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**Tables**

# LIST OF ACRONYMS

| | |
|---|---|
| **AIMS** | Australian Institute of Marine Science |
| **CFDI** | Coral Reef Fish Diversity Index |
| **CITES** | Convention on International Trade in Endangered Species |
| **COTS** | Crown of Thorns |
| **FIME** | Fiji Islands Marine Ecoregion |
| **FLMMA** | Fiji Locally Managed Marine Area Network |
| **GCRMN** | Global Coral Reef Monitoring Network |
| **GDP** | Gross Domestic Product |
| **GSR** | Great Sea Reef |
| **IAS** | Institute of Applied Sciences |
| **IUCN** | International Union for the Conservation of Nature |
| **MPA** | Marine Protected Area |
| **NBSAP** | National Biodiversity Strategy and Action Plan |
| **NGO** | Non Government Organization |
| **NLFC** | Native Lands Fisheries Commission |
| **SCUBA** | Self Contained Unit Breathing Apparatus |
| **SPREP** | South Pacific Regional Environmental Programme |
| **USD** | United States Dollar |
| **USP** | University of the South Pacific |
| **WWF** | WWF, the global conservation organization |

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**PHOTOGRAPH 1.**

*?????? Please provide the caption for the above photograph ????*

**Photo: GSR Team**

# 1. EXECUTIVE SUMMARY

- This report presents the results of a twelve day survey expedition (5 to 16 December, 2004) and represents the first ever systematic effort to document the marine biodiversity of the Great Sea Reef (GSR), locally known as Cakaulevu, to the north of Vanua Levu in the Fiji Archipelago.

- 23 sites were surveyed over 6 major habitat types: outer barrier reefs, back barrier reefs, channels, mangrove island fringing reefs, rocky island fringing reef and submerged patch reefs.

- The diversity of marine biota on the Great Sea Reef and its associated habitats was revealed to be of high importance on a global, regional, national and local scale. This survey alone documented the reef to have approximately 55% of the known coral reef fish in Fiji (with a predicted actual value of 80%), 74% of the known corals found in Fiji and in total 40% of all the known marine flora and fauna in the Fiji Islands. In addition, 117 species of sponges, 31 species of coelenterate and 12 species of ascidian were collected. The number of species recorded was the highest of any other reef area surveyed in Fiji.

- Populations of at least 12 species listed on the 2004 IUCN Redlist of threatened species were observed including 10 species of fish, the IUCN endangered green turtle (*Chelonia midas*) and the spinner dolphin (*Stenella longirostris)*.

- The survey also revealed populations of the nationally endangered bumpheaded parrotfish (Bolbometopom muricatum), previously presumed locally extirpated; one new fish species (Pomacentrus sp.); and one presumed new record (Chromis opercularis) only previously known in the Indian Ocean. 44% of the known endemic reef fish in Fiji were observed.

- Within the hard corals, 43 new records were documented for Fiji. Of these, two were new genera (WHICH ONES???) and three were believed to be geographic range extensions, Echinomorpha nishihirai (Veron, 1990) and Turbinaria heronensis (Wells,1958).

- Sixteen species were found to be new additions to the flora of the Fiji Archipelago. Two possible new species, Ceramium sp. and Crouania sp., were also recorded.

- Habitats of primary importance to the diversity and abundance of marine biota of conservation significance were generally found to be the outer barrier reefs, channels and mangrove island fringing reefs. Increasing levels of intactness were recorded with distance from population centres, land based siltation, pollution and extractive activities.

- Unusual distant offshore mangrove island fringing reef habitats were found to be of surprisingly high diversity and productivity. These highly dynamic, tidally influenced systems are considered to be "keystone habitats " of crucial importance to maintaining the ecological integrity of the entire coastline.

- The most damaged sites in terms of siltation and trash were observed to be in the general vicinity of the Labasa Township.

- Overall, commercially important fish were found in very low numbers and small sizes. Fish important for local subsistence were found in higher numbers, but this varied greatly from site to site. Fishing pressure, as indicated by discarded fishing lines, was greatest around the vicinity of

Labasa.

- Ten specific recommendations for conservation action have been given, including sites for inclusion in a proposed network of protected areas.

- Detailed site descriptions are given for 23 sites in the GSR including baseline information on fish, benthic cover, algae and invertebrates.

# 2. OVERVIEW

## 2.1 INTRODUCTION

The Fiji Islands offers an enormous wealth of coral reef habitat, covering an estimated 10,020 square kilometers of the Fiji archipelago, and representing 9.0 % of the coral reefs of the Pacific and 3.5 % of the total area of coral reefs in the world (Zann et. al.,1997). While some of the reefs within the country have been studied extensively in terms of their ecology and biodiversity, the vast proportion remains poorly known. Species numbers for coral reef biota are high. Currently, at least 298 species of scleractinian coral have been recorded along with 475 species of mollusc and some 60 species of ascidian. A total of 1,208 species of fish have been recorded within Fiji, the majority of these are associated with coral reefs. Algal flora is also reasonably well documented with 448 species known (Spalding et. al. 2001).

Functioning marine systems and productive fisheries are vitally important to the people of Fiji. They are a key source of food, income, employment, foreign exchange and Fiji's cultures. 80% of rural Fijians live within 5 km of the coast and depend heavily on the reefs of Fiji as a primary source of protein. Subsistence catches from reefs are estimated at 17,000 tonnes per year and near shore commercial fisheries contribute a further 6,000 tonnes to the annual fish catch (Spalding et. al 2001). A study conducted in 1999 showed that the artisanal and subsistence fisheries in Fiji were worth around $USD 50 million and supplied 40% of the total animal protein to Fijian rural communities (Ministry of National Planning and Information, 2002). Export fisheries are the fourth largest foreign exchange earner in Fiji after sugar, tourism and garments. The total value of fisheries products exported in 1999 was $USD135 million, with the sector contributing about 1.5% of the national GDP. The marine sector for both commercial and subsistence fisheries also provide direct employment for around 9,000 people (Ministry of National Planning and Information, 2002).

Target stocks have declined significantly in many areas primarily as a result of overfishing, although pollution near urban centres may also play a role. Mangrove clearance for land reclamation, runoff from mines, agriculture, sugar and timber mills and poorly planned coastal developments are also contributing to declining productivity of Fijian reef systems.

The Great Sea Reef (GSR), locally known as Cakaulevu, is the longest and most complex reef system in the Fiji Islands and is the third longest continuous barrier reef system in the world (Spalding et. al 2001). Together with Pascoe Reef, the Great Sea Reef runs along the shelf edge in a near continuous chain for over 200 kilometers, gradually converging towards the coastline of Fiji's second largest island, Vanua Levu, at the north eastern tip. The lagoon side of the GSR is an extensive and complex system of submerged and

emergent coral reefs, mangrove and rocky islands, seagrass beds and other marine ecosystems. These systems provide substantial fisheries resources and important the geophysical functions of shoreline stabilization and prevention of wave damage. The coastal and island mangroves also act as sediment and pollutant filters for these coastal areas, and provide essential nursery areas for various organisms that inhabit the near shore marine systems. The GSR together with the Bligh Waters form the Fiji Island Marine Ecoregion (FIME), an area considered to be of global biological significance for conservation (WWF, 2001). The people of the Macuata and Bua provinces in Vanua Levu have traditional fishing rights over the GSR and associated marine systems and continue to depend heavily on the functioning and biological diversity of these systems for their subsistence and commercial livelihoods.

The marine biodiversity and conservation status of the marine systems within the GSR are very poorly understood and are becoming increasingly threatened by burgeoning human populations, associated industrial and coastal development, and the rising international and local demand for tropical reef products. This report presents the results of a twelve day survey expedition commissioned by WWF-Fiji Country Programme with the support of the coastal communities of Macuata and Bua provinces. It represents the first ever systematic effort to document the marine biodiversity of the Great Sea Reef region of Fiji.

## 2.2 AIMS OF THE GREAT SEA REEF SURVEY

The broad aims for carrying out this survey expedition were to :

- document the marine biodiversity and conservation attributes of a representative subset of coral reef sites within the Great Sea Reef and associated reef systems;
- identify candidate sites for further detailed investigation and key sites for conservation action, including making recommendations for Marine Protected Area establishment; and
- raise the level of global, national and local awareness of the importance of the Great Sea Reef for biodiversity conservation and local livelihoods.

## 2.3 OBJECTIVES OF THE GREAT SEA REEF SURVEY

Specifically, the results of this survey will :

- be used in national level coastal resource development programmes, such as the PROC fish and I qoliqoli management plans, to plan accurately the conservation, management and marine resource use in the Great Sea Reef;
- assist in the formation of a national level Coral Reef Management Strategy and will inform relevant policy, as mandated by the National Biodiversity Strategy and Action Plan (NBSAP);
- provide the baseline information in select sites for long-term monitoring in order to prioritize and measure the effectiveness of conservation and development action;
- be submitted to the Global Coral Reef Monitoring Network (GCRMN) data center, the Reef Check global database, and to the South Pacific Regional Environmental Programme (SPREP) coral reef networks for international comparison;
- enhance the capacity of Fijian nationals to monitor coral reefs through inclusion of USP students and local conservation managers in the planning, survey and subsequent report production;
- assess the impacts of previous and current bleaching events, as well as the level of anthropogenic stress; and
- communicate and disseminate locally, regionally and globally the results of the survey via partner networks.

## 2.4 PHYSICAL ENVIRONMENT

The island of Vanua Levu has a moderate, tropical climate with a distinct wet season, generally recognized as the cyclone season, between November and April. Fiji experiences about 10 to 15 cyclones per decade, two to four of which cause severe damage including extensive wind damage, flooding, storm surges and occasional landslides (Chandra & Mason, 1998). Rainfall is highly variable, even in the wet season, and is predominantly influenced by the prevailing southeast trade winds and local topography. The mountains of Vanua Levu create a wetter zone on the windward side and a drier rain shadow on the leeward side. Annual rainfall averages 1.78 to 2.03 cm on the leeward side and 2.92 to 3.18 cm on the windward side, with weak seasonality. Long-term averages of annual rainfall for the Macuata area (as recorded since 1977-2000) are in the range of 2.2 to 2.5 cm. Temperatures range from 19.8 oC to 30.6 $^{oC}$ (Fiji Meteorological Office). The average yearly temperature is about 25oC with a slightly lower average on the windward side and higher average on the leeward side. The humidity is usually high, ranging from 75 to 80 % (http://www.met.gov.fj/climatefiji.html).

Horizontal underwater visibility within the areas surveyed ranged from less than 3 m during falling tides on many inshore sites and channels, to greater than 30 m on outer barrier reef and patch reefs which were more than 1 km from the mainland. Water temperatures ranged from 27.5 °C to 29°C. Current patterns in the areas surveyed were highly complex and strongly localized although the currents between the mainland and the GSR are primarily influenced by tidal fluctuation. The strongest currents experienced were in the barrier reef passages or in the channels between islands.

## 2.5 HUMAN ENVIRONMENT

Vanua Levu is Fiji's second largest island, occupying an area of 5538 km2. It is also the archipelago's second most populated island, with 18% of the total population. Major industries here include sugar and copra. Gold is also being mined at Mt Kasi in the south-west of the island. The island is divided into the provinces of Cakaudrove (south-east), Bua (south-west) and Macuata (north-west).

The Great Sea Reef stretches from the northern tip of Vanua Levu (Udu point) along the province of Macuata and around the top of Bua province. According to the I qoliqoli (traditional fishing rights boundaries) maps of the Native Lands Fisheries Commission (NLFC), the GSR forms the outer boundary of 8 of the I qoliqolis of Macuata province including the vanua Udu, vanua Namuka/Dogotuki; vanua Nadogo/Nubu; and 3 I qoliqolis from Bua province - vanua Raviravi; vanua Lekutu and vanua Navakasiga.

Macuata province has a population of 80,207 containing 15,101 households (Fiji Bureau of Statistics). 28% of the populations are indigenous Fijian, 70% are Indo-Fijian and 2% are of other ethnicities. People within Macuata province have an average life expectancy of 65 years old and on average the fertility rate is 3.2.

Bua province has a population of 14,998 and 2,710 households. 73% of the populations are indigenous Fijian, 22% are Indo-Fijian and 5 % are of other ethnicities People of Bua province have an average life expectancy of 66 years and a total

**TABLE 1.**
Habitat types surveyed on the GSR

| HABITAT TYPE | SITE CODE |
|---|---|
| Outer Barrier Reef | OB1, OB3 Deep |
| Back Barrier Reef | IB2 , IB5 Shallow |
| Barrier Channel | CH4, CH2, CH1 Deep, Shallow, CH5 Deep, OB1 Shallow |
| Mangrove Island Fringing Reef | IP1, IP3.5 Deep & Shallow, IP3 Deep, IP4.5 Shallow |
| Rocky Island Fringing Reef | IB3, IB4 Shallow, IP2 Deep |
| Submerged Patch Reef | IP4 & IB1 Shallow |

fertility rate of 4.5 (Fiji Bureau of Statistics). Infant mortality is high in Fiji at 1.8 % (Fiji Ministry of Health) with figures for the more isolated areas of Macuata and Bua likely to be even higher.

The major subsistence activities are fishing, farming and gathering wild food produce, while primary industries are sugar cane and pine plantations. Parts of the Bua portion of the GSR are fished commercially for live reef fish. Beche de mer and trochus are harvested by local communities along the entire reef system of Macuata to Bua.

## 2.6 SITE SELECTION

Given that the scope of area to be covered was extensive and the time for field work was limited to 12 days, the survey team needed to balance site representativeness with logistical capabilities. Considering the survey vessel was 125 ft long, was sea-worthy and had a long-range cruising capacity, it was decided that efforts would be concentrated on the more difficult to reach and least explored habitats of the GSR, namely :

1. Windward barrier walls (OB)
2. Leeward barrier walls (IB)
3. Barrier channels (CH)
4. Mid-lagoonal patch reefs (IP)

Of these four habitat types, 20 potential sites, five within each habitat type, were selected based on a combination of information available from 1) a WWF and Fisheries led community mapping workshop on fisheries resources and Marine Protected Area development (WWF, November 2004), 2) Arial photographs, 3) bathymetric and nautical charts, 4) resort diver information, 5) local specialists and 6) local community representatives. Our target was to survey 13 to 15 of these potential sites based on weather conditions, navigational capabilities and time constraints. Twenty sites (shown in Table 1 and Figure 1) were surveyed over the 12 days.

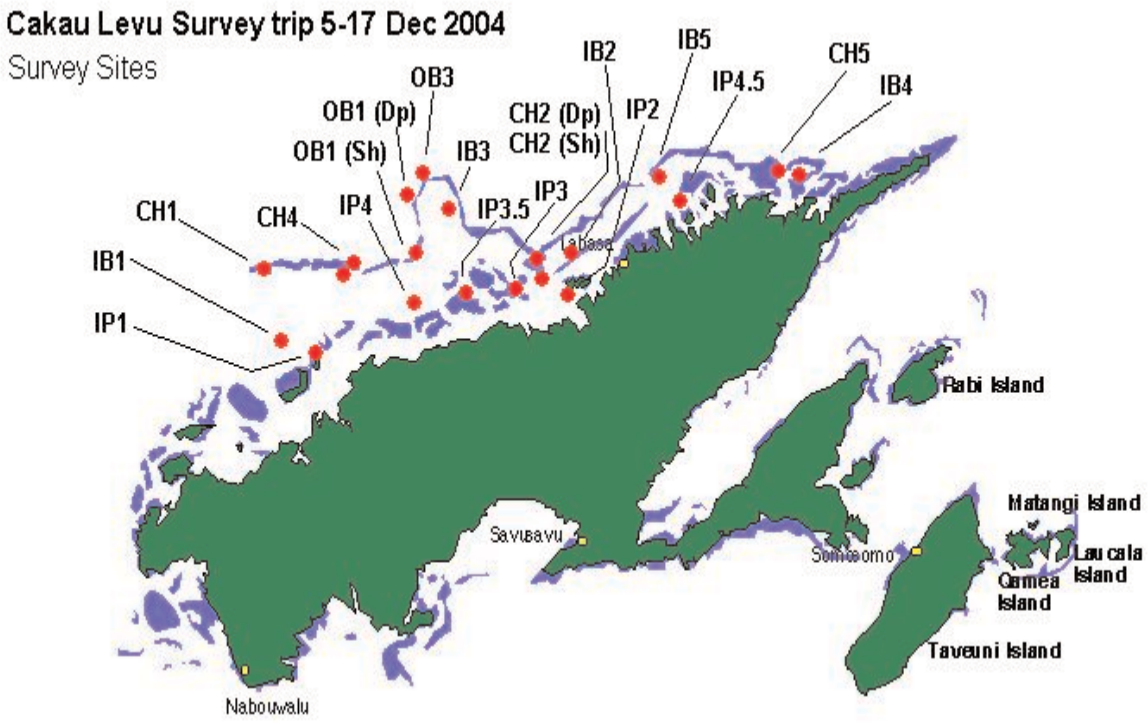


**FIGURE 1.** Sites surveyed on the Great Sea Reef and associated habitats.

# 3. METHODS

## 3.1 SURVEY LOGISTICS

The survey team was divided into three survey groups:

1) an alpha diversity group, surveying primary systematic diversity in fish, corals, algae and sea grasses,
2) a Global Coral Monitoring Network (GCRMN) group, to obtain quantitative data on coral reef indicator groups and benthic cover data, and
3) a collection group, collecting soft corals and sponges primarily for bioassay and systematic work.

Large areas of fringing and patch reef were initially surveyed using a manta tow board to select study sites which were most representative of the reefs within the area. In general, the alpha diversity team and collecting team worked together in an assigned skiff. The GCRMN teams worked together on a second boat and dived a depth contour together, with 50 meter transects stretching in either direction along a contour allowing for a total of

4 x 20 meter transects per depth with 5 meter gaps between transects. All groups were generally within visual distance of each other while on a given section of reef.

## 3.2 ALPHA DIVERSITY PROTOCOL

### 3.2.1 FISH

Each survey dive was conducted in an ascending zigzag search pattern, covering roughly a 100 meter wide search zone along the reef front. Each dive was structured to maximize search time by concentrating on certain "focus groups" within the dive. These groups were generally 1) deep slope (40 m-30 m) fast-moving open water fish, 2) mid-slope (30 m -10 m) large highly conspicuous mid-water fish, 3) Reef crest/flat (10 m to 0 m) with coral and sand-dwelling fish. Snorkel surveys were also conducted in very shallow water and around mangroves. Species seen were recorded on pre-prepared underwater data sheets with space to write in additional species seen.

For potentially new fish taxa, voucher specimens were collected using a three- pronged Hawaiian sling spear, fixed in a 10% formalin solution and transferred to 70% ethanol solution after 5 days of fixation. Some specimens were stored directly in 70% ethanol for DNA analysis. As colour loss is rapid, accurate preservation of colour patterns was recorded by photography. Voucher specimens are to be deposited at the University of the South Pacific in Suva, and the Australian Museum in Sydney. All fish diversity surveys and fish specimen preparation was carried out by Aaron Jenkins.

For purposes of fish fauna comparison the Coral Reef Fish Diversity Index (CFDI) was used in analysis. The CFDI is a rating system based on the number of species present in the following six families: Chaetodontidae, Pomacanthidae, Pomacentridae, Acanthuridae, Scaridae and Labridae. These families are particularly good indicator groups of reef fish diversity and are taxonomically well documented (Werner and Allen, 1998). Using the CFDI, and the following predictor formulae, a reasonable estimate of the total fish fauna for the area can be calculated :

Total fish fauna of surrounding seas encompassing less than 2000 km2 =
3.39 (CFDI) - 20.595 (d.f = 15; R2 = 0.964; P = 0.0001)

Total fish fauna of surrounding seas encompassing more than 50 000 km2 =
4.234 (CFDI) - 114.446 (d.f = 18; R2 = 0.96; P = 0.0001)

### 3.2.2 CORALS

A checklist of species from the Cakaulevu Reef region and for the planned survey habitats was compiled prior to the survey. The survey was conducted using SCUBA with up to three dives per day. The search pattern at each habitat began at depth usually at the margin of the reef. A swimming pattern was conducted which progressed from depth to the surface over the period of the dive. Snorkel surveys were also conducted in very shallow water and around mangroves. A species list was progressively compiled with additions made after each dive. Certain species reputed to occur in Fiji in the literature were items of particular interest and these species were given more attention.

Species were noted, photographed or collected and relevant annotations made during the dive. A voucher collection was made for species which were difficult to identify in situ or which were of particular interest due to their extended range. All specimens have now been

identified and will be entered into the USP coral collection. The taxonomic nomenclature was based on the Scleractinia of Eastern Australia, the Corals of the World, and the Staghorn Corals of the World (Veron and Pichon, 1976; 1979; 1982; Veron, Pichon and Wijsman-Best, 1977; Veron and Wallace, 1984; Veron, 2000; Wallace, 1999).

Photography was by means of a Cool-pix digital camera housed in an Ikelite underwater housing. All coral diversity surveys and coral specimen preparation was carried out by Edward Lovell.

### 3.2.3 ALGAE AND SEAGRASSES

Description of the sites surveyed was made after each survey, emphasizing the presence of algae. These site descriptions are incorporated with those made by other surveyors in the site descriptions (Appendix A).
At each site, algae and seagrasses were recorded to species level. Where species identification is uncertain, representative specimens were collected and preserved in a 5 % formalin in seawater solution. Underwater photos were taken using an underwater digital camera (Canon A95 with Canon Housing WP-DC50). Microscopic examinations of specimens were made using a Nikon SMZ645 dissecting microscope and an Olympus CX 31 stereomicroscope. Where required, hand sections were made to confirm anatomical details of species. Microscopic specimens were mounted on slides using a 30 % corn syrup solution, stained with 1 % aqueous aniline blue. Other specimens were pressed dry and will be deposited in the Phycological Herbarium of the South Pacific Regional Herbarium (SUVA-A), based at the Marine Studies Programme of the University of the South Pacific. All algae and seagrass surveys and specimen preparation were carried by Posa Skelton.

### 3.2.4 GLOBAL CORAL REEF MONITORING NETWORK PROTOCOL

#### 3.2.4.1 SITE DESCRIPTION

The Reef Check site description form (www.reefcheck.org) was used to record the location, standard measurements and dominant pressures on each area of reef, in consultation with a local expert from the area (see Appendix B).

#### 3.2.4.2 REEF PROFILE

At each site, a sketch of the profile of a representative of the reef was made, with key depths and main substrate types and features recorded. Photographs of characteristic areas were also taken. These were used to construct the site profiles sketches used for each area.

#### 3.2.4.3 BELT AND POINT INTERSECT SURVEYS

A team of 6 people recorded benthic cover and numbers of key invertebrates and fish species over 4 x 20 meter lines at each site, with a 5 meter gap between each line. In this way, 100 meters of reef was surveyed at each site. In a few sites, currents were too strong to allow lines to be laid. In these cases, fish and invertebrates were counted over a standard time period of 10 minutes, and benthic cover was recorded over 40 random points. The method used was an expanded Reef Check technique (www.reefcheck.org), using

benthic cover categories from the AIMS manual (English et. al., 1997), and fish and invertebrate species considered to be locally significant. The team was spilt into two groups of three. Each group recorded data along two 20m transects on each reef. Transects were laid at one of two depths, depending on site character:

- Shallow transect: 3-6 meters deep
- Deep transect: 9-12 meters deep

Where possible, both Deep and Shallow measurements were made to give a comprehensive record of reef character, but in many cases due to time or topographical constraints, only one depth was possible.

### 3.2.4.4 SURVEY TYPES

- Benthic Cover - Line Intersect Survey
  Substrate type was recoded at 40 points along each 20 meter line.
- Fish Species - Belt Transect Survey
  Numbers of selected fish species were counted in a 3-dimensional corridor 5 meters wide by 5 meters high along each 20 meter line
- Invertebrate Species - Belt Transect Survey
  Numbers of selected invertebrate species were counted in a 2-dimensional belt 5 meters wide along each 20 meter line

### 3.2.4.5 INVERTEBRATE BELT TRANSECT

Invertebrate taxa were given at the species level if they were considered to be either ecologically important, typically targeted as food species or collected as curios. The invertebrate taxa found were banded coral shrimp (Stenopus hispidus); painted rock lobster (Panulirus versicolour); spiny rock lobster (Panulirus sp.); Three-spot reef crab (Carpilius maculatus); red reef crab (Etisus splendidus); Diadema urchins; Echinometra urchins; Tripneustes gratilla; Acanthaster starfish; Linckia starfish; Cushion starfish (Culcita sp.); pencil urchin (Heterocentrotus mammillatus); pinkfish (Holothuria edulis); brown sandfish (Bohadschia marmorata); surf redfish (Actinopyga mauritiania); Greenfish (Stichopus chloronotus); white teatfish (Holothuria fuscogliva); sandfish (Holothuria scabra); prickly redfish (Thelenota ananas); black teatfish (Holothuria nobilis); Tridacna clams (including T. maxima, T. squamosa); triton shell (Charonia tritonis); tiger cowrie (Cypraea tigris); cone shells; Cephalopods; sea anemones and nudibranchs.

### 3.2.4.6 ANTHROPOGENIC DATA

During the point intersect substrate surveys, trash and coral damage was assessed following the Reef Check guidelines, namely : None=0, Low=1, Medium=2 and High=3.

Damage: Coral damage is separated into three categories

1) boat/anchor
2) dynamite
3) other

Trash: is separated into two categories:

1) General
2) Fish Nets/Traps (including lines)

#### 3.2.4.7 SILTATION DATA

Sediment that remains in suspension if disturbed was recorded. Note that these are practical definitions, not geotechnical. Often, silt is present on top of other indicators such as rock. In these instances, silt was recorded if the depth was >1mm or was if it was not possible to observe the colour of the underlying substrate. If the colour of the underlying substrate could be discerned, then this substrate data was collected.

### 3.2.5 FISH ABUNDANCE AND SIZE CLASS

At each site, in the same area described by the GCRMN team, a visual census was carried out to count all the fish seen and to record them into size categories. This was done along two 3 dimensional corridors that were 5 meters wide, 5 meters high, and 50 meters long, with a 5 meter gap between each line. In this way, 100 meters (2,500 m3) of the reef was surveyed at each site. In a few sites, currents were too strong to allow lines to be laid. In these cases, fish were recorded during a timed swim of 15 minutes. Transects were laid at one of two depths, depending on the character of the site :

- Shallow transect: 3-6 meters deep
- Deep transect: 9-12 meters deep

Where possible, both Deep and Shallow measurements were made to give a comprehensive record of reef character, but in many cases due to time or topographical constraints, only one depth was possible. All fish abundance and size class surveys were carried out by Helen Sykes. The size categories used were: <2cm, 2-5cm, 5-10cm, 10-15cm, 15-20cm, 20-25cm, 25-30cm, 30-35cm, 35-40cm, >40cm.

## 4. RESULTS AND DISCUSSION

### 4.1 ALPHA DIVERSITY

The primary systematic (alpha) diversity of marine biota on the Great Sea Reef and its associated habitats is revealed to be of high importance on global, regional, national and local scales. This high alpha diversity is, in part, related to the high diversity and uniqueness of coral reef habitat types (beta-diversity) within this ecoregion. Of the marine flora known from the entire Fijian archipelago, this two week survey visually documented approximately 55% of the coral reef fish (predicted value of 80%), 74% of the scleractinian corals and 40%. 117 species of sponges, 31 coelenterates and 12 species of ascidians were also collected (see Appendix C), a record number in comparison to surveys in other parts of Fiji. Populations of at least 12 species listed on the 2004 IUCN Redlist of threatened species were observed including 10 species of fish (Table 6), the endangered Green Turtle (Chelonia midas) and the Spinner Dolphin (Stenella longirostris).

This survey also revealed populations of the previously presumed locally extirpated and nationally endangered Bumpheaded Parrotfish (Bolbometopom muricatum), one new fish species (Pomacentrus sp.), one possible new record (Chromis opercularis) only previously known from the Indian Ocean and 44% of the known endemic coral reef fish of Fiji (Ecsenius fijiensis, Meiacanthus ovalauensis, Siganus uspi, Pomacentrus sp.).

**Table 2.**
Coral Reef Fish Diversity Index (CFDI) values for regions or countries and estimated total reef fish species numbers using CFDI regression formula (refer to methods for details).

| LOCALITY | CFDI | ESTIMATED CORAL REEF FISH |
|---|---|---|
| Indonesia | 418 | 1656 |
| Papua New Guinea | 362 | 1419 |
| Great Barrier Reef, Australia | 343 | 1338 |
| Micronesia | 315 | 1220 |
| Fiji Islands | 241 | 908 |
| Maldive Islands | 219 | 813 |
| French Polynesia | 205 | 754 |
| Hawaiian Islands | 121 | 435 |
| Marquesas Islands | 90 | 267 |

*Sources; Werner and Allen, 1998 ; Fiji - combined species lists of Allen and Jenkins.*

For the hard corals, 43 new records were documented for Fiji. Of these, two were new genera (WHICH ONES) and three were geographic range extensions: 1) from Australia Turbinaria heronensis; 2) from New Guinea Canthrellus jebbi and 3) from Indonesia Echinomorpha nishihirai. Sixteen species found to be new additions to the flora of the Fiji Archipelago were recorded along with two additional possible new species (Ceramium sp. Crouania sp.). A number of algae species observed can be considered to be endemic to Fiji - e.g. Avrainvillea rotumensis and Rhipilia neurymenioides. Others could be considered sub-regionally endemic, including Ceramium kramerii and Halophila ovalis ssp. bullosa. These algae and seagrass have so far only been recorded exclusively from Fiji, or from Fiji, Tonga and Samoa.

## 4.2 FISH

### 4.2.1 DIVERSITY OF FISH

The diversity of reef fish fauna within the Great Sea Reef is of high importance on global, regional, national and local scales. This survey visually documented 495 species of fish with a predicted total fauna of 716 species for the Great Sea Reef and associated habitats (Table 2). This represents approximately 80% of the total Fijian coral reef fish fauna and 60% of the total number of all fish species recorded in Fijian waters. To put this level of diversity into a global perspective we use the Coral Reef Fish Diversity Index (CFDI), which is based on the number of species observed in the following six families: Labridae (Wrasses), Pomacentridae (Damselfish), Chaetodontidae (Butterflyfish), Pomacanthidae (Angelfish), Scaridae (Parrotfish) and Acanthuridae (Surgeonfish). The numbers of species within these families are accurate indicators of overall reef fish diversity and are taxonomically well documented enough to make global comparisons (Werner and Allen, 1998). These six families generally represent greater than 50% of the observable fish species at any tropical reef worldwide. Except for wrasse and parrot fish, the GSR fauna appears very highly representative of the Fijian reef fish fauna. GSR is known to contain around 90% of the species known within the Fiji islands, 23.5% of the diversity of the Indo-West Pacific region and 20% of the diversity worldwide (Table 3).

The reef fish of the Great Sea Reef form part of the geater Indo-west and Central Pacific faunal community. The community of fish is very similar to those inhabiting the vast region stretching eastward from East Africa and the Red Sea to the islands of Micronesia and Polynesia. Most of the families present, and many of the genera and species, are seen across the region, although there is a great deal of variation in species composition between localities. The diversity of fish generally declines with increased distance from the Indonesian global centre of diversity.

