Il convient d'envisager des mesures de protection des trocas appartenant aux classes de taille supérieure (≥12 cm de diamètre), qui constituent de précieux géniteurs (pouvant pondre une quantité exceptionnelle d'œufs) et qui sont moins prisés sur le marché.

- D'autres activités de suivi doivent être menées autour des récifs intermédiaires les mieux protégés et dans les zones les plus exposées, afin d'évaluer la taille et l'état des stocks d'holothuries blanches à mamelles (*Holothuria fuscogilva*), espèce des eaux profondes à forte valeur commerciale, sur le site de Thio.

Résultats des travaux de terrain effectués à Luengoni

L'île de Lifou fait partie d'un groupe d'îles coralliennes surélevées, les Îles Loyauté, situé à l'est de la Grande Terre, près de la fosse des Nouvelles-Hébrides. Les sites PROCFish/C de cette île, Luengoni et Joj (tous deux désignés par « Luengoni » aux fins du présent rapport), font partie du district de Lössi et se situent sur la côté est de Lifou, par 21° 02′ 20″ de latitude sud et 167° 25′ 34″ de longitude est. La zone de pêche se trouve entre le Cap des Pins au sud et le site appelé « Hutr », au nord. Elle est divisée en deux petits lagons, qui s'étendent sur environ 1,5 kilomètre de long et 800 mètres de large. Il est difficile de caractériser les habitats sur ce site, notamment en raison de l'étroitesse du système récifal. Les récifs côtiers font office de tombant récifal externe et les récifs intermédiaires peuvent être considérés comme des arrière-récifs. Dans ce pseudo-lagon, la pêche est pratiquée à des fins commerciales et de subsistance. La ciguatera est largement répandue chez bon nombre d'espèces. Le secteur est considéré comme exclusif et ne comprend aucune zone taboue.

Enquêtes socioéconomiques : Luengoni

À Luengoni, la pêche n'est pas la première source de revenus. Les salaires, les petites entreprises, les pensions de retraite et les autres prestations sociales génèrent davantage de revenus. Pourtant, les habitants de Luengoni consomment souvent du poisson frais et des invertébrés, et presque toutes les familles comptent un membre qui pêche pour sa propre consommation ou pour le plaisir. Les produits de la pêche ne sont presque jamais commercialisés au sein de la tribu de Luengoni, les ventes se faisant la plupart du temps sur les marchés extérieurs. La consommation de poisson frais (environ 36 kg par personne et par an) est à peu près égale à la moyenne régionale et figure parmi les plus élevées de tous les sites PROCFish/C étudiés en Nouvelle-Calédonie. La consommation d'invertébrés est extrêmement faible (5,5 kg par personne et par an).

La plupart des pêcheurs sont des hommes, qui capturent exclusivement des poissons, les femmes étant peu nombreuses à pratiquer une quelconque forme de pêche. Les hommes pêchent surtout dans le lagon et parfois sur le récif côtier protégé. Diverses techniques de pêche sont employées, les plus répandues étant la pêche au filet maillant, la pêche à la palangrotte, la pêche à l'épervier et la pêche au fusil-harpon. La collecte d'invertébrés est une activité marginale. La pêche à la langouste joue toutefois un rôle prépondérant, notamment en tant qu'activité rémunératrice.

Ressources en poissons : Luengoni

À Luengoni, l'état des ressources en poissons est identique à celui des autres sites d'étude de Nouvelle-Calédonie, voire légèrement meilleur pour ce qui concerne certaines familles. La biomasse est en revanche faible sur le tombant récifal externe. La taille moyenne des poissons est petite et la densité moyenne, peu élevée. La pêche au fusil-harpon de nuit pourrait bien être à l'origine de ce phénomène, qui se traduit surtout par un faible ratio des tailles chez les scaridés. Dans l'ensemble, les ressources en poissons de Luengoni sont dans un état moyennement bon à bon. L'habitat récifal semble plutôt riche (on observe une couverture corallienne vivante dense sur le tombant récifal externe) et favorable au développement des ressources en poissons. À Luengoni, les populations d'empereurs (lethrinidés) sont plus importantes que sur les autres sites, ce qui est en particulier dû à la présence d'un grand nombre de *Gnathodentex aureolineatus* (empereur strié) sur les arrière-récifs. Les autres carnivores sont en revanche rares. Les populations de mullidés sont relativement denses sur les arrière-récifs : on enregistre les plus fortes densités et abondances du pays, notamment pour le capucin de Vanicolo (*Mulloidichthys vanicolensis*).

Ressources en invertébrés : Luengoni

À Luengoni, les zones protégées dans les eaux peu profondes du lagon et sur le récif sont limitées et exposées aux influences océaniques et à la houle. Le seul récif frangeant exposé et les bancs situés au large ne conviennent pas à toute la variété d'espèces de bénitiers présentes en Nouvelle-Calédonie, puisque seuls trois espèces sont représentées (*Tridacna maxima*, *T. squamosa* et *Hippopus hippopus*). Si le bénitier allongé *T. maxima* présente la densité la plus élevée, on note que ses concentrations sont infimes. Les deux autres espèces présentes sur le site de Luengoni (*Hippopus hippopus* et *T. squamosa*) sont rares et leurs densités sont moins importantes que ce à quoi on aurait pu s'attendre. Bien que l'on observe toutes les classes de taille pour *T. maxima*, y compris des juvéniles de petite taille, ce qui indique que la ponte et le recrutement ont bien lieu, les bénitiers sont en général peu abondants et les spécimens de grande taille, rares. Il semble donc qu'à Luengoni, les stocks de bénitiers sont modérément affectés par la pêche.

L'habitat des trocas adultes (*Trochus niloticus*) est relativement étendu, mais ne convient pas parfaitement à ces gastéropodes brouteurs. Celui des jeunes trocas (arrière-récif couvert de débris) est quant à lui réduit et la nourriture manque dans ce système majoritairement exposé aux influences océaniques. Il semble que les juvéniles introduits dans cette zone en 1989 n'ont pas réussi à s'établir de façon à maintenir le stock en équilibre. *Tectus pyramis*, une espèce à faible valeur commerciale étroitement apparentée aux trocas, et l'huître perlière à lèvres noires (*Pinctada margaritifera*) sont également rares sur le site de Luengoni. Le burgau (*Turbo marmoratus*) est quant à lui totalement absent.

À Luengoni, on dénombre seulement sept espèces commerciales d'holothuries, ce qui est dû à la géographie du site et au niveau d'exposition des habitats. Les espèces commerciales sont bien réparties sur la zone étudiée : les espèces ayant une valeur commerciale moyenne ou élevée, comme l'holothurie léopard (*Bohadschia argus*) et l'holothurie noire à mamelles (*Holothuria nobilis*), sont relativement communes et soumises à une faible pression de pêche. Les densités d'holothuries noires à mamelles (*H. nobilis*) sont particulièrement élevées et rappellent celles enregistrées dans d'autres lieux où l'exploitation commerciale d'holothuries est réglementée. Malheureusement, la superficie de la zone de pêche de Luengoni est très limitée.

Recommandations pour Luengoni

- À l'avenir, le développement de la pêche de poissons devra s'accompagner de mesures de gestion des ressources marines, telles que la création d'aires marines protégées.

- Pour ce qui est des holothuries, les futurs plans en matière de pêche commerciale doivent reconnaître les limites « naturelles » des stocks de la zone (en raison des conditions environnementales défavorables) et prendre en compte le fait que la reconstitution des stocks risque de se faire plus lentement que d'habitude.

- Désormais, il est préférable d'introduire des trocas adultes, plutôt que des juvéniles. Les adultes pourront en effet être regroupés et protégés, de façon à ce que ceux-ci pondent et repeuplent les récifs en juvéniles.

Résultats des travaux de terrain effectués à Oundjo

Située sur la côté ouest de la Grande Terre, par 21° 02′ 30″ de latitude sud et 164° 41′ 47″ de longitude est, la tribu d'Oundjo est une communauté côtière bordée de mangroves. Sa zone de pêche, délimitée au nord par la passe de Gatope et au sud par la passe de Goyeta, s'étend sur 23 kilomètres de long et 4,5 kilomètres de large. Seul un territoire très mal défini, situé au nord, dans un rayon d'environ 7 kilomètres au large des côtes d'Oundjo, est considéré comme « exclusif », le secteur sud n'étant pas réservé à la tribu. Cette zone, partagée avec le clan Gatope, comprend un lieu tabou, le « trou bleu », qui se situe sur le récif-barrière, par 21° 03′ 12″ de latitude sud et 164° 41′ 47″ de longitude est. Le lagon est très peu profond et en grande partie sablonneux. À cet endroit, les rivières déposent durant la saison des pluies des quantités de sédiments terrigènes bien supérieures à celles observées ailleurs. Les pêcheurs d'Oundjo exploitent les ressources du lagon et des mangroves à des fins commerciales et de subsistance.

Enquêtes socioéconomiques : Oundjo

La pêche est la principale source de revenus des habitants d'Oundjo, même si les salaires, les petites entreprises, les pensions de retraite et les autres prestations sociales figurent également en bonne place. Tous les ménages mangent régulièrement du poisson frais et des invertébrés. La consommation de poisson frais (environ 34 kg par personne et par an) est proche de la moyenne régionale et l'une des plus élevées des cinq sites PROCFish étudiés en Nouvelle-Calédonie. La consommation d'invertébrés (46 kg par personne et par an) est extrêmement élevée et dépasse de 35 pour cent celle de poisson frais.

La majorité des hommes pêchent exclusivement du poisson, alors que la plupart des femmes collectent des invertébrés. Les poissons sont en grande partie capturés sur les récifs côtiers protégés, dans les eaux du lagon et, dans une moindre mesure, sur le tombant récifal externe. Les invertébrés sont pour la plupart collectés à des fins commerciales. On les prélève surtout dans les mangroves et sur les platiers récifaux. Les hommes collectent également des holothuries, des langoustes et des trocas dans l'optique de les vendre. Divers engins sont utilisés pour prendre le poisson : éperviers, filets maillants, palangrottes et fusils à harpon. La collecte d'invertébrés se fait quant à elle à l'aide de simples outils, mais nécessite parfois un bateau à moteur pour rejoindre certaines zones de pêche.

La tribu d'Oundjo est l'une des principales sources d'approvisionnement en poisson pour les marchands du Grand Nouméa. La pêche génère donc l'essentiel des revenus. Étant donné que l'éventail des activités pouvant constituer une source de revenus pour les habitants d'Oundjo est limité, on peut penser que la pêche continuera de jouer un rôle majeur dans les années à venir. En fonction des coûts liés au transport et à la commercialisation des produits, et de la demande sur le marché nouméen, il est possible que la pression de pêche qui s'exerce sur certaines espèces, à savoir les crabes de palétuviers, les langoustes, les trocas et certaines espèces de poissons, s'intensifie avec le temps. Si la zone de pêche d'Oundjo est vaste, les stocks de ces espèces très prisées à certaines époques de l'année devront peut-être faire l'objet d'un suivi à l'avenir.

Ressources en poissons : Oundjo

À Oundjo, l'état des ressources en poissons est bien moins bon que la moyenne calculée pour les cinq sites d'étude de Nouvelle-Calédonie et les stocks sont relativement surexploités. L'habitat récifal semble assez riche, mais la biomasse et l'abondance des poissons sont relativement faibles. Une évaluation détaillée à l'échelle du récif a également révélé une abondance des poissons de toutes les familles systématiquement inférieure à la moyenne, excepté pour les acanthuridés et les scaridés présents sur le tombant récifal externe (environnement le plus riche du site) et les arrière-récifs, et les chaetodontidés qui, sur les récifs côtiers et intermédiaires, et le tombant récifal externe, affichent les valeurs les plus élevées de tous les sites. Les premiers résultats des travaux menés et l'absence de carnivores donnent à penser que cette tendance est probablement due à une pêche intense. Seuls les récifs côtiers abritent une quantité relativement importante de vivaneaux, alors que dans les autres habitats, les densités de vivaneaux (lutjanidés) et d'empereurs (lethrinidés) sont systématiquement inférieures à la moyenne régionale. Le développement de la pêche de poissons de récif en vue d'améliorer la sécurité alimentaire et financière des habitants d'Oundjo ne peut se poursuivre en l'état actuel des choses. Bien qu'il existe une zone traditionnellement considérée comme taboue dans la région, la pression de pêche exercée sur les ressources engendre un déséquilibre, lequel souligne les limites des mesures de gestion traditionnelles.

Ressources en invertébrés : Oundjo

Le site d'Oundjo abrite toute une variété d'espèces de bénitiers, dont certaines sont en voie de disparition dans d'autres régions du Pacifique. Les eaux peu profondes du lagon conviennent très bien au bénitier allongé (*Tridacna maxima*) et les zones côtières, à *Hippopus hippopus*, qui est relativement commun à Oundjo, comparativement aux autres sites PROCFish de Nouvelle-Calédonie. Sur ce site, la densité de bénitiers *T. maxima* est relativement élevée. Pour la plupart des autres groupes d'espèces, toutes les classes de taille sont représentées, ce qui confirme l'hypothèse selon laquelle les stocks de bénitiers ne sont que très légèrement affectés par la pêche. Les plus grands bénitiers (*T. derasa* et *T. squamosa*) sont toutefois relativement peu abondants. Ces dernières espèces sont en général les premières à se raréfier du fait de la pression de pêche et sont déjà en voie de disparition sur le site d'Oundjo.

Le troca (*Trochus niloticus*) est, au même titre que d'autres gastéropodes brouteurs (tels que *Tectus pyramis*), relativement commun sur le site d'Oundjo. Les densités des concentrations étudiées sont actuellement inférieures au minimum recommandé pour la pêche commerciale. On note la présence d'individus de petite taille (mesurant moins de 8 cm de diamètre), ce qui laisse présager une future croissance du stock. Si l'huître perlière à lèvres noires (*Pinctada margaritifera*) est relativement commune à Oundjo, sa densité est trop insuffisante pour encourager la pêche de cette espèce à des fins commerciales. Les gisements de coquillages d'Oundjo sont plus riches dans les zones éloignées des côtes, où les arches (*Anadara* spp.) sont relativement abondantes. Des spécimens de toutes les tailles sont présents, ce qui tend à indiquer que la pression de pêche qui s'exerce sur les gisements de coquillages situés à une certaine distance des côtes est faible.

La grande diversité des espèces d'holothuries et les données relatives à leur présence et à leur densité, recueillies dans le cadre de l'enquête, donnent à penser que la pression qui s'exerce sur les stocks, du fait de l'exploitation commerciale, est modérée et que les mesures de gestion des ressources appliquées sont efficaces. L'holothurie de sable (*Holothuria scabra*), espèce à forte valeur commerciale, est présente dans deux endroits, en quantité raisonnable.

Recommandations pour Oundjo

- Il convient de mener des études complémentaires afin de déterminer pourquoi les vivaneaux (lutjanidés) et les empereurs (lethrinidés) sont relativement rares. Tant qu'aucune explication n'est trouvée, il faut adopter une stratégie de gestion des pêches fondée sur le principe de précaution et limiter les prises de ces espèces, dont l'abondance est systématiquement inférieure à la moyenne régionale, excepté sur les récifs côtiers. Le suivi rigoureux de l'état de ces ressources permettra ensuite d'évaluer l'efficacité des mesures prises.

- Compte tenu de l'état actuel des ressources, le développement de la pêche de poissons de récif en vue d'améliorer la sécurité alimentaire et financière des habitants d'Oundjo ne doit pas se poursuivre.

- Des mesures de gestion des ressources marines et des activités de suivi doivent être envisagées et mises en œuvre afin de protéger les poissons restants.

- L'exploitation des stocks de trocas (*Trochus niloticus*) d'Oundjo doit cesser jusqu'à ce que leur densité atteigne environ 500 individus par hectare dans les principales concentrations, seuil au-delà duquel la pêche commerciale pourra de nouveau être envisagée.

- Il convient d'envisager des mesures de protection des trocas appartenant aux classes de taille supérieure (≥12 cm de diamètre), qui constituent de précieux géniteurs et qui sont moins prisés sur le marché.

- D'autres études doivent être conduites pour déterminer dans quelle mesure les stocks d'holothuries blanches à mamelles (*Holothuria fuscogilva*) et d'autres espèces des eaux profondes peuvent être exploités. Les activités devraient se concentrer le long de la passe nord et des deux passes sud.

Résultats des travaux de terrain effectués à Moindou

La commune de Moindou se situe sur la côte ouest de la Grande Terre, par 21° 41´ 31″ de latitude sud et 165° 40´ 38″ de longitude est. Elle se trouve à l'intérieur des terres, à proximité des mangroves. La zone de pêche s'étend de la passe de Ouaraï, au sud, au point de latitude 21° 41' sud et de longitude 165° 30´ est, au nord, sur 25 kilomètres de long et 7 kilomètres de large. Cette zone est libre d'accès et fait l'objet d'une pêche commerciale, récréative et de subsistance intensive. Le secteur de Moindou se caractérise par de larges zones peu profondes aux fonds sablonneux et de vastes étendues d'herbiers. Les habitats côtiers sont difficiles à explorer à l'aide d'équipements de plongée, en raison de la forte turbidité de l'eau. Si la mangrove occupe de vastes zones, son exploitation pose des problèmes en matière de gestion des stocks de crabes de palétuviers. Il n'existe aucune réserve, ni aucune zone taboue sur ce site.

Enquêtes socioéconomiques : Moindou

Les salaires et les petites entreprises constituent la première source de revenus des habitants de la commune. Seuls 30 pour cent des ménages tirent des revenus de la pêche, mais cette activité ne représente qu'une source de revenus secondaire pour la plupart d'entre eux (17,5 %). Cependant, toutes les familles mangent du poisson frais et des invertébrés. La consommation de poisson frais (33 kg par personne et par an) est comparable à la moyenne régionale et l'une des plus élevées des cinq sites PROCFish de Nouvelle-Calédonie. La consommation d'invertébrés (23,5 kg par personne et par an) est moyenne, par rapport aux autres sites étudiés dans ce pays. Le niveau moyen des dépenses des ménages est quant à lui bien supérieur à la moyenne nationale et aucun transfert de fonds n'est reçu, ce qui semble indiquer que les habitants de Moindou ont un mode de vie assez urbain.

La majorité des pêcheurs ciblent aussi bien les poissons que les invertébrés. Quelques hommes pêchent exclusivement du poisson et près de la moitié des femmes se consacrent uniquement à la collecte d'invertébrés. La plupart des pêcheurs sont des hommes, lesquels sont à l'origine de la majeure partie des retombées observées. L'essentiel des prises sont réalisées sur les récifs côtiers protégés, dans le lagon et, dans une moindre mesure, sur le tombant récifal externe. C'est également dans ces zones que l'impact de la pêche est le plus visible. La collecte d'invertébrés se fait principalement dans les mangroves et beaucoup moins sur le platier récifal et les fonds meubles. Divers engins sont utilisés pour prendre le poisson : filets maillants, éperviers, palangrottes et fusils à harpon. La collecte d'invertébrés ne nécessite que des outils très simples. Les crabes de palétuviers sont pêchés à la main, à l'aide de bâtons ou de barres de fer, ou de nasses appâtées. Le nombre de pêcheurs n'appartenant pas à la commune est une source de préoccupation pour la communauté, les services des pêches et d'autres autorités administratives.

Ressources en poissons : Moindou

L'état des ressources en poissons de Moindou est comparable à la moyenne des sites d'étude de Nouvelle-Calédonie, voire légèrement moins bon. L'habitat récifal semble néanmoins assez riche et l'écosystème, qui abrite les ressources en poissons, plutôt sain. Les valeurs relatives aux populations de lutjanidés, lethrinidés et mullidés figurent parmi les plus basses du pays et sont comparables à celles relevées sur les sites de Ouassé, Thio et Oundjo. Cette faible abondance est sans doute due à l'absence d'habitats favorables à ces carnivores (qui préfèrent les fonds meubles). La biomasse est comparable à celle des sites de Luengoni et d'Oundjo, tandis que la densité est proche des moyennes relevées à Oundjo et à Thio. Les récifs de Moindou présentent les plus faibles densités d'acanthuridés, de siganidés et de labridés. La densité et la biomasse des lutjanidés, des lethrinidés et des mullidés sont également faibles dans cette zone. On enregistre en revanche les plus fortes valeurs d'abondance de scaridés (en raison de la densité élevée des petits perroquets sur les récifs intermédiaires). Les populations de siganidés (picots) comptent parmi les moins denses, en particulier sur les arrière-récifs côtiers et le tombant récifal externe, ce qui est sans doute dû à la forte consommation de picots, et notamment de ceux pêchés sur les récifs côtiers. La pression de pêche se traduit peut-être déjà par une diminution de la population de poissons et l'absence de poissons de grande taille, en particulier chez certaines familles de carnivores, est le résultat d'une pêche intensive.

Ressources en invertébrés : Moindou

À Moindou, l'habitat récifal offre de vastes zones refuges, suffisamment profondes et hydrodynamiques pour que toutes les espèces de bénitiers, y compris les plus grandes espèces que sont *T. derasa* et *T. squamosa*, s'y développent. Globalement, les densités relevées et les classes de taille observées tendent à indiquer que la pression de pêche exercée sur les stocks de bénitiers est moins importante que sur les autres sites de Nouvelle-Calédonie. Bien qu'aucun spécimen de *Tridacna crocea* ne soit observé, il est possible que cette espèce soit présente sur les récifs côtiers. On ne trouve aucun *T. gigas* sur le site, cette espèce n'étant généralement pas présente dans les eaux qui bordent la Grande Terre néo-calédonienne. On note la présence de *T. maxima* et du grand bénitier *T. derasa* sur le « pseudo » récif-barrière et les arrière-récifs, leurs populations étant relativement denses. *Hippopus hippopus* est assez commun, en comparaison avec les autres sites PROCFish de Nouvelle-Calédonie, ce qui est une indication encourageante quant à l'état de ce stock. Dans l'ensemble, les plus grandes espèces *T. derasa* et *T. squamosa* sont cependant peu abondantes. Par ailleurs, les résultats de l'enquête donnent à penser que ces bénitiers sont soumis à une forte pression de pêche. La chair de *T. derasa* et *T. squamosa* est en effet encore souvent commercialisée sur le principal marché aux poissons de Nouméa.

Le troca (*Trochus niloticus*) est, au même titre que d'autres gastéropodes brouteurs (tels que *Tectus pyramis*), relativement commun sur le site de Moindou. À l'heure actuelle, les densités des concentrations étudiées sont telles que la pêche commerciale n'est pas recommandée. Même si les densités relevées sur certaines stations dépassent la barre des 500-600 individus par hectare, elles restent limitées à un petit nombre de stations, situées dans des zones difficiles d'accès et se trouvant au-delà du récif-barrière. On note la présence de trocas de toutes les tailles (y compris de coquilles mesurant moins de 8 cm de diamètre), ce qui indique que le recrutement a toujours lieu. On peut donc s'attendre à ce que le stock grandisse dans le futur. Si l'huître perlière à lèvres noires (*Pinctada margaritifera*) et le turbo bouche-d'argent (*Turbo argyrostomus*) sont relativement communs à Moindou, leur nombre est trop insuffisant pour encourager la pêche de ces espèces à des fins commerciales.

Moindou présente une grande diversité de milieux favorables aux holothuries. L'éventail des espèces d'holothuries observées sur ce site est large, ce qui est en partie dû à la richesse du milieu, mais aussi au fait que l'exportation des produits de la pêche est réglementée. Les données relatives à la présence et à la densité des espèces commerciales donnent à penser que la pression exercée sur ces stocks est modérée à forte. La présence d'un nombre raisonnable d'holothuries noires à mamelles (*Holothuria nobilis*) semble indiquer que la pêche est aujourd'hui moins intense, même si bon nombre d'espèces ne sont observées qu'en quantité moyenne. L'holothurie de sable (*H. scabra*), espèce à forte valeur commerciale, est présente sur le site, mais elle est peu abondante, en dépit des valeurs particulièrement élevées qui ont été enregistrées les années précédentes. On trouve des holothuries blanches à mamelles (*Holothuria fuscogilva*) dans les eaux profondes, en quantité raisonnable.

Recommandations pour Moindou

- Il convient de prendre des mesures de gestion et de suivi des ressources en crabes de palétuviers et de réglementer les pratiques de pêche, notamment en fixant des limites quantitatives pour les prises annuelles, en interdisant certaines méthodes de capture et en fixant le nombre de pêcheurs n'appartenant pas à la commune autorisés à capturer des crabes de palétuviers dans la zone de pêche de Moindou.

- Des études complémentaires doivent être menées afin de déterminer s'il existe un lien entre la relative rareté des vivaneaux (lutjanidés), des empereurs (lethrinidés) et des rougets (mullidés), et les pratiques de pêche. Tant qu'aucune explication n'est trouvée, il faut adopter une stratégie de gestion des pêches fondée sur le principe de précaution et limiter les captures de ces trois espèces. Le suivi de l'état de ces ressources permettra ensuite d'évaluer l'efficacité des mesures prises.

- Le développement de la pêche de poissons de récif en vue d'améliorer la sécurité alimentaire et financière des habitants de Moindou doit être géré de manière prudente et s'accompagner de d'activités de suivi. Compte tenu de la qualité de l'habitat sur le site de Moindou, les aires marines protégées peuvent être considérées comme un outil de gestion particulièrement important.

- La collecte des trocas (*Trochus niloticus*) à des fins commerciales ne doit pas débuter avant que leur densité n'atteigne les 500 individus par hectare dans toutes les principales concentrations. Il convient de protéger les trocas de taille supérieure ou égale à 12 centimètres de diamètre, qui constituent de précieux géniteurs et qui sont moins prisés sur le marché.

- Des mesures de protection doivent être prises de manière à permettre la reconstitution des stocks d'holothuries de sable (*Holothuria scabra*), étant donné que l'habitat semble favorable au développement des ces espèces à forte valeur commerciale.

- D’autres études doivent être effectuées afin d’évaluer l’état du stock d’holothuries blanches à mamelles (*Holothuria fuscogilva*) et de déterminer dans quelle mesure celui-ci peut être exploité à des fins commerciales.

ACRONYMS

ACP	African, Caribbean and Pacific Group of States
AIMS	Australian Institute of Marine Science
BdM	bêche-de-mer (or sea cucumber)
B-S	broad scale
CoFish	Pacific Regional Coastal Fisheries Development Programme
COTS	crown of thorns starfish
CPUE	catch per unit effort
Ds	day search
D-UVC	distance-sampling underwater visual census
EDF	European Development Fund
EEZ	exclusive economic zone
EU/EC	European Union/European Commission
FADIL	Fond d'Aide au Développement des Îles
FAO	Food and Agricultural Organization (UN)
FL	fork length
GDP	gross domestic product
GFA	Groupement des Fermes Aquacoles
GPS	global positioning system
ha	hectare
HH	household
IFREMER	Institut Français de Recherche et d'Exploitation de la Mer
IHHN	Infectious Hypodermal and Hematopoietic Necrosis Virus
IRD	Institut de Recherche pour la Développement
JAMARC	Japan Marine Fisheries Resources Research Center
LERVEM	Laboratoire d'Etudes des Ressources Vivantes et de l'Environnement Marin
MCRMP	Millennium Coral Reef Mapping Project
MIRAB	Migration, Remittances, Aid and Bureaucracy (model explaining the economies of small island nations)
MOP	mother-of-pearl
MOPs	mother-of-pearl search
MOPt	mother-of-pearl transect
MSA	medium-scale approach
NASA	National Aeronautics and Space Administration (USA)
NCA	nongeniculate coralline algae
Ns	night search
OCT	Overseas Countries and Territories
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre-Mer
PICTs	Pacific Island countries and territories

PROCFish	Pacific Regional Oceanic and Coastal Fisheries Development Programme
PROCFish/C	Pacific Regional Oceanic and Coastal Fisheries Development Programme (coastal component)
RBt	reef-benthos transect
RFID	Reef Fisheries Integrated Database
RFs	reef-front search
RFs_w	reef-front search: walking
SBt	soft-benthos transect
SBq	soft-benthos quadrat
SCUBA	self-contained underwater breathing apparatus
SE	standard error
SMMPM	Service de la marine marchande et des pêches maritimes
SODACAL	Société d'Aquaculture Calédonienne
SOPAC	Pacific Islands Applied Geoscience Commission
SPC	Secretariat of the Pacific Community
UNC	Université de Nouvelle-Calédonie
USD	United States dollar(s)
WHO	World Health Organization
XPF	Pacific French franc(s)

1. INTRODUCTION AND BACKGROUND

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

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

1.1 The PROCFish and CoFish programmes

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

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

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

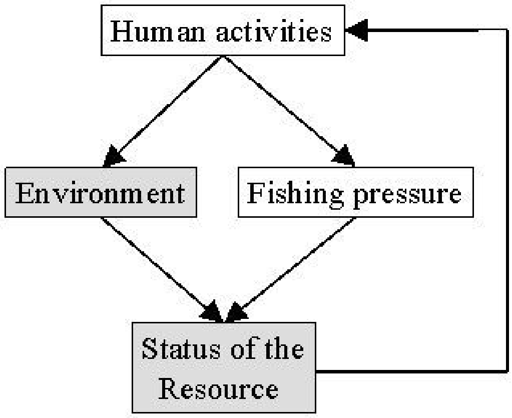

Figure 1.1: Synopsis of the PROCFish/C* multidisciplinary approach.
PROCFish/C conducts coastal fisheries assessment through simultaneous collection of data on the three major components of fishery systems: people, the environment and the resource. This multidisciplinary information should provide the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

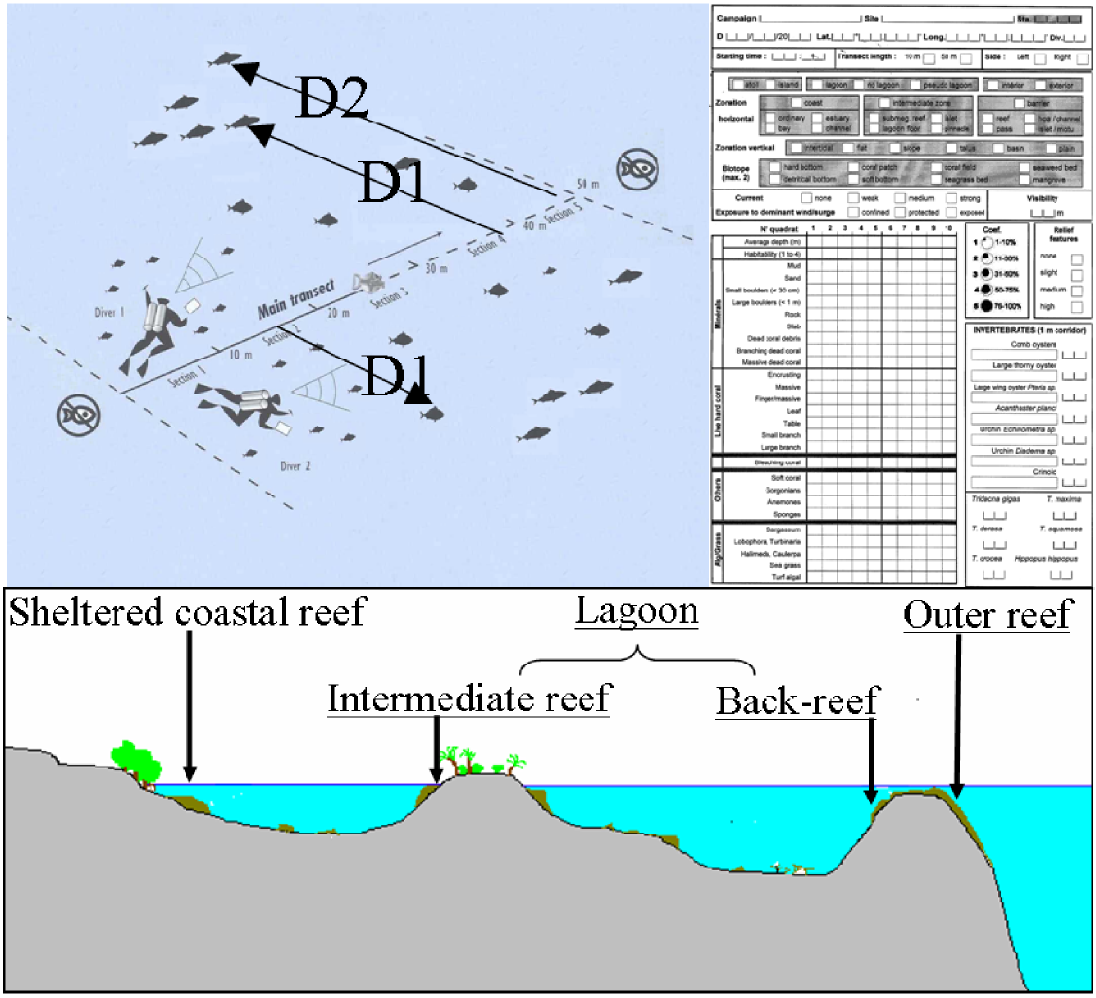

Figure 1.2: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver recorded the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys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

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, 4 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 Figure 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.

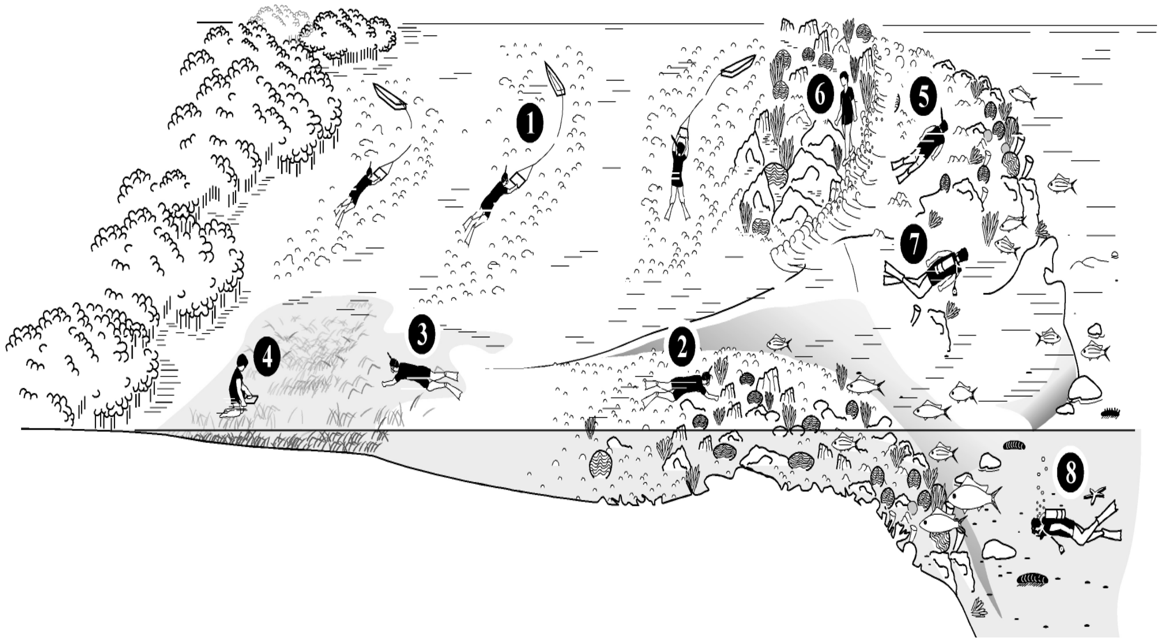

Figure 1.3: Assessment of invertebrate resources and associated environments.
Techniques used include: broad-scale assessments to record large sedentary invertebrates (1); fine-scale assessments to record epi-benthic resources and potential indicator species (2) and (3); quadrats to count targeted infaunal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

1.3.1 General

New Caledonia (Figure 1.4) is made up of a main island, 'La Grande Terre', and many small islands and islets within its lagoon: the Belep archipelago to the north of the Grande Terre, the Loyalty Islands (Ouvea, Lifou, Mare and Tiga) to the east of the Grande Terre, Île des Pins to the south of La Grande Terre, and the Chesterfield Islands and Bellona Reefs further to the west (Chapman 2004, Wikipedia 2008) bounded between 15° and 25°S latitude, and 156° and 170°E longitude. The total land area is 18,575 km² (Turner 2008), while New Caledonia's exclusive economic zone (EEZ) is ~1740,000 km². The country lies 1200 km east of Australia and 1500 km northwest of New Zealand (Wikipedia 2008). New Caledonia shares maritime boundaries with Australia to the west, Norfolk Island to the south, Solomon Islands to the north, and Vanuatu to the northeast. The ownership of the islands of Matthew and Hunter (to the east) and the waters around them are disputed between the Republic of Vanuatu and France (New Caledonia) (Chapman 2004).

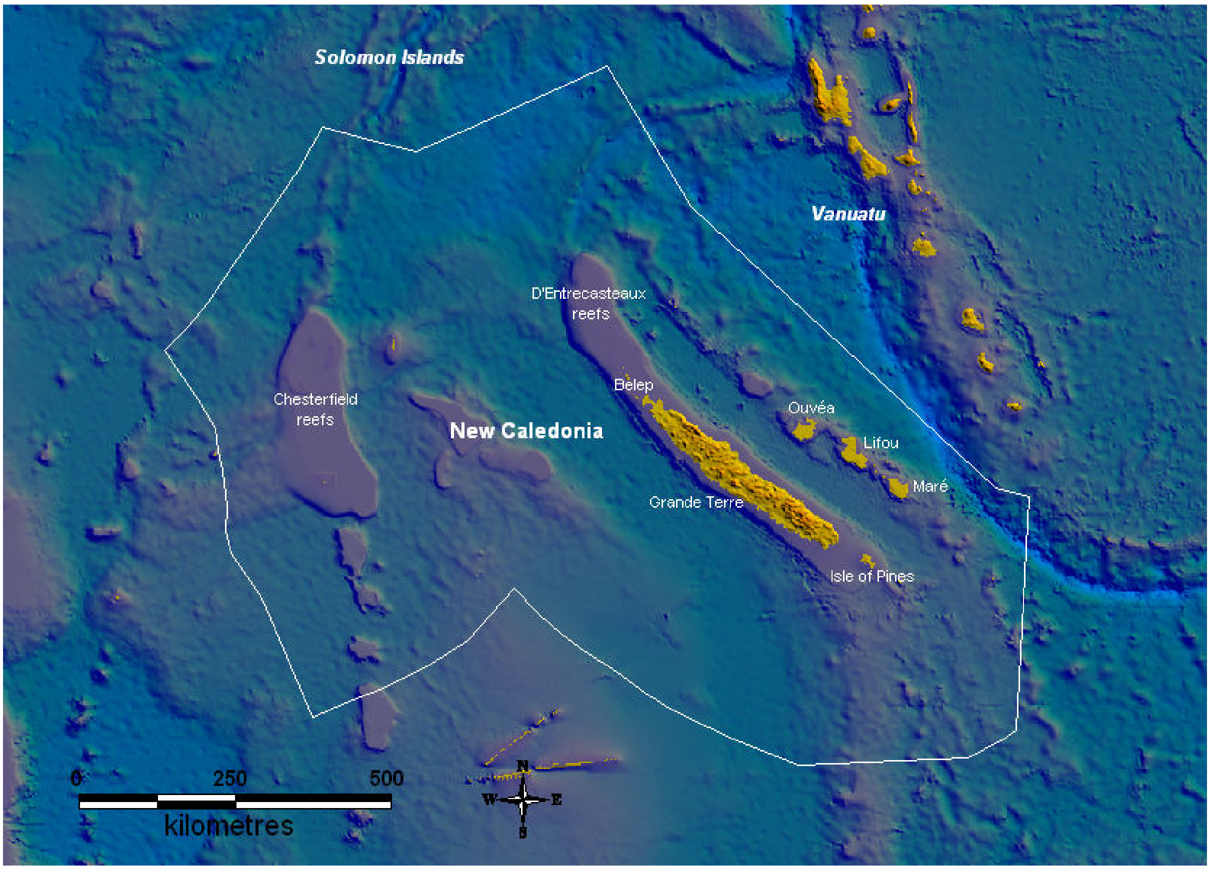

Figure 1.4: Map of New Caledonia.

The geology of La Grande Terre includes ancient volcanic tuffs and younger conglomerates, sandstones and shales. Large masses of igneous rocks are the origin of extensive nickel deposits. Structurally, the mainland is a narrowly compressed, strongly eroded mountain range. The Loyalty Islands are uplifted coral atolls (Anon. 1986). The country has the second-largest coral reef in the world (Turner 2008). A barrier reef ~1600 km long encloses a lagoon of variable width and depth (Fusimalohi and Grandperrin 1979).

Although New Caledonia lies within the tropical belt, the climate is relatively cool because of the southeast trade winds. Tropical cyclones occur between November and April. The average annual rainfall on the east coast is 2300 mm and on the west coast 1100 mm. There is a marked wet season from December to March and a dry season from September to November. Annual temperatures range from a low of 14.6°C to a high of 33.8°C with an average of 23.2°C (Turner 2008).

The 2004 population census results show a population of 230,789 and a density of 12.4 persons/km^2 (ISEE 2008). The 2004 population distribution was as follows: 205,939 in Grand Terre, 22,080 in the Loyalty Islands, 1840 in the Isle of Pines, and 930 people in the Belep Archipelago (Turner 2008). The annual estimated growth rate for 2008–2010 is 1.6 (SPC Statistics and Demography Programme 2008).

New Caledonia is an overseas territory of France. Settled by both Britain and France during the first half of the 19th century, the island was made a French possession in 1853. In 1998, the Nouméa Accord was signed to transfer an increasing amount of governing responsibility from France to New Caledonia over a period of 15–20 years. The agreement also commits

France to conduct as many as three referenda between 2013 and 2018 to decide whether New Caledonia should assume full sovereignty and independence (CIA 2008).

The soils in New Caledonia contain a considerable wealth of industrially-critical elements and minerals, including about one-quarter of the world's nickel resources. Mining is, therefore, a significant industry that greatly benefits the territory's economy (Wikipedia 2008). The natural resources of New Caledonia are nickel, chrome, iron, cobalt, manganese, silver, gold, lead, and copper. Agriculture and fisheries products are vegetables, beef, deer, other livestock products, and fish. Industries are nickel mining and smelting. In 2003, the Gross Domestic Product (GDP) was made up of services (76.2%), agriculture (15%), and industry (8.8%). In terms of the labour force: in 2002, 60% were used in services, 20% in industry, and 20% in agriculture. In 2007, exports from New Caledonia amounted to USD 2.11 billion, 96.3% of which were mineral products and alloys (essentially nickel ore and ferronickel). Export partners were Japan (20.1%), Mainland China (14.5%), ROC/Taiwan (13.3%), France (11.5%), Belgium (10.3%), Spain (8.6%), and South Africa (6.9%). Imports amounted to USD 2.88 billion. The goods imported were machinery and equipment, fuels, chemicals, and foodstuffs. Approximately 26.6% of imports came from Metropolitan France, 16.1% from other European countries, 13.6% from Singapore (essentially fuel), 10.7% from Australia, 4.0% from New Zealand, 3.2% from the United States, 3.0% from Japan, and 22.7% from other countries (CIA 2008, Wikipedia 2008).

1.3.2 The fisheries sector

In New Caledonia, marine products from commercial fisheries and aquaculture accounted for an overall volume of 5500 t in 2005. Production has been steadily increasing since 2000, with a mean annual growth rate of 5% on reported tonnage. Some 58% of this production (3200 t) was destined for export (SMMPM 2007).

This positive trend must, however, be tempered depending on the sector of activity. Aquaculture is the main reason behind this healthy overall situation with production levels that increased by 43% from 2000 (1755 t) to 2005 (2524 t). Longline fisheries increased by 30% from 2000 (1905 t) to 2005 (2473 t) (SMMPM 2007) but remained unchanged between 2003 and 2005 (the most recent statistics available). Finally, the reef/lagoon sector dropped spectacularly by 43% over the same time period (SMMPM 2007).

Offshore tuna fishery

The first data available for oceanic fisheries in the waters around New Caledonia that now forms its EEZ came from scientific campaigns (Angot *et al.* 1957). Between 1957 and 1974, 17 campaigns were carried out by the Office de la Recherche Scientifique et Technique Outre-Mer (ORSTOM) (Angot *et al*. 1958, Anon. 1974). The Japan Marine Fisheries Resources Research Center (JAMARC) also conducted pole-and-line and baitfishing trials around New Caledonia in the early 1970s with positive results (SPC 1985). Japanese pole-and-line vessels started fishing around New Caledonia in 1974, with catches varying among years, with the largest catch being 3236 t in the 1979–1980 season (Skipjack Programme 1980). SPC's Skipjack Survey and Assessment Programme conducted a tuna-tagging cruise around New Caledonia in December 1977 and January 1978, with 10,194 skipjack and 56 yellowfin tuna tagged and released (Kearney and Hallier 1978, SPC 1985). In 1981, a locally based company, the Transpêche Company, started pole-and-line operations. However, catches between 1981 and 1983 were insufficient to make this operation viable, and it closed

(SPC 1985). Also, between 1979 and 1982, ORSTOM conducted a large-scale tuna prospecting and airborne radiometry programme (Marsac *et al*. 1985).

The Japanese were the first to engage in industrial longline fishing in the waters of New Caledonia; their first data were recorded in 1962 (Virly 1996). The Taiwanese and Koreans began fishing in the zone at a later date; their first available data come from 1967 and 1975, respectively. New Caledonia entered the tuna longline fishery in the early 1980s, preferring the zones located in the southeastern part of the EEZ or off the west coast of New Caledonia as well as east and northeast of the Chesterfield Islands. The Japanese concentrated their efforts on the region of the Chesterfield Islands and south of the main island of New Caledonia (Virly 1996). From 1962 to 1983, catches fluctuated between 2600 and 11,000 t/year. Between 1983 (when the first New Caledonia longliners arrived) and 1986, longline catches fluctuated between 210 and 598 t/year with a mean of 455 t/year. The longline fishery stabilised at about 2000 t/year until 1999, with a maximum of 3526 mt in 1999 (SMMPM 1988a, 1990, 1992, 1994, 1996, 1998, 2000). As many as 40 Japanese longliners fished in the New Caledonian EEZ until 1992, when no access agreement was signed and Japanese fishing in these waters ceased (Beverly and Chapman 1997).

The domestic tuna longline fleet has struggled to maintain viability in the 1990s and 2000s. In 1996, the SPC was requested to provide technical assistance to the local longline company, Navimon, as the catch rates were low and the quality of the fish was not up to export standards. Improvements were made during the four fishing trips (Beverly and Chapman 1997). During the 2000s, vessel numbers have slowly dropped from 29 in 2003, to 27 in 2005, and 24 in 2006, with only 21 vessels being active in 2006 (Anon. 2007). Catches also declined in line with vessel numbers, with 2466 t landed in 2003, and an estimated 2108 t in 2006 (Anon. 2007).

Small-scale tuna fishery including fishing around FADs

Traditionally, most local fishing activity in New Caledonia has focused on reef and lagoon species, with little interest in pelagic resources (SPC 1985). In the 1960s several fishers used Tahitian-style pole-troll boats (bonitiers) to fish for skipjack out of Nouméa and the southwest coast. By the early 1980s there were only two vessels still fishing part of the year (Chapman 2004, SPC 1985).

The first FADs were deployed in 1984 by the Transpêche Company for their pole-and-line fishing operations. However, two were lost after eight months and the other was retrieved by the fisheries department and re-deployed off Nouméa in 1985 (Chapman 2004). Also beginning in 1985, several trolling campaigns were carried out by the fisheries department, with the best yields obtained in the northern part of New Caledonia and at Ouvéa (SMMPM 1988b, SPC 1992, SPC 1993). SPC was requested to provide technical assistance in 1985, both with trolling in both open water, around the FAD and along the outer reef edge, as well as experimenting with FAD-associated fishing methods (Chapman and Cusack 1998a). This work was followed up in 1986 with assistance provided to the fishers of Belep Island, with trolling techniques demonstrated as well as appropriate handling and preservation techniques for Spanish mackerel (*Scomberomorus commerson*) (Chapman and Cusack 1998b).

The fisheries department has maintained an active FAD programme during the 1990s and 2000s. These FADs are now fished heavily due to their distance offshore and the total distance from main ports, such as Nouméa. Some local operators troll around the FADs, from both diesel and outboard-powered craft ranging from 5 to 13 m in length (Chapman 2004). Recreational fishers also use the FADs on occasion; in 2000 there were seven charter vessels operating (Whitelaw 2001). Whitelaw (2001) also stated that there were over 500 private or recreational vessels capable of fishing outside the reef—the highest boat ownership per capita in the Pacific. In the early to mid 2000s, around 10 vessels were commercially trolling for tunas as part of their general fishing activities (Chapman 2004).

Between 1992 and 1993, SMMPM also conducted sailfish trial campaigns with quite encouraging yields (75 kg of marketable fish per 100 hooks) (SMMPM 1993).

Deep-water snapper fishing

The deep-water fishery covers the outer-reef slopes and underwater seamounts at depths of 100–1500 m towards the open ocean. These zones cover a surface area of some 224,000 km^2, i.e. 16% of the total surface area of New Caledonia's EEZ (Virly 1997). Deep-sea fishing in New Caledonia is still a limited activity compared to oceanic fishing for pelagic species. Between 2000 and 2005, it accounted for only 1% of fisheries production (SMMPM 2007).

Deep-water snapper fishing trials were first undertaken around New Caledonia in the late 1970s. ORSTOM conducted the first fishing trials using a trotline system, mainly fishing in 150–400 m depths, with encouraging catches of Eteline snappers (Fourmanoir 1979). This was followed by a request to SPC for technical assistance to provide training and conduct experimental fishing trials. Trial fishing and training was conducted in 1979 off Nouméa, Lifou in the Loyalty Islands, and Isle of Pines, with good results (Fusimalohi and Grandperrin 1979). SPC was requested to come back to conduct additional trials and training in 1981, with these conducted off Nouméa and at Doking, Lifou Island and Eni, Mare Island; however, the fishing was not as productive as the previous trip (Fusimalohi and Chapman 1999, Dalzell and Preston 1992).

Further deep-water snapper fishing trials were undertaken in 1985 at the request of the local fisheries department, with most training conducted in the Oundjo and Gatope region to the north of Nouméa (Chapman and Cusack 1998a). Also in 1985, a local commercial fisher undertook 'Z-trap' fishing trials for deep-water snappers to the south of Nouméa. 1390 trap sets were made, mainly in depths of 90–140 m, but some as deep as 400 m. Catches averaged 8.9 kg/trap/day, with a large by-catch of nautilus, especially from the deeper-set traps (Anon. 1985). Only artisanal coastal fisheries, which target the 100–500 m bathymetric zone using a variety of fishing gear (reels, bottom longlines, traps), have been done on a regular basis since 1984 (Virly 1997).

Other fishing trials using deep-water trawls and deep-water longlines were undertaken in the 1980s through ORSTOM and the local fisheries department. The first trawling research was undertaken in 1980 by the Japanese vessel *Kaimon Maru*, and the second in 1986 by ORSTOM (Grandperrin and de Forges 1988). The trawl depths were between 220 and 690 m, targeting deep-water snappers, with night trawls yielding higher catches. Alfonsins (*Beryx* spp.), eteline snappers and armorheads (*Pseudopentaceros* spp.) were the main species taken (Grandperrin and de Forges 1988). No trawling has been undertaken commercially in New Caledonian waters. The deep-water bottom longline sets yielded a catch rate of 18 kg/100 hooks, with 90% of the catch being *Etelis* spp. (Kulbicki and Grandperrin 1988). Further trap fishing trials were undertaken in the late 1980s, testing different trap designs, with low catch rates for the most part (Desurmont 1989). The entire seamount zone of Norfolk Ridge and the southern end of the Loyalty Island Ridge was explored from 1988 to 1991 at depths between 500 and 800 m, using longliners equipped with bottom longlines (Virly 1997).

During the late 1980s and early 1990s the landings of deep-water snappers was consistent at ~17 t/year (Virly 1997). The Loyalty Islands Province has encouraged fishers to exploit deep-water snappers, with most of the catch sold within the province. This trend has continued in the late 1990s and 2000s, but catches have stagnated as a result of competition and limited local markets (Anon. 2001). The high value of these species on the local market (as a species not affected by ciguatera) limits their export potential. In the early 2000s, there were 8–10 full-time vessels targeting deep-water snappers, with another 10 vessels fishing infrequently for these species (Chapman 2004).

Deep-water shrimp trials

Experimental fishing trials for deep-water shrimp and other crustaceans were undertaken by ORSTOM in the late 1970s using three types of pots or traps. The trials were conducted in depths from 200 to 1000 m, although catch rates were generally low (Intes 1978). Several species of deep-water shrimp were taken, with the endemic species of nautilus (*Nautilus macromphalus*) captured in appreciable numbers of up to 26 per pot, with these catches taken mainly around the 400 m depth range (Intes 1978).

Aquaculture and mariculture

In New Caledonia, aquaculture is mainly based on shrimps, even though operations did diversify after 1999 with two new productions, i.e. oyster and crayfish farming (10 t of crayfish were marketed in 2004). Shrimp farming, which has gradually expanded, today holds second place in New Caledonian exports – far behind nickel – and is the leading agricultural export (IOEM 2004). Its rapid growth should continue given its importance in terms of creating jobs and wealth in rural areas. During the 2005/2006 season, the sector had 17 active farms. During the 2004/2005 season, it generated a global turnover estimated at XPF 2.7 billion when sales destined for both export markets (75%) and the New Caledonian market (25%) are counted (SMMPM 2007).

Today, the aquaculture sector accounts for less than 1% of GDP and has about 300 salaried employees but also provides work for another 1000 people. Organised around the Aquacultural Farm Group (Groupement des Fermes Aquacoles (GFA)), the sector includes feed suppliers, hatcheries to produce post-larvae, grow-out farms and two pack houses inaugurated in 2005. IFREMER (Institut Francais de Recherché Pour L'Exploitation de La Mer) has also provided scientific and technical support as part of a series of partnerships with the French and local governments.

Shrimps

From 1970 to 1973, a UNDP–FAO project was carried out to assess shrimp farming potential in New Caledonia. From 1972 to 1977, local species of wild shrimp (*Penaeus monodon*, *Penaeus semisulcatus*, *Metapenaeus ensis*, *Penaeus merguiensis*, *Penaeus monoceros*, *Penaeus longistylus*) (Doumenge 1972) were raised in experimental basins at Saint Vincent. From 1973 to 1979, studies were done on the possibilities for local development. Several local and introduced species were bred and raised, i.e. *Penaeus monodon* (Fiji, Tahiti), *Penaeus vannamei* and *Litopenaeus stylirostris* (Panama, Mexico, Tahiti), *Penaeus japonicus* (Tahiti, Japan) and *Penaeus aztecus (*Tahiti) (Coatanea 1978).

The shrimp *Litopenaeus stylirostris* was imported to New Caledonia in great numbers between 1978 and 1981. Development of the shrimp farming sector was then done on the basis of that single species, which has been bred since that time because it shows adequate levels of resistance to the IHHN virus (Infectious Hypodermal and Hematopoietic Necrosis Virus). In this way, New Caledonia became one of the first countries to develop a shrimp aquaculture industry based exclusively on a stock of animals raised in captivity (35 generations in 2007). In 1983, two farms began operations. The first industrial hatchery and the first pack house opened at SODACAL in 1988 (Galinié 1992). The farms were continuing to expand when the 'winter syndrome' appeared in 1993. *Vibrio penaeicida* brought about very high levels of shrimp mortality. Four years later, one farm was again affected by high rates of mortality, this time during the hot season. This was due to *Vibrio nigripulchritudo*. IFREMER then considered alternatives to get around these diseases (Goarant *et al.* 1998, 1999, 2000). A strain of shrimp from Hawaii that is resistant to these diseases was introduced in 2004. Cross-breeding was carried out and the hybrids seem to be more resistant to the vibriosis disease.

The shrimp *Litopeneus stylirostris* accounts for 99.5% of New Caledonia's aquaculture production, spread out over 98.3% of the total surface area allotted to aquaculture. Total production surface area of aquaculture farms in 2004/2005 was some 674 ha. Production for the 1999–2005 period averaged 1436 t/year with a shrimp survival rate of only 52%. More than 75% of this production is based on six farms, with the other farms relatively less important due to their more restricted production areas and yields. The farms' surface areas are 9–133 ha. All the farms are located on the west coast. Three farms are set up in the Northern Province, while the majority (83%) are located in the Southern Province. This imbalance between the east and west coasts can be explained by the topography needed to set up farms, i.e. large flat areas of inland mangroves, which mainly exist along the shores of the west coast plains.

GFA (2005) reports that local consumption of shrimps in New Caledonia has reached its limit (New Caledonians are today among the highest consumers of shrimp in the world.) and development of the sector must move further towards exports. However, New Caledonian production accounted for less than 0.01% of worldwide production in 2005 (GFA 2005).

Oysters

Aquaculture production based on the giant Pacific oyster (*Crassostrea gigas*) commenced in New Caledonia in the late 1990s, as there is a high demand for oysters in the country. Around 170 mt of oysters were imported annually in the late 1990s, and this increased to 210 mt in 2000 (Anon. 2006a, Anon. 2001). Local production through one company has been expanding in the early 2000s, although the spat need to be imported from France as there is no local hatchery. The oysters take three years to grow out and there are high mortality rates, especially with the spat once it arrives in New Caledonia. Tens of thousands of these oysters are produced annually, and this is increasing. In 2005, 45.5% of the local market was supplied by local production (73 mt). This increased to 60% of the local market in 2006 (90 mt), with further increases expected in 2007 (Anon. 2006a).

Freshwater crayfish

The red claw crayfish (*Cherax quadricarinatus*) was first introduced to New Caledonia from Australia in 1992. During the 1990s, production was low as farms were established. No hatchery is required for these crayfish, as they breed naturally in the ponds, although this is controlled to maintain good production. The grow-out ponds are harvested twice a year, with the minimum weight of 60 g required for the local market (Anon. 2006b). Production increased in the early 2000s, from 4 mt in 2000 to 10 mt in 2004, with this all sold on the local market. In 2006 there were 30 producers operating 150 ponds that covered around 11 ha. There are plans for expansion, with the view to look at exporting (Anon. 2006b).

Fish farming

Plans are underway to establish an integrated farm project (land-based hatchery and sea-based production cages) in the Bay of N'Go (Mont Dore) to produce and grow-out rabbit-fish (*Siganus lineatus*). The first research was undertaken in 2003, with a pilot-scale hatchery established in 2004/2005. Cage trials have shown that this species can be grown to commercial size (300 g) in less than one year. A hatchery is currently being constructed (2008) with production scheduled to commence in 2009. Production is expected to reach 50 to 60 mt during the second year. There is also separate research underway in New Caledonia to establish fish farming for high-value export species (e.g. barramundi cod, *Cromileptes altivelis*; red emperor, *Lutjanus sebae*) for the Hong Kong, Japan and USA markets, although this is in the early stage of development.

Reef and reef fisheries (finfish and invertebrates)

Reef and lagoon fisheries are carried out within the lagoon, including the barrier reef, using gillnets, troll lines, handlines, diving from vessels under 10 m in size, plus some hand collection, especially for sea cucumbers and trochus. Fishing trips usually only last a day. Lagoon fisheries' products are mainly destined for home consumption. Part of the catches is also distributed on the local market while most target species of high market value, such as trochus or sea cucumbers, are exported.

Commercial reef and lagoon fisheries in 2006 were estimated at 475 t, with 73% of production coming from the Southern Province, 22% from the Northern Province and the rest from the Loyalty Islands Province (SMMPM 2007). These figures only cover commercial fishing, which only accounts for a marginal portion of catches in comparison to subsistence and recreational fishing, for which there are no statistics available. This fishery mainly targets fish but also crustaceans (rock lobsters, slipper lobsters and crabs), echinoderms (sea cucumbers) and a few molluscs (giant clams, trochus, etc.).

Finfish

Most fishing in New Caledonia is undertaken in the lagoon, with the main market for the non-subsistence catch being Nouméa. In 1975, FADIL was used to establish a government boatbuilding project. The boats were built for fishers outside of Nouméa to promote rural development in the fisheries sector. There were several designs of vessels 5–8 m in length, powered either by a diesel inboard or petrol outboard engine. Over a 10-year period (1975–1985), many vessels were constructed under this project for rural fishers (Chapman 2004).

In 1986, lagoon fisheries accounted for 87% of total catches, i.e. 4124 t (SMMPM 1988a). Mean annual production then dropped from 1520 t between 1990 and 1999 to just 621 t between 2000 and 2005. This decrease may be explained by the number of ships equipped for commercial fishing and the number of seafarers onboard, which was cut in half over the period 2000–2005. This activity was abandoned for other, less risky professions and those in full-scale expansion, such as public works and mining (Etaix-Bonin, pers. comm. August 2008). Recreational fishing and subsistence fishing took a significant portion of the total catches and thus were in direct competition with commercial fishing. An IRD dissertation currently underway is supposed to provide some answers about recreational fishing pressure in the greater Nouméa area (Jollit pers. comm. August 2008). Whatever the cause may be, a decrease in resources does not seem to be the main cause for the decrease in production since stock surveys on both the reefs of the main island of New Caledonia and those in the Loyalty Islands do not appear to indicate any real overfishing of reef and lagoon resources (Kulbiki 1995, Letourneur *et al.* 1997, Labrosse *et al.* 1998), apart from overfishing of specific species at specific sites. Commercial fishing pressure appears to vary depending on the site. It is mainly concentrated on the west coast of the main island of New Caledonia and mostly targets fish and molluscs (Juncker and Bouvet 2006).

In the Loyalty Island Province, the landed catch from commercial fishing in 2006 was an estimated 22 t. Reef and lagoon fisheries seem to have a limited impact on the marine resources of the islands of Maré, Tiga and Lifou due to the existence of ciguatera at many sites and the layout of the fringing reefs, which are pounded by waves. The Ouvéa lagoon supposedly experiences higher fishing pressure than the other islands in the Loyalty Islands since it is sheltered from the prevailing winds and is apparently free of ciguatera (Léopold 2000). According to a fishing survey that Léopold (2000) carried out on Ouvéa, five out of every six households engage in coastal fisheries for their own consumption, for customary exchanges and for additional financial income. Around 220 t of fish are supposedly harvested each year on this atoll.

In the Northern Province, fishing is mainly commercial and recreational on the west coast and subsistence on the east coast. Commercial fishing in 2006 was estimated at 103 t (commercial fisheries database, Northern Province Aquaculture and Fisheries Department). The mouth of the Diahot River and the fringing and barrier reefs off the Belep Islands are also sites for subsistence fishing. However, according to Labrosse *et al.* (1998), this latter zone can be considered as unexploited given the extent of the reefs, the stocks, the high biomass recorded in the area and the low fishing pressure. According to the bottom-fish resource assessment that the IRD carried out in this lagoon between 1995 and 1998, the Northern Province's lagoon does not show any signs of overfishing overall (Labrosse *et al.* 2000), i.e. fishing pressure is only 10% of total stock (12,600 and 138,300 t).

In the Southern Province, fishing is mainly commercial and recreational on the west coast and subsistence on the east coast. Commercial fisheries in 2006 were estimated at 350 t. Since a large number of reefs and small islands were made into a reserve as part of a southern lagoon park, this has pushed recreational fishing 20–40 km south of the greater Nouméa area. Most commercial fishing takes place off the southern horn and mainly targets fish (88% of total catch in 2006). Most subsistence fishing is done on the fringing and intermediate reefs off the coasts of tribal areas in Yaté (from Unia to Goro), south of Thio to Petit Borendy and all around the Isle of Pines. The passes throughout the Southern Province are subject to high fishing pressure from October to February when fish gather to spawn.

Invertebrates

There are two commercial invertebrate groups, trochus (*Trochus niloticus*) and sea cucumbers (many species) that are harvested for export.

Sea cucumbers

The history of the sea cucumber fishery in New Caledonia dates back to the nineteenth century, with a wide fluctuation in connection with political and socioeconomic events and the status of the resource (Conand 1990). There are 48 species of sea cucumbers recorded in the lagoon around New Caledonia, with the main fishery in the Northern Province (Anon. 1993). Sea cucumbers are processed into bêche-de-mer through a series of processes covering gutting, boiling and drying, with around a 90% weight loss from wet weight to dried weight. The entire production of bêche-de-mer is destined for export to Hong Kong and Singapore (Conand and Hoffschir 1991). It is difficult to get actual catch statistics from this fishery, so export figures for processed dry weigh are the best figures available (Etaix-Bonnin 1999, Conand and Hoffschir 1991).

The most recent period of revival of the sea cucumber fishery in New Caledonia started in 1983 (15 t dry weight), when a few New Caledonians of Chinese origin organised the fishing of these species (Conand and Hoffschir 1991). From 1984 to 1990, exports fluctuated between 55 t in 1989 and 180 t in 1986, with 2–7 exporters involved (Conand and Hoffschir 1991). Exports dropped in the early 1990s, with 79 t in 1994, decreasing to 39 t dried weight in 1998 (Etaix-Bonnin 1999). This decline was attributed to the fishing down of the resource in many locations, indicating that occasionally the stocks of sea cucumber species living near the coasts are depleted (Purcell 2005) and that fishers are forced to harvest these resources farther out to sea, on the reefs. In 2000, the export of bêche-de-mer from New Caledonia amounted to 61.5 t dried weight (Anon. 2001).

Northwest of New Caledonia, Surprise Island (Entrecasteaux Reefs) is a site where sea cucumber fishing (*Holothuria whitmaei* and *Thelenota ananas*) is conducted at a fairly high level (Fao pers. comm. August 2008). The only commercial fisher officially operating in this zone produces more than 50% of the sea cucumbers harvested in the entire Territory, i.e. 1–5 t of sea cucumbers are harvested during a three-week campaign.

Trochus

Trochus (*Trochus niloticus*) occurs naturally around New Caledonia, and has been harvested since the early 1900s (Bouchet and Bour 1980). Harvesting and export was sporadic until the 1970s, when mining activity slowed down. In 1978 the harvest was 1900 t of shell, dropping to around 1000 t in both 1979 and 1980, and dropping further to 725 t in 1981 (Anon. 1982, Bouchet and Bour 1980). Research was undertaken by ORSTOM in the early 1980s to look at declining stock numbers of trochus through intensive fishing. As a result of this research, it was suggested to limit the catch to 100 t, slowly increasing this to 400 t over a five-year period (Bour and Hoffschir 1985). During the rest of the 1980s, the catch did not exceed 200 t in any one year (Anon. 1991). This trend continued in the 1990s and early 2000s, with 100 t exported in 2000 (Anon. 2001).

Also in the late 1980s, ORSTOM and IFREMER carried out spat collection trials for trochus, with the aim of reseeding overfished reefs or introducing trochus to areas where they did not occur naturally (Hoffschir 1990). As a result of this work, 5700 trochus of 19 mm basal width were transplanted to Lifou in the Loyalty Islands, a location that was not natural for this species. Follow-up surveys revealed that, after one year, 19 trochus from the original transplant were still present. A survey four years later (1994) found only one trochus surviving (Chauvet *et al*. 1997).

Ciguatera

Many species of mainly reef fish are considered to be ciguatoxic in New Caledonia. The north of the mainland has more fish that are not affected by this toxin than the south. A similar comparison can be made between the island of Ouvea, where fish are non-toxic, and the other islands of the Loyalty Islands, where some species are toxic (Amade 1993). A study undertaken in 1992 on a representative sample of 500 people from Nouméa indicated that 25% of them had experienced ciguatera fish poison (Laurent *et al.* 1992). Extrapolating this out to the population in Nouméa (excluding children under 10 years of age), gave an estimate of 20,000 people who had experienced this intoxication (Laurent *et al*. 1992, 2005). Laurent *et al*. (2005) report that, according to SPC, the annual incidence rate of ciguatera fish poisoning in New Caledonia is around 1/1000, with the main toxic species groups being Serranidae (groupers and cod), Lethrinidae (emperors and sea bream), Scombridae (Spanish mackerel), and Lutjanidae (sea perch).

1.3.3 Fisheries research activities

Scientific research on marine resources in New Caledonia is carried out by a range of different agencies, e.g. IFREMER, the University, and IRD, to name but the most well known.

IFREMER (Institut Français de Recherche et d'Exploitation de la Mer) has accompanied the development of marine aquaculture in New Caledonia since the very beginning. Their current stated objective is to assist with improving yields in shrimp (*Litopenaeus stylirostris*) culture by means of a biological and technical approach (IFREMER 2007). IFREMER concentrates on experiments that could provide practical solutions to allow professionals to overcome the crisis the sector has been experiencing over the past few years. In particular, the areas IFREMER is currently studying are: the influence of basin bottom types on shrimp growth and survival; evaluating the effects that probiotic drug regimes have on animal health performances; comparing the performances of New Caledonian shrimp strains with Hawaiian and hybrid shrimp strains in environments that are favourable to *Vibrio nigripulchritudo* infections; and managing plankton blooms in farming basins.

At the University of New Caledonia (UNC), marine biology research is carried out by the LIVE laboratory (formerly LERVEM, Laboratoire d'Etudes des Ressources Vivantes et de l'Environnement Marin). Basic research covers the various life-cycle phases of fish (reproduction, settlement, recruitment), as well as population structure and how fish function. At the same time, the LIVE lab is conducting research to assist in managing New Caledonia's lagoons through a survey of stocks of interest for fisheries, e.g. fish, rock lobsters, slipper lobsters, scallops and *Amusium*, along with mother-of-pearl trochus and sea cucumbers on Wallis. The topics also cover the reasons for establishing marine protected areas and their creation and monitoring.

The French Institute of Research for Development (IRD) is a scientific and technical agency placed under the twin leadership of the Ministries of Research and Cooperation. It was created in Nouméa in 1946 under the name of the Institut Français d'Océanie (French Institute of the Pacific Islands). The IRD conducts scientific research programmes revolving around the study of man and his environment in many Pacific islands. Their objective is to contribute to sustainable development. Currently the research unit working on marine resources is entitled 'Communautés récifales et usagers' (Reef communities and resources – CoRéUs). It runs a programme 'Typology of Reef Communities and their Uses in the Pacific Islands'. The unit is developing work in three fields: biology and ecology; fisheries science; and methodology applied to three areas, i.e. the environment, resources and uses. The unit mainly works in the southern and western lagoons of the main island of New Caledonia and in Ouvéa, and works at other sites in the Pacific (Vanuatu, Wallis, French Polynesia).

1.3.4 Fisheries management

The creation of a 'Fisheries' section within the Service de la Marine Marchande et des Pêches Maritimes (SMMPM) in 1981 and onsite supervision of fisheries made it possible to improve the quality of information at the Territorial level and allowed the collection and analysis of fisheries statistics (SMMPM 1988a). In 1988, with the signing of the Matignon Agreement, jurisdiction for this area, which had previously been held by the French Government, was turned over to the Northern, Southern and Loyalty Island Provinces, which are in charge of their own economic development, including fishing. Nevertheless, the French Government retains jurisdiction over the exploration, use, management and conservation of the EEZ's natural resources.

Before August 2001, there was no specific fisheries legislation for SMMPM to work under. However, a general policy was developed in 2001: 'Resolution No. 237 dated 1 August 2001 concerning the implementation of a fisheries policy in New Caledonia' (Délibération no. 237 du 1 août 2001 relative à l'instauration d'une politique des pêches en Nouvelle-Calédonie (Government of New Caledonia 2001)) to allow the local government to implement technical measures to manage fisheries in the territory's EEZ and to issue licences, etc.

1.4 Selection of sites in New Caledonia

This report aims at presenting a preliminary assessment of the finfish resources of the coral reefs of Ouassé, Thio, Luengoni, Oundjo and Moindou in New Caledonia (Figure 1.5).

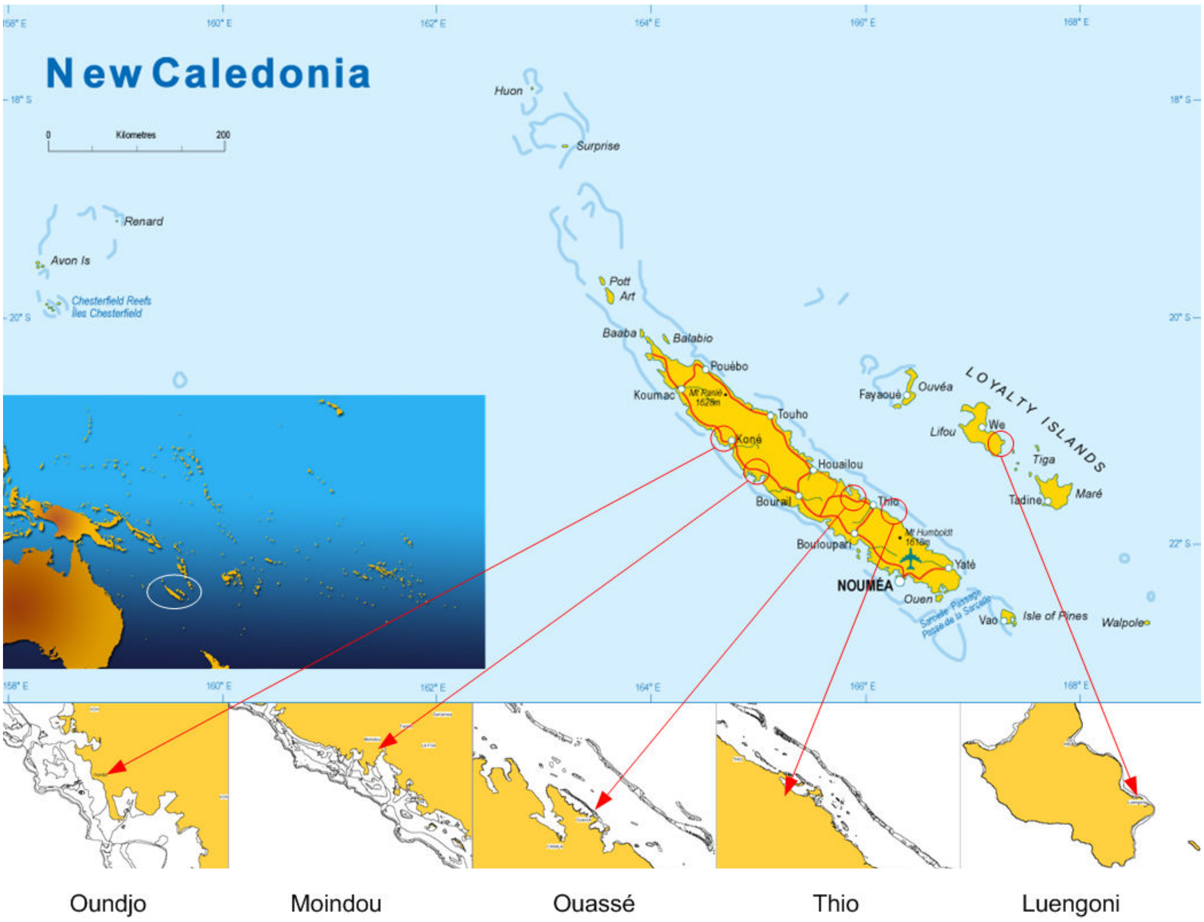

Figure 1.5: Map of the five PROCFish/C sites selected in New Caledonia.

2. PROFILE AND RESULTS FOR OUASSÉ

2.1 Site characteristics

The village of Ouassé is located on the east coast of Grand Terre at the position of 21°28′03″S and 166°02′09″E (Figure 2.1). Its fishing ground is exclusive and limited. The geomorphology of the lagoon is complex, with at least three separate lines of reef (including a secondary, inshore 'false' barrier reef) forming sectors within the lagoon with differing degrees of land–ocean influence and exposure. In the outer lagoon, there were large, deep-water sections that had unrestricted water exchange with the open ocean and very dynamic water flow. As one moved closer to the shoreline, the parallel lines of reef provided ever-increasing levels of protection from the prevailing winds and swell. The bays along the coast were mainly influenced by land, and were therefore richer, with less oceanic through-flow. Coral habitats were also subjected to outflows from the land, including sediments from the nearby mining operations. The fishing area is mostly exploited for subsistence purposes, but may on rare occasions be commercially fished for the benefit of the community as a whole.

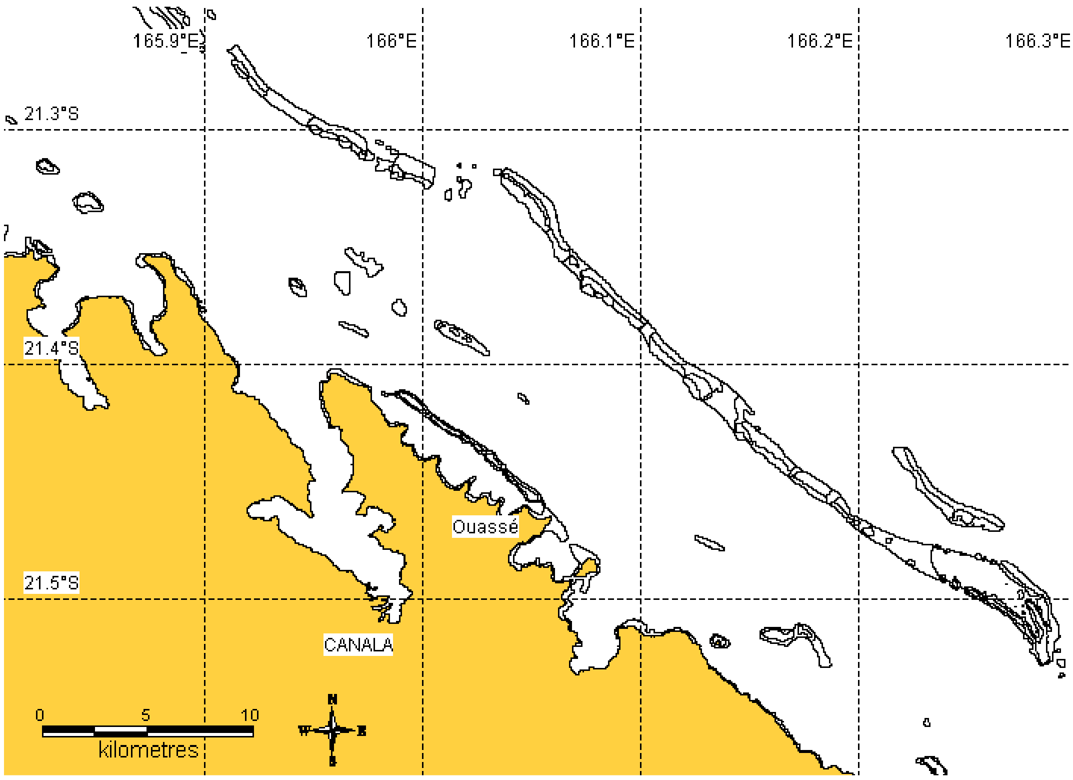

Figure 2.1: Map of Ouassé.

2.2 Socioeconomic surveys: Ouassé

Socioeconomic fieldwork was carried out in the Ouassé community during June 2004. The survey covered 10 households, including 25 people. Thus, the survey represents about 56% of the community's households (18) and total population (45).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 14 individual interviews of finfish fishers (7 males, 7 females) and 12 invertebrate fishers (3 males, 9 females) were conducted. These fishers belonged to one of the 10 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing.

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

Our survey results (Table 2.1) suggest an average of 1.5 fishers/household. If we apply this average to the total number of households, we arrive at a total of 27 fishers in Ouassé. Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of two exclusive finfish fishers (males), a total of two exclusive invertebrate fishers only (females) and 23 fishers (males, females) who fish for both finfish and invertebrates.

Half of all households in Ouassé own a boat; most (80%) are motorised, and 20% are canoes.

Ranked income sources (Figure 2.2) suggest that the primary sector is of no great importance for the generation of income. None of the households reported relying on fisheries as their first source of income, and only 20% did so for secondary income. No respondents indicated that agricultural produce generates any income. However, 40% of all families obtain their first income from salaries, and another 60% indicated other sources, mainly small business, and retirement and social fees. The latter also provide secondary income for another 30% of Ouassé households.

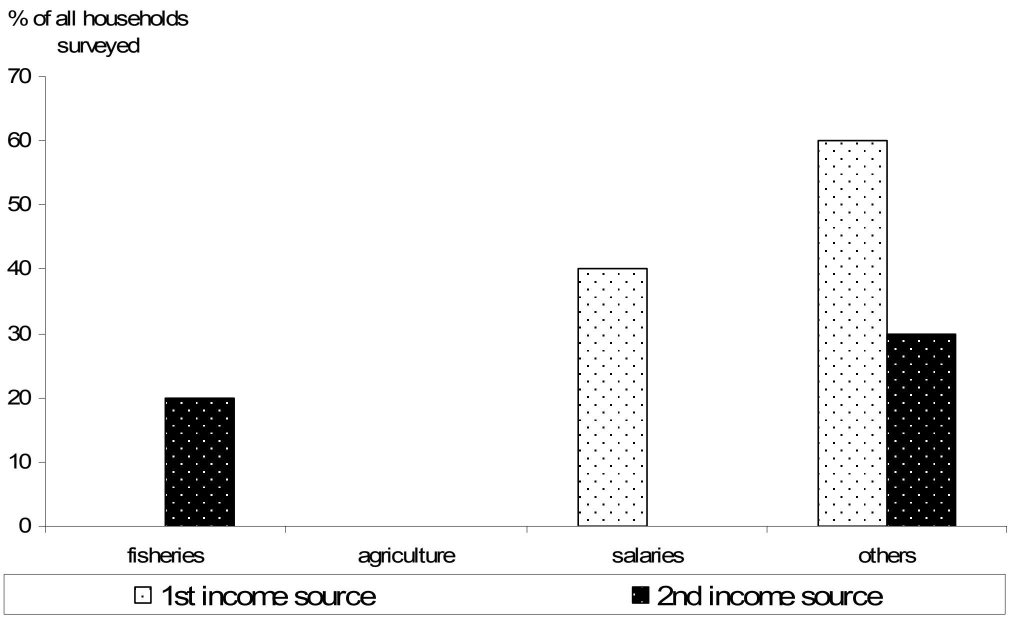

Figure 2.2: Ranked sources of income (%) in Ouassé.
Total number of households = 10 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses, and retirement and social fees.

However, the fact that all households have at least one member who goes fishing, and that all households eat fish and invertebrates rather frequently, shows that fisheries do play an important role. This is also confirmed by the answers indicating that most fresh fish and invertebrates consumed are caught by a member of their household or, on about half of the occasions, obtained as a gift, but never bought. In other words, any fish or invertebrates that are sold are taken to markets outside the Ouassé community.

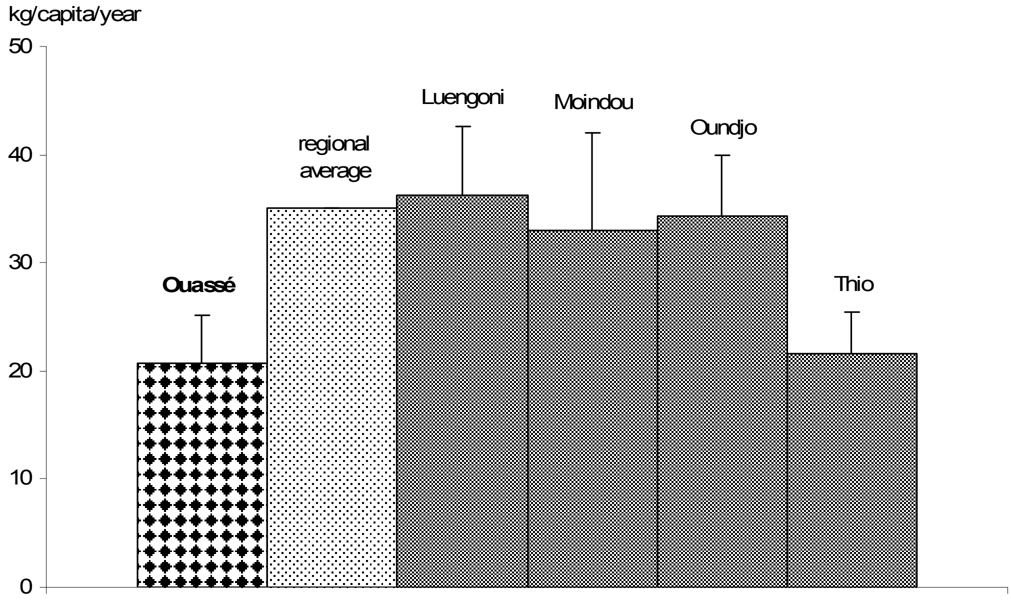

Figure 2.3: Per capita consumption (kg/year) of fresh fish in Ouassé (n = 10) compared to the regional average (FAO 2008) and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

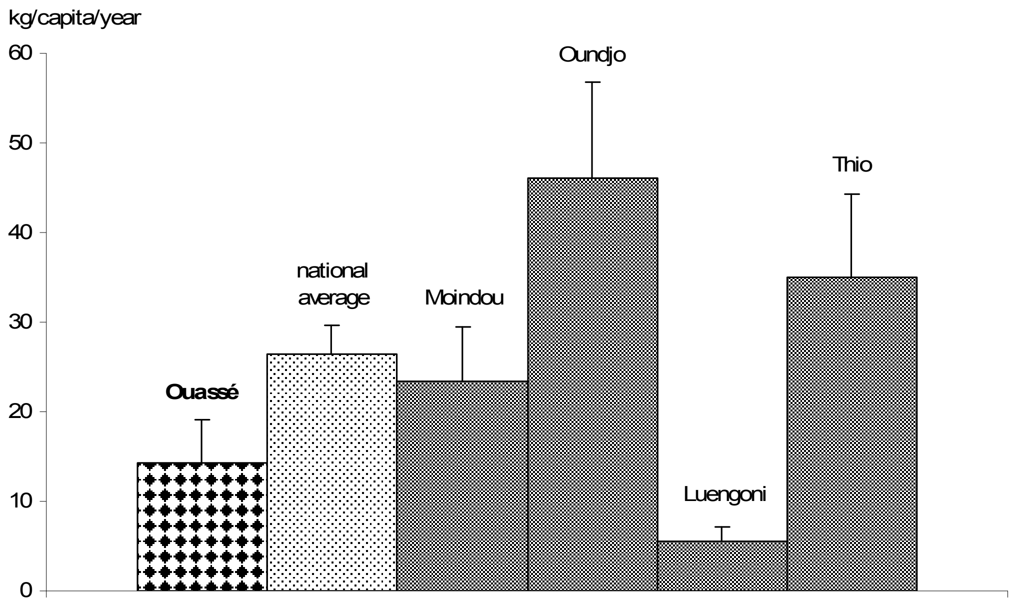

Figure 2.4: Per capita consumption (kg/year) of invertebrates (meat only) in Ouassé (n = 10) compared to the national average and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

The consumption of fresh fish (~21 kg/person/year ±4.4) in Ouassé is significantly below the regional average (FAO 2008) (Figure 2.3) and among the lowest across all New Caledonian sites investigated, i.e. it is comparable to that of Thio. The consumption of invertebrates is also comparatively low (14.3 kg/person/year, Figure 2.4) and below the average for all PROCFish sites investigated in New Caledonia.

Comparison of results across all sites investigated in New Caledonia (Table 2.1), shows that the people of Ouassé are much less dependent on fisheries for income generation, and they eat less finfish than average and about the average amount of invertebrates.

Also, the average annual household expenditure level in Ouassé is about 75% lower than the country average as estimated by the PROCFish/C surveys. There was no reported influx of external money (remittances).

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

Survey coverage	Ouassé (n = 10 HH)	Average across sites (n = 148 HH)
Demography		
HH involved in reef fisheries (%)	100.0	94.6
Number of fishers per HH	1.5 (±0.22)	1.6 (±0.08)
Male finfish fishers per HH (%)	6.7	29.6
Female finfish fishers per HH (%)	0.0	3.3
Male invertebrate fishers per HH (%)	0.0	2.5
Female invertebrate fishers per HH (%)	6.7	16.3
Male finfish and invertebrate fishers per HH (%)	46.7	32.5
Female finfish and invertebrate fishers per HH (%)	40.0	15.8
Income		
HH with fisheries as 1st income (%)	0.0	27.0
HH with fisheries as 2nd income (%)	20.0	23.6
HH with agriculture as 1st income (%)	0.0	2.0
HH with agriculture as 2nd income (%)	0.0	6.1
HH with salary as 1st income (%)	40.0	37.2
HH with salary as 2nd income (%)	0.0	6.1
HH with other source as 1st income (%)	60.0	37.8
HH with other source as 2nd income (%)	30.0	16.9
Expenditure (USD/year/HH)	4928.45 (±698.43)	6587.71 (±456.24)
Remittance (USD/year/HH) (1)		1802.97 (±766.61)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	20.74 (±4.40)	29.81 (±3.16)
Frequency fresh fish consumed (times/week)	2.10 (±0.26)	2.35 (±0.13)
Quantity fresh invertebrate consumed (kg/capita/year)	14.25 (±4.93)	26.46 (±3.16)
Frequency fresh invertebrate consumed (times/week)	0.86 (±0.20)	0.88 (±0.07)
Quantity canned fish consumed (kg/capita/year)	5.36 (±3.90)	6.69 (±1.32)
Frequency canned fish consumed (times/week)	0.95 (±0.70)	1.35 (±0.14)

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

2.2.2 Fishing strategies and gear: Ouassé

Degree of specialisation in fishing

Fishing in Ouassé is performed by both gender groups (Figure 2.5). However, ~7% of all fishers exclusively target either finfish (males only) or invertebrates (females only). Most fishers (~87%) fish both finfish and invertebrates. This observation applies to ~47% of all male fishers and 40% of all female fishers.

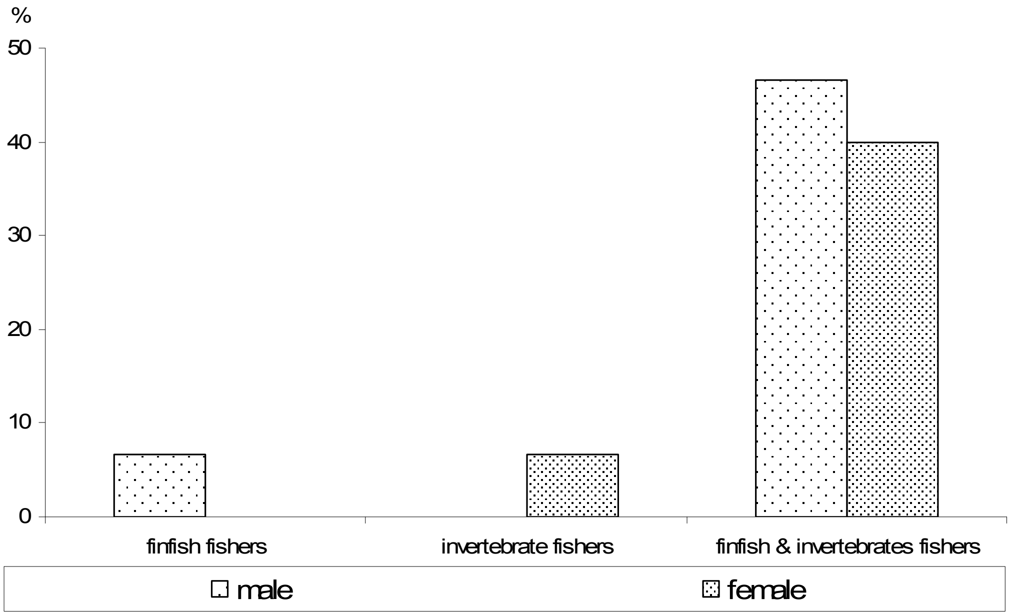

Figure 2.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Ouassé.
All fishers = 100%.

Targeted stocks/habitat

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	14.3	71.4
	Sheltered coastal reef & lagoon	85.7	28.6
	Outer reef	28.6	0.0
Invertebrates	Reeftop	33.3	77.8
	Soft bottom (sand)	0.0	33.3
	Soft bottom (sand) & reeftop	0.0	22.2
	Trochus & lobster & other	66.7	0.0

'Other' refers to the octopus and giant clam fisheries.
Finfish fisher interviews, males: n = 7; females: n = 7. Invertebrate fisher interviews, males: n = 3; females, n = 9.

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 Ouassé on their fishing grounds.

Our survey sample suggests that fishers in Ouassé can choose among sheltered coastal reef, lagoon and outer-reef habitats. The lagoon is usually not targeted specifically but is combined with the sheltered coastal reef in one trip. While female fishers prefer to fish the sheltered coastal reef (~71%), male fishers mainly combine the sheltered coastal reef and the lagoon in one fishing trip (~86%). Only ~29% of all male fishers target the outer reef (Table 2.2).

Most invertebrate fishers glean, but 67% of all male respondents dive for the collection of trochus, lobsters, giant clams and other selected species (Figure 2.6). Females mainly target reeftops and, to a much lesser extent, sandy, soft-bottom areas. Some females combine both reeftop and soft-bottom (sandy intertidal areas) gleaning in one fishing trip. Only males dive for trochus, lobsters and other invertebrates, as elsewhere in the South Pacific; females engage in gleaning only (Figure 2.7).

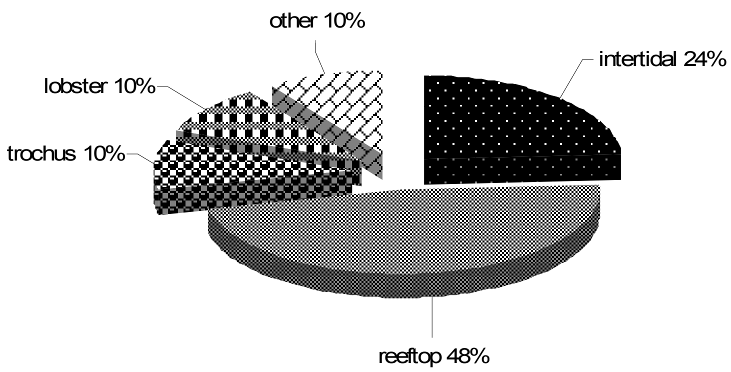

Figure 2.6: Proportion (%) of fishers targeting the five primary invertebrate habitats found in Ouassé.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the octopus and giant clam fisheries.

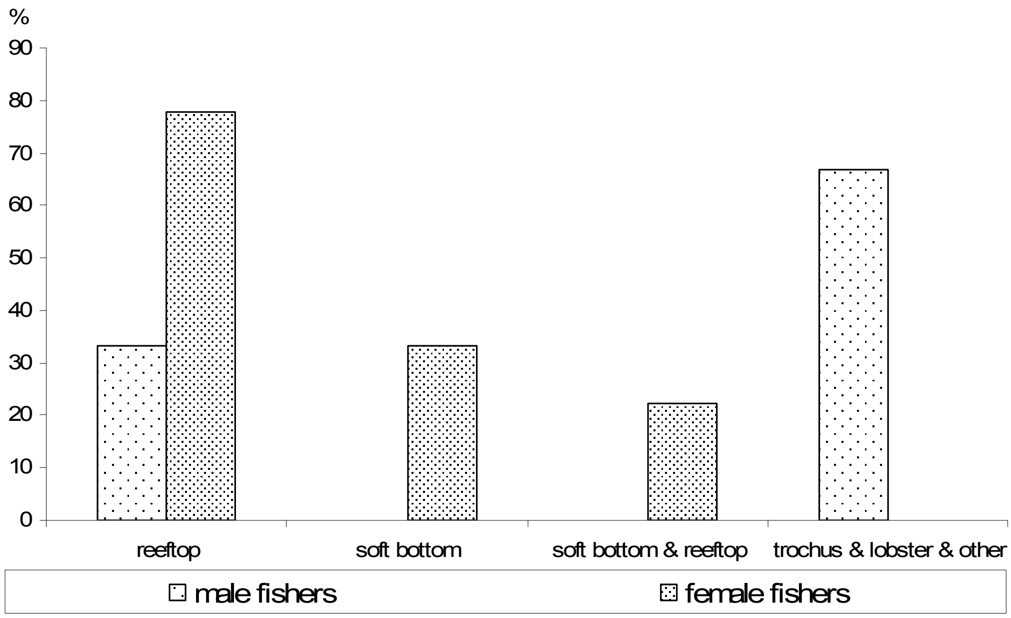

Figure 2.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Ouassé.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 3 for males, n = 9 for females; 'other' refers to the octopus and giant clam fisheries.

Gear

Figure 2.8 shows a distinction between gear used for fishing the sheltered coastal reef and the outer reef. Gillnets and handlines, either alone or combined, are the main gears used in the sheltered coastal reef. Spear diving and the combined use of spear diving, handlines and gillnets are the main techniques used by fishers targeting the outer reef. When the sheltered coastal and the outer reefs are combined in one fishing trip, all methods are used, and in any combination.

Gleaning and free-diving for invertebrates are done using very simple tools only. Lobsters and octopus are often speared, while trochus and many other species that are collected on reeftops are picked up by hand. Diving does not involve any gear other than mask, snorkel, fins and possibly a wet suit. The dive fisheries usually involve motorised (50%) or non-motorised (50%) boat transport. Soft-bottom areas are gleaned by walking and 75% of all reeftop gleaning embarks upon boat transport (50% motorised, 25% non-motorised).

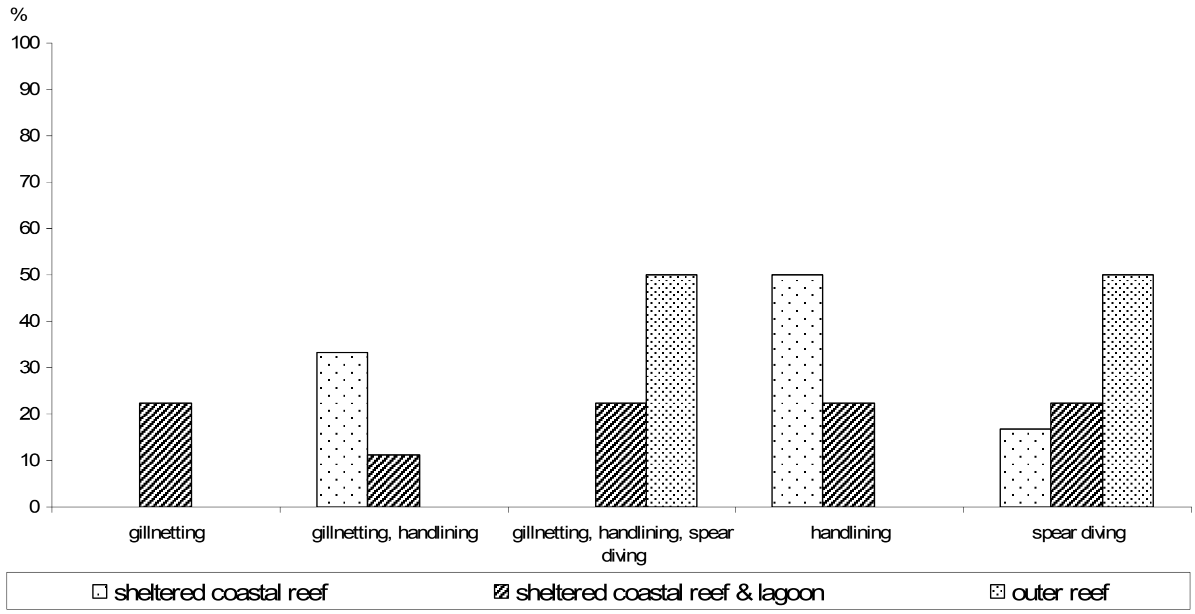

Figure 2.8: Fishing methods commonly used in different habitat types in Ouassé.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Frequency and duration of fishing trips

As shown in Table 2.3, fishing trips to the combined sheltered coastal and outer reef are by far the most frequent (1.3 times/week) and trips to either the sheltered coastal reef or the outer reef alone are rare (0.1 times/month and every second week respectively). There is no significant difference in the frequency of fishing trips between male and female fishers targeting the same areas. However, if comparing the duration of fishing trips, the opposite occurs. Fishing trips to the outer reef are by far the longest (6.5 hours/trip) and trips to the sheltered coastal reef are the shortest (2 hours/trip). The combined fishing of sheltered coastal and outer-reef areas takes on average between 2.5–4 hours.

Overall, invertebrate collection trips are less frequent than finfish fishing trips. The highest frequency of ~once/week was found for reeftop gleaning performed by male and female fishers, followed by soft-bottom gleaning (every second week). The least often trips were for trochus, lobsters and other species, free diving, done by male fishers (once/month). An average trip to collect invertebrates lasts 2.5–3 hours.

Finfish are usually caught according to the tides; hence fishers may go out either at day or night. Most fishers only fish for certain months of the year, and only ~30–45% of all respondents reported fishing continuously throughout the year.

All invertebrate fisheries are performed exclusively during the day and continue for 6–9 months/year for combined reeftop and soft-bottom gleaning.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	0.46 (n/a)	0.90 (±0.29)	2.00 (n/a)	2.10 (±0.10)
	Sheltered coastal reef & lagoon	1.26 (±0.24)	1.29 (±0.71)	3.93 (±0.90)	2.50 (±0.00)
	Outer reef	0.03 (±0.00)	0	6.50 (±2.50)	0
Invertebrates	Reeftop	1.00 (n/a)	0.91 (±0.24)	3.00 (n/a)	3.86 (±0.46)
	Soft bottom (sand)	0	0.56 (±0.23)	0	3.33 (±0.88)
	Soft bottom (sand) & reeftop	0	0.54 (±0.46)	0	2.50 (±0.50)
	Trochus & lobster & other	0.23 (±0.00)	0	3.00 (±0.00)	0

Figures in brackets denote standard error; n/a = standard error not calculated.
Finfish fisher interviews, males: n = 7; females: n = 7. Invertebrate fisher interviews, males: n = 3; females: n = 9.

2.2.3 Catch composition and volume – finfish: Ouassé

Catches from the sheltered coastal reef are dominated (56% of total reported catch) by three major groups: *bossu* (*Lethrinus* spp.), *bec-de-cane* (*Lethrinus olivaceus*) and *dawa* (*Naso unicornis*). In addition, *loche* (*Epinephelus* spp.), *perroquet* (*Scarus* spp.), *picot* (*Siganus* spp.), *sardine* (*Herklotsichthys quadrimaculatus*) and *carangue* (*Caranx* spp.) determine another 32% of the average total reported catch. Catch composition reported for the combined fishing of the sheltered coastal reef and lagoon includes *mulet* (*Crenimugil crenilabis*), *perroquet* (*Scarus* spp.), *dawa* (*Naso unicornis*) and *picot* (*Siganus* spp.) as major species groups. *Dawa* (*Naso unicornis*), *picot* (*Siganus* spp.), *perroquet* (*Scarus* spp.) and *saumonée* (*Plectropomus* spp.) are the most important species groups reported for the composition of average catches from the outer reef (Detailed data are provided in Appendix 2.1.1.).

Our survey sample of finfish fishers interviewed represents about 52% of the projected total number of finfish fishers in Ouassé. We can thus conclude that our results largely represent the overall impact of reef fisheries imposed by the community members of Ouassé on their fishing ground. Those fishers whom we have not included in this survey are reported to be mostly subsistence or leisure-oriented. Given the small community size and the limited number of total fishers, the impact not captured here will not add substantially to the overall assessed current fishing pressure.

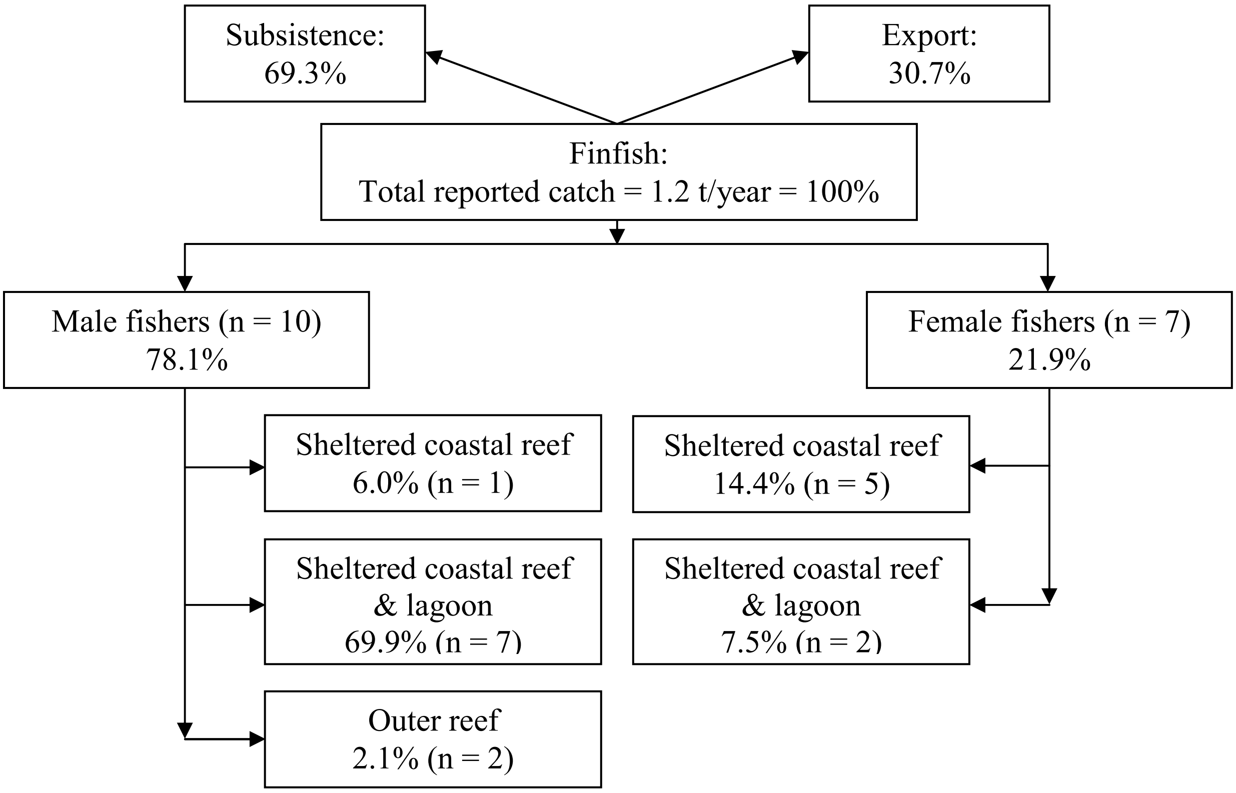

Figure 2.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Ouassé.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and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

As shown in Figure 2.9 most impact is due to subsistence fishing, and only about 32% of all reported catches are sold outside the Ouassé community. Taking into account the total population of Ouassé and the average consumption estimated at 20.7 kg/person/year, a total subsistence demand of 1.2 t/year can be projected. Most of the catch is taken by male fishers (78%); females play only a minor role (~22%). Highest pressure is imposed on the combined sheltered coastal reef and lagoon areas, with a minor impact on the outer reef (2.1% of the total reported annual catch).

The high fishing impact on the combined sheltered coastal reef and lagoon is due to the number of fishers targeting these areas and the reported average annual catches. Catches by male fishers at the sheltered coastal reef amount to ~70 kg/fisher/year, and for the combined catches of sheltered coastal reef and lagoon almost double (120 kg/fisher/year; Figure 2.10). Catches from the outer reef are marginal (<20 kg/fisher/year).

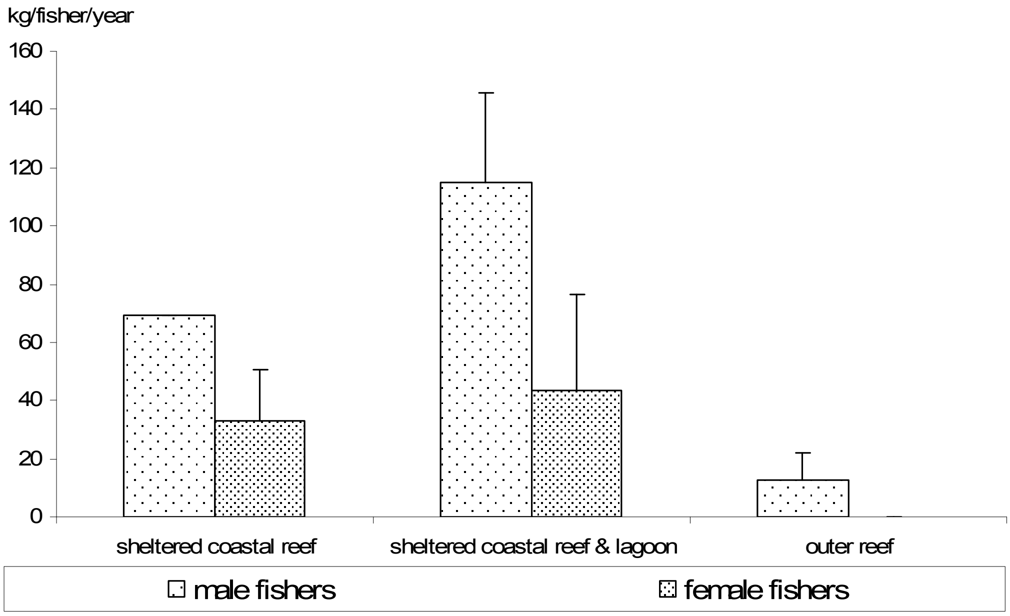

Figure 2.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Ouassé (based on reported catch only).

However, average annual catches are not to be confused with fishing efficiency (CPUE). Considering the average catch per hour of fishing trip spent, highest CPUEs are obtained at the sheltered coastal reef (~3 kg/hour). CPUEs for outer reef and the combined areas of sheltered coastal reef and lagoon are comparative, reaching ~1–1.2 kg/hour each. Figure 2.11 shows that the efficiency of female finfish fishers is much lower than that of male fishers. This may be because female fishers mainly use handlines and rods when targeting the sheltered coastal reef.

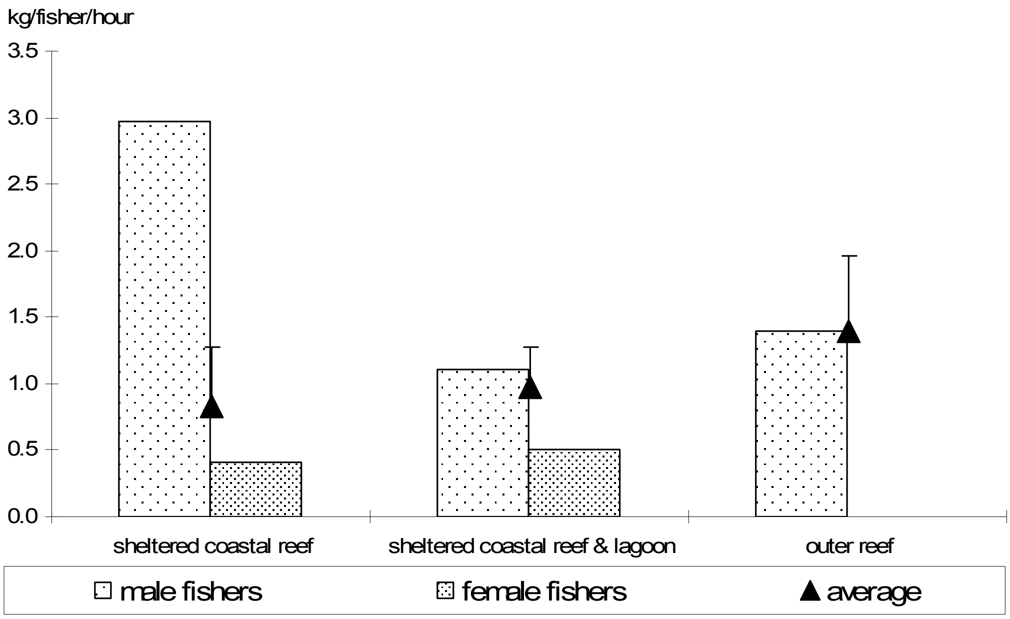

Figure 2.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Ouassé.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

Survey data did not show any significant differences in the objectives of fishing among different habitats targeted (Figure 2.12). Regardless of which area is targeted, most catch is intended for subsistence or non-monetary exchange among family and community members. The least share is caught for sale outside the Ouassé community. Results suggest that fishers who target the sheltered coastal reef or the outer reef separately do not usually sell their catch.

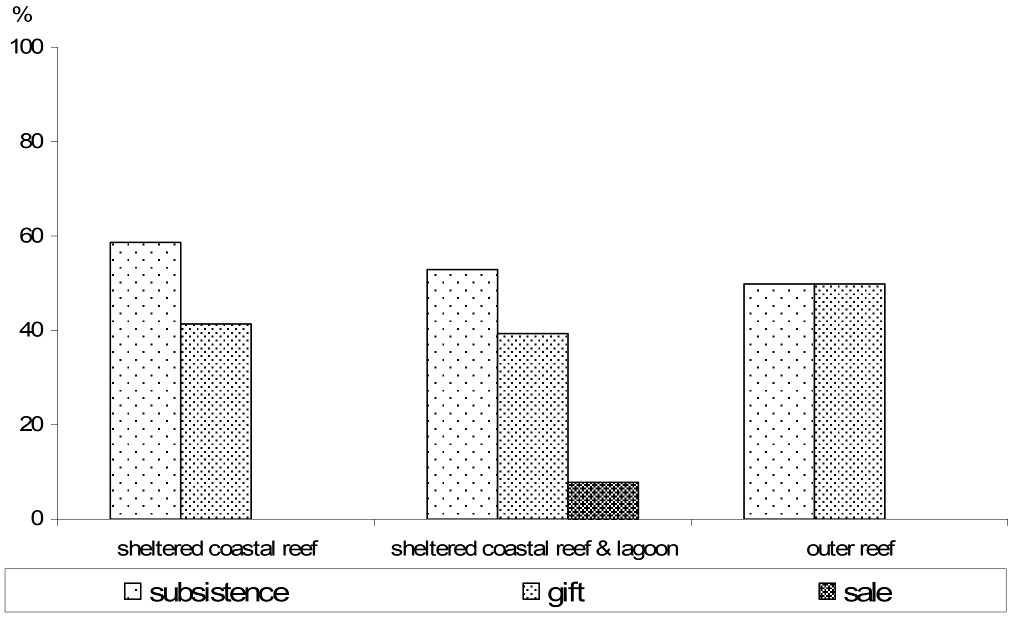

Figure 2.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Ouassé. Proportions are expressed in % of the total number of trips per habitat.

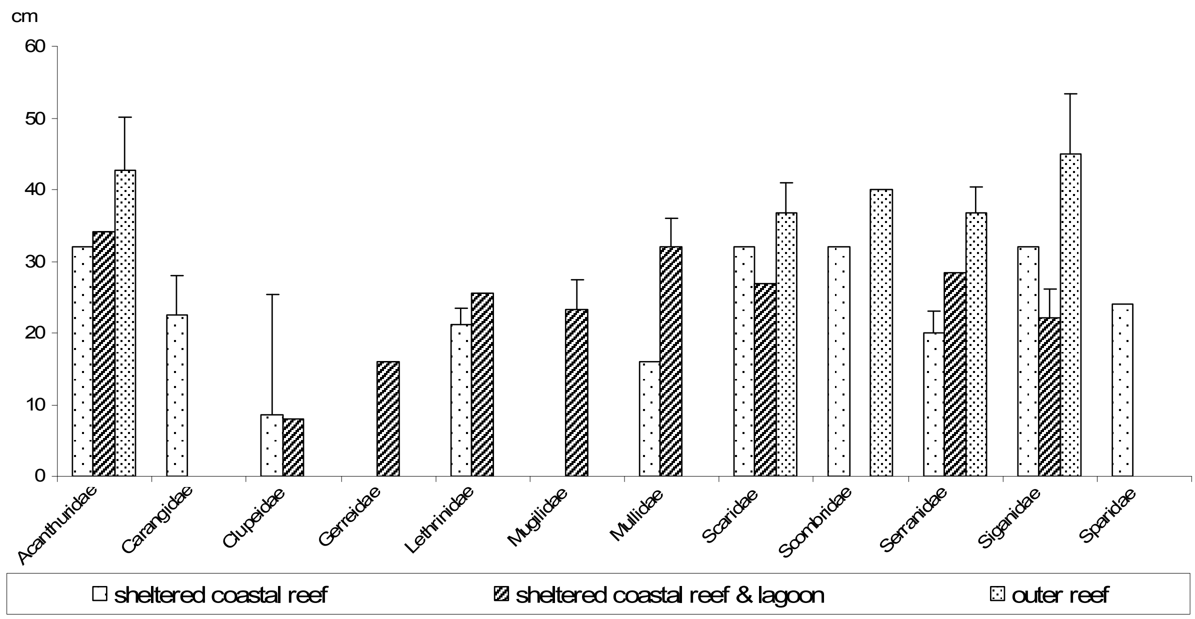

Figure 2.13: Average sizes (cm fork length) of fish caught by family and habitat in Ouassé. Bars represent standard error (+SE).

Data on the average reported finfish sizes by family and habitat (Figure 2.13) show a trend that fish size increases from the sheltered coastal reef towards the outer reef, i.e. the average sizes of Acanthuridae, Scaridae, Scombridae, Serranidae and Siganidae. It seems that usually, the average fish sizes in catches from the combined fishing of sheltered coastal reef and lagoon areas are smaller than those reported in catches from the exclusive fishing of the sheltered coastal reef. However, the often high variability (SE) among finfish sizes in catches from any of the habitats fished may also be misleading.

Some parameters selected to assess the current fishing pressure on Ouassé living reef resources are shown in Table 2.4. The comparison of habitat surfaces that are included in the Ouassé fishing ground shows that the outer reef is the largest area, followed by the sheltered coastal reef. Overall, fisher density is low with an average of one fisher/km² of total fishing ground and of total reef area. Lowest fisher density occurs in the outer reef with <1 fisher/km^2 and relatively low average annual catches per fisher. Overall, population density is low; it reaches about 2 people/km^2 of total reef and total fishing ground. All parameters indicate a low fishing pressure on Ouassé finfish resources, and indeed average annual total catch/km² of total reef or total fishing ground area is low: 0.03 and 0.05 t/km^2/year respectively.

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

Parameters	**Habitat**				
	Sheltered coastal reef	**Sheltered coastal reef & lagoon**	**Outer reef**	**Total reef area**	**Total fishing ground**
Fishing ground area (km^2)	6.33	13.62	7.56	22.00	27.52
Density of fishers (number of fishers/km^2 fishing ground) (1)	1.42		0.4	1.14	0.9
Population density (people/km^2) (2)				2	1.6
Average annual finfish catch (kg/fisher/year) (3)	39.21 (±15.60)	99.09 (±26.19)	12.38 (±9.63)		
Total fishing pressure of subsistence catches (t/km^2)				0.04	0.03

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) total population = 45; total number of fishers = 25; total subsistence demand = 0.91 t/year; (3) catch figures are based on recorded data from survey respondents only.

2.2.4 Catch composition and volume – invertebrates: Ouassé

Calculations of the recorded annual catch rates per species groups are shown in Figure 2.14. The graph shows that the major impact by wet weight is mainly due to four species groups: giant clam (*Tridacna*, *Hippopus*), octopus (*Octopus* spp.), trochus (*Troca*, *Tectus pyramis*, *Trochus niloticus*) and *bigorneau* (*Turbo* spp.). In addition, *Nerita* spp. and *clovis* (*Actadodea striata*) show slightly larger catches than the remaining five species groups (Detailed data are provided in Appendices 2.1.2 and 2.1.3.).

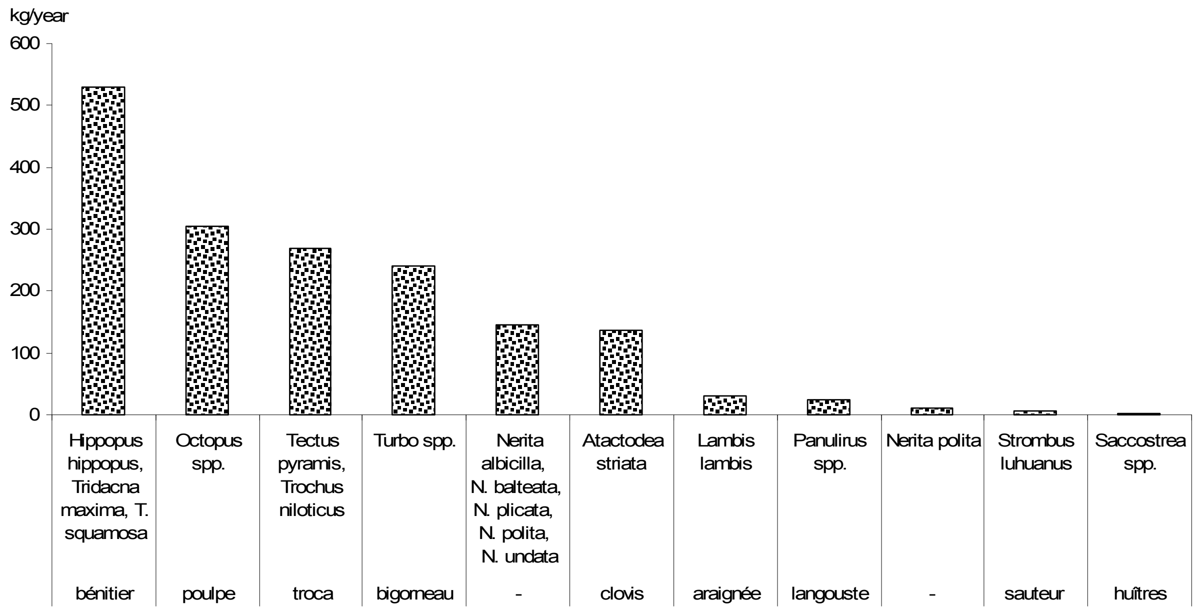

Figure 2.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Ouassé.

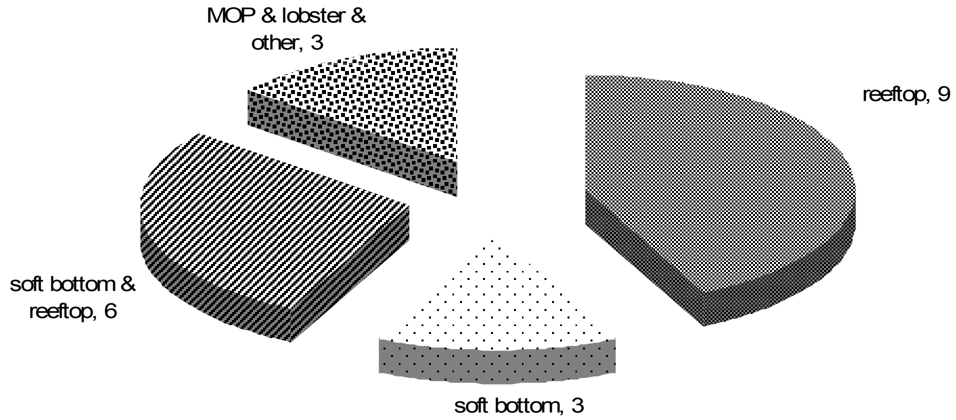

Figure 2.15: Number of vernacular names recorded for each invertebrate fishery in Ouassé.

In agreement with the limited number of invertebrates reported by respondents, overall biodiversity in the Ouassé invertebrate fishery is low (Figure 2.15). Taking into account all reported vernacular names, the reeftop fishery is the most diverse with nine different vernacular names, while most other fisheries are represented by three names only.

As expected, the highest average annual catches by wet weight are from the reeftop (Figure 2.16). Female fishers targeting reeftops have much higher average annual catches than do males. Lowest catches are reported for the dive fisheries (trochus, lobsters and other species), which are only performed by males.

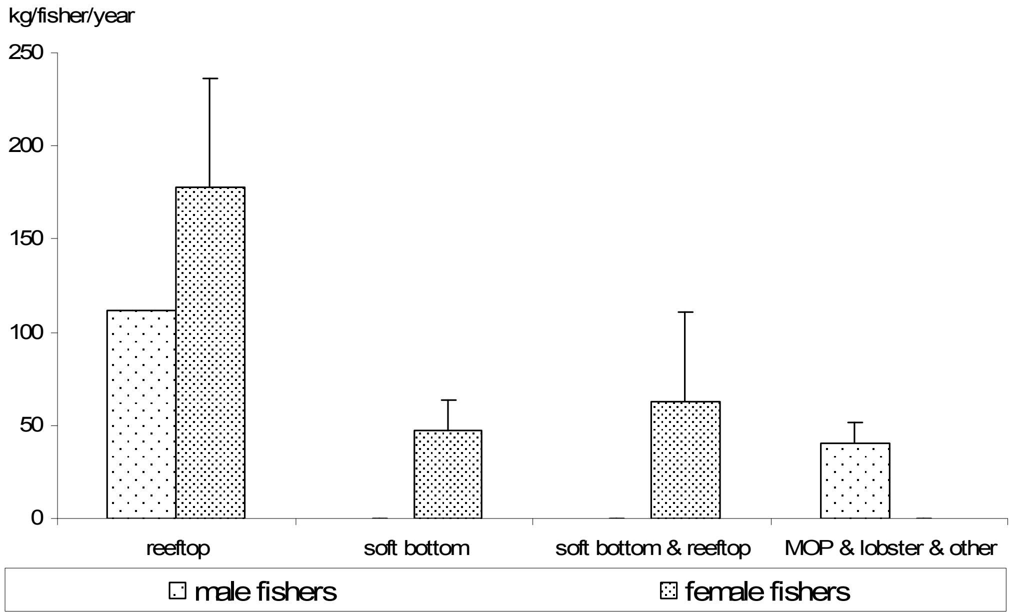

Figure 2.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Ouassé.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 3 for males, n = 12 for females); 'other' refers to the octopus and giant clam fisheries.

As shown in Figure 2.17, the invertebrate fishery in Ouassé is exclusively subsistence-oriented.

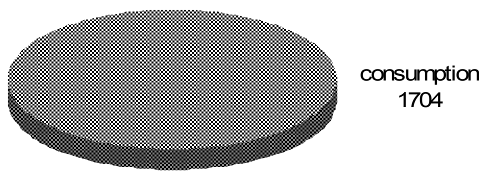

Figure 2.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Ouassé.

The total annual catch volume expressed in wet weight based on recorded data from all respondents interviewed amounts to 1.7 t/year (Figure 2.18). Catches from reeftops represent ~80% of the total reported annual catch. All other fisheries, including soft bottom (sandy intertidal areas), the combined reeftop and soft bottom, and the dive fisheries for trochus, lobsters and other species, such as giant clams and octopus, each account for ~5–8% of the total annual reported catch.

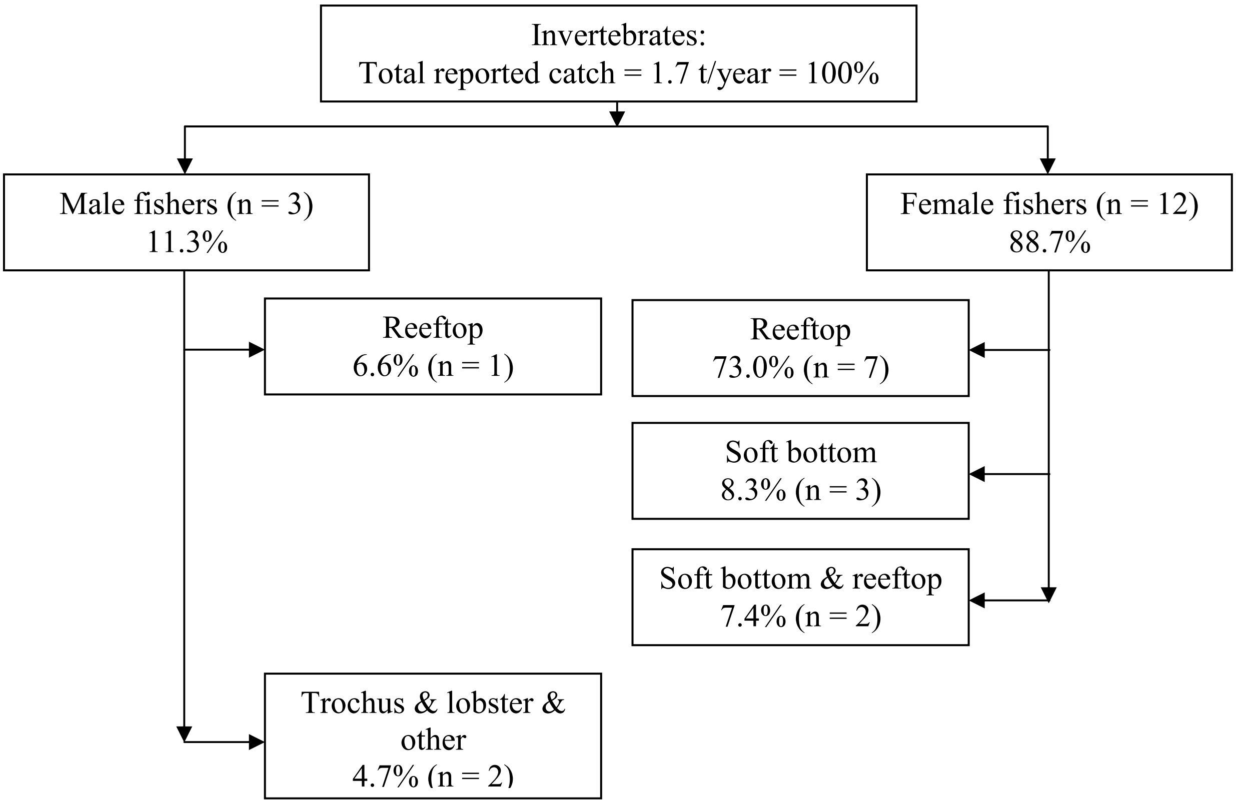

Figure 2.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Ouassé.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

The parameters presented in Table 2.5 show that there are not many differences in size of the fishing grounds available for the various fisheries. Also, overall, fisher density is low and so is the annual productivity of fishers, regardless of which fishery they are engaged in. Taking into consideration all these observations, there is no reason to assume that current fishing pressure is detrimental to the resource. This conclusion is further supported by the small size of the community, its isolation and hence small involvement in commercial fisheries.

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

Parameters	**Fishery / Habitat**			
	Reeftop	**Soft bottom**	**Soft bottom & reeftop**	**Trochus & lobster & other** (4)
Fishing ground area (km^2)	12.7 (3)		12.7	18.23
Number of fishers (per fishery) (1)	14	4	3	8
Density of fishers (number of fishers/km^2 fishing ground)	1.1		0.2	0.5
Average annual invertebrate catch (kg/fisher/year) (2)	169.40 (±51.48)	47.37 (±16.21)	63.14 (±47.82)	40.10 (±11.12)

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; (3) reef length; (4) reeftop fishery is mostly targeting the sheltered coastal reef areas, thus we have disregarded here the outside shallow reef areas, although they represent potential fishing grounds for the reeftop fishery.

2.2.5 Discussion and conclusions: socioeconomics in Ouassé

- Fisheries do not play a major role in generating income in Ouassé; salaries, small business, and retirement and other social revenues are more important. Fishing is, however, a part of the lifestyle, as shown by the number of fishers who fish for subsistence or for leisure purposes.

- Fresh-fish consumption (21 kg/person/year) is low by regional comparison and also compared to the average of all other PROCFish sites in New Caledonia. Invertebrate consumption is also low (14.3 kg/person/year).

- The low household expenditure level also indicates that the community enjoys a traditional lifestyle and that people meet a lot of their subsistence needs with agricultural and fisheries produce.

- Most male and female fishers in Ouassé fish for both finfish and invertebrates. Fishing is not very sophisticated: people use mainly handlines and gillnets and, occasionally, spears. Some motorised boat transport is used to reach certain fishing grounds.

- Highest fishing pressure by fisher density and average annual catch rates is on the sheltered coastal reef and lagoon, which are often combined in one finfish fishing trip and which mainly serve subsistence needs. Highest productivity (CPUE) was found for sheltered coastal reef fishing.

- In the case of invertebrate fisheries, highest pressure was found to be on the reeftops, with highest fisher density, highest catch rate per fisher per year and targeting only about three to four major species. Nevertheless, overall, fisher density and catch per unit area are very low if not insignificant.

- Based on the current data, there is no reason to suspect any problem exists or may evolve in the near future either for the finfish or invertebrate fisheries. Fisher densities and catch per unit area are low if not negligible. People do not currently depend on fisheries for income and are unlikely to do so in the foreseeable future. Also, given the isolated location of the community and the difficulties and costs involved in transport and marketing, there are limited opportunities for commercial fishing of species such as trochus or lobsters.

2.3 Finfish resource surveys: Ouassé

Finfish resources and associated habitats were assessed between 03 and 12 August 2004 from a total of 24 transects (7 sheltered coastal, 5 intermediate, 6 back- and 6 outer-reef transects; see Figure 2.19 for transect locations and Appendix 3.1.1 for coordinates).

