PACIFIC REGIONAL COASTAL FISHERIES DEVELOPMENT PROGRAMME (CoFish)

NAURU COUNTRY REPORT:

PROFILE AND RESULTS FROM IN-COUNTRY SURVEY WORK

(October and November 2005)

by

The PROCFish/C and CoFish Team

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The views expressed herein are those of SPC and can therefore in no way be taken to reflect the official opinion of the European Community

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[1] CoFish and PROCFish/C are part of the same programme, with CoFish covering the countries of Niue, Nauru, Federated States of Micronesia, Palau, the Marshall Islands and the Cook Islands (ACP countries covered under EDF 9 funding) and PROCFish/C countries covered under EDF 8 funding (ACP countries, Fiji, Tonga, Papua New Guinea, Solomon Islands, Vanuatu, Samoa, Tuvalu and Kiribati, and French 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) and the (Pacific Regional) Coastal Fisheries Development Programme (CoFish) conducted fieldwork around Nauru in October and November 2005. Given the size of Nauru, it was treated as a single site, with large areas surveyed and a country profile developed. Survey work in Nauru covered three disciplines (finfish, invertebrate and socioeconomic), with the work undertaken by a team of five programme scientists and several local attachments from the fisheries department. The fieldwork included capacity building for the local counterparts through instruction on survey methodologies in all three disciplines, including the collection of data, and inputting the data into the programme's database.

The aim of the survey work 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. Nauru is one of 17 countries and territories being surveyed over a five to six year period by the PROCFish/C and CoFish programme. Other outputs from the overall work of the programme include the implementing of 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 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; the 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; and the development of data and information management systems, including regional and national databases.

Nauru Island is a single, raised coralline island located 41 km south of the equator. Coastal resources are restricted to a narrow 50–300 m wide coral 'belt' surrounding the 19 km circumference of the island. The bulk of the population lives around a 300 m wide coastal green fringe. The internal water pools are very shallow and narrow (2.15 km^2), and most of the area dries up at low tide. Encircling the island, the fringing reef is characterized by a few coral heads (predominantly *Acropora* and *Porites* genera) growing on mineral rock that lies along the northern (ocean) side of Nauru Island.

Socioeconomic field work was carried out in 11 of the 14 districts in Nauru, with the total resident population at the time was estimated at 10,131 people (1230 households). A total of 245 households were surveyed for income and expenditure, with 97 per cent of these found to be engaged in fishing activities. In addition, a total of 422 finfishers (375 men and 47 women) and 287 invertebrate fishers (152 women and 135 men) were interviewed. Survey results indicate an average of 3.7 fishers per household, and when extrapolated the total number of fishers in Nauru would be 4451, which includes 2972 men and 1579 women fishers. The main source of income is from government employment (86%) with some employed in the private sector. Fisheries do not play any significant role in income for households (5% as first income and 17% as second income). Per capita consumption of fresh fish is 47 kg, and canned fish is 15 kg, with fresh and canned fish consumed 3.8 and 2.4 times per week respectively. The per capita consumption of invertebrates is much lower at 3.7 kg, and is only consumed 0.5 times per week. Overall the catch of finfish is estimated at 589.4 t annually, and most is caught for subsistence (55–72 per cent), some distributed on nomonetary basis (17–20%) and some is sold (8–27%). There is no export of fish. For invertebrates, the annual catch is estimated at 27 t, with all but some lobster catch used for home consumption. Men are mainly engaged in finfishing, with women the main invertebrate fishers.

A total of 18 families, 49 genera, 129 species and 45,043 fish were recorded in the 50 transects conducted during finfish surveys. The assessment includes fish information which represents 42 genera, 120 species and 44,748 individuals. Of this, a mean of 8 fish families, 18 fish genera, 32 fish species and 900±34 individual fishes were observed and recorded in each transect. Nauru's outer reef system is composed primarily by abiotic hard bottom (77% cover, primarily limestone slab) with trenches that cut through the pavement and steeply drop off immediately after the surge zone. Acanthuridae and Balistidae families were predominant in density with fish genera *Acanthurus, Ctenochaetus, Naso, Zebrasoma, Melichthys, Balistapus* and *Sufflamen*. Other large-size families, such as Lethrinids, Lutjanids, Serranids and Scarids, were recorded in very low numbers, which would indicate intense fishing pressure and targeting of these families.

Invertebrate surveys were conducted through broad-scale assessments (manta-tow technique) and finer scale assessment of specific reef and benthic habitats. Giant clams were not recorded, and it appears these were lost from Nauru as early as the 1980s. There were also no records of trochus or blacklip pearl oysters, although there was suitable habitat for trochus and these could be introduced. There is a small lobster fishery, mainly for the restaurant trade, however, anecdotal information indicates this stock is in decline. Six commercial species of sea cucumber were recorded, mainly at low densities. One species, surf redfish, was relatively common (recorded in 92% of broad-scale manta transects and 100% of reef front searches). There is some potential for a small fishery based on this species, however, some locals are starting to eat this species as other marine species become harder to find.

The people of Nauru are going through difficult times with the current economic crisis, low wages and purchasing power for those with jobs, high fuel costs when fuel is available, and the need to put food on the table for themselves and their families. The increased focus on harvesting marine resources to address the food security issue, has the potential to devastate the inshore resources unless appropriate measures are put in place to ensure sustainable harvesting of the resource.

The following recommendations are based on the CoFish survey work (socioeconomic, finfish and invertebrate) conducted in Nauru in October and November 2005, and anecdotal and published information that has been researched over the last 12 months. They are provided to assist the Government of Nauru and its people to look to the future and the sustainable harvesting of marine resources. It is recommended that:

- The Government needs to closely monitor the level of fishing efforts for both finfish and invertebrates (through in-water assessment and socioeconomic surveys) and implement management measures affecting catch (e.g. size limits; total allowable catches of heavily exploited species) and fishing practices (e.g. gear types, mesh sizes);

- Specific management systems are essential for build-up and viability of invertebrate stocks and heavily fished finfish stocks, with the management regimes being controlled by communities, at scales larger than the current village boundaries;

- The Government considers the implementation of one or two marine protected areas (MPAs) that cover appropriate habitat (including reef ecology studies for choice of the best location) and areas where resources are still available, but do not undermine the people's ability to fish for their family needs;

- If the Government starts to implement management arrangements, preferably through communities, that an awareness programme be implemented at the same time to allow people and communities to fully understand the rational behind the management measures and the need for community support if arrangements are to work successfully;

- The Government looks to restrain SCUBA spearfishing, as the efficiency of this gear outweighs all the more traditional means of fishing, and if not properly controlled will have a drastic effect on targeted fish stocks;

- The abundant herbivorous Acanthurids could be sustainably targeted by local fishing activities instead of parrotfish, groupers, snappers and emperors; the latter fish groups are most probably being impacted by fishing activities at present;

- The Government continues to foster development of the offshore resources, more specifically tunas and other pelagics, to reduce fishing pressure on inshore resources;

- The Government looks at options for assisting local fishermen to fish for pelagics, possibly through encouraging Nauruans to use canoes and continue the fishing practices of the I-Kiribati and Tuvaluan fishermen who have departed from Nauru, and through putting out shallow water fish aggregating devices for them to fish around;

- The Government considers strengthening development of the aquaculture sector (such as freshwater farming of milkfish) and look at the possibility of mariculture of certain species, to enlarge options currently available from reef resources;

- The Government has an assessment undertaken to look at the stocks of aquarium fish, with the harvesting of these encouraged through the private sector and appropriate management measures, if the stocks can be sustainably harvested and viably exported;

- Any additional survey work by SPC on invertebrates should focus on the species that are of most concern for Nauruan people and which are the main focus of current harvest activity, including an assessment of the status and population dynamics of *Turbo* sp., and nocturnal crustacean species (especially lobsters and crabs); and

- The Government considers the introduction of *Tridacna maxima*, and possibly trochus adults, within an area protected from fishing and gleaning, possibly as part of an MPA as recommended above.

RÉSUMÉ

ACRONYMS

ACP	African, Caribbean and Pacific (Group of States)
ADB	Asian Development Bank
AUD	Australian dollar
AusAID	Australian Agency for International Development
BdM	Beche-de-mer (or sea cucumber)
CCA	Crustos coralline algae
CMT	Customary marine tenure
CoFish	(Pacific Regional) Coastal Fisheries Development Programme
COTS	Crown of thorns starfish
CPUE	Catch per unit effort
Ds	Day search
D-UVC	Distance-sampling underwater visual census
EDF	European Development Fund
EEZ	Exclusive economic zone
EU/EC	European Union/European Commission
FADs	Fish aggregating devices
FAO	Food and Agricultural Organisation of the United Nations
FFA	Forum Fisheries Agency
FL	Forked length
GDP	Gross domestic production
GPS	Global positioning system
GRT	Gross registered tonnage
Ha	Hectare
HH	Household
MCRMP	Millennium Coral Reef Mapping Project
MIRAB	Migration (MI), remittances (R), aid (A) and bureaucracy (B)
MOP	Mother of pearl
MPA	Marine protected area
MRM	Marine resource management
MSA	Medium scale approach
MSY	Maximum sustainable yield
NFC	Nauru Fisheries Corporation
NFMRA	Nauru Fisheries and Marine Resources Authority
Ns	Night search
OCT	Overseas countries and territories (French)
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
RFID	Reef fisheries integrated database
RFs	Reef front searches
RFs_w	Reef front searches_walking
RoN	Republic of Nauru
SCUBA	Self-contained underwater breathing apparatus
SE	Standard error
SOPAC	Pacific Islands Applied Geosciences Commission
SPC	Secretariat of the Pacific Community
USD	United States dollar
WCPO	Western and central Pacific Ocean

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

The coastal component of the 8th EDF-funded Pacific ACP and OCT Regional Oceanic and Coastal Fisheries Development Programme (PROCFish), in association with the 9th EDF-funded (Pacific Regional) Coastal Fisheries Development Programme (CoFish), was designed to address a major difficulty in the Pacific Islands: that of managing coral reef fisheries in the region in the absence of robust scientific information on the status of the fishery. The purpose of these programmes is to provide the governments and community leaders of the Pacific Island 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 EU French Territories (French Polynesia, Wallis and Futuna and New Caledonia) 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/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).

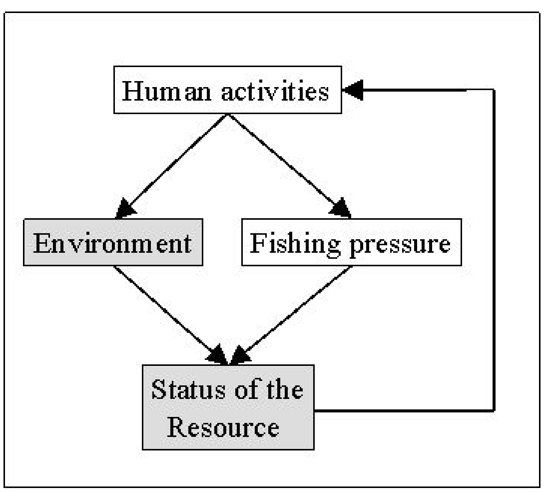

Figure 1.1: Synopsis of the PROCFish/C* multidisciplinary approach. PROCFish/C conducts coastal fisheries assessment through simultaneous collection of data on the three major components of fishery systems: people, the environment and the resource. This multidisciplinary information should provide the 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 standardized 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 standardized survey methodologies.
- 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 includes 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 x 5 m quadrates located on both side of the transects (Figure 1.2).

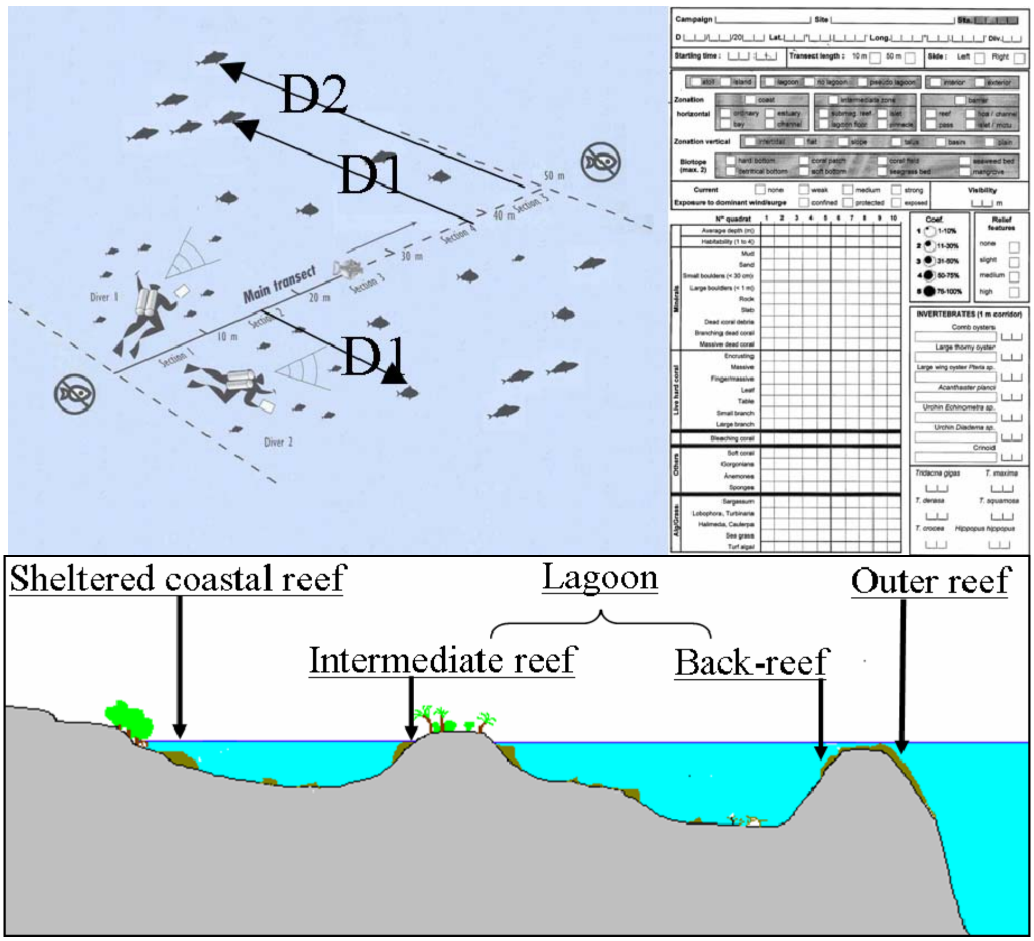

Figure 1.2: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC). Each diver recorded the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys 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 maximized accuracy. It also facilitates repeatability, 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 specie(s); 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, 6 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 × 25 cm^2 quadrates were dug at 8 locations along a 40 m transect line to obtain a count of targeted in-faunal molluscs (molluscs living in bottom sediments, which consist mainly of bivalves); see Figure 1.3 (4).

For trochus and beche-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.

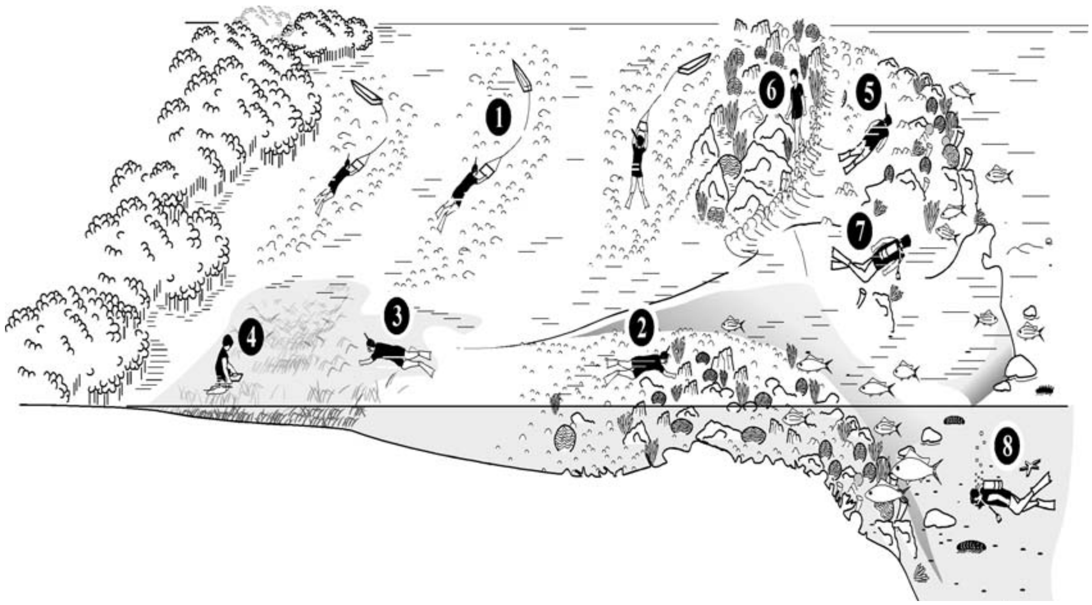

Figure 1.3: Assessment of invertebrate resources and associated environments. Techniques used include: broad-scale assessments to record large sedentary invertebrates (1); fine-scale assessments to record epi-benthic resources and potential indicator species (2) and (3); quadrates to count targeted in-faunal molluscs (4); searches to determine trochus and beche-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 Nauru

1.3.1 General

The Republic of Nauru (Figure 1.4) consists of a single raised coral atoll, 21.9 km^2 in land area with an EEZ, which extends over an area of 320,000 km^2. Located 41 km south of the equator, Nauru has no fresh water source, and has limited fertile land to support subsistence or commercial agriculture, thus future development of the country relies significantly on marine resources. Coastal resources are restricted to a narrow 50–300 m wide coral ‘belt’ surrounding the 19 km circumference of the island, although the open ocean areas are frequented by an abundance of tuna and other pelagic species. As an isolated island, Nauru is dependent on shipping and air services for the provision of food and other supplies, mostly from Australia (FAO 2002).

The economy of Nauru has been based on phosphate mining, which commenced at the start of the 20th century. To assist in export of the mined phosphate, the Pacific Phosphate Company built a small boat harbour in 1904 (Williams and MacDonald 1985). The Nauru Phosphate Company took control of the harbour in 1967. The money generated from royalties paid to local land owners supported a healthy economy through to the 1990s. Declining phosphate prices, the high cost of maintaining an international airline, and the government’s financial mismanagement combined to make the economy collapse in the late 1990s (http://geography.about.com). Referred to as a ‘resource curse’ scenario, what eventuated in the end was the failure of other economic sectors, wasteful expenditure, the existence of a ‘welfare state’, a neglected education system, and people without skills to develop an alternative economy to mining (Connell 2006). To cut costs the government has frozen wages and reduced the size of the civil service (CIA 2005).

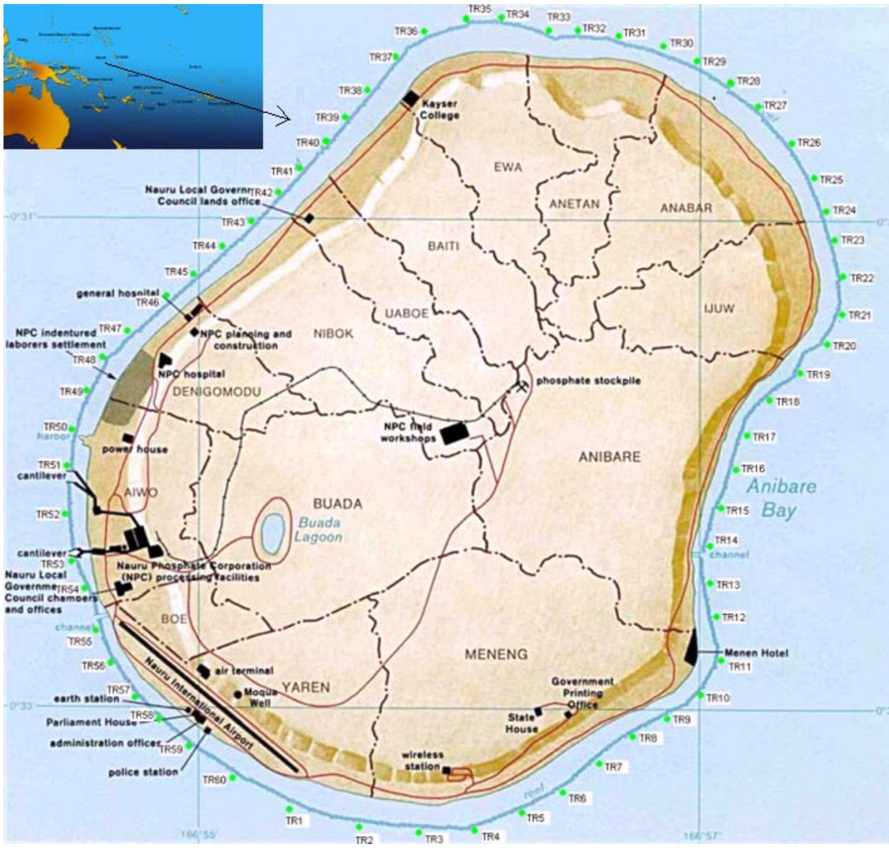

Figure 1.4: Map of Nauru

Nauru had a population of 10,131 people in 2002, of which 7,572 were indigenous Nauruans of predominantly Micronesian origin, and the remainder mostly I-Kiribati, Tuvaluan and Chinese peoples. Of these 5,159 were males and 4,972 were females (SPC 2006). From 2003 estimates, population density was quoted as 577, the highest in the region (SPC 2006). This high density may be attributed to the concentration of settlements along the coastal fringe of the island. From 2003 estimates 38.9 per cent of the population were below the age of 19, projecting a very young population, which means increased demand on land space, education and health services and more importantly accelerated pressure on existing marine resources in future. Total population figures quoted could, however, have dropped significantly following the return of I-Kiribati and Tuvalu foreign workers to their countries at the beginning of 2006 and the gradual decrease in population in the last few years because of increasing migration to other countries following the economic crisis.

There are 630 individual named pieces of land to which people in Nauru have tenure, with no publicly held land, thus the government has no control over land for planning or development (Thaman and Hassal 1998). This has been interpreted as a challenge to any form of development or rehabilitation that may take place. Most of these parcels of land are inherited through the mother, and most areas are shared. For the purpose of dispersing of royalties from phosphate mining, the system worked well and people were affluent, but after mining people have no land for housing, agriculture and other uses. Through phosphate mining, natural vegetation and topsoil have been removed from over 70 per cent of the land area, primarily at the centre of the island, thus preventing the movement of a rapidly-increasing population from the coastal fringe, heightening land pressures and disputes around that fringe, and possibly causing microclimate deterioration (ADB 2000).

Both inland and coastal erosion are increasing problems in Nauru, and coastal erosion is regarded as of special concern owing to the possibility of global warming — induced sea level rise. Coastal erosion has mostly been from development of reef channels, the enlargement of boat harbour at Anibare, and extension of the airport runaway (Thaman and Hassal 1998). In 2000, 17 beach profiles were established around Nauru to monitor the changes in the beach areas. The intention was to identify coastal erosion around the Nauru coast as well as to collect information on countermeasures that were proposed at state level and to establish a baseline data set (SOPAC 2005).

Social issues

A socioeconomic assessment report by AusAID (2004) highlighted a significant deterioration in the humanitarian situation in Nauru since the beginning of 2004. Food security has emerged as a serious issue as a consequence of policy failure and chronic economic decline. This resulted in a total regression of development with people resorting to basic subsistence fishing and farming for survival. Men, women and children forage daily on reefs, the daily hunting of birds for food, and families resorting to extended family systems to barter food for imported food items are indicative of a situation completely opposite to the common trend of the shift from traditional to imported foods (pers comm. 2005). At the same time Nauru's Human Development Index ranking has slipped to a medium level in recent years, as GDP per capita has fallen. Education has remained a neglected sector which had been worsened by years of welfare state governance, which led to a lifestyle of luxury and leisure (ADB 2000). Because of loss in purchasing power, people rely on extended families and on the meagre salaries received to purchase basic necessities. The Government has not established a definition of poverty nor poverty line to determine the incidence of poverty. However, government policies have recognized the disadvantaged state people are in, especially with low incomes and insufficient subsistence production, given the poor health and education status and the fragility of the atoll environment in which people live (ADB 2000).

1.3.2 The fisheries sector

Nauru's fisheries are comprised of the offshore fishery for tuna and other pelagic species, the small-scale tuna fishery around fish aggregating devices (FADs), and reef fisheries for a range of fish and invertebrate species.

Offshore tuna Fishery

Nauru does not have a strong history in offshore tuna fishing. Early surveys conducted from 1971–1974 by the Japan Marine Fishery Resources Research Centre concluded that domestic pole-and-line fishing was not feasible due to the lack of suitable baitfish around Nauru (SPC 1984). However, Japanese distant-water pole-and-line vessels carrying their own baitfish took 25,000 t of tuna between 1972 and 1978 in areas that would now be within the Nauru EEZ (SPC 1984). Foreign longline fishing activities were also undertaken in the mid 1970s, with annual catches of 948 to 2,799 t. Some exploratory purse-seining was also undertaken in the waters around Nauru in the late 1970s, with 83 t of tuna caught in two sets (SPC 1984).

In an attempt to enter the tuna fishery, the Nauru Fishing Corporation was established in 1976 by the Nauru Government. The Nauru Fishing Corporation purchased two 948 GRT purse seiners from the Eastern Pacific in 1980. The two vessels were from Peru, with Peruvian skippers, engineers and crew. The vessels proved to be unsuccessful at catching tuna as the nets being used were too shallow. In 1986/87, one of these vessels sunk off Nauru in a storm. The second vessel was moved to the Philippines in 1987/88, where it was chartered to a local company and eventually sold (Chapman 1998; Sokimi and Chapman 2001).

In 1997, the Nauru Fisheries and Marine Resources Authority (NFMRA) was established and replaced the then Fisheries Department. NFMRA in 1998 established the Nauru Fisheries Corporation (NFC) as its commercial arm, as NFMRA had no legislative power to conduct commercial operations (Sokimi 2005). NFC purchased two longline vessels, one 18.5 m in 2000 and the other 12 m in 2002. Both vessels have experienced extensive breakdowns that have restricted fishing activities. In addition, when the vessels were fishing, only low catch rates were achieved and the fishing operations have not been economically viable.

Small-scale tuna fishery around fish aggregating devices (FADs)

The ocean mooring buoys that are used to secure bulk carriers for loading phosphate have doubled as fish aggregating devices (FADs) for local fishermen. The I-Kiribati and Tuvaluan workers from the phosphate company use traditional canoes they have built to fish around these buoys, which are only 350 m from the reef (Cusack 1987; Sokimi and Chapman 2002). Fishing methods used include light handlines for catching mackerel scad (used for bait for tuna), jigging using a handline with special weight and feather jig for rainbow runner, and drop-stone or mid-water handlining for larger tunas and associated species using the freshly-caught mackerel scad (Cusack 1987). In 1992 there were 128 canoes and 88 outboard powered skiffs owned by the migrant workers (Chapman 2004).

During the 1990s, the Nauru Fisheries Department, which became the NFMRA in 1997, commenced an FAD programme to assist local fishermen. Deep-water FADs were deployed at a distance of 1.5 to 3.5 km off the reef in depths of 1,500 to 2,600 m (Chapman et al 1998). These FADs were mainly to aggregate the passing schools of skipjack tuna and yellowfin tuna, so that local Nauruan fishermen using outboard-powered skiffs could troll at these locations, reducing their fuel costs and increasing their chance of a good catch. In 1992 there were 130 skiffs owned by Nauruans, and these were mainly used for trolling for tunas off the coast and around FADs (Chapman 2004).

Three FADs were deployed off Nauru in early 2005 to further assist local fishermen as the economy of Nauru continued to decline (Sokimi 2005). However, increased fuel costs and a shortage of fuel have greatly limited the ability of Nauruans to fully utilise these FADs, adding to the increasing shortage of fish for local consumption.

Reef fisheries

As stated previously, coastal resources are restricted to a narrow 50–300 m wide coral ‘belt’ surrounding the 19 km circumference of the island. Despite this limitation in coral reef area, Nauru has a relatively rich marine biota. Nauru is estimated to have between 300 and 500 finfish species alone, an estimation based on the number of species around nearby islands (Thaman and Hassal 1998). The main categories of marine resources include a wide range of finfish as mentioned, and a more limited range of turtles, crustaceans, octopus, shellfish, holothurians other invertebrates and algae.

Reef finfish fisheries in Nauru are regarded as subsistence or semi-artisanal. Fish and marine resources have traditionally constituted an important component of the Nauruan diet (Tuara 1998). In 1999, fishing contribution was about 2 per cent of GDP. However, nearly 60 per cent of Nauru's domestic fisheries is derived from coastal pelagic species through the use of trolling and mid-water handlining techniques as mentioned above (Jacobs and Depaune 2001; ADB 2001).

Bottom fishing by handline is conducted along the outer reef slope targeting both shallow and deep demersal species; shallow-water snappers dominate the catch from this fishery (Anon 2002; Jacob and Depaune 2001; Thaman and Hassal 1998; Dalzell 1992). Other common fishing methods practiced in Nauru over the years includes scoop-net fishing for flying fish, and spearfishing (using both SCUBA and the conventional method of skin diving) targeting edible species of snappers, groupers, squirrelfish/soldierfishes, trevallies and surgeonfish. Reef gleaning for octopus, turban shell, and other invertebrates is also common. With the current fuel price and fuel availability, fishing is commonly restricted to canoe fishing, diving (snorkel and some SCUBA) and gleaning on the reef tops, in the immediate outer reef zone.

Fishing and gathering food has recently re-emerged as activities that are critical for maintaining adequate nutrition, but sustainability of the reefs are at the same time a major concern. Fish and marine resources have traditionally been an important component of the Nauruan diet. Much of the catch taken by Nauruans is shared along family lines, although catch in excess of immediate need is occasionally sold. The value of the catch of Nauru's domestic fisheries is about USD $1.7 million (FAO 2002). Because fish form a large part of the diet of Nauruans, it is important that the levels of fishing activity and the volume and composition of landings be determined for management purposes.

Little information is available on the status of fisheries stocks in Nauru, particularly inshore resources (SPC 1994; Dalzell 1992; FFA 1992). The need for a clear comprehensive marine resource profile has been raised over the years (SPC 1994; FFA 1992; FAO 2002; ADB 2005). The only available information is on finfish abundance, which had been collected through the Coral Reef Monitoring work (Jacob 2000). Decline of reef fisheries resources has been documented since 1994 (Dalzell and Debao 1994) and with the recent higher dependence on reef resources, this has become a major concern (ADB 2005; SPC 2005; FAO 2002). Over fishing, pollution, detrimental fishing methods and mining are the main threats to marine resources (Jacob 2000). An FAO (2002) report recorded certain reef species becoming scarce, the decrease in average size of fish, and the use of SCUBA for fishing and collecting.

Some inshore finfish species of cultural importance, which already show evidence of overexploitation, include a wide range of shallow-water snappers, rock cods, groupers or coral trout species, squirrelfish or soldierfish, lined bristletooths and large moray eels. Daily reef gleaning activities have also reportedly led to over exploitation of turban shells or emwari, lobsters and octopus (Thaman and Hassal 1998).

Because of the economic crisis facing Nauruans at the start of the 21st century, there has been a dramatic increase in reef fishing, gleaning and collecting and this has placed enormous pressure on the reef system. Previous reports (Thaman and Hassal 1998; FAO 2002; ADB 2000; SOPAC 2005) have cited concerns on resource status and over-exploitation. Increasing population, commercialization, the use of motorized fishing boats, the use of more efficient fishing techniques, and the use of some destructive fishing techniques have placed great pressure on Nauru's limited inshore resources (Thaman and Hassal 1998). With fisheries resources now being the only major fall back option for people, the vulnerability of marine resources has increased significantly. The challenge for Nauru will be the ability to sustain people's livelihoods, and the need for some management measures to ensure that these resources are able to sustain populations into the future. The need to maintain fragile systems and the impact of any further environmental decline, such as the collapse of marine resources on the reef, could result in further decline in conditions people are currently under (ADB 2002).