**Table 3.**
Coral Reef Fish Diversity Index (numbers of species) for GSR compared on national, regional and global scales.

| FAMILY | GREAT SEA REEF | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 65 | 79 | 350 | 402** |
| Damselfish | 60 | 63 | 274 | 330 |
| Butterflyfish | 35 | 35 | 105 | 122 |
| Angelfish | 13 | 14 | 69 | 82 |
| Parrotfish | 17 | 23 | 64 | 83 |
| Surgeonfish | 27 | 27 | 63 | 71 |
| Total (CFDI) | 217 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins, 1999 **tropical species only*

**Table 4.**
Coral fish diversity index for restricted areas, the number of coral reef fish species as determined by surveys to date, and estimated total species numbers using the CFDI regression formula (refer to methods for details).

| LOCALITY | CFDI | NO OBSERVED SPECIES | ESTIMATED TOTAL SPECIES |
|---|---|---|---|
| Maumare Bay, Flores, Indonesia | 333 | 1111 | 1107 |
| Madang, Papua New Guinea | 259 | 789 | 858 |
| Capricorn Group, Great Barrier Reef | 232 | 803 | 765 |
| GREAT SEA REEF, FIJI | 217 | 495 | 716 |
| Samoa Islands | 211 | 852 | 694 |
| Christmas Island, Indian Ocean | 185 | 560 | 606 |
| Rowley Shoals, Western Australia | 176 | 505 | 576 |
| Johnston Island, Central Pacific | 78 | 227 | 243 |
| Rapa | 77 | 209 | 240 |

*Sources : Werner and Allen 1998; GSR - this survey*

### 4.2.2 HABITATS

Generally the richest sites for fish diversity are those exposed to periodic strong currents and which are in proximity to up-welling from nutrient-rich deeper water. During the survey this pattern was observed, the richest sites for fish diversity being on the outer barrier reef sites and the barrier reef channels (Table 5). GSR habitats are surprisingly diverse for reef fish on a world scale and some sites rank highly against sites near the centre of diversity in Indonesia and Papua New Guinea (Werner and Allen, 1998).

Also notably diverse are the fringing reefs of the mangrove-covered islands that dot the northern coastline of Vanua Levu and which are found up several kilometers off of the mainland. Ordinarily, mangroves are considered among the least diverse habitats for fish. These offshore mangrove islands are, however, species rich, dynamic habitats strongly influenced by large tidal fluctuation. Horizontal visibility on these mangrove island reefs can change from 15 meters to 3 meters within an hour. This habitat serves as major nursery areas for the fish species inhabiting the entire coastline including at least five endangered and CITES listed fish (Table 6) and the previously presumed locally extirpated Bumpheaded Parrotfish (Bolbometopom muricatum). The mangrove fringing habitats also had notably high fish abundance with large numbers of juvenile and sub-adult fish of commercial and subsistence importance. Among the finest examples of these were Vatuka Island (IP1) and Talailau Island (IP 3.5) (Appendix A).

Another unique habitat of importance to fish was Vorovoro Pass, a double barrier reef structure near the Mali Passage. This site, while of moderate diversity, had notably high numbers of juvenile grouper of the genera Variola and Cephalopholis, while other

**Table 5.**
Mean number of fish species observed in coral reef habitats of the Great Sea Reef.

| HABITAT TYPE | MEAN NO. SPECIES |
|---|---|
| Barrier reef channels | 200 |
| Outer barrier reef | 182 |
| Mangrove island fringing reef | 157 |
| Back barrier reef | 143 |
| Submerged patch reef | 113 |
| Rocky island fringing reef | 110 |

**Table 6.**
Fish seen on Great Sea Reef on the 2004 IUCN Redlist of Threatened Species

| COMMON NAME | SPECIES NAME | IUCN STATUS | SITES OBSERVED |
|---|---|---|---|
| Humphead Wrasse | Cheilinus undulatus | Endangered | IP1, OB1, CH2, CH5 |
| Giant Grouper | Epinephalus lanceolatus | Vulnerable | CH2 |
| Estuary Cod | E.coioides | Near threatened | IP4, CH2 |
| Brown-marbled Grouper | E. fuscoguttatus | Near threatened | CH1 |
| Leopard Coralgrouper | Plectropomous leopardus | Near threatened | IP1, IP4, OB1, OB3, CH2, IB4, CH5, IP3.5 |
| Grey reef shark | Carcharhinus amblyrhyncos | Data deficient; likely threatened | CH4, OB1, CH2 |
| Tawny Nurse shark | Nebrius ferrugineus | Vulnerable | IB3 |
| White-tip reef shark | Triaenodon obesus | Low risk | CH4, OB1, OB3, CH2, IB4, CH5, IP3.5 |
| Bluespotted ribbontail ray | Taeniura lymma | Low risk | OB1, IB3, IB4 |
| Manta Ray | Mobula birostris | Data deficient; likely threatened | OB1, CH5 |

sites tended to be dominated by the groupers of the genus Epinephalus.
The lowest diversity recorded was at Nananu Island (IB2) near Malau Wharf, with less than half of the species recorded at most other sites. This rocky fringing reef habitat is highly degraded by high siltation and pollution flowing from Labasa River and the activities associated with the timber wharf (Appendix A). The reef is layered with thick sediment and also had the highest levels of trash and debris of any site (Fig 14 and 15).

### 4.2.3 NEW SPECIES, ENDEMICS, ENDANGERED (IUCN LISTED)

It was recently published that the bumpheaded parrotfish (Bolbometopom muricatum) has not been caught for the last decade around Lau, Kadavu or Vanua Levu (Spalding et. al., 2001) and is facing local extinction in much of Fiji. While this is very likely, this species was observed at two sites. Two juvenile B. muricatum were observed at Vatuka Island (IP1) and an astoundingly large school of over 50 adult B. muricatum around 1 to 1.5 meters long were seen in Raviravi Passage (CH4). This suggests either that (i) they are rare but they do exist in localized populations grouped in similar size classes and (ii) they are using the inner mangrove islands as sub-adults and juveniles and are migrating to the outer channel environments as adults.

A total of 10 species of fish observed on the Great Sea Reef are listed on the 2004 IUCN Redlist of threatened species. The following table shows the species, their conservation status and the sites that they were observed in this survey. For more detailed information on populations, abundance and size classes, see site specific data in the site descriptions (Appendix A).

It should also be mentioned that two other threatened red-list species, the endangered Green Turtle (Chelonia midas) and the low risk Spinner Dolphin (Stenella longirostris) were also seen during the survey. Green turtles were seen near the barrier reef (OB1) and also near the mangrove islands (IP1, IP3.5). The Spinner dolphins were seen in a pod of about 20 in the Bligh waters between Vanua and Viti Levu.

Another indication of how little is known about the GSR is that one of the most commonly seen fish on the inner sites of the mangrove fringing reefs is new to science Pomacentrus n.sp. (Randall and Allen in prep.) and likely a Fijian endemic (Fig. 2)

**PHOTOGRAPH 2.**

*Black-Arsed Damsel Pomacentrus* n.sp (Randall and Allen in prep) Vatuka Island MPA (IP1) .16mm SL.

**Photo credit: Helen Sykes**

It is also worth noting that a number of the ubiquitous species in the region (eg. lemon damsel, Pomacentrus mollucensis and cleaner wrasse, Labroides dimidiatus) have unusual colour variations in Fiji that, within the GSR, are sympatric with the more widespread colour forms. Initial molecular investigation of these colour forms suggests that they are genetically distinct Fijian species (G.Allen, J.Drew, L.Kaufman, personal communication).

Another unique find was what appears to be the distinctive juvenile form of the bar-cheeked chromis (Chromis opercularis). Only two single individuals were seen mixed in with other schooling planktivorous at site OB3 and IB2. This species has only been previously reported from the Indian Ocean.

A number of scenarios might explain the presence of this species. It could be a remnant population of a much contracted historical range, it could be entirely new taxa to science or, it may be the juvenile colouration of Chromis xanthura, a commonly seen similar species, and this is in fact a unique juvenile Fijian colour form of this species. It was a very rarely observed fish and we were unable to collect a specimen for taxonomic verification.

Most coral reef fish have a widely dispersed pelagic larval phase, so it was expected that levels of fish endemism within the GSR would be minimal. However, the GSR contains at least 44% (4 of 9) of the known endemic coral reef fish of Fiji. These species are (1) Fiji blenny (Ecsenius fijiensis), (2) Ovalau blenny (Meiacanthus ovalauensis), (3) USP rabbitfish (Siganus uspi) and (4) the new black-arsed damselfish (Pomacentus sp.). While the present survey was reasonably comprehensive to a depth of around 30 to 40 meters, many cryptics and smaller species will have gone undetected. It is expected that at least 100 to 150 additional mainly cryptic species were undetected during this survey. Some of these species may also be endemic.

## **4.3** CORALS

**PHOTOGRAPH 3.**

Bubble Coral, *Plerogyra sinuosa.*

**Photo credit: Helen Sykes**

Fiji is in the central southwest Pacific with strong affinities to the centre of coral reef diversity in the Philippines/Indonesia/New Guinea/Great Barrier Reef area. However, the number of species is comparably lower in Fiji, reflecting the effects of geographic isolation and the resultant biogeographical trend of eastward-declining diversity across the Pacific. Fiji has no endemic hard coral. Low endemism is common in most marine areas because of the prevalence of larval transport mechanisms (Zann et. al., 1997).

**Table 7.**
Hard coral species diversity in the Pacific Islands and surrounding locations.

| Location | Species number |
|---|---|
| Indonesia- Philippines | 581 |
| Solomon Is. | 494 |
| Australia | 393 |
| Vanuatu | 286 |
| Fiji | 254 |
| American Samoa | 222 |
| Tonga | 192 |
| French Polynesia | 168 |
| Guam | 159 |
| Kiribati | 127 |
| Hawaii | 51 |
| Caribbean | 50 |
| Johnston Atoll | 29 |

*Sources : Werner and Allen 1998; GSR - this survey*

### 7.3.2 SPECIES

188 species were recorded during the expedition, representing 74% of Fiji's total listing of 254 species. 14 families were represented by 66 genera. 43 new records for Fiji were identified. Previously unrecorded ranges for three species were extended to Fiji, namely:

- Turbinaria heronensis (Wells,1958)- Australia
- Canthrellus jebbi - New Guinea
- Echinomorpha nishihirai(Veron,1990) - Indonesia

From Table 7, Fiji has fewer species than Vanuatu and more than any country further to the east (Tonga, American Samoan and Tahiti), with the exception of the atoll nation of Kiribati.

The species listing from the Cakaulevu region represents records from habitats that range from silty inshore environments to the exposed and wave washed Great Sea (Cakaulevu) barrier reef. Several communities can be defined based on dominance of coral species with regard to the physical nature of the environment.

### 7.3.3 HABITATS

Coral reef habitats range from the very soft bottom sediments that host coral assemblages with low living cover to high coral cover in the protected barrier reef sites.

As a general trend, coral communities are defined by the physical environment in which they exist. Acropora species dominated the clear water habitats of the reef flats and the more shallow offshore areas where wave action was not to great (CH4). The outer barrier (OB1) is characterised by high wave action and by robust or encrusting growth forms. Acropora and Montipora dominate. In the channels (CH1, 2, 4), where strong tidal currents exist, the genera are mixed with sciaphilic genera such as Echinophyllia and Oxypora common. In the north eastern (IB4), a sandy substrate dominated the lee side of the barrier reef with massive Favids dominating. Mangrove island fringing reefs were dominated by Acropora on the reef crest and flat but the dominance changed to Porites and Montipora assemblages with depth. The habitat was characterised by silty substrates and soft sediments at the reef base. Mid-reef areas became progressively siltier to the west as the barrier reef extended further offshore.

The wedge-like shape of the Cakaulevu reef system creates an enclosed lagoonal system which traps the silt generated along the full extent of the Vanua Levu. As such, the silty environments are restricted to the coast in the eastern areas and occur progressively further offshore as the silt migrates westerly due to the prevailing wind driven current.

**PHOTOGRAPH 4.**

Brown Algae, *Hydroclathrus clathratus*

**Photo credit: Helen Sykes**

## 4.4 MARINE FLORA

### 4.4.1 DIVERSITY OF MARINE FLORA

The flora of the Great Sea Reef is typical of that of the Indo-west Pacific flora. The majority of the species present have been recorded elsewhere from Fiji and from other Pacific Islands. There are a number of genera that were conspicuously absent during the surveys particularly Halymenia, Predaea, Liagora, Prionitis, Ulva (including Enteromorpha), Colpomenia and Chnoospora to name a few. Such absence of significantly common genera may be due to seasonality, thus surveys throughout the year should be carried out to fully document the overall diversity of the Great Sea Reef. The high percentage of Halimeda and Caulerpa species is comparable to those seen from American Samoa and Manado, North Sulawesi, Indonesia (Skelton pers. obs.). As expected, the diversity of Phaeophyta is considerably lower than the other two main algal groups (Rhodophyta and Chlorophyta). This is typical of the flora throughout the tropical Pacific.

The GSR flora represents about 40 % of the Fiji flora (excluding Cyanophyta and Magnoliophyta). This indicates that potentially up to 60 % of the flora are either absent or have been missed from GSR surveys. When considering the three main algal groups - 50 % of the Fijian Chlorophyta is recorded from GSR, 40 % Phaeophyta and 35 % Rhodophyta. Despite the Rhodophyta being the most diverse algal group at GSR, just over one-third of the

**Table 8.**
Comparison between GSR and other sites in Fiji.

| Place | Chlorophyta | Phaeophyta | Rhodophyta | Total |
|---|---|---|---|---|
| Rotuma | 36 | 11 | 41 | 88 |
| Suva Lagoon | 56 | 14 | 85 | 155 |
| Kadavu-Lomaiviti | 26 | 8 | 36 | 70 |
| GSR | 64 | 18 | 94 | 176 |
| Fiji Islands | 136 | 46 | 266 | 448 |

*Sources: Rotuma - N'Yeurt 1996; Suva Lagoon - N'Yeurt 2001, Skelton 2004; Kadavu-Lomaiviti - Skelton & South 2001; GSR - this report; Fiji - South & Skelton 2003.*

**Table 9.**
Comparision of the flora with other Pacific Islands flora.

| Place | Chlorophyta | Phaeophyta | Rhodophyta | Total |
|---|---|---|---|---|
| Micronesia | 186 | 54 | 324 | 564 |
| Hawaii | 107 | 62 | 343 | 512 |
| Fiji Islands | 136 | 46 | 266 | 448 |
| Samoa Arch. | 103 | 48 | 209 | 360 |
| New Caledonia | 130 | 59 | 147 | 336 |
| Marshall Islands | 116 | 28 | 159 | 303 |
| Mariana Islands | 100 | 32 | 162 | 294 |
| French Polynesia | 89 | 41 | 160 | 290 |
| PNG (Motupore) | 73 | 42 | 161 | 276 |
| American Samoa | 60 | 29 | 133 | 222 |
| Solomon Islands | 121 | 27 | 71 | 219 |
| Yap State | 92 | 20 | 101 | 213 |
| Guam | 71 | 27 | 109 | 207 |
| Apia & Vicinity | 48 | 23 | 134 | 205 |
| Great Sea Reef | 64 | 18 | 94 | 176 |
| Easter Islands | 30 | 28 | 79 | 137 |
| Phoenix Islands | 28 | 5 | 29 | 62 |
| Cook Islands | 24 | 12 | 20 | 56 |
| Nauru | 16 | 7 | 17 | 40 |

*(Data from Skelton 2004)*

known Fijian species were found. Thus the overall flora of GSR remains incompletely documented.

In Table 8, the Great Sea Reef flora is compared to other sites that have been surveyed in the Fiji Archipelago. It is obvious from Table 8 that the flora of GSR is by far the most diverse of the sites that have been surveyed.

Table 9 compares the GSR flora to those of the other Pacific Islands. As can be seen, the flora is fairly diverse considering the low intensity of the surveys. With more concerted and consistent surveying, the diversity of the flora would be expected to be much higher.

### 4.4.2 SPECIES

One of the interesting patterns seen during the surveys is the high number of specimens found to be fertile. Fertile specimens are critical to species identification in algae, and it is good that some of the species identification that was tentative is now confirmed. The high fertility was not confined to a particular group, but was across the board. Halophila species were found to be very fertile as well as Halimeda species (particularly Halimeda macroloba and H. incrassata) and Gracilaria species. This could

indicate that the beginning of the southern hemisphere summer months is critical to the life history of marine organisms. A continuous monitoring regime would provide a clearer picture in the long term.

### 4.4.3 HABITATS

From an algal perspective the most diverse habitat is the double barrier reef (Vorovoro site) recording 63 species. The Vorovoro site also yielded the highest number of new records. Considering that only a small proportion of the double barrier reef was surveyed, there remains much to explore in this unique reef formation. The maximum depth surveyed was 18 meters, although algal communities could be seen at greater depths. The seagrass beds, dominated by Halophila species, were found in the shallower 3 m depth reef flat, with large bommies scattered throughout providing refuge for a range of fish species and benthic organisms. This area should be of high importance from a conservation perspective.

The Raviravi Passage with two survey dives recorded the second highest species diversity of 60 species. This typical outer reef community was dominated by hermatypic corals especially along the reef slope. The site levels at 20 m depth were coarse sand substratum which provides habitat for algae. Caulerpa species were dominant, with Halimeda species also common. In the inner part of the passage, significant rubble and barren rock were found. Algal communities are confined to turf with macro-algae more common in fairly exposed places, usually just below the surf break. Large crevices provide ideal habitat for a range of coralline algae.

From a seagrass perspective two sites stand out as the most significant and efforts to protect them should be encouraged. These are the beds around Kia Island and those in Tilagica Harbour. The Kia Island seagrass is dominated by Halodule species, whereas Tilagica Harbour has a mixed stands of Halodule and Halophila.

### 4.4.4 NEW SPECIES, ENDEMICS, ENDANGERED (IUCN LISTED)

Most of the species recorded at GSR have been recorded elsewhere in the Indo-west Pacific biogeographic region. Sixteen species found to be new additions to the flora of the Fiji Archipelago have been recorded from other Pacific Islands. Two species are possibly new to science. A Ceramium species was found to be unique from those monographed in South and Skelton (2000), by the arrangement of its tetraspores. The gametophyte stages were not found. More material is needed to verify the distinction of this alga and a thorough comparison with other species described from the tropical Pacific is desirable before a final determination is made. The other indeterminate alga possibly belongs to the genus Crouania. Crouania minutissima has been recorded from Fiji, but is considerably smaller than GSR specimens. Only tetrasporic material has been found. Further research is needed to confirm the identity of this species.

Because of the pan-tropical nature of most of the algae found throughout the Pacific, endemic or endangered species are very uncommon. A number of species do lend themselves to be considered endemic from a Fijian perspective - e.g. Avrainvillea rotumensis and Rhipilia neurymenioides. Others could be considered sub-regionally endemic including Ceramium kramerii and Halophila ovalis ssp. bullosa. These algae and seagrass have so far only been recorded exclusively from Fiji, or from Fiji, Tonga and Samoa. Their presence in other neighbouring islands remains possible upon detailed surveys in those places.

From an invasive species perspective - the genera Caulerpa and Codium are fairly high on the list of species to watch out for. Caulerpa taxifolia, for example, is found to be highly invasive in the Mediterranean Sea as well as sub-tropical parts of Australia. Codium fragile ssp. tomentosoides has been considered a serial pest in New Zealand and Australia (Skelton, 2004). In Fiji, and other parts of the tropical Pacific, Caulerpa species are rarely considered invasive. An undescribed species of Codium has been collected from Suva Harbour and also from the Apia Harbour, Samoa, indicating its association with ocean going vessels. The origin of this Codium species is from Thailand (Chacana pers. comm.). No surveys of either site have been carried out to date to see if it has established itself, and fortunately it was not found during the GSR surveys. This further highlights the importance of doing baseline surveys and the need for continuous monitoring to ensure that invasive species are checked and appropriate actions taken to safeguard the GSR marine ecosystem

## 4.5 INVERTEBRATE DENSITY AND DISTRIBUTION

Invertebrate counts for all sites are presented as deep and shallow depths, in recognition of these different micro-habitats in which the indicator species were distributed (see methods for species enumerated). For deep transects, mean density of invertebrates was highest in Tilagica Passage (CH5) at around 27/100m2 (Fig 6). At depths of 6 to 12 m the mean invertebrate density was lowest in the outer barrier reef habitats and increasing in a perpendicular towards the inner patch reef sites. Tilagica Passage (CH5) is the noteable exception as it is contiguous with the outer barrier habitat (Fig 6). It appears that it is distant enough from mainland, Vanua Levu, to reduce influence from inshore fishers, freshwater input or pollution from main urban centers, in comparison to the other channel sites.

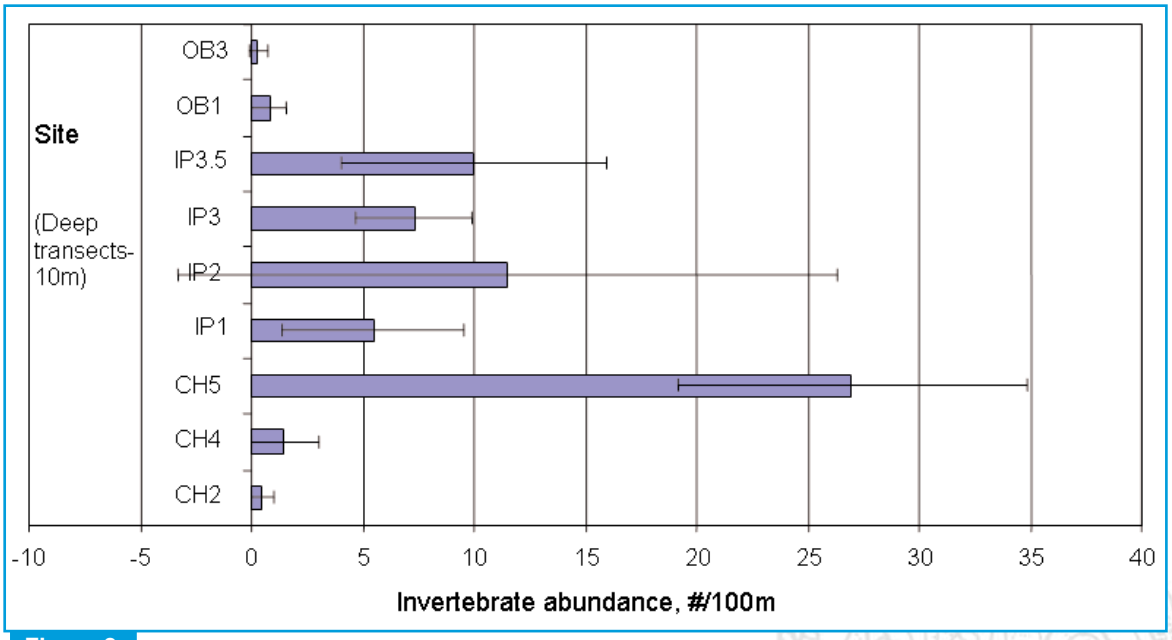


**Figure 2.**

**Mean invertebrate density per transect (100m) sampled on the deep transects of Great Sea Reef, Vanua Levu, Fiji.**

**Table 10.**
Density (#/100m2) of indicator invertebrate taxa by reef habitat type and depth over all sites. Standard deviations are in parentheses.

| Mean Invertebrate density per reef habitat type (400 sq.m) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Taxa** | **Inner Patch** | | **Channel** | | **Outer Barrier** | | **Inner Barrier** |
| | Deep | Shallow | Deep | Shallow | Deep | Shallow | Shallow |
| Giant clams | 1 (0) | 0.8 (0.5) | 0.3 (0.6) | 0 (0) | 1 (0) | 0 (0) | 0.8 (0.5) |
| Sea cucumbers | 1.8 (1.5) | 1.5 (1.7) | 0.7 (1.2) | 1.5 (2.1) | 0 (0) | 2 | 1.2 (0.8) |
| Oysters | 0.8 (1.0) | 0.8 (1.0) | 0.3 (0.6) | 0.5 (0.7) | 0 (0) | 0 | 0.2 (0.5) |
| Starfish | 1.5 (0.6) | 1.3 (1.0) | 0 (0) | 1 (1.4) | 0 (0) | 0 | 1 (1.0) |
| Sea urchins | 1.3 (1.0) | 1.0 (1.4) | 1.3 (0.6) | 1.5 (0.7) | 0 (0) | 0 | 0.4 (0.5) |
| Crustaceans | 0.3 (0.5) | 0 (0) | 0 (0) | 0.5 (0.7) | 0 (0) | 0 | 0.2 (0.5) |

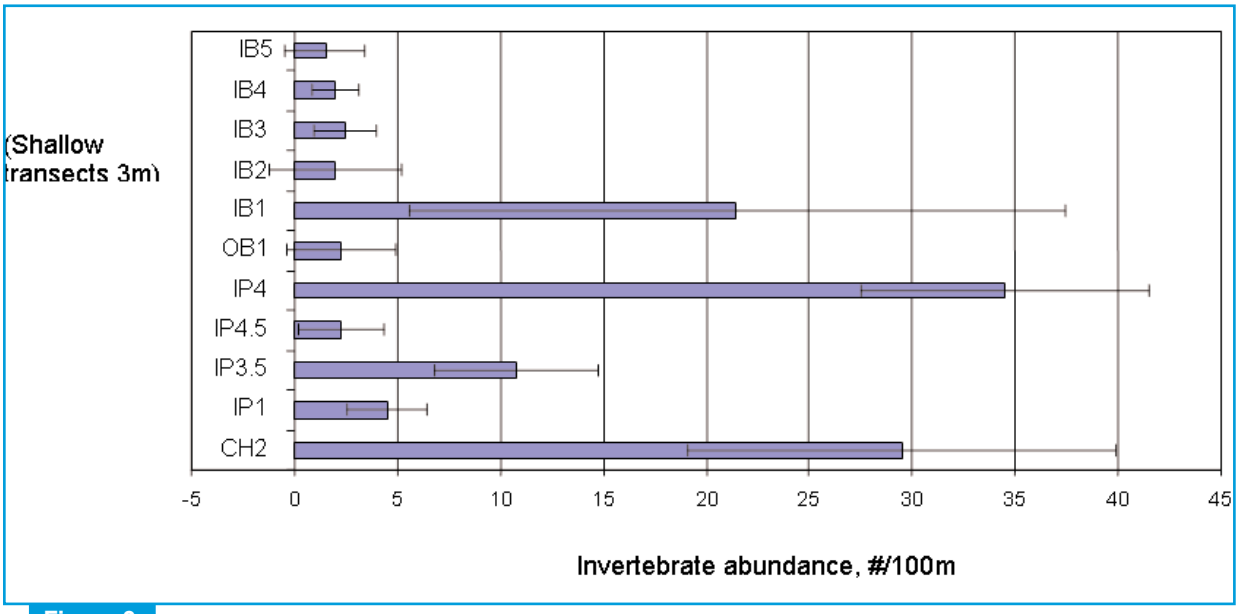


**Figure 3.**
**Mean invertebrate density per transect (100m) sampled on the shallow transects on the Great Sea Reef, Vanua Levu, Fiji.**

For the shallower transects, Motuli Bawa (IP4) inner patch reef, near a mangrove island, exhibited the highest average invertebrate density at around 34/100m2. The shallow transects show a great deal more variation between habitat type, with Bella's reef (IB1) and RaviRavi Passage (CH4) also showing higher densities (Fig 7).

Sea cucumbers were the most commonly recorded invertebrate taxa during the surveys with Holothuria edulis, a species of low commercial value, clearly the species of highest average density (3.8/ m2) across the sites surveyed. There were seven sea cucumber species observed in the reef sites surveyed. Commercially valued species like the Giant Clam and certain sea cucumber species were relatively low in abundance amongst all the sites surveyed. Thirty invertebrate species were selected as reef health indicator species and classed into six invertebrate common groups with their densities in each reef habitat type and for all sites combined are shown in Table 10.

It is apparent that the highest densities of invertebrates were found at the inner patch reef sites ` and most commonly encountered at the shallower depths of 3-6 metres. These are baseline surveys and longer-term patterns of invertebrate distribution are not clear. More in-depth study is needed to classify related species' demography in relation to factors such as siltation, herbivory, as well as commercial harvesting.

Sea cucumbers were observed to be the most common indicator species on transects but their densities were highly varied as shown by relatively high standard deviations. They are found to be the most common indicator invertebrate species at shallower depths of all the reef types surveyed, especially the inner patch reefs which included mangrove island reefs and reefs closer to land. Four of the seven species of sea cucumbers, namely A. mauritiania, S. chloronotus, H. fuscogliva, H. scabra, are commercial species. Another commercial invertebrate group Tridacna clams was observed on the surveys which included T. maxima and T. squamosa. In the sea urchins category, Diadema urchins and E. mathaei are the second most common invertebrate group and have a relatively low density compared to sea cucumbers. However, Diadema, the more common of the two urchins, are important components of the reef's ecology and, along with herbivorous fish, graze and help maintain the competitive balance between corals and macroalgae. Herbivorous invertebrates like most crustaceans (including gastropods) were noted to be very few or absent along transects. Crown-of-thorns starfish A. planci was noted at least twice outside survey transects but there was no evidence of large-scale population outbreaks.

From a commercial perspective, the non-finfish markets in the municipalities of Labasa, Savusavu, Nabouwali, Seaqaqa and Wainikoro are currently estimated to be worth $412,268 or about 24% of the total catch and value of finfish production. For non-municipal markets which include major shops, catch being sold on the roadsides and jetties, non-finfish catch make up 8% of the total catch estimated at 289.58 metric tones and with an estimated worth of $1.3 million (Salusalu B., 2004).

## 4.6 BENTHIC CHARACTERISTICS BY HABITAT TYPE

### 4.6.1 NON-CORAL BENTHOS

Figure 8 shows the rocky island fringing reef habitat is dominated by heavy silt cover, with the only other habitat to have significant amounts of silt being the Mangrove Fringing Reefs. However, in the sample of rocky island fringing reefs, only one out of the three sites (IP2, Yanu Somila Island opposite the Lautoka river mouth) had massive amounts of siltation. The others in this category had no silt at all, whereas all of the mangrove fringing reefs showed some degree of siltation.

The inside of the the barrier reef showed, on average, quite high levels of macro-algae cover, although this was highly variable per site and was not found to dominate any particular site to the exclusion of coral growth. Only the walls of the outer barrier reef were relatively free from macro-algae due to the high energy nature of the habitat. This algal community is largely composed of Halimeda species and mixed assemblages of species such as Sargassum and Padina, (full species lists per site are included in Appendix C) although a few shallow sites had large stretches of turf algae inhabited and cultivated by "Farmer" damselfish in the genus Stegastes and Hemiglyphidodon plagiometopom. The rocky island fringing reef algal mean is lowered significantly by site IP2, (Yanu Somila island opposite the Lautoka river mouth), where heavy siltation had covered any macroalgae which attempted to grow there.