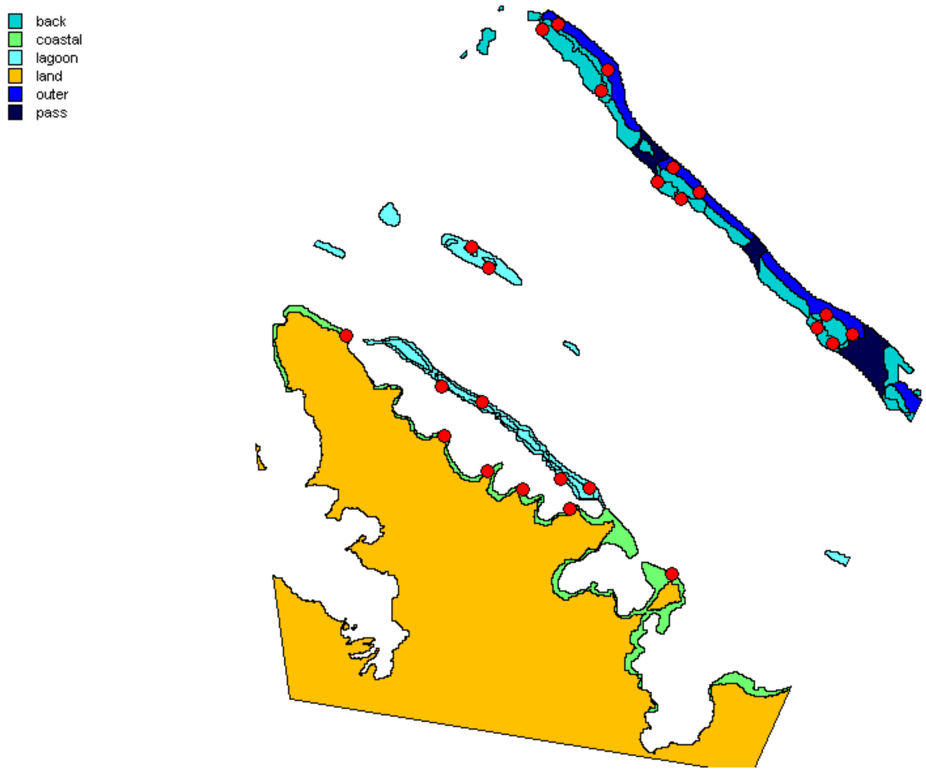

Figure 2.19: Habitat types and transect locations for finfish assessment in Ouassé.

2.3.1 Finfish assessment results: Ouassé

A total of 26 families, 66 genera, 178 species and 9440 fish were recorded in the 24 transects (See Appendix 3.1.2 for list of species.). Only data on the 15 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 49 genera, 152 species and 7971 individuals.

Finfish resources varied greatly among the four reef environments found in Ouassé (Table 2.6). The outer reef contained the greatest number of fish (0.9 fish/m^2), species (44 species/transect), and the largest biomass (551 g/m^2). In contrast, the back-reef displayed the lowest biomass (68 g/m^2) and the smallest fish size (16 cm). Sheltered coastal and intermediate reefs showed intermediate values (densities: 0.4–0.5 fish/m^2; biomass: 100–116 g/m^2). A large part of the observed differences in biomass among the reef types (5–8 times greater in the outer reef) was explained by a single record of 175 bumphead parrotfish (*Bolbometopon muricatum*) of sizes ~55–100 cm FL, representing a biomass of 367 g/m^2. Even without this 'rare' occurrence, the biomass recorded in Ouassé outer reef would still be 2–3 times that observed in the three other reef environments (184 versus 116–68 g/m^2).

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

Parameters	Sheltered coastal reef (1)	Intermediate reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	6	6	6	24
Total habitat area (km^2)	6.3	5.5	8.1	4.7	24.6
Depth (m)	4 (1-8) (3)	5 (1-10) (3)	5 (2-11) (3)	6 (2-11) (3)	5 (1-11) (3)
Soft bottom (% cover)	13 ±4	9 ±3	13 ±6	1 ±1	10
Rubble & boulders (% cover)	15 ±4	17 ±7	38 ±12	3 ±1	21
Hard bottom (% cover)	47 ±4	45 ±5	39 ±13	69 ±3	48
Live coral (% cover)	15 ±5	18 ±4	9 ±5	19 ±3	14
Soft coral (% cover)	11 ±3	11 ±3	1 ±1	8 ±1	7
Biodiversity (species/transect)	31 ±3	38 ±6	32 ±9	44 ±7	36 ±3
Density (fish/m^2)	0.5 ±0.2	0.4 ±0.1	0.5 ±0.01	0.9 ±0.2	0.5
Size (cm FL) (4)	19 ±1	21 ±1	16 ± 1	21 ± 1	19
Size ratio (%)	58 ±3	59 ±3	54 ±3	57 ±2	57
Biomass (g/m^2)	100.3 ±35.3	115.6 ±33.8	67.6 ±24.1	551 ±406	179

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

Sheltered coastal reef environment: Ouassé

The sheltered coastal reef environment of Ouassé was dominated by three families of herbivorous fish: Acanthuridae, Scaridae and Siganidae (Figure 2.20). These three families were represented by 31 species; particularly high abundance and biomass were recorded for *Acanthurus triostegus*, *Ctenochaetus striatus*, *Scarus rivulatus*, *A. lineatus*, *A. blochii*, *Siganus lineatus* and *Scarus altipinnis* (Table 2.7). This reef environment presented a moderately diverse habitat, mainly covered by hard bottom (47% cover) (Table 2.6 and Figure 2.20).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus lineatus*	Lined surgeonfish	0.04 ±0.04	14.4 ±14.4
	Acanthurus triostegus	Convict surgeon fish	0.11 ±0.09	9.1 ±7.8
	Ctenochaetus striatus	Striated surgeonfish	0.05 ±0.03	4.7 ±2.8
	Acanthurus blochii	Ringtail surgeonfish	0.01 ±0.01	2.8 ±0.7
Scaridae	*Scarus rivulatus*	Scribblefaced parrotfish	0.07 ±0.03	20.9 ±7.8
	Scarus altipinnis	Filamentfinned parrotfish	0.005 ±0.003	2.4 ±1.3
Siganidae	*Siganus lineatus*	Goldenlined rabbitfish	0.02 ±0.03	13.0 ±12.8

The density, size and biomass of finfish in the sheltered coastal reefs of Ouassé were higher than values recorded at the other study sites, while biodiversity was lower than in Moindou and Thio. The trophic structure in Ouassé coastal reefs was strongly dominated by herbivorous species, especially Acanthuridae and Scaridae. The sheltered coastal reef of Ouassé displayed a rather high percentage of hard bottom (47%) and a low percentage of soft bottom (13%). Such environmental differences in substrate may explain why herbivorous fish are particularly abundant since they are generally associated with hard bottom, while carnivorous species are generally associated with soft bottom[4]. Additionally, carnivorous species in general, and Lethrinidae species in particular, are particularly targeted by fishing in the sheltered coastal reefs of Ouassé, where most fishing occurs.

[4] Soft-bottom environments are generally rich in small invertebrates, which are the main food item of carnivorous fish, while hard-bottom environments are often covered with algae, the food of herbivorous fish.

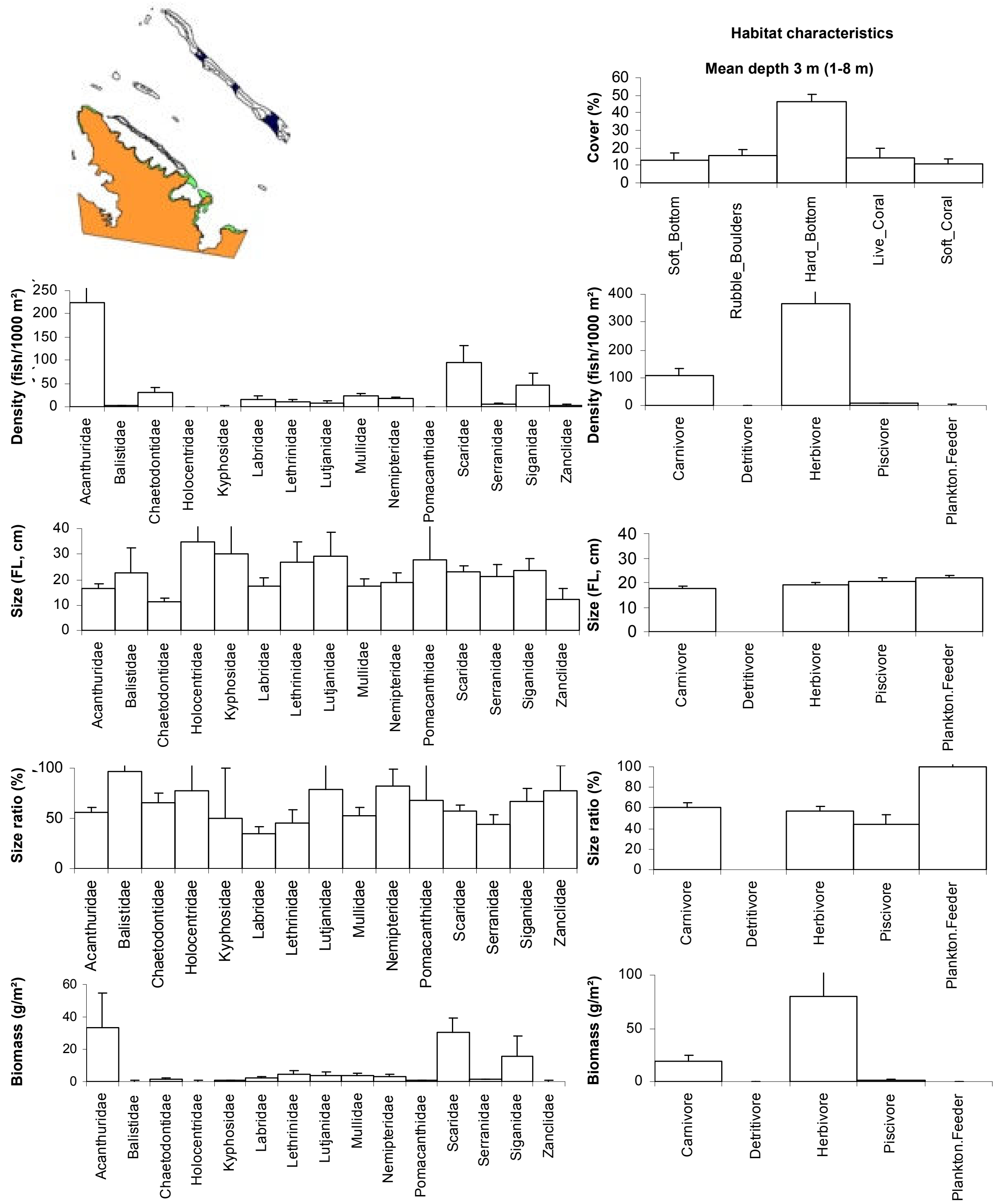

Figure 2.20: Profile of finfish resources in the sheltered coastal reef environment of Ouassé. Bars represent standard error (+SE); FL = fork length.

Intermediate-reef environment: Ouassé

The intermediate-reef environment of Ouassé was dominated by four families: herbivorous Acanthuridae and Scaridae (both in terms of density and biomass) and carnivorous Labridae and Chaetodontidae (density only) (Figure 2.21). These four families were represented by 52 species; particularly high abundance and biomass were recorded for *Scarus rivulatus, Naso unicornis*, *Acanthurus lineatus*, *Ctenochaetus striatus*, *A. blochii*, *Chlorurus microrhinos*, *S. ghobban*, *S. frenatus*, *S. schlegeli*, *Cheilinus chlorourus* and *Choerodon anchorago* (Table 2.8). This reef environment presented a moderately diverse habitat, with hard bottom dominating (45% cover) (Table 2.6 and Figure 2.21).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Naso unicornis*	Bluespine unicornfish	0.03 ±0.01	14.9 ±8.7
	Acanthurus lineatus	Lined surgeonfish	0.01 ±0.01	6.1 ±5.6
	Ctenochaetus striatus	Striated surgeonfish	0.04 ±0.02	5.4 ±2.7
	Acanthurus blochii	Ringtail surgeonfish	0.01 ±0.01	5.4 ±3.5
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.04 ±0.01	14.9 ±7.2
	Chlorurus microrhinos	Steephead parrotfish	0.01 ±0.004	4.6 ±2.8
	Scarus ghobban	Bluebarred parrotfish	0.07 ±0.003	3.9 ±2.1
	Scarus frenatus	Bridled parrotfish	0.07 ±0.005	3.1 ±2.5
	Scarus schlegeli	Schlegel's parrotfish	0.01 ±0.008	2.7 ±2.6
Labridae	*Cheilinus chlorourus*	Floral wrasse	0.009 ±0.002	1.7 ±0.6
	Choerodon anchorago	Orangedotted tuskfish	0.03 ±0.02	0.8 ±0.5

The size and size ratio of finfish in the intermediate reefs of Ouassé were higher than those recorded in other study sites of the country, and biomass was second only to that in Thio; biodiversity was ranked second and density was slightly lower than the average across the site, but comparable to Oundjo (Table 2.6). As in the sheltered coastal reef, there were more herbivorous than carnivorous fish (double the density and four times the biomass of carnivores) in Ouassé intermediate reefs (Figure 2.21). These differences were due to the relative lack of carnivorous Lutjanidae and Lethrinidae and to the presence of large-sized herbivorous Scaridae. The intermediate reefs of Ouassé had very little soft bottom (9%), a substrate that generally favours carnivorous species, compared to similar reef habitats across the country. As for the sheltered coastal reef, these natural differences in substrate may explain the particular trophic structure in Ouassé intermediate reefs. Additionally, fishing in the intermediate reefs of Ouassé selectively targets carnivorous species and more particularly Lethrinidae, which already show low numbers and average size.

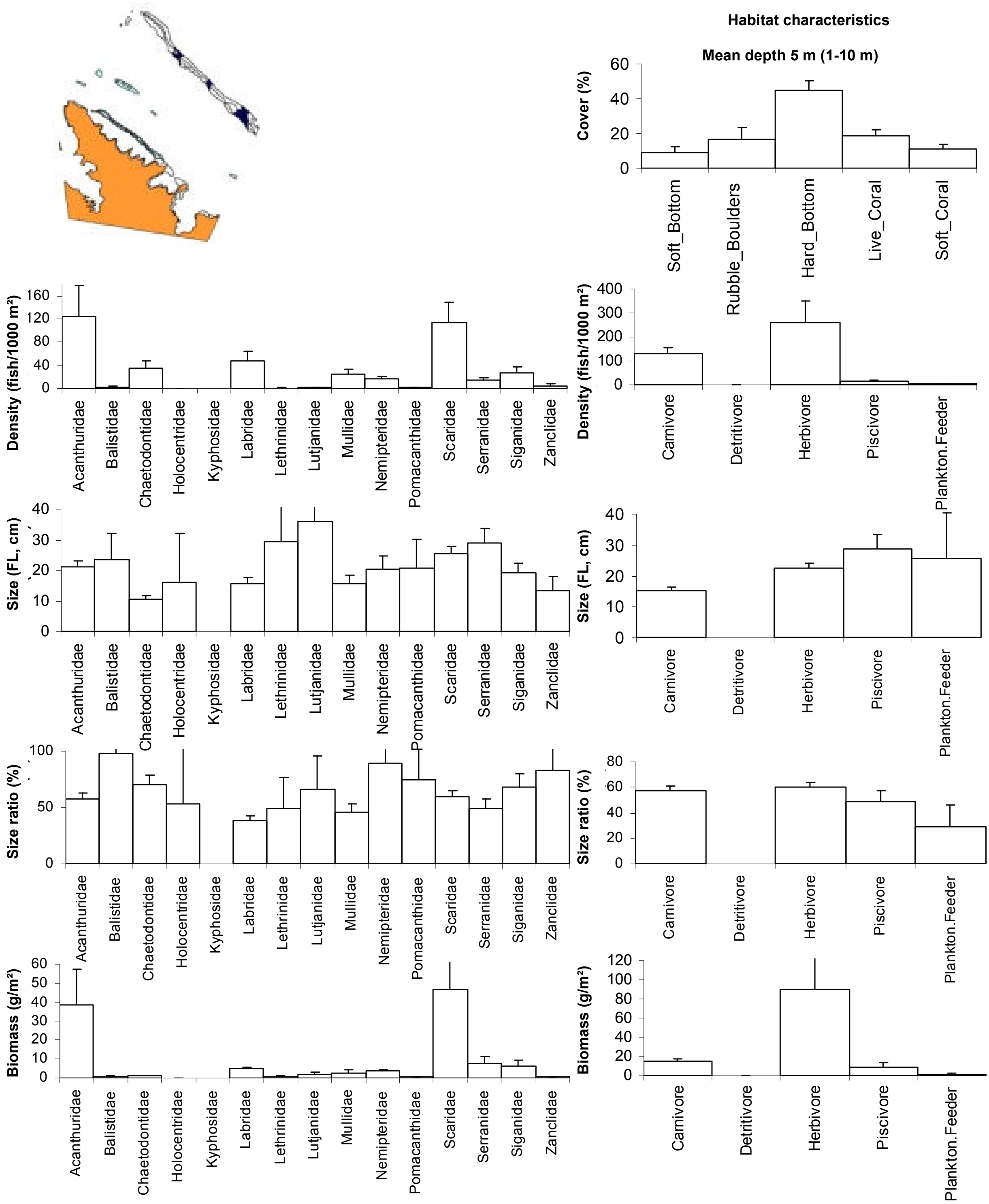

Figure 2.21: Profile of finfish resources in the intermediate-reef environment of Ouassé.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Ouassé

The back-reef environment of Ouassé was dominated by five families: herbivorous Acanthuridae and Scaridae (both in terms of density and biomass), Siganidae (density only), and, to a lesser extent, carnivorous Mullidae and Labridae (density only) (Figure 2.22). These five families were represented by 45 species; particularly high abundance and biomass were recorded for *Acanthurus olivaceus*, *Ctenochaetus striatus*, *Parupeneus multifasciatus*, *Siganus spinus*, *Scarus altipinnis*, *Chlorurus sordidus*, *P. pleurostigma*, *A. blochii*, *Scarus rivulatus* and *Choerodon anchorago* (Table 2.9). This reef environment presented a diverse habitat, mainly both hard bottom (39% cover) and rubble and boulders (38% cover) (Table 2.6 and Figure 2.22); habitat complexity may partly explain the relative complexity of the fish assemblage on this reef.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus olivaceus*	Orangeband surgeonfish	0.02 ±0.01	3.5 ±2.9
	Ctenochaetus striatus	Striated surgeonfish	0.03 ±0.02	3.4 ±2.1
	Acanthurus blochii	Ringtail surgeonfish	0.006 ±0.005	2.5 ±1.89
Mullidae	*Parupeneus multifasciatus*	Many bar goatfish	0.05 ±0.02	3.1 ±0.9
	Parupeneus pleurostigma	Sidespot goatfish	0.03 ±0.01	2.8 ±1.0
Labridae	*Choerodon anchorago*	Orangedotted tuskfish	0.04 ±0.02	1.1 ±0.6
Siganidae	*Siganus spinus*	Little spinefoot	0.08 ±0.05	3.03 ±1.9
Scaridae	*Scarus altipinnis*	Filamentfinned parrotfish	0.003 ±0.002	3.0 ±2.2
	Chlorurus sordidus	Daisy parrotfish	0.01 ±0.004	2.8 ±1.6
	Scarus rivulatus	Rivulated parrotfish	0.008 ±0.003	2.4 ±1.1

The density and biomass of finfish in the back-reef of Ouassé were lower than those recorded in the other study sites of the country; biodiversity was lower only than in Moindou and Oundjo, but fish size and size ratio were the highest among the five sites. Densities and biomass of most families of both herbivorous and carnivorous fish also were slightly lower in Ouassé compared to other country sites, except for a slightly higher biomass of snappers (Figure 2.22). In particular, there were fewer carnivorous Lethrinidae and herbivorous Scaridae but more Labridae (density) and Lutjanidae (biomass) in Ouassé than at other sites. The back-reef of Ouassé had more soft bottom (13% versus 7% average for the country sites) and less hard bottom (39% versus 53% average) than at other sites. This type of substrate generally favours carnivorous species. Hence, the possibility that fishing in the back-reef of Ouassé may be partly responsible for the observed lower abundances of carnivores, especially Lethrinidae, should be explored.

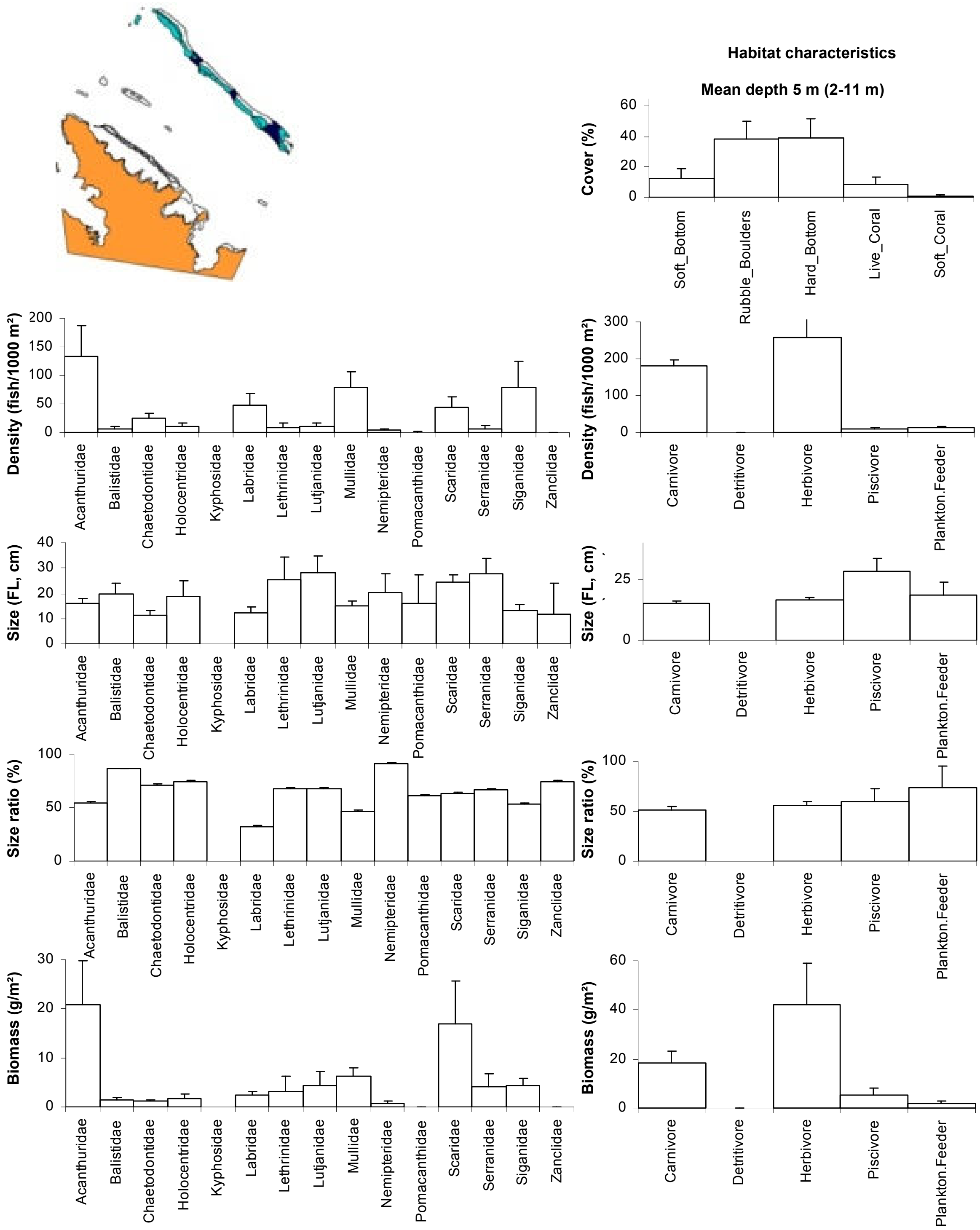

Figure 2.22: Profile of finfish resources in the back-reef environment of Ouassé.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Ouassé

The outer reef of Ouassé was dominated by herbivorous Acanthuridae and Scaridae (both in terms of density and biomass), and by carnivorous Labridae and Chaetodontidae to a lesser extent (density only) (Figure 2.23). These four families were represented by 67 species; particularly high abundance and biomass were recorded for *Bolbometopon muricatum*, *Chlorurus sordidus*, *Acanthurus lineatus*, *Naso tuberosus*, *N. caesius*, *N. annulatus*, *Ctenochaetus striatus*, *Scarus schlegeli*, *A. olivaceus*, *A. nigrofuscus* and *Choerodon anchorago* (Table 2.10). Hard bottom (69% cover) largely covered this reef environment (Table 2.6 and Figure 2.23).

Remarkably, the rare and vulnerable (to fishing) bumphead parrotfish (*Bolbometopon muricatum*) ranked first in term of biomass (367 g/m^2). However, this result was the consequence of a single record of a large group of fish (175 individuals), and the resultant large biomass of Scaridae in the outer reefs of Ouassé should be interpreted with caution.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Bolbometopon muricatum*	Bumphead parrotfish	0.04 ±0.04	367±367
	Chlorurus sordidus	Daisy parrotfish	0.12 ±0.03	33.7 ±9.1
	Scarus schlegeli	Schlegel's parrotfish	0.03 ±0.01	6.5 ±3.4
Acanthuridae	*Acanthurus lineatus*	Lined surgeonfish	0.05 ±0.02	19.0 ±10.0
	Naso tuberosus	Humpnose unicornfish	0.02 ±0.01	12.7 ±7.0
	Naso caesius	Grey unicornfish	0.02 ±0.01	12.6 ±9.5
	Naso annulatus	Whitemargin unicornfish	0.02 ±0.02	10.0 ±6.8
	Ctenochaetus striatus	Striated surgeonfish	0.07 ±0.02	8.7 ±2.8
	Acanthurus olivaceus	Orangeband surgeonfish	0.01 ±0.01	6.4 ±5.6
	Acanthurus nigrofuscus	Brown surgeonfish	0.09 ±0.02	5.8 ±1.5
Labridae	*Choerodon anchorago*	Orangedotted tuskfish	0.09 ±0.02	2.3 ±0.6

The size, density and biomass of finfish in the outer reefs of Ouassé were higher than those recorded in the other study sites of the region (Table 2.6). Biodiversity was lower only than in Oundjo. Difference in biomass was spectacular (551 g/m^2 for Ouassé versus 274 g/m^2 average value among the four habitats) but mostly due to the unique record of 175 bumphead parrotfish (367 g/m^2). Substrate composition showed a strong dominance of hard bottom with high cover of live coral (19%). However, the number and biomass of carnivorous Lutjanidae and Lethrinidae in Ouassé outer reefs were particularly low. This unusual low abundance could possibly be due to fishing. However, other carnivorous species were more abundant in Ouassé, counterbalancing the observed deficit in snappers (Lutjanidae) and emperors (Lethrinidae). Furthermore, the higher observed mean densities and biomass of edible species (except snappers and emperors), the presence of large, rare and vulnerable species in an otherwise similar habitat, along with records of lowest fishing pressure (lowest density of fishers, lowest fishing frequency, as well as lowest yearly catches) indicate that Ouassé outer reef is subject to less fishing impact than are other study sites in the region, albeit with possible problem of overfishing of snappers and emperors.

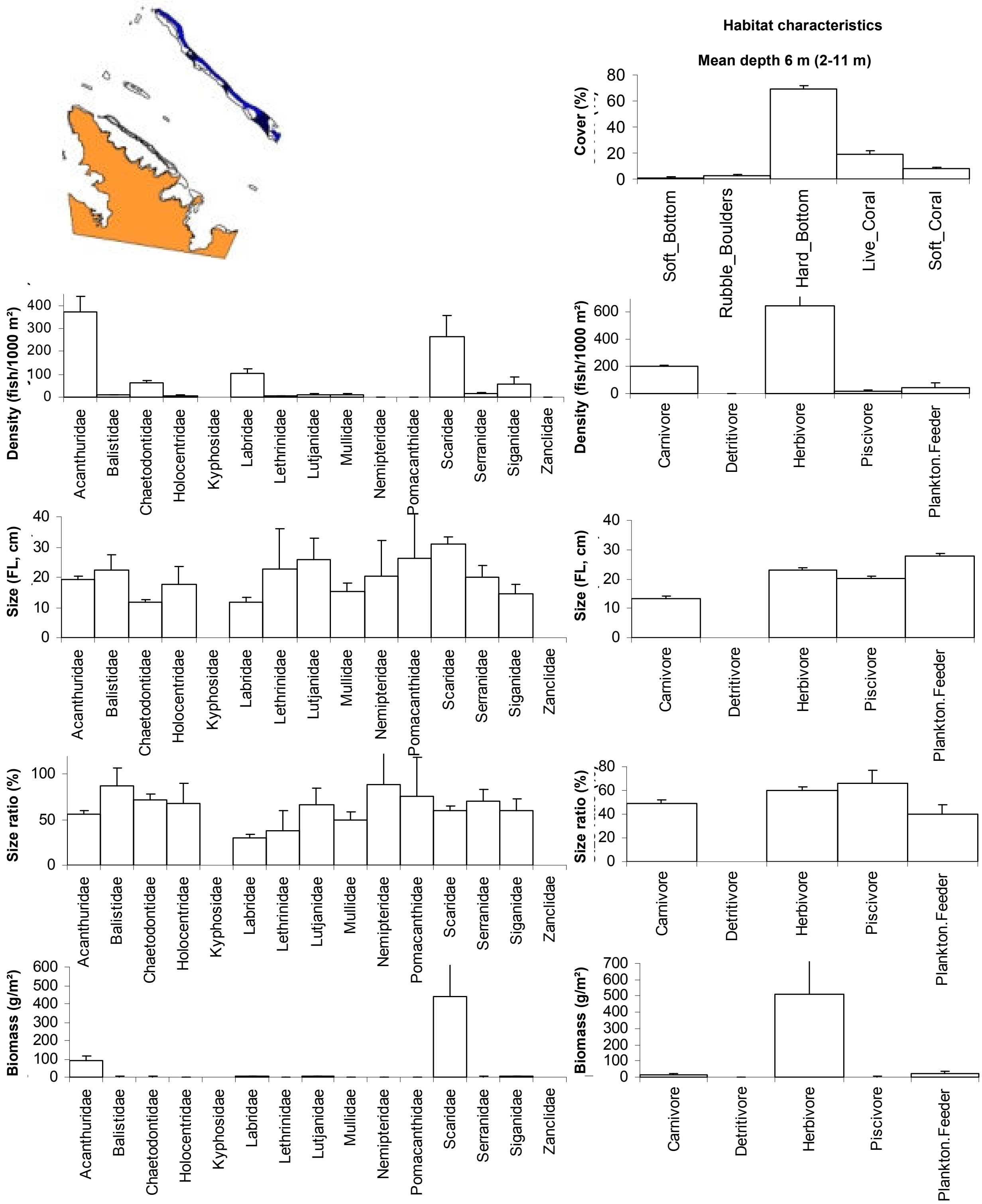

Figure 2.23: Profile of finfish resources in the outer-reef environment of Ouassé.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Ouassé

Overall, the fish assemblage of Ouassé was dominated by Acanthuridae and Scaridae (both in terms of density and biomass) and by Labridae and Siganidae to a much lesser extent (density only) (Figure 2.24). These four families were represented by a total of 70 species; particular high density and biomass were recorded for *Ctenochaetus striatus*, *Siganus spinus*, *Choerodon anchorago*, *Acanthurus triostegus*, *Chlorurus sordidus*, *Scarus rivulatus*, *A. nigrofuscus* and *A. lineatus* (Table 2.11). As expected, the overall fish assemblage in Ouassé shared characteristics of primarily back-reef (33%), then sheltered coastal reef (26%), intermediate reef (22%) and outer reef (19% of habitat).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.05	5.2
	Acanthurus lineatus	Lined surgeonfish	0.02	8.9
	Acanthurus triostegus	Convict surgeon fish	0.03	2.7
	Acanthurus nigrofuscus	Brown surgeonfish	0.02	1.6
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.03	9.2
	Scarus rivulatus	Rivulated parrotfish	0.03	9.7
Labridae	*Choerodon anchorago*	Orangedotted tuskfish	0.04	1.0
Siganidae	*Siganus lineatus*	Goldenlined rabbitfish	0.04	1.7

Overall, Ouassé appears to support a healthier finfish resource than the other sites, with highest biomass (169 g/m^2), third-lowest value of biodiversity (36 species/transect), second-highest density (0.5 fish/m^2), and greatest size (19 cm) and size ratio (57%) (Table 2.6). While these results suggest that the finfish resource in Ouassé is relatively healthy, detailed assessment at reef level also revealed a systematic, lower-than-average abundance for both snappers (Lutjanidae) and emperors (Lethrinidae). Unfavourable environmental conditions (either natural or human-generated) for the development of these species may explain this trend in Ouassé. Alternatively, it is possible that these results also reflect a greater impact from fishing carnivorous species (especially Lethrinidae) at Ouassé compared to the average for study sites in the country. In any case, further studies to elucidate the deficit in snappers and emperors in Ouassé are needed.

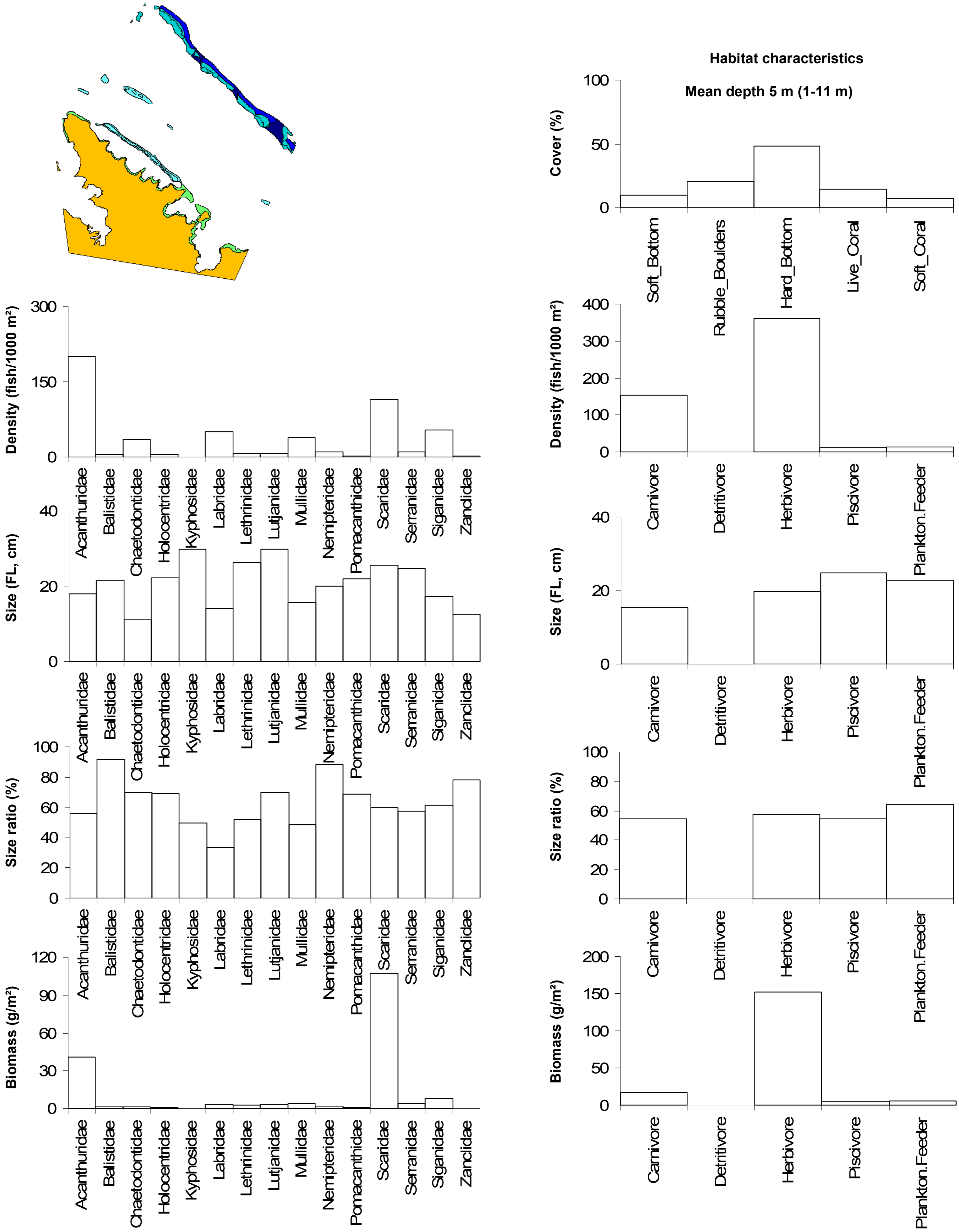

Figure 2.24: Profile of finfish resources in the combined reef habitats of Ouassé (weighted average).
FL = fork length.

2.3.2 Discussion and conclusions: finfish resources in Ouassé

- The finfish resource assessment indicated that the status of finfish resources in Ouassé is slightly better than the average across the five New Caledonia study sites. This result, combined with the sighting of a large group of very rare and vulnerable bumphead parrotfish, suggests that the area's finfish resources are relatively healthy. However, detailed assessment at reef level also revealed a systematic, lower-than-average abundance for both snappers (Lutjanidae) and emperors (Lethrinidae). Preliminary results suggest that this trend could either be due to unfavourable environmental conditions (either naturally occurring or caused by humans) for the development of these species, or to over-fishing selected carnivorous species in Ouassé.

- Overall, Ouassé finfish resources appear to be in relatively good condition. The reef habitat seems relatively rich and the ecosystem supporting finfish resources healthy.

- First signs of impacts on carnivore species (especially Lethrinidae) were visible as lower biomass and sizes in the coastal and back-reefs, where most fishing is done and gillnets are often used.

2.4 Invertebrate resource surveys: Ouassé

The diversity and abundance of invertebrate species at Ouassé were independently determined using a range of survey techniques (Table 2.12**)**: broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 2.25) and finer-scale assessment of specific reef and benthic habitats (Figures 2.26 and 2.27).

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

Table 2.12: Number of stations and replicate measures completed at Ouassé

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	11	66 transects
Reef-benthos transects (RBt)	13	78 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	2	12 transects
Mother-of-pearl searches (MOPs)	2	12 search periods
Reef-front searches (RFs)	4	24 search periods
Sea cucumber day searches (Ds)	1	6 search periods
Sea cucumber night searches (Ns)	2	12 search periods

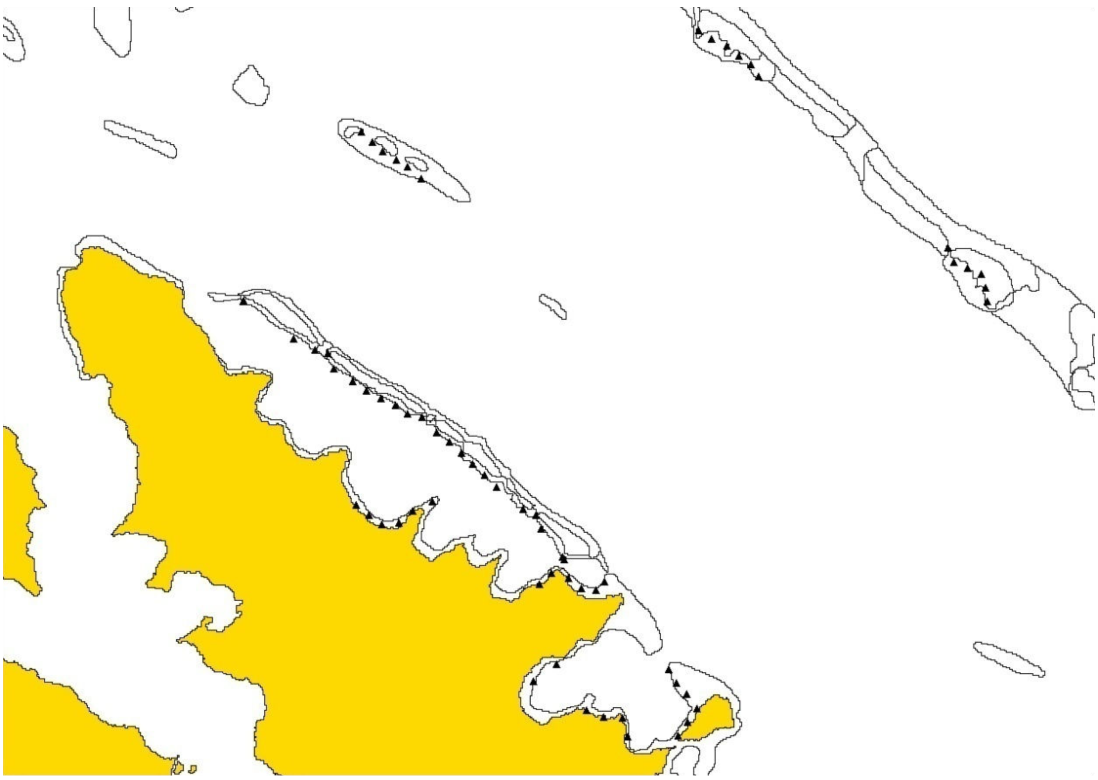

Figure 2.25: Broad-scale survey stations for invertebrates in Ouassé.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

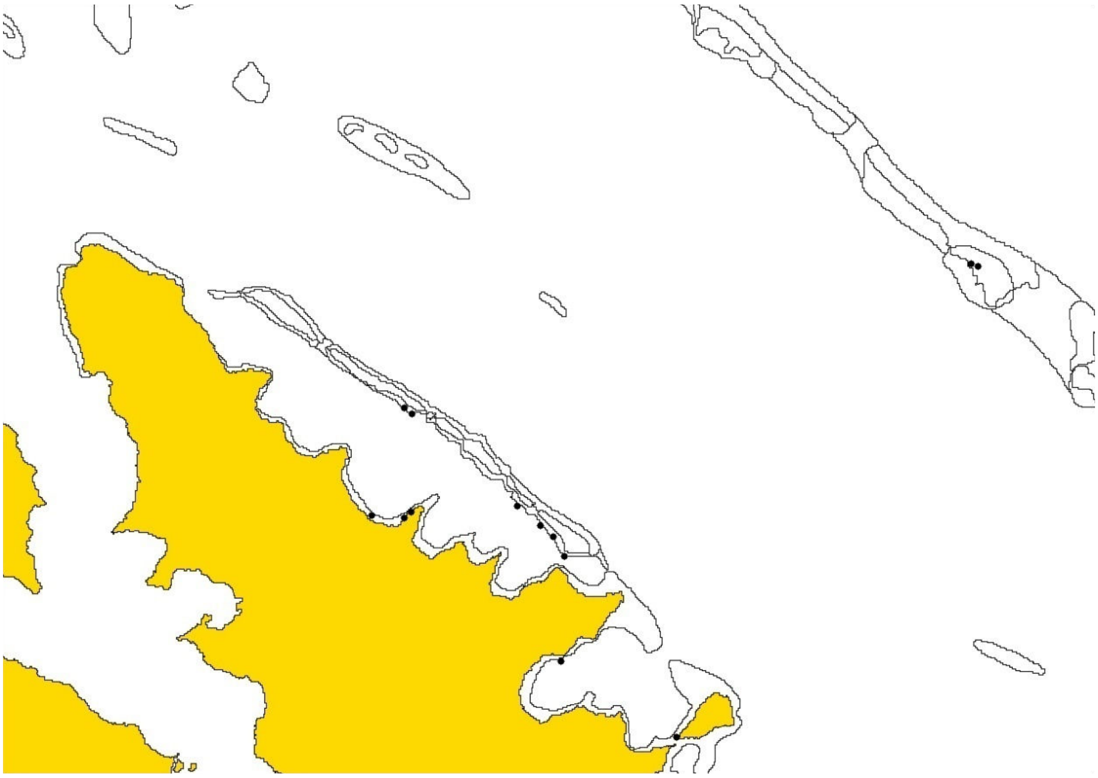

Figure 2.26: Fine-scale reef-benthos transect survey stations for invertebrates in Ouassé.
Black circles: reef-benthos transect stations (RBt).

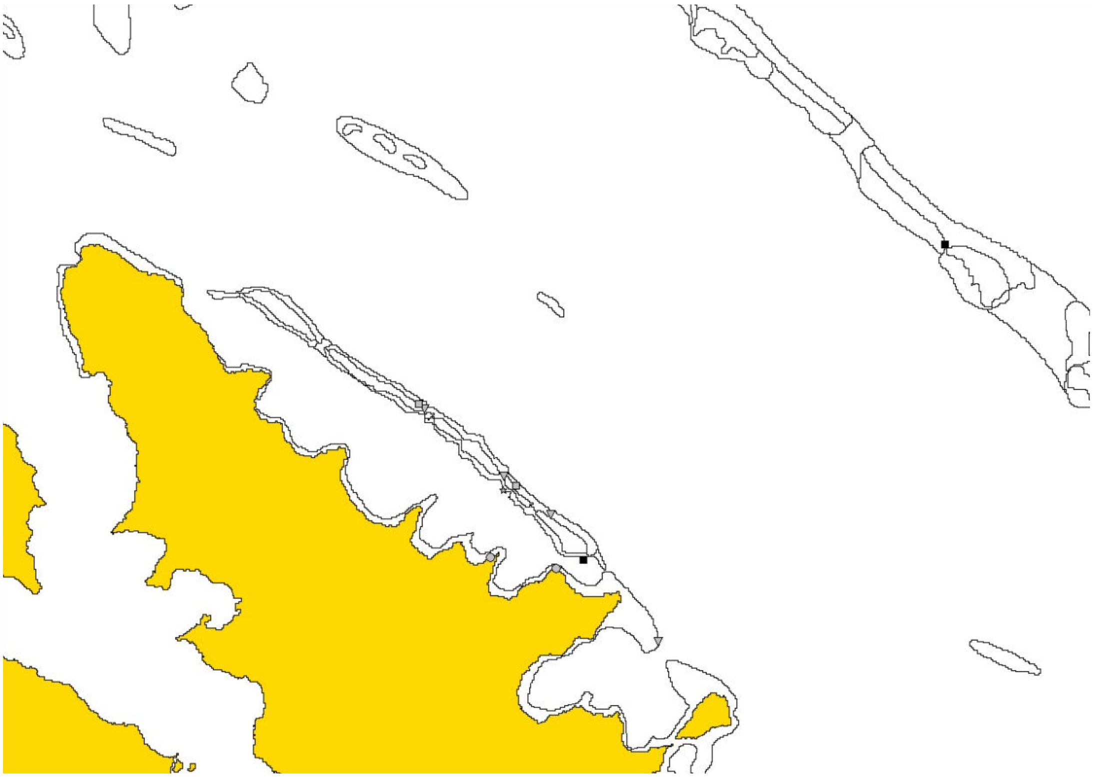

Figure 2.27: Fine-scale survey stations for invertebrates in Ouassé.
Inverted grey triangles: reef-front search stations (RFs);
grey squares: mother-of-pearl search stations (MOPs);
black squares: mother-of-pearl transect stations (MOPt);
grey stars: sea cucumber day search stations (Ds);
grey circles: sea cucumber night search stations (Ns).

Forty-nine species or species groupings (groups of species within a genus) were recorded in the Ouassé invertebrate surveys: 8 bivalves, 14 gastropods, 17 sea cucumbers, 6 urchins, 2 sea stars, 1 cnidarian and 1 lobster (Appendix 4.1.1). Information on key families and species is detailed below.

2.4.1 Giant clams: Ouassé

Broad-scale sampling provided an overview of giant clam distribution at Ouassé. Shallow reef habitat that is suitable for giant clams was extensive (22.5 km^2: 12.7 km^2 within the lagoon and 9.8 km^2 on the reef front or slope of the barrier reef). The lagoon was complex, with at least three lines of reef (including a secondary, inshore 'false' barrier) forming sectors with differing levels of land-ocean influence and exposure. In the outer lagoon there were large areas where there was unrestricted water interchange with the open ocean and water flow was dynamic.

Reefs at Ouassé held four species of giant clam: the elongate clam *Tridacna maxima*, fluted clam *T. squamosa*, boring clam *T. crocea* and the horse-hoof or bear's paw clam *Hippopus hippopus*. Records from broad-scale sampling revealed that *T. crocea* had the widest occurrence (found in 8 stations and 41 transects) followed by *T. maxima* (5 stations and 21 transects) and *T. squamosa* (4 stations and 7 transects). *H. hippopus* is well camouflaged but was still recorded at four stations (6 transects in total, Figure 2.28).

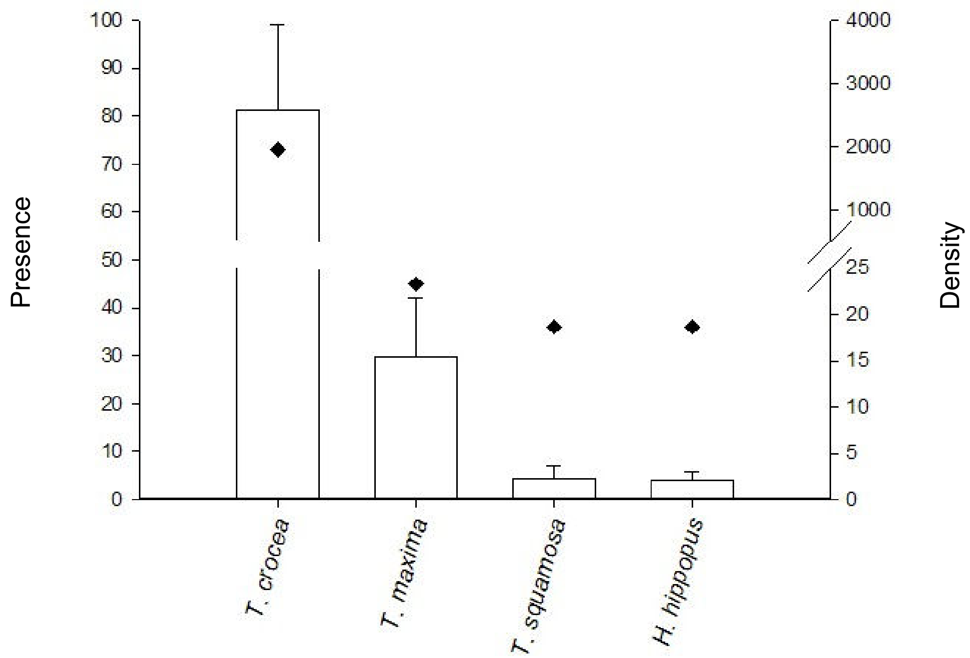

Figure 2.28: Presence and mean density of giant clam species in Ouassé based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat. At these reef-benthos transect stations (RBt), *T. crocea* were the most common (recorded in 85% of reef-benthos stations), whereas *T. maxima* was recorded in 31% of stations (Figure 2.29).

The boring clams were aggregated into patches. At the 11 stations where *T. crocea* were found, the mean density was 7678 individuals/ha ±2502, reaching a density of 44,750 /ha for a single transect (averaging >4 /m^2 over an area of 40 m^2). Thirteen *T. squamosa* were recorded in broad-scale and MOP surveys but none were found in reef-benthos surveys. *H. hippopus* were uncommon on shallow reefs (RBt), but were moderately common in broad-scale assessments.

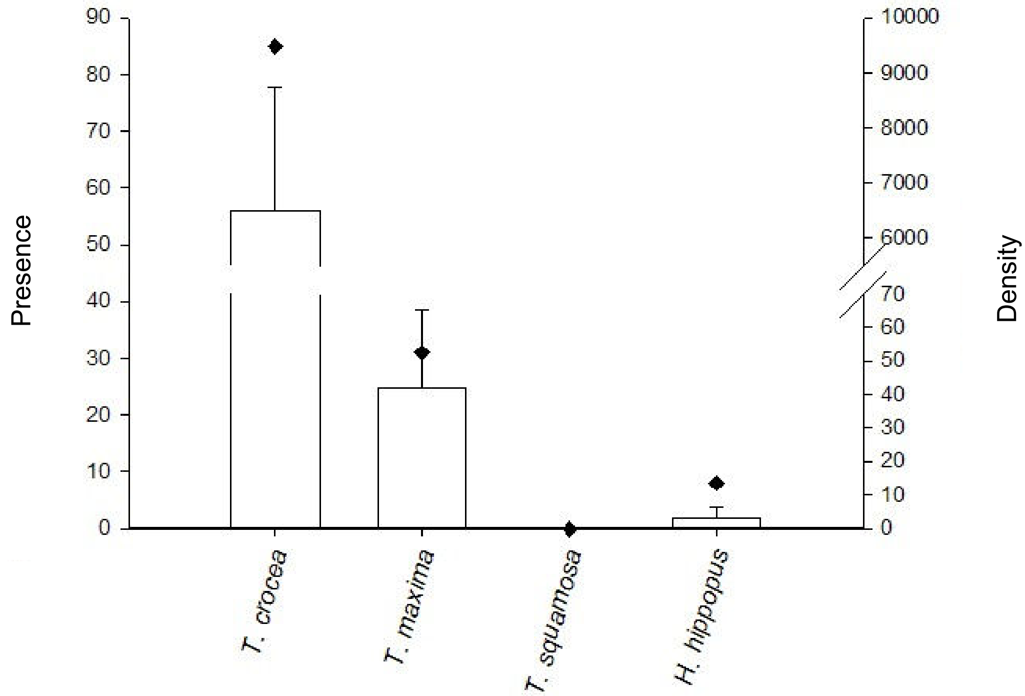

Figure 2.29: Presence and mean density of giant clam species in Ouassé based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Both small and large individuals of *T. crocea* were recorded in surveys (mean length 10 cm ±0.2). *T. maxima* from reef-benthos transects (on shallow-water reefs) had an average length of 9.8 cm ±1.9 (~4–5 years old). When clams from deeper water and more exposed locations were included in the calculation (from other assessments), the mean size increased to 14.9 cm ±0.6. The faster growing *T. squamosa* (which grow to an asymptotic length L_∞ of 40 cm) averaged 29.3 cm ±2.7 (>6 years old). *H. hippopus* found in broad-scale and reef-benthos assessments were generally large (mean 29.4 cm ±2.4), although smaller specimens of *H. hippopus* and *T. squamosa* were also recorded in survey (Figure 2.30). A creel survey of fished giant clam observed that the average wet meat weight of *H. hippopus* was almost 1 kg/individual (904 g ±193, n = 9). A single *T. squamosa* wet meat weight recording was 619 g. Both these recordings indicate that large clams are still available for fishers at Ouassé.

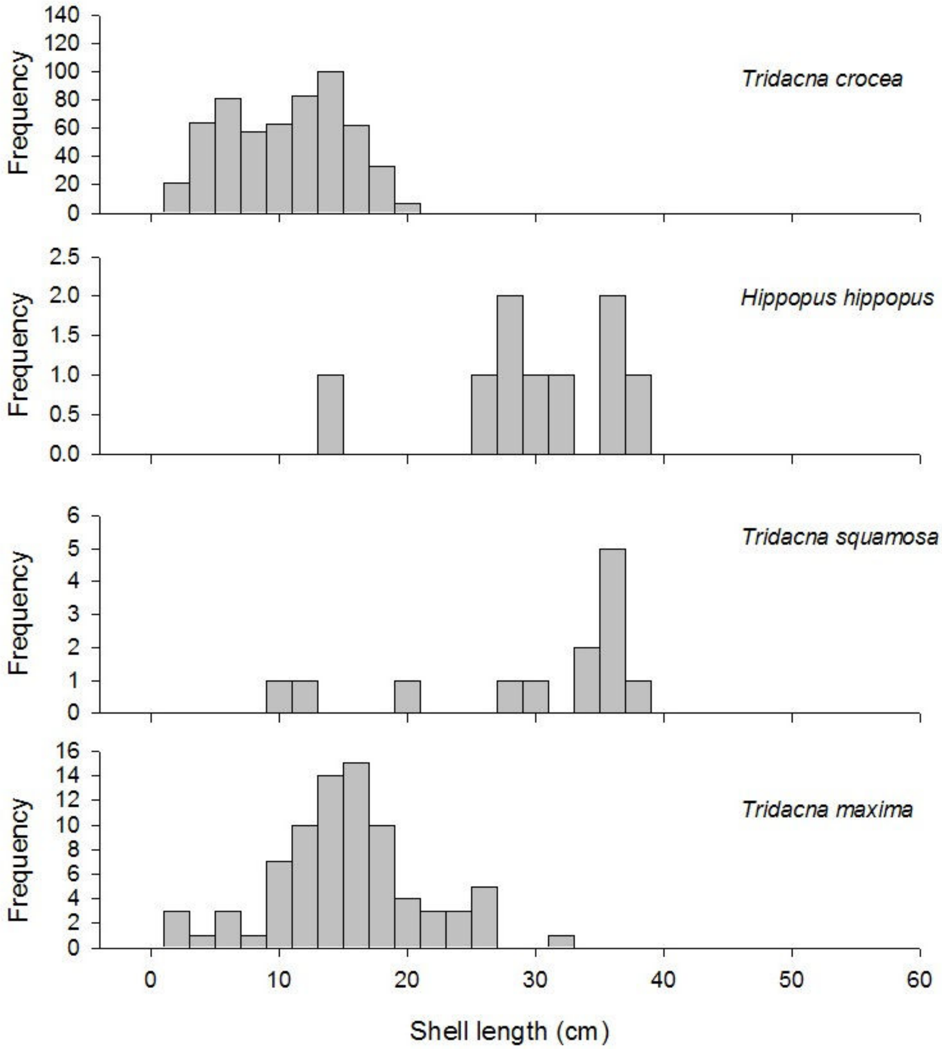

Figure 2.30: Size frequency histograms of giant clam shell length (cm) for Ouassé.

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

New Caledonia is relatively close to the southern limit of the natural distribution of the commercial topshell *Trochus niloticus* in the Pacific. The multiple reef lines at differing levels of exposure around Ouassé constitute an extensive suitable benthos for *T. niloticus* and this area could potentially support significant populations of trochus (18 km lineal distance of exposed outer reef). PROCFish survey work revealed that *T. niloticus* was present in Ouassé on both 'inner' and 'outer' reef sectors (Table 2.13).

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

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S	3.8	1.5	4/11 = 36	8/66 = 12
RBt	32.1	28.8	2/13 = 15	2/78 = 3
RFs	40.2	13.0	4/4 = 100	18/24 = 75
MOPs	0	0	0/2 = 0	0/12 = 0
MOPt	229.2	20.8	2/2 = 100	10/12 = 83
Pinctada margaritifera				
B-S	4.0	1.5	7/11 = 64	11/66 = 17
RBt	6.4	4.3	2/13 = 15	2/78 = 3
RFs	0	0	0/4 = 0	0/24 = 0
MOPs	0	0	0/2 = 0	0/12 = 0
MOPt	0	0	0/2 = 0	0/12 = 0
Tectus pyramis				
B-S	2.5	2.3	2/11 = 18	2/66 = 3
RBt	3.2	3.2	1/13 = 8	1/78 = 1
RFs	0	0	0/4 = 0	0/24 = 0
MOPs	7.6	7.6	1/2 = 50	2/12 = 17
MOPt	62.5	62.5	1/2 = 50	3/12 = 25

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

On the exposed side of the inner 'false' barrier and at the outer barrier reef, 94 trochus were found in survey. The density for the best two locations was 229 individuals/ha. These densities are too low for general commercial fishing but such aggregations of broodstock will allow stocks to rapidly regenerate if they are 'rested' from fishing. This was especially true for the 'false' barrier, where densities were highest and management potential greatest. There is a history of large harvests of trochus originating from Ouassé; on one occasion, a vehicle snapped its axle attempting to transport the trochus harvest back to Noumea.

Inner reefs that are closer to the Ouassé village can be overseen and protected from fishing by the community at Ouassé. On the other hand, anecdotal reports suggest that more remote reefs held much greater concentrations of trochus in the past but that these aggregations have been targeted by visiting divers. This is reportedly still occurring, despite the low density of trochus here today. The mean basal width of all trochus at Ouassé was 11.3 cm ±1.9 (n = 37, Figure 2.31).

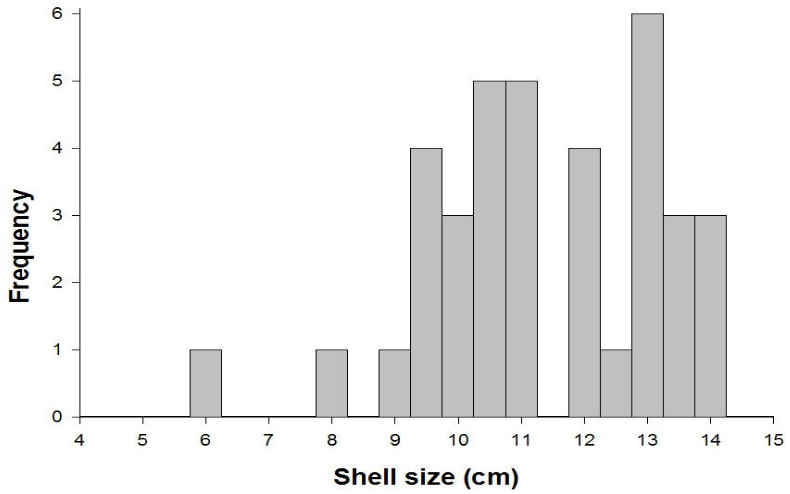

Figure 2.31: Size frequency histogram of trochus shell base diameter (cm) for Ouassé.

Despite blacklip pearl oysters (*Pinctada margaritifera*) being cryptic and generally sparsely distributed in open lagoon systems (such as Ouassé), the number of blacklip seen during assessments was relatively high (n = 18 individuals, mean anterior–posterior measure = 14.6 cm ±0.6). The green topshell (*Tectus pyramis*), a related but less valuable species than trochus (with a similar life history), was not abundant at Ouassé. The mean size (basal width) of *T. pyramis* (n = 4) was 7.3 cm ±0.3.

2.4.3 Infaunal species and groups: Ouassé

The soft benthos of the margins of the lagoon was generally stony and sandy without areas of seagrass or notable shell 'beds' for 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.

2.4.4 Other gastropods and bivalves: Ouassé

Seba's spider conch (*Lambis truncata*), the larger of the two common spider conchs, and *L. lambis* were detected in broad-scale and finer-scale surveys at reasonably high density (38 individuals recorded); however, *Strombus luhuanus* was absent (Appendices 4.1.1 to 4.1.8). The more inshore *Turbo chrysostomus* was relatively common and some *T. argyrostomus* individuals were recorded in reef-benthos stations. No *Turbo setosus* was seen in reef-front searches or MOP surveys. Other resource species targeted by fishers, e.g. *Astralium*, *Cerithium*, *Charonia*, *Conus*, *Cypraea*, *Tectus*, *Thais* and *Vasum*, were also recorded during independent surveys (Appendices 4.1.1 to 4.1.8).

Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Periglypta* and *Spondylus* spp. are also in Appendices 4.1.1 to 4.1.8. A single creel survey was conducted, which allowed us to record the weight of clam meat collected by inshore fishers fishing at the bay north of Ouassé.

2.4.5 Lobsters: Ouassé

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, lobsters were relatively common; eight P*anulirus* spp. were recorded in the survey. Two slipper lobsters *Parribacus* spp. were observed during night-time assessments for nocturnal sea cucumber species (Ns).

2.4.6 Sea cucumbers[5]: Ouassé

Ouassé has an extensive lagoon system bordering a large land mass. There was a high degree of exposure in the outer lagoon, as numerous passages and areas of submerged barrier reef linked the lagoon to the open ocean. Inner-lagoon reef areas were less exposed and subject to riverine and allochthonous input (inputs from land) and in areas this was quite significant. A full range of environmental exposure gradients was seen as one worked from the embayments on the coast outwards through the 'false barrier' to the outer lagoon. Reef margins and shallow, mixed hard- and soft-benthos habitat (suitable for sea cucumbers) was extensive in the lagoon. These habitats suited sea cucumbers, which are generally deposit feeders that eat organic matter in the upper few mm of bottom substrates.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 2.14, Appendices 4.1.1 to 4.1.8, see also Methods). Seventeen commercial species of sea cucumber were recorded during in-water assessments (Table 2.14), a similar amount to that found in other PROCFish sites on Grande Terre in New Caledonia.

Species associated with shallow reef areas, such as the leopardfish (*Bohadschia argus*) and the high-value black teatfish (*Holothuria nobilis*), were quite common at Ouassé (found in 15–39% of assessment units), indicating a stock under generally low fishing pressure. The medium/high-value greenfish (*Stichopus chloronotus*) was also relatively plentiful across most of the exposure gradient (recorded in 55% of broad-scale transects). The low-value flowerfish (*B. graeffei*) was common across the inshore reefs.

Surf redfish (*Actinopyga mauritiana*), which is found at the most exposed locations, was common but no high-density aggregations were recorded. This site has a number of habitats suitable for this species (two barrier-reef fronts with a lineal distance of 35 km).

More protected areas of reef and soft benthos in the lagoon held good densities of blackfish (*A. miliaris*) and stonefish (*A. lecanora*), plus a few lower-value species, e.g. brown sandfish (*B. vitiensis*), elephant trunkfish (*H. fuscopunctata*), lollyfish (*H. atra*) and pinkfish (*H. edulis*).

A single deep (25–35 m) dive on SCUBA was conducted to obtain a preliminary assessment of deep-water stocks, such as the high-value white teatfish (*H. fuscogilva*) and the lower-value amberfish (*T. anax*). In this assessment (average 24.3 m in depth) white teatfish (*H. fuscogilva*) and amberfish (*T. anax*) were present at low density. Also found at reasonable density at depth was *H. flavomaculata*, a species which resembles *H. coluber* but has red spots on the ends of its bodily projections. The passage dived was a breach in the 'false'

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

barrier, within the main body of the lagoon and relatively close to the coast. An exploration of areas further offshore (with greater influence from oceanic conditions) would be useful to further assess deep-water stocks and the presence of the prickly redfish *T. ananas*.

2.4.7 Other echinoderms: Ouassé

Edible urchins, such as the slate urchin (*Heterocentrotus mammillatus*) and collector urchin (*Tripneustes gratilla*) were recorded in Ouassé at low levels. Other urchins that can be used within assessments as potential indicators of habitat condition (*Echinometra mathaei* and *Echinothrix* spp.) were recorded at relatively low levels in survey.

The blue starfish (*Linckia laevigata*) was commonly recorded in survey (in 82% of broad-scale stations). Corallivorous (coral-eating) starfish were rare, with only one pincushion star (*Culcita novaeguineae*) and no crown of thorns (*Acanthaster planci*, COTS) recorded in Ouassé (See presence and density estimates in Appendices 4.1.1 to 4.1.8.).

Table 2.14: Sea cucumber species records for Ouassé

Species	Common name	Commercial value [5]	B-S transects n = 66			Reef-benthos stations n = 13			Other stations RFs = 4; MOPs = 2; MOPt = 2			Other stations Ds = 1; Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H												
Actinopyga lecanora	Stonefish	M/H	0.3	16.7	2	6.4	41.7	15				35.6	71.1	50 Ns
Actinopyga mauritiana	Surf redfish	M/H	2.8	45.6	6				18.6 10.4	18.6 20.8	100 RFs 50 MOPt			
Actinopyga miliaris	Blackfish	M/H	3.2	21.1	15	35.3	152.8	23	7.6	15.2	50 MOPs	88.9	99.9	100 Ns
Actinopyga palauensis	No name as yet	M	3.0	33.3	9									
Actinopyga spinea		M/H												
Bohadschia argus	Leopardfish	M	43.9	111.5	39	28.8	93.8	31	3.8	7.6	50 MOPs	8.9	17.8	50 Ns
Bohadschia graeffei	Flowerfish	L	175.5	304.7	58	22.4	72.9	31	1.0 7.6 20.8	3.9 15.2 41.7	25 RFs 50 MOPs 50 MOPt	4.4	8.9	50 Ns
Bohadschia similis	False sandfish	L												
Bohadschia vitiensis	Brown sandfish	L	2.9	27.8	11									
Holothuria atra	Lollyfish	L	36.3	60.0	61	214.7	253.8	85	2.0 3.8	7.8 7.6	25 RFs 50 MOPs			
Holothuria coluber	Snakefish	L	3.7	18.9	20	3.2	41.7	8						
Holothuria edulis	Pinkfish	L	57.7	119.0	20	83.3	120.4	69	3.8	7.6	50 MOPs			
Holothuria flavomaculata	-	L										Recorded out of assessment		
Holothuria fuscogilva [4]	White teatfish	H										2.4	2.4	100 Ds
Holothuria fuscopunctata	Elephant trunkfish	M	9.2	43.5	21							2.4	2.4	100 Ds
Holothuria nobilis [4]	Black teatfish	H	5.3	23.3	23	9.6	62.5	15	3.8 10.4	7.6 20.8	50 MOPs 50 MOPt			
Holothuria scabra	Sandfish	H												
Holothuria scabra versicolor	Golden sandfish	H												
Stichopus chloronotus	Greenfish	H/M	127.1	233.1	55	166.7	541.7	31	31.3	62.5	50 MOPt			
Stichopus hermanni	Curryfish	H/M	0.8	16.7	5							7.1	7.1	100 Ds
Stichopus horrens	Dragonfish	M/L												
Thelenota ananas	Prickly redfish	H	0.5	16.7	3									
Thelenota anax	Amberfish	M										4.8	4.8	100 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; MOPs = mother-of-pearl search; MOPt = mother-of-pearl transect; Ds = sea cucumber day search; Ns = sea cucumber night search.

2.4.8 Discussion and conclusions: invertebrate resources in Ouassé

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.

- In general, the range of giant clam species, their occurrence across the site, and the density of aggregations indicate that giant clam stocks in Ouassé are only marginally impacted by fishing.

- Moderate exploitation is most evident in the lower abundance of the larger species *Tridacna squamosa* and *Hippopus hippopus*.

- Shell size ranges of *T. maxima* and the larger clam species show that fishing is occurring. Giant clams are protandrous hermaphrodites, which means that only larger, older individuals produce eggs. Therefore, to sustain healthy populations of clams, larger, older individuals are needed.

- *T. crocea* are well suited to the embayments at Ouassé and represent a healthy, non-impacted stock.

- Data on MOP distribution, density and shell size suggest that trochus (*Trochus niloticus*) are relatively common at Ouassé, especially on the mid-shore 'false' barrier reef. However, present densities of trochus are too low to support commercial fishing, and stocks should be rested from commercial fishing until densities at the best locations reach ~500 trochus/ha.

- At present, the regulations in New Caledonia prohibit the sale of trochus <9 cm in shell basal width. Consideration may be given to protecting the larger size classes of trochus (≥12 cm), which are valuable spawners (produce large numbers of eggs) and are not preferred by industry buyers (because their shells are too thick and often damaged by boring sponge). This clause was included in the fisheries regulations in the 1980s but was removed in 1991. The removal of this regulation is not common knowledge and most fishers and agents still respect this useful control.

- The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common, while *Tectus pyramis* was less abundant than might be expected.

- The presence of a wide range of sea cucumber stocks reflected the varied environment of the extensive east coast lagoon at Ouassé.

- The presence and density data on commercial sea cucumber species collected in survey show that there is limited pressure on stocks from commercialisation and that stocks are only marginally impacted by fishing.

2.5 Overall recommendations for Ouassé

- Further studies are needed to find out why snappers (Lutjanidae) and emperors (Lethrinidae) are systematically lower in abundance in Ouassé than the regional average. Until further information is available, a precautionary approach to fisheries management may consist in limiting the catches of snappers and emperors. The efficiency of this trial should then be evaluated by closely monitoring these resources.

- Marine resource management measures and monitoring activities be undertaken to accompany any expansion in finfish fishing to ensure that finfish remain available for subsistence use by future generations.

- Considering the high quality of habitat in Ouassé, marine protected areas be considered as a primary management tool.

- The use of gillnets be controlled in the shallow lagoons and back-reefs, which are the areas under most pressure from fishing.

- Trochus stocks be rested from commercial fishing until densities double at the best locations (until they reach ~500 trochus/ha). The abundance of smaller-sized shells on the reef be monitored to get an indication if there is any upcoming strong recruitment to the fishery. Consideration may be given to protecting the larger size classes of trochus (≥12 cm), which are valuable spawners (produce large numbers of eggs) and are not preferred by industry buyers.

- Further dive assessments be completed both in the more protected inshore lagoon and at more exposed locations to get an indication of the extent and strength of deep-water stocks of high-value white teatfish (*Holothuria fuscogilva*) in Ouassé.

3. PROFILE AND RESULTS FOR THIO

3.1 Site characteristics

The survey site called 'Thio' in this report (22 km x 10 km), actually centres on Port Bouquet (21°43′35″S and 166°26′15″E), whose fishing ground includes the bay of Thio and the barrier reef located between Toupeti pass and north Ngoé pass (Figure 3.1). Here the geomorphology is quite characteristic, with a bay formed by high islands and long intermediate reefs offering 360° protection. Terrigenous (land-based) effects are very important here, in the form of siltation washed from the nearby mines. Each clan owns its own fishing area; however, shared associations among fishers make it difficult to define precise sectors as exclusive to specific clans. To simplify, we can define this area as exclusive to the combined set of clans. The exploitation of the lagoon is for commercial as well as subsistence purposes.

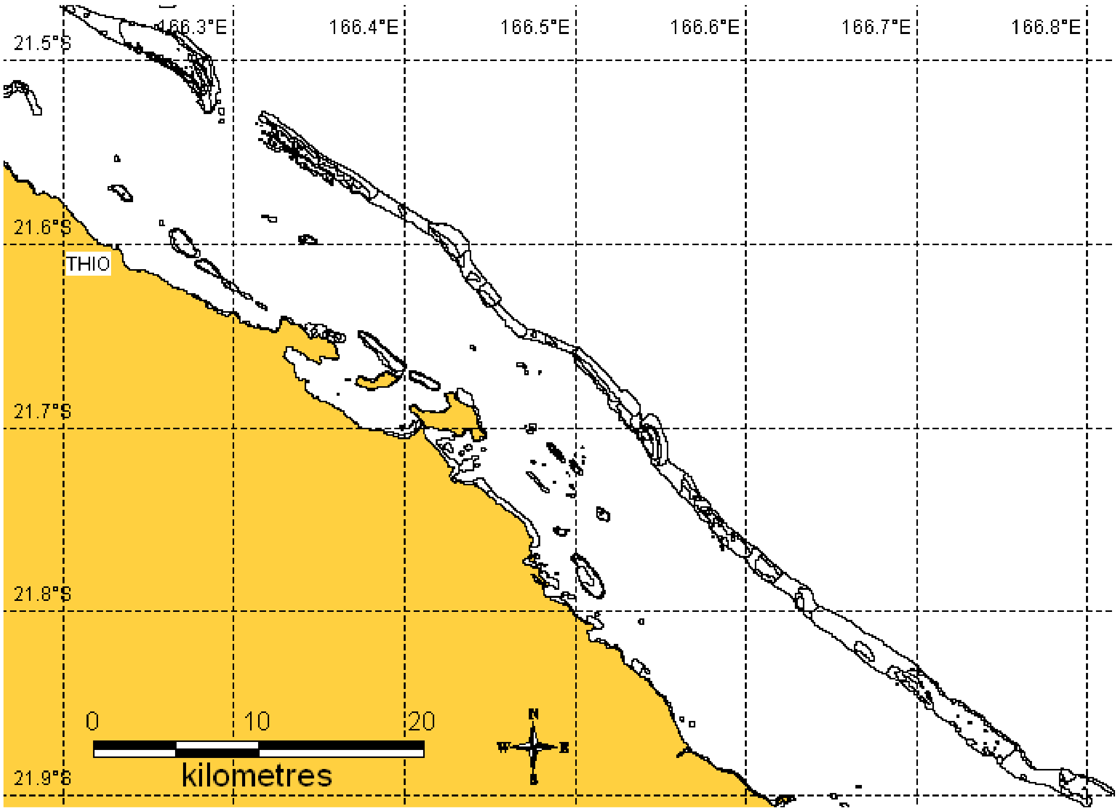

Figure 3.1: Map of Thio.

3.2 Socioeconomic surveys: Thio

Socioeconomic fieldwork was carried out in the Thio community during June – July 2003. The survey covered 42 households, including 111 people. Thus, the survey represents about 59% of the community's households (71) and total population (188).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 40 individual interviews of finfish fishers (males only) and 25 invertebrate fishers (14 males, 11 females) were conducted. These fishers belonged to one of the 42 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing.

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

Our survey results (Table 3.1) suggest an average of 1.6 fishers/household. If we apply this average to the total number of households, we arrive at a total of 114 fishers in Thio. Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of 18 fishers who only fish for finfish (males, females), a total of 18 fishers who only fish for invertebrates (females) and 78 fishers (males, females) who fish for both finfish and invertebrates.

About 45% of all households in Thio own a boat; most (95%) are motorised and 5% are canoes.

Ranked income sources (Figure 3.2) suggest that fisheries are one of the most important sectors. Almost half (47.6%) of all households indicated that fisheries is their first source of income, and another ~36% of all households surveyed rely on fisheries for secondary income. In addition, other sources, such as small business retirement and social fees are also important first (~36%) and second (19%) income sources, and salaries are important as first income source (19%). Agriculture does not play any major role for income generation in Thio.

The importance of fisheries also shows in the fact that all households consume fresh fish and invertebrates. Also, all households reported that the fresh fish and the invertebrates they eat are mostly caught by a member of their household. In addition, most households (95%) also eat fresh fish and invertebrates (67%) that are given on a non-commercial basis. Seafood is rarely bought within the community. Accordingly, households that depend on fisheries for first or secondary income target markets external to the Thio community.

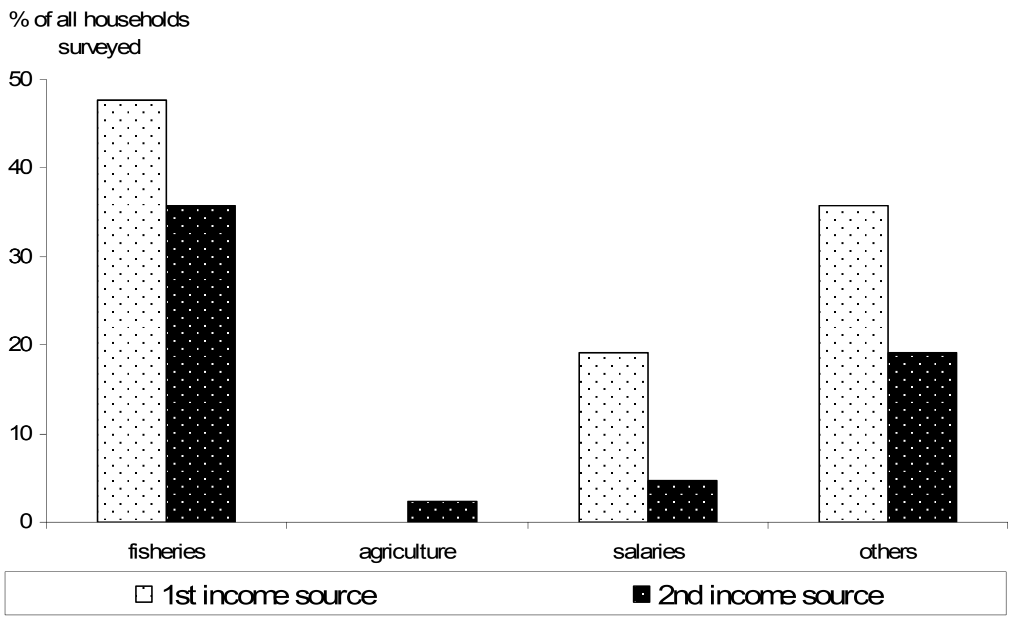

Figure 3.2: Ranked sources of income (%) in Thio.
Total number of households = 42 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses and retirement and social fees.

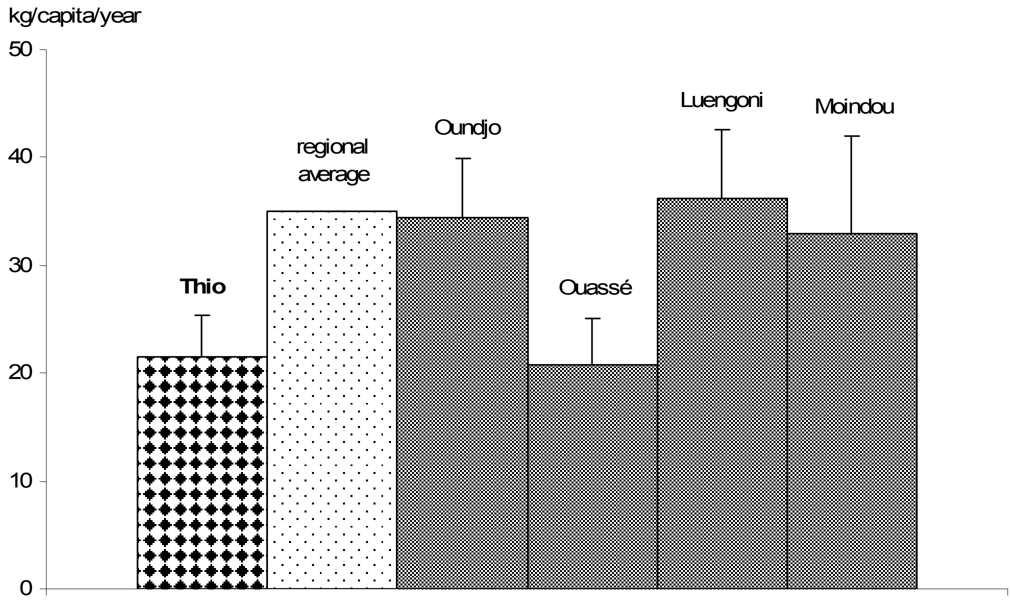

Figure 3.3: Per capita consumption (kg/year) of fresh fish in Thio (n = 42) compared to the regional average (FAO 2008) and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

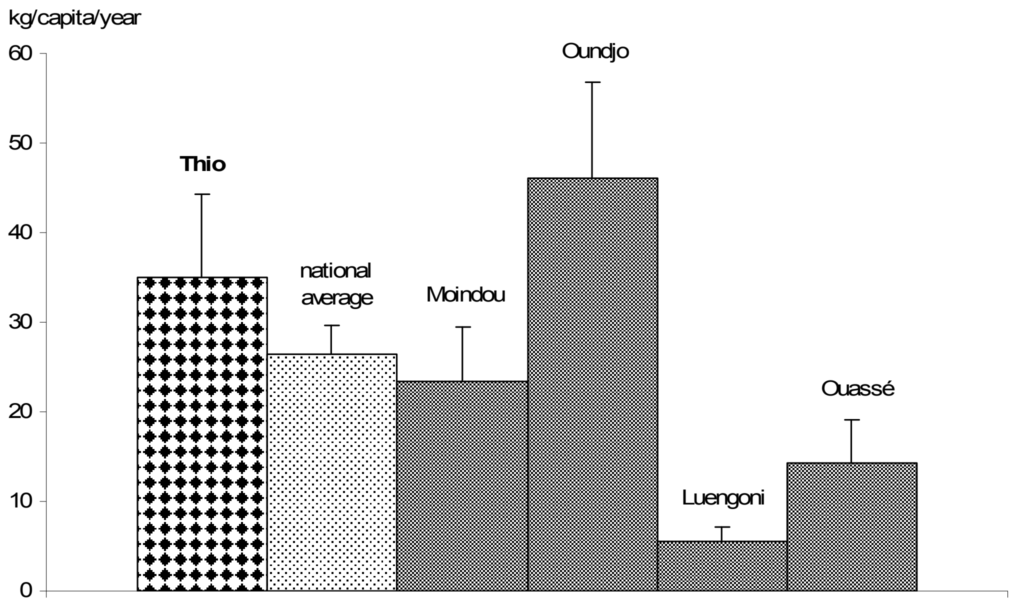

Figure 3.4: Per capita consumption (kg/year) of invertebrates (meat only) in Thio (n = 42) compared to the national average and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Fresh-fish consumption in Thio (~22 kg/person/year ±3.8) is significantly below the regional average (FAO 2008) (Figure 3.3). It is lower than the average across all five country sites, and similar to the consumption observed for Ouassé. This low consumption rate is surprising given the high dependency on fisheries for income generation and the high engagement of the household members in supplying seafood for subsistence purposes. However, the Thio community also enjoys a rich and diverse agricultural production, although mainly for subsistence purposes. In contrast, Thio's people consume a lot of invertebrates (35 kg/person/year) (Figure 3.4), exceeding the fresh-fish consumption rate by almost 60% and among the highest of all PROCFish sites surveyed in New Caledonia.

Also, comparing results across all sites investigated in New Caledonia (Table 3.1), the people of Thio eat fresh fish and, to some extent, invertebrates more frequently but in less quantities than observed on average.

The average annual household expenditure level in Thio is only about half of the country average estimated by the PROCFish surveys, and the influx of external money (remittances) is very low.

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

Survey coverage	Thio (n = 42 HH)	Average across sites (n = 148 HH)
Demography		
HH involved in reef fisheries (%)	97.6	94.6
Number of fishers per HH	1.6 (±0.11)	1.6 (±0.08)
Male finfish fishers per HH (%)	12.3	29.6
Female finfish fishers per HH (%)	3.1	3.3
Male invertebrate fishers per HH (%)	0.0	2.5
Female invertebrate fishers per HH (%)	15.4	16.3
Male finfish and invertebrate fishers per HH (%)	47.7	32.5
Female finfish and invertebrate fishers per HH (%)	21.5	15.8
Income		
HH with fisheries as 1st income (%)	47.6	27.0
HH with fisheries as 2nd income (%)	35.7	23.6
HH with agriculture as 1st income (%)	0.0	2.0
HH with agriculture as 2nd income (%)	2.4	6.1
HH with salary as 1st income (%)	19.0	37.2
HH with salary as 2nd income (%)	4.8	6.1
HH with other source as 1st income (%)	35.7	37.8
HH with other source as 2nd income (%)	19.0	16.9
Expenditure (USD/year/HH)	3896.47 (±573.63)	6587.71 (±456.24)
Remittance (USD/year/HH) (1)	518.78 (n/a)	1802.97 (±766.61)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	21.57 (±3.81)	29.81 (±3.16)
Frequency fresh fish consumed (times/week)	2.55 (±0.21)	2.35 (±0.13)
Quantity fresh invertebrate consumed (kg/capita/year)	34.99 (±9.33)	26.46 (±3.16)
Frequency fresh invertebrate consumed (times/week)	0.97 (±0.09)	0.88 (±0.07)
Quantity canned fish consumed (kg/capita/year)	4.68 (±0.82)	6.69 (±1.32)
Frequency canned fish consumed (times/week)	1.19 (±0.16)	1.35 (±0.14)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	100.0	88.5
HH eat canned fish (%)	95.2	82.4
HH eat fresh fish they catch (%)	100.0	83.3
HH eat fresh fish they buy (%)	2.4	10.0
HH eat fresh fish they are given (%)	78.6	70.0
HH eat fresh invertebrates they catch (%)	97.6	46.7
HH eat fresh invertebrates they buy (%)	2.4	3.3
HH eat fresh invertebrates they are given (%)	66.7	36.7

HH = household; (1) average sum for households that receive remittances; numbers in brackets are standard error; n/a = standard error not calculated.

3.2.2 Fishing strategies and gear: Thio

Degree of specialisation in fishing

Fishing in Thio is performed by both males and females (Figure 3.5). Most fishers, namely ~48% of all males and ~22% of all females, target both finfish and invertebrates. Twelve per cent of male fishers but only 3% of female fishers exclusively target finfish. In contrast, the 15% of all fishers who exclusively collect invertebrates are females only.

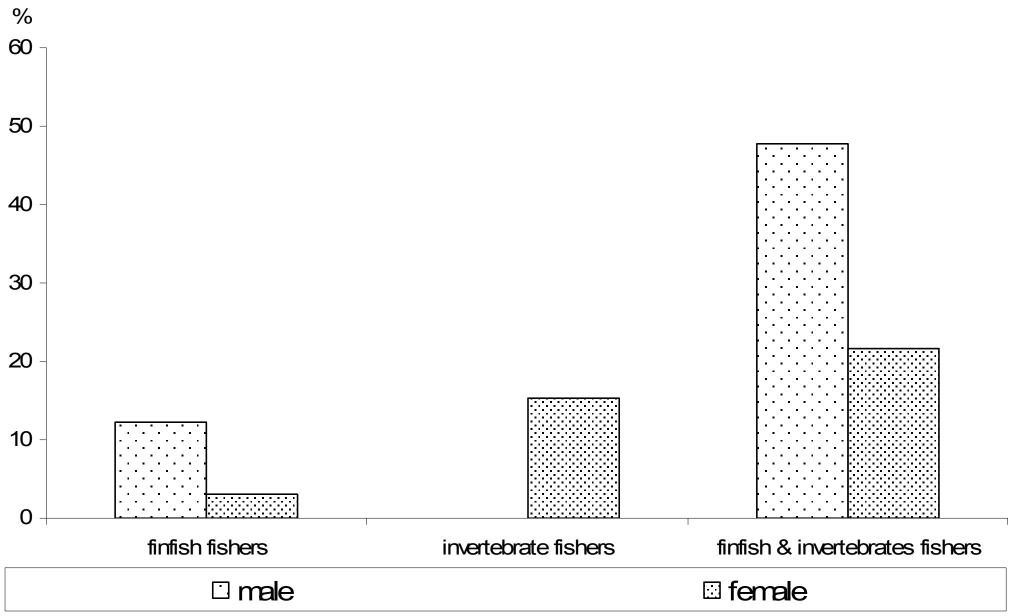

Figure 3.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Thio.
All fishers = 100%.

Targeted stocks/habitats

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	72.5	0.0
	Sheltered coastal reef & lagoon	25.0	0.0
	Lagoon	10.0	0.0
	Outer reef	7.5	0.0
Invertebrates	Bêche-de-mer	14.3	18.2
	Bêche-de-mer & trochus	14.3	0.0
	Bêche-de-mer & trochus & lobster & other	7.1	0.0
	Lobster	57.1	27.3
	Lobster & other	7.1	0.0
	Mangrove	0.0	18.2
	Other	50.0	27.3
	Reeftop	42.9	81.8
	Reeftop & other	0.0	9.1
	Soft bottom (sand)	7.1	9.1
	Trochus	14.3	0.0
	Trochus & other	14.3	9.1

'Other' refers to the giant clam and octopus fisheries.
Finfish fisher interviews, males: n = 40; females: n = 0. Invertebrate fisher interviews, males: n = 14; females, n = 11.

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 Thio on their fishing grounds.

Our survey sample suggests that fishers in Thio can choose among sheltered coastal reef, lagoon and outer-reef habitats. Some combine the sheltered coastal reef and lagoon in one fishing trip. Most fishers, however, target the sheltered coastal reef and the combined sheltered coastal reef and lagoon areas. Only 10% of male fishers target the lagoon, and 7.5% the outer reef (Table 3.2).

About half the invertebrate fishers glean; the other half dive to collect selected species (Figure 3.6). Invertebrate fishers mainly target reeftops (>80% of all females and >40% of all males). Some female fishers target mangrove areas (~18%) and collect shells on soft bottom (sandy intertidal areas) (~9%). Only males free-dive for invertebrates. Diving for lobsters engages most of these male fishers (>57%) as well as other fisheries, i.e. giant clam and octopus collection (>50%). Some female fishers also collect lobsters by hand, when walking on the reeftop. A few male fishers specialise in bêche-de-mer fishing (~14% of all male fishers); bêche-de-mer harvesting in combination with trochus (~14%); and lobster, giant clam and octopus diving (~7%) (Figure 3.7).

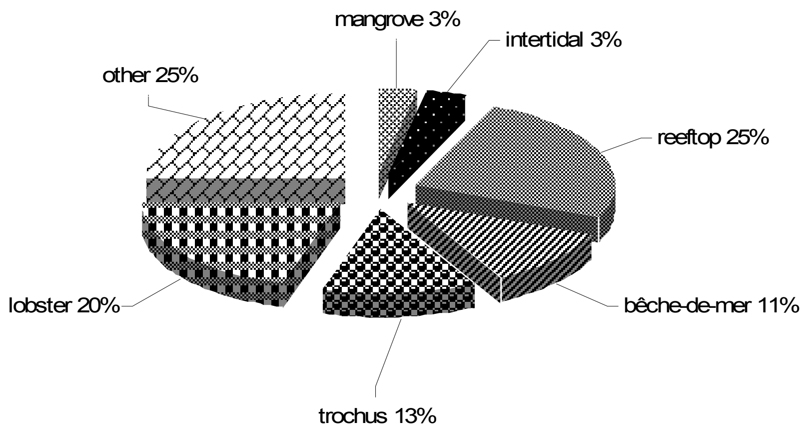

Figure 3.6: Proportion (%) of fishers targeting the seven primary invertebrate habitats found in Thio.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the giant clam and octopus fisheries.

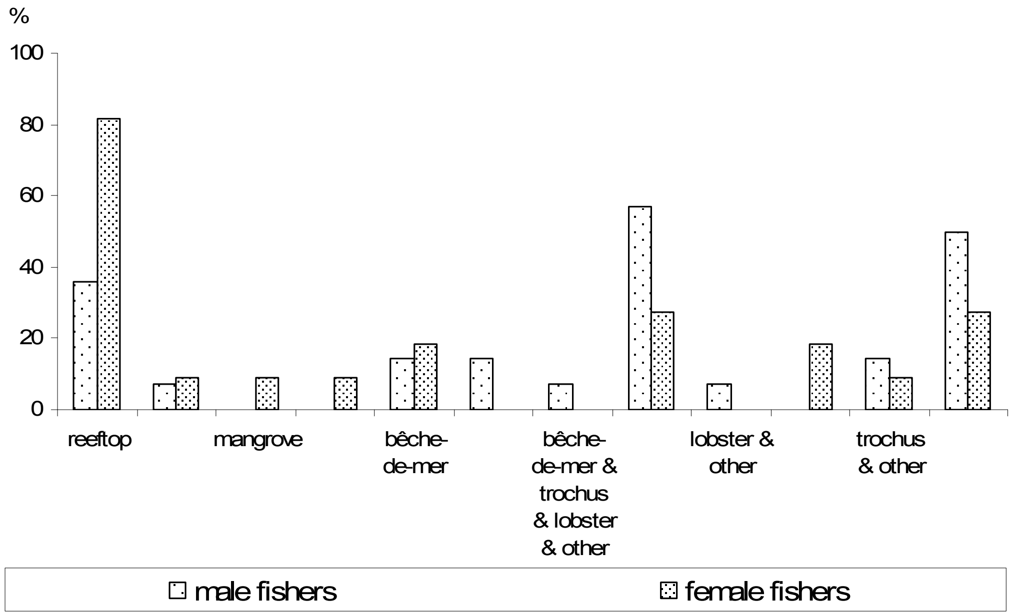

Figure 3.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Thio.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers who target each habitat: n = 14 for males, n = 11 for females; 'other' refers to the giant clam and octopus fisheries.

Gear

Figure 3.8 shows a difference between fishing techniques used at the sheltered coastal reef and lagoon as compared to the outer reef. In the first two habitats a combination of many possible techniques, including handlines, gillnets, castnets and various spears are used. At the outer reef, fishers use only two techniques in combination, that is mainly gillnets and handlines, or gillnets and spears.

Gleaning and free-diving for invertebrates is done using very simple tools only. Lobsters and octopus are often speared, while trochus, bêche-de-mer and many other species collected on reeftops are picked up by hand. Diving involves only mask, snorkel, fins and, possibly, a wet suit. Motorised boat transport is used for bêche-de-mer, lobster and other dive fisheries, and mangrove and reeftop collection. Some reeftop and other gleaning is done by walking; canoes are rarely used.

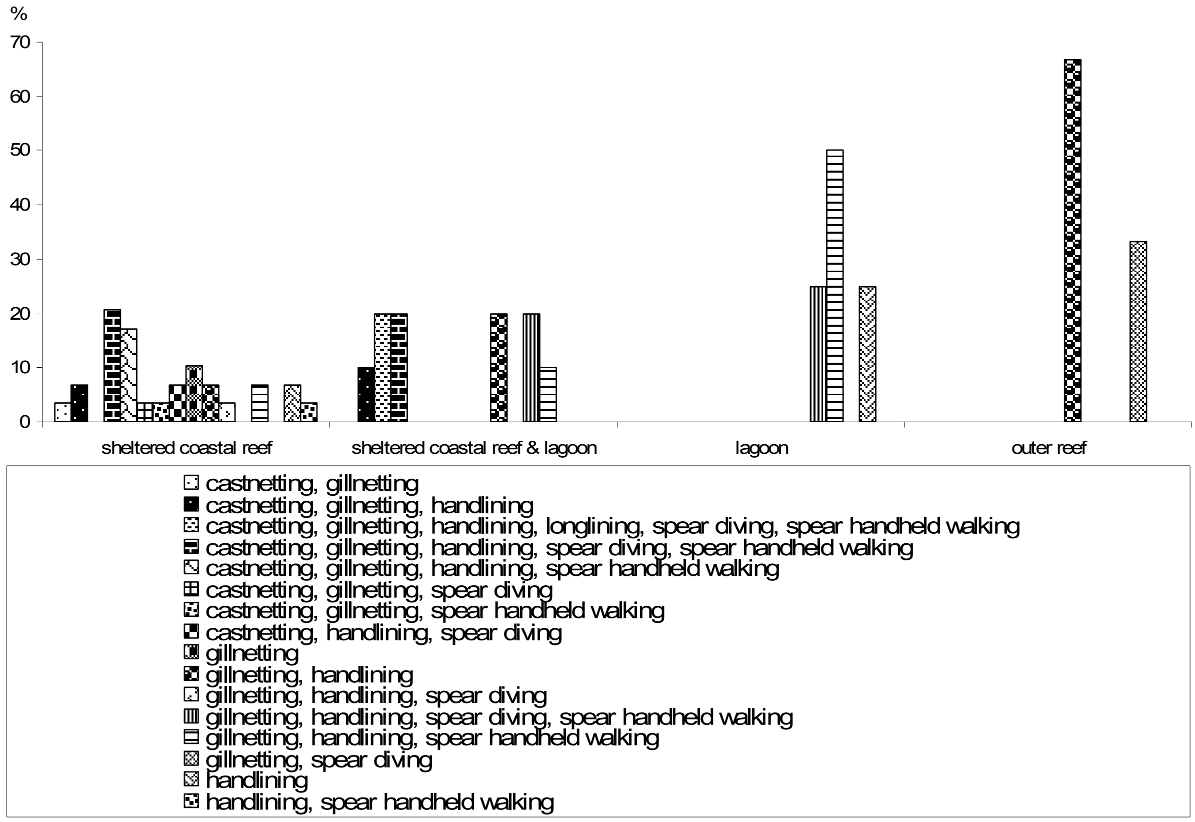

Figure 3.8: Fishing methods commonly used in different habitat types in Thio.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Frequency and duration of fishing trips

As shown in Table 3.3, the fishing trips to the outer reef are the least frequent and all other habitats are targeted 1–1.5 times/week. However, fishing trips to the outer reef on average take about one hour more than to all other habitats, i.e. 4.6 hours/trip as compared to 3.6–3.9 hours/trip to the sheltered coastal reef and lagoon. Because female finfish fishers were not included in this survey, no comparison can be made between genders.

Overall, invertebrate collection trips are less frequent than finfish fishing trips. Lobster fishing (~1.5 times/week) and diving for giant clams and octopus (1.4 times/week) are the most frequent. Female collectors usually go out every second week. The average trip duration varies considerably among target species. For example, lobster dive trips take about four hours on average, while bêche-de-mer and trochus collection trips last for six hours on average. Gleaning activities are generally shorter (2–4 hours).

Finfish is usually caught according to the tides (hence at day or night) except for outer reef fishing, which is mainly performed during the day. While finfish fishers usually catch fish throughout the year, outer-reef fishing is more dependent upon tidal and weather conditions and hence often disrupted. Female fishers mainly fish during the day.

Most invertebrate fishing is done only during the day. However, there are some exceptions, such as lobster and other dive fisheries, which may be performed at night. Most invertebrate fishers harvest throughout the year. In the case of lobster, bêche-de-mer and gleaning activities, interruptions due to adverse weather and seasonal conditions are frequent.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	1.40 (±0.18)		3.66 (±0.29)	
	Sheltered coastal reef & lagoon	1.69 (±0.28)	0	3.85 (±0.39)	0
	Lagoon	0.99 (±0.54)	0	3.75 (±0.14)	0
	Outer reef	0.49 (±0.28)	0	4.67 (±0.67)	0
Invertebrates	Bêche-de-mer	0.29 (±0.17)	0.23 (±0.00)	4.50 (±0.50)	4.00 (±2.00)
	Bêche-de-mer & trochus	0.46 (±0.00)	0	6.00 (±0.00)	0
	Bêche-de-mer & trochus & lobster & other	0.23 (n/a)	0	2.00 (n/a)	0
	Lobster	1.52 (±0.32)	0.54 (±0.27)	3.88 (±0.40)	3.33 (±0.67)
	Lobster & other	1.00 (n/a)	0	2.00 (n/a)	0
	Mangrove	0	1.01 (±0.99)	0	2.25 (±0.25)
	Other	1.39 (±0.51)	1.67 (±0.44)	3.29 (±0.29)	4.00 (±0.00)
	Reeftop	0.81 (±0.29)	0.46 (±0.21)	2.08 (±0.27)	4.06 (±0.44)
	Reeftop & other	0	0.46 (n/a)	0	6.00 (n/a)
	Soft bottom (sand)	0.23 (n/a)	0.10 (n/a)	3.00 (n/a)	4.00 (n/a)
	Trochus	1.06 (±0.94)	0	4.50 (±0.50)	0
	Trochus & other	1.50 (±0.50)	3.00 (n/a)	4.00 (±2.00)	3.00 (n/a)

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam and octopus fisheries.
Finfish fisher interviews, males: n = 40; females: n = 0. Invertebrate fisher interviews, males: n = 14; females: n = 11.

3.2.3 Catch composition and volume – finfish: Thio

Catches from the sheltered coastal reef are dominated (~58% of total reported catch) by four major groups: *bec-de-cane* (*Lethrinus* spp.), *mulet* (*Crenimugil crenilabis*), *saumonée* (*Plectropomus* spp.) and *loche* (*Epinephelus* spp.). *Dawa* (*Naso unicornis*), *bossu* (*Lethrinus* spp.), *perroquet* (*Scarus* spp.) and *picot* (*Siganus* spp.) determine another ~29% of the reported catches. All other vernacular fish groups reported by vernacular name only constitute 12–13% of the total catch from the sheltered coastal reef. Catch composition reported for lagoon fishing is less diverse and mainly consists of eight reported species groups. Of these eight, the following six determine most the catch (~99%): *bossu* (*Lethrinus* spp.), *perroquet* (*Scarus* spp.), *picot* (*Siganus* spp.), *saumonée* (*Plectropomus* spp.), *bec-de-cane* (*Lethrinus* spp.) and *loche* (*Epinephelus* spp.). At the outer reef, only five fish groups were reported, with *perroquet* (*Scarus* spp.) and *dawa* (*Naso unicornis*) alone representing >68% of the total reported catch. The remaining shares are determined by *vivaneau* (*Lipocheilus* spp.), *saumonée* (*Plectropomus* spp.) and *bec-de-cane* (*Lethrinus* spp.) (Detailed data are provided in Appendix 2.2.1.).

Our survey sample of finfish fishers interviewed represents about 60% of the projected total number of finfish fishers in Thio. Our survey included all commercial and subsistence fishers. Hence our results largely represent the overall impact of reef fisheries imposed by the community members of Thio on their fishing ground. Fishers not included in this survey are leisure fishers, who may or may not fish regularly and only for subsistence purposes. Hence, the impact not captured here is presumably small or negligible.

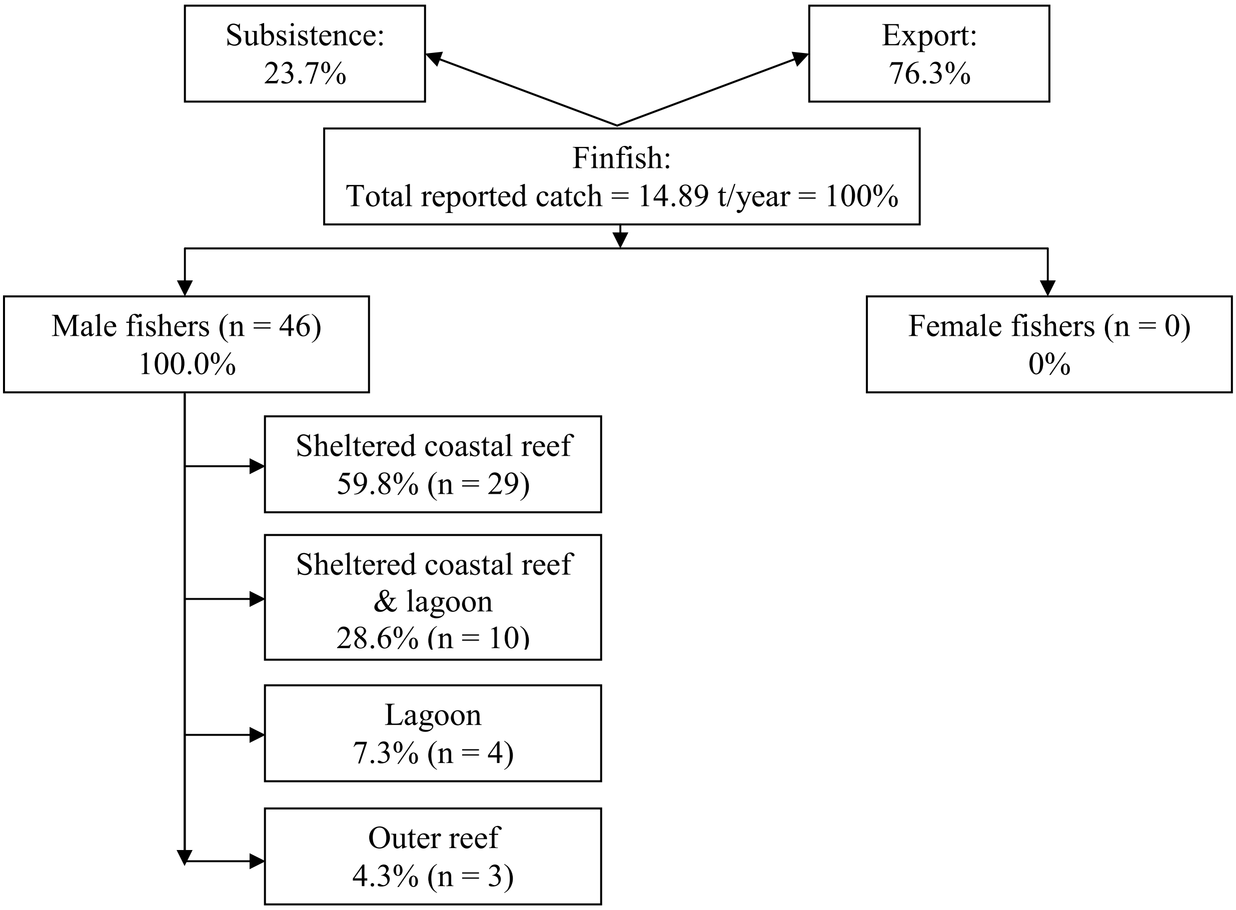

Figure 3.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Thio.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and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

As shown in Figure 3.9 most impact is due to commercial fishing, i.e. catches that are sold outside the Thio community (>76% of the total annual reported catch, or 11.4 t/year). Subsistence needs only determine about 24% of all catches, corresponding to a total annual consumption of about 5.1 t. Most of the catch is taken by male fishers; females only play a minor role (Note that, although females were not included in this survey, some do occasionally fish to provide fresh fish for the household). Highest pressure is imposed on the sheltered coastal reef and, to some extent, on the lagoon. Minor impacts were reported on the outer reef (4.3% of the total reported annual catch).

The high impact on the sheltered coastal reef is mainly due to the number of fishers targeting this area. If comparing average annual catches, fishers who target the sheltered coastal reef and the lagoon in one fishing trip seem to catch more on average than all others.

However, all average catches are low compared to the regional average (200–400 kg/fisher/year; Figure 3.10).

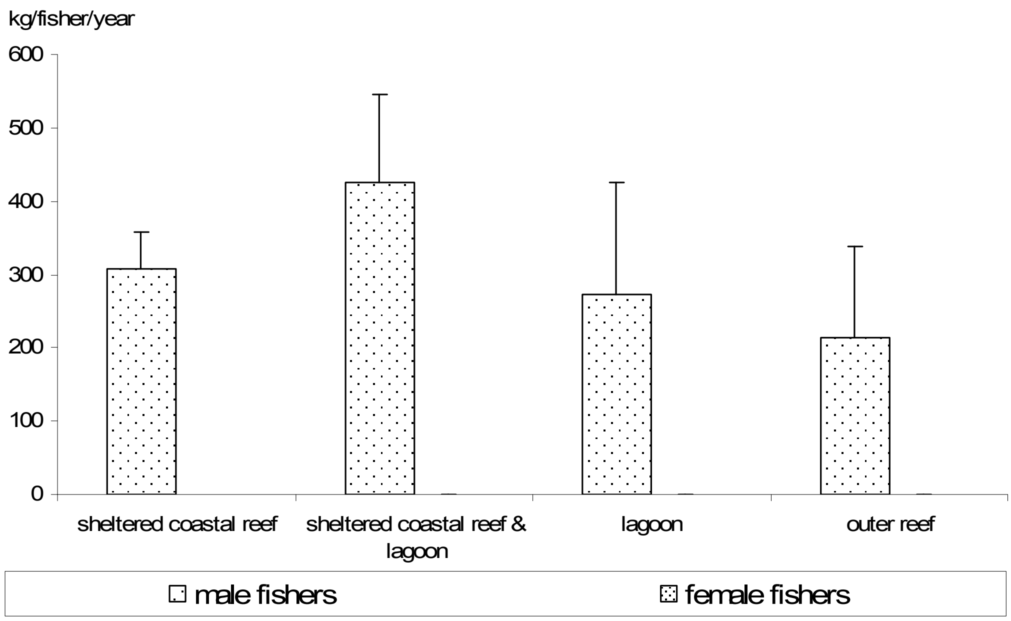

Figure 3.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Thio (based on reported catch only).

Regarding fishing efficiency (CPUE) a similar picture appears (Figure 3.11). The CPUE for sheltered coastal reef, lagoon or these two habitats combined are similar (1.6–1.8 kg/hour fishing trip). Outer-reef fishing seems to be an exception, where fishers reach 2 kg/hour of fishing trip (Figure 3.11). This difference may indicate that the resource status at the outer reef may be better than in the closer-to-shore habitats, as the composition of catches does not differ significantly. Because no female respondents were included, we cannot compare fishing efficiency between gender groups.

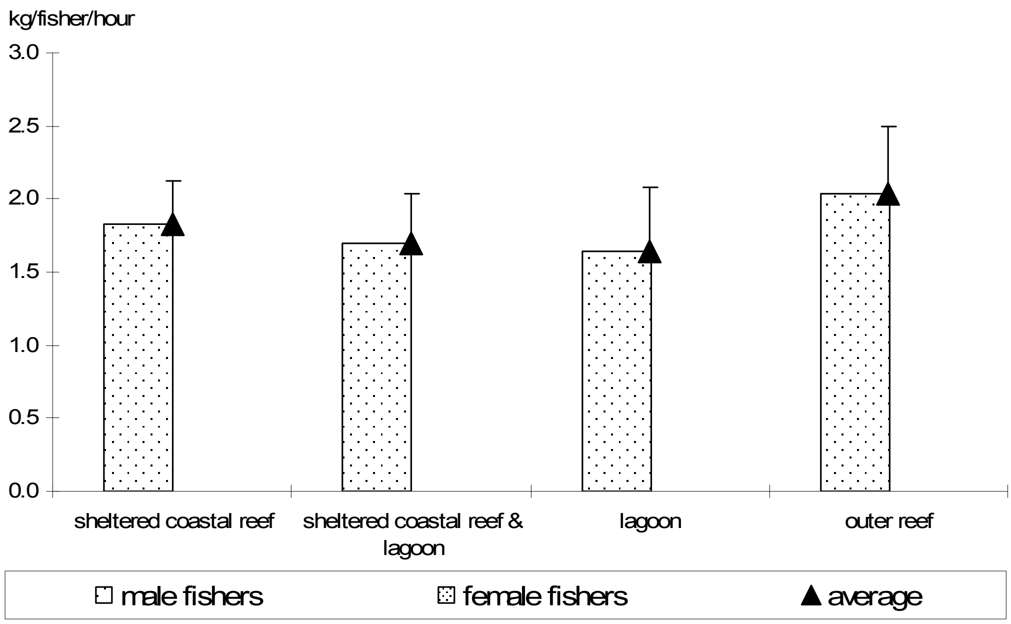

Figure 3.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in Thio.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Survey data show significant differences in the objectives of fishing among the various habitats targeted (Figure 3.12). Fishing the sheltered coastal reef and the lagoon separately serves both subsistence and commercial interests. However, taking into account that a high proportion of catches from both areas are also distributed on a non-commercial basis, it seems that these areas are mainly fished for subsistence purposes. If sheltered coastal reef and lagoon are combined in one fishing trip or if the outer reef is targeted, commercial objectives are the most important.

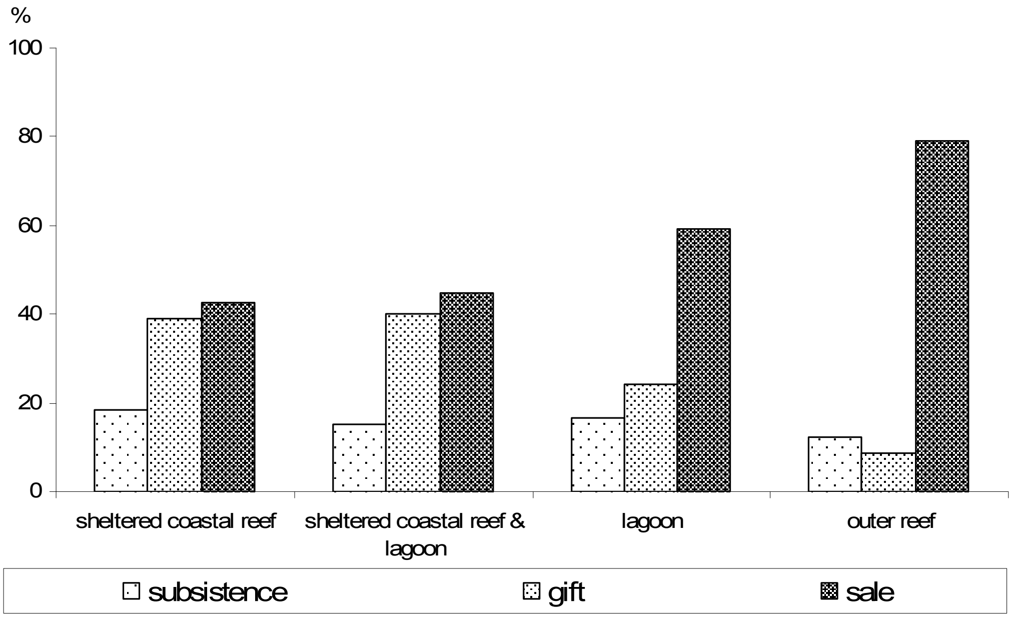

Figure 3.12: The use of finfish catches for subsistence, gift and sale, by habitat in Thio. Proportions are expressed in % of the total number of trips per habitat.

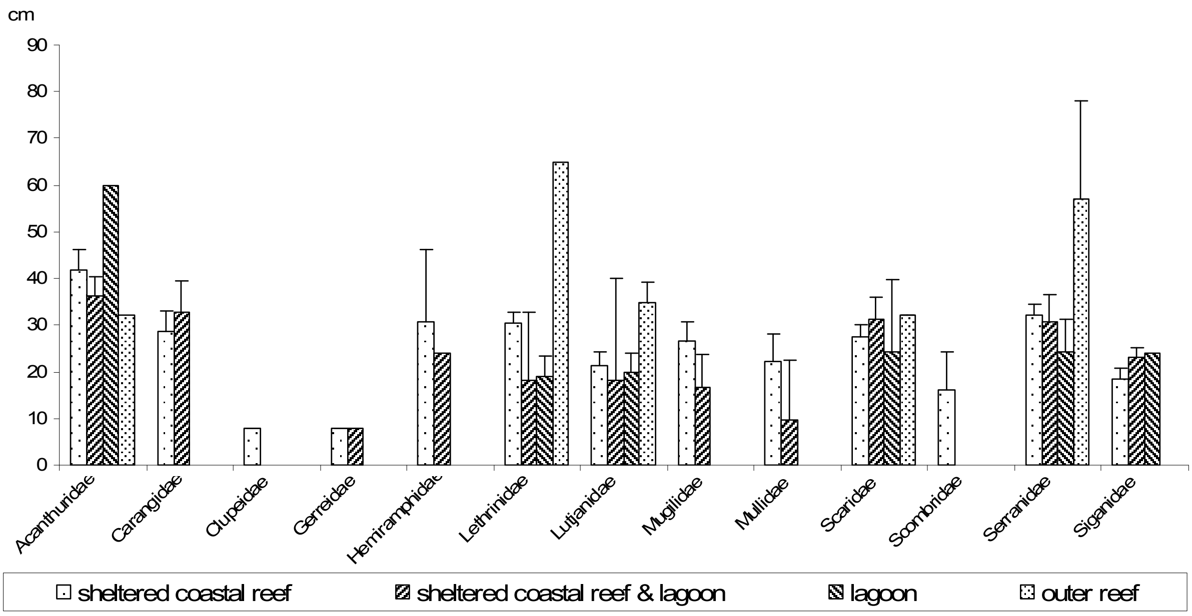

Figure 3.13: Average sizes (cm fork length) of fish caught by family and habitat in Thio. Bars represent standard error (+SE).

Data on the average reported finfish sizes by family and habitat as shown in Figure 3.13 show a trend that the average fish size is largest at the outer reef. This observation applies in particular for Serranidae, Lethrinidae and Lutjanidae. Data collected from respondents also indicate that the average fish sizes at the sheltered coastal reef are similar to if not larger than those reported for the lagoon catches, i.e. Lethrinidae and Mugilidae. In the case of Acanthuridae, average fish sizes in lagoon catches were significantly larger than in sheltered coastal reef catches.

Some parameters selected to assess the current fishing pressure on the living reef resources of Thio are shown in Table 3.4. The comparison of habitat surfaces that are included in the fishing ground show that the lagoon area is the largest, followed by the outer reef and the sheltered coastal reef. Overall fisher density is low, with an average of 1.5–2 fishers/km^2 of total fishing ground and total reef area, but is highest in the sheltered coastal reef (5 fishers/km^2). The low fisher density in the outer-reef area (<1 fisher/km^2) may explain why fishing efficiency is slightly higher than in the sheltered coastal reef and lagoon. Overall, population density is low ~4.5–6 people/km^2 of total reef and total fishing ground. All parameters indicate a low fishing pressure on Thio finfish resources, and indeed average annual total catch per km² of total fishing ground or total reef area is low: 0.09–0.11 t/year/km^2 respectively.

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

Parameters	Habitat					
	Sheltered coastal reef	Sheltered coastal reef & lagoon	Lagoon	Outer reef	Total reef area	Total fishing ground [(1)]
Fishing ground area (km^2)	8.79		18.33	14.73	33.70	41.85
Total number of fishers	42	14	6	4	66	66
Density of fishers (number of fishers/km^2 fishing ground) [(1)]	4.77		0.33	0.27	1.96	1.58
Population density (people/km^2) [(2)]					5.58	4.5
Average annual finfish catch (kg/fisher/year) [(3)]	306.99 (±51.73)	425.23 (±119.22)	273.03 (±152.81)	213.22 (±123.96)		
Total fishing pressure of subsistence catches (t/km^2)					0.11	0.09

Figures in brackets denote standard error; [(1)] total number of fishers is extrapolated from household surveys; [(2)] total population = 188; total number of fishers = 66; total subsistence demand = 3.56 t/year; [(3)] catch figures are based on recorded data from survey respondents only.

3.2.4 Catch composition and volume – invertebrates: Thio

Calculations of the recorded annual catch rates per species groups are shown in Figure 3.14. The graph shows that the major impact by wet weight is mainly due to *troca* (*Tectus pyramis*, *Trochus niloticus*). In addition, catches of *poulpe* (*Octopus* spp.) and *langouste* (*Panulirus* spp.) are slightly higher than those of the remaining 17 species groups (Detailed data are provided in Appendices 2.2.2 and 2.2.3.).

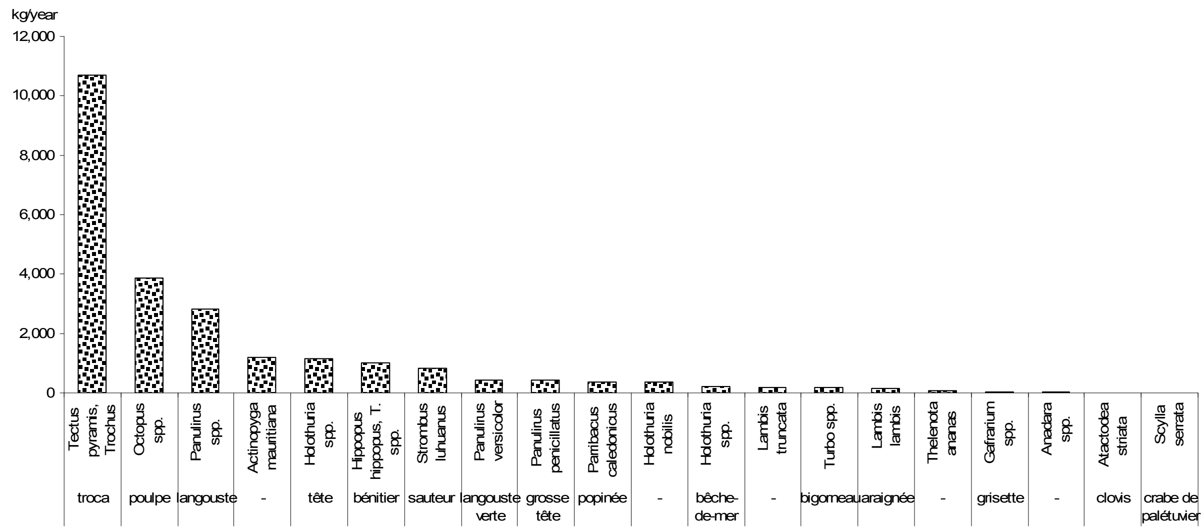

Figure 3.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Thio.

In accordance with the limited number of invertebrates reported by respondents, the overall biodiversity of the invertebrate fishery in Thio is low (Figure 3.15). The reeftop fishery scores highest, with eight different vernacular names, while most other fisheries are represented by only 1–4 vernacular names.

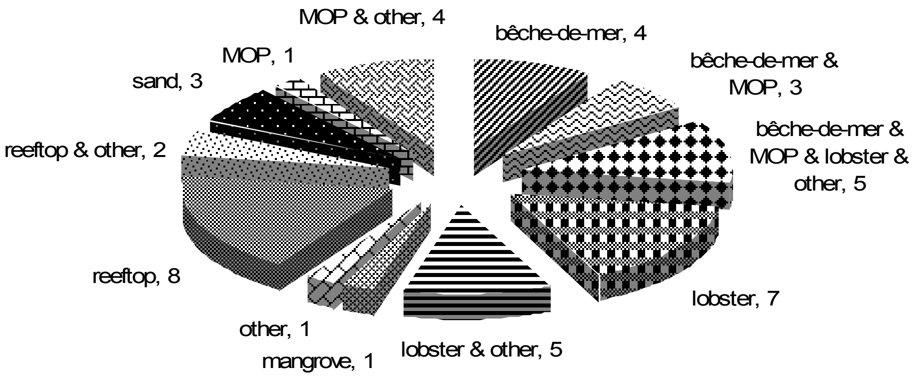

Figure 3.15: Number of vernacular names recorded for each invertebrate fishery in Thio.
MOP = mother-of-pearl; 'other' refers to the giant clam and octopus fisheries.

As expected, the highest average annual catches by wet weight occur in the trochus fishery and any other fishery that combines trochus with other target species (Figure 3.16). Lobster catches are high; however, due to the limited sample size the figure presented may be misleading. Other fisheries, such as reeftop gleaning, other dive fishing (octopus and giant clam), bêche-de-mer and soft-bottom collection (sandy intertidal habitats) show very low average annual catch rates. Because the dive fisheries (which show the highest annual catch rates) are exclusively done by males, it is not surprising that the annual productivity of female invertebrate fishers is generally very low.

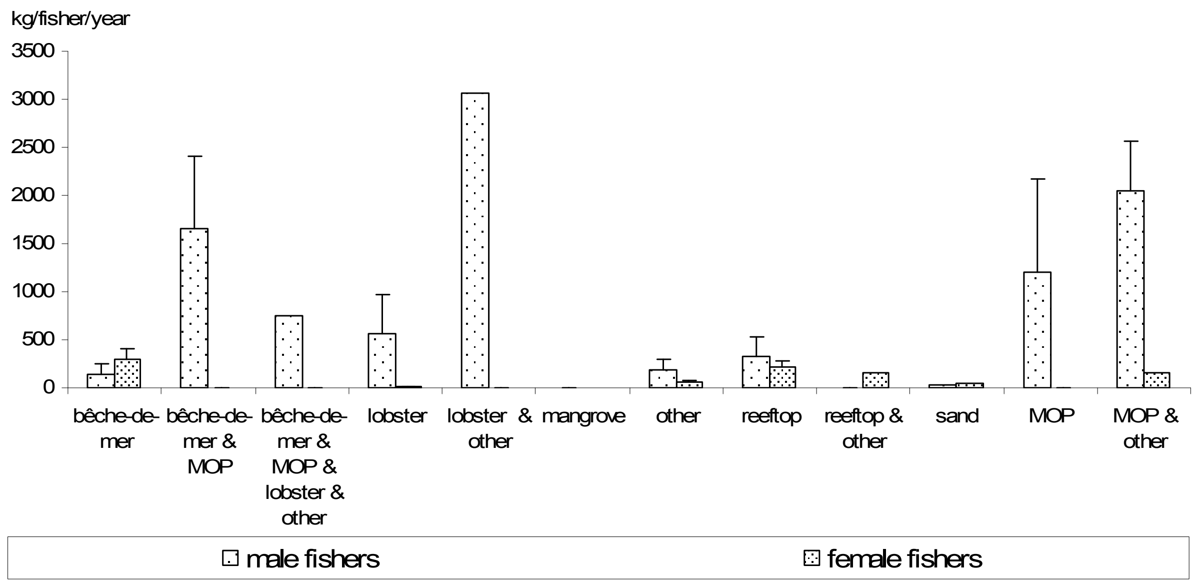

Figure 3.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Thio.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 31 for males, n = 21 for females); 'other' refers to the giant clam and octopus fisheries; MOP = mother-of-pearl.

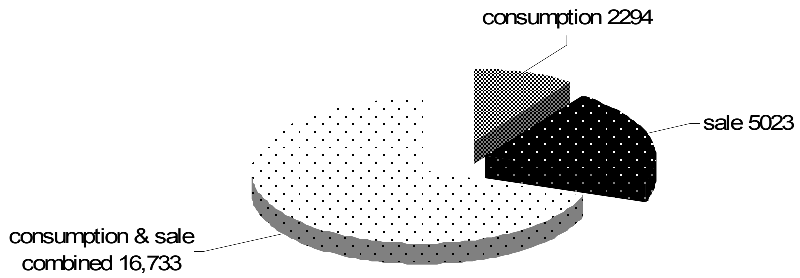

Figure 3.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Thio.

Not unlike finfish fisheries, invertebrate fisheries are also mainly pursued for commercial purposes, i.e. marketing outside the Thio community (Figure 3.17). Only 10% of the reported total catch is harvested exclusively for subsistence purposes. Adding half of the category that may be used for both subsistence and sale, subsistence demand may not exceed 44% of the total catch. In contrast, about 21–56% is caught for sale outside the Thio community. As a result, it can be concluded that any impact on the invertebrate resources of Thio is mainly determined by external rather than internal demand.

The total annual catch volume (expressed in wet weight based on recorded data from all respondents interviewed) amounts to 24.05 t/year (Figure 3.18). Catches from the trochus fishery and fisheries that combine trochus with others, such as octopus, giant clams, bêche-de-mer and lobster, are prominent, representing ~10% if taking trochus fishery alone, and ~44% if regarding all combined fisheries that include trochus as a target species. Reeftop gleaning and lobster diving also significantly contribute to the overall annual recorded harvest in wet weight. Reeftop gleaners determine about 12% and lobster divers another 30%

of the total catch. Soft-bottom gleaning, mangrove, bêche-de-mer and other (giant clam and octopus) fisheries are of minor importance or insignificant.

Figure 3.18 also shows that female fishers play a much smaller role (12.5%) in invertebrate fisheries than do males (87.5%).

The parameters presented in Table 3.5 show a high variability in the size of the available fishing grounds for the various fisheries. Taking into consideration the average recorded annual catch per fisher and the density of fishers, fishing pressure on most habitats is negligible. The mainly subsistence-oriented fisheries, including reeftop and mangrove gleaning, seem to have a slightly higher fisher density than the trochus and lobster dive fisheries, which are mainly commercially oriented. As annual productivity and fisher density are relatively low, there is no reason to anticipate excessive fishing pressure on most resources. However, in the case of the trochus and lobster fisheries, annual productivity rates (wet weight) are high. Because these fisheries concentrate on one or two species and mainly serve commercial purposes, their resource status needs to be monitored.

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

Fishery / Habitat	Parameters			
	Fishing ground area (km^2)	Number of fishers (per fishery) (1)	Density of fishers (number of fishers/km^2 fishing ground)	Average annual invertebrate catch (kg/fisher/year) (2)
Bêche-de-mer		15		218.63 (±77.27)
Bêche-de-mer & trochus	23.78	7	0.3	1649.09 (±749.59)
Bêche-de-mer & trochus & lobster & other	23.78	4	0.2	750.84 (n/a)
Lobster	23.78	41	1.7	413.67 (±298.89)
Lobster & other	23.78	4	0.2	3061.71 (n/a)
Mangrove	3.06	7	2.4	3.06 (n/a)
Other	21.42	37	1.7	154.20 (±86.98)
Reeftop (3)	13.27	59	4.5	248.37 (±77.91)
Reeftop (3) & other	13.27	4	0.3	154.08 (n/a)
Soft bottom (sand)		7		37.90 (±7.91)
Trochus	23.78	7	0.3	1210.65 (±960.78)
Trochus & other	23.78	11	0.5	1414.78 (±694.88)

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam and octopus fisheries; (1) total number of fishers is extrapolated from household surveys; (2) catch figures are based on recorded data from survey respondents only; (3) reeftop fishery mostly targets the sheltered coastal reef areas, thus we have disregarded here the outside shallow reef areas, although they represent potential fishing grounds for the reeftop fishery.