1.3.3 Fisheries management

NFMRA is a statutory cooperation, which has the responsibility to oversee, manage and develop the country's natural marine resources and environment. Under the Fisheries Act 1997, the general objectives of fisheries management in Nauru are "the sustainable utilization of the fisheries and marine resources of Nauru to achieve economic growth, improved social standards, improved nutritional standards, human resource development, increased employment and a sound ecological balance" (RoN 1997). NFMRA operates under the Fisheries Act 1997, which applies to all local and foreign persons and to all foreign and local fishing vessels. Under the Act, the Minister has powers to determine allowable catch, to advise NFMRA to draw up a strategy for management of a fishery, specify limitations for licenses, quotas for foreign vessels, etc. Under the Act the Minister can also prohibit fishing or a fisheries activity which can include prohibitions by species, sub-species, class or type of fish, methods, time, date, season, and period and so on. Drift netting, use of explosives and poison, use of fish aggregating devices, importation of live fish and sale of fish are also covered in the Act (RoN 1997). Regulations are well covered under the Fisheries Act, but the enforcement of these regulations is a challenge given the financial state of the country.

Aside from fisheries development efforts, there is little government intervention in the inshore fisheries. This is an important sector and like any other island in the Pacific, coastal fishery commodities often go a long way towards fulfilling the immediate cash needs of the largely subsistence communities in many island nations (Adams and Ledua 1997). Because of the declining state of resources coupled with the increasing over dependence of the population on reef and inshore species, there is an urgent need to strengthen management capabilities.

Primary responsibility for the enforcement of the Fisheries Act 1997 is by the Police Force, and one of the concerns is the lack of training of officers on maritime surveillance or on regulations and enforcement of regulations in inshore areas. Two main provisions in the Act are the provision on restrictions on certain fishing methods and the protection of certain identified vulnerable invertebrate and finfish species (FAO 2005). "Traditional marine tenure systems once formed an important link to Nauruan communities but since the commencement of phosphate mining, it has generated into an open access or "free for all" system, which means that there are no longer any community or traditionally managed fisheries on Nauru." (FAO 2005). Some conservation ethics remain known to Nauruans and these could be used when implementing management.

In addition to the Nauru Fisheries and Marine Resources Authority Act, other fisheries legislations include: The Fisheries Act (1997), which regulates both foreign and domestic fishing activities; The Sea Boundaries Act (1997), which establishes Nauru's claim over a 12-

mile territorial waters zone, a 24-mile contiguous zone, and a 200-mile EEZ; and The Fisheries Regulations (1998) which regulates foreign fishing vessels in Nauru's zone.

A Micronesia sub regional meeting on coastal legislation acknowledged that coastal fisheries legislation in the Pacific Island States of Micronesia is highly undeveloped and that there is insufficient capacity and/or resources available at the national level to effectively manage coastal fisheries in the Pacific Island States of Micronesia (FAO, 2005). Also, development of fish farming could alleviate pressure on reef fishing (SPC 2005).

There is definitely a need for management of marine resources and the best way to do this would be by regulation, based on a scientifically determined maximum sustainable yield catch, but this will however require better resource profiles on the population dynamics of Nauru's fisheries resources (Thaman and Hassal 1998).

1.4 Selection of sites in Nauru

Under normal operations, the PROCFish/C and CoFish programme selects four representative sites to work in each country or territory. However, in the case of Nauru, it was possible to survey the whole country due to the small size of the island and the limited reef area. Therefore, Nauru was considered a single site, and this is how the results are presented in this report.

2. PROFILE AND RESULTS

2.1 Site characteristics

Nauru Island is a single, raised coralline island located 41 km south of the equator. Coastal resources are restricted to a narrow 50–300 m wide coral ‘belt’ surrounding the 19 km circumference of the island. The bulk of the population lives around a 300 m wide coastal green fringe. Reef related fishing concentrates mostly on the immediate surrounding outer reef. Similar to other study sites elsewhere in the Pacific region, the total area of the fishing ground (67 km^2) in Nauru is calculated form maps of the island. Nauru fishing ground (Figure 2.1) includes a narrow fringing intertidal flat (3.4 km^2) and an outer reef immediately behind the breakers (2.6 km^2), and adjacent deep ocean areas over the continental shelves around the island (61 km^2). The inner pools are very shallow and narrow (2.15 km^2 of the intertidal flat), much of which dries up at low tide. Encircling the island, the fringing reef is characterized by a few coral heads (predominantly *Acropora* and *Porites* genera) growing on mineral rock that lies along the northern (ocean) side of Nauru Island (Figure 2.2). Two channels that cut into the narrow fringing reef give ready access to boats and canoes. The different location of Gabab (west coast) and Anibare (east coast) channels permits access to the sea when prevailing winds change directions.

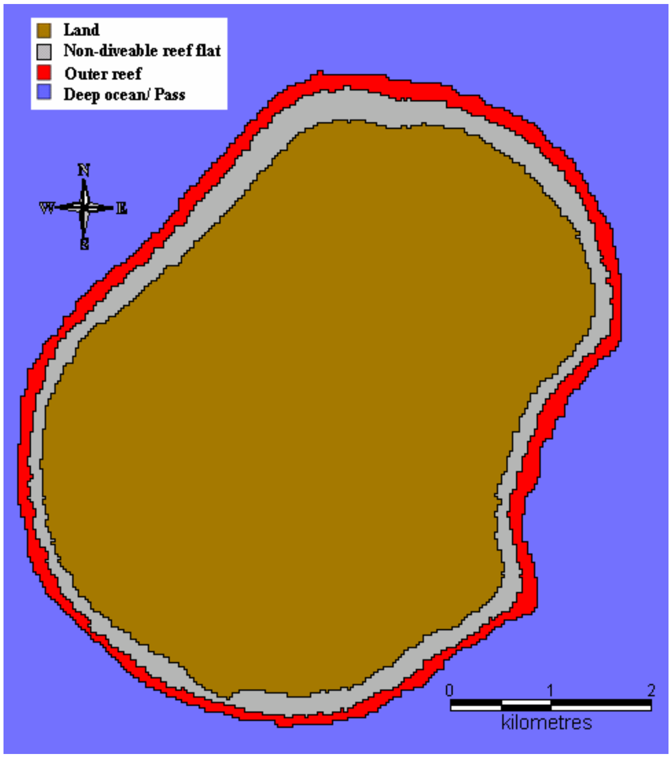

Figure 2.1: Main reefal structures adjoining Nauru Island.

Figure 2.2: Aerial images of Nauru Island showing the coastline and reef area

2.2 Socioeconomic surveys

Socioeconomic field work was carried out in 11 of the 14 districts in Nauru during October 2005. The resident population at this time was estimated at 10,131 people (1230 households) and this was the figure used for extrapolation of data in the study. Household interviews focused on the collection of general demographic, socioeconomic and consumption data, with 245 households surveyed. From the households interviewed, 97 per cent were engaged in fishing activities.

In addition, a total of 422 finfishers were interviewed, made up of 375 men and 47 women. For invertebrates, 287 fishers were interviewed, 152 women and 135 men. There was a higher participation of men in finfishing, with women more involved in invertebrate fishing. In some cases the same person may have been interviewed for both finfishing and invertebrate harvesting.

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

Survey results indicate an average of 3.7 fishers per household. If this average is consistent for all households in Nauru, when extrapolated the total number of fishers in Nauru would be 4451, which includes 2972 men and 1579 women fishers.

Data on income sources indicate that the main source of income is from government employment with some people employed in the private sector. Nauru has minimal income generation alternatives except through salaries from government work which account for 86 per cent of total income source (Figure 2.3). Those who rely on fisheries as first income account for only 5 per cent of households interviewed and these were mainly the Kiribati and Tuvalu people who sell pelagics and offshore species, thus income from fisheries and agriculture are negligible. There is no external export of fish in Nauru, thus all sales are domestic. Some people (7%) have moved to small home-based business ventures or informal selling as a first or second means of income (Figure 2.30, and this involves the selling of cooked food, cigarettes, and home brewed alcohol. The selling of sea birds for food has also increased. Very few households received any form of remittance, thus external input into the economy was insignificant. Nauru has no commercial bank and no means of financial transactions, which restricted remittances being a possible form of income.

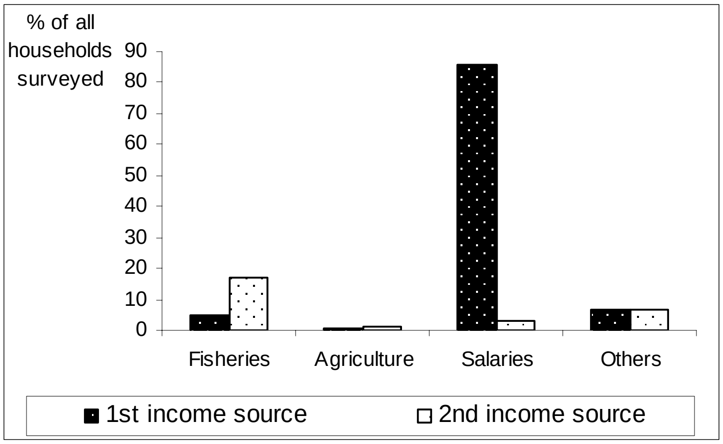

Figure 2.3: Income sources with salaries being the most important source of income. Sales from fisheries are mostly that of pelagic and offshore species.

Per capita consumption was recorded at 47 kg per year which is slightly higher than the previously recorded 44 kg per year (FAO 2002). Increasing per capita consumption directly relates to the high reliance on seafood as a source of protein given the continuing economic decline. The standardized salaries at AUD $140.00 a fortnight for all government workers in the country means that the purchasing power of people is very low. This is apart from those employed in the private sector on lower salaries, or inconsistent wages, and those without any form of employment. Finfish is consumed at an average of 3.8 times per week, while invertebrate consumption is much lower with a frequency of about twice a month (Table 2.1). Canned fish is also frequently consumed at an average of 2.4 times a week for most households, with per capita consumption per year at 15.25 kg, which is much less in quantity than finfish. For many families canned fish was an affordable substitute and can be cooked as soup and in many other ways to feed large families. The low consumption of invertebrates could be due to the over harvest of invertebrates, as supported by the missing species groups and depleted state of resources as shown in the independent assessment. Interviewees talked of walking longer distances and decreases in size of species, although invertebrates may have not been important in traditional harvests. There is very high reliance on fresh fish, with many households interviewed consuming their own catches; buying or being given fish by relatives and neighbours. Catches recorded show a move to species not previously targeted or commonly consumed like some species of the *Acanthuridae* family.

Annual household expenditures is low with families spending within the AUD $140.00 a fortnight limit on household necessities, basic food stuff and electricity. People are barely surviving financially, thus there is not much purchasing of items apart from basic household necessities.

Table 2.1: Fishery demographics, income and seafood consumption patterns in Nauru.

	Survey coverage	**Site** (n=245 HH)
Demography	HH involved in reef fisheries (%)	97.1
	Number of fishers per HH (%)	3.7 (±0.16*)
	Finfishermen per HH (%)	37.0
	Finfisherwomen per HH (%)	0.3
	Invertebrate fishermen per HH (%)	0.1
	Invertebrate fisherwomen per HH (%)	17.6
	Finfish and invertebrate fishermen per HH (%)	28.1
	Finfish and invertebrate fisherwomen per HH (%)	16.8
	Income	
Income	HH with fisheries as 1st income (%)	4.9
	HH with fisheries as 2nd income (%)	17.1
	HH with agriculture as 1st income (%)	0.4
	HH with agriculture as 2nd income (%)	1.2
	HH with salary as 1st income (%)	85.7
	HH with salary as 2nd income (%)	2.9
	HH with other source as 1st income (%)	6.9
	HH with other source as 2nd income (%)	6.9
	Expenditure US$/year/HH	3,048.88 (±86.35)
	Remittance US$/year/HH(1)	159.96 (±47.63)
	Seafood Consumption	
Consumption	Quantity fresh fish consumed (kg/capita/year)	46.54 (±3.16)
	Frequency fresh fish consumed (time/week)	3.81 (±0.14)
	Quantity fresh invertebrate consumed (kg/capita/year)	3.72 (±0.47)
	Frequency fresh invertebrate consumed (time/week)	0.53 (±0.04)
	Quantity canned fish consumed (kg/capita/year)	15.25 (±1.13)
	Frequency canned fish consumed (time/week)	2.41 (±0.12)
	HH eat fresh fish (%)	100.0
	HH each invertebrates (%)	75.1
	HH eat canned fish (%)	92.2
	HH eat fresh fish they catch (%)	89.8
	HH eat fresh fish they buy (%)	60.4
	HH eat fresh fish they are given (%)	62.0
	HH eat fresh invertebrates they catch (%)	67.8
	HH eat fresh invertebrates they buy (%)	2.0
	HH eat fresh invertebrates they are given (%)	31.8

Notes: HH = household; (1) Average sum for households that receive remittances; *Qualifiers are Standard Error

2.2.2 Fishing strategies and gear

Fishing is a daily activity with men, women and children out on the reef and tidal flats at low tide. Fishers in Nauru hardly targeted beche-de-mer, trochus, or giant clams, as trochus and clams were not present as confirmed by the invertebrate survey results. Beche-de-mer has until recently never been harvested, but because of food needs, people are starting to consume some species of surf redfish and lollyfish, and this was verified by the findings of the invertebrate team. Sea urchins are also being targeted more for consumption. Children actively participate in fishing and this is increasingly common when children are not at school, both because of lack of transportation and the lack of food to take to school.

Degree of specialization in fishing

Men dominate both fisheries with 37 per cent of male fishers engaged in finfishing only. Women generally target both the finfish and invertebrate fisheries (Figure 2.4). The trend is where both male (28%) and female (17%) fishers are largely engaged in both finfish and invertebrate fishing.

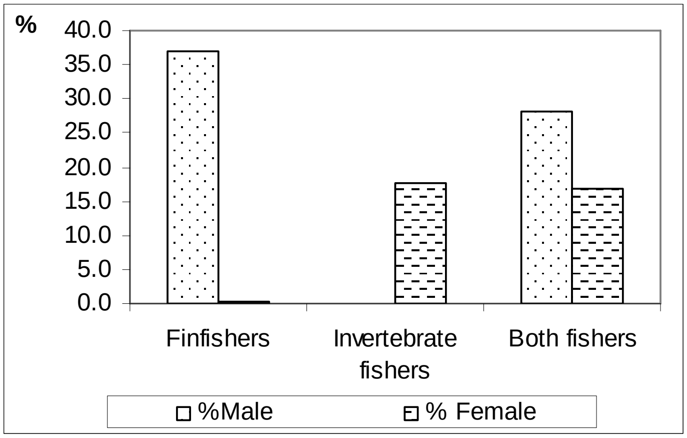

Figure 2.4: Proportion of fishers exclusively targeting finfish or invertebrates, and those that target both (although not necessarily during a single fishing trip). Figure shows proportion of all fishers (all fishers = 100%)

From all interviews recorded, 95 per cent of all coastal finfishing is within the coastal reefs and passages (canoe and boat fishers fish close to the passages and in the boat harbour in some cases), while the remaining includes pelagic and deep ocean species. Pelagics and deep sea fisheries are not taken into account in this study, thus the general mention of the involvement of fishers in the fishery with no specific data on their participation. For invertebrates, most fishing is concentrated on the reef tops (reef platforms — Figure 2.5) with 87 per cent of men fishers and 95 per cent of women fishers engaging in some form of reef top gleaning or general collecting activities along the intertidal zones.

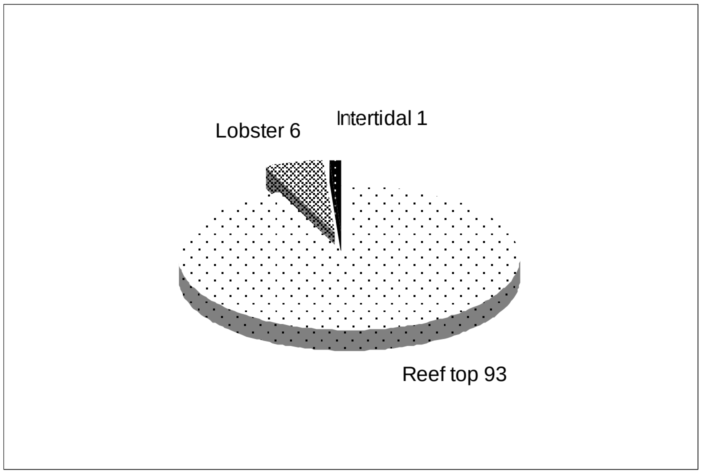

Figure 2.5: Proportion (%) of fishers targeting the three primary invertebrate habitats found in Nauru. Based on individual fisher surveys.

Fishing strategies

Boat ownership in Nauru at the time of survey could not be used as an accurate indication of fishing participation because of the fuel shortage coupled with the inability of people to purchase fuel. People mostly walked on the reefs and free dived along reef slopes. Boat usage was confined to the use of canoes by the Kiribati and Tuvalu communities.

Fishing trips were during the day except for lobster diving, which was mostly at night. Night fishing was not pursued because people could not afford torches or fuel for boat trips. Frequency of invertebrate fishing trips was between 1 and 2.5 days per week with trips averaging 2 to 4 hours for both men and women. As most fishing was on reef tops, the longest trips were mainly by people walking on reefs to collect invertebrates. Most of the areas directly opposite or close to the communities were fished out, thus people walked further to fish, and as a consequence, spent longer hours fishing.

Targeted stocks/habitats

Women had a higher involvement in the invertebrate fisheries while free diving for lobsters was practiced almost exclusively by men (Figure 2.6 and Table 2.2). Lobster diving was not a regular activity as fishing was mostly by groups of fishers and it was mainly in response to orders received from buyers.

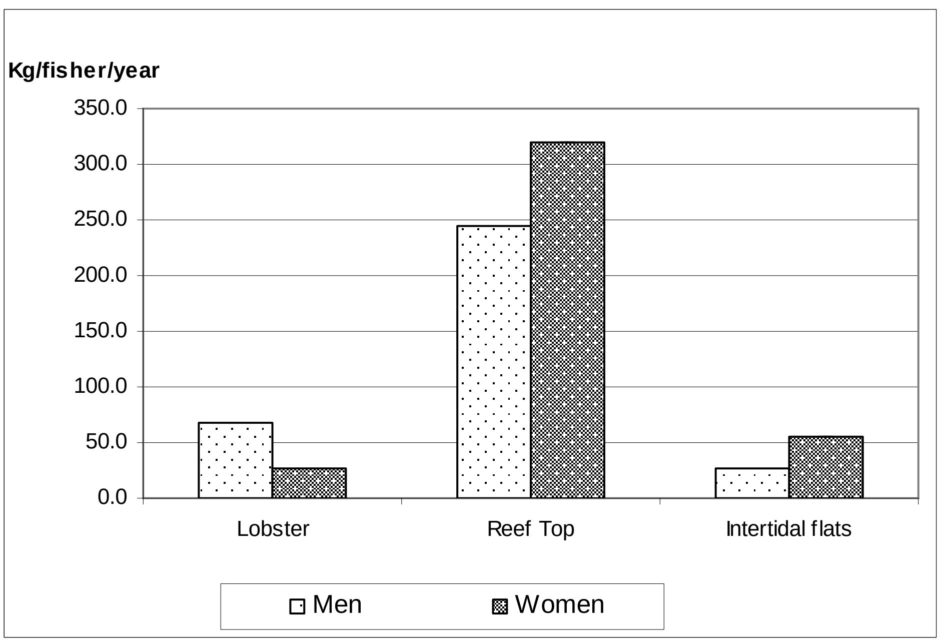

Figure 2.6: Proportion of male and female fishers targeting various invertebrate habitats in Nauru or species as is the case for the lobster fishery. Data based on individual fisher surveys. Figures refer to the proportion of all fishers that target each habitat. n=135 for males, n=152 for females.

Table 2.2: Stocks harvested by interviewed fishers in Nauru

Resource	Stock	Percentage of fishermen interviewed	Percentage of fisher women interviewed
Invertebrates	Lobster	14.0	0.0
	Reef Top (platform)	96.3	96.7
	Intertidal	0.7	2.6
Finfish	Sheltered coastal reefs	83.5	95.7
	Passage	19.5	2.1

Notes: Finfish fisher interviews, men: n=375; women: n=47. Invertebrate fisher interviews, men: n=135; women, n=152. Passage fishing was limited to fishing within boat passage at Anibare.

Gear

Various fishing techniques were used in finfishing in Nauru (Table 2.3). Most fishers used more than one technique, and sometimes several methods were used on fishing trips. This applied in particular for spear diving that was hardly reported to be exclusively performed. Castnets, handlines and spear diving were the most dominant techniques used, followed by gillnets and deep-bottom lines or other techniques used to target deep-bottom species. Deep bottom line and drop-stone were dominant techniques for deep sea and pelagic species. Free diving was more commonly practised than SCUBA diving.

Table 2.3: Techniques commonly used in finfishing activities in Nauru (proportions are expressed in % of total number of trips to each habitat)

Technique\fishery	Sheltered coastal reef	Passage
Spear diving and others	73	4
Castnet, handline	41	0
Gillnet	30	0
Deep-bottom line and others	7	96

Fishing Pressure

Information on the number of fishers, the frequency of fishing trips and the average catch per fishing trip was used to estimate the fishing pressure on the fishing grounds (Table 2.4).

Frequency and Duration

Nauru has limited coastal reef areas with shallow inner pools, thus fishing was generally on the coastal reef areas, in passages and along the reef slopes. Both men and women fishers target the sheltered coastal reef and passages at an average of 2 to 3 times per week, respectively (Table 2.4). This is far less than deep sea and pelagic fishing which is frequented at an average of 4.5 times per week. There is not much difference in hours spent on finfishing by both men and women and this ranged from 3 to 4 hours, and if compared to invertebrate collection, finfishing is generally not only done more frequently, but is also more time consuming.

Table 2.4: Average (±SE) frequency and duration of fishing trip for interviewed fishermen and fisherwomen

Resource	Stock	Trip frequency (trip/week)		Trip duration (hour)	
		Men	Women	Men	Women
Invertebrates	Lobster	0.43 (±0.06)	0.23 (n/a)	4.31 (±0.11)	4.00 (n/a)
	Reef Top (platform)	1.06 (±0.25)	1.28 (±0.15)	2.75 (±0.18)	2.76 (±0.11)
	Reef Top+Lobster	0.38 (±0.07)	0	4.00 (±0.00)	0
	Reef Top+Other	1.58 (±0.10)	1.82 (±0.10)	2.88 (±0.07)	3.25 (±0.08)
	Soft bottom+Reef Top	1.00 (n/a)	0	3.00 (n/a)	0
Finfish	Sheltered coastal reef	3.07 (±0.08)	2.27 (±0.18)	3.54 (±0.09)	3.01 (±0.10)
	Passage	2.41 (±0.11)	2.00 (n/a)	3.15 (±0.12)	4.00 (n/a)

Number of fishermen interviewed: Finfish fisher interviews, men: n=375; women: n=47. Invertebrate fisher interviews, men: n=135; women, n=152

2.2.3 Catch composition and volume — finfish

The reported total annual catch of finfish by survey respondents was 138 t per year (87.2% by men and 12.8% by women fishers). Of the total annual finfish catch 79 per cent was from the sheltered coastal reefs, 13 per cent from passages, and the remaining 8 per cent were caught if sheltered coastal reef and passages were jointly fished in one trip, and also due to some reported pelagic fishing. Please note that because pelagic fishing is not the subject of this reported survey, the reported pelagic catch may not be exhaustive. Details on recorded annual catch by vernacular and scientific names are given in Appendix 2.1.

Proportion of reported annual finfish catch by habitat and gender in Nauru.

Respondents indicated that 55 to 72 per cent of all reef fish catches were for the purpose of household consumption, 17 to 20 per cent shared or distributed, and another 8 to 27 per cent of the catch sold on Nauru (Figure 2.7). The share of fish caught for subsistence, distribution and income generating reasons is very much determined by the recent economic crisis. Respondents highlighted in particular, the now more common way of sharing was between families and with neighbours. Sometimes fish was reported to be exchanged for imported goods. The small proportion of catch sold locally corresponds to the low financial power that is now common amongst all Nauruan people. The survey showed that mainly Kiribati and Tuvalu families who favour pelagic fishing are engaged in local selling of catch, i.e. predominantly pelagic rather than reef fish. There is no international export of finfish or invertebrates.

The catch per unit effort (CPUE) calculated is generally low and does not much differ for men or women targeting the sheltered coastal reef areas, or the combines sheltered coastal reef and passages. Deep sea fishing and pelagics are included in these discussions because of the nature of habitats where the coastal reef immediately drops off into deep sea areas, thus fishermen are actively engaged in both the coastal fisheries and pelagic for deep ocean species. The highest CPUE occurred in sheltered coastal reef areas which was the main fishing habitat in Nauru (Figure 2.8).

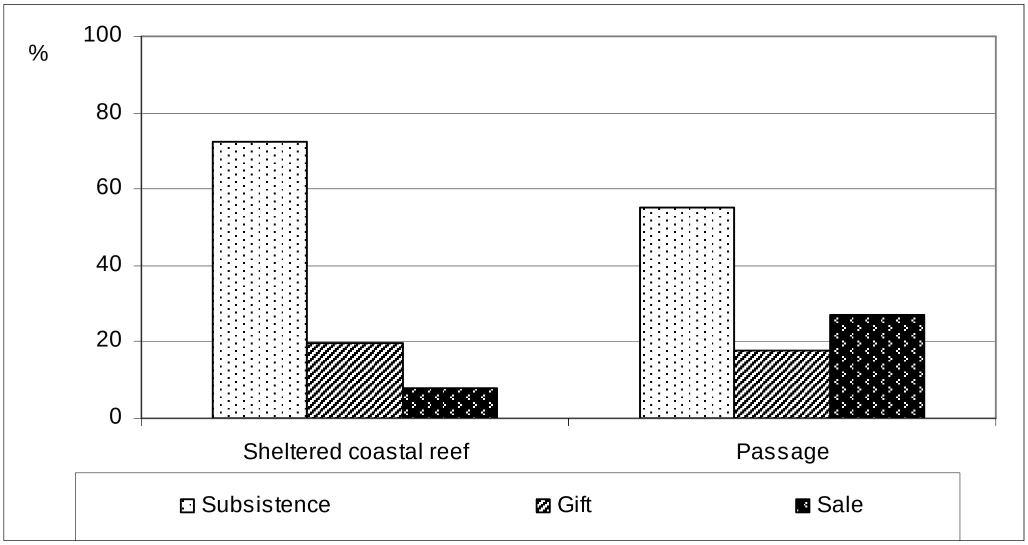

Figure 2.7: The use of finfish catches for subsistence, gift and sale by habitat. (Proportions are expressed as the per cent of the total number of trips to each habitat).

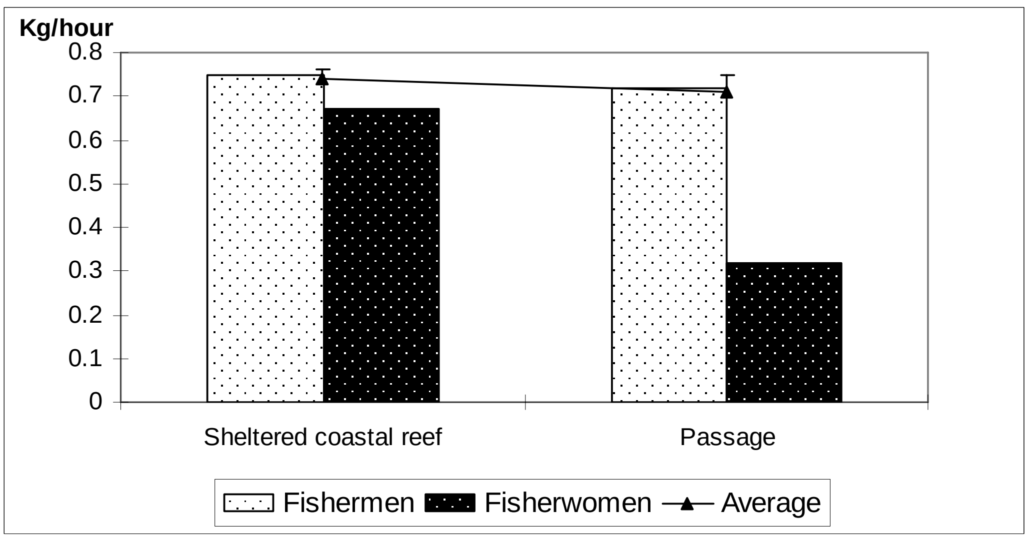

Figure 2.8: Catch per unit effort (CPUE) (kg/hour) for male and female fishers in Nauru, by habitat type. (Time includes transport, fishing, and landing).

Catches from the coastal sheltered reefs were composed predominantly from the families *Acanthuridae*, *Lethrinidae*, *Scaridae*, *Lutjanidae*, *Holocentridae* with some families (e.g. *Acanthuridae*) comprising several targeted species. Other commonly targeted species were from the families *Kyphosidae, Serranidae, Balistidae, Carangidae, Mugilidae and Mullidae*. Detailed information on the distribution of fish families in reported catches and the percent of total weight per habitat fished is provided in Appendix 2.2.

Comparison of the average size of fish of various families across the different habitats where these fish were caught (Figure 2.9) reveals that, in general fish sizes were average to small sizes with larger sizes recorded for the families *Acanthuridae, Balistidae, Carangidae, Chaetodontidae, Mullidae and Serranidae* in coastal reef areas. In passages, which were mostly around the sheltered coastal areas, the larger sized species were the same as above. The explanation for this was that some species of the *Acanthuridae* family are only now beginning to be targeted as suitable food fish and consumed.

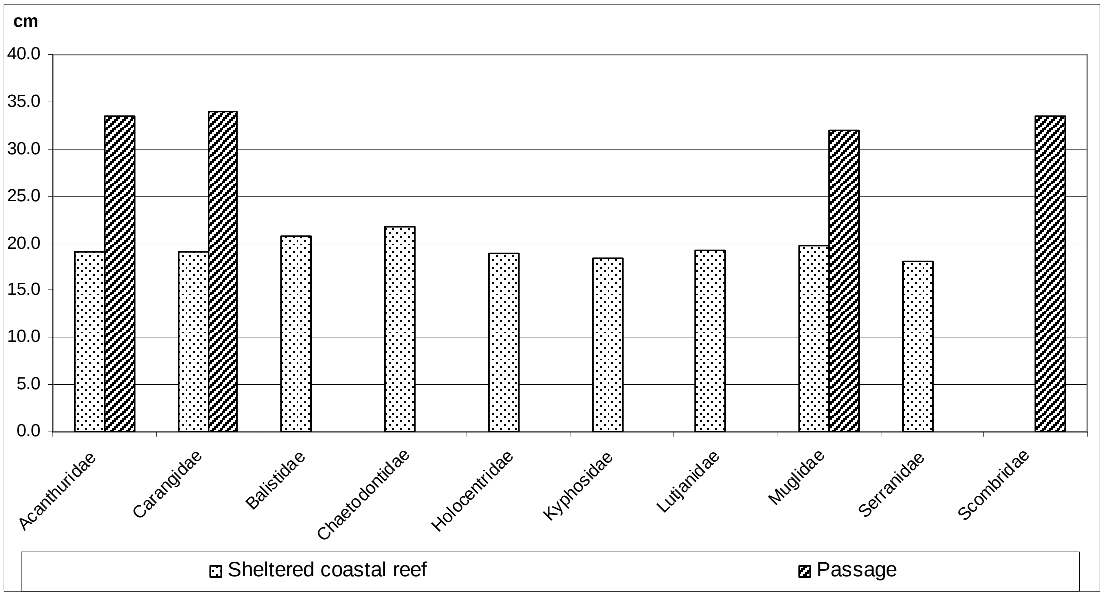

Figure 2.9: Average sizes of fish caught in Nauru by family and habitat.