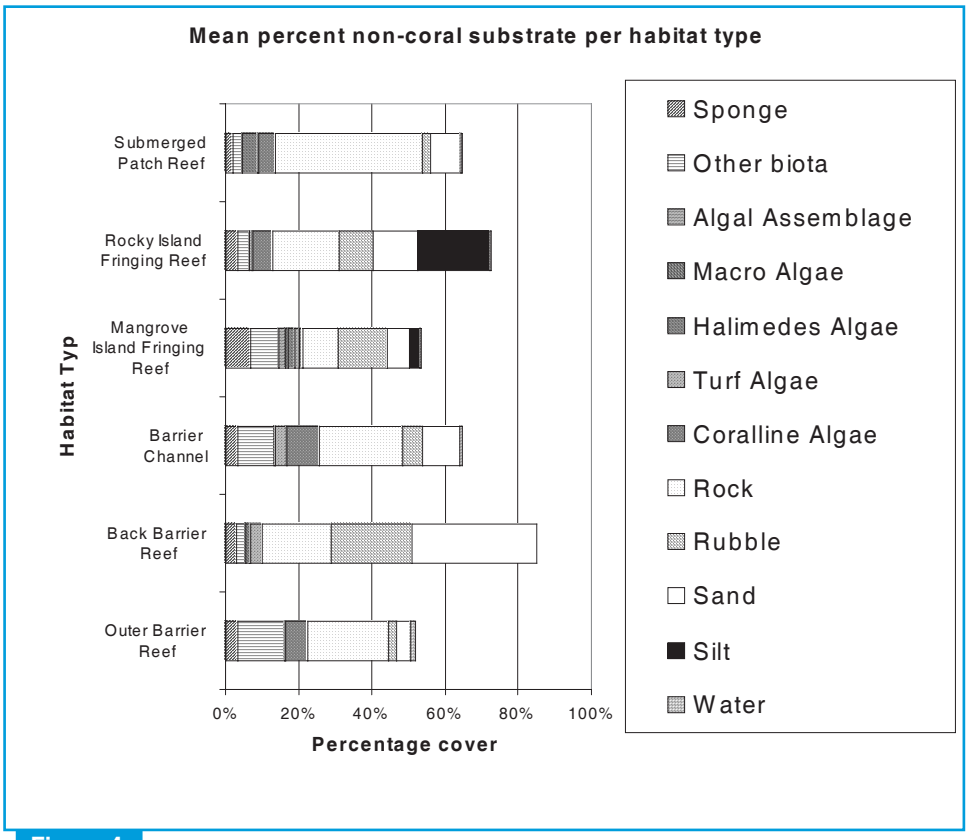


**Figure 4.**

**Mean percentage of non-coral benthos by habitat type.**

### 4. 4.6.2 CORAL BENTHOS

For all the sites surveyed, hard coral cover was highest on the outer barrier reefs, where siltation and macroalgae was at a minimum, followed by the rich habitat of the mangrove fringing reefs and patch reefs, where siltation levels were higher. The lowest coral cover was found in the back barrier reefs, which were mostly made up of rubble, sand and dead coral as is common on the lee side of high energy habitats. The high amount of dead coral in this habitat is possibly a remnant from the 2000 and 2002 bleaching events. The channels in the Barrier Reefs had mostly solid rock sides, which are regularly scoured by strong tidal currents, preventing settlement and growth of many large corals. On most reefs, the soft corals seen were largely species of Sarcophyton, Sinularia or Lobophyton, except in the Mangrove Fringing Reefs, where large quantities of a pale gold/beige Dendronepthea were common. The back barrier reefs consistently had the lowest percentage cover of both soft and hard corals.

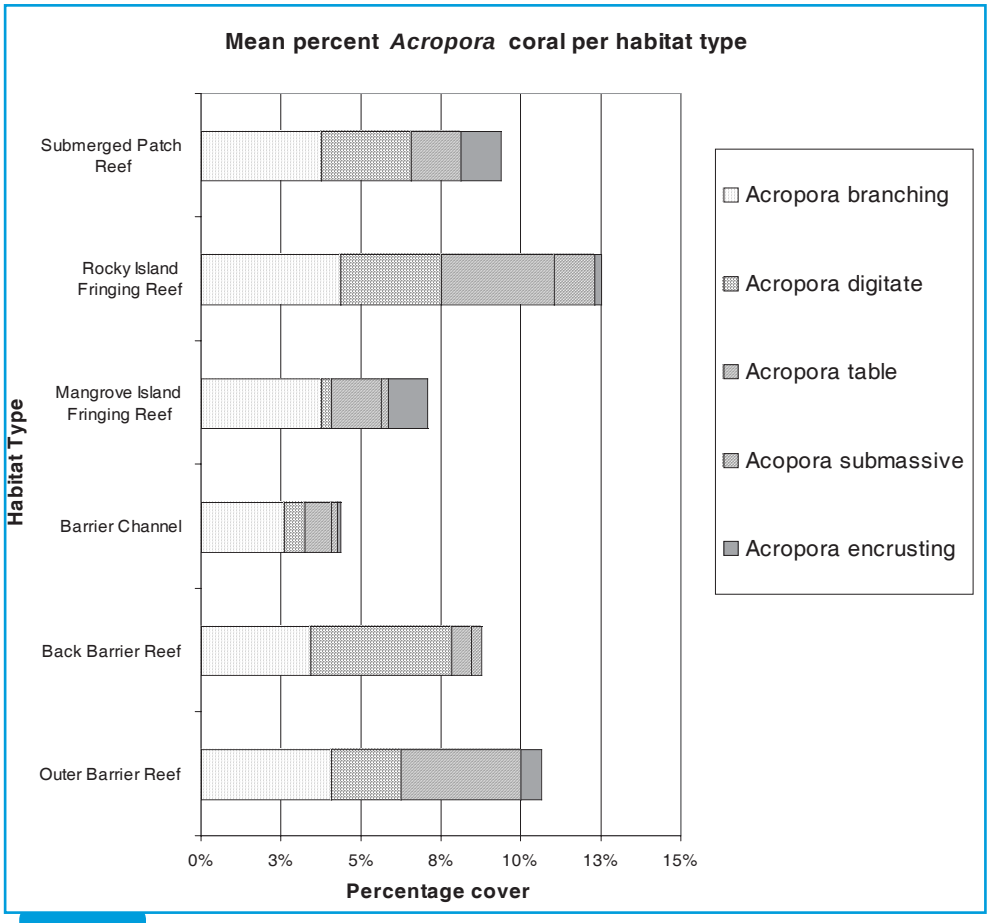


**Figure 5.**

**Mean percentage of Acropora corals by habitat type.**

The submerged patch reefs showed the greatest variety of morphometric coral types, likely due to lack of harsh current and wave action. IP4 (Motuli Bawa) was in an area of low visibility, and although there was no deep layer of sediment, conditions obviously favoured silt-adapted corals in the genera Porites and Montipora, while IB1"Bella's Reef" (a ribbon reef in the clearer waters of the western area of the lagoon) had much higher levels of Acropora. In the rocky island fringing reefs the variation between sites was high, with extremely low levels of any coral at the badly silted IP2 Deep (Yanu Somila island opposite the Lautoka river mouth) while other rocky islands showed a range of coral forms and species.

The mangrove fringing reefs generally had poor water clarity and high levels of sedimentation. Coral cover was, however, still high. Most hard corals found were of sediment-tolerant families such as Porites and Montipora, and there were large stands of an Antipatharian black coral on many reefs.

The soft coral levels were extremely high in this habitat, mostly of a single pale-gold/beige species of Dendronepthea, found on several sites.

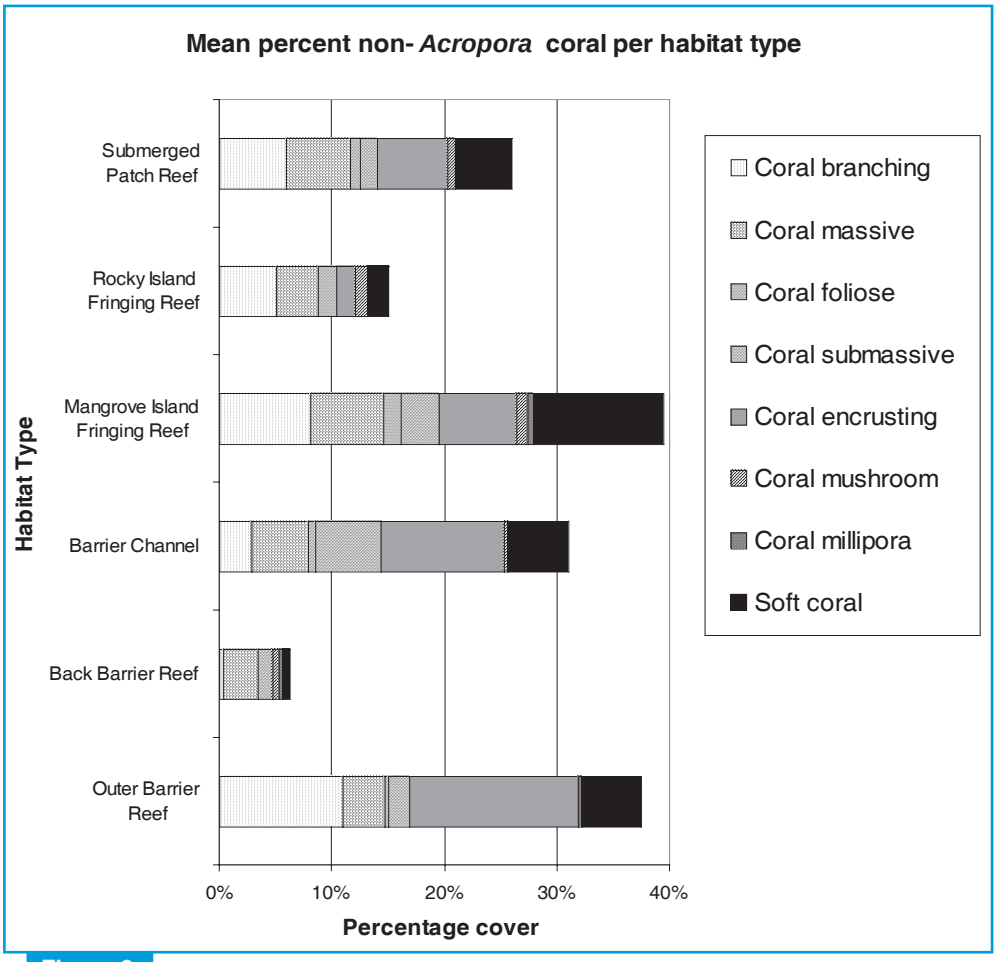


**Figure 6.**
**Mean percentage of non-Acropora corals by habitat type**

Corals in the barrier channels have to withstand high current levels, and consequently are represented mostly by low-relief encrusting non-branching forms. Most branching corals were on the shallow reef top rather than the channel wall. Soft corals in high current areas were mostly purple-red Dendronepthea species. Overall coral cover was low.

The back barrier reefs had the lowest coral cover of any habitat, consisting of mostly rubble slopes, including areas of dead coral which may have died as a result of the bleaching events of 2000 and 2002. The few corals present were mostly massive forms, with a few Acropora digitate and branching corals in some areas, mostly small new colonies.

The outer barrier reefs had the highest cover of hard corals, made up primarily of low-relief non-Acropora branching and encrusting forms such as Pocillopora and Montipora spp. Small table, digitate and branching Acropora species were found, which may be new growth since the coral bleaching events of 2000 and 2002.

## 4.7 FISH ABUNDANCE BY HABITAT TYPE

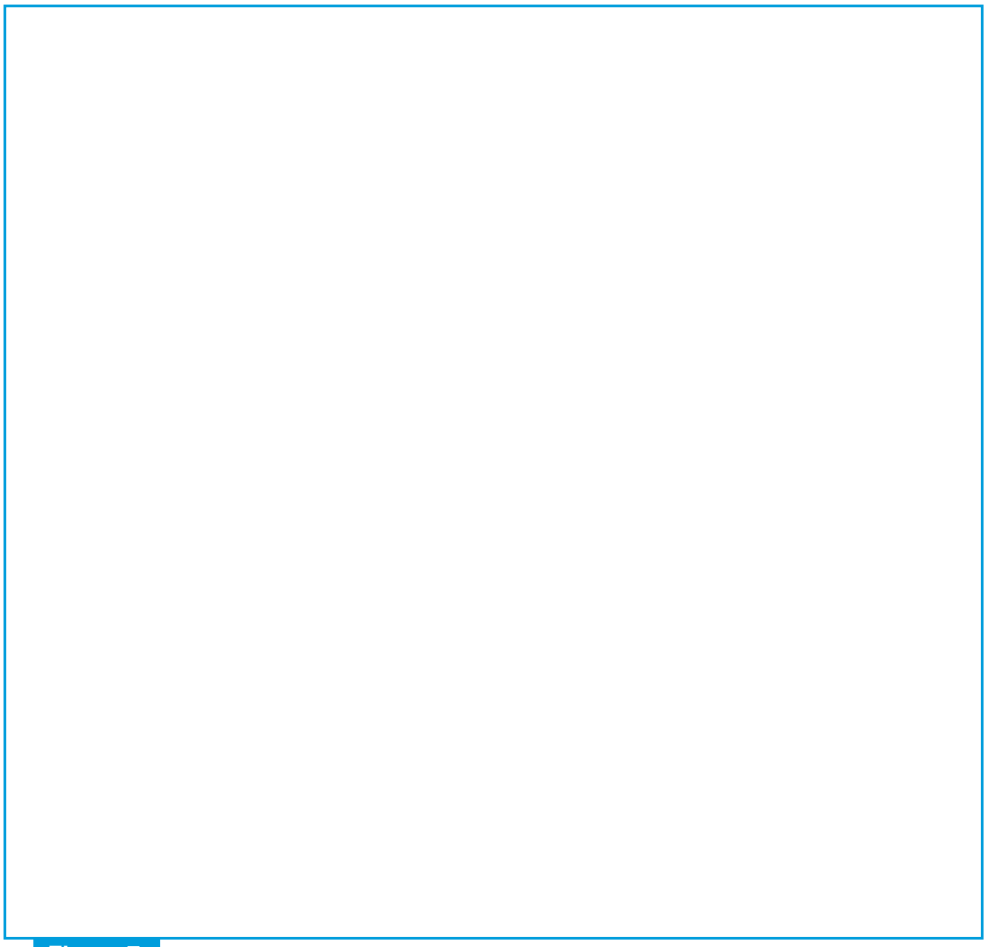

**Figure 7.**
**Mean total fish abundance by habitat type.**

The outer barrier reefs had by far the highest overall numbers of fish, with the barrier channels and patch reefs also showing high populations. Although the average number of fish seen on mangrove fringing reefs was not particularly high, one site in particular was extremely rich in fish life (see individual fish abundance and size category description of IP4.5 Nukuvadra). The back barrier reefs rank the lowest in terms of fish numbers, also being very limited in terms of micro-habitats for other biota.

## 4.8 SIZE CLASSES OF FISH BY HABITAT AND TAXA

High variation in size class was seen across the sites in each habitat (see individual site description and size class records for each site's details). Over the GSR, the most fish counted were in the 2 to15 cm size range, with the largest number of these size classes occurring on the Submerged Patch Reefs and dominated by damselfish, butterfly fish, wrasse, angelfish, surgeonfish and juvenile parrotfish. The rocky island fringing reefs and back barrier reefs had the smallest number of fish over 30 cm, having very low numbers of the larger fish of interest to local fishers. The habitats with the largest number of fish over 30 cm were the barrier channels, the outer barrier reef and the mangrove fringing reefs, mostly represented by terminal phase parrotfish and adult snappers.

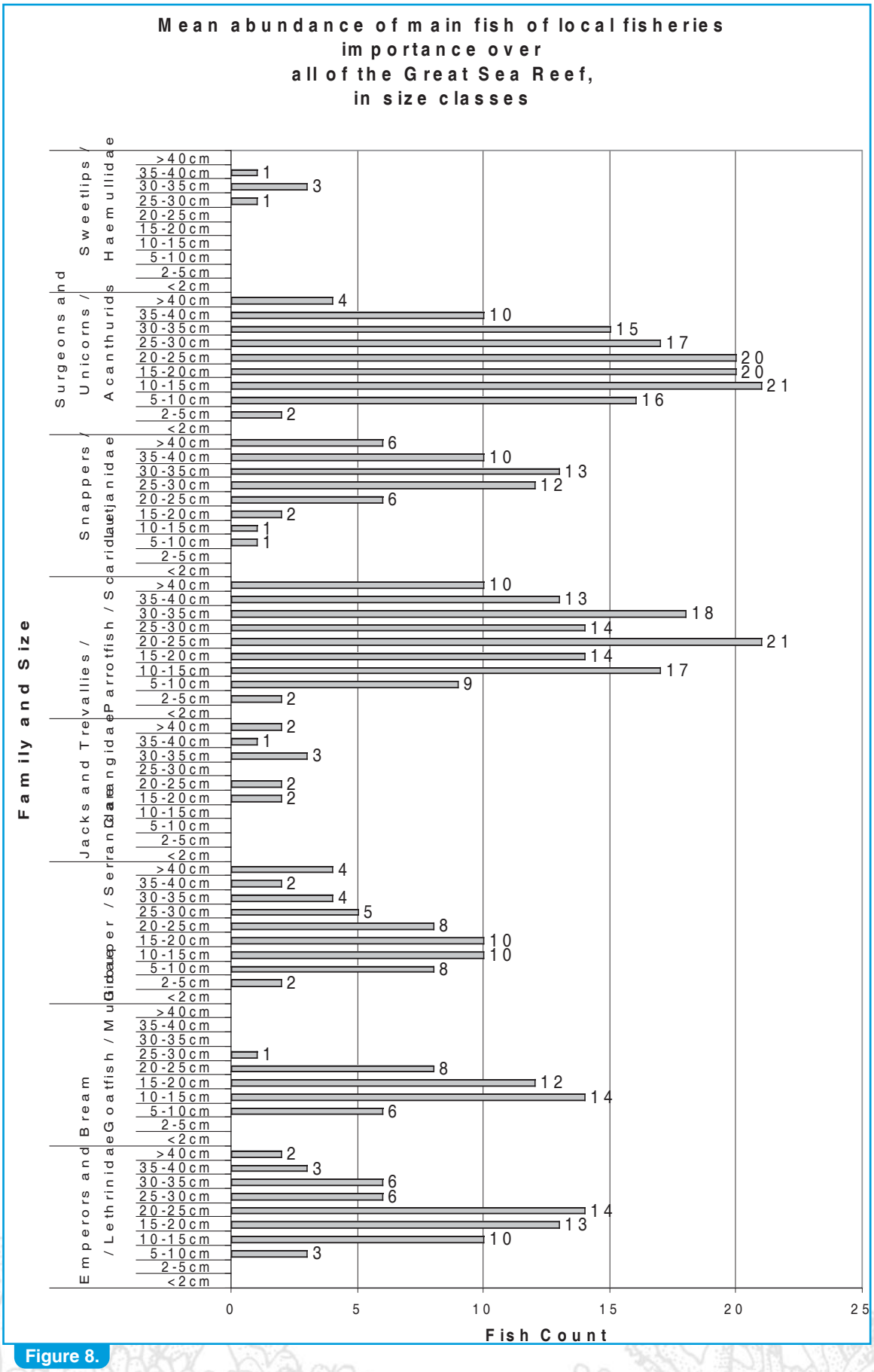


**Figure 8.**

**Mean abundance of fish most important to local fisheries, in size classes, over GSR. See individual descriptions for specific site information.**

The fish families most important to local fisheries were examined for size classes over the entire areas surveyed. See individual site descriptions and size/abundance reports for each area.

Surgeon fish were the most common, across all size ranges, followed by parrot fish, of which most of the large specimens were found in the barrier channels, and many medium-sized individuals in the mangrove fringing reefs. Small goatfish and emperors were found in a few areas. These species are not targeted by commercial fishers, but are important to local subsistence fishers.

Numbers of large Groupers were extremely low, most of those seen being below 20cm in length. There is a live food fishery of groupers of the 30 to 50cm size range (these fish were seen being off loaded at Ellington Wharf on the expedition's arrival and departure), which are known to be harvesting in the area. Very few Jacks or Trevallies were seen. Those that were found were mostly hunting on the mangrove fringing reefs, and practically no sweetlips were seen, a species targeted by spearfishermen. A few areas had reasonable numbers of snappers, but most of these were the smaller ones not usually focused on by fishermen, as some of them are ciguatoxic[2].

Overall, commercial fish species were found in very low numbers and small sizes. Fish important to local subsistence fishers were found in somewhat higher numbers, but this varied greatly from site to site. This size class data also suggests that the Mangrove fringing reefs are important habitats for spawning and maturation of fish stocks.

### **4.9** DAMAGE AND TRASH

Silt was found in all habitats except the outer and back barrier reefs which were either out of the direct route of water flow from the land, or in high energy wave areas where silt could not settle. Some sites had extremely high levels of deep silt; while others only had fine layers over recognisable substrate (see individual site descriptions in Appendix A). In general, the highest silt levels were found on mangrove fringing reefs, but the single site with the highest level of silt was the rocky island fringing reef in the direct outflow of the river at Labasa (IP2, Yanu Somila). Fishing lines were found entangled on the corals on the rocky island fringing reefs, the mangrove fringing reefs and the barrier channels, but not on the deeper sites further from land, where subsistence level hand line fishing would not be practical. All other trash was found on the rocky island and mangrove fringing reefs close to centers of population.

[2] WHAT DOES CIGUATOXIC fish causes ciguatera poisoning. Its toxicity maybe due to consumption of an algae Gambierdiscus toxicus (a marine dinoflagellate) by the fish or by one of its prey.

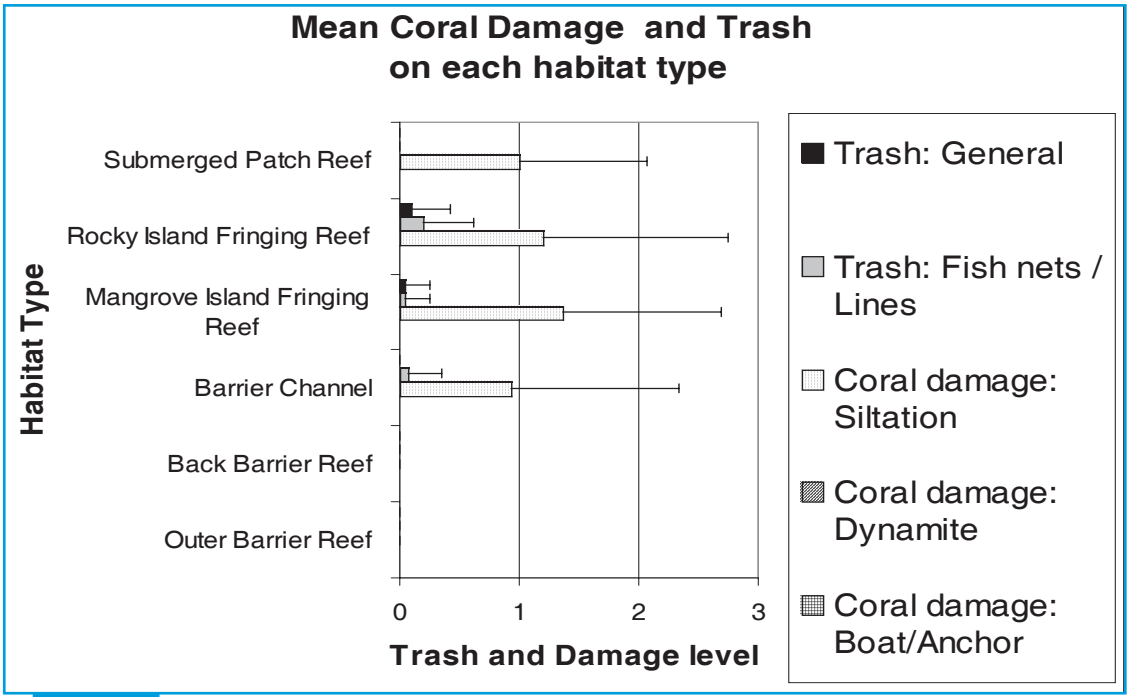


**Figure 9.**

**Mean level of coral damage and trash per habitat type + / - 1 Std Dev. None = 0, Low = 1, Medium = 2 and High + 3**

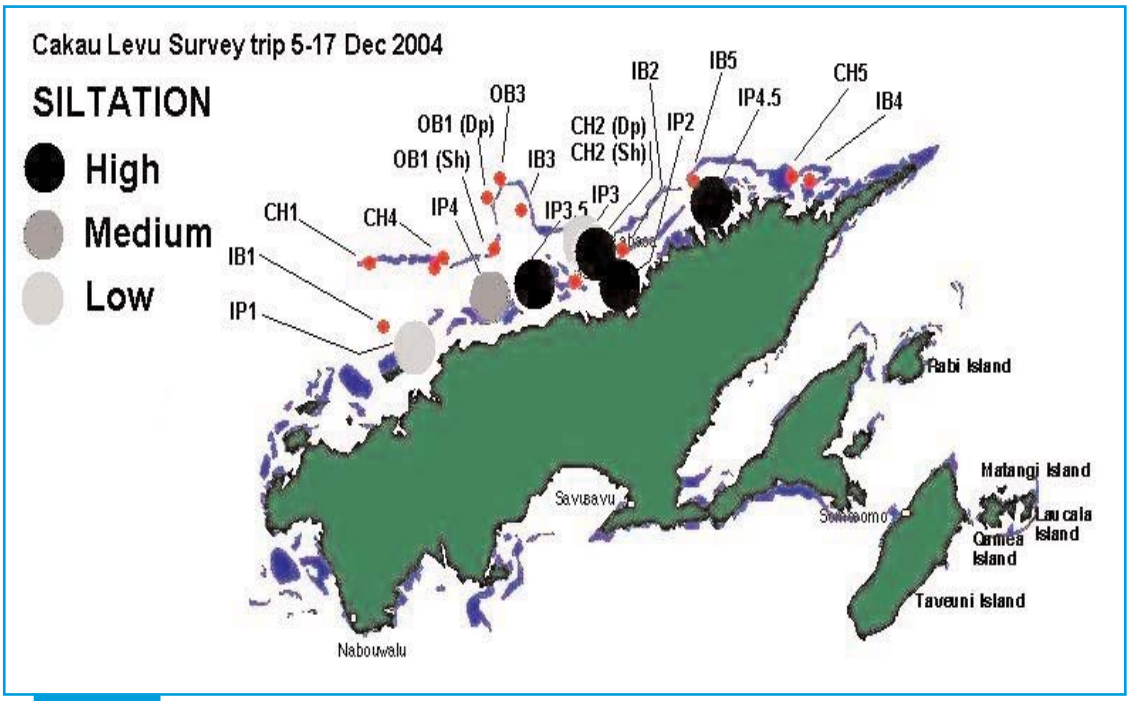


**Figure 10.**

**Map showing location of most silted reefs.**

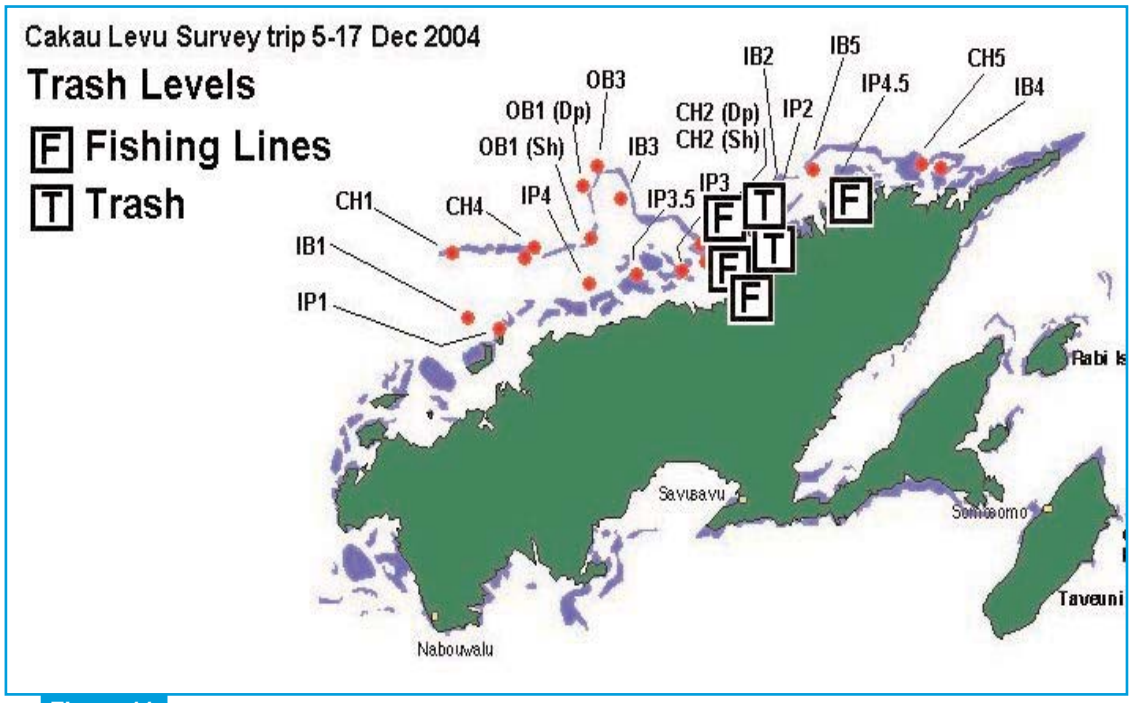


**Figure 11.**
**Map showing location of reefs with most trash**

## 5. CONSERVATION RECOMMENDATIONS

The results of this survey indicate that the Great Sea Reef and associated habitats are a high priority for conservation action, particularly for maintaining or improving local livelihoods and protecting populations of globally threatened species and areas of international importance for marine diversity and fisheries productivity.

### 1. ASSESS AND MITIGATE ENVIRONMENTAL IMPACTS OF LAND BASED ACTIVITIES.

Many of the major threats to the coastal habitats of the region originate from land-based activities such as logging, agriculture and mining. These sectors of national development need to work towards elimination or mitigation of these downstream impacts. Watershed management needs to be a primary objective in provincial land-use plans if coastal systems are to be conserved.

### 2. ESTABLISH REPRESENTATIVE NETWORKS OF PROTECTED AREAS ACROSS MARINE AND TERRESTRIAL HABITATS.

The opportunity exists to establish networks of managed sites to protect numerous populations of threatened species, areas of high species and habitat diversity and to maintain or improve natural resources for local livelihoods. 20 to 30% of the total land-sea area should be assigned within managed areas. This should be carried out through an integrated landscape-seascape approach from the outset of programme design. The established Fiji Locally Managed Marine Area (FLMMA) Network should be promoted and involved in the broader multi-system network development. Marine sites of high conservation importance that should be further investigated and considered for inclusion in the network are as follows: Vatuka Island (IP1), Raviravi Passage (CH4), Timeless (OB1), Mali Passage (CH2), Mali Double Barrier (IB2), Nukuvadra Island (IP4.5), Tilagica Island (IB4), Talailau Island (IP3.5)

and Bella's Reef (IB1). Special attributes and locations of these sites are described within the individual site descriptions (Appendix A).

### 3. STRENGTHEN CAPACITY WITHIN PROVINCES TO MANAGE NATURAL RESOURCES.

Human and financial resources for conservation and sustainable development are scarce within the provinces of Macuata and Bua. Strengthening the capacity of villages, government departments and non-government organizations (NGOs) to actively manage and confront the growing pressures on the environment is an obvious priority.

### 4. DEVELOP A SPECIFIC PROGRAMME OF ACTION FOR RARE AND ENDANGERED MARINE WILDLIFE.

Populations of at least 12 species listed on the 2004 IUCN Redlist of threatened species were observed including 10 species of fish, the Endangered IUCN green turtle (Chelonia midas) and the spinner dolphin (Stenella longirostris). A specific programme of awareness, monitoring and management should be established focusing on these globally important species.