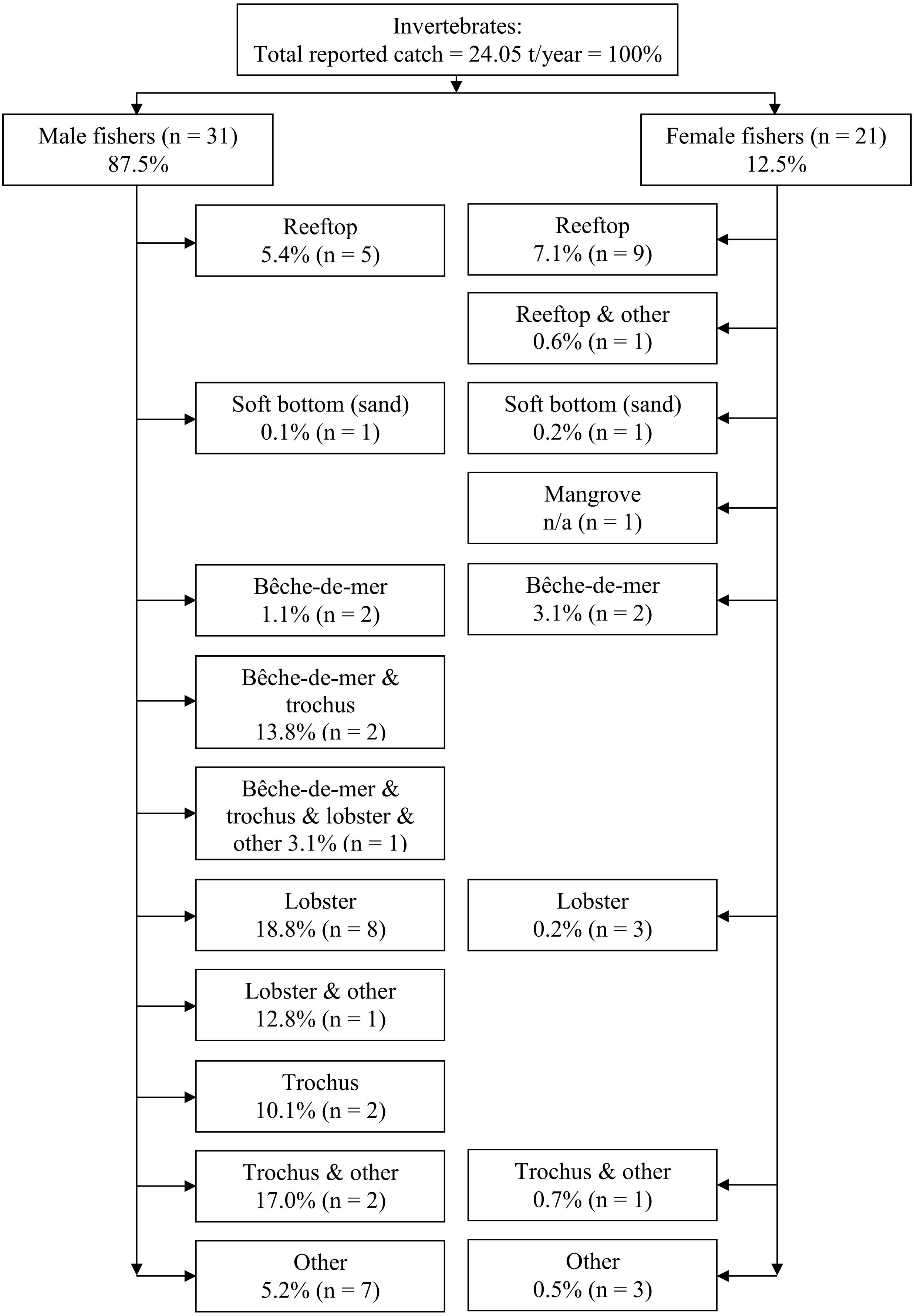

Figure 3.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Thio.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

3.2.5 Discussion and conclusions: socioeconomics in Thio

- Most fishers in Thio fish for commercial purposes and fishing is the most important source of income for almost 48% of all households.

- Within the community, all households eat fresh fish and invertebrates and these are caught or acquired as a gift from somebody in the family or village; hence, seafood is marketed outside the community. Canned fish does not play any substantial role.

- Fresh-fish consumption (22 kg/person/year) is low compared to the regional average and the average of all five PROCFish sites in New Caledonia. In contrast, invertebrate consumption in Thio exceeds that of fresh fish and is among the highest of all sites surveyed in New Caledonia.

- The low level of household expenditure and the high dependency of household revenues on the primary sector, in particular fisheries, suggest that the Thio community is rather traditional.

- Both males and females target finfish and invertebrates, but more males are exclusive finfish fishers and more females are exclusive invertebrate fishers.

- Fisheries are diverse: finfish are caught in the sheltered coastal reef, lagoon and outer-reef; invertebrates are gleaned from reeftop, mangrove and soft-bottom areas. In addition, bêche-de-mer, lobsters, trochus, giant clams and octopus are dive fisheries and mainly commercially-oriented.

- Various fishing techniques are used: gillnets, castnets, handlines and a variety of spear techniques, as well as free-diving and simple collection techniques in the case of invertebrate fishing.

- Concerning finfish fisheries, the highest fishing pressure by quantity fished and fisher density exists on the sheltered coastal reef and in combination with the lagoon area. Also, highest fishing pressure is induced by commercial rather than subsistence catches. However, overall, fishing pressure seems to be low.

- Fishing efficiency as expressed in CPUE does not allow clear distinctions to be made among habitats, although CPUE for outer-reef fishing is slightly higher. This suggests either that the resource status at the outer reef is better or that outer-reef fishers are more efficient in using their time, as they are fishing commercially.

- In the case of invertebrate fisheries, highest fishing pressure exists on one single species group (*Trochus* spp.), which is mainly fished commercially. Catches of lobster and species from reeftop gleaning also contribute important amounts to the total annual invertebrate catch.

- However, annual productivity and fisher density are generally relatively low, and give no reason to suspect excessive fishing pressure on most of the invertebrate resources in Thio. Only in the case of the lobster and trochus fisheries, where one or two species only are selectively targeted and annual catch rates are large, may resource status need to be monitored.

Combining the observations that fisheries represent an important source of income for the Thio community, that this small community enjoys a more traditional lifestyle, and that it has access to large fishing grounds, it can be concluded that present fishing pressure does not give any cause for alarm. Nevertheless, some specific target species, such as trochus and lobsters, may need to be surveyed to avoid overexploitation or detrimental effects to stocks and populations.

Taking into account that distance and the costs of transport from Thio to New Caledonia's main market in Noumea may be limiting factors, and also considering that an effort to establish a cooperative for improving marketing and boosting fisheries productivity has not yielded the expected results, it can be anticipated that fisheries targeting the local market may not significantly develop in the near future. However, this may change in the case of the trochus and, perhaps, the lobster fisheries, which target or may target export markets.

3.3 Finfish resource surveys: Thio

Finfish resources and associated habitats were assessed between 3 March and 14 May 2004 from a total of 24 transects (7 sheltered coastal, 5 intermediate, 6 back- and 6 outer-reef transects, see Figure 3.19 and Appendix 3.2.1 for transect locations and coordinates respectively).

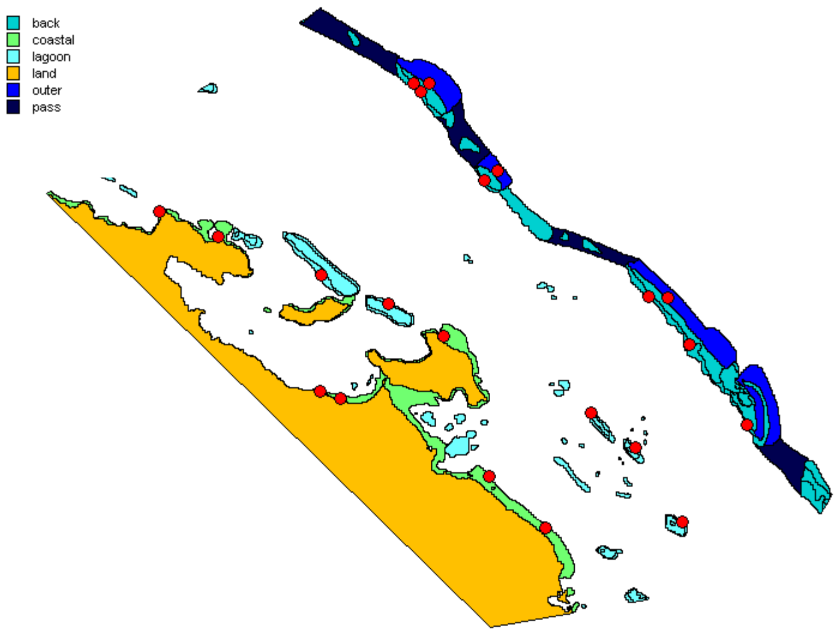

Figure 3.19: Habitat types and transect locations for finfish assessment in Thio.

3.3.1 Finfish assessment results: Thio

A total of 22 families, 56 genera, 164 species and 10,844 fish were recorded in the 24 transects (See Appendix 3.2.2 for list of species.). Only data on the 15 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 44 genera, 141 species and 7229 individuals.

Finfish resources varied greatly among the four reef environments found in Thio (Table 3.6). The back-reef contained the greatest density of fish (0.6 fish/m^2) but the lowest average fish size and biomass, while the intermediate reefs contained the largest average fish size (21 cm), the highest biomass (138 g/m^2) and the highest biodiversity (50 species/transect). Outer reefs displayed the second-highest biomass (64 g/m^2) and biodiversity among the four habitats. Sheltered coastal reefs showed intermediate values between the back-reefs and intermediate reefs (biodiversity: 36 species/transect; density: 0.4 fish/m^2; biomass: 64 g/m^2).

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

Parameters	Habitat				
	Sheltered coastal reef (1)	Intermediate reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	7	5	6	6	24
Total habitat area (km^2)	8.8	8.2	10.2	7.6	44.8
Depth (m)	4 (1-8) (3)	5 (1-10) (3)	2 (1-5) (3)	6 (4-13) (3)	4 (1-13) (3)
Soft bottom (% cover)	16 ±5	8 ±6	11 ±4	3 ±1	10
Rubble & boulders (% cover)	28 ±5	9 ±3	18 ±4	2 ±1	15
Hard bottom (% cover)	33 ±6	44 ±6	58 ±7	61 ±6	49
Live coral (% cover)	15 ±2	23 ±6	12 ±3	15 ±5	16
Soft coral (% cover)	8 ±3	16 ±0	1 ±1	18 ±4	10
Biodiversity (species/transect)	36 ±5	50 ±5	27 ±5	42 ±8	38 ±3
Density (fish/m^2)	0.4 ±0.1	0.5 ±0.1	0.6 ±0.1	0.3 ±0.1	0.5
Size (cm FL) (4)	18 ±1	21 ±1	14 ±1	18 ±1	17
Size ratio (%)	49 ±2	55 ±2	47 ±2	57 ±57	51
Biomass (g/m^2)	63.6 ±10.3	138.4 ±23.1	56.6 ±14.1	64.1±17.7	80

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

Sheltered coastal reef environment: Thio

The sheltered coastal reef environment of Thio was dominated by two families of herbivorous fish: Scaridae and Acanthuridae for both density and biomass and, to a much lower extent, by Chaetodontidae and Mullidae for density only (Figure 3.20). These four families were represented by 49 species; particularly high abundance and biomass were recorded for *Scarus rivulatus*, *Acanthurus blochii*, *Parupeneus ciliatus*, *Ctenochaetus striatus* and *P. multifasciatus* (Table 3.7). This reef environment presented a moderately diverse habitat with hard bottom and rubble in similar proportions (Table 3.7 and Figure 3.20).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.11 ±0.04	21.72 ±6.74
Acanthuridae	*Acanthurus blochii*	Ringtail surgeonfish	0.03 ±0.01	6.59 ±3.44
	Ctenochaetus striatus	Striated surgeonfish	0.02 ±0.01	1.99 ±1.05
Mullidae	*Parupeneus ciliatus*	Whitesaddle goatfish	0.01 ±0.01	2.27 ±1.06
	Parupeneus multifasciatus	Manybar goatfish	0.01 ±0.01	1.09 ±0.68

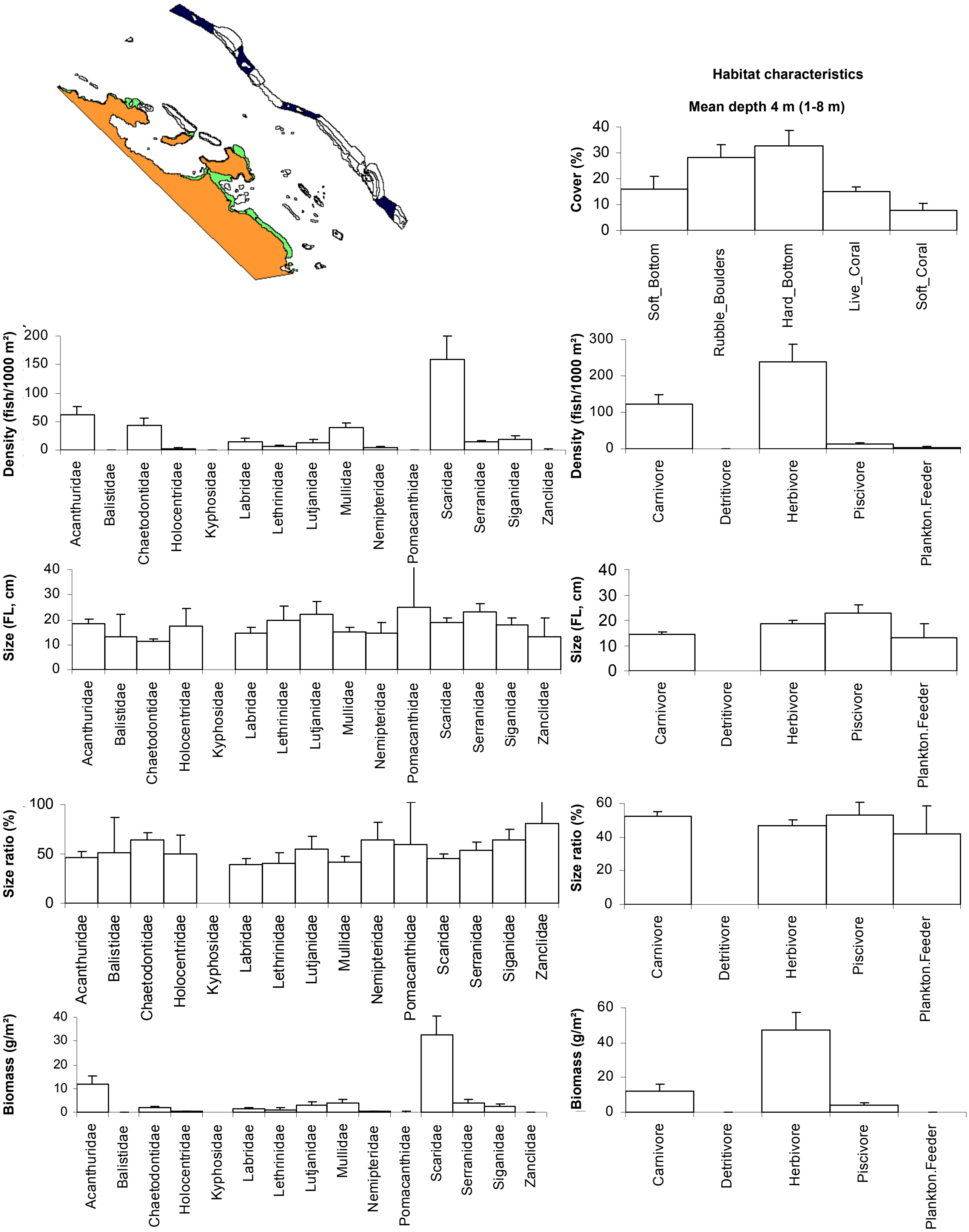

Figure 3.20: Profile of finfish resources in the sheltered coastal reef environment of Thio.
Bars represent standard error (+SE); FL = fork length.

The density, size and biomass of finfish in the sheltered coastal reefs of Thio were higher than in Oundjo and similar to Moindou but lower than Ouassé. Biodiversity was the highest among the sites, however (Table 2.6). The trophic structure in Thio coastal reef was dominated by herbivorous species, particularly in terms of biomass (four times higher than that of carnivorous species) especially due to the high abundance of Scaridae. Carnivorous species, especially Labridae, Lethrinidae and Lutjanidae, were particularly scarce. The very low cover of soft bottom could at least partially explain the low density of emperors.

Intermediate-reef environment: Thio

The intermediate-reef environment of Thio was dominated by two families: herbivorous Scaridae (dominant in numbers) and Acanthuridae (Figure 3.21). These two families were represented by 32 species; particularly high abundance and biomass were recorded for *Scarus altipinnis*, *S. rivulatus*, *Acanthurus dussumieri*, *Ctenochaetus striatus*, *Naso annulatus*, *Chlorurus bleekeri*, *C. sordidus*, *S. niger* and, to a smaller extent, *Siganus argenteus* (Table 3.8). This reef environment presented a moderately diverse habitat with hard bottom dominating (more than 40%, Table 3.6).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus altipinnis*	Filamentfinned parrotfish	0.06 ±0.06	17.19 ±12.67
	Scarus rivulatus	Rivulated parrotfish	0.05 ±0.02	16.86 ±6.43
	Scarus niger	Dusky parrotfish	0.01 ±0.01	3.46 ±2.17
	Chlorurus bleekeri	Bleeker's parrotfish	0.02 ±0.01	6.08 ±4.42
	Chlorurus sordidus	Daisy parrotfish	0.02 ±0.01	4.49 ±2.40
Acanthuridae	*Acanthurus dussumieri*	Eyestripe surgeonfish	0.03 ±0.02	15.61 ±10.05
	Ctenochaetus striatus	Striated surgeonfish	0.05 ±0.02	7.22 ±2.47
	Naso annulatus	Whitemargin unicornfish	0.02 ±0.02	6.93 ±5.79
Siganidae	*Siganus argenteus*	Streamline spinefoot	0.03 ±0.02	3.21 ±2.09

The density of finfish in the intermediate reefs of Thio was similar to that in the other survey sites. However, size, biomass and biodiversity were the highest among the country sites (Table 2.6) and for this site. Biomass was strongly dominated by herbivores, mostly due to the large presence of Scaridae. Scaridae displayed the second-highest density and highest biomass in the country. Acanthuridae and Siganidae also displayed the highest country density and biomass among the four sites with intermediate reefs (all sites except Luengoni). Similarly to in Ouassé, Moindou and Oundjo, Lethrinidae and Lutjanidae were present in very small numbers.

The intermediate reefs of Thio had a large cover of hard bottom (44%) and the highest coral cover (23%) among the different habitats as well as among the different sites, evidence of a healthy habitat. It is possible that fishing in the intermediate reef of Thio may selectively target carnivorous species, especially Lethrinidae, as appeared from the interviews with the fishers. Lethrinidae and Lutjanidae displayed also the lowest size ratios, an index of impact from fishing pressure.

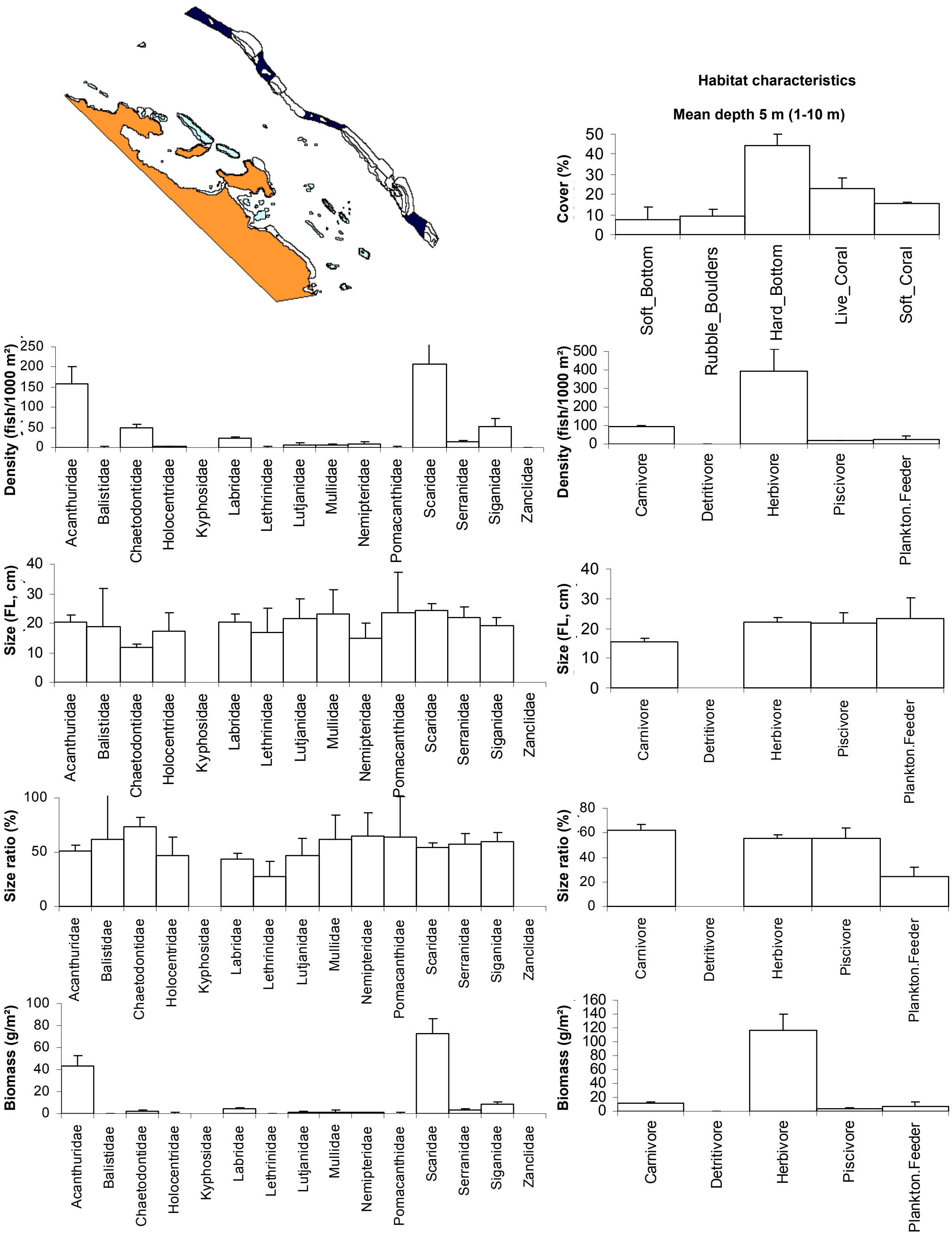

Figure 3.21: Profile of finfish resources in the intermediate-reef environment of Thio.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Thio

The back-reef environment of Thio was dominated by three families: herbivorous Siganidae, (highest in terms of density), Scaridae and Acanthuridae (both in terms of density and biomass, Figure 3.22). These three families were represented by 27 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Scarus rivulatus*, *Siganus spinus*, *Chlorurus sordidus*, *Acanthurus lineatus* and *A. nigrofuscus* (Table 3.9). This reef environment had a diverse substrate, strongly dominated by hard bottom (58% cover) (Table 3.6 and Figure 3.22).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Siganidae	*Siganus spinus*	Little spinefoot	0.23 ±0.11	5.69 ±2.86
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.04 ±0.02	8.84 ±4.31
	Acanthurus lineatus	Lined surgeonfish	0.01 ±0.01	2.31 ±2.31
	Acanthurus nigrofuscus	Brown surgeonfish	0.04 ±0.03	1.66 ±1.28
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.08 ±0.04	7.98 ±2.79
	Chlorurus sordidus	Daisy parrotfish	0.03 ±0.01	3.38 ±1.40

The density of finfish in the back-reef of Thio was comparable to the back-reefs in the other sites, although size, biomass and biodiversity were the lowest recorded in the country (Table 3.6). The biomass of Scaridae and Acanthuridae was among the highest of all the back-reefs surveyed. In contrast, the carnivorous Labridae, Lethrinidae, Lutjanidae and Mullidae were less abundant in Thio.

The back-reef of Thio had less cover of soft bottom (11%) but more hard bottom (58%) than similar reef habitats in the country. Therefore, the possibility is high that fishing in the back-reef of Thio could be partly responsible for the observed lower abundances of Lethrinidae and Lutjanidae. Lethrinidae, along with Mugilidae, are the most fished families in internal reefs.

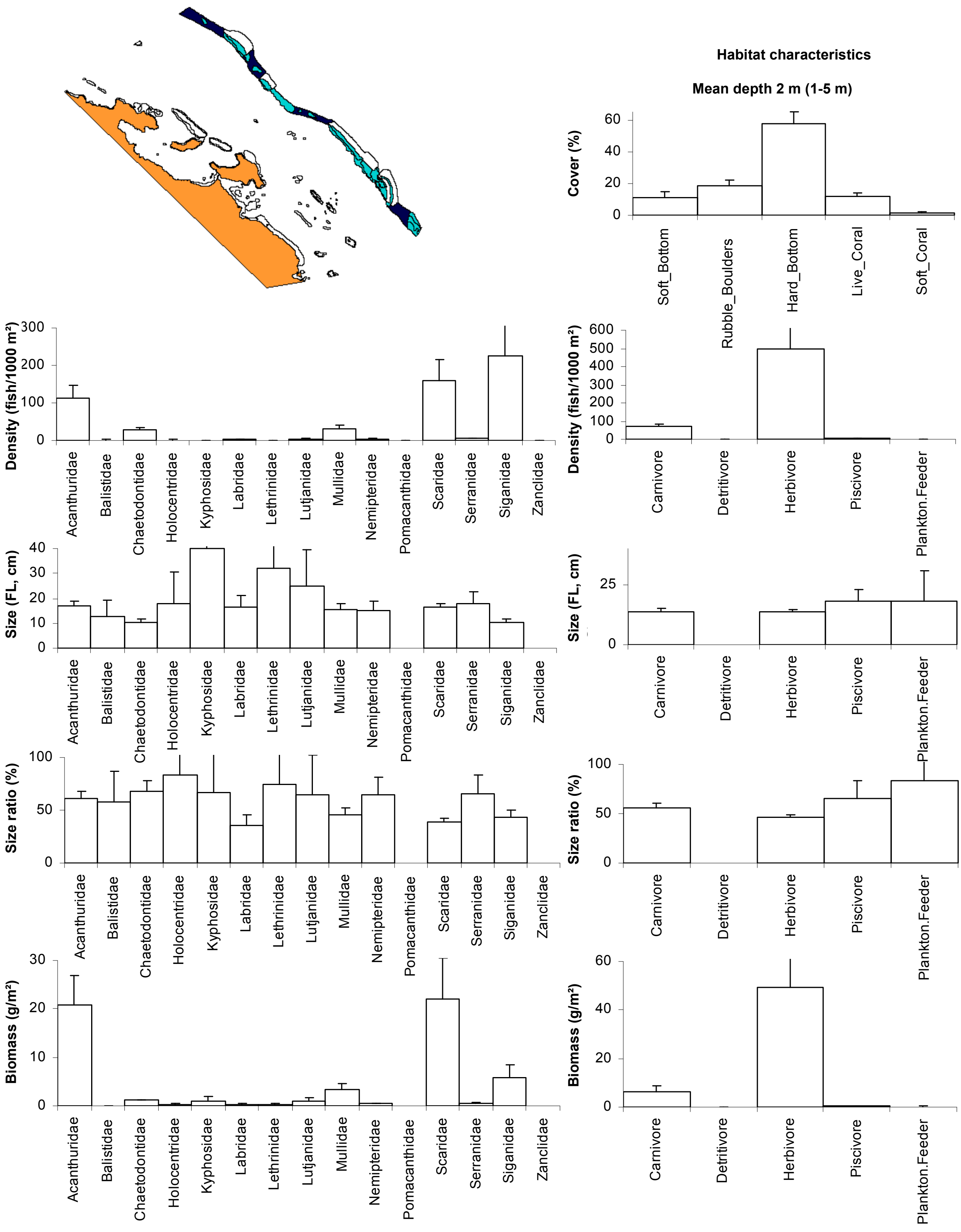

Figure 3.22: Profile of finfish resources in the back-reef environment of Thio.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Thio

The outer reef of Thio was dominated by two herbivorous families: Scaridae and Acanthuridae, both in terms of density and biomass, with parrotfish dominating in terms of biomass (Figure 3.23). These two families were represented by 27 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Chlorurus sordidus*, *Acanthurus lineatus*, *A. dussumieri*, *Scarus frenatus*, *S. altipinnis* and *S. niger* (Table 3.10). Hard bottom (61% cover) largely dominated this reef environment (Table 3.6 and Figure 3.23).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.06 ±0.02	10.50 ±2.55
	Acanthurus lineatus	Lined surgeonfish	0.01 ±0.01	3.36 ±2.58
	Acanthurus dussumieri	Eyestripe surgeonfish	0.01 ±0.01	3.21 ±3.21
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.05 ±0.02	5.24 ±1.94
	Scarus frenatus	Bridled parrotfish	0.01 ±0.01	3.07 ±1.41
	Scarus altipinnis	Filamentfinned parrotfish	0.01 ±0.01	2.46 ±1.91
	Scarus niger	Dusky parrotfish	0.01 ±0.01	2.24 ±1.35

The density and biomass of finfish in the outer reef of Thio were average and second in value only to Oundjo. Biodiversity was comparable to the other sites but at the lower end of the country range (42 versus 30–53 species/transect) (Table 3.6). Carnivores were very low in abundance although Serranidae displayed the highest biomass among the five sites. Substrate composition was very similar to the outer-reef country average, but displayed slightly lower cover of hard substrate (67%) and live coral (15%) than the other sites.

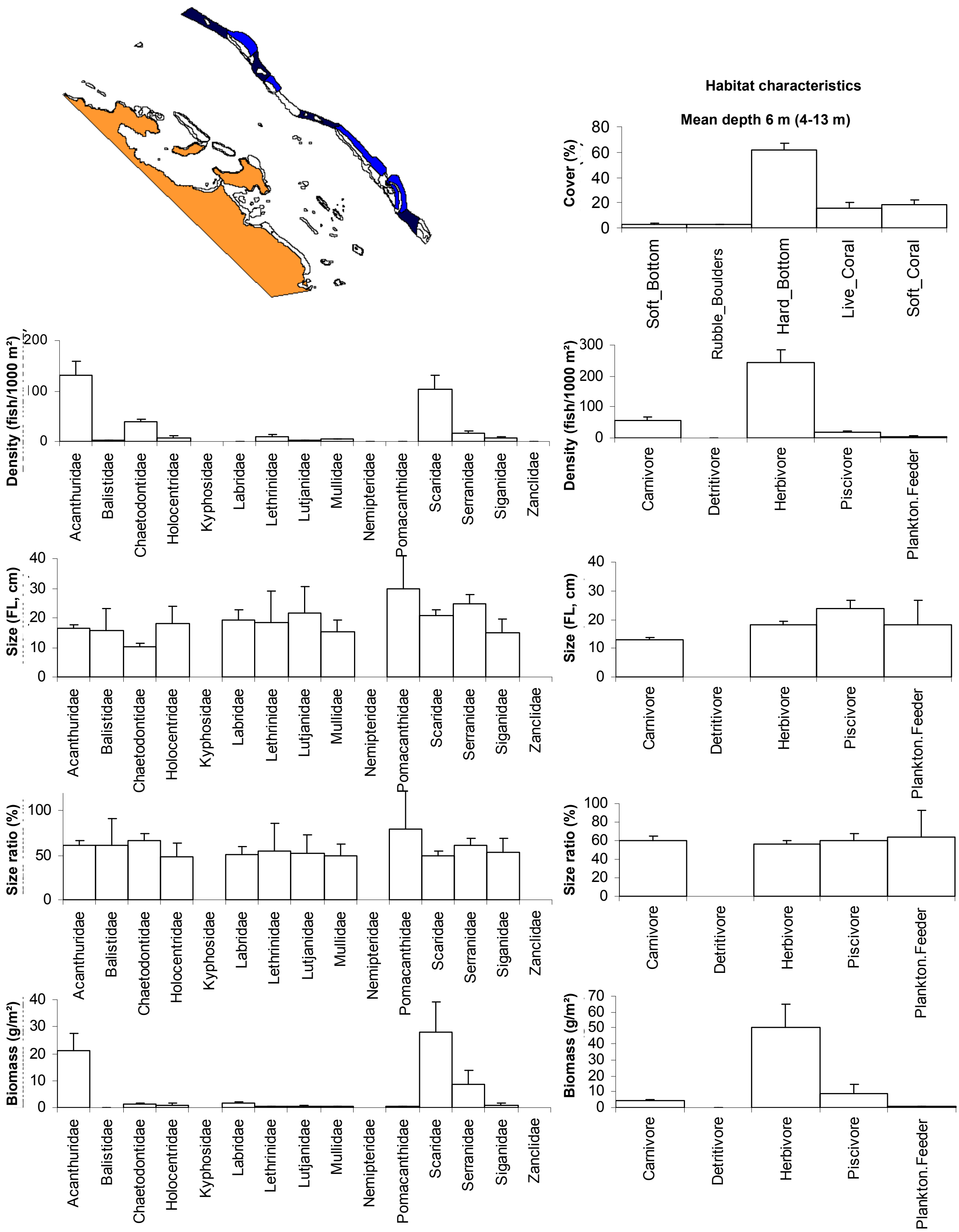

Figure 3.23: Profile of finfish resources in the outer-reef environment of Thio.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Thio

Overall, the fish assemblage of Thio was dominated by Scaridae and Acanthuridae (both in terms of density and biomass) and Siganidae (in terms of density only) (Figure 3.24). These three families were represented by a total of 48 species, dominated (in term of density and biomass) by *Siganus spinus*, *Scarus rivulatus*, *Ctenochaetus striatus*, *S. altipinnis*, *Acanthurus blochii* and *Chlorurus microrhinos* (Table 3.11). The overall fish assemblage in Thio shared characteristics of back-reef (29% of total habitat), followed by sheltered coastal reef (25%), intermediate reef (23%) and outer reef (22%).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.06	11.8
	Scarus altipinnis	Filamentfinned parrotfish	0.02	5.4
	Chlorurus microrhinos	Steephead parrotfish	0.01	4.5
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.04	7.1
	Acanthurus blochii	Ringtail surgeonfish	0.01	2.3
Siganidae	*Siganus spinus*	Little spinefoot	0.07	1.7

Overall, Thio appears to support a similar finfish resource to the average for PROCFish sites surveyed in the country, with the second-highest biodiversity (38 species/transect), similar density to Ouassé and Moindou (0.5 fish/m^2), large average fish size (second-highest after Ouassé, 17 cm FL), second-highest size ratio (51%) and second-highest biomass (80 g/m^2, only lower than the extremely high value recorded in Ouassé, 179 g/m^2) (Table 3.6). While these results suggest that the finfish resource in Thio is in relatively good condition, detailed assessment at the family level also revealed a systematic lower-than-average abundance for the carnivores Labridae, Lutjanidae, Lethrinidae and Mullidae, and comparable abundance for Scaridae, Siganidae and Acanthuridae. Unfavourable environmental conditions (either natural or human-generated) for the development of these carnivore species may explain this trend in Thio. Alternatively, a greater impact from fishing carnivorous species (especially Lethrinidae) at this site compared to the average could be the cause. In any case, further studies to elucidate the deficit in snappers and emperors are needed.

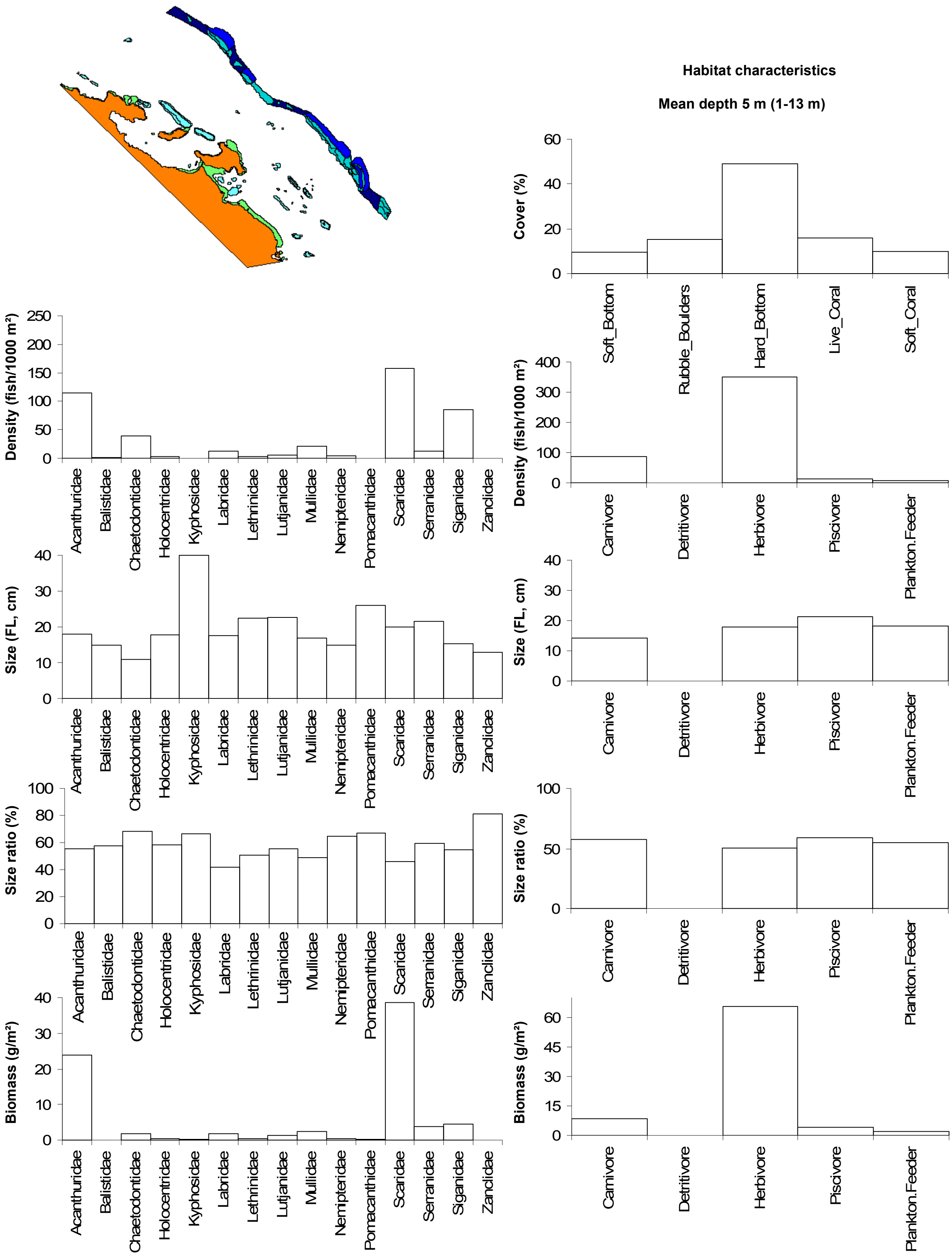

Figure 3.23: Profile of finfish resources in the combined reef habitats of Thio (weighted average).
FL = fork length.

3.3.2 Discussion and conclusions: finfish resources in Thio

The finfish resource assessment indicated that the status of finfish resources in Luengoni is similar to that in other New Caledonia study sites but slightly better for some specific families. However, detailed assessment also revealed a low biomass, due to the general small average size of fish and to low average density in the outer reefs. This could be the direct impact of the common practice of spearfishing at night, especially manifest in the small size ratio for Scaridae. Carnivores were rare, except in the back-reefs, which displayed a high abundance of goldlined seabream (*Gnathodentex aureolineatus*).

- Overall, Luengoni finfish resources appeared to be in average-to-good condition. The reef habitat seemed relatively rich, with good cover of live coral on the outer reefs, and able to support healthy finfish resources.

- Populations of emperors (Lethrinidae) in Luengoni were richer than in the other sites, due especially to a large population of *Gnathodentex aureolineatus* (goldlined seabream) in the back-reefs.

- Populations of Mullidae were relatively rich in the back-reefs, displaying the highest abundance and biomass in the country, especially of yellowfin goatfish (*Mulloidichthys vanicolensis*).

- Impacts from the common practice of night-time spearfishing were evident as low abundance and very small average sizes of Scaridae in the outer reefs.

3.4 Invertebrate resource surveys: Thio

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

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

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

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	13	78 transects
Reef-benthos transects (RBt)	12	72 transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	6	48 quadrat groups
Mother-of-pearl transects (MOPt)	4	24 transects
Mother-of-pearl searches (MOPs)	1	6 search periods
Reef-front searches (RFs)	4	24 search periods
Sea cucumber day searches (Ds)	1	6 search periods
Sea cucumber night searches (Ns)	3	18 search periods

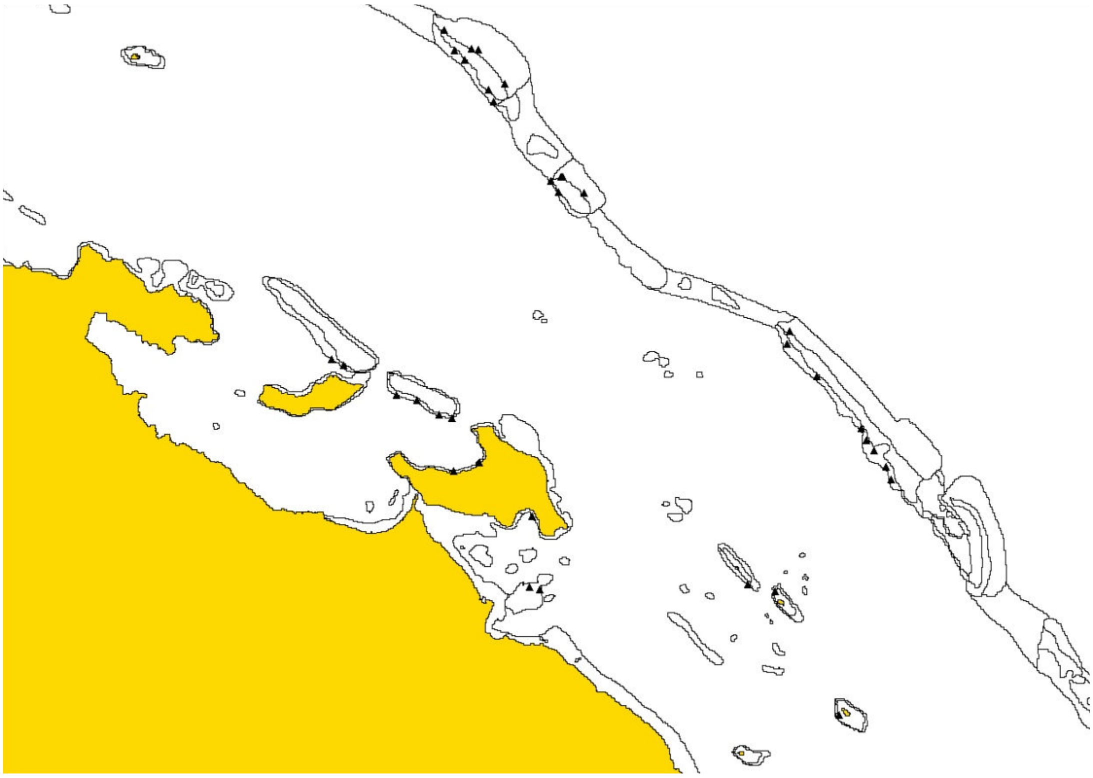

Figure 3.25: Broad-scale survey stations for invertebrates in Thio.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

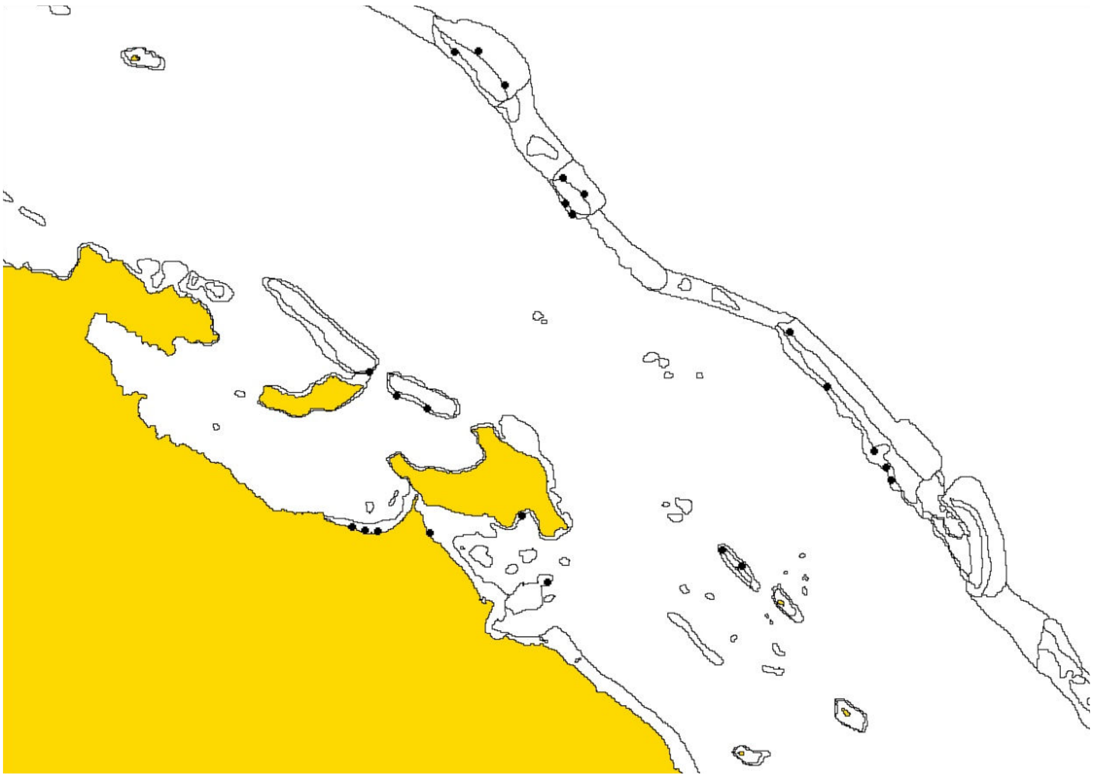

Figure 3.26: Fine-scale reef-benthos transect survey stations for invertebrates in Thio.
Black circles: reef-benthos transect stations (RBt).

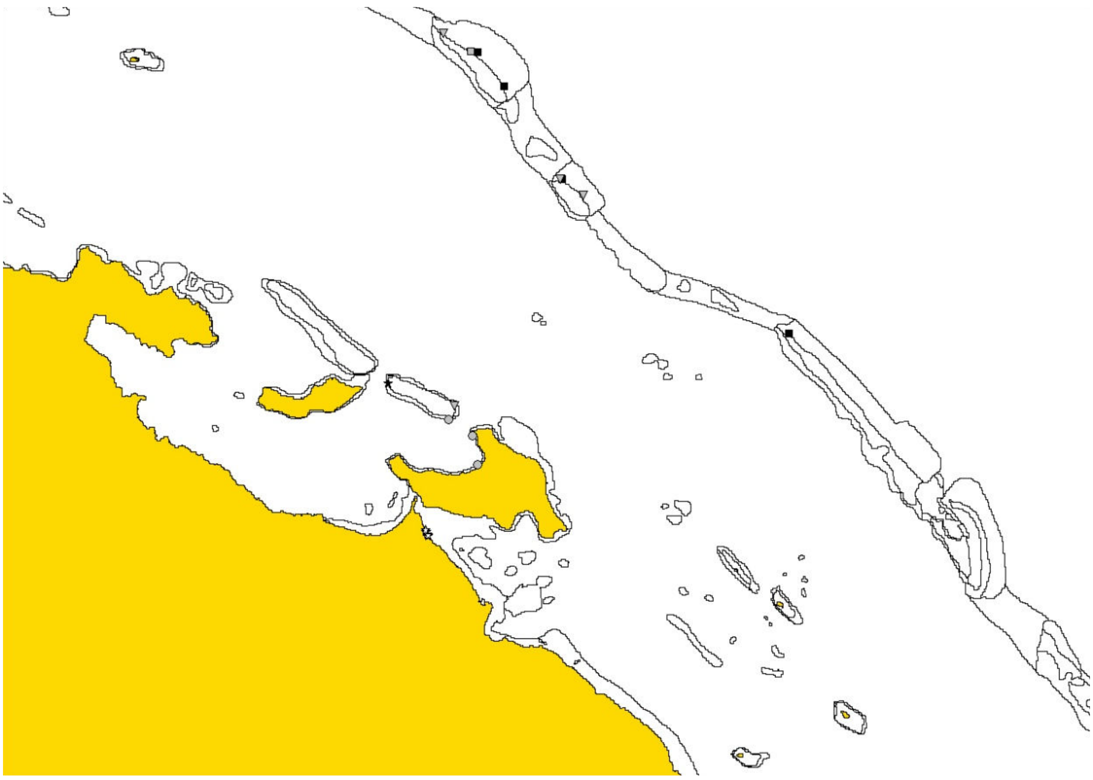

Figure 3.27: Fine-scale survey stations for invertebrates in Thio.
Grey stars: soft-benthos quadrat stations (SBq);
inverted grey triangles: reef-front search stations (RFs);
grey squares: mother-of-pearl search stations (MOPs);
black squares: mother-of-pearl transect stations (MOPt);
grey circles: sea cucumber night search stations (Ns);
black stars: sea cucumber day search stations (Ds).

Sixty-one species or species groupings (groups of species within a genus) were recorded in the Thio invertebrate surveys. These included 13 bivalves, 20 gastropods, 17 sea cucumbers, 5 urchins, 2 sea stars, 1 cnidarian and 1 lobster (Appendix 4.2.1). Information on key families and species is detailed below.

3.4.1 Giant clams: Thio

Shallow-reef habitat that is suitable for giant clams was extensive at Thio (21.4 km^2: 13.3 km^2 within the lagoon and 8.1 km^2 on the reef-front or slope). Similar to the lagoon in Ouassé, there were at least two sectors to the lagoon (A secondary, 'false' barrier reef existed.), with differing levels of exposure and influences from land. At the main barrier reef there were many submerged sections of reef and passes, which facilitated dynamic water flow between the lagoon and the open ocean.

Broad-scale sampling provided an overview of giant clam distribution at Thio. Reefs held five species of giant clam: elongate clam *Tridacna maxima*, fluted clam *T. squamosa*, boring clam *T. crocea*, 'smooth' derasa clam *T. derasa* and horse-hoof or bear's paw clam *Hippopus hippopus*. *T. maxima* had the widest occurrence (found in 10 stations and 40 transects), followed by *T. crocea* (in 8 stations and 40 transects), *T. squamosa* (5 stations and 8 transects) and *T. derasa* (4 stations and 5 transects). *H. hippopus* is a relatively well camouflaged species, but was still recorded in one station (2 transects in total, Figure 3.28).

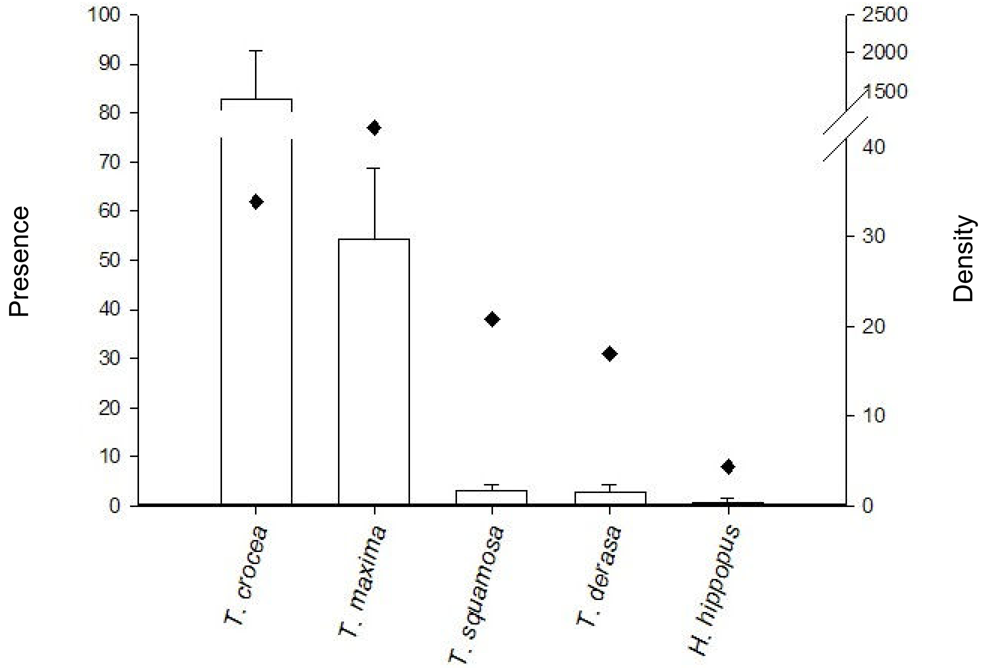

Figure 3.28: Presence and mean density of giant clam species in Thio based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys (reef-benthos transect stations) targeted specific areas of clam habitat. At these stations (RBt), both *T. crocea* and *T. maxima* were commonly found (present in 58% and 42% stations respectively, Figure 3.29). At the seven stations where *T. crocea* were found, the mean density was 5268 individuals/ha ±2842. The highest density recorded for a single 40 m transect for this highly aggregated species was 32,750 individuals/ha (>3 individuals/m^2).

All the *T. derasa* and most *T. squamosa* were recorded in broad-scale assessments (only 3 *T. squamosa* found in RBt assessments). *H. hippopus* clams were uncommon, and none were recorded in fine-scale transects or searches.

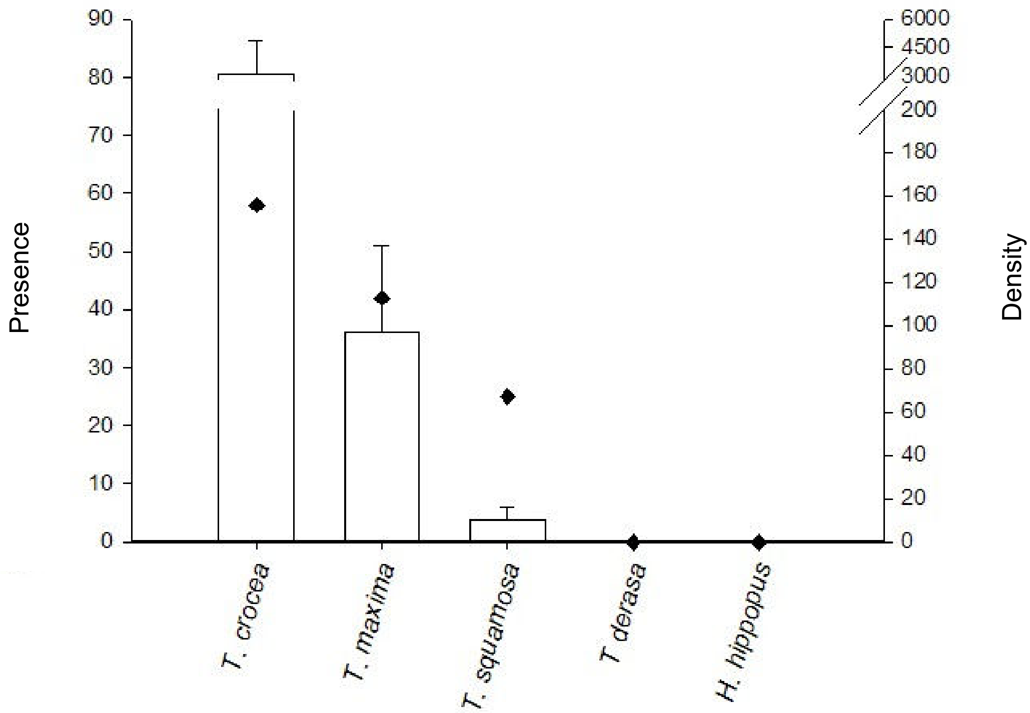

Figure 3.29: Presence and mean density of giant clam species in Thio based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

In a recent study of giant clams ('bénitier') in the Northern Province of New Caledonia (Virly 2004), it was found that clam density (except for *H. hippopus*) was mostly higher in the west coast reefs of Grande Terre (the main island). In the two PROCFish sites examined on the east coast this result has in general been replicated.

The lengths of *T. crocea* recorded in survey included a full range of size classes (both small and large individuals, mean size 8.2 cm ±0.3). *T. maxima* from reef-benthos transects (in shallow-water reefs) had an average length of 17.7 cm ±1.1 (which represents a clam >10 years old), which was similar to the size of clams from deeper water and more exposed locations (found in other assessments, mean 16.9 cm ±0.5). The faster-growing *T. squamosa* (which grow to an asymptotic length L_∞ of 40 cm) averaged 24.4 cm ±2.5 (>5 years old) whereas *H. hippopus* were generally small (mean size 17.0 cm ±1, Figure 3.30).

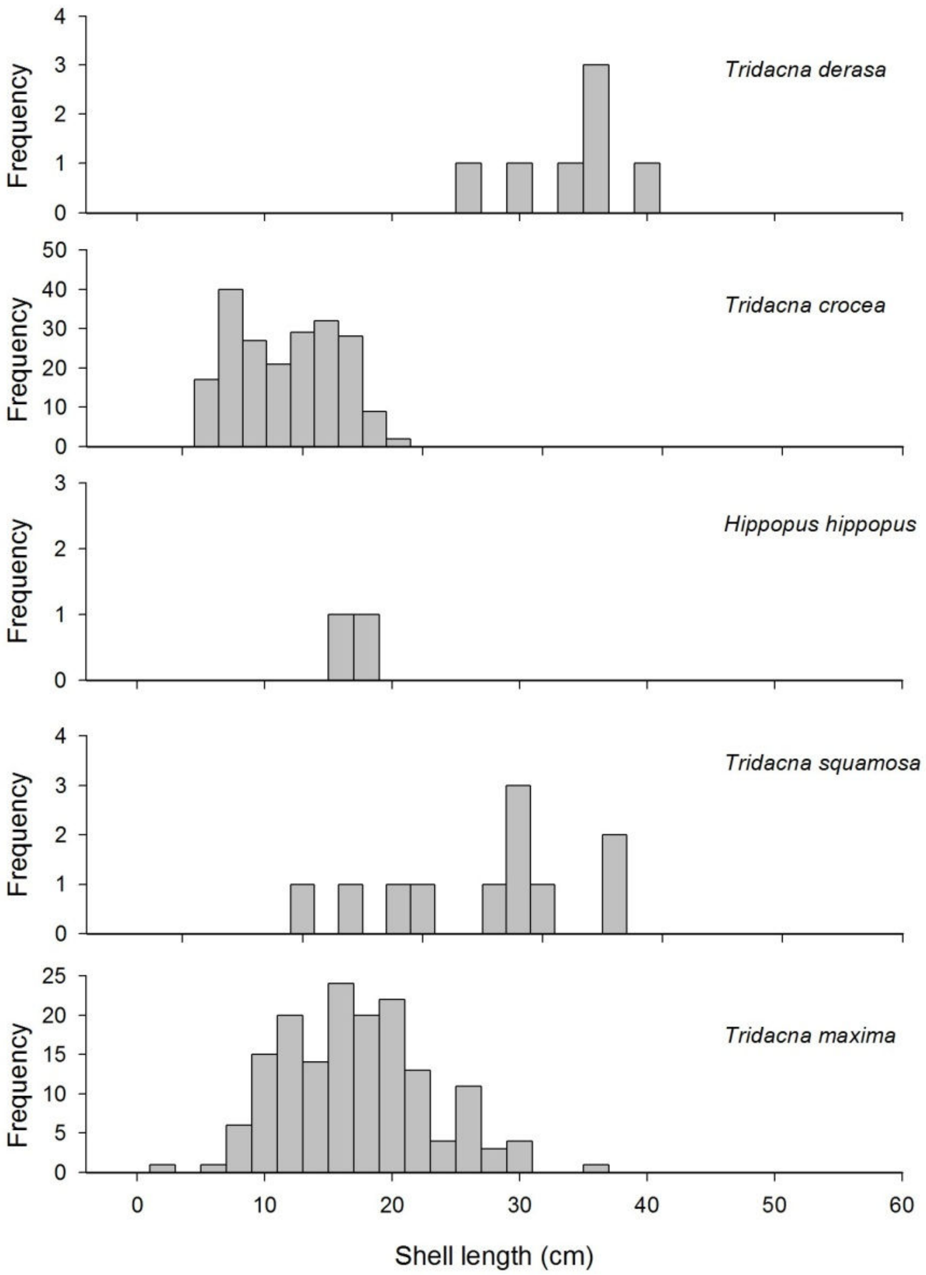

Figure 3.30: Size frequency histograms of giant clam shell length (cm) for Thio.

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

New Caledonia is relatively close to the southern limit of the natural distribution of the commercial topshell *Trochus niloticus* in the Pacific. The multiple barrier reefs at differing levels of exposure at Thio constitute an extensive suitable benthos for *T. niloticus*, and this area could potentially support significant populations of trochus (23.8 km lineal distance of exposed reef, with an extra 10 km reef front on the 'false' barrier within the lagoon).

PROCFish survey work revealed that *T. niloticus* and a number of other mother-of-pearl species were present on a number of reef systems in Thio (Table 3.13).

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

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S	6.4	1.6	10/13 = 77	19/78 = 24
RBt	52.1	31.3	4/12 = 33	10/72 = 14
RFs	28.4	10.5	2/4 = 50	13/24 = 54
MOPs	68.2		1/1 = 100	5/6 = 83
MOPt	88.5	41.1	4/4 = 100	9/24 = 38
Pinctada margaritifera				
B-S	1.5	0.7	3/13 = 23	5/78 = 6
RBt	6.9	4.7	2/12 = 17	2/72 = 3
RFs	0	0	0/4 = 0	0/24 = 0
MOPs	0	0	0/1 = 0	0/6 = 0
MOPt	0	0	0/2 = 0	0/24 = 0
Tectus pyramis				
B-S	3.0	1.1	5/13 = 38	9/78 = 12
RBt	76.4	29.8	6/12 = 50	15/72 = 21
RFs	176.5	75.7	2/4 = 50	14/24 = 58
MOPs	0	0	0/1 = 0	0/6 = 0
MOPt	57.3	10.0	4/4 = 100	7/24 = 29

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

Although trochus occurred across a broad area of the lagoon (total n = 100 individuals), aggregations were mainly concentrated on the barrier reef. These aggregations have adequate broodstock to allow rapid regeneration of stock if they are ‘rested’ from fishing, but densities are considered too low for general commercial fishing (Appendix 4.2.3). Before commercial harvests are considered, densities of 500–600 /ha within main aggregations need to be available, with a full range of shell sizes.

The mean basal width of trochus (n = 45) was 12.4 cm ±0.3, but the mode was 13 cm, which shows that the main bulk of stock in Thio is of older, mature shells. Some new recruitment was noted (shells <8 cm), which is promising for future growth of the stock (Figure 3.31).

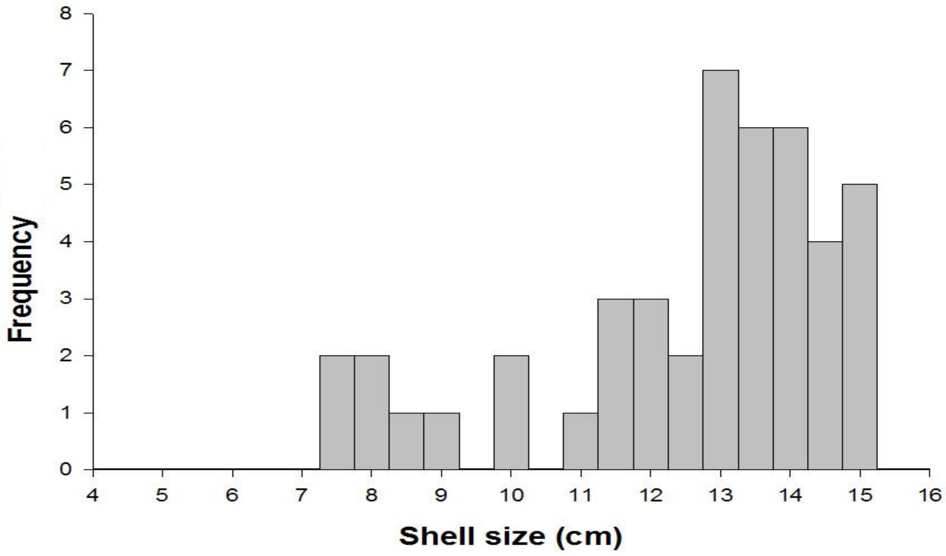

Figure 3.31: Size frequency histogram of trochus shell base diameter (cm) for Thio.

Despite blacklip pearl oysters (*Pinctada margaritifera*) being cryptic and normally sparsely distributed in open lagoon systems (such as in Thio), the number of blacklip seen during assessments was moderately high (n = 9). The mean shell length (anterior–posterior measure) was 13.1 cm ±1.0. The green topshell (*Tectus pyramis*), a related but less valuable species than trochus (with a similar life history) was also abundant at Thio, with 227 individuals recorded in survey. The mean size (basal width) of *T. pyramis* (n = 32) was 6.9 cm ±0.2, with only 9% recorded at sizes ≤6.0 cm (young shells).

3.4.3 Infaunal species and groups: Thio

The soft benthos at the margins of the lagoon was generally stony and sandy without areas of seagrass or notable shell 'beds' for in-ground resource species, such as arc (*Anadara* spp.) or venus shells (*Gafrarium* spp.). However, there was an indication from local fishers that a limited collection area (0.13 km^2) did exist for collecting infaunal species and quadrat surveys were made at this location (6 stations).

Arc shells (*Anadara antiquata*) were recorded at a density of 4.9 /m^2 ±1.5 and shells were common across the area sampled (recorded in 63% of quadrat groupings; see Methods). In general, the shell beds were dominated by smaller *A. antiquata* (mean length 38.1 mm ±1.5). However, examination of the length frequency revealed that the full complement of shell sizes was present, and that the small mean size was due to the relative abundance of smaller shells present (showing recruitment); there were numerous small shells (mode = 30 mm) and larger *Anadara* were less common (Figure 3.32). In addition to arc shells, *Tellina palatum* and *Pitar prora* were found at low density (Appendix 4.2.4).

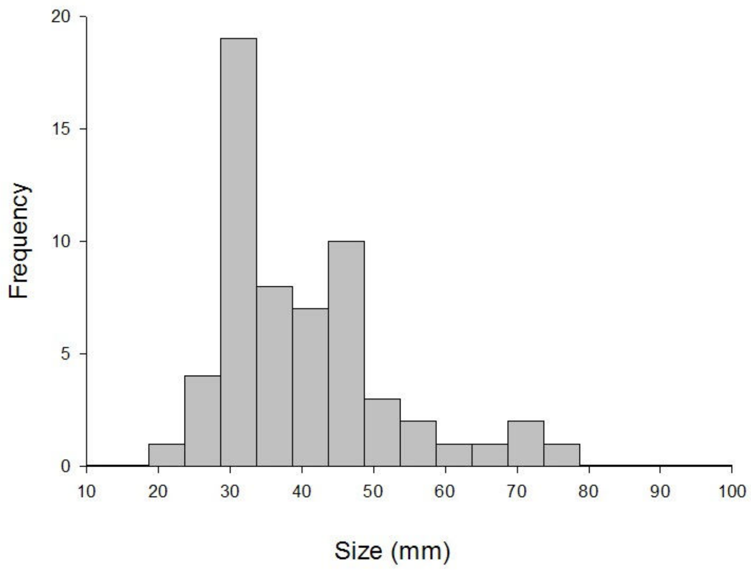

Figure 3.32: Size frequency histogram of *Anadara antiquata* shell size (mm) for Thio.

3.4.4 Other gastropods and bivalves: Thio

Seba's spider conch (*Lambis truncata*), the larger of the two common spider conchs, and the smaller *L. lambis* were both detected in broad-scale and finer-scale surveys at reasonably high density (27 individuals recorded); however, *Strombus luhuanus* was absent (Appendices 4.2.1 to 4.2.9). Three species of *Turbo* were recorded at low density (*T. argyrostomus, T. crassus* and *T. chrysostomus*), although no *T. setosus* was seen (expected in reef or MOP surveys). Other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Dolabella*, *Ovula*, *Tectus*, *Thais* and *Vasum* spp.) were also recorded during independent surveys (Appendices 4.2.1 to 4.2.9).

Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Periglypta*, *Pitar*, *Spondylus*, *Tapes and Tellina* spp. are also in Appendices 4.2.1 to 4.2.9. No creel survey was conducted at Thio.

3.4.5 Lobsters: Thio

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, lobsters were relatively common and 13 *Panulirus* spp. individuals were recorded in the survey. No lobsters were observed during night-time assessments for nocturnal sea cucumber species (Ns).

3.4.6 Sea cucumbers[6]: Thio

Thio has an extensive and complex lagoon system bordering a large land mass. As in the other Grande Terre PROCFish/C site on the east coast (Ouassé), reef margins and shallow, mixed hard- and soft-benthos habitat (suitable for sea cucumbers) were wide-ranging in the lagoon and around the 'false' barrier and main barrier reef. Throughout the lagoon, water

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

movement was dynamic and there was a high degree of exposure to oceanic condition in the outer lagoon, where numerous passages and areas of submerged barrier link the lagoon to the ocean. Rivers were present and allochthonous input (riverine or other inputs from land) was significant at more inshore locations.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 3.14, Appendices 4.2.2 to 4.2.9; see also Methods). Seventeen commercial species of sea cucumber were recorded during in-water assessments (Table 3.14). The presence of valuable commercial species reflected the varied environment of Thio, which suited many of these deposit-feeding sea cucumber species (which eat organic matter in the upper few mm of bottom substrates) and was similar to other PROCFish sites on Grande Terre in New Caledonia.

Sea cucumber species associated with shallow reef areas, such as the leopardfish (*Bohadschia argus*) and the high-value black teatfish (*Holothuria nobilis*) were not found as regularly as further north along the east-coast lagoon of Grande Terre (found in 4–26% of assessment units), possibly indicating that there was greater fishing or environmental pressure at this site. Similar to found in Ouassé, the fast-growing and medium/high-value greenfish (*Stichopus chloronotus*) was relatively plentiful (found in 67% of broad-scale transects) and, on occasion, found at high density (Table 3.14).

Again, surf redfish (*Actinopyga mauritiana*), a species well suited to the conditions found at Thio, was never recorded in high-density aggregations, despite being present in many locations.

More protected reef and soft-benthos habitats in less exposed areas of the lagoon had good coverage of blackfish (*Actinopyga miliaris*), and stonefish (*A. lecanora*) at medium density. A few lower-value species, e.g. elephant trunkfish (*H. fuscopunctata*), lollyfish (*H. atra*) and pinkfish (*H. edulis*) were also present. Flowerfish (*B. graeffei*) were particularly common at Ouassé and were also found at high levels across the inshore areas of the lagoon at Thio.

A single deep dive (25–35 m) on SCUBA was conducted to obtain a preliminary assessment of deep-water stocks, such as the high-value white teatfish (*H. fuscogilva*) and the lower-value amberfish (*Thelenota anax*). In deep-water assessments (average 27.5 m depth for 6 replicate search periods) white teatfish (*H. fuscogilva*) were present at low density, but no amberfish (*T. anax*) were found. The passage dived in was a breach in the 'false' barrier within the main body of the lagoon and relatively close to the coast. An exploration of areas further offshore (with greater influence from oceanic conditions) would be useful to further assess deep-water stocks and the presence of the prickly redfish (*T. ananas*).

3.4.7 Other echinoderms: Thio

Edible urchins, such as the collector urchin (*Tripneustes gratilla*) were rare, but the slate urchin (*Heterocentrotus mammillatus*) was found at relatively high levels during two reef-front search stations (242.2 /ha ±120.7). Other urchins that can be used within assessments as potential indicators of habitat condition (*Echinometra mathaei* and *Echinothrix* spp.) were recorded at relatively low levels in surveys.

Table 3.14: Sea cucumber species records at Thio

Species	Common name	Commercial value [5]	B-S transects n = 78			Reef-benthos stations n = 12			Other stations RFs = 4 MOPs = 1; MOPt = 4			Other stations Ds = 1 Ns = 3		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H	0.2	16.7	1									
Actinopyga lecanora	Stonefish	M/H	1.1	41.7	3	10.4	62.5	17				20.7	31.1	67 Ns
Actinopyga mauritiana	Surf redfish	M/H	4.4	28.9	15	20.8	83.3	25	135.4 9.6	180.6 19.6	75 MOPt 25 RFs			
Actinopyga miliaris	Blackfish	M/H	1.1	16.6	6							11.9 4.8	17.8	67 Ns 100 Ds
Actinopyga palauensis	No name as yet	M	1.3	20.0	6									
Actinopyga spinea		M/H												
Bohadschia argus	Leopardfish	M	12.9	50.5	20	3.5	41.7	8						
Bohadschia graeffei	Flowerfish	L	75.7	281.3	27	31.3	75	42						
Bohadschia similis	False sandfish	L												
Bohadschia vitiensis	Brown sandfish	L												
Holothuria atra	Lollyfish	L	80.2	260.7	31	319.4	479.2	67	11.8	15.7	50 RFs			
Holothuria coluber	Snakefish	L	4.7	183.3	3									
Holothuria edulis	Pinkfish	L	49.3	160.2	31	34.7	416.7	8						
Holothuria flavomaculata	-	L												
Holothuria fuscogilva [4]	White teatfish	H										2.4		100 Ds
Holothuria fuscopunctata	Elephant trunkfish	M	26.8	149.5	18									
Holothuria nobilis [4]	Black teatfish	H	0.6	16.3	4				5.2	20.8	25 MOPt	3.0	8.9	33 Ns
Holothuria scabra	Sandfish	H												
Holothuria scabra versicolor	Golden sandfish	H	1.7	22.2	7									
Stichopus chloronotus	Greenfish	H/M	433.3	637.7	68	541.7	650.0	83	10.4	20.8	50 MOPt			
Stichopus hermanni	Curryfish	H/M	1.1	20.8	5									
Stichopus horrens	Dragonfish	M/L												
Thelenota ananas	Prickly redfish	H	4.1	52.8	8									
Thelenota anax	Amberfish	M												

[1] D = Mean density/ha; [2] DwP = Mean density/ha for transects or stations where the species was present; [3] PP = Percentage presence (Units where the species was found); [4] There has been a recent variation to sea cucumber taxonomy which has changed the name of the black teatfish in the Pacific to *H. whitmaei*. There is also the possibility of a future change in the white teatfish name. This should be noted when comparing texts, as in this report the 'original' taxonomic names are used; [5] 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; MOPs = mother-of-pearl search; MOPt = mother-of-pearl transect; Ds = sea cucumber day search; Ns = sea cucumber night search.

Starfish (e.g. *Linckia laevigata*, the blue starfish) were not as common in Thio as further north in Ouassé (22% rather than 82% of manta stations). Corallivorous (coral-eating) starfish were rare, with no pincushion stars (*Culcita novaeguineae*) and only two crown of thorns (*Acanthaster planci*) recorded in Thio (See presence and density estimates in Appendices 4.2.1 to 4.2.9.).

3.4.8 Discussion and conclusions: invertebrate resources in Thio

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.

- Thio has a relatively complete range of giant clam species, some of which are now becoming rare in other parts of the Pacific, even in New Caledonia.

- This promising indication of stock condition is reported despite there being relatively low abundances of the largest species (*T. derasa* and *T. squamosa*) and a scarcity of *Hippopus hippopus*. These species are usually the first to decline when fishing pressure impacts giant clam stocks, and this seems to be the case in Thio.

- The densities of *T. maxima* and *T. crocea* in Thio were reasonably high, and these species displayed a 'complete' range of size classes, which supports the assumption that the more common clam stocks are only marginally impacted by fishing pressure.

- The small number of juveniles of *T. derasa*, *H. hippopus* and, to some extent, *T. squamosa*, reflects both the scarcity of recruitment in these species and the cryptic habit of these solitary clam species. Lack of recruitment stemming from 'Allee' effects (whereby distance between adults affects success rates in the fertilisation of gametes) is a common factor in the decline of benthic invertebrates.

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

- Trochus (*Trochus niloticus*) are relatively common at Thio, as are other grazing gastropods (e.g. *Tectus pyramis*). Aggregations assessed show that there is a good stock of adult trochus of spawning size, but that densities are presently below the level at which commercial fishing is recommended.

- The blacklip pearl oyster (*Pinctada margaritifera*) was relatively common at Thio but not at sufficient densities to encourage commercial fishing of shell.

- The scale of shell beds was limited at Thio, but *Anadara* spp. (arc shells) were relatively common and a full complement of shell sizes was found. This result implies that the present shell beds are not significantly impacted by fishing pressure.

- Based on the wide range of sea cucumber stocks and the presence and density data collected in survey, stocks are only marginally impacted by fishing.

- Greenfish (*Stichopus chloronotus*) had a good coverage across Thio and was at relatively high density in survey. Despite evidence of past fishing at Thio, this species especially has been noted to return to high density following a 'rest' period from fishing at some

PROCFish sites across the Pacific. Greenfish has a relatively good market price but a low recovery rate after processing (when dried, only 3–4% of the wet, gutted weight).

3.5 Overall recommendations for Thio

- Further studies be conducted to find out why snappers (Lutjanidae), emperors (Lethrinidae) and goatfish (Mullidae) are relatively scarce. Until the cause has been found, a precautionary approach to fisheries management should be taken by limiting the catches of snappers, emperors and goatfish. The efficiency of this trial then be evaluated by monitoring these resources.

- Further development of reef finfish fisheries to improve food and financial security of the people of Thio may be sustainable in the intermediate and outer reef areas, provided any expansion of finfish fishing is accompanied by marine resource management and monitoring activities to prevent overfishing.

- Considering the high quality of habitat in Thio, marine protected areas be considered as a primary management tool.

- Trochus (*Trochus niloticus*) stocks be 'rested' until densities increase to approximately 500 individuals per ha in the main aggregations and a larger component of smaller shell sizes are seen on the reef.

- Consideration be given to protecting the larger size classes of trochus (≥12 cm), which are valuable spawners (produce exceptionally large numbers of eggs), and not preferred by industry buyers.

- Further monitoring be conducted, both around the more protected mid-shore reefs and at more exposed locations, to determine the extent and strength of deep-water stocks of the high-value white teatfish (*Holothuria fuscogilva*) in Thio.

4. PROFILE AND RESULTS FOR LUENGONI

4.1 Site characteristics

The island of Lifou is part of a group of uplifted coral islands, the Loyalty Islands, located to the east of Grand Terre, near the trench of New Hebrides. The PROCFish/C sites on this island, Luengoni and Joj (combined for the purpose of this report as 'Luengoni'), are part of the district of Losi, and are located on the east coast of Lifou, at the central position of 21°02′20″S and 167°25′34″E (Figure 4.1). The fishing area is contained between the Cape of Pines in the south and the site called 'Hutr' in the north. It is divided into two small lagoons, ~1.5 km x 0.8 km in surface area. The habitats at this site are difficult to classify, especially since the reef system is very small in size. The coastal reefs function as outer reefs, and the intermediate reefs can be classified as back-reefs. Fishing in this pseudo-lagoon is both for commercial and subsistence purposes. Ciguatera is very common among many species. The region is classified 'exclusive', with no *tabu* areas.

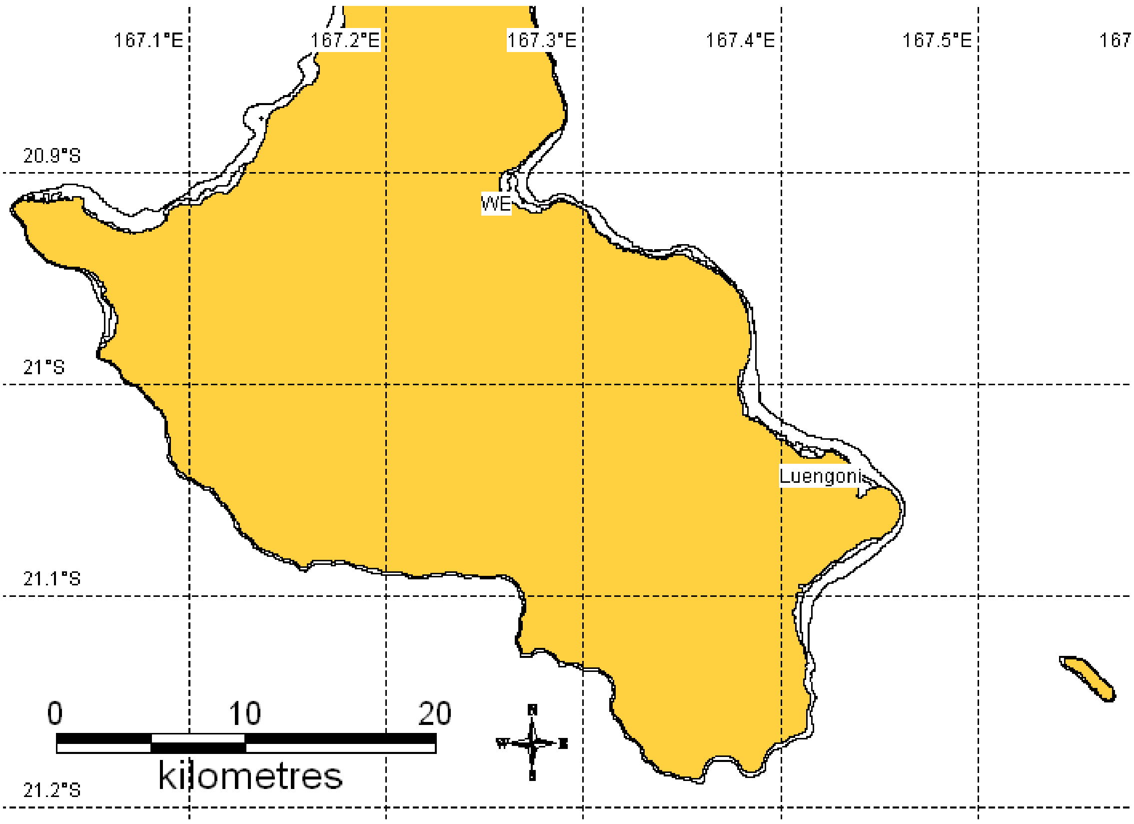

Figure 4.1: Map of Luengoni.

The habitats at this site are difficult to classify, especially due to the small size of this reef system. The coastal reefs function as outer reefs and the intermediate reefs can be classified as back-reefs.

Fishing in this pseudo-lagoon is both for commercial and subsistence purposes. Ciguatera is very common among many species.

4.2 Socioeconomic surveys: Luengoni

Socioeconomic fieldwork was carried out in April 1993 in the communities of Luengoni and Joj, in the following referred to as 'Luengoni' only. The survey covered 30 households, including 131 people. Thus, the survey represents about 60% of the community's households (50) and total population (218).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption information. A total of 28 individual interviews of finfish fishers (24 males, 4 females) and 18 invertebrate fishers (14 males, 4 females) were conducted. These fishers belonged to one of the 30 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing.

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

Our survey results (Table 4.1) suggest an average of 1.6 fishers/household. If we apply this average to the total number of households, we arrive at a total of 80 fishers in Luengoni. Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of 66 exclusive finfish fishers (males, females), and a total of 14 fishers (males, females) who fish for both finfish and invertebrates.

About 23% of all households in Luengoni own a boat; 86% are motorised, 14% are canoes.

Ranked income sources (Figure 4.2) suggest that fisheries are not an important sector as compared to all other sectors. Only ~7% of all households indicated that fisheries are their first source of income, and another 10% rely on fisheries to provide secondary income. Agriculture is of a similarly low importance, providing 3% of all households with first, and 20% with secondary income. Most of Luengoni's households obtain their first income from salaries (53%) or other income sources (43%), such as small business, and retirement and other social payments.

In Luengoni, 90% of households reported to have a household member who sometimes fishes. All households eat fresh fish, and half also eat invertebrates. The frequency of fresh-fish consumption is high (2–3 times/week) and invertebrates are eaten on average twice a month. Canned fish constitutes a regular meal in 90% of all households interviewed and is eaten as often as fresh fish. While most fresh fish eaten is caught by a member of the household, 10% also buy fish and another 70% are given fresh fish. Invertebrates are either caught (~47%) or received as a gift (~37%) but hardly ever bought (~3%). The low dependency of Luengoni's household on fisheries for income and the reported sources of seafood consumed suggest that most finfish caught is offered for sale on markets outside the community.

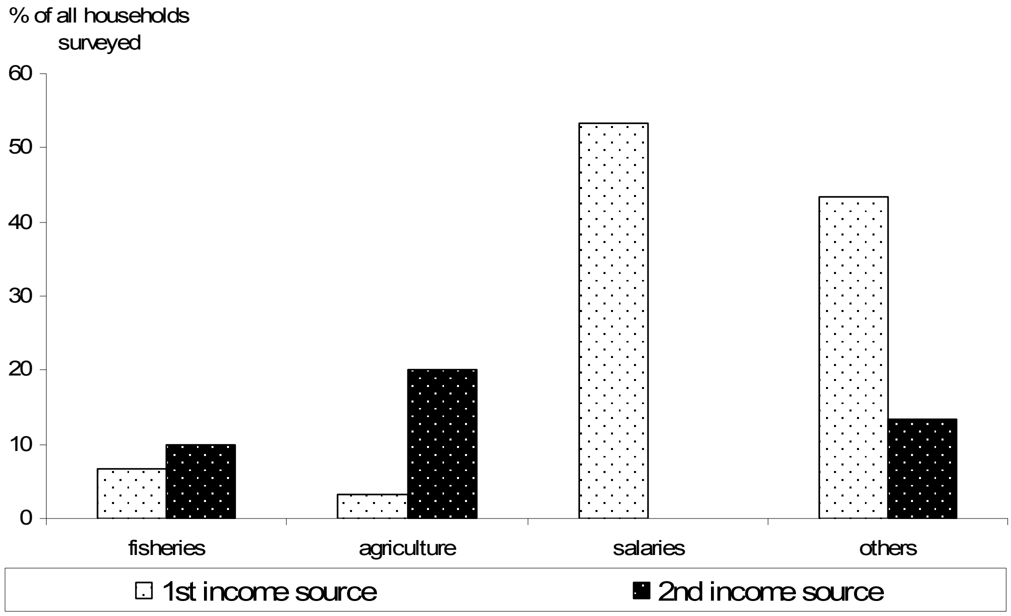

Figure 4.2: Ranked sources of income (%) in Luengoni.
Total number of households = 30 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses and retirement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

The consumption of fresh fish (~36 kg/person/year ±6.4) in Luengoni is about the same as the regional average (FAO 2008) (Figure 4.3). Across all New Caledonian sites investigated, the fish consumption of the Luengoni community ranks relatively high and is similar to the consumption observed in Moindou and Oundjo. By contrast, invertebrate consumption is extremely low, at 5.5 kg/person/year (Figure 4.4) and by far the lowest across all other PROCFish sites in New Caledonia.

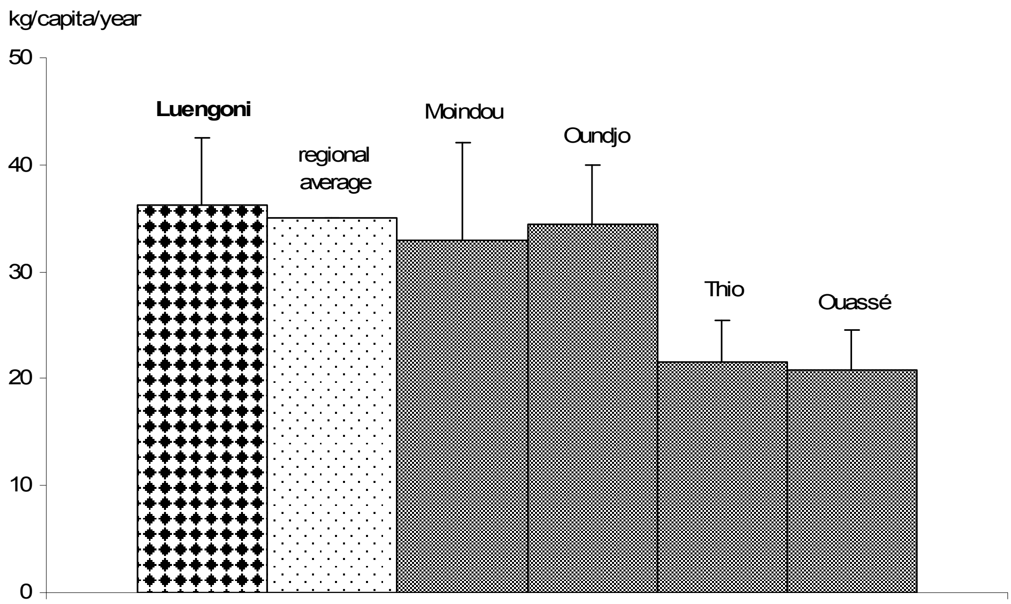

Figure 4.3: Per capita consumption (kg/year) of fresh fish in Luengoni (n = 30) compared to the regional average (FAO 2008) and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars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

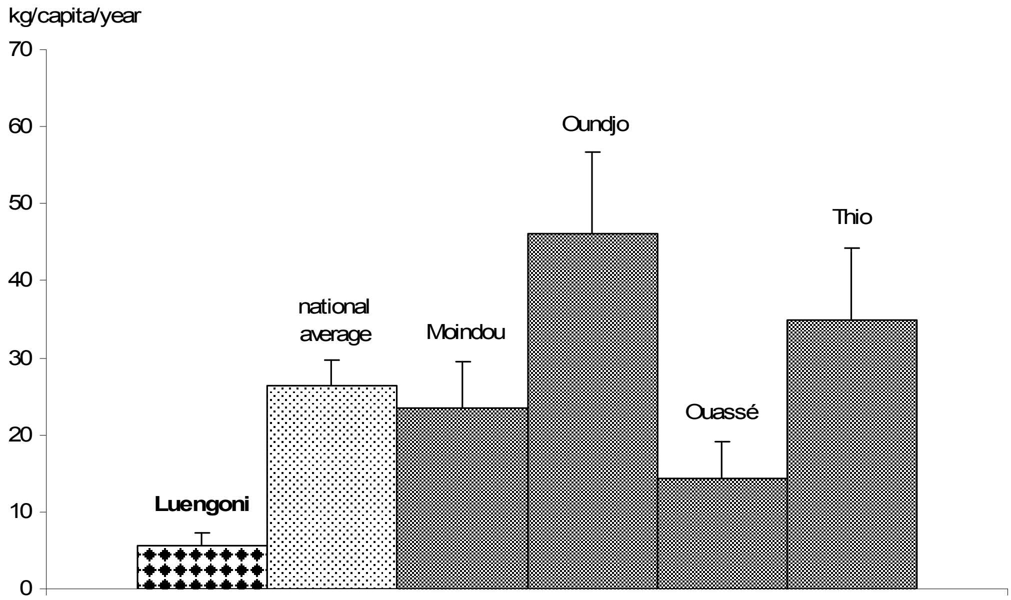

Figure 4.4: Per capita consumption (kg/year) of invertebrates (meat only) in Luengoni (n = 30) compared to the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard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

Comparison of results across all sites investigated in New Caledonia (Table 4.1) shows that the people of Luengoni are far less dependent on fisheries for income; however, they eat seafood (finfish and invertebrates) slightly more often than average.

By comparison, the average annual household expenditure level in Luengoni is substantially higher than the country average estimated by the PROCFish surveys, and the influx of money from overseas (remittances) is substantial.

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

Survey coverage	Luengoni (n = 30 HH)	Average across sites (n = 148 HH)
Demography		
HH involved in reef fisheries (%)	90.0	94.6
Number of fishers per HH	1.6 (±0.20)	1.6 (±0.08)
Male finfish fishers per HH (%)	70.2	29.6
Female finfish fishers per HH (%)	12.8	3.3
Male invertebrate fishers per HH (%)	0.0	2.5
Female invertebrate fishers per HH (%)	0.0	16.3
Male finfish and invertebrate fishers per HH (%)	14.9	32.5
Female finfish and invertebrate fishers per HH (%)	2.1	15.8
Income		
HH with fisheries as 1st income (%)	6.7	27.0
HH with fisheries as 2nd income (%)	10.0	23.6
HH with agriculture as 1st income (%)	3.3	2.0
HH with agriculture as 2nd income (%)	20.0	6.1
HH with salary as 1st income (%)	53.3	37.2
HH with salary as 2nd income (%)	0.0	6.1
HH with other source as 1st income (%)	43.3	37.8
HH with other source as 2nd income (%)	13.3	16.9
Expenditure (USD/year/HH)	10,069.33 (±1,489.32)	6587.71 (±456.24)
Remittance (USD/year/HH) (1)	2669.58 (±1,257.50)	1802.97 (±766.61)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	36.21 (±6.37)	29.81 (±3.16)
Frequency fresh fish consumed (times/week)	2.76 (±0.37)	2.35 (±0.13)
Quantity fresh invertebrate consumed (kg/capita/year)	5.52 (±1.71)	26.46 (±3.16)
Frequency fresh invertebrate consumed (times/week)	0.57 (±0.18)	0.88 (±0.07)
Quantity canned fish consumed (kg/capita/year)	18.05 (±5.76)	6.69 (±1.32)
Frequency canned fish consumed (times/week)	2.77 (±0.42)	1.35 (±0.14)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	50.0	88.5
HH eat canned fish (%)	90.0	82.4
HH eat fresh fish they catch (%)	83.3	83.3
HH eat fresh fish they buy (%)	10.0	10.0
HH eat fresh fish they are given (%)	70.0	70.0
HH eat fresh invertebrates they catch (%)	46.7	46.7
HH eat fresh invertebrates they buy (%)	3.3	3.3
HH eat fresh invertebrates they are given (%)	36.7	36.7

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

4.2.2 Fishing strategies and gear: Luengoni

Degree of specialisation in fishing

Fishing in Luengoni is performed by both genders (Figure 4.5). However, most fishers target exclusively finfish and these are mainly males (70%). Only ~13% of all female fishers exclusively target finfish. There was no reported case of exclusive invertebrate fisher, and those who target both finfish and invertebrates are a minority, i.e. ~15% of all male and 2% of female respondents.

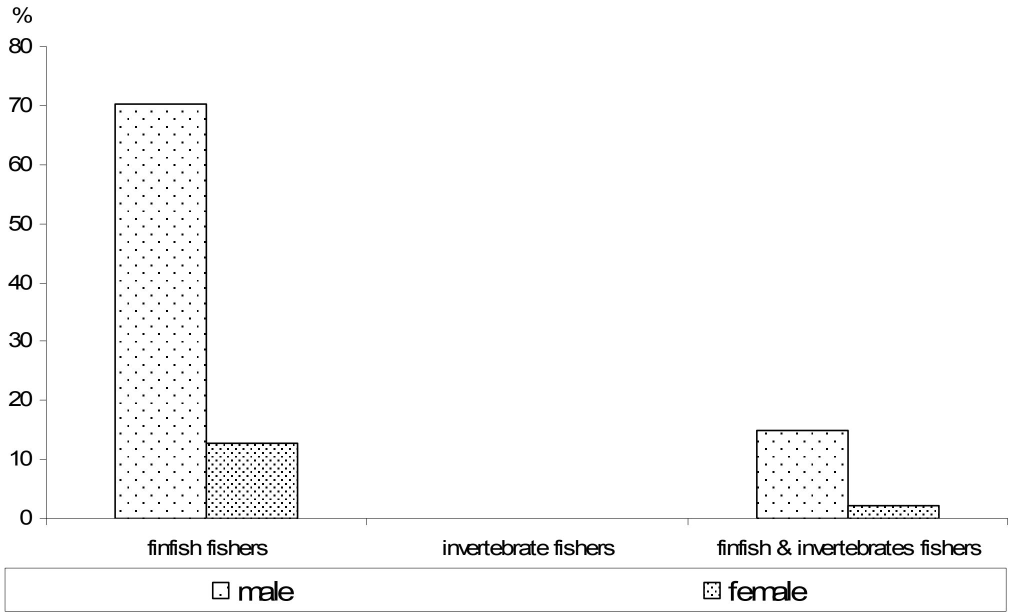

Figure 4.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Luengoni.
All fishers = 100%.

Targeted stocks/habitat

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

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Reef flats	4.2	50.0
	Reef flats & lagoon	8.3	0.0
	Lagoon	62.5	50.0
	Sheltered coastal reef & lagoon	16.7	0.0
	Sheltered coastal reef	20.8	0.0
Invertebrates	Lobster	85.7	0.0
	Other	28.6	0.0
	Reeftop	42.9	100.0
	Soft bottom (sand)	7.1	0.0

'Other' refers to the giant clam and octopus fisheries.
Finfish fisher interviews, males: n = 24; females: n = 4. Invertebrate fisher interviews, males: n = 14; females, n = 4.

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 the Luengoni community on its fishing grounds.

Our survey sample suggests that fishers in Luengoni can choose among reef flats, sheltered coastal reef and lagoon habitats. Some combine the reef flats and lagoon or the lagoon and sheltered coastal reef in one fishing trip. Most fishers, males and females, however, target the lagoon, and most female finfish fishers also the reef flats. About 17% of all male fishers combine the lagoon and sheltered coastal reef in one fishing trip, and ~21% target the sheltered coastal reef alone (Table 4.2).

All female and 43% of male invertebrate fishers glean the reeftops (Figure 4.6). The majority of male fishers (~86%) dive for lobsters, and another 29% dive for other species, such as octopus and giant clams. The exclusive participation of males in lobster and other invertebrate dive fisheries suggests that as elsewhere in the South Pacific, females do not engage in dive fishing (Figure 4.7).

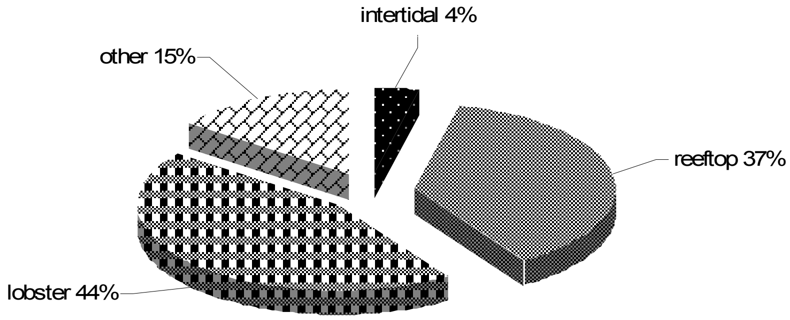

Figure 4.6: Proportion (%) of fishers targeting the four primary invertebrate habitats found in Luengoni.
Data based on individual fisher surveys; data for combined fisheries are disaggregated. 'Other' refers to the giant clam and octopus fisheries.

Figure 4.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Luengoni.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 14 for males, n = 4 for females; 'other' refers to the giant clam and octopus fisheries.

Gear

Figure 4.8 shows that the combined use of gillnets, castnets, handlines and spears (spear diving and handheld spearing either used when walking or from a canoe) is prominent in any habitat fished. Castnets and gillnets are often used if fishing the reef flats alone or in combination with the lagoon, and handlines are mostly used in the lagoon. At the sheltered coastal reef fishers also prefer the combination of handlines and spear diving.

Gleaning and free-diving for invertebrates is done using very simple tools only. Lobsters and octopus are often speared, while other species collected on reeftops are picked up by hand. Diving does not involve any gear other than mask, snorkel, fins and, possibly, a wet suit. Lobster and other dive fisheries often involve boat transport, and most of the boats used are motorised. Reeftop gleaning and shell collecting on soft bottom (sandy intertidal areas) are done by walking.

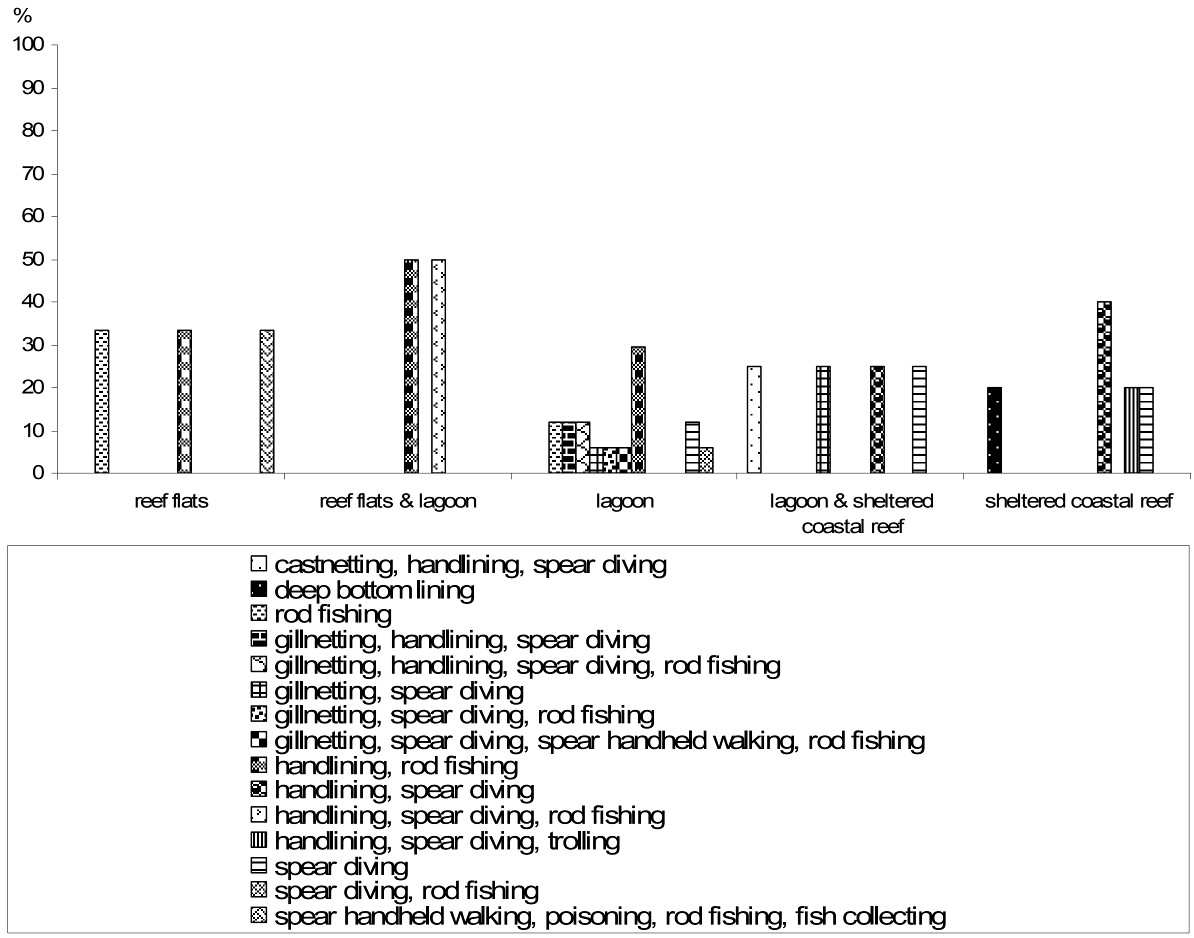

Figure 4.8: Fishing methods commonly used in different habitat types in Luengoni.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Frequency and duration of fishing trips

As shown in Table 4.3, the frequency of fishing trips to the various habitats varies considerably. The combined fishing of the lagoon and sheltered coastal reef is done most frequently (1.75 times/week) followed by fishing trips to the lagoon by male fishers (1.2 times/week) and female fishers (1.5 times/week). Fishing at the reef flats alone or the sheltered coastal reef alone are performed less frequently. The duration of fishing trips, regardless of which habitat is targeted, is 2.25–3 hours each, with trips to the sheltered coastal reef alone lasting the longest on average.

By comparison, invertebrate fishing is performed less frequently. Only shell collecting from intertidal, soft-bottom habitats is done 1.5 times/week; all other collection is performed 1–2 times/month. Gleaning trips are generally short (1–2 hours), while diving trips are longer (2.25 hours on average).

Finfish is usually caught according to the tide; hence fishers may go out either at day or night. However, half of all male fishers who combine the lagoon and sheltered coastal reef in one fishing trip prefer going out at night and female fishers mainly targeting the reef flats prefer to fish by day. The reef flats are fished throughout the year, while fishers visiting any of the other habitats usually stop fishing during unfavourable months.

Most invertebrate fisheries are daytime activities and are performed during most months of the year. However, lobster diving is preferably done at night and reeftop collection is performed either by day or night. Only soft-bottom collection (sandy intertidal areas) is performed continuously throughout the year.

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

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Reef flats	0.04 (n/a)	0.79 (±0.21)	3.00 (n/a)	2.25 (±0.75)
	Reef flats & lagoon	1.00 (±0.00)	0	2.25 (±0.25)	0
	Lagoon	1.20 (±0.33)	1.50 (±0.50)	2.87 (±0.26)	3.75 (±2.25)
	Lagoon & sheltered coastal reef	1.75 (±0.14)	0	2.75 (±0.43)	0
	Sheltered coastal reef	0.89 (±0.11)	0	3.20 (±0.62)	0
Invertebrates	Lobster	0.82 (±0.19)	0	2.25 (±0.27)	0
	Other	0.30 (±0.13)	0	2.25 (±0.75)	0
	Reeftop	0.65 (±0.16)	0.51 (±0.17)	1.88 (±0.51)	2.50 (±0.61)
	Sand	1.50 (n/a)	0	1.00 (n/a)	0

Figures in brackets denote standard error; n/a = standard error not calculated; 'other' refers to the giant clam and octopus fisheries.
Finfish fisher interviews, males: n = 24; females: n = 4. Invertebrate fisher interviews, males: n = 14; females: n = 4.

4.2.3 Catch composition and volume – finfish: Luengoni

Reported catches from the reef flats are constituted by four major species groups: *bec-de-cane* (*Lethrinus olivaceus*, ~30%), *perroquet* (*Scarus* spp., ~27%), *rouget* (*Parupeneus* spp., ~26%) and *loche* (*Epinephelus* spp., ~17%). *Naso unicornis* (*dawa*) and *Lethrinus olivaceus* (*bec-de-cane*) are the most prominent species reported for the combined fishing of reef flats and lagoon habitats. They determine >40% of the reported average catches. Reported lagoon catches represent the highest diversity, with over 15 species groups. *Perroquet* (*Scarus* spp.), *bec-de-cane* (*Lethrinus olivaceus*) and *rouget* (*Parupeneus* spp.) account for almost half. The reported average catches at the sheltered coastal reef are dominated by *bec-de-cane* (*Lethrinus olivaceus*, ~23%), *loche* (*Epinephelus* spp., ~13%), *picot canaque* (*Acanthurus xanthopterus*, ~12%) and *perroquet* (*Scarus* spp., ~11%) (Detailed data are provided in Appendix 2.3.1.).

Our survey sample of finfish fishers interviewed represents about 35% of the projected total number of finfish fishers in Luengoni. The survey included all active fishers, i.e. those who fish regularly. It is concluded that results largely represent the overall impact of reef fisheries imposed by the community members of Luengoni on their fishing ground. Those fishers that we have not included in this survey are leisure fishers, who may or may not fish regularly and fish for subsistence purposes only. Hence, the impact not captured here is presumably small, if not negligible.

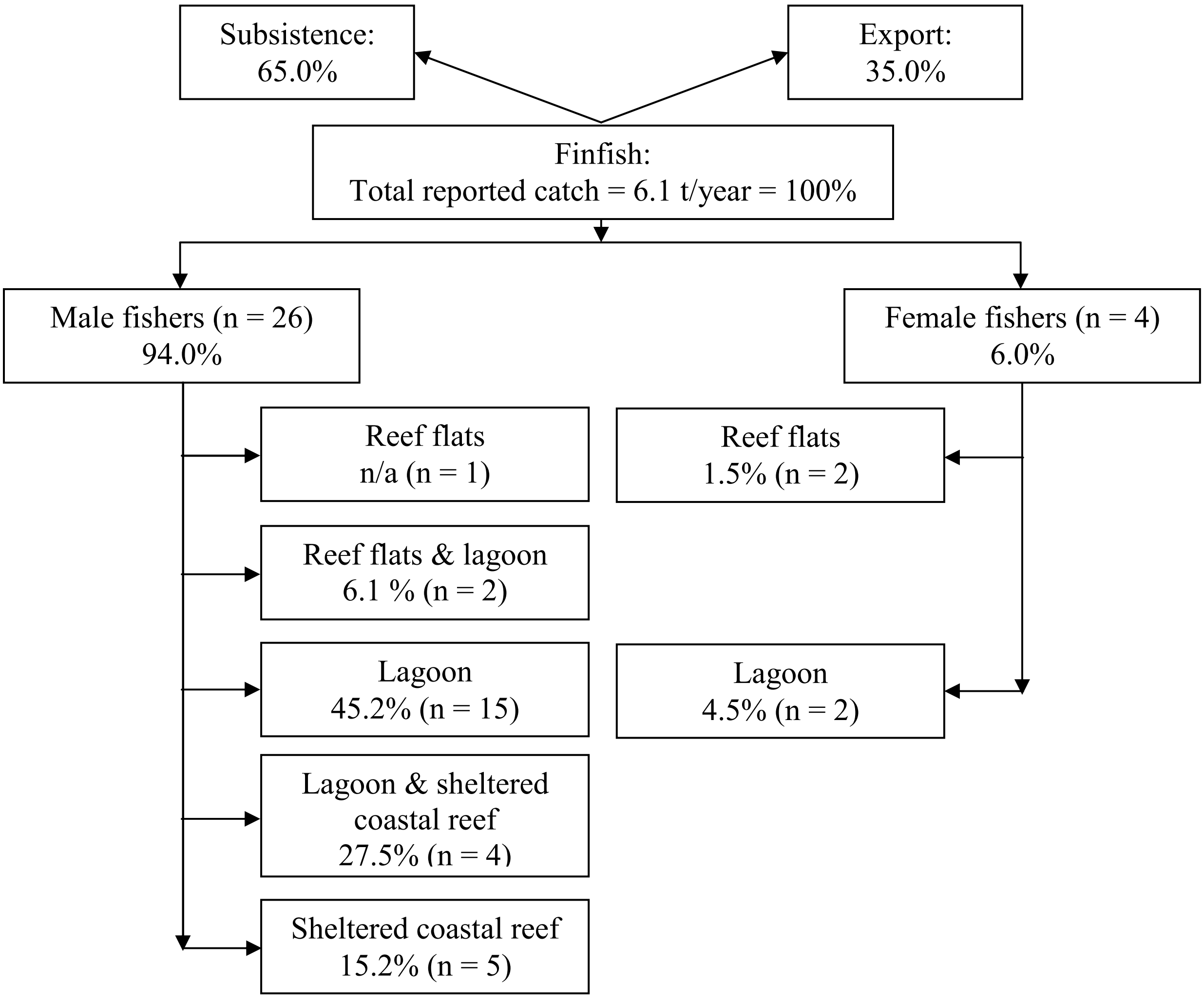

Figure 4.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Luengoni.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey. n/a = no information available.

As shown in Figure 4.9, most impact is due to subsistence reef fishing, i.e. catches that are sold outside the Luengoni community only account for 35% of the total annual reported catches. Taking into account an average consumption of 36.2 kg/person/year and a total population of 218 people, a total possible impact of 9.9 t/year can be estimated. Most of the catch is taken by male fishers (94%); females only play a minor role (6%). Highest pressure is imposed on the lagoon (~50%), followed by the combined lagoon and sheltered coastal reef fishing (~28%) and the sheltered coastal reef (15%). Lowest pressure is observed for the reef flats.

The high impact on the lagoon is mainly due to the large number of fishers rather than the average annual catch per fisher. The highest average annual catches were reported for the combined fishing of lagoon and sheltered coastal reefs (>400 kg/fisher/year) (Figure 4.10). Actually, the average catch indicated for lagoon fishers (~195 kg/fisher/year) is comparable to those of targeting either the sheltered coastal reef or the combined reef flats and lagoon. Female finfish fishers catch less than males (in the lagoon).

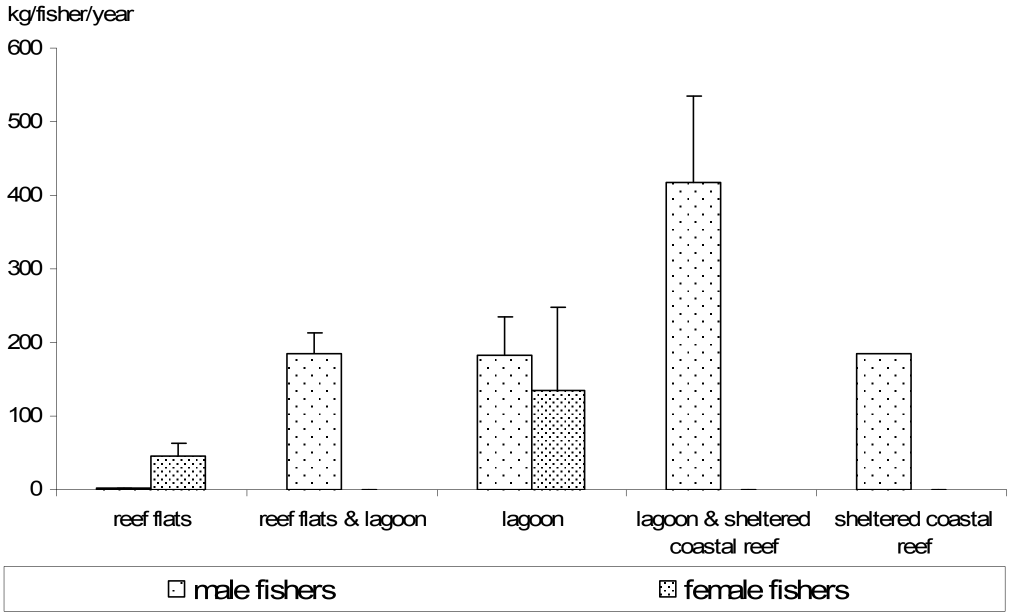

Figure 4.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Luengoni (based on reported catch only).

However, if comparing CPUEs, i.e. the catch in kg per time spent fishing, the highest rates are obtained by fishers targeting the sheltered coastal reef, the combined lagoon and sheltered coastal reef and the combined reef flats and lagoon (~2 kg/hour) (Figure 4.11). Lagoon and reef flats fishing render much lower CPUEs (1.25 kg/hour and 0.5 kg/hour respectively). The CPUE of female fishers is generally much lower than that of males except for fishing the reef flats, where females are twice as efficient as males.

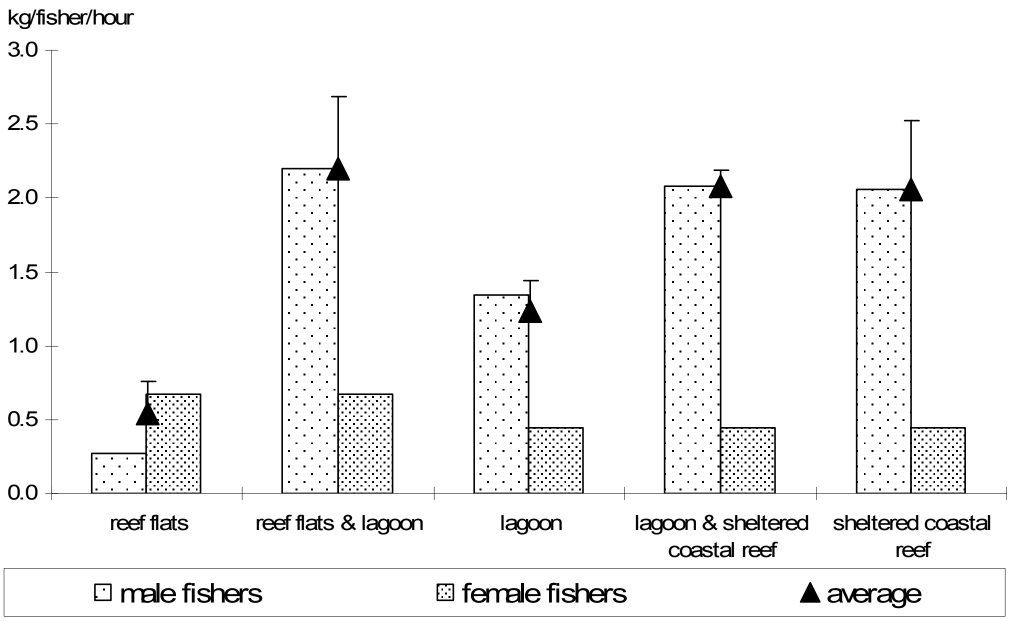

Figure 4.11: Average catch per unit effort (CPUE) (kg catch per hour of total fishing trip, +SE), by gender and habitat in Luengoni.

Survey data suggest differences in the objective of fishing among different habitats targeted (Figure 4.12). Catches from the reef flats and the combined fishing of reef flats and lagoon habitats are only used for subsistence and gift purposes, while some of the catches from the lagoon, lagoon and sheltered coastal reef combined, and sheltered coastal reef alone may be used for sale.

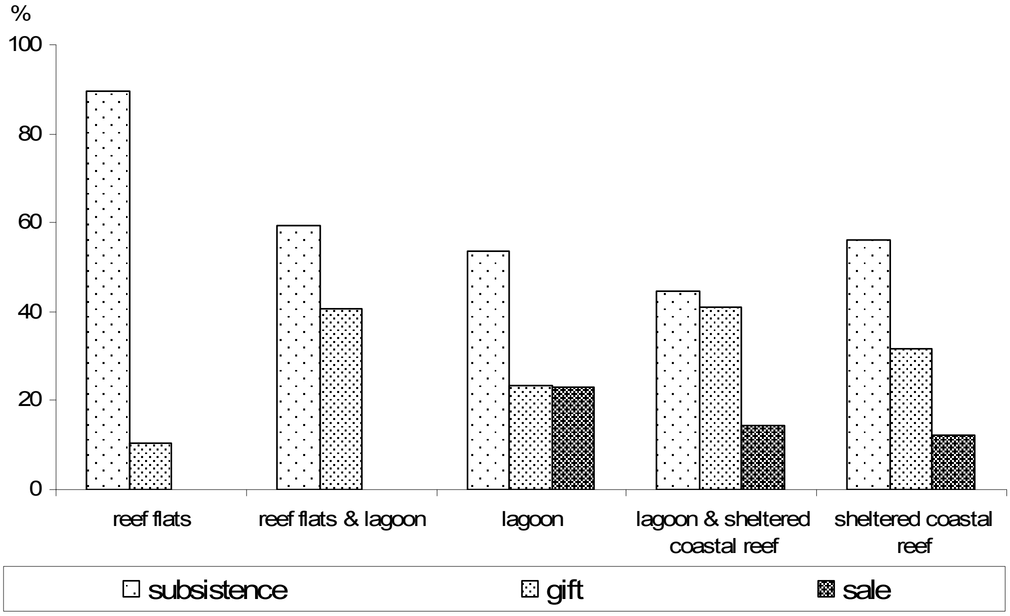

Figure 4.12: The use of finfish catches for subsistence, gift and sale, by habitat in Luengoni.
Proportions are expressed in % of the total number of trips per habitat.

Data on the average reported finfish sizes by family and habitat (Figure 4.13) do not show substantial differences in fish size per habitat. Lutjanidae may be the exception, as the largest of these are reported in catches from the sheltered coastal reef. However, the limited sample size may be misleading. Other families, such as Acanthuridae, Lethrinidae and Siganidae, are similar in size in all reported catches. In the case of Mullidae and Scaridae, there is a slight tendency for larger fish to be associated with lagoon catches rather than sheltered coastal reef or reef-flat catches. However, the size differences are not sufficient to suggest any visible impacts caused by variations in techniques used or in fishing pressure among the various habitats investigated.

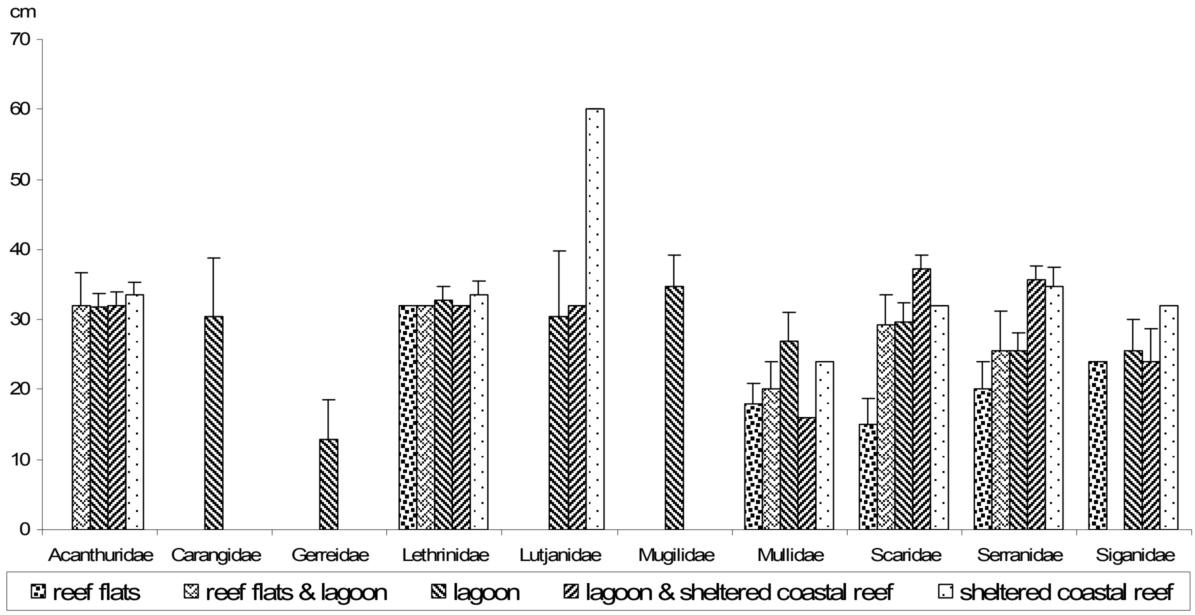

Figure 4.13: Average sizes (cm fork length) of fish caught by family and habitat in Luengoni. Bars represent standard error (+SE).

Some parameters selected to assess the current fishing pressure on Luengoni's living reef resources are shown in Table 4.4. The comparison of habitat surfaces included in Luengoni's fishing ground shows that the sheltered coastal reef provides the largest fishing area. Overall fisher density is moderate to low, with an average of 10 fishers/km^2 of total fishing ground and ~14 fishers/km^2 of total reef area, but highest in the lagoon (~21 fishers/km^2), where annual catches are higher as compared to reef flats. Overall, population density is moderate (~28–38 people/km^2 of total fishing ground and total reef respectively). Parameters indicate that fishing pressure on Luengoni finfish resources is low-to-moderate; however, fisher density is relatively high for the limited lagoon areas. Taking into account only the subsistence needs of Luengoni, total fishing pressure does not exceed 1 t/year/km^2 for the total fishing ground and 1.3 t/year/km^2 for the total reef area.

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

Parameters	**Habitat**						
	Reef flats	**Reef flats & lagoon**	**Lagoon**	**Lagoon & sheltered coastal reef**	**Sheltered coastal reef**	**Total reef area**	**Total fishing ground**
Fishing ground area (km^2)	1.03		2.08		4.68	5.71	7.79
Density of fishers (number of fishers/km^2 fishing ground) (1)	7.8		20.6		2.6	13.7	10
Population density (people/km^2) (2)						38	28
Average annual finfish catch (kg/fisher/year) (3)	30.73 (±17.91)	184.48 (±29.58)	178.01 (±45.40)	418.20 (±116.16)	185.54 (±25.56)		
Total fishing pressure of subsistence catches (t/km^2)						1.32	0.97

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) total population = 218; total number of fishers = 78; total subsistence demand = 7.56 t/year; (3) catch figures are based on recorded data from survey respondents only.

4.2.4 Catch composition and volume – invertebrates: Luengoni

Calculations of the recorded annual catch rates per species groups are shown in Figure 4.14. The graph shows that the major impact by wet weight is mainly due to one species group, i.e. *Panulirus* spp. (*langouste*). In addition, *Parribacus caledonicus* (*popinée*), giant clams (*Tridacna* spp., *Hippopus* spp.) and, perhaps, *Cardisoma* spp. play a minor role in the invertebrate catch in Luengoni. All 15 remaining species groups listed by respondents show insignificant impact by wet weight (Detailed data are provided in Appendices 2.3.2 and 2.3.3.).

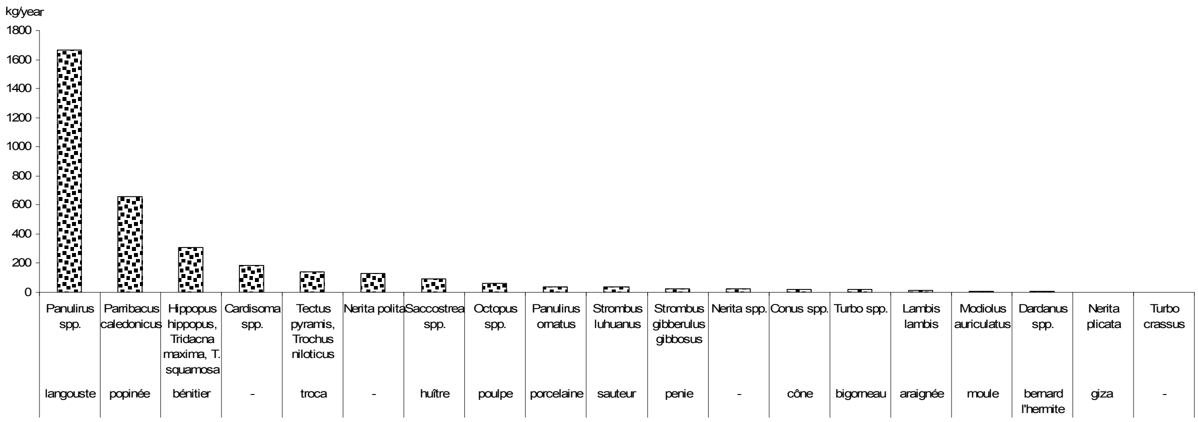

Figure 4.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Luengoni.

Overall, biodiversity in Luengoni's invertebrate fishery as reported by respondents is moderate-to-low (Figure 4.15). The reeftop fishery scores highest with 15 vernacular names, while most other fisheries are represented by only 3–4 vernacular names.

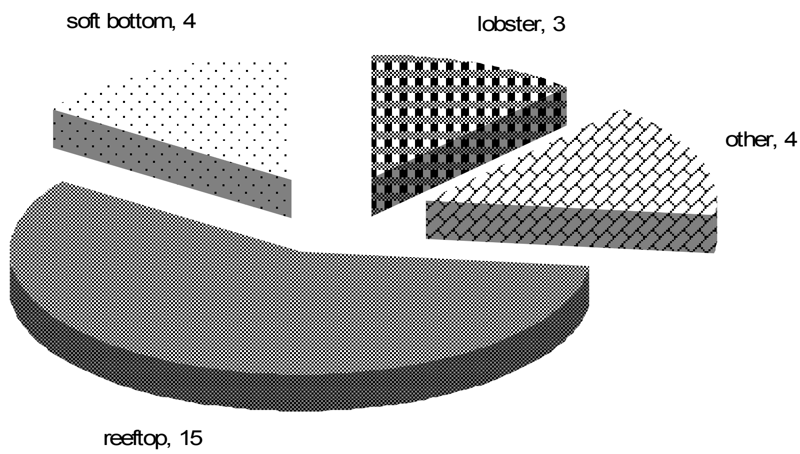

Figure 4.15: Number of vernacular names recorded for each invertebrate fishery in Luengoni.

Figure 4.16 shows that the highest average annual catches by wet weight are from the soft-bottom (sandy intertidal areas) and lobster fisheries. However, the sample size of respondents for soft-bottom fisheries is small (n = 1). Reeftop and other dive fishers (males) do not harvest exhaustively, while female reeftop fishers collect ~150 kg/fisher/year.

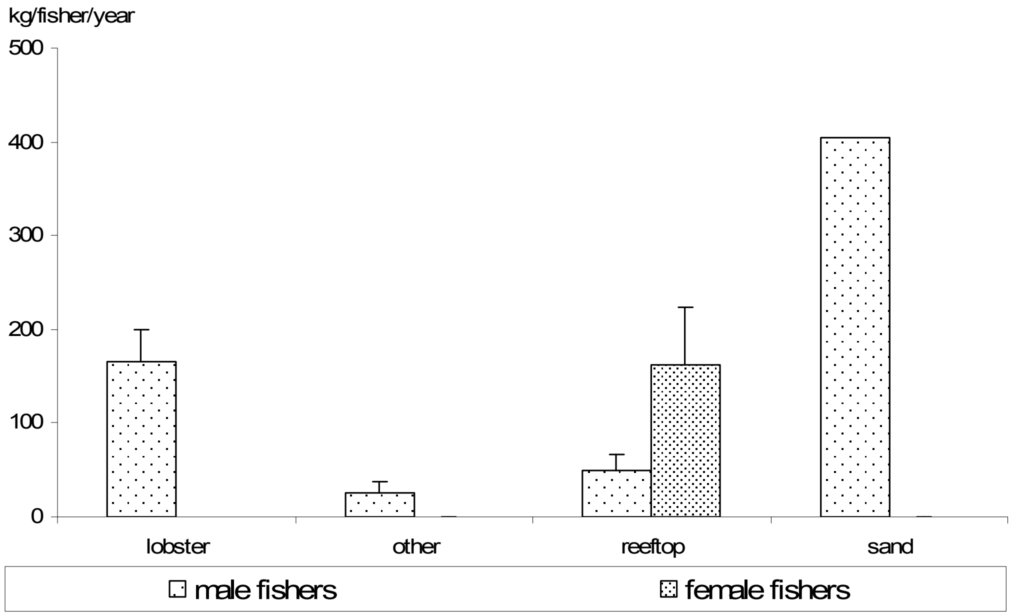

Figure 4.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Luengoni.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 34 for males, n = 21 for females). 'Other' refers to the giant clam and octopus fisheries.

As in the case for finfish fisheries, invertebrate fisheries are mainly for subsistence purposes, i.e., only ~7–22% of the catch is marketed (Figure 4.17). The higher percentage is based on the assumption that about half of catches intended for either sale or subsistence are indeed sold. However, as stated earlier, all invertebrate sales are done outside the Luengoni community, and sales mainly are lobsters and other crustaceans, which are often sold to restaurants and hotels. It can be concluded that most impact on Luengoni invertebrate resources is determined by internal rather than external demand.

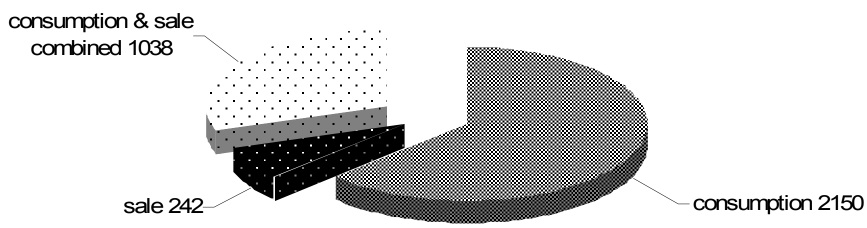

Figure 4.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Luengoni.

The total annual catch volume expressed in wet weight based on recorded data from all respondents interviewed amounts to 3.43 t/year (Figure 4.18). Lobster catches alone contribute ~58% to the total annual reported catch. Collection from reeftop areas and soft-bottom (sandy intertidal) habitats contribute ~28% and ~12% respectively. Other diving for giant clams and octopus is of minor importance (~3%). Female fishers only target reeftops; all other fishing, in particular free-diving for lobsters etc., is exclusively performed by males.

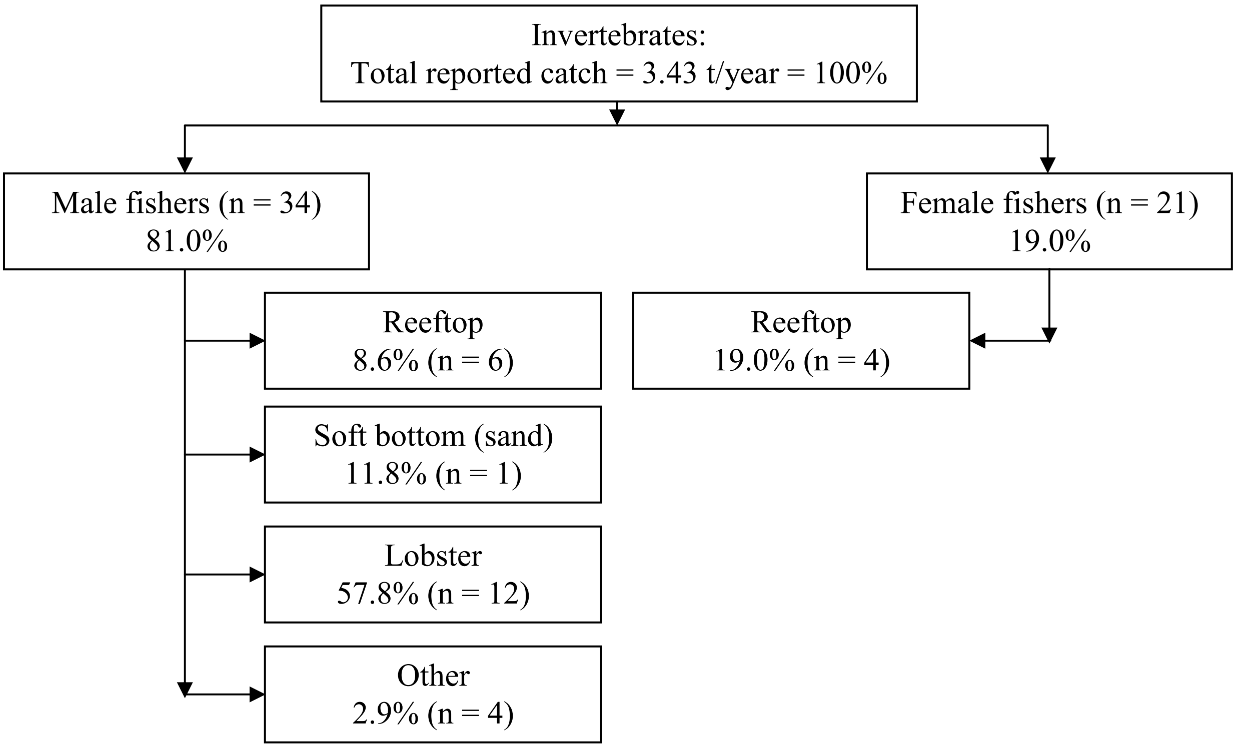

Figure 4.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Luengoni.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery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

The parameters presented in Table 4.5 show a high variability in fisher density as a result of the differences in the size of habitats available per fishery and the number of fishers harvesting each. However, in general, fisher density is not high. Considering the average recorded annual catch per fisher (wet weight) and the density of fishers, fishing pressure on most habitats is negligible. This observation is further supported by the fact that most invertebrates (apart from some lobster catches) are collected for subsistence purposes only.