Estimates of fishing pressure (Table 2.5) can only be determined for the coastal sheltered reef area where the majority of fishing took place. The total annual catch from the coastal sheltered reef is extremely high, and so are population and fisher density. However, these figures must be used with caution as Nauru does not have a lagoon system but a rather open exchange between the here presented heavily fished sheltered coastal reef and the open ocean system. This argument is supported by the reported catch figures with a high proportion of pelagic species, and hence clearly indicating the high exchange between reef and open ocean habitats.

Table 2.5: Parameters characterizing finfish fishing pressure in Nauru

Habitat	Sheltered coastal reef	Passage	Total reef (FG) area
Area km²	2.5		2.5
Average annual finfish catch kg/fisher/year	309.17 (±10.33)	231.62 (±18.02)	
Total no fishers/km²	1156		1472
Population density people/km²	4015		4015
Total fishing pressure of subsistence catches t/km²	234		234
Total no of fishers per habitat	**2917**	**569**	**4262**
Total population	**10,131**		**10,131**
Total subsistence catch (t/year)	**589.4**		**589.4**

2.2.4 Catch composition and volume — invertebrates

All invertebrate catches are from reef tops (platforms) and the intertidal flats with the exception of lobsters, which are targeted along reef slopes. Lobsters are especially targeted for commercial purposes. A total of 14 vernacular names were recorded for gleaning, while lobster diving is represented by one common name only (Figure 2.10).

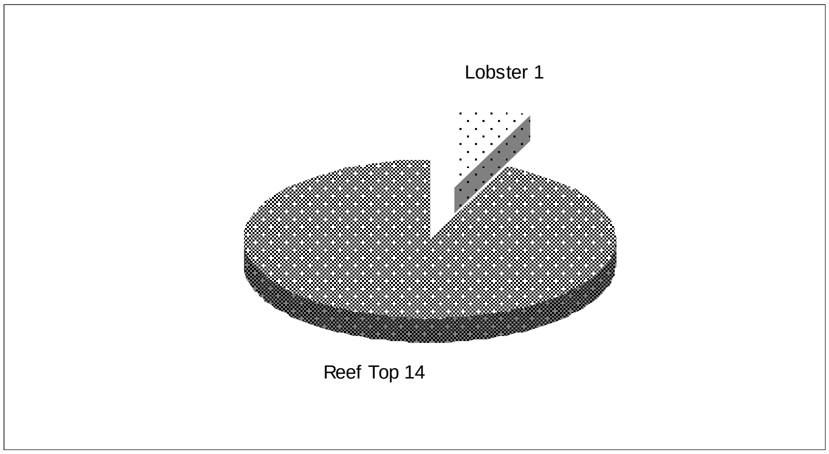

Figure 2.10: Number of recorded vernacular names for each of the invertebrate fisheries performed in Nauru.

The estimated total annual catch from interviewed invertebrate fishers equalled 27 t per year (Appendix 2.5). Of these, 41 per cent are men's catches and 59 per cent women's catches. Using the catch data as provided by respondents the annual reported catch of 27 t (wet weight) is mainly removed from reef tops (platforms) by gleaning (~95%), while the share of mainly lobster diving (~5%) and perhaps mainly intertidal gleaning (<1%) are low if not insignificant (Figure 2.11).

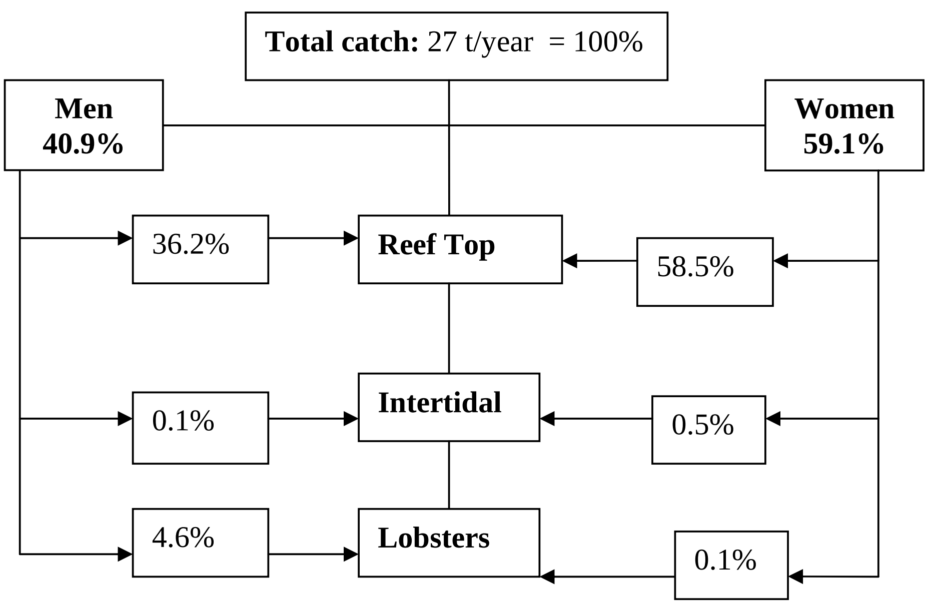

Figure 2.11: Estimated annual catch (biomass wet weight kg/year) by fishery and gender, for survey respondents in Nauru. Notes: (Significant catches were from the reef tops with >36% of men's and 58.5% of women's catches are attributed to this fishery alone).

Calculation of the total annual impact per species group (Figure 2.12) shows that the highest annual catches (in terms of kg wet weight removed) occurred in seven major species groups (i.e. *Etisus* sp., *Turbo* sp., *Cardisoma* sp., *Octopus* sp., *Thais* sp., *Tripneustes* sp. and *Actinopyga* sp. In addition, there are four further species groups that also contribute, though to a much lesser extent, (i.e. *Panurilus* sp., *Grapsus* sp., *Cypraea* sp. and *Nerita* sp. Respondents stated concerns on decline of catches and sizes on *Turbo* sp., *Cardisoma* sp. and *Octopus* sp. Concern on decline in certain species, especially the *Turbo sp*. has also been mentioned in the invertebrate section of the report, with recommendation for measures to manage the species. Details on the species distribution per habitat, and on size distribution by species, are provided in Appendices 2.3 and 2.4.

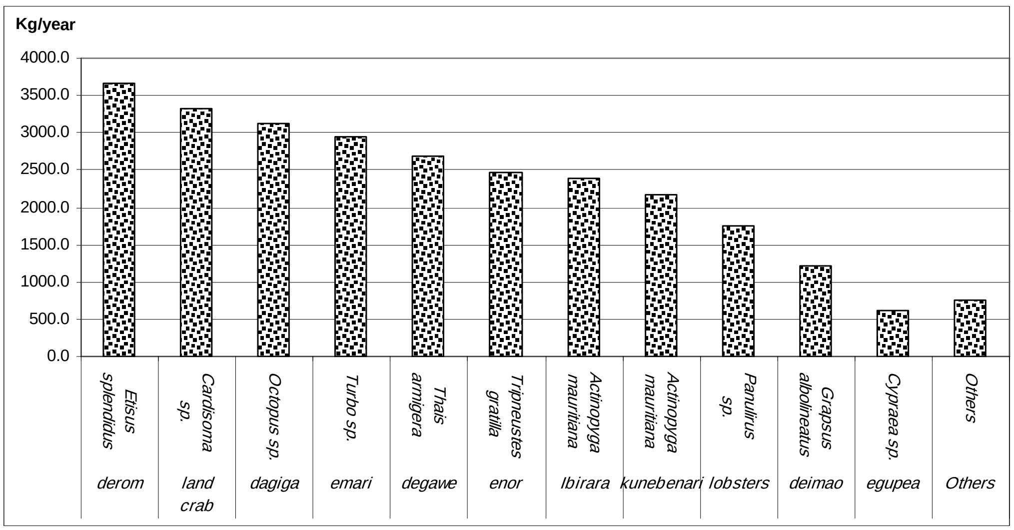

Figure 2.12: Total annual recorded catch of various species groups by Nauru survey respondents (biomass wet weight kg/year). Note that others is made up of: *Nerita plicata* (goigoi), *Trochus* sp. (trochus), *Spondylus* sp. (oyster), *Lambis lambis* (irinme), *Cymatium* sp. (eom) and *Grapsus albolineatus* (kika)

Invertebrate fishing was predominantly for home consumption. The very marginal quantity (wet weight) caught for sale mainly refers to lobsters, which is sold on the local market (Figure 2.13). With the economic crisis, food security became a priority for the people of Nauru, and this trend also shows in the invertebrate resource use.

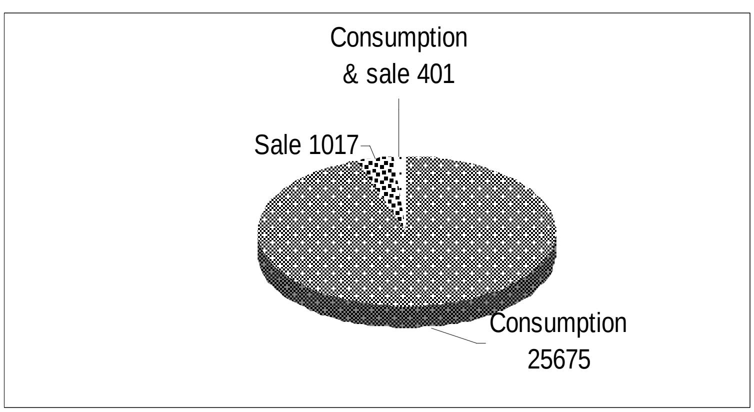

Figure 2.13: Total annual biomass used for subsistence, sale and both purposes (kg wet weight/year)

As indicated earlier, both men and women participate in invertebrate fishing and the invertebrate fisheries can be classified as a common fishery for both genders, with women slightly dominating the fisheries over men. The highest fisher density and highest annual catch per fisher (in kg wet weight/fisher/year) is on reef top fishing which is the only major fishing habitat in Nauru (Figure 2.14 and Table 2.6). The over fishing of the reef top areas result from this high concentration on a single habitat. Appendix 2.5 provides the total annual catch of invertebrates by species and category of use.

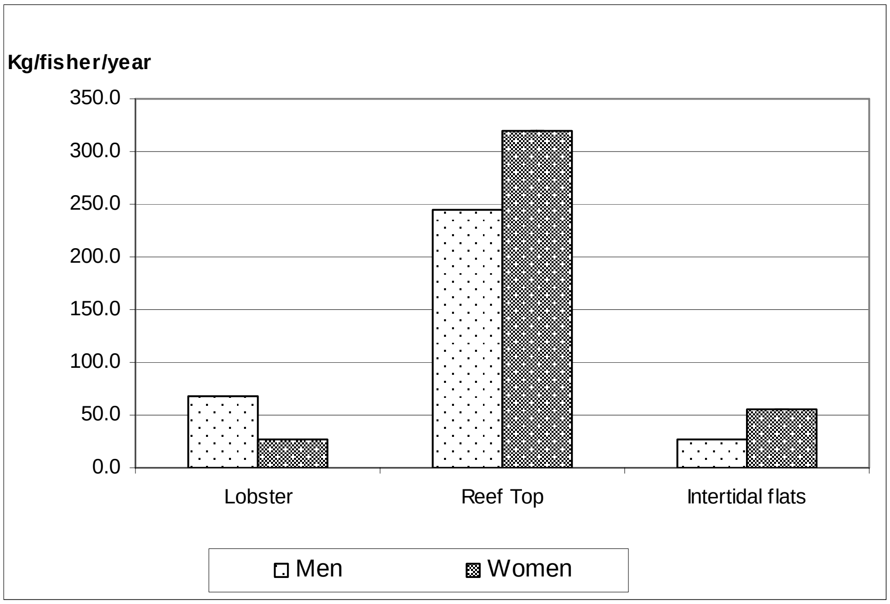

Figure 2.14: Average annual recorded catch (biomass wet weight kg) per fisher, by gender and habitat, for respondents in Nauru.

Table 2.6: Selected parameters characterizing the current level of invertebrate fishing pressure in Nauru

Fishery	Lobster	Reef Top	Intertidal Flats
Fishing ground area km²	2.5	2.5	
No of fishers / fishery	227	2699	60
No of fisher/km² fishing ground	90	1070	
Average recorded catch kg biomass wet weight/fisher/year	64.80 (±12.83)	100.36 (±23.63)	35.94 (±10.69)

2.2.5 Discussion and conclusions

There had been a steady increase in the intensity and frequency of fishing since the economic crisis in 1999 and this is trend continues. Shortage of fuel and economic hardships faced by the people limit the use of improved fishing gear and powered boats, but this has, however, not lessened the fishing pressure.

The reported catch data indicated that almost all catches were from the coastal reef areas with most fishermen combining reef fishing activities with deep bottom and deep sea fishing. Men targeted finfish more than women and were the more regular fishers. Reef fishing was predominantly for home consumption while pelagic and deep sea fishing was both for subsistence and income generation especially for the I-Kiribati and Tuvaluan communities. Like finfish fishing, invertebrate fishing was basically for home consumption with lobsters frequently sold locally.

Current fishing carried out in Nauru, is low cost with people walking and the main boats used are canoes. Sharing of catches with families and in communities is common and sharing of finfish is more common than invertebrates. Gleaning activities in Nauru is dominated by species such as the *Turbo* sp., *Thais* sp., with *Tripneustes gratilla*, some *Holothuria* sp. and *Etisus* sp. There is also collection of *Octopus* sp., *Cardisoma* sp. and *Panulirus* sp. Most of these species were recorded as consumed in most of the households interviewed with respondents acknowledging declines in catches and sizes.

Canned fish consumption was high, as households also increasingly relied on tinned fish for protein source. Tinned fish was affordable to most families as small quantities could be prepared as soup and in other ways to feed large families. Dietary pattern is a reversal of the common trend of increased reliance on imported foods, as people have now moved back to relying on traditional food sources.

Local marketing of finfish is very low and marketing of invertebrates is non-existent (apart from lobsters). The reliance on marine products for basic food needs and the lack of transportation and outlets for marketing contribute to this. Almost 92 per cent of all finfish catch was consumed or given to relatives and only 8 per cent of catches were reported sold.

With increasing pressure on resources, there is an urgent need for management strategies to be put in place. This could be implemented at the district or national level taking into account the open access nature of tenureship. There are no traditional institutions in place in Nauru, but there exist district administrations which could be utilized to organize people and activities at the district and community level. There also exists, various legislation which principally empower the Minister of Fisheries to implement various management measures ranging from quotas, restrictions on gear and bans on fishing in certain reef areas. These wide ranging powers allow the provision for various forms of management.

The very high fishing pressure on the coastal reef resources practically requires a move into the pelagic and deep oceanic species. At the moment this is hindered by fuel shortage and financial inability to engage in the fishery for most people. District-based and community implemented and monitored management mechanisms could be a starting point of the planned setting up of MPAs (NSDS 2005). Expansion of existing aquaculture initiatives is required to address needs for alternative food sources, and to take the pressure off declining wild stocks. There is, however, an urgent need for public awareness work on the vulnerability of marine resources given the high fishing intensity and increased household dependence on reef fisheries. Public education and awareness work is necessary before implementation of any form of management.

2.3 Finfish resource surveys

Finfish resources and associated habitats were assessed between 4 October and 3 November 2005, from a total of 50 transects (see Figure 2.15 for transect locations and Appendix 3.1 for transect coordinates). With the exception of adverse weather and sea conditions, the surveys were planned in a way as to enable similar numbers of dives for each working day. There was an opportunity for local Fisheries Officers to work and learn on the job with regard to the survey techniques, and thereby enhancing their fish and habitat identification skills.

2.3.1 Finfish assessment results

A total of 18 families, 49 genera, 129 species and 45,043 fish were recorded in the 50 transects (Appendix 3.2). Data relating to the 15 most dominant families in the region (here represented by only 13) form the basis of this assessment. The assessment includes fish information which represents 42 genera, 120 species and 44,748 individuals. Of this, a mean of 8 fish families, 18 fish genera, 32 fish species and 900±33.9 individual fishes were observed and recorded in each transect in Nauru (Table 2.7).

Nauru's outer reef system is composed primarily by abiotic hard bottom (77% cover, primarily limestone slab) with trenches that cut through the pavement and steeply drops off immediately after the surge zone (Table 2.7). No soft coral was observed during the surveys. The structure of fish families is relatively similar to other study sites. The dominance of Acanthuridae and Balistidae is particularly similar to what is found in Kiribati's outer reef. In these families, the predominance in density of fish genera *Acanthurus, Ctenochaetus, Naso, Zebrasoma, Melichthys, Balistapu* and *Sufflamen* is noted. The two families are represented by a total of 34 species with particularly high abundance of *Acanthurus nigricans, Ctenochaetus striatus, Acanthurus lineatus, Melichthys vidua, Naso lituratus, Zebrasoma scopas, Acanthurus triostegus, Balistapus undulatus, Sufflamen bursa, Rhinecanthus rectangulus* and *Sufflamen chrysopterus* (Tables 2.8 and 2.9).

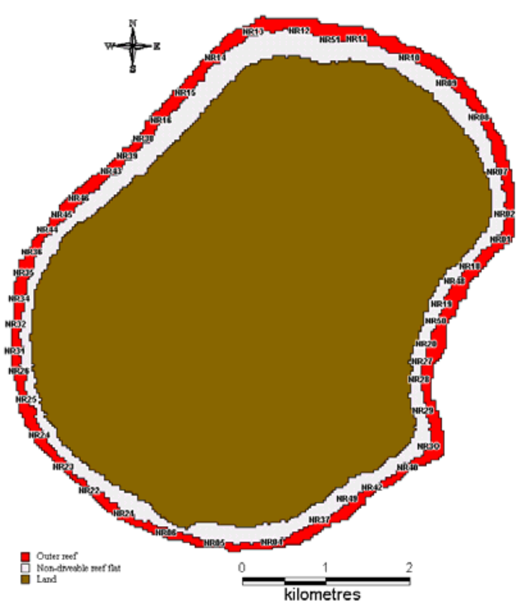

Figure 2.15: Habitat types and transects locations for finfish assessment in Nauru.

Table 2.7: Primary finfish habitat and resource parameters recorded in Nauru (average values ± standard error, and depth range)

	Outer reef
Number of transects	50
Total habitat area (km^2)	2.52
Depth (m)	8.5 (3-16)$^{(1)}$
Soft Bottom (% cover)	0.20±0.08
Rubble/Boulders	1.37±0.74
Hard Bottom	77.15±1.96
Live Coral	21.19±1.98
Soft Coral	0
Biodiversity (sp/transect)	32
Density (fish/m^2)	1.49±0.06
Biomass (g/m^2)	212.85±9.46
Size (cm FL)$^{(2)}$	16.81±0.20
Size ratio (%)	60.07±0.71

Notes: (1) minimum and maximum value on all sites
(2) FL = fork length

Table 2.8: Finfish resource assessment in Nauru.

Main habitat	Outer reef
Main substrate	Hard bottom
Main families	Acanthuridae and Balistidae
Main species	*Acanthurus nigricans, Ctenochaetus striatus, Acanthurus lineatus, Acanthurus triostegus, Melichthys vidua*, *Naso lituratus, Zebrasoma scopas*, *Balistapus undulatus*, *Sufflamen bursa, Rhinecanthus rectangulus* and *Sufflamen chrysopterus*
Assessment	Resources targeted relatively low Possible negative human impact on targeted populations of Lutjanids, Lethrinids, Scarids and Serranids. Predominance of populations of Acanthurids and Balistids

Table 2.9: Species contributing most to main families in term of densities and biomass in Nauru's outer reef.

Family	Species	Common names	Density (fish per m^2)	Biomass (g per m^2)
Acanthuridae	*Acanthurus nigricans*	White-cheek surgeonfish	3.24E-01	3.10E+01
	Ctenochaetus striatus	Lined bristle-tooth	2.20E-01	1.97E+01
	Acanthurus lineatus	Striped surgeonfish	1.95E-01	4.88E+01
	Zebrasoma scopas	Two-tone tang	1.04E-01	4.74E+00
	Acanthurus triostegus	Convict surgeonfish	6.04E-02	4.02E+00
	Naso lituratus	Orange-spine unicornfish	1.13E-01	3.41E+01
Balistidae	*Melichthys vidua*	Pink-tail triggerfish	1.17E-01	1.47E+01
	Balistapus undulatus	Orange-line triggerfish	5.31E-02	9.96E+00
	Sufflamen bursa	Scythe triggerfish	2.16E-02	2.34E+00
	Rhinecanthus rectangulus	Wedge-tail triggerfish	2.05E-02	2.39E+00
	Sufflamen chrysopterus	Half-moon triggerfish	1.90E-02	2.48E+00

The dominant herbivorous surgeonfishes show their typical association with hard substrate areas of clear and seaward reefs from the lower surge zone. The often mixed-species aggregations of these fishes occurs in fact over coral, rock, pavement or rubble substrates where they feed on filamentous algae, blue-green algae and diatoms as well as on various small invertebrates. Similarly, the dominant population of triggerfishes were observed in large numbers in seaward reefs, particularly in coral-rich areas exposed to oceanic currents. Unlike surgeonfishes, the triggers diets consist mainly of detritus with addition of crustaceans. Therefore the outer reef environment provides suitable conditions and habitat characteristics for the dominance of large groups of surgeonfishes and triggers around the island.

The dominant biomass of fish genera follows the same trend as the density, with dominance of the two same families of Acanthuridae and Balistidae and includes, in order of decreasing biomass, *Acanthurus*, *Ctenochaetus*, *Melichthys*, *Naso*, *Zebrasoma*, *Balistapus* and *Sufflamen*. The total biomass is not sensitively influenced by other large-size families such as Lethrinids, Lutjanids, Serranids and Scarids that are present in very low numbers (Figure 2.16). These trends can only be explained by intense fishing pressure on reef fisheries.

Nauru: outer reef

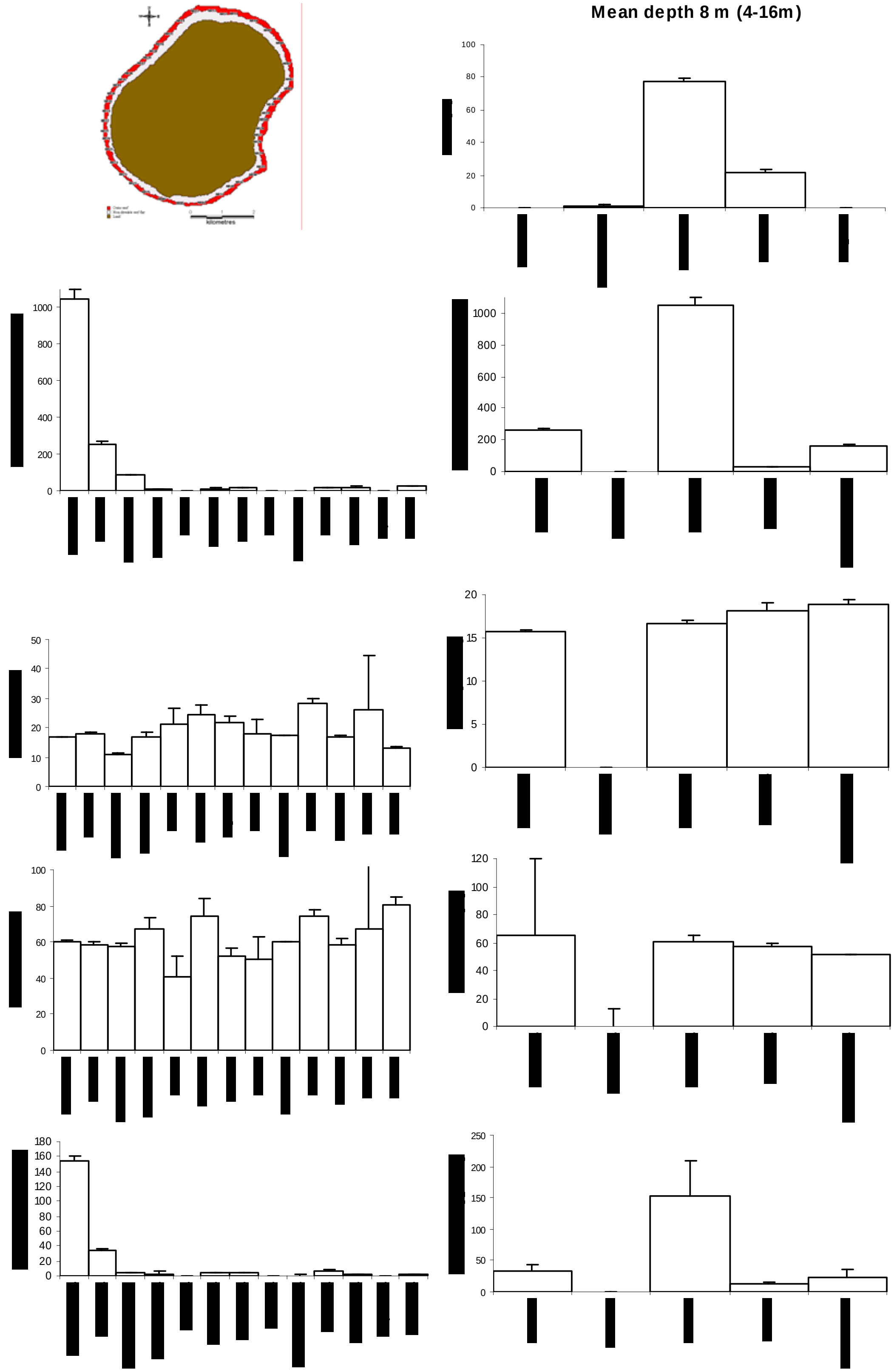

Figure 2.16: Profile of finfish resource in Nauru's outer reef

2.3.2 Comparison of Nauru results to regional average (13 countries)

Table 2.10 presented the top nine families recorded in Nauru, and these are compared to the regional average based on PROCFish/C and CoFish survey work in 13 countries and territories. Nauru's biomass and density for Acanthuridae and Balistidae are much higher than the regional average, while the mean size is very similar to the regional average. For other families, the Nauru biomass is significantly lower, while the density is similar to the regional average.

Table 2.10: Average values of biomass, density and mean size for Nauru compared to the rest of region (13 countries).

Family	Biomass N/m^2		Density (n/1000m^2)		Mean size (cm)	
	Nauru	All countries	Nauru	All countries	Nauru	All countries
Acanthuridae	153.33	59.47	1.05	0.34	16.74	17.27
Balistidae	34.18	10.07	0.26	0.09	18.11	18.39
Holocentridae	1.45	1.92	0.00	0.06	16.91	16.99
Lethrinidae	4.51	9.34	0.01	0.01	24.42	26.31
Lutjanidae	4.29	25.61	0.03	0.01	21.78	27.18
Mullidae	0.24	3.13	0.36	0.03	18.20	17.49
Scaridae	6.91	40.67	0.04	0.09	28.33	22.98
Serranidae	2.05	5.40	0.05	0.02	16.69	22.91
Siganidae	0.07	2.05	0.00	0.01	26.00	21.71

2.3.3 Discussion and conclusions

The finfish resource assessment indicates that Nauru has a very high population of surgeonfish and triggerfish, but alarmingly low populations of targeted and commercial species of groupers, snappers, emperors and scarids. The semi-pelagic species of trevallies, fusiliers, baitfishes and tunas appear to be relatively in good numbers; perhaps only sustainable for local needs. The relatively high abundance of surgeons and triggers correlates well with the high cover of hard substrate and abundant algae; moreover such herbivorous fishes are common of an outer reef environment, the only habitat surveyed in Nauru. However, Acanthurids and Balistids high abundance in Nauru, especially when compared to other country average values, could be related to recurrent ciguatera events. Available stocks of these two fish families far exceed that of the other remaining 11 families. Nonetheless, small size schooling species of mullets, snappers and goatfishes are still common immediately behind the breaker zone.

Preliminary results suggest that the relatively low populations of commercially targeted groupers, snappers and emperors signal that stock sizes are currently at, or already exceeded sustainable and optimum levels. Similarly, stock biomass of other less targeted edible species of parrotfish, now targeted by spearfishers (free diving and SCUBA), appear to be increasingly affected as well. Surgeons are the highest in abundance and therefore suitable candidates for targeting as edible species.

When comparing the results of the finfish and the socioeconomic surveys, specifically the species composition recorded, Balistidae is not common in the socioeconomic data. Those that are recorded in the socioeconomic data are mainly of different species to those recorded in the finfish results. This would indicate that Balistidae is not a favoured food fish and as such is not targeted when fishing, which would support the larger numbers of this family recorded during finfish surveys.

The family Acanthuridae is well represented in the socioeconomic data, although not to the species level in most cases. *Acanthurus lineatus* is the one species common in both data sets, which would indicate this is a species targeted during fishing activities. For other species in the Acanthuridae family, it is difficult to determine whether the species observed in the finfish data are targeted as food fish, or whether other species in this family are targeted, and thus do not show up as significant in the finfish data.

The recent 'fish kill' phenomenon experienced in Nauru in 2004 remains a mystery, with algal bloom and/or heat shock triggered by prolonged uncommon elevated water temperature, or an upwelling of de-oxygenated water from depth, as possible explanations. Similar cases were also reported from neighbouring islands and atolls of Kiribati. While this phenomenon is not common, the mortality rate was considerably high; thus, there is need to consider it with other factors affecting current state of reef fishes. Other known environment-related problems on the Island considered as having detrimental effect on the coral reefs are: sewage pipeline discharges on the surf zone; remnant bulk-metal rubbish along the continental shelf of the port area; dredging work on the new fisheries channel and jetty (Figure 2.17); as well as the extension of the runway into the intertidal reef flat.

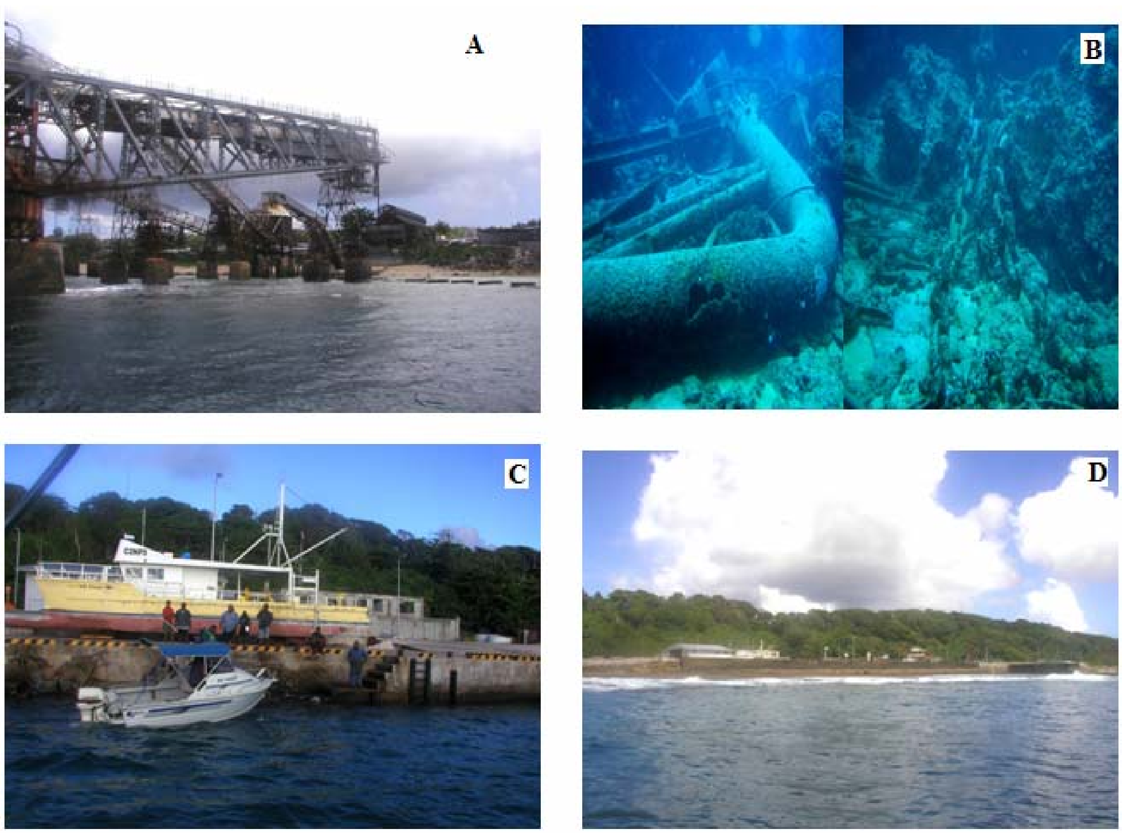

Figure 2.17: Examples of environmentally-related coastal developments on Nauru (A) Port Harbour (phosphate loading facility), (B) Metal debris remains on continental shelf along the port reef area, (C) Fisheries jetty and man-made harbour, and (D) associated reef channel.