### 5. DEVELOP ECONOMIC INCENTIVES THAT SUPPORT CONSERVATION.

The conservation of the natural resources of the GSR and associated habitats including terrestrial areas will likely provide the best long term economic returns for the people. Promoting non-extractive economic options, such as eco-tourism, should be encouraged and developed. For the area around Kia Island, the high biodiversity and relatively intact reefs also have some of the best surfing waves in the world. Promoting a sustainable surfing tourism industry, through local surf-lodges, is worth investigating as a sustainable income earner for portions of the GSR.

### 6. RESEARCH AND PROPOSE OPTIONS FOR THE DESIGNATION OF SIZE LIMITS AND/OR SEASONAL QUOTA FOR COMMERCIAL FISHERIES.

It was obvious from our encounters with commercial live-fish enterprises in Bua that size limits and seasonal quotas were not being enforced as several boats of immature grouper were observed. Locals claim that the boats are also fishing and collecting year round. This is highly unsustainable and grouper populations are already low in relatively remote sections of the GSR and very low overall. Government, NGOs and communities need to get a working system of fisheries management in place quickly before populations are locally extirpated.

### 7. RESEARCH AND PROPOSE OPTIONS FOR THE ACTIVE ENFORCEMENT OF EXISTING LAWS.

Existing laws ban the use of destructive fishing practices such as cyanide and the use of dynamite and duva (Derris root). The active enforcement of these laws will greatly assist in reducing the damage to aquatic systems.

### 8. PROMOTE COMMUNITY-DRIVEN CONSERVATION PLANNING AND MANAGEMENT.

As the primary owners and decision-makers regarding the use of natural resources in the coastal zone, local communities must be promoted as the primary stewards and managers of these resources. Programmes with community ownership that accurately reflect community needs and aspirations and involve multiple segments of the community have a greater chance of long-term success and sustainability. The FLMMA process should be a good basis for achieving this recommendation.

### **9.** ESTABLISH SENTINAL-SITE LONG-TERM MONITORING FOR WATERSHED AND REEF HEALTH.

The health of the watersheds and reefs of the area is absolutely critical to the long-term health and well being of its people. Long-term monitoring of portability of water, keystone species and general provision of ecosystem services to people should be carried out at a few key sites in freshwater, estuarine and marine systems. This will aid in long-term conservation planning and adaptive management within the area and provide the up-to-date resource information that government, NGOs and communities need.

### **10.** PROMOTE CROSS-DISCIPLINARY, MULTI-SYTEM AND INTER-AGENCY PLANNING AND CO-ORDINATION.

The partitioning of ecosystems and disciplines (e.g. Marine vs freshwater / biology vs social science / conservation vs development) is pervasive in conservation and in science in general. This division is counter-productive as the ecological and social processes that we try to positively influence are overlapping, inter-related and interacting across systems. Our ability to understand how systems interact and respond to change and hence our ability to intervene effectively for purposes of ecosystem management are hindered by this partitioning of knowledge, lack of broader inter-government and development agency coordination and on-the-ground application, and restricted funding. It is suggest that a programme of action is developed which is sincerely inter-agency, cross-disciplinary and cross-cutting in terms of ecosystems. The success of this approach should be measured using social, economic and ecological indicators. Measuring success against Millennium Development Goals would be both feasible and practical. A good first step would be to convene a meeting of major conservation organizations, public-health related organizations, donor organizations and international development agencies to illustrate and gauge the understanding of this problem in our fields and clearly elucidate the major barriers to building this type of conservation/development programme.

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## **APPENDIX A.** REEF CHECK SITE DESCRIPTION FORM

Site name:
Date:
Time of day that work started:
Time of day that work ended:
Longitude of transect start point:
Latitude of transect start point:
From chart or by GPS? (If GPS, indicate units): Chart ☐ GPS ☐
Orientation of transect: N-S ☐ NE-SW ☐ E-W ☐ SE-NW ☐
Distance from shore:
Distance from nearest river: ☐ km
River mouth width: <10m ☐ 11-50m ☐ 51-100m ☐ 101-500m ☐
Weather: sunny ☐ cloudy ☐ raining ☐
Air temperature: ☐ degrees C
Water temperature at surface ☐ degrees C
Water temperature at 3 m ☐ degrees C
Water temperature at 10 m ☐ degrees C
Distance to nearest population centre ☐ <1km
Approximate population size:
Horizontal visibility in water:
Why was this site selected? _____

Is this site - sheltered ☐ exposed ☐
Any major coral damaging storms in past years? yes ☐ no ☐ unknown ☐
How do you rate this site overall in terms of anthropogenic impact? none ☐ low ☐ moderate ☐ heavy ☐
What types of impacts do you believe occur? Storm damage and possible past bleaching event(s)
_____

Dynamite fishing none ☐ low ☐ moderate ☐ heavy ☐
Poison fishing none ☐ low ☐ moderate ☐ heavy ☐
Aquarium fish collection none ☐ low ☐ moderate ☐ heavy ☐
Harvest of invertebrates for food none ☐ low ☐ moderate ☐ heavy ☐
Harvest of invertebrates for curio sales none ☐ low ☐ moderate ☐ heavy ☐
Tourist diving none ☐ low ☐ moderate ☐ heavy ☐
Sewage pollution none ☐ low ☐ moderate ☐ heavy ☐
Industrial pollution none ☐ low ☐ moderate ☐ heavy ☐
Other forms of fishing? (Specify) none ☐ low ☐ moderate ☐ heavy ☐
Other impacts? (Specify) none ☐ low ☐ moderate ☐ heavy ☐
Is there any form of protection (statutory or other) at this site? yes ☐ no ☐
If yes, what type of protection? _____

Other comments:

Submitted by (enter TL/TS and your name):
_____

## VATUKA ISLAND MPA

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow |
|---|---|---|---|---|---|
| 1 | 6.12.04 | 9.40 | 10.40 | IP1 | Deep |
| 2 | 6.12.04 | 12.30 | 13.05 | IP1 | Shallow |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o29.345' | 178o49.557' | 10m | 18m | None | Rising | 28 |
| 16o29.345' | 178o49.557' | 5m | 18m | None | Rising | 28 |

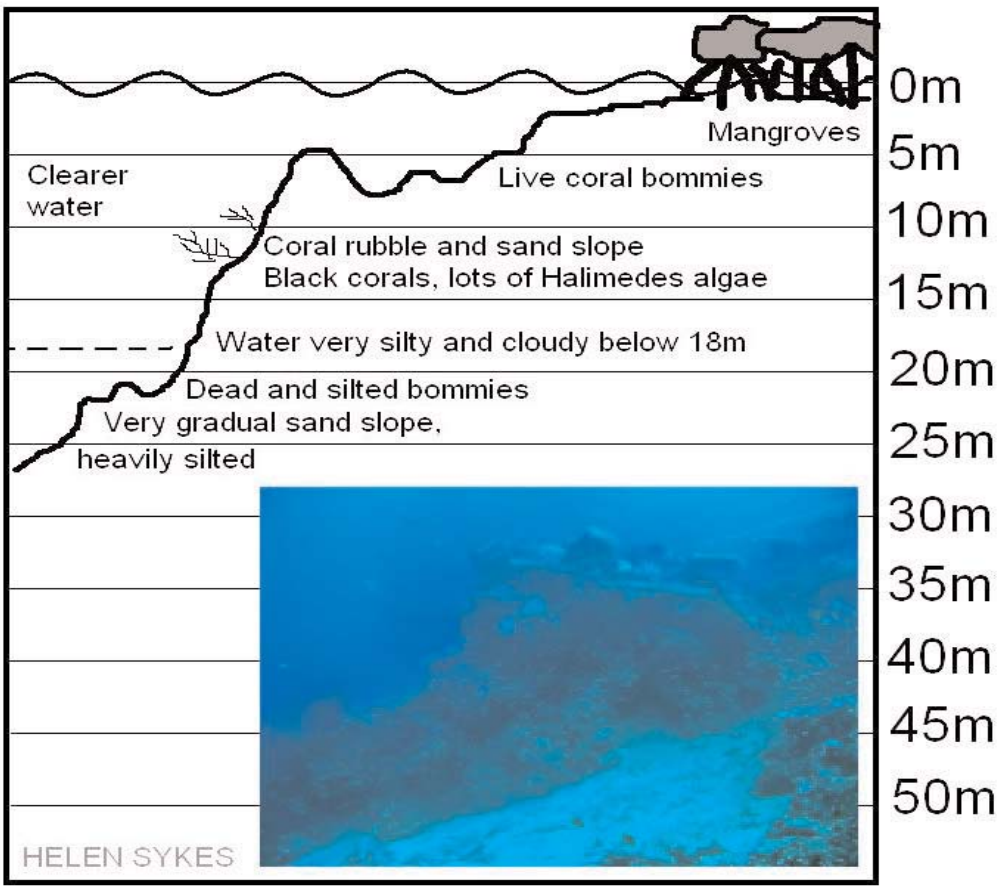


# APPENDIX B. SITE DESCRIPTIONS

## 7.1 VATUKA ISLAND MPA

Vatuka is a low mangrove islet near Nadogo Island at the western end of the inner barrier surveys. Overall, it showed very high levels of varied corals above 10m, some siltation, high cover of Halimedes algae, and abundant fish life. Vatuka Island is a designated community marine protected area that lies in the interior of the Great Sea Reef. This mangrove dominated islet is semicircular with a series of openings through the mangrove canopy allowing for the flow of water. A strong current flows from the short reef flat through the mangroves during tidal changes, and into the inner part of the islet.

Coarse sand is the main substratum near the mangroves, giving way to a narrow band of algae-dominated substratum (composed mainly of Fucales and Dictyotales) and Halimeda spp seaward. A mixed calcium carbonate and sand substratum, with the occasional alga, follows the algal band. A film of brown filamentous cyanophytes was noted on the sand. From the mid-part of the reef flat (low-tide mark) to the edge of the reef flat (5 m depth), healthy coral communities take over. The drop-off from the reef flat is approximately 45-90 degrees down to 10-15 m before gently sloping off to 20 m. At 20 m depth the substratum levels off and visibility is generally low. The reef slope often has bommies and large boulders scattered parallel to the reef contour. Below 10 m most communities of algae, coral, etc., become depauperate, and rubble and fine muddy sand dominate. Large beds of Halimeda species are found from 5-12 m depth.




## ALPHA DIVERSITY

### FISH

The diversity of fish around Vatuka Island MPA is high with a total recorded fauna of 190 species (see complete species list in Appendix A). This is the third highest recorded diversity of the sites surveyed, with CFDI families representing 54% of the visible community of fish. Vatuka island MPA alone possesses 57% of the known Butterflyfish and 56% of the known Surgeonfish of the entire Fiji islands (Table 11). About 9.5% of the worlds known fish diversity within the CFDI families are found at this one site. IUCN Redlisted species present are sub-adult Humphead Wrasse (Chelienus undulatus) and Leopard Coralgrouper (Plectropomous leopardus) of a range of sizes including adults greater than 30 cm.

### CORALS

The mangrove island fringing reef with a reef flat that drops steeply to a sandy base of reef at 20.6m. From 15m few hard corals with encrusting Leptoseris and Mycedium common. At 11m depth coral cover was 20% though this increased to 60% at 5m and to 80% on the Acropora dominated reef crest and reef flat. Solitary corals (Fungidae) evident on sand substrate with Herpolitha limax and Fungia simplex common. Pachyseris colonies common as were clumps of Acropora granulosa.

| FAMILY | VATUKA ISLAND MPA | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasse | 26 | 79 | 350 | 402** |
| Damselfish | 30 | 63 | 274 | 330 |
| Butterflyfish | 20 | 35 | 105 | 122 |
| Angelfish | 4 | 14 | 69 | 82 |
| Parrotfish | 8 | 23 | 64 | 83 |
| Surgeonfish | 15 | 27 | 63 | 71 |
| Total (CFDI) | 103 | 241 | 925 | 1090 |

**Table 11.** Coral Reef Fish Diversity Index (numbers of species for Vatuka Islands MPA compared on national, regional and global scales.

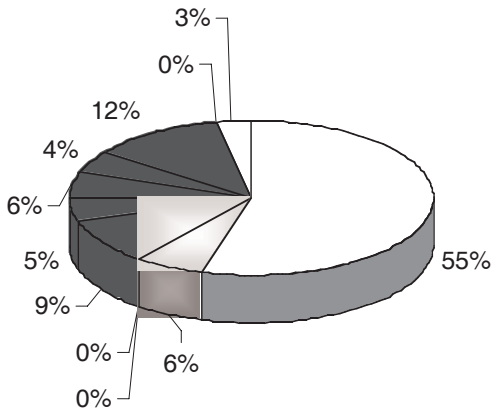
*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999.*
***tropical species only*

## MARINE FLORA

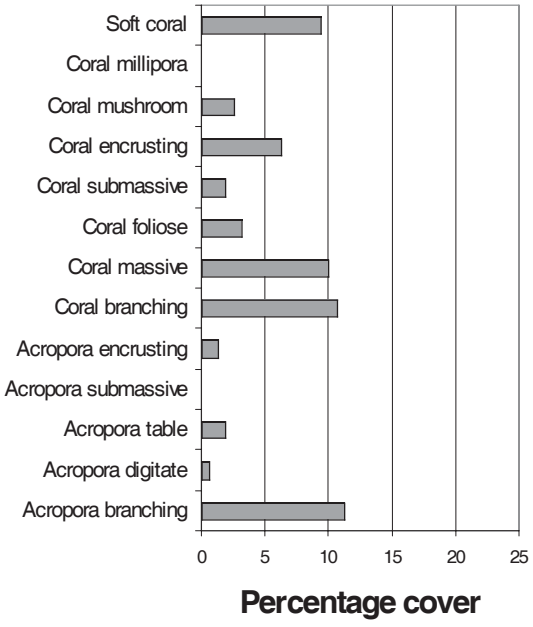
Twenty two species of marine flora were recorded around Vatuka Island (full species list in Appendix G).

## SITE CHARACTER AND POPULATIONS
## VATUKA DEEP (10M)

**Percentage Benthic Cover**



## Mean percentage coral cover Site 1

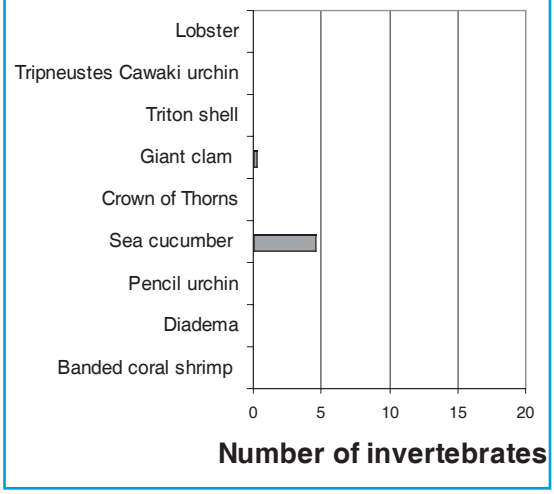



At 10m, this reef has a high level of a variety of hard coral species, with many branching corals. Although some siltation was seen, it was mostly fine white sand which did not appear to be harming coral growth. The majority of the substrate was white sand, and there was quite a lot of macroalgae observed, mostly Halimedes.

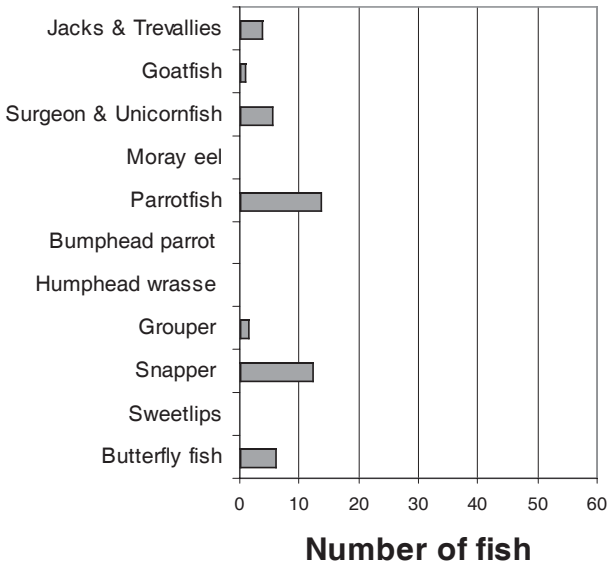
The area was low in invertebrates, although some sea cucumbers and Tridachna giant clams were found. Overall fish numbers were quite high, with small schools of parrotfish, snapper and surgeonfish. Not on the transects were a few schools of small jacks (Trevallies).

The overall impression was of a healthy and vital reef system, albeit with some siltation.

## Mean invertebrates Site 1

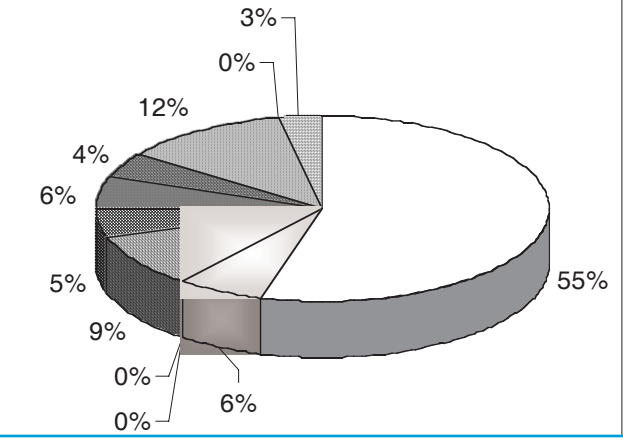



## Mean fish numbers Site 1



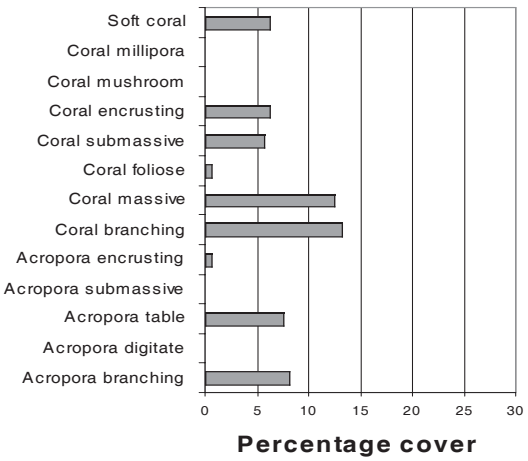
## VATUKA SHALLOW (5M)

### Percentage Benthic Cover Site 2




- Hard Coral
- Soft Coral
- Recently Killed Coral
- Nutrient Indicator Algae
- Fleshy Seaweed
- Sponge
- Rock
- Rubble
- Sand
- Silt

### Mean percentage coral cover Site 2

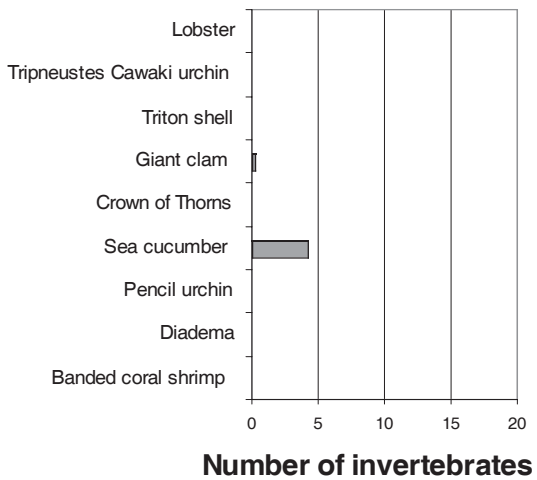



At 5m, this reef has a high level of coral cover, mostly of a variety of hard coral species, with some large Acropora tables.

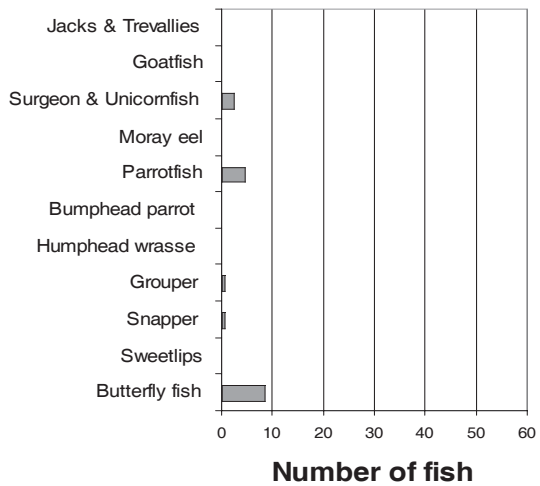
The majority of the non-biotic substrate was white sand, and there was quite a lot of Macro Algae seen, mostly Halimedes.

The area was low in invertebrates, although some sea cucumbers were found. The overall impression of fish life was high, but in the shallows it was mostly small non-commercially important species such as butterfly and damselfish.

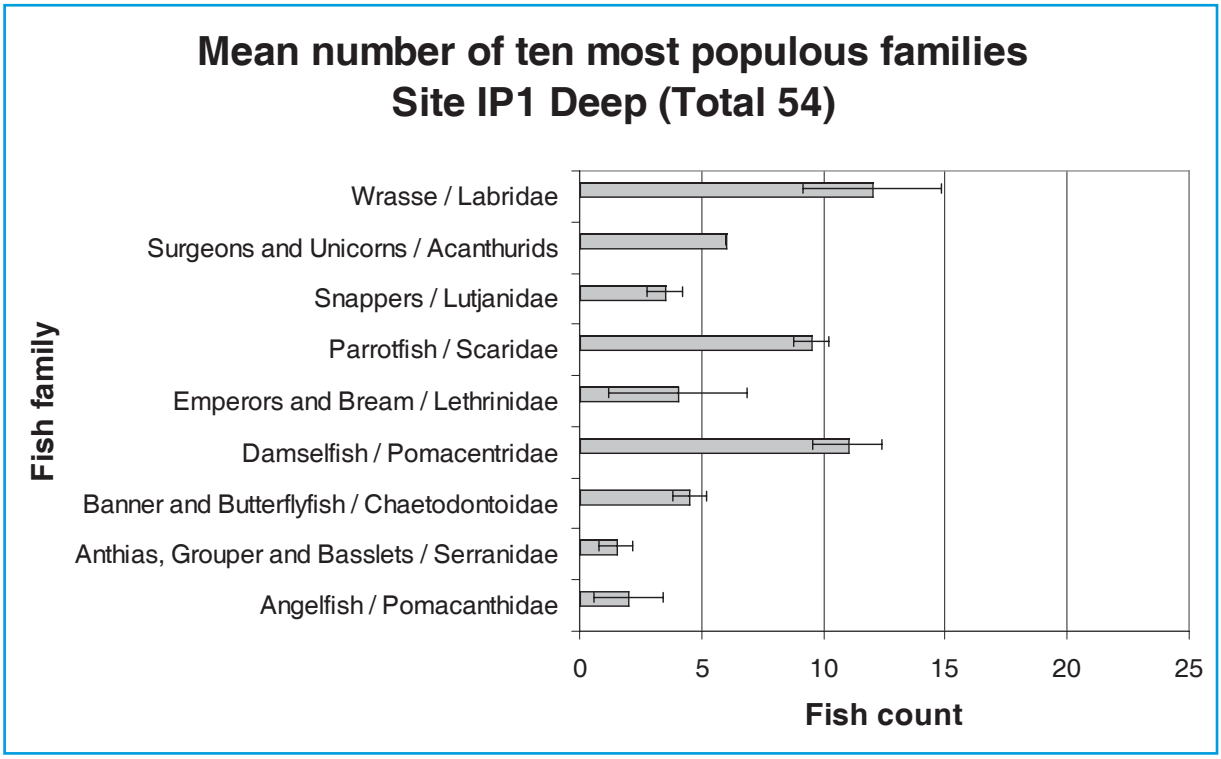
### Mean invertebrates Site 2

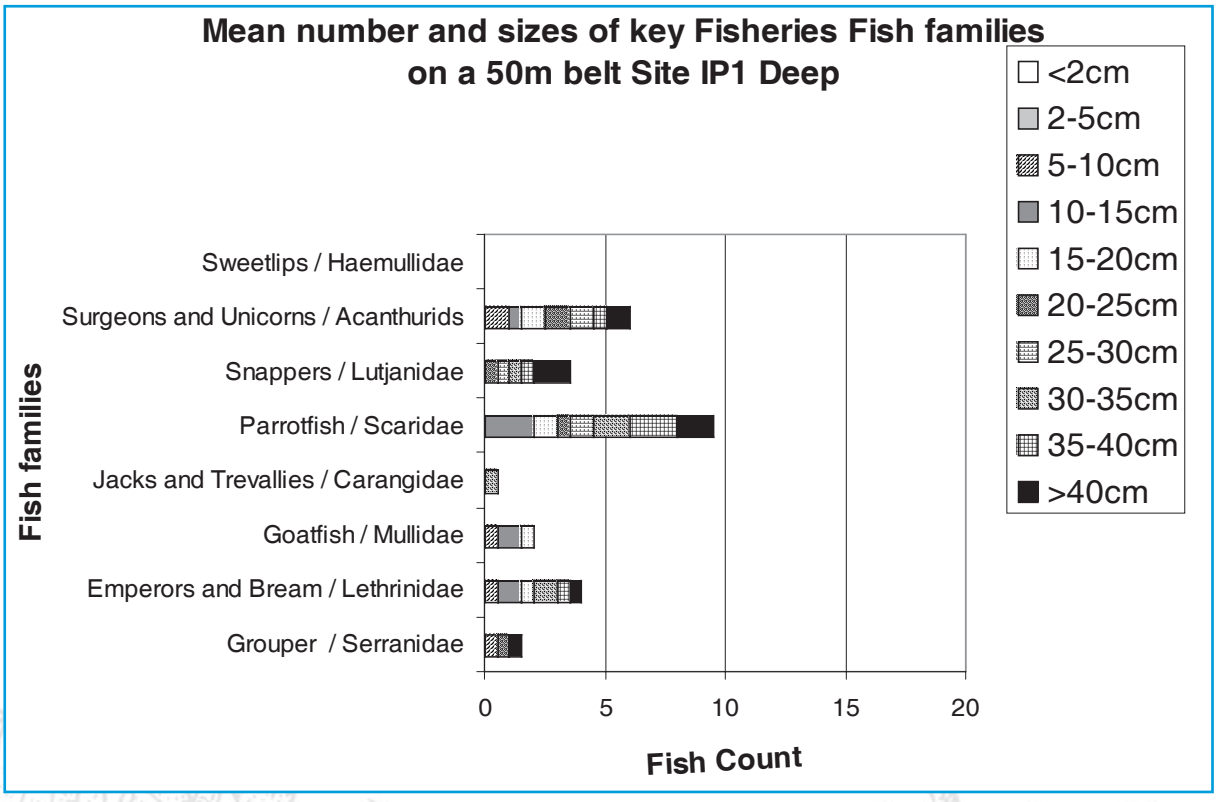



### Mean fish numbers Site 2



## FISH ABUNDANCE AND SIZE CLASSES
## IP1 VATUKA DEEP

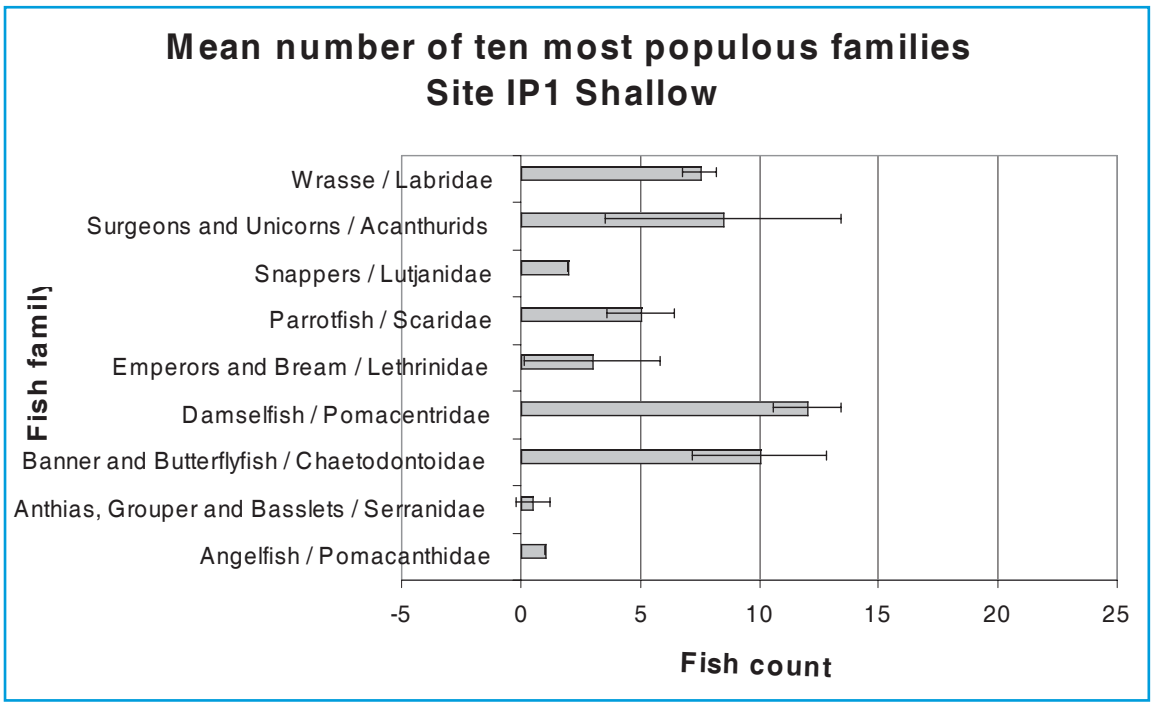


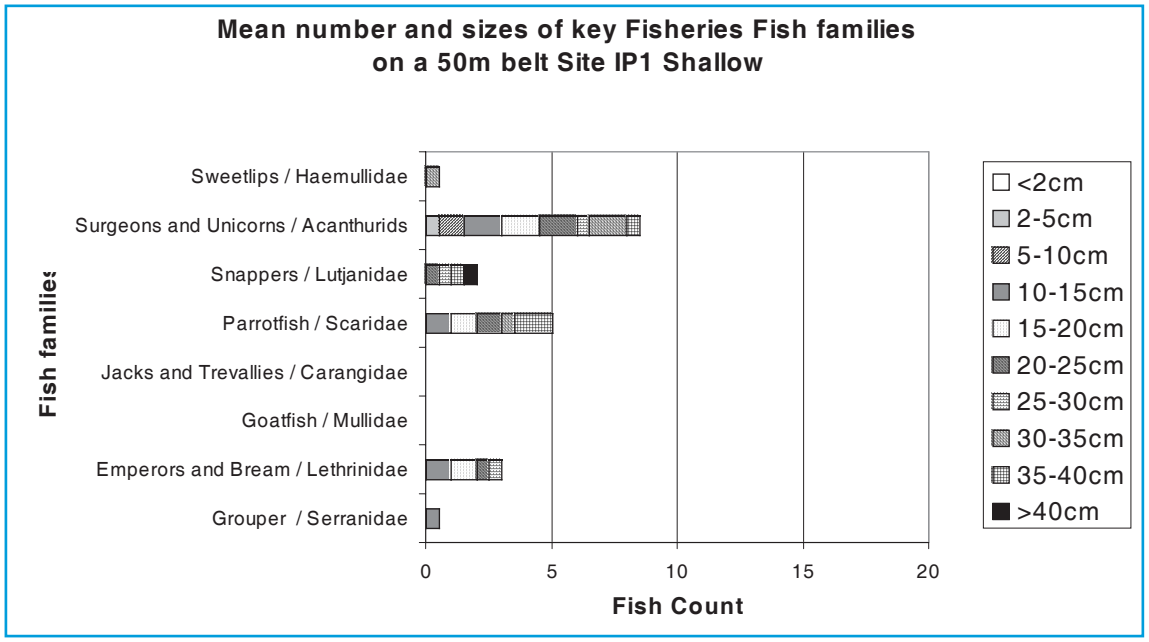




The deeper reef slope is dominated by damselfish, wrasse and parrotfish of all sizes, although there were quite a few large snappers and emperors. A few large groupers were seen, and a school of small trevallies. Overall, there was a large

spread of fish size, with all stages from small juveniles to large adults being found.