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

Parameters	Fishery / Habitat			
	Lobster	Other	Reeftop [4]	Soft bottom (sand)
Fishing ground area (km^2)	2.54 [3]	3.19	0.65	
Number of fishers (per fishery) [1]	10	3	7	1
Density of fishers (number of fishers/km^2 fishing ground)	3.9	1.0	10.3	
Average annual invertebrate catch (kg/fisher/year) [2]	165.05 (±35.45)	24.87 (±13.48)	94.56 (±30.62)	403.75 (n/a)

Figures in brackets denote standard error; n/a = standard error not calculated; [1] total number of fishers is extrapolated from household surveys; [2] catch figures are based on recorded data from survey respondents only; [3] reef length; [4] reeftop fishery is mostly targeting the sheltered coastal reef areas, thus we have disregarded here the outside shallow reef areas, although they represent potential fishing grounds for the reeftop fishery.

4.2.5 Discussion and conclusions: socioeconomics in Luengoni

- Fisheries do not play an important role as a source of revenue in Luengoni, but salaries and other sources, including small business and retirement and other social fees are the main sources of income.

- However, the people in Luengoni frequently eat fresh fish and invertebrates and almost all households have a member who sometimes goes fishing for subsistence or leisure.

- Fishery produce is hardly ever marketed within the Luengoni community and any sales mainly target external markets.

- Fresh-fish consumption in Luengoni is about the same as the regional average and ranks among the highest across all five PROCFish sites investigated in New Caledonia. Invertebrate consumption is extremely low (5.5 kg/person/year).

- Most fishers are males who fish for finfish; very few women are engaged in any fisheries. Male fishers target mainly the lagoon and some the sheltered coastal reef. Fishing techniques are varied; mainly gillnets, handlines, castnets and spears are used in combination. Invertebrate fisheries are marginal; however, the lobster fishery plays a relatively important role, particularly in generating income.

- The highest fishing pressure exists on finfish resources in the lagoon, and is determined by the number of fishers targeting this habitat rather than the average annual catch per fisher. In general, fishing pressure is low given the low fisher density and low catch rates. In this context, the low CPUEs and large average fish sizes caught in almost all habitats fished suggest that fishing is performed on a lifestyle rather than commercial basis, i.e. maximising catch is not the overall purpose of a fishing trip. This argument also applies to lagoon fishing, where fisher density is considerably higher, since CPUEs, annual catch rates and average fish sizes do not vary significantly compared to the other habitats fished.

- Invertebrate fishing is also mainly subsistence-oriented and fishing pressure is generally low. Highest catch rates and impact by wet weight were observed for lobster diving. However, taking into consideration fisher density, average annual catch rates and size of habitats targeted, current fishing pressure is almost negligible.

Based on the above observations, it can be concluded that current fishing pressure on Luengoni's finfish and invertebrate resources has not reached any alarming level. Taking into consideration the limited market potential on Lifou and the additional costs and effort involved in marketing any reef produce from Lifou at New Caledonia's main market in Noumea, the potential for future development is limited. As a consequence, no major increase in current fishing pressure is likely to occur in the near future. In contrast, the local population enjoys fishing as part of their lifestyle and will continue to eat finfish and invertebrates. However, the percentage of people living in Luengoni who earn salaries or who migrate to seek employment and facilitate education for their children on the main island is relatively high. This situation may support a more urban lifestyle and a shift in food preferences, resulting in a decrease in fishing.

4.3 Finfish resource surveys: Luengoni

Finfish resources and associated habitats were assessed between 08 June and 15 June 2004 from a total of 24 transects (14 back- and 10 outer-reef transects, see Figure 4.19 and Appendix 3.3.1 for transect locations and coordinates respectively).

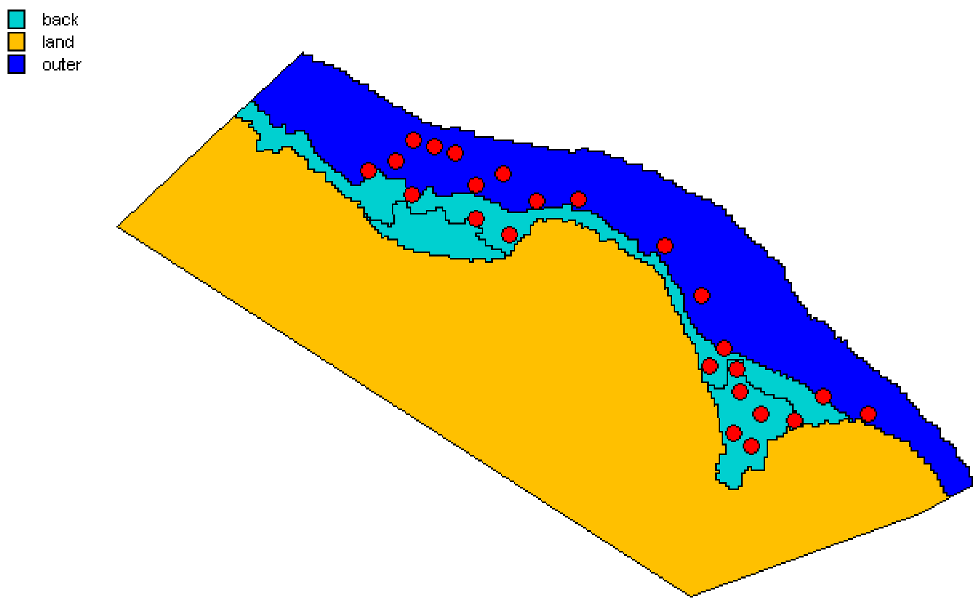

Figure 4.19: Habitat types and transect locations for finfish assessment in Luengoni.

4.3.1 Finfish assessment results: Luengoni

A total of 23 families, 48 genera, 128 species and 9892 fish were recorded in the 24 transects (See Appendix 3.3.2 for list of species.). Only data on the 15 most dominant families (See Methods.) are presented below, representing 39 genera, 117 species and 8441 individuals.

Finfish resources differed greatly between the two reef environments found in Luengoni (Table 4.6). The outer reef contained the lowest number of fish (0.3 fish/m^2), lowest biomass (39 g/m^2) and lowest number of species than in the other outer reefs of the country. A large part of the observed difference in biomass between the two reef types present in Luengoni, where biomass was almost three times greater in the back-reef than in the outer reef, was explained by a high biomass of parrotfish.

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

Parameters	Habitats		
	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	14	10	24
Total habitat area (km^2)	2.1	4.7	6.8
Depth (m)	3 (1-7) (3)	7 (3-17) (3)	6 (1-17) (3)
Soft bottom (% cover)	35 ±6	9 ±2	17
Rubble & boulders (% cover)	5 ±1	3 ±1	3
Hard bottom (% cover)	50 ±7	64 ±3	60
Live coral (% cover)	10 ±1	22 ±3	18
Soft coral (% cover)	0 ±0	2 ±1	2
Biodiversity (species/transect)	30 ±2	30 ±3	30 ±2
Density (fish/m^2)	1.4 ±0.9	0.3 ±0.0	0.7
Size (cm FL) (4)	14 ±0	16 ±1	15
Size ratio (%)	42 ±1	51 ±2	48
Biomass (g/m^2)	115.6 ±63	39.1 ±6.6	67.7

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

Back-reef environment: Luengoni

The back-reef environment of Luengoni was dominated by four families: two herbivorous families (Scaridae and Acanthuridae) and two carnivorous families (Lethrinidae and Mullidae) (Figure 4.20). These four families were represented by 42 species; particularly high abundance and biomass were recorded for *Gnathodentex aureolineatus*, *Chlorurus sordidus*, *Scarus altipinnis*, *S. rivulatus*, *S. schlegeli*, *Acanthurus triostegus*, *Ctenochaetus striatus*, *S. frenatus* and *A. blochii* (Table 4.7). This reef environment presented a complex habitat with similar cover of hard and soft bottom (50 and 35% cover respectively) (Table 4.6 and Figure 4.20).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.13 ±0.07	8.61 ±3.92
	Scarus altipinnis	Filamentfinned parrotfish	0.05 ±0.04	5.94 ±3.70
	Scarus rivulatus	Rivulated parrotfish	0.11 ±0.06	5.36 ±2.20
	Scarus schlegeli	Schlegel's parrotfish	0.13 ±0.12	4.95 ±3.94
	Scarus frenatus	Bridled parrotfish	0.01 ±0.01	3.86 ±2.78
Lethrinidae	*Gnathodentex aureolineatus*	Goldlined seabream	0.34 ±0.31	23.84 ±19.77
	Monotaxis grandoculis	Bigeye bream	0.01 ±0.01	2.69 ±1.86
Acanthuridae	*Acanthurus triostegus*	Convict surgeonfish	0.08 ±0.06	4.63 ±3.00
	Ctenochaetus striatus	Striated surgeonfish	0.03 ±0.01	4.01 ±1.24
	Acanthurus blochii	Ringtail surgeonfish	0.01 ±0.00	3.47 ±2.30

The density and biomass of finfish in the back-reefs of Luengoni were much higher than in the back-reefs of the other four country sites; biodiversity was average and lower only than in Moindou and Oundjo. The trophic structure was almost equally composed of herbivores and carnivores in terms of both biomass and density. Hard and soft bottom were almost equal in proportion of cover (Table 4.6, Figure 4.20), partially explaining the complexity of the finfish community and the high presence of Lethrinidae, which prefers soft substrate.

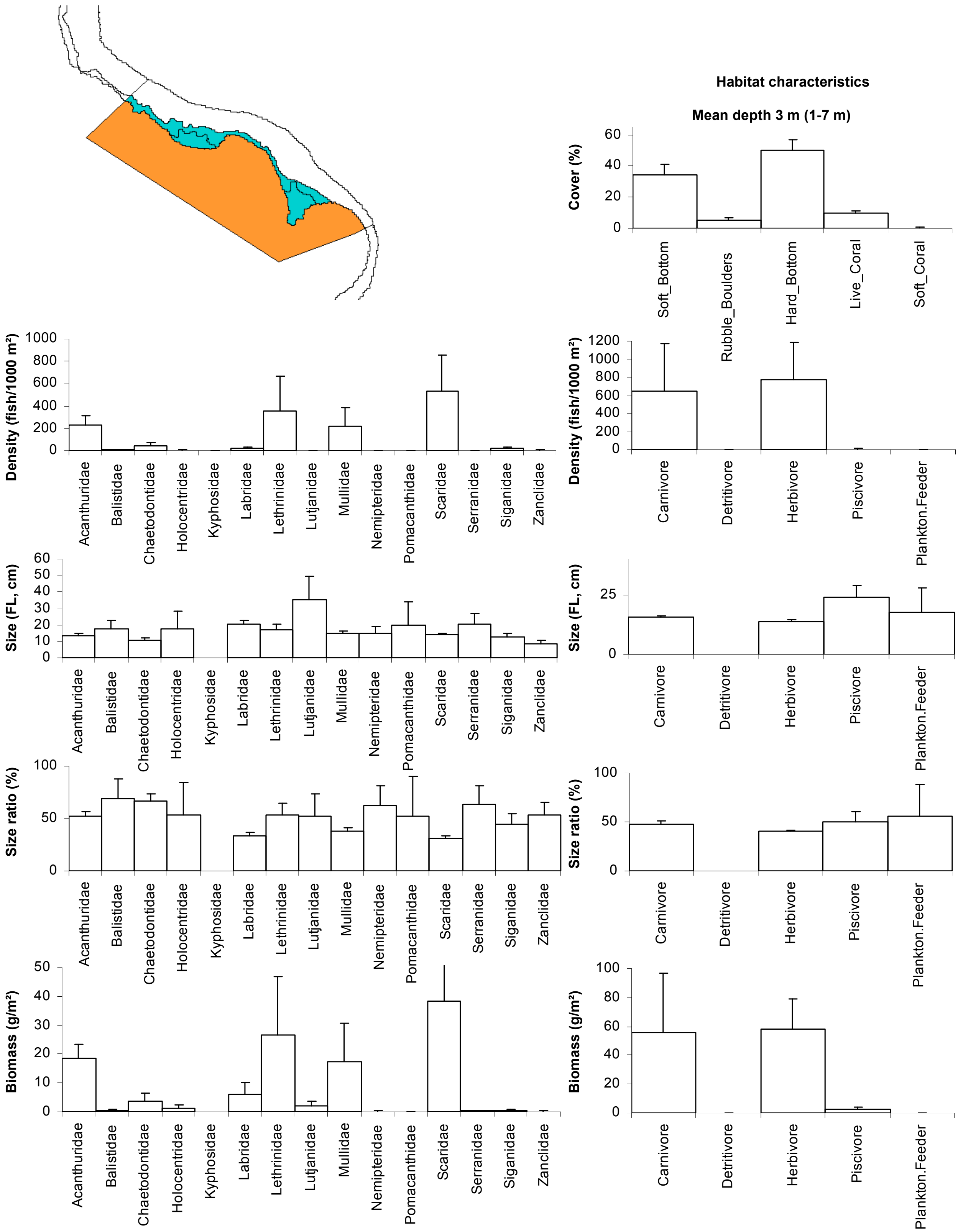

Figure 4.20: Profile of finfish resources in the back-reef environment of Luengoni.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Luengoni

The outer-reef environment of Luengoni was dominated by two families: Acanthuridae and Scaridae (Figure 4.21). These families were represented by 25 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Acanthurus lineatus*, *Scarus frenatus*, *Chlorurus sordidus*, *S. altipinnis*, *A. nigrofuscus* and *S. chameleon*. This reef environment presented a high percentage of hard bottom (64%) with a high cover of live corals (Table 4.6 and Figure 4.21).

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.08 ±0.02	10.97 ±2.18
	Acanthurus lineatus	Lined surgeonfish	0.04 ±0.02	9.80 ±4.25
	Acanthurus nigrofuscus	Brown surgeonfish	0.04 ±0.01	1.03 ±0.34
Scaridae	*Scarus frenatus*	Bridled parrotfish	0.01 ±0.003	2.82 ±0.82
	Chlorurus sordidus	Daisy parrotfish	0.02 ±0.004	2.31 ±0.53
	Scarus altipinnis	Filamentfinned parrotfish	0.01 ±0.004	2.29 ±1.21
	Scarus chameleon	Chameleon parrotfish	0.01 ±0.003	0.66 ±0.37

The density, biomass and biodiversity of finfish in the outer reefs of Luengoni were the lowest recorded in outer reefs throughout the country (Table 4.6). The trophic composition was dominated by herbivorous fish, mainly Acanthuridae and Scaridae. Carnivores were almost absent from this habitat. The high percentage cover of hard-bottom substrate and live corals would normally support a richer and more diverse fish community. However, the lack of a real lagoon system is the main explanation for this lack of carnivorous species and poverty of species.

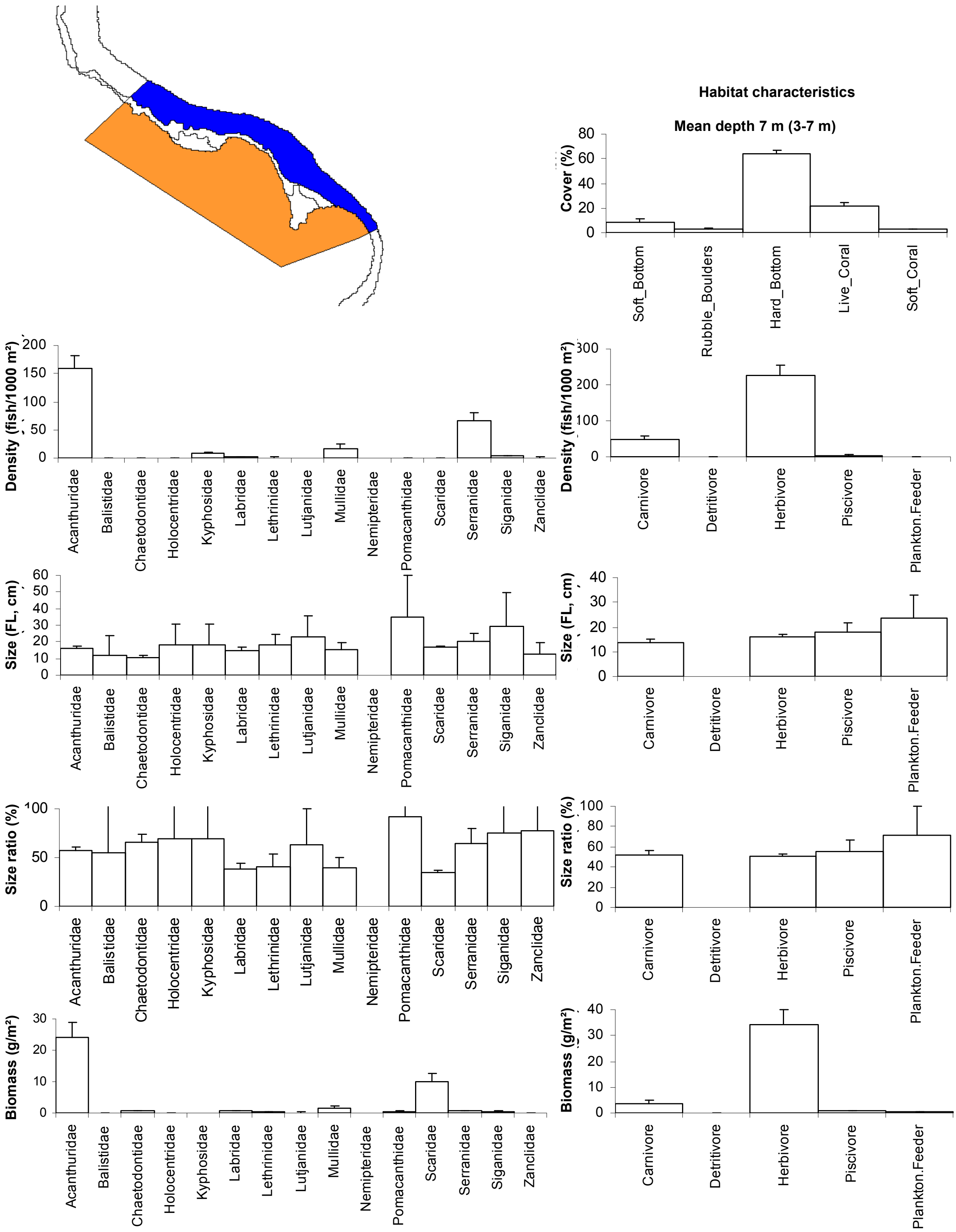

Figure 4.21: Profile of finfish resources in the outer-reef environment of Luengoni.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Luengoni

Overall, the fish assemblage of Luengoni was dominated by two families of herbivorous fish: Acanthuridae and Scaridae, and two families of carnivorous fish Lethrinidae and Mullidae (Figure 4.22). These four families were represented by a total of 47 species, dominated (in terms of density and biomass) by *Gnathodentex aureolineatus, Ctenochaetus striatus*, *Chlorurus sordidus*, *Scarus schlegeli*, *Acanthurus nigrofuscus*, *Mulloidichthys vanicolensis*, *Scarus rivulatus*, *A. triostegus* and *A. lineatus* (Table 4.9). As expected, the overall fish assemblage in Ouassé shared characteristics of outer reef (69% of habitat) and back-reef (31%) to a lesser extent.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.06	9.4
	Acanthurus nigrofuscus	Brown surgeonfish	0.05	1.3
	Acanthurus triostegus	Convict tang	0.03	1.4
	Acanthurus lineatus	Lined surgeonfish	0.02	6.7
Lethrinidae	*Gnathodentex aureolineatus*	Goldlined seabream	0.10	7.4
Mullidae	*Mulloidichthys vanicolensis*	Yellowfin goatfish	0.04	2.4
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.05	4.2
	Scarus schlegeli	Schlegel’s parrotfish	0.05	1.7
	Scarus rivulatus	Rivulated parrotfish	0.03	1.7

Overall, Luengoni appears to support a similar finfish resource to the other sites, with highest value of density (0.7 fish/m^2) but third-lowest biomass (68 g/m^2), due to low average fish size (15 cm) and size ratio (48%) (Table 4.7). These results suggest that the finfish resource in Luengoni is in average condition, showing presence of carnivores, both goatfish (Mullidae) and emperors (Lethrinidae), which were rather scarce in the other sites but recorded in very high abundances in the back-reefs of Luengoni. However, sizes of fish are quite small, the second-smallest among the five sites. In Luengoni, night spear fishing is common and this practice generally has a heavy impact on larger fish. Scaridae displayed the lowest size ratio and these are normally targeted by spear fishing.

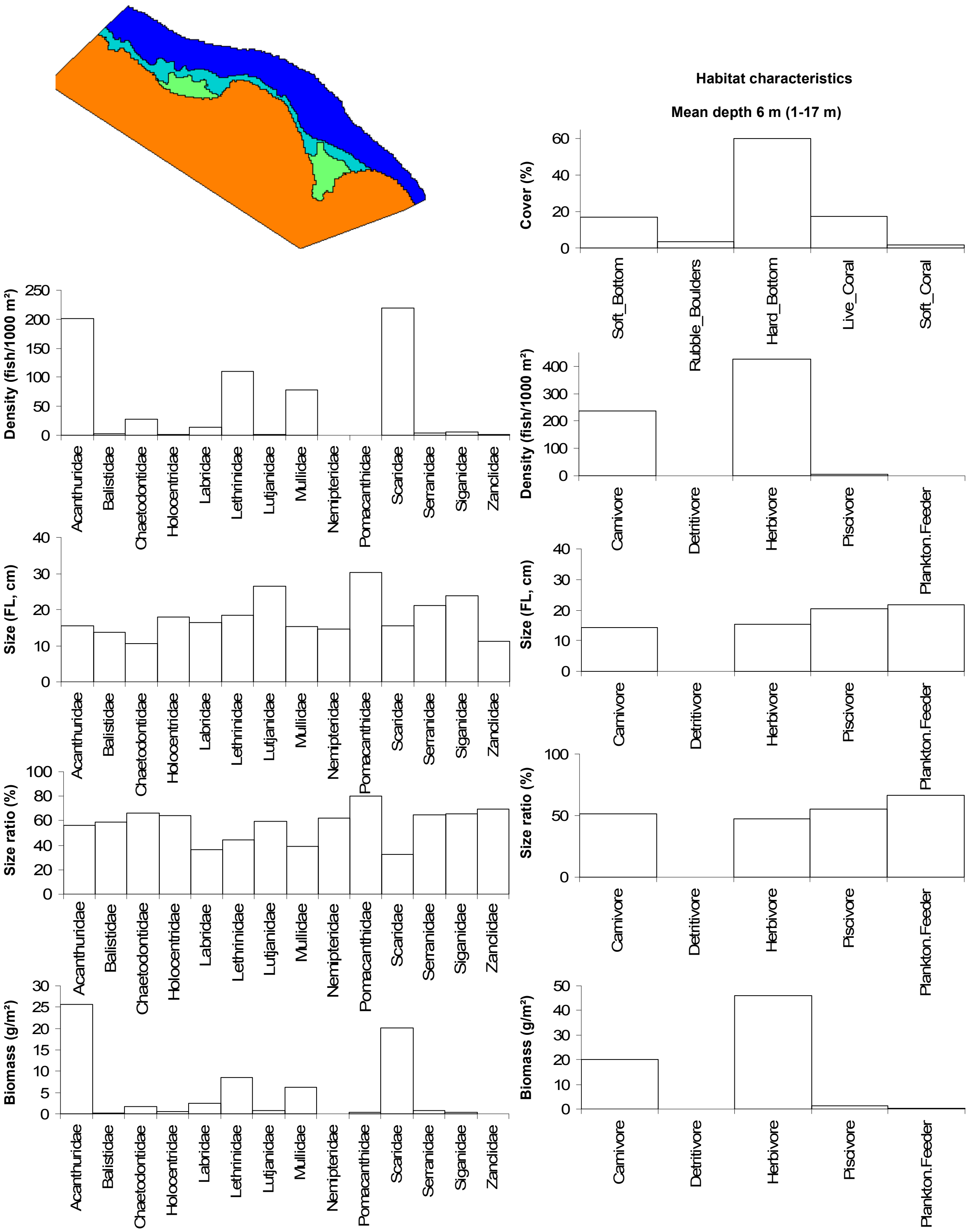

Figure 4.22: Profile of finfish resources in the combined reef habitats of Luengoni (weighted average).
FL = fork length.

4.3.2 Discussion and conclusions: finfish resources in Luengoni

The finfish resource assessment indicated that the status of finfish resources in Luengoni is similar to that in other New Caledonia study sites but slightly better for some specific families. However, detailed assessment also revealed a low biomass, due to the general small average size of fish and to low average density in the outer reefs. This could be the direct impact of the common practice of spearfishing at night, especially manifest in the small size ratio for Scaridae. Carnivores were rare, except in the back-reefs, which displayed a high abundance of goldlined seabream (*Gnathodentex aureolineatus*).

- Overall, Luengoni finfish resources appeared to be in average-to-good condition. The reef habitat seemed relatively rich, with good cover of live coral on the outer reefs, and able to support healthy finfish resources.

- Populations of emperors (Lethrinidae) in Luengoni were richer than in the other sites, due especially to a large population of *Gnathodentex aureolineatus* (goldlined seabream) in the back-reefs.

- Populations of Mullidae were relatively rich in the back-reefs, displaying the highest abundance and biomass in the country, especially of yellowfin goatfish (*Mulloidichthys vanicolensis*).

- Impacts from the common practice of night-time spearfishing were evident as small abundance and very small average sizes of Scaridae in the outer reefs.

4.4 Invertebrate resource surveys: Luengoni

The diversity and abundance of invertebrate species at Luengoni were independently determined using a range of survey techniques (Table 4.10): broad-scale assessment (using the ‘manta tow’ technique; locations shown in Figure 4.23) and finer-scale assessment of specific reef and benthic habitats (Figures 4.24 and 4.25).

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

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

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	7	42 transects
Reef-benthos transects (RBt)	15 (+2 in Mu*)	90 (+12) transects
Soft-benthos transects (SBt)	0	0 transect
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	0	0 transect
Mother-of-pearl searches (MOPs)	0	0 search period
Reef-front searches (RFs)	5 RFs	30 search periods
Sea cucumber day searches (Ds)	3	18 search periods
Sea cucumber night searches (Ns)	2	12 search periods

* Two stations were completed in the nearby village of Mu.

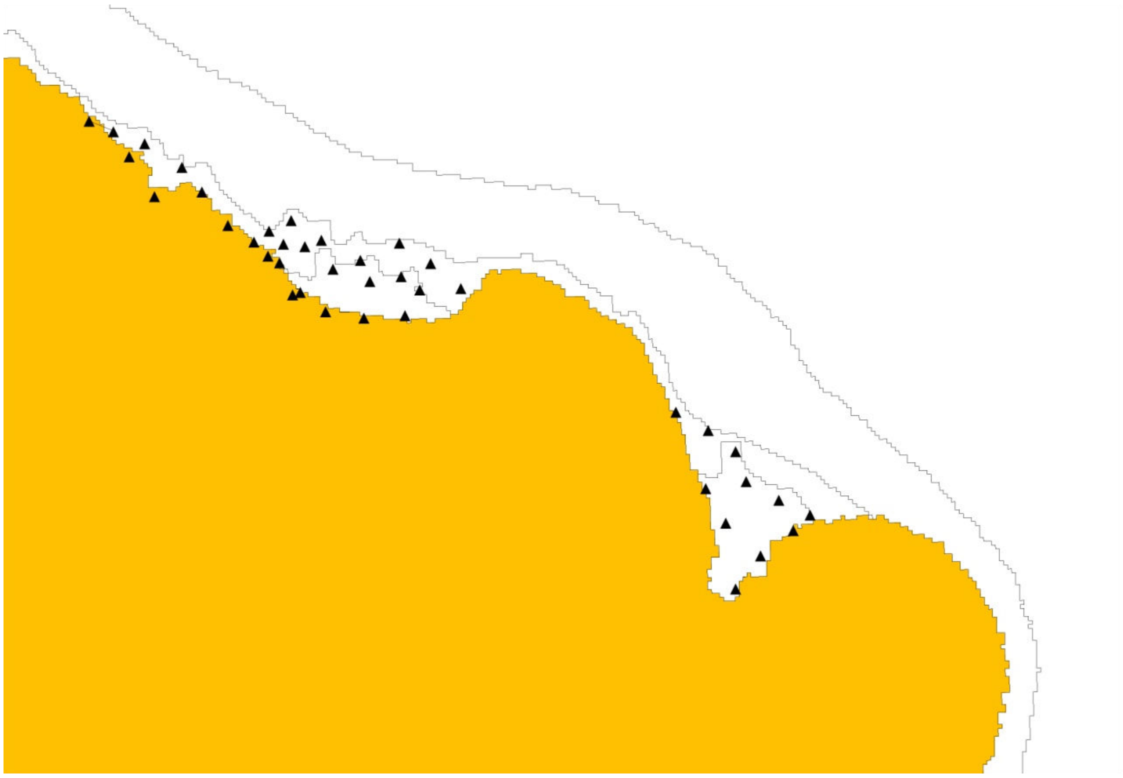

Figure 4.23: Broad-scale survey stations for invertebrates in Luengoni.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

Figure 4.24: Fine-scale reef-benthos transect survey stations for invertebrates in Luengoni.
Black circles: reef-benthos transect stations (RBt).
Two stations were also conducted south of the main study area, near Mu.

Figure 4.25: Fine-scale survey stations for invertebrates in Luengoni.
Inverted black triangles: reef-front search stations (RFs);
grey stars: sea cucumber day search stations (Ds);
grey circles: sea cucumber night search stations (Ns).

Thirty-eight species or species groupings (groups of species within a genus) were recorded in the Luengoni invertebrate surveys. These included 6 bivalves, 14 gastropods, 8 sea cucumbers, 3 urchins, 1 cnidarian and 1 lobster (Appendix 4.3.1). Information on key families and species is detailed below.

4.4.1 Giant clams: Luengoni

Luengoni is at the southeast of Lifou, a submerged volcano that became an uplifted coral atoll. The whole island is largely calcareous in nature, which influences water flows and nutrient profiles related to invertebrate resources. The study area comprised two coastline pseudo-embayments, with pseudo-lagoons behind lines of shallow reef habitat and coastal fringing reefs. Reefs at the study area were suitable for giant clams but limited in scale (3.2 km^2 of oceanic fringing reef and reef in shoreline embayments) and in level of exposure. In general, the fringing and inshore reefs were oceanic-influenced. As Luengoni is in the southeast, reefs were exposed to oceanic swell, especially during the trade wind season. Land influences were not generally noted, as the calcareous nature of the land meant shoreline areas did not have any river inflows, with all fresh water entering the system through seepage.

Broad-scale sampling provided an overview of giant clam distribution at the study site at Luengoni. Reefs held three species of giant clam: the elongate clam *Tridacna maxima,* the fluted clam *T. squamosa*, and the horse-hoof or bear's paw clam *Hippopus hippopus*. Records from broad-scale sampling revealed that *T. maxima* had the widest occurrence (found in all 7 stations and 22 transects), followed by *H. hippopus* (1 station and 1 transect).

T. squamosa was not recorded in broad-scale surveys. The average station density of the most common species, *T. maxima*, in broad-scale survey was 12.3 /ha ±2.8, which is relatively low for reefs in New Caledonia (Figure 4.26).

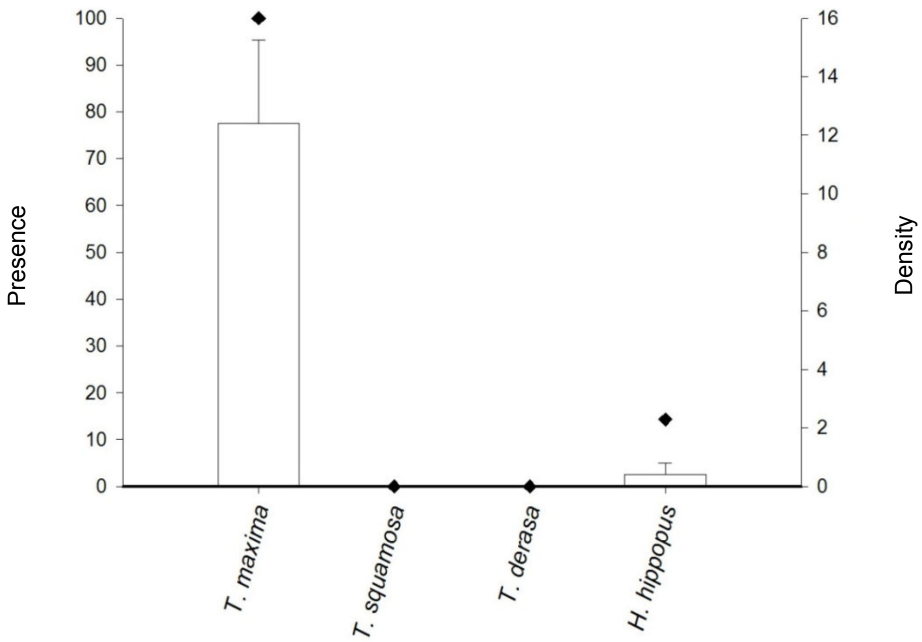

Figure 4.26: Presence and mean density of giant clam species in Luengoni based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Based on the findings of the broad-scale survey, finer-scale surveys targeted specific areas of clam habitat (Figure 4.27). In these reef-benthos transect surveys (RBt), *T. maxima* was present in 87% of stations at a mean density of 150.0 /ha ±33.5.

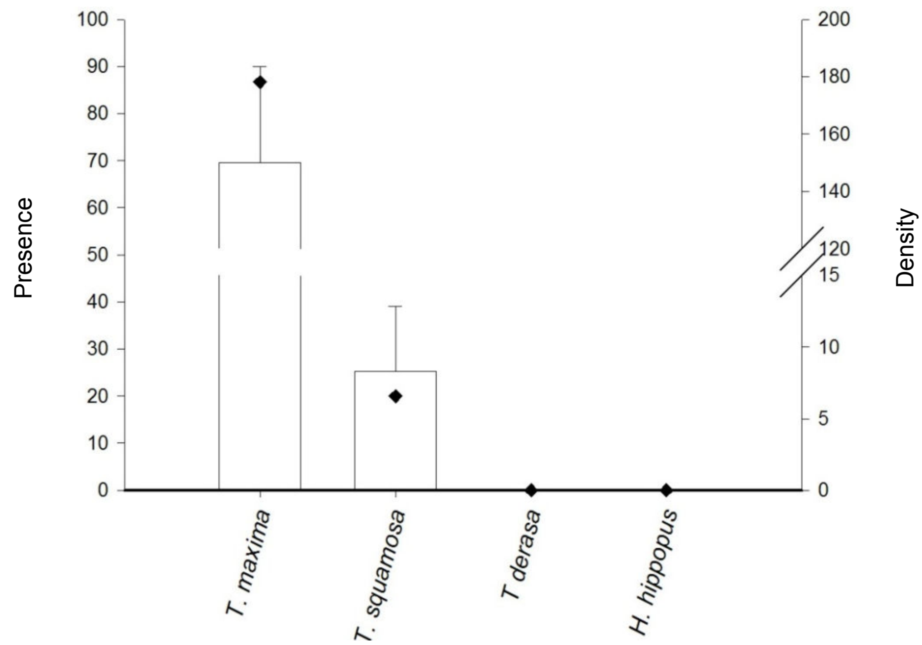

Figure 4.27: Presence and mean density of giant clam species in Luengoni based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

The density of *T. maxima* was relatively consistent across RBt stations, with the greatest densities (>200 /ha) mostly being recorded in the embayment at Luengoni (although the highest density was from 1 station in Joj, average density = 458 /ha ±150.2). Only two stations did not contain *T. maxima*, and these were both close to the shoreline.

Of the 94 clam records (from all assessment methods), the average shell length of giant clam was 18.2 cm ±0.6 for *T. maxima* (n = 82), 23.6 cm ±3.0 for *T. squamosa* (n = 3) and 35.0 cm for *H. hippopus* (n = 3, including 2 individuals observed outside of recording stations).

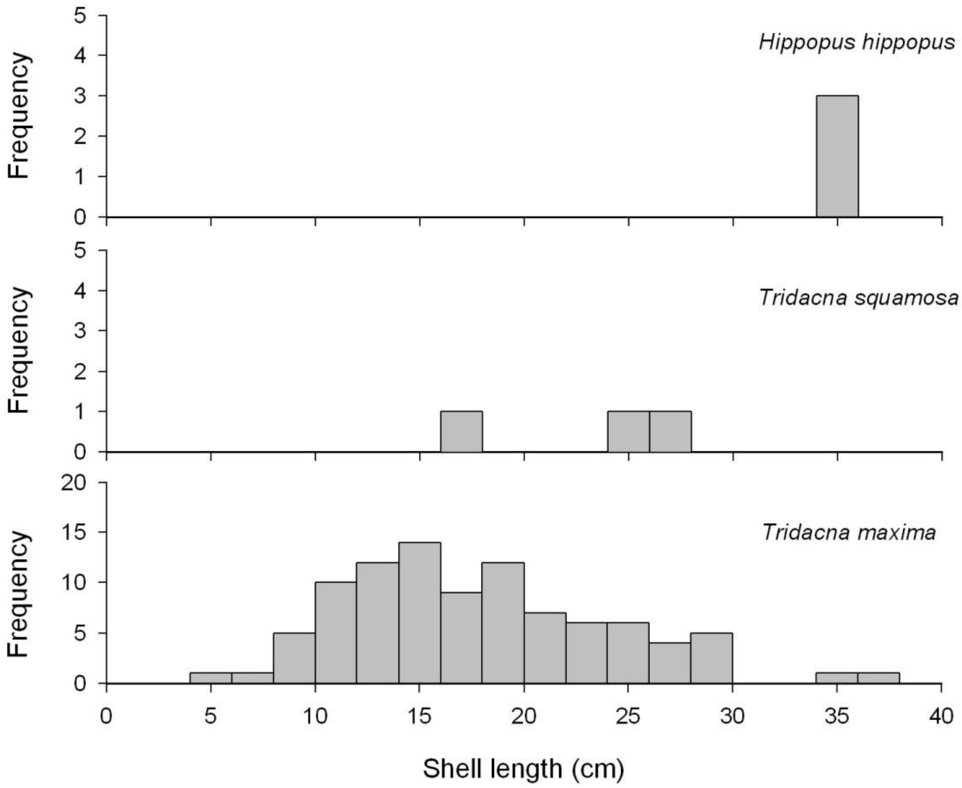

Figure 4.28: Size frequency histograms of giant clam shell length (cm) for Luengoni.

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

The commercial topshell *Trochus niloticus* is endemic to New Caledonia, but is not generally recorded in Lifou. Suitable reef habitat at Luengoni (6.1 km lineal distance of exposed reef perimeter) provides relatively extensive benthos for *T. niloticus*, although rubble-covered back-reef suitable for juvenile stages in the life cycle was not developed on these exposed, fringing-reef shorelines. Nevertheless, the exposed shorelines are subject to dynamic water movement and, in places, suitable for trochus.

In 1989, trochus were moved from the mainland of New Caledonia (Grande Terre) to the Loyalty Islands, with 5709 juveniles translocated to Lifou, 1600 of them to the east-coast reefs north of the village Mu. There was some indication that these transplanted trochus may have spawned early in 1990, when 19 living trochus were recaptured; however, most subsequent searches failed to find any established population (Hoffschir 1990, Hoffschir *et al.* 1990, Eldridge 1995, Chauvet *et al.* 1997). Interestingly, a biodiversity survey conducted in 2000 did note the presence of *T. niloticus* on the west coast, even though its prevalence was not recorded (Bouchet *et al.* 2000).

PROCFish work around Luengoni completed a number of surveys that were designed to assess commercial species, such as trochus (Table 4.11).

Table 4.11: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Luengoni
Based on various assessment techniques; mean density measured in numbers per ha (±SE)

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S			0/7 = 0	0/42 = 0
RBt			0/15 = 0	0/90 = 0
RFs			0/5 = 0	0/30 = 0
Tectus pyramis				
B-S	0.8	0.5	1/7 = 14	2/42 = 5
RBt	5.6	3.8	2/15 = 14	2/90 = 2
RFs	5.5	2.9	3/5 = 60	6/30 = 20
Pinctada margaritifera				
B-S	0.4	0.4	1/7 = 14	1/42 = 2
RBt	8.3	8.3	1/15 = 7	2/90 = 2
RFs			0/5 = 0	0/30 = 0

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

Despite suitable habitat being noted and the wide range of reefs surveyed, no live or dead shells of commercial trochus were found at Luengoni.

The suitability of these reefs for grazing gastropods was assessed by looking at the distribution and density results for a similar gastropod species, false trochus or green topshell (*Tectus pyramis*). This closely related species (with a similar life habit) was rarely noted (n = 11) and, when recorded, was at low density (<6 /ha). The average size of *T. pyramis* was very large at 8.8 cm ±0.3. This is because it is a specific form of Tectus (*Tectus pyramis nodiluferus*), which is not noted in reference texts as being larger than the normal *T. pyramis*, but here was often recorded above 10 cm basal size. This may be worth further investigation to study its genetic linkage with the classical form of green topshell.

Blacklip pearl oysters (*Pinctada margaritifera*) are cryptic and normally sparsely distributed in open reef systems. This was the case for Luengoni, where only four blacklip were recorded in survey. Anecdotal reports state that this pearl oyster is fished as a delicacy for subsistence purposes. No green snail (*Turbo marmoratus*) was noted.

4.4.3 Infaunal species and groups: Luengoni

Soft-benthos areas were not common along the calcareous coastal margins of Luengoni. No notable concentrations of in-ground resources (shell 'beds'), for resource species, such as arc shells (*Anadara* spp.) or Venus shells (*Gafrarium* spp.) were recorded and no infaunal survey (quadrats) was conducted.

4.4.4 Other gastropods and bivalves: Luengoni

Seba's spider conch (*Lambis truncata*, the larger of the common spider conchs) was relatively common (10 individuals seen), but mostly in deeper water. The usually more numerous *L. lambis* and the strawberry or red-lipped conch *Strombus luhuanus* were not common (<15% of B-S and RBt stations), reaching an average of <10 /ha.

Like trochus, small turban shells that also graze on epiphytes growing on limestone surfaces were not abundant. The usually common *Turbo argyrostomus* was rare (only 2 individuals recorded), whereas other turbans, such as *T. setosus*, *T. chrysostomus* and *T. petholatus*, were not noted in survey. Other resource species targeted by fishers in the Pacific (e.g. *Astralium*, *Cerithium*, *Conus*, *Cymatium*, *Cypraea*, *Latirolagena*, *Mitra*, *Pleuroploca* and *Thais*) were also recorded during independent surveys (Appendices 4.3.1 to 4.3.7). Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Anadara* and *Pinna*, are also in Appendices 4.3.1 to 4.3.7. No creel survey was conducted at Luengoni.

4.4.5 Lobsters: Luengoni

Luengoni had 6.1 km (lineal distance) of exposed fringing reef. This exposed reef provided a very suitable habitat for lobsters. Outer reefs had a high relief and complexity, including lots of caves, tunnels and crevices. Lobsters are an unusual invertebrate species, which can recruit from near and distant reefs as larvae drift in the ocean for 6–12 months (sometimes up to 22 months) before settling as transparent miniature versions of the adult (pueruli, 20–30 mm in length).

There was no dedicated night reef-front assessment of lobsters (See Methods.) but, nevertheless, surveys still recorded a single lobster (*Panulirus* sp.) during night searches for nocturnal sea cucumbers. No sand lobsters (*Lysiosquillina maculata*) or slipper lobsters were noted.

4.4.6 Sea cucumbers[7]: Luengoni

The mainland at Lifou was large (>1000 km^2) but calcareous in make-up and bordered by a narrow system of reefs. There was a limited amount of protected shallow water with reef margins suitable for commercial sea cucumbers. Sea cucumbers are generally deposit feeders and require areas of shallow, mixed hard and soft benthos, with nutrient sources. The mainly oceanic-influenced reefs (with no heavy epiphytic growth), dynamic water movement and flushing only suited a limited range of species. Interestingly, local people reported that the inner side of Luengoni bay used to have sea grass beds that held a lot of sea cucumbers and were home to dugong in the past. Presently, there is little sea grass, and the sand is mostly covered with red filamentous algae.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 4.12, Appendices 4.3.2 to 4.3.6; see also Methods). At Luengoni, seven commercial species of sea cucumber were recorded during in-water assessments, plus one indicator species (Table 4.12). The restricted range of sea cucumber species recorded in

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

Luengoni somewhat reflected the lack of diversity of habitats, and stocks were not as varied as in other parts of New Caledonia.

Sea cucumber species associated with shallow reef areas, such as leopardfish (*Bohadschia argus*), were surprisingly common in broad-scale surveys considering the environment, and found in 33% of transects. Average density records for this species (12.7 /ha in B-S and 28 /ha in RBt stations) suggests that stocks are at moderately high density considering the nature of the habitat.

Black teatfish (*Holothuria nobilis*), a high-value species that is highly susceptible to over-fishing, was also common in survey records (recorded in 52% of broad-scale transects and 40% of RBt stations, total of 90 individuals). This species was also recorded at one of the two extra RBt stations conducted at the nearby village of Mu (average density at Mu 20.8 /ha). Densities for this species, averaging >10 /ha, indicate that fishing pressure around Luengoni is low. In fact, the average density recorded (19.7 /ha for B-S and 97.2 /ha for RBt) is unusually high for black teatfish records in the Pacific. When individual stations are examined, some of the station results are exceptional (Figure 4.29).

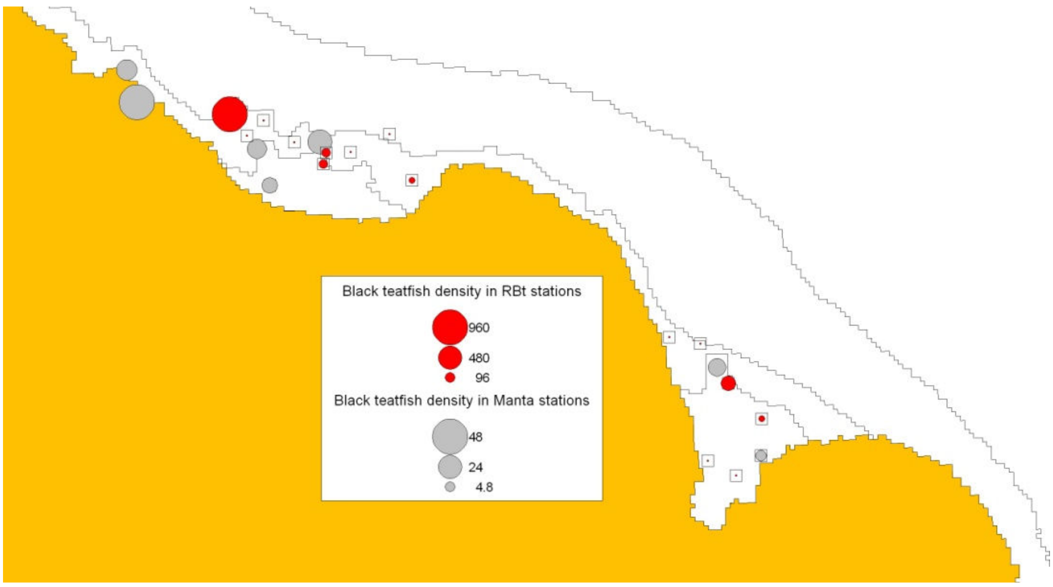

Figure 4.29: Thematic map of average black teatfish densities at RBt (red) and B-S (grey) stations at Luengoni.

The fast growing and medium/high-value greenfish (*Stichopus chloronotus*) was not found at any stations of Luengoni. Surf redfish (*Actinopyga mauritiana*), another easily targeted species, was relatively common across RFs stations at Luengoni, but at a low average density of 15–25 /ha in RFs, B-S and RBt stations. No high-density aggregations of surf redfish were recorded, and the low densities may be related to food availability as, in general, reefs were not covered in epiphytes. This species can be recorded at commercial densities of 500–600 /ha in parts of Solomon Islands, Cook Islands, French Polynesia and Tonga.

There were few protected embayed areas of reef and soft benthos or places that were less dynamic or oceanic-influenced. This was reflected in the lack of blackfish (*Actinopyga miliaris*), pinkfish (*Holothuria edulis*), and curryfish (*Stichopus hermanni*) and the rarity of brown sandfish (*Bohadschia vitiensis*). The low-value lollyfish (*H. atra*) was not particularly common and at moderately low density. As expected, the premium-value sandfish (*H. scabra*), which is usually found near mangroves, was absent.

Deeper-water assessments (18 five-minute searches, average depth 16.5 m, maximum 21 m) were completed to obtain a preliminary abundance estimate for white teatfish (*H. fuscogilva*), prickly redfish (*Thelenota ananas*), amberfish (*T. anax*) and partially for elephant trunkfish (*H. fuscopunctata*). Oceanic-influenced benthos outside the banks of offshore reef was surveyed but *H. fuscogilva* was not recorded. The lower-value and generally more common *T. ananas* was not common in survey, and *T. anax* was absent from records.

4.4.7 Other echinoderms: Luengoni

The edible collector urchin (*Tripneustes gratilla*) was not recorded in survey, but slate urchins (*Heterocentrotus mammillatus*) were recorded in small numbers (total n = 8). Large black *Echinothrix diadema* were similarly present at low density (n = 2, seen during night surveys). *Echinometra mathaei* was relatively common (80% of RBt stations) and at moderately high density at some stations (mean station density 733.3 /ha ±362.0). No *Diadema* spp. were noted (Appendices 4.3.1 to 4.3.7).

There was an unusual result for starfish around Luengoni, with no records made of the common blue and yellow starfish (*Linckia laevigata* and *L. guildingi*), pincushion stars (*Culcita novaeguineae*) or the crown of thorns starfish (*Acanthaster planci*).

Table 4.12: Sea cucumber species records for Luengoni

Species	Common name	Commercial value [5]	B-S transects n = 42			Reef-benthos stations n = 15			Other stations RFs = 5			Other stations Ds = 3 Ns = 2		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H												
Actinopyga lecanora	Stonefish	M/H												
Actinopyga mauritiana	Surf redfish	M/H	16.8	101.0	17	25.0	53.6	47	14.9	14.9	100			
Actinopyga miliaris	Blackfish	M/H												
Actinopyga palauensis	-	M												
Bohadschia argus	Leopardfish	M	12.7	38.0	33	27.8	138.9	20						
Bohadschia graeffei	Flowerfish	L												
Bohadschia similis	False sandfish	L												
Bohadschia vitiensis	Brown sandfish	L	0.4	16.7	2									
Holothuria atra	Lollyfish	L	105.4	368.8	29	11.1	83.3	13	0.8	3.9	20	0.8	2.4	33 Ds
Holothuria coluber	Snakefish	L												
Holothuria edulis	Pinkfish	L												
Holothuria fuscogilva [4]	White teatfish	H												
Holothuria fuscopunctata	Elephant trunkfish	M	1.9	19.9	10									
Holothuria leucospilota	-	L												
Holothuria nobilis [4]	Black teatfish	H	19.7	37.5	52	97.2	243.1	40				4.4 0.8	8.9 2.4	50 Ns 33 Ds
Holothuria scabra	Sandfish	H												
Holothuria scabra versicolor	Golden sandfish	H												
Stichopus chloronotus	Greenfish	H/M												
Stichopus hermanni	Curryfish	H/M												
Stichopus horrens	Dragonfish	M/L												
Thelenota ananas	Prickly redfish	H										3.2	9.5	33 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; Ds = sea cucumber day search; Ns = sea cucumber night search.

4.4.8 Discussion and conclusions: invertebrate resources in Luengoni

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 data collected on habitat, distribution, density and shell length of giant clams in Luengoni revealed that:

- At Luengoni, sheltered areas of shallow-water lagoon and reef were not extensive and were largely open to ocean influences and swell.

- The exposed, simple fringing reef and offshore banks were not suitable for the full range of giant clams found in New Caledonia, and only three species were recorded in survey (*Tridacna maxima*, *T. squamosa* and *Hippopus hippopus)*. *T. derasa* shells were not recorded during surveys, but were noted on shore, decorating gardens of several houses around the area.

- Giant clam presence was in general moderate considering the nature of the environment, but density was quite low. The elongate clam *T. maxima* had the highest density, but its aggregations were unremarkable. The other species present at Luengoni (*Hippopus hippopus* and *T. squamosa*) were rare and at lower densities than expected.

- Giant clams are broadcast spawners that only mature as females at larger size classes (protandric hermaphrodites). This means that, for successful stock management, clams need to be maintained at higher density and include larger individuals to ensure there is sufficient spawning taking place to produce new generations.

- Although *T. maxima* displayed a relatively 'full' range of size classes, including young clams, which indicate successful spawning and recruitment, the general low abundance of clams and sparsity of large clams suggest that clams are moderately impacted by fishing at Luengoni.

- Clams are especially easy to overfish in 'open', exposed reef systems, such as at Luengoni, as the pelagic larvae of these species may drift outside the reefs and not remain inside the reefs where they were spawned.

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

- Local reef conditions at Luengoni constitute a moderately extensive habitat for adult trochus. Reef habitat was relatively narrow and recordings of species related to trochus suggest the area might not be particularly well suited to grazing gastropods. Rubble-covered back-reef habitat (suitable for juvenile trochus) was not extensive, and algal growth in the form of epiphytes on limestone surfaces was relatively undeveloped, which may indicate that food was limiting in this mainly oceanic-influenced system.

- Trochus were introduced to this area in relatively large numbers in 1989 as juveniles (average size 1.9 cm, size range 1.4–2.5 cm). However, these do not seem to have become established as a self-maintaining population.

- Current thinking suggests that trochus introductions are best made using adult trochus to create aggregations, which can be protected and allowed to breed and supply reefs with product from subsequent episodes of sexual reproduction. Adult trochus have the advantage of being more hardy for transportation and seeding, less susceptible to predators, and able to produce large numbers of larger, more viable eggs. Trochus eggs and larvae have a limited dispersal distance, such that their offspring are likely to settle near to the areas where they were spawned.

- The low commercial value green topshell (*Tectus pyramis*) and blacklip pearl oyster (*Pinctada margaritifera*) were also rare at Luengoni, while the green snail (*Turbo marmoratus*) was absent.

The distribution, density and length recordings of sea cucumbers at Luengoni revealed that:

- Lifou as a whole has a marginal environment for most deposit feeders. Most commercial sea cucumbers fit into this category and prefer relatively protected areas, typically lagoon systems with an allochthonous (land-based) nutrient source or depositional environments. The environment of Joj bay was perceived to be less impacted than that of Luengoni, with less filamentous algae growth and greater amounts of live-coral cover.

- Only seven commercial sea cucumber species were recorded at Luengoni, which reflected the geography of the location and the exposed nature of the habitats present.

- Data on the distribution of sea cucumbers showed that commercial species were well distributed across the study area. Medium- and high-value commercial species, such as leopardfish or tigerfish (*Bohadschia argus*) and black teatfish (*Holothuria nobilis*), were relatively common, and indicative of a stock under low fishing pressure.

- Density records for black teatfish (*H. nobilis*) were especially high, similar to those recorded in locations where sea cucumber stocks are protected from commercial fishing. Unfortunately, the area available for any prospective fishery for this valuable species is very limited at Luengoni.

4.5 Overall recommendations for Luengoni

- Any future expansion of finfish fishing be accompanied by marine resource management measures, such as marine protected areas.

- Any future commercial fishing plans for sea cucumber acknowledge the 'natural' limit of stocks in this area (due to the limited environmental conditions) and allow for the fact that stock recovery from fishing is likely to be slower than normal.

- Any future trochus introductions be made using adult trochus, instead of juveniles. Adults can be aggregated and then protected and be allowed to breed and replenish the reefs with young.

5. PROFILE AND RESULTS FOR OUNDJO

5.1 Site characteristics

Located on the west coast of Grand Terre, at 21°02′30″S and 164°41′47″E, Oundjo is a coastal village surrounded by mangroves (Figure 5.1). Its fishing area is limited by the Gatope pass in the north and the Goyeta pass in the south, with a surface area of 23 km x 4.5 km. Only a very poorly defined zone in the north within a radius of about 7 km from the village can be considered as exclusive to Oundjo; the southern sector is not under the control of the village. This zone, which is shared with the Gatope clan, includes a *tabu* area, the 'blue hole', located on the barrier reef at the position 21°03′12″S and 164°41′47″E. The lagoon is very shallow and a large part is sandy. Here, rivers discharge their siltation from the land during the rainy season in larger amounts than found elsewhere. The fishers of Oundjo exploit the lagoon and the mangroves both commercially and for subsistence purposes.

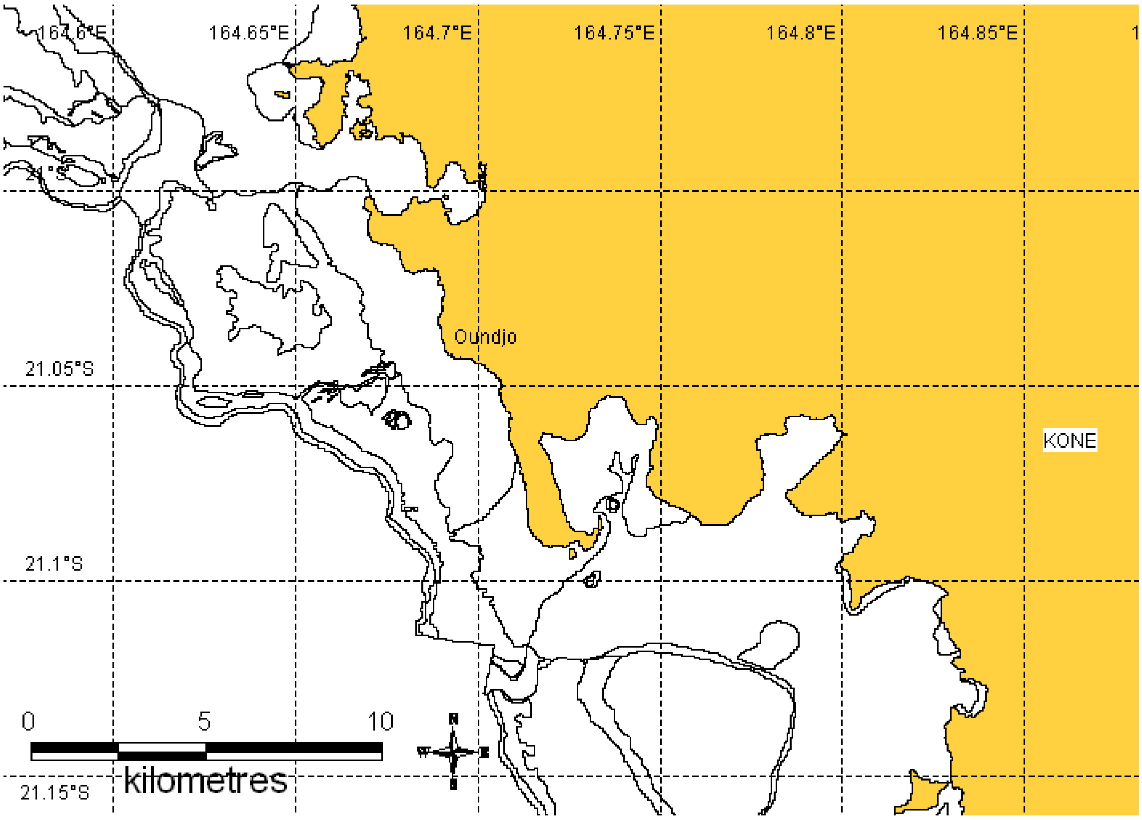

Figure 5.1: Map of Oundjo.

5.2 Socioeconomic surveys: Oundjo

Socioeconomic fieldwork was carried out in the Oundjo community in June 2003. The survey covered 26 households, including 142 people. Thus, the survey represents about 48% of the community's households (54) and total population (295).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 25 individual interviews of finfish fishers (20 males, 5 females) and 26 invertebrate fishers (13 males, 13 females) were conducted. These fishers belonged to one of the 26 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing.

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

Our survey results (Table 5.1) suggest an average of 2.4 fishers per household. If we apply this average to the total number of households, we arrive at a total of 127 fishers in Oundjo (65 males, 62 females). Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of 46 exclusive finfish fishers (males only), a total of 56 exclusive invertebrate fishers (10 males, 46 females), and 25 fishers who fish for both finfish and invertebrates (8 males, 17 females).

About 80% of all households in Oundjo own a boat; 81% are motorised, 19% are canoes.

Ranked income sources (Figure 5.2) suggest that fisheries are the most important source of income. About half of all households indicated that fisheries provide their first source of income, and another 30% rely on fisheries for secondary income. Agriculture does not play a major role; however, salaries provide first and second income for 42% and 15% of all households surveyed respectively. Small-business activities provide first and second income for 15% and 27% of all households interviewed in Oundjo respectively.

The importance of fisheries also shows in the fact that all households eat fresh fish, and that the fish they consume is mostly caught by a member of their household. In addition, most households (96%) consume invertebrates, and most of these are caught by a household member, or received as a gift from somebody else in the community, but never bought. Fresh fish is also frequently distributed among community members on a non-monetary basis. No respondent reported buying the fish that they eat. Accordingly, households that depend on fisheries for first or secondary income target markets outside the Oundjo community.

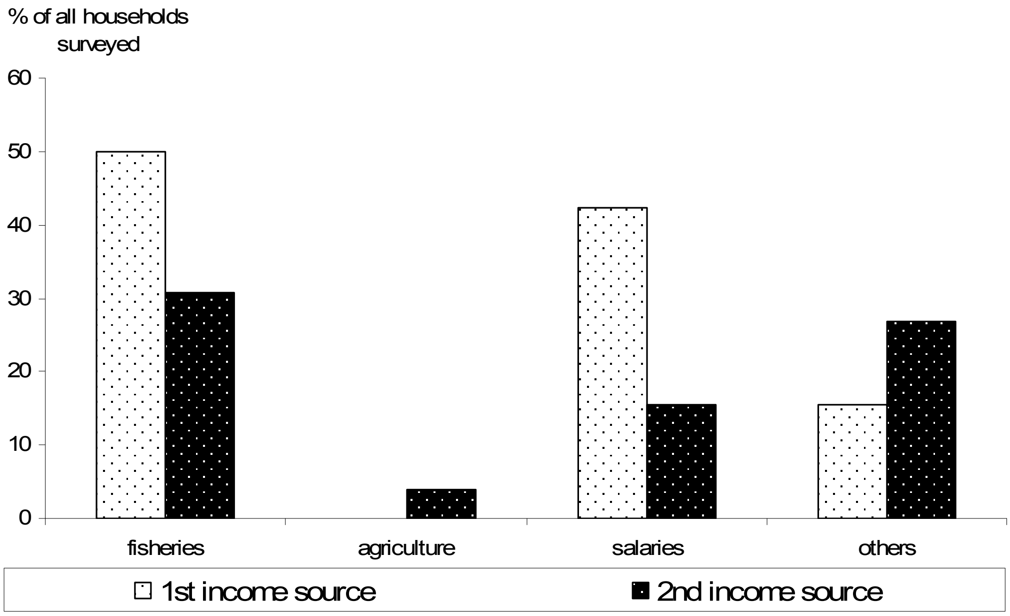

Figure 5.2: Ranked sources of income (%) in Oundjo.
Total number of households = 26 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible.
'Others' are mostly home-based small businesses.

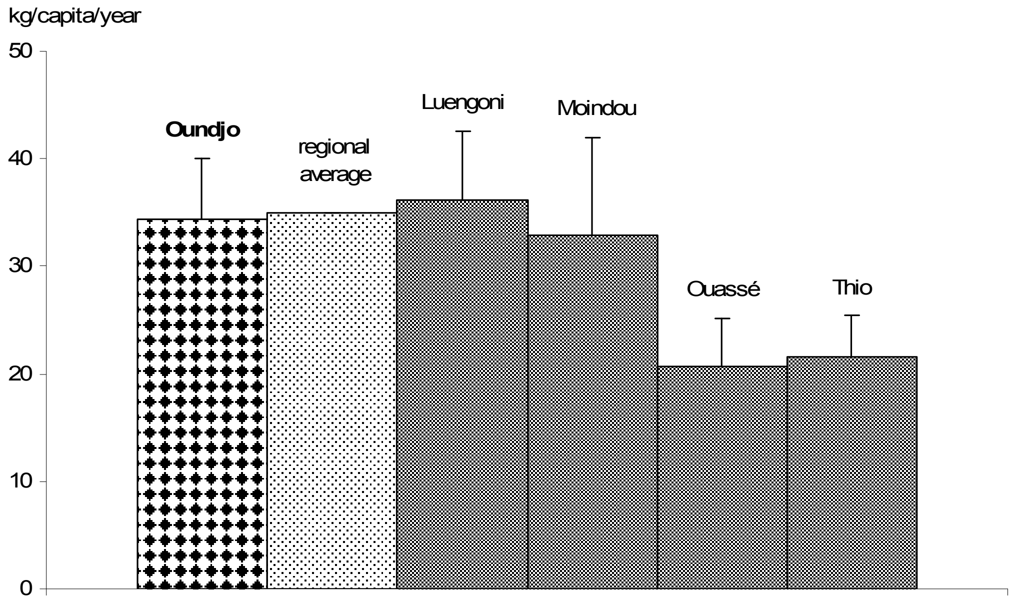

Figure 5.3: Per capita consumption (kg/year) of fresh fish in Oundjo (n = 26) compared to the regional average (FAO 2008) and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

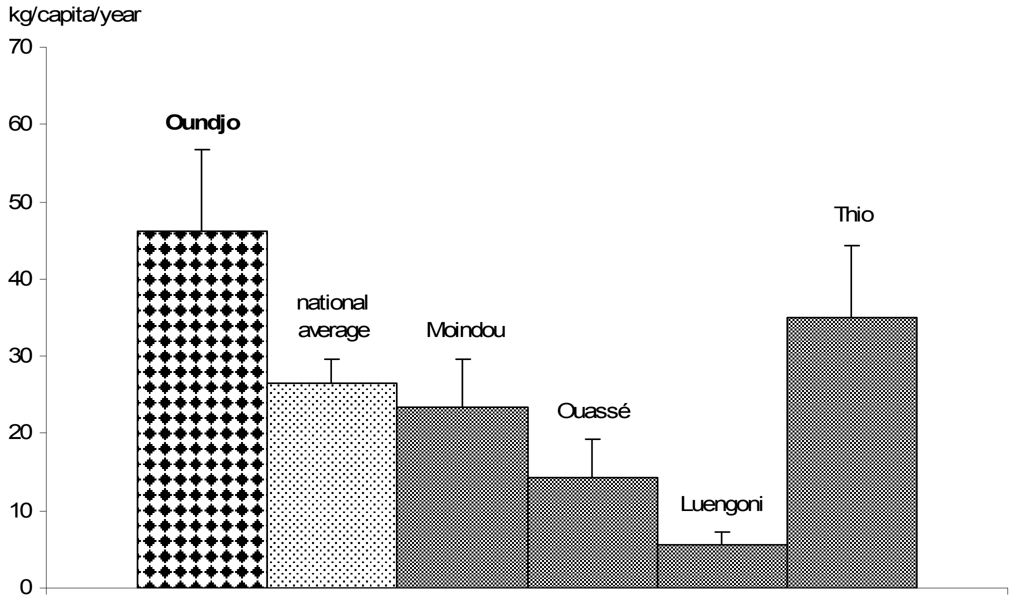

Figure 5.4: Per capita consumption (kg/year) of invertebrates (meat only) in Oundjo (n = 26) compared to the national average and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Fresh-fish consumption (~34 kg/person/year ±5.6) in Oundjo is about the same as the regional average (FAO 2008) (Figure 5.3). Across all New Caledonian sites investigated, fish consumption in Oundjo is similar to that observed in Luengoni and Moindou. Invertebrate consumption (meat only) with 46 kg/person/year (Figure 5.4) exceeds that of finfish by 35% and is by far the highest across all sites surveyed in New Caledonia.

Comparison of results across all sites investigated in New Caledonia shows that the people of Oundjo are more dependent on fisheries for income generation and eat seafood (finfish and invertebrates) more frequently than observed on average (Table 5.1).

In contrast, the average annual household expenditure level in Oundjo is only about half of the country average as estimated by the PROCFish surveys, and the influx of external money (remittances) is significantly less.

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

Survey coverage	Oundjo (n = 26 HH)	Average across sites (n = 148 HH)
Demography		
HH involved in reef fisheries (%)	100	95
Number of fishers per HH	2.4 (±0.24)	1.6 (±0.08)
Male finfish fishers per HH (%)	36.1	29.6
Female finfish fishers per HH (%)	0.0	3.3
Male invertebrate fishers per HH (%)	8.2	2.5
Female invertebrate fishers per HH (%)	36.1	16.3
Male finfish and invertebrate fishers per HH (%)	6.6	32.5
Female finfish and invertebrate fishers per HH (%)	13.1	15.8
Income		
HH with fisheries as 1st income (%)	50.0	27.0
HH with fisheries as 2nd income (%)	30.8	23.6
HH with agriculture as 1st income (%)	0.0	2.0
HH with agriculture as 2nd income (%)	3.8	6.1
HH with salary as 1st income (%)	42.3	37.2
HH with salary as 2nd income (%)	15.4	6.1
HH with other source as 1st income (%)	15.4	37.8
HH with other source as 2nd income (%)	26.9	16.9
Expenditure (USD/year/HH)	3652.24 (±288.77)	6587.71 (±456.24)
Remittance (USD/year/HH) (1)	824.11 (±654.27)	1802.97 (±766.61)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	34.39 (±5.58)	29.81 (±3.16)
Frequency fresh fish consumed (times/week)	3.17 (±0.31)	2.35 (±0.13)
Quantity fresh invertebrate consumed (kg/capita/year)	46.12 (±10.63)	26.46 (±3.16)
Frequency fresh invertebrate consumed (times/week)	1.53 (±0.22)	0.88 (±0.07)
Quantity canned fish consumed (kg/capita/year)	5.82 (±1.31)	6.69 (±1.32)
Frequency canned fish consumed (times/week)	1.64 (±0.32)	1.35 (±0.14)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	96.2	88.5
HH eat canned fish (%)	88.5	82.4
HH eat fresh fish they catch (%)	100.0	83.3
HH eat fresh fish they buy (%)	0.0	10.0
HH eat fresh fish they are given (%)	76.9	70.0
HH eat fresh invertebrates they catch (%)	92.3	46.7
HH eat fresh invertebrates they buy (%)	0.0	3.3
HH eat fresh invertebrates they are given (%)	65.4	36.7

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

5.2.2 Fishing strategies and gear: Oundjo

Degree of specialisation in fishing

Fishing in Oundjo is performed by both gender groups (Figure 5.5). However, 35% of all fishers exclusively target finfish and all these fishers are males. Female fishers, who target finfish, do so in combination with invertebrate collection (~10% of all fishers). Most female fishers (35%) specialise in harvesting invertebrates, as compared to ~7% males who exclusively collect invertebrates and ~5% of male fishers, who fish for both finfish and invertebrates.

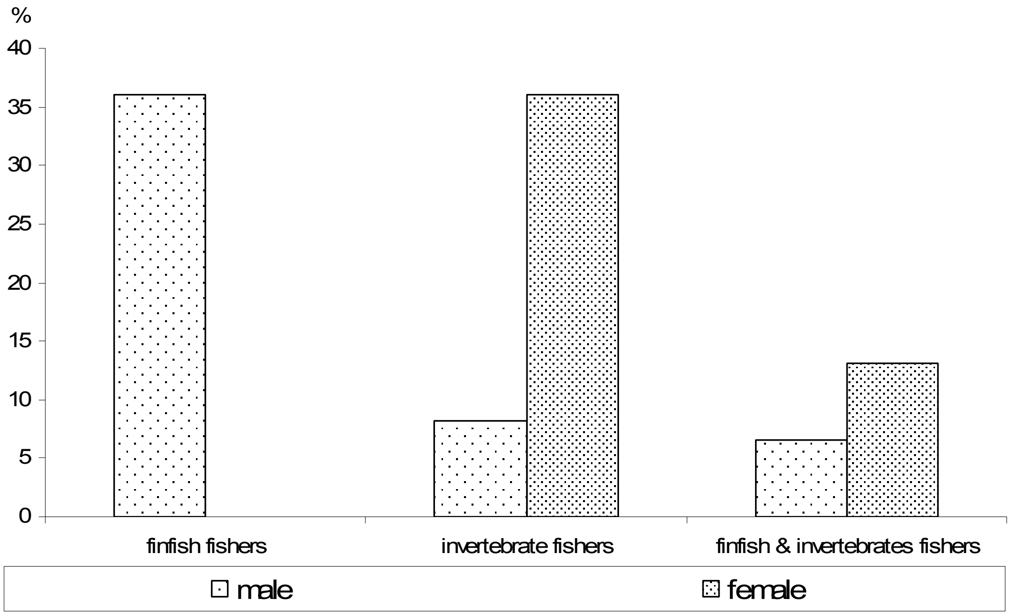

Figure 5.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Oundjo.
All fishers = 100%.

Targeted stocks/habitat

Table 5.2: Proportion (%) of male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Oundjo

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reefs	40.0	40.0
	Sheltered coastal reefs & lagoon	40.0	0.0
	Lagoon	25.0	60.0
	Outer reef	10.0	0.0
Invertebrates	Reeftop	15.4	53.8
	Mangrove	69.2	100.0
	Bêche-de-mer	38.5	0.0
	Lobster	61.5	0.0
	Trochus	46.2	0.0
	Other	69.2	7.7

'Other' refers to the giant clam and octopus fisheries.
Finfish fisher interviews, males: n = 20; females: n = 5. Invertebrate fisher interviews, males: n = 13; females: n = 13.

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 Oundjo on their fishing grounds (Table 5.2).

Our survey sample suggests that fishers in Oundjo can choose among sheltered coastal reef, lagoon and outer-reef habitats. Some combine the sheltered coastal reef and lagoon in one fishing trip. Most fishers, males and females, however, target the sheltered coastal reef and the lagoon. Only 10% of all male fishers target the outer reef.

About half of all invertebrate fishers glean and the other half dive for selected species (Figure 5.6). Invertebrate fishers mainly target the mangroves (all female fishers and about 75% male fishers) and reef areas. Some male fishers specialise in harvesting bêche-de-mer (~40% male fishers), lobsters (~60% male fishers), trochus (~40% male fishers), octopus and giant clam ('other') (~70% male fishers). The fact that only males engage in the bêche-de-mer, lobster, trochus and other invertebrate fisheries suggests that, as elsewhere in the South Pacific, females do not engage in dive fishing for invertebrates but in gleaning only (Figure 5.7).

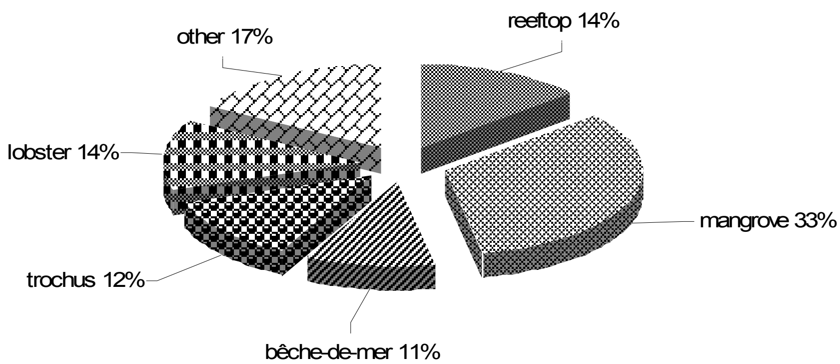

Figure 5.6: Proportion (%) of fishers targeting the six primary invertebrate habitats found in Oundjo.
Data based on individual fisher surveys; data for combined fisheries are disaggregated.

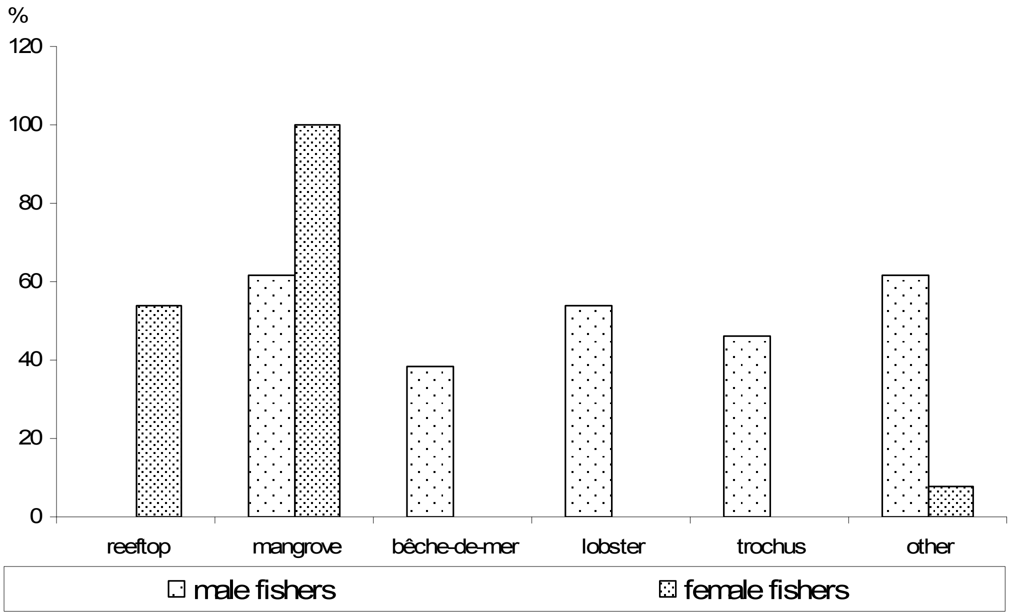

Figure 5.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Oundjo.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers who target each habitat: n = 13 for males, n = 13 for females.

Gear

Figure 5.8 shows that the main technique used in any habitat is the combined use of gillnets, castnets, handlines and spears (spear diving or handheld spearing either when walking or from a canoe). Castnets and gillnets are often used for fishing the sheltered coastal reef alone or in combination with the lagoon, and handlines are mostly used in the lagoon. At the outer-reef fishers also prefer the combination of handlines and spear diving.

Gleaning and free-diving for invertebrates are done using very simple tools only. Lobsters and octopus are often speared, while trochus, bêche-de-mer and many other species that are collected on reeftops are picked up by hand. Diving does not involve any gear other than mask, snorkel, fins and possibly a wet suit. Bêche-de-mer, lobster and other dive fisheries usually involve motorised boat transport. Mangrove and reeftop gleaning is done by walking, using canoes or sometimes motorised boat transport to reach the fishing ground.

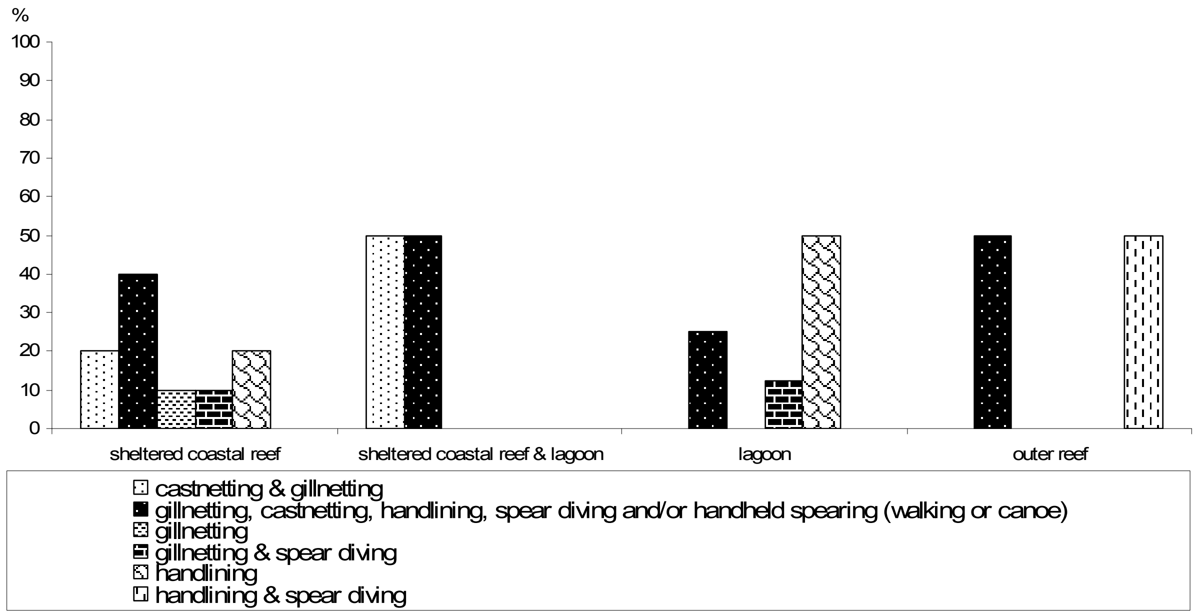

Figure 5.8: Fishing methods commonly used in different habitat types in Oundjo.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Frequency and duration of fishing trips

As shown in Table 5.3, the frequency of fishing trips increases from the outer reef to the lagoon and sheltered coastal reef habitats with 0.4, 0.9 and 1.5 times/week. However, the duration of fishing trips is similar regardless of which habitat is fished and ranges from 4 to 5 hours. Data show no major differences in frequency and duration of fishing trips between male and female fishers.

Overall, invertebrate collection trips are less frequent than trips for finfish. The highest frequency of ~1.5 times/week was found for mangrove gleaning by female fishers and lobster free-diving by male fishers. All other fisheries are performed less than once a week. The average trip duration for invertebrate collection is 3–4 hours/trip; occasionally >5 hours/trip in the case of trochus fishing.

Finfish is usually caught according to the tide; hence, fishers may go out either at day or night. However, female fishers tend to fish only during the day, which explains the high percentage of daytime fishers targeting the lagoon. The same argument may be used to explain why most fishers are active all or most of the year, but female fishers cease fishing during the colder season (On average, the lagoon is fished only during half of the year.).

For invertebrate fisheries, bêche-de-mer harvesting and reeftop and mangrove gleaning are exclusively performed at daytime, regardless of who is involved. Others, such as trochus, lobsters, octopus and giant clams may be targeted at night or at day depending on the tide and the personal preference of the fisher. While bêche-de-mer, mangrove and reeftop resources are harvested during most of the year, the lobster and trochus fisheries are performed during short and distinct periods only (3–4 months for lobster and 8–9 months for trochus).

Table 5.3: Average frequency and duration of fishing trips reported by male and female fishers in Oundjo

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	1.45 (±0.19)	1.00 (±0.00)	4.63 (±0.72)	6.00 (±3.00)
	Sheltered coastal reef & lagoon	1.56 (±0.18)	0	4.00 (±0.76)	0
	Lagoon	0.85 (±0.15)	1.82 (±0.74)	4.80 (±1.02)	4.17 (±0.93)
	Outer reef	0.35 (±0.12)	0	4.25 (±0.75)	0
Invertebrates	Reeftop	0	0.46 (±0.27)	0	4.14 (±1.07)
	Mangrove	0.60 (±0.20)	1.43 (±0.27)	3.83 (±0.72)	4.04 (±0.49)
	Bêche-de-mer	0.70 (±0.47)	0	4.58 (±0.71)	0
	Lobster	1.57 (±0.58)	0	3.13 (±0.35)	0
	Trochus	0.92 (±0.52)	0	5.42 (±0.37)	0
	Other	0.25 (±0.08)	0.04 (n/a)	4.10 (±0.50)	4.00 (n/a)

Figures in brackets denote standard error; n/a = standard error not calculated.
Finfish fisher interviews, males: n = 25; females: n = 5. Invertebrate fisher interviews, males: n = 26; females: n = 13.

5.2.3 Catch composition and volume – finfish: Oundjo

Catches from the sheltered coastal reef are dominated (64% of total reported catch) by three major groups: *mulet* (*Crenimugil crenilabis*), *bec-de-cane* (*Lethrinus* spp.) and *picot* (*Siganus* spp.). *Dawa* (*Naso unicornis*), *perroquet* (*Scarus* spp.), *blanc blanc* and *bossu* (*Lethrinus* spp.) determine another 28% of the reported catches. All other fish groups reported by vernacular name do not make up more than 8% of the total reported catch for sheltered coastal reef areas. Catch composition reported for lagoon fishing is more balanced. *Naso unicornis* (*dawa*), *Scarus* spp. (*perroquet*), *Lethrinus* spp. (*bec-de-cane*, *bossu*, *bossu doré*) and *Crenimugil crenilabis* (*mulet*) represent most (84%). At the outer reef, only four fish groups were reported, including *Naso unicornis* (*dawa*), *Plectropomus* spp. (*saumonée*) and *Scarus* spp. (*perroquet*) (Detailed data are provided in Appendix 2.4.1.).

Our survey sample of finfish fishers interviewed represents about 35% of the projected total number of finfish fishers in Oundjo. However, the survey included all subsistence fishers and commercial fishers. Hence, our results largely represent the overall impact of reef fisheries imposed by the community members of Oundjo on their fishing ground. Those fishers that we have not included in this survey are rather leisure fishers, who may or may not fish regularly, and fish for subsistence purposes only. Hence, the impact not captured here is presumably small, if not negligible.

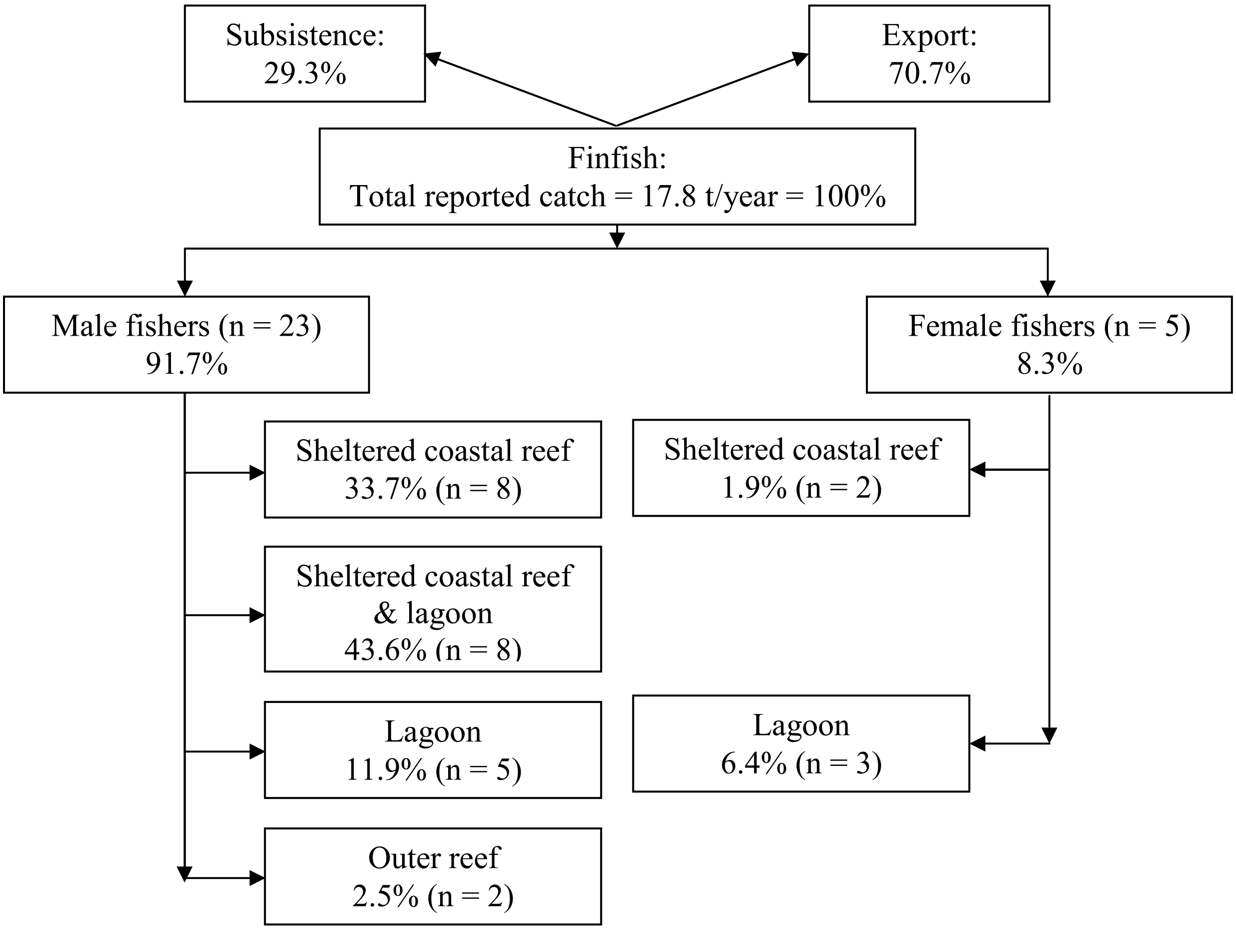

Figure 5.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Oundjo.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and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

As shown in Figure 5.9, most impact is due to commercial reef fishing, i.e. catches that are sold outside the Oundjo community (71% of the total annual reported catch or 13.2 t/year). Subsistence need only determines about 30% of all catches, corresponding to a total annual consumption of about 4.6 t. Most of the catch is done by male fishers; females only play a minor role (~8%). Highest pressure is imposed on the combined sheltered coastal reef and lagoon resources, with a minor impact on the outer-reef resources (2.5% of the total reported annual catch).

The high impact on the combined sheltered coastal reef and lagoon resources is not only due to the number of fishers targeting these areas but also the relatively high average annual catches. As shown in Figure 5.10, catches are ~0.7–1.0 t/fisher/year for sheltered coastal reef and the combination of sheltered coastal reef and lagoon. For exclusive lagoon fishers, catches go down to 0.4 t/fisher/year; at the outer reef, catches are the lowest, ~0.2 t/fisher/year only.

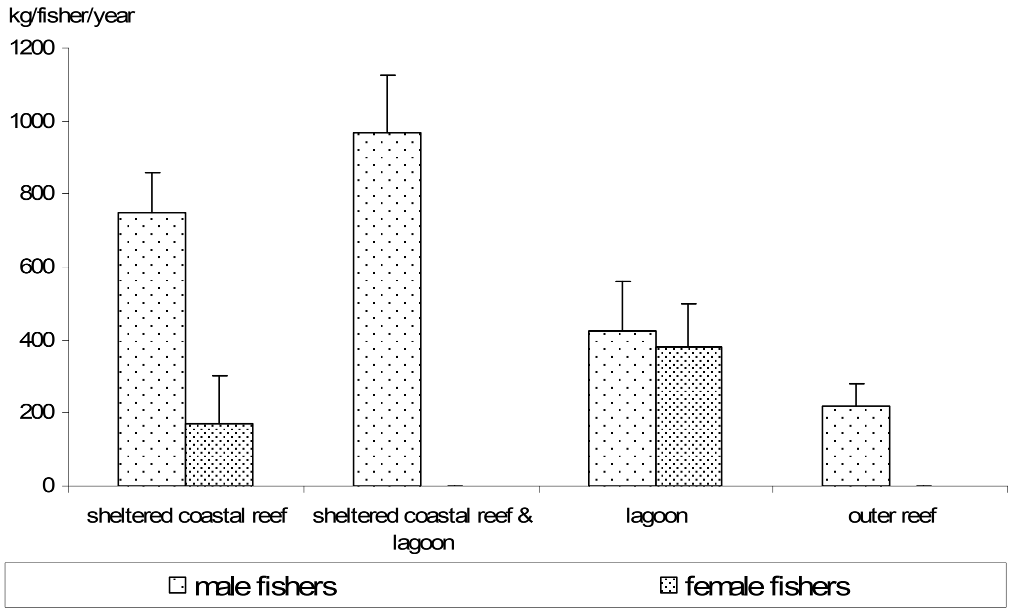

Figure 5.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Oundjo (based on reported catch only).

However, average annual catches are not to be confused with fishing efficiency (CPUE). Considering the average catch per hour of fishing trip spent, highest CPUEs are obtained at the outer reef (~4 kg/hour) and the combined areas of sheltered coastal reef and lagoon. Exclusive lagoon and sheltered coastal reef fishers reported lowest CPUEs, ~2.5–3.2 kg/hour respectively. Figure 5.11 shows that the fishing efficiency of female fishers is often below that of males. Only in the case of exclusive lagoon fishers does there seem to be no significant difference in CPUE between females or males.

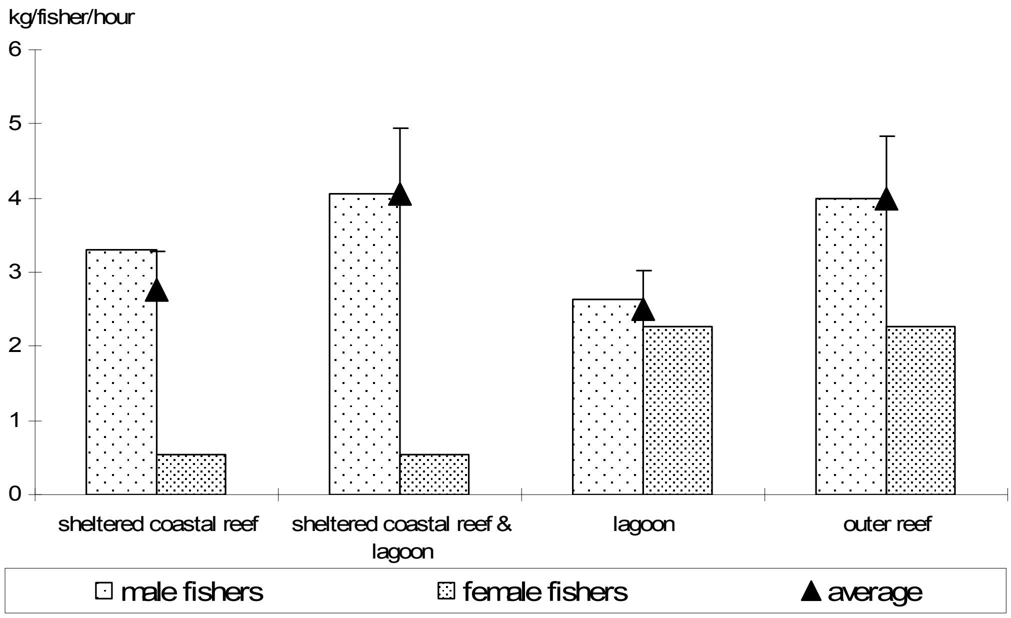

Figure 5.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat type in Oundjo.
Effort includes time spent transporting, fishing and landing catch. Bars represent standard error (+SE).

Survey data did not show any significant differences in the objectives of fishing among different habitats targeted (Figure 5.12). Regardless of which area is targeted, most catch is intended for sale outside the Oundjo community. The share of catch that is caught for non-monetary distribution among community members usually equals the share caught for subsistence purposes. Outer-reef catches are the only exception, as these are usually not intended as a gift but for subsistence and commercial purposes only.

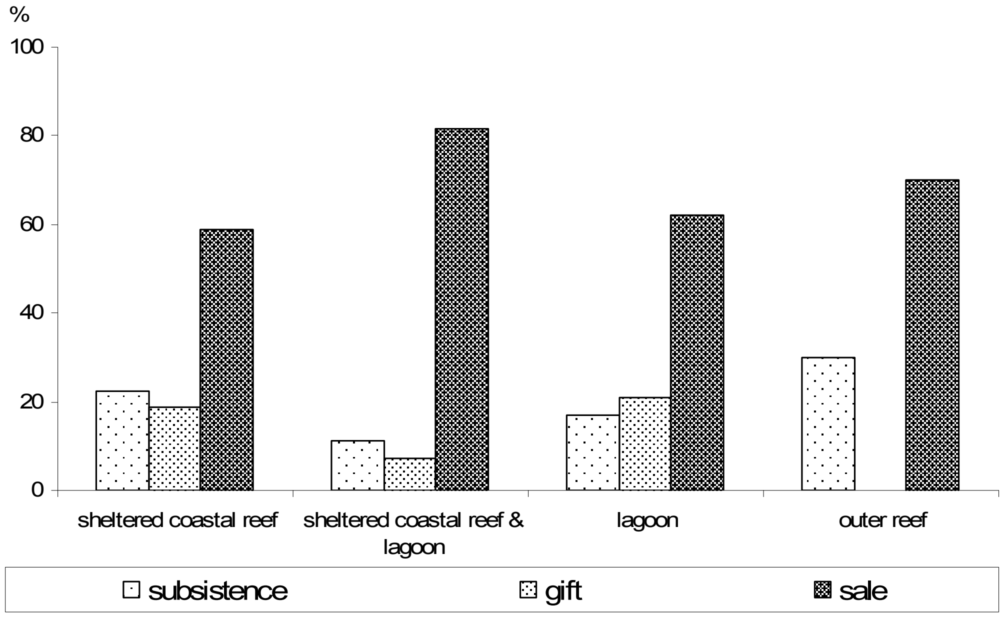

Figure 5.12: The use of finfish catches for subsistence, gifts and sale, by habitat in Oundjo. Proportions are expressed in % of the total number of trips per habitat.

Data on the average reported finfish sizes by family and habitat (Figure 5.13) show an increasing trend in fish size from the sheltered coastal reef towards the outer reef (for Acanthuridae and Serranidae). However, this is not the case for Scaridae. The frequent use of spear diving at the outer reef may be a possible explanation for this observation. It seems that usually fish sizes in catches from the combined fishing of the sheltered coastal reef and lagoon are smaller than those reported for catches from the exclusive fishing of either the sheltered coastal reef or the lagoon. However, the high variability (SE) of reported average finfish sizes for catches from any habitat fished (Figure 5.13) may be misleading.

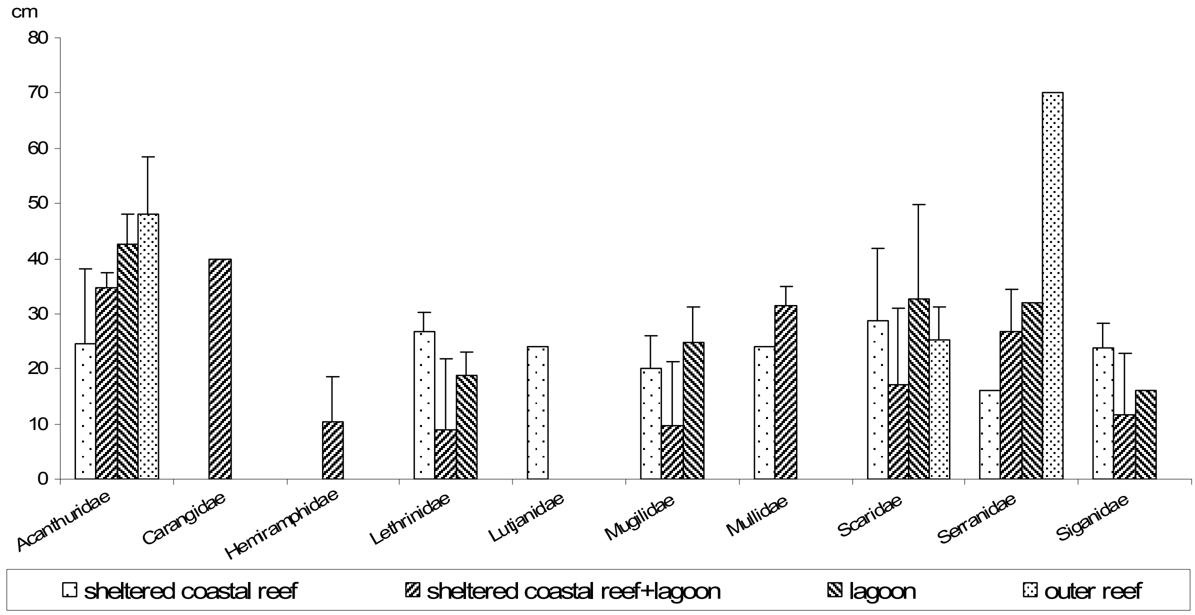

Figure 5.13: Average sizes (cm fork length) of fish caught by family and habitat in Oundjo. Bars represent standard error (+SE).

Some parameters selected to assess the current fishing pressure on Oundjo's living reef resources are shown in Table 5.4. The comparison of habitat surfaces included in the Oundjo fishing ground shows that the lagoon is the largest area, followed by the sheltered coastal reef. Overall, fisher density is low, with an average of <1 fisher/km^2 for any habitat. Highest average annual catches are reported from the sheltered coastal reef if combined with lagoon in one fishing trip, followed by the sheltered coastal reef alone. Overall, population density is low; it reaches about 2 people/km^2 of total reef and total fishing ground. All parameters indicate that fishing pressure on Oundjo finfish resources is low, and indeed average annual total catch/km^2 of total reef or total fishing ground area is very low: 0.06 and 0.05 t/km^2/year respectively.

Table 5.4: Parameters used in assessing fishing pressure on finfish resources in Oundjo

Parameters	Habitat					
	Sheltered coastal reef	Sheltered coastal reef & lagoon	Lagoon	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	58.54		124.30	11.36	142.64	194.20
Density of fishers (number of fishers/km^2 fishing ground) (1)	0.43		0.18	0.44	0.5	0.37
Population density (people/km^2) (2)					2.1	1.52
Average annual finfish catch (kg/fisher/year) (3)	632.88 (±117.98)	969.30 (±154.28)	408.63 (±90.32)	219.79 (±61.87)		
Total fishing pressure of subsistence catches (t/km^2)					0.06	0.05

Figures in brackets denote standard error; n/a = no information available or standard error not calculated; (1) total number of fishers is extrapolated from household surveys; (2) total population = 295; total number of fishers = 71; total subsistence demand = 8.96 t/year; (3) catch figures are based on recorded data from survey respondents only.

5.2.4 Catch composition and volume – invertebrates: Oundjo

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 mainly due to two species, i.e. *Scylla serrata* (*crabe de palétuvier*) and trochus (*troca*: *Tectus pyramis*, *Trochus niloticus*). In addition, *Anadara* spp. and *Holothuria scabra* have slightly higher catches wet weight than the remaining 10 species groups (Detailed data are provided in Appendix 2.4.2 and 2.4.3.).

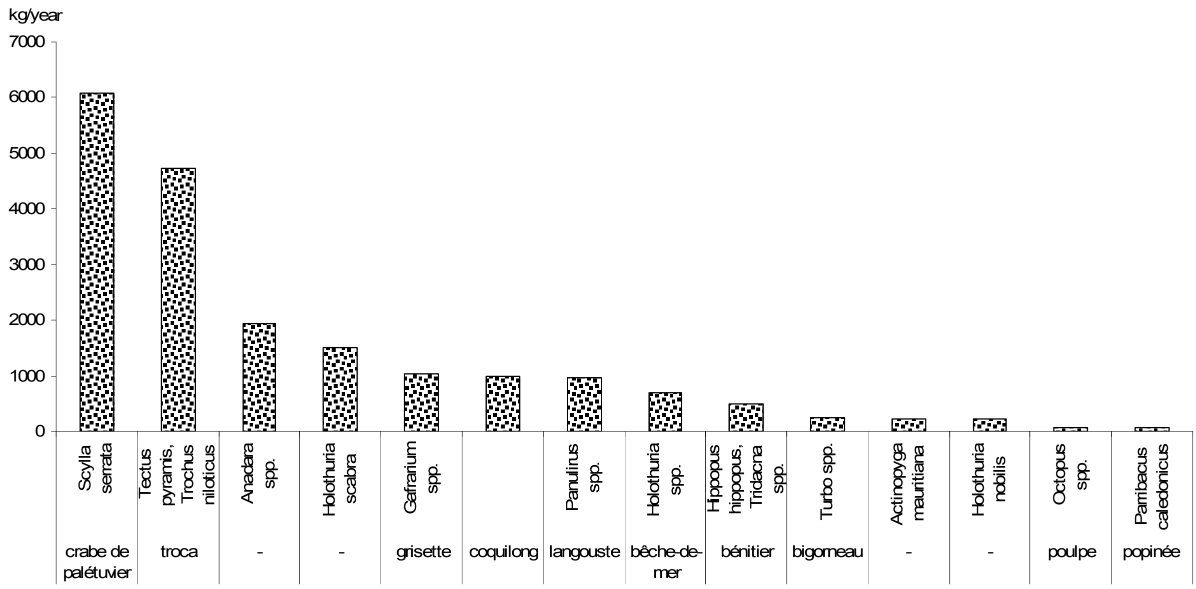

Figure 5.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Oundjo.

In accordance with the limited number of invertebrates reported by respondents in Oundjo, the overall biodiversity in the invertebrate fishery is low (Figure 5.15). Taking into account all reported vernacular names, reeftop fishery scores highest with five different species names, while most other fisheries are represented by 1–3 reported vernacular names only.

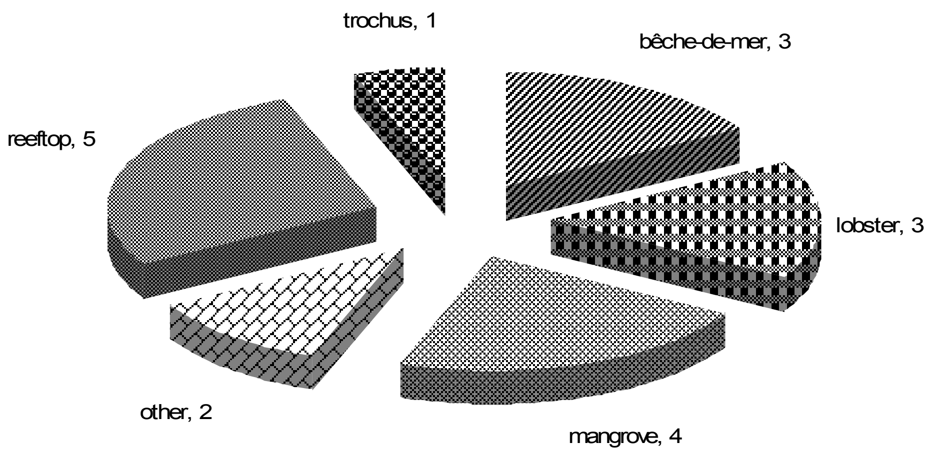

Figure 5.15: Number of vernacular names recorded for each invertebrate fishery in Oundjo.

As expected, the highest average annual catches by wet weight occur in mangrove, MOP (trochus) and reeftop fisheries (Figure 5.16). Surprisingly, female fishers targeting the mangrove areas, have more than double the average annual catches by wet weight than do male fishers. This comparison could not be made for reef fisheries as the survey had no male respondents.

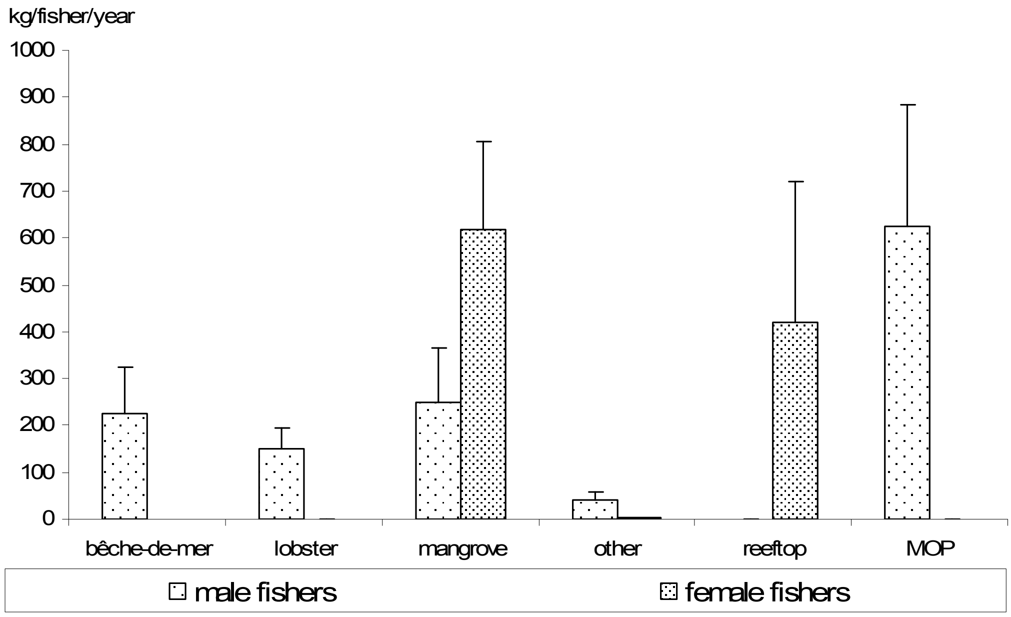

Figure 5.16: Average annual invertebrate catch (kg wet weight/year) by fisher and gender in Oundjo.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 34 for males, n = 21 for females); 'other' refers to the giant clam and octopus fisheries; MOP = mother-of-pearl.

Invertebrate fishing, as finfish fishing, is mainly performed for commercial purposes, i.e. marketing outside the Oundjo community (Figure 5.17). Only 14% of the reported total annual wet weight is exclusively harvested for subsistence purposes. If we add half of the category that may be used for both 'consumption and sale', subsistence demand may not exceed 32% of the total annual reported wet weight caught. In contrast, ~51–68% is caught for sale outside the Oundjo community. As a result, it can be concluded that any impact on invertebrate resources is mainly determined by external rather than internal demand.

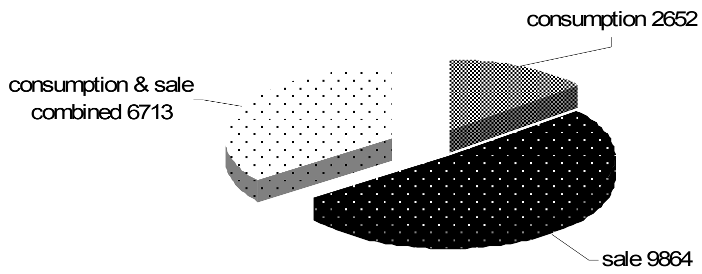

Figure 5.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Oundjo.

The total annual catch volume (expressed in wet weight based on recorded data from all respondents interviewed) amounts to 19.2 t/year (Figure 5.18). Catches from mangroves, trochus fishery and reeftops are prominent, representing ~52%, ~20% and ~15% respectively. Bêche-de-mer (~5%), lobster (~5%) and other species collected by diving, such as octopus and giant clams (~2%), are much less important in terms of their proportion of total catch. Female invertebrate fishers are responsible for most of the annual reported catch, i.e. 57%. However, Figure 5.18 also shows a clear difference between genders. Free-diving fisheries for bêche-de-mer, trochus, lobsters and 'others' (giant clam, octopus) are only performed by males, while reeftop and mangrove gleaning are mostly performed by females.

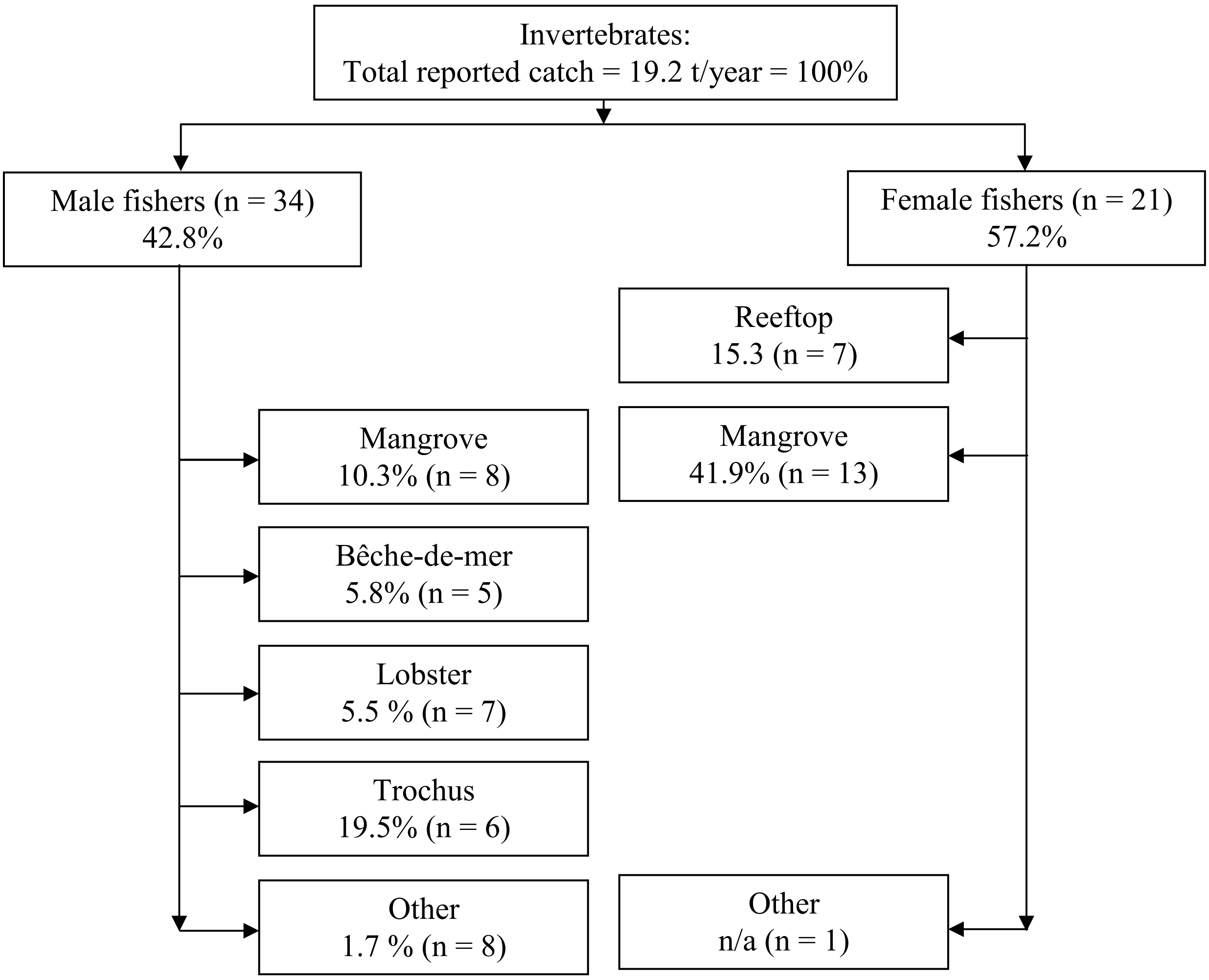

Figure 5.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Oundjo.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey; n/a = no information available; 'other' refers to the giant clam and octopus fisheries.

Table 5.5: Parameters used in assessing fishing pressure on invertebrate resources in Oundjo

Parameters	Fishery / Habitat					
	Reeftop [4]	Mangrove	Bêche-de-mer	Lobster	Trochus	Other
Fishing ground area (km^2)	64.5	48.04		38 [3]	38 [3]	73.5
Number of fishers (per fishery) [1]	34	75	9	12	9	19
Density of fishers (number of fishers/km^2 fishing ground)	0.5	1.6		0.3	0.2	0.3
Average annual invertebrate catch (kg/fisher/year) [2]	420.71 (±299.40)	477.59 (±127.73)	224.28 (±99.85)	150.92 (±43.26)	624.51 (±258.69)	36.60 (±15.19)

Figures in brackets denote standard error; [1] total number of fishers is extrapolated from household surveys; [2] catch figures are based on recorded data from survey respondents only; [3] reef length; [4] reeftop fishery mostly targets the sheltered coastal reef areas; thus we have not included the outside shallow reef areas, although they represent potential fishing grounds for the reeftop fishery; 'other' refers to the giant clam and octopus fisheries.

The parameters presented in Table 5.5 show a high variability in the size of available fishing grounds for the various fisheries. However, generally speaking, habitats supporting the various fisheries are large. Considering the annual catch per fisher (wet weight) and the density of fishers, fishing pressure on most habitats is negligible or low. This argument applies regardless of whether the fisheries are more for subsistence or commercial purposes. As a result, the data collected and presented here do not give any cause for alarm concerning current or future fishing pressure.

5.2.5 Discussion and conclusions: socioeconomics in Oundjo

- Fisheries are the most important sector for income generation in Oundjo; however, salaries and income from other sources, such as small business, and retirement and other social fees, also play a role.

- All households consume fresh fish and most also consume invertebrates regularly. Fresh-fish consumption is about average and among the highest values of the five PROCFish sites surveyed in New Caledonia. Invertebrate consumption is outstandingly high and exceeds that of fresh fish by 35%.

- The fact that the average household expenditure level only reaches half of the country's average as estimated by the PROCFish survey suggests that the people in Oundjo enjoy a rather traditional, subsistence-oriented lifestyle.

- Most male fishers target only finfish and most female fishers collect invertebrates. Finfish fishers mainly target the sheltered coastal reefs and lagoon and much less the outer reef. Invertebrate collection is mainly from mangroves and on reeftops, while some male fishers also collect bêche-de-mer, lobsters and trochus for commercial purposes.

- Finfish are caught using a combination of castnets, gillnets, handlines and spears. Invertebrate fisheries mainly involve the use of simple tools and sometimes motorised boat transport to reach certain fishing areas.

- Highest fishing pressure is on the sheltered coastal reef and the lagoon. This is due to the comparatively high annual catch rates, even though fisher densities are low. CPUEs for sheltered coastal reef and lagoon fishing do not vary substantially from those reported for the outer-reef fishing. However, average fish sizes are larger in catches reported from the outer reef. This observation suggests that the resource status improves and/or fishing pressure, fisher density and annual catch decrease as the distance from shore increases.

- Invertebrate fisheries also mainly serve markets outside Oundjo and most of the catch by wet weight is sold. Highest fishing pressure is observed for the mangrove fishery and, to some extent, the trochus fishery. Because the habitats supporting the invertebrate fisheries are relatively large and fisher density and average catch rates relatively low, fishing pressure is generally low or even negligible.

The above observations lead to two major conclusions. Firstly, present pressure on finfish and invertebrate resources in Oundjo does not seem to have reached any alarming level although both resources are mainly exploited to supply outside market demand. In fact, the Oundjo community is one of the major suppliers of fish to agents for the greater Noumea market. Secondly, fisheries play an important role for income generation. Given the limited local alternatives for other income sources for people in Oundjo, it can be assumed that fisheries will continue to play an important role in the future. Depending on transport and marketing cost and market demand in Noumea, it is possible that fishing pressure on certain species, e.g. mud crabs, lobsters, trochus and selected finfish species, will increase. Although the fishing grounds in Oundjo are large, stocks of these selectively targeted species may need to be monitored in the future.

5.3 Finfish resource surveys: Oundjo

Finfish resources and associated habitats were assessed between 16 February and 18 November 2004 from a total of 24 transects (6 sheltered coastal, 6 intermediate-, 6 back- and 6 outer-reef transects, see Figure 5.19 and Appendix 3.4.1 for transect locations and coordinates respectively).

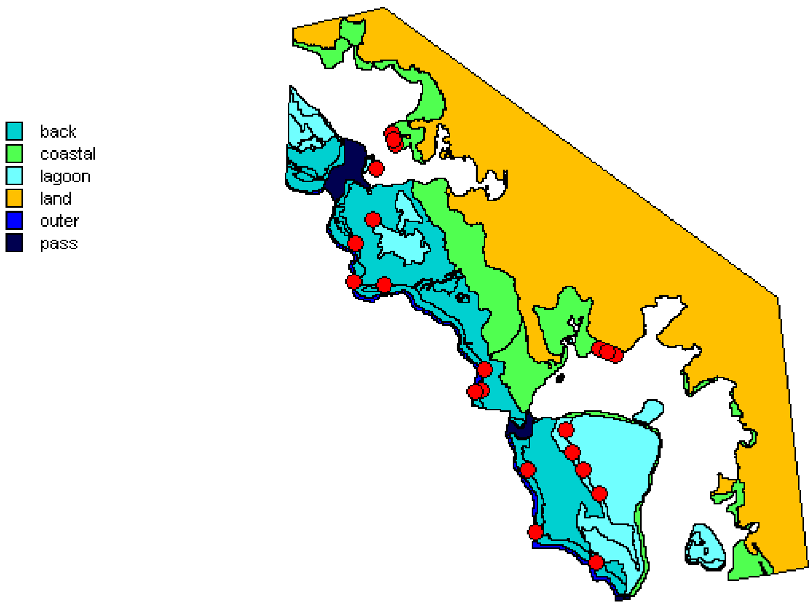

Figure 5.19: Habitat types and transect locations for finfish assessment in Oundjo.

5.3.1 Finfish assessment results: Oundjo

A total of 26 families, 66 genera, 183 species and 9631 fish were recorded in the 24 transects (See Appendix 3.4.2 for list of species.). Only data on the 15 most dominant families (See Appendix 1.2 for species selection.) are presented below, representing 49 genera, 153 species and 7057 individuals.

Finfish resources varied slightly among the four reef environments found in Oundjo (Table 5.6). The back-reef contained the highest density (0.6 fish/m^2) and biomass (93 g/m^2) as well as the largest size (16 cm). In contrast, the coastal reefs displayed the lowest density (0.3 fish/m^2), size (9 cm), biomass (16 g/m^2) and biodiversity. Outer reefs displayed the highest biodiversity at the site with 53 species/transect.

Table 5.6: Primary finfish habitat and resource parameters recorded in Oundjo (average values ±SE)

Parameters	Habitat				
	Sheltered coastal reef (1)	Intermediate reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	6	6	6	6	24
Total habitat area (km^2)	58.5	51.6	72.7	5.6	188.4
Depth (m)	2 (1-6)	4 (2-6)	2 (1-3)	5 (1-11)	3 (1-11)
Soft bottom (% cover)	16 ±10	33 ±8	37 ±12	0 ±0	29
Rubble & boulders (% cover)	24 ±7	23 ±7	17 ±6	1 ±1	20
Hard bottom (% cover)	26 ±5	33 ±5	37 ±12	67 ±7	34
Live coral (% cover)	31 ±12	7 ±2	7 ±2	30 ±7	15
Soft coral (% cover)	2 ±1	2 ±1	1 ±1	3 ±1	2
Biodiversity (species/transect)	23 ±3	41 ±4	40 ±4	53 ±5	39 ±3
Density (fish/m^2)	0.3 ±0.1	0.4 ±0.1	0.6 ±0.2	0.5 ±0.1	0.4
Size (cm FL) (4)	9 ±0	16 ±1	16 ±1	16 ±1	14
Size ratio (%)	32 ±2	52 ±2	49 ±2	57 ±2	45
Biomass (g/m^2)	16.5 ±4.4	52.6 ±8.5	93.1 ±30.1	77.3 ±13.6	57.7

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

Sheltered coastal reef environment: Oundjo

The sheltered coastal reef environment of Oundjo was dominated by four families in terms of density and biomass: Chaetodontidae, Scaridae, Acanthuridae and Lutjanidae, and by one family of carnivores only in terms of biomass, Serranidae (Figure 5.20). These five families were represented by 38 species; highest abundance and biomass – although in very low values) were recorded for *Plectropomus leopardus*, *Acanthurus blochii*, *Lutjanus fulviflamma*, *Scarus rivulatus*, *Ctenochaetus striatus*, *Acanthurus xanthopterus*, *Chlorurus sordidus*, *L. fulvus* and *L. gibbus* (Table 5.7). This reef environment presented almost equal proportions of hard bottom, rubbles/boulders and soft substrate, and a very high cover of live coral (31%). Such diverse habitat was reflected in the diversity of the fish community composition (Table 5.6 and Figure 5.20).

Table 5.7: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Oundjo

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Acanthurus blochii*	Ringtail surgeonfish	0.01 ±0.003	2.1 ±1.7
	Ctenochaetus striatus	Striated surgeonfish	0.01 ±0.004	0.6 ±0.4
	Acanthurus xanthopterus	Yellowfin surgeonfish	0.01 ±0.004	0.6 ±0.4
Lutjanidae	*Lutjanus fulviflamma*	Longspot snapper	0.02 ±0.018	2.1 ±1.8
	Lutjanus fulvus	Blacktail snapper	0.01 ±0.002	0.2 ±0.2
	Lutjanus gibbus	Humpback snapper	0.02 ±0.016	0.2 ±0.2
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.02 ±0.009	1.9 ±1.3
	Chlorurus sordidus	Daisy parrotfish	0.03 ±0.010	0.5 ±0.2
Serranidae	*Plectropomus leopardus*	Leopard coral grouper	0.01 ±0.000	3.5 ±2.2

The density, size, biomass and biodiversity of fish in the coastal reefs of Oundjo were the lowest in the country, as well as at the site (Table 5.6). Herbivorous and carnivorous fish displayed similar density and biomass, with a slight dominance of carnivores in terms of biomass. The substrate was almost equally composed of hard-bottom, soft bottom and rubbles, offering different habitats for the different families, which partially explains the high diversity of the dominant fish community.

The high cover of live coral (31%), the highest among the five sites, explains the striking abundance of butterflyfish.

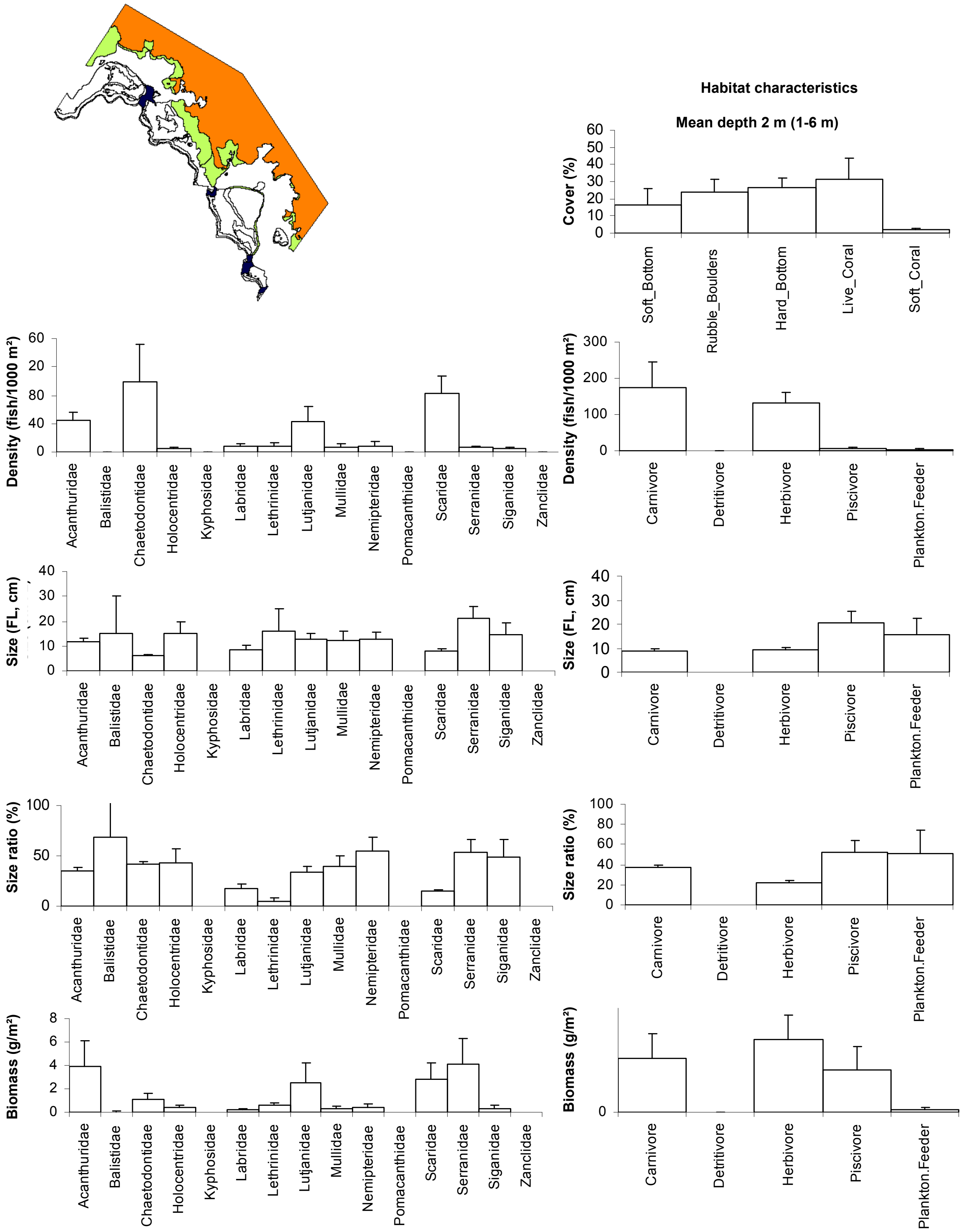

Figure 5.20: Profile of finfish resources in the sheltered coastal reef environment of Oundjo.
Bars represent standard error (+SE); FL = fork length.

Intermediate-reef environment: Oundjo

The intermediate-reef environment of Moindou was dominated by four families: herbivorous Scaridae and Acanthuridae (both in terms of density and biomass), carnivorous Chaetodontidae (in terms of density only) and, to a much lesser extent, Mullidae (Figure 5.21). These four families were represented by 51 species; particularly high abundance and biomass were recorded for *Scarus ghobban*, *Ctenochaetus striatus*, *Chlorurus sordidus*, *S. schlegeli*, *S. niger*, *S. psittacus*, *Acanthurus blochii*, *Ctenochaetus binotatus* and *Parupeneus barberinoides* (Table 5.8). This reef environment presented a moderately diverse habitat with equal proportion of soft and hard bottom (33% each; Table 5.6 and Figure 5.21). Live coral was, however, very limited (7%).

Table 5.8: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Oundjo

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Scarus ghobban*	Bluebarred parrotfish	0.03 ±0.005	7.1 ±2.8
	Chlorurus sordidus	Daisy parrotfish	0.05 ±0.024	5.9 ±2.5
	Scarus schlegeli	Schlegel's parrotfish	0.02 ±0.007	2.2 ±1.2
	Scarus niger	Swarthy parrotfish	0.01 ±0.006	2.0 ±1.1
	Scarus psittacus	Palenose parrotfish	0.02 ±0.011	1.4 ±0.7
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.04 ±0.020	6.8 ±4.0
	Acanthurus blochii	Ringtail surgeonfish	0.01 ±0.003	1.4 ±0.6
	Ctenochaetus binotatus	Two-spot bristletooth	0.01 ±0.004	1.1 ±0.5
Mullidae	*Parupeneus barberinoides*	Bicolor goatfish	0.01 ±0.002	0.8 ±0.2

The density of fish in the intermediate reefs of Oundjo was slightly lower than in the outer reefs of the other sites, only higher than in Luengoni. However, sizes and biomass were among the lowest, together with those in Moindou, of the intermediate reefs in the country (Table 5.6). Herbivorous fish dominated the trophic structure of the fish community in this habitat, both in terms of density and especially of biomass. Carnivorous families such as Lethrinidae, Lutjanidae and Mullidae, were present in very low numbers and biomass, suggesting high fishing pressure on these resources. As in other sites, Lethrinidae is one of the top preferred target families in the sheltered reefs and lagoon. Sizes and size ratios were particularly low for Scaridae, Lethrinidae and Lutjanidae, suggesting intensive fishing of these families.