In looking at the future, it is essential that Nauru start to monitor catches and look at management options for inshore finfish resources. There is scope to increase the catch of Acanthurids and triggerfish, as the numbers of some species are quite high. They may not be the preferred target species for food, however, their numbers would support additional fishing. In saying this, SCUBA fishing should be restricted as this is a very effective method that can lead to overfishing in a short period of time. Another management measure that can be considered is the implementation of a marine protected area (or several), to protect selected habitats and fish stocks, while ensuring adequate fishing areas are available for local fishing activities. There may also be potential for developing a small aquarium trade, as suitable species were recorded during the finfish surveys. However, a full assessment may need to be undertaken before promoting such an activity, including an economic evaluation of the transport costs versus potential returns, and it should be managed from the start.

2.4 Invertebrate resource surveys

The diversity and abundance of invertebrate species at Nauru were independently determined using a range of survey techniques (Table 2.11); broad-scale assessment (using the 'manta tow' technique; locations shown in Figure 2.18) and finer scale assessment of specific reef and benthic habitats (Figures 2.19 and 2.20).

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 2.11: Number of stations and replicates completed at Nauru

	Broad scale 'manta' assess-ments	*Reef benthos transects*	*Soft benthos transects*	*Soft benthos infaunal quadrats*	*MOP Trochus transects*	*MOP Trochus searches*	*Reef front searches*	*Sea cucumber night searches*	*Sea cucumber day searches*
Stations	8	3	-	-	-	7	16 RFs 20 RFs_ walk	-	9
Replicate measures	48 transects	18 transects	- transects	- quadrat groups	- transects	42 search periods	96+120 search periods	- search periods	54 search periods

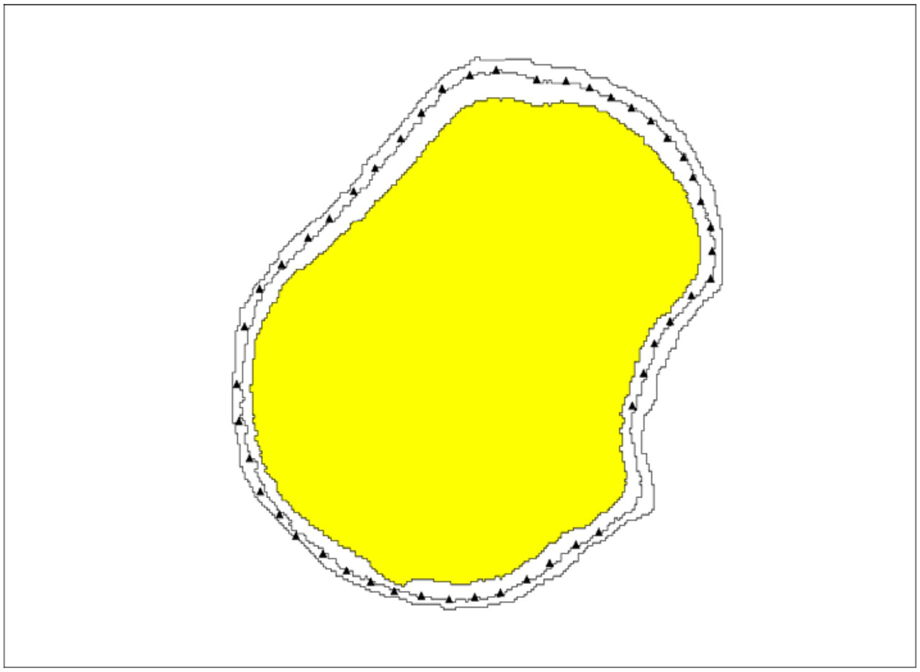

Figure 2.18: Nauru study area — broad-scale (manta-tow board) with 300 m transect waypoints (black triangles)

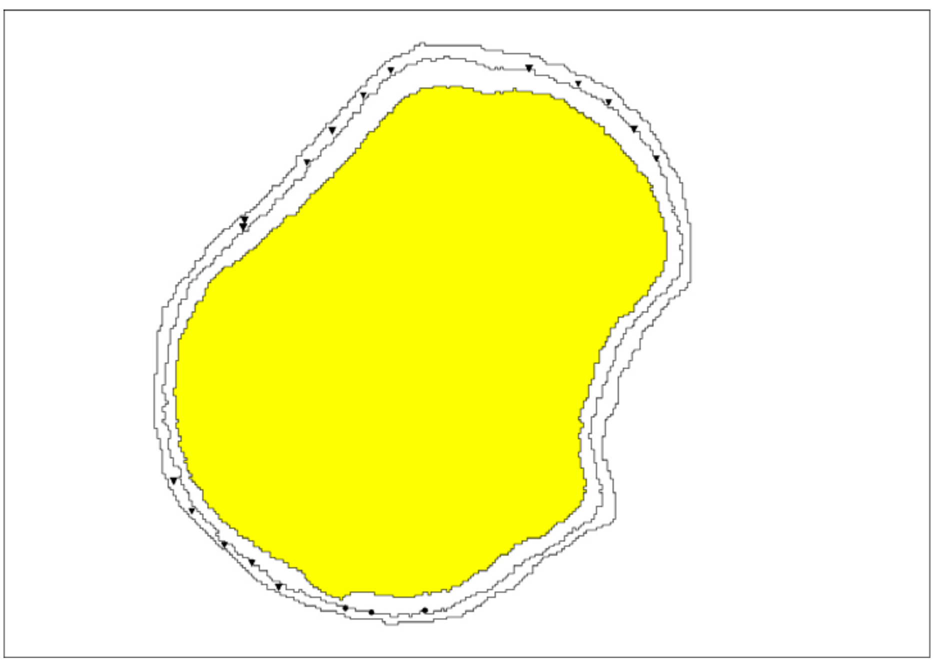

Figure 2.19: Fine scale reef benthos transect assessment stations ("RBt", circles), reef-front search stations ("RFs", inverted triangles)

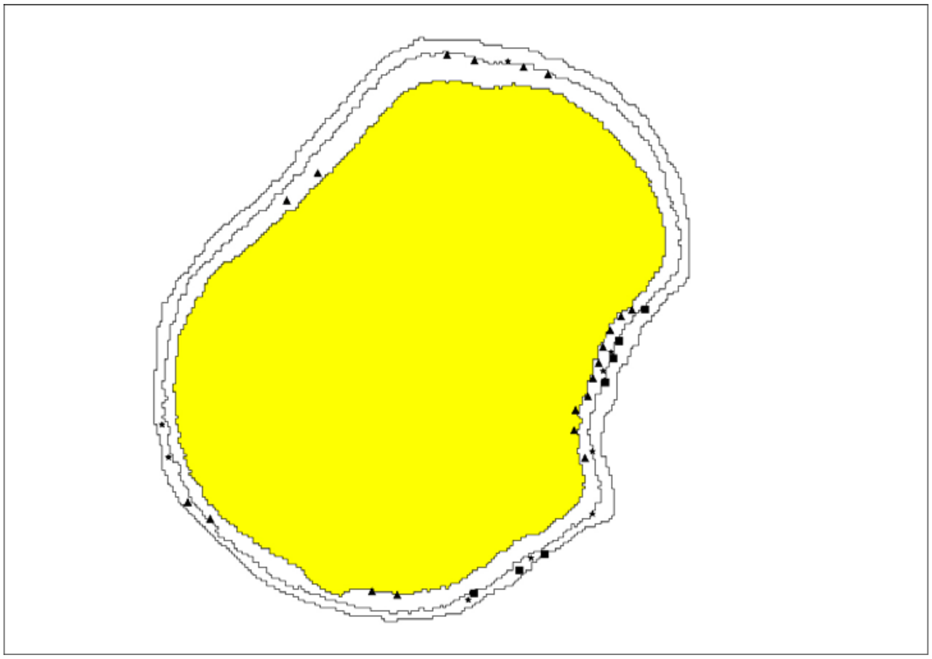

Figure 2.20: Fine scale reef-front search walk ("RFs_w", triangles), mother of pearl search ("MOPs", squares) and sea cucumber day search ("Ds", stars) stations

Forty one species or species groupings (groups of species within a genus) were recorded in the Nauru invertebrate surveys. These included, among others, 1 bivalve, 15 gastropods, 5 sea cucumbers, 9 crustaceans, 4 urchins and 3 starfish (Appendix 4.1). Information on key families and species is detailed below.

2.4.1 Giant clams

Giant clam habitat was present in the form of reef platform and reef slope but was not extensive in area. The reef platform (3.4 km^2) presented only a marginal habitat for giant clams, being predominantly exposed at low tide and having no large areas of pool habitat where water exchange with the ocean was regular. Reef slope provided a more suitable habitat for giant clams, but again was also limited in scale (2.5 km^2, lineal distance 19 km).

All reef around Nauru was accessible to fishers (no areas are protected from fishing), and reef facing south east to north east were comparatively the most exposed to ocean swell. The partially damaged wharf infrastructure in Anibare Bay is a result of exposure to constant and powerful wave action (no cyclone activity, Deiye pers comm., 2006).

The comparatively more sheltered western side was more accessible during the survey, with less current and swell (prevailing conditions came from the east north east). Reef slope (below the low tide mark) provided a relatively complex habitat with good areas for sedentary invertebrates such as giant clams. Live coral cover (mainly encrusting and small colonies) was not high and was measured at 22.8 per cent for broad scale manta transects, and 18.9 per cent for fine scale reef benthos transect stations (Figure 2.21).

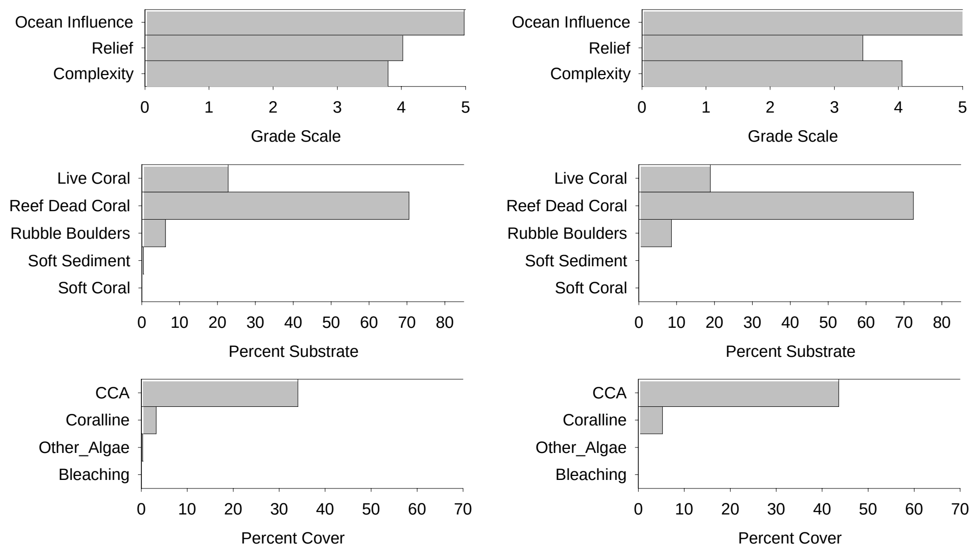

Figure 2.21 Habitat recordings from manta (left) and reef benthos transect survey (right). Note CCA = crustos coralline algae

Broad-scale manta board sampling provided an overview of potential giant clam distribution across reefs of Nauru, as did reef front searches (RFs) and reef benthos transect stations (RBt).

A study conducted in the late 1990's noted anecdotally that *Tridacna* clams in Nauru had become extinct (South and Skelton 2000). In our surveys on reefs at Nauru, this result was confirmed as no dead or live giant clams were found. The only bivalve of interest recorded was the encrusting, inequivalve jewel box shell, *Chama* sp.

There is no mention in anecdotal records of when species of giant clams become extinct on Nauru or if the larger species (*Tridacna squamosa*, *Tridacna gigas*, and *Hippopus hippopous*) were ever present in living memory. Unlike for many other Pacific Island Nations, aquaculture of these species has not occurred in Nauru for restocking (Adams et al 2001), although it remains on the priority list for aquaculture development (SPC 2005).

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

Nauru is within the geographical range of naturally distributed stocks of trochus (*Trochus niloticus*), but there are no reports of these commercial topshells in the literature. During this survey no commercial trochus were recorded (live or dead), and as a remote coralline island, Nauru is unlikely to receive in-coming recruits from remote reefs in the future (the planktonic larval life of trochus is short; 2–3 days and normally <7 days). This commercial species is one of only two invertebrate species considered as high priority on the list for aquaculture development in Nauru (SPC 2005).

The reefs around Nauru constitute a suitable benthos for adult trochus (19 km lineal distance of reef front). However, the reef platform on the coastline of Nauru is generally uplifted, with little submerged reef or shallow water rubble areas, which are characteristic habitat for juveniles of this species. Platform areas north and south of

Anibare bay held some areas that were an exception, and in these locations reef tops were more complex (Figure 2.22), with limestone pinnacles, boulders and seawater pools.

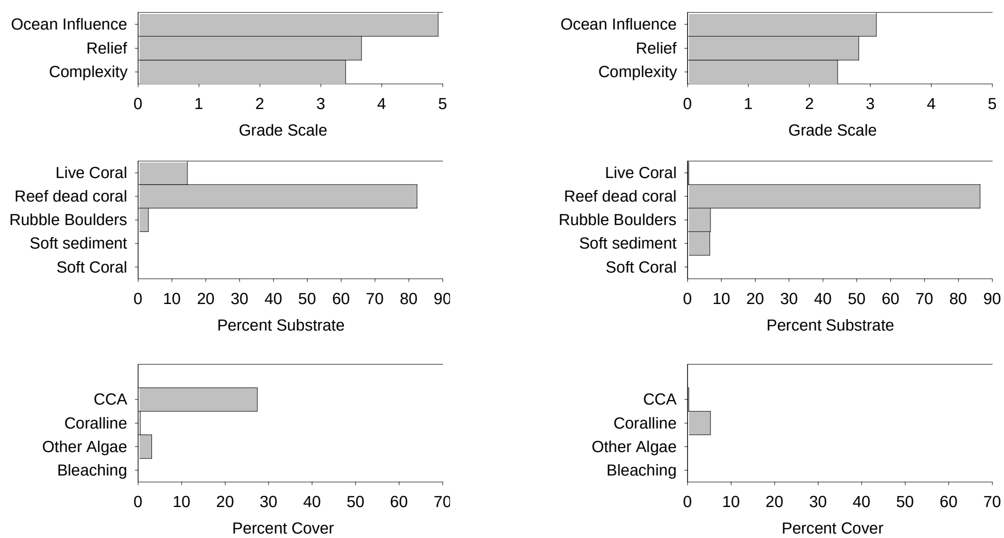

Figure 2.22: Habitat recordings from reef front searches (left) and reef front search_walk surveys (reef top, right)

The condition of shallow water areas at the reef crest and on top of the reef platform were not especially suitable, as substrates were generally covered by a high degree of epiphytes (the red algae *Jania adherens* that dominate algal growth-forming carpets on reef platforms), and there was little habitat for cryptic invertebrate juveniles. In addition, there were few other species with a similar life history to trochus, e.g. the green topshell *T. pyramis* (low commercial value) and members of the *Astralium* complex.

No blacklip pearl oysters, *Pinctada margaritifera* (live or dead shells) were found in the survey.

2.4.3 Infaunal species and groups

The reef systems in Nauru do not hold shell beds of in-ground resource species such as arc shells, *Anadara* sp. or *Gafrarium* sp. Therefore no fine scale assessments or infaunal stations (quadrat surveys) were made.

2.4.4 Other gastropods and bivalves

The smaller spider conch, *Lambis lambis*, was recorded once while on deep dives for sea cucumber assessments, whereas Seba's spider conch, *Lambis truncata* was detected in low number in shallow water dives (<10 m, mother of pearl searches) and deeper water assessments (sea cucumber day survey). Unusually, *Astralium,* and *Cerithium* were not recorded in surveys on reef benthos transects, reef front searches (snorkel) or reef front walks (reef top during low tide). *Turbo* sp. *(T. argyrostomus, T. setosus*) and *Conus*, were recorded in only low numbers. Results from other species targeted by fishers (resource species e.g. *Cypraea, Nerita, Thais* and *Vasum*) were also recorded during independent survey. A review of all assessment data can be found at Appendices 4.1 to 4.7.

Other bivalves such as *Chama* sp., which is a local rock oyster prized by gleaners, were rare.

2.4.5 Lobster

There was no dedicated night reef-front work for the assessment of lobsters in this assessment (see methods), no night work for sea cucumbers and only a single daytime observations of a lobster (MOPs, see methods).

There is a small lobster fishery in Nauru. A small group of local dive spearfishermen usually fish lobster at night to fill orders, generally from the restaurant sector. Lobsters are rarely available to the public and stocks seem to have decreased over recent years (Deiye pers comm., 2006).

2.4.6 Sea cucumbers[2]

Nauru's 21.9 km^2 of landmass is bordered by approx 6 km^2 of reef. The landmass is relatively large (karstified limestone cap of coral origin about 550 m thick lies over an ancient submerged volcano (Hill and Jacobson 1989), but there was little in the way of riverine outputs to explain the significant algal and epiphytic growth on reef platforms. In general, the oceanic influence of coastal reefs was offset by nutrient inputs into the system from land.

There was little in the way of sandy protected shallow water areas. The lack of sediment and high degree of exposure across reefs at Nauru makes them less than ideal for most deposit feeding sea cucumbers (which eat organic matter in upper few mm of bottom substrates). Even the reef platforms partially protected from swell, were generally exposed (to sun and wind) at low tides.

Species presence and density were determined through broad-scale, fine-scale and dedicated survey methods (Table 2.12, Appendix 4.7, also see methods). During in-water assessments, six commercial species of sea cucumber were recorded (Table 2.12). The small range of commercial sea cucumbers were generally found at low density. Higher value species associated with reef were rare; black teatfish (*Holothuria nobilis*), blackfish (*Actinopyga miliaris*), and prickly redfish (*Thelenota ananas*). Lower value species, such as flowerfish (*Bohadschia graeffei*) was similarly uncommon.

Surf redfish, *Actinopyga mauritiana* which is typically found on reef paltforms and reef slopes (in dynamic conditions characteristic of Nauru), were common and presented the most promising commercial option. This species has not been heavily targeted in Nauru, or alternatively the reefs are especially well suited to this species. Surf redfish were recorded in 92 per cent of broad-scale manta transects, and 100 per cent of reef front swim searches. In walking searches on the reef platform, surf redfish were at lower abundance, as would be expected for an emerged platform, but the coverage was still relatively good compared with other sites in the Pacific (45% of RFs_w stations held surf redfish in Nauru).

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[2] 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.

The methods of assessment put the density of *A. mauritiana* at approximately 200 per hectare. Although promising, the density of surf redfish was not exceptional (600+ individuals per ha has been recorded in Solomon Islands and French Polynesia). Abundances of surf redfish should be allowed to build before any commercial harvest is considered. It was noted that surf redfish is now also used as a subsistence food (lining of internal body wall is eaten raw). This is another factor to be considered by fisheries managers, if this species is going to be targeted for export.

More protected areas of reef and areas of soft benthos were generally not available at Nauru. Lollyfish, *Holothuria atra* were recorded behind reef crest areas on the exposed platform. This low value species was recorded at high density at these locations, which is typical for this type of reef habitat.

Deep dives on SCUBA (average 23 m ±0.7SE depth) were conducted in Nauru to obtain preliminary assessments of deepwater stocks, such as the high value white teatfish (*Holothuria fuscogilva*), prickly redfish, *Thelenota ananas*, and the lower value amberfish (*Thelenota anax*). Only prickly redfish, *Thelenota ananas* was found, and this was recorded at low to moderate abundance.

Table 2.12: Sea cucumber species records at Nauru

Species	Common name	Comm. Value[6]	B-S Transects n=48			Reef Benthos Stations n=3			Other *RFs = Reef Front* N=6			Other *RFs_w = Reef Front* *Ms = MOP search*			Other *Ms = MOP search* *Ds = Day search*		
			D[1]	DwP[2]	PP[3]	D[1]	DwP[2]	PP[3]	D[1]	DwP[2]	PP[3]	D[1]	DwP[2]	PP[3]	D[1]	DwP[2]	PP[3]
Actinopyga lecanora	Stonefish	M/H															
Actinopyga mauritiana	Surf redfish	M/H	164.2	179.2	92	250.0	250.0	100	87	87	100	1.4	3.1	45(RFs_w)	370.1	370.1	100 (MOPs)
Actinopyga miliaris	Blackfish	M/H													1 observation		
Bohadschia argus	Leopardfish	M															
Bohadschia graeffei	Flowerfish	L													5.2	46.4	11 (Ds)
Bohadschia similis	False sandfish	L															
Bohadschia vitiensis[4]	Brown sandfish	L															
Holothuria atra	Lollyfish	L	2	24.6	8				0.2	3.9	6	5362	5362	100(RFs_w)	3.6	8	44 (Ds)
Holothuria coluber	Snakefish	L															
Holothuria edulis	Pinkfish	L															
Holothuria fuscogilva[5]	White teatfish	H															
H. fuscopunctata	Elephant trunk	M															
Holothuria nobilis[5]	Black teatfish	H													1.1 1.2	7.6 10.7	14 (MOPs) 11 (Ds)
Holothuria scabra	Sandfish	H															
H. scabra versicolor	Golden sandfish	H															
Stichopus chloronotus	Greenfish	H/M															
Stichopus hermanni	Curryfish	H/M															
Stichopus horrens	Peanutfish	H/M															
Stichopus vastus	Brown curry	M/H															
Synapta sp.	-	-															
Thelenota ananas	Prickly redfish	H	0.3	16.4	2										54.7	82.1	67 (Ds)
Thelenota anax	Amberfish	M															

Notes: [1] D = mean density per hectare; [2] DwP = mean density per hectare for transects or stations where the species was present; [3] PP = percentage presence (units where the species was found); [4] B-S manta record from Pele Reserve area [5] 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; [6] L = low value; M = medium value; H= high value.

2.4.7 Other echinoderms

No edible slate urchins *Heterocentrotus mammillatus* were recorded on the reef front searches or subtidally in Nauru. *Echinothrix* sp. (mainly *E. diadema*) were very common (>95% of manta transects and reef front searches, at a mean density of close to 1000 per ha, see Table 2.13 and Appendices 4.1 to 4.8). No collector urchins, *Tripneustes gratilla*, were recorded in independent survey, despite this species being recorded as the one targeted by fishers in the socioeconomic surveys.

Table 2.13: Average density (total number) of sea urchins found in various assessment methods at Nauru.

Assessment Type	*Echinometra mathaei*	*Echinothrix* sp.
B-S Manta transects		1029.3 (3050)
Reef_Benthos_Transect stations		2711.8 (244)
Reef_Front_Search stations	4.7 (19)	782.1 (3191)
Reef_Front_Search_Walk stations	0.2 (2)	0.3 (3)
MOP_Search stations	4.3 (4)	1245.7 (1151)
Sea_Cucumber_Day_Search stations		2.4 (6)

Although urchins are collected as a subsistence food source, the high number on Nauru's reefs and low number of other sedentary species reflect a habitat that is becoming partially dominated by urchins. This type of situation has the potential to limit further recruitment of other species, as urchins dominate the cryptic spaces in the day and feed on or dislodge newly settled invertebrates at night.

Starfish such as *Linckia laevigata*, the blue starfish, corallivore starfish such as the pincushion star *Culcita novaeguineae* and crown of thorns (COTS *Acanthaster planci*), were rarely observed in the survey (2% of manta transects).

2.4.8 Discussion and conclusions

The key issues for Nauru with respect to management of coastal fisheries resources are that the island is geographically isolated from other Pacific reef systems that could be a source of replenishment/recruitment. Nauru is small in overall size and has limited area of intertidal and reef habitats, and intertidal reef habitats are often emerged for extended periods, and could not support large numbers of invertebrates. Even submerged reef supports a low diversity of coral reef habitat and commercial/subsistence species complement — compared to what is normally present in Pacific island systems.

The loss of giant clams around Nauru is significant, as these are generally considered a cornerstone invertebrate group of species in subsistence reef fisheries. Anecdotal evidence suggests that a viable *Tridacna* (probably *T. maxima*) population was lost from Nauru as early as the 1980s, although a single specimen (18–25cm) was reported as being seen as late as 2002 (at Gebab Channel south west of the island in about 20 m depth, Deiye pers comm., 2006). There are reports of the presence of dead giant clam shells seen outside of people's homes, which suggest they were once commonly used in traditional customs (Petit-Skinner 1995 quoted in Jacob 2000). Although clams have been lost from the general catches of Nauru fishers, North et al (1903 quoted in Jacob 2000) documented the existence of *T. maxima* (as *T. elongate*). The existence of a local name for giant clam in the Nauru dialect "Earinbawo", suggest there was a more significant presence of giant clam in the past.

It is also unfortunate that no MPAs exist to protect remnant stocks of overfished species and habitat for future restocking ventures. Effort to protect an area of reef may be considered for the North East corner of Nauru, where habitat is less impacted and there appears to be greater diversity of species.

Data collected on this mission suggest that trochus, *T. niloticus* can be transplanted to Nauru, although the reef platform habitat was not generally suitable for juvenile stages of their life history. Therefore, any releases of trochus may consider first using adults, and making initial placement of transplanted shell in protective cages within well circulated pools, and then proceed to a more staged release to the reef slope. Staged release of trochus acclimatises the shell to local conditions, and careful placement in areas where epiphytic growth (and potential food sources for trochus is more developed) will ensure the transplanted stock has the best chance of survival.

Based on the information collected, there are a very limited number of sea cucumber species available for commercial fishing at Nauru. The exposed environment of Nauru plays a large part in defining its potential. High value species such as black teatfish, *Holothuria. nobilis* and prickly redfish, *Thelenota ananas* are insufficient to support commercial fishing. The medium to high value species, surf redfish, *Actinopyga mauritiana* looks to be well suited to conditions in Nauru. Occurrence across stations was high, and density was moderate. If densities were to build (400–600 per ha), then commercial harvests of this species should be considered. Monitoring of this stock is suggested, as in future years, good recruitment could offer opportunities for periodic commercial harvests. It was noted that surf redfish, *A. mauritiana* and lollyfish, *Holothuria atra*, are presently targeted for subsistence purposes, being eaten raw or cooked by gleaning fishers. In the interests of food security, this activity may delay the development of an export fishery.

Present densities of urchins, particularly *Echinothrix* sp. are high. Although these urchins stop the build-up of algae and therefore are useful in the system, they may also have a negative influence on incoming recruitment. Present densities of corallivore starfish, such as the crown of thorn starfish are not presently a concern to Nauru.

2.5 Overall recommendations for Nauru

The people of Nauru are going through difficult times with the current economic crisis, low wages and purchasing power for those with jobs, high fuel costs when fuel is available, and the need to put food on the table for themselves and their families. The increased focus on harvesting marine resources to address the food security issue, has the potential to devastate the inshore resources unless appropriate measures are put in place to ensure sustainable harvesting of the resource.

The following recommendations are based on the CoFish survey work (socioeconomic, finfish and invertebrate) conducted in Nauru in October and November 2005, and anecdotal and published information that has been researched over the last 12 months. They are provided to assist the Government of Nauru and its people to look to the future and the sustainable harvesting of marine resources. It is recommended that:

- The Government needs to closely monitor the level of fishing efforts for both finfish and invertebrates (through in-water assessment and socioeconomic surveys) and implement management measures affecting catch (e.g. size limits; total allowable catches of heavily exploited species) and fishing practices (e.g. gear types, mesh sizes);

- Specific management systems are essential for build-up and viability of invertebrate stocks and heavily fished finfish stocks, with the management regimes being controlled by communities, at scales larger than the current village boundaries;

- The Government considers the implementation of one or two marine protected areas (MPAs) that cover appropriate habitat (including reef ecology studies for choice of the best location) and areas where resources are still available, but do not undermine the people's ability to fish for their family needs;

- If the Government starts to implement management arrangements, preferably through communities, that an awareness programme be implemented at the same time to allow people and communities to fully understand the rational behind the management measures and the need for community support if arrangements are to work successfully;

- The Government looks to restrain SCUBA spearfishing, as the efficiency of this gear outweighs all the more traditional means of fishing, and if not properly controlled will have a drastic effect on targeted fish stocks;

- The abundant herbivorous Acanthurids could be sustainably targeted by local fishing activities instead of parrotfish, groupers, snappers and emperors; the latter fish groups are most probably being impacted by fishing activities at present;

- The Government continues to foster development of the offshore resources, more specifically tunas and other pelagics, to reduce fishing pressure on inshore resources;

- The Government looks at options for assisting local fishermen to fish for pelagics, possibly through encouraging Nauruans to use canoes and continue the fishing practices of the I-Kiribati and Tuvaluan fishermen who have departed from Nauru, and through putting out shallow water fish aggregating devices for them to fish around;

- The Government considers strengthening development of the aquaculture sector (such as freshwater farming of milkfish) and look at the possibility of mariculture of certain species, to enlarge options currently available from reef resources;

- The Government has an assessment undertaken to look at the stocks of aquarium fish, with the harvesting of these encouraged through the private sector and appropriate management measures, if the stocks can be sustainably harvested and viably exported;

- Any additional survey work by SPC on invertebrates should focus on the species that are of most concern for Nauruan people and which are the main focus of current harvest activity, including an assessment of the status and population dynamics of *Turbo* sp., and nocturnal crustacean species (especially lobsters and crabs); and

- The Government considers the introduction of *Tridacna maxima*, and possibly trochus adults, within an area protected from fishing and gleaning, possibly as part of an MPA as recommended above.

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APPENDICES

APPENDIX 1 PROCFISH/C AND COFISH 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. The socioeconomic survey 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 urbanization 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 maximize income, changes in lifestyle and diet, and increased dependence on imported foods). The latter are not considered in this survey.

The project utilizes a "snapshot approach" that provides 5–7 working days per site (with up to 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 practiced by a particular community, the degree to which both gender groups 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 or fishery, respectively. Thus, the project's time, 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, persons involved in marketing (at local, regional, or international scale) who operate in targeted community are also surveyed (e.g. agents, middlemen, shop owners, etc.).

Key informants are targeted in each community to collect general information on the nature of local fisheries, 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 village(s) 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. In such cases, representative villages, or a cross section of the population of all villages, are selected to be included in the survey.

In addition, fishers (and 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 that 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-standardized format. The complete set of questionnaires used is attached as Appendix 1.1–2).

Most of the data is 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 finalized, 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 also 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 characterized;
- 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)
- **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 <u>demographic assessment</u> 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 that practice either finfish or invertebrate fisheries exclusively, or that practice both. The share of adult men and women pursuing each of the three fishery categories are 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 per cent. 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 organizing 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 expenditures only, on a weekly, bi-weekly, or monthly basis, depending on the payment interval common in a particular community. Expenditures quoted in local currency are converted into US dollars (USD) to enable regional comparison. Conversion factors used are indicated.

Geomorphologic differences between low and high islands influence the role that agriculture plays in a community, but differences in land tenure systems and the particulars of each site are also important, and the latter factors are used in determining the percentage of households that have access to gardens and agricultural land, the average size of these areas, and the type (and if possible number) of livestock that are at the disposal of an average household. A community whose members are equally engaged in agriculture and fisheries will either show distinct groups of fishers and farmers/gardeners, or reveal active and non-active fishing seasons in response to the agricultural calendar.