## IP1 VATUKA SHALLOW




The shallow reef at this site has a larger number of butterfly and surgeonfish than the deeper slope, and fewer parrotfish, snappers and emperors. The fish in the shallows were generally smaller than those found on the deeper slope, and fewer of the fish important to local fisheries were seen.

Overall, fish counts on the reef were relatively high, and many groups were represented, including fisheries important species of all ages.

## RAVIRAVI PASSAGE

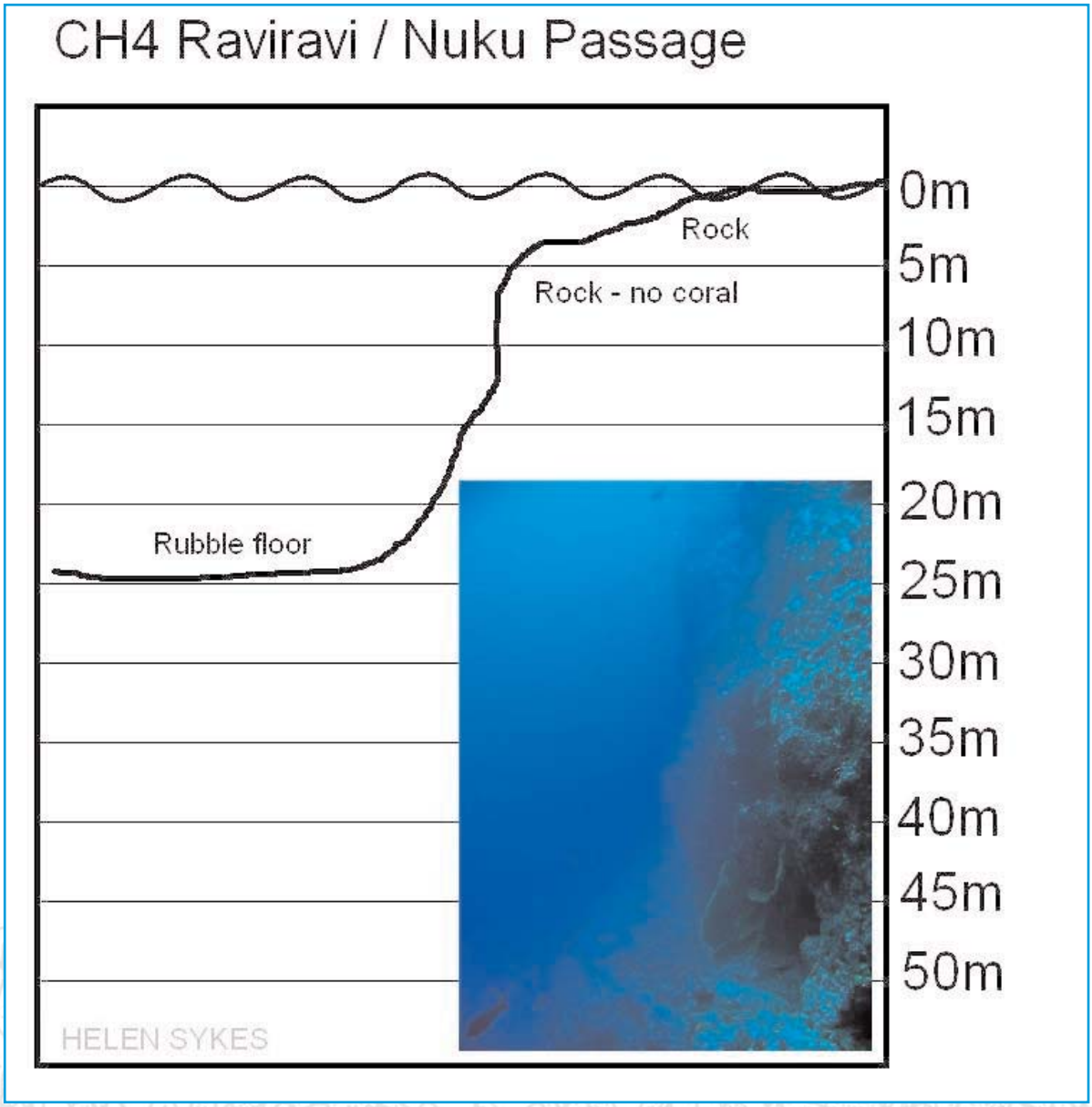
Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 3 | 7.12.04 | 7.25 | 8.00 | CH4 | Deep | Raviravi/ Nuku Passage | Passage in outer barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o19.490' | 178o55.383' | 10m | 30m | Strong incoming | Low to Rising | 27.5 |

### 10.2 RAVIRAVI PASSAGE

This is a passage in the outer barrier reef, shown as Raviravi passage on charts and Nuku passage on maps, west of the barrier reef outcrop around Kia Island. The passage is an area of strong current, with walls of scoured rock, little coral, and very little algal cover. Algae, coral and sponge collectors surveyed the front reef slope from 3-20 m depth at the northern entry of the channel. In this area there is a gentle slope from the reef crest that continues beyond the 20 m depth. Current was fairly strong flowing inwards to the channel. Consolidated carbonate structures with coarse sand are the main substratum. Solitary soft corals (Dendronepthya spp.) dominate the 20 m depth environment. Caulerpa species (ca. nine species) were found to be the dominant algal group from 5-20 m depth.



| FAMILY | VATUKA ISLAND MPA | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasse | 26 | 79 | 350 | 402** |
| Damselfish | 30 | 63 | 274 | 330 |
| Butterflyfish | 20 | 35 | 105 | 122 |
| Angelfish | 4 | 14 | 69 | 82 |
| Parrotfish | 8 | 23 | 64 | 83 |
| Surgeonfish | 15 | 27 | 63 | 71 |
| Total (CFDI) | 103 | 241 | 925 | 1090 |

**Table 12.** Coral Reef Fish Diversity Index (numbers of species) for Raviravi channel compared on national, regional and global scales.

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999.*
***tropical species only*

## ALPHA DIVERSITY

### FISH

The diversity of fish around RaviRavi Channel and back reef is high with a total recorded fauna of 195 species (see complete species list in Appendix B). This is the second highest recorded diversity of the sites surveyed with CFDI families representing 52% of the visible community of fish. RaviRavi Channel and back reef alone possesses 58% of the known Angelfish and 48% of the known Surgeonfish of the entire Fiji islands (Table 12). About 9.3% of the worlds known fish diversity within the CFDI families are found at this one site. IUCN Redlisted species present are large adult Grey reef sharks (Carcharhinus amblyrhyncos) and adult White-tip reef sharks (Triaenodon obesus). Also an astoundingly large school of over 50 adult Bumpheaded parrotfish (B. muricatum) around 1 -1.5 meters long were seen in Raviravi Passage. This species was previously thought to be locally extirpated.

### CORALS

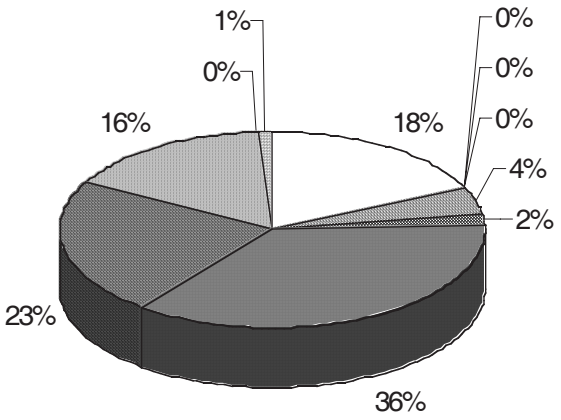
At 18m depth there is a flat expanse of wave scoured reef with 2x1m high boulders with <5% coral cover. Lots of Dendronephya and tabulate corals occur. Acropora divaricata were common as isolated colonies. Species noted were Anacropora spp., Acropora crateriformis, A. sarmentosa A. monticulosa A. nobilis, A. florida, A. humilis, A. hyacinthus, Pocillopora verrucosa , Turbinaria mesenterina , Diploastrea heliopora, Favites russeli, Astrepora and Porites common.

### MARINE FLORA

Fifty nine species of marine flora were recorded around Raviravi passage (full species list in Appendix C).

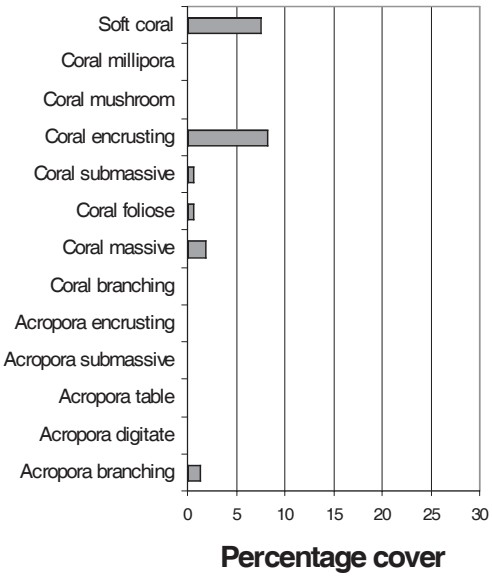
## SITE CHARACTER AND POPULATIONS
## CH4 RAVIRAVI CHANNEL

### Percentage Benthic Cover Site 4




- Hard Coral
- Soft Coral
- Recently Killed Coral
- Nutrient Indicator Algae
- Fleshy Seaweed
- Sponge
- Rock
- Rubble
- Sand
- Silt
- Other

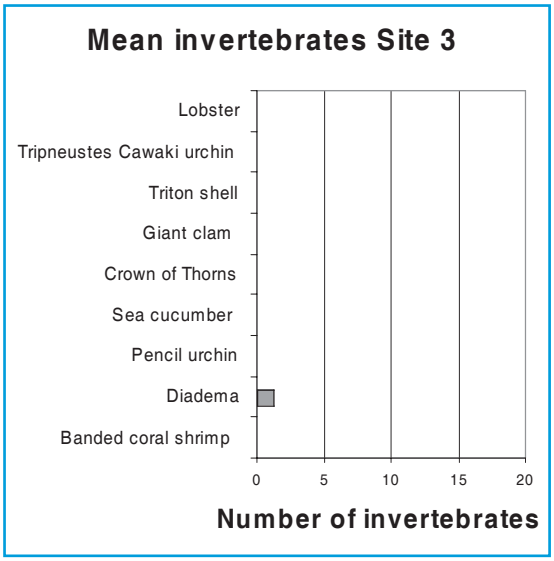
### Mean percentage coral cover Site 3

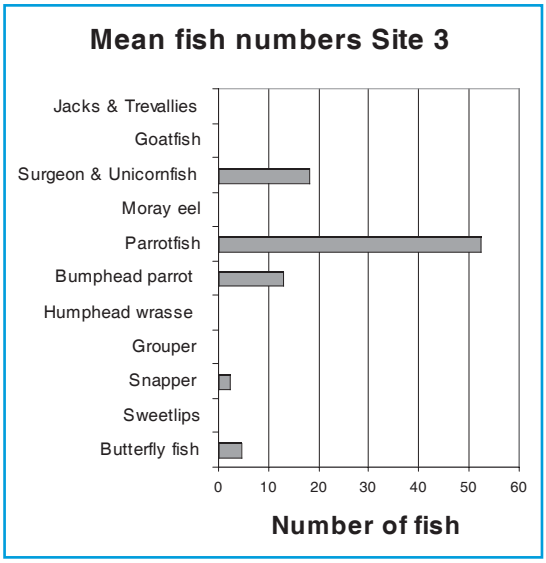



This passage had very little live coral growth, consisting mostly of bare rock sides and sand floors. It is an area of very strong tidal currents, which probably discourage coral settlement. What corals were present were mostly low-relief encrusting and soft species.

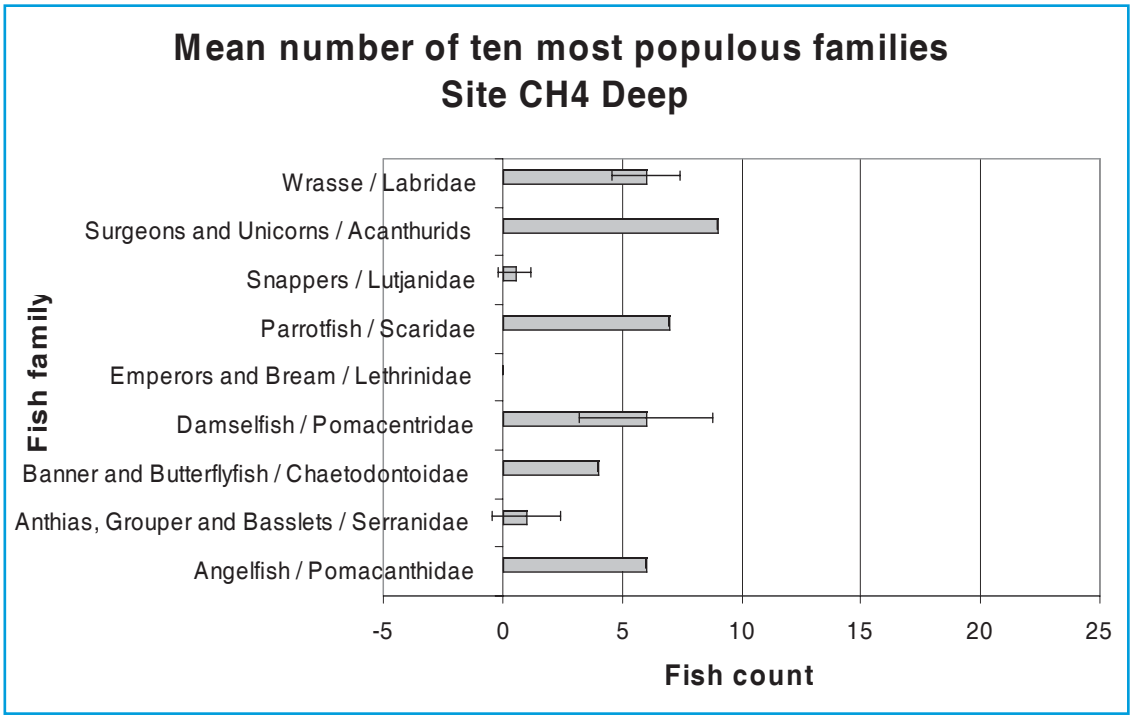
Practically no invertebrates were found, with a few Diadema urchins seen in the rocks.

The channel housed a huge school of large mixed-species parrotfish, and a school of over 50 Bumphead Parrotfish, an exciting find, as this species is facing a local extinction in Fiji.

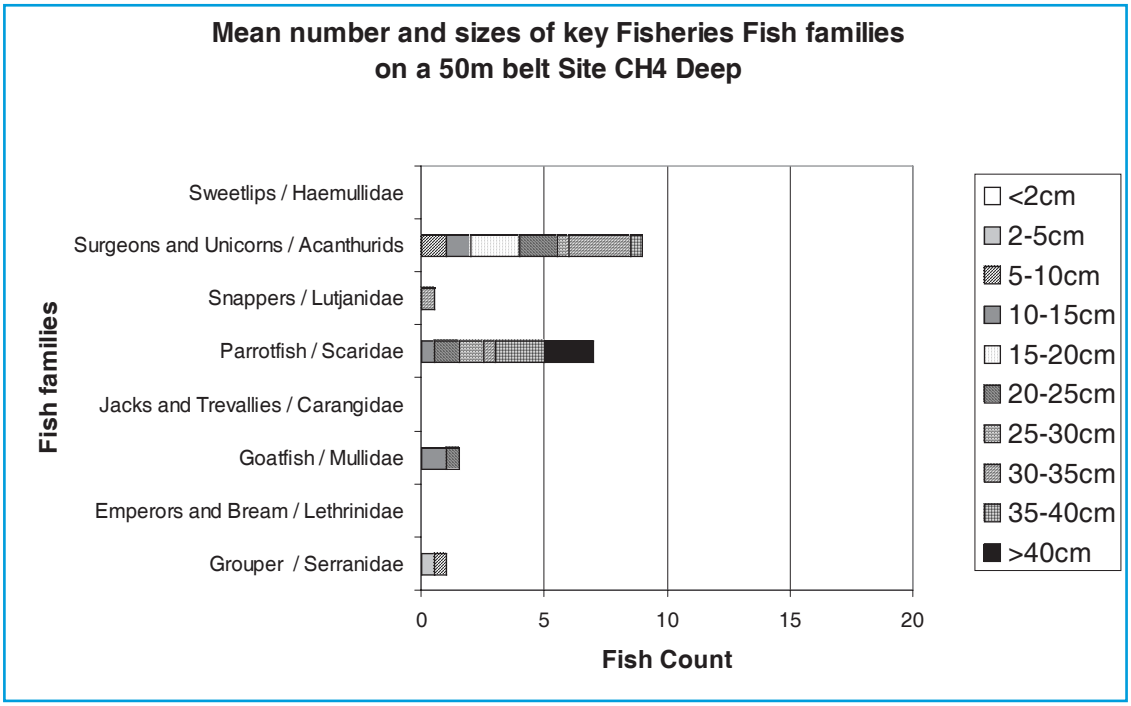



## FISH ABUNDANCE AND SIZE CLASS




Fish counts on this reef were relatively low, with surgeon, parrot and damselfish being the most represented groups. Angelfish numbers were relatively high. Fisheries-important species such as snappers emperors and trevallies, were mostly absent, but there were schools of large parrotfish including a school of 52 adult bumphead parrotfish.

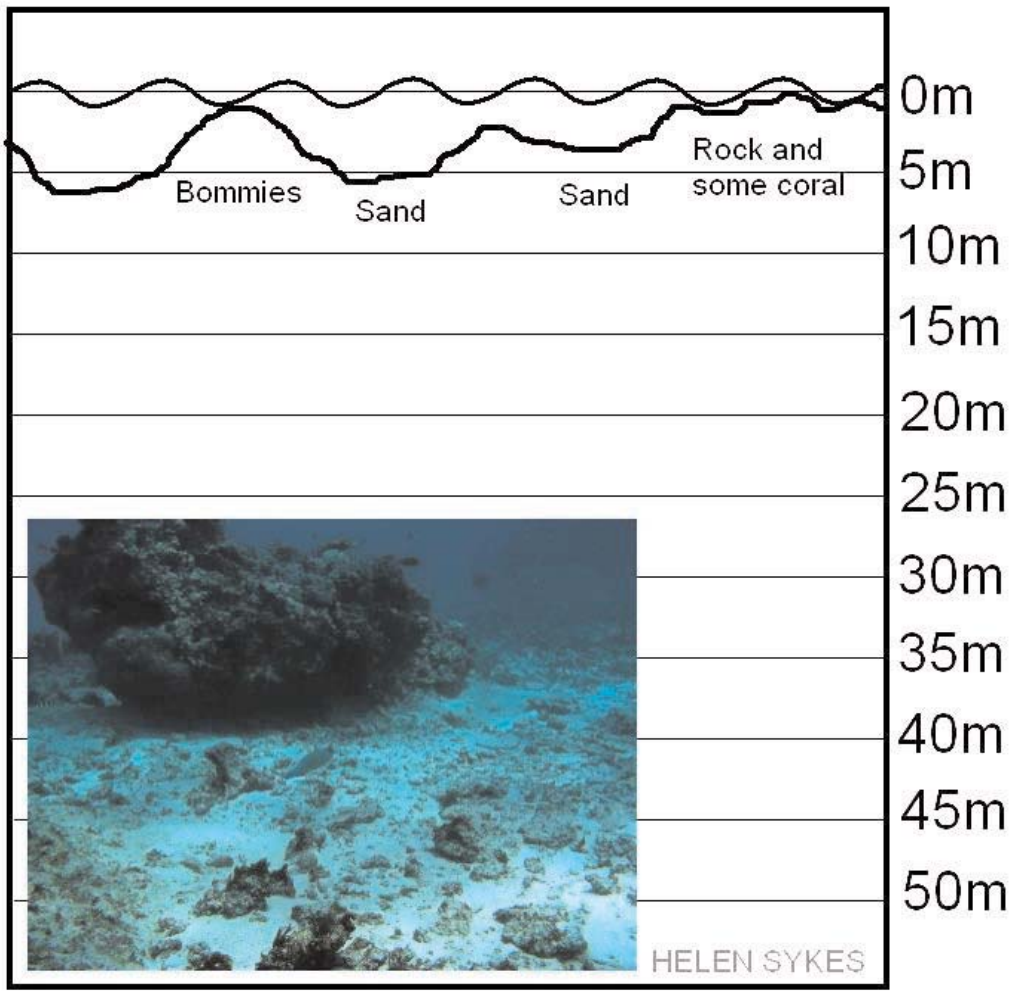

Mean number and sizes of key Fisheries Fish families on a 50m belt Site CH4 Deep
Fish families
Sweetlips / Haemullidae
Surgeons and Unicorns / Acanthurids
Snappers / Lutjanidae
Parrotfish / Scaridae
Jacks and Trevallies / Carangidae
Goatfish / Mullidae
Emperors and Bream / Lethrinidae
Grouper / Serranidae
0
5
10
15
20
Fish Count
<2cm
2-5cm
5-10cm
10-15cm
15-20cm
20-25cm
25-30cm
30-35cm
35-40cm
>40cm

## RAVIRAVI BACK REEF

Survey details

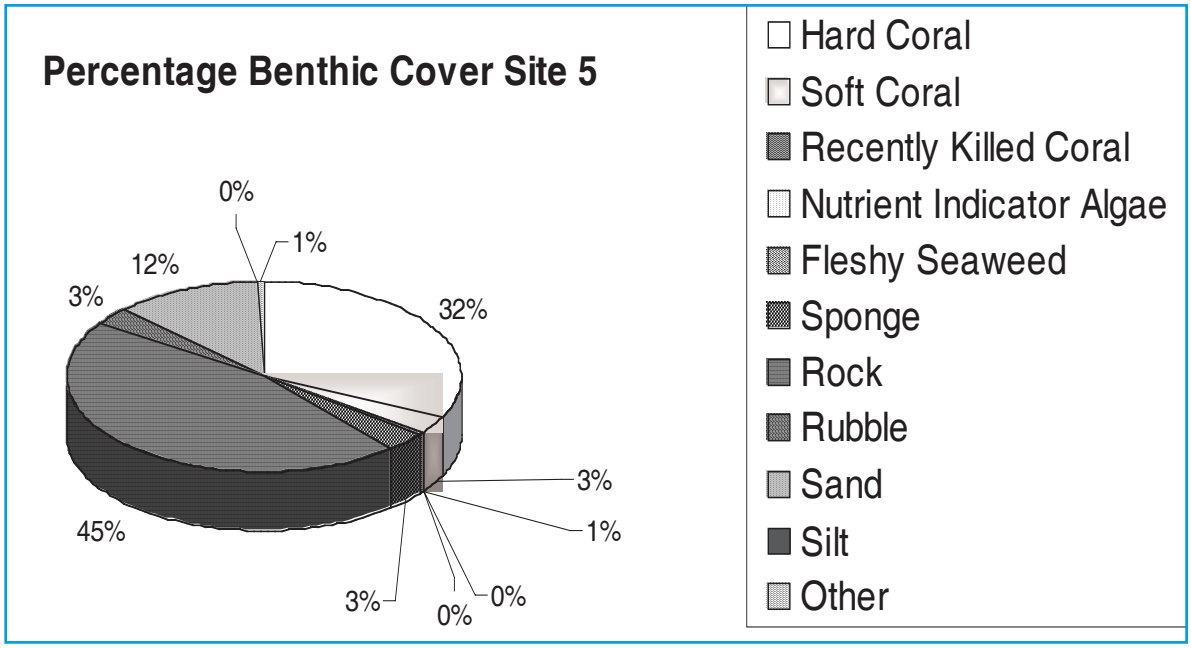
| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 4 | 7.12.04 | 10.15 | 10.50 | CH4 | Shallow | Raviravi/ Nuku Passage | Inside passage in barrier reef |

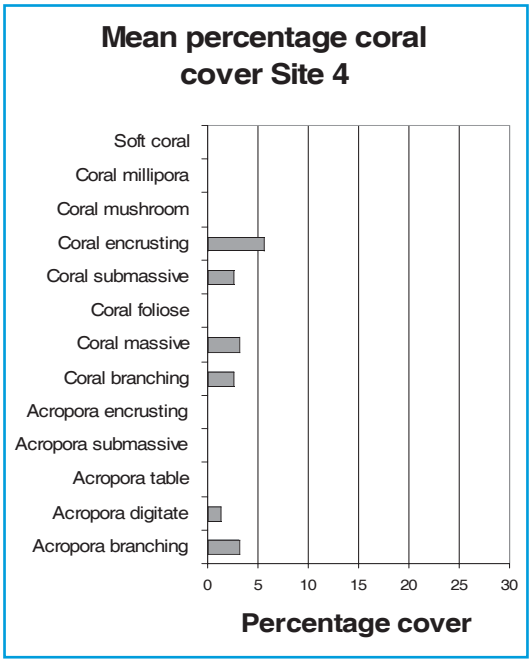
| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o19.674' | 178o54.806' | 4m | 20m | Little surge | Rising | 2 |




### 7.3 RAVIRAVI BACK REEF

This area is on the back of the barrier reef just inside the Raviravi or Nuku passage. It is a shallow area mostly made up of rock and rubble, with low coral growth, and dense patches of filamentous algae. It is affected by current and waves that break over the outer edge of the barrier. A moderate current flowed from the channel towards the back reef. Large boulders, remnants of corals, were encrusted with various organisms including cyanophytes and very few macro-algae. The 3 m depth reef flat slopes down to 10 m or more. Large crevices were found, dominated by encrusting corallines and sponges.




This area consists mostly of dead coral rocks and rubble, with patches of white sand. What corals survive here are mostly massive or encrusting species, adapted to the high energy conditions, although patches of branching Acropora were found in places.

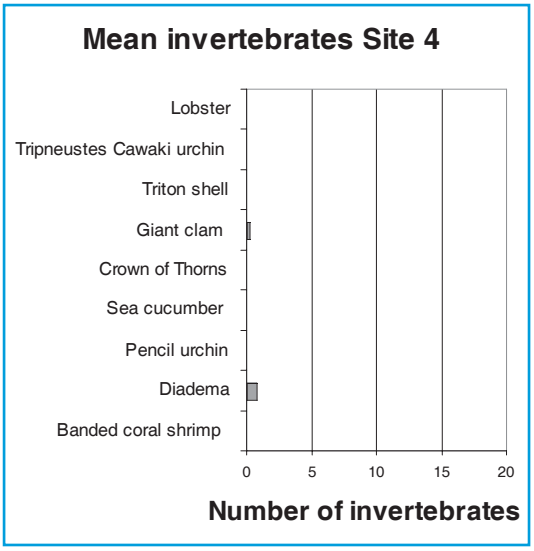
A very few Tridachna giant clams and Diadema urchins were found, otherwise the invertebrate population was non-existent.

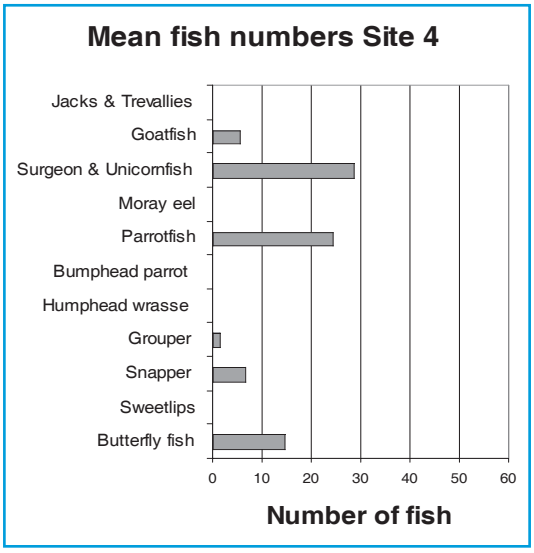
The area had a high level of fish life, with many surgeon and parrotfish grazing on algae-covered rocks. A few juvenile snapper were found, as well as goatfish and butterfly fish.

## CORALS

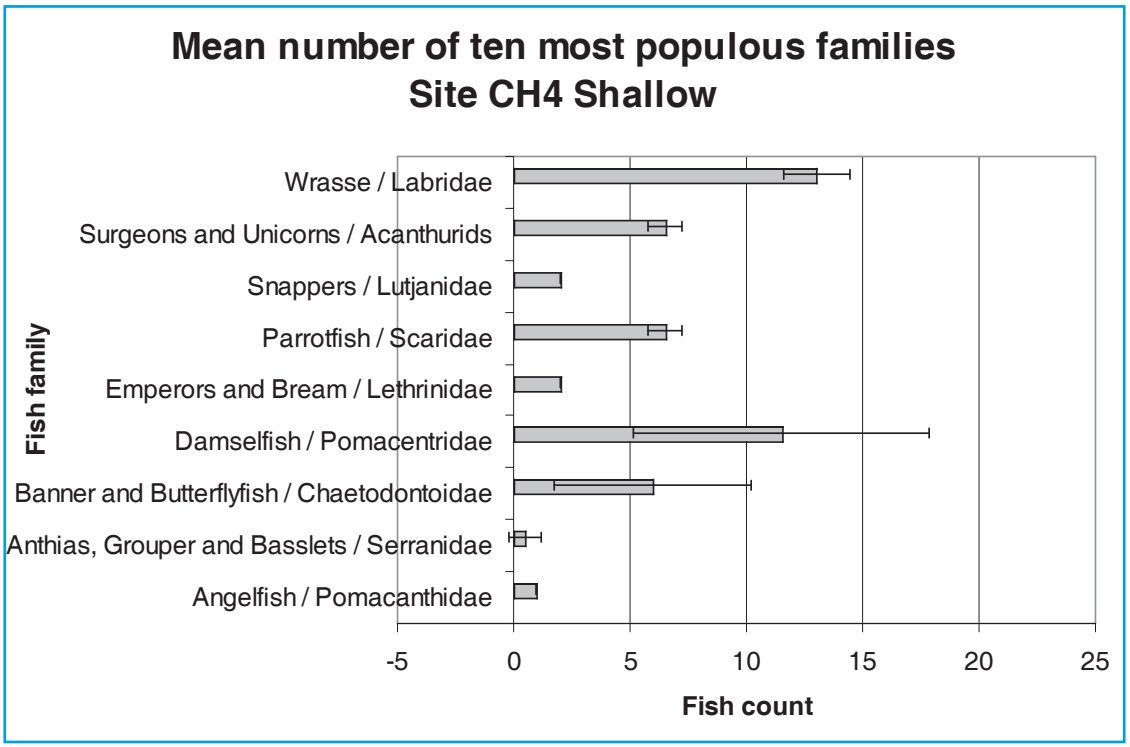
At the base of the reef, the depth was 1m. The location is inside the channel 1/2km from the seaward entrance. On the reef slope (<10m depth) living coral is minimized by the presence of sand and rubble substrate. Acropora divaricata is common at depth though Millepora tenella dominates the mid-slope. On the reef top in 2m depth, species were Platygyra lamellina, P. meandrina, Acropora humilis, A. millepora, Euphyllia glabrescens, Montastrea curta, Goniastrea reniformis, G. aspera, Favia pallida, Pocillopora eydouxi, Hydnophora exesa, and Tubipora musica.