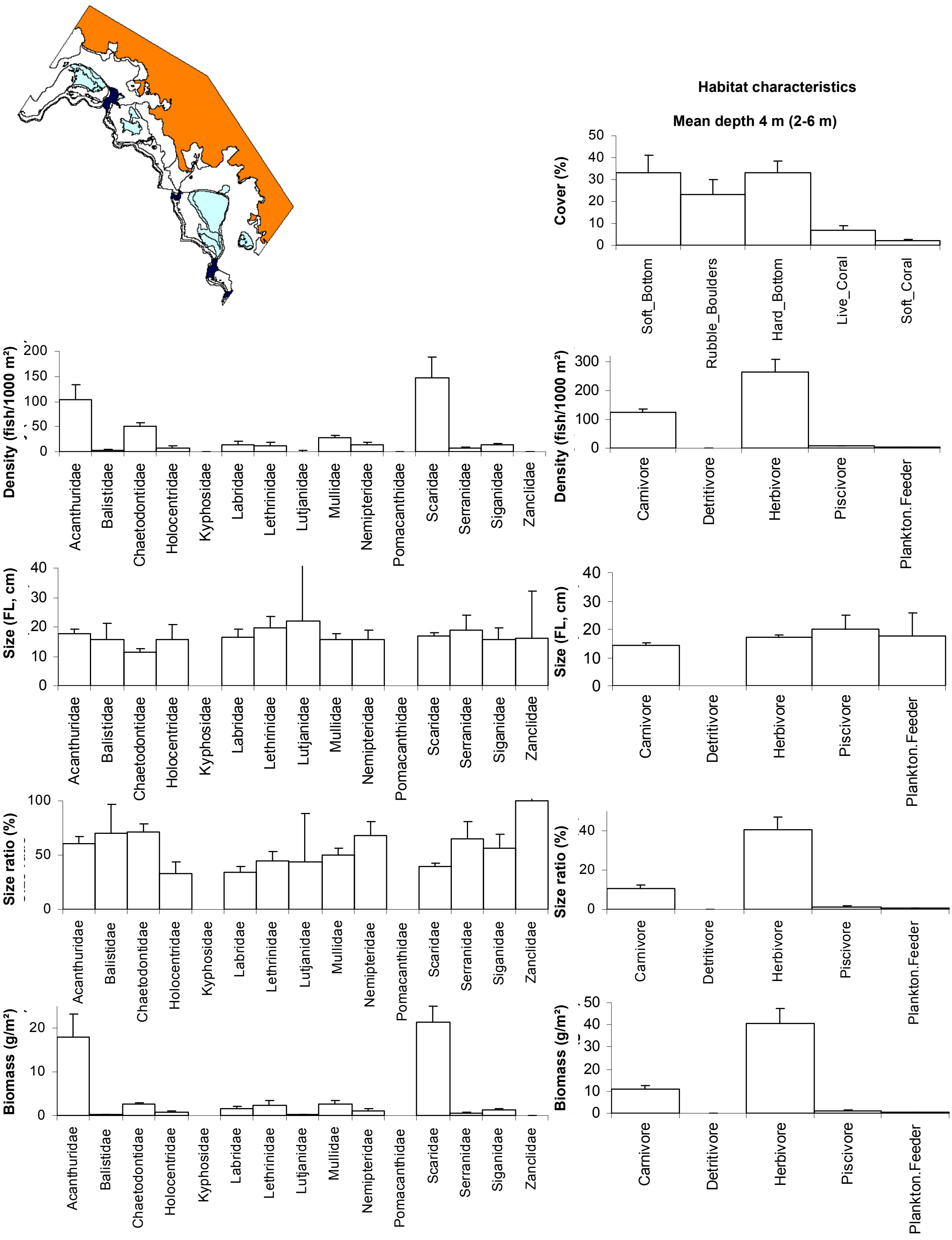

Figure 5.21: Profile of finfish resources in the intermediate-reef environment of Oundjo.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Oundjo

The back-reef environment of Oundjo was dominated by three families of herbivorous fish: Scaridae, Acanthuridae and Siganidae (Figure 5.22). These families were represented by 24 species; particularly high abundance and biomass were recorded for *Naso tuberosus*, *Chlorurus sordidus*, *Acanthurus blochii*, *Ctenochaetus striatus*, *Scarus ghobban*, *Siganus spinus* and *Scarus psittacus* (Table 5.9). This reef environment presented identical proportions of soft and hard bottom as well as a high cover of rubble (Table 5.6 and Figure 5.22). The variety of the environment might explain the diversity of the fish composition.

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

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Naso tuberosus*	Humpnose unicornfish	0.01 ±0.01	27.2 ±24.8
	Acanthurus blochii	Ringtail surgeonfish	0.04 ±0.03	8.2 ±7.3
	Ctenochaetus striatus	Striated surgeonfish	0.04 ±0.02	6.9 ±3.6
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.12 ±0.03	9.7 ±2.6
	Scarus ghobban	Bluebarred parrotfish	0.02 ±0.01	3.8 ±1.5
	Scarus psittacus	Palenose parrotfish	0.04 ±0.01	2.1 ±0.8
Siganidae	*Siganus spinus*	Little spinefoot	0.09 ±0.08	3.2 ±3.0

The density and biomass of finfish in the back-reefs of Oundjo were high and second only to the top values recorded in Luengoni; both size and biodiversity were the highest recorded in the country for this type of habitat. The trophic structure in Oundjo back-reefs was dominated in terms of density and biomass by herbivorous species, of which Acanthuridae, Scaridae and Siganidae composed most of the density of the finfish population. Mullidae, Lethrinidae and Lutjanidae contributed significantly to the biomass, although they were at low density. The substrate composition of identical cover of hard and soft bottom may explain the rather diverse composition of important families. However, the dominance of Scaridae and Acanthuridae and the low importance of carnivorous families despite the large amount of their preferred habitat, could be seen as response to heavy fishing on certain target families, e.g. Lethrinidae.

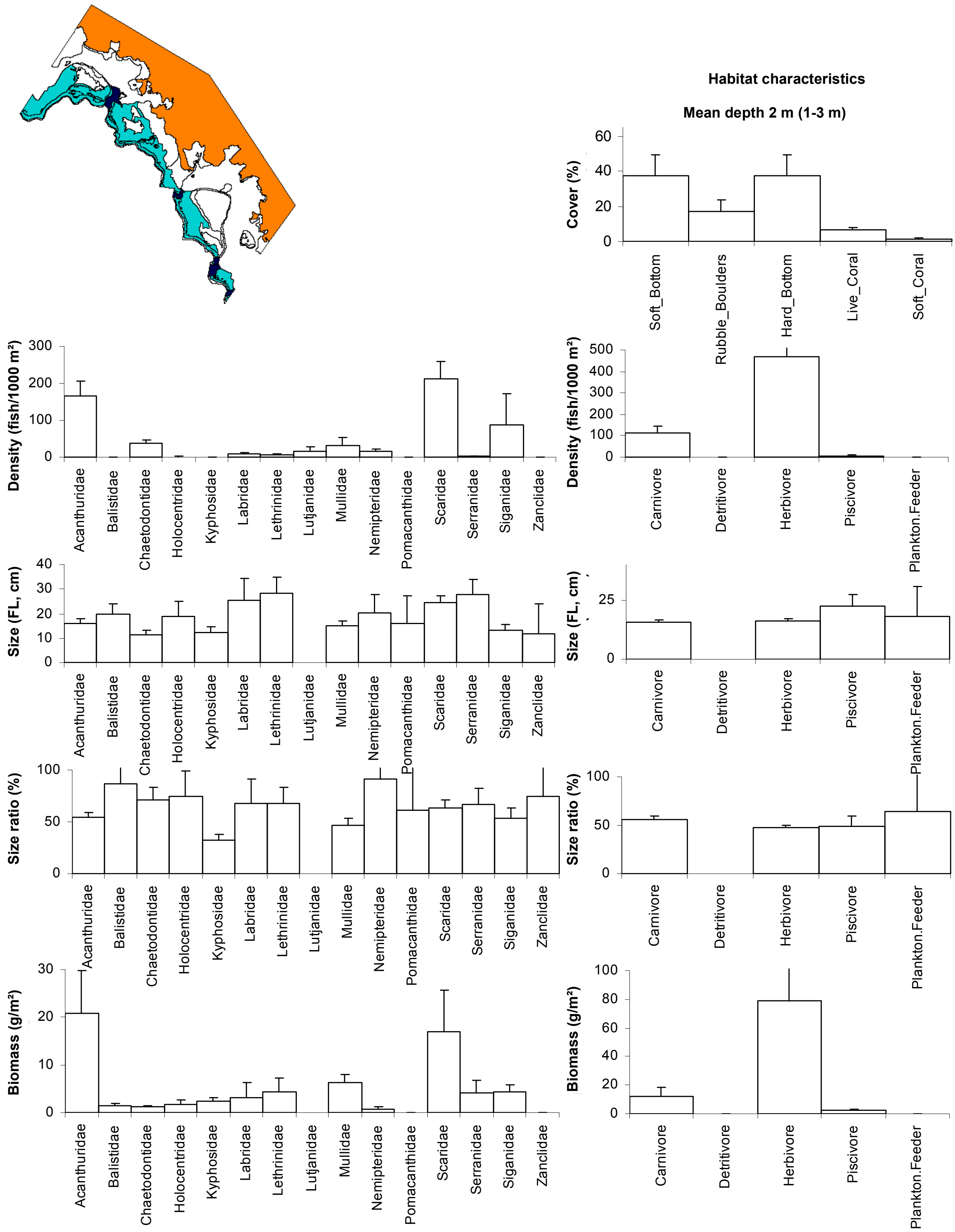

Figure 5.22: Profile of finfish resources in the back-reef environment of Oundjo.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Oundjo

The outer reef of Oundjo was dominated by herbivorous Scaridae and Acanthuridae (both in terms of density and biomass) and, to a lesser extent, by carnivorous Lutjanidae (mainly for biomass, Figure 5.23). Chaetodontidae were also very abundant. These four families were represented by 61 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Chlorurus sordidus*, *Lutjanus gibbus*, *Naso lituratus*, *Scarus altipinnis*, *S. frenatus* and *S. psittacus* (Table 5.10). Hard bottom (67% cover) largely dominated the substrate of this reef environment, which also displayed a high cover of live corals (30%, Table 5.6 and Figure 5.23). These were the highest values of hard bottom and live-coral cover recorded in the outer reefs of all the country sites.

Table 5.10: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Oundjo

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.15 ±0.03	23.7 ±4.4
	Naso lituratus	Orangespine unicornfish	0.01 ±0.00	4.7 ±2.7
Lutjanidae	*Lutjanus gibbus*	Humpback snapper	0.01 ±0.01	4.9 ±4.6
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.07 ±0.02	6.0 ±2.3
	Scarus altipinnis	Filamentfinned parrotfish	0.01 ±0.01	3.0 ±2.3
	Scarus frenatus	Bridled parrotfish	0.01 ±0.01	2.5 ±1.6
	Scarus psittacus	Palenose parrotfish	0.02 ±0.00	1.5 ±0.5

The size and biomass of finfish in the outer reef of Oundjo were, respectively, third and second highest in the country, while density was in the upper end of the range (0.5 in the range 0.3–0.9 fish/m^2) for outer reefs and lower only to Ouassé (Table 5.6). Biodiversity was the highest among values for outer reefs and overall in the country. The trophic structure was dominated by herbivores, mainly Acanthuridae and Scaridae, but carnivores (Lutjanidae) were also important in terms of biomass. Substrate was healthy and mainly composed of hard bottom with high abundance of live corals, which explain the very high density and diversity of Chaetodontidae.

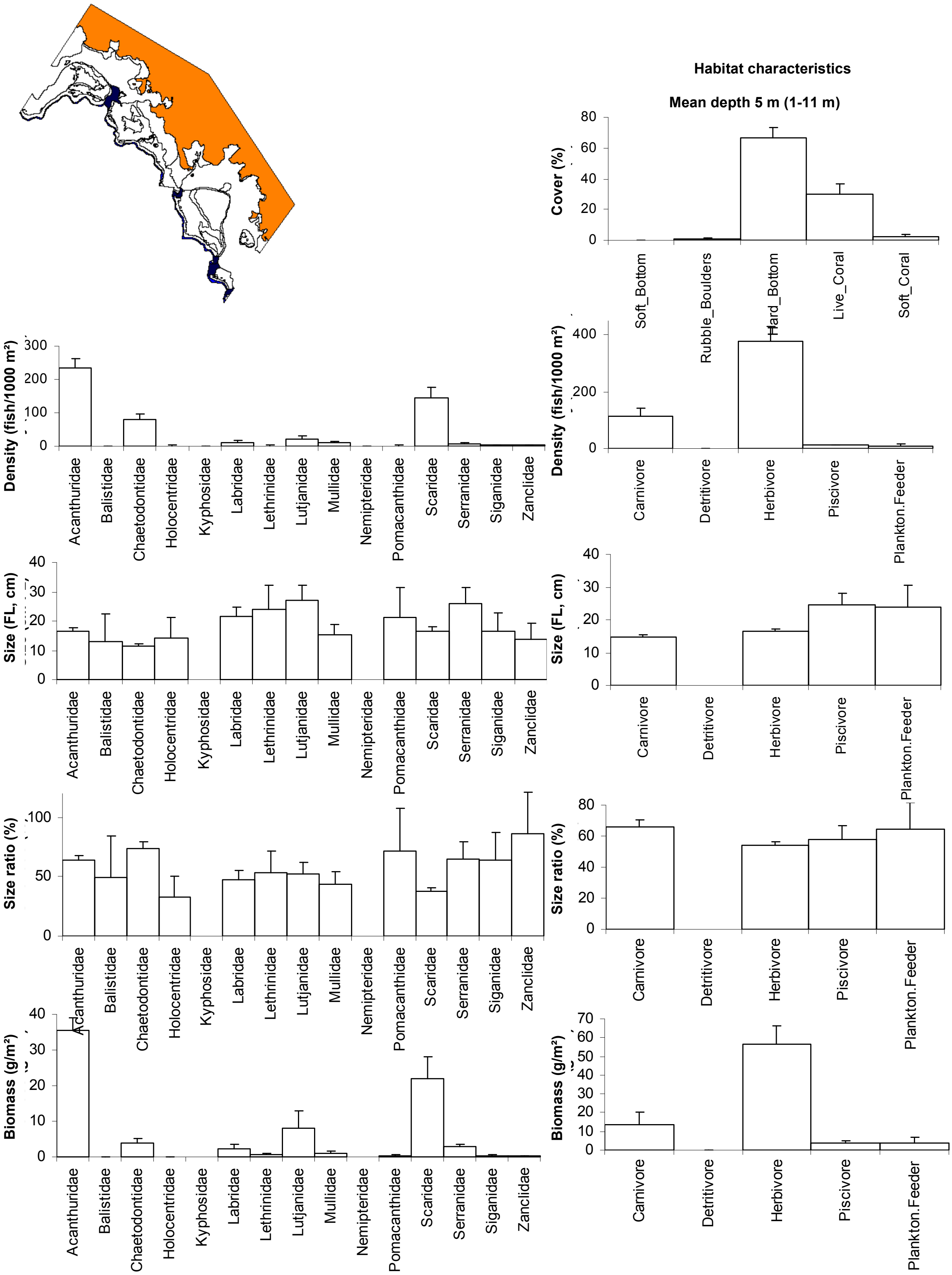

Figure 5.23: Profile of finfish resources in the outer-reef environment of Oundjo.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Oundjo

Overall, the fish assemblage of Oundjo was dominated by Scaridae and Acanthuridae (both in terms of density and biomass) and by Chaetodontidae (density, Figure 5.24). These three families were represented by a total of 66 species, dominated (in terms of density and biomass) by *Chlorurus sordidus*, *Ctenochaetus striatus*, *Scarus psittacus*, *Acanthurus blochii*, *S. ghobban* and *Naso tuberosus* (Table 5.11). As expected, the overall fish assemblage in Oundjo shared characteristics of back-reef (39% of habitat), coastal reefs (31%), intermediate reef (27%) and, to a small extent, outer reefs (3%).

Table 5.11: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Oundjo (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.07	5.7
	Scarus ghobban	Bluebarred parrotfish	0.02	3.5
	Scarus psittacus	Palenose parrotfish	0.02	1.2
Acanthuridae	*Naso tuberosus*	Humpnose unicornfish	0.01	10.5
	Ctenochaetus striatus	Striated surgeonfish	0.04	5.4
	Acanthurus blochii	Ringtail surgeonfish	0.02	4.2

Overall, Oundjo appears to support a poorer finfish resource than the other sites, with lowest values of density (0.4 fish/m^2), size (14 cm), biomass (58 g/m^2) but highest values of biodiversity (39 species/transect, Table 5.6). While these results suggest that the finfish resource in Oundjo is in relatively poor condition, detailed assessment at site level revealed a richer fish population in the back-reefs and outer reefs and much poorer fish population in the coastal reefs. The average trophic structure for this site was dominated by herbivores in terms of both density and biomass, mainly represented by Acanthuridae and Scaridae. Chaetodontidae were present in very high numbers, higher than at any other site, evidence of the high quality of the substrate, especially at the coastal and outer reefs.

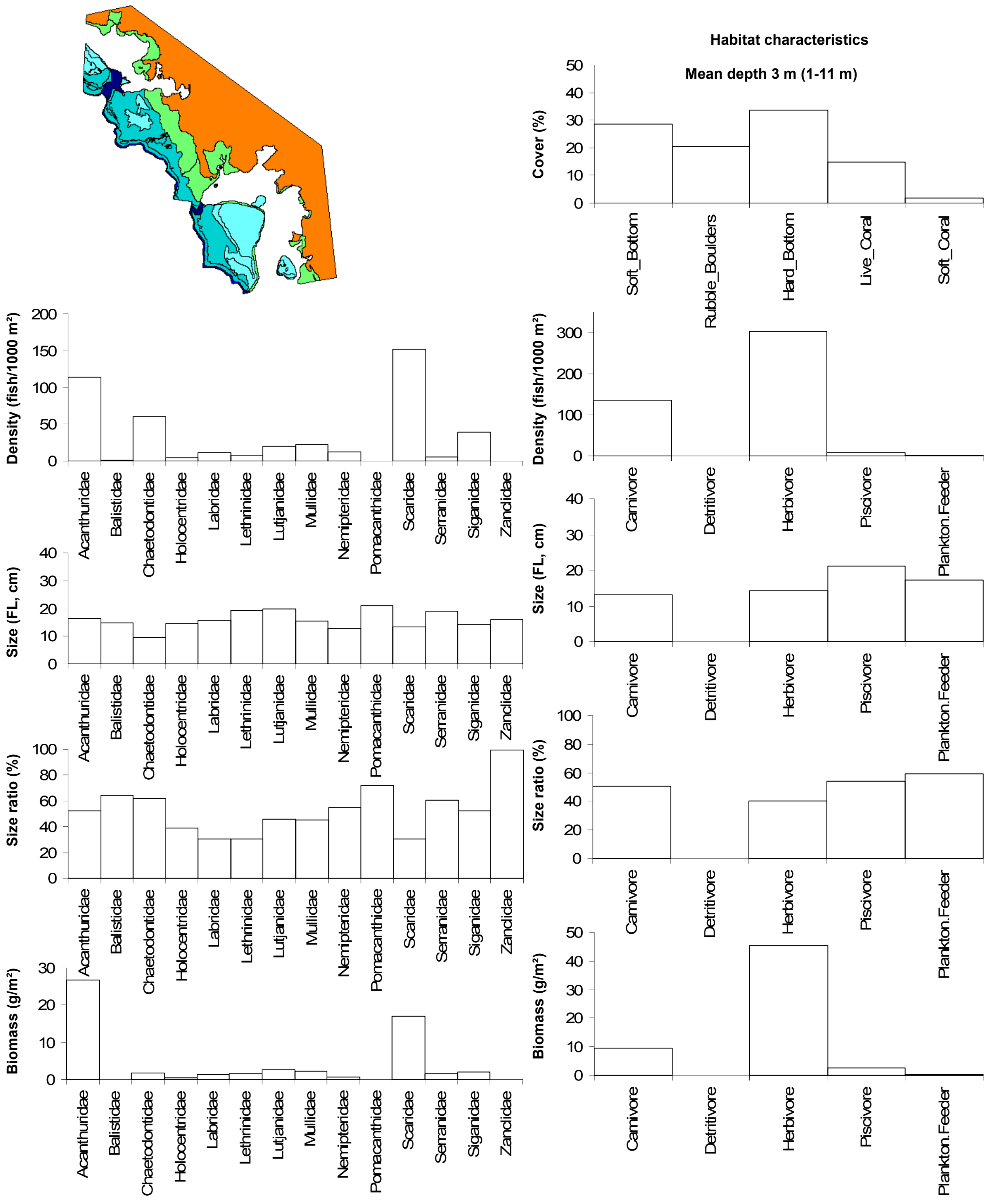

Figure 5.24: Profile of finfish resources in the combined reef habitats of Oundjo (weighted average).
FL = fork length.

5.3.2 Discussion and conclusions: finfish resources in Oundjo

The present assessment indicated that the status of finfish resources in Oundjo is much worse than the average across New Caledonia study sites and relatively overfished. Detailed assessment at reef level also revealed a systematic, lower-than-average abundance of all families except Acanthuridae and Scaridae in the outer reefs (the richest environments at this site) and the back-reefs, and Chaetodontidae, which, in the coastal, intermediate and outer reefs, have the highest abundance of all sites. Preliminary results, together with the lack of carnivores observed, suggest that this trend is probably due to intense fishing. Only coastal reefs displayed relatively high density of snappers. Further studies to elucidate the observed lack of snappers and emperors in Oundjo are needed.

- Overall, Oundjo finfish resources appeared to be in relatively poor condition. The reef habitat seemed relatively rich but the biomass and abundance of fish were low. Oundjo has the highest catches per year and the highest reliance on fishing for both subsistence and income generation of the country sites. Although the density of fishers per area of fishing ground is one of the lowest in the country, the continuous stress from fishing can cause low values in resources availability.

- Oundjo populations of snappers (Lutjanidae) and emperors (Lethrinidae) were systematically lower than the regional average, except at coastal reefs.

- Further development of reef finfish fisheries to improve food and financial security of the people of Oundjo may not be sustainable at this point.

- Oundjo has a traditional *tabu* area but the fishing pressure on resources has reached too precarious a level to show any advantage from such a traditional management measure.

- Without further information, a precautionary approach to fisheries management may consist in trying to limit catch of snappers and emperors. The efficiency of this trial should then be evaluated via resource monitoring.

5.4 Invertebrate resource surveys: Oundjo

The diversity and abundance of invertebrate species at Oundjo were independently determined using a range of survey techniques (Table 5.12): broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 5.25) and finer-scale assessment of specific reef and benthic habitats (Figures 5.26 and 5.27).

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

Table 5.12: Number of stations and replicate measures completed at Oundjo

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	13	81 transects
Reef-benthos transects (RBt)	12	72 transects
Soft-benthos transects (SBt)	6 + 11	36 + 66 transects
Soft-benthos infaunal quadrats (SBq)	16	128 quadrat groups
Mother-of-pearl transects (MOPt)	4	24 transects
Mother-of-pearl searches (MOPs)	1	6 search periods
Reef-front searches by walking (RFs_w) (1)	4	24 search periods
Sea cucumber day searches (Ds)	0	0 search period
Sea cucumber night searches (Ns)	3	18 search periods

(1) Conducted on the reef platform, but due to water presence walking was not an option – conducted on snorkel.

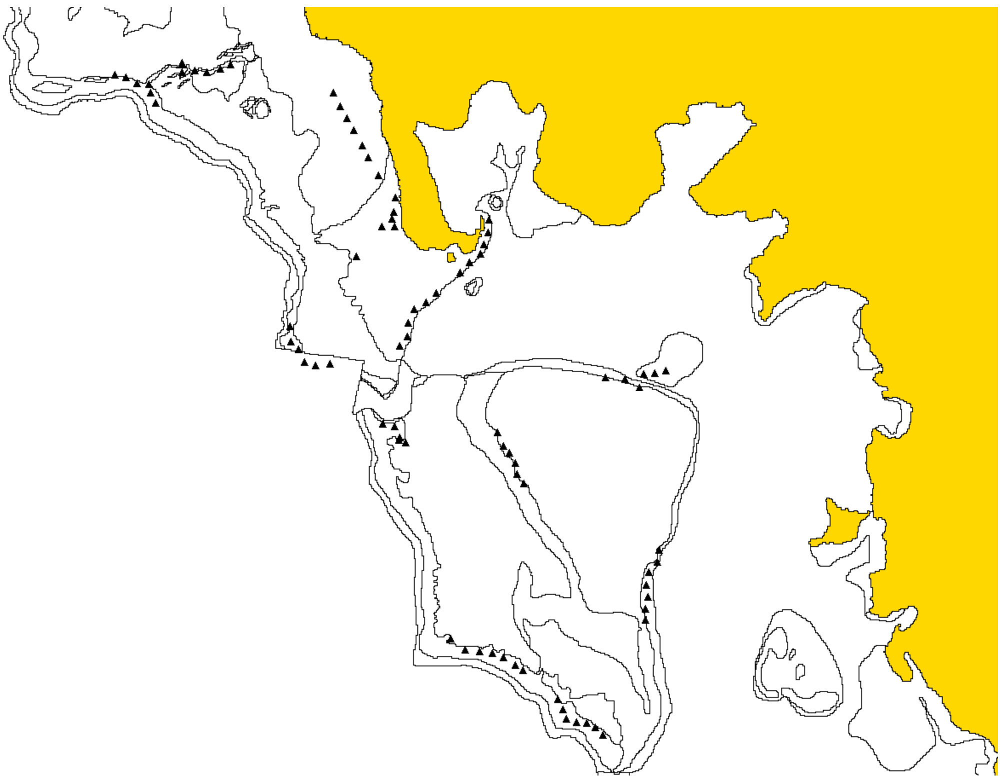

Figure 5.25: Broad-scale survey stations for invertebrates in Oundjo.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

Figure 5.26: Fine-scale reef-benthos transect survey stations and soft-benthos transect survey stations for invertebrates in Oundjo.
Black circles: reef-benthos transect stations (RBt);
black stars: soft-benthos transect stations (SBt).

Figure 5.27: Fine-scale survey stations for invertebrates in Oundjo.
Inverted black triangles: reef-front search by walking stations (RFs_w);
grey stars: soft-benthos infaunal quadrat stations (SBq);
grey squares: mother-of-pearl search stations (MOPs);
black squares: mother-of-pearl transect stations (MOPt);
grey circles: sea cucumber night search stations (Ns).

Sixty-three species or species groupings (groups of species within a genus) were recorded in the Oundjo invertebrate surveys. These included: 15 bivalves, 22 gastropods, 16 sea cucumbers, 4 urchins, 2 sea stars, 1 cnidarian and 1 lobster (Appendix 4.4.1). Information on key families and species is detailed below.

5.4.1 Giant clams: Oundjo

Shallow reef habitat that is suitable for giant clams was very extensive at Oundjo (73.5 km^2: ~64.5 km^2 within the lagoon and 9 km^2 on the reef-front or slope of the barrier). Unlike the PROCFish sites on the east coast of Grande Terre, the lagoon was very shallow and, behind the line of reefs that could be considered as a second 'barrier', sand, coral and rubble in large areas of the lagoon were periodically exposed at spring low tides. Exposure within the lagoon was high (mainly due to shallowness) and the influence of 'land' (riverine) inputs near the coast was substantial. Despite this, various patch reefs could be found in the outer sector of the lagoon that were in water deep enough to provide suitable habitat for clams. There was dynamic water flow across the barrier reef and through the passes to the north and south of Oundjo.

Broad-scale sampling provided an overview of giant clam distribution at Oundjo. Reefs held five species of giant clam: the elongate clam *Tridacna maxima*, fluted clam *T. squamosa*, boring clam *T. crocea*, smooth clam *T. derasa* and horse-hoof or bear's paw clam *Hippopus hippopus*. No live or dead *Tridacna gigas* clams were found although fossilised remains of this species have been recorded on reefs in New Caledonia (Virly 2004).

T. maxima had the widest occurrence (found in 11 broad-scale stations and 57 transects) followed by *T. squamosa* (in 6 stations and 6 transects), *T. derasa* (in 5 stations and 9 transects) and *T. crocea* (in 1 station and 1 transect). *H. hippopus* is well camouflaged and usually relatively sparsely distributed, but was recorded in five broad-scale stations (7 transects in total, Figure 5.28).

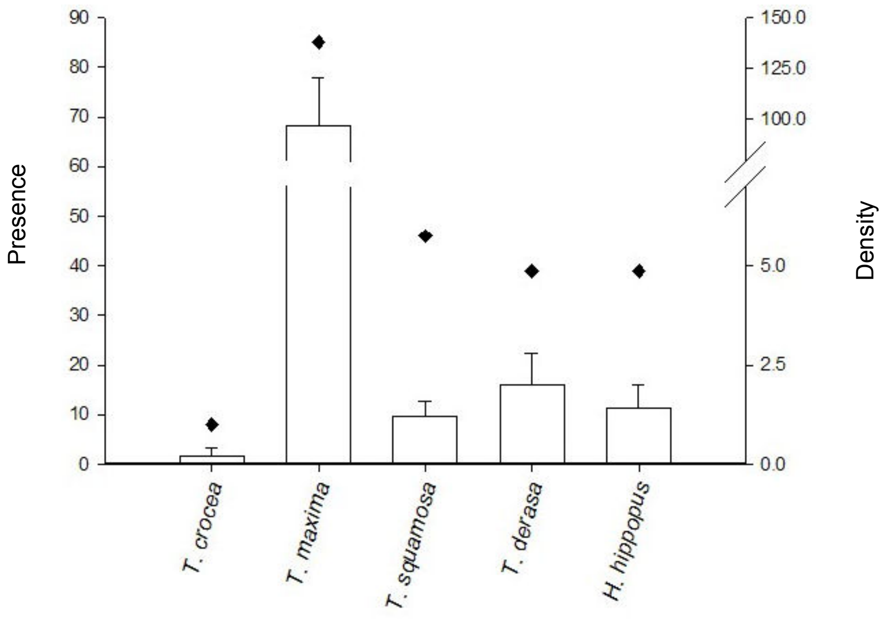

Figure 5.28: Presence and mean density of giant clam species in Oundjo based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Finer-scale surveys targeted specific areas of clam habitat (Figure 5.29). In these reef-benthos assessments (RBt), *T. maxima* was present in 100% of stations and *H. hippopus* was common, being recorded in 25% of stations. The lack of boring clams was mainly due to the exposure in the outer lagoon and the difficulty of surveying the coastal reef south of Oundjo (low visibility) where densities were higher. No *T. derasa* or *T. squamosa* were recorded on fine-scale assessments of shallow-water reefs or on SCUBA surveys conducted for mother-of-pearl species on the outer reef.

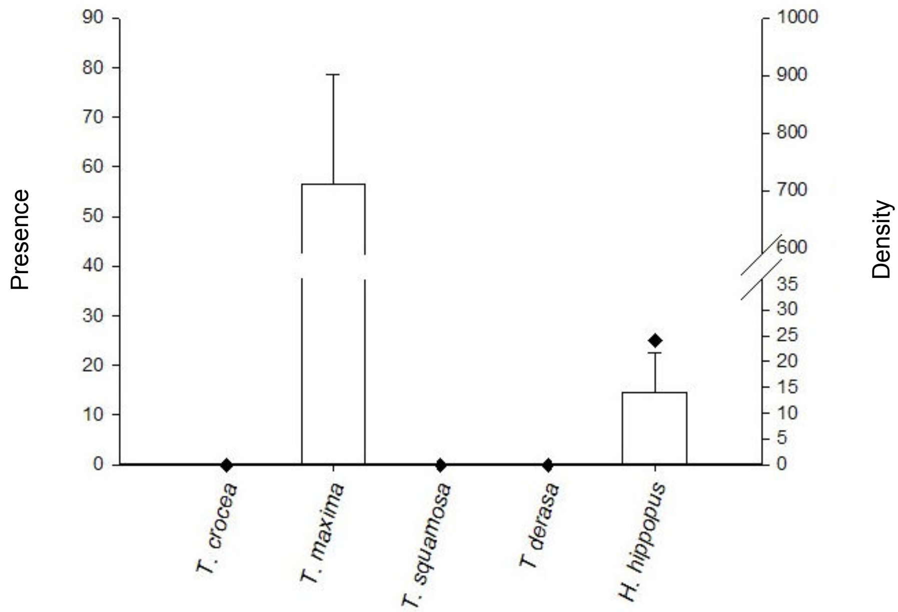

Figure 5.29: Presence and mean density of giant clam species in Oundjo based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

A full range of possible lengths of *T. maxima* was recorded in survey. Small and large individuals (mean 14.1 cm ±0.2) showed that stocks were not under critical fishing pressure, and that recruitment was still strong. *T. maxima* from reef-benthos transects alone (on shallow-water reefs) had a slightly smaller mean length (12.6 cm ±0.3, which represents a clam 5–6 years old). The faster-growing *T. squamosa* (which grows to an asymptotic length L_∞ of 40 cm) averaged 27.7 cm ±2.2 (>6 years old), *H. hippopus* averaged 22.4 cm ±2.0 (~5 years old), and *T. derasa* had a mean shell length of 26.7 cm ±3.2 (Figure 5.30).

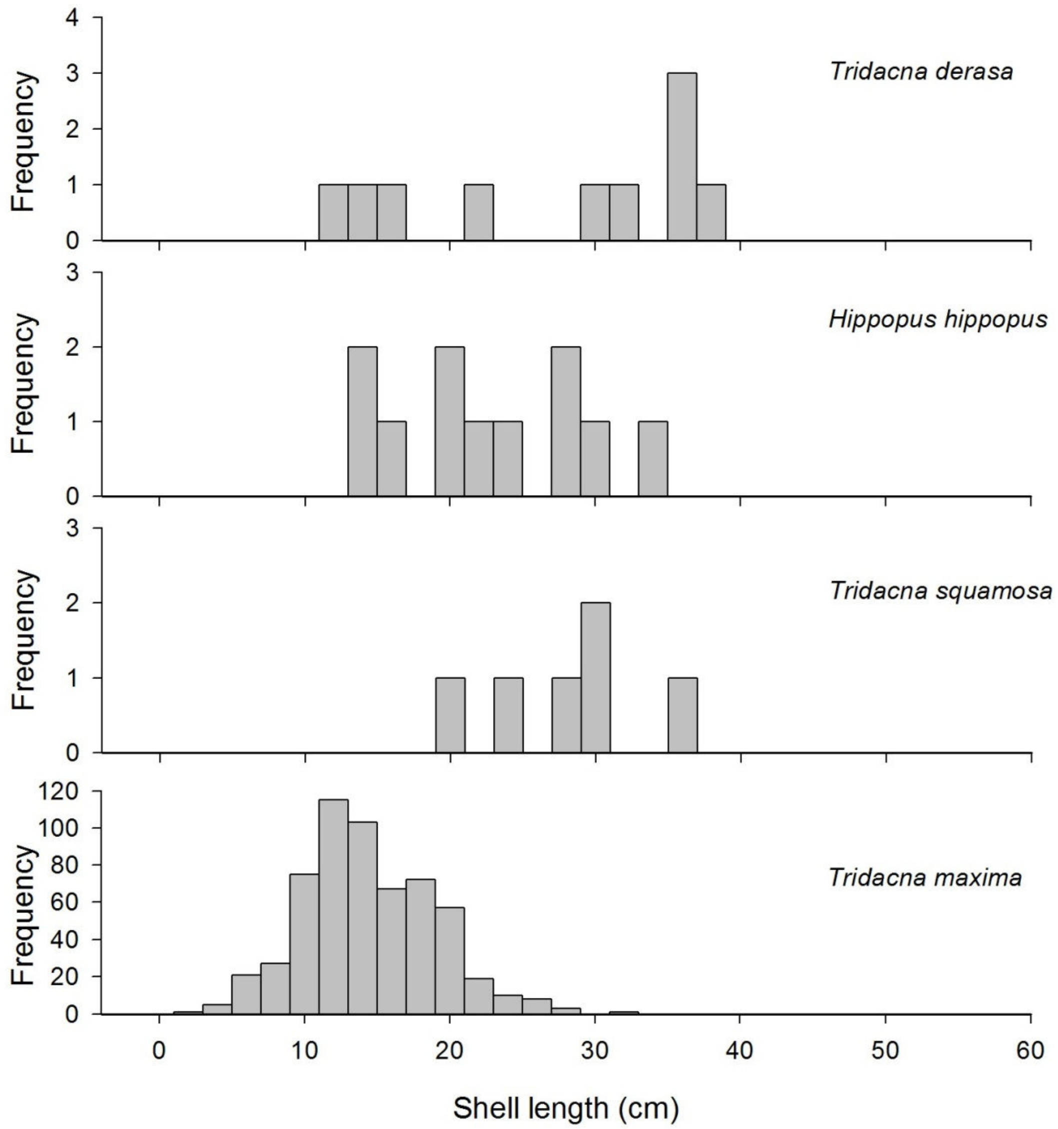

Figure 5.30: Size frequency histograms of giant clam shell length (cm) for Oundjo.

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

New Caledonia is relatively close to the southern limit of the natural distribution of the commercial topshell *Trochus niloticus* in the Pacific. The outer and lagoon reef at Oundjo constitute an extensive suitable benthos for *T. niloticus* and this area could potentially support significant populations of this commercial species (38 km lineal distance of exposed reef perimeter). PROCFish survey work revealed that *T. niloticus* was present on both the barrier reef (outer-reef slope and reef platform) and on reefs within the lagoon (Table 5.14).

Table 5.14: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Oundjo
Based on various assessment techniques; mean density measured in numbers per ha (±SE)

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S	5.0	1.3	6/13 = 46	16/81 = 20
RBt	20.8	10.9	4/12 = 33	6/72 = 8
RFs_w	35.6	17.9	3/4 = 75	12/24 = 50
MOPs	22.7	-	1/1 = 100	2/6 = 33
MOPt	213.5	54.0	4/4 = 100	17/24 = 71
Tectus pyramis				
B-S	15.6	3.9	6/13 = 46	23/81 = 28
RBt	361.1	103.6	12/12 = 100	37/72 = 51
RFs_w	164.1	44.0	4/4 = 100	20/24 = 83
MOPs	0	0	0/1 = 0	0/6 = 0
MOPt	36.5	36.5	1/4 = 25	3/24 = 13
Pinctada margaritifera				
B-S	5.8	1.8	7/13 = 54	16/81 = 20
RBt	13.9	7.8	3/12 = 25	4/72 = 6
RFs-w	0.9	0.9	1/4 = 25	1/24 = 4
MOPs	0	0	0/1 = 0	0/6 = 0
MOPt	5.2	5.2	1/4 = 25	1/24 = 4

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

Aggregations of trochus found in survey were mainly concentrated in patches of reef on the ocean side of the barrier reef and on the barrier-reef platform. The reef on the seaward side of the barrier was restricted in scale, and was probably the remains of spur reef that had become cut off from the barrier. This reef rose from a depth of 10–12 m and supported trochus on reef shoals (submerged platforms) at ~4–5 m depth. On the barrier-reef platform there was dynamic water movement, but reef conditions were not ideal for trochus as crevice sites were limited.

Although trochus was found at various locations around Oundjo (total n = 116 individuals), densities were too low for general commercial fishing (Appendix 1.3). These aggregations, however, if 'rested' from fishing, are sufficient to act as broodstock. With successful spawning from this broodstock, stocks have the potential to rapidly regenerate. Shell size-class results already indicate that successful recruitment has taken place in recent years and 'new' young trochus are entering the population (First maturity of trochus is at 7–8 cm in New Caledonia, ~3 years old.). The mean basal width of trochus at Oundjo (n = 53) was 10.7 cm ±0.3 but the main bulk of stock in Oundjo are larger, mature shells (Figure 5.31).

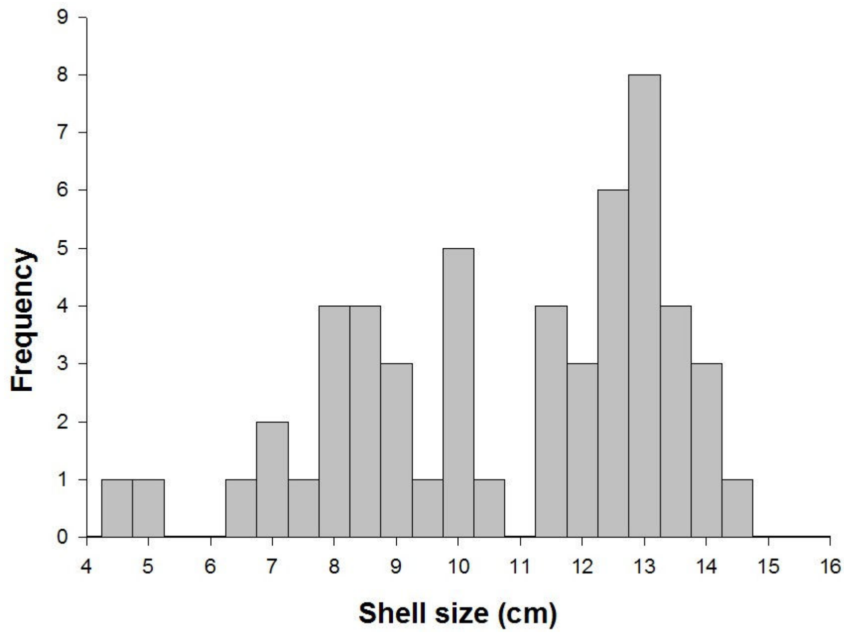

Figure 5.31: Size frequency histogram of trochus shell base diameter (cm) for Oundjo.

Reefs in Oundjo were characteristic of those found associated with high-island lagoon environments, and supported reasonably good numbers of grazing gastropods. This was further highlighted by results recorded for a gastropod with a similar life history to trochus, the related green topshell (*Tectus pyramis*). This less valuable species of topshell (also an algal grazer) was also abundant at Oundjo, with 377 recorded in survey. The mean size (basal width) of *T. pyramis* (n = 103) was 5.0 cm ±0.1. The numbers of smaller green topshell were also high in survey, which suggests that conditions for recent spawning and/or settlement of *T. pyramis* (and possibly trochus) may have been favourable in recent years.

Despite blacklip pearl oysters (*Pinctada margaritifera*) being cryptic and normally sparsely distributed in open lagoon systems (such as found at Oundjo), the number of blacklip seen during assessments was high (n = 34). The mean shell length (anterior–posterior measure) was 14.2 cm ±0.3.

5.4.3 Infaunal species and groups: Oundjo

The coastal margin of the lagoon was generally characterised by mangrove and soft benthos and was suitable for seagrass and concentrations of in-ground resources (shell 'beds'). Fishers reported a number of areas that they target for shell collection. Two such areas bordering mangrove were assessed with transects (SBt) to record the above-ground fauna (mostly for sea cucumbers). No *Strombus luhuanus* were found but *Lambis*, *Gafrarium*, *Periglypta, Pinna* and *Anadara* spp. were seen (Appendices 4.4.4 to 4.4.5).

Three sites were also sampled for in-ground bivalve species, mostly arc shells (*Anadara antiquata*) and Venus shells (*Gafrarium* spp.). Arc shells were only recorded at sites furthest from the village and the overall density for this species group was 2.3 /m^2 ±0.7. As mentioned, shells were not common across all the areas sampled (Arc shells were recorded in only 29% of quadrat groupings; see Methods.) but, at the two shell-bed areas sampled south of the village, the mean density for *Anadara* was 3.8 /m^2 ±0.8. The average length of arc shells was 5.4 cm ±0.14 (Figure 5.32).

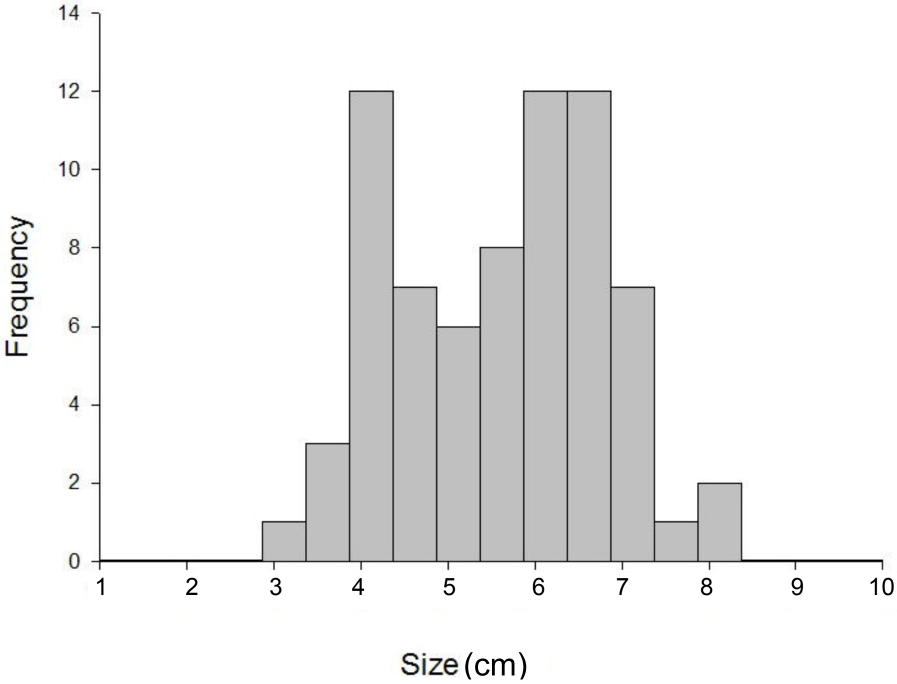

Figure 5.32: Size frequency histogram of arc shell size (cm) for Oundjo.

In addition to arc shells, Venus shells (*Gafrarium* spp.), *Tellina palatum* and *Cerithium aluco* were also found (Appendix 4.4.5).

5.4.4 Other gastropods and bivalves: Oundjo

Seba's spider conch (*Lambis truncata*, the larger of the two common spider conchs) was not detected and *L. lambis* was recorded at low density in broad-scale and finer-scale surveys (11 individuals recorded). The strawberry or red-lipped conch *Strombus luhuanus* was also present but again at low density except for a single transect within a reef-benthos station (Appendices 4.4.1 to 4.4.9). Two species of *Turbo* were recorded at relatively high density (*T. argyrostomus,* and *T. chrysostomus*). The larger, silver-mouthed turban (*T. argyrostomus*) was recorded in 75% of reef-benthos stations at a mean density of 371.5 /ha ±248.9. Higher densities were recorded in reef-front search stations (mean 689.2 /ha ±288.1), where reef was more exposed and water movement more dynamic. No *Turbo setosus* was seen in reef-benthos or MOP surveys. Other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Conus*, *Cymatium*, *Cypraea*, *Haliotis*, *Ovula*, *Pleuroploca*, *Tectus* and *Vasum*) were also recorded during independent surveys (Appendices 4.4.1 to 4.4.9).

Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Chama*, *Periglypta*, *Pinna*, *Spondylus*, and *Tellina* spp., are also in Appendices 4.4.1 to 4.4.9. No creel survey was conducted at Oundjo.

5.4.5 Lobsters: Oundjo

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, one lobster (*Panulirus* sp.) was recorded in the survey. Night-time assessments for nocturnal sea cucumber species (Ns) were conducted, offering a further opportunity to record lagoon species of lobster; however, none were seen.

5.4.6 Sea cucumbers[8]: Oundjo

Oundjo has an extensive and complex lagoon system bordering a large land mass. There was a high degree of exposure at the barrier reef and water movement was dynamic across to the lagoon at partially submerged areas of the barrier. Deep passages to the north and south allowed water movement across the generally shallow lagoon. Land influences (riverine and other inputs from land) were notable within the inner lagoon, and the shallow lagoon was easily stirred up by wind and tide. Habitat that suits sea cucumbers, such as reef margins and shallow, mixed hard- and soft-benthos habitat, was extensive in the lagoon.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 5.15, Appendices 4.4.1 to 4.4.9, also see Methods). The presence of sixteen commercial species (Table 5.15), reflected the varied environment of the west coast lagoon at Oundjo suitable for cucumber species, which are generally deposit feeders.

Sea cucumber species associated with shallow reef areas, such as leopardfish (*Bohadschia argus*) and the high-value black teatfish (*Holothuria nobilis*), were found commonly (in 25–50% of fine- and broad-scale assessments), indicating a stock that is not under heavy fishing pressure. The fast-growing and medium/high-value greenfish (*Stichopus chloronotus*) was not as common as found in the east coast PROCFish sites, but was still numerous both spatially (in 22% of broad-scale transects, 50% of reef-benthos assessments) and in aggregations (when present at RBt stations had a mean density of over 700 /ha, see Appendix 4.4.3). Surf redfish (*Actinopyga mauritiana*) was, in general, recorded at low density, despite the suitable environment.

More protected areas of reef and soft benthos in the more enclosed areas of the lagoon had relatively good coverage of blackfish (*A. miliaris*) and stonefish (*A. lecanora*) at medium density. Night surveys targeting blackfish yielded reasonable density records from all stations (78% of replicates).

Lower-value species were also recorded at Oundjo, e.g. elephant trunkfish (*H. fuscopunctata*), lollyfish (*H. atra*) and pinkfish (*H. edulis*). Flowerfish (*Bohadschia graeffei*), which was particularly common on the east coast of Grande Terre, was not recorded in Oundjo.

On soft benthos near the mangroves south of Oundjo, premium-value sandfish (*H. scabra*) were recorded at high density (average station density 2292 /ha), alongside false sandfish (*Bohadschia similis*). At an embayment north of Oundjo (near Gatope), sandfish were less common (average station density 155 /ha), although the size of the individuals within both areas differed greatly. The sandfish in the south were mainly juvenile (too small for commercial harvest), averaging 13.5 cm in length ±0.1 and few large adults were recorded in these stations. At the bay north of Oundjo (near Gatope), the average length was significantly greater (average 20.8 cm ±0.8, see Figure 5.33).

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

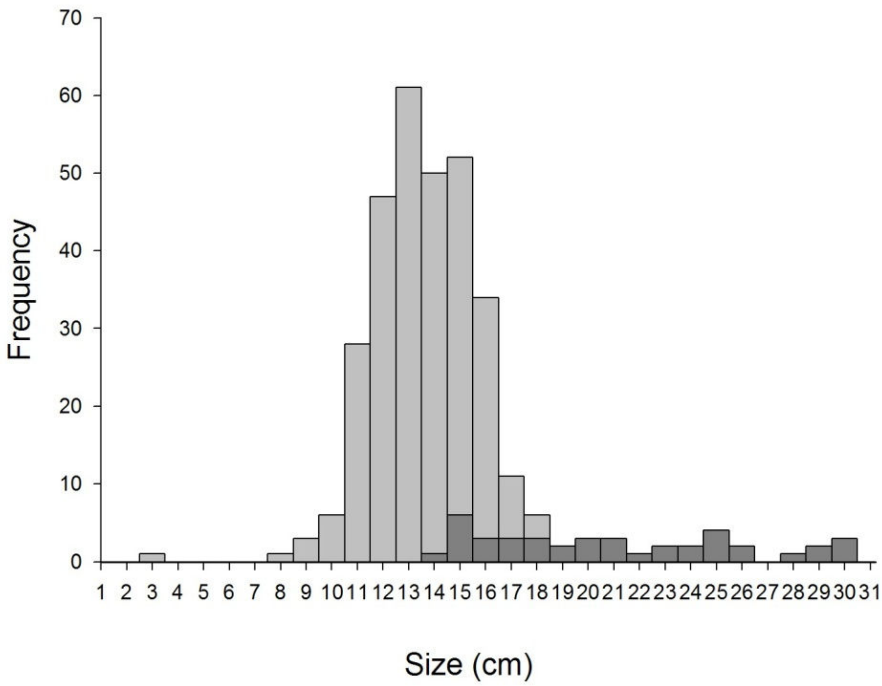

Figure 5.33: Histogram of sandfish length measured in-situ (cm) at sites south (light grey bars) and north (dark grey bars) of Oundjo.

As no deep-water assessments were completed, no preliminary results were obtained for white teatfish (*Holothuria fuscogilva*) at Oundjo. An exploration of pass areas would be useful to assess these important deep-water stocks (also presence of prickly redfish, *Thelenota ananas,* and amberfish, *T. anax*).

5.4.7 Other echinoderms: Oundjo

Edible urchins, such as the collector urchin (*Tripneustes gratilla*) were rare, but the slate urchin (*Heterocentrotus mammillatus*) was found at high densities along the wave face of the barrier reef (MOPs station) and in other fine-scale surveys. Other urchins that can be used within assessments as potential indicators of habitat condition (*Echinometra mathaei* and *Echinothrix* spp.) were also recorded at relatively high levels (barrier reeftop and reef-benthos stations).

Starfish (e.g. *Linckia laevigata*, the blue starfish) were common (found in 77% of broad-scale stations) but not at high density. Corallivorous (coral-eating) starfish were rare, with a single recording of a pincushion star (*Culcita novaeguineae*) and no crown of thorns (*Acanthaster planci*) recorded. The horned or chocolate-chip star (*Protoreaster nodosus*) was recorded at reasonably high density at two inner broad-scale stations (See presence and density estimates in Appendices 4.4.1 to 4.4.9.).

5.4.8 Discussion and conclusions: invertebrate resources in Oundjo

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.

- Oundjo has a relatively complete range of giant clam species, some of which are now becoming rare in other parts of the Pacific.

- The shallow-water lagoon was very suitable for the elongate clam *Tridacna maxima* and inshore sites were suitable for *Hippopus hippopus*, which was relatively common at Oundjo compared to other PROCFish sites in New Caledonia. There were fewer refuges for the larger species, such as *T. derasa* and *T. squamosa.*

- Giant clam density in Oundjo was reasonably high for *T. maxima*, and most species groups displayed a 'complete' range of size classes, which supports the assumption that clam stocks are only marginally impacted by fishing pressure.

- This promising indication of stock condition is reported despite there being relatively low abundances of the largest species (*T. derasa* and *T. squamosa*). These two species are usually the first to decline when fishing pressure impacts stocks, and these giant clam species are already depleted at Oundjo. The Northern Province generally markets 2–4 t/year of clams, <100 kg originating from the Kone–Oundjo area (Virly 2004).

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

- Trochus (*Trochus niloticus*) at Oundjo are relatively common, as are other grazing gastropods (e.g. *Tectus pyramis*). Densities of the aggregations assessed are presently below the level at which commercial fishing is recommended.

- Small trochus were noted (shells <8 cm). Smaller trochus are generally very cryptic and counts are generally an underestimate of their density. This result is promising for future growth of the stock.

- The blacklip pearl oyster, *Pinctada margaritifera* was relatively common at Oundjo, but not sufficient to encourage commercial fishing of shell.

- Shell beds at Oundjo were richer further away from the village, where *Anadara* spp. were relatively common. A full complement of shell sizes was recorded, which implies that the shell beds distant from the village are not significantly impacted by fishing pressure.

- In addition to fishing pressure, the collection area close to the village may have undergone changes resulting from the construction of a small boat harbour and the presence of regular boat traffic.

- Based on the wide range of sea cucumber species and the presence and density data collected in survey, it is concluded that there is only moderate pressure on stocks from commercialisation, and that fishing pressure is being successfully managed.

- The premium-value sandfish (*Holothuria scabra*) was found at reasonable density at two locations. In the southerly location, juveniles were at high density in an area protected from size overfishing, whereas larger individuals recorded in the north were being protected as broodstock for future generations.

Table 5.15: Sea cucumber species records for Oundjo

Species	Common name	Commercial value (5)	B-S transects n = 81			Reef-benthos stations n = 12			Other stations SBt = 17; RFs_w = 4; MOPs = 1; MOPt = 4			Other stations Ns = 3		
			D (1)	DwP (2)	PP (3)	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H												
Actinopyga lecanora	Stonefish	M/H				3.5	41.7	8	5.2	20.8	25 MOPt			
Actinopyga mauritiana	Surf redfish	M/H				6.9	41.7	17	0.9 15.2	3.5 15.2	25 RFs_w 100 MOPs			
Actinopyga miliaris	Blackfish	M/H	4.8	38.6	12							83.0	83.0	100 Ns
Actinopyga palauensis	No name as yet	M	5.4	29.1	19	6.9	41.7	17						
Actinopyga spinea		M/H												
Bohadschia argus	Leopardfish	M	17.7	49.5	36	121.5	243.1	50						
Bohadschia graeffei	Flowerfish	L												
Bohadschia similis	False sandfish	L	46.1	1,244.4	4				676.5	1,916.7	35 SBt	14.8	22.2	66 Ns
Bohadschia vitiensis	Brown sandfish	L												
Holothuria atra	Lollyfish	L	78.6	172.0	46	451.4	677.1	67	438.7 139.8	1243.1 139.8	35 SBt 100 RFs_w			
Holothuria coluber	Snakefish	L	1.6	25.6	6							5.9	8.9	66 Ns
Holothuria edulis	Pinkfish	L	3.1	27.5	11	10.4	41.7	25						
Holothuria flavomaculata	-	L												
Holothuria fuscogilva (4)	White teatfish	H												
Holothuria fuscopunctata	Elephant trunkfish	M	2.0	54.2	4									
Holothuria nobilis (4)	Black teatfish	H	4.8	19.4	25	20.8	62.5	33						
Holothuria scabra	Sandfish	H	17.3	700.0	2				892.2	1,166.7	76 SBt			
Holothuria scabra versicolor	Golden sandfish	H												
Stichopus chloronotus	Greenfish	H/M	27.6	124.4	22	385.4	770.8	50	43.4	57.9	75 RFs_w			
Stichopus hermanni	Curryfish	H/M	0.8	21.4	4									
Stichopus horrens	Dragonfish	M/L	0.4	33.3	1							53.3	53.3	100 Ns
Thelenota ananas	Prickly redfish	H	0.2	16.7	1				5.2	20.8	25 MOPt			
Thelenota anax	Amberfish	M												

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

5.5 Overall recommendations for Oundjo

- Further studies to elucidate the cause of the relative scarcity of snappers (Lutjanidae) and emperors (Lethrinidae) be initiated. Until the cause has been found, a precautionary approach to fisheries management be taken by limiting the catches of snappers and emperors, which were systematically lower in abundance than the regional average, except at coastal reefs. The efficiency of this trial then needs to be evaluated by closely monitoring these resources.

- There be no further development of reef finfish fisheries to improve food and financial security of the people of Oundjo as this is considered not to be sustainable at this point.

- Marine resource management and monitoring activities need to be developed and implemented to protect the remaining finfish resources.

- Before commercial fishing is re-considered, stocks of trochus (*Trochus niloticus*) at Oundjo be ‘rested’ until densities increase to approximately 500 /ha in the main aggregations.

- Consideration be given to protecting the larger size classes of trochus (≥12 cm), which are valuable spawners and not preferred by industry buyers.

- Further assessment be undertaken to determine the availability of the white teatfish (*Holothuria fuscogilva)* and other deep-water sea cucumber stocks. Effort should preferably be concentrated along the northerly and two southerly passages.

6. PROFILE AND RESULTS FOR MOINDOU

6.1 Site characteristics

Moindou village is located on the west coast of Grande Terre, at the position 21°41′31″S and 165°40′38″E (Figure 6.1). The village is located inland, near the mangroves. The fishing area is limited by Ouarai pass in the south and by the point 21°41′S and 165°30′E in the north, with a surface area of 25 km x 7 km. This is an 'open-access' area and subject to strong fishing pressure for commercial, recreational and sustenance purposes. The Moindou sector is characterised by very large areas of shallow sandy bottom and by large seagrass meadows. The coastal habitats were very difficult to explore with diving gear due to the elevated turbidity of the water. Mangroves occupy large areas and their exploitation causes problems regarding the management of mangrove crab stocks. There are no reserves protected from fishing, nor any *tabu* areas.

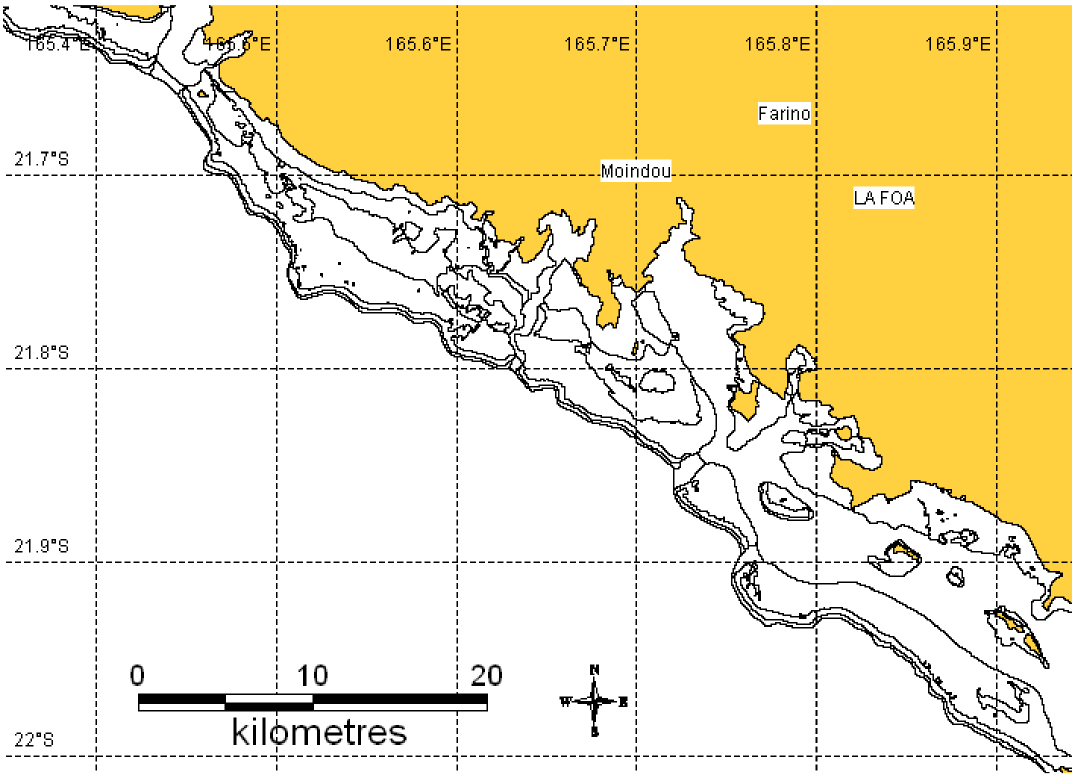

Figure 6.1: Map of Moindou.

6.2 Socioeconomic surveys: Moindou

Socioeconomic fieldwork was carried out in the Moindou community during April 2005. The survey covered 40 households, including 118 people. Thus, the survey represents about 27% of the community's households (147) and total population (434).

Household interviews aimed at the collection of general demographic, socioeconomic and consumption parameters. A total of 37 individual interviews of finfish fishers (32 males, 5 females) and 36 invertebrate fishers (24 males, 12 females) were conducted. These fishers belonged to one of the 40 households surveyed. Sometimes, the same person was interviewed for both finfish and invertebrate fishing.

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

Our survey results (Table 6.1) suggest an average of 1.3 fishers/household. If we apply this average to the total number of households, we arrive at a total of 191 fishers in Moindou. Applying our household survey data concerning the type of fisher (finfish fisher, invertebrate fisher) by gender, we can project a total of 26 exclusive finfish fishers (males), a total of 26 exclusive invertebrate fishers (males, females) and 139 (males, females) fishers who fish both for finfish and invertebrates.

About 47.5% of all households in Moindou own a boat; most (87.5%) are motorised, 12.5% are canoes.

Ranked income sources (Figure 6.2) suggest that fisheries do not play an important role as first or second source of income. In total, only 30% of all households reported to rely on fisheries for income generation, 12.5% as first and 17.5% as second income. In comparison, salaries and 'other' (small business) provide most income for Moindou households, i.e. 40% and 45% respectively as first sources of income. Agriculture plays an even smaller role in income generation, providing 5% of households with first income and 2.5% with second.

However, fisheries are important to the people of Moindou; 90% of all households have fishers, and all households eat fresh fish and invertebrates, which are usually caught by a member of their household. Some fish and invertebrates are either received as a gift from a member of the extended family or the community (25% for finfish and 22.5% for invertebrates) or, sometimes bought (12.5% for both finfish and invertebrates).

Households that depend on fisheries for first or second income target mostly the local market and, for invertebrates (mud crabs), markets or clients outside the Moindou community.

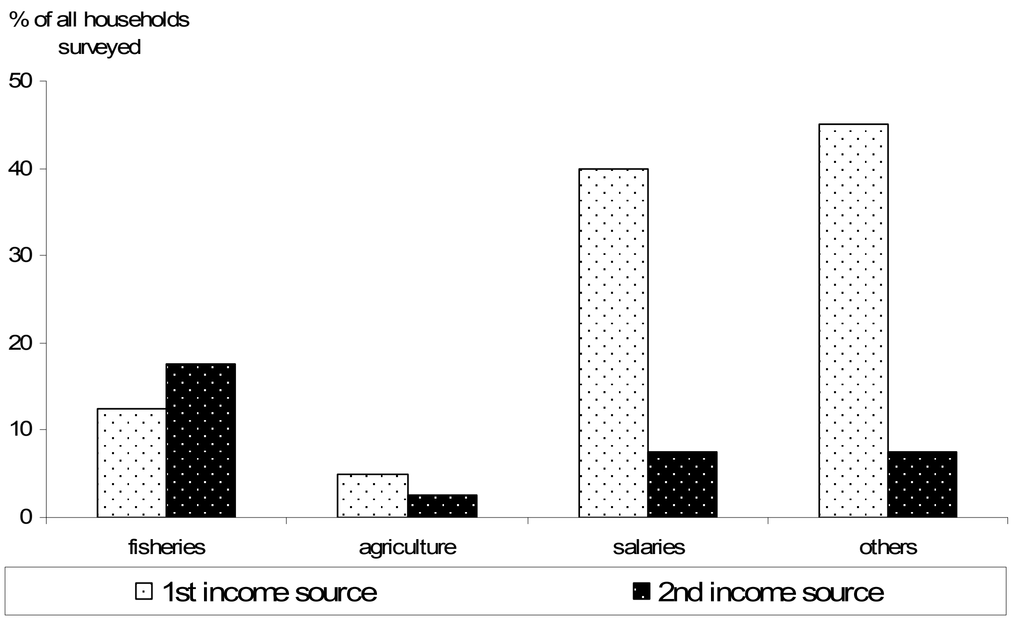

Figure 6.2: Ranked sources of income (%) in Moindou.
Total number of households = 40 = 100%. Some households have more than one income source and those may be of equal importance; thus double quotations for 1st and 2nd incomes are possible. 'Others' are mostly home-based small businesses.

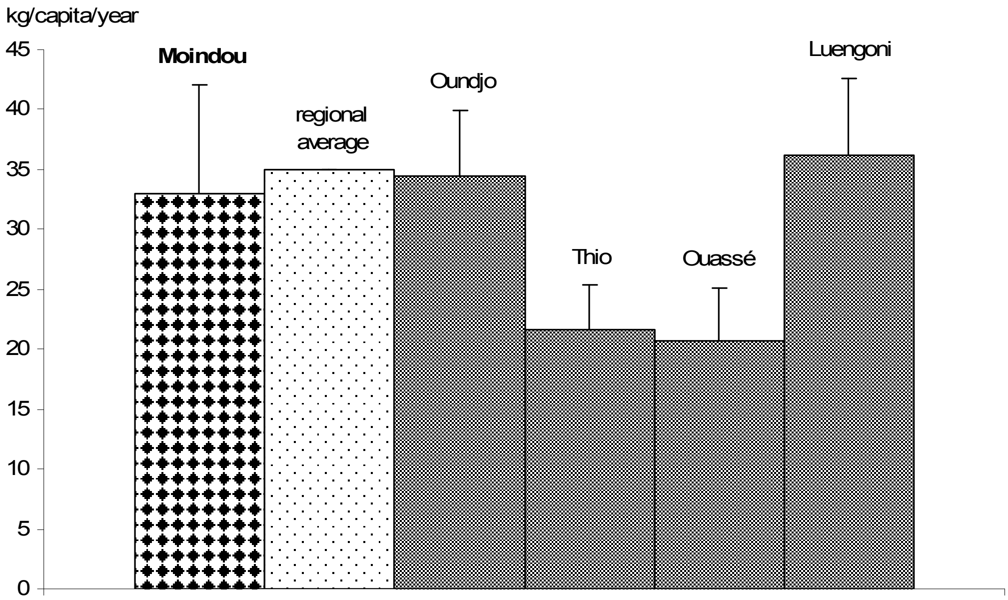

Figure 6.3: Per capita consumption (kg/year) of fresh fish in Moindou (n = 40) compared to the regional average (FAO 2008) and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of fish. Bars represent standard error (+SE).

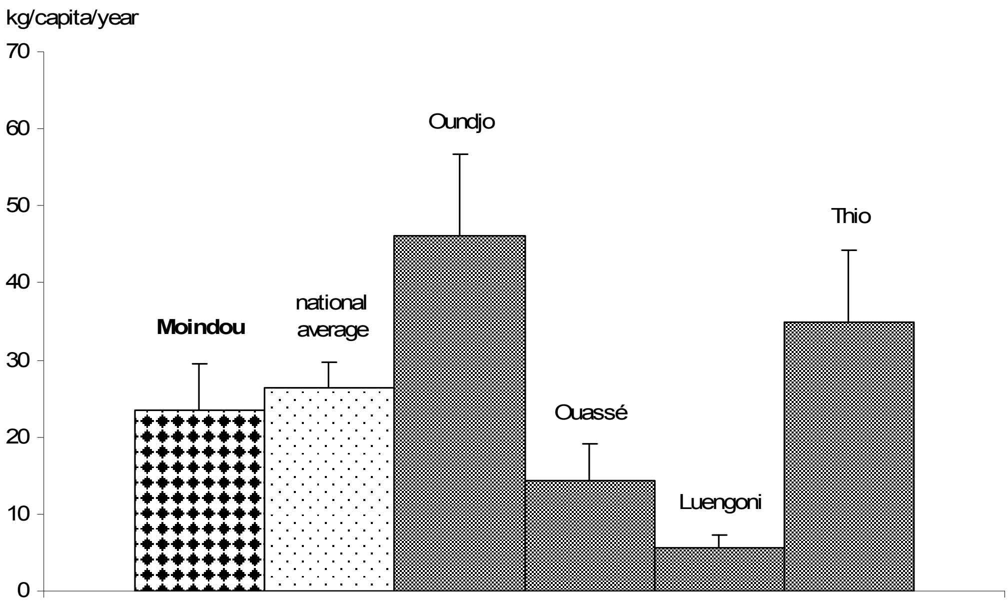

Figure 6.4: Per capita consumption (kg/year) of invertebrates (meat only) in Moindou (n = 40) compared to the national average and the other four PROCFish/C sites in New Caledonia.
Figures are averages from all households interviewed, and take into account age, gender and non-edible parts of invertebrates. Bars represent standard error (+SE).

Fresh-fish consumption in Moindou (~33 kg/person/year ±9.1) is about the same as the regional average (FAO 2008) (Figure 6.3). Across all New Caledonian sites investigated, the consumption in Moindou is relatively high and similar to that in Luengoni and Oundjo. By comparison, the people in Moindou eat less invertebrates (23.5 kg/person/year, Figure 6.4). This consumption rate is about the average for all PROCFish sites investigated in New Caledonia.

Comparison of results across all sites investigated in New Caledonia (Table 6.1) suggest that the people of Moindou are less dependent on fisheries for income generation and, although their seafood consumption is relatively high, they eat seafood (finfish and invertebrates) less often than observed on average.

In contrast, the average annual household expenditure level in Moindou is well above the country average as estimated by the PROCFish surveys. No influx of external money (remittances) was reported.

Table 6.1: Fishery demography, income and seafood consumption patterns in Moindou

Survey coverage	Moindou (n = 40 HH)	Average across sites (n = 148 HH)
Demography		
HH involved in reef fisheries (%)	90.0	94.6
Number of fishers per HH	1.3 (±0.13)	1.6 (±0.08)
Male finfish fishers per HH (%)	13.5	29.6
Female finfish fishers per HH (%)	0.0	3.3
Male invertebrate fishers per HH (%)	1.9	2.5
Female invertebrate fishers per HH (%)	11.5	16.3
Male finfish and invertebrate fishers per HH (%)	55.8	32.5
Female finfish and invertebrate fishers per HH (%)	17.3	15.8
Income		
HH with fisheries as 1st income (%)	12.5	27.0
HH with fisheries as 2nd income (%)	17.5	23.6
HH with agriculture as 1st income (%)	5.0	2.0
HH with agriculture as 2nd income (%)	2.5	6.1
HH with salary as 1st income (%)	40.0	37.2
HH with salary as 2nd income (%)	7.5	6.1
HH with other source as 1st income (%)	45.0	37.8
HH with other source as 2nd income (%)	7.5	16.9
Expenditure (USD/year/HH)	9114.98 (±685.79)	6587.71 (±456.24)
Remittance (USD/year/HH) (1)		1802.97 (±766.61)
Consumption		
Quantity fresh fish consumed (kg/capita/year)	32.95 (±9.08)	29.81 (±3.16)
Frequency fresh fish consumed (times/week)	1.35 (±0.19)	2.35 (±0.13)
Quantity fresh invertebrate consumed (kg/capita/year)	23.47 (±6.07)	26.46 (±3.16)
Frequency fresh invertebrate consumed (times/week)	0.60 (±0.13)	0.88 (±0.07)
Quantity canned fish consumed (kg/capita/year)	1.17 (±0.42)	6.69 (±1.32)
Frequency canned fish consumed (times/week)	0.38 (±0.13)	1.35 (±0.14)
HH eat fresh fish (%)	100.0	100.0
HH eat invertebrates (%)	97.5	88.5
HH eat canned fish (%)	57.5	82.4
HH eat fresh fish they catch (%)	87.5	83.3
HH eat fresh fish they buy (%)	12.5	10.0
HH eat fresh fish they are given (%)	25.0	70.0
HH eat fresh invertebrates they catch (%)	82.5	46.7
HH eat fresh invertebrates they buy (%)	12.5	3.3
HH eat fresh invertebrates they are given (%)	22.5	36.7

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

6.2.2 Fishing strategies and gear: Moindou

Degree of specialisation in fishing

Fishing in Moindou is performed by both gender groups (Figure 6.5). However, only 13.5% of all fishers exclusively target finfish and these fishers are all males. Female fishers who target finfish do so in combination with invertebrate collection (~17% of all fishers). Some female fishers (11.5%) specialise in invertebrate harvesting, as compared to ~2% male invertebrate collectors; ~56% of male fishers fish for both finfish and invertebrates.

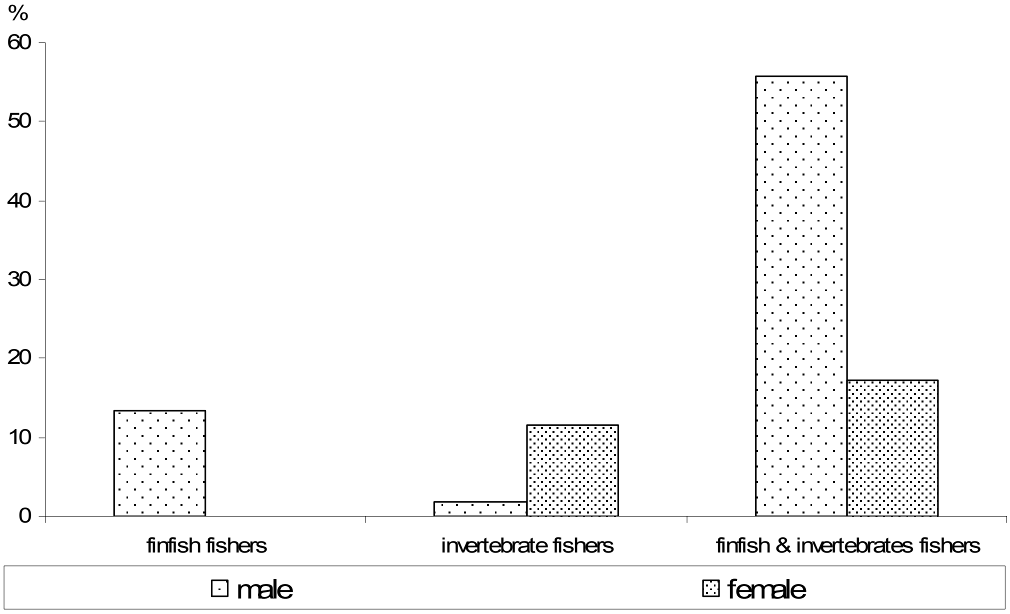

Figure 6.5: Proportion (%) of fishers who target finfish or invertebrates exclusively, and those who target both finfish and invertebrates in Moindou.
All fishers = 100%.

Targeted stocks/habitat

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

Our survey sample suggests that fishers in Moindou can choose between sheltered coastal reef and outer-reef habitats. Most male fishers and all female fishers, however, target the sheltered coastal reef. Only ~6% of male fishers target the outer reef (Table 6.2).

Table 6.2: Proportion (%) of male and female fishers harvesting finfish and invertebrate stocks across a range of habitats (reported catch) in Moindou

Resource	Fishery / Habitat	% of male fishers interviewed	% of female fishers interviewed
Finfish	Sheltered coastal reef	93.8	100.0
	Outer reef	6.3	0.0
Invertebrates	Mangrove	87.5	83.3
	Reeftop	4.2	8.3
	Soft bottom (sand)	41.7	50.0

Finfish fisher interviews, males: n = 27; females: n = 5. Invertebrate fisher interviews, males: n = 24; females, n = 12.

Fishing patterns and strategies

All invertebrate fishers glean; none of the respondents claimed to dive for selected species (Figure 6.6). Invertebrate fishers mainly target the mangroves (83% of female fishers and 88% of male fishers) and soft bottom, i.e. intertidal sandy areas. Rarely do fishers exploit reeftops (~4% of male fishers, ~8% of female fishers) (Figure 6.7).

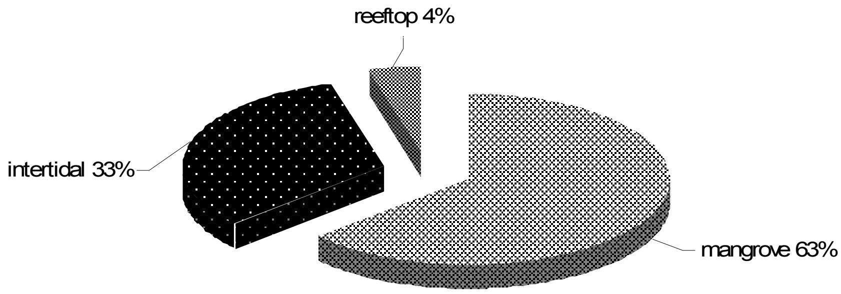

Figure 6.6: Proportion (%) of fishers targeting the three primary invertebrate habitats found in Moindou.
Data based on individual fisher surveys; data for combined fisheries are disaggregated.

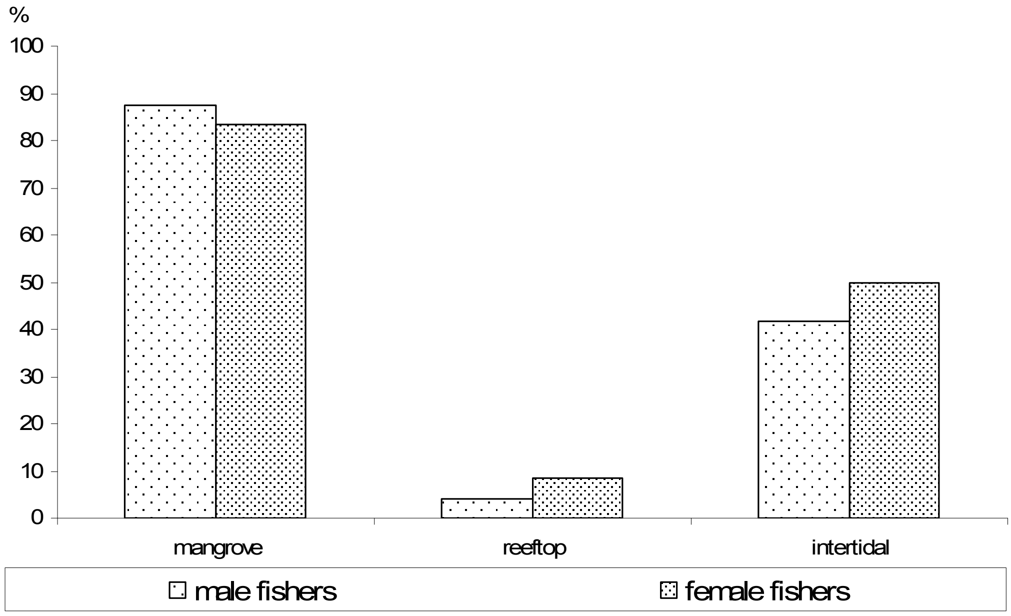

Figure 6.7: Proportion (%) of male and female fishers targeting various invertebrate habitats in Moindou.
Data based on individual fisher surveys; data for combined fisheries are disaggregated; fishers commonly target more than one habitat; figures refer to the proportion of all fishers that target each habitat: n = 24 for males, n = 12 for females.

Gear

Figure 6.8 shows that gillnets, castnets, handlines and spears (including spear diving and handheld spearing either while walking or from a canoe) are used in combination for sheltered coastal reef fishing. Handlines seem to be the main technique that is exclusively used during one fishing trip (25% of all fishers interviewed). The few fishers who target the outer reef either spear dive or use handheld spears.

Gleaning for invertebrates is done using only very simple tools. Mud crabs are caught by hand, using sticks and iron bars to probe holes, or by baited cages. Other invertebrates, such as bivalves and gastropods collected from sandy intertidal areas or from the reeftop, are picked up by hand. Gleaning of mangroves and soft-bottom (sandy) areas is mostly done by walking, and rarely involves motorised boat transport to reach the fishing ground. However, reeftops are reached by boat, mostly motorised boat.

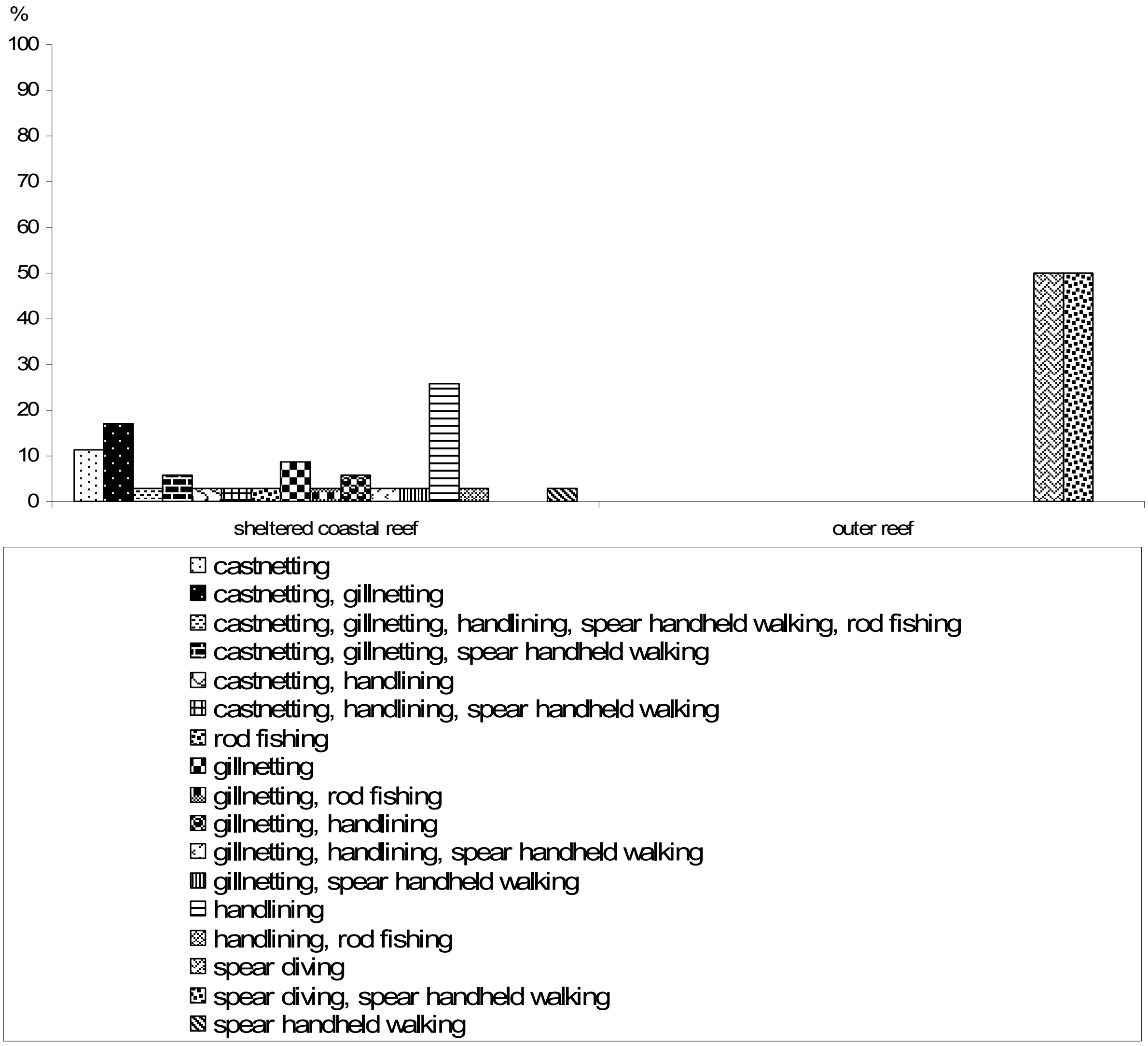

Figure 6.8: Fishing methods commonly used in different habitat types in Moindou.
Proportions are expressed in % of total number of trips to each habitat. One fisher may use more than one technique per habitat and target more than one habitat in one trip.

Frequency and duration of fishing trips

As shown in Table 6.3, fishing trips made by male fishers to the sheltered coastal reef are shorter (3.9 hours/trip) than to the outer reef (5 hours/trip). Female fishers, who only target the sheltered coastal reef, fish longer (~ 5 hours/trip). Not only do fewer male fishers target the outer reef but also, those who do, fish less often than those targeting the sheltered coastal reef. On average, a male fisher visits the sheltered coastal reef almost once a week, but the outer reef only once a month. There is no major difference between male and female fishers in the frequency of fishing trips to the sheltered coastal reef.

Overall, invertebrate collection trips are made more often than finfish fishing trips. The highest frequency (~1.3–1.8 times/week) was found for mangrove gleaning performed by both gender groups, and the lowest frequency for reeftop gleaning. The average trip duration for invertebrate collection is 3–4 hours, except for reeftop gleaning by female fishers, which may take >5 hours.

Finfish is usually caught at day in the sheltered coastal reef areas; however, at times also according to the tides; hence fishers may go out day or night. At the outer reef, half of the fishing is done only during the day, and half depending on the tide, i.e. day or night. Most fishers fish throughout the year (89% fish all year round at the sheltered coastal reef and 100% at the outer reef).

Invertebrates are usually caught during the day. Only ~3% of mangrove fishers collect at night. Fishers collect invertebrates throughout the year, except for mangrove gleaners, who break for two months a year.

Table 6.3: Average frequency and duration of fishing trips reported by male and female fishers in Moindou

Resource	Fishery / Habitat	Trip frequency (trips/week)		Trip duration (hours/trip)	
		Male fishers	Female fishers	Male fishers	Female fishers
Finfish	Sheltered coastal reef	0.80 (±0.13)	0.70 (±0.45)	3.90 (±0.35)	4.90 (±1.08)
	Outer reef	0.23 (±0.00)	0	5.00 (±1.00)	0
Invertebrates	Mangrove	1.28 (±0.39)	1.83 (±0.50)	3.95 (±0.39)	4.20 (±0.55)
	Reeftop	0.04 (n/a)	0.46 (n/a)	3.00 (n/a)	6.00 (n/a)
	Intertidal	0.16 (±0.04)	0.32 (±0.15)	2.70 (±0.40)	3.00 (±0.52)

Figures in brackets denote standard error; n/a = standard error not calculated.
Finfish fisher interviews, males: n = 27; females: n = 5. Invertebrate fisher interviews, males: n = 24; females: n = 12.

6.2.3 Catch composition and volume – finfish: Moindou

Catches from the sheltered coastal reef are dominated (62% of total reported catch) by two major groups: *mulet* (*Crenimugil crenilabis*, accounting for 52% of the total reported catch), and *picot* (*Siganus* spp. determining 10% of the total reported catch). *Bec-de-cane* (*Lethrinus* spp.) and *rouget* (*Parupeneus* spp.) add another 9 and 7% of the total reported catch respectively. Others, including *bossu doré* (*Lethrinus atkinsoni*), *bec rose* (n/a), *loche* (*Epinephelus* spp.), *carangue* (*Caranx* spp.) and *blanc blanc* (n/a) each contribute about 2% of the total reported catch. About 16 other species or species groups account for the remainder of the reported catch. In the case of outer-reef catches, only five species or species groups were reported. One quarter of the reported catch is accounted for by each of: *perroquet* (*Scarus* spp.), *picot* (*Siganus* spp.) and *dawa* (*Naso unicornis*), while *loche* (*Epinephelus* spp.) and *saumonée* (*Plectropomus* spp.) contribute 12–13% each (Detailed data are provided in Appendix 2.5.1.).

Our survey sample of finfish fishers interviewed represents about 32% of the projected total number of finfish fishers in Moindou. However, the survey included most commercial and subsistence fishers. Hence, our results largely represent the overall impact of reef fisheries imposed by the community members of Moindou on their fishing ground. Those fishers not included in this survey are rather leisure fishers, who may or may not fish regularly, and if doing so, fish for subsistence purposes only. We also have not included any potential impact imposed on the Moindou fishing ground by fishers from outside the Moindou community.

However, we assume that these external fishers mainly target pelagic species, or add to fishing pressure at the outer reef as they may spearfish during the warmer summer months. Hence, the impact not recorded here is presumably small, if not negligible, in terms of the overall assessment of current fishing pressure.

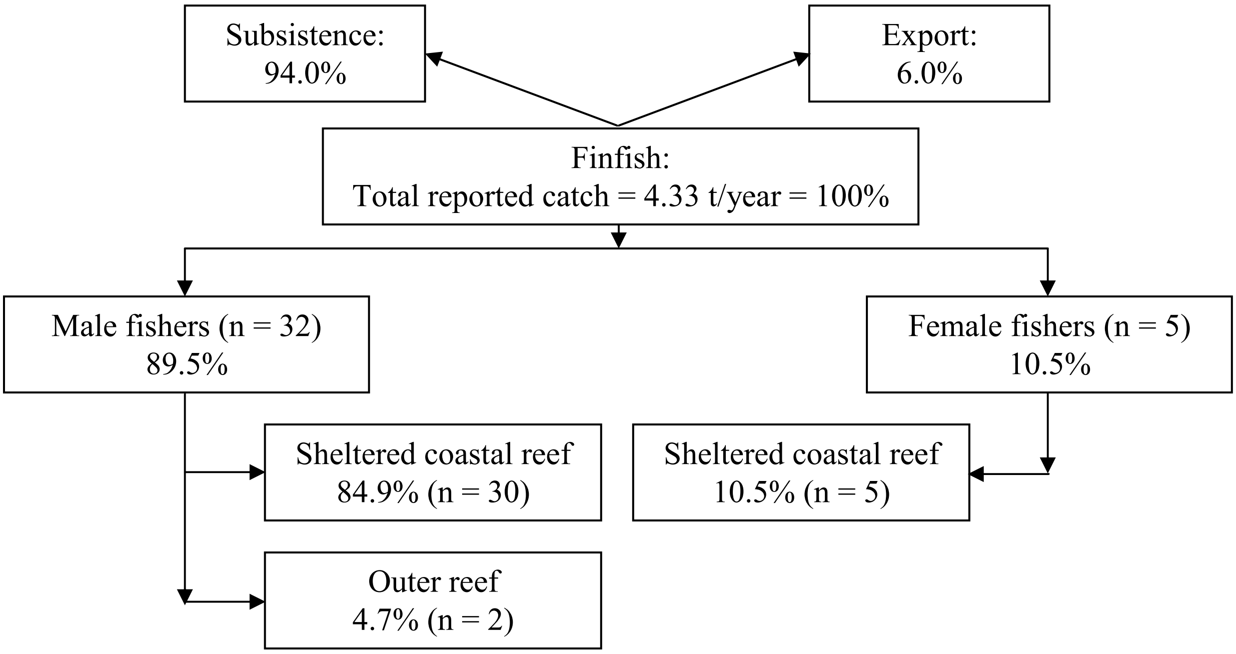

Figure 6.9: Total annual finfish catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Moindou.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

As shown in Figure 6.9, most impact is from subsistence reef fishing, i.e., catches that are sold outside the Moindou community only account for 6% of the total annual reported catch (~0.25 t/year). These figures support the earlier finding that few households rely on fisheries as first or second source of income. The high share of subsistence needs corresponds to a total annual estimated local consumption of 4.2 t/year. Most of the catch is taken by male fishers (~90%); females only play a minor role (~10%). Highest pressure is imposed on the sheltered coastal reef, with minor impact on the outer-reef resources (~5% of the total reported annual catch).

The high impact on the sheltered coastal reef is not only due to the number of fishers targeting this area but also the higher average annual catches. As shown in Figure 6.10, average annual catches are about 120 kg/fisher/year for the sheltered coastal reef compared to only 100 kg/year at the outer reef. Females' catches at the sheltered coastal reef are less, ~85 kg/fisher/year.

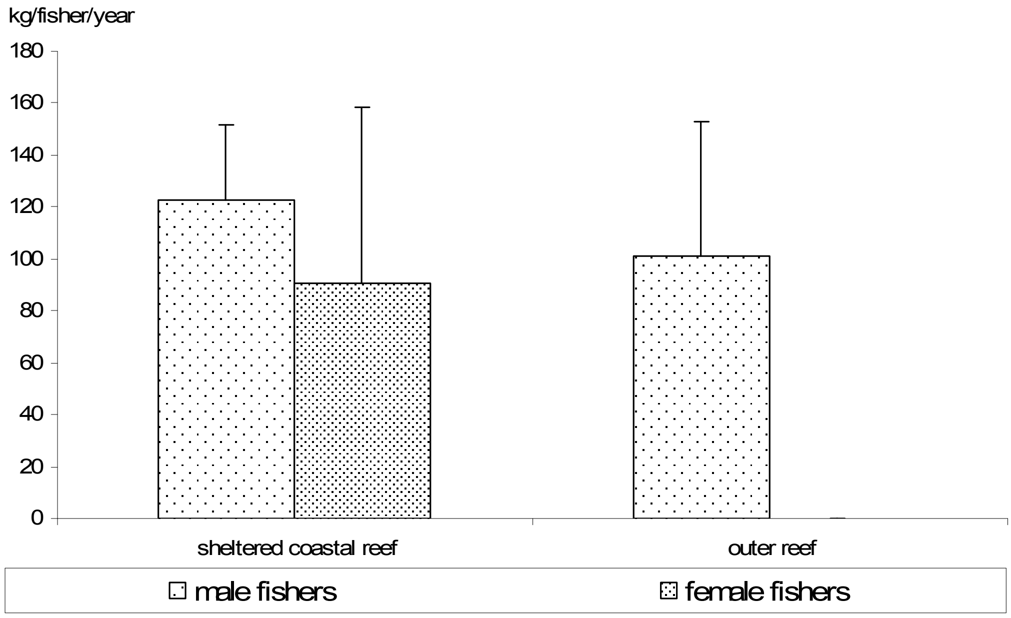

Figure 6.10: Average annual catch (kg/year, +SE) per fisher by gender and habitat in Moindou (based on reported catch only).

However, average annual catches are not to be confused with fishing efficiency. Considering the average catch per hour of fishing trip spent, highest CPUEs are obtained at the outer reef (~2.5 kg/hour) as compared to 1 kg/hour fished at the sheltered coastal reef. Figure 6.11 also shows that the fishing efficiency of female fishers is even lower, less than half of the CPUE of male fishers at the sheltered coastal reef.

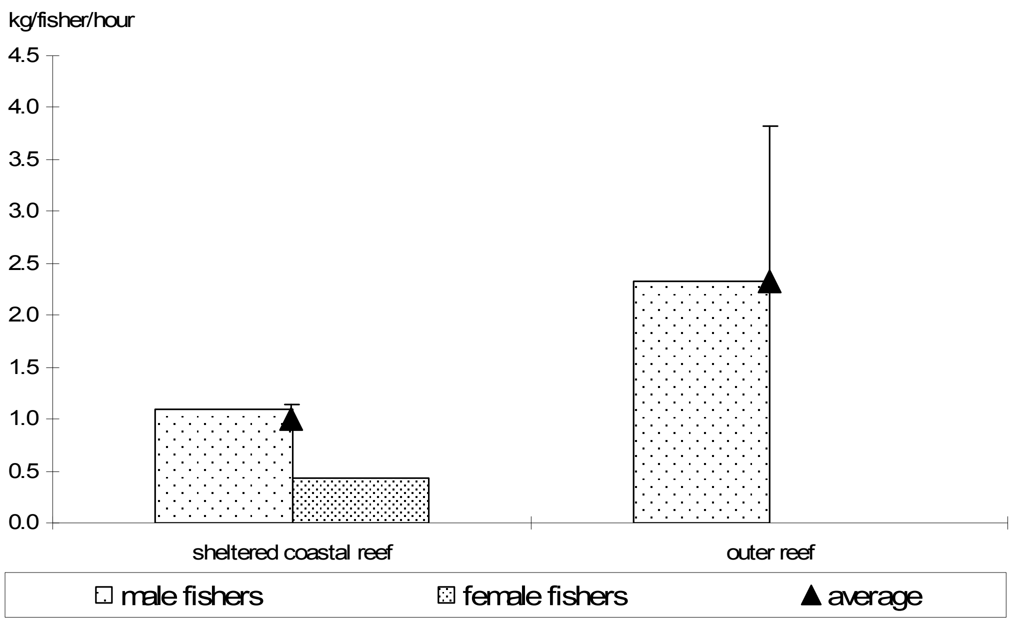

Figure 6.11: Catch per unit effort (kg/hour of total fishing trip) for male and female fishers by habitat in Moindou.
Effort includes time spent in transporting, fishing and landing catch. Bars represent standard error (+SE).

Survey data did not show any significant difference in the objectives of fishing between different habitats targeted (Figure 6.12). Regardless of which area is targeted, most catch is reported to be for subsistence, and very little for sale outside the Moindou community. The amount of catch caught for non-monetary distribution among community members is about half of that for subsistence purposes if targeting the sheltered coastal reef, and equal to the share caught for subsistence purposes at the outer reef.

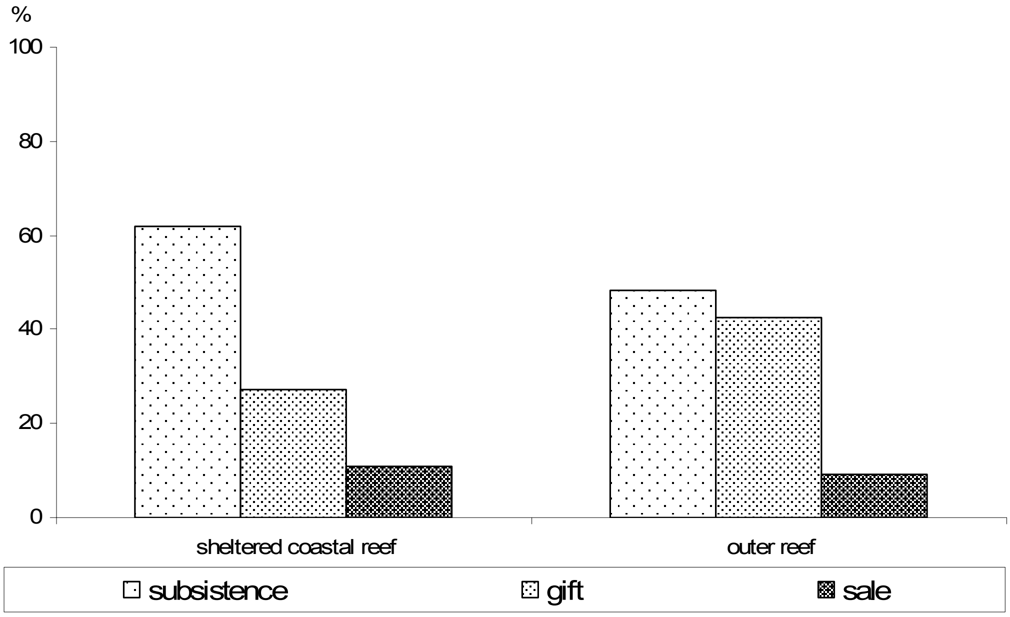

Figure 6.12: The use of finfish catches for subsistence, gift and sale, by habitat in Moindou. Proportions are expressed in % of the total number of trips per habitat.

Data on the average reported finfish sizes by family and habitat as shown in Figure 6.13 show an increasing trend in fish size from the sheltered coastal reef to the outer reef (for Serranidae, Siganidae and Acanthuridae). It is also interesting to note that Scaridae were not reported for catches from the sheltered coastal reef. The predominant use of spear diving at the outer reef as compared to gillnets, castnets and handlines used at the sheltered coastal reef may be a possible explanation for this absence of Scaridae.

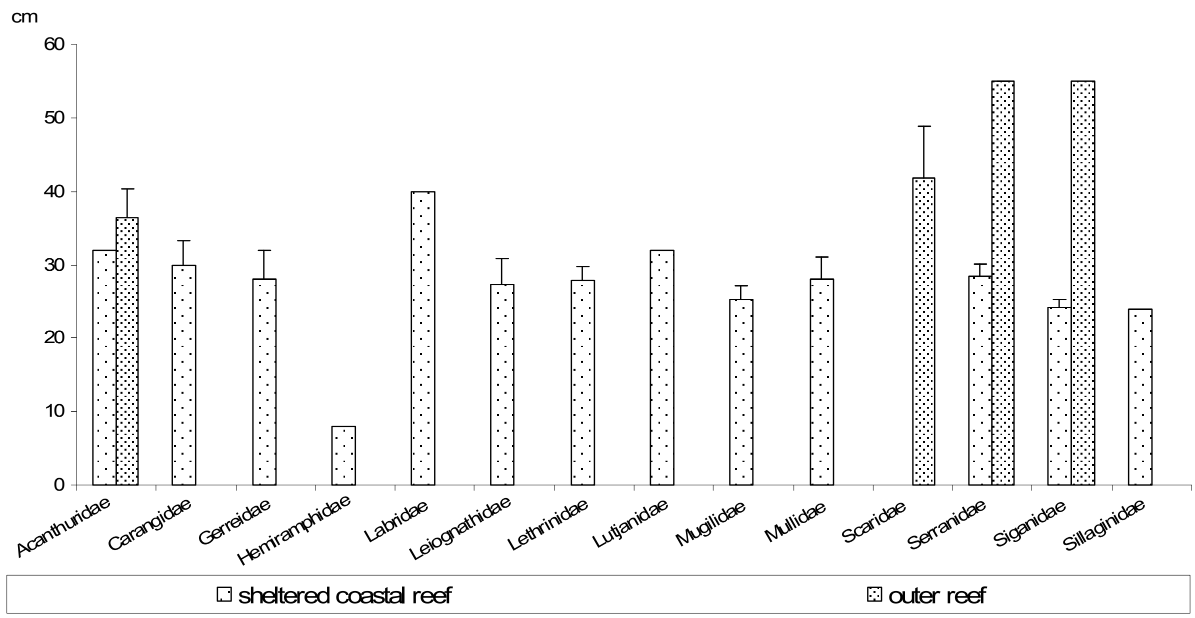

Figure 6.13: Average sizes (cm fork length) of fish caught by family and habitat in Moindou. Bars represent standard error (+SE).

Some parameters selected to assess the current fishing pressure on Moindou's living reef resources are shown in Table 6.4. The comparison of habitat surfaces included in Moindou's fishing ground shows that the lagoon is the largest area, followed by the sheltered coastal and the outer reef. However, fishers do not target the lagoon, which is, therefore, not shown as an individual habitat but included in the total reef area (proportion of back-reef) and total fishing ground (lagoon and back-reef). Overall fisher density is low, with an average of 1 fisher/km^2 of total fishing ground and 2 fishers/km^2 of total reef area, but highest in the sheltered coastal reef where average annual catches per fisher and total annual catch are also highest. Lowest fisher density occurs in the outer reef, with 1 fisher/km^2 but relatively high average productivity (CPUE). Population density is low; it reaches ~4 people/km^2 of total reef and 2 people/km^2 of total fishing ground. All parameters indicate a low fishing pressure on Moindou finfish resources and, indeed, average annual total subsistence catch/km^2 of total reef or total fishing ground area is very low, 0.1 t/year/km^2.

Table 6.4: Parameters used in assessing fishing pressure on finfish resources in Moindou

Parameters	Habitat			
	Sheltered coastal reef	Outer reef	Total reef area	Total fishing ground
Fishing ground area (km^2)	23.46	7.70	102.42	184.61
Density of fishers (number of fishers/km^2 fishing ground) (1)	7	1	2	1
Population density (people/km^2) (2)			4	2
Average annual finfish catch (kg/fisher/year) (3)	117.85 (±26.68)	101.14 (±51.95)		
Total fishing pressure of subsistence catches (t/km^2)			0.1	0.1

Figures in brackets denote standard error; (1) total number of fishers is extrapolated from household surveys; (2) total population = 434; total number of fishers = 165; total subsistence demand = 11.33 t/year; (3) catch figures are based on recorded data from survey respondents only.

6.2.4 Catch composition and volume – invertebrates: Moindou

Calculations of the recorded annual catch rates per species groups are shown in Figure 6.14. The graph shows that the major impact by wet weight is mainly due to one species, *Scylla serrata* (*crabe de palétuvier*). All other eight reported species groups account for less than 1% of the total reported annual catch by wet weight (Detailed data are provided in Appendices 2.5.2 and 2.5.3.).

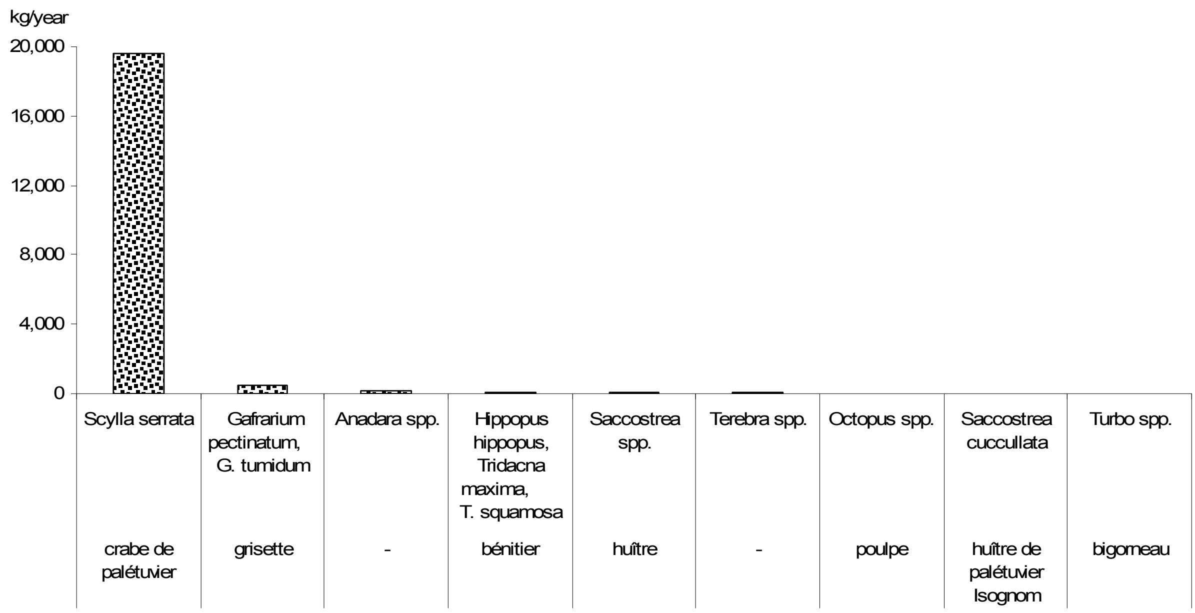

Figure 6.14: Total annual invertebrate catch (kg wet weight/year) by species (reported catch) in Moindou.

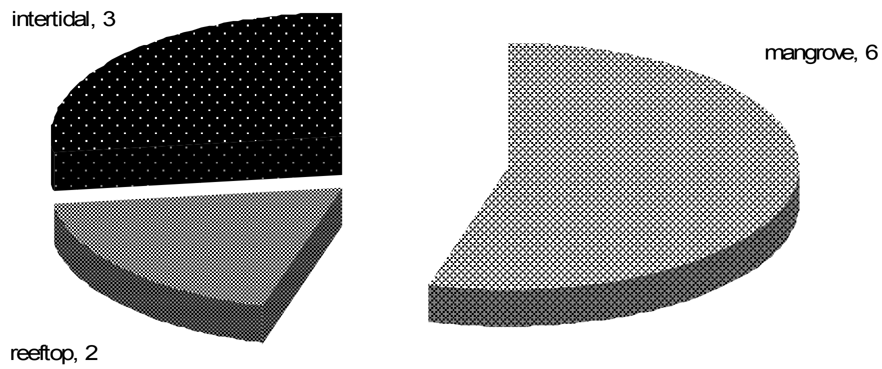

Figure 6.15: Number of vernacular names recorded for each invertebrate fishery in Moindou.

In accordance with the limited number of invertebrates reported by respondents, overall biodiversity in Moindou's invertebrate fishery is low (Figure 6.15). Taking into account all reported vernacular names, the mangrove fishery scores highest, with six different names, while most other fisheries are represented by two (reeftop) and three (soft bottom, i.e. sandy intertidal areas) names only.

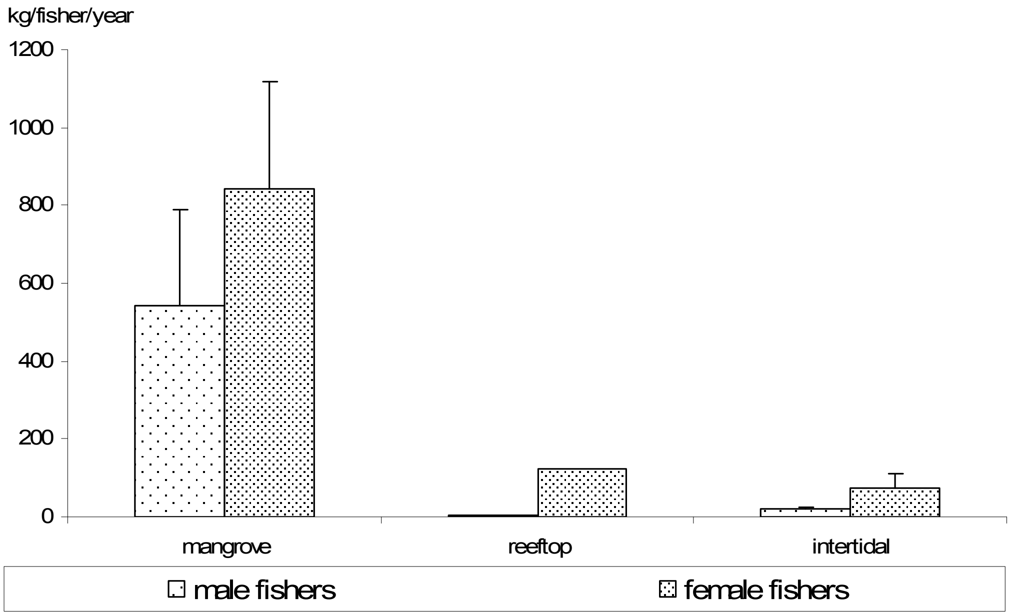

Figure 6.16: Average annual invertebrate catch (kg wet weight/year) in reeftop habitat by fisher and gender in Moindou.
Data based on individual fisher surveys. Figures refer to the proportion of all fishers who target each habitat (n = 32 for males, n = 17 for females).

Figure 6.16 shows that the highest average annual catches by wet weight are from the mangrove and much less from the reeftop and soft-bottom fisheries. Surprisingly, female fishers targeting mangrove areas take substantially higher average annual catches by wet weight than do males. This observation also applies to the reeftop and soft-bottom fisheries.

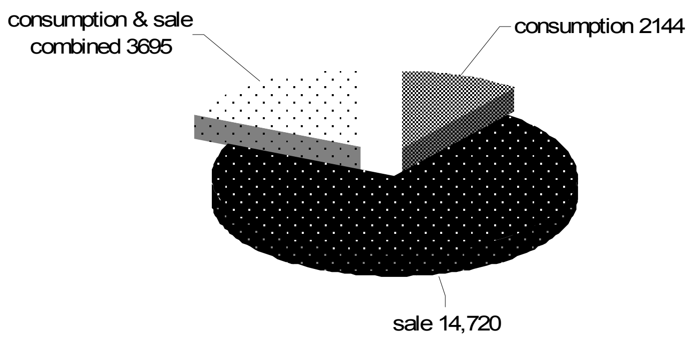

Figure 6.17: Total annual invertebrate biomass (kg wet weight/year) used for consumption, sale, and consumption and sale combined (reported catch) in Moindou.

In contrast to finfish fisheries, invertebrate fisheries are mainly performed for commercial purposes, i.e. marketing outside the Moindou community (Figure 6.17). Only 10% of the reported total annual wet weight is harvested exclusively for subsistence purposes. Adding half of the category that may be used for both ‘consumption and sale’, subsistence demand may not exceed 19% of the total annual catch. In contrast, about 80–90% is caught for sale outside the Moindou community, and most of this is contributable to mud crab catches. As a result it can be concluded that the impact on Moindou’s invertebrate resources is mainly determined by external rather than internal demand.

The total annual catch volume (expressed in wet weight based on recorded data from all respondents interviewed) amounts to 20.6 t/year (Figure 6.18). Catches from mangroves represent ~96% of the total reported wet weight. By comparison, all other fisheries, including reeftop (0.6%) and soft-bottom (3.1%) gleaning, are insignificant. Results presented in Figure 6.18 do not suggest a major difference in gender roles. Both genders mainly target the mangrove areas.

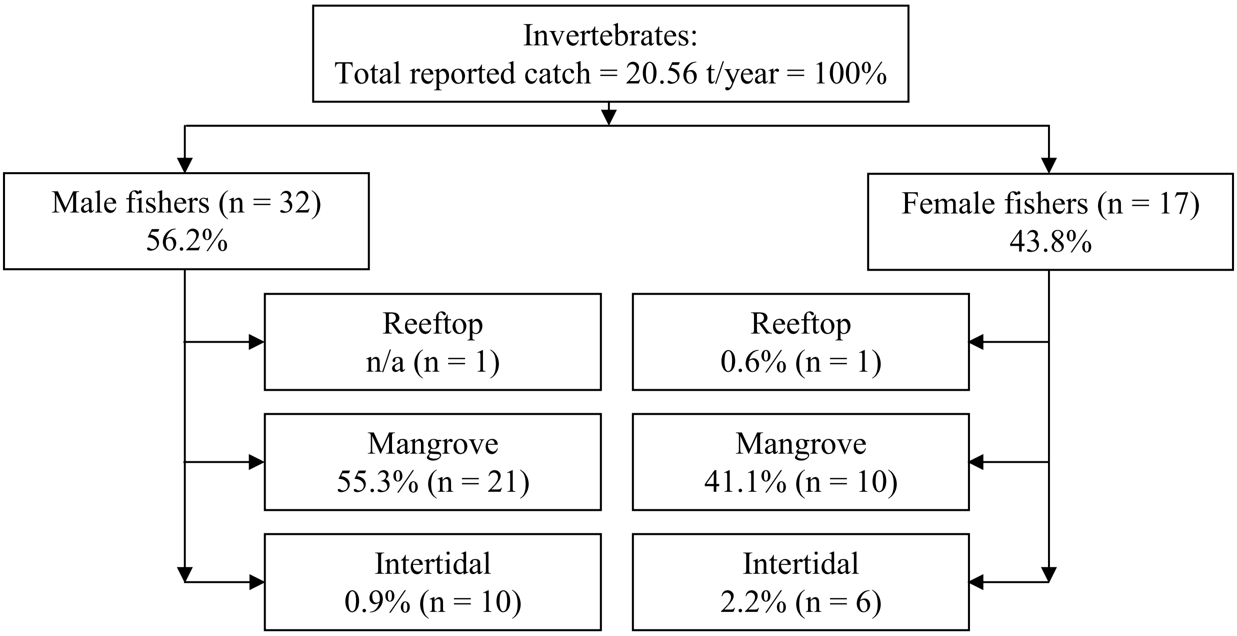

Figure 6.18: Total annual invertebrate catch (tonnes) and proportion (%) by fishery and gender (reported catch) in Moindou.
n is the total number of interviews conducted per each fishery; total number of interviews may exceed total number of fishers surveyed as one fisher may target more than one fishery and thus respond to more than one fishery survey.

Table 6.5: Parameters used in assessing fishing pressure on invertebrate resources in Moindou

Parameters	Fishery / Habitat		
	Mangrove	Reeftop [(3)]	Intertidal
Fishing ground area (km^2)	22.6	57.9	n/a
Number of fishers (per fishery) [(1)]	142	9	73
Density of fishers (number of fishers/km^2 fishing ground)	6.3	0.2	n/a
Average annual invertebrate catch (kg/fisher/year) [(2)]	639.15 (±188.26)	63.26 (±58.68)	41.29 (±15.74)

Figures in brackets denote standard error; n/a: no information available; [(1)] total number of fishers is extrapolated from household surveys; [(2)] catch figures are based on recorded data from survey respondents only; [(3)] For the reeftop fishery only the inside lagoon shallow reef area has been considered here. The percentage of the lagoon area that is to be considered suitable to support soft-bottom gleaning has not been determined at this stage.

The parameters presented in Table 6.5 show a high variability in the size of the available fishing grounds for mangrove and reeftop gleaning. Taking into consideration the average recorded annual catch per fisher (wet weight), fisher density and the percentage of total catch by fishery (Figure 6.18), fishing pressure on mangrove resources, in particular mud crabs (*Scylla serrata*) (Figure 6.14), is high. Fishing pressure from reeftop gleaning seems to be negligible. The proportion of total invertebrate catch that is sold commercially, mainly mud crabs (*Scylla serrata*), is high.

6.2.5 Discussion and conclusions: socioeconomics in Moindou

- Salaries and small business are the most important income sources for households in Moindou. Only 30% of all households reported relying on fisheries for income generation but most (17.5%) only as secondary income.

- However, about 90% of all households have at least one member who fishes frequently and all households eat fresh fish and invertebrates. Fresh-fish consumption is about average for the region and among the higher values of the five PROCFish sites surveyed in New Caledonia. Invertebrate consumption is about average compared to the country sites surveyed.

- The fact that the average household expenditure level in Moindou is well above the country average as estimated by the PROCFish surveys, and that no remittances are received, suggest that the people in Moindou have adopted a rather urbanised lifestyle.

- Most fishers target both finfish and invertebrates. A few male fishers target exclusively finfish and slightly fewer than half of female fishers specialise in collecting only invertebrates. However, most fishers are male, and they account for most of the reported impact. Main impact by fisher and catch is imposed on the sheltered coastal reefs and lagoon and very little on the outer reef. Invertebrates are mostly collected from the mangroves and much less impact is reported for reeftop and soft-benthos gleaning.

- Finfish are caught using a combination of gillnets, castnets, handlines and spears (including spear diving and handheld spears used while walking or from a canoe). Gleaning for invertebrates is done using very simple tools only. Mud crabs are caught by hand, using sticks and iron bars, or by baited cages. Both finfish and invertebrate fishing may involve motorised boat transport to reach fishing grounds.

- Highest fishing pressure is on the sheltered coastal reef resources, due to the number of fishers, and is mainly accounted for by subsistence demand. In contrast, invertebrate fishing is mainly performed for commercial purposes and focuses on mud crabs (*Scylla serrata*). Total invertebrate catch by wet weight is accounted for equally by male and female fishers, and both are heavily involved in commercial mud crab fishing.

The above observations lead to two major conclusions. Firstly, current pressure on finfish resources in Moindou does not seem to have reached any alarming level as it mainly serves subsistence needs. However, it should be borne in mind that the results presented here do not take into consideration any possible impact by fishers external to the Moindou community. Fishery services also expressed concern regarding the possible impact caused by leisure fishing.

However, the high exploitation level of mud crabs for commercial sale to agents and to the greater Noumea market requires careful monitoring of resource development and fishing practices. This recommendation is strengthened by the concern of the community, fishery services and other administrative authorities. There is a need to control the total annual catch of mud crabs, and/or the catch methods. Locally, discussions centre around the use of traditional catch methods, i.e. collection by hand, which are considered sustainable and target only large specimens, as opposed to the allowed method of using baited cages. In addition, there is a significant number of external fishers who target mud crabs in the Moindou fishing ground. The increase in mud-crab fishing has resulted in disputes among residents, as well as between residents and external fishers, over rights to 'traditional' fishing grounds. The current limit, which allows a certain number of cages per boat, has not proved effective, because many fishers gain access to the mangroves by road and thus are not restricted in the number of cages set. Residents also reported misuse of cages, including a lack of regular harvesting, use of undersized crabs as bait, pirating of catch, etc. The bait needed for the cage method was also voiced as one of the major problems, i.e. the use of reef fish, illegally speared turtle and dugong meat, etc. At the time of survey, a registered commercial mud-crab fisher in the area, who uses round cages (made in Australia) reported buying chicken meat to use as bait.

6.3 Finfish resource surveys: Moindou

Finfish resources and associated habitats were assessed between 06 April and 11 September 2004 from a total of 24 transects (4 sheltered coastal, 8 intermediate, 6 back- and 6 outer-reef transects, see Figure 6.19 and Appendix 3.5.1 for transect locations and coordinates respectively).

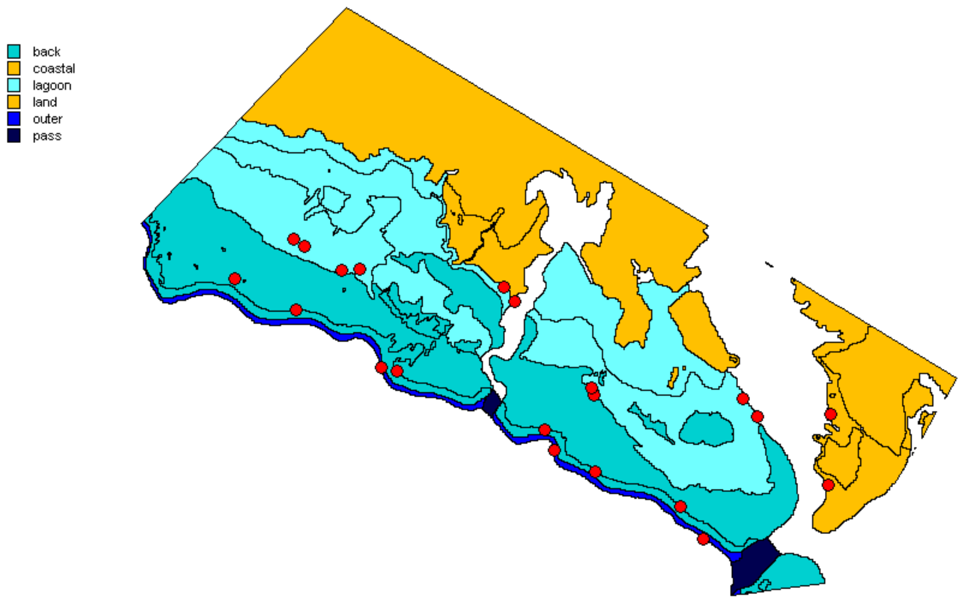

Figure 6.19: Habitat types and transect locations for finfish assessment in Moindou.

6.3.1 Finfish assessment results: Moindou

A total of 25 families, 61 genera, 171 species and 10,087 fish were recorded in the 24 transects (See Appendix 3.5.2 for list of species.). Only data on the 15 most dominant families are presented below, representing 47 genera, 149 species and 7108 individuals.

Finfish resources varied slightly among the four reef environments found in Moindou (Table 6.6). The coastal reef contained the largest average size (18 cm) and biomass (77 g/m^2) but the lowest density of fish (0.3 fish/m^2) and number of species (35 species/transect). In contrast, the intermediate reefs displayed the lowest biomass (58 g/m^2), though not much different from the coastal-reef values, and the outer reefs displayed the highest biodiversity (43 species/transect). Intermediate, back- and outer reefs showed similar values of density (0.5 fish/m^2) and size (15–16 cm).

Table 6.6: Primary finfish habitat and resource parameters recorded in Moindou (average values ±SE)

Parameters	Habitat				
	Sheltered coastal reef (1)	Intermediate reef (1)	Back-reef (1)	Outer reef (1)	All reefs (2)
Number of transects	4	8	6	6	24
Total habitat area (km^2)	23.5	79.7	73.7	5.2	182.1
Depth (m)	3 (1-8) (3)	2 (1-7) (3)	2 (1-4) (3)	4 (2-12) (3)	2 (1-12) (3)
Soft bottom (% cover)	18 ±10	14 ±3	14 ±3.7	3 ±0	14
Rubble & boulders (% cover)	33 ±2	22 ±7	26 ±4.2	7 ±1	25
Hard bottom (% cover)	34 ±6	50 ±7	45 ±6.4	63 ±3	47
Live coral (% cover)	12 ±3	12 ±2	14 ±0.5	24 ±3	13
Soft coral (% cover)	2 ±1	1 ±0	1 ±0.5	2 ±1	1
Biodiversity (species/transect)	35 ±5	34 ±4	39 ±6.9	43 ±3	38 ±2
Density (fish/m^2)	0.3 ±0.0	0.5 ±0.1	0.5 ±0.1	0.5 ±0.0	0.5
Size (cm FL) (4)	18 ±1	16 ±1	15 ±0.7	16 ±1	16
Size ratio (%)	47 ±3	43 ±2	46 ±2.2	48 ±48	45
Biomass (g/m^2)	77.4 ±32.3	58.2 ±17.2	68.2 ±19	61.3 ±6.1	64.8

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

Sheltered coastal reef environment: Moindou

The sheltered coastal reef environment of Moindou was dominated by four families in terms of biomass: Acanthuridae, Scaridae, Lutjanidae and Mullidae, but mainly by Lutjanidae in terms of biomass (Figure 6.20). These four families were represented by 30 species; particularly high abundance and biomass were recorded for *Lutjanus argentimaculatus* (one large school), *Ctenochaetus striatus*, *L. fulvus*, *Scarus rivulatus*, *S. ghobban*, *L. fulviflamma*, *Acanthurus blochii*, *Chlorurus sordidus* and *Parupeneus multifasciatus* (Table 6.7). This reef environment presented equal proportions of hard bottom and rubble/boulders, and a relatively high presence of soft bottom as well. Such diverse habitat was reflected in the diversity of fish community composition (Table 6.6 and Figure 6.20).

Table 6.7: Finfish species contributing most to main families in terms of densities and biomass in the sheltered coastal reef environment of Moindou

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Lutjanidae	*Lutjanus argentimaculatus*	Mangrove red snapper	0.02 ±0.015	30.54 ±30.54
	Lutjanus fulvus	Blacktail snapper	0.02 ±0.017	6.51 ±5.71
	Lutjanus fulviflamma	Longspot snapper	0.02 ±0.012	2.17 ±1.55
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.04 ±0.014	7.21 ±3.52
	Acanthurus blochii	Ringtail surgeonfish	0.02 ±0.005	1.96 ±0.62
Mullidae	*Parupeneus multifasciatus*	Many bar goatfish	0.02 ±0.006	0.73 ±0.29
Scaridae	*Scarus rivulatus*	Rivulated parrotfish	0.02 ±0.007	4.32 ±2.28
	Scarus ghobban	Bluebarred parrotfish	0.02 ±0.007	2.22 ±1.03
	Chlorurus sordidus	Daisy parrotfish	0.02 ±0.006	1.39 ±0.69

Figure 6.20: Profile of finfish resources in the sheltered coastal reef environment of Moindou.
Bars represent standard error (+SE); FL = fork length.

The density of fish in the coastal reefs of Moindou was one of the lowest in the country, at the same value as Oundjo, as well as the lowest at the site. However, size and biomass displayed some of the highest values, second only to Ouassé coastal reefs. Average biodiversity (35 species/transect) was the second-highest among the coastal reefs analysed in the country (Table 6.6). Herbivorous and carnivorous fish displayed similar density and biomass, while piscivorous fish showed the highest biomass in the trophic profile of the fish community in this habitat. The substrate was almost equally composed of hard, soft bottom and rubbles, offering different habitats for the main families and partially explaining the high diversity of the fish community.

Intermediate-reef environment: Moindou

The intermediate-reef environment of Moindou was dominated by three families: herbivorous Scaridae, Acanthuridae and, to a much lesser extent, Siganidae (both in terms of density and biomass, Figure 6.21). These three families were represented by 31 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Chlorurus sordidus*, *Scarus altipinnis*, *S. ghobban*, *Acanthurus blochii*, *S. niger*, *S. rivulatus* and *Siganus doliatus* (Table 6.8). This reef environment presented a moderately diverse habitat with half of the substrate surface covered by hard bottom (50%), and soft bottom and rubble in similar proportions (Table 6.6 and Figure 6.21). The dominance of hard bottom favours the presence of herbivores, as observed.

Table 6.8: Finfish species contributing most to main families in terms of densities and biomass in the intermediate-reef environment of Moindou

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.05 ±0.01	7.09 ±2.40
	Acanthurus blochii	Ringtail surgeonfish	0.01 ±0.01	2.86 ±2.28
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.09 ±0.02	6.81 ±2.52
	Scarus altipinnis	Filamentfinned parrotfish	0.02 ±0.01	5.55 ±2.05
	Scarus ghobban	Bluebarred parrotfish	0.04 ±0.01	4.83 ±1.97
	Scarus niger	Swarthy parrotfish	0.01 ±0.01	2.82 ±2.25
	Scarus rivulatus	Rivulated parrotfish	0.01 ±0.00	2.79 ±1.28
Siganidae	*Siganus doliatus*	Barred rabbitfish	0.02 ±0.01	3.36 ±2.87

The density of fish in the intermediate reefs of Moindou was the highest recorded among similar habitats in the country. However, size and biomass displayed some of the lowest values among intermediate reefs. Biodiversity was also particularly low (34 species/transect), the lowest at this site and of all the intermediate reefs (Table 6.6). The presence of small *Bolbometopon muricatum* was noted in this habitat (average size 24 cm). Herbivorous fish strongly dominated the trophic structure of the fish community in this habitat, both in terms of density and biomass. Carnivorous families were almost absent from this habitat. The substrate was dominated by hard bottom, favouring the presence of herbivores.

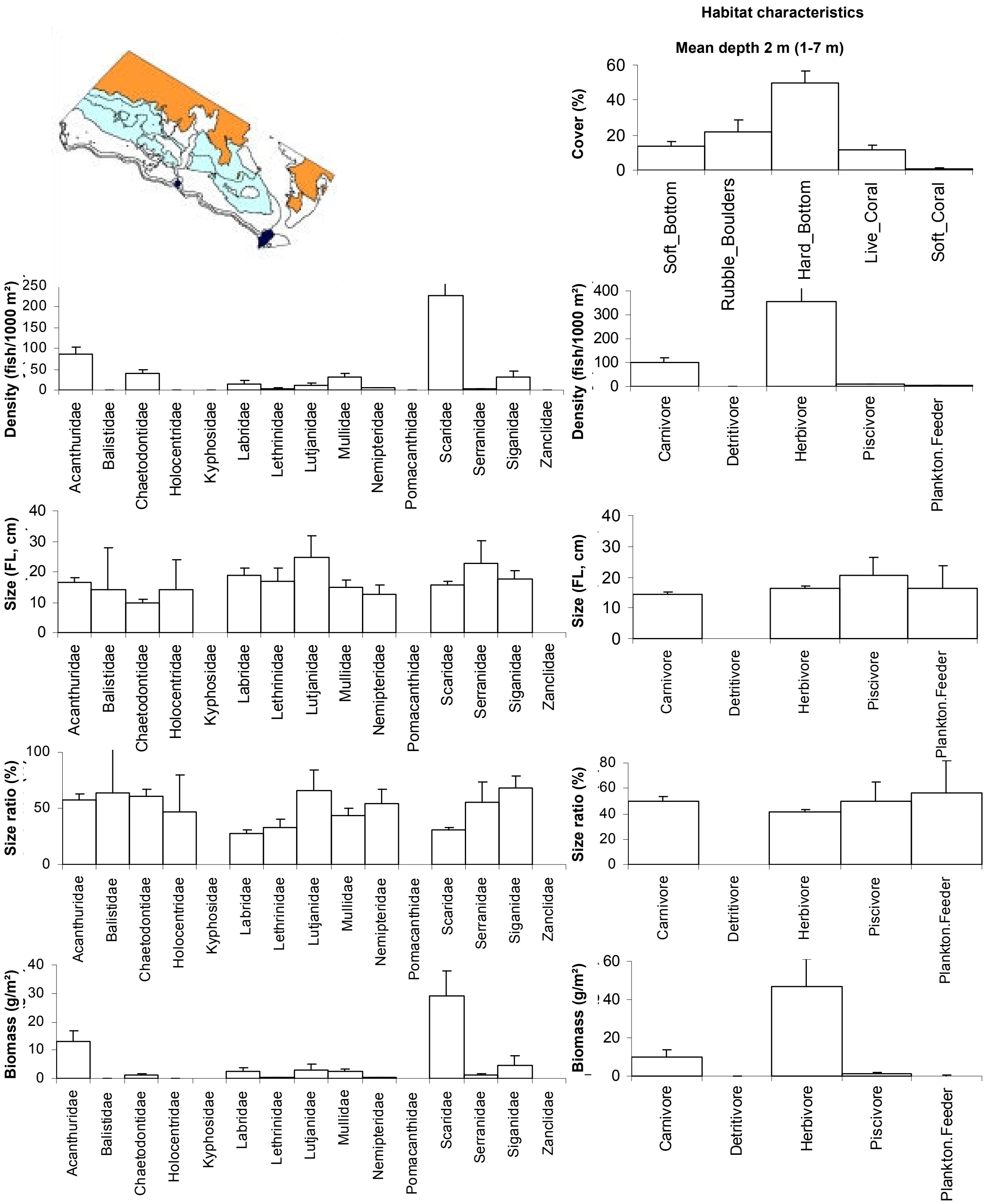

Figure 6.21: Profile of finfish resources in the intermediate-reef environment of Moindou.
Bars represent standard error (+SE); FL = fork length.