The frequency and amount of remittances received from family members working elsewhere in the country or overseas is a proxy to assess the degree to which principles of the MIRAB[1] economy apply. MIRAB was coined to characterize an economy dependent on migration, remittances, foreign aid, and government bureaucracy as its major sources of revenue (Small and Dixon 2004, Bertram 1999, Bertram and Watters 1985). A high influx of foreign financing, and in particular remittances, is considered to yield flexible and stable economic conditions at the community level (Evans 2001), and may also substitute for or reduce the need for local income-generating activities, such as fishing.

The number of boats per household is indicative of the level of isolation, and is generally higher for communities that are located on small islands and far from the nearest regional centre and market. The nature of the boats (e.g. non-motorized, handmade dugout canoes, dugouts equipped with sails, and the number and size of any motorized 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 minimize extrapolation errors.

A variety of data are collected to characterize 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. comm.). Size classes are identified using size charts (Figure A1.1.1).

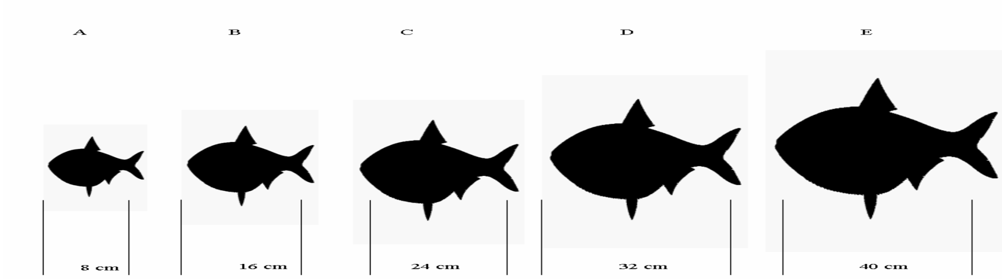

Figure A1.1.1: Finfish size field survey chart for estimating average length of reef and lagoon fish (including 5 size classes from A=8 cm to E=40 cm, in 8 cm intervals).

[1] MIRAB stands for migration (MI), remittances (R), aid (A) and bureaucracy (B)

The total weight of fresh fish consumed is calculated using the following equation.

Total weight of fresh fish consumed

$$F_{wj} = \sum_{i=1}^{n} (N_{ij} \bullet W_i) \bullet 0.8 \bullet F_{dj} \bullet 52 \bullet 0.83$$

Where:

F_{wj} = finfish net weight consumption (kg/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[(1)] = total number of weeks/year

0.83[(2)] = correction factor for frequency of consumption

1) 52.1429 2) 304/365

Two correction factors are used: a correction for the 20 per cent of fish parts that are non-edible (factor of 0.8) (Kronen et al. 2005) and a downward correction of 17 per cent for frequency of consumption (factor of 0.83), 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 (by weather conditions, feasts, travel time, etc.).

In the case of invertebrates, we record the species, usually the vernacular names, invertebrates most often consumed, and the quantities and size classes (Figure A1.1.2) that constitute a normal daily meal for the entire household. At this stage of the project we can provide information on the frequency with which invertebrates are consumed by the average household in any of the communities surveyed. As far as the quantity of invertebrates consumed is concerned we can only approximate for total wet weight, and the proportion of edible and non-edible parts per major species groups reported (Annex 1.1–3). The acquisition of more detailed information on wet weight, edible and non-edible as well as valuable and non-valuable parts of the most important invertebrate species harvested in the region is currently underway.

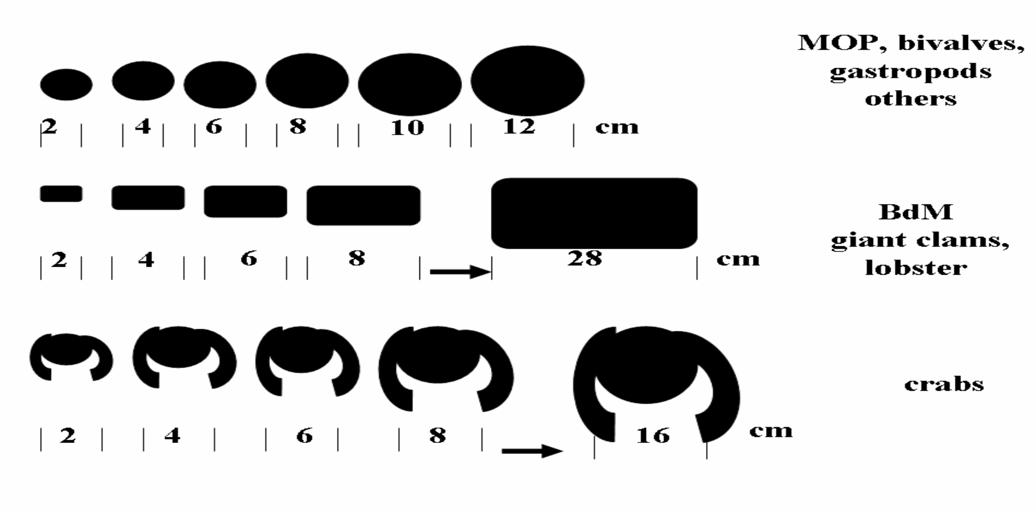

Figure A1.1.2: Invertebrate size field survey chart for estimating average length of different species groups (2 cm size intervals).

Information on canned fish consumption is assumed to render an insight into the degree that westernization (and specifically a lack of free time and the increased value of convenience) has led villagers to substitute canned fish in place of fresh fish. This assumption is based on the hypothesis that villagers prefer fish on the basis of taste, and that canned fish is also the cheapest protein substitute (as compared to fresh and canned meat products). Quantities are established by recording the number and size (usually small, medium or large) of cans consumed. Net weight of fish contained in the various can sizes recorded is obtained from local shops and suppliers.

Total household canned fish consumption is calculated using the following equation, with canned fish data entered as the total number of cans per can size consumed by the household at a daily meal.

<u>Total household canned fish consumption</u>

$$CF_{wj} = \sum_{i=1}^{n} \frac{(N_{cij} \bullet Wc_i)}{1000} \bullet F_{dcj} \bullet 52 \bullet 0.83$$

Where:

CF_{wj} = canned fish net weight consumption (kg/household/year) of household *j*

N_{cij} = number of cans of can size *i* for household *j*

n = number of can size classes

W_{ci} = weight (kg) of can size class *i*

1000 = to convert g fish weight per can into kg

F_{dcj} = frequency of canned fish consumption (days/week) for household *j*

52[2] = total number of weeks/year

0.83[3] = correction factor for frequency of consumption

[2] 52.1429

[3] 304/365

A correction factor of 0.83 is applied to take into account exceptional periods (periods or occasions such as feasts, special occasions, particular fishing seasons, etc.), where canned fish may be substituted by other foods.

Per capita consumption figures are determined using age-gender correction figures for all members of each household surveyed and the total annual consumption of fresh fish, and canned fish. As mentioned above, these figures can only be calculated for fresh fish and canned fish; per capita invertebrate consumption is determined by using the approximate ratios between edible and non-edible parts for the major invertebrate groups (Annex 1.1–3).

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 5 year-old child. The following age-gender corrections are applied (Kronen et al 2005; Becker and Helsing 1991):

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 equations used to calculate per capita fresh fish and canned fish consumption are as follows.

Per capita consumption of finfish

$$F_{pcj} = \frac{F_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

Where:

F_{pcj} = Finfish net weight consumption (kg/per 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 persons for age class *i* and household *j*

C_i = correction factor for age-gender class *i*

Per capita consumption of canned fish

$$CF_{pcj} = \frac{CF_{wj}}{\sum_{i=1}^{n} AC_{ij} \bullet C_i}$$

Where:

CF_{pcj} = Canned fish net weight consumption (kg/per 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 persons for age class *i* and household *j*

C_i = correction factor of age-gender class *i*

Finfish Fisher Survey

The finfish fisher survey primarily aims to collect the data needed to understand the finfish fisheries strategies, patterns and dimensions, 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 habitats, 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, preferences of members of the fishing party, etc. 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 on 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 practiced by most fishers, the resource data for individual geomorphologic habitats needs 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 localized, 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 to 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. This is not always possible, however, 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. First, some fish species are seasonal and may be dominant during a short period of the year but do not necessarily appear frequently in the average catch. Depending on the time of survey implementation this may result in over or under representation of these species. Secondly, fishers usually employ more than one technique. Average catches may vary substantially by quantity and quality depending on which technique they use.

We address these problems by recording any fish that plays a seasonal role. This information may be added and helpful for joint interpretation of resource and socioeconomic data. Average catch records are complemented by information on the technique used, and fishers are encouraged to provide the average catch information for the technique that they employ most often.

The design of the finfish fisher survey allows the collection of details on fishing strategies, and quantitative and qualitative data on average catches for each habitat. Targeting men and women fishers allows differences between genders to be established.

Determination of fishing strategies includes:

- frequency of fishing trips
- mode and frequency of transport used for fishing
- size of fishing parties
- duration of the fishing trip
- time of fishing
- months fished
- techniques used
- ice used
- use of catch
- additional involvement in invertebrate fisheries.

The frequency of fishing trips is determined by the number of weekly (or monthly) trips that are regularly made. The average figure resulting from data for all fishers surveyed, per habitat targeted, provides a first impression of the community's engagement in finfish fisheries and shows whether or not different habitats are fished with the same frequency.

Information on the utilization of non-motorized or motorized boat transport for fishing helps to assess accessibility, availability and choice of fishing grounds. Motorized 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 maximization, 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 percent 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 2 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, spear fishing targets particular species, and the impacts of spear fishing 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 that 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 is 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 commercialization, 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 per cent (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
- 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 5 major size classes. The length of any fish that exceeds the largest size class 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 fishes, 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 is further used to calculate the total weight for each family (includes all species reported) and habitat. We then convert these figures into the percentage distribution of the total annual catch, by family and habitat. Comparison of relative catch composition helps to identify commonalities and major differences, by habitat, and between those fish families that are most frequently caught.

A number of parameters from the household and fisher surveys are used to calculate the total annual catch volume per site, habitat, gender, and use of the catch (for subsistence and/or commercial purposes).

Data from the household survey regarding the number of fishers (by gender and type of fishery) in each household interviewed is extrapolated to determine the total number of men and women that target finfish, invertebrates, or both.

Data from the fisher survey is used to determine what proportion of men and women fishers target various habitats or combination of habitats. These figures are assumed to be representative of the community as a whole, and hence 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 that collect only invertebrates and those that target both invertebrates and finfish. These numbers are also disaggregated by gender.

The total annual catch per fisher interviewed is calculated, and the average total annual catch reported for each type of fishing activity/fishery (including finfish and invertebrates) by gender is then multiplied by the total number of fishers (calculated as detailed above, for each type of fishing activity/fishery and both genders). More details on the calculation applied to invertebrate fisheries are provided below.

Total annual catch (t/year)

$$TAC = \sum_{h=1}^{N_h} \frac{Fif_h \bullet Acf_h + Fim_h \bullet Acm_h}{1000}$$

Where:

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

The average annual catch of female fishers for habitat *h* is calculated as follows (the equivalent formula is used for male fishers):

$$Acf_h = \frac{\sum_{i=1}^{If_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{12 - Nfm_i}{12} \bullet Cfi}{If_h}$$

Where:

If_h	=	number of interviews of female fishers for habitat *h*
f_i	=	frequency of fishing trips (days/week) as reported on interview *i*

Nfm_i = Number of months not fished (reported on interview *i*)
Cf_i = Average catch reported for interview *i* (all species)

(In all cases, 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 their fishing ground.

The accuracy of this calculation is determined by reliability of the data provided by interviewees, and the extrapolation procedure. The variability of the data obtained through fisher surveys is illuminated by providing standard errors for the calculated average total annual catches. The size of any error stemming from our extrapolation procedure will vary according to the total population at each site. As mentioned above, this approach is best suited to assess small and predominantly traditional coastal communities. Thus, the risk of over- or underestimating fishing impact increases in larger communities, and those with greater urban influences. We provide both the total annual catch by interviewees (as determined from fisher records) and the extrapolated total impact of the community, so as to allow comparison between recorded and extrapolated data.

The total annual finfish consumption of the surveyed community is used to determine the share of the total annual catch that is used for subsistence, with the remainder being the proportion of the catch that is exported (sold externally).

Total annual finfish export

$$E = TAC - \left(\frac{F_{tot}}{1000} \bullet \frac{1}{0.8}\right)$$

Where:
E = total annual export (t)
TAC = total annual catch (t)
F_{tot} = total annual finfish consumption (net weight kg)
$\frac{1}{0.8}$ = to calculate total biomass/weight, i.e. compensate for the earlier deduction by 0.8 to determine edible weight parts only.

In order to establish fishing pressure, we use the habitat areas as determined by satellite interpretation. However, as already mentioned earlier, 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 field work. 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.

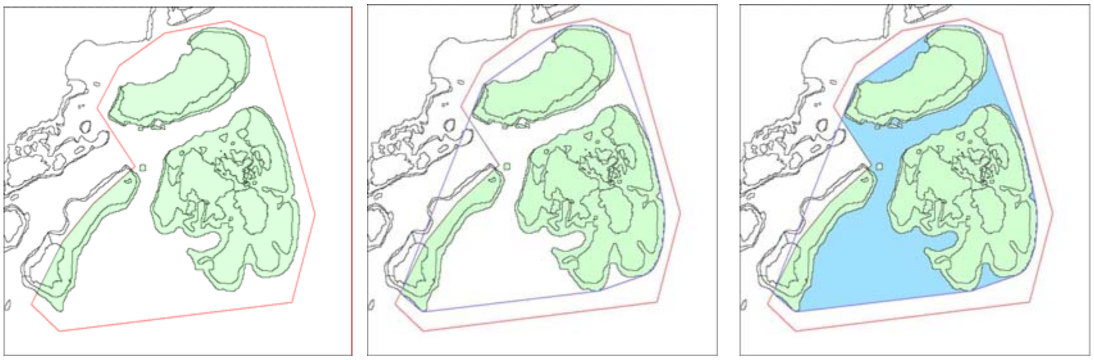

Figure A1.1.3: Determination of lagoon area. The fishing ground (in red) is initially delineated using information from fishers. Reef areas within the fishing area, (in green; interpreted from satellite data) are then identified. The remaining non-reef areas within the fishing grounds are labelled as lagoon (in blue) (developed using MapInfo).

We use the calculated total annual impact and fishing ground areas to determine relative fishing pressure. Fishing pressure proxies 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 proxies, 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 be also done at the regional level in the future.

The catch per unit effort (CPUE) is generally acknowledged as a proxy to monitor development 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 maximization 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 follows that 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 thus 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:

(i) The invertebrate resource survey defines invertebrate fisheries using differing parameters (several are primarily determined by habitat, others by target species).

These fisheries classifications do not necessarily coincide with the perceptions and fishing strategies of local people, however. In general, there are two major groups of invertebrate fishers: those that walk and collect with simple tools, and those that 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 production (trochus, BdM, lobster, etc.). However, some of the divers may harvest invertebrates as a byproduct of spear finfish fishing. Fishers that primarily walk (some may or may not use non-motorized or even motorized 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 the 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 localized, 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. Thus variations in the association of vernacular and scientific names are not that frequent between different languages.

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 rather than rare species that are used mainly for consumption. Seasonality of invertebrate species appears to be a less important issue as compared to finfish.

We address these problems by encouraging people to also share with us the names of species that 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 considerable 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; and we have also approximated the proportion of edible and non-edible biomass. However, the latter does not necessarily take into account the potential value of, in particular, non-edible parts of invertebrates. More detailed data is currently being acquired.

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 performs finfisheries.

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 specified by number, size and/or total weight. If local units such as bags (plastic bags, flour bags), cups, bottles, buckets, etc. are used the approximate weight of each unit is estimated and/or weighed during the field survey and average weight applied accordingly. For size classes, size charts for different species groups are used (Figure A1.1.2).

The proportion of fishers targeting each fishery (as defined by the resource survey) is presented as a percentage of all fishers. Records of fisheries that are combined in one trip are disaggregated by counting each fishery as a single data entry. The same process is applied to determine the share of women and men fishers per fishery (as defined by the resource survey).

The number of different vernacular names recorded for each fishery is useful to distinguish between opportunistic and specialized 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 2 months (304/365 days) of each year are not used for fishing due to festivals, funerals, and bad weather conditions).

Total annual catch

$$TACj = \sum_{h=1}^{N_h} \frac{F_{inv} f_h \bullet Ac_{inv} f_{hj} + F_{inv} m_h \bullet Ac_{inv} m_{hj}}{1000}$$

Where:

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 of 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 of male invertebrate fishers (kg/year) for habitat *h* and species *j*
N_h	=	number of habitats

The average annual catch of female invertebrate fishers for habitat *h* is calculated as follows (the equivalent formula is used for male fishers):

$$Ac_{inv}f_{hj} = \frac{\sum_{i=1}^{I_{inv} f_h} f_i \bullet 52 \bullet 0.83 \bullet \frac{Fm_i}{12} \bullet Cf_{ij}}{I_{inv} f_h}$$

Where:

$I_{inv}f_h$	=	number of interviews of invertebrate female fishers for habitat *h*
f_i	=	frequency of fishing trips (days/week) as reported on interview *i*
Fm_i	=	Number of months fished (reported on interview *i*)
Cf_{ij}	=	Average catch reported for interview *i* and species *j*

The total annual biomass (t/year) removed is also calculated and presented by species after transferring vernacular names into 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). The size frequency distribution 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 and both. We also provide an index of all species recorded through fisher interviews and their use (in per cent 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 by 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 proxies 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 proxies, 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 be also 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 makes the determination of catch per unit effort (CPUE) difficult. Substantial differences in the economic value of species adds another challenge. We therefore refrain 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 is 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, which allow automatic retrieval of the descriptive statistics that are used when summarizing 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 fishing)
- Fisheries (finish and invertebrate and socioeconomics) general information survey

HOUSEHOLD CENSUS AND CONSUMPTION SURVEY

HHNO ☐

Name of Head of Household: ________________ Village:_________________

Name of person asked: _____________________ Date: __________________

Surveyor's ID: __________________

1. Who is the head of your household? male ☐ female ☐
   (must be living there; tick box)
2. How old is the head of household? *(enter year of birth)* ☐
3. How many people ALWAYS life 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 do live in your household? ☐
   (*enter number of people who go fishing/collecting regularly)*

invertebrate fishers		finfishers		invertebrate&finfishers	
M	F	M	F	M	F
☐	☐	☐	☐	☐	☐

8. Does anybody in this household own a boat? yes ☐ no ☐

9a. Canoe ☐ length? ☐ meter/feet

Boat with outboard engine ☐ length ☐ meter/feet ☐ HP

9b. Canoe ☐ length? ☐ meter/feet

Boat with outboard engine ☐ length ☐ meter/feet ☐ HP

9c. Canoe ☐ length? ☐ meter/feet

Boat with outboard engine ☐ length ☐ meter/feet ☐ HP

10. (Where do you get your CASH Money 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 (handicraft, etc.) ☐ specify: ____________________

11. Do you get remittance? yes ☐ no ☐

12. How often? 1 per month ☐ 1 per 3 month ☐ 1 six months ☐ other *(specify)* ☐

13. How much? *(*enter amount) every time? (currency) ☐

14. How much CASH money do you use in average for household expenditures (food, fuel of 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, how often do you prepare for your family: *(tick box)*

	7 days	6days	5days	4days	3days	2days	1day	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 in average per day? *(tick box)*

	Number	kg	size: A	B	C	D	E	F
fresh fish	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

other seafood:

name:	no:	size:	kg:	plastic bag ¼	½	¾	1
______________________________	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
______________________________	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
______________________________	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

____

19. Canned Fish (no of cans) ☐ seize 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 for)

☐ 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 for)

☐ buy it at __________________________

which is the most important source? ☐ caught ☐ given ☐ bought

21. Which is the last day you had fish as normally that you remember?

____

22. Which is the last day \you had other seafood as normally that you remember?

____

-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 ☐ 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?

no ☐ habitats: coastal reef ☐ lagoon ☐ outer reef ☐

4. How often (days/week) do you fish in each of the habitats visited?

habitats

coastal reef	lagoon	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	☐	☐	☐
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 go ALWAYS with you fishing?
Names:____
____
____
____

INFORMATION BY FISHERIES **HH NO** ☐

Fisheries: coastal reef ☐ lagoon ☐ outer reef ☐ **name of fisher**:_______________

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	1day/ week	others, specify:
☐	☐	☐	☐	☐	☐	____________________

2. What time do you spend fishing this habitat per average trip ? ____________________
(if the fisher can't specify, tick the box)

< 2 hrs	2-6 hrs	6-12 hrs	> 12 hrs
☐	☐	☐	☐

3. WHEN do you go fishing? *(tick box)* Day ☐ Night ☐ Day&Night ☐

4. You go all year?

yes ☐ no ☐

5. If no, which months you don't fish?

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6. Which 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? ____________

☐ others, specify: ____

7. Do you use more than one technique per trip for this habitat ? 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 **OR:**

size class:	A	B	C	D	E	F
number:	☐	☐	☐	☐	☐	☐

10. Do you sell fish? yes ☐ no ☐

you sell all species? yes ☐ no ☐

If no, which species you sell? ______________________

____

____

____

____

11. Do you give fish as gift (for no money)? yes ☐ no ☐

you gift all species? yes ☐ no ☐

If no, which species you gift? ______________________

____

____

____

____

12. Which species you use for family consumption?

all I catch ☐ selected species only ☐

If selected species, please list ________________________

____

____

____

____

13. How much of your usual catch do you keep for family consumption?

kg ☐ **OR:**

size class	A	B	C	D	E	F
no	☐	☐	☐	☐	☐	☐

and the rest you:

gift? ☐ frequency; every catch ☐ **OR**:

___________times/week/month, other_____

how much each time? ☐ kg **OR:**

size class	A	B	C	D	E	F
no	☐	☐	☐	☐	☐	☐

sale? ☐ frequency: every catch ☐ **OR**:

___________times/week/month, other_____

how much each time? kg

size class	A	B	C	D	E	F
no	☐	☐	☐	☐	☐	☐

14. What sizes of fish do you use for your family consumption, what for sale and which do you give away without getting any money ?

size classes:	all	A	B	C	D	E	and larger ?
consumption	☐	☐	☐	☐	☐	☐	☐
sale	☐	☐	☐	☐	☐	☐	☐
giving 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	kg	A	B	C	

20. Do you also fish invertebrates?

yes ☐ no ☐ if yes for consumption ☐ sale? ☐

-THANK YOU-

INVERTEBRATE FISHING AND MARKETING SURVEY
FISHERS

HHNO ☐

Name: ______________________________________

Gender: ☐ female ☐ male age: ☐

Village: ______________________________________

Date: ________________ Surveyor's name:___________________

Invertebrates = everything that is not a fish with fins!

1. Which fisheries do you do?

☐ seagrass gleaning ☐ mangrove & mud gleaning

☐ sand & beach gleaning ☐ reeftop gleaning

☐ beche-de mer diving ☐ mother of pearl diving trochus, pearl shell etc

☐ lobster diving ☐ others, such as clams, octopus

2. (if more than one fisheries in question 1): Do you usually go fishing only for one of the fisheries or do you do 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 to the fisheries (*tick as from questions 1& 2 above & watch for combinations*), for how long, and do you also finfish at the same time?

	times/week?	duration in hours				fish/glean at:			fish from months
		(if the fisher can't specify, tick the box)							
		<2	2-4	4-6	>6	D	N	D&N	
☐ seagrass gleaning	☐ ____	☐	☐	☐	☐	☐	☐	☐	
☐ mangrove &	☐	☐	☐	☐	☐	☐	☐	☐	

mud gleaning ____

☐ sand & beach gleaning ☐ ____ ☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ reef top gleaning ☐ ____ ☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ beche-de-mer diving ☐ ____ ☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ lobster diving ☐ ____ ☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ mother of pearl diving trochus, pearl shell etc ☐ ____ ☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ others 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 fin fish? yes ☐ no ☐

   for: ☐ consumption ☐ sale

   at the same time? yes ☐ no ☐

INVERTEBRATE FISHING AND MARKETING SURVEY - FISHERS

GLEANING: seagrass ☐ mangrove & mud ☐ sand & beach ☐ reef top ☐

DIVING: beche-de-mer ☐ lobster ☐ mother of pearl, trochus, pearl shell etc ☐ others (clams, octopus) ☐

SHEET 1: EACH FISHERIES PER FISHER INTERVIEWED: ☐ **HHNO name of fisher:______________ __gender: F** ☐ **M** ☐

What transport do you mainly use? ☐ walk ☐ canoe (no engine) ☐ motorised boat (HP) ☐ sailboat

how many fisher are usually on that boat? (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				

Socioeconomic surveys, questionnaires and average invertebrate wet weights

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 ☐ reef top ☐

DIVING: beche-de-mer ☐ lobster ☐ mother of pearl, trochus, pearl shell etc ☐ others (clams, octopus) ☐

SHEET 2: SPECIES SOLD PER FISHER INTERVIEWED: **HHNO** ☐ **name of fisher:**______________________

Copy all species that have been named for "SALE" in previous sheet

Who markets any of your products? ☐ you ☐ your wife ☐ your husband ☐ a group of fishers ☐ others __________________

Species for sale copy from sheet 2 (for each fisheries 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 & INVERTEBRATE & SOCIOECONOMICS)
GENERAL INFORMATION SURVEY:
Target group: key persons, groups of fishers, fisheries officers,etc.

1. Management rules that do apply for your fisheries, and are they specifically targeting fnfish or invertebrates, or do they apply for both sectors?

a) legal/Ministry of Fisheries

b) traditional/community/village determined:

2. What do you think, people obey to

traditional/village management rules?

most ☐ sometimes ☐ hardly ☐

legal/Ministry of Fisheries management rules ?

most ☐ sometimes ☐ hardly ☐

3. Are there any particular rules that you know people do not respect or follow at all? And would 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. 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? and can you specific 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? and can you specific the particular months that they are **NOT** fished?

vernacular name	scientific name (s)	months NOT fished:

How many people do the below invertebrate fisheries 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	☐	☐	______	☐	______
☐ reef top gleaning	☐	☐	______	☐	______
DIVING					
☐ beche-de-mer diving	☐	☐	______	☐	______
☐ lobster diving	☐	☐	______	☐	______
☐ mother of pearldiving trochus, pearl shell etc	☐	☐	______	☐	______
☐ others (clams, octopus) diving	☐	☐	______	☐	______

What gear do invertebrate fishers use? (tick box of technique per each fishery)

GLEANING: (soft-bottom = seagrass)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ googles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ others__________		

GLEANING: (soft-bottom = mangrove & mud)

☐ spoon	☐ wooden stick	☐ knife	☐ iron rod	☐ spade
☐ hand net	☐ net	☐ trap	☐ googles	☐ dive mask
☐ snorkel	☐ fins	☐ weight belt		
☐ air tanks	☐ hookah	☐ others__________		

GLEANING: (soft-bottom = sand & beach)

☐ ☐ ☐ ☐ ☐

spoon wooden stick knife iron rod spade

☐ hand net ☐ net ☐ trap ☐ googles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ others__________

GLEANING: (hard bottom =reeftop)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ googles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ others__________

DIVING: (beche-de-mer)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ googles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ others__________

DIVING: (lobster)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ googles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ others__________

DIVING: (mother of pearl, trochus, pearl shell etc.)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ googles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ ☐ ☐

air tanks hookah others__________

DIVING: (others, such as clams, octopus)

☐ spoon ☐ wooden stick ☐ knife ☐ iron rod ☐ spade

☐ hand net ☐ net ☐ trap ☐ googles ☐ dive mask

☐ snorkel ☐ fins ☐ weight belt

☐ air tanks ☐ hookah ☐ others__________

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, edible and non-edible weight, and edible part per piece applied for invertebrate species groups (Unit weights used in conversions for invertebrates).

Country	Vernacular name	Scientific_Names	g_per piece	% edible weight	% non-edible weight	g edible part per piece
		Acanthopleura gemmata	29	35	65	10.15
		Actinopyga lecanora	300	10	90	30
		Actinopyga mauritiana	350	10	90	35
		Actinopyga miliaris	300	10	90	30
		Anadara sp., *A.* sp.	21	35	65	7.35
		Asaphis violascens	15	35	65	5.25
		Asaphis violascens, Gafrarium pectinatum, G. tumidum	15	35	65	5.25
		Astralium sp.	20	25	75	5
		Atactodea striata , A. striata , Donax cuneatus , D. cuneatus	2.75	35	65	0.9625
		Atrina vexillum	225	35	65	78.75
		Atrina vexillum, Pinctada margaritifera	225	35	65	78.75
		Birgus latro	1000	35	65	350
		Bohadschia argus	462.5	10	90	46.25
		Bohadschia sp.	462.5	10	90	46.25
		Bohadschia vitiensis	462.5	10	90	46.25
		Cardisoma carnifex	227.83	35	65	79.7405
		Cardisoma sp.	227.83	35	65	79.7405
		Carpilius maculatus	350	35	65	122.5
		Cassis cornuta, C. cornuta, Thais aculeata, T. aculeata	20	25	75	5
		Cerithium nodulosum, C. nodulosum	240	25	75	60
		Chama sp.	25	35	65	8.75
		Codakia punctata	20	35	65	7
		Coenobita sp.	50	35	65	17.5
		Conus sp.	240	25	75	60
		Cypraea annulus	10	25	75	2.5
		Cypraea annulus, C. moneta	10	25	75	2.5
		Cypraea caputserpensis	15	25	75	3.75
		Cypraea mauritiana	20	25	75	5
		Cypraea sp.	95	25	75	23.75
		Cypraea tigris	95	25	75	23.75
		Dardanus sp.	10	35	65	3.5
		Dendropoma maximum	15	25	75	3.75
		Diadema sp.	50	48	52	24
		Dolabella auricularia	35	50	50	17.5
		Donax cuneatus	15	35	65	5.25
		Drupa sp.	20	25	75	5
		Echinometra mathaei	50	48	52	24
		Echinothrix sp.	100	48	52	48

Country	Vernacular name	Scientific_Names	g_per piece	% edible weight	% non-edible weight	g edible part per piece
		Eriphia sebana	35	35	65	12.25
		Gafrarium pectinatum	21	35	65	7.35
		Gafrarium pectinatum, G. tumidum	21	35	65	7.35
		Gafrarium pectinatum, G. tumidum, Periglypta puerpera, P. reticulata	21	35	65	7.35
		Grapsus albolineatus	35	35	65	12.25
		Hippopus hippopus	35	19	81	6.65
		Hippopus hippopus, Tridacna maxima, T. squamosa	500	19	81	95
		Holothuria atra	100	10	90	10
		Holothuria atra, H. coluber	100	10	90	10
		Holothuria fuscogilva	2000	10	90	200
		Holothuria fuscopunctata	1800	10	90	180
		Holothuria nobilis	2000	10	90	200
		Holothuria scabra	2000	10	90	200
		Holothuria sp.	2000	10	90	200
		Lambis lambis	25	25	75	6.25
		Lambis sp.	25	25	75	6.25
		Lambis truncata	500	25	75	125
		Mammilla melanostoma, Polinices mammilla	10	25	75	2.5
		Modiolus auriculatus	21	35	65	7.35
		Nerita sp.	5	25	75	1.25
		Nerita albicilla, N. polita	5	25	75	1.25
		Nerita balteata, N. plicata, N. polita, Polinices mammilla	5	25	75	1.25
		Nerita plicata	5	25	75	1.25
		Octopus sp.	550	90	10	495
		Panulirus ornatus	1000	35	65	350
		Panulirus penicillatus	1000	35	65	350
		Panulirus versicolor	1000	35	65	350
		Parribacus antarcticus	750	35	65	262.5
		Parribacus caledonicus	750	35	65	262.5
		Patella flexuosa	15	35	65	5.25
		Periglypta puerpera, P. reticulata	15	35	65	5.25
		Periglypta sp., *P.* sp., *Spondylus* sp., *S.* sp.	15	35	65	5.25
		Pinctada margaritifera	200	35	65	70
		Pitar proha	15	35	65	5.25
		Planaxis sulcatus	15	25	75	3.75
		Pleuroploca filamentosa	150	25	75	37.5
		Pleuroploca trapezium	150	25	75	37.5
		Portunus pelagicus	227.83	35	65	79.7405
		Saccostrea cuccullata	35	35	65	12.25
		Saccostrea sp.	35	35	65	12.25
		Scylla serrata	700	35	65	245

Country	Vernacular name	Scientific_Names	g_per piece	% edible weight	% non-edible weight	g edible part per piece
		Serpulorbis sp.	5	25	75	1.25
		Sipunculus indicus	50	10	90	5
		Spondylus squamosus	40	35	65	14
		Stichopus chloronotus	100	10	90	10
		Stichopus sp.	543	10	90	54.3
		Strombus gibberulus gibbosus	25	25	75	6.25
		Strombus luhuanus	25	25	75	6.25
		Tapes literatus	20	35	65	7
		Tectus pyramis, Trochus niloticus	300	25	75	75
		Tellina palatum	21	35	65	7.35
		Tellina sp.	20	35	65	7
		Terebra sp.	37.56	25	75	9.39
		Thais armigera	20	25	75	5
		Thais sp.	20	25	75	5
		Thelenota ananas	2500	10	90	250
		Thelenota anax	2000	10	90	200
		Tridacna maxima	500	19	81	95
		Tridacna maxima, T. squamosa	500	19	81	95
		Tridacna sp.	500	19	81	95
		Trochus niloticus, T. niloticus	200	25	75	50
		Turbo argyrostomus, T. chrysostomus, T. crassus, T. marmoratus, T. setosus, T. sp.	20	25	75	5
		Turbo crassus	80	25	75	20
		Turbo crassus, T. setosus	80	25	75	20
		Turbo marmoratus, T. setosus	20	25	75	5
		Turbo setosus	20	25	75	5
		Turbo sp.	20	25	75	5

Note: List of scientific names is subject to further additions as survey work progresses

1.2 Methods used to assess the status of finfish resources

Fish counts

We use the **distance-sampling underwater visual census (D-UVC)** method (Kulbicki and Sarramegna 1999, Kulbicki et al. 2000) to assess the status of finfish resources in selected sites. D-UVC is 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.