In both inside and outside dive areas, the coral cover was very low. This was attributed to wave action on the outside where the reef is exposed to northerly swells. The inside is exposed to the prevailing wind wave chop and is dominated by mobile sand sediments. Coral was depauperate in both areas.

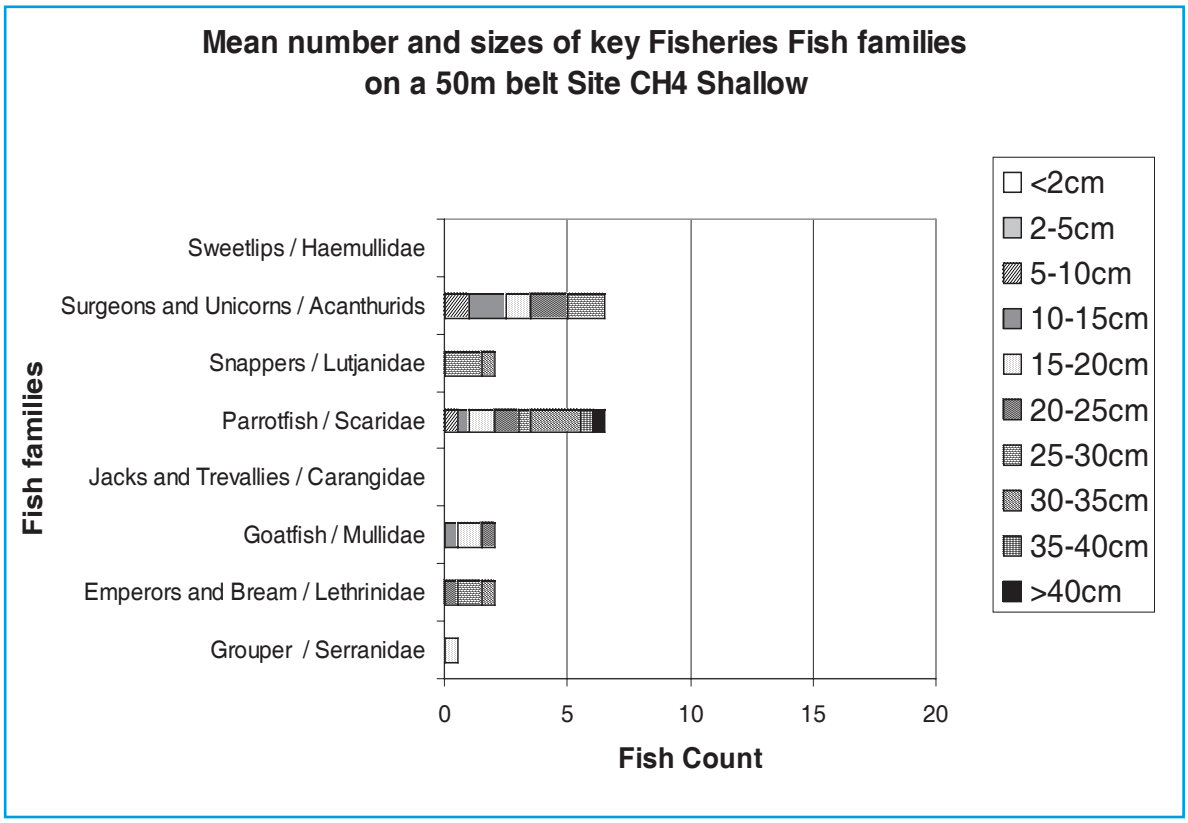



## FISH ABUNDANCE AND SIZE CLASS




Fish numbers at this site were around the average of those seen in the area, dominated by damselfish and wrasse, and with a few small snappers, emperors and a very few small grouper. Parrotfish were found in a range of sizes, but most other fish species were small to moderate size.

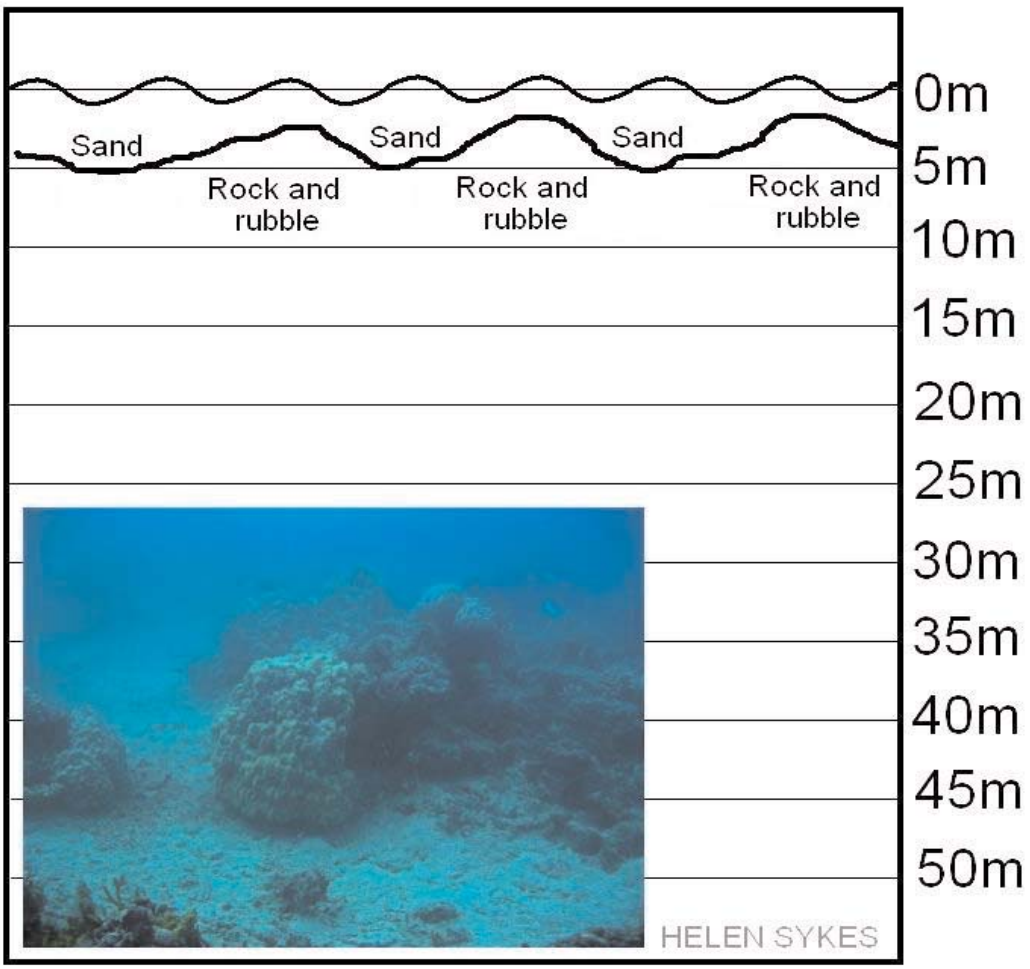

Mean number and sizes of key Fisheries Fish families on a 50m belt Site CH4 Shallow
Fish families
Sweetlips / Haemullidae
Surgeons and Unicorns / Acanthurids
Snappers / Lutjanidae
Parrotfish / Scaridae
Jacks and Trevallies / Carangidae
Goatfish / Mullidae
Emperors and Bream / Lethrinidae
Grouper / Serranidae
0
5
10
15
20
Fish Count
<2cm
2-5cm
5-10cm
10-15cm
15-20cm
20-25cm
25-30cm
30-35cm
35-40cm
>40cm

## MOTULI BAWA -INNER PATCH REEF

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 5 | 7.12.04 | 15.10 | 15.45 | IP4 | Shallow | Motuli Bawa | Inner patch |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o23.310' | 179o01.660' | 4m | 10m | None | Falling | 28 |




### 7.4 MOTULI BAWA - INNER PATCH REEF

This site is a sizable patch reef in the lagoon, forming part of a complex of shallow reef shoals in the middle of the lagoon opposite Macuata-i-Wai, to the immediate west of Naduri Bay. At the time of the survey the lagoon water had a high silt content making the visibility low (about 5 m or less). Large boulders often with encrusting organisms were common throughout the reef. The top of the reef is flat at 1m depth then quickly slopes off to more than 10m. Fine muddy substratum is common especially near the sloping zone. One of the notable features of this site were the bountiful giant clams (Tridacna squamosa and T. maxima), with well over 100 noted. Four crown of thorns starfish (COTS) were seen foraging in the open, feeding on Acropora and Porites corals. Very low algal cover was noted, except cyanophytes which were common.

**Table 13.**
Coral Reef Fish Diversity Index (numbers of species) for Motuli Bawa Reef compared on national, regional and global scales.

| FAMILY | MOTULI BAWA REEF | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLD-WIDE |
|---|---|---|---|---|
| Wrasses | 9 | 79 | 350 | 402** |
| Damselfish | 14 | 63 | 274 | 330 |
| Butterflyfish | 12 | 35 | 105 | 122 |
| Angelfish | 2 | 14 | 69 | 82 |
| Parrotfish | 4 | 23 | 64 | 83 |
| Surgeonfish | 9 | 27 | 63 | 71 |
| Total (CFDI) | 50 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999*
***tropical species only*

## ALPHA DIVERSITY

### FISH

The diversity of fish around Motuli Bawa reef is quite poor in comparison to other GSR sites with a total recorded fauna of 113 species (see complete species list in Appendix C). This is the second lowest recorded diversity of the sites surveyed. CFDI families represented 44% of the visible community of fish. IUCN Redlisted species present are sub-adult Estuary Cod (Epinephalus coioides) and Leopard Coralgrouper (Plectropomous leopardus).

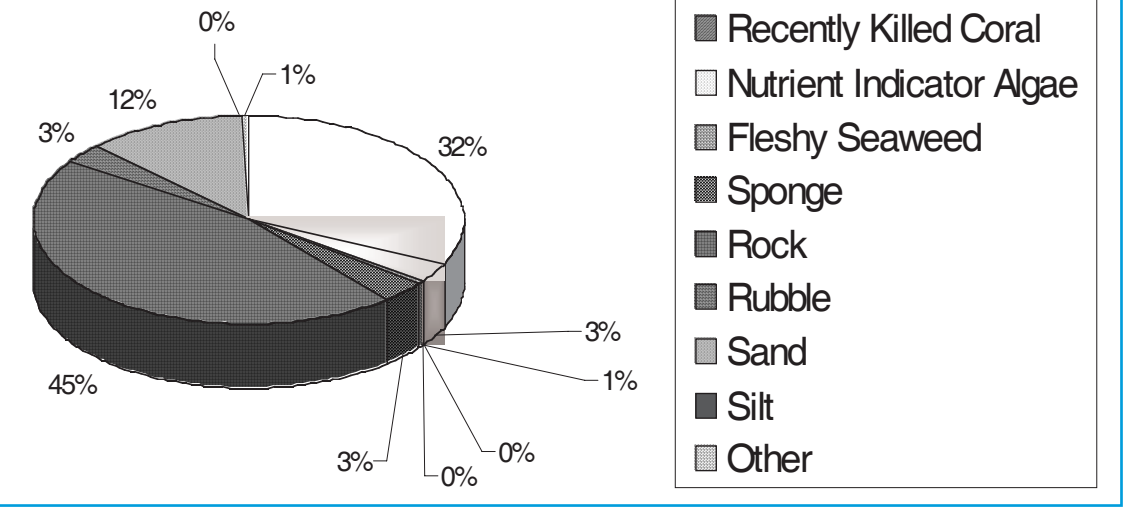
### CORALS

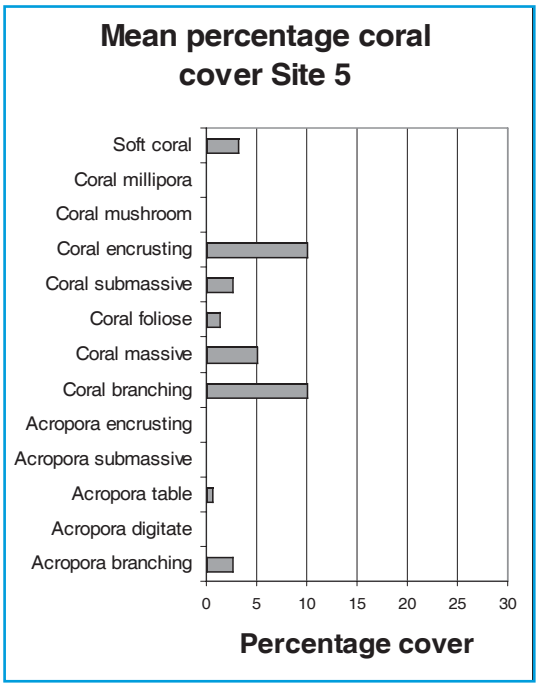
At 6m depth, Canthrellus jebbi, Mycedium elephantotus, Leptastrea spp. were common. At 13m depth, Porites rus was dominant. Other species noted were Acropora echinata. A. carduus, A. grandis, A. millepora, A. cytherea, A. paniculata, Leptoseris scabra Turbinaria heronensis, T. reniformis, Galaxea fascicularis, Favia pallida, Pavona varians, Pachyseris rugosa, P. speciosa, Gardineroseris planulata, Goniopora lobata, G. tenuidens, Pavona motuporensis. At 15m, Zoopilus echinatus and Echinophyllia echinata were recorded. Many coral block isolates occurred with gorgonians and small corals. Soft sediments were highly perturbed by borrowing organisms. The area had 50 Tridacna clams sighted during a 40min swim. Four large crown-of-thorns starfish were observed. On one of the reef isolates at 9m depth, common species were Plerogyra sinuosa, Goniopora lobata, Porites rus, Pavona varians and Gorgonians,. Where reef rises abruptly out off the sediments abundant Porites rus, P. lobata, P. cylindrica, P. annae, Pavona clavus, P. cactus, Lobophyllia sp., Fungia spp., Pectinia latuca, Oxypora glabra, Gardineroseris planulata, and Coscinarea exesa.

### MARINE FLORA

Nineteen species of marine flora were recorded around Motuli Bawa Reef (full species list in Appendix G).

## SITE CHARACTER AND POPULATIONS

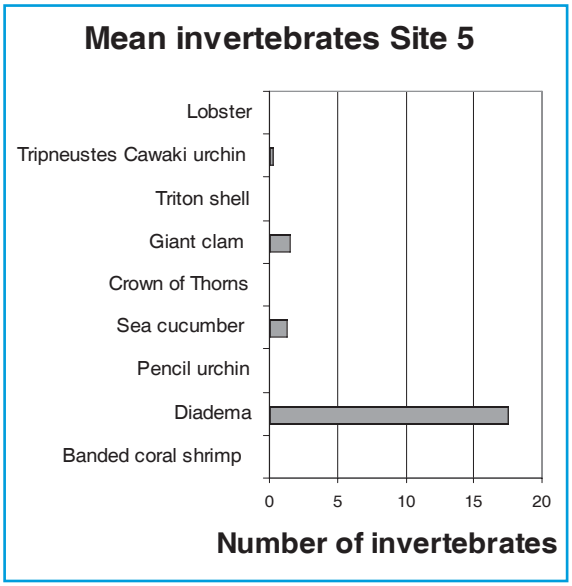


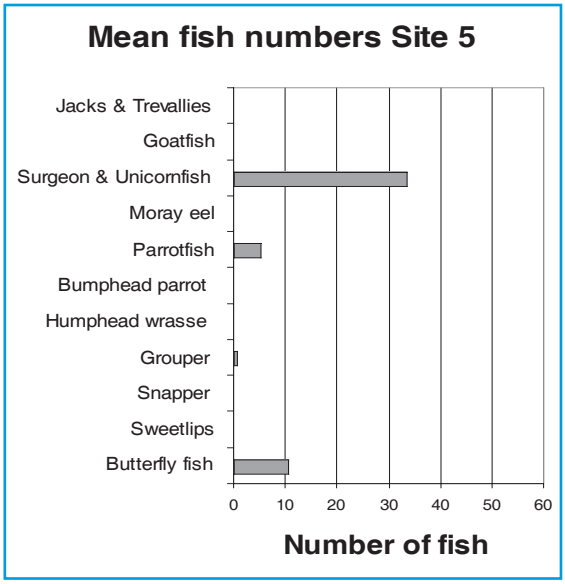




The surface of the shoal is made up mostly of rock and dead coral boulders, with sand patches between, but there are some quite large outcrops of live hard coral, mostly Porites and Monitipora, in massive, encrusting and branching forms.

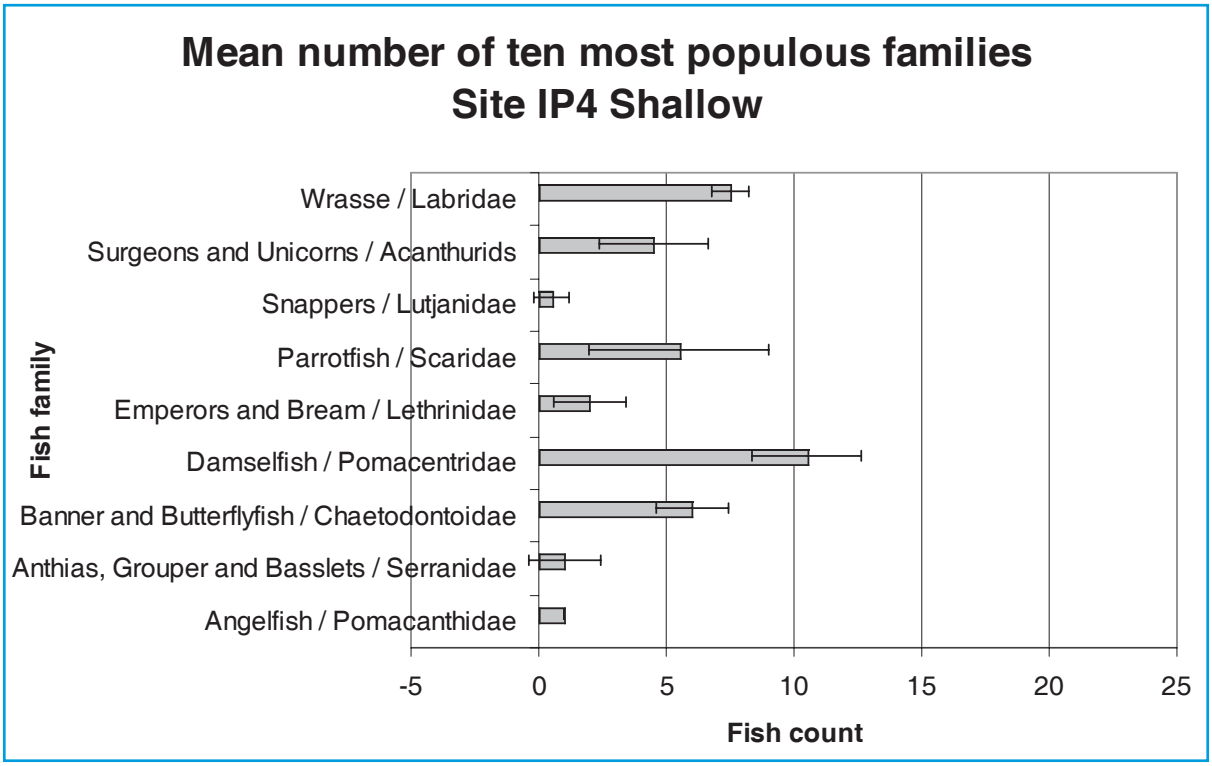
This area is relatively rich in invertebrates, with high numbers of Diadema urchins, and Tridachna giant clams, Tripnuestes cawaki urchins and sea cucumbers.

Large numbers of surgeonfish were seen, plus a few butterfly and parrot fish, but generally fish numbers were low, with the main other species present being wrasses and damselfish.

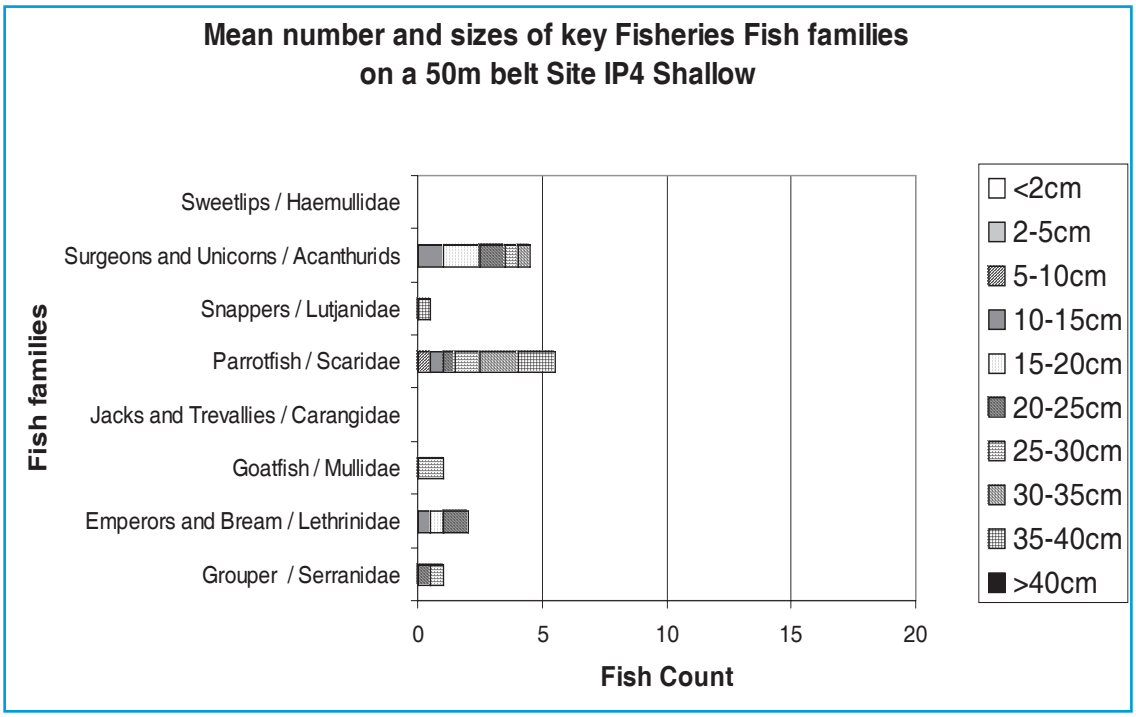



## FISH ABUNDANCE AND SIZE CLASS




Fish numbers were low, dominated by damselfish, wrasse and butterflyfish. A very few snappers, emperors and grouper were found, and all of these were small.


Mean number and sizes of key Fisheries Fish families on a 50m belt Site IP4 Shallow
Fish families
Sweetlips / Haemullidae
Surgeons and Unicorns / Acanthurids
Snappers / Lutjanidae
Parrotfish / Scaridae
Jacks and Trevallies / Carangidae
Goatfish / Mullidae
Emperors and Bream / Lethrinidae
Grouper / Serranidae
0
5
10
15
20
Fish Count
<2cm
2-5cm
5-10cm
10-15cm
15-20cm
20-25cm
25-30cm
30-35cm
35-40cm
>40cm

# CAKAULEVU REEF - (TIMELESS) OUTER BARRIER REEF

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 6 | 8.12.04 | 8.45 | 9.25 | OB1 | Deep | Timeless | Outer barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o12.780' | 179o01.961' | 12m | 30m | Slight surge | Dead Low | 27.5 |

## 7.5 CAKAULEVU REEF - (TIMELESS) OUTER BARRIER REEF

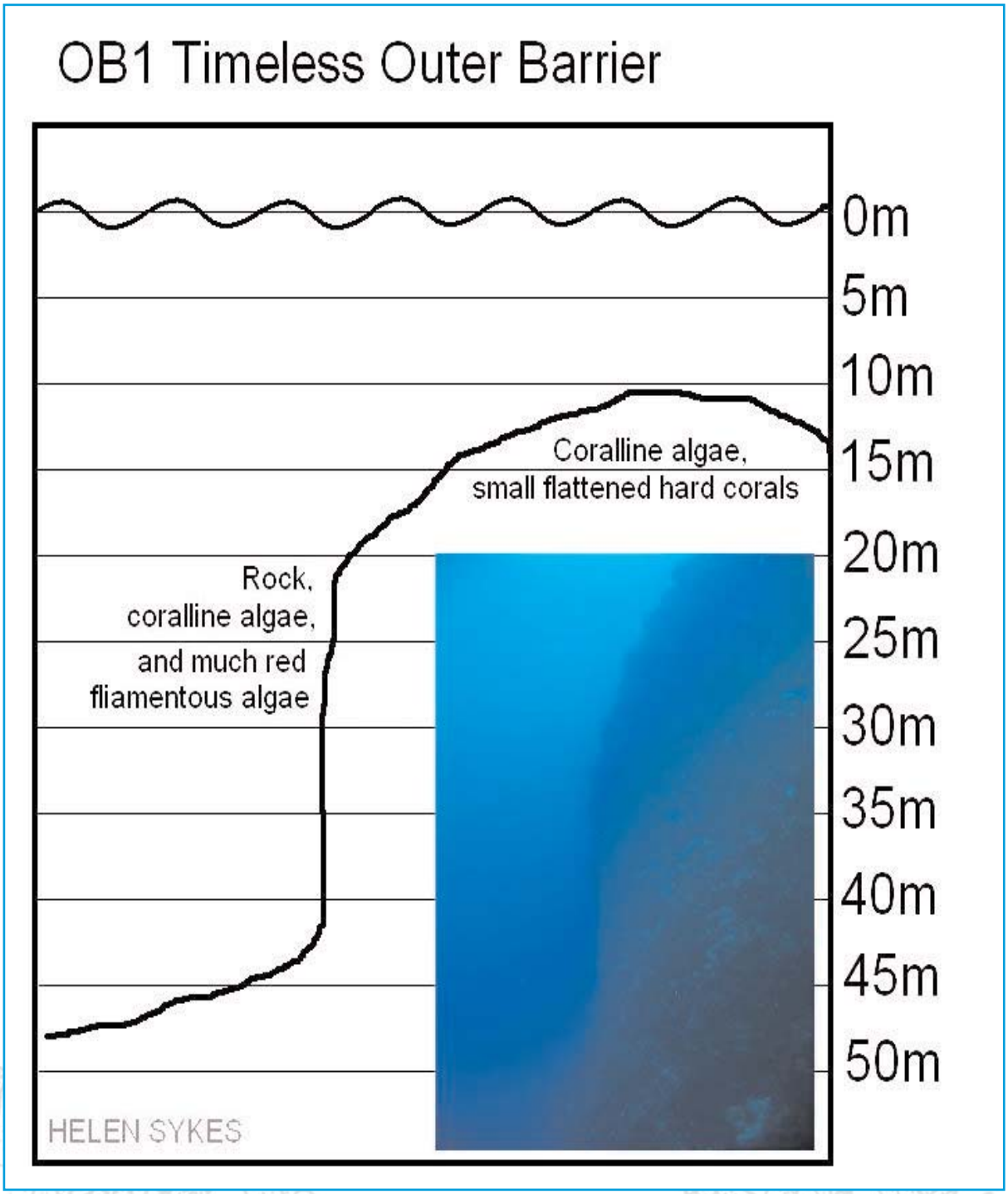


**Table 14.** Coral Reef Fish Diversity Index (numbers of species) for Timeless and Fernando's hideaway compared on national, regional and global scales.

| FAMILY | TIMELESS & FERNANDO'S HIDEAWAY | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 35 | 79 | 350 | 402** |
| Damselfish | 29 | 63 | 274 | 330 |
| Butterflyfish | 24 | 35 | 105 | 122 |
| Angelfish | 6 | 14 | 69 | 82 |
| Parrotfish | 9 | 23 | 64 | 83 |
| Surgeonfish | 16 | 27 | 63 | 71 |
| Total (CFDI) | 119 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

This is the outer wall of the extreme northern edge of the barrier reef that protrudes around Kia island. It is a wave-scoured wall, facing deep open water, covered in much clean coralline algae and small low-relief hard corals. This site is used as a tourist dive site by Nukubati Resort, who know it as"Timeless" and also growing in popularity as a world-class surfing destination. The survey was carried out at the outer barrier reef, where the substratum was dominated by hermatypic corals, bommies and boulders. Encrusting corallines were dominant in gaps where corals were absent. In the shallower parts (5m depth), Hydrolithon onkodes and Hydrolithon craspedium dominated. In crevices and shaded sides of large boulders, Lithothamnion proliferum dominated. Some large macro- algae were observed, but often appearing opportunistically. These include Gibsmithia hawaiiense, Chlorodesmis fastigiata, Caulerpa racemosa, Portieria hornemannii, Amphiroa crassa and Neogoniolithon brassica-florida.

## ALPHA DIVERSITY

### FISH

The diversity of fish around Timeless outer barrier reef and contiguous nearby shallow channel (known to dive operators as Fernando's hideaway) is very high with a total recorded fauna of 221 species (see complete species list in Appendix C). This is the highest recorded diversity of the sites surveyed, with CFDI families representing 54% of the visible community of fish. This site alone possesses 69% of the known Butterflyfish and 60% of the known Surgeonfish of the entire Fiji islands (Table 14). About 11% of the worlds known fish diversity within the CFDI families are found at this site. This site also supports populations of six IUCN Redlisted species; Humphead Wrasse (Chelienus undulatus), Leopard Coralgrouper (Plectropomous leopardus), Grey reef shark (Carcharhinus amblyrhyncos), White-tip reef shark (Triaenodon obesus), Bluespotted ribbontail ray (Taeniura lymma) and Manta Ray (Mobula birostris).