Back-reef environment: Moindou

The back-reef environment of Moindou was dominated by five families: two families of herbivorous fish (Scaridae and Acanthuridae) and, to a lesser extent, three families of carnivorous fish (Mullidae and Lethrinidae for both density and biomass, and Lutjanidae for biomass only) (Figure 6.22). These five families were represented by 45 species; particularly high abundance and biomass were recorded for *Ctenochaetus striatus*, *Chlorurus sordidus*, *Acanthurus blochii*, *Mulloidichthys vanicolensis*, *Lethrinus xanthochilus*, *Scarus psittacus*, *Lutjanus bohar*, *L. gibbus*, *Lethrinus genivittatus* and *Lethrinus variegatus* (Table 6.9). This reef environment presented a very diverse habitat with dominance of hard bottom, high cover of rubble–boulder and slightly less cover of soft bottom (14%), partially explaining the high diversity of dominant species (Table 6.6 and Figure 6.22).

Table 6.9: Finfish species contributing most to main families in terms of densities and biomass in the back-reef environment of Moindou

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.05 ±0.03	10.2 ±5.2
	Acanthurus blochii	Ringtail surgeonfish	0.02 ±0.02	5.2 ±3.8
Lethrinidae	*Lethrinus xanthochilus*	Yellowlip emperor	0.003 ±0.002	2.4 ±2.2
	Lethrinus genivittatus	Longspine emperor	0.01 ±0.01	0.6 ±0.7
	Lethrinus variegatus	Slender emperor	0.02 ±0.02	0.4 ±0.4
Lutjanidae	*Lutjanus bohar*	Red snapper	0.002 ±0.002	2.1 ±2.1
	Lutjanus gibbus	Humpback snapper	0.01 ±0.01	1.5 ±1.5
Mullidae	*Mulloidichthys vanicolensis*	Yellowfin goatfish	0.01 ±0.01	3.9 ±3.9
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.10 ±0.06	8.9 ±5.5
	Scarus psittacus	Palenose parrotfish	0.03 ±0.02	2.3 ±1.6

The size and biomass of finfish in the sheltered coastal reefs of Moindou were comparable to values recorded at the other study sites (third-highest value of average biomass for back-reefs), while density was lower; biodiversity displayed the second-highest value (39 versus 40 species/transect in Oundjo). The trophic structure in Moindou back-reefs was dominated by herbivorous species. Similar to Oundjo, Luengoni and Thio, Acanthuridae and Scaridae displayed very high values of biomass and density, and for Scaridae the highest density over all back-reefs. The back-reef of Moindou displayed a rather high percentage of hard bottom (45%) and rubble and boulders (26%) and a low cover of soft bottom (14%). Such environmental differences in substrate may explain the rather diverse composition of families and feeding guilds (herbivorous and carnivorous), but the dominance of hard bottom can be seen as favouring the higher biomass of herbivores.

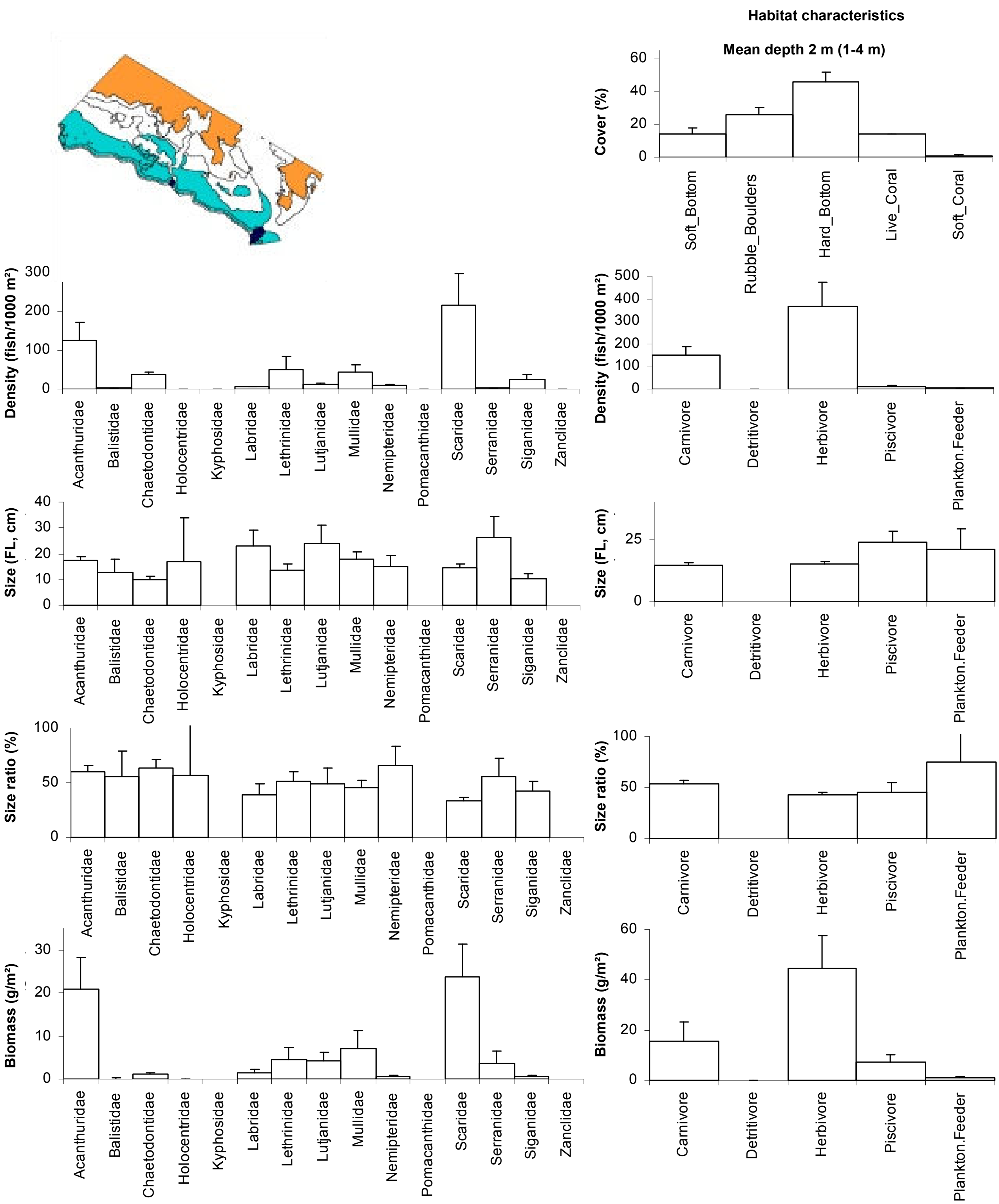

Figure 6.22: Profile of finfish resources in the back-reef environment of Moindou.
Bars represent standard error (+SE); FL = fork length.

Outer-reef environment: Moindou

The outer reef of Moindou was dominated by herbivorous Acanthuridae and Scaridae (both in terms of density and biomass) and, to a lesser extent, by carnivorous Serranidae and Lethrinidae (mainly for biomass, Figure 6.23). These four families were represented by 30 species; particularly high abundance and biomass were recorded for *Chlorurus sordidus*, *Ctenochaetus striatus*, *Plectropomus laevis*, *Scarus frenatus*, *Acanthurus dussumieri*, *Monotaxis grandoculis*, *Naso unicornis*, *Gnathodentex aureolineatus*, *N. lituratus*, *S. niger* and *Zebrasoma scopas* (Table 6.10). Hard bottom (63% cover) largely dominated this reef environment, which also displayed a high cover of live corals (24%, Table 6.6 and Figure 6.23).

Table 6.10: Finfish species contributing most to main families in terms of densities and biomass in the outer-reef environment of Moindou

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.01 ±0.02	9.6 ±2.1
	Acanthurus dussumieri	Eyestripe surgeonfish	0.01 ±0.01	4.2 ±2.7
	Naso unicornis	Bluespine unicornfish	0.01 ±0.01	2.4 ±1.7
	Naso lituratus	Orangespine unicornfish	0.01 ±0.01	2.1 ±1.1
	Zebrasoma scopas	Brushtail tang	0.05 ±0.01	1.5 ±0.2
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.11 ±0.02	9.9 ±1.8
	Scarus frenatus	Bridled parrotfish	0.02 ±0.01	5.3 ±1.2
	Scarus niger	Swarthy parrotfish	0.01 ±0.01	1.8 ±0.8
Serranidae	*Plectropomus laevis*	Blacksaddle coral grouper	0.01 ±0.00	5.9 ±2.9
Lethrinidae	*Monotaxis grandoculis*	Bigeye bream	0.01 ±0.01	2.5 ±2.3
	Gnathodentex aureolineatus	Goldlined seabream	0.02 ±0.01	2.3 ±0.6

The size and biomass of finfish in the outer reef of Moindou were lower than the country average and higher only than those in Luengoni outer reefs (Table 6.6). Density was similar to average outer-reef habitat values. Biodiversity was lower only to Oundjo and Ouassé values. The trophic structure was dominated by herbivores, but carnivores Serranidae and Lethrinidae were present in relatively high biomass. Substrate was mainly hard bottom with high cover of live coral, normally providing a habitat preferred by herbivorous families.

Figure 6.23: Profile of finfish resources in the outer-reef environment of Moindou.
Bars represent standard error (+SE); FL = fork length.

Overall reef environment: Moindou

Overall, the fish assemblage of Moindou was dominated by Scaridae and Acanthuridae (both in terms of density and biomass) (Figure 6.24). These two families were represented by a total of 37 species, dominated (in terms of density and biomass) by *Chlorurus sordidus*, *Ctenochaetus striatus*, *Scarus ghobban* and *Acanthurus blochii* (Table 6.11). As expected, the overall fish assemblage in Moindou shared characteristics of mostly intermediate reef (44% of habitat), back-reefs (40%), sheltered coastal reef (13%) and, to a small extent, outer reefs (3%).

Table 6.11: Finfish species contributing most to main families in terms of densities and biomass across all reefs of Moindou (weighted average)

Family	Species	Common name	Density (fish/m^2)	Biomass (g/m^2)
Scaridae	*Chlorurus sordidus*	Daisy parrotfish	0.08	7.0
	Scarus ghobban	Bluebarred parrotfish	0.03	2.8
Acanthuridae	*Ctenochaetus striatus*	Striated surgeonfish	0.05	8.4
	Acanthurus blochii	Ringtail surgeonfish	0.02	3.6

Overall, Moindou appears to support a similar finfish resource to the other sites, with relatively low density (0.5 fish/m^2), second-lowest biomass (64.8 g/m^2, lower than in Ouassé, Luengoni and Thio), and second-lowest biodiversity (34 species/transect) (Table 6.6). These results suggest that the finfish resource in Moindou is in a relatively poor condition. Moreover, detailed assessment at family level revealed a dominance of herbivorous parrotfish and surgeonfish and very low abundance of carnivorous families. The average trophic structure for this site was dominated by herbivores in terms of both density and biomass; however, a relatively high biomass of Lutjanidae was evident and due mostly to small-sized snappers: *Lutjanus fulvus* and *L. fulviflamma.*

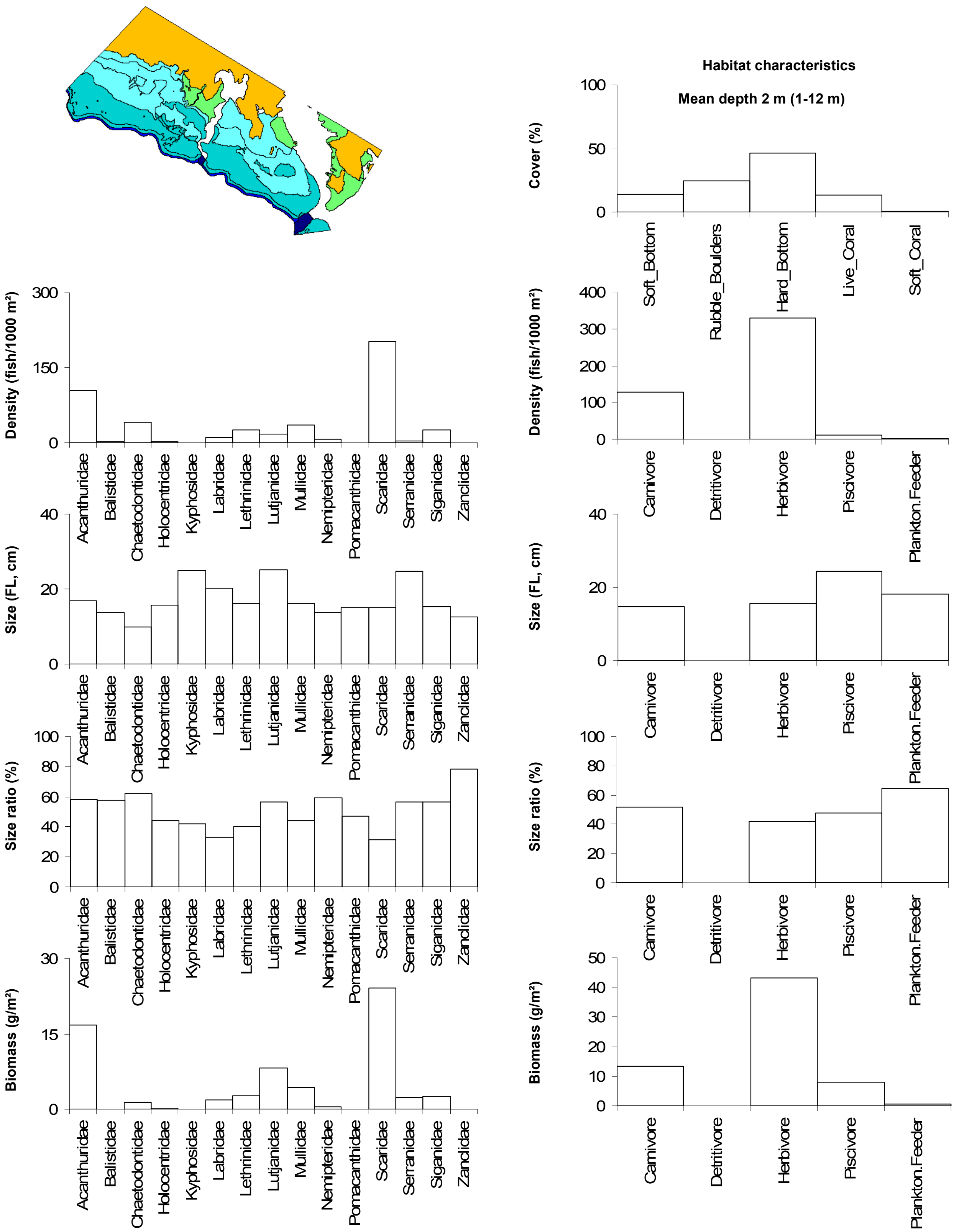

Figure 6.24: Profile of finfish resources in the combined reef habitats of Moindou (weighted average).
FL = fork length.

6.3.2 Discussion and conclusions: finfish resources in Moindou

The finfish resource assessment indicated that the status of finfish resources in Moindou was similar to or slightly poorer than the average across the New Caledonia study sites. Biomass was comparable to values in Luengoni and Oundjo, while density was similar to the averages in Oundjo and Thio. Moindou reefs displayed some of the lowest values of density for Acanthuridae, Siganidae and Labridae, low values of density and biomass for Lutjanidae, Lethrinidae and Mullidae (as also found in the other sites), but the highest abundance of Scaridae (due to a very high density of small parrotfish, especially *Chlorurus sordidus*, *Scarus altipinnis* and young *Bolbometopon muricatum*) in the intermediate reefs. Siganidae (rabbitfish) displayed some of the lowest densities, particularly in the coastal, back- and outer reefs. This could be directly related to the high consumption of rabbitfish, especially of those caught in coastal reefs. The lack of carnivores (especially Lethrinidae) may partially be explained by the type of habitat, which had little soft-bottom cover. The Moindou community relies heavily on finfish for sustenance, and fish consumption was the highest among the five sites. However, results from the socioeconomic study suggested that the impact on the fishing grounds was relatively small, due to the low density of fishers and the high efficiency of fishing in the outer reefs. However, the fishing pressure may already have impacted the fish population, and the lack of large-sized fish, especially among carnivorous families, is a response to heavy fishing.

- Overall, Moindou finfish resources appeared to be in quite poor condition, but still among the average levels for the country. The reef habitat seemed relatively rich and the ecosystem supporting finfish resources quite healthy.

- The populations of Lutjanidae, Lethrinidae and Mullidae were in the low-value ranges for the country, but similar to those in Ouassé, Thio and Oundjo. A lack of suitable habitats for these carnivores could possibly explain this low abundance. Only in Luengoni, whose fishing ground had the highest cover of soft bottom, were abundances of Lethrinidae and Mullidae relatively high.

6.4 Invertebrate resource surveys: Moindou

The diversity and abundance of invertebrate species at Moindou were independently determined using a range of survey techniques (Table 6.12); broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 6.25) and finer-scale assessment of specific reef and benthic habitats (Figures 6.26 and 6.27).

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

Table 6.12: Number of stations and replicate measures completed at Moindou

Survey method	Stations	Replicate measures
Broad-scale transects (B-S)	12	72 transects
Reef-benthos transects (RBt)	13	78 transects
Soft-benthos transects (SBt)	20	120 transects
Soft-benthos infaunal quadrats (SBq)	0	0 quadrat group
Mother-of-pearl transects (MOPt)	3	18 transects
Mother-of-pearl searches (MOPs)	1	6 search periods
Reef-front searches (RFs)	5	30 search periods
Sea cucumber day searches (Ds)	3	18 search periods
Sea cucumber night searches (Ns)	0	0 search period

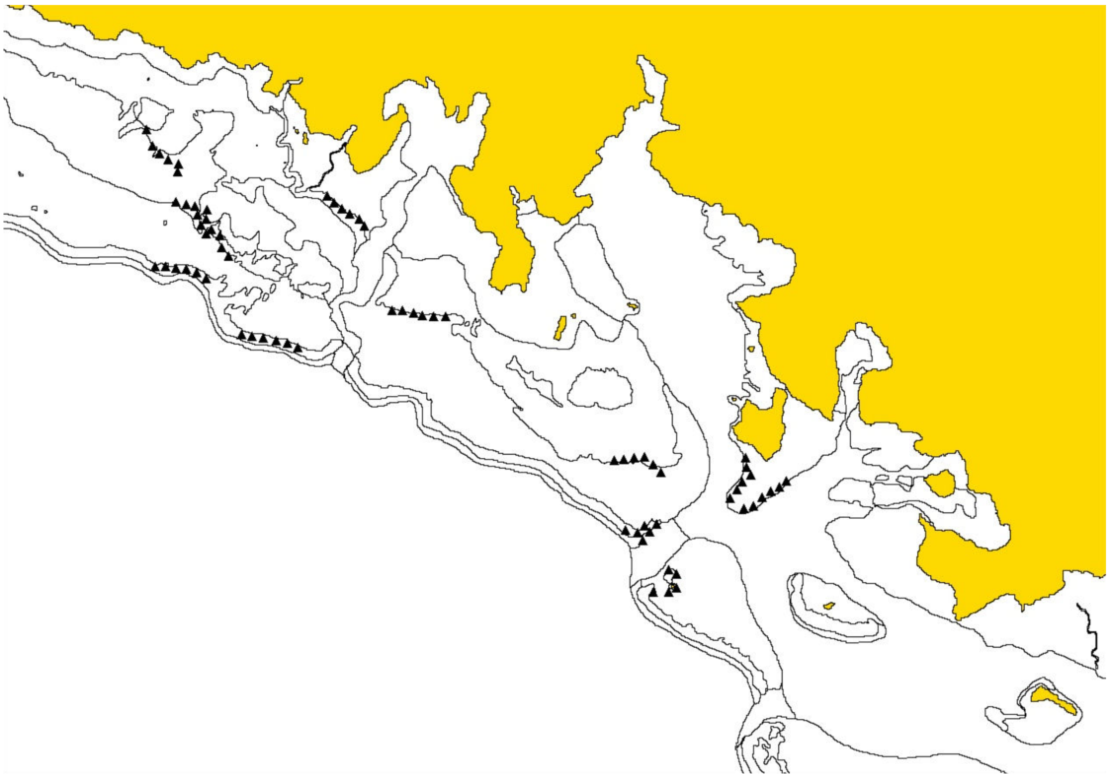

Figure 6.25: Broad-scale survey stations for invertebrates in Moindou.
Data from broad-scale surveys conducted using 'manta-tow' board;
black triangles: transect start waypoints.

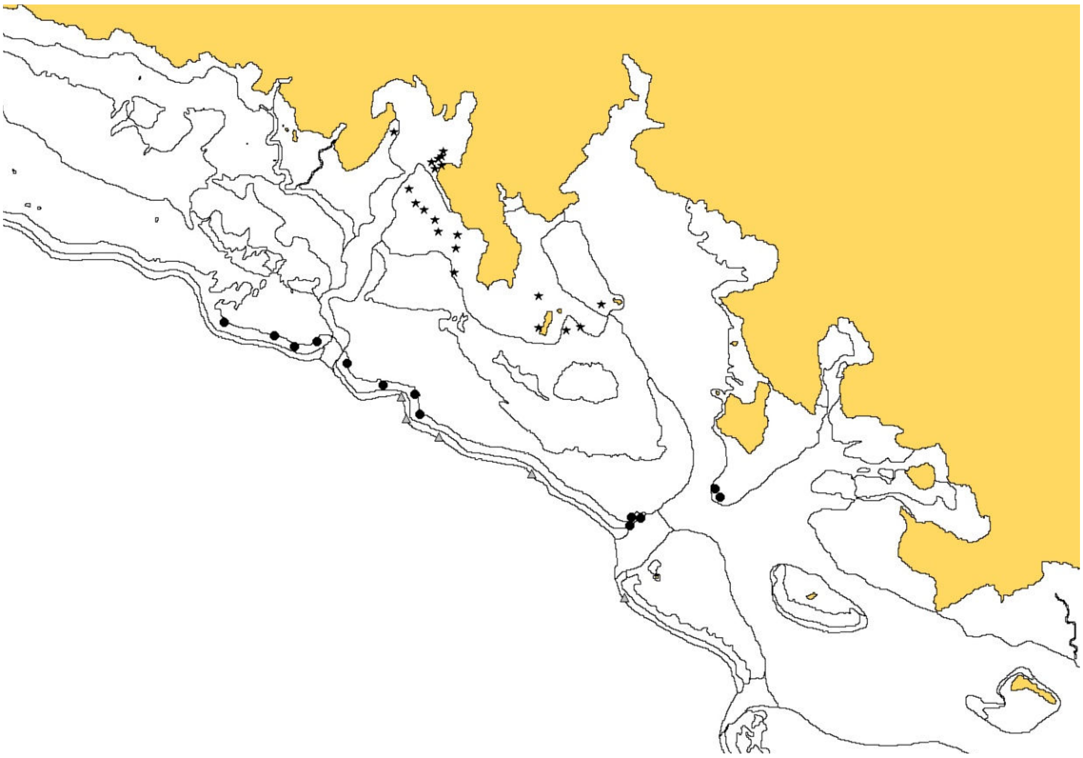

Figure 6.26: Fine-scale reef-benthos transect survey stations, reef-front search survey stations and soft-benthos transect survey stations for invertebrates in Moindou.
Black circles: reef-benthos transect stations (RBt);
grey triangles: reef-front search stations (RFs);
black stars: soft-benthos transect stations (SBt).

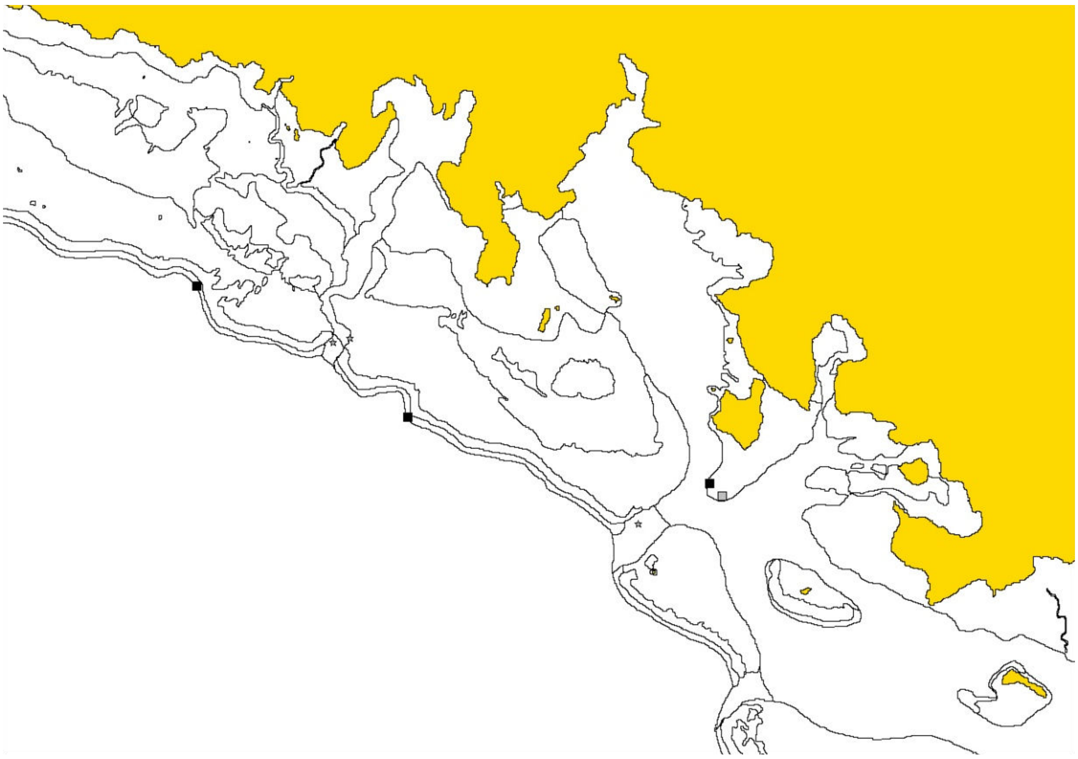

Figure 6.27: Fine-scale survey stations for invertebrates in Moindou.
Grey squares: mother-of-pearl search stations (MOPs);
black squares: mother-of-pearl transect stations (MOPt);
grey stars: sea cucumber day search stations (Ds).

Seventy-seven species or species groupings (groups of species within a genus) were recorded in Moindou invertebrate surveys. These included 16 bivalves, 26 gastropods, 16 sea cucumbers, 7 urchins, 5 sea stars, 2 cnidarians and 1 lobster (Appendix 4.5.1). Information on key families and species is detailed below.

6.4.1 Giant clams: Moindou

Shallow-reef habitat suitable for giant clams was very extensive at Moindou (66.2 km^2: ~57.9 km^2 within the lagoon and 8.3 km^2 on the reef front or slope of the barrier). Unlike the PROCFish sites on the east coast of Grande Terre, the lagoon was relatively shallow. At Moindou, expanses of mud and sand with some coral patches behind the secondary lines of reef within the lagoon (pseudo or secondary 'barriers') bordered the large coastal mangrove system. These shallow areas were periodically exposed at spring low tides and heavily influenced by inputs from the land (riverine inputs).

Dynamic water flow across the barrier reef and through the passes to the north and south of Moindou subjected large areas of the lagoon to dynamic water exchange. Extensive patch-reef and back-reef habitat could be found in the outer sector of the lagoon, and these locations were suitable for clams. Four species of giant clam were recorded: elongate clam *Tridacna maxima*, fluted clam *T. squamosa*, smooth clam *T. derasa*, and horse-hoof or bear's paw clam *Hippopus hippopus* (locally called *rouleur*). Inshore reefs were difficult to survey because there was poor visibility at the time of survey, which limited the chance of finding the boring clam *T. crocea*. No live or dead *T. gigas* clams were found, although fossilised remains of this species have been reported in the literature (Virly 2004) and examples have been noted on reefs in New Caledonia, such as a buried shell dug up on Îlot Canard near Noumea (Kim Friedman pers. comm.) and valves found at Port Boisé in Province Sud, Emmanuel Tardy pers. comm.).

Broad-scale sampling provided an overview of giant clam distribution across the lagoon. *T. maxima* had the widest occurrence (found in 12 broad-scale stations and 57 transects), followed by *T. derasa* (in 6 stations and 7 transects), *T. squamosa* (in 4 stations and 4 transects) and, despite being well camouflaged, *H. hippopus* (in 4 stations and 9 transects) (Figure 6.28).

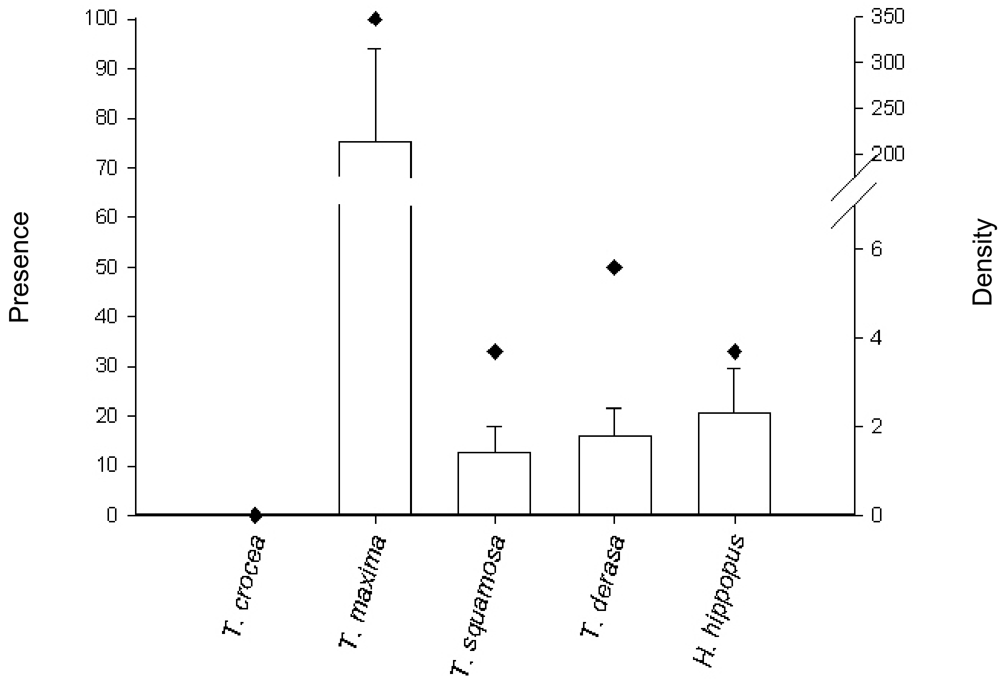

Figure 6.28: Presence and mean density of giant clam species in Moindou based on broad-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

Finer-scale surveys targeted specific areas of clam habitat (Figure 6.29). In reef-benthos assessments (RBt), *T. maxima* was present in 92% of survey stations. The elongate clam was numerous at stations at the outer lagoon (back-reef). Two stations recorded an average of >6000 clams/ha, or almost 2 clams/m². As mentioned above, the RBt stations were concentrated on healthy reef near the outer barrier, where *T. crocea* would probably be less common. These boring clams would more generally be found in the less exposed, inshore areas of the lagoon. Neither *T. derasa* nor *T. squamosa* were recorded on SCUBA surveys conducted for mother-of-pearl species on the outer-reef or in deeper-water surveys for sea cucumbers (Ds).

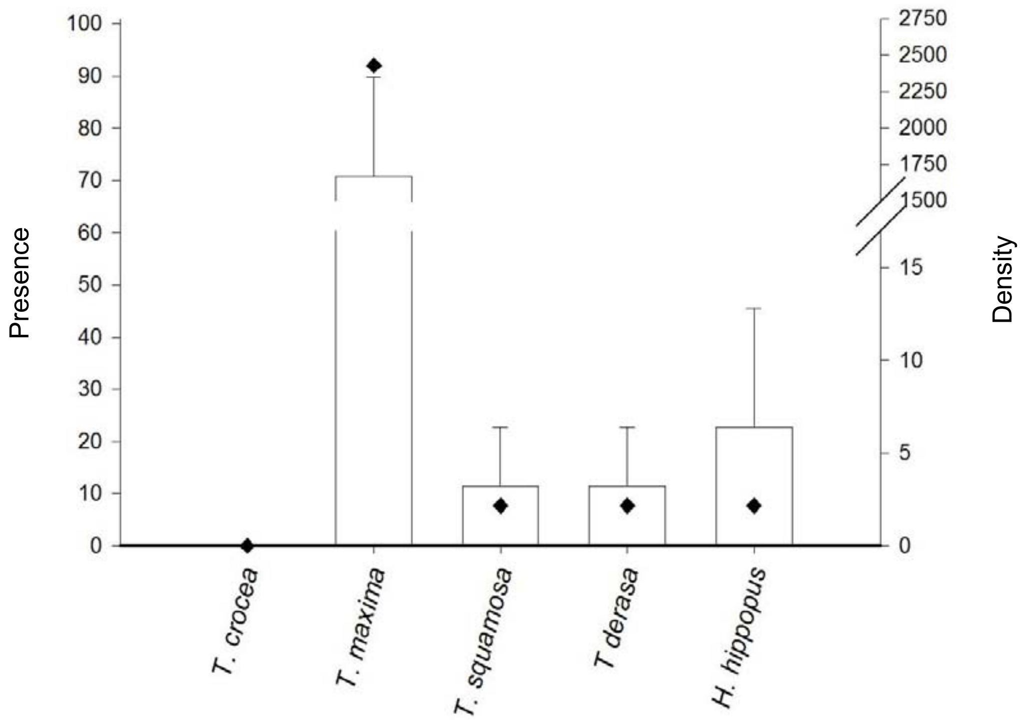

Figure 6.29: Presence and mean density of giant clam species in Moindou based on fine-scale survey.
Presence is measured as % of stations surveyed where clams were present and denoted by black diamonds; density is measured in numbers per hectare and is represented by bars (+SE).

A full range of possible sizes (lengths) of *T. maxima* were recorded in survey. The presence of both small and large individuals (mean 14.6 cm ±0.3) showed that stocks were not under critical fishing pressure, and that recruitment was still strong. *T. maxima* from reef-benthos transects alone (shallow-water reefs) had a slightly smaller mean length (12.8 cm ±0.4, which represents a clam ≥5 years old). The faster-growing *T. squamosa* (which grows to an asymptotic length L∞ of 40 cm) averaged 24.0 cm ±1.6 (>5 years old), whereas *T. derasa*, which were found in relatively good numbers at this site, had a mean shell length of 37.9 cm ±2.0 (~10 years old, L∞ = 47.5 cm). *H. hippopus* averaged 21.8 cm ±2.4 in length, (~5 years old) (Figure 6.30).

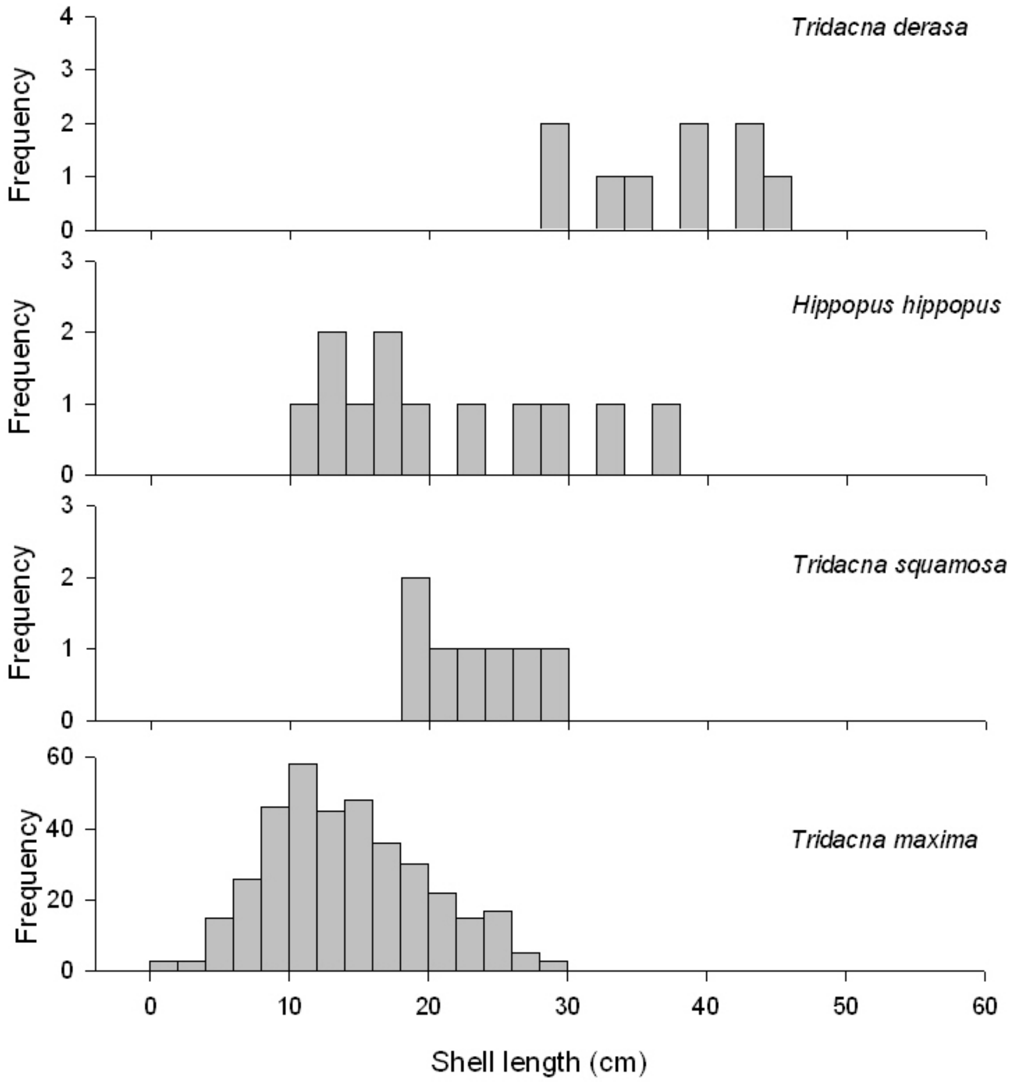

Figure 6.30: Size frequency histograms of giant clam shell length (cm) for Moindou.

6.4.2 Mother-of-pearl species (MOP) – trochus and pearl oysters: Moindou

New Caledonia is relatively close to the southern limit of the natural distribution of the commercial topshell (*Trochus niloticus*) in the Pacific. The outer and lagoon reef at Moindou constitute an extensive suitable benthos for *T. niloticus* and this area could potentially support significant populations of this commercial species (33 km lineal distance of exposed reef perimeter and 23.4 km lineal distance of inner 'false' barrier). PROCFish survey work revealed that *T. niloticus* was present on both the barrier reef (outer-reef slope and reef platform) and within the lagoon (Table 6.13).

Table 6.13: Presence and mean density of *Trochus niloticus*, *Tectus pyramis* and *Pinctada margaritifera* in Moindou
Based on various assessment techniques; mean density measured in numbers per ha (±SE)

	Density	SE	% of stations with species	% of transects or search periods with species
Trochus niloticus				
B-S	4.9	2.1	6/12 = 50	8/72 = 11
RBt	80.1	34.8	6/13 = 46	13/78 = 18
RFs	42.4	22.8	3/5 = 60	14/30 = 47
MOPs	0.0	0.0	0/1 = 0	0/6 = 0
MOPt	687.5	342.5	3/3 = 100	14/18 = 78
Tectus pyramis				
B-S	31.7	7.4	6/12 = 50	25/72 = 35
RBt	871.8	221.3	13/13 = 100	52/78 = 67
RFs	25.1	10.3	5/5 = 100	9/30 = 30
MOPs	36.4		1/1 = 0	2/6 = 33
MOPt	20.8	12.0	2/3 = 66	2/18 = 11
Pinctada margaritifera				
B-S	3.0	0.9	6/12 = 50	10/72 = 14
RBt	6.4	4.3	2/13 = 15	2/78 = 3
RFs	0.0	0.0	0/5 = 0	0/30 = 0
MOPs	0	0	0/1 = 0	0/6 = 0
MOPt	0	0	0/3 = 0	0/18 = 0

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

Aggregations of trochus found in survey were located within the lagoon and on both sides of the barrier reef. The reef on the seaward side of the barrier was quite substantial in area, sloping gently into deeper water. The barrier-reef platform was wave-affected, but embayments behind undulations in the barrier reef provided some protection in this high-energy environment.

Trochus was found at many locations around Moindou (total n = 179 individuals), and densities at areas of the greatest aggregations (MOPt stations) suggest that commercial fishing could be considered under the recommended density threshold of ≥500–600 /ha (Appendix 4.6). However, even though some stations had densities >500–600 /ha, these areas were limited in scale, and only in locations outside the barrier that were difficult to reach (Appendices 4.5.2 to 4.5.8). Presence and density records from reef front searches and shallow reef were far less robust.

To understand the data better, we can examine the range of assessments made within the PROCFish survey. Trochus were recorded in reef-front searches in the surf zone and at reef-benthos transect stations. In the wave zone, trochus were common but at low density, whereas in the shallow reef stations, trochus were patchy and at low-to-moderate density. These results suggest that caution may be needed in recommending that commercial fishing may begin until densities increase across much of the fishery. An increase in density in shallow reefs and a good indication of upcoming recruitment from size measures would allow stocks to respond in a more robust way to fishing pressure.

Analysis of shell size results gives a further indication on whether there has been good spawning in recent years and successful recruitment to the fishery (i.e. whether young, 'new' trochus are entering the adult population). The mean basal width of trochus at Moindou (n = 126) was 9.5 cm ±0.2, which suggests that the bulk of stock in Moindou is relatively young. Trochus reach first maturity at 7–8 cm in New Caledonia, and reach 9 cm at ~3–4 years of age (Figure 6.31).

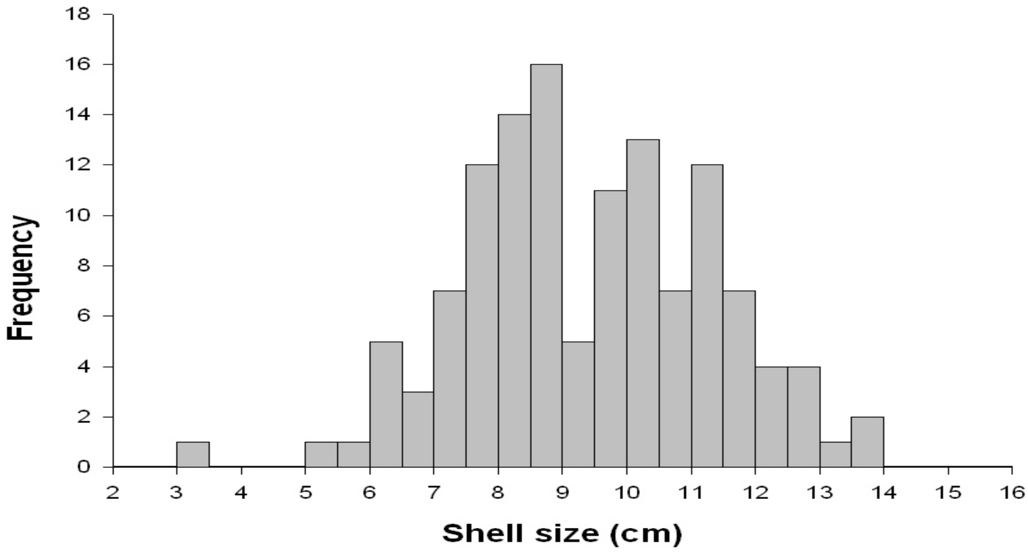

Figure 6.31: Size frequency histogram of trochus shell base diameter (cm) for Moindou.

Reefs in Moindou were characteristic of those found associated with high-island lagoon environments, and supported a large abundance of grazing gastropods. This was further highlighted by results recorded for a gastropod with a similar life history to trochus, the related green topshell (*Tectus pyramis*). This less-valuable species of topshell (also an algal grazer) was also abundant at Moindou, with 450 individuals recorded in survey. The mean size (basal width) of *T. pyramis* (n = 44) was 5.6 cm ±0.2. There was also a full range of green topshell sizes recorded, which suggests that conditions for recent spawning and/or settlement of *T. pyramis* (and possibly trochus) may have been favourable in recent years.

Despite blacklip pearl oysters (*Pinctada margaritifera*) being cryptic and normally sparsely distributed in open lagoon systems (such as found at Moindou), the number of blacklip seen during assessments was relatively high (n = 15). The mean shell length (anterior–posterior measure) was 14.9 cm ±0.7.

The silver-mouthed turban (*Turbo argyrostomus*) is currently being cut for MOP blanks in Vanuatu in experimental operations. This species was common in Moindou (n = 194).

6.4.3 Infaunal species and groups: Moindou

The coastal margin of the lagoon was generally characterised by mangrove and soft benthos and was suitable for concentrations of in-ground resources (shell 'beds'). Fishers reported a number of areas that are targeted for shell collection, but no areas were assessed by the PROCFish team due to time limitations. There was difficulty in working at Moindou as the lagoon and outer reefs could only be reached during periods of high tide, and inshore areas had very low visibility due to wind, and riverine outputs. The extra assessments that were targeted for Moindou concentrated on trying to locate important sea cucumbers that were characteristic to this area, to the detriment of the surveys for infaunal species. However, both

Anadara and *Gafrarium* spp. were recorded as common in soft-benthos transect stations where seagrass and muddy areas were surveyed.

6.4.4 Other gastropods and bivalves: Moindou

Seba's spider conch (*Lambis truncata*, the larger of the two common spider conchs) and *L. lambis* were recorded (n = 7) at low density in broad-scale and fine-scale surveys. *L. chiragra* and *L. crocata* were also seen. The strawberry or red-lipped conch (*Strombus luhuanus*) was also present but again recorded at low density (Appendices 4.5.1–4.5.7). All four species of *Turbo* were recorded in survey (*T. argyrostomus*, *T. chrysostomus*, *T. setosus* and *T. crassus*). The larger, silver-mouthed turban (*T. argyrostomus*) was recorded in 30% of reef-benthos stations at a mean density of 32.1 /ha ±17.7. Higher densities of the more land-influenced species (*T. chrysostomus*) were recorded (in 82% of reef-benthos transect stations, mean density 278.8 /ha ±101.9). In MOPt assessments in front of the barrier reef, where there was more ocean influence and water movement was more dynamic, *T. argyrostomus* was recorded at high density in certain areas (mean density 85.2 /ha ±617.0). Other resource species targeted by fishers (e.g. *Astralium*, *Cerithium*, *Chicoreus*, *Conus*, *Cypraea*, *Ovula*, *Pleuroploca*, *Tectus*, *Telescopium*, *Thais* and *Tutufa*) were also recorded during independent surveys (Appendices 4.5.1–4.5.7).

Data on other bivalves in broad-scale and fine-scale benthos surveys, such as *Atrina*, *Chama*, *Pinna* and *Spondylus*, are also in Appendices 4.5.1–4.5.7. No creel survey was conducted at Moindou.

6.4.5 Lobsters: Moindou

There was no dedicated night reef-front assessment of lobsters (See Methods.). However, three adult lobsters (*Panulirus versicolor* and *Panulirus* sp.) were recorded in broad-scale surveys.

The mud crab (*Scylla serrata*) was recorded on the most inner part of the fringing reef flat, close to the mangrove, in the place called 'le pic à Albert'. It is reportedly quite common in this location, despite not being recorded in the remainder of the study area. Overall, at SBt stations, *S. serrata* was recorded at a density of 4.2 /ha ±2.9, but the actual density at 'le pic à Albert' area was higher: 7 crabs were observed swimming and several burrows were recorded while walking on this part of the reef flat. Another palatable crab (*Portunus pelagicus*) was also recorded on one occasion during the SBt station surveys. *Thalassina* sp., an edible species of crustacean burrowing in the sandy bottom was also recorded at low density.

6.4.6 Sea cucumbers[9]: Moindou

Moindou has an extensive and complex lagoon system bordering a developed mangrove system, and a large land mass (Grande Terre). There was a high degree of exposure at the barrier reef and water movement was dynamic across to the lagoon through two deep passages to the south and west of the site. During the period of the survey, land influences (riverine and other inputs from land) were notable within the inner and mid lagoon, and these

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

shallow-water areas were constantly affected by river outflows and silt stirred up from the muddy bottom by wind and tide, resulting in almost zero visibility. Reef margins and shallow, mixed hard- and soft-benthos habitat (suitable for sea cucumbers, which are generally deposit feeders) was extensive in the lagoon.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 6.14, Appendices 4.5.2–4.5.8; see also Methods). The presence of fifteen commercial species and one indicator species (Table 6.14), reflected the varied and extensive environment of the west-coast lagoon at Moindou. It is possible that an even greater number may have been found had there been more time and access for night searches. Night search stations were not completed, as access to the lagoon through the mangrove at night was difficult and water visibility inshore was poor. The bulk of the survey work was concentrated on reef in the main lagoon and barrier reefs, although later surveys were made to specifically target soft benthos, notably to ascertain the presence and density of the high-value sandfish (*Holothuria scabra*).

Sea cucumber species associated with shallow reef areas, such as leopardfish (*Bohadschia argus*) and the high-value black teatfish (*H. nobilis*) were relatively numerous, but not as common as at Oundjo (found in 15–38% of fine- and broad-scale assessments). Inshore areas closer to the mangrove were highly depositional and silty, which limited the reef species close to shore.

The fast-growing and medium/high-value greenfish (*Stichopus chloronotus*) was not as common as recorded in the east coast PROCFish sites, or in Oundjo (found in 7% of broad-scale transects and in 23% of reef-benthos assessments). Aggregations of greenfish recorded in shallow reefs were not at high density (mean density in RBt stations was only 150 /ha; see Appendix 4.5.3).

Surf redfish (*Actinopyga mauritiana*) was recorded at low density, despite the suitable environment and good coverage (100% of RFs stations). In other locations in the Pacific, this species is recorded in densities >400–500 /ha.

Lower-value species were also recorded, e.g. the elephant trunkfish (*Holothuria fuscopunctata*), lollyfish (*H. atra*) and pinkfish (*H. edulis*). Flowerfish (*Bohadschia graeffei*), which was particularly common on the east coast of Grande Terre, was rare at Moindou. The common, low-value species, *H. atra*, was rarely recorded at sites close to shore, with only two specimens noted in these very rich habitats (average density of 4.2 /ha ±2.9).

Three deep-water passage dives were completed at Moindou to provide a preliminary result for white teatfish (*H. fuscogilva*) and other deeper-water sea cucumber species. White teatfish (*H. fuscogilva*) was recorded at reasonable coverage and density, whereas prickly redfish (*Thelenota ananas*) and amberfish (*T. anax*) were less common.

Protected areas of reef and soft benthos in the more enclosed areas of the lagoon were not easy to access (due to lack of visibility and tide-related access through the mangroves). It is reported that these shallow areas and reef flats were traditionally covered with sandfish, but have been depleted by fishing in the last 30 years (local fisher, M. Maurice Poulain, pers. comm.). A dedicated survey of this coastal fringing flat to see if sandfish and related species were present was made over 20 soft-benthos transect stations (SBt) covering much of the traditional fishing grounds.

In this area, six sea cucumber species were noted; all were at low density except for the false sandfish (*Bohadschia similis*), which is often found in close proximity to the true sandfish (*Holothuria scabra*). Sandfish (*H. scabra*) were recorded only from one area ('pic à Albert'), a reef flat west of Grandjo peninsula (average density for all SBt stations: 14.6 /ha ±6.3). The average length of the seven *H. scabra* noted was 20.9 cm ±1.1, which represents a mature size for this species (largest size noted = 26.5 cm). No juvenile *H. scabra* were noted, with the smallest size being 17.5 cm.

Bohadschia similis, locally called *bêche vermicelle*, was not recorded at the 'pic à Albert' area, but was very abundant southeast of Grandjo peninsula, on the reef flat around Terremba islet, Corbeille islet and Mara island. Overall, the average density recorded was 3379.2 /ha ±816.6 (n = 20 SBt stations). However, on the southeast of Grandjo peninsula, density was very high at 13,516.7 /ha ±6312.4 (n = 5 SBt stations).

Actinopyga spinea was recorded only once, and the more nocturnal *A. miliaris* was recorded twice at a density of 4.2 /ha ±2.9, which is very low for this species.

6.4.7 Other echinoderms: Moindou

Edible urchins, such as the collector urchin (*Tripneustes gratilla*), were absent, but slate urchins (*Heterocentrotus mammillatus*) were common and at high density along the wave face of the barrier reef (in RFs and MOP stations). Other urchins that can be used within assessments as potential indicators of habitat condition (*Echinometra mathaei*, *Mespilia globulus*, and *Echinothrix* spp.) were recorded at moderately high levels. *Echinothrix diadema* was recorded at 33% of broad-scale stations at a density of 400.6 /ha ±191.6 in RBt, and *Mespilia globulus* was recorded at 197.9 /ha ±62.8 in SBt stations.

Starfish, such as the blue starfish (*Linckia laevigata*), were common (found in 58% of broad-scale stations) but were not at high density (<8 /ha). Coralivore (coral-eating) starfish were rare, with nine recordings of a pincushion star (*Culcita novaeguineae*) and seven crown of thorns starfish (*Acanthaster planci*). The horned or chocolate-chip star (*Protoreaster nodosus*) was recorded at moderate density (Appendices 4.5.1–4.5.7).

Table 6.14: Sea cucumber species records for Moindou

Species	Common name	Commercial value [5]	B-S transects n = 66			Reef-benthos stations n = 16			Other stations MOPs = 1; MOPt = 3; SBt = 20; RFs = 5			Other stations Ds = 3		
			D [1]	DwP [2]	PP [3]	D	DwP	PP	D	DwP	PP	D	DwP	PP
Actinopyga echinities	Deepwater redfish	M/H												
Actinopyga lecanora	Stonefish	M/H												
Actinopyga mauritiana	Surf redfish	M/H	1.2	27.8	4				6.9 6.3	20.8 6.3	33 MOPt 100 RFs			
Actinopyga miliaris	Blackfish	M/H	0.9	22.0	4				4.2	41.7	10 SBt	1.2	3.6	33
Actinopyga palauensis	No name as yet	M												
Actinopyga spinea		M/H							2.1	41.7	5 SBt			
Bohadschia argus	Leopardfish	M	22.0	87.8	25	28.8	93.8	31						
Bohadschia graeffei	Flowerfish	L	0.2	16.7	1									
Bohadschia similis	False sandfish	L							3379.2	13,516.7	25 SBt			
Bohadschia vitiensis	Brown sandfish	L	0.2	16.7	1									
Holothuria atra	Lollyfish	L	7.3	33.0	22	41.7	135.4	31	7.6 4.2	7.6 41.7	100 MOPs 10 SBt	3.6	10.7	33
Holothuria coluber	Snakefish	L												
Holothuria edulis	Pinkfish	L	6.4	51.5	13									
Holothuria fuscogilva [4]	White teatfish	H										19.0	28.6	66
Holothuria fuscopunctata	Elephant trunkfish	M	1.4	24.8	6	3.2	41.7	8				3.6	10.7	33
Holothuria nobilis [4]	Black teatfish	H	2.5	16.6	15	38.5	71.4	54	27.3	27.3	100 MOPs	5.9	5.9	100
Holothuria scabra	Sandfish	H							14.6	58.3	25 SBt			
Holothuria scabra versicolor	Golden sandfish	H												
Stichopus chloronotus	Greenfish	H/M	3.2	46.7	7	38.5	166.7	23						
Stichopus hermanni	Curryfish	H/M	0.2	15.4	1							5.9	17.8	33
Stichopus horrens	Dragonfish	M/L												
Thelenota ananas	Prickly redfish	H	1.4	100.0	1				0.8	3.9	20 RFs			
Thelenota anax	Amberfish	M				3.2	41.7	8				3.6	10.7	33

[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; MOPs = mother-of-pearl search; MOPt = mother-of-pearl transect; SBt = soft-benthos transect; Ds = sea cucumber day search.

6.4.8 Discussion and conclusions: invertebrate resources in Moindou

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.

- Moindou has a relatively complete range of giant clam species, some of which are now becoming rare in other parts of the Pacific. In general, the current densities and the range of size classes at Moindou supported the assumption that giant clam stocks were less impacted by fishing pressure than at other sites in New Caledonia.

- *Tridacna crocea* was not recorded but may be present on inshore reefs. *T. gigas* was missing from the site and is generally not found around Grande Terre, New Caledonia.

- Reef habitat at Moindou traversed a range of exposure gradients (from land to ocean influences). The lagoon system at Moindou was generally shallow, but there were ample refuge areas with sufficient depth and water flow for all the species of clams, including the larger species *T. derasa* and *T. squamosa*.

- *T. maxima* and the larger *T. derasa* were located in clearer waters at the 'false' barrier reef and back-reefs at relatively high densities. *H. hippopus* was also relatively common compared to in the other PROCFish sites in New Caledonia.

- This promising indication of stock condition is reported despite there being generally low abundances of the largest species *T. derasa* and *T. squamosa*. These two species are usually the first to decline when fishing pressure impacts stocks. *T. derasa* and *T. squamosa* clam meat is still regularly marketed at the main fish market in Noumea and results from the PROCFish studies across New Caledonia suggest that these species are already depleted – heavily impacted from fishing.

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

- Trochus (*Trochus niloticus*) at Moindou are moderately common, as are other grazing gastropods (e.g. *Tectus pyramis*). Densities of the main aggregations assessed are presently at levels at which commercial fishing is not recommended. Even though some stations had densities >500–600 /ha, these were limited to a small number of stations in difficult-to-reach locations outside the barrier reef (Appendices 4.5.2 to 4.5.8). Presence and density records from reef-front searches and shallow reef support this suggestion for a precautionary approach.

- All sizes of trochus were noted (including shells <8 cm). Smaller trochus are generally very cryptic and their density is usually underestimated in surveys. This result is promising for future growth of the stock.

- The blacklip pearl oyster (*Pinctada margaritifera*) and silver-mouthed turban (*Turbo argyrostomus*) were relatively common at Moindou, but not in sufficient amounts to encourage commercial fishing of shell.

Data collected on sea cucumbers suggest that:

- Moindou has a diverse range of environments and depths suitable for sea cucumbers. Inshore locations were very rich in mangroves and seagrass, while more offshore locations were less protected within a multiple barrier-reef system. Although the scale of the land masses was significant, oceanic influence generally prevailed in the more exposed areas of the outer lagoon.

- The range of sea cucumber species recorded at Moindou was large, partially reflecting the varied environment, but also the fact that the export fishery is controlled and New Caledonia is found in the west Pacific (biogeographical influences).

- Based on the range of sea cucumber species and the general indication from presence and density data collected in survey, there has been moderate-to-high pressure on stocks from commercialisation. The presence of reasonable numbers of black teatfish (*Holothuria nobilis*) suggests that fishing is now less active, although many species are only found at moderate densities.

- The high-value sandfish (*H. scabra*) was found, but in low amounts. Local fisher, Mr Maurice Poulain, stated that early catches were so large that boats sank while transporting catches back to shore. He also suggested there was anecdotal evidence to support the assumption that subsequent recoveries of the fishery were affected by agricultural development on the catchment behind Moindou, when pesticide and farm effluents (agricultural run-off) may have negatively impacted the system.

- The premium-value white teatfish (*H. fuscogilva*) was noted in deep-water assessments at reasonable densities.

6.5 Overall recommendations for Moindou

- Careful monitoring and management of the mud crab resource and fishing practices be implemented, including limiting the total annual catch, the catching methods, and the number of external fishers who target mud crabs in the Moindou fishing ground.

- Further studies be conducted to find out if the cause of the relative scarcity of snappers (Lutjanidae), emperors (Lethrinidae) and goatfish (Mullidae) is related to fishing practice. Until the cause has been found, a precautionary approach to fisheries management may be taken by limiting the catches of snappers, emperors and goatfish. The efficiency of this trial can then be evaluated by monitoring these resources.

- Any further development of reef fish fisheries to improve food and financial security of the people of Moindou be carefully managed and accompanied by monitoring activities. Considering the high quality of habitat in Moindou, marine protected areas can be considered as a primary management tool.

- Commercial trochus (*Trochus niloticus*) fishing not begin until densities reach >500 trochus/ha) in all main aggregations. Protection needs to be given to trochus ≥12 cm, which are valuable spawners and are not preferred by industry buyers.

- Protective measures be taken to allow the sandfish (*Holothuria scabra*) to recover, as the habitat looked very suitable for this high-value species.

- Further assessment of the premium-value white teatfish (*Holothuria fuscogilva*) be undertaken to determine the full condition of this stock and availability for commercial fishing.

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APPENDIX 1: SURVEY METHODS

1.1 Socioeconomic surveys, questionnaires and average invertebrate wet weights

1.1.1 Socioeconomic survey methods

Preparation

The PROCFish/C socioeconomic survey is planned in close cooperation with local counterparts from national fisheries authorities. It makes use of information gathered during the selection process for the four sites chosen for each of the PROCFish/C participating countries and territories, as well as any information obtained by resource assessments, if these precede the survey.

Information is gathered regarding the target communities, with preparatory work for a particular socioeconomic field survey carried out by the local fisheries counterparts, the project's attachment, or another person charged with facilitating and/or participating in the socioeconomic survey. In the process of carrying out the surveys, training opportunities are provided for local fisheries staff in the PROCFish/C socioeconomic field survey methodology.

Staff are careful to respect local cultural and traditional practices, and follow any local protocols while implementing the field surveys. The aim is to cause minimal disturbance to community life, and surveys have consequently been modified to suit local habits, with both the time interviews are held and the length of the interviews adjusted in various communities. In addition, an effort is made to hold community meetings to inform and brief community members in conjunction with each socioeconomic field survey.

Approach

The design of the socioeconomic survey stems from the project focus, which is on rural coastal communities in which traditional social structures are to some degree intact. Consequently, survey questions assume that the primary sectors (and fisheries in particular) are of importance to communities, and that communities currently depend on coastal marine resources for their subsistence needs. As urbanisation increases, other factors gain in importance, such as migration, as well as external influences that work in opposition to a subsistence-based socioeconomic system in the Pacific (e.g. the drive to maximise income, changes in lifestyle and diet, and increased dependence on imported foods). The latter are not considered in this survey.

The project utilises a 'snapshot approach' that provides 5–7 working days per site (with four sites per country). This timeframe generally allows about 25 households (and a corresponding number of associated finfish and invertebrate fishers) to be covered by the survey. The total number of finfish and invertebrate fishers interviewed also depends on the complexity of the fisheries practised by a particular community, the degree to which both sexes are engaged in finfish and invertebrate fisheries, and the size of the total target population. Data from finfish and invertebrate fisher interviews are grouped by habitat and fishery, respectively. Thus, the project's time and budget and the complexity of a particular site's fisheries are what determine the level of data representation: the larger the population and the number of fishers, and the more diversified the finfish and invertebrate fisheries, the lower the level of representation that can be achieved. It is crucial that this limitation be taken into consideration, because the data gathered through each survey and the emerging distribution patterns are extrapolated to estimate the total annual impact of all fishing activity reported for the entire community at each site.

If possible, people involved in marketing (at local, regional or international scale) who operate in targeted communities are also surveyed (e.g. agents, middlemen, shop owners).

Key informants are targeted in each community to collect general information on the nature of local fisheries and to learn about the major players in each of the fisheries that is of concern, and about fishing rights and local problems. The number of key informants interviewed depends on the complexity and heterogeneity of the community's socioeconomic system and its fisheries.

At each site the extent of the community to be covered by the socioeconomic survey is determined by the size, nature and use of the fishing grounds. This selection process is highly dependent on local marine tenure rights. For example, in the case of community-owned fishing rights, a fishing community includes all villages that have access to a particular fishing ground. If the fisheries of all the villages concerned are comparable, one or two villages may be selected as representative samples, and consequently surveyed. Results will then be extrapolated to include all villages accessing the same fishing grounds under the same marine tenure system.

In an open access system, geographical distance may be used to determine which fishing communities realistically have access to a certain area. Alternatively, in the case of smaller islands, the entire island and its adjacent fishing grounds may be considered as one site. In this case a large number of villages may have access to the fishing ground, and representative villages, or a cross-section of the population of all villages, are selected to be included in the survey.

In addition, fishers (particularly invertebrate fishers) are regularly asked how many people external to the surveyed community also harvest from the same fishing grounds and/or are engaged in the same fisheries. If responses provide a concise pattern, the magnitude of additional impact possibly imposed by these external fishers is determined and discussed.

Sampling

Most of the households included in the survey are chosen by simple random selection, as are the finfish and invertebrate fishers associated with any of these households. In addition, important participants in one or several particular fisheries may be selected for complementary surveying. Random sampling is used to provide an average and representative picture of the fishery situation in each community, including those who do not fish, those engaged in finfish and/or invertebrate fishing for subsistence, and those engaged in fishing activities on a small-scale artisanal basis. This assumption applies provided that selected communities are mostly traditional, relatively small (~100–300 households) and (from a socioeconomic point of view) largely homogenous. Similarly, gender and participation patterns (types of fishers by gender and fishery) revealed through the surveys are assumed to be representative of the entire community. Accordingly, harvest figures reported by male and female fishers participating in a community's various fisheries may be extrapolated to assess the impacts resulting from the entire community, sample size permitting (at least 25–30% of all households).

Data collection and analysis

Data collection is performed using a standard set of questionnaires developed by PROCFish/C's socioeconomic component, which include a household survey (key socioeconomic parameters and consumption patterns), finfish fisheries survey, invertebrate fisheries survey, marketing of finfish survey, marketing of invertebrates survey, and general information questionnaire (for key informants). In addition, further observations and relevant details are noted and recorded in a non-standardised format. The complete set of questionnaires used is attached as Appendix 1.1.2.

Most of the data are collected in the context of face-to-face interviews. Names of people interviewed are recorded on each questionnaire to facilitate cross-identification of fishers and households during data collection and to ensure that each fisher interview is complemented by a household interview. Linking data from household and fishery surveys is essential to permit joint data analysis. However, all names are suppressed once the data entry has been finalised, and thus the information provided by respondents remains anonymous.

Questionnaires are fully structured and closed, although open questions may be added on a case-to-case situation. If translation is required, each interview is conducted jointly by the leader of the project's socioeconomic team and the local counterpart. In cases where no translation is needed, the project's socioeconomist may work individually. Selected interviews may be conducted by trainees receiving advanced field training, but trainees are monitored by project staff in case clarification or support is needed.

The questionnaires are designed to allow a minimum dataset to be developed for each site, one that allows:

- the community's dependency on marine resources to be characterised;
- assessment of the community's engagement in and the possible impact of finfish and invertebrate harvesting; and
- comparison of socioeconomic information with data collected through PROCFish/C resource surveys.

Household survey

The major objectives of the household survey are to:

- **collect recent demographic information** (needed to calculate seafood consumption);
- **determine the number of fishers per household, by gender and type of fishing activity** (needed to assess a community's total fishing impact); and
- **assess the community's relative dependency on marine resources** (in terms of ranked source(s) of income, household expenditure level, agricultural alternatives for subsistence and income (e.g. land, livestock), external financial input (i.e. remittances), assets related to fishing (number and type of boat(s)), and seafood consumption patterns by frequency, quantity and type).

The demographic assessment focuses only on permanent residents, and excludes any family members who are absent more often than they are present, who do not normally share the household's meals or who only join on a short-term visitor basis (for example, students during school holidays, or emigrant workers returning for home leave).

The number of fishers per household distinguishes three categories of adult (≥ 15 years) fishers for each gender: (1) exclusive finfish fishers, (2) exclusive invertebrate fishers, and (3) fishers who pursue both finfish and invertebrate fisheries. This question also establishes the percentage of households that do not fish at all. We use this pattern (i.e. the total number of fishers by type and gender) to determine the number of female and male fishers, and the percentage of these who practise either finfish or invertebrate fisheries exclusively, or who practise both. The share of adult men and women pursuing each of the three fishery categories is presented as a percentage of all fishers. Figures for the total number of people in each fishery category, by gender, are also used to calculate total fishing impact (see below).

The role of fisheries as a source of income in a community is established by a ranking system. Generally, rural coastal communities represent a combined system of traditional (subsistence) and cash-generating activities. The latter are often diversified, mostly involving the primary sector, and are closely associated with traditional subsistence activities. Cash flow is often irregular, tailored to meet seasonal or occasional needs (school and church fees, funerals, weddings, etc.). Ranking of different sources of income by order of importance is therefore a better way to render useful information than trying to quantify total cash income over a certain time period. Depending on the degree of diversification, multiple entries are common. It is also possible for one household to record two different activities (such as fisheries and agriculture) as equally important (i.e. both are ranked as a first source of income, as they equally and importantly contribute to acquisition of cash within the household). In order to demonstrate the degree of diversification and allow for multiple entries, the role that each sector plays is presented as a percentage of the total number of households surveyed. Consequently, the sum of all figures may exceed 100%. Income sources include fisheries, agriculture, salaries, and 'others', with the latter including primarily handicrafts, but sometimes also small private businesses such as shops or kava bars.

Cash income is often generated in parallel by various members of one household and may also be administered by many, making it difficult to establish the overall expenditure level. On the other hand, the head of the household and/or the woman in charge of managing and organising the household are typically aware and in control of a certain amount of money that is needed to ensure basic and common household needs are met. We therefore ask for the level of average household expenditure only, on a weekly, bi-weekly or monthly basis, depending on the payment interval common in a particular community. Expenditures quoted in local currency are converted into US dollars (USD) to enable regional comparison. Conversion factors used are indicated.

Geomorphologic differences between low and high islands influence the role that agriculture plays in a community, but differences in land tenure systems and the particulars of each site are also important, and the latter factors are used in determining the percentage of households that have access to gardens and agricultural land, the average size of these areas, and the type (and if possible number) of livestock that are at the disposal of an average household. A community whose members are equally engaged in agriculture and fisheries will either show distinct groups of fishers and farmers/gardeners, or reveal active and non-active fishing seasons in response to the agricultural calendar.

We can use the frequency and amount of remittances received from family members working elsewhere in the country or overseas to assess the degree to which principles of the MIRAB economy apply. MIRAB was coined to characterise an economy dependent on migration, remittances, foreign aid and government bureaucracy as its major sources of revenue (Small and Dixon 2004; Bertram 1999; Bertram and Watters 1985). A high influx of foreign financing, and in particular remittances, is considered to yield flexible yet stable economic conditions at the community level (Evans 2001), and may also substitute for or reduce the need for local income-generating activities, such as fishing.

The number of boats per household is indicative of the level of isolation, and is generally higher for communities that are located on small islands and far from the nearest regional centre and market. The nature of the boats (e.g. non-motorised, handmade dugout canoes, dugouts equipped with sails, and the number and size of any motorised boats) provides insights into the level of investment, and usually relates to the household expenditure level. Having access to boats that are less sensitive to sea conditions and equipped with outboard engines provides greater choice of which fishing grounds to target, decreases isolation and increases independence in terms of transport, and hence provides fishing and marketing advantages. Larger and more powerful boats may also have a multiplication factor, as they accommodate bigger fishing parties. In this context it should be noted that information on boats is usually complemented by a separate boat inventory performed by interviewing key informants and senior members of the community. If possible, we prefer to use the information from the complementary boat inventory surveys rather than extrapolating data from household surveys, in order to minimise extrapolation errors.

A variety of data are collected to characterise the seafood consumption of each community. We distinguish between fresh fish (with an emphasis on reef and lagoon fish species), invertebrates and canned fish. Because meals are usually prepared for and shared by all household members, and certain dishes may be prepared in the morning but consumed throughout the day, we ask for the average quantity prepared for one day's consumption. In the case of fresh fish we ask for the number of fish per size class, or the total weight, usually consumed. However, the weight is rarely known, as most communities are largely self-sufficient in fresh fish supply and local, non-metric units are used for marketing of fish (heap, string, bag, etc.). Information on the number of size classes consumed allows calculation of weight using length–weight relationships, which are known for most finfish species (FishBase 2000, refer to Letourneur *et al.* 1998; Kulbicki pers. com.). Size classes (using fork length) are identified using size charts (Figure A1.1.1).

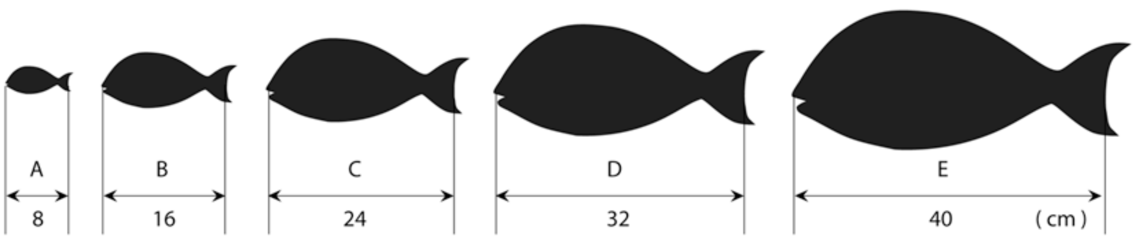

Figure A1.1.1: Finfish size field survey chart for estimating average length of reef and lagoon fish (including five size classes from A = 8 cm to E = 40 cm, in 8 cm intervals).

The frequency of all consumption data is adjusted downwards by 17% (a factor of 0.83 determined on the basis that about two months of the year are not used for fishing due to festivities, funerals and bad weather conditions) to take into account exceptional periods throughout the year when the supply of fresh fish is limited or when usual fish eating patterns are interrupted.

Equation for fresh finfish:

$$F_{wj} = \sum_{i=1}^{n} (N_{ij} \bullet W_i) \bullet 0.8 \bullet F_{dj} \bullet 52 \bullet 0.83$$

F_{wj} = finfish net weight consumption (kg edible meat/household/year) for household$_j$
n = number of size classes
N_{ij} = number of fish of size class$_i$ for household$_j$
W_i = weight (kg) of size class$_i$
0.8 = correction factor for non-edible fish parts
F_{dj} = frequency of finfish consumption (days/week) of household$_j$
52 = total number of weeks/year
0.83 = correction factor for frequency of consumption

For invertebrates, respondents provide numbers and sizes or weight (kg) per species or species groups usually consumed. Our calculation automatically transfers these data entries per species/species group into wet weight using an index of average wet weight per unit and species/species group (Appendix 1.1.3).[1] The total wet weight is then automatically further broken down into edible and non-edible proportions. Because edible and non-edible proportions may vary considerably, this calculation is done for each species/species group individually (e.g. compare an octopus that consists almost entirely of edible parts with a giant clam that has most of its wet weight captured in its non-edible shell).

Equation for invertebrates:

$$Inv_{wj} = \sum_{i=1}^{n} E_{p_i} \bullet (N_{ij} \bullet W_{wi}) \bullet F_{dj} \bullet 52 \bullet 0.83$$

Inv_{wj} = invertebrate weight consumption (kg edible meat/household/year) of household$_j$
E_{pi} = percentage edible (1 = 100%) for species/species group$_i$ (Appendix 1.1.3)
N_{ij} = number of invertebrates for species/species group$_i$ for household$_j$
n = number of species/species group consumed by household$_j$
W_{wi} = wet weight (kg) of unit (piece) for invertebrate species/species group$_i$
1000 = to convert g invertebrate weight into kg
F_{dj} = frequency of invertebrate consumption (days/week) for household$_j$
52 = total number of weeks/year
0.83 = correction factor for consumption frequency

[1] The index used here mainly consists of estimated average wet weights and ratios of edible and non-edible parts per species/species group. At present, SPC's Reef Fishery Observatory is making efforts to improve this index so as to allow further specification of wet weight and edible proportion as a function of size per species/species group. The software will be updated and users informed about changes once input data are available.

Equation for canned fish:

Canned fish data are entered as total number of cans per can size consumed by the household at a daily meal, i.e.:

$$CF_{wj} = \sum_{i=1}^{n} (N_{cij} \bullet W_{ci}) \bullet F_{dcj} \bullet 52$$

CF_{wj} = canned fish net weight consumption (kg meat/household/year) of household$_j$
N_{cij} = number of cans of can size$_i$ for household$_j$
n = number and size of cans consumed by household$_j$
W_{ci} = average net weight (kg)/can size$_i$
F_{dcj} = frequency of canned fish consumption (days/week) for household$_j$
52 = total number of weeks/year

Age-gender correction factors are used because simply dividing total household consumption by the number of people in the household will result in underestimating per head consumption. For example, imagine the difference in consumption levels between a 40-year-old man as compared to a five-year-old child. We use simplified gender-age correction factors following the system established and used by the World Health Organization (WHO; Becker and Helsing 1991), i.e. (Kronen *et al.* 2006):

Age (years)	Gender	Factor
≤5	All	0.3
6–11	All	0.6
12–13	Male	0.8
≥12	Female	0.8
14–59	Male	1.0
≥60	Male	0.8

The per capita finfish, invertebrate and canned fish consumptions are then calculated by selecting the relevant formula from the three provided below:

Finfish per capita consumption:

$$F_{pcj} = \frac{F_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

F_{pcj} = Finfish net weight consumption (kg/capita/year) for household$_j$
F_{wj} = Finfish net weight consumption (kg/household/year) for household$_j$
n = number of age-gender classes
AC_{ij} = number of people for age class i and household j
C_i = correction factor of age-gender class$_i$

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Invertebrate per capita consumption:

$$Inv_{pcj} = \frac{Inv_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

Inv_{pcj} = Invertebrate weight consumption (kg edible meat/capita/year) for household$_j$
Inv_{wj} = Invertebrate weight consumption (kg edible meat/household/year) for household$_j$
n = number of age-gender classes
AC_{ij} = number of people for age class i and household j
C_i = correction factor of age-gender class$_i$

Canned fish per capita consumption:

$$CF_{pcj} = \frac{CF_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) for household$_j$
CF_{wj} = canned fish net weight consumption (kg/household/year) for household$_j$
n = number of age-gender classes
AC_{ij} = number of people for age class$_i$ and household$_j$
C_i = correction factor of age-gender class$_i$

The total finfish, invertebrate and canned fish consumption of a known population is calculated by extrapolating the average per capita consumption for finfish, invertebrates and canned fish of the sample size to the entire population.

Total finfish consumption:

$$F_{tot} = \frac{\sum_{j=1}^{n} F_{pcj}}{n_{ss}} \bullet n_{pop}$$

F_{pcj} = finfish net weight consumption (kg/capita/year) for household$_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

Total invertebrate consumption:

$$Inv_{tot} = \frac{\sum_{j=1}^{n} Inv_{pcj}}{n_{ss}} \bullet n_{pop}$$

Inv_{pcj} = invertebrate weight consumption (kg edible meat/capita/year) for household$_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

Total canned fish consumption:

$$CF_{tot} = \frac{\sum_{j=1}^{n} CF_{pcj}}{n_{ss}} \bullet n_{pop}$$

CF_{pcj} = canned fish net weight consumption (kg/capita/year) of household$_j$
n_{ss} = number of people in sample size
n_{pop} = number of people in total population

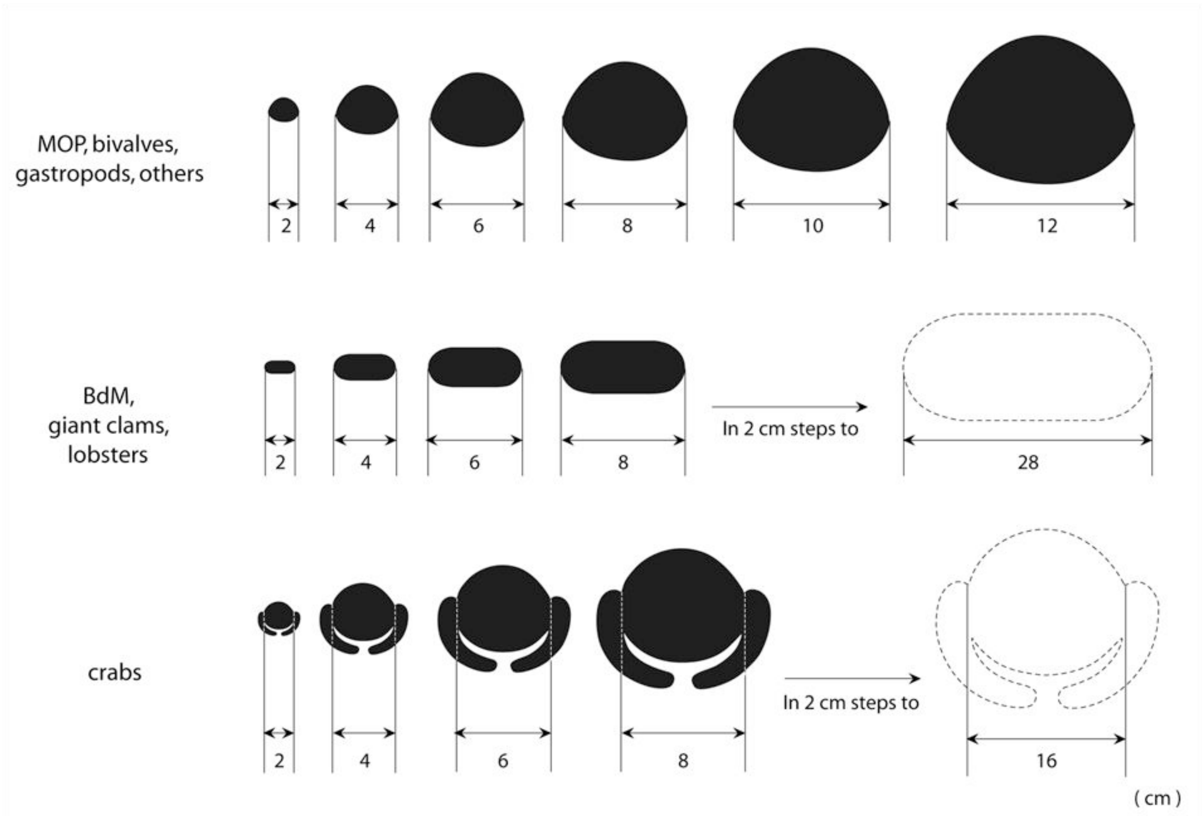

Figure A1.1.2: Invertebrate size field survey chart for estimating average length of different species groups (2 cm size intervals).

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Finfish fisher survey

The finfish fisher survey primarily aims to collect the data needed to understand finfish fisheries strategies, patterns and dimensions, and thus possible impacts on the resource. Data collection faces the challenge of retrieving information from local people that needs to match resource survey parameters, in order to make joint data analysis possible. This challenge is highlighted by the following three major issues:

(i) Fishing grounds are classified by habitat, with the latter defined using geomorphologic characteristics. Local people's perceptions of and hence distinctions between fishing grounds often differ substantially from the classifications developed by the project. Also, fishers do not target particular areas according to their geomorphologic characteristics, but instead due to a combination of different factors including time and transport availability, testing of preferred fishing spots, and preferences of members of the fishing party. As a result, fishers may shift between various habitats during one fishing trip. Fishers also target lagoon and mangrove areas, as well as passages if these are available, all of which cannot be included in the resource surveys. It should be noted that a different terminology for reef and other areas fished is needed to communicate with fishers.

    These problems are dealt with by asking fishers to indicate the areas they refer to as coastal reef, lagoon, outer-reef and pelagic fishing on hydrologic charts, maps or aerial photographs. In this way we can often further refine the commonly used terms of coastal or outer reef to better match the geomorphologic classification. The proportion of fishers targeting each habitat is provided as a percentage of all fishers surveyed; the socioeconomic analysis refers to habitats by the commonly used descriptive terms for these habitats, rather than the ecological or geomorphologic classifications.

    Fishers may travel between various habitats during a single fishing trip, with differing amounts of time spent in each of the combined habitats; the catch that is retrieved from each combined habitat may potentially vary from one trip to the next. If targeting combined habitats is a common strategy practised by most fishers, the resource data for individual geomorphologic habitats need to be lumped to enable comparison of results.

(ii) People usually provide information on fish by vernacular or common names, which are far less specific than (and thus not compatible with) scientific nomenclature. Vernacular name systems are often very localised, changing with local languages, and thus may differ significantly between the sites surveyed in one country alone. As a result, one fish species may be associated with a number of vernacular names, but each vernacular name may also apply to more than one species.

    This issue is addressed, as much as possible, through indexing the vernacular names recorded during a survey to the scientific names for those species. However, this is not always possible due to inconsistencies between informants. The use of photographic indices is helpful but can also trigger misleading information, due to the variety of photos presented and the limitations of species recognition using photos alone. In this respect, collaboration with local counterparts from fisheries departments is crucial.

(iii) The assessment of possible fishing impacts is based on the collection of average data. Accordingly, fishers are requested to provide information on a catch that is neither exceptionally good nor exceptionally bad. They are also requested to provide this information concerning the most commonly caught species. This average information suffers from two major shortcomings. Firstly, some fish species are seasonal and may be dominant during a short period of the year but do not necessarily appear frequently in the average catch. Depending on the time of survey implementation this may result in over- or under-representation of these species. Secondly, fishers usually employ more than one technique. Average catches may vary substantially by quantity and quality depending on which technique they use.

We address these problems by recording any fish that plays a seasonal role. This information may be added and helpful for joint interpretation of resource and socioeconomic data. Average catch records are complemented by information on the technique used, and fishers are encouraged to provide the average catch information for the technique that they employ most often.

The design of the finfish fisher survey allows the collection of details on fishing strategies, and quantitative and qualitative data on average catches for each habitat. Targeting men and women fishers allows differences between genders to be established.

Determination of <u>fishing strategies</u> includes:

- frequency of fishing trips
- mode and frequency of transport used for fishing
- size of fishing parties
- duration of the fishing trip
- time of fishing
- months fished
- techniques used
- ice used
- use of catch
- additional involvement in invertebrate fisheries.

The frequency of fishing trips is determined by the number of weekly (or monthly) trips that are regularly made. The average figure resulting from data for all fishers surveyed, per habitat targeted, provides a first impression of the community's engagement in finfish fisheries and shows whether or not different habitats are fished with the same frequency.

Information on the utilisation of non-motorised or motorised boat transport for fishing helps to assess accessibility, availability and choice of fishing grounds. Motorised boats may also represent a multiplication factor as they may accommodate larger fishing parties.

We ask about the size of the fishing party that the interviewee usually joins to learn whether there are particularly active or regular fisher groups, whether these are linked to fishing in certain habitats, and whether there is an association between the size of a fishing party and fishing for subsistence or sale. We also use this information to determine whether information regarding an average catch applies to one or to several fishers.

The duration of a fishing trip is defined as the time spent from any preparatory work through the landing of the catch. This definition takes into account the fact that fishing in a Pacific Island context does not follow a western economic approach of benefit maximisation, but is a more integral component of people's lifestyles. Preparatory time may include up to several hours spent reaching the targeted fishing ground. Fishing time may also include any time spent on the water, regardless of whether there was active fishing going on. The average trip duration is calculated for each habitat fished, and is usually compared to the average frequency of trips to these habitats (see discussion above).

Temporal fishing patterns – the times when most people go fishing – may reveal whether the timing of fishing activities depends primarily on individual time preferences or on the tides. There are often distinct differences between different fisher groups (e.g. those that fish mostly for food or mostly for sale, men and women, and fishers using different techniques). Results are provided in percentage of fishers interviewed for each habitat fished.

To calculate total annual fishing impact, we determine the total number of months that each interviewee fishes. As mentioned earlier, the seasonality of complementary activities (e.g. agriculture), seasonal closing of fishing areas, etc. may result in distinct fishing patterns. To take into account exceptional periods throughout the year when fishing is not possible or not pursued, we apply a correction factor of 0.83 to the total provided by people interviewed (this factor is determined on the basis that about two months of every year – specifically, 304/365 days – are not used for fishing due to festivals, funerals and bad weather conditions).

Knowing the range of techniques used and learning which technique(s) is/are predominantly used helps to identify the possible causes of detrimental impacts on the resource. For example, the predominant use of gillnets, combined with particular mesh sizes, may help to assess the impact on a certain number of possible target species, and on the size classes that would be caught. Similarly, spearfishing targets particular species, and the impacts of spearfishing on the abundance of these species in the habitats concerned may become evident. To reveal the degree to which fishers use a variety of different techniques, the percentage of techniques used refers to the proportion of all fishers who use that technique. Percentages show which techniques are used by most or even all fishers, and which are used by smaller groups. In addition, the data are presented by habitat (what percentage of fishers targeting a habitat use a particular technique, where n = the total number of fishers interviewed by habitat).

The use of ice (whether it is used at all, used infrequently or used regularly) hints at the degree of commercialisation, available infrastructure and investment level. Usually, communities targeted by our project are remote and rather isolated, and infrastructure is rudimentary. Thus, ice needs to be purchased and is often obtained from distant sources, with attendant costs in terms of transport and time. On the other hand, ice may be the decisive input that allows marketing at a regional or urban centre. The availability of ice may also be a decisive factor in determining the frequency of fishing trips.

Determining the use of the catch or shares thereof for various purposes (subsistence, non-monetary exchange and sale) is a necessary prerequisite to providing fishery management advice. Fishing pressure is relatively stable if determined predominantly by the community's subsistence demand. Fishing is limited by the quantity that the community can consume, and changes occur in response to population growth and/or changes in eating habits. In contrast, if fishing is performed mainly for external sale, fishing pressure varies according to outside market demand (which may be dynamic) and the cost-benefit (to fishers) of fishing. Fishing strategies may vary accordingly and significantly. The recorded purposes of fishing are presented as the percentage of all fishers interviewed per habitat fished. We distinguish these figures by habitat so as to allow for the fact that one fisher may fish several habitats but do so for different purposes.

Information on the additional involvement of interviewed fishers in invertebrate fisheries, for either subsistence or commercial purposes, helps us to understand the subsistence and/or commercial importance of various coastal resources. The percentage of finfish fishers who also harvest invertebrates is calculated, with the share of these who do so for subsistence and/or for commercial purposes presented in percentage (the sum of the latter percentages may exceed 100, because fishers may harvest invertebrates for both subsistence and sale).

The average catch per habitat (technique and transport used) is recorded, including:

- a list of species, usually by vernacular names; and
- the kg or number per size class for each species.

These data are used to calculate total weight per species and size class, using a weight–length conversion factor (FishBase 2000, refer to Letourneur *et al.* 1998; Kulbicki pers. com.). This requires using the vernacular/scientific name index to relate (as far as possible) local names to their scientific counterparts. Fish length is reported by using size charts that comprise five major size classes in 8 cm intervals, i.e. 8 cm, 16 cm, 24 cm, 32 cm and 40 cm. The length of any fish that exceeds the largest size class (40 cm) presented in the chart is individually estimated using a tape measure. The length–weight relationship is calculated for each site using a regression on catch records from finfish fishers' interviews weighted by the annual catch. Data used from the catch records consist of scientific names correlated to the vernacular names given by fishers, number of fish, size class (or measured size) and/or weight. In other words, we use the known length–weight relationship for the corresponding species to vernacular names recorded.

Once we have established the average and total weight per species and size class recorded, we provide an overview of the average size for each family. The resulting pattern allows analysis of the degree to which average and relative sizes of species within the various families present at a particular site are homogeneous. The same average distribution pattern is calculated for all families, per habitat, in order to reveal major differences due to the locations where the fish were caught. Finally, we combine all fish records caught, per habitat and site, to determine what proportion of the extrapolated total annual catch is composed of each of the various size classes. This comparison helps to establish the most dominant size class caught overall, and also reveals major differences between the habitats present at a site.

Catch data are further used to calculate the total weight for each family (includes all species reported) and habitat. We then convert these figures into the percentage distribution of the total annual catch, by family and habitat. Comparison of relative catch composition helps to identify commonalities and major differences, by habitat and between those fish families that are most frequently caught.

A number of parameters from the household and fisher surveys are used to calculate the total annual catch volume per site, habitat, gender, and use of the catch (for subsistence and/or commercial purposes).

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Data from the household survey regarding the number of fishers (by gender and type of fishery) in each household interviewed are extrapolated to determine the total number of men and women that target finfish, invertebrates, or both.

Data from the fisher survey are used to determine what proportion of men and women fishers target various habitats or combinations of habitats. These figures are assumed to be representative of the community as a whole, and hence are applied to the total number of fishers (as determined by the household survey). The total number of finfish fishers is the sum of all fishers who solely target finfish, and those who target both finfish and invertebrates; the same system is applied for invertebrate fishers (i.e. it includes those who collect only invertebrates and those who target both invertebrates and finfish. These numbers are also disaggregated by gender.

The total annual catch per fisher interviewed is calculated, and the average total annual catch reported for each type of fishing activity/fishery (including finfish and invertebrates) by gender is then multiplied by the total number of fishers (calculated as detailed above, for each type of fishing activity/fishery and both genders). More details on the calculation applied to invertebrate fisheries are provided below.

<u>Total annual catch (t/year):</u>

$$\text{TAC} = \sum_{h=1}^{N_h} \frac{Fif_h \bullet Acf_h + Fim_h \bullet Acm_h}{1000}$$

TAC = total annual catch t/year
Fif_h = total number of female fishers for habitat_h
Acf_h = average annual catch of female fishers (kg/year) for habitat_h
Fim_h = total number of male fishers for habitat_h
Acm_h = average annual catch of male fishers (kg/year) for habitat_h
N_h = number of habitats

Where:

$$\text{Acf}_h = \frac{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cfi}{If_h} \bullet \frac{\sum_{k=1}^{Rf_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

If_h = number of interviews of female fishers for habitat_h (total number of interviews where female fishers provided detailed information for habitat_h)
f_i = frequency of fishing trips (trips/week) as reported on interview_i
Fm_i = number of months fished (reported in interview_i)
Cf_i = average catch reported in interview_i (all species)
Rf_h = number of targeted habitats as reported by female fishers for habitat_h (total numbers of interviews where female fishers reported targeting habitat_h but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat_k
Fm_k = number of months fished for reported habitat_k (fishers = sum of finfish fishers and mixed fishers, i.e. people pursuing both finfish and invertebrate fishing)

Thus, we obtain the total annual catch by habitat and gender group. The sum of all catches from all habitats and both genders equals the total annual impact of the community on its fishing ground.

The accuracy of this calculation is determined by reliability of the data provided by interviewees, and the extrapolation procedure. The variability of the data obtained through fisher surveys is illuminated by providing standard errors for the calculated average total annual catches. The size of any error stemming from our extrapolation procedure will vary according to the total population at each site. As mentioned above, this approach is best suited to assess small and predominantly traditional coastal communities. Thus, the risk of over- or underestimating fishing impact increases in larger communities, and those with greater urban influences. We provide both the total annual catch by interviewees (as determined from fisher records) and the extrapolated total impact of the community, so as to allow comparison between recorded and extrapolated data.

The total annual finfish consumption of the surveyed community is used to determine the share of the total annual catch that is used for subsistence, with the remainder being the proportion of the catch that is exported (sold externally).

<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.

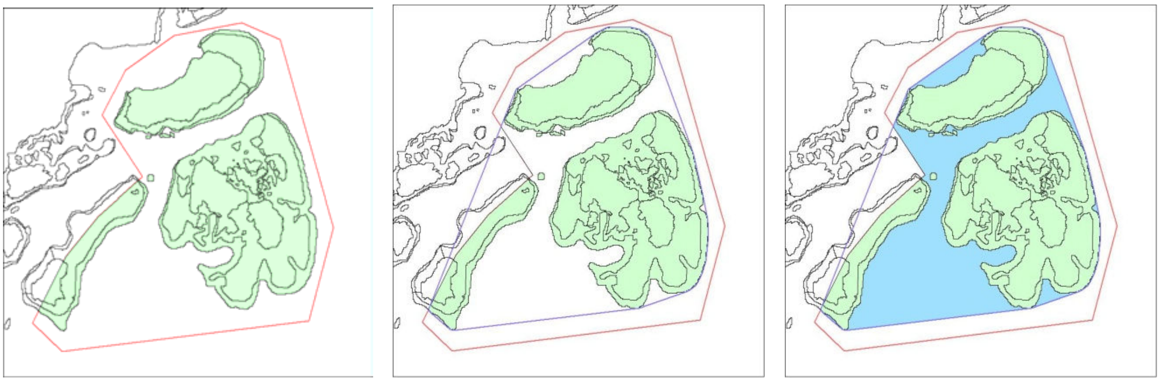

Figure A1.1.3: Determination of lagoon area.
The fishing ground (in red) is initially delineated using information from fishers. Reef areas within the fishing area (in green; interpreted from satellite data) are then identified. The remaining non-reef areas within the fishing grounds are labelled as 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).

Appendix 1: Survey methods
Socioeconomics

The number of different vernacular names recorded for each fishery is useful to distinguish between opportunistic and specialised harvesting strategies. This distribution is particularly interesting when comparing gleaning fisheries, while commercial dive fisheries are species specific by definition.

The calculation of catch volumes is based on the determination of the total number of invertebrate fishers and fishers targeting both finfish and invertebrates, by gender group and by fishery, as described above.

The average invertebrate catch composition by number, size and species (with vernacular names transferred to scientific nomenclature), and by fishery and gender group, is extrapolated to include all fishers concerned. Conversion of numbers and species by average weight factors (Appendix 1.1.3) results in a determination of total biomass (wet weight) removed, by fishery and by gender. The sum of all weights determines the total annual impact, in terms of biomass removed.

To calculate total annual impact, we determine the total numbers of months fished by each interviewee. As mentioned above, seasonality of complementary activities, seasonal closing of fishing areas, etc. may result in distinct fishing patterns. Based on data provided by interviewees, we apply – as for finfish – a correction factor of 0.83 to take into account exceptional periods throughout the year when fishing is not possible or not pursued (this is determined on the basis that about two months (304/365 days) of each year are not used for fishing due to festivals, funerals and bad weather conditions).

Total annual catch:

$$\text{TACj} = \sum_{h=1}^{N_h} \frac{F_{inv}f_h \bullet Ac_{inv}f_{hj} + F_{inv}m_h \bullet Ac_{inv}m_{hj}}{1000}$$

TACj = total annual catch t/year for species_j
$F_{inv}f_h$ = total number of female invertebrate fishers for habitat_h
$Ac_{inv}f_{hj}$ = average annual catch by female invertebrate fishers (kg/year) for habitat_h and species_j
$F_{inv}m_h$ = total number of male invertebrate fishers for habitat_h
$Ac_{inv}m_{hj}$ = average annual catch by male invertebrate fishers (kg/year) for habitat_h and species_j
N_h = number of habitats

Where:

$$Ac_{inv}f_{hj} = \frac{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cf_{ij}}{I_{inv}f_h} \bullet \frac{\sum_{k=1}^{R_{inv}f_h} f_k \bullet 52 \bullet 0.83 \bullet \frac{Fm_k}{12}}{\sum_{i=1}^{I_{inv}f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12}}$$

$I_{inv}f_h$ = number of interviews of female invertebrate fishers for habitat_h (total numbers of interviews where female invertebrate fishers provided detailed information for habitat_h)
f_i = frequency of fishing trips (trips/week) as reported in interview_i

Fm_i = number of months fished as reported in interview$_i$
Cf_{ij} = average catch reported for species$_j$ as reported in interview$_i$
$R_{inv}f_h$ = number of targeted habitats reported by female invertebrate fishers for habitat$_h$ (total numbers of interviews where female invertebrate fishers reported targeting habitat$_h$ but did not necessarily provide detailed information)
f_k = frequency of fishing trips (trips/week) as reported for habitat$_k$
Fm_k = number of months fished for reported habitat$_k$

The total annual biomass (t/year) removed is also calculated and presented by species after transferring vernacular names to scientific nomenclature. Size frequency distributions are provided for the most important species, by total annual weight removed, expressed in percentage of each size group of the total annual weight harvested. The size frequency distribution may reveal the impact of fishing pressure for species that are represented by a wide size range (from juvenile to adult state). It may also be a useful parameter to compare the status of a particular species or species group across various sites at the national or even regional level.

To further determine fishing strategies, we also inquire about the purpose of harvesting each species (as recorded by vernacular name). Results are depicted as the proportion (in kg/year) of the total annual biomass (net weight) removed for each purpose: consumption, sale or both. We also provide an index of all species recorded through fisher interviews and their use (in percentage of total annual weight) for any of the three categories.

In order to gain an idea of the productivity of and differences between the fisheries practices used in each site we calculate the average annual catch per fisher, by gender and fishery. This calculation is based on the total biomass (net weight) removed from each fishery and the total number of fishers by gender group.

For invertebrate species that are marketed, detailed information is collected on total numbers (weight and/or combination of number and size), processing level, location of sale or client, frequency of sales and price received per unit sold. At this stage of our project we do not fully analyse this marketing information. However, prices received for major commercial species, as well as an approximation of sale volumes by fishery and fisher, help to assess what role invertebrate fisheries (or a particular fishery) play(s) in terms of income generation for the surveyed community, and in comparison to the possible earnings from finfish fisheries.

We use the calculated total annual impact in combination with the fishing ground area to determine relative fishing pressure. Fishing pressure indicators are calculated as the annual catch per km^2 for each area that is considered to support any of the fisheries present at each study site. In some instances (e.g. intertidal fisheries), areas are replaced by linear km; accordingly, fishing pressure is then related to the length (in km) of the supporting habitat. Due to the lack of baseline data, we compare selected indicators, such as the fisher density (number of fishers per km^2 – or linear km – of fishing ground, for each fishery), productivity (catch per fisher and year) and total annual catch per fishery, across all sites for each country surveyed. This comparison may also be done at the regional level in the future.

The differing nature of invertebrate species that may be caught during one fishing trip, and hence the great variability between edible and non-edible, useful and non-useful parts of species caught, make the determination of CPUE difficult. Substantial differences in the economic value of species add another challenge. We have therefore refrained from calculating CPUE values at this stage of the project.

Data entry and analysis

Data from all questionnaire forms are entered in the Reef Fisheries Integrated Database (RFID) system. All data entered are first verified and 'cleaned' prior to analysis. In the process of data entry, a comprehensive list of vernacular and corresponding scientific names for finfish and invertebrate species is developed.

Database queries have been defined and established that allow automatic retrieval of the descriptive statistics used when summarising results at the site and national levels.

1.1.2 Socioeconomic survey questionnaires

- Household census and consumption survey
- Finfish fishing and marketing survey (for fishers)
- Invertebrate fishing and marketing survey (for fishers)
- Fisheries (finfish and invertebrate and socioeconomics) general information survey

HOUSEHOLD CENSUS AND CONSUMPTION SURVEY

HH NO. ☐

Name of head of household: ________________ Village: _________________

Name of person asked: _____________________ Date: __________________

Surveyor's ID: __________________

1. Who is the head of your household? *(must be living there; tick box)* male ☐ female ☐

2. How old is the head of household? *(enter year of birth)* ☐

3. How many people ALWAYS live in your household? *(enter number)* ☐

4. How many are male and how many are female? (*tick box and enter age in years or year of birth)*

male	age	female	age
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐

5. Does this household have any agricultural land?

yes ☐ no ☐

6. How much (*for this household only*)?

for permanent/regular cultivation ☐ (unit)

for permanent/regular livestock ☐ (unit)

type of animals__________ no. ☐

7. How many fishers live in your household? ☐
(*enter number of people who go fishing/collecting regularly)*

invertebrate fishers		finfish fishers		invertebrate & finfish fishers	
M	F	M	F	M	F
☐	☐	☐	☐	☐	☐

8. Does this household own a boat? yes ☐ no ☐

9a. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP
9b. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP
9c. Canoe	☐	length?	☐	metres/feet		
Sailboat	☐	length?	☐	metres/feet		
Boat with outboard engine	☐	length?	☐	metres/feet	☐	HP

10. Where does the CASH money in this household come from? (*rank options*, *1 = most money*, *2 = second important income source*, *3 = 3rd important income source*, *4 = 4th important income source*)

Fishing/seafood collection ☐

Agriculture (crops & livestock) ☐

Salary ☐

Others (handicrafts, etc.) ☐ specify: ____________________

11. Do you get remittances? yes ☐ no ☐

12. How often?

1 per month	1 per 3 months	1 per 6 months	other *(specify)*
☐	☐	☐	☐

13. How much? *(enter amount)* Every time? (currency) [ ]

14. How much CASH money do you use on average for household expenditures (food, fuel for cooking, school bus, etc.)?

(currency) [ ] per week/2-weekly/month (or? specify_______)

15. What is the educational level of your household members?

no. of people	having achieved:
[ ]	elementary/primary education
[ ]	secondary education
[ ]	tertiary education (college, university, special schools, etc.)

CONSUMPTION SURVEY

16. During an average/normal week, on how many days do you prepare fish, other seafood and canned fish for your family? *(tick box)*

	7 days	6 days	5 days	4 days	3 days	2 days	1 day	other, specify
Fresh fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Other seafood	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Canned fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

17. Mainly at	breakfast	lunch	supper
Fresh fish	[ ]	[ ]	[ ]
Other seafood	[ ]	[ ]	[ ]
Canned fish	[ ]	[ ]	[ ]

18. How much do you cook on average per day for your household? *(tick box)*

	number	kg	size: A	B	C	D	E	>E (cm)
Fresh fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Other seafood

name:	no.	size	kg	plastic bag ¼	½	¾	1
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐
______________________	☐	☐	☐	☐	☐	☐	☐

19. Canned fish No. of cans: ☐ Size of can: ☐ small
☐ medium
☐ big

20. Where do you normally get your fish and seafood from?

Fish:

☐ caught by myself/member of this household

☐ get it from somebody in the family/village (no money paid)

☐ buy it at ______________________

Which is the most important source? ☐ caught ☐ given ☐ bought

Invertebrates:

☐ caught by myself/member of this household

☐ get it from somebody in the family/village (no money paid)

☐ buy it at ______________________

Which is the most important source? ☐ caught ☐ given ☐ bought

21. Which is the last day you had fish? ______________________

22. Which is the last day you had other seafood? ______________________

–THANK YOU–

FISHING (FINFISH) AND MARKETING SURVEY

Name: ____________________ F ☐ M ☐ **HH NO.** ☐

Name of head of household: ______________________ Village: ______________

Surveyor's name: ____________________ Date: ______________

1. Which areas do you fish?

coastal reef ☐ lagoon ☐ outer reef ☐ mangrove ☐ pelagic ☐

2. Do you go to only one habitat per trip?

Yes ☐ no ☐

3. If no, how many and which habitats do you visit during an average trip?

total no. ☐ habitats: coastal reef ☐ lagoon ☐ mangrove ☐ outer reef ☐

4. How often (days/week) do you fish in each of the habitats visited?

coastal reef	lagoon	mangrove	outer reef	
☐	☐	☐	☐	__________/times per week/month
☐	☐	☐	☐	__________/times per week/month
☐	☐	☐	☐	__________/times per week/month

5. Do you use a boat for fishing?

	Always	sometimes	never
coastal reef	☐	☐	☐
lagoon	☐	☐	☐
mangrove	☐	☐	☐
outer reef	☐	☐	☐

6. If you use a boat, which one?

1 canoe (paddle) ☐ sailing ☐
motorised ☐ HP outboard ☐ 4-stroke engine ☐

coastal reef ☐ lagoon ☐ outer reef ☐

2 canoe (paddle) ☐ sailing ☐
motorised ☐ HP outboard ☐ 4-stroke engine ☐
coastal reef ☐ lagoon ☐ outer reef ☐

3 canoe (paddle) ☐ sailing ☐
motorised ☐ HP outboard ☐ 4-stroke engine ☐
coastal reef ☐ lagoon ☐ outer reef ☐

7. How many fishers ALWAYS go fishing with you?

Names:____
____
____
____

INFORMATION BY FISHERY **Name of fisher:** ______________ **HH NO.** ☐

coastal reef ☐ lagoon ☐ mangrove ☐ outer reef ☐

1. HOW OFTEN do you normally go out FISHING for this habitat? *(tick box)*

Every Day	5 days/ week	4 days/ week	3 days/ week	2 days/ week	1 day/ week	other, specify:
☐	☐	☐	☐	☐	☐	____________________

2. What time do you spend fishing this habitat per average trip? ____________________
(if the fisher can't specify, tick a box)

<2 hrs	2–6 hrs	6–12 hrs	>12 hrs
☐	☐	☐	☐

3. WHEN do you go fishing? *(tick box)* day ☐ night ☐ day & night ☐

4. Do you go all year?

Yes ☐ no ☐

5. If no, which months <u>don't</u> you fish?

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6. Which fishing techniques do you use (*in the habitat referred to here*)?

☐ handline	
☐ castnet	☐ gillnet
☐ spear (dive)	☐ longline
☐ trolling	☐ spear (handheld) walking ☐ canoe ☐
☐ deep bottom line	☐ poison: which one? ______________
☐ other, specify: ____	

7. Do you use more than one technique per trip for this habitat? If yes, which ones usually?

☐ one technique/trip ☐ more than one technique/trip:

____

8. Do you use ice on your fishing trips?

☐ always ☐ sometimes ☐ never

☐ is it homemade? ☐ or bought?

9. What is your average catch (kg) per trip? ☐ Kg <u>OR:</u>

size class:	A	B	C	D	E	>E (cm)
number:	☐	☐	☐	☐	☐	☐

10. Do you sell fish? yes ☐ no ☐

11. Do you give fish as a gift (for no money)? yes ☐ no ☐

12. Do you use your catch for family consumption? yes ☐ no ☐

13. How much of your usual catch do you keep for family consumption?

kg ☐ <u>OR:</u>

size class	A	B	C	D	E	>E (cm)
no	☐	☐	☐	☐	☐	☐

and the rest you gift? yes ☐

how much? kg ☐ <u>OR:</u>

size class	A	B	C	D	E	>E (cm)
no.	☐	☐	☐	☐	☐	☐

and/or sell? yes ☐

how much? kg ☐ <u>OR</u>:

size class	A	B	C	D	E	>E (cm)
no.	☐	☐	☐	☐	☐	☐

14. What sizes of fish do you use for your family consumption, what for sale and what do you give away without getting any money?

size classes:	all	A	B	C	D	E	and larger (no. and cm)
consumption	☐	☐	☐	☐	☐	☐	☐
sale	☐	☐	☐	☐	☐	☐	☐
give away	☐	☐	☐	☐	☐	☐	☐

15. You sell where?

☐ inside village ☐ outside village where? ____________________________

and to whom?

market ☐ agents/middlemen ☐ shop owners ☐ others ☐ ___________

16. In an average catch what fish do you catch, and how much of each species? *(write down the species in the table)*

technique usually used:_____________________ boat type usually used:________________
habitat usually fished: ____

Specify the number by size

Name of fish	kg	A	B	C	D	E	>E cm

20. Do you also fish invertebrates?

Yes ☐ no ☐ if yes for consumption? ☐ sale? ☐

–THANK YOU–

INVERTEBRATE FISHING AND MARKETING SURVEY
FISHERS

HH NO. ☐

Name: ______________________________

Gender: ☐ female ☐ male Age: ☐

Village: ______________________________

Date: ________________ Surveyor's name: ____________________

Invertebrates = everything that is not a fish with fins!

1. Which type of fisheries do you do?

☐ seagrass gleaning ☐ mangrove & mud gleaning

☐ sand & beach gleaning ☐ reeftop gleaning

☐ bêche-de mer diving ☐ mother-of-pearl diving trochus, pearl shell, etc.

☐ lobster diving ☐ other, such as clams, octopus

2. *(if more than one fishery in question 1):* Do you usually go fishing at only one of the fisheries or do you visit several during one fishing trip?

☐ one only ☐ several

If several fisheries at a time, which ones do you combine?

----

3. How often do you go gleaning/diving (*tick as from questions 1 and 2 above and watch for combinations*) and for how long, and do you also finfish at the same time?

	times/week		duration in hours *(if the fisher can't specify, tick the box)* <2	2–4	4–6	>6	glean/dive at D	N	D&N	fish no. of months/year
☐ seagrass gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ mangrove & mud gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ sand & beach gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ reeftop gleaning	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ bêche-de-mer diving	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ lobster diving	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ mother-of-pearl diving trochus, pearl shell, etc.	☐	____	☐	☐	☐	☐	☐	☐	☐	________
☐ other diving (clams, octopus)	☐	____	☐	☐	☐	☐	☐	☐	☐	________

D = day, N = night, D&N = day and night (no preference but fish with tide)

4. Do you sometimes go gleaning/fishing for invertebrates outside your village fishing grounds?

yes ☐ no ☐

If yes, where? ____

5. Do you finfish? yes ☐ no ☐

for: ☐ consumption? ☐ sale?

at the same time? yes ☐ no ☐

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐ other (clams, octopus) ☐

SHEET 1: EACH FISHERY PER FISHER INTERVIEWED: ☐ **HH NO. __Name of fisher: ______________** **gender: F** ☐ **M** ☐

What transport do you mainly use? ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

How many fishers are usually on a trip? (total no.) ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit							
			1	3/4	1/2	1/4				

Socioeconomics

Species vernacular/common name and scientific code if possible	**Average quantity/trip**							**Used for** (specify how much from average for each category (cons., given or sold), and the main size for sale and cons. or given) gift = giving away for no money		
	total number/ trip	weight/trip					average size cm	cons.	gift	sale
		total kg	plastic bag unit							
			1	3/4	1/2	1/4				

INVERTEBRATE FISHING AND MARKETING SURVEY – FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reeftop ☐

DIVING: bêche-de-mer ☐ lobster ☐ mother-of-pearl, trochus, pearl shell, etc. ☐ other (clams, octopus) ☐

SHEET 2: SPECIES SOLD PER FISHER INTERVIEWED: **HH NO**. ☐ **Name of fisher:** ________________________

Copy all species that have been named for 'SALE' in previous sheet

Who markets your products? ☐ you ☐ your wife ☐ your husband ☐ a group of fishers ☐ other __________________

Species for sale – copy from sheet 2 (for each fishery per fisher) above	Processing level of product sold (see list)	Where do you sell? (see list)	How often? Days/week?	How much each time? Quantity/unit	Price

FISHERIES (FINFISH AND INVERTEBRATE AND SOCIOECONOMICS) GENERAL INFORMATION SURVEY

Target group: key people, groups of fishers, fisheries officers, etc.

1. Are there management rules that apply to your fisheries? Do they specifically target finfish or invertebrates, or do they target both sectors?

a) legal/Ministry of Fisheries

b) traditional/community/village determined:

2. What do you think – do people obey:

traditional/village management rules?

mostly ☐ sometimes ☐ hardly ☐

legal/Ministry of Fisheries management rules?

mostly ☐ sometimes ☐ hardly ☐

3. Are there any particular rules that you know people do not respect or follow at all? And do you know why?

4. What are the main techniques used by the community for:

a) finfishing

gillnets – most-used mesh sizes:

What is usually used for bait? And is it bought or caught?

b) invertebrate fishing → ***see end!***

5. Please give a quick inventory and characteristics of boats used in the community (length, material, motors, etc.).

Seasonality of species

What are the **FINFISH** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

Seasonality of species

What are the **INVERTEBRATE** species that you do not catch during the total year? Can you specify the particular months that they are **NOT** fished?

Vernacular name	Scientific name(s)	Months NOT fished

How many people carry out the invertebrate fisheries below, from inside and from outside the community?

GLEANING	no. from this village	no.	from village	no.	from village
seagrass gleaning					
mangrove & mud gleaning					
sand & beach gleaning					
reeftop gleaning					
DIVING					
bêche-de-mer diving					
lobster diving					
mother-of-pearl diving trochus, pearl shell, etc.					
other (clams, octopus)					

What gear do invertebrate fishers use? *(tick box of technique per fishery)*

GLEANING (soft bottom = seagrass)

spoon	wooden stick	knife	iron rod	spade
hand net	net	trap	goggles	dive mask
snorkel	fins	weight belt		
air tanks	hookah	other ___________		

GLEANING (soft bottom = mangrove & mud)

spoon	wooden stick	knife	iron rod	spade
hand net	net	trap	goggles	dive mask
snorkel	fins	weight belt		
air tanks	hookah	other ___________		

GLEANING (soft bottom = sand & beach)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

GLEANING (hard bottom = reeftop)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (bêche-de-mer)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (lobster)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other __________

DIVING (mother-of-pearl, trochus, pearl shell, etc.)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other ___________

DIVING (other, such as clams, octopus)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ goggles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ other ___________

Any traditional/customary/village fisheries?

Name:

Season/occasion:

Frequency:

Quantification of marine resources caught:

Species name	Size	Quantity (unit?)

1.1.3 Average wet weight applied for selected invertebrate species groups

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Acanthopleura gemmata	29	35	65	10.15	Chiton
Actinopyga lecanora	300	10	90	30	BdM (1)
Actinopyga mauritiana	350	10	90	35	BdM (1)
Actinopyga miliaris	300	10	90	30	BdM (1)
Anadara sp.	21	35	65	7.35	Bivalves
Asaphis violascens	15	35	65	5.25	Bivalves
Astralium sp.	20	25	75	5	Gastropods
Atactodea striata, *Donax cuneatus*, *Donax cuneatus*	2.75	35	65	0.96	Bivalves
Atrina vexillum, *Pinctada margaritifera*	225	35	65	78.75	Bivalves
Birgus latro	1000	35	65	350	Crustacean
Bohadschia argus	462.5	10	90	46.25	BdM (1)
Bohadschia sp.	462.5	10	90	46.25	BdM (1)
Bohadschia vitiensis	462.5	10	90	46.25	BdM (1)
Cardisoma carnifex	227.8	35	65	79.74	Crustacean
Carpilius maculatus	350	35	65	122.5	Crustacean
Cassis cornuta, *Thais aculeata*, *Thais aculeata*	20	25	75	5	Gastropods
Cerithium nodulosum, *Cerithium nodulosum*	240	25	75	60	Gastropods
Chama sp.	25	35	65	8.75	Bivalves
Codakia punctata	20	35	65	7	Bivalves
Coenobita sp.	50	35	65	17.5	Crustacean
Conus miles, *Strombus gibberulus gibbosus*	240	25	75	60	Gastropods
Conus sp.	240	25	75	60	Gastropods
Cypraea annulus, *Cypraea moneta*	10	25	75	2.5	Gastropods
Cypraea caputserpensis	15	25	75	3.75	Gastropods
Cypraea mauritiana	20	25	75	5	Gastropods
Cypraea sp.	95	25	75	23.75	Gastropods
Cypraea tigris	95	25	75	23.75	Gastropods
Dardanus sp.	10	35	65	3.5	Crustacean
Dendropoma maximum	15	25	75	3.75	Gastropods
Diadema sp.	50	48	52	24	Echinoderm
Dolabella auricularia	35	50	50	17.5	Others
Donax cuneatus	15	35	65	5.25	Bivalves
Drupa sp.	20	25	75	5	Gastropods
Echinometra mathaei	50	48	52	24	Echinoderm
Echinothrix sp.	100	48	52	48	Echinoderm
Eriphia sebana	35	35	65	12.25	Crustacean
Gafrarium pectinatum	21	35	65	7.35	Bivalves
Gafrarium tumidum	21	35	65	7.35	Bivalves
Grapsus albolineatus	35	35	65	12.25	Crustacean
Hippopus hippopus	500	19	81	95	Giant clams
Holothuria atra	100	10	90	10	BdM (1)
Holothuria coluber	100	10	90	10	BdM (1)

1.1.3 Average wet weight applied for selected invertebrate species groups (continued)

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Holothuria fuscogilva	2000	10	90	200	BdM (1)
Holothuria fuscopunctata	1800	10	90	180	BdM (1)
Holothuria nobilis	2000	10	90	200	BdM (1)
Holothuria scabra	2000	10	90	200	BdM (1)
Holothuria sp.	2000	10	90	200	BdM (1)
Lambis lambis	25	25	75	6.25	Gastropods
Lambis sp.	25	25	75	6.25	Gastropods
Lambis truncata	500	25	75	125	Gastropods
Mammilla melanostoma, *Polinices mammilla*	10	25	75	2.5	Gastropods
Modiolus auriculatus	21	35	65	7.35	Bivalves
Nerita albicilla, *Nerita polita*	5	25	75	1.25	Gastropods
Nerita plicata	5	25	75	1.25	Gastropods
Nerita polita	5	25	75	1.25	Gastropods
Octopus sp.	550	90	10	495	Octopus
Panulirus ornatus	1000	35	65	350	Crustacean
Panulirus penicillatus	1000	35	65	350	Crustacean
Panulirus sp.	1000	35	65	350	Crustacean
Panulirus versicolor	1000	35	65	350	Crustacean
Parribacus antarcticus	750	35	65	262.5	Crustacean
Parribacus caledonicus	750	35	65	262.5	Crustacean
Patella flexuosa	15	35	65	5.25	Limpet
Periglypta puerpera, *Periglypta reticulate*	15	35	65	5.25	Bivalves
Periglypta sp., *Periglypta* sp., *Spondylus* sp., *Spondylus* sp.,	15	35	65	5.25	Bivalves
Pinctada margaritifera	200	35	65	70	Bivalves
Pitar proha	15	35	65	5.25	Bivalves
Planaxis sulcatus	15	25	75	3.75	Gastropods
Pleuroploca filamentosa	150	25	75	37.5	Gastropods
Pleuroploca trapezium	150	25	75	37.5	Gastropods
Portunus pelagicus	227.83	35	65	79.74	Crustacean
Saccostrea cuccullata	35	35	65	12.25	Bivalves
Saccostrea sp.	35	35	65	12.25	Bivalves
Scylla serrata	700	35	65	245	Crustacean
Serpulorbis sp.	5	25	75	1.25	Gastropods
Sipunculus indicus	50	10	90	5	Seaworm
Spondylus squamosus	40	35	65	14	Bivalves
Stichopus chloronotus	100	10	90	10	BdM (1)
Stichopus sp.	543	10	90	54.3	BdM (1)
Strombus gibberulus gibbosus	25	25	75	6.25	Gastropods
Strombus luhuanus	25	25	75	6.25	Gastropods
Tapes literatus	20	35	65	7	Bivalves
Tectus pyramis, *Trochus niloticus*	300	25	75	75	Gastropods
Tellina palatum	21	35	65	7.35	Bivalves
Tellina sp.	20	35	65	7	Bivalves

1.1.3 Average wet weight applied for selected invertebrate species groups (continued)

Unit weights used in conversions for invertebrates.

Scientific names	g/piece	% edible part	% non-edible part	Edible part (g/piece)	Group
Terebra sp.	37.5	25	75	9.39	Gastropods
Thais armigera	20	25	75	5	Gastropods
Thais sp.	20	25	75	5	Gastropods
Thelenota ananas	2500	10	90	250	BdM (1)
Thelenota anax	2000	10	90	200	BdM (1)
Tridacna maxima	500	19	81	95	Giant clams
Tridacna sp.	500	19	81	95	Giant clams
Trochus niloticus	200	25	75	50	Gastropods
Turbo crassus	80	25	75	20	Gastropods
Turbo marmoratus	20	25	75	5	Gastropods
Turbo setosus	20	25	75	5	Gastropods
Turbo sp.	20	25	75	5	Gastropods

BdM = Bêche-de-mer; (1) edible part of dried Bêche-de-mer, i.e. drying process consumes about 90% of total wet weight; hence 10% are considered as the edible part only.

1.2 Methods used to assess the status of finfish resources

Fish counts

In order to count and size fish in selected sites, we use the **distance-sampling underwater visual census (D-UVC)** method (Kulbicki and Sarramegna 1999, Kulbicki *et al.* 2000), fully described in Labrosse *et al.* (2002). Briefly, the method consists of recording the species name, abundance, body length and the distance to the transect line for each fish or group of fish observed; the transect consists of a 50 m line, represented on the seafloor by an underwater tape (Figure A1.2.1). For security reasons, two divers are required to conduct a survey, each diver counting fish on a different side of the transect. Mathematical models are then used to estimate fish density (number of fish per unit area) and biomass (weight of fish per unit area) from the counts.

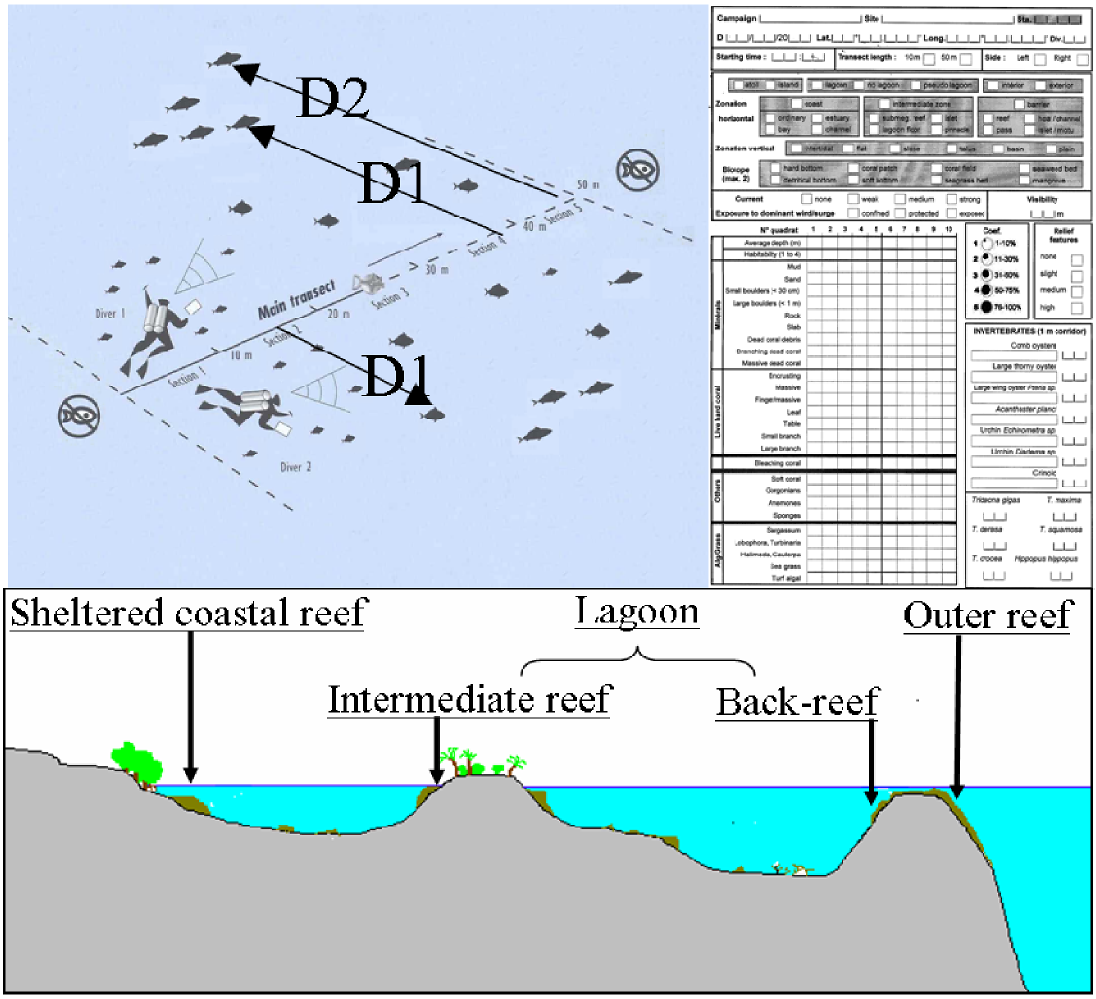


Figure A1.2.1: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC).
Each diver records the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys are conducted along 24 transects, with six transects in each of the four main geomorphologic coral reef structures: sheltered coastal reefs, intermediate reefs and back-reefs (lumped into the ‘lagoon reef’ category of socioeconomic assessment), and outer reefs. D1 is the distance of an observed fish from the transect line. If a school of fish is observed, D1 is the distance from the transect line to the closest fish; D2 the distance to the furthest fish.

Species selection

Only reef fish of interest for consumption or sale and species that could potentially serve as indicators of coral reef health are surveyed (see Table A1.2.1; Appendix 3.2 provides a full list of counted species and abundance for each site surveyed).

Table A1.2.1: List of finfish species surveyed by distance sampling underwater visual census (D-UVC)
Most frequently observed families on which reports are based are highlighted in yellow.

Family	Selected species
Acanthuridae	All species
Aulostomidae	*Aulostomus chinensis*
Balistidae	All species
Belonidae	All species
Caesionidae	All species
Carangidae	All species
Carcharhinidae	All species
Chaetodontidae	All species
Chanidae	All species
Dasyatidae	All species
Diodontidae	All species
Echeneidae	All species
Ephippidae	All species
Fistulariidae	All species
Gerreidae	*Gerres* spp.
Haemulidae	All species
Holocentridae	All species
Kyphosidae	All species
Labridae	*Bodianus axillaris*, *Bodianus loxozonus*, *Bodianus perditio*, *Bodianus* spp., *Cheilinus:* all species, *Choerodon:* all species, *Coris aygula*, *Coris gaimard*, *Epibulus insidiator*, *Hemigymnus:* all species, *Oxycheilinus diagrammus*, *Oxycheilinus* spp.
Lethrinidae	All species
Lutjanidae	All species
Monacanthidae	*Aluterus scriptus*
Mugilidae	All species
Mullidae	All species
Muraenidae	All species
Myliobatidae	All species
Nemipteridae	All species
Pomacanthidae	*Pomacanthus semicirculatus*, *Pygoplites diacanthus*
Priacanthidae	All species
Scaridae	All species
Scombridae	All species
Serranidae	Epinephelinae: all species
Siganidae	All species
Sphyraenidae	All species
Tetraodontidae	*Arothron*: all species
Zanclidae	All species

Analysis of percentage occurrence in surveys at both regional and national levels indicates that of the initial 36 surveyed families, only 15 families are frequently seen in country counts.

Appendix 1: Survey methods
Finfish

Since low percentage occurrence could either be due to rarity (which is of interest) or low detectability (representing a methodological bias), we decided to restrict our analysis to the 15 most frequently observed families, for which we can guarantee that D-UVC is an efficient resource assessment method.

These are:

- Acanthuridae (surgeonfish)
- Balistidae (triggerfish)
- Chaetodontidae (butterflyfish)
- Holocentridae (squirrelfish)
- Kyphosidae (drummer and seachubs)
- Labridae (wrasse)
- Lethrinidae (sea bream and emperor)
- Lutjanidae (snapper and seaperch)
- Mullidae (goatfish)
- Nemipteridae (coral bream and butterfish)
- Pomacanthidae (angelfish)
- Scaridae (parrotfish)
- Serranidae (grouper, rockcod, seabass)
- Siganidae (rabbitfish)
- Zanclidae (moorish idol).

Substrate

We used the **medium-scale approach** (MSA) to record substrate characteristics along transects where finfish were counted by D-UVC. MSA has been developed by Clua *et al.* (2006) to specifically complement D-UVC surveys. Briefly, the method consists of recording depth, habitat complexity, and 23 substrate parameters within ten 5 m x 5 m quadrats located on each side of a 50 m transect, for a total of 20 quadrats per transect (Figure A1.2.1). The transect's habitat characteristics are then calculated by averaging substrate records over the 20 quadrats.

Parameters of interest

In this report, the status of finfish resources has been characterised using the following seven parameters:

- **biodiversity –** the number of families, genera and species counted in D-UVC transects;
- **density** (fish/m^2) – estimated from fish abundance in D-UVC;
- **size** (cm fork length) – direct record of fish size by D-UVC;
- **size ratio** (%) – the ratio between fish size and maximum reported size of the species. This ratio can range from nearly zero when fish are very small to nearly 100 when a given fish has reached the greatest size reported for the species. Maximum reported size (and source of reference) for each species are stored in our database;
- **biomass** (g/m^2) – obtained by combining densities, size, and weight–size ratios (Weight–size ratio coefficients are stored in our database and were provided by Mr Michel Kulbicki, IRD Noumea, Coreus research unit);
- **community structure –** density, size and biomass compared among families; and

- **trophic structure –** density, size and biomass compared among trophic groups. Trophic groups are stored in our database and were provided by Mr Michel Kulbicki, IRD Noumea, Coreus research unit. Each species was classified into one of five broad trophic groups: 1) carnivore (feed predominantly on zoobenthos), 2) detritivore (feed predominantly on detritus), 3) herbivore (feed predominantly on plants), 4) piscivore (feed predominantly on nekton, other fish and cephalopods) and 5) plankton feeder (feed predominantly on zooplankton). More details on fish diet can be found online at: http://www.fishbase.org/manual/english/FishbaseThe_FOOD_ITEMS_Table.htm.