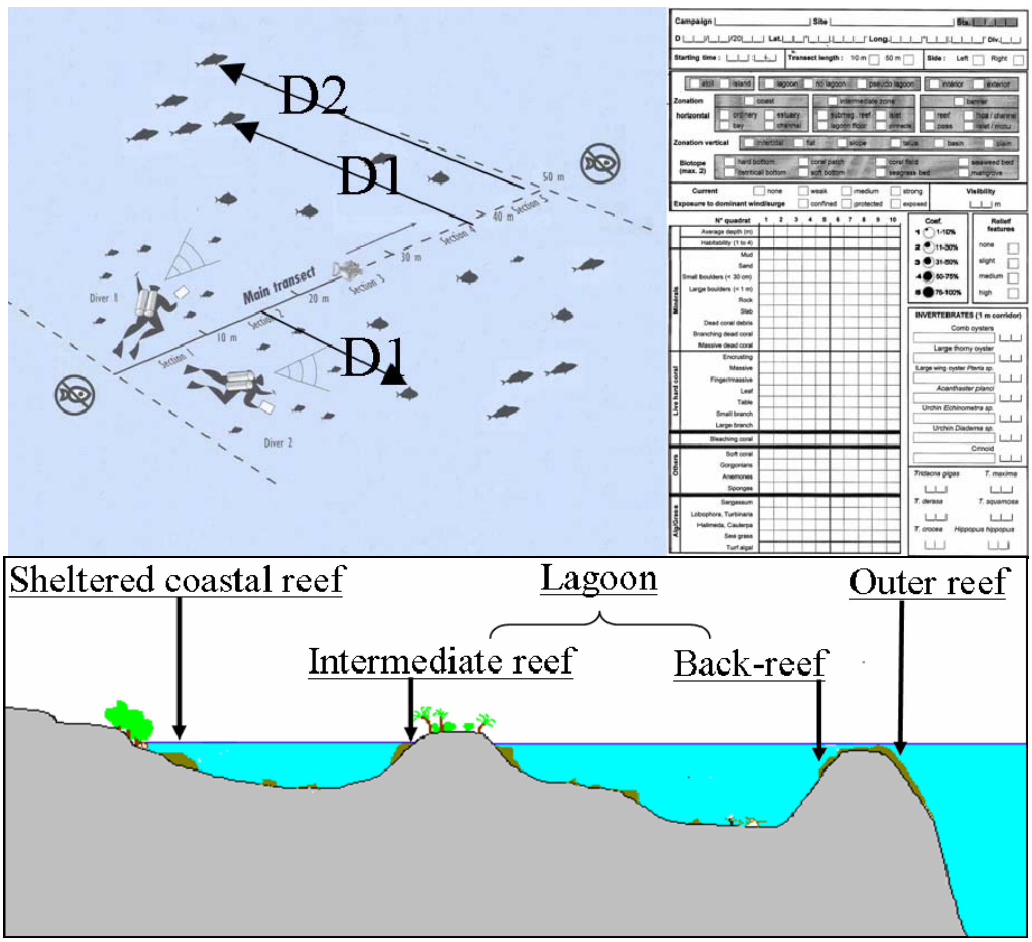

Figure A1.2.1: Assessment of finfish resources and associated environments using distance-sampling underwater visual censuses (D-UVC). Each diver records the number of fish, fish size, distance of fish to the transect line, and habitat quality, using pre-printed underwater paper. At each site, surveys 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.

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 lists of counted species and abundance for each site surveyed).

Table A1.2.1: List of finfish species surveyed by PROCFish/C 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 sp.
Haemulidae	All species
Holocentridae	All species
Kyphosidae	All species
Labridae	*Bodianus axillaris, Bodianus loxozonus, Bodianus perditio, Bodianus* sp., *Cheilinus:* all species, *Choerodon:* all species, *Coris aygula, Coris gaimard, Epibulus insidiator, Hemigymnus:* all species, *Oxycheilinus digrammus, Oxycheilinus* sp.
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 indicate that of the initial 36 surveyed families, only 15 families are frequently seen in country counts. Since low percentage occurrence could either be due to rarity (which is of interest) or low detectability (representing a methodological bias), we decided to restrict our analysis to the 15 most frequently observed families, for which we can guarantee that D-UVC is an efficient resource assessment method. These are:

- Acanthuridae (surgeonfish);
- Balistidae (triggerfish);
- Chaetodontidae (butterflyfish);
- Holocentridae (squirrelfish);
- Kyphosidae (drummer and seachubs);
- Labridae (wrasse);
- Lethrinidae (sea bream and emperor);
- Lutjanidae (snapper and seaperch);
- Mullidae (goatfish);
- Nemipteridae (coral bream and butterfish);
- Pomacanthidae (angelfish);
- Scaridae (parrotfish);
- Serranidae (grouper, rockcod, seabass);
- Siganidae (rabbitfish); and
- 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 5x5 m quadrates located on each side of a 50 m transect, for a total of 20 quadrates per transect (Figure A1.2.1). The transect's habitat characteristics are then calculated by averaging substrate records over the 20 quadrates.

Parameters of interest

In this report, the status of finfish resource has been characterized using the following seven parameters:

- **Biodiversity —** the number of families, genera and species counted in D-UVC transects;
- **Density** (fish per 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 per 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;
- **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 5 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 6 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 sizes, 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. Those 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 South 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); and
- **Outer reef —** ocean side of fringing or barrier reefs.

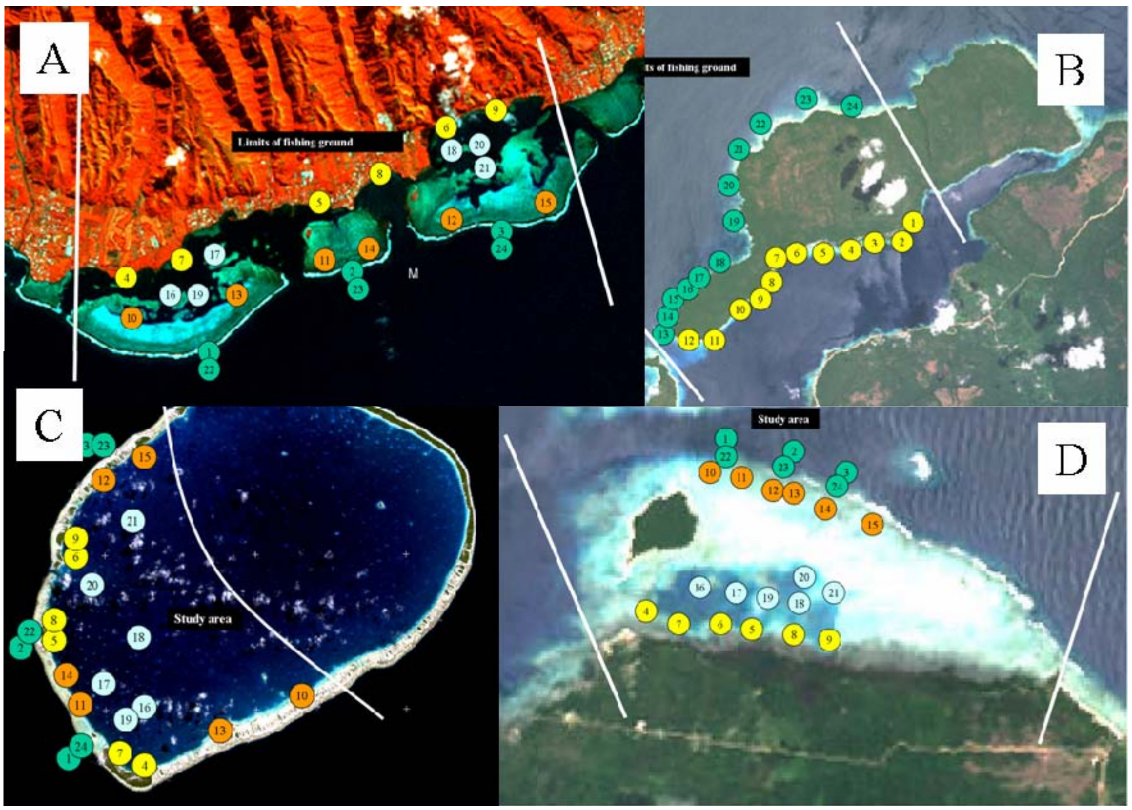

Figure A1.2.2: Position of the 24 D-UVC transects surveyed in A) an island with a lagoon, B) an island with a pseudo-lagoon C) an atoll and D) an island with an extensive reef enclosing a small lagoon pool. Sheltered coastal reef transects are in yellow, lagoon intermediate reef transects in blue, lagoon back-reef transects in orange and outer reef transects in green. Transect locations are determined prior to going to the field using satellite imagery, which greatly enhances fieldwork efficiency.

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 6 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 still 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 are determined in advance using satellite imagery, to assist in locating the exact positions in the field; this maximizes accuracy and allows for repeatability 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") with the proportion of surface of each type of reef over the total reef present in the site ("the weights"), by using a weighted average formulae. The result is a village-level figure for finfish biomass, which 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 (i.e. the area of sheltered coastal reef + the area of intermediate reef, etc.). Thus the calculated weighted biomass value for the site would be:

$$B_{Vk} = \sum_j [B_{H1} * S_{H1} / \sum_j S_{Hj}]$$

where

B_{Vk} is the computed biomass or fish stock for village k
B_{H1} is the average biomass in habitat H_1
S_{H1} is the surface of that habitat
S_{Hj} the surface of each of all reef habitats

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 are only proxies of the available resource; it would be a great mistake (possibly leading to mismanagement) to consider these estimates as indicative of the actual available resource.

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 are used to provide information on key invertebrate species commonly targeted. These provide measures at scales relevant to specie(s) targeted and the fishing grounds being studied, and provide results 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 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) are also presented as part of the PROCFish/C results, so as to give managers a general picture of invertebrate fishery status at study sites.

Field methods

We examine invertebrate stocks (and fisheries) for approximately 7 days at each site. In this time at least two research officers (SPC invertebrate Fisheries Biologist and fisheries Officer, plus Officers from the local Fisheries Department) assess stocks using both fishery-dependant and fishery-independent surveys. Survey activities at each site are determined by local habitats and fishing activities, although fishery-independent surveys predominate.

Fishery-dependent surveys

Fishery-dependent surveys involve accompanying fishers, whenever the opportunity arises, to areas generally targeted for the collection of invertebrate resources (e.g. reef benthos, soft benthos, trochus habitat). The location of the fishing activity is marked (using a GPS) and the catch composition and catch per unit effort (CPUE) recorded (kg/hour).

This record is 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, also provides an additional dataset to expand records from reported catches (as recorded by the socioeconomic survey). In addition, size and weight measures collected through fisher-dependent surveys are compared with records from fishery-independent assessments, in order to assess the level of harvesting selectivity adopted by fishers.

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 fisheries that target gastropods and crabs on the shoreline, searches are very subjective, and weather and tidal conditions affect outcomes. In such cases, observed and reported catch records are used to determine the status of species and fisheries.

A further reason for accompanying groups of fishers, is to gain a first hand insight into fishing activities, which facilitate the informal exchange of ideas and information. By talking to fishers in the fishing grounds, information useful for guiding the independent resource assessment is generally more forthcoming than when trying to gather information using maps and aerial photos while in the village. As fishery-independent surveys are not conducted randomly over the fishing ground, the identification of knowledgeable fishers and the positions (concentrations) of resource stocks allows better targeting of subsequent fishery-independent surveys.

Fishery-independent surveys

A series of fishery-independent surveys (direct, in-water resource assessments) are conducted to determine the status of targeted invertebrates stocks. Independent assessments are 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 limit the relevance of the results.

PROCFish/C assessments need to be wide ranging within sites and well replicated to overcome the fact that distribution patterns of target invertebrate species can be strongly influenced by habitat, and commonly aggregated (even within a single habitat type). PROCFish/C assessments, generally, 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 areas, or areas of naturally higher abundance. The implications of this approach are important, as these non-random measures are indicative of stock health in pre-selected locations, and should not be extrapolated across the study site to estimate the size of the overall resource.

This approach is 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 judgments on the status of stocks from such data relies on the assumption that the state of "unit stocks"[4] in some way 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 would not hold high densities of large clams within fished locations. Conversely, a fishery under no stress would be unlikely to be depleted of important target species, or show skewed size ratios that reflected depletion with the adult component of the population.

In addition to examining the density of species, information on spatial distribution and size/weight is also collected, to add confidence to the study's inferences.

The basic assumption of looking at unit stocks 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

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[4] As used here, unit stock refers to the biomass and cohorts of adults of a species in a given area, which 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).

usually unavailable within remote locations to infer such changes. The lack of historical data also precludes speculation on "missing" species, which may still remain within remnant populations at isolated locations within study sites.

Assessment scales: site, station and replicates

Various assessment methods are used to conduct fishery-independent surveys. In each site (4 sites are chosen for most countries), surveys are generally made within specific areas (termed stations). At least 6 replicate measures are made at each station (termed transects, search periods, or quadrats, depending on the resource and method) (Figure A1.3.1).

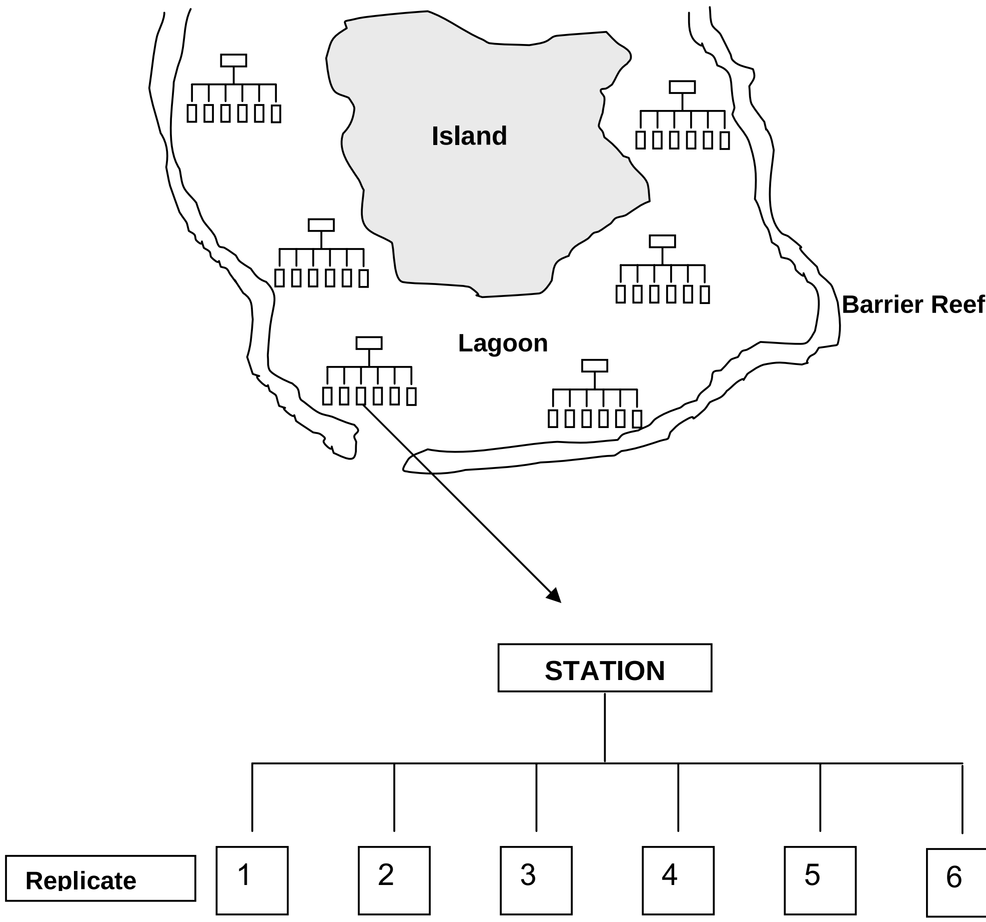

Figure A1.3.1: Stations and replicate measures at a given site. (Note: replicate measures could be a transect, search period, or quadrat group).

Invertebrate species diversity, spatial distribution and abundance are determined using fishery-independent surveys at stations over broad- and fine-scales. Broad-scale surveys aim to record a range of macro invertebrates across sites, whereas fine-scale surveys concentrate on specific habitats, and groups of important resource species. More detailed explanations of the various survey methods are given below.

Broad-scale manta "tow-board" assessments

A general assessment of large sedentary invertebrates (and habitat) is conducted using a tow board technique adapted from English et al. (1997), with a snorkeller travelling at low speeds (approx 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 assessments are completed at 12 stations per site. Stations are spread across the available habitat at a site; 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), are conducted in between 1 and 10 m of water (mostly 1.5–6 m), covering broken ground (coral stone and sand) and at the edges of reefs. Transects can not be conducted in areas that are too shallow for an outboard powered boat (<1 m) or adjacent to wave impacted reef.

Each transect covers a distance of 300 m (thus the total of 6 transects covers a linear distance of ~2 km). This distance is calibrated using the odometer function within the trip computer option of a hand-held GPS receiver (generally use a Garmin 72, or 76Map® GPS). Waypoints are recorded at the start and end of each transect to an accuracy of ≤10 m. The abundance and size estimations for large sedentary invertebrates are taken within a 2 m swathe of benthos for each transect. Broad-based assessments at each station take approx one hour to complete (7–8 min per transect × 6, plus recording and moving time between transects). Hand counters and board-mounted bank counters are used to assist with enumerating common species.

The tow board surveys differ from many manta surveys by utilizing a lower speed and concentrating on a smaller swathe on the benthos, which meant greater care can be taken to get a reliable measure of invertebrate presence. The slower speed, reduced swathe and greater length of tows used within PROCFish/C protocols are adopted to maximize efficiency when spotting and identifying cryptic invertebrates, while covering areas that are large enough to make representative measures.

Fine-scale transect assessments on reef and soft benthos (RBt and SBt)

To assess the range, abundance, size and condition of invertebrate species (and habitat) with greater accuracy and at smaller scales, reef and soft benthos assessments are conducted within fishing areas and areas of aggregated stock. Reef benthos and soft benthos are not mutually exclusive, in that coral reefs generally have patches of sand, while soft benthos areas can be strewn with rubble or contain patches of coral. The definitions are merely an attempt to characterize and determine the productivity of largely different habitats, to enable later cross-comparison between sites and countries.

In reef and soft benthos assessments, survey stations (covering approx 5000 m^2) are selected within areas representative of the habitat (those generally accessed by fishers, although MPAs are examined on occasion). Six 40 m transects (1 m swathe) are examined per station to record most epi-benthic invertebrate resources and some seastars and urchin species (as potential indicators). Transects are randomly positioned, but laid across environmental gradients where possible (e.g. across reefs and not along reef edges). A single waypoint is recorded for each station (to an accuracy of ≤10 m) and habitat recordings are made for each transect (see Figure A1.3.2 and Appendix 1.3–2).

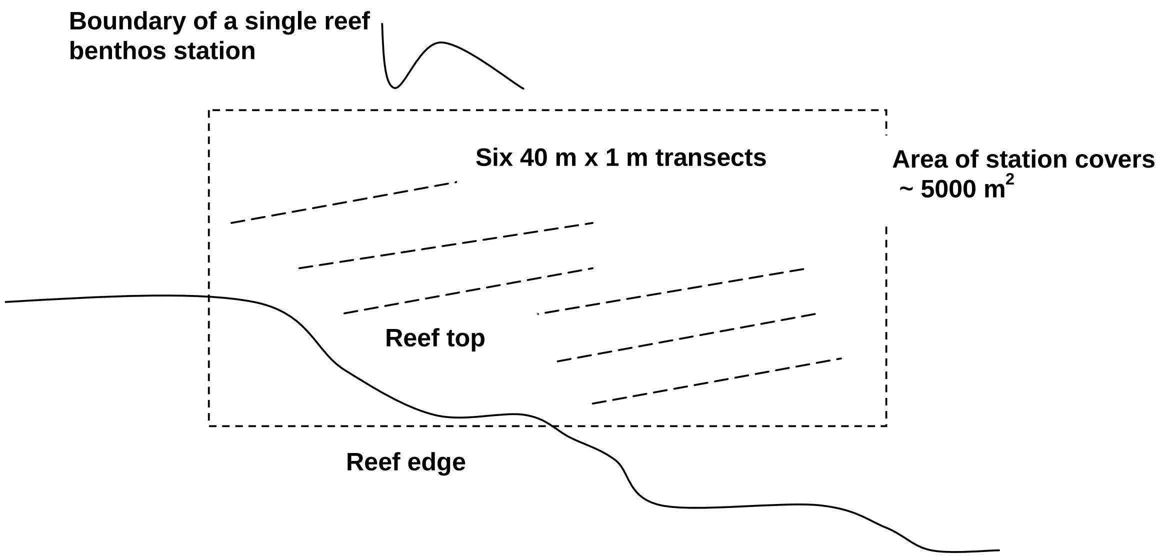

Figure A1.3.2: Example of a reef benthos station.

To record infaunal resources, quadrats (SBq) are used within a 40 m strip transect to measure densities of molluscs (mainly bivalves) in soft bottom areas. Each 25 cm^2 quadrats (in asset of four = one quadrat group) is dug to approx 5–8 cm to retrieve and measure infaunal target species and potential indicator species. Eight quadrat groups are sampled from a ~ 2 m^2 swathe, spaced randomly along the 40 m transect line (Figure A1.3.3). A single waypoint and habitat recording is taken for each infaunal station.

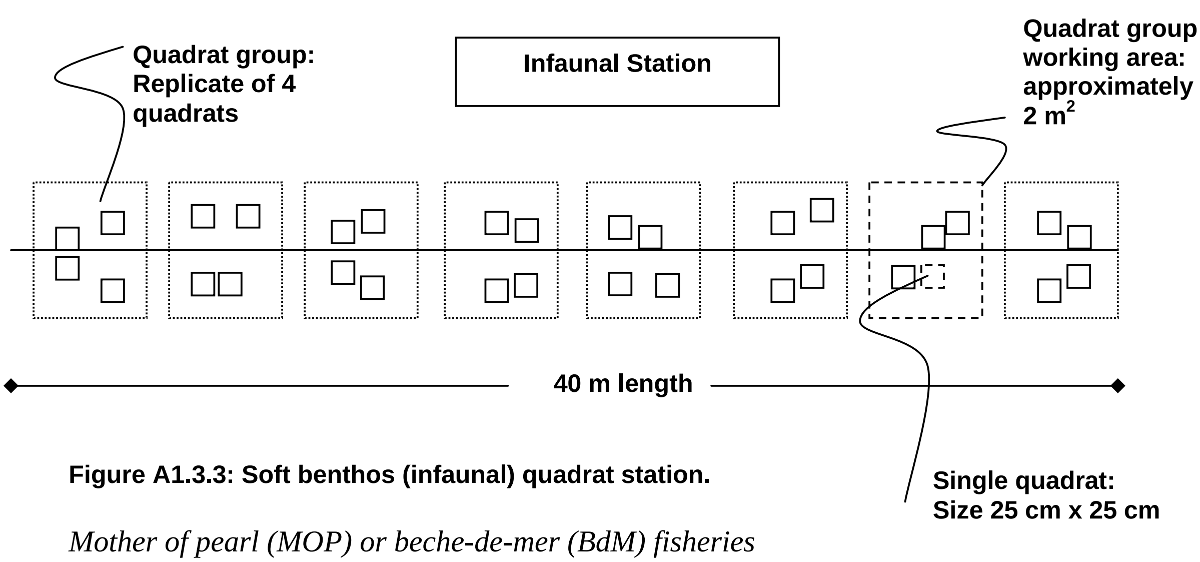

Figure A1.3.3: Soft benthos (infaunal) quadrat station.

Mother of pearl (MOP) or beche-de-mer (BdM) fisheries

To assess fisheries such as those for trochus or sea cucumbers, results from broad-scale, reef and soft benthos assessments are used. However, other assessments are incorporated into the work programme, to more closely target species or species groups that may not be well represented in the primary assessments.

In the case of *Trochus niloticus*, searches are usually made (using snorkel) for trochus aggregations identified by local fishers, before recorded assessments are begun (also see

Reef-front searches). A survey is undertaken using SCUBA search periods, and SCUBA transects are adopted if trochus are shown to be present at reasonable densities.

MOP search (MOPs)

Initially, two divers (using SCUBA) actively search for trochus for three 5 min search periods (30 min total). Distance searched is estimated from marked GPS start and end waypoints. If on these searches more than 3 individual trochus are found, the stock is considered dense enough to proceed with a more defined area assessment technique (MOPt).

MOP Transects (MOPt)

Also on SCUBA, six 40 m transects (2 m swathe) are run perpendicular to the reef edge and not exceeding 15 m depth. In most cases the depth ranges between 2–6 m, although dives can reach 12 m at some sites where more shallow water habitat or stocks can not be found. In cases where the reef lopes (drops off) steeply, more oblique transect lines are followed. On MOP transects, a hip mounted Chainman® measurement system (thread release) is adopted to measure 40 m transects. This allows for hands free searching and saves time and energy (no tape repositioning and retrieval) in the often dynamic conditions where *T. niloticus* is found.

Reef Front Searches (RFs) and (RFs(w))

If swell conditions allow, two snorkellers conduct three 5 min search periods (30 min total search time per station) along exposed reef edges (RFs) where trochus (*T. niloticus*) and surf redfish (*Actinopyga mauritiana*) are generally aggregated. Due to the dynamic conditions of the reef front, it is not generally possible to lay transects, however the start and end waypoints of reef front searches, and the abundance (generally not size measures) of large sedentary species (concentrating on trochus, surf redfish, gastropods and clams) are recorded.

On occasions when it is too dangerous to conduct in-water reef front searches (due to swell conditions or limited access), and the reef top is accessible, searches are conducted on foot along the platform close to the reef front (RFs(w)). In this case, two officers walk side by side (5 m apart) in the pools and cuts alongshore to the reef crest. This search is conducted at low tide, as close as is safe to the wave zone. In this style of assessment reef front counts of sea cucumbers, gastropod shells, urchins and clams are made during three 5 min search periods (total 30 min search time per station).

Sea Cucumber Night Search (Ns)

In the case of sea cucumber fisheries, dedicated night searches (Ns) on snorkel are conducted for predominantly nocturnal species (e.g. blackfish, *Actinopyga miliaris*, stonefish, *Actinopyga lecanora* and peanut fish, *Stichopus horrens*). Sea cucumbers are collected for three 5 minute search periods by two snorkellers (30 min total search time per station), and if possible weighed (*A. miliaris* and *A. lecanora* length and width measures are more dependant on the condition than the age of an individual).

Sea Cucumber Day Search (Ds)

Deep dives on SCUBA are conducted to obtain a preliminary assessment of deepwater sea cucumber stocks such as the high value white teatfish (*Holothuria fuscogilva*), prickly redfish (*Thelenota ananas*) and the lower value amberfish (*Thelenota anax*). Dives to 25–35 m depth for three 5 minute search periods (30 min total search time per station) are made at suitable locations by two divers who record the number and sizes of these deep water sea cucumber species (and habitat).

Habitats

Recordings of habitat are generally taken for all replicates within stations (see Appendix 1.3–2). Comparison of species complements and densities among stations and sites do not factor in differences in habitats within survey methods, as there is presently no established method that can be used to make allowances for variations in habitat. The complete dataset from PROCFish/C will be a valuable resource to assess habitat preferences for different species groups, and by identifying salient habitat factors that reliably affect resource abundance, we may be able to recalculate records to account for some of the differences. This will be examined once the full Pacific data set has been collected.

Methods of analysis

As has been presented, a range of survey techniques are used to assess resource status. For national 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) were 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.

Reporting format (example only)

An example and explanation of the reporting style adopted for invertebrate results follows:

1. The mean density range of *Tridacna* spp. on broad-scale manta stations (n =8) is 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 manta transects (n =48) is 127.8 ±21.8SE (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 only for stations or transects where the species of interest is found at an abundance = 0. In this case the arithmetic mean would only include stations (or replicates) where the species of interest is found (excluding zero replicates). If this is presented for stations, even stations with a single clam from six transects would be included. If a mean was taken from such a truncated part of the data set, this would be highlighted in the text. Note: a full data break-down is presented in the appendices to each report.

Written after the mean density figure is a descriptor that highlights variability in the data used to calculate the mean. Standard error[5] (SE) is used in this example to highlight this variability (SE= (standard deviation of records)/$\sqrt{n}$). 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).

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 per cent of all transects held *Tridacna* sp., which equates to 14 of a possible 48 transects (14/48*100 = 29%).

3. The mean length (cm, ±SE) of *T. maxima* is 12.4 ±1.1 (n =114).

n indicates the number of units used in the calculation. In the last case, 114 clams were measured.

[5] 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. 95% confidence limits can be generated through other methods (bootstrapping methods) and will be presented in the final report where appropriate.

1.3–2 Habitat section of invertebrate recording sheets with instructions to users

Figure A1.3.4 depicts the habitat part of the form used during invertebrate surveys, and it is split up into seven broad categories.