### CORALS

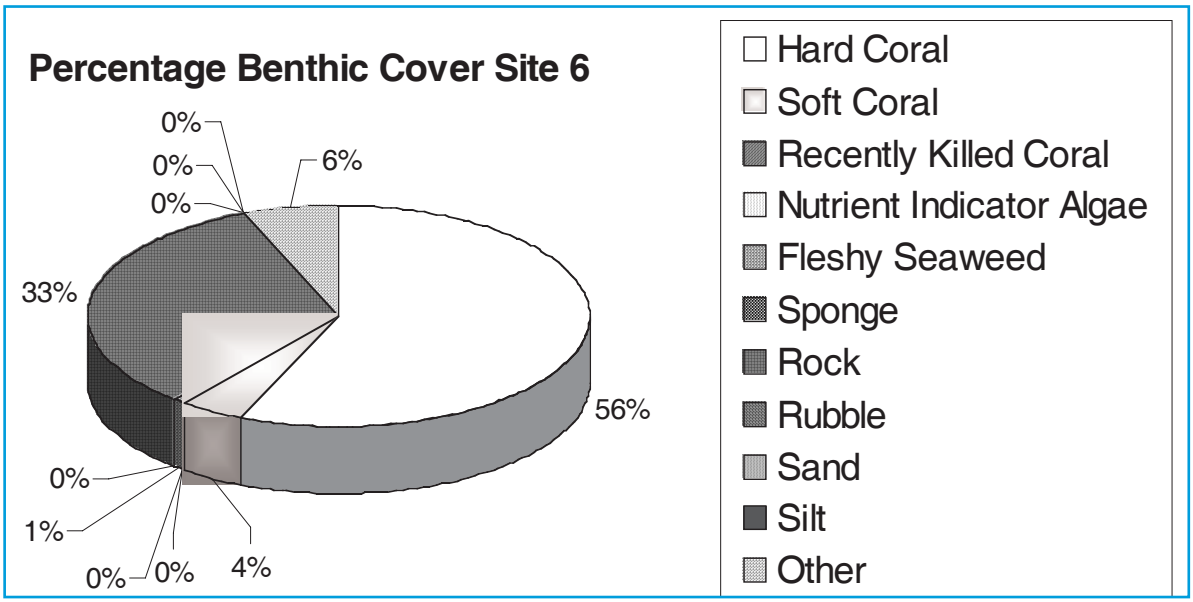
Diversity is moderated by distance from the surf, depth and the general drop off. The area is semi-protected from the prevailing northeasterly swells though exposed from the north to west. The bathymetry stretches from the reef top or flat of the barrier reef descending depth as a gentle slope in some areas and a highly undulating surface with mounds and channels in others. The reef slope becomes vertical at the 15m depths and descends to 40-50m to a sandy floor. The reef slope had a mixed assemblage of hard and soft corals. The hard corals were dominated by corymbosa and caespitose Acropora colonies. Massive and encrusting colonies on the reef surface were very uneven with ridges, furrows and holes. It has very heavily cemented with coralline algae with a hummocky, hilly terrain. The area has an estimated 40% hard coral cover. Faviidae and Poritidae were subdominant. Coral disease was evident in Acropora spp. such as Acropora secale.

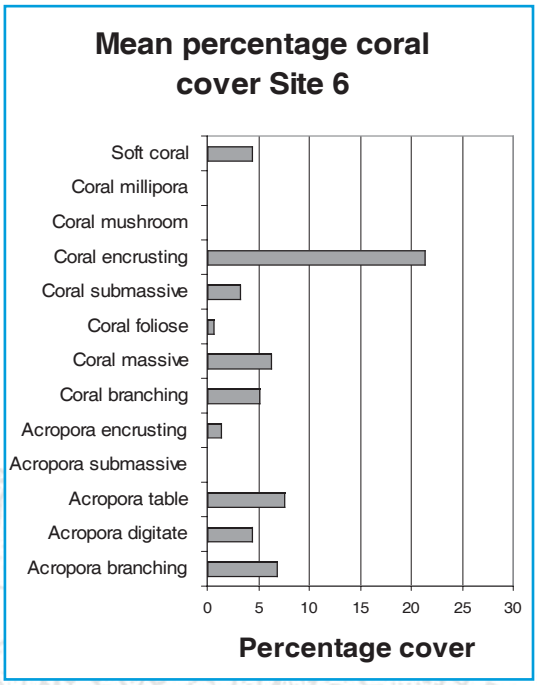
Species present were Acropora humilis, A. micropthalma, A. clathrata, A. loripes, A. valida, A. sarmentosa, A. microclados, A. divaricata, A. secale, A. palifera, A. millepora, A. florida, A. robusta, Pocillopora meandrina, P. eydouxi, P. damicornis, Astreopora listeri, A myriopthalma, Goniastrea pini, G. edwardsi, Montipora spp. Euphyllia glabrescens, Echinophyllia aspera, Cyphastrea decadia, Merulina ampliata, Scapophyllia cylindrica, Platygyra sp., Hydnophora rigida, Favites magnestellata, Leptoseris yabei and Symphyllia sp.

## MARINE FLORA

Twenty eight species of marine flora were recorded around Timeless outer barrier (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS

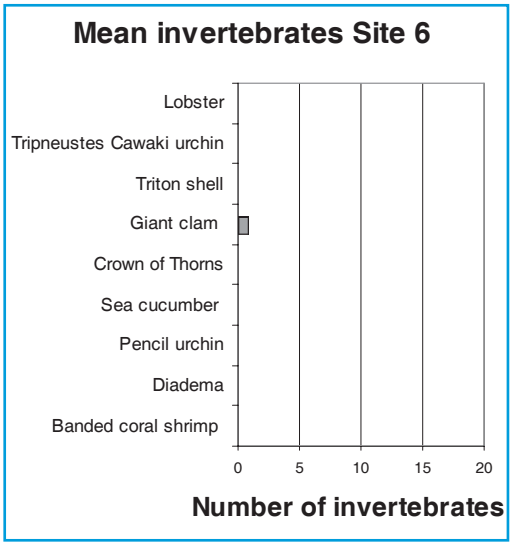


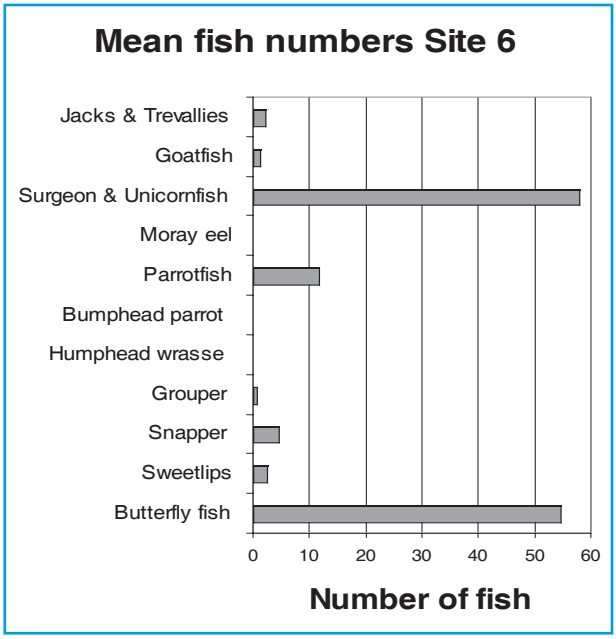




This reef is a very steep wall facing deep water, with a high amount of low-relief corals, including Acropora, that are able to survive the daily wave battering. Most of the rest of the reef is coralline algae (represented in the pie chart as "rock").

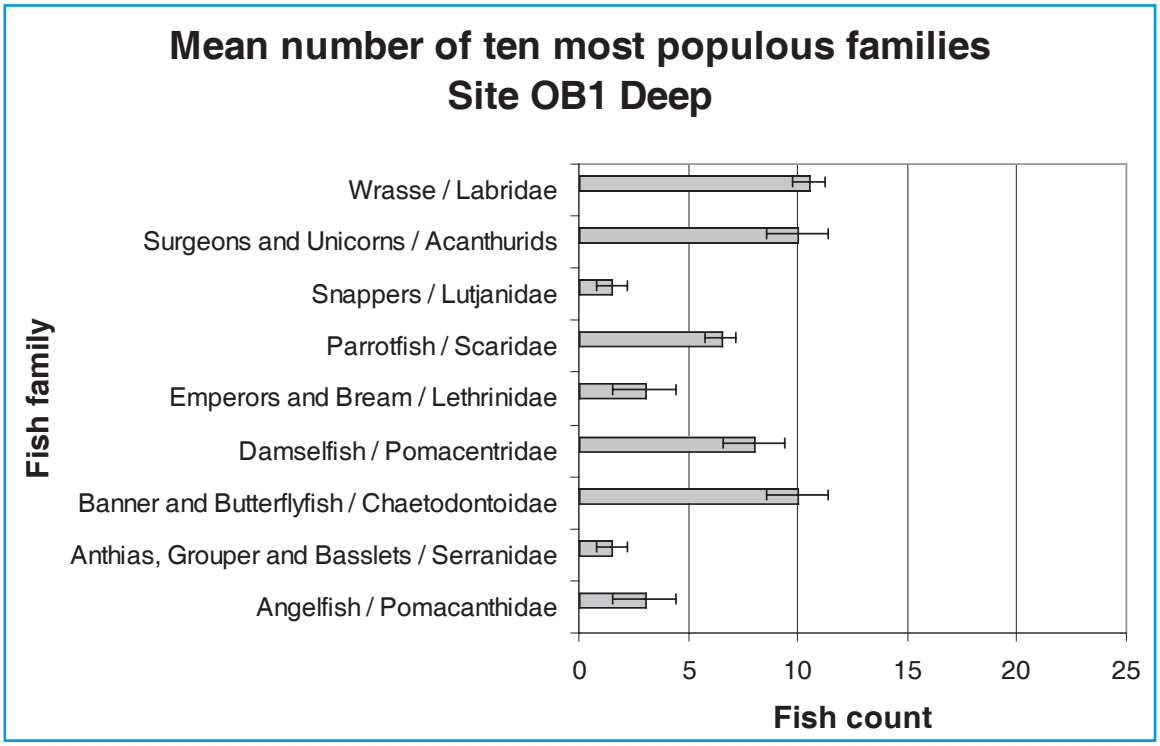
The only invertebrate indicator species was a single Tridacna giant clam.

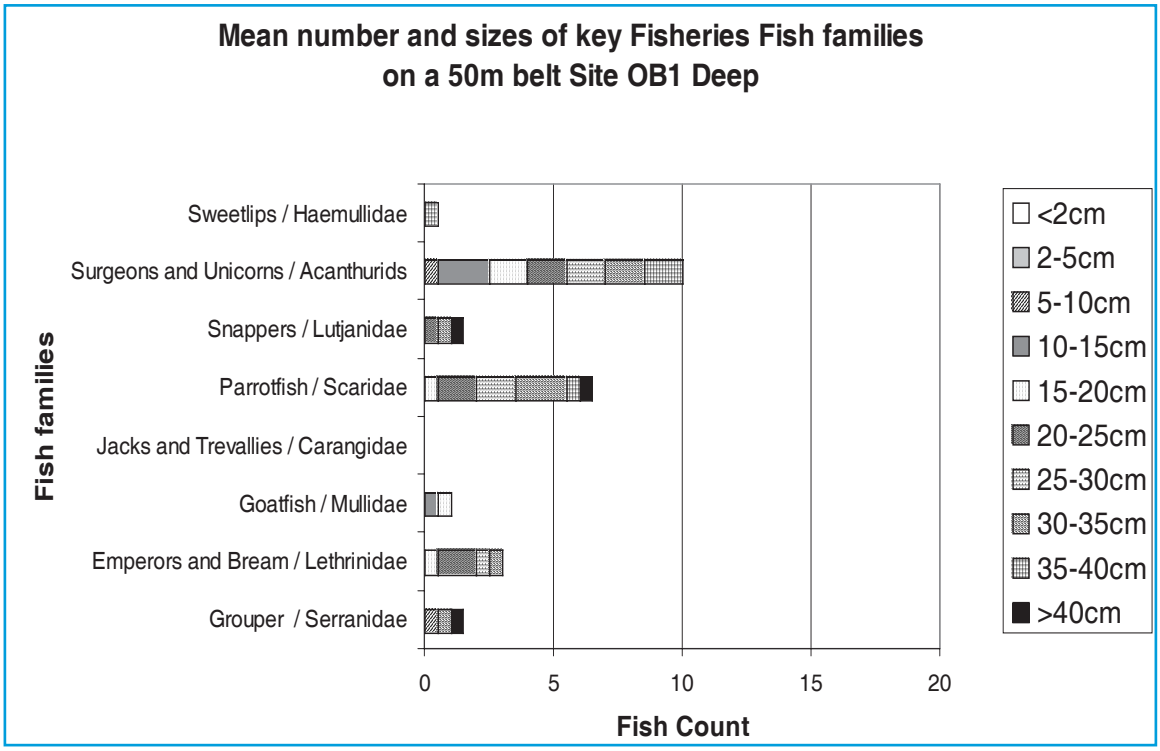
Surgeon and unicornfish were found here in high numbers, as were butterfly fish, mostly of the deep-water species Hemitaurichthys polylepis (Pyramid butterflies). Other fish were generally small species, apart from a school of barracuda seen off-transect.




## FISH ABUNDANCE AND SIZE CLASS



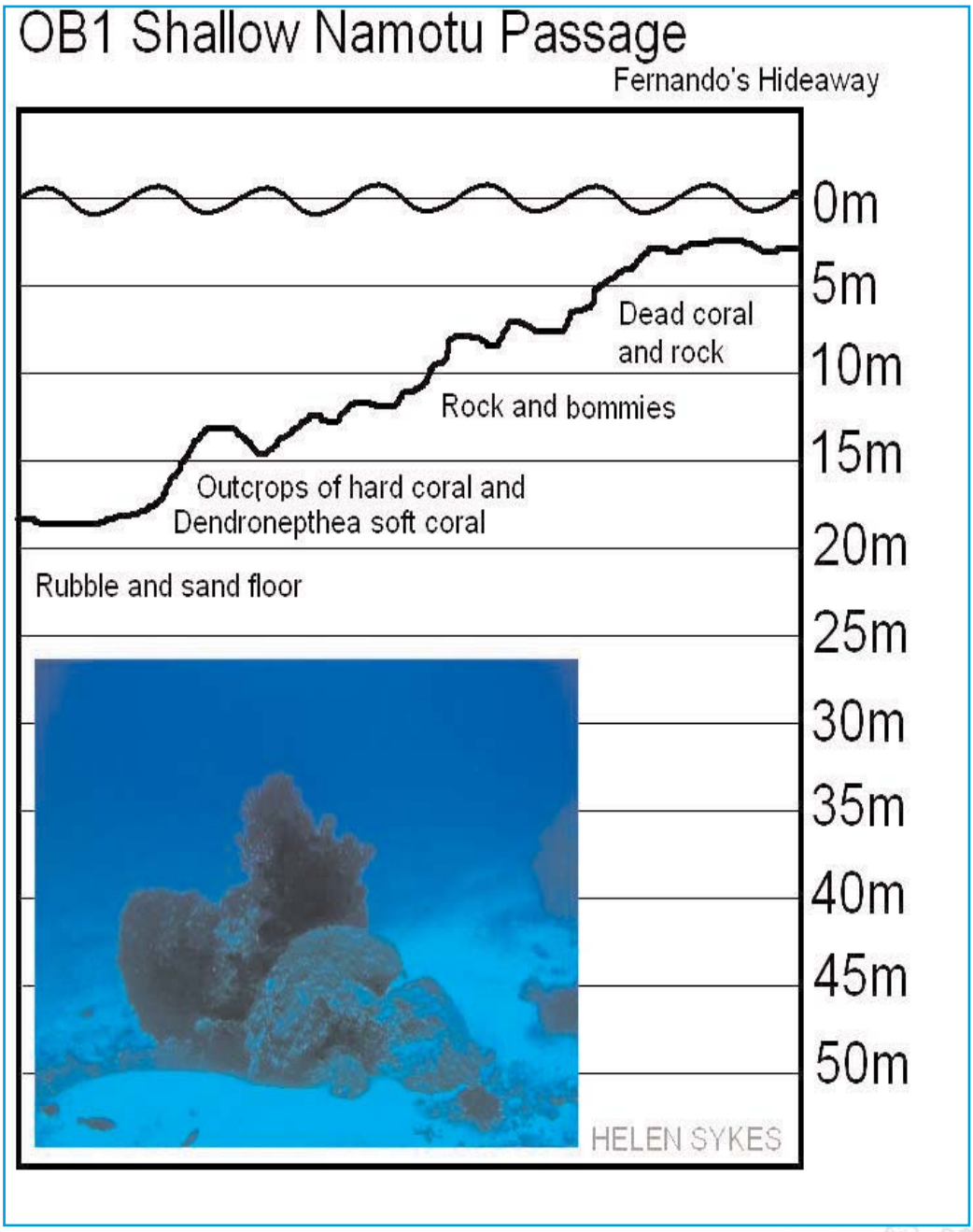



The large numbers of fish seen on this outer reef were dominated by small wrasse, surgeonfish & unicornfish, damselfish and butterflyfish. Surgeonfish and unicornfish were found in a variety of sizes with some reasonably large ones. Snappers and groupers were found in low numbers, but those seen were fairly large adults.

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 7 | 8.12.04 | 12.10 | 12.40 | OB1 | Shallow | Fernando's Hideaway | Passage in barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o18.007' | 179o02.050' | 6m | 25m | Moderate incoming | Rising | 27.5 |

## 7.6 CAKAULEVU REEF - NAMOTU PASSAGE & INNER REEF




This shallow passage through Namotu reef below and to the west of Kia Island, is not marked on the charts, but is known by Nukubati resort who use it for tourist diving and call it "Fernando's Hideaway". The passage has current-scoured rock

walls, a white sand floor and bays, and Dendronepthea soft corals on boulders towards the inner end. Algae surveys were made in the inner lagoon, directly beneath where the boat anchored. The site was relatively flat at 10-15 m depth and of soft sand substratum. Some large boulders, up to 5m tall, were scattered along the flat and most were heavily encrusted by various organisms, mostly sponges, hydroids and some algae. The seafloor was dominated by Caulerpa and Halimeda species, with some Halimeda specimens with fertile structures. Cyanophytes were also common. A moderate current flow was noted becoming fairly strong in the shallows (< 5 m depth). Visibility was moderate (around 10 m).

## ALPHA DIVERSITY

### FISH

Details are summarized under OB1 Timeless.

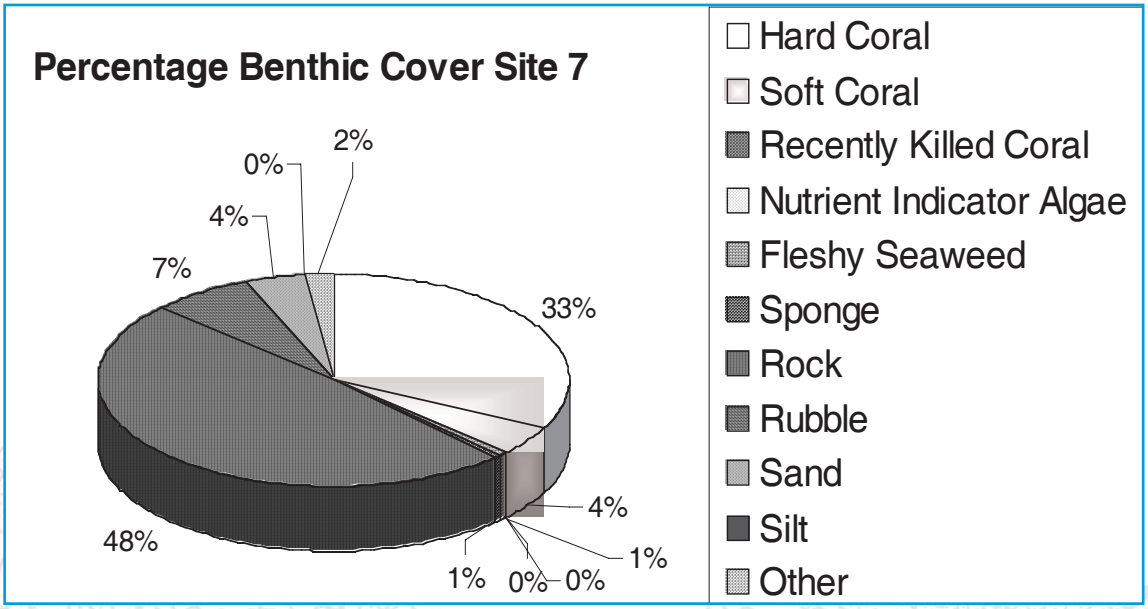
### CORALS

The reef descends to 18m depth on a flat sandy floor. It is characterised by reef areas rising as 2m patches off the sand as flat-topped steep sided reef patches. Tubastrea micrantha occur as large 1-1.5m dia. Colonies. These colonies extend from the perimeter of the mommies. Small colonies occur on what is a largely algae and sponge covered reef. Species present were Pachyseris speciosa, Lobophyllia pachysepta, Astreopora listeri, Mycedium elephantotus, Cyphastrea decadia, Acropora humilis, Galaxea astreata, Favites abdita, Montipora tuberculosa, M. granulosa, Diploastrea heliopora, Porites lobata, Symphyllia sp., S. agaricia, Favites matthai, F. pentagona, Goniastrea edwardsi and Sandalolitha dentata.

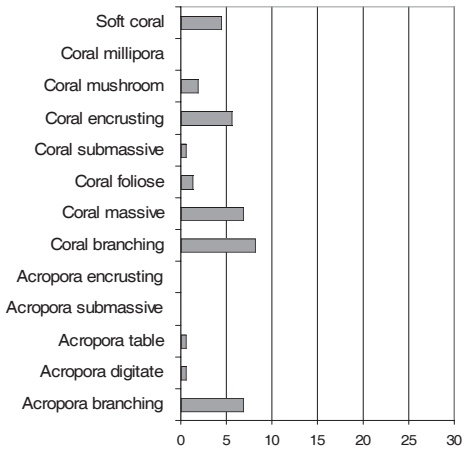
### MARINE FLORA

Thirty species of marine flora were recorded around the inner lagoon of Kia island (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS



**Mean percentage coral cover Site 7**



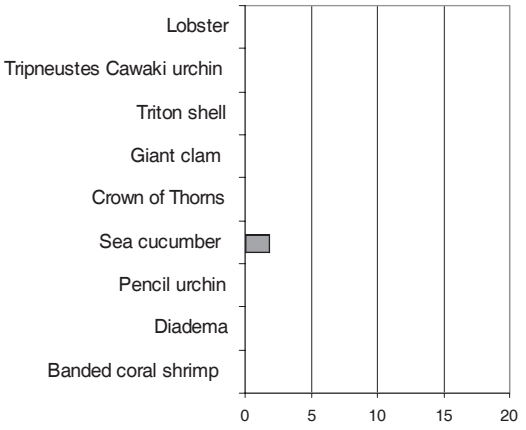

The passage is subject to tidal currents, and the walls are mostly dead coral boulders and rock where corals may find it hard to settle. In sheltered bays and on boulders, there are quite large colonies of branching Acropora and non-Acropora corals, as well as Dendronepthea soft corals.

The only invertebrates found were a few sea cucumbers.

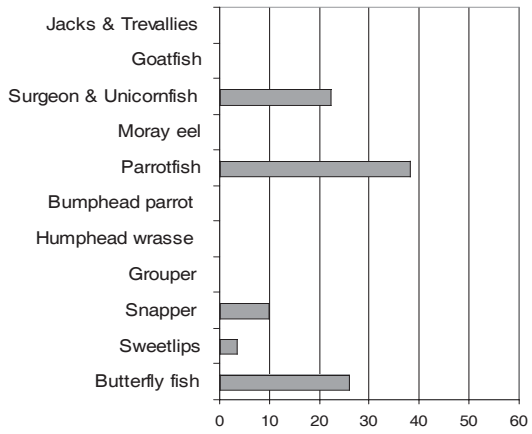
Parrotfish were found here in high numbers, as well as several surgeon and butterfly fish, and a few snappers and sweetlips.

Heteroconger hassi (spotted garden eels) were found off-transect.

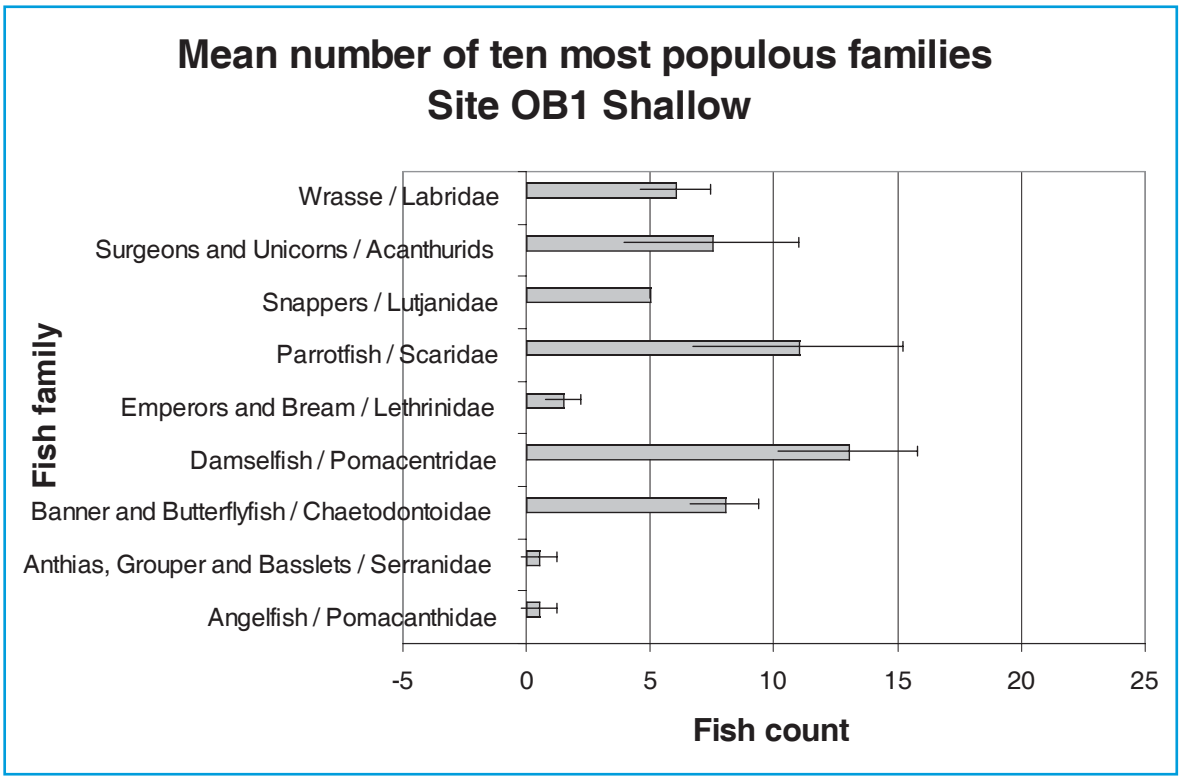
**Mean invertebrates Site 7**

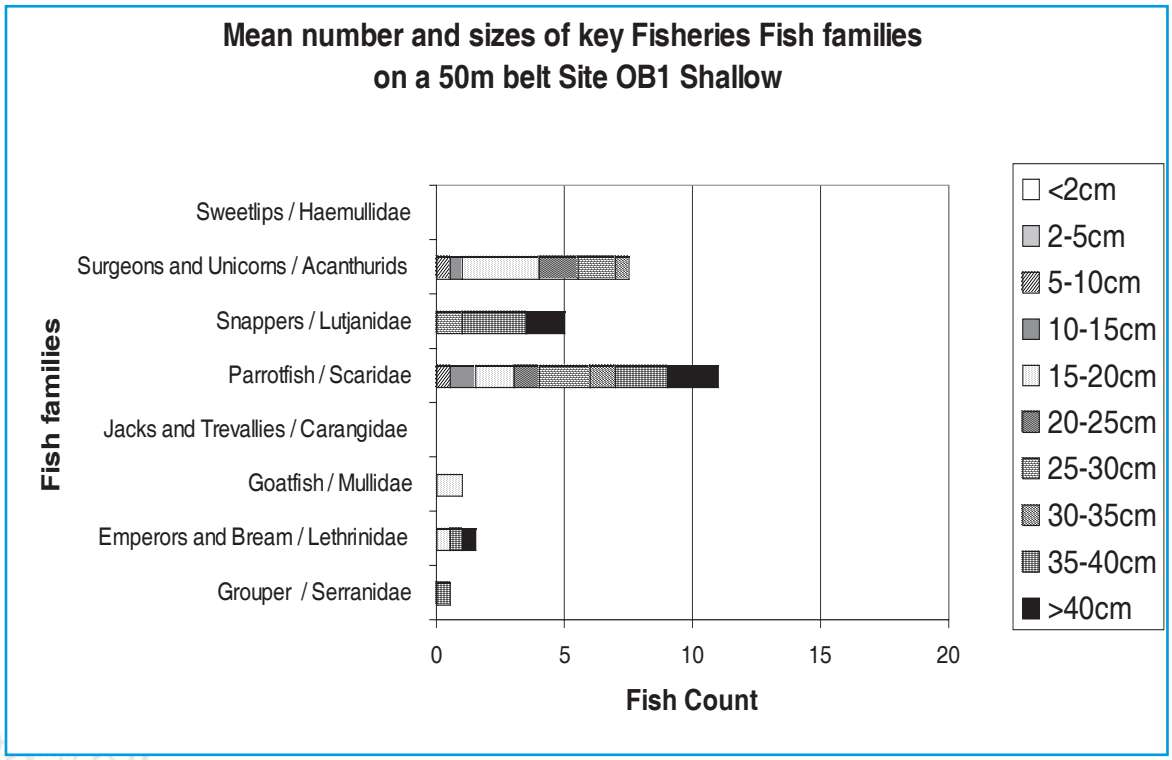



**Mean fish numbers Site 7**



## FISH ABUNDANCE AND SIZE CLASS




This channel has quite high fish numbers, dominated by damsel, parrot, surgeon and butterflyfish, with relatively high numbers of large snappers and a few large emperors. Parrotfish were found in a full range of sizes, including large terminal phase males.