The relationship between environment quality and resource status has not been fully explored at this stage of the project, as this task requires complex statistical analyses on the regional dataset. Rather, the living resources assessed at all sites in each country are placed in an environmental context via the description of several crucial habitat parameters. These are obtained by grouping the original 23 substrate parameters recorded by divers into the following six parameters:

- **depth** (m)
- **soft bottom** (% cover) – sum of substrate components:
  (1) mud (sediment particles <0.1 mm), and
  (2) sand and gravel (0.1 mm <hard particles <30 mm)
- **rubble and boulders** (% cover) – sum of substrate components:
  (3) dead coral debris (carbonated structures of heterogeneous size, broken and removed from their original locations),
  (4) small boulders (diameter <30 cm), and
  (5) large boulders (diameter <1 m)
- **hard bottom** (% cover) – sum of substrate components:
  (6) slab and pavement (flat hard substratum with no relief), rock (massive minerals) and eroded dead coral (carbonated edifices that have lost their coral colony shape),
  (7) dead coral (dead carbonated edifices that are still in place and retain a general coral shape), and
  (8) bleaching coral
- **live coral** (% cover) – sum of substrate components:
  (9) encrusting live coral,
  (10) massive and sub-massive live corals,
  (11) digitate live coral,
  (12) branching live coral,
  (13) foliose live coral,
  (14) tabulate live coral, and
  (15) *Millepora* spp.
- **soft coral** (% cover) – substrate component:
  (16) soft coral.

Sampling design

Coral reef ecosystems are complex and diverse. The NASA Millennium Coral Reef Mapping Project (MCRMP) has identified and classified coral reefs of the world in about 1000 categories. These very detailed categories can be used directly to try to explain the status of living resources or be lumped into more general categories to fit a study's particular needs. For the needs of the finfish resource assessment, MCRMP reef types were grouped into the four main coralline geomorphologic structures found in the Pacific (Figure A1.2.2):

- **sheltered coastal reef**: reef that fringes the land but is located inside a lagoon or a pseudo-lagoon
- **lagoon reef**:
  - **intermediate reef** – patch reef that is located inside a lagoon or a pseudo-lagoon, and
  - **back-reef** – inner/lagoon side of outer reef
- **outer reef**: ocean side of fringing or barrier reefs.

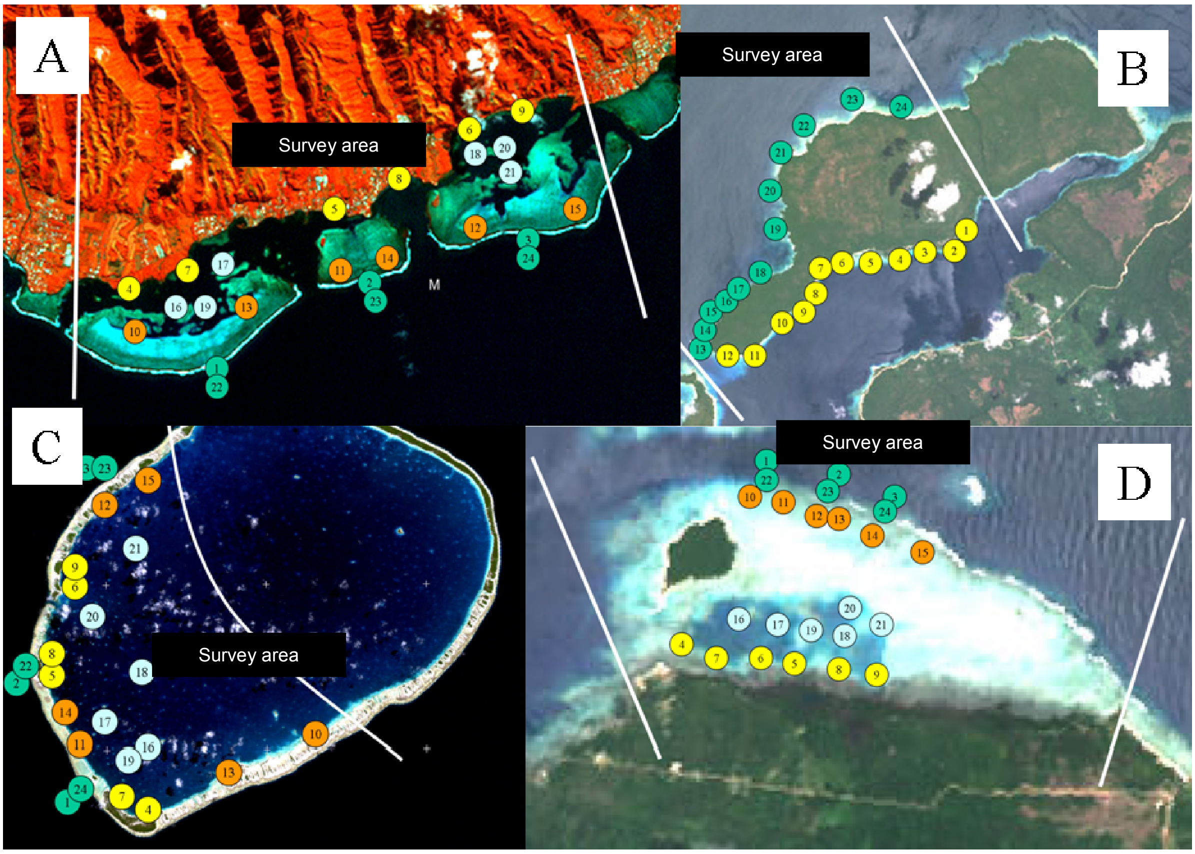


Figure A1.2.2: Position of the 24 D-UVC transects surveyed in A) an island with a lagoon, B) an island with a pseudo-lagoon C) an atoll and D) an island with an extensive reef enclosing a small lagoon pool.
Sheltered coastal reef transects are in yellow, lagoon intermediate-reef transects in blue, lagoon back-reef transects in orange and outer-reef transects in green. Transect locations are determined using satellite imagery prior to going into the field, which greatly enhances fieldwork efficiency. The white lines delimit the borders of the survey area.

Fish and associated habitat parameters are recorded along 24 transects per site, with a balanced design among the main geomorphologic structures present at a given site (Figure A1.2.2). For example, our design results in at least six transects in each of the sheltered coastal, lagoon intermediate, lagoon back-reef, and outer reefs of islands with lagoons (Figure A1.2.2A) or 12 transects in each of the sheltered coastal and outer reefs of islands with pseudo-lagoons (Figure A1.2.2B). This balanced, stratified and yet flexible sampling design was chosen to optimise the quality of the assessment, given the logistical and time constraints that stem from the number and diversity of sites that have to be covered over the life of the project. The exact position of transects is determined in advance using satellite imagery, to assist in locating the exact positions in the field; this maximises accuracy and allows replication for monitoring purposes (Figure A1.2.2).

Scaling

Maps from the Millennium Project allow the calculation of reef areas in each studied site, and those areas can be used to scale (using weighted averages) the resource assessment at any spatial level. For example, the average biomass (or density) of finfish at site (i.e. village) level would be calculated by relating the biomass (or density) recorded in each of the habitats sampled at the site ('the data') to the proportion of surface of each type of reef over the total reef present in the site ('the weights'), by using a weighted average formula. The result is a village-level figure for finfish biomass that is representative of both the intrinsic characteristics of the resource and its spatial distribution. Technically, the weight given to the average biomass (or density) of each habitat corresponds to the ratio between the total area of that reef habitat (e.g. the area of sheltered coastal reef) and the total area of reef present (e.g. the area of sheltered coastal reef + the area of intermediate reef, etc.). Thus the calculated weighted biomass value for the site would be:

$$B_{Vk} = \sum j_l \, [B_{Hj} \bullet S_{Hj}] \, / \sum_j S_{Hj}$$

Where:

B_{Vk} = computed biomass or fish stock for village k
B_{Hj} = average biomass in habitat H_j
S_{Hj} = surface of that habitat H_j

A comparative approach only

Density and biomass estimated by D-UVC for each species recorded in the country are given in Appendix 3.2. However, it should be stressed that, since estimates of fish density and biomass (and other parameters) are largely dependent upon the assessment method used (this is true for any assessment), the resource assessment provided in this report can only be used for management in a comparative manner. Densities, biomass and other figures given in this report provide only estimates of the available resource; it would be a great mistake (possibly leading to mismanagement) to consider these as true indicators of the actual available resource.

Campaign |__________| Site |__________________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|,|__|__|__|' Long.|__|__|__|°|__|__|,|__|__|__|' WT |__|__|__|

Starting time : |__|__| :|__|__|	Visibility |__|__| m	Side : Left ☐ Right ☐

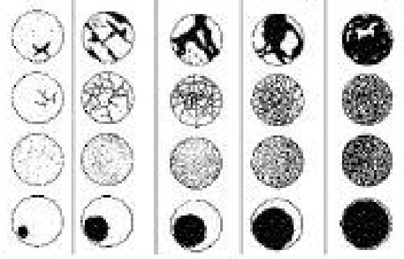
☐ coast		☐ intermediate zone		☐ barrier	
☐ linear	☐ cape	☐ submerg. reef	☐ pinnacle	☐ outer slope	☐ pass
☐ bay mouth	☐ back of bay	☐ near surf. reef	☐ islet lagoon	☐ reef crest	☐ hoa/channel
☐ estuary	☐ channel	☐ lagoon floor	☐ islet fringing reef	☐ back reef	☐ motu

☐ intertidal ☐ flat ☐ gentle slope ☐ steep slope ☐ talus ☐ basin ☐ lagoon plain

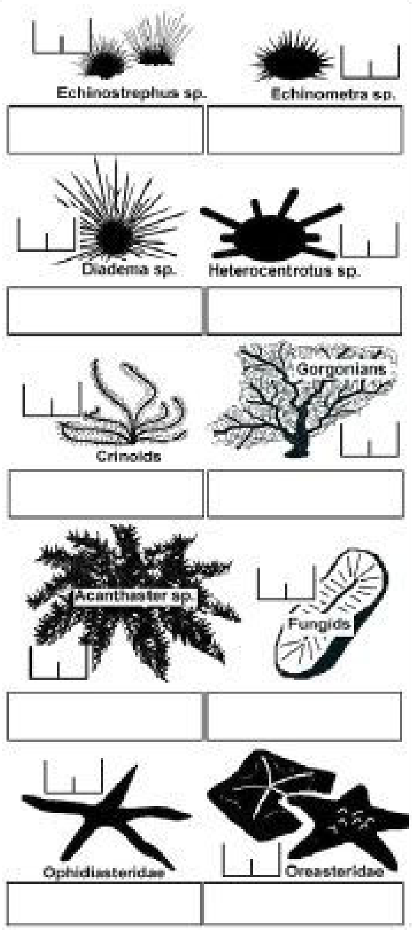
☐ hard bottom	☐ large coral patches	☐ small coral patches	☐ coral field	☐ seaweed bed
☐ detritical bottom	☐ soft bottom		☐ seagrass bed	☐ mangrove

	current	relief features	exposure to dominant wind	oceanic influence	terrigenous influence
none	☐	☐	☐	☐	☐
medium	☐	☐	☐	☐	☐
strong	☐	☐	☐	☐	☐

1	2	3	4	5
1-10%	11-30%	31-50%	51-75%	76-100%



Quadrat limits	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Average depth (m)										
Habitability (1 to 4)										
General coverage										
Mud										
Sand										
Dead coral debris										
Small boulders (< 30 cm)										
Large boulders (< 1 m)										
Eroded dead coral, rock										
Old dead coral in place										
Bleaching coral										
(1) Live corals										
(2) Soft invertebrates										
(1) Live corals										
Encrusting										
Massive										
Digitate										
Branch										
Foliose										
Tabulate										
Millepora sp.										
(2)										
Soft corals										
Sponges										
Grass/alg										
Cyanophyceae										
Sea grass										
Encrusting algae										
Small macro-algae										
Large macro-algae										
Drifting algae										
Micro-algae, Turf										
Others :										



Appendix 1: Survey methods
Finfish

Campaign |___________________| Site |_____________________________| Diver |__|__| Transect |__|__|__|

D |__|__|/|__|__|/20|__|__| Lat.|__|__|°|__|__|,|__|__|__|’ Long.|__|__|__|°|__|__|,|__|__|__|’ Left ☐ Right ☐

ST	SCIENTIFIC NAME	NBER	LGT	D1	D2	COMMENTS

1.3 Invertebrate resource survey methods

1.3.1 Methods used to assess the status of invertebrate resources

Introduction

Coastal communities in the Pacific access a range of invertebrate resources. Within the PROCFish/C study, a range of survey methods were used to provide information on key invertebrate species commonly targeted. These provide information on the status of resources at scales relevant to species (or species groups) and the fishing grounds being studied that can be compared across sites, countries and the region, in order to assess relative status.

Species data resulting from the resource survey are combined with results from the socioeconomic survey of fishing activity to describe invertebrate fishing activity within specific 'fisheries'. Whereas descriptions of commercially orientated fisheries are generally recognisable in the literature (e.g. the sea cucumber fishery), results from non-commercial stocks and subsistence-orientated fishing activities (e.g. general reef gleaning) will also be presented as part of the results, so as to give managers a general picture of invertebrate fishery status at study sites.

Field methods

We examined invertebrate stocks (and fisheries) for approximately seven days at each site, with at least two research officers (SPC Invertebrate Biologist and Fisheries Officer) plus officers from the local fisheries department. The work completed at each site was determined by the availability of local habitats and access to fishing activity.

Two types of survey were conducted: fishery-dependent surveys and fishery independent surveys.

- Fishery-dependent surveys rely on information from those engaged in the fishery, e.g. catch data;
- Fishery-independent surveys are conducted by the researchers independently of the activity of the fisheries sector.

Fishery-dependent surveys were completed whenever the opportunity arose. This involved accompanying fishers to target areas for the collection of invertebrate resources (e.g. reef-benthos, soft-benthos, trochus habitat). The location of the fishing activity was marked (using a GPS) and the catch composition and catch per unit effort (CPUE) recorded (kg/hour).

This record was useful in helping to determine the species complement targeted by fishers, particularly in less well-defined 'gleaning' fisheries. A CPUE record, with related information on individual animal sizes and weights, provided an additional dataset to expand records from reported catches (as recorded by the socioeconomic survey). In addition, size and weight measures collected through fishery-dependent surveys were compared with records from fishery-independent surveys, in order to assess which sizes fishers were targeting.

For a number of reasons, not all fisheries lend themselves to independent snapshot assessments: density measures may be difficult to obtain (e.g. crab fisheries in mangrove systems) or searches may be greatly influenced by conditions (e.g. weather, tide and lunar conditions influence lobster fishing). In the case of crab or shoreline fisheries, searches are very subjective and weather and tidal conditions affect the outcome. In such cases, observed and reported catch records were used to determine the status of species and fisheries.

A further reason for accompanying groups of fishers was to gain a first-hand insight into local fishing activities and facilitate the informal exchange of ideas and information. By talking to fishers in the fishing grounds, information useful for guiding independent resource assessment was generally more forthcoming than when trying to gather information using maps and aerial photographs while in the village. Fishery-independent surveys were not conducted randomly over a defined site 'study' area. Therefore assistance from knowledgeable fishers in locating areas where fishing was common was helpful in selecting areas for fishery-independent surveys.

A series of fishery-independent surveys (direct, in-water resource assessments) were conducted to determine the status of targeted invertebrate stocks. These surveys needed to be wide ranging within sites to overcome the fact that distribution patterns of target invertebrate species can be strongly influenced by habitat, and well replicated as invertebrates are often highly aggregated (even within a single habitat type).

PROCFish/C assessments do not aim to determine the size of invertebrate populations at study sites. Instead, these assessments aim to determine the status of invertebrates within the main fishing grounds or areas of naturally higher abundance. The implications of this approach are important, as the haphazard measures taken in main fishing grounds are indicative of stock health in these locations only and should not be extrapolated across all habitats within a study site to gain population estimates.

This approach was adopted due to the limited time allocated for surveys and the study's goal of 'assessing the status of invertebrate resources' (as opposed to estimating the standing stock). Making judgements on the status of stocks from such data relies on the assumption that the state of these estimates of 'unit stock'[2] reflects the health of the fishery. For example, an overexploited trochus fishery would be unlikely to have high-density 'patches' of trochus, just as a depleted shallow-reef gleaning fishery would not hold high densities of large clams. Conversely, a fishery under no stress would be unlikely to be depleted or show skewed size ratios that reflected losses of the adult component of the stock.

In addition to examining the density of species, information on spatial distribution and size/weight was collected, to add confidence to the study's inferences.

The basic assumption that looking at a unit stock will give a reliable picture of the status of that stock is not without weaknesses. Resource stocks may appear healthy within a much-restricted range following stress from fishing or environmental disturbance (e.g. a cyclone), and historical information on stock status is not usually available for such remote locations. The lack of historical datasets also precludes speculation on 'missing' species, which may be 'fished-out' or still remain in remnant populations at isolated locations within study sites.

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[2] As used here, 'unit stock' refers to the biomass and cohorts of adults of a species in a given area that is subject to a well-defined fishery, and is believed to be distinct and have limited interchange of adults from biomasses or cohorts of the same species in adjacent areas (Gulland 1983).

As mentioned, specific independent assessments were not conducted for mud crab and shore crabs (mangrove fishery), lobster or shoreline stocks (e.g. nerites, surf clams and crabs), as limited access or the variability of snapshot assessments would have limited relevance for comparative assessments.

Generic terminology used for surveys: site, station and replicates

Various methods were used to conduct fishery-independent assessments. At each site, surveys were generally made within specific areas (termed 'stations'). At least six replicate measures were made at each station (termed 'transects', 'searches' or 'quadrats', depending on the resource and method) (Figure A1.3.1).

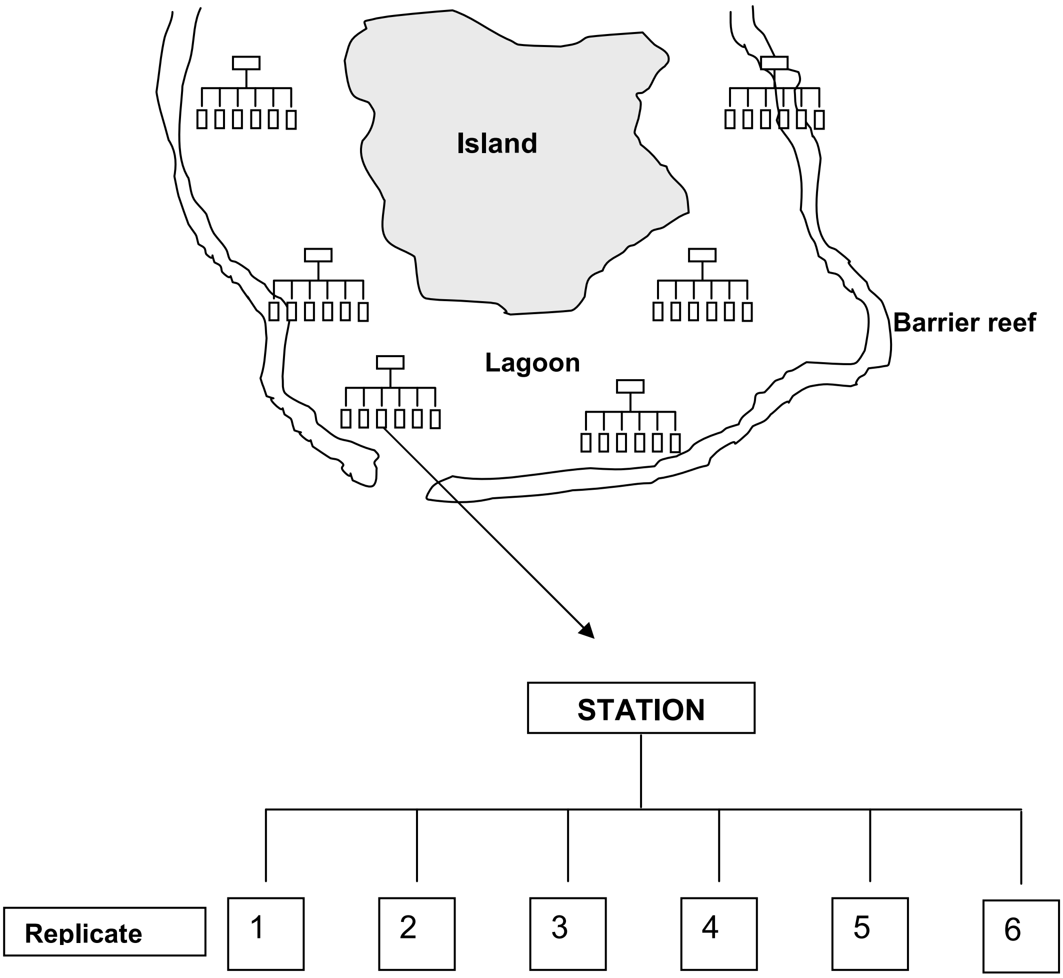


Figure A1.3.1: Stations and replicate measures at a given site.
A replicate measure could be a transect, search period or quadrat group.

Invertebrate species diversity, spatial distribution and abundance were determined using fishery-independent surveys at stations over broad-scale and more targeted surveys. Broad-scale surveys aimed to record a range of macro invertebrates across sites, whereas more targeted surveys concentrated on specific habitats and groups of important resource species.

Recordings of habitat are generally taken for all replicates within stations (see Appendix 1.3.3). Comparison of species complements and densities among stations and sites does not factor in fundamental differences in macro and micro habitat, as there is presently no established method that can be used to make allowances for these variations. The complete dataset from PROCFish/C will be a valuable resource to assess such habitat effects, and by identifying salient habitat factors that reliably affect resource abundance, we may be able to account for these habitat differences when inferring 'status' of important species groups. This will be examined once the full Pacific dataset has been collected.

More detailed explanations of the various survey methods are given below.

Broad-scale survey

Manta 'tow-board' transect surveys

A general assessment of large sedentary invertebrates and habitat was conducted using a tow-board technique adapted from English *et al.* (1997), with a snorkeller towed at low speed (<2.5 km/hour). This is a slower speed than is generally used for manta transects, and is less than half the normal walking pace of a pedestrian.

Where possible, manta surveys were completed at 12 stations per site. Stations were positioned near land masses on fringing reefs (inner stations), within the lagoon system (middle stations) and in areas most influenced by oceanic conditions (outer stations). Replicate measures within stations (called transects) were conducted at depths between 1 m and <10 m of water (mostly 1.5–6 m), covering broken ground (coral stone and sand) and at the edges of reefs. Transects were not conducted in areas that were too shallow for an outboard-powered boat (<1 m) or adjacent to wave-impacted reef.

Each transect covered a distance of ~300 m (thus the total of six transects covered a linear distance of ~2 km). This distance was calibrated using the odometer function within the trip computer option of a Garmin 76Map® GPS. Waypoints were recorded at the start and end of each transect to an accuracy of ≤ 10 m. The abundance and size estimations for large sedentary invertebrates were taken within a 2 m swathe of benthos for each transect. Broad-based assessments at each station took approximately one hour to complete (7–8 minutes per transect × 6, plus recording and moving time between transects). Hand tally counters and board-mounted bank counters (three tally units) were used to assist with enumerating common species.

The tow-board surveys differed from traditional manta surveys by utilising a lower speed and concentrating on a smaller swathe on the benthos. The slower speed, reduced swathe and greater length of tows used within PROCFish/C protocols were adopted to maximise efficiency when spotting and identifying cryptic invertebrates, while covering areas that were large enough to make representative measures.

Targeted surveys

Reef- and soft-benthos transect surveys (RBt and SBt), and soft-benthos quadrats (SBq)

To assess the range, abundance, size and condition of invertebrate species and their habitat with greater accuracy at smaller scales, reef- and soft-benthos assessments were conducted within fishing areas and suitable habitat. Reef benthos and soft benthos are not mutually exclusive, in that coral reefs generally have patches of sand, while soft-benthos seagrass areas can be strewn with rubble or contain patches of coral. However, these survey stations (each covering approximately 5000 m^2) were selected in areas representative of the habitat (those generally accessed by fishers, although MPAs were examined on occasion). Six 40 m transects (1 m swathe) were examined per station to record most epi-benthic invertebrate resources and some sea stars and urchin species (as potential indicators of habitat condition). Transects were randomly positioned but laid across environmental gradients where possible (e.g. across reefs and not along reef edges). A single waypoint was recorded for each station (to an accuracy of ≤ 10 m) and habitat recordings were made for each transect (see Figure A1.3.2 and Appendix 1.3.2).

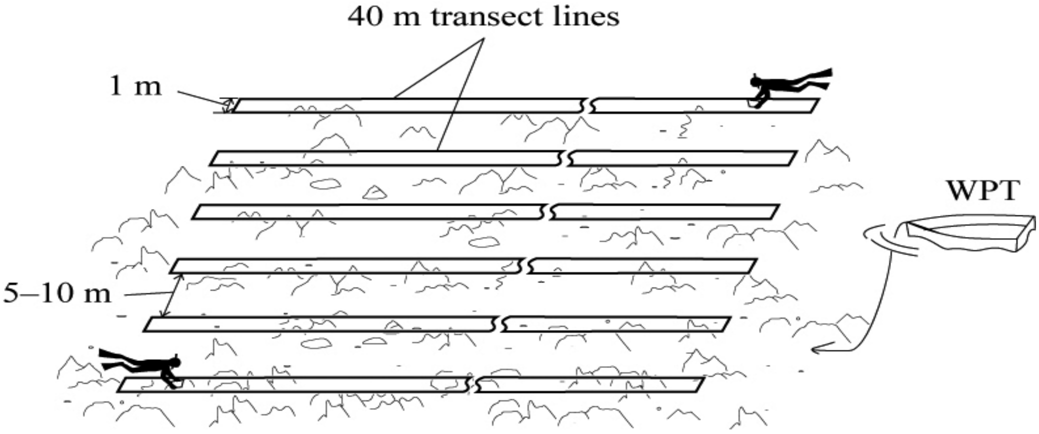


Figure A1.3.2: Example of a reef-benthos transect station (RBt).

To record infaunal resources, quadrats (SBq) were used within a 40 m × 2 m strip transect to measure densities of molluscs (mainly bivalves) in soft-benthos 'shell bed' areas. Four 25 cm x 25 cm quadrats (one quadrat group) were dug to approximately 5–8 cm to retrieve and measure infaunal target species and potential indicator species. Eight randomly spaced quadrat groups were sampled along the 40 m transect line (Figure A1.3.3). A single waypoint and habitat recording was taken for each infaunal station.

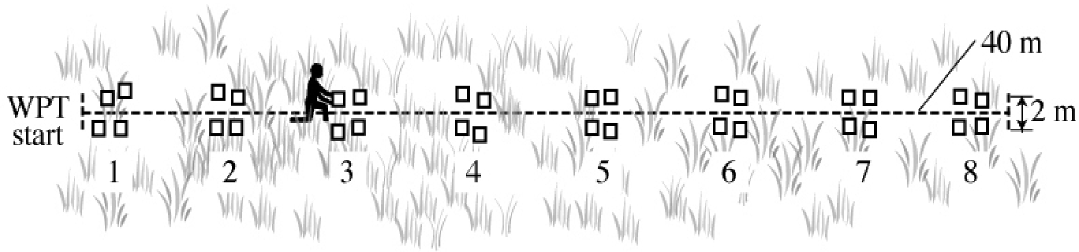


Figure A1.3.3: Soft-benthos (infaunal) quadrat station (SBq).
Single quadrats are 25 cm x 25 cm in size and four make up one 'quadrat group'.

<u>Mother-of-pearl (MOP) or sea cucumber (BdM) fisheries</u>

To assess fisheries such as those for trochus or sea cucumbers, results from broad-scale, reef- and soft-benthos assessments were used. However, other specific surveys were incorporated into the work programme, to more closely target species or species groups not well represented in the primary assessments.

<u>Reef-front searches (RFs and RFs_w)</u>

If swell conditions allowed, three 5-min search periods (conducted by two snorkellers, i.e. 30 min total) were conducted along exposed reef edges (RFs) where trochus (*Trochus niloticus*) and surf redfish (*Actinopyga mauritiana*) generally aggregate (Figure A1.3.4). Due to the dynamic conditions of the reef front, it was not generally possible to lay transects, but the start and end waypoints of reef-front searches were recorded, and two snorkellers recorded the abundance (generally not size measures) of large sedentary species (concentrating on trochus, surf redfish, gastropods and clams).

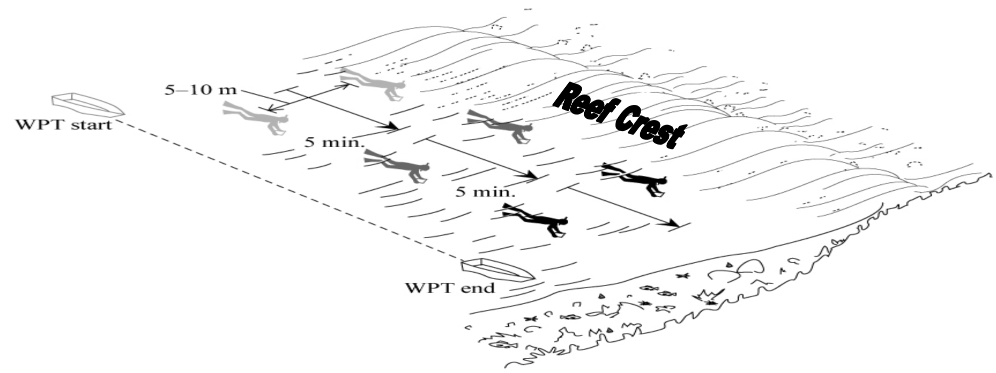


Figure A1.3.4: Reef-front search (RFs) station.

On occasions when it was too dangerous to conduct in-water reef-front searches (due to swell conditions or limited access) and the reeftop was accessible, searches were conducted on foot along the top of the reef front (RFs_w). In this case, two officers walked side by side (5–10 m apart) in the pools and cuts parallel to the reef front. This search was conducted at low tide, as close as was safe to the wave zone. In this style of assessment, reef-front counts of sea cucumbers, gastropod shells, urchins and clams were made during three 5-min search periods (total of 30 minutes search per station).

In the case of *Trochus niloticus*, reef-benthos transects, reef-front searches and local advice (trochus areas identified by local fishers) led us to reef-slope and shoal areas that were surveyed using SCUBA. Initially, searches were undertaken using SCUBA, although SCUBA transects (greater recording accuracy for density) were adopted if trochus were shown to be present at reasonable densities.

<u>Mother-of-pearl search (MOPs)</u>

Initially, two divers (using SCUBA) actively searched for trochus for three 5-min search periods (30 min total). Distance searched was estimated from marked GPS start and end waypoints. If more than three individual shells were found on these searches, the stock was considered dense enough to proceed with the more defined area assessment technique (MOPt).

<u>Mother-of-pearl transects (MOPt)</u>

Also on SCUBA, this method used six 40-m transects (2 m swathe) run perpendicular to the reef edge and not exceeding 15 m in depth (Figure A1.3.5). In most cases the depth ranged between 2 and 6 m, although dives could reach 12 m at some sites where more shallow-water habitat or stocks could not be found. In cases where the reef dropped off steeply, more oblique transect lines were followed. On MOP transect stations, a hip-mounted (or handheld) Chainman® measurement system (thread release) was used to measure out the 40 m. This allowed a hands-free mode of survey and saved time and energy in the often dynamic conditions where *Trochus niloticus* are found.

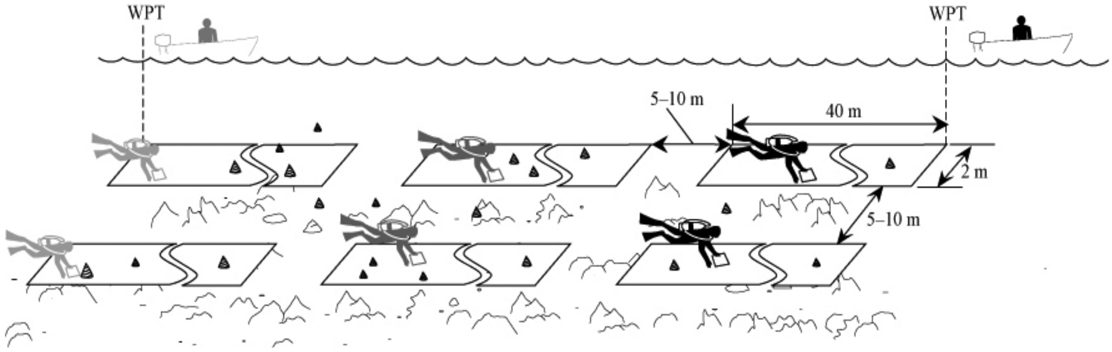


Figure A1.3.5: Mother-of-pearl transect station (MOPt).

Sea cucumber day search (Ds)

When possible, dives to 25–35 m were made to establish if white teatfish (*Holothuria (Microthele) fuscogilva*) populations were present and give an indication of abundance. In these searches two divers recorded the number and sizes of valuable deep-water sea cucumber species within three 5-min search periods (30 min total). This assessment from deep water does not yield sufficient presence/absence data for a very reliable inference on the status (i.e. 'health') of this and other deeper-water species.

Sea cucumber night search (Ns)

In the case of sea cucumber fisheries, dedicated night searches (Ns) for sea cucumbers and other echinoderms were conducted using snorkel for predominantly nocturnal species (blackfish *Actinopyga miliaris*, *A. lecanora*, and *Stichopus horrens*). Sea cucumbers were collected for three 5-min search periods by two snorkellers (30 min total), and if possible weighed (length and width measures for *A. miliaris* and *A. lecanora* are more dependent on the condition than the age of an individual).

Reporting style

For country site reports, results highlight the presence and distribution of species of interest, and their density at scales that yield a representative picture. Generally speaking, mean densities (average of all records) are presented, although on occasion mean densities for areas of aggregation ('patches') are also given. The later density figure is taken from records (stations or transects, as stated) where the species of interest is present (with an abundance >zero). Presentation of the relative occurrence and densities (without the inclusion of zero records) can be useful when assessing the status of aggregations within some invertebrate stocks.

An example and explanation of the reporting style adopted for invertebrate results follows.

1. The mean density range of *Tridacna* spp. on broad-scale stations (n = 8) was 10–120 per ha.

Density range includes results from all stations. In this case, replicates in each station are added and divided by the number of replicates for that station to give a mean. The lowest and highest station averages (here 10 and 120) are presented for the range. The number in brackets (n = 8) highlights the number of stations examined.

2. The mean density (per ha, ±SE) of all *Tridacna* clam species observed in broad-scale transects (n = 48) was 127.8 ±21.8 (occurrence in 29% of transects).

Mean density is the arithmetic mean, or average of measures across all replicates taken (in this case broad-scale transects). On occasion mean densities are reported for stations or transects where the species of interest is found at an abundance greater than zero. In this case the arithmetic mean would only include stations (or replicates) where the species of interest was found (excluding zero replicates). If this was presented for stations, even stations with a single clam from six transects would be included. (Note: a full breakdown of data is presented in the appendices.)

Written after the mean density figure is a descriptor that highlights variability in the figures used to calculate the mean. Standard error[3] (SE) is used in this example to highlight variability in the records that generated the mean density (SE = (standard deviation of records)/√n). This figure provides an indication of the dispersion of the data when trying to estimate a population mean (the larger the standard error, the greater variation of data points around the mean presented).

Following the variability descriptor is a presence/absence indicator for the total dataset of measures. The presence/absence figure describes the percentage of stations or replicates with a recording >0 in the total dataset; in this case 29% of all transects held *Tridacna* spp., which equated to 14 of a possible 48 transects (14/48*100 = 29%).

3. The mean length (cm, ±SE) of *T. maxima* was 12.4 ±1.1 (n = 114).

The number of units used in the calculation is indicated by *n*. In the last case, 114 clams were measured.

[3] In order to derive confidence limits around the mean, a transformation (usually y = log (x+1)) needs to be applied to data, as samples are generally non-normally distributed. Confidence limits of 95% can be generated through other methods (bootstrapping methods) and will be presented in the final report where appropriate.

1.3.2 General fauna invertebrate recording sheet with instructions to users

DATE		RECORDER		Pg No	

STATION NAME																		
WPT - WIDTH																		
RELIEF / COMPLEXITY **1–5**																		
OCEAN INFLUENCE **1–5**																		
DEPTH (M)																		
% SOFT SED (M – S – CS)																		
% RUBBLE / BOULDERS																		
% CONSOL RUBBLE / PAVE																		
% CORAL *LIVE*																		
% CORAL *DEAD*																		
SOFT / SPONGE / FUNGIDS																		
ALGAE *CCA*																		
CORALLINE																		
OTHER																		
GRASS																		
EPIPHYTES **1–5** / SILT **1–5**																		
bleaching: % of																		
entered /																		

Figure A1.3.6: Sample of the invertebrate fauna survey sheet.

The sheet above (Figure A1.3.6) has been modified to fit on this page (the original has more line space (rows) for entering species data). When recording abundance or length data against species names, columns are used for individual transects or 5-min search replicates. If more space is needed, more than a single column can be used for a single replicate.

A separate sheet is used by a recorder in the boat to note information from handheld GPS equipment. In addition to the positional information, this boat sheet has space for manta transect distance (from GPS odometer function) and for sketches and comments.

1.3.3 Habitat section of invertebrate recording sheet with instructions to users

Figure A1.3.7 depicts the habitat part of the form used during invertebrate surveys; it is split into seven broad categories.

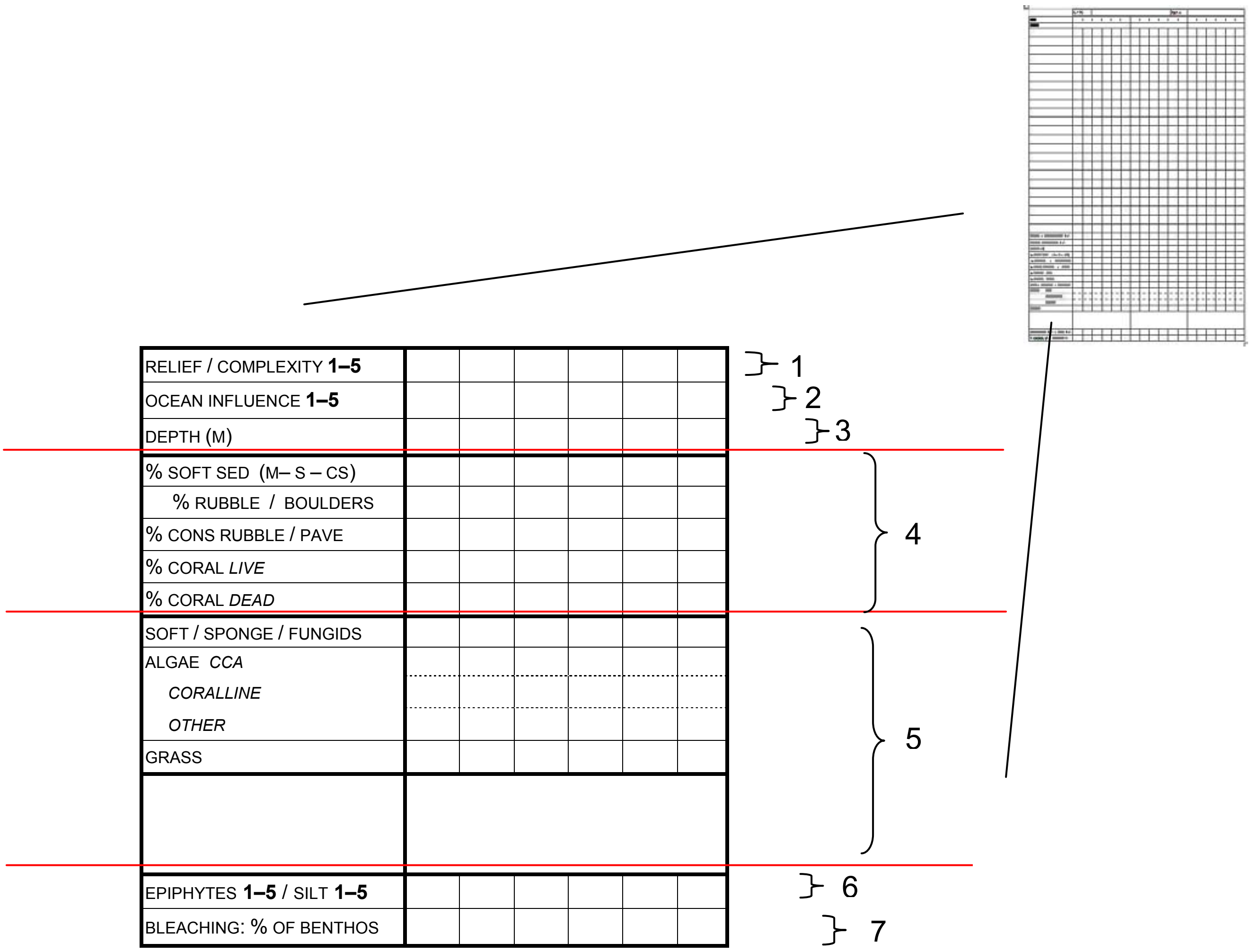


Figure A1.3.7: Sample of the invertebrate habitat part of survey form.

Relief and complexity (section 1 of form)

Each is on a scale of 1 to 5. If a record is written as 1/5, relief is 1 and complexity is 5, with the following explanation.

Relief describes average height variation for hard (and soft) benthos transects:

1 = flat (to ankle height)
2 = ankle up to knee height
3 = knee to hip height
4 = hip to shoulder/head height
5 = over head height

Complexity describes average surface variation for substrates (relative to places for animals to find shelter) for hard (and soft) benthos transects:

1 = smooth – no holes or irregularities in substrate
2 = some complexity to the surfaces but generally little

3 = generally complex surface structure
4 = strong complexity in surface structure, with cracks, spaces, holes, etc.
5 = very complex surfaces with lots of spaces, nooks, crannies, under-hangs and caves

Ocean influence (section 2 of form)

1 = riverine, or land-influenced seawater with lots of allochthonous input
2 = seawater with some land influence
3 = ocean and land-influenced seawater
4 = water mostly influenced by oceanic water
5 = oceanic water without land influence

Depth (section 3 of form)

Average depth in metres

Substrate – bird's-eye view of what's there (section 4 of form)

All of section 4 must make up 100%. Percentage substrate is estimated in units of 5% so, e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Soft substrate	Soft sediment – mud
Soft substrate	Soft sediment – mud and sand
Soft substrate	Soft sediment – sand
Soft substrate	Soft sediment – coarse sand
Hard substrate	Rubble
Hard substrate	Boulders
Hard substrate	Consolidated rubble
Hard substrate	Pavement
Hard substrate	Coral live
Hard substrate	Coral dead

Mud, *sand*, *coarse sand:* The sand is not sieved – it is estimated visually and manually. Surveyors can use the 'drop test', where sand drops through the water column and mud stays in suspension. Patchy settled areas of silt/clay/mud in very thin layers on top of coral, pavement, etc. are not listed as soft substrate unless the layer is significant (>a couple of cm).

Rubble is small (<25–30 cm) fragments of coral (reef), pieces of coral stone and limestone debris. AIMS' definition is very similar to that for Reefcheck (found on the 'C-nav' interactive CD): 'pieces of coral (reef) between 0.5 and 15 cm. If smaller, it is sand; if larger, then rock or whatever organism is growing upon it'.

Boulders are detached, big pieces (>30 cm) of stone, coral stone and limestone debris.

Consolidated rubble is attached, cemented pieces of coral stone and limestone debris. We tend to use 'rubble' for pieces or piles loose in the sediment of seagrass, etc., and 'consolidated rubble' for areas that are not flat pavement but concreted rubble on reeftops and cemented talus slopes.

Appendix 1: Survey methods
Invertebrates

Pavement is solid, substantial, fixed, flat stone (generally limestone) benthos.

Coral live is any live hard coral.

Coral dead is coral that is recognisable as coral even if it is long dead. Note that long-dead and *eroded* coral that is found in flat pavements is called 'pavement' and when it is found in loose pieces or blocks it is termed 'rubble' or 'boulders' (depending on size).

Cover – what is on top of the substrate (section 5 of form)

This cannot exceed 100%, but can be anything from 0 to 100%. Surveyors give scores in blocks of 5%, so e.g. 5, 10, 15, 20 (%) etc. and not 2, 13, 17, 56.

Elements to consider:

Cover	Soft coral
Cover	Sponge
Cover	Fungids
Cover	Crustose-nongeniculate coralline algae
Cover	Coralline algae
Cover	Other (algae like *Sargassum*, *Caulerpa* and *Padina* spp.)
Cover	Seagrass

Soft coral is all soft corals but not Zoanthids or anemones.

Sponge includes half-buried sponges in seagrass beds – only sections seen on the surface are noted.

Fungids are fungids.

Crustose – nongeniculate coralline algae are pink rock. Crustose or nongeniculate coralline algae (NCA) are red algae that deposit calcium carbonate in their cell walls. Generally they are members of the division Rhodophyta.

Coralline algae – halimeda are red coralline algae (often seen in balls – *Galaxaura*). (Note: AIMS lists *halimeda* and other coralline algae as macro algae along with fleshy algae not having $CaCo_3$ deposits.)

Other algae include fleshy algae such as *Turbinaria*, *Padina* and *Dictyota*. Surveyors describe coverage by taking a bird's-eye view of what is covered, not by delineating the spatial area of the algae colony within the transect (i.e. differences in very low or high density are accounted for). The large space on the form is used to write species information if known.

Seagrass includes seagrass spp. such as *Halodule*, *Thalassia*, *Halophila* and *Syringodium*. Surveyors note types by species if possible or by structure (i.e. flat versus reed grass), and describe coverage by taking a bird's-eye view of what benthos is covered, not by delineating the spatial area of the grass meadow within the transect (i.e. differences in very low or high density are accounted for).

Cover continued – epiphytes and silt (section 6 of form)

Epiphytes 1–5 grade are mainly turf algae – turf that grows on hard and soft substrates, but also on algae and grasses. The growth is usually fine-stranded filamentous algae that have few noticeable distinguishing features (more like fuzz).

1 = none
2 = small areas or light coverage
3 = patchy, medium coverage
4 = large areas or heavier coverage
5 = very strong coverage, long and thick almost choking epiphytes – normally including strands of blue-green algae as well

Silt 1–5 grade (or a similar fine-structured material sometimes termed 'marine snow') consists of fine particles that slowly settle out from the water but are easily re-suspended. When re-suspended, silt tends to make the water murky and does not settle quickly like sand does. Sand particles are not silt and should not be included here when seen on outer-reef platforms that are wave affected.

1 = clear surfaces
2 = little silt seen
3 = medium amount of silt-covered surfaces
4 = large areas covered in silt
5 = surfaces heavily covered in silt

Bleaching (section 7 of form)

The percentage of bleached live coral is recorded in numbers from 1 to 100% (Not 5% blocks). This is the percentage of benthos that is dying hard coral (just-bleached) or very recently dead hard coral showing obvious signs of recent bleaching.

APPENDIX 2: SOCIOECONOMIC SURVEY DATA

2.1 Ouassé socioeconomic survey data

2.1.1 Annual catch (kg) of fish groups per habitat – Ouassé
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Bossu	Lethrinidae	*Lethrinus* spp.	53	25
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	45	21
Dawa	Acanthuridae	*Naso unicornis*	21	10
Loche	Serranidae	*Epinephelus* spp.	18	8
Perroquet	Scaridae	*Scarus* spp.	14	7
Picot	Siganidae	*Siganus* spp.	14	7
Sardine	Clupeidae	*Herklotsichthys quadrimaculatus*	12	6
Carangue	Carangidae	*Caranx* spp.	11	5
Saumonée	Serranidae	*Plectropomus* spp.	8	4
Tazard	Scombridae	*Grammatorycnus* spp.	7	3
Dorade	Sparidae	*Sparus* spp.	3	1
Rouge (dara)	-	-	3	1
Rouget	Mullidae	*Parupeneus* spp.	3	1
Total:			**213**	**100**
Sheltered coastal reef & lagoon				
Mulet	Mugilidae	*Crenimugil crenilabis*	252	30
Perroquet	Scaridae	*Scarus* spp.	160	19
Dawa	Acanthuridae	*Naso unicornis*	151	18
Picot	Siganidae	*Siganus* spp.	117	14
Saumonée	Serranidae	*Plectropomus* spp.	63	7
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	37	4
Bossu	Lethrinidae	*Lethrinus* spp.	23	3
Loche	Serranidae	*Epinephelus* spp.	22	3
Rouget	Mullidae	*Parupeneus* spp.	12	1
Sardine	Clupeidae	*Herklotsichthys quadrimaculatus*	8	1
Blanc blanc	Gerreidae	*Gerres* spp.	7	1
Total:			**852**	**100**
Outer reef				
Dawa	Acanthuridae	*Naso unicornis*	8	30
Picot	Siganidae	*Siganus* spp.	7	28
Perroquet	Scaridae	*Scarus* spp.	4	16
Saumonée	Serranidae	*Plectropomus* spp.	4	14
Tazard	Scombridae	*Grammatorycnus* spp.	3	12
Loche	Serranidae	*Epinephelus* spp.	1	2
Total:			**26**	**100**

2.1.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Ouassé

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Reeftop	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	35
	Poulpe	*Octopus* spp.	22
	Bigorneau	*Turbo* spp.	16
	Troca	*Tectus pyramis*, *Trochus niloticus*	15
	-	*Nerita albicilla*, *Nerita balteata*, *Nerita plicata*, *Nerita polita*, *Nerita undata*	7
	Araignée	*Lambis lambis*	2
	-	*Nerita polita*	1
	Sauteur	*Strombus luhuanus*	1
	Huîtres	*Saccostrea* spp.	0
Soft bottom (sandy intertidal)	Clovis	*Atactodea striata*	77
	Bigorneau	*Turbo* spp.	12
	-	*Nerita albicilla*, *Nerita balteata*, *Nerita plicata*, *Nerita polita*, *Nerita undata*	11
Soft bottom (sandy intertidal) & reeftop	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	28
	-	*Nerita albicilla*, *Nerita balteata*, *Nerita plicata*, *Nerita polita*, *Nerita undata*	26
	Clovis	*Atactodea striata*	22
	Troca	*Tectus pyramis*, *Trochus niloticus*	22
	Bigorneau	*Turbo* spp.	2
	Araignée	*Lambis lambis*	0
Trochus & lobster & other	Troca	*Tectus pyramis*, *Trochus niloticus*	44
	Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	31
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	25

2.1.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Ouassé

Vernacular name	Scientific name	Size class	% of total catch (weight)
Araignée	*Lambis lambis*	10-12 cm	12
		12 cm	74
		14 cm	14
Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	08 cm	3
		08-10 cm	4
		10 cm	46
		14 cm	9
		14-18 cm	13
		16-22 cm	1
		18-28 cm	1
		22-24 cm	21
		24 cm	3
Bigorneau	*Turbo* spp.	02 cm	47
		04 cm	49
		04-06 cm	4
		06-08 cm	1
Clovis	*Atactodea striata*	02 cm	100
Huîtres	*Saccostrea* spp.	08-12 cm	100
Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	14-16 cm	70
		24 cm	30
-	*Nerita polita*	02 cm	100
-	*Nerita albicilla*, *Nerita balteata*, *Nerita plicata*, *Nerita polita*, *Nerita undata*	02 cm	100
Poulpe	*Octopus* spp.	04-06 cm	7
		06 cm	18
		06-08 cm	6
		08-10 cm	30
		10-12 cm	39
Sauteur	*Strombus luhuanus*	04 cm	100
		04-06 cm	0
Troca	*Tectus pyramis*, *Trochus niloticus*	08 cm	9
		08-10 cm	2
		09-12 cm	1
		10 cm	74
		10-12 cm	2
		12 cm	11

2.2 Thio socioeconomic survey data

2.2.1 Annual catch (kg) of fish groups per habitat – Thio
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Mulet	Mugilidae	*Crenimugil crenilabis*	1786	19
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	1537	16
Saumonée	Serranidae	*Plectropomus* spp.	1239	13
Dawa	Acanthuridae	*Naso unicornis*	1015	11
Loche	Serranidae	*Epinephelus* spp.	824	9
Bossu	Lethrinidae	*Lethrinus* spp.	661	7
Aiguillette	Hemiramphidae	*Hemiramphus far*	546	6
Perroquet	Scaridae	*Scarus* spp.	519	6
Picot	Siganidae	*Siganus* spp.	370	4
Carangue	Carangidae	*Caranx* spp.	192	2
Rouget	Mullidae	*Parupeneus* spp.	140	1
Jaunet noire	-	-	91	1
Barbillon	Lutjanidae	*Symphorus nematophorus*	85	1
Wiwa	-	-	70	1
Bossu d'herbe	Lethrinidae	*Lethrinus lentjan*	65	1
Mimosa	-	-	60	1
Maquereau	Scombridae	*Rastrelliger kanagurta*	59	1
Sardine	Clupeidae	*Herklotsichthys quadrimaculatus*	32	0
Jaunet	Lutjanidae	*Lutjanus boutton*	28	0
Rouget de nuit	Lutjanidae	*Lutjanus adetii*	17	0
Mère-loche	-	-	9	0
Brème	Lethrinidae	*Monotaxis grandoculis*	3	0
Dorade	-	-	2	0
Total:			**9349**	**100**
Sheltered coastal reef & lagoon				
Saumonée	Serranidae	*Plectropomus* spp.	1306	23
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	844	15
Mulet	Mugilidae	*Crenimugil crenilabis*	532	10
Wiwa	-	-	495	9
Bossu	Lethrinidae	*Lethrinus* spp.	485	9
Loche	Serranidae	*Epinephelus* spp.	451	8
Perroquet	Scaridae	*Scarus* spp.	391	7
Carangue	Carangidae	*Caranx* spp.	308	6
Blanc blanc	-	-	225	4
Vivaneau jaune	-	-	174	3
Dawa	Acanthuridae	*Naso unicornis*	166	3
Picot	Siganidae	*Siganus* spp.	132	2
Rouget	Mullidae	*Parupeneus* spp.	32	1
Jaunet	Lutjanidae	*Lutjanus boutton*	15	0
Aiguillette	Hemiramphidae	*Hemiramphus far*	10	0
Dorade	-	-	7	0
Total:			**5573**	**100**

2.2.1 Annual catch (kg) of fish groups per habitat – Thio (continued)
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon				
Bossu	Lethrinidae	*Lethrinus* spp.	434	29
Saumonée	Serranidae	*Plectropomus* spp.	233	15
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	217	14
Loche	Serranidae	*Epinephelus* spp.	217	14
Perroquet	Scaridae	*Scarus* spp.	212	14
Picot	Siganidae	*Siganus* spp.	195	13
Dawa	Acanthuridae	*Naso unicornis*	10	1
Vivaneau rose	-	-	3	0
Total:			**1522**	**100**
Outer reef				
Perroquet	Scaridae	*Scarus* spp.	219	34
Dawa	Acanthuridae	*Naso unicornis*	217	34
Vivaneau jaune	-	-	80	13
Saumonée	Serranidae	*Plectropomus* spp.	62	10
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	60	9
Total:			**639**	**100**

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Thio

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Bêche-de-mer	Tête	*Holothuria* spp.	34
	-	*Actinopyga mauritiana*	34
	Bêche-de-mer	*Holothuria* spp.	23
	Ananas	*Thelenota ananas*	10
Bêche-de-mer & trochus	Troca	*Tectus pyramis*, *Trochus niloticus*	48
	-	*Actinopyga mauritiana*	26
	Tête	*Holothuria* spp.	26
Bêche-de-mer & trochus & lobster & other	-	*Holothuria nobilis*	47
	Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	23
	Troca	*Tectus pyramis*, *Trochus niloticus*	20
	-	*Actinopyga mauritiana*	8
	Popinée	*Parribacus caledonicus*	2
Lobster	Troca	*Tectus pyramis*, *Trochus niloticus*	48
	Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	24
	Poulpe	*Octopus* spp.	14
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	7
	-	*Lambis truncata*	4
	Sauteur	*Strombus luhuanus*	2
	Popinée	*Parribacus caledonicus*	2

2.2.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Thio (continued)

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Lobster & other	Troca	*Tectus pyramis*, *Trochus niloticus*	57
	Grosse tête	*Panulirus penicillatus*	14
	Langouste verte	*Panulirus versicolor*	14
	Poulpe	*Octopus* spp.	8
	Popinée	*Parribacus caledonicus*	7
Mangrove	Crabe de palétuvier	*Scylla serrata*	100
Other	Poulpe	*Octopus* spp.	100
Reeftop	Poulpe	*Octopus* spp.	37
	Sauteur	*Strombus luhuanus*	24
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	15
	Troca	*Tectus pyramis*, *Trochus niloticus*	12
	Bigorneau	*Turbo* spp.	5
	Araignée	*Lambis lambis*	4
	Popinée	*Parribacus caledonicus*	2
	Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	1
Reeftop & other	Poulpe	*Octopus* spp.	89
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	11
Soft bottom (sandy intertidal)	Grisette	*Gafrarium pectinatum*, *Gafrarium tumidum*	48
	Anadara	*Anadara* spp.	41
	Clovis	*Atactodea striata*	11
Trochus	Troca	*Tectus pyramis*, *Trochus niloticus*	100
Trochus & other	Troca	*Tectus pyramis*, *Trochus niloticus*	53
	Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	36
	Poulpe	*Octopus* spp.	6
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	5

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Thio

Vernacular name	Scientific name	Size class	% of total catch (weight)
-	*Actinopyga mauritiana*	12 cm	17
		14 cm	1
		16-20 cm	12
		18 cm	58
		22 cm	7
		24 cm	5
Ananas	*Thelenota ananas*	28 cm	100
Anadara	*Anadara* spp.	08 cm	100
Araignée	*Lambis lambis*	14 cm	99
		18 cm	0
		20-26 cm	1
Bêche-de-mer	*Holothuria* spp.	18 cm	100
Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	06-18 cm	17
		08 cm	1
		10 cm	3
		16-18 cm	0
		18 cm	2
		20 cm	21
		20-28 cm	1
		24 cm	25
		26-28 cm	30
Bigorneau	*Turbo* spp.	02-04 cm	29
		04-06 cm	5
		04-08 cm	66
Clovis	*Atactodea striata*	02 cm	100
Crabe de palétuvier	*Scylla serrata*	09-14 cm	100
Grisette	*Gafrarium pectinatum*, *Gafrarium tumidum*	04 cm	100
Grosse tête	*Panulirus penicillatus*	22-24 cm	100
-	*Holothuria nobilis*	24 cm	100
-	*Lambis truncata*	12 cm	100
Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	14-16 cm	6
		14-18 cm	10
		14-20 cm	1
		16-18 cm	2
		18 cm	1
		18-20 cm	0
		18-22 cm	1
		22 cm	9
		22-24 cm	12
		26-28 cm	54
		28 cm	5
Langouste verte	*Panulirus versicolor*	22-24 cm	100
Popinée	*Parribacus caledonicus*	12 cm	6
		14 cm	16
		14-16 cm	1
		16 cm	59
		20 cm	18

2.2.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Thio (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Poulpe	*Octopus* spp.	06-14 cm	4
		08 cm	3
		08-10 cm	23
		08-12 cm	0
		10 cm	19
		10-12 cm	6
		10-14 cm	7
		12 cm	2
		14 cm	7
		14-16 cm	3
		16 cm	5
		16-18 cm	22
Sauteur	*Strombus luhuanus*	02-05 cm	35
		04 cm	1
		04-10 cm	6
		06 cm	38
		08 cm	10
		12 cm	10
Tête	*Holothuria* spp.	18-22 cm	13
		20 cm	25
		26 cm	1
		28 cm	61
Troca	*Tectus pyramis*, *Trochus niloticus*	06-08 cm	20
		08 cm	1
		08-10 cm	16
		08-12 cm	9
		09 cm	1
		09-10 cm	0
		09-12 cm	25
		10 cm	1
		10-12 cm	20
		10-14 cm	6

2.3 Luengoni socioeconomic survey data

2.3.1 Annual catch (kg) of fish groups per habitat – Luengoni

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	27	30
Perroquet	Scaridae	*Scarus* spp.	25	27
Rouget	Mullidae	*Parupeneus* spp.	24	26
Loche	Serranidae	*Epinephelus* spp.	15	17
Picot	Siganidae	*Siganus* spp.	1	1
Total:			**92**	**100**
Sheltered coastal reef & lagoon				
Dawa	Acanthuridae	*Naso unicornis*	73	21
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	70	20
Saumonée	Serranidae	*Plectropomus* spp.	48	14
Perroquet	Scaridae	*Scarus* spp.	45	13
Loche	Serranidae	*Epinephelus* spp.	39	11
Rouget	Mullidae	*Parupeneus* spp.	26	7
Bossu	Lethrinidae	*Lethrinus* spp.	25	7
Perroquet bleu	Scaridae	*Chlorurus microrhinos*	11	3
Picot canaque	Acanthuridae	*Acanthurus xanthopterus*	11	3
Total:			**348**	**100**
Lagoon				
Perroquet	Scaridae	*Scarus* spp.	617	22
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	479	17
Rouget	Mullidae	*Parupeneus* spp.	377	13
Dawa	Acanthuridae	*Naso unicornis*	281	10
Loche	Serranidae	*Epinephelus* spp.	229	8
Picot	Siganidae	*Siganus* spp.	227	8
Saumonée	Serranidae	*Plectropomus* spp.	126	4
Picot bleu	-	-	120	4
Vivaneau	Lutjanidae	*Lipocheilus carnolabrum*, *Macolor macularis*	109	4
Bossu	Lethrinidae	*Lethrinus* spp.	74	3
Carangue	Carangidae	*Caranx* spp.	70	2
Chirurgien	Acanthuridae	*Acanthurus* spp.	59	2
Perroquet bleu	Scaridae	*Chlorurus microrhinos*	41	1
Blanc blanc	Gerreidae	*Gerres* spp.	22	1
Picot canaque	Acanthuridae	*Acanthurus xanthopterus*	17	1
Mulet	Mugilidae	*Crenimugil crenilabis*	12	0
Barbillon	Lutjanidae	*Symphorus nematophorus*	1	0
Total:			**2861**	**100**

2.3.1 Annual catch (kg) of fish groups per habitat – Luengoni (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon & outer reef				
Loche	Serranidae	*Epinephelus* spp.	240	15
Dawa	Acanthuridae	*Naso unicornis*	214	14
Perroquet	Scaridae	*Scarus* spp.	211	13
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	177	11
Perroquet rouge	-	-	159	10
Perroquet bleu	Scaridae	*Chlorurus microrhinos*	159	10
Barbillon	Lutjanidae	*Symphorus nematophorus*	95	6
Picot	Siganidae	*Siganus* spp.	79	5
Picot canaque	Acanthuridae	*Acanthurus xanthopterus*	55	3
Bossu	Lethrinidae	*Lethrinus* spp.	55	3
Rouget de nuit	Lutjanidae	*Lutjanus adetii*	55	3
Saumonée	Serranidae	*Plectropomus* spp.	52	3
Rouget	Mullidae	*Parupeneus* spp.	18	1
Total:			**1570**	**100**
Outer reef				
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	195	23
Loche	Serranidae	*Epinephelus* spp.	111	13
Picot canaque	Acanthuridae	*Acanthurus xanthopterus*	107	12
Perroquet	Scaridae	*Scarus* spp.	91	11
Vivaneau	Lutjanidae	*Lipocheilus carnolabrum*, *Macolor macularis*	79	9
Mekua	Lutjanidae	*Aprion virescens*	79	9
Bossu	Lethrinidae	*Lethrinus* spp.	64	7
Dawa	Acanthuridae	*Naso unicornis*	57	7
Picot	Siganidae	*Siganus* spp.	41	5
Saumonée	Serranidae	*Plectropomus* spp.	27	3
Rouget	Mullidae	*Parupeneus* spp.	12	1
Total:			**863**	**100**

2.3.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Luengoni

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Lobster	Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	82
	Popinée	*Parribacus caledonicus*	18
	Araignée	*Lambis lambis*	0
Other	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	60
	Poulpe	*Octopus* spp.	28
	Troca	*Tectus pyramis*, *Trochus niloticus*	11
	-	*Turbo crassus*	0
Reeftop	Popinée	*Parribacus caledonicus*	32
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	17
	Troca	*Tectus pyramis*, *Trochus niloticus*	14
	Huîtres	*Saccostrea* spp.	10
	Porcelaine	*Panulirus ornatus*	4
	Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	4
	Poulpe	*Octopus* spp.	4
	Sauteur	*Strombus luhuanus*	4
	Penie	*Strombus gibberulus gibbosus*	3
	-	*Nerita albicilla*, *Nerita balteata*, *Nerita plicata*, *Nerita polita*, *Nerita undata*	2
	Cône	*Conus* spp.	2
	Bigorneau	*Turbo* spp.	2
	Araignée	*Lambis lambis*	2
	Moules	*Modiolus auriculatus*	1
	Giza	*Nerita plicata*	0
Soft bottom (sandy intertidal)	-	*Cardisoma* spp.	46
	-	*Nerita polita*	32
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	20
	Bernard l'hermite	*Dardanus* spp.	2

2.3.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Luengoni

Vernacular name	Scientific name	Size class	% of total catch (weight)
Araignée	*Lambis lambis*	08 cm	94
		22-26 cm	6
Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	06-10 cm	27
		10-12 cm	18
		18-22 cm	0
		20 cm	36
		28 cm	9
		28-40 cm	2
		30-35 cm	8
Bernard l'hermite	*Dardanus* spp.	02-04 cm	100
Bigorneau	*Turbo* spp.	08 cm	9
		08-10 cm	91
-	*Cardisoma* spp.	04-06 cm	100
Cône	*Conus* spp.	22 cm	100
Giza	*Nerita plicata*	02 cm	100
Huîtres	*Saccostrea* spp.	08 cm	100
Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	18-26 cm	20
		19-26 cm	3
		20-24 cm	13
		20-28 cm	6
		22-24 cm	3
		22-26 cm	4
		22-28 cm	16
		24 cm	12
		24-26 cm	4
		24-28 cm	19
		26 cm	2
Moules	*Modiolus auriculatus*	04 cm	100
-	*Nerita polita*	02 cm	100
-	*Nerita albicilla*, *Nerita balteata*, *Nerita plicata*, *Nerita polita*, *Nerita undata*	02 cm	76
		02-04 cm	24
Penie	*Strombus gibberulus gibbosus*	02 cm	100
Popinée	*Parribacus caledonicus*	12 cm	27
		12-16 cm	1
		16-18 cm	21
		20 cm	27
		26 cm	23
Porcelaine	*Panulirus ornatus*	04-08 cm	100
Poulpe	*Octopus* spp.	08 cm	44
		10-12 cm	56
Sauteur	*Strombus luhuanus*	03-04 cm	59
		06 cm	41
Troca	*Tectus pyramis*, *Trochus niloticus*	06-08 cm	42
		08 cm	7
		08-10 cm	32
		10 cm	10
		12 cm	9
-	*Turbo crassus*	06-08 cm	100

2.4 Oundjo socioeconomic survey data

2.4.1 Annual catch (kg) of fish groups per habitat – Oundjo

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef & lagoon				
Mulet	Mugilidae	*Crenimugil crenilabis*	1974	24
Picot	Siganidae	*Siganus* spp.	1445	17
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	1260	15
Dawa	Acanthuridae	*Naso unicornis*	593	7
Aiguillette	Hemiramphidae	*Hemiramphus far*	499	6
Blanc blanc	Gerreidae	*Gerres* spp.	489	6
Loche	Serranidae	*Epinephelus* spp.	443	5
Perroquet	Scaridae	*Scarus* spp.	327	4
Rouget	Mullidae	*Parupeneus* spp.	315	4
Bossu	Lethrinidae	*Lethrinus* spp.	261	3
Pointe coeur	-	-	261	3
Carangue	Carangidae	*Caranx* spp.	174	2
Brème	Lethrinidae	*Monotaxis grandoculis*	174	2
Picot rayé	Siganidae	*Siganus lineatus*	163	2
Total:			**8375**	**100**
Sheltered coastal reef				
Mulet	Mugilidae	*Crenimugil crenilabis*	1360	22
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	1305	21
Picot	Siganidae	*Siganus* spp.	1303	21
Dawa	Acanthuridae	*Naso unicornis*	597	10
Perroquet	Scaridae	*Scarus* spp.	586	9
Blanc blanc	Gerreidae	*Gerres* spp.	293	5
Bossu	Lethrinidae	*Lethrinus* spp.	275	4
Vivaneau	Lutjanidae	*Lipocheilus carnolabrum*, *Macolor macularis*	175	3
Perroquet bleu	Scaridae	*Chlorurus microrhinos*	77	1
Rouget	Mullidae	*Parupeneus* spp.	55	1
Brème	Lethrinidae	*Monotaxis grandoculis*	55	1
Zebra jaune et noir	Acanthuridae	*Zebrasoma* spp.	45	1
Picot canaque	Acanthuridae	*Acanthurus xanthopterus*	43	1
Barbillon	Lutjanidae	*Symphorus nematophorus*	43	1
Loche	Serranidae	*Epinephelus* spp.	9	0
Total:			**6221**	**100**

2.4.1 Annual catch (kg) of fish groups per habitat – Oundjo (continued)

(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Lagoon				
Dawa	Acanthuridae	*Naso unicornis*	662	21
Perroquet	Scaridae	*Scarus* spp.	575	18
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	530	17
Bossu	Lethrinidae	*Lethrinus* spp.	384	12
Mulet	Mugilidae	*Crenimugil crenilabis*	380	12
Bossu doré	Lethrinidae	*Lethrinus atkinsoni*	239	7
Vivaneau	Lutjanidae	*Lipocheilus carnolabrum*, *Macolor macularis*	136	4
Bec rose	Lethrinidae	*Lethrinus olivaceus*	101	3
Picot	Siganidae	*Siganus* spp.	98	3
Blanc blanc	Gerreidae	*Gerres* spp.	65	2
Loche bleue	Serranidae	*Epinephelus cyanopodus*	40	1
Total:			**3210**	**100**
Outer reef				
Dawa	Acanthuridae	*Naso unicornis*	196	49
Saumonée	Serranidae	*Plectropomus* spp.	110	27
Vivaneau	Lutjanidae	*Lipocheilus carnolabrum*, *Macolor macularis*	60	15
Perroquet	Scaridae	*Scarus* spp.	35	9
Total:			**401**	**100**

2.4.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Oundjo

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Bêche-de-mer	Bêche-de-mer	*Holothuria* spp.	61
	-	*Holothuria nobilis*	19
	-	*Actinopyga mauritiana*	19
Lobster	Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	92
	Popinée	*Parribacus caledonicus*	6
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	2
Mangrove	Crabe de palétuvier	*Scylla serrata*	61
	Anadara	*Anadara* spp.	19
	Grisette	*Gafrarium pectinatum*, *Gafrarium tumidum*	10
	Coquilong	-	10
Other	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	85
	Poulpe	*Octopus* spp.	15
Reeftop	-	*Holothuria scabra*	51
	Troca	*Tectus pyramis*, *Trochus niloticus*	34
	Bigorneau	*Turbo* spp.	8
	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	7
	Poulpe	*Octopus* spp.	1
Trochus	Troca	*Tectus pyramis*, *Trochus niloticus*	100

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Oundjo

Vernacular name	Scientific name	Size class	% of total catch (weight)
-	*Actinopyga mauritiana*	26-28 cm	100
Anadara	*Anadara* spp.	02-06 cm	7
		04-08 cm	5
		06 cm	64
		08 cm	24
Bêche-de-mer	*Holothuria* spp.	14-20 cm	9
		16-28 cm	73
		22-24 cm	6
		26-28 cm	12
Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	10-20 cm	3
		16-18 cm	31
		16-20 cm	19
		20 cm	8
		20-22 cm	7
		20-25 cm	1
		22-24 cm	3
		22-28 cm	14
		26 cm	5
		28 cm	9
		28-30 cm	2
Bigorneau	*Turbo* spp.	02-04 cm	0
		04-06 cm	59
		08 cm	41
Coquilong	-	04 cm	7
		08 cm	88
		08-10 cm	5
Crabe de palétuvier	*Scylla serrata*	06-08 cm	1
		06-12 cm	9
		09-10 cm	1
		10-12 cm	12
		10-14 cm	4
		12-14 cm	1
		12-15 cm	7
		13-14 cm	12
		13-15 cm	13
		14 cm	23
		14-15 cm	3
		14-16 cm	13
Grisette	*Gafrarium pectinatum*, *Gafrarium tumidum*	04 cm	15
		04-06 cm	85
-	*Holothuria nobilis*	26-28 cm	100
-	*Holothuria scabra*	28 cm	100
Langouste	*Panulirus longipes*, *Panulirus* spp., *Panulirus versicolor*	14-18 cm	2
		18 cm	15
		18-24 cm	37
		18-28 cm	15
		22 cm	8
		24-26 cm	24

2.4.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Oundjo (continued)

Vernacular name	Scientific name	Size class	% of total catch (weight)
Popinée	*Parribacus caledonicus*	12-15 cm	100
Poulpe	*Octopus* spp.	10 cm	53
		10-12 cm	28
		15 cm	19
Troca	*Tectus pyramis*, *Trochus niloticus*	04-06 cm	0
		08 cm	13
		08-09 cm	2
		09 cm	0
		09-12 cm	37
		09-14 cm	34
		12 cm	13

2.5 Moindou socioeconomic survey data

2.5.1 Annual catch (kg) of fish groups per habitat – Moindou
(includes only reported catch data by interviewed finfish fishers)

Vernacular name	Family	Scientific name	Total weight (kg)	% of reported catch
Sheltered coastal reef				
Mulet	Mugilidae	*Crenimugil crenilabis*	1666	47
Picot	Siganidae	*Siganus* spp.	390	11
Bec de cane	Lethrinidae	*Lethrinus olivaceus*, *Lethrinus nebulosus*	331	9
Rouget	Mullidae	*Parupeneus* spp.	270	8
Bossu doré	Lethrinidae	*Lethrinus atkinsoni*	143	4
Loche	Serranidae	*Epinephelus* spp.	120	3
Blanc blanc	Gerreidae	*Gerres* spp.	87	2
Carangue	Carangidae	*Caranx* spp.	85	2
Bec rose	Lethrinidae	*Lethrinus olivaceus*	85	2
Bossu	Lethrinidae	*Lethrinus* spp.	67	2
Crocro	Leiognathidae	*Gazza minuta*	56	2
Balabio	-	-	41	1
Bossu d'herbe	Lethrinidae	*Lethrinus lentjan*	36	1
Vieille rouge de palétuvier	Lutjanidae	*Lutjanus argentimaculatus*	25	1
Tarpon	-	-	24	1
Perroquet banana	Labridae	*Bodianus perditio*	23	1
Gueule d'acier	Lethrinidae	*Lethrinus xanthochilus*	23	1
Loche grise	-	-	17	0
Tazard	-	-	11	0
Dawa	Acanthuridae	*Naso unicornis*	10	0
Baleinier	Sillaginidae	*Sillago ciliata*, *Sillago sihama*	10	0
Picot rayé	Siganidae	*Siganus lineatus*	2	0
Gluant	-	-	1	0
Aiguillette	Hemiramphidae	*Hemiramphus far*	1	0
Lochon	Eleotridae	*Eleotris fusca*	1	0
Perroquet	Scaridae	*Scarus* spp.	0	0
Saumonée	Serranidae	*Plectropomus* spp.	0	0
Total:			**3524**	**100**
Outer reef				
Picot	Siganidae	*Siganus* spp.	62	27
Perroquet	Scaridae	*Scarus* spp.	60	26
Dawa	Acanthuridae	*Naso unicornis*	49	21
Loche	Serranidae	*Epinephelus* spp.	31	13
Saumonée	Serranidae	*Plectropomus* spp.	31	13
Total:			**233**	**100**

2.5.2 Invertebrate species caught by fishery with the percentage of annual wet weight caught – Moindou

Fishery	Vernacular name	Scientific name	% annual catch (weight)
Mangrove	Crabe de palétuvier	*Scylla serrata*	99
	Huîtres	*Saccostrea* spp.	0
	-	*Terebra* spp.	0
	Grisette	*Gafrarium pectinatum*, *Gafrarium tumidum*	0
	Huîtres de palétuvier Isognom	*Saccostrea cuccullata*	0
	Anadara	*Anadara* spp.	0
Reeftop	Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	83
	Poulpe	*Octopus* spp.	17
Soft bottom (sandy intertidal)	Grisette	*Gafrarium pectinatum*, *Gafrarium tumidum*	76
	Anadara	*Anadara* spp.	24
	Bigorneau	*Turbo* spp.	0

2.5.3 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight – Moindou

Vernacular name	Scientific name	Size class	% of total catch (weight)
Anadara	*Anadara* spp.	04-06 cm	4
		06 cm	96
Bénitier	*Hippopus hippopus*, *Tridacna maxima*, *Tridacna squamosa*	20 cm	96
		28 cm	4
Bigorneau	*Turbo* spp.	08 cm	100
Crabe de palétuvier	*Scylla serrata*	10 cm	0
		10-14 cm	0
		12 cm	0
		12-14 cm	1
		14 cm	25
		14-15 cm	47
		14-16 cm	15
		14-18 cm	2
		15 cm	1
		17-20 cm	8
Grisette	*Gafrarium pectinatum*, *Gafrarium tumidum*	04 cm	91
		04-05 cm	3
		04-06 cm	2
		06 cm	4
Huître de palétuvier Isognom	*Saccostrea cuccullata*	12-14 cm	100
Huîtres	*Saccostrea* spp.	06 cm	100
Poulpe	*Octopus* spp.	10 cm	100
-	*Terebra* spp.	08 cm	100

APPENDIX 3: FINFISH SURVEY DATA

3.1 Ouassé finfish survey data

3.1.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Ouassé

Transect	Habitat	Latitude	Longitude
TRA01	Sheltered coastal reef	21°28'49.1988" S	166°04'37.38" E
TRA02	Intermediate reef	21°27'19.1988" S	166°03'05.1012" E
TRA03	Intermediate reef	21°27'09.1188" S	166°02'33.54" E
TRA04	Sheltered coastal reef	21°27'40.6188" S	166°02'42.7812" E
TRA05	Intermediate reef	21°25'48.8388" S	166°01'05.5812" E
TRA06	Sheltered coastal reef	21°26'23.9388" S	166°00'22.3812" E
TRA07	Sheltered coastal reef	21°27'01.5012" S	166°01'11.0388" E
TRA08	Sheltered coastal reef	21°27'19.8" S	166°01'50.4588" E
TRA09	Intermediate reef	21°23'06.4788" S	166°00'53.3412" E
TRA10	Intermediate reef	21°23'27.96" S	166°01'11.9388" E
TRA11	Sheltered coastal reef	21°24'38.9412" S	165°58'32.88" E
TRA12	Intermediate reef	21°25'32.9988" S	166°00'20.0412" E
TRA13	Outer reef	21°24'37.3788" S	166°08'00.3588" E
TRA14	Outer reef	21°24'16.8012" S	166°07'31.3212" E
TRA15	Back-reef	21°24'31.5" S	166°07'20.46" E
TRA16	Back-reef	21°24'47.7" S	166°07'37.6788" E
TRA17	Outer reef	21°20'00.24" S	166°03'25.1388" E
TRA18	Outer reef	21°19'12.6588" S	166°02'30.7212" E
TRA19	Back-reef	21°19'18.5988" S	166°02'12.4188" E
TRA20	Back-reef	21°20'22.56" S	166°03'18.0612" E
TRA21	Outer reef	21°22'08.58" S	166°05'08.16" E
TRA22	Outer reef	21°21'43.92" S	166°04'38.5212" E
TRA23	Back-reef	21°21'57.96" S	166°04'21.6588" E
TRA24	Back-reef	21°22'15.8988" S	166°04'48.4788" E

Appendix 3: Finfish survey data
Ouassé

3.1.2 Weighted average density and biomass of all finfish species recorded in Ouassé
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Acanthuridae	*Acanthurus blochii*	0.008	2.69
Acanthuridae	*Acanthurus dussumieri*	0.002	1.20
Acanthuridae	*Acanthurus lineatus*	0.034	12.58
Acanthuridae	*Acanthurus mata*	0.000	0.12
Acanthuridae	*Acanthurus nigricauda*	0.001	0.30
Acanthuridae	*Acanthurus nigrofuscus*	0.039	2.49
Acanthuridae	*Acanthurus nigroris*	0.001	0.09
Acanthuridae	*Acanthurus olivaceus*	0.007	2.91
Acanthuridae	*Acanthurus pyroferus*	0.000	0.04
Acanthuridae	*Acanthurus triostegus*	0.036	2.84
Acanthuridae	*Acanthurus xanthopterus*	0.001	0.16
Acanthuridae	*Ctenochaetus binotatus*	0.002	0.10
Acanthuridae	*Ctenochaetus striatus*	0.053	6.25
Acanthuridae	*Naso annulatus*	0.010	4.14
Acanthuridae	*Naso brachycentron*	0.000	0.11
Acanthuridae	*Naso caesius*	0.008	4.82
Acanthuridae	*Naso lituratus*	0.004	2.57
Acanthuridae	*Naso tuberosus*	0.008	5.50
Acanthuridae	*Naso unicornis*	0.011	4.83
Acanthuridae	*Paracanthurus hepatus*	0.001	0.12
Acanthuridae	*Zebrasoma scopas*	0.015	0.72
Acanthuridae	*Zebrasoma veliferum*	0.005	0.56
Balistidae	*Balistapus undulatus*	0.001	0.51
Balistidae	*Melichthys niger*	0.000	0.01
Balistidae	*Melichthys vidua*	0.000	0.06
Balistidae	*Rhinecanthus rectangulus*	0.000	0.00
Balistidae	*Sufflamen bursa*	0.000	0.01
Balistidae	*Sufflamen chrysopterum*	0.003	0.69
Balistidae	*Xanthichthys auromarginatus*	0.000	0.07
Caesionidae	*Caesio caerulaurea*	0.022	7.07
Caesionidae	*Caesio cuning*	0.014	2.48
Caesionidae	*Caesio teres*	0.005	1.17
Caesionidae	*Pterocaesio digramma*	0.001	0.20
Caesionidae	*Pterocaesio marri*	0.010	0.92
Caesionidae	*Pterocaesio pisang*	0.003	0.25
Caesionidae	*Pterocaesio tile*	0.025	2.03
Caesionidae	*Pterocaesio trilineata*	0.006	0.33
Carangidae	*Caranx melampygus*	0.000	0.14
Carangidae	*Scomberoides commersonnianus*	0.000	1.25
Carangidae	*Scomberoides lysan*	0.001	0.22
Carcharhinidae	*Carcharhinus amblyrhynchos*	0.000	19.43
Carcharhinidae	*Triaenodon obesus*	0.000	5.48
Chaetodontidae	*Chaetodon auriga*	0.001	0.04
Chaetodontidae	*Chaetodon baronessa*	0.004	0.19
Chaetodontidae	*Chaetodon citrinellus*	0.004	0.11
Chaetodontidae	*Chaetodon flavirostris*	0.000	0.05
Chaetodontidae	*Chaetodon kleinii*	0.001	0.01

3.1.2 Weighted average density and biomass of all finfish species recorded in Ouassé (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Chaetodontidae	*Chaetodon lunula*	0.001	0.03
Chaetodontidae	*Chaetodon lunulatus*	0.006	0.25
Chaetodontidae	*Chaetodon melannotus*	0.002	0.08
Chaetodontidae	*Chaetodon mertensii*	0.000	0.01
Chaetodontidae	*Chaetodon pelewensis*	0.002	0.08
Chaetodontidae	*Chaetodon plebeius*	0.006	0.15
Chaetodontidae	*Chaetodon rafflesii*	0.001	0.03
Chaetodontidae	*Chaetodon reticulatus*	0.000	0.01
Chaetodontidae	*Chaetodon trifascialis*	0.005	0.16
Chaetodontidae	*Chaetodon ulietensis*	0.000	0.01
Chaetodontidae	*Chaetodon unimaculatus*	0.002	0.15
Chaetodontidae	*Chaetodon vagabundus*	0.006	0.33
Chaetodontidae	*Forcipiger longirostris*	0.001	0.10
Chaetodontidae	*Heniochus chrysostomus*	0.000	0.04
Chaetodontidae	*Heniochus singularius*	0.000	0.03
Chaetodontidae	*Heniochus varius*	0.000	0.01
Chanidae	*Chanos chanos*	0.000	2.54
Diodontidae	*Diodon hystrix*	0.000	0.04
Ephippidae	*Platax* spp.	0.000	0.06
Haemulidae	*Diagramma pictum*	0.000	0.06
Haemulidae	*Plectorhinchus orientalis*	0.000	0.04
Holocentridae	*Myripristis berndti*	0.000	0.06
Holocentridae	*Myripristis kuntee*	0.000	0.05
Holocentridae	*Myripristis* spp.	0.000	0.09
Holocentridae	*Myripristis violacea*	0.001	0.13
Holocentridae	*Neoniphon sammara*	0.001	0.09
Holocentridae	*Sargocentron caudimaculatum*	0.001	0.14
Holocentridae	*Sargocentron spiniferum*	0.000	0.08
Kyphosidae	*Kyphosus vaigiensis*	0.000	0.10
Labridae	*Bodianus axillaris*	0.000	0.00
Labridae	*Bodianus loxozonus*	0.000	0.04
Labridae	*Bodianus perditio*	0.000	0.14
Labridae	*Cheilinus chlorourus*	0.005	0.83
Labridae	*Cheilinus fasciatus*	0.002	0.23
Labridae	*Cheilinus trilobatus*	0.000	0.02
Labridae	*Cheilinus undulatus*	0.000	0.12
Labridae	*Choerodon anchorago*	0.046	1.20
Labridae	*Choerodon fasciatus*	0.000	0.02
Labridae	*Coris aygula*	0.001	0.19
Labridae	*Coris gaimard*	0.000	0.05
Labridae	*Coris* spp.	0.000	0.01
Labridae	*Hemigymnus fasciatus*	0.003	0.22
Labridae	*Hemigymnus melapterus*	0.002	0.65
Labridae	*Oxycheilinus digramma*	0.000	0.03
Labridae	*Oxycheilinus unifasciatus*	0.000	0.06
Lethrinidae	*Gnathodentex aureolineatus*	0.000	0.21

3.1.2 Weighted average density and biomass of all finfish species recorded in Ouassé (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Lethrinidae	*Lethrinus harak*	0.002	1.03
Lethrinidae	*Monotaxis grandoculis*	0.002	0.69
Lutjanidae	*Aprion virescens*	0.000	0.43
Lutjanidae	*Lutjanus bohar*	0.001	0.15
Lutjanidae	*Lutjanus fulviflamma*	0.001	0.66
Lutjanidae	*Lutjanus fulvus*	0.002	0.72
Lutjanidae	*Lutjanus gibbus*	0.000	0.14
Lutjanidae	*Lutjanus kasmira*	0.002	1.00
Lutjanidae	*Lutjanus quinquelineatus*	0.000	0.07
Lutjanidae	*Macolor niger*	0.000	0.00
Mullidae	*Mulloidichthys flavolineatus*	0.003	0.17
Mullidae	*Parupeneus barberinoides*	0.000	0.02
Mullidae	*Parupeneus barberinus*	0.001	0.32
Mullidae	*Parupeneus ciliatus*	0.001	0.43
Mullidae	*Parupeneus cyclostomus*	0.000	0.00
Mullidae	*Parupeneus indicus*	0.000	0.04
Mullidae	*Parupeneus multifasciatus*	0.014	1.11
Mullidae	*Parupeneus pleurostigma*	0.003	0.33
Mullidae	*Parupeneus spilurus*	0.001	0.29
Mullidae	*Parupeneus trifasciatus*	0.001	0.05
Nemipteridae	*Pentapodus* spp.	0.000	0.01
Nemipteridae	*Scolopsis bilineata*	0.009	1.84
Pomacanthidae	*Pomacanthus imperator*	0.000	0.23
Pomacanthidae	*Pomacanthus semicirculatus*	0.000	0.08
Pomacanthidae	*Pomacanthus sexstriatus*	0.000	0.05
Pomacanthidae	*Pygoplites diacanthus*	0.001	0.09
Priacanthidae	*Priacanthus hamrur*	0.000	0.02
Scaridae	*Bolbometopon muricatum*	0.016	140.72
Scaridae	*Cetoscarus bicolor*	0.001	0.51
Scaridae	*Chlorurus bleekeri*	0.002	0.66
Scaridae	*Chlorurus frontalis*	0.000	0.02
Scaridae	*Chlorurus japanensis*	0.002	0.81
Scaridae	*Chlorurus microrhinos*	0.003	1.66
Scaridae	*Chlorurus sordidus*	0.054	15.28
Scaridae	*Hipposcarus longiceps*	0.002	0.80
Scaridae	*Leptoscarus vaigiensis*	0.000	0.01
Scaridae	*Scarus altipinnis*	0.002	1.57
Scaridae	*Scarus chameleon*	0.005	1.87
Scaridae	*Scarus flavipectoralis*	0.001	0.28
Scaridae	*Scarus forsteni*	0.001	0.26
Scaridae	*Scarus frenatus*	0.009	3.10
Scaridae	*Scarus ghobban*	0.002	1.22
Scaridae	*Scarus globiceps*	0.003	1.05
Scaridae	*Scarus longipinnis*	0.000	0.10
Scaridae	*Scarus niger*	0.003	2.19
Scaridae	*Scarus oviceps*	0.002	0.71

3.1.2 Weighted average density and biomass of all finfish species recorded in Ouassé (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Scaridae	*Scarus psittacus*	0.005	1.96
Scaridae	*Scarus quoyi*	0.000	0.02
Scaridae	*Scarus rivulatus*	0.029	9.85
Scaridae	*Scarus rubroviolaceus*	0.000	0.21
Scaridae	*Scarus schlegeli*	0.014	3.38
Scaridae	*Scarus* spp.	0.002	0.08
Scaridae	*Scarus spinus*	0.001	0.42
Scombridae	*Acanthocybium solandri*	0.000	0.94
Serranidae	*Aethaloperca rogaa*	0.001	0.06
Serranidae	*Cephalopholis boenak*	0.000	0.04
Serranidae	*Cephalopholis urodeta*	0.007	0.84
Serranidae	*Epinephelus hexagonatus*	0.000	0.01
Serranidae	*Epinephelus merra*	0.001	0.10
Serranidae	*Epinephelus polyphekadion*	0.000	0.12
Serranidae	*Epinephelus spilotoceps*	0.000	0.00
Serranidae	*Plectropomus laevis*	0.000	0.10
Serranidae	*Plectropomus leopardus*	0.002	2.00
Serranidae	*Plectropomus maculatus*	0.001	0.33
Serranidae	*Variola louti*	0.000	0.12
Siganidae	*Siganus corallinus*	0.003	1.81
Siganidae	*Siganus doliatus*	0.002	0.47
Siganidae	*Siganus lineatus*	0.007	3.24
Siganidae	*Siganus puellus*	0.002	0.41
Siganidae	*Siganus spinus*	0.031	1.64
Siganidae	*Siganus vulpinus*	0.003	0.41
Sphyraenidae	*Sphyraena qenie*	0.000	0.57
Zanclidae	*Zanclus cornutus*	0.002	0.19

3.2 Thio finfish survey data

3.2.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Thio

Transect	Habitat	Latitude	Longitude
TRA01	Sheltered coastal reef	21°42'13.86" S	166°23'36.96" E
TRA02	Sheltered coastal reef	21°42'04.4388" S	166°23'09.96" E
TRA03	Intermediate reef	21°40'18.2388" S	166°24'40.0212" E
TRA04	Intermediate reef	21°39'42.9012" S	166°23'11.4" E
TRA05	Sheltered coastal reef	21°38'55.9212" S	166°20'56.04" E
TRA06	Sheltered coastal reef	21°38'25.3788" S	166°19'38.5212" E
TRA07	Sheltered coastal reef	21°40'56.8812" S	166°25'52.0788" E
TRA08	Sheltered coastal reef	21°43'49.62" S	166°26'51.9612" E
TRA09	Sheltered coastal reef	21°44'51.9612" S	166°28'06.1212" E
TRA10	Intermediate reef	21°42'31.2588" S	166°29'06.9" E
TRA11	Intermediate reef	21°44'44.7" S	166°31'06.96" E
TRA12	Intermediate reef	21°43'13.8612" S	166°30'04.3812" E
TRA13	Back-reef	21°42'45.54" S	166°32'31.92" E
TRA14	Back-reef	21°41'07.1412" S	166°31'15.6612" E
TRA15	Outer reef	21°40'10.1388" S	166°30'48.24" E
TRA16	Outer reef	21°40'10.1388" S	166°30'48.24" E
TRA17	Back-reef	21°40'09.5412" S	166°30'22.32" E
TRA18	Back-reef	21°37'47.5212" S	166°26'45.6" E
TRA19	Outer reef	21°35'47.6412" S	166°25'34.4388" E
TRA20	Outer reef	21°35'47.6412" S	166°25'34.4388" E
TRA21	Back-reef	21°35'58.0812" S	166°25'22.3788" E
TRA22	Back-reef	21°35'48.2388" S	166°25'12.6588" E
TRA23	Outer reef	21°37'34.4388" S	166°27'03.1788" E
TRA24	Outer reef	21°37'34.4388" S	166°27'03.1788" E

3.2.2 Weighted average density and biomass of all finfish species recorded in Thio
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Acanthuridae	*Acanthurus blochii*	0.009	2.57
Acanthuridae	*Acanthurus dussumieri*	0.008	5.05
Acanthuridae	*Acanthurus lineatus*	0.007	1.69
Acanthuridae	*Acanthurus nigricauda*	0.000	0.23
Acanthuridae	*Acanthurus nigrofuscus*	0.013	0.49
Acanthuridae	*Acanthurus olivaceus*	0.001	0.14
Acanthuridae	*Acanthurus pyroferus*	0.000	0.01
Acanthuridae	*Acanthurus* spp.	0.001	0.17
Acanthuridae	*Acanthurus thompsoni*	0.000	0.01
Acanthuridae	*Acanthurus triostegus*	0.002	0.09
Acanthuridae	*Acanthurus xanthopterus*	0.002	0.57
Acanthuridae	*Ctenochaetus binotatus*	0.000	0.01
Acanthuridae	*Ctenochaetus striatus*	0.045	7.09
Acanthuridae	*Naso annulatus*	0.006	1.67
Acanthuridae	*Naso lituratus*	0.002	0.78
Acanthuridae	*Naso tuberosus*	0.001	0.73
Acanthuridae	*Naso unicornis*	0.004	1.80
Acanthuridae	*Paracanthurus hepatus*	0.000	0.04
Acanthuridae	*Zebrasoma scopas*	0.012	0.46
Acanthuridae	*Zebrasoma veliferum*	0.002	0.30
Balistidae	*Balistapus undulatus*	0.001	0.05
Balistidae	*Sufflamen chrysopterum*	0.000	0.04
Caesionidae	*Caesio caerulaurea*	0.042	4.61
Caesionidae	*Caesio cuning*	0.020	3.55
Caesionidae	*Caesio lunaris*	0.000	0.02
Caesionidae	*Pterocaesio marri*	0.063	4.68
Caesionidae	*Pterocaesio* spp.	0.003	0.35
Caesionidae	*Pterocaesio tile*	0.012	0.75
Caesionidae	*Pterocaesio trilineata*	0.042	1.53
Carangidae	*Carangoides ferdau*	0.000	0.04
Carangidae	*Caranx ignobilis*	0.000	0.77
Carangidae	*Caranx melampygus*	0.001	0.36
Carangidae	*Scomberoides lysan*	0.004	0.98
Carcharhinidae	*Carcharhinus melanopterus*	0.000	10.52
Carcharhinidae	*Triaenodon obesus*	0.000	0.79
Chaetodontidae	*Chaetodon auriga*	0.001	0.06
Chaetodontidae	*Chaetodon baronessa*	0.004	0.18
Chaetodontidae	*Chaetodon bennetti*	0.000	0.00
Chaetodontidae	*Chaetodon citrinellus*	0.004	0.07
Chaetodontidae	*Chaetodon ephippium*	0.000	0.02
Chaetodontidae	*Chaetodon flavirostris*	0.001	0.08
Chaetodontidae	*Chaetodon kleinii*	0.001	0.02
Chaetodontidae	*Chaetodon lineolatus*	0.000	0.03
Chaetodontidae	*Chaetodon lunula*	0.001	0.08
Chaetodontidae	*Chaetodon lunulatus*	0.009	0.35
Chaetodontidae	*Chaetodon melannotus*	0.001	0.03
Chaetodontidae	*Chaetodon mertensii*	0.000	0.00

3.2.2 Weighted average density and biomass of all finfish species recorded in Thio (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Chaetodontidae	*Chaetodon ornatissimus*	0.000	0.05
Chaetodontidae	*Chaetodon pelewensis*	0.004	0.07
Chaetodontidae	*Chaetodon plebeius*	0.003	0.05
Chaetodontidae	*Chaetodon rafflesii*	0.002	0.08
Chaetodontidae	*Chaetodon semeion*	0.000	0.00
Chaetodontidae	*Chaetodon speculum*	0.000	0.01
Chaetodontidae	*Chaetodon trifascialis*	0.002	0.06
Chaetodontidae	*Chaetodon ulietensis*	0.001	0.04
Chaetodontidae	*Chaetodon unimaculatus*	0.001	0.05
Chaetodontidae	*Chaetodon vagabundus*	0.004	0.30
Chaetodontidae	*Heniochus acuminatus*	0.000	0.00
Chaetodontidae	*Heniochus chrysostomus*	0.000	0.02
Chaetodontidae	*Heniochus monoceros*	0.000	0.01
Chaetodontidae	*Heniochus singularius*	0.000	0.06
Chaetodontidae	*Heniochus varius*	0.001	0.09
Diodontidae	*Diodon hystrix*	0.000	0.10
Ginglymostomatidae	*Nebrius ferrugineus*	0.000	0.40
Haemulidae	*Plectorhinchus chaetodonoides*	0.000	0.44
Haemulidae	*Plectorhinchus lessonii*	0.000	0.04
Haemulidae	*Plectorhinchus lineatus*	0.000	0.04
Haemulidae	*Plectorhinchus orientalis*	0.001	0.37
Holocentridae	*Myripristis kuntee*	0.000	0.03
Holocentridae	*Myripristis* spp.	0.000	0.05
Holocentridae	*Neoniphon sammara*	0.002	0.23
Holocentridae	*Sargocentron spiniferum*	0.001	0.17
Kyphosidae	*Kyphosus vaigiensis*	0.000	0.11
Labridae	*Bodianus loxozonus*	0.000	0.14
Labridae	*Bodianus perditio*	0.000	0.04
Labridae	*Cheilinus chlorourus*	0.005	0.46
Labridae	*Cheilinus fasciatus*	0.001	0.07
Labridae	*Cheilinus trilobatus*	0.001	0.13
Labridae	*Choerodon fasciatus*	0.001	0.18
Labridae	*Coris aygula*	0.001	0.20
Labridae	*Coris gaimard*	0.000	0.06
Labridae	*Epibulus insidiator*	0.001	0.14
Labridae	*Hemigymnus fasciatus*	0.002	0.15
Labridae	*Hemigymnus melapterus*	0.003	0.44
Labridae	*Oxycheilinus digramma*	0.001	0.07
Lethrinidae	*Gnathodentex aureolineatus*	0.000	0.03
Lethrinidae	*Lethrinus atkinsoni*	0.001	0.29
Lethrinidae	*Lethrinus harak*	0.001	0.14
Lethrinidae	*Monotaxis grandoculis*	0.001	0.04
Lutjanidae	*Lutjanus bohar*	0.000	0.10
Lutjanidae	*Lutjanus fulviflamma*	0.000	0.03
Lutjanidae	*Lutjanus fulvus*	0.005	1.24
Lutjanidae	*Lutjanus gibbus*	0.000	0.02

3.2.2 Weighted average density and biomass of all finfish species recorded in Thio (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Mullidae	*Mulloidichthys flavolineatus*	0.004	0.12
Mullidae	*Parupeneus barberinoides*	0.000	0.02
Mullidae	*Parupeneus barberinus*	0.001	0.20
Mullidae	*Parupeneus ciliatus*	0.004	1.01
Mullidae	*Parupeneus multifasciatus*	0.007	0.55
Mullidae	*Parupeneus pleurostigma*	0.001	0.06
Mullidae	*Parupeneus spilurus*	0.000	0.05
Mullidae	*Parupeneus trifasciatus*	0.000	0.04
Nemipteridae	*Scolopsis bilineata*	0.004	0.28
Pomacanthidae	*Pomacanthus imperator*	0.000	0.04
Pomacanthidae	*Pomacanthus semicirculatus*	0.000	0.12
Pomacanthidae	*Pomacanthus sexstriatus*	0.000	0.10
Pomacanthidae	*Pygoplites diacanthus*	0.000	0.01
Scaridae	*Cetoscarus bicolor*	0.001	0.99
Scaridae	*Chlorurus bleekeri*	0.006	1.97
Scaridae	*Chlorurus microrhinos*	0.007	4.14
Scaridae	*Chlorurus sordidus*	0.029	3.67
Scaridae	*Hipposcarus longiceps*	0.005	4.61
Scaridae	*Scarus altipinnis*	0.020	5.78
Scaridae	*Scarus chameleon*	0.001	0.15
Scaridae	*Scarus dimidiatus*	0.000	0.01
Scaridae	*Scarus forsteni*	0.001	0.37
Scaridae	*Scarus frenatus*	0.007	1.91
Scaridae	*Scarus ghobban*	0.003	0.96
Scaridae	*Scarus globiceps*	0.001	0.31
Scaridae	*Scarus niger*	0.006	1.76
Scaridae	*Scarus oviceps*	0.001	0.26
Scaridae	*Scarus psittacus*	0.002	0.27
Scaridae	*Scarus quoyi*	0.000	0.02
Scaridae	*Scarus rivulatus*	0.052	11.16
Scaridae	*Scarus rubroviolaceus*	0.001	0.21
Scaridae	*Scarus schlegeli*	0.003	0.49
Scaridae	*Scarus* spp.	0.004	0.04
Scaridae	*Scarus spinus*	0.001	0.35
Serranidae	*Anyperodon leucogrammicus*	0.000	0.02
Serranidae	*Cephalopholis argus*	0.000	0.13
Serranidae	*Cephalopholis urodeta*	0.006	0.54
Serranidae	*Epinephelus cyanopodus*	0.000	0.06
Serranidae	*Epinephelus fasciatus*	0.000	0.04
Serranidae	*Epinephelus merra*	0.003	0.30
Serranidae	*Epinephelus polyphekadion*	0.000	0.50
Serranidae	*Plectropomus laevis*	0.000	1.17
Serranidae	*Plectropomus leopardus*	0.003	1.78
Serranidae	*Variola louti*	0.000	0.45
Siganidae	*Siganus argenteus*	0.007	0.78
Siganidae	*Siganus corallinus*	0.002	0.27

3.2.2 Weighted average density and biomass of all finfish species recorded in Thio (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Siganidae	*Siganus doliatus*	0.004	0.62
Siganidae	*Siganus puellus*	0.002	0.21
Siganidae	*Siganus punctatus*	0.002	0.66
Siganidae	*Siganus spinus*	0.027	0.71
Siganidae	*Siganus vulpinus*	0.003	0.34
Sphyraenidae	*Sphyraena flavicauda*	0.050	1.45
Synanceiidae	*Synanceia verrucosa*	0.000	0.00
Zanclidae	*Zanclus cornutus*	0.000	0.01

3.3 Luengoni finfish survey data

3.3.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Luengoni

Transect	Habitat	Latitude	Longitude
TRA01	Outer reef	21°01'30.4212" S	167°24'42.2388" E
TRA02	Outer reef	21°01'32.4588" S	167°24'48.78" E
TRA03	Back-reef	21°01'37.0812" S	167°24'36.54" E
TRA04	Back-reef	21°01'39.6588" S	167°24'27.9" E
TRA05	Outer reef	21°01'34.3812" S	167°24'55.5012" E
TRA06	Outer reef	21°01'40.44" S	167°25'10.6788" E
TRA07	Back-reef	21°01'44.04" S	167°25'02.28" E
TRA08	Back-reef	21°01'54.0588" S	167°25'02.0388" E
TRA09	Outer reef	21°01'48.2412" S	167°25'34.9788" E
TRA10	Outer reef	21°01'48.8388" S	167°25'21.36" E
TRA11	Back-reef	21°01'58.98" S	167°25'12.9612" E
TRA12	Back-reef	21°01'47.0388" S	167°24'41.5188" E
TRA13	Outer reef	21°02'01.9788" S	167°26'02.6988" E
TRA14	Outer reef	21°02'17.0988" S	167°26'14.46" E
TRA15	Back-reef	21°02'32.82" S	167°26'21.5988" E
TRA16	Back-reef	21°02'58.0812" S	167°26'24.4788" E
TRA17	Outer reef	21°02'52.44" S	167°27'07.38" E
TRA18	Outer reef	21°02'47.1588" S	167°26'53.34" E
TRA19	Back-reef	21°02'54.1788" S	167°26'44.0988" E
TRA20	Back-reef	21°03'01.7388" S	167°26'30.0588" E
TRA21	Back-reef	21°02'52.44" S	167°26'33.2412" E
TRA22	Back-reef	21°02'45.78" S	167°26'26.7" E
TRA23	Back-reef	21°02'39.0588" S	167°26'25.6812" E
TRA24	Back-reef	21°02'37.7988" S	167°26'16.8" E

3.3.2 Weighted average density and biomass of all finfish species recorded in Luengoni
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Acanthuridae	*Acanthurus albipectoralis*	0.001	0.22
Acanthuridae	*Acanthurus blochii*	0.002	1.21
Acanthuridae	*Acanthurus dussumieri*	0.001	0.57
Acanthuridae	*Acanthurus lineatus*	0.027	7.56
Acanthuridae	*Acanthurus nigricauda*	0.000	0.12
Acanthuridae	*Acanthurus nigrofuscus*	0.045	1.29
Acanthuridae	*Acanthurus olivaceus*	0.000	0.17
Acanthuridae	*Acanthurus pyroferus*	0.000	0.02
Acanthuridae	*Acanthurus triostegus*	0.021	1.18
Acanthuridae	*Acanthurus xanthopterus*	0.000	0.12
Acanthuridae	*Ctenochaetus* spp.	0.000	0.01
Acanthuridae	*Ctenochaetus striatus*	0.065	9.20
Acanthuridae	*Naso lituratus*	0.001	0.30
Acanthuridae	*Naso tuberosus*	0.000	0.12
Acanthuridae	*Naso unicornis*	0.001	0.14
Acanthuridae	*Zebrasoma scopas*	0.007	0.20
Acanthuridae	*Zebrasoma veliferum*	0.001	0.14
Balistidae	*Odonus niger*	0.000	0.02
Balistidae	*Rhinecanthus aculeatus*	0.002	0.11
Balistidae	*Sufflamen chrysopterum*	0.000	0.02
Caesionidae	*Pterocaesio marri*	0.006	0.36
Caesionidae	*Pterocaesio tile*	0.028	1.55
Carangidae	*Caranx sexfasciatus*	0.000	0.00
Carcharhinidae	*Negaprion acutidens*	0.000	12.37
Chaetodontidae	*Chaetodon auriga*	0.001	0.04
Chaetodontidae	*Chaetodon citrinellus*	0.005	0.07
Chaetodontidae	*Chaetodon ephippium*	0.002	0.33
Chaetodontidae	*Chaetodon flavirostris*	0.003	0.23
Chaetodontidae	*Chaetodon lineolatus*	0.001	0.26
Chaetodontidae	*Chaetodon lunula*	0.001	0.06
Chaetodontidae	*Chaetodon lunulatus*	0.004	0.12
Chaetodontidae	*Chaetodon ornatissimus*	0.000	0.02
Chaetodontidae	*Chaetodon pelewensis*	0.001	0.01
Chaetodontidae	*Chaetodon plebeius*	0.003	0.05
Chaetodontidae	*Chaetodon rafflesii*	0.001	0.02
Chaetodontidae	*Chaetodon reticulatus*	0.000	0.02
Chaetodontidae	*Chaetodon speculum*	0.000	0.00
Chaetodontidae	*Chaetodon trifascialis*	0.003	0.12
Chaetodontidae	*Chaetodon ulietensis*	0.001	0.02
Chaetodontidae	*Chaetodon vagabundus*	0.001	0.05
Chaetodontidae	*Heniochus chrysostomus*	0.000	0.00
Chaetodontidae	*Heniochus singularius*	0.000	0.00
Dasyatidae	*Dasyatis kuhlii*	0.000	0.08
Diodontidae	*Diodon hystrix*	0.000	0.03
Holocentridae	*Neoniphon sammara*	0.000	0.02
Holocentridae	*Sargocentron caudimaculatum*	0.000	0.04
Holocentridae	*Sargocentron spiniferum*	0.001	0.35

3.3.2 Weighted average density and biomass of all finfish species recorded in Luengoni (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Labridae	*Bodianus loxozonus*	0.001	0.23
Labridae	*Bodianus perditio*	0.000	0.05
Labridae	*Cheilinus chlorourus*	0.005	0.22
Labridae	*Cheilinus fasciatus*	0.000	0.03
Labridae	*Cheilinus undulatus*	0.000	0.08
Labridae	*Choerodon fasciatus*	0.000	0.05
Labridae	*Coris aygula*	0.004	1.20
Labridae	*Coris gaimard*	0.000	0.00
Labridae	*Epibulus insidiator*	0.000	0.01
Labridae	*Hemigymnus fasciatus*	0.001	0.04
Labridae	*Hemigymnus melapterus*	0.000	0.03
Labridae	*Oxycheilinus digramma*	0.001	0.01
Lethrinidae	*Gnathodentex aureolineatus*	0.086	6.07
Lethrinidae	*Lethrinus atkinsoni*	0.000	0.07
Lethrinidae	*Monotaxis grandoculis*	0.004	0.82
Lutjanidae	*Lutjanus bohar*	0.000	0.48
Lutjanidae	*Lutjanus fulvus*	0.000	0.03
Lutjanidae	*Lutjanus kasmira*	0.001	0.11
Mugilidae	*Valamugil seheli*	0.000	0.08
Mullidae	*Mulloidichthys flavolineatus*	0.019	0.90
Mullidae	*Mulloidichthys vanicolensis*	0.037	1.96
Mullidae	*Parupeneus barberinoides*	0.000	0.00
Mullidae	*Parupeneus barberinus*	0.001	0.16
Mullidae	*Parupeneus ciliatus*	0.004	1.77
Mullidae	*Parupeneus cyclostomus*	0.001	0.07
Mullidae	*Parupeneus multifasciatus*	0.005	0.40
Mullidae	*Parupeneus pleurostigma*	0.000	0.00
Mullidae	*Parupeneus spilurus*	0.000	0.02
Mullidae	*Parupeneus trifasciatus*	0.000	0.03
Nemipteridae	*Scolopsis bilineata*	0.000	0.02
Nemipteridae	*Scolopsis lineata*	0.000	0.00
Nemipteridae	*Scolopsis trilineata*	0.000	0.01
Pomacanthidae	*Pomacanthus imperator*	0.000	0.01
Pomacanthidae	*Pomacanthus semicirculatus*	0.000	0.32
Scaridae	*Cetoscarus bicolor*	0.000	0.28
Scaridae	*Chlorurus microrhinos*	0.002	1.02
Scaridae	*Chlorurus sordidus*	0.047	3.91
Scaridae	*Hipposcarus longiceps*	0.000	0.21
Scaridae	*Scarus altipinnis*	0.017	3.22
Scaridae	*Scarus chameleon*	0.009	0.79
Scaridae	*Scarus dimidiatus*	0.000	0.01
Scaridae	*Scarus frenatus*	0.012	3.08
Scaridae	*Scarus ghobban*	0.003	0.01
Scaridae	*Scarus globiceps*	0.002	0.38
Scaridae	*Scarus longipinnis*	0.000	0.00
Scaridae	*Scarus niger*	0.001	0.16

3.3.2 Weighted average density and biomass of all finfish species recorded in Luengoni (continued)
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Scaridae	*Scarus oviceps*	0.001	0.22
Scaridae	*Scarus psittacus*	0.001	0.24
Scaridae	*Scarus rivulatus*	0.027	1.36
Scaridae	*Scarus rubroviolaceus*	0.000	0.01
Scaridae	*Scarus schlegeli*	0.037	1.41
Scaridae	*Scarus* spp.	0.018	0.37
Serranidae	*Cephalopholis argus*	0.000	0.12
Serranidae	*Cephalopholis urodeta*	0.002	0.20
Serranidae	*Epinephelus merra*	0.001	0.06
Serranidae	*Epinephelus polyphekadion*	0.000	0.16
Serranidae	*Plectropomus laevis*	0.000	0.00
Serranidae	*Plectropomus leopardus*	0.000	0.01
Siganidae	*Siganus argenteus*	0.001	0.18
Siganidae	*Siganus punctatus*	0.000	0.20
Siganidae	*Siganus spinus*	0.003	0.07
Zanclidae	*Zanclus cornutus*	0.002	0.06

3.4 Oundjo finfish survey data

3.4.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Oundjo

Transect	Habitat	Latitude	Longitude
TRA01	Outer reef	21°10'42.06" S	164°43'04.3212" E
TRA02	Outer reef	21°10'42.06" S	164°43'04.3788" E
TRA03	Outer reef	21°06'21.96" S	164°41'04.3188" E
TRA04	Outer reef	21°06'21.6612" S	164°41'04.4412" E
TRA05	Back-reef	21°05'41.7588" S	164°41'24.4788" E
TRA06	Back-reef	21°06'18.9598" S	164°41'19.0198" E
TRA07	Outer reef	21°02'58.4988" S	164°37'05.16" E
TRA08	Outer reef	21°02'58.4988" S	164°37'05.16" E
TRA13	Intermediate reef	20°59'30.7788" S	164°37'48.54" E
TRA14	Back-reef	21°03'06.4188" S	164°38'06.4788" E
TRA15	Back-reef	21°01'48.7812" S	164°37'09.48" E
TRA16	Intermediate reef	21°01'05.16" S	164°37'43.9212" E
TRA17	Intermediate reef	21°07'33.6" S4	°44'05.8812" E
TRA18	Intermediate reef	21°08'14.1612" S	164°44'18.7188" E
TRA19	Intermediate reef	21°09'30.96" S	164°45'11.6388" E
TRA20	Intermediate reef	21°08'47.2812" S	164°44'41.1612" E
TRA21	Back-reef	21°11'37.7988" S	164°45'06.5412" E
TRA22	Back-reef	21°08'47.76" S	164°42'48.78" E
TRA23	Sheltered coastal reef	20°58'26.04" S	164°38'19.7412" E
TRA24	Sheltered coastal reef	20°58'36.66" S	164°38'23.5788" E
TRA25	Sheltered coastal reef	20°58'47.3412" S	164°38'27.4812" E
TRA26	Sheltered coastal reef	21°05'09.7188" S	164°45'27.0612" E
TRA27	Sheltered coastal reef	21°05'04.02" S	164°45'10.44" E
TRA28	Sheltered coastal reef	21°05'13.6788" S	164°45'42.5988" E

3.4.2 Weighted average density and biomass of all finfish species recorded in Oundjo
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Acanthuridae	*Acanthurus blochii*	0.0108	2.61
Acanthuridae	*Acanthurus lineatus*	0.0002	0.04
Acanthuridae	*Acanthurus nigricans*	0.0003	0.06
Acanthuridae	*Acanthurus nigricauda*	0.0061	2.36
Acanthuridae	*Acanthurus nigrofuscus*	0.0072	0.32
Acanthuridae	*Acanthurus pyroferus*	0.0001	0.01
Acanthuridae	*Acanthurus* spp.	0.0018	0.06
Acanthuridae	*Acanthurus thompsoni*	0.0003	0.09
Acanthuridae	*Acanthurus triostegus*	0.0016	0.09
Acanthuridae	*Acanthurus xanthopterus*	0.0014	0.17
Acanthuridae	*Ctenochaetus binotatus*	0.0059	0.62
Acanthuridae	*Ctenochaetus striatus*	0.0412	6.22
Acanthuridae	*Ctenochaetus strigosus*	0.0014	0.08
Acanthuridae	*Naso lituratus*	0.0007	0.36
Acanthuridae	*Naso lopezi*	0.0001	0.07
Acanthuridae	*Naso tuberosus*	0.0023	4.32
Acanthuridae	*Naso unicornis*	0.0033	1.36
Acanthuridae	*Zebrasoma scopas*	0.0153	0.84
Acanthuridae	*Zebrasoma veliferum*	0.0060	0.50
Balistidae	*Balistapus undulatus*	0.0000	0.00
Balistidae	*Rhinecanthus aculeatus*	0.0001	0.01
Balistidae	*Sufflamen bursa*	0.0000	0.00
Balistidae	*Sufflamen chrysopterum*	0.0013	0.13
Caesionidae	*Caesio caerulaurea*	0.0049	0.36
Caesionidae	*Pterocaesio marri*	0.0043	0.22
Caesionidae	*Pterocaesio tile*	0.0613	2.92
Caesionidae	*Pterocaesio trilineata*	0.0517	2.17
Carangidae	*Carangoides ferdau*	0.0000	0.02
Carangidae	*Scomberoides lysan*	0.0000	0.01
Carangidae	*Scomberoides tol*	0.0010	0.14
Carangidae	*Trachinotus baillonii*	0.0000	0.01
Carangidae	*Trachinotus blochii*	0.0000	0.03
Carcharhinidae	*Carcharhinus melanopterus*	0.0031	0.00
Carcharhinidae	*Triaenodon obesus*	0.0002	3.35
Chaetodontidae	*Chaetodon auriga*	0.0040	0.23
Chaetodontidae	*Chaetodon baronessa*	0.0000	0.00
Chaetodontidae	*Chaetodon bennetti*	0.0014	0.01
Chaetodontidae	*Chaetodon citrinellus*	0.0042	0.10
Chaetodontidae	*Chaetodon ephippium*	0.0005	0.05
Chaetodontidae	*Chaetodon flavirostris*	0.0021	0.18
Chaetodontidae	*Chaetodon kleinii*	0.0008	0.01
Chaetodontidae	*Chaetodon lineolatus*	0.0002	0.00
Chaetodontidae	*Chaetodon lunula*	0.0001	0.00
Chaetodontidae	*Chaetodon lunulatus*	0.0188	0.43
Chaetodontidae	*Chaetodon melannotus*	0.0009	0.03
Chaetodontidae	*Chaetodon mertensii*	0.0042	0.15
Chaetodontidae	*Chaetodon ornatissimus*	0.0001	0.01

3.4.2 Weighted average density and biomass of all finfish species recorded in Oundjo (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Chaetodontidae	*Chaetodon pelewensis*	0.0036	0.10
Chaetodontidae	*Chaetodon plebeius*	0.0125	0.09
Chaetodontidae	*Chaetodon rafflesii*	0.0002	0.01
Chaetodontidae	*Chaetodon reticulatus*	0.0002	0.01
Chaetodontidae	*Chaetodon semeion*	0.0001	0.00
Chaetodontidae	*Chaetodon speculum*	0.0001	0.01
Chaetodontidae	*Chaetodon trifascialis*	0.0019	0.04
Chaetodontidae	*Chaetodon ulietensis*	0.0014	0.04
Chaetodontidae	*Chaetodon unimaculatus*	0.0006	0.03
Chaetodontidae	*Chaetodon vagabundus*	0.0030	0.13
Chaetodontidae	*Forcipiger longirostris*	0.0015	0.11
Chaetodontidae	*Hemitaurichthys polylepis*	0.0002	0.02
Chaetodontidae	*Heniochus acuminatus*	0.0001	0.00
Chaetodontidae	*Heniochus chrysostomus*	0.0004	0.04
Chaetodontidae	*Heniochus monoceros*	0.0004	0.05
Chaetodontidae	*Heniochus singularius*	0.0004	0.05
Chaetodontidae	*Heniochus varius*	0.0006	0.06
Chanidae	*Chanos chanos*	0.0000	0.22
Dasyatidae	*Dasyatis kuhlii*	0.0003	0.15
Echeneidae	*Echeneis naucrates*	0.0005	0.33
Ephippidae	*Platax orbicularis*	0.0001	0.05
Haemulidae	*Plectorhinchus gibbosus*	0.0001	0.22
Haemulidae	*Plectorhinchus lessonii*	0.0001	0.07
Haemulidae	*Plectorhinchus lineatus*	0.0001	0.04
Haemulidae	*Plectorhinchus orientalis*	0.0004	0.08
Holocentridae	*Myripristis* spp.	0.0014	0.18
Holocentridae	*Neoniphon sammara*	0.0024	0.21
Holocentridae	*Neoniphon* spp.	0.0002	0.01
Holocentridae	*Sargocentron caudimaculatum*	0.0008	0.06
Holocentridae	*Sargocentron rubrum*	0.0001	0.00
Holocentridae	*Sargocentron* spp.	0.0003	0.02
Holocentridae	*Sargocentron spiniferum*	0.0001	0.00
Labridae	*Bodianus axillaris*	0.0000	0.00
Labridae	*Bodianus loxozonus*	0.0001	0.02
Labridae	*Cheilinus chlorourus*	0.0047	0.28
Labridae	*Cheilinus fasciatus*	0.0002	0.02
Labridae	*Cheilinus trilobatus*	0.0002	0.01
Labridae	*Cheilinus undulatus*	0.0004	0.10
Labridae	*Coris aygula*	0.0003	0.15
Labridae	*Coris gaimard*	0.0003	0.04
Labridae	*Epibulus insidiator*	0.0001	0.02
Labridae	*Halichoeres hortulanus*	0.0001	0.01
Labridae	*Hemigymnus fasciatus*	0.0009	0.07
Labridae	*Hemigymnus melapterus*	0.0045	0.53
Labridae	*Oxycheilinus digramma*	0.0000	0.00
Lethrinidae	*Gnathodentex aureolineatus*	0.0008	0.11

3.4.2 Weighted average density and biomass of all finfish species recorded in Oundjo (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Lethrinidae	*Lethrinus atkinsoni*	0.0011	0.30
Lethrinidae	*Lethrinus obsoletus*	0.0021	0.35
Lethrinidae	*Lethrinus* spp.	0.0020	0.14
Lethrinidae	*Lethrinus xanthochilus*	0.0001	0.05
Lethrinidae	*Monotaxis grandoculis*	0.0031	0.58
Lutjanidae	*Aphareus furca*	0.0000	0.01
Lutjanidae	*Lutjanus bohar*	0.0006	0.32
Lutjanidae	*Lutjanus fulviflamma*	0.0087	0.93
Lutjanidae	*Lutjanus fulvus*	0.0011	0.11
Lutjanidae	*Lutjanus gibbus*	0.0064	0.56
Lutjanidae	*Lutjanus kasmira*	0.0002	0.01
Lutjanidae	*Lutjanus monostigma*	0.0000	0.01
Lutjanidae	*Lutjanus quinquelineatus*	0.0001	0.00
Lutjanidae	*Macolor niger*	0.0003	0.18
Mullidae	*Mulloidichthys flavolineatus*	0.0044	0.52
Mullidae	*Parupeneus barberinoides*	0.0043	0.39
Mullidae	*Parupeneus barberinus*	0.0008	0.16
Mullidae	*Parupeneus ciliatus*	0.0003	0.06
Mullidae	*Parupeneus cyclostomus*	0.0008	0.26
Mullidae	*Parupeneus indicus*	0.0008	0.01
Mullidae	*Parupeneus multifasciatus*	0.0043	0.22
Mullidae	*Parupeneus pleurostigma*	0.0035	0.23
Mullidae	*Parupeneus spilurus*	0.0012	0.15
Mullidae	*Parupeneus trifasciatus*	0.0000	0.00
Mullidae	*Upeneus tragula*	0.0005	0.05
Muraenidae	*Gymnothorax javanicus*	0.0000	0.02
Nemipteridae	*Scolopsis bilineata*	0.0084	0.57
Nemipteridae	*Scolopsis lineata*	0.0012	0.11
Nemipteridae	*Scolopsis trilineata*	0.0015	0.10
Pomacanthidae	*Pomacanthus semicirculatus*	0.0000	0.02
Pomacanthidae	*Pygoplites diacanthus*	0.0001	0.01
Scaridae	*Chlorurus microrhinos*	0.0010	1.29
Scaridae	*Chlorurus sordidus*	0.0578	4.89
Scaridae	*Hipposcarus longiceps*	0.0010	0.28
Scaridae	*Scarus altipinnis*	0.0023	0.53
Scaridae	*Scarus chameleon*	0.0030	0.27
Scaridae	*Scarus dimidiatus*	0.0000	0.00
Scaridae	*Scarus flavipectoralis*	0.0003	0.08
Scaridae	*Scarus frenatus*	0.0024	0.63
Scaridae	*Scarus ghobban*	0.0183	3.96
Scaridae	*Scarus globiceps*	0.0005	0.12
Scaridae	*Scarus niger*	0.0049	0.99
Scaridae	*Scarus oviceps*	0.0002	0.04
Scaridae	*Scarus psittacus*	0.0170	1.08
Scaridae	*Scarus rivulatus*	0.0059	0.65
Scaridae	*Scarus schlegeli*	0.0123	1.31

3.4.2 Weighted average density and biomass of all finfish species recorded in Oundjo (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Scaridae	*Scarus* spp.	0.0109	0.14
Scaridae	*Scarus spinus*	0.0001	0.02
Scombridae	*Scomber* spp.	0.0000	0.00
Scombridae	*Scomberomorus commerson*	0.0000	0.21
Serranidae	*Anyperodon leucogrammicus*	0.0003	0.03
Serranidae	*Cephalopholis argus*	0.0003	0.16
Serranidae	*Cephalopholis boenak*	0.0001	0.01
Serranidae	*Cephalopholis miniata*	0.0001	0.04
Serranidae	*Cephalopholis urodeta*	0.0001	0.00
Serranidae	*Cromileptes altivelis*	0.0001	0.00
Serranidae	*Epinephelus areolatus*	0.0002	0.06
Serranidae	*Epinephelus fasciatus*	0.0001	0.01
Serranidae	*Epinephelus maculatus*	0.0001	0.03
Serranidae	*Epinephelus merra*	0.0043	0.33
Serranidae	*Epinephelus polyphekadion*	0.0000	0.02
Serranidae	*Plectropomus leopardus*	0.0002	1.05
Siganidae	*Siganus argenteus*	0.0001	0.00
Siganidae	*Siganus corallinus*	0.0003	0.03
Siganidae	*Siganus doliatus*	0.0014	0.19
Siganidae	*Siganus puellus*	0.0016	0.22
Siganidae	*Siganus punctatus*	0.0006	0.19
Siganidae	*Siganus spinus*	0.0174	0.66
Siganidae	*Siganus vulpinus*	0.0001	0.01
Tetraodontidae	*Arothron nigropunctatus*	0.0000	0.01
Zanclidae	*Zanclus cornutus*	0.0004	0.05

3.5 Moindou finfish survey data

3.5.1 Coordinates (WGS84) of the 24 D-UVC transects used to assess finfish resource status in Moindou

Transect	Habitat	Latitude	Longitude
TRA01	Back-reef	21°48'23.94" S	165°39'08.7012" E
TRA02	Back-reef	21°49'15.3012" S	165°40'14.9412" E
TRA03	Sheltered coastal reef	21°45'47.6388" S	165°38'28.0212" E
TRA04	Sheltered coastal reef	21°45'29.4012" S	165°38'14.82" E
TRA05	Outer reef	21°47'08.52" S	165°35'33.36" E
TRA06	Outer reef	21°47'08.52" S	165°35'33.36" E
TRA07	Back-reef	21°47'12.3612" S	165°35'54.1212" E
TRA08	Back-reef	21°45'58.3812" S	165°33'41.22" E
TRA09	Outer reef	21°48'49.5612" S	165°39'21.1212" E
TRA10	Outer reef	21°48'49.5612" S	165°39'21.1212" E
TRA11	Intermediate reef	21°47'42.1188" S	165°40'12.0612" E
TRA12	Intermediate reef	21°47'33.54" S	165°40'10.38" E
TRA13	Outer reef	21°50'37.2012" S	165°42'36.9" E
TRA14	Outer reef	21°50'37.2012" S	165°42'36.9" E
TRA15	Back-reef	21°49'58.3788" S	165°42'06.0588" E
TRA16	Back-reef	21°45'20.4012" S	165°32'20.3388" E
TRA17	Intermediate reef	21°44'31.4412" S	165°33'38.0988" E
TRA18	Intermediate reef	21°44'39.48" S	165°33'52.8588" E
TRA19	Intermediate reef	21°45'07.56" S	165°35'05.28" E
TRA20	Intermediate reef	21°45'09.54" S	165°34'41.88" E
TRA21	Sheltered coastal reef	21°49'32.0412" S	165°45'20.16" E
TRA22	Sheltered coastal reef	21°48'04.86" S	165°45'23.5188" E
TRA23	Intermediate reef	21°48'08.82" S	165°43'47.9388" E
TRA24	Intermediate reef	21°47'45.7188" S	165°43'28.3188" E

3.5.2 Weighted average density and biomass of all finfish species recorded in Moindou
(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Acanthuridae	*Acanthurus albipectoralis*	0.0001	0.02
Acanthuridae	*Acanthurus blochii*	0.0119	2.77
Acanthuridae	*Acanthurus dussumieri*	0.0013	0.65
Acanthuridae	*Acanthurus nigricauda*	0.0023	0.48
Acanthuridae	*Acanthurus nigrofuscus*	0.0018	0.05
Acanthuridae	*Acanthurus olivaceus*	0.0001	0.00
Acanthuridae	*Acanthurus pyroferus*	0.0001	0.00
Acanthuridae	*Acanthurus* spp.	0.0022	0.29
Acanthuridae	*Acanthurus thompsoni*	0.0010	0.24
Acanthuridae	*Acanthurus triostegus*	0.0002	0.00
Acanthuridae	*Acanthurus xanthopterus*	0.0002	0.05
Acanthuridae	*Ctenochaetus binotatus*	0.0006	0.02
Acanthuridae	*Ctenochaetus striatus*	0.0476	7.57
Acanthuridae	*Naso lituratus*	0.0004	0.11
Acanthuridae	*Naso* spp.	0.0002	0.00
Acanthuridae	*Naso tuberosus*	0.0000	0.03
Acanthuridae	*Naso unicornis*	0.0028	1.17
Acanthuridae	*Zebrasoma scopas*	0.0179	0.65
Acanthuridae	*Zebrasoma veliferum*	0.0042	0.55
Aulostomidae	*Aulostomus chinensis*	0.0000	0.00
Balistidae	*Balistoides viridescens*	0.0001	0.02
Balistidae	*Rhinecanthus aculeatus*	0.0002	0.01
Balistidae	*Sufflamen bursa*	0.0000	0.00
Balistidae	*Sufflamen chrysopterum*	0.0004	0.02
Caesionidae	*Caesio caerulaurea*	0.0070	0.33
Caesionidae	*Caesio cuning*	0.0002	0.02
Caesionidae	*Pterocaesio marri*	0.0020	0.14
Caesionidae	*Pterocaesio pisang*	0.0070	0.11
Caesionidae	*Pterocaesio* spp.	0.0259	0.25
Caesionidae	*Pterocaesio tile*	0.0610	1.20
Carangidae	*Caranx melampygus*	0.0002	0.17
Carangidae	*Scomberoides lysan*	0.0000	0.03
Carcharhinidae	*Carcharhinus amblyrhynchos*	0.0000	0.86
Carcharhinidae	*Triaenodon obesus*	0.0001	1.08
Chaetodontidae	*Chaetodon auriga*	0.0030	0.13
Chaetodontidae	*Chaetodon bennetti*	0.0031	0.05
Chaetodontidae	*Chaetodon citrinellus*	0.0061	0.08
Chaetodontidae	*Chaetodon ephippium*	0.0015	0.13
Chaetodontidae	*Chaetodon flavirostris*	0.0012	0.10
Chaetodontidae	*Chaetodon kleinii*	0.0000	0.00
Chaetodontidae	*Chaetodon lineolatus*	0.0007	0.03
Chaetodontidae	*Chaetodon lunulatus*	0.0099	0.30
Chaetodontidae	*Chaetodon melannotus*	0.0006	0.01
Chaetodontidae	*Chaetodon mertensii*	0.0024	0.10
Chaetodontidae	*Chaetodon pelewensis*	0.0019	0.03
Chaetodontidae	*Chaetodon plebeius*	0.0038	0.05
Chaetodontidae	*Chaetodon reticulatus*	0.0001	0.00

3.5.2 Weighted average density and biomass of all finfish species recorded in Moindou (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Chaetodontidae	*Chaetodon semeion*	0.0002	0.01
Chaetodontidae	*Chaetodon trifascialis*	0.0017	0.06
Chaetodontidae	*Chaetodon ulietensis*	0.0015	0.04
Chaetodontidae	*Chaetodon unimaculatus*	0.0001	0.01
Chaetodontidae	*Chaetodon vagabundus*	0.0013	0.07
Chaetodontidae	*Forcipiger longirostris*	0.0002	0.01
Chaetodontidae	*Heniochus acuminatus*	0.0009	0.06
Chaetodontidae	*Heniochus chrysostomus*	0.0005	0.02
Chaetodontidae	*Heniochus monoceros*	0.0005	0.04
Chaetodontidae	*Heniochus singularius*	0.0003	0.02
Chaetodontidae	*Heniochus varius*	0.0002	0.01
Diodontidae	*Diodon hystrix*	0.0000	0.01
Haemulidae	*Plectorhinchus lineatus*	0.0007	0.31
Haemulidae	*Plectorhinchus obscurus*	0.0003	0.69
Haemulidae	*Plectorhinchus orientalis*	0.0001	0.05
Holocentridae	*Myripristis kuntee*	0.0000	0.00
Holocentridae	*Myripristis murdjan*	0.0000	0.00
Holocentridae	*Myripristis* spp.	0.0006	0.09
Holocentridae	*Neoniphon sammara*	0.0006	0.04
Holocentridae	*Sargocentron spiniferum*	0.0000	0.00
Kyphosidae	*Kyphosus vaigiensis*	0.0003	0.11
Labridae	*Bodianus loxozonus*	0.0001	0.02
Labridae	*Bodianus perditio*	0.0003	0.02
Labridae	*Cheilinus chlorourus*	0.0011	0.10
Labridae	*Cheilinus fasciatus*	0.0010	0.09
Labridae	*Cheilinus trilobatus*	0.0003	0.04
Labridae	*Cheilinus undulatus*	0.0027	0.83
Labridae	*Choerodon fasciatus*	0.0001	0.01
Labridae	*Choerodon graphicus*	0.0001	0.03
Labridae	*Coris aygula*	0.0002	0.12
Labridae	*Epibulus insidiator*	0.0002	0.03
Labridae	*Hemigymnus fasciatus*	0.0008	0.09
Labridae	*Hemigymnus melapterus*	0.0049	0.60
Labridae	*Oxycheilinus digramma*	0.0003	0.02
Labridae	*Oxycheilinus unifasciatus*	0.0000	0.00
Lethrinidae	*Gnathodentex aureolineatus*	0.0024	0.20
Lethrinidae	*Lethrinus atkinsoni*	0.0005	0.09
Lethrinidae	*Lethrinus genivittatus*	0.0012	0.07
Lethrinidae	*Lethrinus harak*	0.0013	0.19
Lethrinidae	*Lethrinus nebulosus*	0.0017	0.45
Lethrinidae	*Lethrinus obsoletus*	0.0005	0.06
Lethrinidae	*Lethrinus variegatus*	0.0025	0.04
Lethrinidae	*Lethrinus xanthochilus*	0.0003	0.27
Lethrinidae	*Monotaxis grandoculis*	0.0016	0.28
Lutjanidae	*Lutjanus argentimaculatus*	0.0030	6.09
Lutjanidae	*Lutjanus bohar*	0.0005	0.26

Appendix 3: Finfish survey data
Moindou

3.5.2 Weighted average density and biomass of all finfish species recorded in Moindou (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Lutjanidae	*Lutjanus fulviflamma*	0.0058	1.12
Lutjanidae	*Lutjanus fulvus*	0.0078	2.53
Lutjanidae	*Lutjanus gibbus*	0.0005	0.15
Lutjanidae	*Lutjanus monostigma*	0.0006	0.23
Lutjanidae	*Lutjanus quinquelineatus*	0.0005	0.06
Lutjanidae	*Macolor niger*	0.0000	0.00
Mullidae	*Mulloidichthys flavolineatus*	0.0081	1.03
Mullidae	*Mulloidichthys vanicolensis*	0.0014	0.41
Mullidae	*Parupeneus barberinoides*	0.0025	0.05
Mullidae	*Parupeneus barberinus*	0.0029	0.20
Mullidae	*Parupeneus ciliatus*	0.0008	0.20
Mullidae	*Parupeneus cyclostomus*	0.0017	0.28
Mullidae	*Parupeneus indicus*	0.0009	0.16
Mullidae	*Parupeneus multifasciatus*	0.0125	0.67
Mullidae	*Parupeneus pleurostigma*	0.0002	0.01
Mullidae	*Parupeneus spilurus*	0.0002	0.03
Nemipteridae	*Scolopsis bilineata*	0.0049	0.31
Nemipteridae	*Scolopsis lineata*	0.0001	0.01
Nemipteridae	*Scolopsis trilineata*	0.0012	0.04
Pomacanthidae	*Pomacanthus sexstriatus*	0.0001	0.01
Pomacanthidae	*Pygoplites diacanthus*	0.0001	0.01
Scaridae	*Bolbometopon muricatum*	0.0004	0.34
Scaridae	*Cetoscarus bicolor*	0.0003	0.03
Scaridae	*Chlorurus bleekeri*	0.0002	0.02
Scaridae	*Chlorurus microrhinos*	0.0018	1.07
Scaridae	*Chlorurus sordidus*	0.0752	6.11
Scaridae	*Hipposcarus longiceps*	0.0050	1.67
Scaridae	*Scarus altipinnis*	0.0137	3.64
Scaridae	*Scarus chameleon*	0.0003	0.04
Scaridae	*Scarus frenatus*	0.0033	0.72
Scaridae	*Scarus ghobban*	0.0333	3.66
Scaridae	*Scarus globiceps*	0.0012	0.19
Scaridae	*Scarus niger*	0.0063	2.07
Scaridae	*Scarus oviceps*	0.0010	0.18
Scaridae	*Scarus psittacus*	0.0041	0.33
Scaridae	*Scarus rivulatus*	0.0101	2.69
Scaridae	*Scarus rubroviolaceus*	0.0000	0.01
Scaridae	*Scarus schlegeli*	0.0059	0.83
Scaridae	*Scarus* spp.	0.0302	0.49
Scaridae	*Scarus spinus*	0.0002	0.03
Scombridae	*Scomber* spp.	0.0001	0.06
Serranidae	*Anyperodon leucogrammicus*	0.0000	0.01
Serranidae	*Cephalopholis argus*	0.0001	0.02
Serranidae	*Cephalopholis boenak*	0.0000	0.00
Serranidae	*Cephalopholis urodeta*	0.0001	0.01
Serranidae	*Epinephelus areolatus*	0.0001	0.04

3.5.2 Weighted average density and biomass of all finfish species recorded in Moindou (continued)

(using distance-sampling underwater visual censuses (D-UVC))

Family	Species	Density (fish/m²)	Biomass (g/m²)
Serranidae	*Epinephelus cyanopodus*	0.0000	0.02
Serranidae	*Epinephelus fasciatus*	0.0000	0.01
Serranidae	*Epinephelus howlandi*	0.0004	0.13
Serranidae	*Epinephelus maculatus*	0.0002	0.04
Serranidae	*Epinephelus merra*	0.0015	0.08
Serranidae	*Epinephelus polyphekadion*	0.0003	0.16
Serranidae	*Plectropomus laevis*	0.0001	0.61
Serranidae	*Plectropomus leopardus*	0.0002	0.53
Siganidae	*Siganus corallinus*	0.0008	0.15
Siganidae	*Siganus doliatus*	0.0108	2.24
Siganidae	*Siganus lineatus*	0.0012	0.46
Siganidae	*Siganus puellus*	0.0029	0.39
Siganidae	*Siganus punctatus*	0.0000	0.01
Siganidae	*Siganus spinus*	0.0095	0.33
Sphyraenidae	*Sphyraena flavicauda*	0.0502	12.40
Zanclidae	*Zanclus cornutus*	0.0002	0.01

APPENDIX 4: INVERTEBRATE SURVEY DATA

4.1 Ouassé invertebrate survey data

4.1.1 Invertebrate species recorded in different assessments in Ouassé

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga lecanora*	+	+		+
Bêche-de-mer	*Actinopyga mauritiana*	+			+
Bêche-de-mer	*Actinopyga miliaris*	+	+		+
Bêche-de-mer	*Actinopyga palauensis*	+			
Bêche-de-mer	*Bohadschia argus*	+	+		+
Bêche-de-mer	*Bohadschia graeffei*	+	+		+
Bêche-de-mer	*Bohadschia vitiensis*	+			
Bêche-de-mer	*Holothuria atra*	+	+		+
Bêche-de-mer	*Holothuria coluber*	+	+		
Bêche-de-mer	*Holothuria edulis*	+	+		+
Bêche-de-mer	*Holothuria flavomaculata*				+
Bêche-de-mer	*Holothuria fuscogilva*				+
Bêche-de-mer	*Holothuria fuscopunctata*	+			+
Bêche-de-mer	*Holothuria nobilis*	+	+		+
Bêche-de-mer	*Stichopus chloronotus*	+	+		+
Bêche-de-mer	*Stichopus hermanni*	+			+
Bêche-de-mer	*Thelenota ananas*	+			
Bêche-de-mer	*Thelenota anax*				+
Bivalve	*Atrina* spp.	+			
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Periglypta puerpera*		+		
Bivalve	*Pinctada margaritifera*	+	+		
Bivalve	*Spondylus* spp.	+			
Bivalve	*Tridacna crocea*	+	+		
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+			+
Cnidarian	*Stichodactyla* spp.	+	+		
Crustacean	*Panulirus* spp.	+			+
Crustacean	*Panulirus versicolor*	+			
Gastropod	*Astralium* spp.		+		
Gastropod	*Cerithium nodulosum*		+		
Gastropod	*Charonia tritonis*	+			
Gastropod	*Conus flavidus*		+		
Gastropod	*Conus litteratus*		+		
Gastropod	*Conus miles*		+		
Gastropod	*Conus* spp.	+	+		+
Gastropod	*Cypraea caputserpensis*				+
Gastropod	*Cypraea tigris*	+	+		
Gastropod	*Lambis lambis*	+	+		+
Gastropod	*Lambis truncata*	+			+
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Tectus pyramis*	+	+		+
Gastropod	*Trochus maculata*		+		+
Gastropod	*Trochus niloticus*	+	+		+

+ = presence of the species.