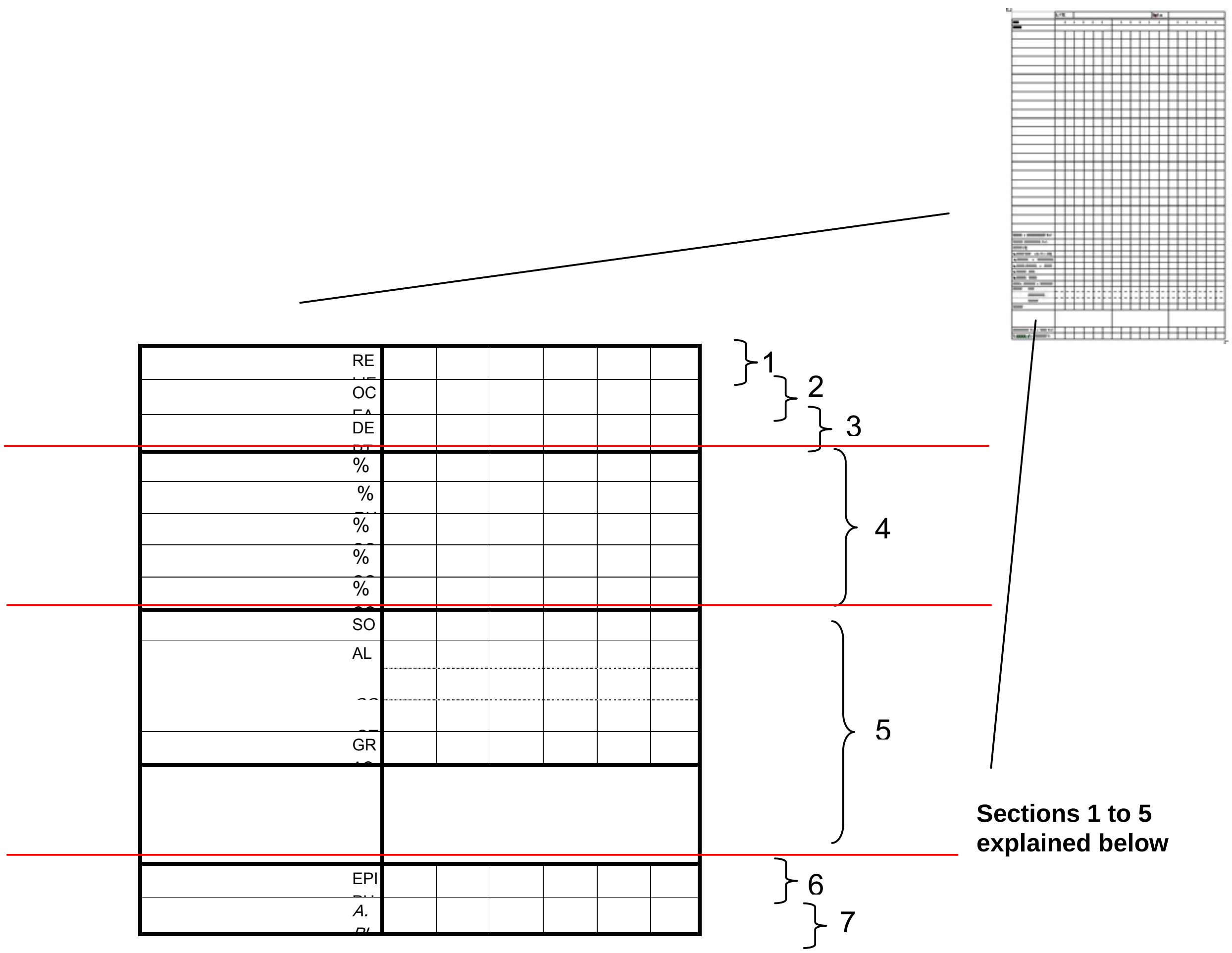

Figure A1.3.4: Sample of the invertebrate habitat part of survey form

Relief & Complexity (section 1 of form)

Each on a scale of 1 to 5. If 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 below knee height,
3= knee to hip height,
4 = above hip to head height,
5 = over head height

Complexity: describes average surfaces variation for substrates (places for invertebrates to find shelter) for hard (and soft) benthos transects:
1= smooth - no holes and divots in substrate
2= some complexity to the surfaces but generally not complex
3= generally complex surface structure
4= strong complexity in surface structure, with many cracks, spaces, holes etc.
5= very complex surfaces with lots of hidden spaces, nooks, crannies, under-hangs and caves.

Ocean Influence (section 2 of form)

1= high riverine (land) influence, 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= mostly oceanic water, without land influence

Depth (section 3 of form)

Average depth in metres

Substrate — birds' eye view of what's there (section 4 of form)

ALL OF SECTION 4 MUST MAKE UP 100 PER CENT

Give estimate of percentage substrate in units of 5 per cent (e.g. 5, 10, 15, 20 % etc etc, and not 2, 13, 17, 56).

Elements to consider

soft substrate	soft sediment - mud
soft substrate	soft sediment - mud & 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

Substrates described

Mud, sand, coarse sand — not sieved — estimated visually and manually. Can use drop test — sand drops through the water column — mud stays in suspension. Patchy settled areas of silt/clay/mud in very thin layers on top of coral, pavement etc is not listed as soft substrate — unless the layer is significant (>a couple of cm).

Rubble — small (<25–30 cm) fragments of coral (reef), pieces of coral stone and limestone debris. The Australian Institute of Marine Science (AIMS) definition is similar to that for

Reefcheck: 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 **—** detached big pieces (>30 cm) of coral stone limestone debris or other stone.

Consolidated Rubble — attached, cemented pieces of coral stone and limestone debris. Tend to use rubble for pieces or piles that are loose in the sediment, and consolidated rubble for areas that are not flat pavement but concreted rubble on reef tops and cemented talus slopes.

Pavement **—** solid, fixed, stone (generally limestone) benthos. This is usually flat, and in wave affected areas, although is also found on the bottom of passes and some atolls

Coral live — any live hard coral (soft coral is listed elsewhere – as a cover).

Coral dead — coral which is recognisable as coral even if long dead — note that long dead and *eroded* coral which are found in flat pavements are called pavement and when found in loose pieces or blocks they are termed rubble or boulders (depending on size).

Cover — what is on top of the substrate (section 5 of form)

This cannot exceed 100 per cent, but can be anything from 0 to 100 per cent.
Give scores in blocks of 5 per cent (e.g. 5, 10, 15, 20 % etc and not 2, 13, 17, 56).

Elements to consider

	soft coral
	sponge
	fungids
	crustose-nongeniculate coralline algae
	coralline algae
	other (algaes like sargassum, caulerpa and padina)

	seagrass

Soft coral — soft corals not including Zoanthids or anemones

Sponge — including half buried sponges in seagrass beds, where only sections are seen on the surface

Fungids — fungids

Crustose — nongeniculate coralline algae — pink rock. Crustose or nongeniculate coralline algae (CCA) are generally red/pink algae that deposit calcium carbonate in their cell walls. Generally members of the Division Rhodophyta.

Coralline algae — halimeda, red coralline algaes (often seen in balls — *Galaxaura).* Note: AIMS lists *halimeda* and other coralline algaes as Macro algaes along with fleshy algaes not having $CaCo_3$ deposits.

Other Algae — fleshy algaes, Use the large space to write species information if you know it.

Seagrass — note types by species if possible or by structure — (ie flat vs. reed grass).

Cover continued — Epiphytes and Silt (section 6 of form)

Epiphytes 1–5 grade: Epiphytes are mainly turf algaes and surface films — both grow on hard and soft substrates, but also on algae and grasses. The growth is usually fine stranded and filamentous, with few noticeable distinguishing features (more like fuzz or new beard growth).

1= none
2= little or light coverage
3= small areas, patchy coverage
4= large areas, heavier coverage
5= very heavy coverage, long and thick almost chocking epiphytes – normally including live and dead patches of blue-green algae as well.

Silt 1–5 grade: Silt (or a similar fine structured material sometimes termed “marine snow”) consists of very fine particles that settle out from the water, but are easily re-suspended. When re-suspended silt tends to make the water murky and not settle back out of suspension quickly (unlike sand). Sand particles are not silt and shouldn’t be included here when seen on outer reef platforms which are wave affected.

1= clear surfaces
2= little silt seen
3= some patchy areas with silt covering surfaces
4= large areas covered with silt
5= large areas with surfaces heavily covered in silt

A. Planci & Bleaching (section 7 of form)

A. Planci: Number of crown of thorns starfish.

Bleaching: Percentage (0-100%) of live or very recently dead hard and soft coral showing obvious signs of bleaching. Percentage of live coral bleached can be recorded in numbers from 1 to 100%. No 5 percentage blocks required.

APPENDIX 2 SOCIOECONOMIC SURVEY DATA

2.1 Total annual weight (kg) of fish groups per habitat (reported catch data by interviewed finfish fishers only).

Vernacular name	Family	Species	Total weight (kg)				Total
			Sheltered coastal reef	Pass	Other (pelagic)	Sheltered coastal reef+pass	All habitats
eweo	Acanthuridae	*Acanthurus* sp.	11,022	0	0	1050	12,072
earamai	Scaridae	*Scarus* sp.	9987	0	0	177	10,164
iname	Lutjanidae	*Lutjanus fulvus*	9039	0	0	1075	10,114
emon	Holocentridae	*Myripristis vittata*	8877	0	0	640	9517
iwiyi	Acanthuridae	*Acanthurus lineatus*	8158	0	0	296	8454
bonito	Scombridae	*Thunnus* sp.	0	7015	1693	477	9185
deiboe	Acanthuridae	*Acanthurus* sp.	6824	0	0	412	7235
ebo	Holocentridae	*Sargocentron caudimaculatum*	5568	0	0	0	5568
iubwiya	Acanthuridae	*Acanthurus leucocheilus*	5246	0	0	65	5311
iyibawo	Kyphosidae	*Kyphosus* sp.	4858	0	0	115	4973
ewenai	Acanthuridae, Carangidae	*Naso* sp., *Scomberoides* sp.	3523	0	0	684	4208
eokwoy	Nototheniidae	*Eleginops* sp.	0	3160	0	634	3794
iwururo	Serranidae	*Epinephelus polyphekadion*	3053	0	0	140	3193
ipo	Balistidae	*Abalistes* sp., *A. stellaris*	3025	0	0	321	3346
ereb	Carangidae	*Scomberoides* sp.	2837	0	0	596	3433
eagram	Acanthuridae, Carangidae	*Acanthurus* sp., *Caranx sexfasciatus*	1076	1931	0	125	3132
ebawo	Mugilidae	*Mugil cephalus*	1908	0	0	260	2169
irer	Acanthuridae	*Naso lituratus*	1824	232	0	285	2341
gatala	Serranidae	*Epinephelus* sp.	1807	0	0	0	1807
kanase	Mugilidae	*Mugil cephalus*	1634	0	0	0	1634
kimago	Chaetodontidae	*Chaetodon guttatissimus*	1589	0	0	78	1667
kwidada	Acanthuridae	*Naso lituratus*	1562	0	0	0	1562
kamai	Carangidae	*Elagatis bipinnulata*	365	1440	0	0	1805
itsibab	Scombridae	*Thunnus albacares*	0	1401	0	179	1580
eaeo	Carangidae	*Carangoides* sp.	1374	340	0	126	1840
eanit	Serranidae	*Cephalopholis miniata*	1202	0	0	138	1340
eanape	Serranidae	*Cephalopholis sonnerati*	1177	119	0	166	1462
ikakoa	Plotosidae	*Plotosus* sp.	1131	0	0	9	1140
teu	Carangidae	*Carangoides fulvoguttatus*	1073	0	0	0	1073
eaywiwi	Coryphaenidae	*Coryphaena hippurus*	0	1044	0	358	1401
Ikioquwo	Mugilidae	*Liza vaigiensis*	1025	0	0	0	1025
eaeor	Mugilidae	*Mugil cephalus*	889	119	0	9	1017
ianit	Serranidae	*Cephalopholis miniata*	650	0	0	0	650
emwan	Holocentridae	*Myripristis amaena*	103	0	0	0	103

Vernacular name	Family	Species	Total weight kg				Total
			Sheltered coastal reef	Pass	Other (pelagic)	Sheltered coastal reef+pass	All habitats
dereba	Acanthuridae	*Acanthurus* sp.	742	26	0	296	1064
filoa	Lutjanidae	*Lutjanus sebae*	720	0	0	377	1096
eamwe	Serranidae	*Cephalopholis spiloparaea*	690	0	0	103	793
ituwabu	Lutjanidae	*Lutjanus russellii*	533	0	0	0	533
etom	Serranidae	*Cephalopholis argus*	508	0	0	0	508
etareb	Lutjanidae	*Pristipomoides filamentosus*	501	0	0	0	501
iquri	Carangidae	*Selar crumenophthalmus*	337	0	0	117	454
earata	Lutjanidae	*Lutjanus kasmira*	331	0	0	0	331
dorangarang	Chimaeridae	*Chimaera monstrosa*	543	0	0	313	856
tangau	Lutjanidae	*Lutjanus* sp.	291	0	0	0	291
earo	Serranidae	*Epinephelus* sp.	271	0	0	0	271
degabouwa	Sphyraenidae	*Sphyraena barracuda*	266	119	0	0	386
eaiar	Mugilidae	*Neomyxus chaptalii*	241	119	0	0	361
fagamea	Lutjanidae	*Lutjanus bohar*	236	0	0	117	353
egarokoa	Holocentridae	*Holocentrus* sp.	153	0	0	0	153
dabugubug	Pomacentridae	*Abudefduf septemfasciatus*	0	119	0	119	238
eqow	Scombridae	*Acanthocybium* sp.	0	89	0	0	89
ikuri	Carangidae	*Decapterus* sp.	68	0	0	0	68
eaor	Mugilidae	*Mugil cephalus*	39	0	0	39	78
		Total:	**108,877**	**17,275**	**1693**	**9896**	**137,741**

2.2 Annual finfish catch composition: percentage of total weight for each habitat

Scientific name	Vernacular name	Percentage of total catch
Sheltered coastal reef		
Sphyraena barracuda	degabouwa	0.2
Acanthurus sp.	deiboe	6.2
Acanthurus sp.	dereba	0.7
Chimaera monstrosa	dorangarang	0.5
Carangoides sp.	eaeo	1.3
Mugil cephalus	eaeor	0.8
Acanthurus sp., *Caranx sexfasciatus*	eagram	1.0
Neomyxus chaptalii	eaiar	0.2
Cephalopholis spiloparaea	eamwe	0.6
Cephalopholis sonnerati	eanape	1.1
Cephalopholis miniata	eanit	1.1
Scarus sp.	earamai	9.1
Lutjanus kasmira	earata	0.3
Epinephelus sp.	earo	0.2
Mugil cephalus	ebawo	1.7
Sargocentron caudimaculatum	ebo	5.1
Holocentrus sp.	egarokoa	0.1
Myripristis vittata	emon	8.1
Myripristis amaena	emwan	0.7
Myripristis berndti	emwan	0.1
Scomberoides sp.	ereb	2.6
Pristipomoides filamentosus	etareb	0.5
Cephalopholis argus	etom	0.5
Naso sp., *Scomberoides* sp.	ewenai	3.2
Acanthurus sp.	eweo	10.1
Lutjanus bohar	fagamea	0.2
Lutjanus sebae	filoa	0.7
Epinephelus sp.	gatala	1.6
Cephalopholis miniata	ianit	0.6
Plotosus sp.	Ikakoa	1.0
Liza vaigiensis	Ikioquwo	0.9
Decapterus sp.	Ikuri	0.1
Lutjanus fulvus	iname	8.2
Abalistes sp., A. *stellaris*	ipo	2.8
Selar crumenophthalmus	iquri	0.3
Naso lituratus	irer	1.7
Lutjanus russellii	ituwabu	0.5
Acanthurus leucocheilus	iubwiya	5.8
Acanthurus lineatus	iwiyi	7.4
Epinephelus polyphekadion	iwururo	2.8
Kyphosus sp.	Iyibawo	4.4
Elagatis bipinnulata	kamai	0.3
Mugil cephalus	kanase	1.5
Chaetodon guttatissimus	kimago	1.4
Naso lituratus	kwidada	1.4
Lutjanus sp.	tangau	0.3
Carangoides fulvoguttatus	teu	1.0

Scientific name	Vernacular name	Percentage of total catch
Pelagic		
Thunnus sp.	bonito	100.0
Passage		
Thunnus sp.	bonito	40.6
Abudefduf septemfasciatus	dabugubug	0.7
Sphyraena barracuda	degabouwa	0.7
Acanthurus sp.	dereba	0.2
Carangoides sp.	eaeo	2.0
Mugil cephalus	eaeor	0.7
Acanthurus sp., *Caranx sexfasciatus*	eagram	11.2
Neomyxus chaptalii	eaiar	0.7
Cephalopholis sonnerati	eanape	0.7
Coryphaena hippurus	eaywiwi	6.0
Eleginops sp.	eokwoy	18.3
Acanthocybium sp.	eqow	0.5
Naso lituratus	irer	1.3
Thunnus albacares	itsibab	8.1
Elagatis bipinnulata	kamai	8.3
Sheltered Coastal reef and pass		
Thunnus sp.	bonito	4.8
Abudefduf septemfasciatus	dabugubug	1.2
Acanthurus sp.	deiboe	4.2
Acanthurus sp.	dereba	3.0
Chimaera monstrosa	dorangarang	3.2
Carangoides sp.	eaeo	1.3
Mugil cephalus	eaeor	0.1
Acanthurus sp., *Caranx sexfasciatus*	eagram	1.3
Cephalopholis spiloparaea	eamwe	1.0
Cephalopholis sonnerati	eanape	1.7
Cephalopholis miniata	eanit	1.4
Mugil cephalus	eaor	0.4
Scarus sp.	earamai	1.8
Coryphaena hippurus	eaywiwi	3.6
Mugil cephalus	ebawo	2.6
Myripristis vittata	emon	6.5
Eleginops sp.	eokwoy	6.4
Scomberoides sp.	ereb	6.0
Naso sp., *Scomberoides* sp.	ewenai	6.9
Acanthurus sp.	eweo	10.6
Lutjanus bohar	fagamea	1.2
Lutjanus sebae	filoa	3.8
Plotosus sp.	ikakoa	0.1
Lutjanus fulvus	iname	10.9
Abalistes sp., *A. stellaris*	ipo	3.2
Selar crumenophthalmus	iquri	1.2
Naso lituratus	irer	2.9
Thunnus albacares	itsibab	1.8
Acanthurus leucocheilus	iubwiya	0.7
Acanthurus lineatus	iwiyi	3.0
Epinephelus polyphekadion	iwururo	1.4
Kyphosus sp.	iyibawo	1.2
Chaetodon guttatissimus	kimago	0.8

2.3 Invertebrate species caught by fishery with the percentage of annual wet weight caught

Fishery	Vernacular name	Scientific name	Percentage of annual catch weight
Lobster	lobsters	*Panulirus* sp.	99.3
	degawe	*Thais armigera*	0.7
Lobster+Other	lobsters	*Panulirus* sp.	100.0
Other	dagiga	*Octopus* sp.	69.6
	emari	*Turbo* sp.	30.4
Reef Top	derom	*Etisus splendidus*	32.8
	kunebenari	*Actinopyga mauritiana*	12.4
	Ibirara	*Actinopyga mauritiana*	10.7
	land crab	*Cardisoma* sp.	9.5
	enor	*Tripneustes gratilla*	9.4
	emari	*Turbo* sp.	6.5
	dagiga	*Octopus* sp.	5.5
	degawe	*Thais armigera*	5.4
	egupea	*Cypraea* sp.	3.3
	deimao	*Grapsus albolineatus*	2.8
	goigoi	*Nerita plicata*	0.8
	eom	*Cymatium* sp.	0.5
	oyster	*Spondylus* sp.	0.4
Reef Top+Beche-de-mer	degawe	*Thais armigera*	75.0
	emari	*Turbo* sp.	25.0
Reef Top+Beche-de-mer+Other	emari	*Turbo* sp.	50.6
	degawe	*Thais armigera*	49.4
Reef Top+Lobster	lobsters	*Panulirus* sp.	100.0

Fishery	Vernacular name	Scientific name	Percentage of annual catch weight
Reef Top+Other	land crab	*Cardisoma* sp.	14.4
	dagiga	*Octopus* sp.	14.2
	emari	*Turbo* sp.	12.4
	degawe	*Thais armigera*	11.6
	enor	*Tripneustes gratilla*	10.0
	Ibirara	*Actinopyga mauritiana*	9.0
	derom	*Etisus splendidus*	8.5
	kunebenari	*Actinopyga mauritiana*	7.3
	deimao	*Grapsus albolineatus*	5.5
	egupea	*Cypraea* sp.	2.2
	lobsters	*Panulirus* sp.	1.6
	trochus	*Trochus* sp.	0.9
	goigoi	*Nerita plicata*	0.8
	Irinme	*Lambis lambis*	0.8
	oyster	*Spondylus* sp.	0.7
Reef Top + MOP	emari	*Turbo* sp.	100.0
Sand + Reef Top	degawe	*Thais armigera*	66.7
	emari	*Turbo* sp.	16.7
	Irinme	*Lambis lambis*	16.6
Sand + Reef Top + Other	emari	*Turbo* sp.	43.5
	dagiga	*Octopus* sp.	33.2
	degawe	*Thais armigera*	17.2
	goigoi	*Nerita plicata*	6.0
Soft benthos + Reef Top + Other	degawe	*Thais armigera*	100.0

2.4 Average length-frequency distribution for invertebrates, with percentage of annual total catch weight

Vernacular name	Scientific name	Size class	Percentage of annual total catch weight
dagiga	*Octopus* sp.	08-14 cm	20.1
		10-12 cm	20.2
		10-14 cm	44.0
		12-15 cm	1.5
		12-16 cm	9.1
		14-16 cm	5.0
degawe	*Thais armigera*	02-08 cm	31.3
		03-07 cm	13.4
		03-08 cm	7.4
		04-06 cm	19.7
		04-08 cm	13.7
		04-10 cm	3.6
		05-08 cm	2.3
		06-08 cm	4.9
		08-10 cm	2.4
		08-12 cm	0.6
		12-14 cm	0.6
deimao	*Grapsus albolineatus*	02-06 cm	7.5
		03-05 cm	14.0
		03-06 cm	13.0
		03-08 cm	4.5
		04-06 cm	23.4
		04-08 cm	20.8
		05-07 cm	3.5
		06-08 cm	3.7
		06-10 cm	2.5
		08-10 cm	0.1
		08-12 cm	4.9
		08-15 cm	0.5
		10-12 cm	1.8
derom	*Etisus splendidus*	04-06 cm	16.2
		06-08 cm	1.6
		06-10 cm	0.7
		08-10 cm	25.2
		08-12 cm	19.3
		08-13 cm	5.4
		10-12 cm	9.6
		10-14 cm	9.7
		12-14 cm	12.4

Vernacular name	Scientific name	Size class	Percentage of annual total catch weight
egupea	*Cypraea* sp.	04-06 cm	13.3
		04-08 cm	8.0
		06-08 cm	20.5
		06-10 cm	20.5
		06-12 cm	10.6
		08-12 cm	13.9
		10-12 cm	13.3
emari	*Turbo* sp.	02-04 cm	1.6
		02-06 cm	11.9
		02-08 cm	3.0
		03-04 cm	1.3
		03-05 cm	2.5
		03-06 cm	2.7
		03-08 cm	4.0
		04-06 cm	8.5
		04-08 cm	21.9
		04-10 cm	0.4
		05-07 cm	0.9
		05-08 cm	0.6
		06-08 cm	18.7
		06-10 cm	2.9
		07-12 cm	1.1
		08-10 cm	1.9
		08-12 cm	7.7
		08-14 cm	1.1
		09-12 cm	0.7
		10-12 cm	5.8
		10-14 cm	0.2
		12-14 cm	0.3
		14-15 cm	0.3
enor	*Tripneustes gratilla*	08-10 cm	98.2
		10-14 cm	1.8
eom	*Cymatium* sp.	06-12 cm	46.3
		08-14 cm	53.7
goigoi	*Nerita plicata*	02-04 cm	12.0
		02-05 cm	4.5
		02-06 cm	13.9
		03-05 cm	12.0
		03-06 cm	8.4
		04-06 cm	34.6
		04-08 cm	13.9
		06-08 cm	0.6

Vernacular name	Scientific name	Size class	Percentage of annual total catch weight
Ibirara	*Actinopyga mauritiana*	03-06 cm	12.8
		08-12 cm	64.7
		08-14 cm	7.7
		10-12 cm	14.9
Irinme	*Lambis lambis*	08-12 cm	35.0
		10-12 cm	36.1
		10-14 cm	28.9
kunebenari	*Actinopyga mauritiana*	03-05 cm	10.5
		08-12 cm	47.8
		10-12 cm	41.7
land crab	*Cardisoma* sp.	08-10 cm	13.9
		08-12 cm	16.1
		08-14 cm	21.5
		10-12 cm	19.0
		10-14 cm	29.5
lobsters	*Panulirus* sp.	16-20 cm	8.7
		18-20 cm	11.2
		18-22 cm	32.0
		18-24 cm	25.4
		20-22 cm	1.1
		20-24 cm	21.6
oyster	*Spondylus* sp.	03-06 cm	31.3
		04-06 cm	19.4
		04-08 cm	31.4
		06-08 cm	17.9
trochus	*Trochus* sp.	10-12 cm	100.0

2.5 Total annual catch of invertebrates (wet weight, kg year) by species and category of use.

Scientific name	Vernacular name	Total catch (wet weight, kg/year)			
		Consumption	Sale	Consumption and sale	Total
Octopus sp.	dagiga	3128	0	0	3128
Thais armigera	degawe	2658	0	35	2692
Grapsus albolineatus	deimao	1222	0	0	1222
Etisus splendidus	derom	3672	0	0	3672
Cypraea sp.	egupea	623	0	0	623
Turbo sp.	emari	2935	0	12	2947
Tripneustes gratilla	enor	2475	0	0	2475
Cymatium sp.	eom	32	0	0	32
Nerita plicata	goigoi	217	0	0	217
Actinopyga mauritiana	Ibirara	2383	0	0	2383
Lambis lambis	Irinme	147	0	0	147
Actinopyga mauritiana	kunebenari	2164	0	0	2164
Cardisoma sp.	land crab	3314	0	0	3314
Panulirus sp.	lobsters	375	1017	354	1747
Spondylus sp.	oyster	155	0	0	155
Trochus sp.	trochus	174	0	0	174
	Total	**25,675**	**1017**	**401**	**27,093**

APPENDIX 3 FINFISH SURVEY DATA

3.1 Coordinates (WGS 84) of the 50 D-UVC transects used to assess finfish resource status in Nauru.

Transect	Latitude	Longitude	Latitude	Longitude
TRA01	-0.52252	166.9606	31'21.0612" S	166 57'37.98" E
TRA02	-0.51972	166.9609	31'10.9812" S	166 57'39.3012" E
TRA03	-0.52645	166.9566	31'35.22" S	166 57'23.8212" E
TRA04	-0.55563	166.936	33'20.2788" S	166 56'09.7188" E
TRA05	-0.55568	166.9298	33'20.4588" S	166 55'47.3412" E
TRA06	-0.55455	166.9247	33'16.38" S	166 55'28.8012" E
TRA07	-0.51512	166.9602	30'54.4212" S	166 57'36.7812" E
TRA08	-0.5092	166.9582	30'33.12" S	166 57'29.5812" E
TRA09	-0.50545	166.9547	30'19.62" S	166 57'16.9812" E
TRA10	-0.5027	166.9507	30'09.72" S	166 57'02.6388" E
TRA11	-0.50057	166.9451	30'02.0412" S	166 56'42.2412" E
TRA12	-0.49972	166.9389	29'58.9812" S	166 56'20.1588" E
TRA13	-0.49983	166.934	29'59.3988" S	166 56'02.3388" E
TRA14	-0.50262	166.9299	30'09.4212" S	166 55'47.7012" E
TRA15	-0.50647	166.9268	30'23.2812" S	166 55'36.3" E
TRA16	-0.50948	166.9242	30'34.1388" S	166 55'26.94" E
TRA17	-0.52548	166.9573	31'31.7388" S	166 57'26.1612" E
TRA18	-0.52963	166.9542	31'46.6788" S	166 57'15.1812" E
TRA19	-0.53395	166.9526	32'02.22" S	166 57'09.2412" E
TRA20	-0.55247	166.9202	33'08.8812" S	166 55'12.54" E
TRA21	-0.54995	166.9164	32'59.82" S	166 54'58.9788" E
TRA22	-0.54738	166.9136	32'50.5788" S	166 54'49.0788" E
TRA23	-0.54392	166.911	32'38.1012" S	166 54'39.6" E
TRA24	-0.54002	166.9096	32'24.0612" S	166 54'34.6212" E
TRA25	-0.53693	166.9088	32'12.9588" S	166 54'31.7988" E
TRA26	-0.53588	166.9521	32'09.1788" S	166 57'07.4988" E
TRA27	-0.53785	166.9518	32'16.26" S	166 57'06.3612" E
TRA28	-0.54122	166.9522	32'28.3812" S	166 57'07.8588" E
TRA29	-0.54517	166.9528	32'42.6012" S	166 57'10.1988" E
TRA30	-0.53472	166.9084	32'04.9812" S	166 54'30.3588" E
TRA31	-0.53177	166.9085	31'54.3612" S	166 54'30.7188" E
TRA32	-0.55458	166.9385	33'16.4988" S	166 56'18.42" E
TRA33	-0.52902	166.9089	31'44.4612" S	166 54'31.86" E
TRA34	-0.52618	166.9094	31'34.2588" S	166 54'33.84" E
TRA35	-0.52393	166.9103	31'26.1588" S	166 54'37.0188" E
TRA36	-0.55317	166.9411	33'11.4012" S	166 56'28.0212" E
TRA37	-0.5115	166.9223	30'41.4" S	166 55'20.1" E
TRA38	-0.5134	166.9205	30'48.24" S	166 55'13.7388" E
TRA39	-0.54743	166.9506	32'50.7588" S	166 57'02.16" E

Transect	Latitude	Longitude	Latitude	Longitude
TRA40	-0.54802	166.9484	32'52.8612" S	166 56'54.3588" E
TRA41	-0.54965	166.9467	32'58.74" S	166 56'48.12" E
TRA42	-0.51507	166.9188	30'54.2412" S	166 55'07.6188" E
TRA43	-0.52147	166.9119	31'17.2812" S	166 54'42.84" E
TRA44	-0.51983	166.9135	31'11.3988" S	166 54'48.6" E
TRA45	-0.51797	166.9153	31'04.6812" S	166 54'55.1412" E
TRA46	-0.51635	166.9174	30'58.86" S	166 55'02.7588" E
TRA47	-0.52708	166.9556	31'37.4988" S	166 57'20.2212" E
TRA48	-0.55087	166.9441	33'03.1212" S	166 56'38.6412" E
TRA49	-0.5314	166.9536	31'53.04" S	166 57'12.8412" E
TRA50	-0.50068	166.9422	30'02.4588" S	166 56'31.92" E

3.2 Average density and biomass of all finfish species recorded in Nauru using D-UVC

Family	Genus	Species	Density	SE Density	Biomass	SE Biomass
Acanthuridae	*Acanthurus*	*blochii*	1.20E-04	9.00E-05	5.00E-02	4.00E-02
Acanthuridae	*Acanthurus*	*guttatus*	8.00E-05	6.00E-05	1.00E-02	1.00E-02
Acanthuridae	*Acanthurus*	*leucocheilus*	8.00E-05	8.00E-05	5.00E-02	5.00E-02
Acanthuridae	*Acanthurus*	*lineatus*	1.95E-01	2.12E-02	4.88E+01	5.37E+00
Acanthuridae	*Acanthurus*	*nigricans*	3.24E-01	2.29E-02	3.10E+01	2.28E+00
Acanthuridae	*Acanthurus*	*nigricauda*	1.68E-03	1.11E-03	8.10E-01	4.70E-01
Acanthuridae	*Acanthurus*	*olivaceus*	4.80E-04	2.70E-04	9.00E-02	5.00E-02
Acanthuridae	*Acanthurus*	*pyroferus*	1.16E-02	1.89E-03	1.19E+00	2.70E-01
Acanthuridae	*Acanthurus*	*sp.*	1.60E-04	1.60E-04	1.00E-02	1.00E-02
Acanthuridae	*Acanthurus*	*thompsoni*	1.10E-04	1.10E-04	1.00E-02	1.00E-02
Acanthuridae	*Acanthurus*	*triostegus*	6.04E-02	1.49E-02	4.02E+00	1.08E+00
Acanthuridae	*Acanthurus*	*xanthopterus*	1.04E-03	8.30E-04	1.05E+00	9.50E-01
Acanthuridae	*Ctenochaetus*	*binotatus*	8.00E-05	6.00E-05	0.00E+00	0.00E+00
Acanthuridae	*Ctenochaetus*	*marginatus*	2.12E-03	7.40E-04	4.50E-01	1.70E-01
Acanthuridae	*Ctenochaetus*	*sp.*	8.00E-05	8.00E-05	1.00E-02	1.00E-02
Acanthuridae	*Ctenochaetus*	*striatus*	2.20E-01	1.53E-02	1.97E+01	1.58E+00
Acanthuridae	*Naso*	*annulatus*	1.00E-03	8.00E-04	2.40E-01	1.60E-01
Acanthuridae	*Naso*	*brevirostris*	1.60E-04	1.30E-04	1.20E-01	9.00E-02
Acanthuridae	*Naso*	*caesius*	2.40E-04	1.40E-04	1.50E-01	8.00E-02
Acanthuridae	*Naso*	*lituratus*	1.13E-01	9.52E-03	3.41E+01	2.26E+00
Acanthuridae	*Naso*	*thynnoides*	4.00E-05	4.00E-05	2.00E-02	2.00E-02
Acanthuridae	*Naso*	*unicornis*	1.12E-03	3.60E-04	7.70E-01	2.70E-01
Acanthuridae	*Naso*	*vlamingii*	1.14E-02	3.67E-03	5.97E+00	1.82E+00
Acanthuridae	*Paracanthurus*	*hepatus*	1.00E-03	6.10E-04	5.00E-02	3.00E-02
Acanthuridae	*Zebrasoma*	*scopas*	1.04E-01	7.26E-03	4.74E+00	4.00E-01
Acanthuridae	*Zebrasoma*	*veliferum*	8.00E-05	8.00E-05	0.00E+00	0.00E+00
Balistidae	*Balistapus*	*undulatus*	5.31E-02	2.58E-03	9.96E+00	6.60E-01
Balistidae	*Melichthys*	*niger*	7.09E-03	1.76E-03	1.06E+00	3.40E-01
Balistidae	*Melichthys*	*vidua*	1.17E-01	8.06E-03	1.47E+01	1.39E+00
Balistidae	*Odonus*	*niger*	1.76E-02	5.41E-03	9.00E-01	2.90E-01
Balistidae	*Pseudobalistes*	*flavimarginatus*	2.40E-04	1.20E-04	3.10E-01	1.60E-01
Balistidae	*Rhinecanthus*	*rectangulus*	2.05E-02	4.04E-03	2.39E+00	4.30E-01
Balistidae	*Sufflamen*	*bursa*	2.16E-02	2.84E-03	2.34E+00	3.20E-01
Balistidae	*Sufflamen*	*chrysopterus*	1.90E-02	2.41E-03	2.48E+00	3.30E-01
Carangidae	*Carangoides*	*sp.*	3.00E-04	3.00E-04	1.00E-01	1.00E-01
Carangidae	*Caranx*	*melampygus*	4.00E-05	4.00E-05	4.00E-02	4.00E-02
Carcharhinidae	*Triaenodon*	*obesus*	2.40E-04	1.10E-04	7.87E+00	4.48E+00
Chaetodontidae	*Chaetodon*	*auriga*	9.60E-04	3.80E-04	3.00E-02	1.00E-02
Chaetodontidae	*Chaetodon*	*citrinellus*	1.96E-03	6.00E-04	4.00E-02	1.00E-02
Chaetodontidae	*Chaetodon*	*ephippium*	5.60E-04	2.30E-04	2.00E-02	1.00E-02
Chaetodontidae	*Chaetodon*	*kleinii*	2.88E-03	6.00E-04	7.00E-02	2.00E-02
Chaetodontidae	*Chaetodon*	*lunula*	7.68E-03	1.25E-03	3.10E-01	5.00E-02
Chaetodontidae	*Chaetodon*	*mertensii*	8.00E-05	8.00E-05	0.00E+00	0.00E+00

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Family	Genus	Species	Density	SE Density	Biomass	SE Biomass
Chaetodontidae	*Chaetodon*	*meyeri*	1.70E-02	1.68E-03	5.20E-01	5.00E-02
Chaetodontidae	*Chaetodon*	*ornatissimus*	1.15E-02	1.09E-03	4.00E-01	4.00E-02
Chaetodontidae	*Chaetodon*	*pelewensis*	2.40E-04	1.80E-04	1.00E-02	1.00E-02
Chaetodontidae	*Chaetodon*	*reticulatus*	7.08E-03	9.30E-04	2.40E-01	3.00E-02
Chaetodontidae	*Chaetodon*	*ulietensis*	1.60E-04	1.10E-04	0.00E+00	0.00E+00
Chaetodontidae	*Chaetodon*	*unimaculatus*	6.00E-04	2.60E-04	2.00E-02	1.00E-02
Chaetodontidae	*Chaetodon*	*vagabundus*	5.40E-03	1.05E-03	1.90E-01	4.00E-02
Chaetodontidae	*Forcipiger*	*flavissimus*	1.60E-04	1.60E-04	0.00E+00	0.00E+00
Chaetodontidae	*Forcipiger*	*longirostris*	2.54E-02	1.92E-03	1.43E+00	1.20E-01
Chaetodontidae	*Heniochus*	*acuminatus*	1.96E-03	8.30E-04	1.80E-01	8.00E-02
Chaetodontidae	*Heniochus*	*chrysostomus*	1.00E-03	3.80E-04	7.00E-02	3.00E-02
Chaetodontidae	*Heniochus*	*varius*	1.80E-03	4.50E-04	1.10E-01	3.00E-02
Diodontidae	*Diodon*	*hystrix*	2.40E-04	1.20E-04	2.50E-01	1.20E-01
Diodontidae	*Diodon*	*sp.*	2.40E-04	1.50E-04	1.20E-01	9.00E-02
Holocentridae	*Myripristis*	*berndti*	3.44E-03	8.40E-04	5.30E-01	1.30E-01
Holocentridae	*Myripristis*	*botche*	8.00E-05	8.00E-05	0.00E+00	0.00E+00
Holocentridae	*Myripristis*	*kuntee*	3.60E-04	3.60E-04	1.00E-01	1.00E-01
Holocentridae	*Myripristis*	*murdjan*	1.60E-04	1.60E-04	2.00E-02	2.00E-02
Holocentridae	*Myripristis*	*pralinia*	1.60E-04	1.10E-04	1.00E-02	1.00E-02
Holocentridae	*Myripristis*	*sp.*	2.80E-04	1.60E-04	5.00E-02	3.00E-02
Holocentridae	*Myripristis*	*vittata*	1.20E-04	9.00E-05	3.00E-02	2.00E-02
Holocentridae	*Neoniphon*	*sammara*	3.60E-04	2.30E-04	3.00E-02	2.00E-02
Holocentridae	*Neoniphon*	*sp.*	4.00E-05	4.00E-05	1.00E-02	1.00E-02
Holocentridae	*Sargocentron*	*caudimaculatum*	4.04E-03	9.80E-04	4.90E-01	1.20E-01
Holocentridae	*Sargocentron*	*cornutum*	4.40E-04	2.20E-04	3.00E-02	2.00E-02
Holocentridae	*Sargocentron*	*diadema*	2.80E-04	1.50E-04	3.00E-02	2.00E-02
Holocentridae	*Sargocentron*	*sp.*	8.00E-05	8.00E-05	4.00E-02	4.00E-02
Holocentridae	*Sargocentron*	*spiniferum*	2.80E-04	1.70E-04	7.00E-02	4.00E-02
Holocentridae	*Sargocentron*	*tiere*	1.60E-04	1.60E-04	1.00E-02	1.00E-02
Labridae	*Coris*	*aygula*	1.20E-04	7.00E-05	3.00E-02	1.00E-02
Labridae	*Hemigymnus*	*fasciatus*	2.00E-04	9.00E-05	4.00E-02	3.00E-02
Labridae	*Oxycheilinus*	*digrammus*	1.20E-04	7.00E-05	1.00E-02	1.00E-02
Lethrinidae	*Gnathodentex*	*aureolineatus*	1.11E-02	4.99E-03	3.38E+00	1.63E+00
Lethrinidae	*Lethrinus*	*olivaceus*	4.40E-04	2.30E-04	4.80E-01	2.50E-01
Lethrinidae	*Lethrinus*	*xanthochilus*	2.40E-04	1.10E-04	2.50E-01	1.20E-01
Lethrinidae	*Monotaxis*	*grandoculis*	4.80E-04	2.40E-04	4.10E-01	1.90E-01
Lutjanidae	*Aphareus*	*furca*	4.80E-04	2.20E-04	4.00E-02	2.00E-02
Lutjanidae	*Lutjanus*	*bohar*	3.80E-04	2.00E-04	1.70E-01	1.10E-01
Lutjanidae	*Lutjanus*	*fulvus*	1.31E-02	4.88E-03	3.26E+00	9.40E-01
Lutjanidae	*Lutjanus*	*monostigma*	2.16E-03	8.00E-04	8.00E-01	3.10E-01
Lutjanidae	*Lutjanus*	*semicinctus*	4.00E-05	4.00E-05	0.00E+00	0.00E+00
Lutjanidae	*Macolor*	*niger*	8.00E-05	6.00E-05	1.00E-02	1.00E-02
Mullidae	*Mulloidichthys*	*flavolineatus*	4.00E-05	4.00E-05	0.00E+00	0.00E+00
Mullidae	*Mulloidichthys*	*vanicolensis*	9.40E-04	9.00E-04	7.00E-02	7.00E-02
Mullidae	*Parupeneus*	*bifasciatus*	1.60E-04	8.00E-05	1.00E-01	5.00E-02

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Family	Genus	Species	Density	SE Density	Biomass	SE Biomass
Mullidae	*Parupeneus*	*cyclostomus*	4.00E-05	4.00E-05	1.00E-02	1.00E-02
Mullidae	*Parupeneus*	*multifasciatus*	2.00E-04	1.00E-04	3.00E-02	2.00E-02
Mullidae	*Parupeneus*	*pleurostigma*	4.00E-05	4.00E-05	3.00E-02	3.00E-02
Pomacanthidae	*Apolemichthys*	*trimaculatus*	4.00E-04	1.70E-04	1.00E-02	1.00E-02
Pomacanthidae	*Apolemichthys*	*xanthopunctatus*	1.60E-04	1.30E-04	1.00E-02	1.00E-02
Pomacanthidae	*Centropyge*	*bicolor*	1.20E-04	9.00E-05	0.00E+00	0.00E+00
Pomacanthidae	*Centropyge*	*flavissimus*	6.72E-02	4.83E-03	1.14E+00	8.00E-02
Pomacanthidae	*Centropyge*	*loriculus*	3.04E-02	4.86E-03	3.80E-01	6.00E-02
Pomacanthidae	*Centropyge*	*sp.*	8.00E-05	6.00E-05	0.00E+00	0.00E+00
Pomacanthidae	*Pomacanthus*	*imperator*	4.00E-05	4.00E-05	2.00E-02	2.00E-02
Pomacanthidae	*Pygoplites*	*diacanthus*	1.60E-04	1.00E-04	1.00E-02	1.00E-02
Scaridae	*Cetoscarus*	*bicolor*	4.00E-05	4.00E-05	4.00E-02	4.00E-02
Scaridae	*Chlorurus*	*japanensis*	4.00E-05	4.00E-05	2.00E-02	2.00E-02
Scaridae	*Chlorurus*	*microrhinos*	1.20E-04	9.00E-05	1.10E-01	8.00E-02
Scaridae	*Scarus*	*flavipectoralis*	7.08E-03	1.16E-03	3.25E+00	5.60E-01
Scaridae	*Scarus*	*forsteni*	4.00E-04	1.40E-04	1.90E-01	6.00E-02
Scaridae	*Scarus*	*frenatus*	4.00E-05	4.00E-05	1.00E-02	1.00E-02
Scaridae	*Scarus*	*niger*	8.40E-04	2.90E-04	6.30E-01	2.40E-01
Scaridae	*Scarus*	*psittacus*	8.00E-05	8.00E-05	3.00E-02	3.00E-02
Scaridae	*Scarus*	*rubroviolaceus*	2.04E-03	2.90E-04	1.71E+00	2.60E-01
Scaridae	*Scarus*	*sp.*	4.00E-05	4.00E-05	1.00E-02	1.00E-02
Scaridae	*Scarus*	*spinus*	1.60E-04	1.60E-04	1.00E-02	1.00E-02
Scaridae	*Scarus*	*tricolor*	2.48E-03	7.30E-04	9.00E-01	2.50E-01
Serranidae	*Aethaloperca*	*rogaa*	1.20E-04	7.00E-05	1.00E-02	0.00E+00
Serranidae	*Anyperodon*	*leucogrammicus*	4.00E-05	4.00E-05	0.00E+00	0.00E+00
Serranidae	*Cephalopholis*	*argus*	3.16E-03	7.90E-04	5.20E-01	1.30E-01
Serranidae	*Cephalopholis*	*leopardus*	6.80E-04	2.90E-04	5.00E-02	2.00E-02
Serranidae	*Cephalopholis*	*sexmaculata*	4.00E-05	4.00E-05	0.00E+00	0.00E+00
Serranidae	*Cephalopholis*	*sp.*	8.00E-05	8.00E-05	1.00E-02	1.00E-02
Serranidae	*Cephalopholis*	*urodeta*	1.63E-02	2.08E-03	1.40E+00	1.90E-01
Serranidae	*Epinephelus*	*howlandi*	4.00E-05	4.00E-05	0.00E+00	0.00E+00
Serranidae	*Epinephelus*	*melanostigma*	8.00E-05	8.00E-05	0.00E+00	0.00E+00
Serranidae	*Epinephelus*	*merra*	8.00E-05	8.00E-05	0.00E+00	0.00E+00
Serranidae	*Epinephelus*	*sexfasciatus*	8.00E-05	6.00E-05	0.00E+00	0.00E+00
Serranidae	*Epinephelus*	*spilotoceps*	6.00E-04	1.60E-04	5.00E-02	2.00E-02
Siganidae	*Siganus*	*argenteus*	8.00E-05	8.00E-05	1.00E-02	1.00E-02
Siganidae	*Siganus*	*punctatus*	8.00E-05	8.00E-05	5.00E-02	5.00E-02
Tetraodontidae	*Arothron*	*sp.*	4.00E-05	4.00E-05	2.00E-02	2.00E-02
Zanclidae	*Zanclus*	*cornutus*	2.47E-02	2.85E-03	2.05E+00	2.30E-01

Finfish survey data

APPENDIX 4 INVERTEBRATE SURVEY DATA

4.1 Invertebrate species recorded in different assessments

Group	Species	Broad Scale	Reef Benthos	Others
Beche-de-mer	*Actinopyga mauritiana*	+	+	+
Beche-de-mer	*Bohadschia graeffei*			+
Beche-de-mer	*Holothuria atra*	+		+
Beche-de-mer	*Holothuria nobilis*			+
Beche-de-mer	*Thelenota ananas*	+		+
Bivalve	*Chama* sp.	+		
Cnidarians	*Actinodendron* sp.			+
Cnidarians	*Stichodactyla* sp.			+
Crustacean	*Calappa* sp.			+
Crustacean	*Calcinus* sp.			+
Crustacean	*Carpilius maculatus*			+
Crustacean	*Coenobita* sp.			+
Crustacean	*Eriphia sebana*			+
Crustacean	*Grapsus albolineatus*			+
Crustacean	*Grapsus grapsus*			+
Crustacean	*Lysiosquillina* sp.			+
Crustacean	*Panulirus* sp.			+
Crustacean	*Pilumnus* sp.			+
Gastropod	*Bulla* sp.			+
Gastropod	*Conus flavidus*			+
Gastropod	*Conus miles*			+
Gastropod	*Conus* sp.			+
Gastropod	*Cypraea caputserpensis*			+
Gastropod	*Cypraea moneta*			+
Gastropod	*Cypraea talpa*			+
Gastropod	*Cypraea tigris*			+
Gastropod	*Drupa morum*			+
Gastropod	*Drupa* sp.			+
Gastropod	*Drupella* sp.			+
Gastropod	*Lambis truncata*			+
Gastropod	*Latirolagena smaragdula*			+
Gastropod	*Morula* sp.			+
Gastropod	*Nerita polita*			+
Gastropod	*Nerita* sp.			+
Gastropod	*Oliva* sp.			+
Gastropod	*Ovula ovum*			+
Gastropod	*Thais armigera*		+	+
Gastropod	*Thais* sp.			+
Gastropod	*Turbo argyrostomus*	+	+	+
Gastropod	*Turbo setosus*			+
Gastropod	*Vasum ceramicum*			+
Gastropod	*Vasum* sp.			+

Invertebrate survey data

Group	Species	Broad Scale	Reef Benthos	Others
Star	*Acanthaster planci*	+		
Star	*Culcita novaeguineae*			+
Star	*Fromia* sp.			+
Star	*Linckia laevigata*		+	+
Urchin	*Diadema* sp.	+		
Urchin	*Echinometra mathaei*			+
Urchin	*Echinothrix calamaris*	+		
Urchin	*Echinothrix diadema*	+	+	+
Urchin	*Echinothrix* sp.			+

4.2 Nauru broad-scale assessment data review

Station: 6 x 300m transects, density per ha.

Species	Transects			Transects_P			Stations			Stations_P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Acanthaster planci	0.3	0.3	48	15.7	-	1	0.3	0.3	8	2.6	-	1
Actinopyga mauritiana	164.2	21.0	48	179.2	21.5	44	164.2	39.7	8	164.2	39.7	8
Chama sp.	0.3	0.3	48	15.6	-	1	0.3	0.3	8	2.6	-	1
Echinothrix calamaris	0.3	0.3	48	15.6	-	1	0.3	0.3	8	2.6	-	1
Echinothrix diadema	1013.0	180.8	48	1057.0	186.0	46	1013.0	429.2	8	1013.0	429.2	8
Echinothrix sp.	16.4	12.8	48	392.5	195.8	2	16.4	16.4	8	130.8	-	1
Holothuria atra	2.0	1.0	48	24.6	4.8	4	2.0	1.3	8	5.5	2.7	3
Thelenota ananas	0.3	0.3	48	16.4	-	1	0.3	0.3	8	2.7	-	1
Turbo argyrostomus	1.0	0.7	48	24.2	8.0	2	1.0	1.0	8	8.1	-	1

Notes: Mean = mean density per hectare; _P = result for transects or stations where the species was present (units where the species was found); n = number of units.

4.3 Nauru reef benthos assessment data review

Station: 6 x 40m transects, density per ha. Qualifier (_P) describes results for only units when the species of interest was present.

Species	Transects			Transects_P			Stations			Stations_P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	250.0	70.6	18	375.0	85.3	12	250.0	86.7	3	250.0	86.7	3
Echinothrix diadema	2711.8	1014.5	18	4437.5	1448.2	11	2711.8	1392.1	3	2711.8	1392.1	3
Linckia laevigata	250.0	129.4	18	900.0	331.7	5	250.0	250.0	3	750.0	-	1
Thais armigera	27.8	27.8	18	500.0	-	1	27.8	27.8	3	83.3	-	1
Turbo argyrostomus	489.6	292.2	18	1468.8	763.7	6	489.6	484.4	3	734.4	724.0	2

Notes: Mean = mean density per hectare; _P = result for transects or stations where the species was present (units where the species was found); n = number of units.

4.4 Nauru Reef Front Search (RFs).
Station: 6 x 5 min search periods, density per ha

Species	Search Period			Search Period_P			Station			Station_P		
	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	87.0	10.7	96	114.4	12.5	73	87.0	17.1	16	87.0	17.1	16
Calappa sp.	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1
Coenobita sp.	2.0	1.0	96	37.6	9.4	5	2.0	1.3	16	10.5	4.7	3
Conus flavidus	1.0	0.6	96	31.4	7.8	3	1.0	0.6	16	5.2	1.3	3
Conus miles	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1
Culcita novaeguineae	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1
Cypraea caputserpensis	6.4	2.0	96	38.2	8.8	16	6.4	2.2	16	11.3	3.0	9
Cypraea tigris	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1
Drupa morum	202.9	41.3	96	453.1	77.0	43	202.9	54.6	16	202.9	54.6	16
Drupa sp.	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1
Echinometra mathaei	4.7	1.6	96	44.7	8.2	10	4.7	2.0	16	14.9	3.4	5
Echinothrix diadema	774.8	70.1	96	791.2	70.6	94	774.8	141.9	16	774.8	141.9	16
Echinothrix sp.	7.4	7.4	96	705.9	-	1	7.4	7.4	16	117.6	-	1
Eriphia sebana	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1
Holothuria atra	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1
Latirolagena smaragdula	0.7	0.7	96	70.6	-	1	0.7	0.7	16	11.8	-	1
Morula sp.	18.4	6.8	96	196.1	39.4	9	18.4	10.1	16	73.5	25.9	4
Oliva sp.	4.4	2.2	96	84.7	21.8	5	4.4	2.9	16	23.5	10.4	3
Ovula ovum	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1
Thais armigera	11.5	2.6	96	48.1	6.2	23	11.5	2.3	16	15.4	2.1	12
Turbo argyrostomus	3.7	1.1	96	32.1	3.6	11	3.7	1.2	16	7.4	1.4	8
Vasum sp.	0.2	0.2	96	23.5	-	1	0.2	0.2	16	3.9	-	1

Notes: Mean = mean density per hectare; _P = result for transects or stations where the species was present (units where the species was found); n = number of units.

4.5 Nauru Reef Front Search (RFs_w).

Station: 6 x 5 min search periods, density per ha

	Search Period			Search Period_P			Station			Station_P		
Species	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**
Actinopyga mauritiana	1.4	0.4	120	13.9	2.0	12	1.4	0.5	20	3.1	0.7	9
Bulla sp.	0.5	0.3	120	18.5	7.4	3	0.5	0.3	20	3.1	1.2	3
Calcinus sp.	0.5	0.5	120	55.6	-	1	0.5	0.5	20	9.3	-	1
Carpilius maculatus	0.1	0.1	120	11.1	-	1	0.1	0.1	20	1.9	-	1
Conus sp.	0.3	0.2	120	16.7	5.6	2	0.3	0.3	20	5.6	-	1
Cypraea moneta	0.4	0.2	120	14.8	3.7	3	0.4	0.2	20	2.5	0.6	3
Cypraea talpa	0.1	0.1	120	11.1	-	1	0.1	0.1	20	1.9	-	1
Drupa morum	2.0	1.2	120	61.1	24.6	4	2.0	1.7	20	20.4	13.0	2
Drupa sp.	0.1	0.1	120	11.1	-	1	0.1	0.1	20	1.9	-	1
Echinometra mathaei	0.2	0.1	120	11.1	0.0	2	0.2	0.1	20	1.9	0.0	2
Echinothrix diadema	0.3	0.2	120	11.1	0.0	3	0.3	0.2	20	1.9	0.0	3
Eriphia sebana	0.2	0.1	120	11.1	0.0	2	0.2	0.1	20	1.9	0.0	2
Grapsus albolineatus	11.3	5.1	120	135.6	46.9	10	11.3	7.2	20	32.3	18.7	7
Grapsus grapsus	0.1	0.1	120	11.1	-	1	0.1	0.1	20	1.9	-	1
Holothuria atra	5361.8	418.6	120	5406.8	419.7	119	5361.8	672.9	20	5361.8	672.9	20
Lysiosquillina sp.	0.1	0.1	120	11.1	-	1	0.1	0.1	20	1.9	-	1
Morula sp.	0.1	0.1	120	11.1	-	1	0.1	0.1	20	1.9	-	1
Nerita polita	1.4	1.0	120	55.6	29.4	3	1.4	1.0	20	9.3	4.9	3
Nerita sp.	0.1	0.1	120	11.1	-	1	0.1	0.1	20	1.9	-	1
Pilumnus sp.	0.6	0.6	120	38.9	27.8	2	0.6	0.6	20	6.5	4.6	2
Thais armigera	10.7	2.0	120	31.4	4.4	41	10.7	2.3	20	15.3	2.3	14
Thais sp.	1.7	0.9	120	40.0	13.0	5	1.7	0.9	20	8.3	2.9	4
Turbo setosus	0.2	0.2	120	22.2	-	1	0.2	0.2	20	3.7	-	1
Vasum ceramicum	0.1	0.1	120	11.1	-	1	0.1	0.1	20	1.9	-	1
Vasum sp.	1.8	0.6	120	23.5	2.2	9	1.8	0.7	20	5.9	0.9	6

Notes: Mean = mean density per hectare; _P = result for transects or stations where the species was present (units where the species was found); n = number of units.

4.6 Nauru MOPs data review

Station: 6 x 5 min search periods, density per ha

	Search period			Search period_P			Stations			Stations_P		
Species	Mean	SE	n	Mean	SE	n	Mean	SE	n	Mean	SE	n
Actinopyga mauritiana	370.1	40.0	42	370.1	40.0	42	370.1	61.4	7	370.1	61.4	7
Carpilius maculatus	1.1	1.1	42	45.5	-	1	1.1	1.1	7	7.6	-	1
Conus sp.	6.5	3.7	42	68.2	22.7	4	6.5	5.3	7	22.7	15.2	2
Cypraea tigris	1.1	1.1	42	45.5	-	1	1.1	1.1	7	7.6	-	1
Drupa morum	3.2	2.4	42	68.2	22.7	2	3.2	2.3	7	11.4	3.8	2
Drupella sp.	6.5	6.5	42	272.7	-	1	6.5	6.5	7	45.5	-	1
Echinometra mathaei	4.3	3.4	42	90.9	45.5	2	4.3	4.3	7	30.3	-	1
Echinothrix diadema	1245.7	299.9	42	2092.7	429.2	25	1245.7	407.2	7	1245.7	407.2	7
Fromia sp.	2.2	2.2	42	90.9	-	1	2.2	2.2	7	15.2	-	1
Holothuria nobilis	1.1	1.1	42	45.5	-	1	1.1	1.1	7	7.6	-	1
Lambis truncata	2.2	2.2	42	90.9	-	1	2.2	2.2	7	15.2	-	1
Linckia laevigata	9.7	3.6	42	58.4	8.4	7	9.7	2.7	7	13.6	1.5	5
linckia sp.	6.5	3.7	42	68.2	22.7	4	6.5	4.5	7	22.7	7.6	2
Panulirus sp.	1.1	1.1	42	45.5	-	1	1.1	1.1	7	7.6	-	1
Thais armigera	2.2	2.2	42	90.9	-	1	2.2	2.2	7	15.2	-	1
Thais sp.	3.2	3.2	42	136.4	-	1	3.2	3.2	7	22.7	-	1
Turbo argyrostomus	30.3	7.7	42	90.9	11.7	14	30.3	15.0	7	53.0	19.6	4
Vasum ceramicum	4.3	3.0	42	90.9	0.0	2	4.3	2.8	7	15.2	0.0	2

Notes: Mean = mean density per hectare; _P = result for transects or stations where the species was present (units where the species was found); n = number of units.

4.7 Nauru sea cucumber day search (Ds) assessment data review

Station: 6 x 5minutes periods per station, estimated density per ha

	Search Period			Search Period_P			Station			Station_P		
Species	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**	**Mean**	**SE**	**n**
Actinodendron sp.	0.4	0.4	54	21.4	-	1	0.4	0.4	9	3.6	-	1
Bohadschia graeffei	5.2	3.1	54	92.8	25.7	3	5.2	5.2	9	46.4	-	1
Culcita sp.	0.4	0.4	54	21.4	-	1	0.4	0.4	9	3.6	-	1
Echinothrix diadema	2.4	2.4	54	128.5	-	1	2.4	2.4	9	21.4	-	1
Holothuria atra	3.6	1.2	54	24.1	2.7	8	3.6	1.7	9	8.0	2.2	4
Holothuria nobilis	1.2	0.9	54	32.1	10.7	2	1.2	1.2	9	10.7	-	1
Lambis lambis	0.4	0.4	54	21.4	-	1	0.4	0.4	9	3.6	-	1
Lambis truncata	2.0	0.9	54	21.4	0.0	5	2.0	0.9	9	4.5	0.9	4
Linckia laevigata	0.8	0.6	54	21.4	0.0	2	0.8	0.8	9	7.1	-	1
Stichodactyla sp.	2.0	0.9	54	21.4	0.0	5	2.0	0.9	9	4.5	0.9	4
Thelenota ananas	54.7	23.9	54	140.7	57.3	21	54.7	45.5	9	82.1	67.2	6

Notes: Mean = mean density per hectare; _P = result for transects or stations where the species was present (units where the species was found); n = number of units.

4.8 Nauru species size review — all techniques

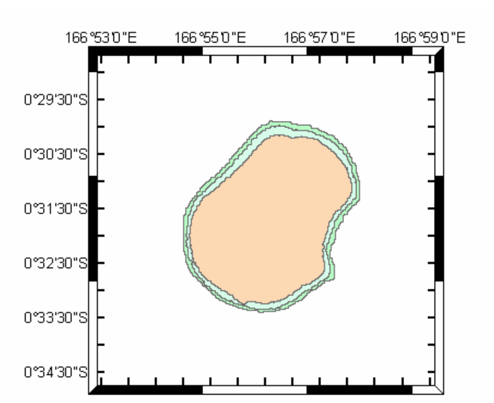
Genus species	Mean Length (cm)	SE	n
Holothuria atra	9.5	0.2	684
Actinopyga mauritiana	18.2	0.1	552
Turbo argyrostomus	5.8	0.1	39
Thelenota ananas	44.4	1.0	27
Bohadschia graeffei	32.4	1.5	12
Lambis truncata	22.8	0.8	8
Thais armigera	6.7	0.7	7
Holothuria nobilis	22.8	1.1	4
Conus flavidus	5.5	0.5	2
Turbo setosus	2.5	0.5	2
Pilumnus sp	9.0		1
Conus miles	7.0		1
Cypraea talpa	6.0		1
Cypraea tigris	7.5		1

5. MILLENNIUM CORAL REEF MAPPING PROJECT, NAURU

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 Nauru

(December 2006)



The Institute for Marine Remote Sensing (IMaRS) of University of South Florida (USF) was funded in 2002 by the Oceanography Program of the National Aeronautics and Space Administration (NASA) to provide an exhaustive inventory of coral reefs worldwide using high-resolution multispectral satellite imagery (Landsat 7 images acquired between 1999 and 2002 at 30 meters resolution). Since mid-2003, the project is a partnership between Institut de Recherche Pour le Développement (IRD, France) and USF. The goal is to characterize, map and estimate the extent of shallow coral reef ecosystems in the main coral reef provinces (Caribbean-Atlantic, Pacific, Indo-Pacific, Red Sea). The program aims to highlight similarities and differences between reef structures at a scale never considered so far by traditional work based on field studies. We believe the data set generated by this research program will be critical for comparative geochemical, biological and geological studies. It provides a reliable, spatially well constrained data set for biogeochemical budgets, biodiversity assessment, reef structure comparisons, and management. It provides critical information for reef managers in terms of reef location, distribution and extent since this basic information is still of high priority for scientists and managers.

As part of this project, Nauru Island was mapped. The figure on the left column shows the Nauru Millennium product. Millennium products provide maps at geomorphological level, the result of a compromise between richness of information and accuracy when no ground-truthing is available. Only two geomorphological classes can be discriminated for Nauru, namely an oceanic exposed fringing reef flat (3.4 km^2, light blue on the figure) and its forereef (2.5 km^2 from crest down to 25 m deep, light green on the figure). They surround 21.9 km^2 of uplifted limestone.

The PROCFish/Coastal project who is reporting in this document on Nauru fishery status has been using Millennium products in the last three years in all targeted countries in order to optimize sampling strategy, access reliable reef maps, and further help in fishery data interpretation. The level of mapping used by PROCFish/C is generally a thematically simplified version of the Millennium standard. PROCFish/C is using Millennium maps only for the fishery grounds surveyed for the project.

For further inquiries regarding the status of the coral reef mapping of Nauru and data availability (satellite images and Geographical Information Systems mapped products), please contact:

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For further information on the project: http://imars.marine.usf.edu/corals.

Reference: Andréfouët S, and 6 authors (2005), Global assessment of modern coral reef extent and diversity for regional science and management applications: a view from space. Proc 10th ICRS, Okinawa 2004, Japan: pp. 1732-1745.