4.1.1 Invertebrate species recorded in different assessments in Ouassé (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Trochus* spp.		+		
Gastropod	*Turbo argyrostomus*		+		
Gastropod	*Turbo chrysostomus*		+		
Gastropod	*Vasum turbinellum*		+		
Octopus	*Octopus cyanea*	+			
Star	*Culcita novaeguineae*				+
Star	*Linckia laevigata*	+	+		+
Star	*Nardoa* spp.	+	+		+
Urchin	*Diadema* spp.	+	+		
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix diadema*	+	+		+
Urchin	*Heterocentrotus mammillatus*	+	+		+
Urchin	*Toxopneustes* spp.	+			
Urchin	*Tripneustes gratilla*	+			

+ = presence of the species.

4.1.2 Ouassé broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga lecanora	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1
Actinopyga mauritiana	2.8	1.9	66	45.6	24.0	4	2.8	2.8	11	30.4		1
Actinopyga miliaris	3.2	1.0	66	21.1	2.3	10	3.3	1.0	11	6.0	0.9	6
Actinopyga palauensis	3.0	1.5	66	33.3	10.5	6	3.0	1.6	11	8.3	2.8	4
Atrina spp.	2.8	0.9	66	20.4	2.4	9	2.8	1.6	11	7.6	3.2	4
Bohadschia argus	43.9	13.7	66	111.5	30.6	26	43.9	21.9	11	60.3	28.3	8
Bohadschia graeffei	175.5	34.1	66	304.7	49.8	38	174.6	46.0	11	213.4	46.9	9
Bohadschia vitiensis	2.9	1.3	66	27.8	7.0	7	3.0	2.0	11	11.0	5.6	3
Charonia tritonis	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1
Conus spp.	1.3	0.5	66	16.7	0.0	5	1.3	0.4	11	2.8	0.0	5
Cypraea tigris	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1
Diadema spp.	53.7	21.6	66	394.0	104.6	9	53.8	24.6	11	118.4	37.7	5
Echinometra mathaei	31.6	25.9	66	1041.7	625.0	2	32.1	32.1	11	353.1		1
Echinothrix diadema	46.3	18.4	66	509.3	38.4	6	47.2	31.7	11	259.6	4.3	2
Heterocentrotus mammillatus	4.9	3.7	66	54.2	37.5	6	5.0	4.0	11	18.4	12.9	3
Hippopus hippopus	2.0	0.9	66	22.2	5.6	6	2.0	1.0	11	5.5	1.6	4
Holothuria atra	36.3	6.1	66	60.0	8.2	40	36.2	7.7	11	39.8	7.5	10
Holothuria coluber	3.7	1.1	66	18.9	2.6	13	3.8	1.3	11	5.9	1.5	7
Holothuria edulis	57.7	15.4	66	119.0	28.2	32	57.5	30.1	11	79.0	39.2	8
Holothuria fuscopunctata	9.2	2.7	66	43.5	7.7	14	9.2	3.4	11	14.5	4.1	7
Holothuria nobilis	5.3	1.4	66	23.3	3.5	15	5.3	1.7	11	8.3	1.8	7
Lambis lambis	2.8	1.0	66	22.8	3.0	8	2.8	0.8	11	4.3	0.8	7
Lambis truncata	2.6	1.1	66	24.5	5.7	7	2.5	1.6	11	9.3	4.1	3
Linckia laevigata	26.4	4.4	66	47.1	6.0	37	26.4	5.8	11	32.3	5.2	9
Nardoa spp.	2.0	1.2	66	44.4	5.6	3	2.0	1.4	11	11.1	2.8	2
Octopus cyanea	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1
Panulirus spp.	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1
Panulirus versicolor	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.2 Ouassé broad-scale assessment data review (continued)

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Pinctada margaritifera	4.0	1.5	66	24.2	6.1	11	4.0	1.7	11	6.3	2.3	7
Spondylus spp.	0.7	0.6	66	24.5	8.9	2	0.7	0.7	11	8.2		1
Stichodactyla spp.	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1
Stichopus chloronotus	127.1	39.8	66	233.1	68.5	36	127.3	55.9	11	155.5	65.0	9
Stichopus hermanni	0.8	0.4	66	16.7	0.0	3	0.7	0.4	11	2.7	0.0	3
Tectus pyramis	2.5	2.3	66	83.3	66.7	2	2.6	2.3	11	14.1	11.3	2
Thelenota ananas	0.5	0.4	66	16.7	0.0	2	0.5	0.3	11	2.8	0.0	2
Toxopneustes spp.	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1
Tridacna crocea	2570.1	688.8	66	4137.2	1038.8	41	2571.3	1343.0	11	3535.5	1748.1	8
Tridacna maxima	15.5	3.4	66	48.7	6.3	21	15.5	6.4	11	34.0	8.2	5
Tridacna squamosa	2.3	0.9	66	21.4	3.1	7	2.3	1.3	11	6.2	2.6	4
Tripneustes gratilla	0.3	0.3	66	16.7		1	0.3	0.3	11	2.8		1
Trochus niloticus	3.8	1.5	66	31.0	7.8	8	3.8	2.5	11	10.4	5.9	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.3 Ouassé reef-benthos transect (RBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga lecanora	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Actinopyga miliaris	35.3	18.1	78	458.3	163.5	6	35.3	19.4	13	152.8	27.8	3
Astralium spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Bohadschia argus	28.8	9.1	78	250.0	0.0	9	28.8	15.2	13	93.8	31.3	4
Bohadschia graeffei	22.4	9.3	78	291.7	41.7	6	22.4	10.1	13	72.9	10.4	4
Cerithium nodulosum	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Conus flavidus	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Conus litteratus	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Conus miles	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Conus spp.	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Cypraea tigris	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Diadema spp.	721.2	246.1	78	4326.9	1015.7	13	721.2	322.7	13	1562.5	527.8	6
Echinometra mathaei	134.6	67.9	78	954.5	416.7	11	134.6	63.8	13	250.0	101.7	7
Echinothrix diadema	407.1	223.3	78	5291.7	2193.2	6	407.1	331.2	13	1763.9	1286.6	3
Heterocentrotus mammillatus	9.6	7.1	78	375.0	125.0	2	9.6	9.6	13	125.0		1
Hippopus hippopus	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Holothuria atra	214.7	38.9	78	465.3	62.3	36	214.7	68.7	13	253.8	75.5	11
Holothuria coluber	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Holothuria edulis	83.3	26.9	78	464.3	101.0	14	83.3	40.3	13	120.4	54.4	9
Holothuria nobilis	9.6	5.5	78	250.0	0.0	3	9.6	6.9	13	62.5	20.8	2
Lambis lambis	48.1	15.2	78	340.9	50.8	11	48.1	24.0	13	125.0	45.6	5
Latirolagena smaragdula	112.2	43.4	78	1093.8	221.3	8	112.2	93.3	13	729.2	479.2	2
Linckia laevigata	73.7	21.9	78	479.2	65.0	12	73.7	30.6	13	191.7	40.8	5
Nardoa spp.	19.2	10.0	78	375.0	72.2	4	19.2	10.1	13	83.3	0.0	3
Periglypta puerpera	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Pinctada margaritifera	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Stichodactyla spp.	9.6	7.1	78	375.0	125.0	2	9.6	6.9	13	62.5	20.8	2
Stichopus chloronotus	166.7	53.1	78	928.6	196.9	14	166.7	121.5	13	541.7	352.3	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.3 Ouassé reef-benthos transect (RBt) assessment data review (continued)
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Tectus pyramis	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Tridacna crocea	6496.8	1096.6	78	8307.4	1312.5	61	6496.8	2248.4	13	7678.0	2502.5	11
Tridacna maxima	41.7	24.3	78	650.0	280.6	5	41.7	23.6	13	135.4	54.8	4
Trochus maculata	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Trochus niloticus	32.1	29.0	78	1250.0	1000.0	2	32.1	28.8	13	208.3	166.7	2
Trochus spp.	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Turbo argyrostomus	6.4	4.5	78	250.0	0.0	2	6.4	6.4	13	83.3		1
Turbo chrysostomus	19.2	7.6	78	250.0	0.0	6	19.2	16.1	13	125.0	83.3	2
Vasum turbinellum	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.4 Ouassé 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	18.6	4.5	24	34.4	5.1	13	18.6	3.3	4	18.6	3.3	4
Bohadschia graeffei	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Echinothrix diadema	14.7	10.8	24	176.5	58.8	2	14.7	14.7	4	58.8		1
Holothuria atra	2.0	2.0	24	47.1		1	2.0	2.0	4	7.8		1
Lambis lambis	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1
Panulirus spp.	3.9	2.3	24	31.4	7.8	3	3.9	2.8	4	7.8	3.9	2
Tridacna maxima	2.0	1.4	24	23.5	0.0	2	2.0	1.1	4	3.9	0.0	2
Trochus niloticus	40.2	7.4	24	53.6	7.6	18	40.2	13.0	4	40.2	13.0	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.5 Ouassé mother-of-pearl search (MOPs) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga miliaris	7.6	7.6	12	90.9		1	7.6	7.6	2	15.2		1
Bohadschia argus	3.8	3.8	12	45.5		1	3.8	3.8	2	7.6		1
Bohadschia graeffei	7.6	7.6	12	90.9		1	7.6	7.6	2	15.2		1
Holothuria atra	3.8	3.8	12	45.5		1	3.8	3.8	2	7.6		1
Holothuria edulis	3.8	3.8	12	45.5		1	3.8	3.8	2	7.6		1
Holothuria nobilis	3.8	3.8	12	45.5		1	3.8	3.8	2	7.6		1
Panulirus spp.	7.6	5.1	12	45.5	0.0	2	7.6	7.6	2	15.2		1
Stichopus chloronotus	3.8	3.8	12	45.5		1	3.8	3.8	2	7.6		1
Tectus pyramis	7.6	5.1	12	45.5	0.0	2	7.6	7.6	2	15.2		1
Tridacna maxima	7.6	5.1	12	45.5	0.0	2	7.6	7.6	2	15.2		1
Tridacna squamosa	11.4	11.4	12	136.4		1	11.4	11.4	2	22.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.6 Ouassé mother-of-pearl transect (MOPt) assessment data review

Station: Six 1 m x 40 m.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Bohadschia graeffei	20.8	14.0	12	125.0	0.0	2	20.8	20.8	2	41.7		1
Conus spp.	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Culcita novaeguineae	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Cypraea caputserpensis	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Echinometra mathaei	895.8	555.8	12	2687.5	1339.0	4	895.8	875.0	2	895.8	875.0	2
Heterocentrotus mammillatus	20.8	14.0	12	125.0	0.0	2	20.8	20.8	2	41.7		1
Holothuria nobilis	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Lambis truncata	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Linckia laevigata	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Nardoa spp.	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Stichopus chloronotus	31.3	16.3	12	125.0	0.0	3	31.3	31.3	2	62.5		1
Tectus pyramis	62.5	36.1	12	250.0	72.2	3	62.5	62.5	2	125.0		1
Tridacna maxima	20.8	14.0	12	125.0	0.0	2	20.8	20.8	2	41.7		1
Tridacna squamosa	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Trochus maculata	10.4	10.4	12	125.0		1	10.4	10.4	2	20.8		1
Trochus niloticus	229.2	45.7	12	275.0	40.8	10	229.2	20.8	2	229.2	20.8	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.7 Ouassé sea cucumber night search (Ns) assessment data review
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga lecanora	35.6	12.0	12	71.1	11.2	6	35.6	35.6	2	71.1		1
Actinopyga miliaris	88.9	28.1	12	177.8	17.8	6	88.9	71.1	2	88.9	71.1	2
Bohadschia argus	8.9	6.0	12	53.3	0.0	2	8.9	8.9	2	17.8		1
Bohadschia graeffei	4.4	4.4	12	53.3		1	4.4	4.4	2	8.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.8 Ouassé sea cucumber day search (Ds) assessment data review
Station: Six 5-min search periods.

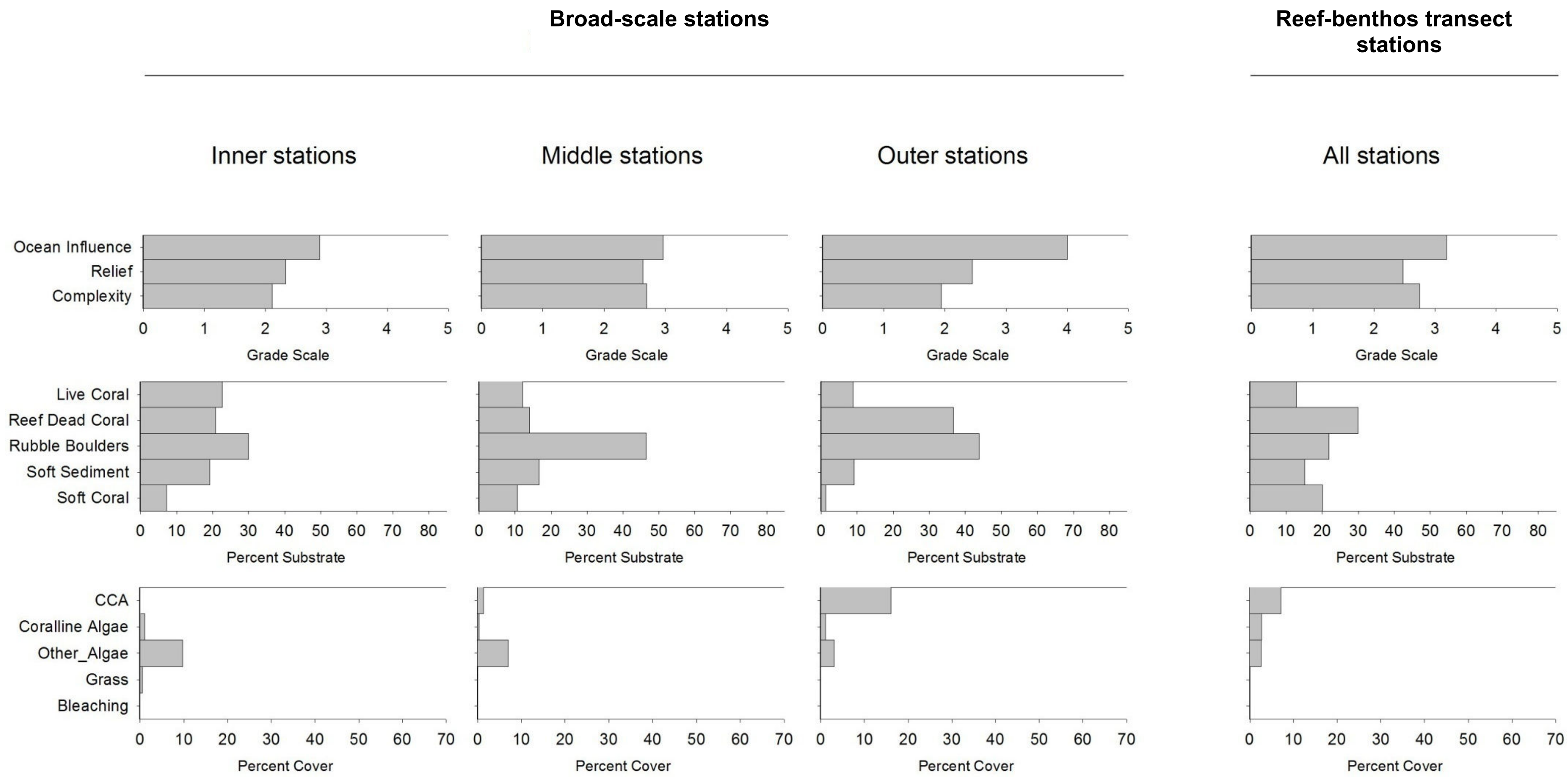
Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Holothuria fuscogilva	2.4	2.4	6	14.3		1	2.4		1	2.4		1
Holothuria fuscopunctata	2.4	2.4	6	14.3		1	2.4		1	2.4		1
Stichopus hermanni	7.1	3.2	6	14.3	0.0	3	7.1		1	7.1		1
Thelenota anax	4.8	3.0	6	14.3	0.0	2	4.8		1	4.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.1.9 Ouassé species size review – all survey methods

Species	Mean length (cm)	SE	n
Tridacna crocea	10.9	0.3	10,663
Bohadschia graeffei	29.0	2.0	704
Stichopus chloronotus	16.4	0.4	515
Holothuria edulis	19.7	1.0	237
Bohadschia argus	33.7	0.4	180
Holothuria atra	20.4	1.7	161
Linckia laevigata	22.5	0.5	109
Trochus niloticus	11.5	0.3	78
Tridacna maxima	14.8	0.7	77
Holothuria fuscopunctata	37.2	1.0	38
Actinopyga miliaris	25.9	0.9	35
Actinopyga mauritiana	23.0	0.9	31
Holothuria nobilis	28.9	0.6	24
Tectus pyramis	6.9	0.4	19
Pinctada margaritifera	14.6	0.6	17
Lambis lambis	17.0	0.5	14
Tridacna squamosa	29.3	2.7	13
Bohadschia vitiensis	28.3	0.5	12
Actinopyga palauensis	35.0	0.0	12
Lambis truncata	29.0	0.5	11
Hippopus hippopus	29.4	2.4	9
Conus spp.	10.0	0.7	8
Panulirus spp.	15.0	0.0	7
Stichopus hermanni	37.2	3.8	6
Thelenota ananas	39.0	1.0	2
Thelenota anax	52.0	0.0	2
Trochus maculata	5.5	2.5	2
Turbo chrysostomus	4.4	0.2	2
Actinopyga lecanora	20.0	0.0	10
Cypraea tigris	9.1	0.0	2
Holothuria fuscogilva	23.0	0.0	1
Panulirus versicolor	15.0	0.0	1
Charonia tritonis	35.0	0.0	1
Trochus spp.	3.2	0.0	1
Echinothrix diadema			257
Diadema spp.			244
Echinometra mathaei			241
Heterocentrotus mammillatus			24
Holothuria coluber			15
Latirolagena smaragdula			12
Atrina spp.			11
Nardoa spp.			9
Spondylus spp.			3
Stichodactyla spp.			3
Holothuria flavomaculata			1
Cypraea caputserpensis			1
Octopus cyanea			1
Culcita novaeguineae			1
Toxopneustes spp.			1
Tripneustes gratilla			1

4.1.10 Habitat descriptors for independent assessment – Ouassé



4.2 Thio invertebrate survey data

4.2.1 Invertebrate species recorded in different assessments in Thio

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga echinites*	+			
Bêche-de-mer	*Actinopyga lecanora*	+	+		+
Bêche-de-mer	*Actinopyga mauritiana*	+	+		+
Bêche-de-mer	*Actinopyga miliaris*	+			+
Bêche-de-mer	*Actinopyga palauensis*	+			
Bêche-de-mer	*Bohadschia argus*	+	+		
Bêche-de-mer	*Bohadschia graeffei*	+	+		
Bêche-de-mer	*Holothuria atra*	+	+		+
Bêche-de-mer	*Holothuria coluber*	+			
Bêche-de-mer	*Holothuria edulis*	+	+		+
Bêche-de-mer	*Holothuria fuscogilva*				+
Bêche-de-mer	*Holothuria fuscopunctata*	+			+
Bêche-de-mer	*Holothuria nobilis*	+			+
Bêche-de-mer	*Holothuria scabra versicolor*	+			
Bêche-de-mer	*Stichopus chloronotus*	+	+		+
Bêche-de-mer	*Stichopus hermanni*	+			+
Bêche-de-mer	*Thelenota ananas*	+			
Bivalve	*Anadara antiquata*			+	
Bivalve	*Atrina* spp.	+			
Bivalve	*Chama* spp.	+	+		
Bivalve	*Hippopus hippopus*	+			
Bivalve	*Pinctada margaritifera*	+	+		
Bivalve	*Pitar prora*			+	
Bivalve	*Spondylus* spp.	+	+		
Bivalve	*Tapes literatus*			+	
Bivalve	*Tellina palatum*			+	
Bivalve	*Tridacna crocea*	+	+		
Bivalve	*Tridacna derasa*	+			
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+	+		
Cnidarian	*Stichodactyla* spp.	+	+		
Crustacean	*Panulirus* spp.	+	+		
Crustacean	*Panulirus versicolor*		+		
Gastropod	*Astralium* spp.		+		
Gastropod	*Cerithium aluco*		+		
Gastropod	*Cerithium nodulosum*	+			
Gastropod	*Chicoreus ramosus*	+			
Gastropod	*Chicoreus* spp.			+	
Gastropod	*Conus* spp.	+	+		
Gastropod	*Cypraea tigris*	+	+		
Gastropod	*Dolabella auricularia*	+			
Gastropod	*Lambis lambis*	+	+		
Gastropod	*Lambis truncata*	+	+		
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Ovula ovum*	+			
Gastropod	*Tectus pyramis*	+	+		+

+ = presence of the species.

4.2.1 Invertebrate species recorded in different assessments in Thio (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Thais armigera*				+
Gastropod	*Trochus maculata*		+		
Gastropod	*Trochus niloticus*	+	+		+
Gastropod	*Turbo argyrostomus*				+
Gastropod	*Turbo chrysostomus*		+		
Gastropod	*Turbo crassus*		+		+
Gastropod	*Vasum ceramicum*		+		
Gastropod	*Vasum turbinellum*		+		
Octopus	*Octopus cyanea*	+	+		+
Star	*Acanthaster planci*	+			
Star	*Linckia laevigata*	+	+		
Star	*Nardoa* spp.	+	+		
Urchin	*Diadema* spp.	+	+		
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix diadema*		+		
Urchin	*Echinothrix* spp.		+		
Urchin	*Heterocentrotus mammillatus*	+	+		+
Urchin	*Tripneustes gratilla*	+			

+ = presence of the species.

4.2.2 Thio broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	0.4	0.3	78	16.7	0.0	2	0.4	0.3	13	2.8	0.0	2
Actinopyga echinites	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Actinopyga lecanora	1.1	0.9	78	41.7	25.0	2	1.1	1.1	13	13.9		1
Actinopyga mauritiana	4.4	1.4	78	28.9	5.1	12	4.5	2.2	13	9.7	3.8	6
Actinopyga miliaris	1.1	0.5	78	16.6	0.1	5	1.1	0.5	13	3.5	0.7	4
Actinopyga palauensis	1.3	0.6	78	20.0	3.3	5	1.3	0.6	13	4.1	0.8	4
Atrina spp.	2.0	0.9	78	26.2	6.2	6	2.1	1.2	13	6.8	2.5	4
Bohadschia argus	13.2	3.6	78	51.3	9.9	20	13.2	5.5	13	24.4	8.1	7
Bohadschia graeffei	75.7	38.1	78	281.3	133.8	21	75.7	55.2	13	140.6	98.9	7
Cerithium nodulosum	0.4	0.3	78	16.7	0.0	2	0.4	0.4	13	5.6		1
Chama spp.	0.9	0.9	78	66.7		1	0.9	0.9	13	11.1		1
Chicoreus ramosus	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Conus spp.	0.4	0.3	78	16.7	0.0	2	0.4	0.3	13	2.7	0.0	2
Cypraea tigris	0.9	0.5	78	22.2	5.6	3	0.9	0.5	13	3.7	0.9	3
Diadema spp.	16.9	11.1	78	263.7	145.1	5	17.2	11.1	13	55.9	29.7	4
Dolabella auricularia	0.6	0.4	78	16.7	0.0	3	0.6	0.5	13	4.2	1.4	2
Echinometra mathaei	18.8	12.8	78	209.5	130.1	7	18.8	17.7	13	81.5	74.6	3
Heterocentrotus mammillatus	8.5	3.4	78	66.5	18.5	10	8.5	4.1	13	18.4	7.0	6
Hippopus hippopus	0.4	0.3	78	16.7	0.0	2	0.4	0.4	13	5.6		1
Holothuria atra	80.2	24.6	78	260.7	67.5	24	80.2	42.8	13	115.8	58.8	9
Holothuria coluber	4.7	3.3	78	183.3	0.0	2	4.7	4.7	13	61.1		1
Holothuria edulis	49.3	11.8	78	160.2	27.4	24	49.4	26.5	13	106.9	49.3	6
Holothuria fuscopunctata	26.8	12.7	78	149.5	62.4	14	27.0	19.0	13	70.1	45.5	5
Holothuria nobilis	0.6	0.4	78	16.3	0.3	3	0.6	0.3	13	2.8	0.0	3
Holothuria scabra versicolor	1.7	0.8	78	22.2	5.6	6	1.7	1.0	13	7.4	2.4	3
Lambis lambis	2.0	0.7	78	19.6	3.0	8	2.1	0.8	13	4.6	1.1	6
Lambis truncata	1.7	0.8	78	26.6	4.0	5	1.7	0.7	13	4.4	0.7	5

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.2 Thio broad-scale assessment data review (continued)

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Linckia laevigata	15.7	5.6	78	72.1	21.1	17	15.6	7.1	13	22.5	9.4	9
Nardoa spp.	0.8	0.4	78	15.9	0.8	4	0.8	0.5	13	3.6	0.9	3
Octopus cyanea	0.6	0.4	78	16.7	0.0	3	0.6	0.5	13	4.2	1.4	2
Ovula ovum	0.4	0.4	78	33.3		1	0.4	0.4	13	5.5		1
Panulirus spp.	2.1	0.8	78	20.5	2.7	8	2.1	0.7	13	3.9	0.8	7
Pinctada margaritifera	1.5	0.7	78	23.3	4.1	5	1.5	0.9	13	6.5	1.8	3
Spondylus spp.	1.2	0.5	78	16.1	0.5	6	1.3	0.7	13	5.4	1.5	3
Stichodactyla spp.	1.9	0.9	78	30.0	6.2	5	1.9	1.1	13	8.3	1.6	3
Stichopus chloronotus	433.3	106.1	78	637.7	148.4	53	434.3	205.5	13	513.3	236.3	11
Stichopus hermanni	1.1	0.6	78	20.8	4.2	4	1.1	0.7	13	4.6	1.9	3
Tectus pyramis	3.0	1.1	78	25.9	5.6	9	3.0	1.4	13	7.8	2.2	5
Thelenota ananas	4.1	2.3	78	52.8	23.3	6	4.0	2.8	13	26.3	6.9	2
Tridacna crocea	1388.6	430.4	78	2707.8	788.4	40	1369.3	626.7	13	2225.0	906.7	8
Tridacna derasa	1.5	0.8	78	23.3	6.7	5	1.5	0.9	13	4.8	2.1	4
Tridacna maxima	29.8	4.4	78	56.7	5.6	41	29.8	7.8	13	35.2	8.1	11
Tridacna squamosa	1.7	0.6	78	16.6	0.1	8	1.7	0.7	13	4.4	1.1	5
Tripneustes gratilla	0.2	0.2	78	16.7		1	0.2	0.2	13	2.8		1
Trochus niloticus	6.4	1.6	78	26.1	3.8	19	6.4	1.9	13	8.3	2.1	10

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.3 Thio reef-benthos transect (RBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga lecanora	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Actinopyga mauritiana	20.8	9.6	72	300.0	50.0	5	20.8	12.0	12	83.3	24.1	3
Astralium spp.	13.9	6.8	72	250.0	0.0	4	13.9	7.8	12	55.6	13.9	3
Bohadschia argus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Bohadschia graeffei	31.3	11.0	72	281.3	31.3	8	31.3	14.6	12	75.0	24.3	5
Cerithium aluco	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Chama spp.	55.6	38.7	72	1333.3	650.9	3	55.6	55.6	12	666.7		1
Conus spp.	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1
Cypraea tigris	13.9	10.9	72	500.0	250.0	2	13.9	10.7	12	83.3	41.7	2
Diadema spp.	284.7	150.4	72	3416.7	1309.7	6	284.7	258.7	12	1138.9	993.1	3
Echinometra mathaei	90.3	41.2	72	812.5	266.2	8	90.3	62.1	12	270.8	161.8	4
Echinothrix diadema	13.9	10.9	72	500.0	250.0	2	13.9	10.7	12	83.3	41.7	2
Echinothrix spp.	13.9	9.8	72	500.0	0.0	2	13.9	13.9	12	166.7		1
Heterocentrotus mammillatus	17.4	7.5	72	250.0	0.0	5	17.4	9.5	12	69.4	13.9	3
Holothuria atra	319.4	77.1	72	718.8	146.3	32	319.4	116.8	12	479.2	145.6	8
Holothuria edulis	34.7	16.6	72	500.0	111.8	5	34.7	34.7	12	416.7		1
Lambis lambis	10.4	7.7	72	375.0	125.0	2	10.4	7.5	12	62.5	20.8	2
Lambis truncata	20.8	12.8	72	500.0	144.3	3	20.8	20.8	12	250.0		1
Latirolagena smaragdula	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Linckia laevigata	79.9	28.8	72	575.0	123.9	10	79.9	44.6	12	239.6	95.3	4
Nardoa spp.	45.1	13.4	72	295.5	30.5	11	45.1	16.6	12	90.3	19.9	6
Octopus cyanea	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
Panulirus versicolor	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Pinctada margaritifera	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Spondylus spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Stichodactyla spp.	31.3	13.0	72	375.0	55.9	6	31.3	17.9	12	93.8	39.4	4
Stichopus chloronotus	541.7	87.6	72	829.8	113.8	47	541.7	140.6	12	650.0	145.6	10

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.3 Thio reef-benthos transect (RBt) assessment data review (continued)
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Tectus pyramis	76.4	19.6	72	366.7	41.3	15	76.4	29.8	12	152.8	39.8	6
Tridacna crocea	3072.9	876.3	72	6704.5	1719.5	33	3072.9	1784.0	12	5267.9	2841.6	7
Tridacna maxima	97.2	22.4	72	368.4	44.3	19	97.2	39.5	12	233.3	48.6	5
Tridacna squamosa	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Trochus maculata	13.9	6.8	72	250.0	0.0	4	13.9	5.9	12	41.7	0.0	4
Trochus niloticus	52.1	18.5	72	375.0	76.8	10	52.1	31.3	12	156.3	72.9	4
Turbo chrysostomus	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Turbo crassus	6.9	4.9	72	250.0	0.0	2	6.9	6.9	12	83.3		1
Vasum ceramicum	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
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; SE = standard error.

4.2.4 Thio soft-benthos quadrats (SBq) assessment data review
Station: 8 quadrat groups (4 quadrats/group).

Species	Station			Station _P		
	Mean	SE	n	Mean	SE	n
Anadara antiquata	4.9	1.5	6	4.9	1.5	6
Chicoreus spp.	0.1	0.1	6	0.5		1
Pitar prora	1.3	0.3	6	1.3	0.3	6
Tapes literatus	0.2	0.1	6	0.5	0.0	2
Tellina palatum	1.8	0.6	6	2.6	0.5	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.5 Thio 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	9.8	2.8	24	26.1	2.6	9	9.8	4.7	4	19.6		1.0
Heterocentrotus mammillatus	242.2	70.1	24	322.9	85.6	18	242.2	120.7	4	392.2	184.3	2
Holothuria atra	11.8	3.7	24	31.4	5.5	9	11.8	6.2	4	15.7	11.8	2
Octopus cyanea	1.0	1.0	24	23.5		1	1.0	1.0	4			0
Tectus pyramis	176.5	45.5	24	302.5	57.9	14	176.5	75.7	4	274.5	98.0	2
Tridacna maxima	8.8	4.0	24	42.4	8.8	5	8.8	2.9	4	7.8	3.9	2
Trochus niloticus	28.4	8.0	24	52.5	11.0	13	28.4	10.5	4	41.2	9.8	2
Turbo crassus	1.0	1.0	24	23.5		1	1.0	1.0	4	3.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.6 Thio mother-of-pearl search (MOPs) assessment data review
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Tridacna maxima	15.2	9.6	6	45.5	0	2	15.2		1	15.2		1
Trochus niloticus	68.2	19.5	6	81.8	17.0	5	68.2		1	68.2		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

Appendix 4: Invertebrate survey data
Thio

4.2.7 Thio mother-of-pearl transect (MOPt) assessment data review

Station: Six 1 m x 40 m.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	135.4	38.3	24	295.5	51.3	11	135.4	72.4	4	180.6	80.1	3
Echinometra mathaei	31.3	21.6	24	375.0	0.0	2	31.3	31.3	4	125.0		1
Heterocentrotus mammillatus	67.7	36.1	24	406.3	118.3	4	67.7	54.7	4	135.4	93.8	2
Holothuria nobilis	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Stichopus chloronotus	10.4	7.2	24	125.0	0.0	2	10.4	6.0	4	20.8	0.0	2
Tectus pyramis	57.3	21.3	24	196.4	37.2	7	57.3	10.0	4	57.3	10.0	4
Thais armigera	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Tridacna maxima	26.0	13.0	24	156.3	31.3	4	26.0	15.6	4	52.1	10.4	2
Trochus niloticus	88.5	28.6	24	236.1	43.9	9	88.5	41.1	4	88.5	41.1	4
Turbo argyrostomus	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.8 Thio sea cucumber night search (Ns) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga lecanora	20.7	8.8	18	74.7	13.1	5	20.7	16.5	3	31.1	22.2	2
Actinopyga miliaris	11.9	5.4	18	53.3	0.0	4	11.9	5.9	3	17.8	0.0	2
Holothuria nobilis	3.0	3.0	18	53.3		1	3.0	3.0	3	8.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.2.9 Thio 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	4.8	3.0	6	14.3	0.0	2	4.8		1	4.8		1
Holothuria atra	21.4	21.4	6	128.6		1	21.4		1	21.4		1
Holothuria edulis	4.8	4.8	6	28.6		1	4.8		1	4.8		1
Holothuria fuscogilva	2.4	2.4	6	14.3		1	2.4		1	2.4		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

Appendix 4: Invertebrate survey data
Thio

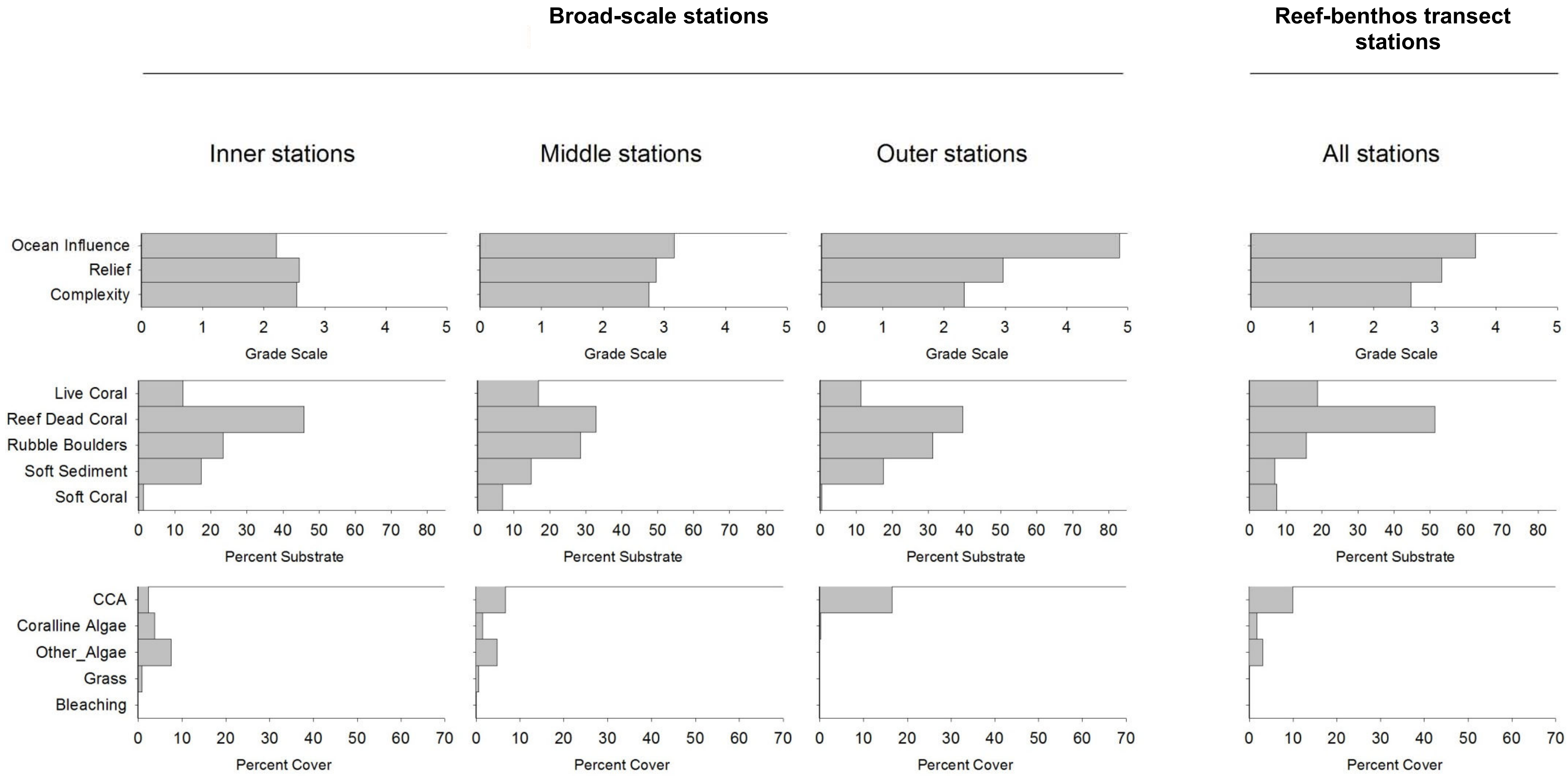
4.2.10 Thio species size review – all survey methods

Species	Mean length (cm)	SE	n
Stichopus chloronotus	18.7	0.6	2050
Bohadschia graeffei	35.0	0.0	355
Tectus pyramis	6.3	0.2	204
Tridacna maxima	16.3	0.5	156
Holothuria fuscopunctata	38.2	1.0	127
Trochus niloticus	12.7	0.4	80
Bohadschia argus	31.3	0.6	62
Anadara antiquata	3.8	0.2	59
Actinopyga mauritiana	22.6	1.1	54
Tellina palatum	3.3	0.3	21
Thelenota ananas	41.7	1.3	19
Pitar prora	3.2	0.1	15
Panulirus spp.	20.0	0.8	10
Lambis lambis	15.3	0.6	10
Tridacna squamosa	25.8	2.3	8
Lambis truncata	30.0	1.7	8
Tridacna derasa	33.7	1.7	7
Pinctada margaritifera	14.2	0.7	7
Stichopus hermanni	45.0	5.2	6
Actinopyga miliaris	27.5	2.8	6
Holothuria nobilis	30.0	2.4	5
Hippopus hippopus	17.0	1.0	2
Tapes literatus	5.5	0.7	2
Conus spp.	11.0	0.0	2
Holothuria scabra versicolor	22.0	0.0	8
Cypraea tigris	6.5	0.0	4
Actinopyga echinites	22.0	0.0	1
Chicoreus ramosus	18.0	0.0	1
Chicoreus spp.	5.1	0.0	1
Thais armigera	6.2	0.0	1
Turbo argyrostomus	6.9	0.0	1
Tridacna crocea			6522
Holothuria atra			401
Heterocentrotus mammillatus			300
Holothuria edulis			233
Echinometra mathaei			94
Diadema spp.			81
Linckia laevigata			74
Holothuria coluber			22
Atrina spp.			10
Stichodactyla spp.			9
Actinopyga lecanora			8
Actinopyga palauensis			6
Spondylus spp.			6
Chama spp.			4
Nardoa spp.			4
Dolabella auricularia			3
Octopus cyanea			3

4.2.10 Thio species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Cerithium nodulosum			2
Ovula ovum			2
Acanthaster planci			2
Turbo crassus			1
Tripneustes gratilla			1

4.2.11 Habitat descriptors for independent assessment – Thio



4.3 Luengoni invertebrate survey data

4.3.1 Invertebrate species recorded in different assessments in Luengoni

Group	Species	Broad scale	Reef benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*	+	+	+
Bêche-de-mer	*Bohadschia argus*	+	+	
Bêche-de-mer	*Bohadschia vitiensis*	+		
Bêche-de-mer	*Holothuria atra*	+	+	+
Bêche-de-mer	*Holothuria fuscopunctata*	+		
Bêche-de-mer	*Holothuria hilla*		+	+
Bêche-de-mer	*Holothuria nobilis*	+	+	+
Bêche-de-mer	*Thelenota ananas*			+
Bivalve	*Anadara scapha*		+	
Bivalve	*Hippopus hippopus*	+		
Bivalve	*Pinctada margaritifera*	+	+	
Bivalve	*Pinna* spp.		+	
Bivalve	*Tridacna maxima*	+	+	+
Bivalve	*Tridacna squamosa*		+	
Cnidarians	*Heteractis* spp.		+	+
Cnidarians	*Stichodactyla* spp.	+	+	+
Crustacean	*Calappa* spp.		+	
Crustacean	*Panulirus longipes*			+
Crustacean	*Portunus* spp.			+
Gastropod	*Astralium* spp.	+		
Gastropod	*Cerithium nodulosum*	+	+	+
Gastropod	*Conus arenatus*		+	
Gastropod	*Conus capitaneus*			+
Gastropod	*Conus coronatus*		+	
Gastropod	*Conus distans*		+	+
Gastropod	*Conus emaciatus*		+	
Gastropod	*Conus flavidus*		+	+
Gastropod	*Conus imperialis*		+	+
Gastropod	*Conus leopardus*		+	+
Gastropod	*Conus litteratus*	+		+
Gastropod	*Conus lividus*		+	+
Gastropod	*Conus miliaris*		+	
Gastropod	*Conus pulicarius*		+	+
Gastropod	*Conus rattus*		+	
Gastropod	*Conus sanguinolentus*		+	+
Gastropod	*Conus virgo*	+		+
Gastropod	*Cypraea moneta*		+	
Gastropod	*Cypraea tigris*			+
Gastropod	*Lambis lambis*		+	
Gastropod	*Lambis truncata*			+
Gastropod	*Latirolagena smaragdula*		+	+
Gastropod	*Mitra mitra*			+
Gastropod	*Mitra stictica*			+
Gastropod	*Pleuroploca trapezium*		+	
Gastropod	*Strombus luhuanus*		+	
Gastropod	*Tectus pyramis*		+	+

+ = presence of the species.

4.3.1 Invertebrate species recorded in different assessments in Luengoni (continued)

Group	Species	Broad scale	Reef benthos	Others
Gastropod	*Terebra areolata*		+	
Gastropod	*Terebra maculata*			+
Gastropod	*Thais* spp.		+	
Gastropod	*Trochus maculata*		+	+
Gastropod	*Trochus* spp.			+
Gastropod	*Turbo argyrostomus*			+
Octopus	*Octopus cyanea*		+	
Urchin	*Echinometra mathaei*	+	+	+
Urchin	*Echinothrix diadema*			+
Urchin	*Heterocentrotus mammillatus*		+	+

+ = presence of the species.

4.3.2 Luengoni 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	16.8	7.3	42	101.0	28.1	7	16.8	15.9	7	58.9	53.4	2
Astralium spp.	0.4	0.4	42	16.7		1	0.4	0.4	7	2.8		1
Bohadschia argus	12.7	3.8	42	38.0	7.9	14	12.7	3.4	7	12.7	3.4	7
Bohadschia vitiensis	0.4	0.4	42	16.7		1	0.4	0.4	7	2.8		1
Cerithium nodulosum	3.5	2.2	42	49.2	17.1	3	3.5	2.0	7	8.2	2.8	3
Conus litteratus	1.2	0.7	42	16.7	0.0	3	1.2	0.8	7	4.2	1.4	2
Conus spp.	5.1	2.2	42	30.6	7.8	7	5.1	4.3	7	17.9	12.7	2
Conus virgo	1.6	1.0	42	22.2	5.6	3	1.6	0.8	7	3.7	0.9	3
Echinometra mathaei	2.8	1.8	42	38.9	14.7	3	2.8	2.8	7	19.4		1
Hippopus hippopus	0.4	0.4	42	16.7		1	0.4	0.4	7	2.8		1
Holothuria atra	105.4	55.0	42	368.8	175.2	12	105.4	50.5	7	184.4	63.8	4
Holothuria fuscopunctata	1.9	1.0	42	19.9	3.6	4	1.9	1.1	7	4.4	1.6	3
Holothuria nobilis	19.7	4.8	42	37.5	7.3	22	19.7	5.1	7	19.7	5.1	7
Pinctada margaritifera	0.4	0.4	42	16.7		1	0.4	0.4	7	2.8		1
Stichodactyla spp.	2.0	1.3	42	27.8	11.1	3	2.0	1.3	7	6.9	1.4	2
Strombus luhuanus	3.4	3.4	42	144.1		1	3.4	3.4	7	24.0		1
Synapta spp.	0.7	0.7	42	30.8		1	0.7	0.7	7	5.1		1
Tectus pyramis	0.8	0.5	42	16.0	0.6	2	0.8	0.8	7	5.3		1
Tridacna maxima	12.3	2.5	42	23.6	3.3	22	12.3	2.8	7	12.3	2.8	7

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.3 Luengoni 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	25.0	7.9	90	250.0	0.0	9	25.0	7.9	15	53.6	7.7	7
Anadara scapha	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Bohadschia argus	27.8	14.5	90	500.0	158.1	5	27.8	19.8	15	138.9	77.3	3
Calappa spp.	5.6	5.6	90	500.0		1	5.6	5.6	15	83.3		1
Cerithium nodulosum	19.4	8.1	90	291.7	41.7	6	19.4	9.0	15	58.3	16.7	5
Conus arenatus	5.6	3.9	90	250.0	0.0	2	5.6	3.8	15	41.7	0.0	2
Conus coronatus	5.6	3.9	90	250.0	0.0	2	5.6	3.8	15	41.7	0.0	2
Conus distans	16.7	9.5	90	375.0	125.0	4	16.7	8.9	15	62.5	20.8	4
Conus emaciatus	5.6	5.6	90	500.0		1	5.6	5.6	15	83.3		1
Conus flavidus	13.9	7.2	90	312.5	62.5	4	13.9	6.6	15	52.1	10.4	4
Conus imperialis	11.1	8.8	90	500.0	250.0	2	11.1	11.1	15	166.7		1
Conus leopardus	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Conus lividus	25.0	7.9	90	250.0	0.0	9	25.0	8.9	15	62.5	9.3	6
Conus miliaris	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Conus pulicarius	5.6	3.9	90	250.0	0.0	2	5.6	3.8	15	41.7	0.0	2
Conus rattus	8.3	8.3	90	750.0		1	8.3	8.3	15	125.0		1
Conus sanguinolentus	5.6	3.9	90	250.0	0.0	2	5.6	3.8	15	41.7	0.0	2
Cypraea moneta	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Echinometra mathaei	733.3	204.8	90	1650.0	420.3	40	733.3	362.0	15	916.7	439.6	12
Heteractis spp.	11.1	6.7	90	333.3	83.3	3	11.1	8.6	15	83.3	41.7	2
Heterocentrotus mammillatus	16.7	7.7	90	300.0	50.0	5	16.7	7.9	15	62.5	12.0	4
Holothuria atra	11.1	5.5	90	250.0	0.0	4	11.1	8.6	15	83.3	41.7	2
Holothuria hilla	22.2	10.2	90	333.3	83.3	6	22.2	11.4	15	66.7	25.0	5
Holothuria nobilis	97.2	33.0	90	583.3	145.7	15	97.2	63.5	15	243.1	145.3	6
Lambis lambis	8.3	6.2	90	375.0	125.0	2	8.3	6.0	15	62.5	20.8	2
Latirolagena smaragdula	66.7	18.4	90	461.5	47.8	13	66.7	35.9	15	200.0	82.7	5
Octopus cyanea	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Pinctada margaritifera	8.3	6.2	90	375.0	125.0	2	8.3	8.3	15	125.0		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.3 Luengoni reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Pinna spp.	25.0	22.4	90	1125.0	875.0	2	25.0	25.0	15	375.0		1
Pleuroploca trapezium	8.3	4.8	90	250.0	0.0	3	8.3	4.5	15	41.7	0.0	3
Stichodactyla spp.	13.9	7.2	90	312.5	62.5	4	13.9	8.8	15	69.4	27.8	3
Strombus luhuanus	8.3	8.3	90	750.0		1	8.3	8.3	15	125.0		1
Tectus pyramis	5.6	3.9	90	250.0	0.0	2	5.6	3.8	15	41.7	0.0	2
Terebra areolata	2.8	2.8	90	250.0		1	2.8	2.8	15	41.7		1
Thais spp.	5.6	3.9	90	250.0	0.0	2	5.6	5.6	15	83.3		1
Tridacna maxima	150.0	26.4	90	421.9	44.1	32	150.0	33.5	15	173.1	34.3	13
Tridacna squamosa	8.3	4.8	90	250.0	0.0	3	8.3	4.5	15	41.7	0.0	3
Trochus maculata	5.6	3.9	90	250.0	0.0	2	5.6	3.8	15	41.7	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.4 Luengoni 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	14.9	3.5	30	31.9	4.0	14	14.9	4.4	5	14.9	4.4	5
Cerithium nodulosum	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Conus distans	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Conus leopardus	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Conus lividus	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Cypraea tigris	1.6	1.1	30	23.5	0.0	2	1.6	1.0	5	3.9	0.0	2
Heteractis spp.	1.6	1.1	30	23.5	0.0	2	1.6	1.0	5	3.9	0.0	2
Heterocentrotus mammillatus	1.6	1.1	30	23.5	0.0	2	1.6	1.0	5	3.9	0.0	2
Holothuria atra	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Latirolagena smaragdula	4.7	2.9	30	47.1	13.6	3	4.7	2.3	5	7.8	2.3	3
Tectus pyramis	5.5	2.2	30	27.5	3.9	6	5.5	2.9	5	9.2	3.5	3
Tridacna maxima	2.4	1.7	30	35.3	11.8	2	2.4	1.6	5	5.9	2.0	2
Trochus maculata	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Trochus spp.	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Turbo argyrostomus	1.6	1.1	30	23.5	0.0	2	1.6	1.0	5	3.9	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.5 Luengoni 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
Conus capitaneus	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Conus distans	13.3	9.6	12	80	26.7	2.0	13.3	4.4	2	13.3	4.4	2
Conus flavidus	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Conus imperialis	8.9	6.0	12	53	0.0	2.0	8.9	8.9	2	17.8		1
Conus leopardus	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Conus litteratus	8.9	6.0	12	53	0.0	2.0	8.9	0.0	2	8.9	0.0	2
Conus pulicarius	8.9	6.0	12	53	0.0	2.0	8.9	8.9	2	17.8		1
Conus sanguinolentus	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Conus virgo	17.8	12.0	12	107	0.0	2.0	17.8	17.8	2	35.6		1
Echinometra mathaei	57.8	31.8	12	231	47.0	3.0	57.8	57.8	2	115.6		1
Echinothrix diadema	8.9	6.0	12	53	0.0	2.0	8.9	0.0	2	8.9	0.0	2
Holothuria hilla	22.2	22.2	12	267		1.0	22.2	22.2	2	44.4		1
Holothuria nobilis	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Latirolagena smaragdula	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Mitra stictica	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Panulirus longipes	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Portunus spp.	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1
Tridacna maxima	4.4	4.4	12	53		1.0	4.4	4.4	2	8.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.3.6 Luengoni 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
Echinometra mathaei	2.4	2.4	18	42.9		1	2.4	2.4	3	7.1		1
Holothuria atra	0.8	0.8	18	14.3		1	0.8	0.8	3	2.4		1
Holothuria nobilis	0.8	0.8	18	14.3		1	0.8	0.8	3	2.4		1
Lambis truncata	6.3	3.1	18	28.6	5.8	4	6.3	6.3	3	19.0		1
Mitra mitra	0.8	0.8	18	14.3		1	0.8	0.8	3	2.4		1
Stichodactyla spp.	4.8	1.6	18	14.3	0.0	6	4.8	2.7	3	7.1	2.4	2
Terebra maculata	0.8	0.8	18	14.3		1	0.8	0.8	3	2.4		1
Thelenota ananas	3.2	1.8	18	19.0	4.8	3	3.2	3.2	3	9.5		1
Tridacna maxima	2.4	1.3	18	14.3	0.0	3	2.4	1.4	3	3.6	1.2	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

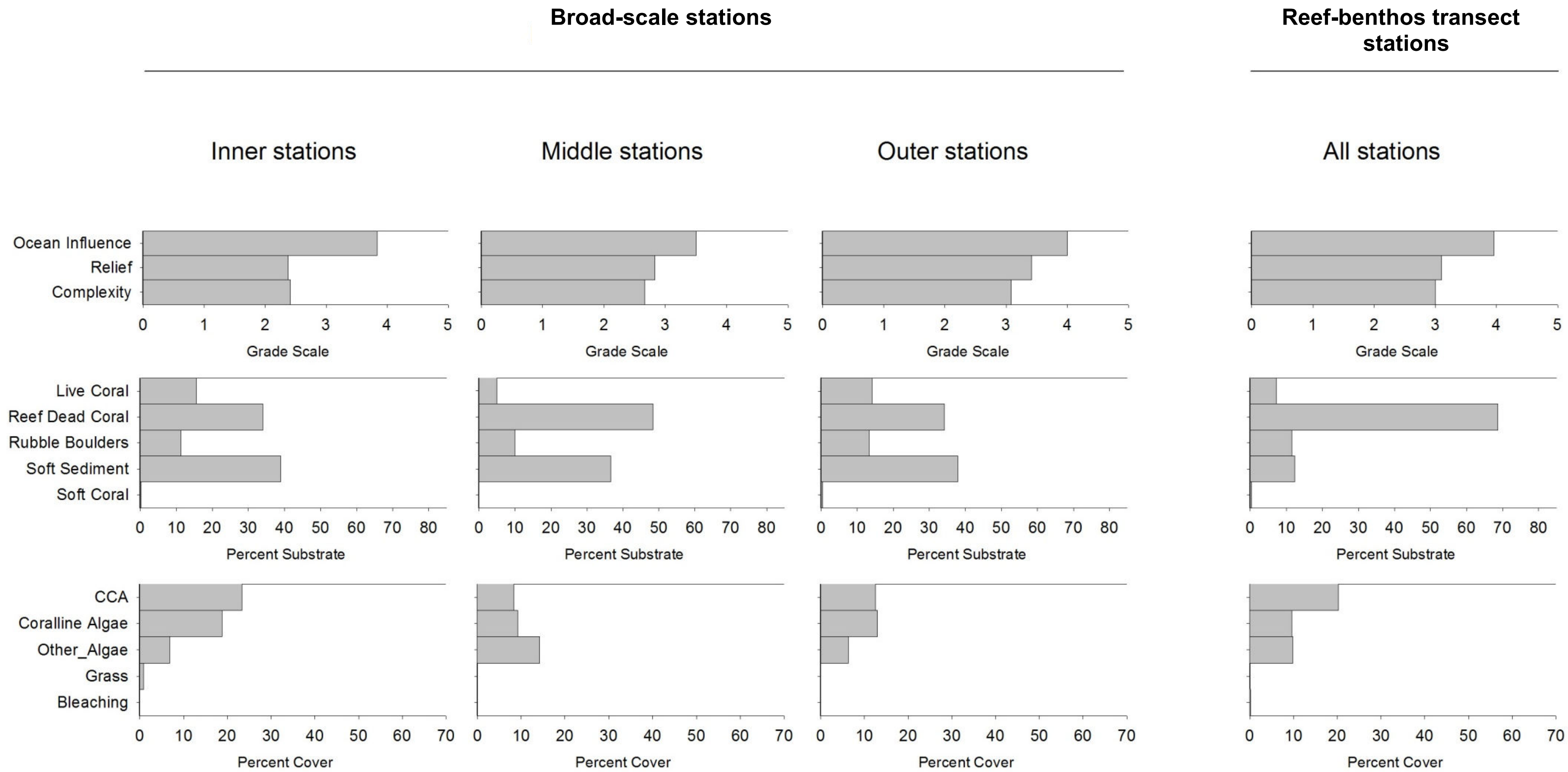
4.3.7 Luengoni species size review – all survey methods

Species	Mean length (cm)	SE	n
Holothuria atra	37.3	3.6	206
Tridacna maxima	17.6	0.6	77
Holothuria nobilis	29.1	0.7	62
Bohadschia argus	40.0	1.5	31
Latirolagena smaragdula	4.6	0.3	31
Actinopyga mauritiana	20.0	0.9	30
Cerithium nodulosum	10.7	0.4	15
Conus distans	9.9	1.0	10
Conus lividus	5.3	0.3	10
Tectus pyramis	9.2	0.3	9
Lambis truncata	27.3	0.9	8
Conus virgo	9.0	0.0	8
Conus flavidus	3.8	0.2	6
Conus imperialis	5.2	0.1	6
Conus litteratus	9.4	1.1	5
Thelenota ananas	45.0	3.3	4
Conus pulicarius	4.5	1.3	4
Pinctada margaritifera	13.8	0.6	4
Lambis lambis	18.0	3.5	3
Conus leopardus	10.3	3.3	3
Tridacna squamosa	23.7	3.0	3
Conus sanguinolentus	3.5	1.5	3
Strombus luhuanus	5.8	0.2	3
Trochus maculata	3.0	0.0	3
Holothuria fuscopunctata	41.0	4.0	2
Thais spp.	4.8	1.3	2
Cypraea tigris	9.3	0.3	2
Turbo argyrostomus	8.3	0.3	2
Conus rattus	4.4	0.0	3
Pleuroploca trapezium	3.8	0.0	3
Conus arenatus	2.9	0.0	2
Hippopus hippopus	35.0	0.0	1
Bohadschia vitiensis	30.0	0.0	1
Panulirus longipes	25.0	0.0	1
Terebra maculata	13.0	0.0	1
Holothuria fuscogilva	10.5	0.0	1
Anadara scapha	8.9	0.0	1
Mitra mitra	6.5	0.0	1
Conus capitaneus	6.0	0.0	1
Conus miliaris	2.4	0.0	1
Echinometra mathaei			287
Stichodactyla spp.			16
Holothuria hilla			13
Pinna spp.			9
Heterocentrotus mammillatus			8
Heteractis spp.			6
Calappa spp.			2
Conus coronatus			2

4.3.7 Luengoni species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Conus emaciatus			2
Echinothrix diadema			2
Portunus spp.			1
Astralium spp.			1
Cypraea moneta			1
Mitra stictica			1
Terebra areolata			1
Trochus spp.			1
Octopus cyanea			1

4.3.8 Habitat descriptors for independent assessment – Luengoni



4.4 Oundjo invertebrate survey data

4.4.1 Invertebrate species recorded in different assessments in Oundjo

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga lecanora*		+		+
Bêche-de-mer	*Actinopyga mauritiana*		+		+
Bêche-de-mer	*Actinopyga miliaris*	+			+
Bêche-de-mer	*Actinopyga palauensis*	+	+		
Bêche-de-mer	*Bohadschia argus*	+	+		
Bêche-de-mer	*Bohadschia similis*	+		+	+
Bêche-de-mer	*Holothuria atra*	+	+	+	+
Bêche-de-mer	*Holothuria coluber*	+			+
Bêche-de-mer	*Holothuria edulis*	+	+		
Bêche-de-mer	*Holothuria fuscopunctata*	+			
Bêche-de-mer	*Holothuria nobilis*	+	+		
Bêche-de-mer	*Holothuria scabra*	+		+	
Bêche-de-mer	*Stichopus chloronotus*	+	+		+
Bêche-de-mer	*Stichopus hermanni*	+			
Bêche-de-mer	*Stichopus horrens*	+			+
Bêche-de-mer	*Thelenota ananas*	+			+
Bivalve	*Anadara scapha*			+	
Bivalve	*Anadara* spp.	+		+	+
Bivalve	*Atrina vexillum*			+	
Bivalve	*Chama* spp.	+	+		
Bivalve	*Gafrarium pectinatum*			+	
Bivalve	*Gafrarium* spp.			+	
Bivalve	*Gafrarium tumidum*			+	
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Periglypta puerpera*			+	
Bivalve	*Pinctada margaritifera*	+	+		+
Bivalve	*Pinna bicolor*			+	
Bivalve	*Pinna* spp.			+	
Bivalve	*Spondylus* spp.	+	+		
Bivalve	*Spondylus squamosus*		+		
Bivalve	*Tellina palatum*			+	
Bivalve	*Trachycardium enode*				+
Bivalve	*Tridacna crocea*	+			
Bivalve	*Tridacna derasa*	+			
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+			
Cnidarians	*Stichodactyla* spp.	+			
Crustacean	*Panulirus* spp.	+			
Crustacean	*Portunus* spp.			+	
Gastropod	*Astralium* spp.		+		+
Gastropod	*Cerithium aluco*			+	
Gastropod	*Cerithium nodulosum*	+			
Gastropod	*Cerithium* spp.			+	
Gastropod	*Conus eburneus*			+	
Gastropod	*Conus leopardus*		+	+	
Gastropod	*Conus litteratus*		+		+

+ = presence of the species.

4.4.1 Invertebrate species recorded in different assessments in Oundjo (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Conus miles*		+		
Gastropod	*Conus* spp.	+	+	+	+
Gastropod	*Cymatium muricinum*			+	
Gastropod	*Cypraea annulus*		+		
Gastropod	*Cypraea tigris*	+	+		+
Gastropod	*Dolabella auricularia*				+
Gastropod	*Haliotis asinina*		+		
Gastropod	*Lambis lambis*	+	+	+	
Gastropod	*Lambis truncata*				+
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Nassarius* spp.			+	
Gastropod	*Oliva* spp.			+	
Gastropod	*Ovula ovum*		+		
Gastropod	*Pleuroploca filamentosa*				+
Gastropod	*Strombus gibberulus gibbosus*			+	
Gastropod	*Strombus luhuanus*	+	+		
Gastropod	*Strombus mutabilis*			+	
Gastropod	*Tectus pyramis*	+	+		+
Gastropod	*Trochus maculata*		+		+
Gastropod	*Trochus niloticus*	+	+		+
Gastropod	*Trochus* spp.		+	+	
Gastropod	*Turbo argyrostomus*	+	+		+
Gastropod	*Turbo chrysostomus*		+	+	
Gastropod	*Vasum turbinellum*		+		
Octopus	*Octopus cyanea*	+			
Star	*Culcita novaeguineae*	+			
Star	*Linckia laevigata*	+	+		+
Star	*Nardoa* spp.	+			
Star	*Protoreaster nodosus*	+			+
Urchin	*Diadema* spp.	+	+		+
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix diadema*	+	+		+
Urchin	*Heterocentrotus mammillatus*	+	+		+

+ = presence of the species.

4.4.2 Oundjo 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 miliaris	4.8	1.9	81	38.6	11.0	10	4.9	3.7	13	10.7	7.6	6
Actinopyga palauensis	5.4	1.5	81	29.1	4.0	15	5.4	2.1	13	10.0	2.8	7
Anadara spp.	0.8	0.5	81	22.2	5.6	3	0.8	0.8	13	10.8		1
Bohadschia argus	17.7	4.9	81	49.5	11.5	29	17.9	7.6	13	29.1	10.6	8
Bohadschia similis	46.1	29.7	81	1244.4	457.8	3	45.3	45.3	13	589.5		1
Cerithium nodulosum	1.0	0.7	81	41.7	8.3	2	0.9	0.9	13	11.9		1
Chama spp.	0.6	0.5	81	25.0	8.3	2	0.6	0.6	13	8.1		1
Conus spp.	1.4	0.6	81	19.4	2.8	6	1.4	0.6	13	3.7	0.6	5
Culcita novaeguineae	0.2	0.2	81	16.7		1	0.2	0.2	13	2.8		1
Cypraea tigris	0.8	0.5	81	22.2	5.6	3	0.9	0.6	13	5.9	1.1	2
Diadema spp.	2.7	0.8	81	19.6	2.1	11	2.6	0.9	13	4.8	1.1	7
Echinometra mathaei	73.0	17.5	81	227.3	40.8	26	70.8	39.1	13	153.4	73.7	6
Echinothrix diadema	0.6	0.5	81	25.0	8.3	2	0.6	0.6	13	8.3		1
Heterocentrotus mammillatus	5.4	3.2	81	48.8	25.3	9	5.6	3.8	13	14.5	9.1	5
Hippopus hippopus	1.4	0.5	81	16.5	0.1	7	1.4	0.6	13	3.6	0.6	5
Holothuria atra	78.6	27.1	81	172.0	55.9	37	78.4	50.1	13	101.9	63.9	10
Holothuria coluber	1.6	0.8	81	25.6	6.2	5	1.6	1.2	13	10.5	3.4	2
Holothuria edulis	3.1	1.1	81	27.5	4.0	9	3.2	2.0	13	10.4	5.0	4
Holothuria fuscopunctata	2.0	1.7	81	54.2	39.6	3	2.0	1.8	13	13.0	10.3	2
Holothuria nobilis	4.8	1.0	81	19.4	1.7	20	4.9	1.4	13	7.1	1.4	9
Holothuria scabra	17.3	12.6	81	700.0	188.9	2	17.0	17.0	13	221.1		1
Lambis lambis	1.8	0.6	81	16.5	0.2	9	1.9	0.6	13	4.0	0.6	6
Linckia laevigata	15.1	2.8	81	39.5	4.9	31	15.4	4.6	13	20.0	5.1	10
Nardoa spp.	0.8	0.5	81	22.2	5.6	3	0.9	0.5	13	3.7	0.9	3
Octopus cyanea	0.4	0.4	81	33.3		1	0.4	0.4	13	5.6		1
Panulirus spp.	0.2	0.2	81	16.7		1	0.2	0.2	13	2.8		1
Pinctada margaritifera	5.8	1.8	81	29.2	6.4	16	5.9	2.6	13	10.9	4.1	7

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.2 Oundjo broad-scale assessment data review (continued)

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Protoreaster nodosus	40.2	19.8	81	406.5	155.2	8	42.8	29.9	13	185.3	100.3	3
Spondylus spp.	1.0	0.4	81	16.7	0.0	5	1.0	0.6	13	4.3	0.8	3
Stichodactyla spp.	3.7	1.1	81	24.9	2.5	12	3.7	1.2	13	6.8	1.4	7
Stichopus chloronotus	27.6	10.9	81	124.4	42.7	18	28.6	17.8	13	93.1	46.0	4
Stichopus hermanni	0.8	0.5	81	21.4	6.0	3	0.8	0.8	13	10.8		1
Stichopus horrens	0.4	0.4	81	33.3		1	0.4	0.4	13	5.4		1
Strombus luhuanus	1.6	0.9	81	43.6	6.4	3	1.7	1.3	13	10.9	5.7	2
Tectus pyramis	15.6	3.9	81	55.0	10.0	23	15.8	7.3	13	34.2	12.1	6
Thelenota ananas	0.2	0.2	81	16.7		1	0.2	0.2	13	2.4		1
Tridacna crocea	0.2	0.2	81	16.7		1	0.2	0.2	13	2.8		1
Tridacna derasa	2.1	0.7	81	18.5	1.9	9	2.0	0.8	13	5.1	0.8	5
Tridacna maxima	105.4	16.2	81	149.7	20.4	57	106.4	29.2	13	125.8	31.1	11
Tridacna squamosa	1.2	0.5	81	16.6	0.1	6	1.2	0.4	13	2.6	0.1	6
Trochus niloticus	5.0	1.3	81	25.5	3.8	16	5.1	2.1	13	11.1	3.1	6
Turbo argyrostomus	0.4	0.3	81	16.7	0.0	2	0.4	0.3	13	2.8	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.3 Oundjo reef-benthos transect (RBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga lecanora	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Actinopyga mauritiana	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Actinopyga palauensis	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Astralium spp.	76.4	18.9	72	366.7	33.3	15	76.4	20.4	12	114.6	18.9	8
Bohadschia argus	121.5	31.7	72	460.5	79.4	19	121.5	57.0	12	243.1	91.6	6
Chama spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus leopardus	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Conus litteratus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Conus miles	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Conus spp.	10.4	5.9	72	250.0	0.0	3	10.4	7.5	12	62.5	20.8	2
Cypraea annulus	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Cypraea tigris	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Diadema spp.	76.4	31.1	72	687.5	168.7	8	76.4	61.9	12	305.6	222.2	3
Echinometra mathaei	902.8	262.1	72	2407.4	600.8	27	902.8	510.6	12	1083.3	600.5	10
Echinothrix diadema	13.9	8.4	72	333.3	83.3	3	13.9	7.8	12	55.6	13.9	3
Haliotis asinina	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Heterocentrotus mammillatus	107.6	29.6	72	516.7	78.9	15	107.6	46.6	12	184.5	66.7	7
Hippopus hippopus	13.9	6.8	72	250.0	0.0	4	13.9	7.8	12	55.6	13.9	3
Holothuria atra	451.4	84.2	72	928.6	131.9	35	451.4	189.0	12	677.1	249.7	8
Holothuria edulis	10.4	5.9	72	250.0	0.0	3	10.4	5.4	12	41.7	0.0	3
Holothuria nobilis	20.8	8.2	72	250.0	0.0	6	20.8	9.6	12	62.5	12.0	4
Lambis lambis	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Latirolagena smaragdula	194.4	69.3	72	1272.7	292.8	11	194.4	83.9	12	333.3	119.9	7
Linckia laevigata	48.6	17.6	72	388.9	73.5	9	48.6	18.4	12	97.2	23.2	6
Ovula ovum	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Pinctada margaritifera	13.9	6.8	72	250.0	0.0	4	13.9	7.8	12	55.6	13.9	3
Spondylus spp.	6.9	4.9	72	250.0	0.0	2	6.9	4.7	12	41.7	0.0	2
Spondylus squamosus	6.9	6.9	72	500.0		1	6.9	6.9	12	83.3		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.3 Oundjo reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Stichopus chloronotus	385.4	107.1	72	1261.4	272.5	22	385.4	217.5	12	770.8	385.6	6
Strombus luhuanus	138.9	138.9	72	10,000.0		1	138.9	138.9	12	1666.7		1
Tectus pyramis	361.1	60.5	72	702.7	86.0	37	361.1	103.6	12	361.1	103.6	12
Tridacna maxima	711.8	110.5	72	854.2	124.8	60	711.8	190.1	12	711.8	190.1	12
Trochus maculata	66.0	22.1	72	395.8	84.0	12	66.0	31.0	12	113.1	46.1	7
Trochus niloticus	20.8	8.2	72	250.0	0.0	6	20.8	10.9	12	62.5	20.8	4
Trochus spp.	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1
Turbo argyrostomus	371.5	211.9	72	1114.6	616.2	24	371.5	248.9	12	495.4	325.5	9
Turbo chrysostomus	430.6	89.9	72	1033.3	161.1	30	430.6	134.4	12	469.7	140.8	11
Vasum turbinellum	3.5	3.5	72	250.0		1	3.5	3.5	12	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.4 Oundjo soft-benthos transect (SBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Anadara scapha	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Anadara spp.	17.2	8.0	102	350.0	61.2	5	17.2	8.8	17	72.9	19.9	4
Atrina vexillum	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Bohadschia similis	676.5	124.9	102	1971.4	244.9	35	676.5	251.4	17	1916.7	312.5	6
Cerithium aluco	39.2	17.0	102	500.0	141.7	8	39.2	25.1	17	166.7	85.1	4
Cerithium spp.	24.5	15.8	102	625.0	297.6	4	24.5	16.0	17	138.9	60.5	3
Conus eburneus	22.1	11.1	102	450.0	122.5	5	22.1	17.2	17	125.0	83.3	3
Conus leopardus	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Conus spp.	31.9	11.4	102	361.1	60.5	9	31.9	10.4	17	67.7	13.5	8
Cymatium muricinum	9.8	6.9	102	500.0	0.0	2	9.8	6.7	17	83.3	0.0	2
Gafrarium pectinatum	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Gafrarium tumidum	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Holothuria atra	438.7	81.4	102	1278.6	160.3	35	438.7	172.7	17	1243.1	265.1	6
Holothuria scabra	892.2	134.6	102	1784.3	203.4	51	892.2	309.6	17	1166.7	374.7	13
Lambis lambis	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Nassarius spp.	4.9	3.4	102	250.0	0.0	2	4.9	3.4	17	41.7	0.0	2
Oliva spp.	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Periglypta puerpera	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Pinna bicolor	14.7	6.8	102	300.0	50.0	5	14.7	8.7	17	83.3	24.1	3
Pinna spp.	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Portunus spp.	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1
Strombus gibberulus gibbosus	9.8	6.0	102	333.3	83.3	3	9.8	7.6	17	83.3	41.7	2
Strombus mutabilis	14.7	9.1	102	500.0	144.3	3	14.7	8.7	17	83.3	24.1	3
Trochus spp.	4.9	4.9	102	500.0		1	4.9	4.9	17	83.3		1
Turbo chrysostomus	2.5	2.5	102	250.0		1	2.5	2.5	17	41.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.5 Oundjo soft-benthos quadrats (SBq) assessment data review

Station: 8 quadrat groups (4 quadrats/group).

Species	Quadrat groups			Quadrat groups _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Anadara spp.	2.3	0.4	128	8.1	0.8	37	2.3	0.7	16	4.2	0.8	9
Cerithium aluco	0.1	0.1	128	4.0	0.0	4	0.1	0.1	16	1.0	0.5	2
Gafrarium spp.	2.9	0.6	128	10.9	1.5	34	2.9	1.3	16	5.8	2.3	8
Tellina palatum	0.8	0.2	128	6.9	1.2	14	0.8	0.3	16	1.5	0.4	8

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.6 Oundjo reef-front search by walking (RFs_w) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	0.9	0.9	24	20.8		1	0.9	0.9	4	3.5		1
Astralium spp.	13.0	9.2	24	104.2	55.1	3	13.0	7.8	4	17.4	9.2	3
Conus litteratus	0.9	0.9	24	20.8		1	0.9	0.9	4	3.5		1
Conus spp.	6.9	4.6	24	55.6	25.0	3	6.9	6.9	4	27.8		1
Cypraea tigris	0.9	0.9	24	20.8		1	0.9	0.9	4	3.5		1
Diadema spp.	1.7	1.7	24	41.7		1	1.7	1.7	4	6.9		1
Echinometra mathaei	1141.5	198.9	24	1304.6	203.4	21	1141.5	526.2	4	1141.5	526.2	4
Echinothrix diadema	0.9	0.9	24	20.8		1	0.9	0.9	4	3.5		1
Heterocentrotus mammillatus	44.3	15.4	24	132.8	25.8	8	44.3	20.9	4	59.0	20.9	3
Holothuria atra	139.8	29.4	24	186.3	32.3	18	139.8	64.9	4	139.8	64.9	4
Linckia laevigata	0.9	0.9	24	20.8		1	0.9	0.9	4	3.5		1
Pinctada margaritifera	0.9	0.9	24	20.8		1	0.9	0.9	4	3.5		1
Stichopus chloronotus	43.4	13.4	24	86.8	20.3	12	43.4	24.1	4	57.9	27.2	3
Tectus pyramis	164.1	38.8	24	196.9	42.9	20	164.1	44.0	4	164.1	44.0	4
Tridacna maxima	110.2	19.2	24	126.0	19.6	21	110.2	28.3	4	110.2	28.3	4
Trochus niloticus	35.6	11.2	24	71.2	17.1	12	35.6	17.9	4	47.5	18.9	3
Turbo argyrostomus	689.2	200.6	24	827.1	229.0	20	689.2	288.1	4	689.2	288.1	4

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.7 Oundjo mother-of-pearl search (MOPs) assessment data review

Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	15.2	15.2	6	90.9		1	15.2		1	15.2		1
Echinometra mathaei	11,363.6	0.0	6	11,363.6	0.0	6	11,363.6		1	11,363.6		1
Heterocentrotus mammillatus	11,363.6	0.0	6	11,363.6	0.0	6	11,363.6		1	11,363.6		1
Tridacna maxima	30.3	19.2	6	90.9	0.0	2	30.3		1	30.3		1
Trochus niloticus	22.7	15.5	6	68.2	22.7	2	22.7		1	22.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.8 Oundjo mother-of-pearl transect (MOPt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga lecanora	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Heterocentrotus mammillatus	312.5	180.9	24	1875.0	727.1	4	312.5	298.8	4	625.0	583.3	2
Pinctada margaritifera	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Pleuroploca filamentosa	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Tectus pyramis	36.5	21.9	24	291.7	83.3	3	36.5	36.5	4	145.8		1
Thelenota ananas	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1
Tridacna maxima	78.1	31.8	24	267.9	69.2	7	78.1	28.7	4	78.1	28.7	4
Trochus maculata	10.4	7.2	24	125.0	0.0	2	10.4	6.0	4	20.8	0.0	2
Trochus niloticus	213.5	45.4	24	301.5	50.3	17	213.5	54.0	4	213.5	54.0	4
Turbo argyrostomus	5.2	5.2	24	125.0		1	5.2	5.2	4	20.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.4.9 Oundjo 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 miliaris	83.0	19.4	18	106.7	20.9	14	83.0	14.8	3	83.0	14.8	3
Anadara spp.	3.0	3.0	18	53.3		1	3.0	3.0	3	8.9		1
Bohadschia similis	14.8	9.5	18	88.9	35.6	3	14.8	7.8	3	22.2	4.4	2
Dolabella auricularia	3.0	3.0	18	53.3		1	3.0	3.0	3	8.9		1
Echinometra mathaei	5.9	4.1	18	53.3	0.0	2	5.9	3.0	3	8.9	0.0	2
Holothuria coluber	5.9	4.1	18	53.3	0.0	2	5.9	3.0	3	8.9	0.0	2
Lambis truncata	3.0	3.0	18	53.3		1	3.0	3.0	3	8.9		1
Protoreaster nodosus	47.4	14.2	18	106.7	14.3	8	47.4	12.9	3	47.4	12.9	3
Stichopus horrens	53.3	9.6	18	68.6	8.7	14	53.3	8.9	3	53.3	8.9	3
Trachycardium enode	3.0	3.0	18	53.3		1	3.0	3.0	3	8.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

Appendix 4: Invertebrate survey data
Oundjo

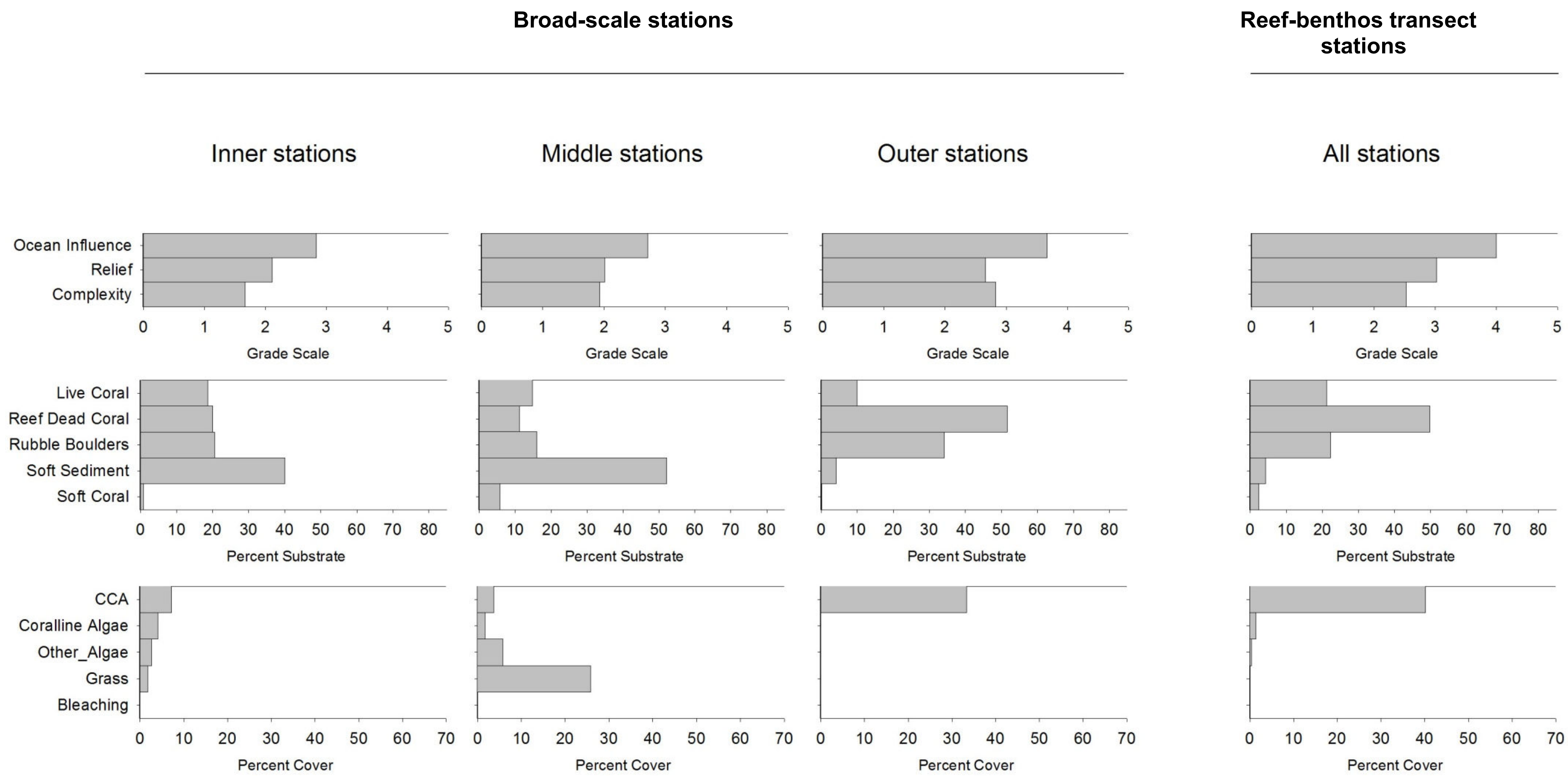
4.4.10 Oundjo species size review – all survey methods

Species	Mean length (cm)	SE	n
Turbo argyrostomus	5.2	0.2	819
Tridacna maxima	14.3	0.2	744
Holothuria atra	15.9	0.2	695
Bohadschia similis	13.2	0.2	449
Holothuria scabra	14.4	0.2	427
Tectus pyramis	5.1	0.1	327
Stichopus chloronotus	16.5	0.4	196
Trochus niloticus	10.6	0.4	103
Bohadschia argus	32.6	0.6	102
Gafrarium spp.	4.2	0.1	93
Anadara spp.	5.4	0.1	87
Turbo chrysostomus	3.9	0.1	55
Actinopyga miliaris	21.7	0.8	52
Pinctada margaritifera	14.0	0.3	31
Conus spp.	6.8	0.7	30
Holothuria nobilis	32.2	0.7	29
Astralium spp.	3.9	0.1	29
Tellina palatum	4.0	0.1	24
Stichopus horrens	27.0	1.7	20
Cerithium aluco	5.4	0.1	20
Trochus maculata	3.6	0.2	13
Tridacna derasa	26.7	3.2	10
Lambis lambis	18.2	0.9	10
Holothuria fuscopunctata	41.1	2.5	10
Hippopus hippopus	23.6	2.2	9
Tridacna squamosa	27.7	2.2	6
Cypraea tigris	7.0	1.1	6
Stichopus hermanni	31.8	4.6	4
Cymatium muricinum	4.5	0.5	4
Thelenota ananas	37.5	7.5	2
Conus litteratus	9.3	1.8	2
Trochus spp.	1.7	0.4	2
Holothuria edulis	14.0	0.0	16
Actinopyga lecanora	18.0	0.0	1
Anadara scapha	5.0	0.0	1
Gafrarium pectinatum	3.0	0.0	1
Periglypta puerpera	4.9	0.0	1
Conus miles	5.5	0.0	1
Haliotis asinina	5.1	0.0	1
Ovula ovum	6.8	0.0	1
Vasum turbinellum	4.3	0.0	1
Echinometra mathaei			3303
Heterocentrotus mammillatus			1655
Protoreaster nodosus			218
Linckia laevigata			85
Actinopyga palauensis			27
Latirolagena smaragdula			26
Stichodactyla spp.			18

4.4.10 Oundjo species size review – all survey methods (continued)

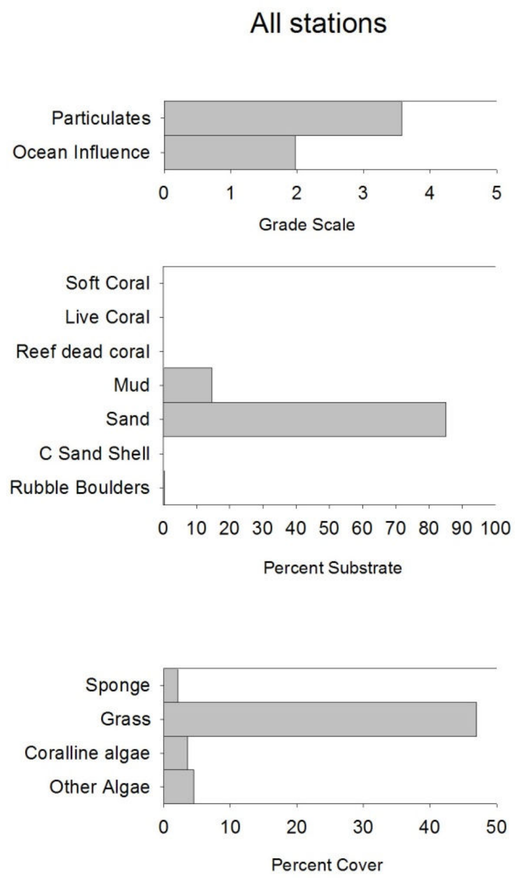
Species	Mean length (cm)	SE	n
Diadema spp.			18
Cerithium spp.			10
Holothuria coluber			9
Conus eburneus			9
Strombus luhuanus			8
Pinna bicolor			6
Strombus mutabilis			6
Spondylus spp.			5
Cerithium nodulosum			5
Echinothrix diadema			5
Actinopyga mauritiana			4
Strombus gibberulus gibbosus			4
Nardoa spp.			4
Chama spp.			3
Nassarius spp.			2
Octopus cyanea			2
Atrina vexillum			1
Gafrarium tumidum			1
Pinna spp.			1
Trachycardium enode			1
Tridacna crocea			1
Panulirus spp.			1
Portunus spp.			1
Conus leopardus			1
Dolabella auricularia			1
Lambis truncata			1
Oliva spp.			1
Culcita novaeguineae			1

4.4.11 Habitat descriptors for independent assessment – Oundjo

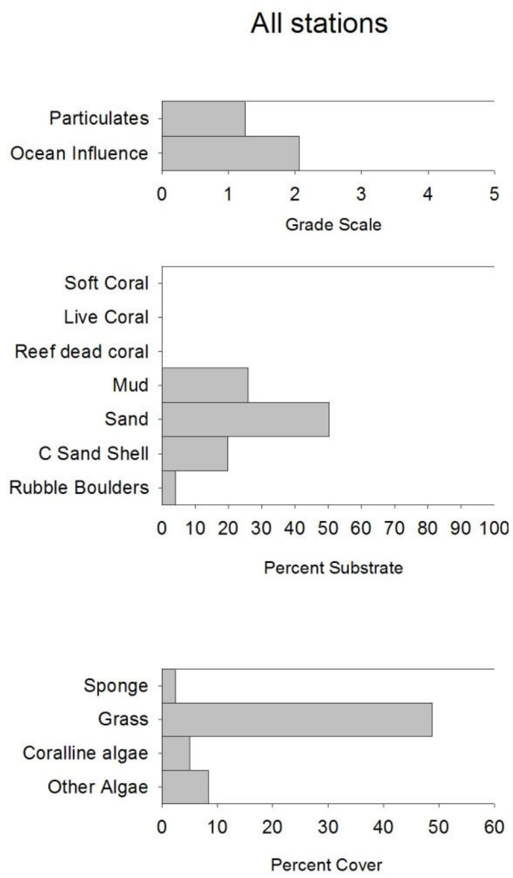


4.4.11 Habitat descriptors for independent assessment – Oundjo (continued)

Soft-benthos transect stations



Soft-infaunal quadrats stations



4.5 Moindou invertebrate survey data

4.5.1 Invertebrate species recorded in different assessments in Moindou

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Bêche-de-mer	*Actinopyga mauritiana*	+			+
Bêche-de-mer	*Actinopyga miliaris*	+		+	+
Bêche-de-mer	*Actinopyga spinea*			+	
Bêche-de-mer	*Bohadschia argus*	+	+		
Bêche-de-mer	*Bohadschia similis*			+	
Bêche-de-mer	*Bohadschia vitiensis*	+			
Bêche-de-mer	*Holothuria atra*	+	+	+	+
Bêche-de-mer	*Holothuria edulis*	+			
Bêche-de-mer	*Holothuria fuscogilva*				+
Bêche-de-mer	*Holothuria fuscopunctata*	+	+		+
Bêche-de-mer	*Holothuria impatiens*			+	
Bêche-de-mer	*Holothuria nobilis*	+	+		+
Bêche-de-mer	*Holothuria scabra*			+	
Bêche-de-mer	*Stichopus chloronotus*	+	+		
Bêche-de-mer	*Stichopus hermanni*	+			+
Bêche-de-mer	*Synapta* spp.			+	
Bêche-de-mer	*Thelenota ananas*	+			+
Bêche-de-mer	*Thelenota anax*		+		+
Bivalve	*Anadara scapha*			+	
Bivalve	*Anadara* spp.	+			
Bivalve	*Atrina* spp.	+			
Bivalve	*Chama* spp.	+	+		
Bivalve	*Gafrarium tumidum*			+	
Bivalve	*Hippopus hippopus*	+	+		
Bivalve	*Modiolus* spp.			+	
Bivalve	*Periglypta puerpera*			+	
Bivalve	*Pinctada fucata*			+	
Bivalve	*Pinctada margaritifera*	+	+		
Bivalve	*Pinna* spp.	+		+	
Bivalve	*Spondylus* spp.	+	+		
Bivalve	*Tapes literatus*			+	
Bivalve	*Tellina palatum*			+	
Bivalve	*Tridacna derasa*	+	+		
Bivalve	*Tridacna maxima*	+	+		+
Bivalve	*Tridacna squamosa*	+	+		
Cnidarian	*Cassiopea andromeda*			+	
Cnidarian	*Stichodactyla* spp.	+	+		+
Crustacean	*Panulirus* spp.	+			
Crustacean	*Panulirus versicolor*	+			
Crustacean	*Portunus pelagicus*			+	
Crustacean	*Scylla serrata*			+	
Crustacean	*Thalamita* spp.			+	
Crustacean	*Thalassina* spp.			+	
Gastropod	*Astralium* spp.		+		+
Gastropod	*Cerithium aluco*			+	
Gastropod	*Cerithium nodulosum*	+	+		

+ = presence of the species.

4.5.1 Invertebrate species recorded in different assessments in Moindou (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Gastropod	*Chicoreus ramosus*	+			
Gastropod	*Conus eburneus*			+	
Gastropod	*Conus marmoreus*		+	+	
Gastropod	*Conus quercinus*			+	
Gastropod	*Conus* spp.	+	+		+
Gastropod	*Conus textile*		+		
Gastropod	*Cypraea arabica*		+		
Gastropod	*Cypraea caputserpensis*		+		+
Gastropod	*Cypraea moneta*			+	
Gastropod	*Dolabella auricularia*			+	
Gastropod	*Drupa* spp.		+		
Gastropod	*Lambis chiragra*	+			
Gastropod	*Lambis crocata*	+	+		
Gastropod	*Lambis lambis*	+	+		
Gastropod	*Latirolagena smaragdula*		+		
Gastropod	*Ovula ovum*	+			
Gastropod	*Pleuroploca* spp.		+		+
Gastropod	*Rhinoclavis fasciata*			+	
Gastropod	*Strombus gibberulus gibbosus*			+	
Gastropod	*Strombus luhuanus*	+		+	
Gastropod	*Tectus conus*		+		
Gastropod	*Tectus fenestratus*			+	
Gastropod	*Tectus pyramis*	+	+		+
Gastropod	*Telescopium telescopium*		+		
Gastropod	*Thais aculeata*		+		
Gastropod	*Thais* spp.		+		+
Gastropod	*Trochus maculata*		+		
Gastropod	*Trochus niloticus*	+	+		+
Gastropod	*Trochus* spp.				+
Gastropod	*Turbo argyrostomus*	+	+		+
Gastropod	*Turbo chrysostomus*	+	+		
Gastropod	*Turbo crassus*		+		
Gastropod	*Turbo setosus*		+		+
Gastropod	*Turbo* spp.	+			+
Gastropod	*Tutufa bubo*	+			
Star	*Acanthaster planci*	+	+		+
Star	*Archaster typicus*			+	
Star	*Culcita novaeguineae*	+			
Star	*Culcita* spp.	+			
Star	*Linckia laevigata*	+	+		
Star	*Protoreaster nodosus*	+		+	
Urchin	*Diadema* spp.	+			+
Urchin	*Echinodiscus bisperforatus*			+	
Urchin	*Echinometra mathaei*	+	+		+
Urchin	*Echinothrix calamaris*	+	+		
Urchin	*Echinothrix diadema*	+	+		
Urchin	*Heterocentrotus mammillatus*	+	+		
Urchin	*Heterocentrotus* spp.		+		+

+ = presence of the species

4.5.1 Invertebrate species recorded in different assessments in Moindou (continued)

Group	Species	Broad scale	Reef benthos	Soft benthos	Others
Urchin	*Laganum depressum*			+	
Urchin	*Mespilia globulus*			+	
Urchin	*Tripneustes gratilla*	+			

4.5.2 Moindou broad-scale assessment data review

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	0.6	0.4	72	15.4	1.2	3	0.7	0.7	12	7.9		1
Actinopyga mauritiana	1.2	0.8	72	27.8	11.1	3	1.2	0.9	12	6.9	4.2	2
Actinopyga miliaris	0.9	0.6	72	22.0	5.4	3	0.9	0.5	12	3.6	0.9	3
Anadara spp.	0.7	0.5	72	24.3	7.6	2	0.7	0.5	12	4.1	1.4	2
Atrina spp.	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.7	0.0	2
Bohadschia argus	22.0	5.8	72	87.8	15.0	18	22.0	12.7	12	65.9	28.2	4
Bohadschia vitiensis	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Cerithium nodulosum	1.1	0.8	72	27.2	11.4	3	1.1	0.7	12	4.5	1.7	3
Chama spp.	2.3	0.9	72	23.5	5.0	7	2.3	1.4	12	6.8	3.2	4
Chicoreus ramosus	0.7	0.4	72	16.4	0.2	3	0.7	0.5	12	4.1	1.4	2
Conus spp.	0.9	0.4	72	16.5	0.1	4	0.9	0.7	12	5.5	2.8	2
Culcita novaeguineae	0.9	0.6	72	22.1	5.6	3	0.9	0.7	12	5.3	2.6	2
Culcita spp.	1.1	0.6	72	20.5	4.3	4	1.1	0.8	12	6.7	1.2	2
Diadema spp.	45.7	16.7	72	299.4	73.6	11	46.1	41.3	12	276.3	221.3	2
Echinometra mathaei	49.6	10.1	72	105.1	16.9	34	49.7	23.8	12	54.2	25.5	11
Echinothrix calamaris	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Echinothrix diadema	15.9	4.7	72	76.2	14.4	15	15.8	10.2	12	47.4	25.5	4
Heterocentrotus mammillatus	8.5	3.9	72	68.2	24.3	9	8.3	7.6	12	25.0	22.2	4
Hippopus hippopus	2.3	0.8	72	18.4	1.9	9	2.3	1.0	12	6.9	0.8	4
Holothuria atra	7.3	2.6	72	33.0	9.4	16	7.3	3.2	12	11.0	4.3	8
Holothuria edulis	6.4	4.2	72	51.5	31.1	9	6.4	5.4	12	25.7	20.1	3
Holothuria fuscopunctata	1.4	0.8	72	24.8	8.4	4	1.4	0.9	12	5.5	2.8	3
Holothuria nobilis	2.5	0.7	72	16.6	0.0	11	2.5	0.7	12	3.8	0.7	8
Lambis chiragra	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Lambis crocata	0.5	0.3	72	16.7	0.0	2	0.5	0.5	12	5.5		1
Lambis lambis	1.1	0.5	72	16.6	0.1	5	1.1	0.5	12	3.4	0.7	4
Linckia laevigata	7.8	2.9	72	37.6	10.9	15	7.8	4.0	12	13.4	6.2	7
Ovula ovum	0.5	0.3	72	16.7	0.0	2	0.5	0.3	12	2.8	0.0	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.5.2 Moindou broad-scale assessment data review (continued)

Station: Six 2 m x 300 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Panulirus spp.	0.5	0.3	72	16.2	0.2	2	0.5	0.5	12	5.5		1
Panulirus versicolor	0.2	0.2	72	16.7		1	0.2	0.2	12	2.8		1
Pinctada margaritifera	3.0	0.9	72	21.5	2.6	10	3.0	1.0	12	5.9	1.1	6
Pinna spp.	0.5	0.3	72	16.5	0.1	2	0.5	0.5	12	5.5		1
Protoreaster nodosus	0.2	0.2	72	15.9		1	0.2	0.2	12	2.7		1
Spondylus spp.	4.4	1.2	72	22.5	2.8	14	4.3	1.4	12	6.5	1.6	8
Stichodactyla spp.	5.7	1.3	72	21.5	2.2	19	5.7	1.6	12	6.8	1.7	10
Stichopus chloronotus	3.2	1.5	72	46.7	9.7	5	3.2	2.6	12	19.4	11.1	2
Stichopus hermanni	0.2	0.2	72	15.4		1	0.2	0.2	12	2.7		1
Strombus luhuanus	1.4	0.7	72	24.9	4.7	4	1.4	0.9	12	5.5	2.8	3
Tectus pyramis	31.7	7.4	72	91.3	15.5	25	31.3	16.6	12	62.7	28.6	6
Thelenota ananas	1.4	1.4	72	100.0		1	1.4	1.4	12	16.6		1
Tridacna derasa	1.8	0.7	72	18.9	2.4	7	1.8	0.6	12	3.7	0.6	6
Tridacna maxima	211.1	44.1	72	266.7	53.4	57	2	2	12	212.6	102.9	12
Tridacna squamosa	1.4	0.7	72	25.0	4.8	4	1.4	0.6	12	4.1	0.8	4
Tripneustes gratilla	0.5	0.3	72	16.7	0.0	2	0.4	0.3	12	2.7	0.0	2
Trochus niloticus	4.9	2.1	72	43.8	13.0	8	4.8	1.9	12	9.6	2.7	6
Turbo argyrostomus	0.7	0.5	72	25.0	8.3	2	0.7	0.5	12	4.1	1.4	2
Turbo chrysostomus	1.2	0.5	72	16.6	0.1	5	1.1	0.6	12	4.6	0.9	3
Turbo spp.	1.4	0.5	72	16.4	0.2	6	1.4	0.6	12	4.1	0.8	4
Tutufa bubo	0.5	0.3	72	16.6	0.1	2	0.4	0.4	12	5.2		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.5.3 Moindou 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	9.6	5.5	78	250.0	0.0	3	9.6	6.9	13	62.5	20.8	2
Astralium spp.	192.3	51.0	78	652.2	131.3	23	192.3	68.8	13	250.0	81.2	10
Bohadschia argus	28.8	13.7	78	450.0	93.5	5	28.8	15.2	13	93.8	31.3	4
Cerithium nodulosum	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Chama spp.	12.8	7.8	78	333.3	83.3	3	12.8	7.3	13	55.6	13.9	3
Conus marmoreus	16.0	7.0	78	250.0	0.0	5	16.0	7.5	13	52.1	10.4	4
Conus spp.	9.6	7.1	78	375.0	125.0	2	9.6	6.9	13	62.5	20.8	2
Conus textile	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Cypraea arabica	6.4	6.4	78	500.0		1	6.4	6.4	13	83.3		1
Cypraea caputserpensis	6.4	6.4	78	500.0		1	6.4	6.4	13	83.3		1
Drupa spp.	6.4	6.4	78	500.0		1	6.4	6.4	13	83.3		1
Echinometra mathaei	615.4	106.9	78	1116.3	157.0	43	615.4	175.7	13	666.7	182.7	12
Echinothrix calamaris	25.6	10.8	78	333.3	52.7	6	25.6	13.8	13	83.3	29.5	4
Echinothrix diadema	307.7	72.3	78	1142.9	164.2	21	307.7	158.4	13	571.4	261.0	7
Heterocentrotus mammillatus	6.4	4.5	78	250.0	0.0	2	6.4	6.4	13	83.3		1
Heterocentrotus spp.	179.5	73.8	78	933.3	325.0	15	179.5	118.1	13	388.9	237.1	6
Hippopus hippopus	6.4	4.5	78	250.0	0.0	2	6.4	6.4	13	83.3		1
Holothuria atra	41.7	15.4	78	406.3	65.8	8	41.7	25.8	13	135.4	66.7	4
Holothuria fuscopunctata	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Holothuria nobilis	38.5	12.1	78	300.0	33.3	10	38.5	12.9	13	71.4	15.0	7
Lambis crocata	9.6	7.1	78	375.0	125.0	2	9.6	6.9	13	62.5	20.8	2
Lambis lambis	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Latirolagena smaragdula	346.2	124.9	78	2700.0	578.3	10	346.2	288.4	13	900.0	724.0	5
Linckia laevigata	96.2	25.1	78	468.8	64.0	16	96.2	34.8	13	178.6	45.2	7
Pinctada margaritifera	6.4	4.5	78	250.0	0.0	2	6.4	4.3	13	41.7	0.0	2
Pleuroploca spp.	9.6	7.1	78	375.0	125.0	2	9.6	9.6	13	125.0		1
Spondylus spp.	12.8	7.8	78	333.3	83.3	3	12.8	8.7	13	83.3	0.0	2
Stichodactyla spp.	9.6	5.5	78	250.0	0.0	3	9.6	5.1	13	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; SE = standard error.

4.5.3 Moindou reef-benthos transect (RBt) assessment data review (continued)

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Stichopus chloronotus	38.5	13.0	78	333.3	41.7	9	38.5	24.7	13	166.7	72.2	3
Tectus conus	80.1	39.6	78	892.9	322.1	7	80.1	37.0	13	208.3	63.2	5
Tectus pyramis	871.8	127.8	78	1307.7	160.7	52	871.8	221.3	13	871.8	221.3	13
Telescopium telescopium	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Thais aculeata	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Thais spp.	54.5	29.4	78	1062.5	277.2	4	54.5	30.7	13	236.1	55.6	3
Thelenota anax	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Tridacna derasa	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Tridacna maxima	1663.5	401.5	78	2544.1	578.7	51	1663.5	682.1	13	1802.1	726.1	12
Tridacna squamosa	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Trochus maculata	9.6	7.1	78	375.0	125.0	2	9.6	6.9	13	62.5	20.8	2
Trochus niloticus	80.1	31.4	78	480.8	148.3	13	80.1	34.8	13	173.6	55.3	6
Turbo argyrostomus	32.1	14.0	78	416.7	83.3	6	32.1	17.7	13	104.2	39.9	4
Turbo chrysostomus	278.8	76.3	78	1144.7	217.4	19	278.8	101.9	13	453.1	132.8	8
Turbo crassus	3.2	3.2	78	250.0		1	3.2	3.2	13	41.7		1
Turbo setosus	6.4	6.4	78	500.0		1	6.4	6.4	13	83.3		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.5.4 Moindou soft-benthos transect (SBt) assessment data review

Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga miliaris	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Actinopyga spinea	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Anadara scapha	177.1	37.9	120	787.0	104.0	27	177.1	76.8	20	442.7	152.5	8
Archaster typicus	550.0	179.8	120	3300.0	858.7	20	550.0	416.0	20	2750.0	1861.2	4
Bohadschia similis	3379.2	816.6	120	13,516.7	2493.8	30	3379.2	1974.9	20	13,516.7	6312.4	5
Cassiopea andromeda	27.1	8.3	120	295.5	30.5	11	27.1	14.3	20	108.3	40.8	5
Cerithium aluco	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus eburneus	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Conus marmoreus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Conus quercinus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Cypraea moneta	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Dolabella auricularia	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Echinodiscus bisperforatus	10.4	8.6	120	625.0	375.0	2	10.4	10.4	20	208.3		1
Gafrarium tumidum	116.7	28.1	120	666.7	91.8	21	116.7	53.0	20	333.3	115.7	7
Holothuria atra	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Holothuria impatiens	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Holothuria scabra	14.6	5.4	120	250.0	0.0	7	14.6	6.3	20	58.3	10.2	5
Laganum depressum	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Mespilia globulus	197.9	62.8	120	1979.2	326.3	12	197.9	146.1	20	1979.2	729.2	2
Modiolus spp.	2550.0	845.3	120	13,909.1	3816.0	22	2550.0	2005.6	20	10,200.0	7544.6	5
Periglypta puerpera	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Pinctada fucata	8.3	4.1	120	250.0	0.0	4	8.3	3.8	20	41.7	0.0	4
Pinna spp.	14.6	7.4	120	350.0	100.0	5	14.6	9.2	20	97.2	36.7	3
Portunus pelagicus	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Protoreaster nodosus	14.6	8.0	120	437.5	119.7	4	14.6	14.6	20	291.7		1
Rhinoclavis fasciata	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Scylla serrata	4.2	2.9	120	250.0	0.0	2	4.2	2.9	20	41.7	0.0	2
Strombus gibberulus gibbosus	14.6	6.8	120	350.0	61.2	5	14.6	12.6	20	145.8	104.2	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.5.4 Moindou soft-benthos transect (SBt) assessment data review (continued)
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Strombus luhuanus	6.3	3.6	120	250.0	0.0	3	6.3	6.3	20	125.0		1
Synapta spp.	16.7	6.4	120	285.7	35.7	7	16.7	11.1	20	111.1	50.1	3
Tapes literatus	4.2	2.9	120	250.0	0.0	2	4.2	4.2	20	83.3		1
Tectus fenestratus	8.3	5.1	120	333.3	83.3	3	8.3	6.5	20	83.3	41.7	2
Tellina palatum	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Thalamita spp.	2.1	2.1	120	250.0		1	2.1	2.1	20	41.7		1
Thalassina spp.	6.3	4.6	120	375.0	125.0	2	6.3	4.6	20	62.5	20.8	2

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.5.5 Moindou 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	6.3	1.9	30	23.5	0.0	8	6.3	1.6	5	6.3	1.6	5
Conus spp.	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Cypraea caputserpensis	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Echinometra mathaei	35.3	16.7	30	105.9	43.3	10	35.3	20.7	5	44.1	24.1	4
Heterocentrotus spp.	796.9	176.9	30	853.8	185.0	28	796.9	331.0	5	796.9	331.0	5
Pleuroploca spp.	4.7	4.0	30	70.6	47.1	2	4.7	4.7	5	23.5		1
Tectus pyramis	25.1	13.1	30	83.7	38.0	9	25.1	10.3	5	25.1	10.3	5
Thelenota ananas	0.8	0.8	30	23.5		1	0.8	0.8	5	3.9		1
Tridacna maxima	30.6	7.7	30	61.2	10.7	15	30.6	9.1	5	30.6	9.1	5
Trochus niloticus	42.4	12.9	30	90.8	21.3	14	42.4	22.8	5	70.6	27.2	3
Turbo argyrostomus	65.9	27.1	30	247.1	70.6	8	65.9	41.3	5	164.7	27.5	2
Turbo setosus	2.4	1.7	30	35.3	11.8	2	2.4	2.4	5	11.8		1
Turbo spp.	9.4	3.5	30	40.3	6.7	7	9.4	8.5	5	23.5	19.6	2
Thais spp.	1.6	1.6	30	47.1		1	1.6	1.6	5	7.8		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.5.6 Moindou mother-of-pearl search (MOPs) assessment data review
Station: Six 5-min search periods.

Species	Search period			Search period _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Holothuria atra	7.6	7.6	6	45.5		1	7.6		1	7.6		1
Holothuria nobilis	22.7	15.5	6	68.2	22.7	2	27.3		1	27.3		1
Tectus pyramis	30.3	19.2	6	90.9	0.0	2	36.4		1	36.4		1
Tridacna maxima	7.6	7.6	6	45.5		1	9.1		1	9.1		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.5.7 Moindou mother-of-pearl transect (MOPt) assessment data review
Station: Six 1 m x 40 m transects.

Species	Transect			Transect _P			Station			Station _P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	6.9	6.9	18	125.0		1	6.9	6.9	3	20.8		1
Astralium spp.	13.9	13.9	18	250.0		1	9.3	9.3	3	27.8		1
Diadema spp.	13.9	13.9	18	250.0		1	9.3	9.3	3	27.8		1
Echinometra mathaei	55.6	38.1	18	500.0	0.0	2	46.3	24.5	3	69.4	13.9	2
Heterocentrotus spp.	3215.3	834.9	18	4822.9	954.5	12	2784.7	1393.4	3	4177.1	93.8	2
Tectus pyramis	20.8	15.2	18	187.5	62.5	2	20.8	12.0	3	31.3	10.4	2
Tridacna maxima	312.5	93.9	18	562.5	119.7	10	296.3	168.5	3	444.4	138.9	2
Trochus niloticus	687.5	152.0	18	883.9	159.7	14	687.5	342.5	3	687.5	342.5	3
Trochus spp.	13.9	13.9	18	250.0		1	9.3	9.3	3	27.8		1
Turbo argyrostomus	673.6	285.3	18	1515.6	512.4	8	685.2	617.0	3	1027.8	888.9	2
Turbo setosus	76.4	76.4	18	1375.0		1	76.4	76.4	3	229.2		1
Turbo spp.	69.4	48.7	18	625.0	125.0	2	46.3	46.3	3	138.9		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

4.5.8 Moindou 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	18	21.4		1	1.2	1.2	3	3.6		1
Actinopyga miliaris	1.2	1.2	18	21.4		1	1.2	1.2	3	3.6		1
Holothuria atra	3.6	1.9	18	21.4	0.0	3	3.6	3.6	3	10.7		1
Holothuria fuscogilva	19.0	7.1	18	57.1	9.0	6	19.0	17.3	3	28.6	25.0	2
Holothuria fuscopunctata	3.6	3.6	18	64.2		1	3.6	3.6	3	10.7		1
Holothuria nobilis	5.9	2.3	18	21.4	0.0	5	5.9	1.2	3	5.9	1.2	3
Stichodactyla spp.	8.3	3.1	18	25.0	3.6	6	8.3	2.4	3	8.3	2.4	3
Stichopus hermanni	5.9	3.4	18	35.7	7.1	3	5.9	5.9	3	17.8		1
Thelenota anax	3.6	1.9	18	21.4	0.0	3	3.6	3.6	3	10.7		1

Mean = mean density (numbers/ha); _P = result for transects or stations where the species was located during the survey; n = number; SE = standard error.

Appendix 4: Invertebrate survey data
Moindou

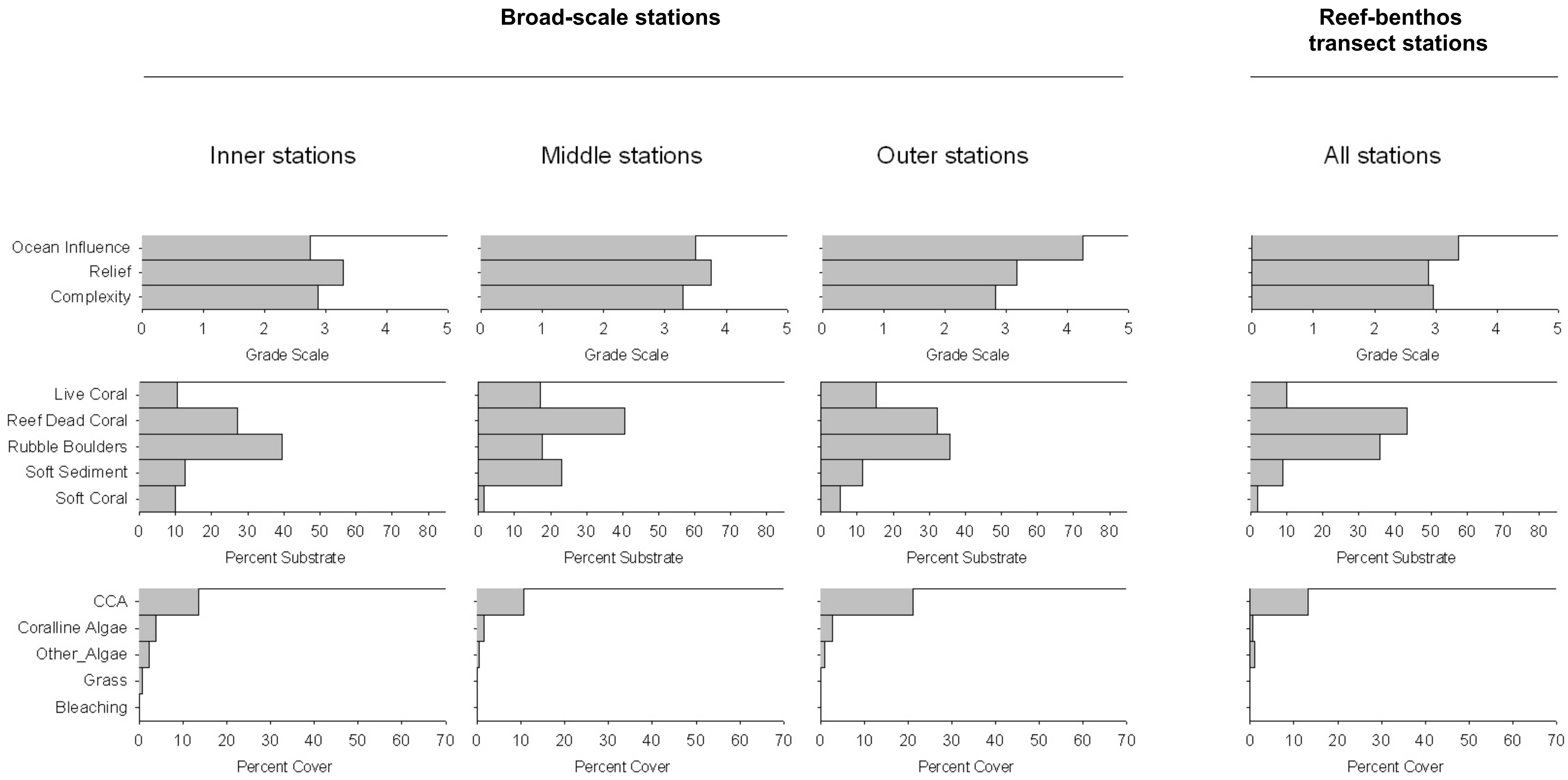
4.5.9 Moindou species size review – all survey methods

Species	Mean length (cm)	SE	n
Bohadschia similis	11.7	0.1	1622
Tridacna maxima	14.6	0.3	1524
Tectus pyramis	5.6	0.2	450
Turbo argyrostomus	6.1	0.3	194
Trochus niloticus	9.5	0.2	179
Latirolagena smaragdula	4.5	0.0	108
Bohadschia argus	31.4	0.8	106
Turbo chrysostomus	4.0	0.3	92
Anadara scapha	6.9	0.1	85
Astralium spp.	4.8	0.7	61
Gafrarium tumidum	4.4	0.1	56
Holothuria atra	19.6	1.7	51
Holothuria nobilis	29.2	0.9	31
Stichopus chloronotus	11.5	1.2	26
Spondylus spp.	5.9	0.9	23
Thais spp.	6.4	0.7	19
Holothuria fuscogilva	31.0	0.8	16
Pinctada margaritifera	14.9	0.7	15
Actinopyga mauritiana	17.9	0.4	14
Hippopus hippopus	21.8	2.4	12
Holothuria fuscopunctata	28.2	3.0	10
Tridacna derasa	37.9	2.0	9
Strombus luhuanus	5.5	0.3	9
Pleuroploca spp.	10.8	1.8	9
Conus spp.	11.0	0.0	8
Actinopyga miliaris	24.9	1.9	7
Holothuria scabra	20.9	1.1	7
Tridacna squamosa	24.0	1.6	7
Strombus gibberulus gibbosus	3.4	0.4	7
Cerithium nodulosum	9.8	0.8	7
Lambis lambis	16	0	7
Conus marmoreus	8.8	0.9	6
Stichopus hermanni	31.5	3.5	6
Lambis crocata	14.7	1.3	5
Thelenota anax	59.3	9.8	4
Pinctada fucata	7.1	0.2	4
Chicoreus ramosus	22.0	1.5	3
Tapes literatus	5.9	0.9	2
Panulirus spp.	25.0	0.0	2
Conus eburneus	5.5	0.5	2
Modiolus spp.	4		1224
Tectus conus	4.1		25
Thelenota ananas	38		7
Tectus fenestratus	1.7		4
Trochus maculata	8		3
Tutufa bubo	25		2
Actinopyga spinea	17		1
Holothuria impatiens	10		1

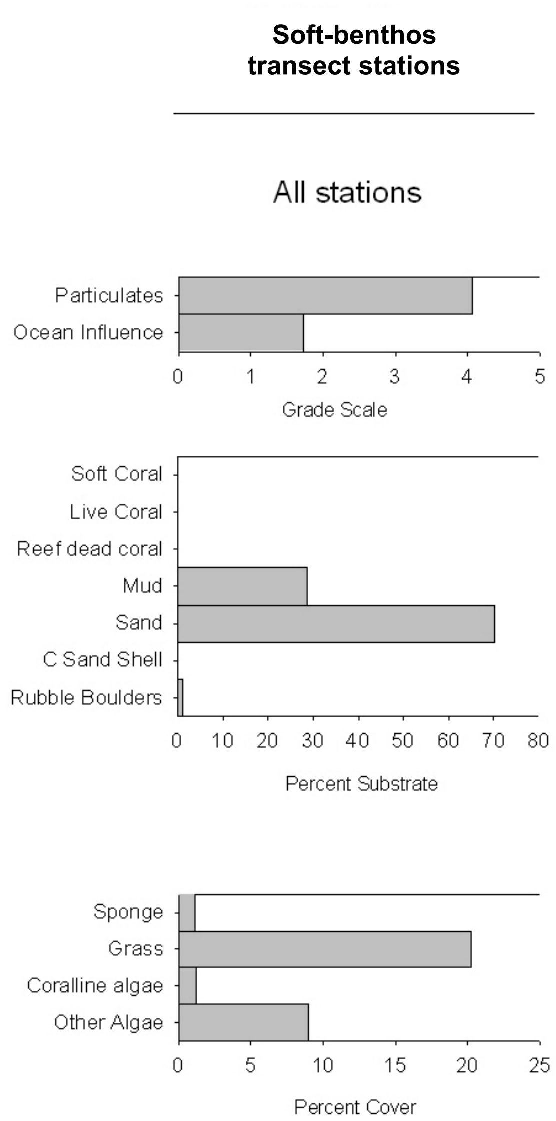
4.5.9 Moindou species size review – all survey methods (continued)

Species	Mean length (cm)	SE	n
Tellina palatum	5		1
Panulirus versicolor	25		1
Cerithium aluco	5.9		1
Conus quercinus	9.6		1
Conus textile	8.5		1
Thais aculeata	5		1
Heterocentrotus spp.			1424
Echinometra mathaei			463
Archaster typicus			264
Diadema spp.			211
Echinothrix diadema			167
Mespilia globulus			95
Linckia laevigata			64
Heterocentrotus mammillatus			40
Stichodactyla spp.			35
Holothuria edulis			28
Turbo spp.			23
Turbo setosus			16
Chama spp.			14
Cassiopea andromeda			13
Pinna spp.			9
Echinothrix calamaris			9
Synapta spp.			8
Protoreaster nodosus			8
Acanthaster planci			7
Culcita spp.			5
Echinodiscus bisperforatus			5
Culcita novaeguineae			4
Anadara spp.			3
Thalassina spp.			3
Cypraea caputserpensis			3
Atrina spp.			2
Scylla serrata			2
Cypraea arabica			2
Cypraea moneta			2
Drupa spp.			2
Ovula ovum			2
Rhinoclavis fasciata			2
Tripneustes gratilla			2
Bohadschia vitiensis			1
Periglypta puerpera			1
Portunus pelagicus			1
Thalamita spp.			1
Dolabella auricularia			1
Lambis chiragra			1
Telescopium telescopium			1
Trochus spp.			1
Turbo crassus			1
Laganum depressum			1

4.5.10 Habitat descriptors for independent assessment – Moindou



4.5.10 Habitat descriptors for independent assessment – Moindou (continued)

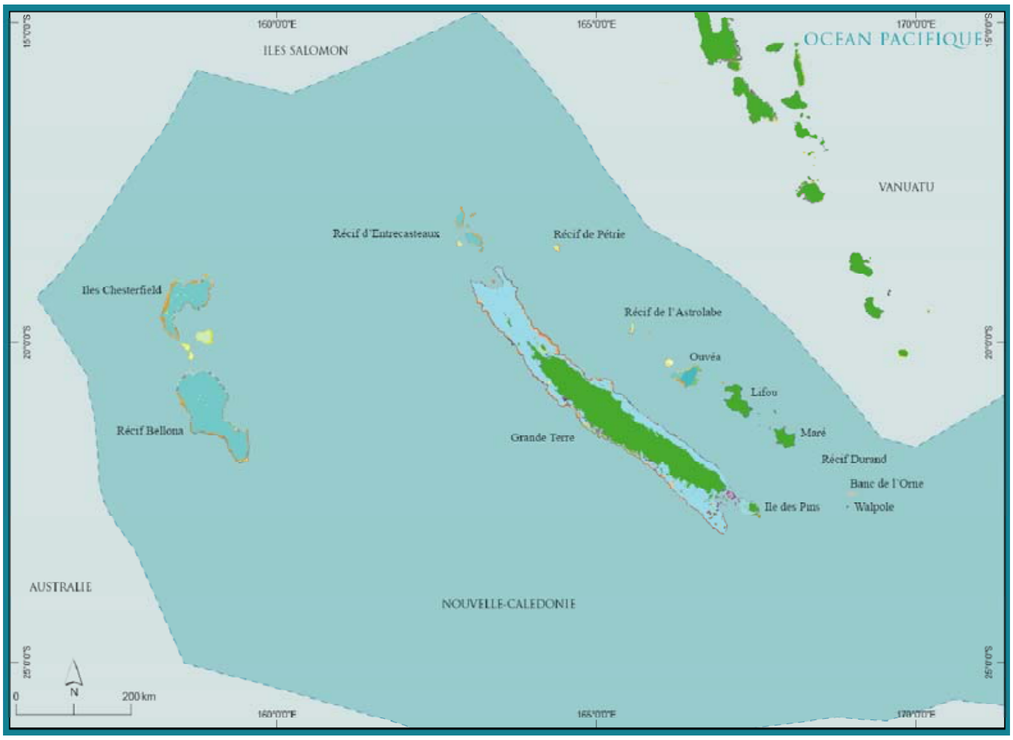


APPENDIX 5: MILLENNIUM CORAL REEF MAPPING PROJECT – NEW CALEDONIA

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
New Caledonia

(January 2009)



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 New Caledonia 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 New Caledonia and data availability, please contact:

Dr Serge Andréfouët
IRD, Research Unit COREUS 128, BP A5, Nouméa Cedex,
98848 New Caledonia;
E-mail: serge.andrefouet@ird.fr

Reference: Andréfouët S, and 6 authors (2005), Global assessment of modern coral reef extent and diversity for regional science and management applications: a view from space. Proc 10th ICRS, Okinawa 2004, Japan: pp. 1732-1745.