# CAKAULEVU REEF - (END OF THE EARTH) OUTER BARRIER REEF

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 8 | 9.12.04 | 8.10 | 9.00 | OB3 | Deep | End of the World | Outer barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o10.574' | 179o03.116' | 12m | 30m | Moderate Outgoing plus slight surge | Falling | 27.5 |

## 7.7 CAKAULEVU REEF - (END OF THE EARTH) OUTER BARRIER REEF

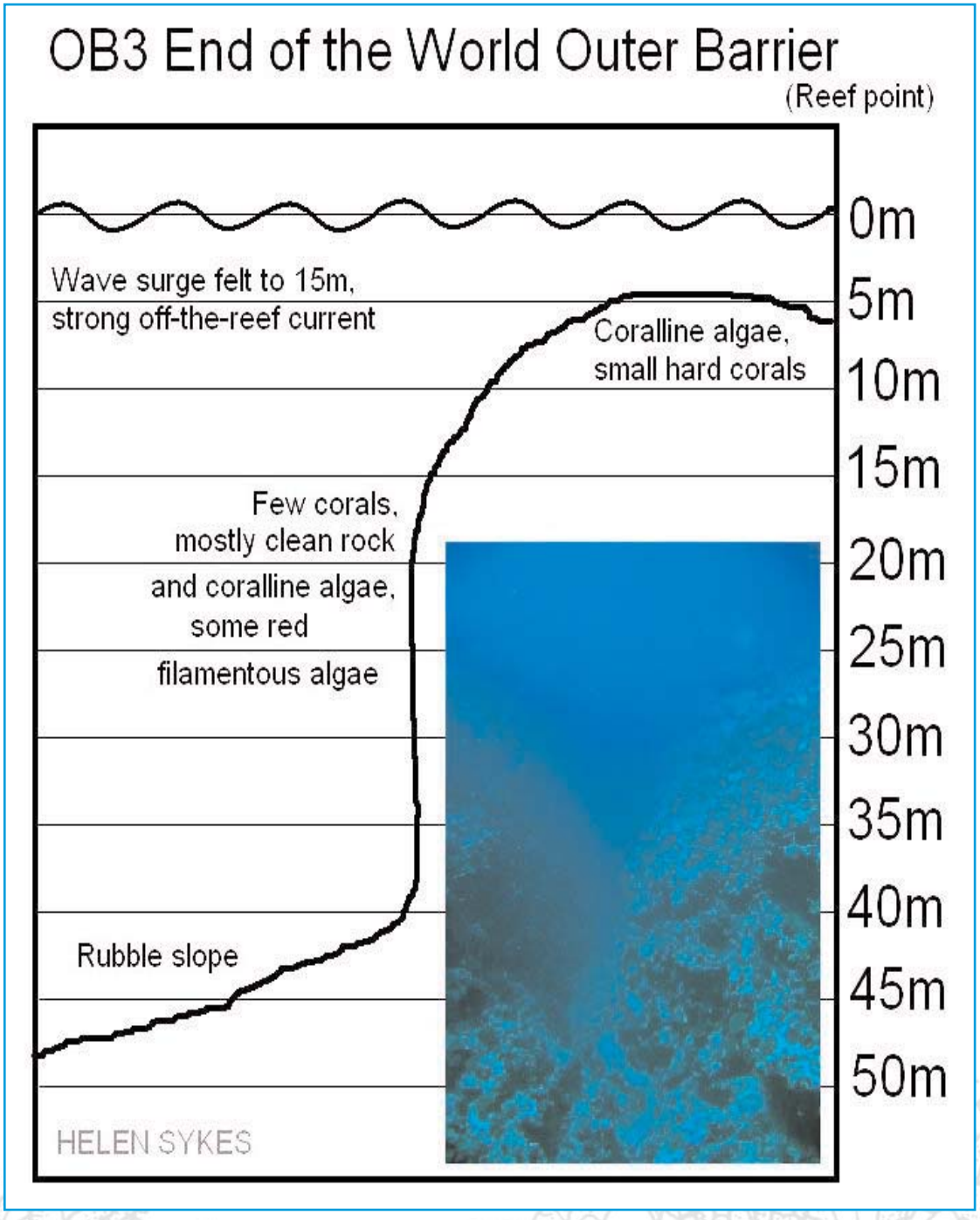


**Table 15.** Coral Reef Fish Diversity Index (numbers of species) for End of the Earth compared on national, regional and global scales.

| FAMILY | END OF THE EARTH | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 23 | 79 | 350 | 402** |
| Damselfish | 24 | 63 | 274 | 330 |
| Butterflyfish | 14 | 35 | 105 | 122 |
| Angelfish | 5 | 14 | 69 | 82 |
| Parrotfish | 6 | 23 | 64 | 83 |
| Surgeonfish | 10 | 27 | 63 | 71 |
| Total (CFDI) | 82 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

This is a point on the extreme northern edge of the barrier reef that protrudes around Kia island. It is a corner in a wave-scoured wall, facing deep open water, and has a strong off-the-reef current. The wall is covered in much coralline algae and small low-relief hard corals. The deeper wall was found to have a high covering of red filamentous algae. This site is used as a tourist dive site by Nukubati Resort, who know it as "End of the World". This site was of a steep wall dropping to over 50 m depth. Survey depth was 3-30 m depth. Coral communities were common, protruding from the contours of the carbonate structure. Coralline algae and other encrusting algae (Peyssonnelia spp.) were common as well as Halimeda species. The honeycomb forming coralline alga (Hydrolithon onkodes) was common at 3-10 m depth, becoming encrusting in the deeper depths. Fish diversity was particularly notable here with schools of Scaridae, Acanthuridae (especially Acanthurus nigricans) and Lutjanidae (dominated by Lutjanus kasmira) very common at < 5 m depth.

## ALPHA DIVERSITY

### FISH

The diversity of fish around End of the Earth is moderate with a total recorded fauna of 142 species (see complete species list in Appendix C). CFDI families represented 58% of the visible community of fish. End of the Earth possesses 40% of the known Butterflyfish and 37% of the known Surgeonfish of the entire Fiji islands (Table 15). About 7.5% of the worlds known fish diversity within the CFDI families are found at this one site. This site also supports populations of two IUCN Redlisted species, the Leopard Coralgrouper (Plectropomous leopardus) and the White-tip reef shark (Triaenodon obesus.

### CORALS

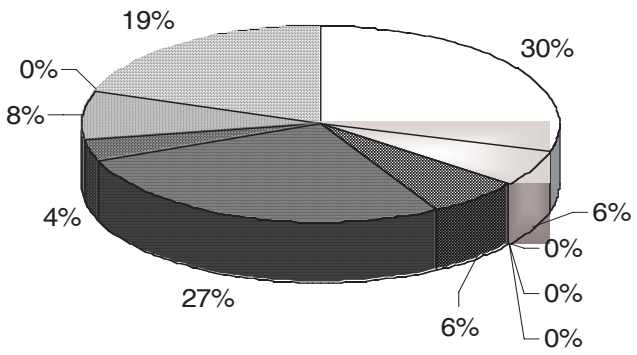
Deep reef slope extended to the base of the reef at 40m where rubble rock on sand had 1% coral cover. Acropora divaricata was common. Tabulate and corymbose colonies were scattered on rubble. The reef profile ascends at a 600 angle with a consolidated reef of irregular substrate. Coral colonies are maximized at the reef crest with a living coverage of 30%. There was an abundance of Pocillopora eydouxi and P. meandrina. Acropora corymbosa and caespitose were dominated. Acropora intermedia and A. florida are the dominant branching species. Coral disease observed on a colony of P. meandrina. Dead colonies of A. selago were seen, where death was evidently due to disease. Zonation conditioned by wave action in shallow areas. The reef is open to the oceanic swells from northerly directions. Encrusting corals become more abundant in the shallows. A. crateriformis appear seaward of the crest, where it is dominant.

### MARINE FLORA

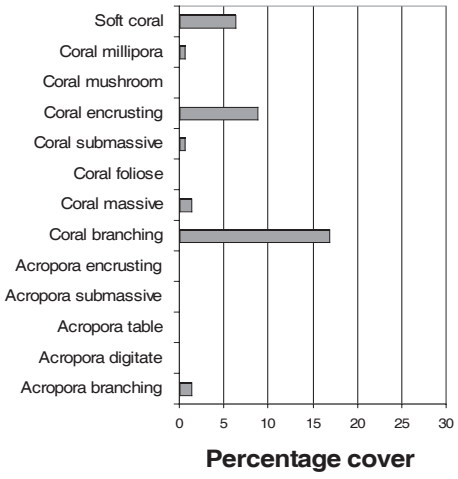
Nineteen species of marine flora were recorded around End of the Earth (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS

### Percentage Benthic Cover Site 8




### Mean percentage coral cover Site 8



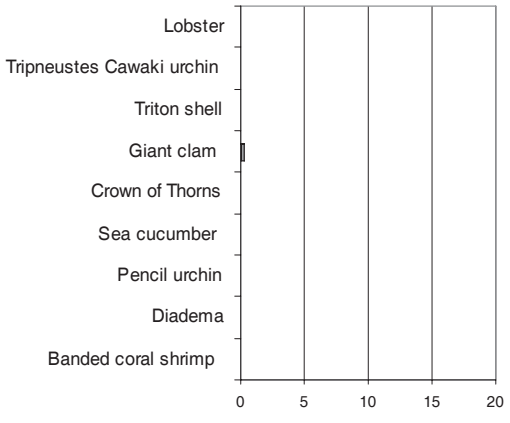

This reef is a corner on a very steep wall facing deep water, with a high amount of non-Acropora low-relief corals that are able to survive the daily wave battering. Most of the rest of the reef is coralline algae (represented in the pie chart as "rock").

The only invertebrate found was a single Tridacna giant clam.

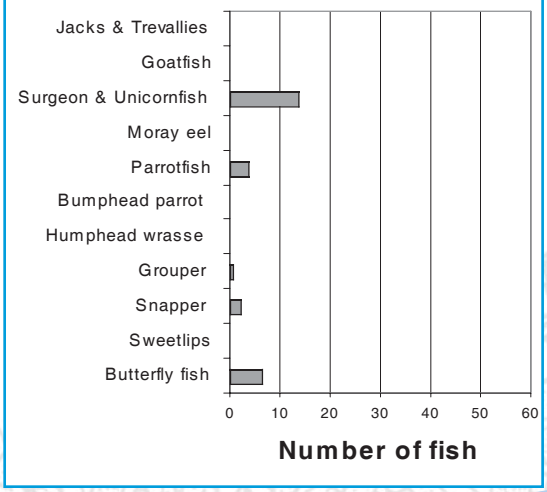
Fish numbers were moderate to low at this site, mostly surgeon and unicornfish and small wrasse and damselfish.

A large school of barracuda was found in the deep water.

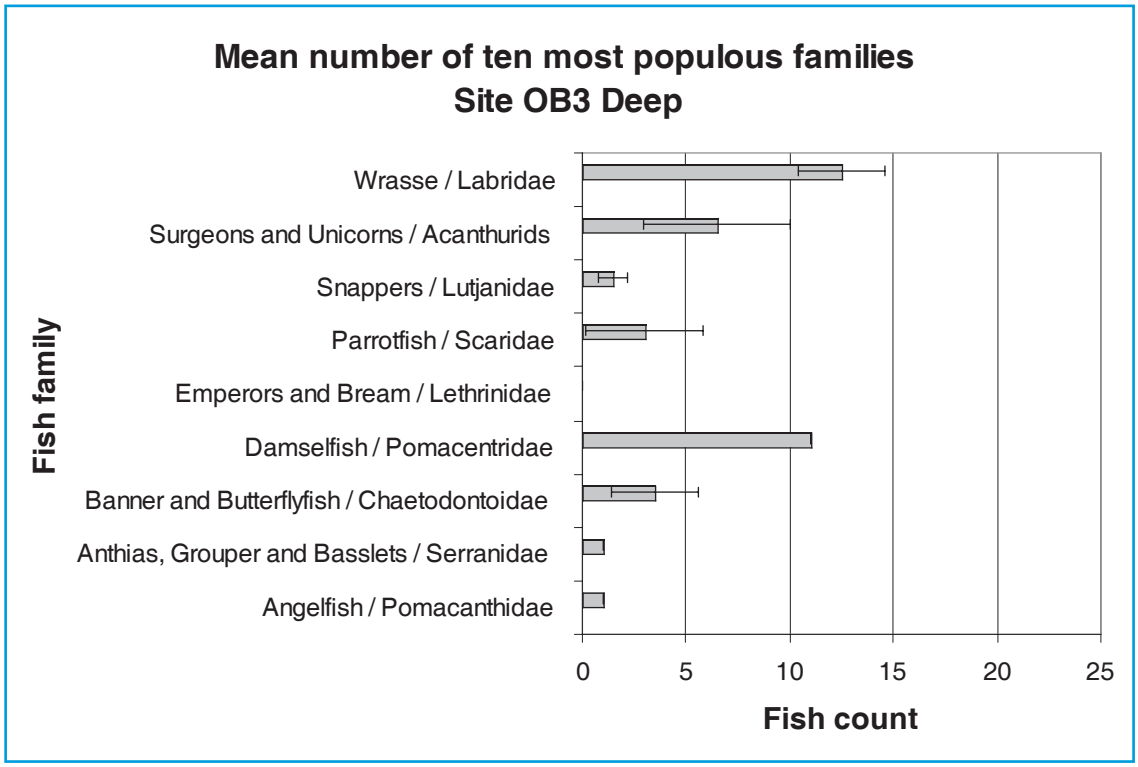
### Mean invertebrates Site 8

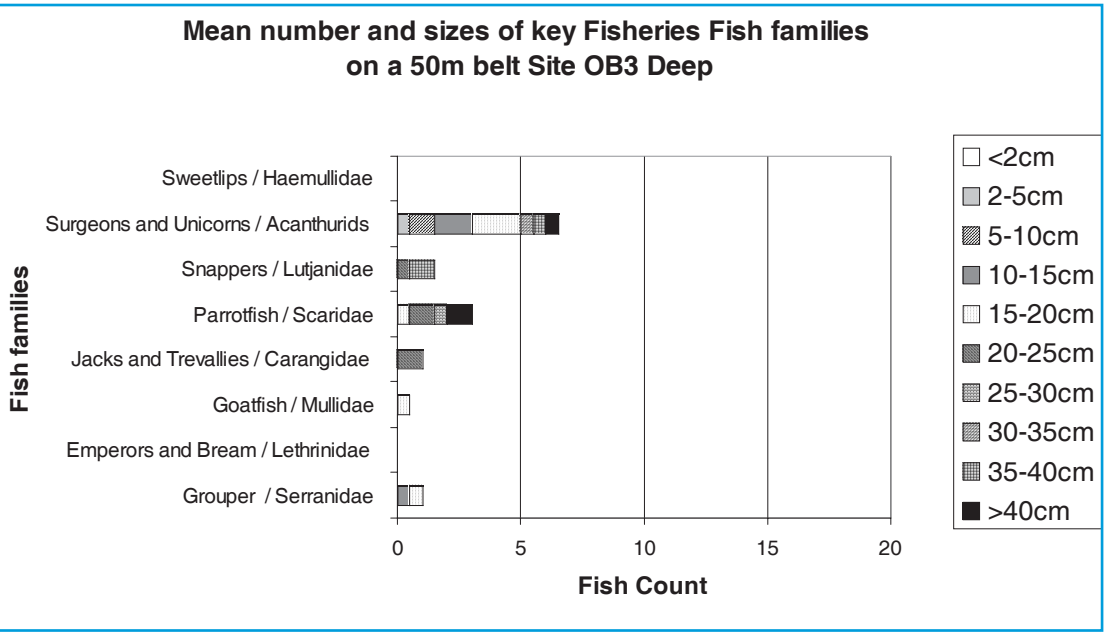



### Mean fish numbers Site 8



## FISH ABUNDANCE AND SIZE CLASS



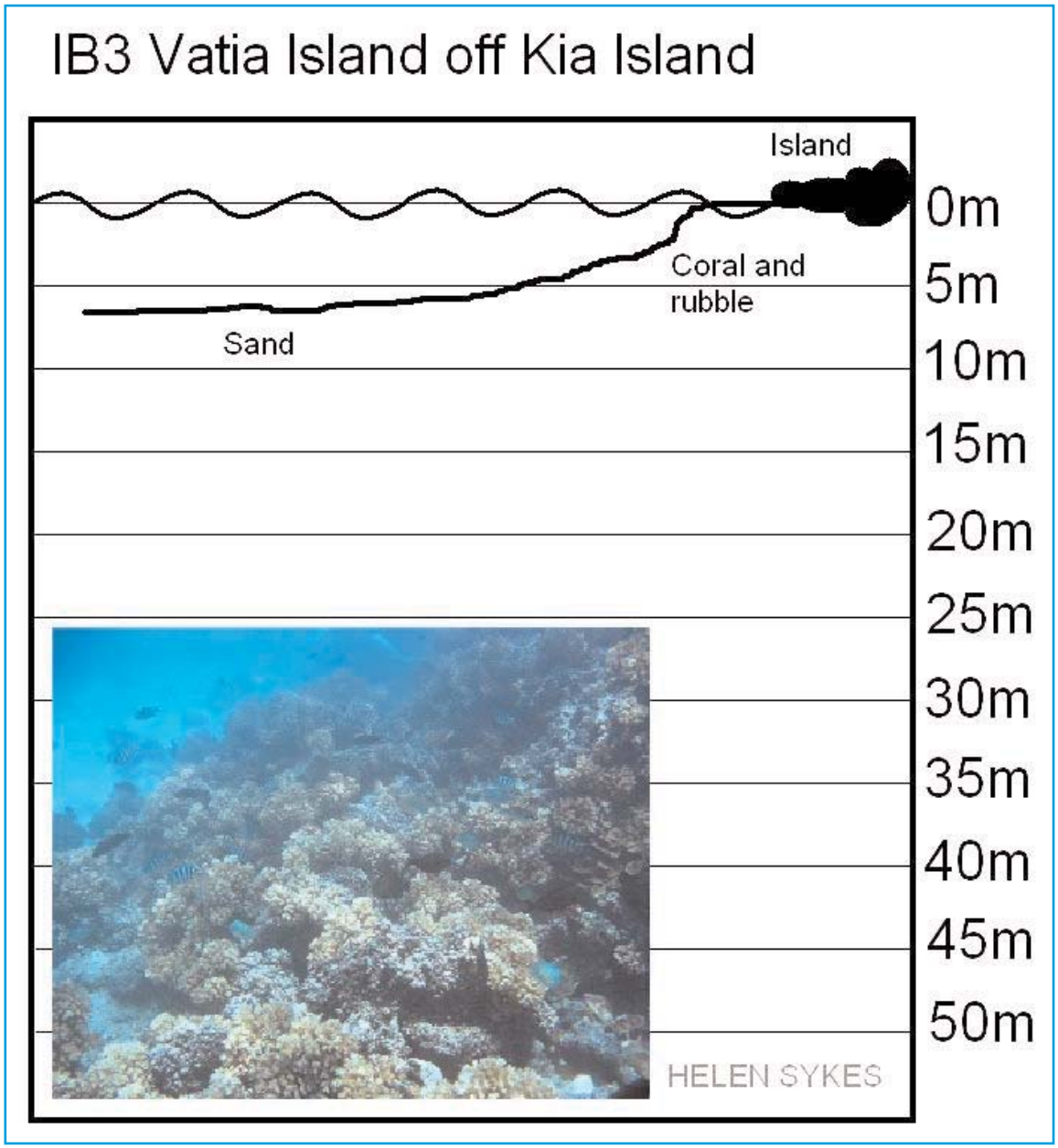

This outer wall had quite low fish numbers, those seen being mostly wrasse, damsel and surgeonfish. Butterfly and parrotfish were unusually low in number. Very few fish important to local fisheries were seen.

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 9 | 9.12.04 | 12.00 | 12.30 | IB3 | Shallow | Vatia islet off Kia | Inside barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o13.807' | 179o06.277' | 4m | 10m | None | Rising | 28 |



## 10.8 VATIA ISLET (OFF KIA ISLAND)




This very shallow reef on a sandy slope fringes a rocky islet inside the barrier reef, in the waters around Kia island. There are many Porities and Pocillopora corals where small fish shelter. Vatia islet had a high cover of dead corals, encrusted with turf algae. The current flow was moderately strong. At 5-10 m depth, the substratum was of fine soft muddy sand. A sandy bay on the eastern side of Kia Island was also surveyed and 2 large nurse-sharks were spotted. Large beds of Halodule uninervis and H. pinifolia were found, with depauperate communities of Halophila ovalis ssp. bullosa. This site had high algal cover of various species including Padina sp., and Rhodymenia cf. divaricata.

**Table 16.** Coral Reef Fish Diversity Index (numbers of species) for Vatia Islet compared on national, regional and global scales.

| FAMILY | VATIA ISLET | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 28 | 79 | 350 | 402** |
| Damselfish | 29 | 63 | 274 | 330 |
| Butterflyfish | 8 | 35 | 105 | 122 |
| Angelfish | 4 | 14 | 69 | 82 |
| Parrotfish | 4 | 23 | 64 | 83 |
| Surgeonfish | 4 | 27 | 63 | 71 |
| Total (CFDI) | 77 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

## ALPHA DIVERSITY

### FISH

The diversity of fish around Vatia islet is moderate with a total recorded fauna of 148 species (see complete species list in Appendix C). CFDI families represented 52% of the visible community of fish. Vatia islet reefs possesses 46% of the known Damselfish and 35% of the known wrasses of the Fiji islands (Table 16). About 7% of the worlds known fish diversity within the CFDI families are found at this site. This site also supports populations of two IUCN Red Listed species, the Tawny Nurse shark (Nebrius ferrugineus) and the Bluespotted ribbontail ray (Taeniura lymma).

### CORALS

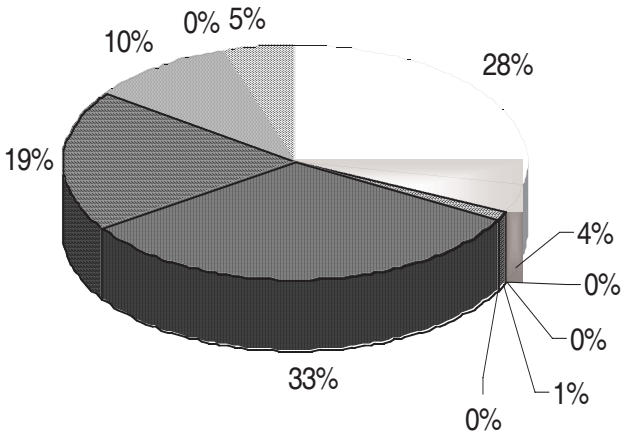
The shallow fringing reef extended around islet 100m from shore. Patchy coral cover occurred as 20-60% around the edge of the reef flat. Large colonies of Pocillopora verrucosa, P. damicornis occur with a mixed assemblage of other species. Abundant Goniastrea edwardsi exist with large colonies of Echinopora lamellosa and E. gemmacea both foliose and branched. Many Fungia spp., including large Sandalolitha robusta and Ctenactis simplex. Psammocora contigua, were common. Large Merulina ampliata colonies and of Sarcophyton colonies were evident. Species observed were Platygyra pini, Acropora millepora, A. tortuosa, A. hyacinthus, A. nasuta, and A. humilis. Massive colonies of Lobophyllia spp., Symphyllia spp., Porites rus, P. lobata and P. cylindrica occurred on the perimeter of the reef area.

### MARINE FLORA

Thirty one species of marine flora were recorded around Vatia islet (full species list in Appendix C).

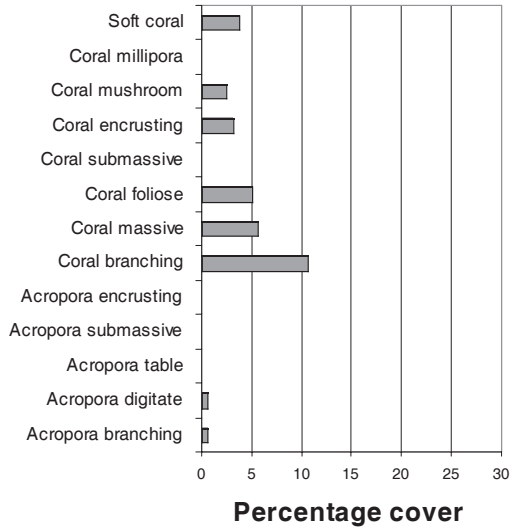
## SITE CHARACTER AND POPULATIONS

### Percentage Benthic Cover Site 9




- Hard Coral
- Soft Coral
- Recently Killed Coral
- Nutrient Indicator Algae
- Fleshy Seaweed
- Sponge
- Rock
- Rubble
- Sand
- Silt
- Other

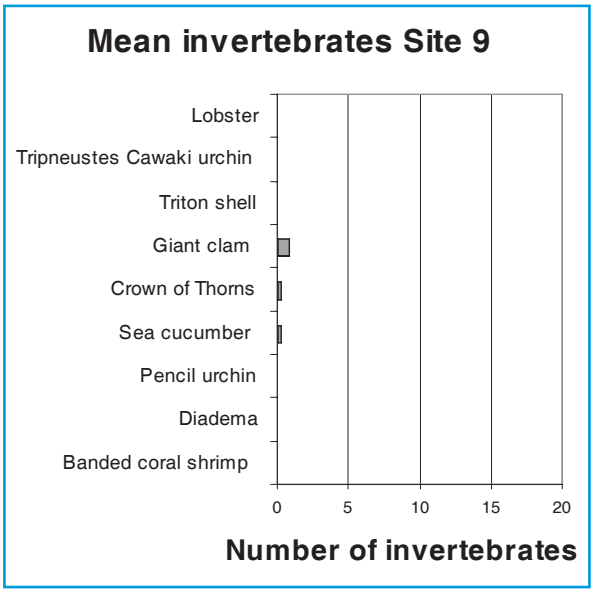
### Mean percentage coral cover Site 9

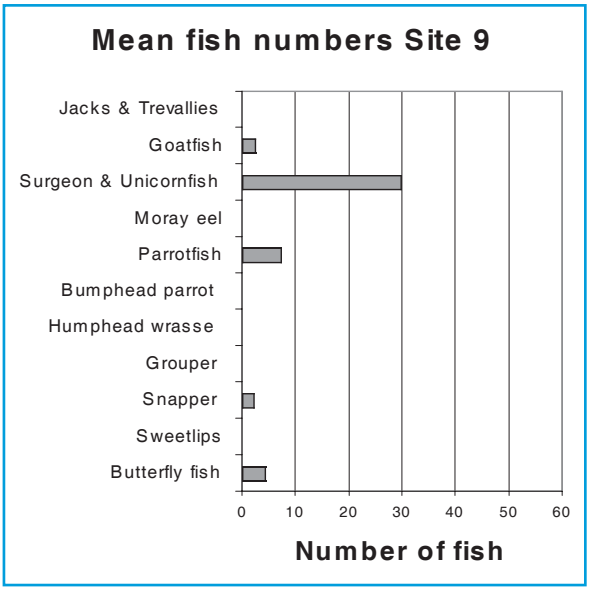



The reef is a mixture of volcanic rock and dead coral boulders, with sand patches, and large outcrops of Pocillopora damicornis corals and Porites boulders.

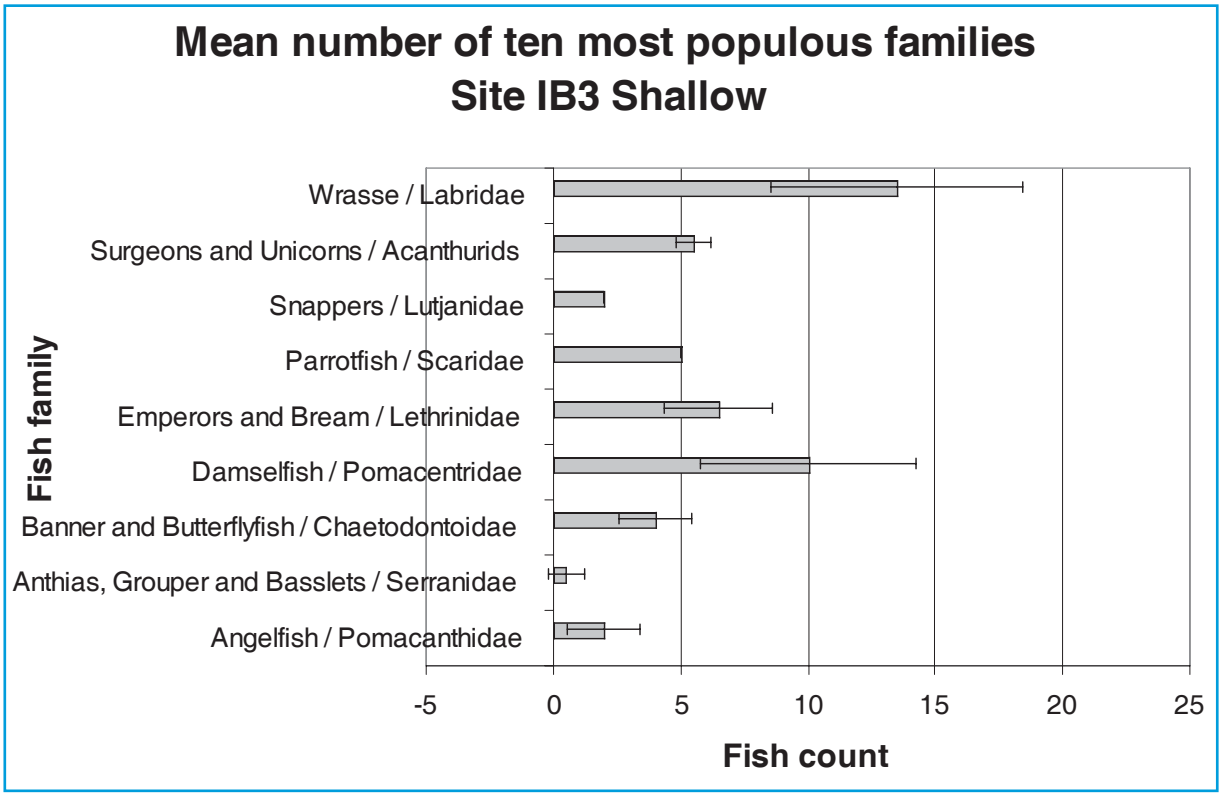
Very few sea cucumbers, Tridachna giant clams and Acanthaster Crown of Thorns Seastars were found.

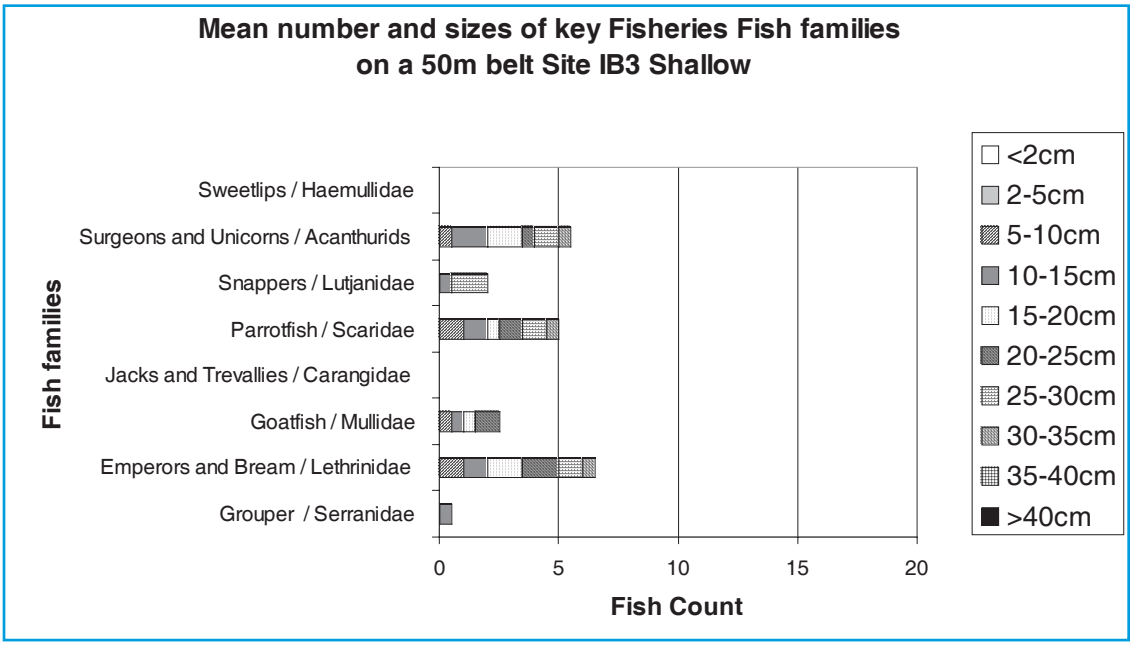
Schools of small surgeonfish and Monotaxis grandoculus (bigeye emperor) were found in the Pocillopora stands, as well as juvenile parrotfish.




## FISH ABUNDANCE AND SIZE CLASS






Fish numbers seen here were around the average for the region, mostly damselfish and wrasse, but with a large number of mid-size emperors (mostly schools of Big-eye Emperors, Monotaxis grandoculis) for which this may be an important juvenile habitat.

# NADOGO ISLAND (SASA) - MANGROVE ISLAND

Survey details

| Dive/ Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 10 | 9.12.04 | 15.55 | 16.25 | IP3 | Deep | Nadogo island | Mangrove Island |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o23.428' | 179o10.080' | 10m | 4m | None | Dead High | 28 |

## 7.9 NADOGO ISLAND (SASA) - MANGROVE ISLAND

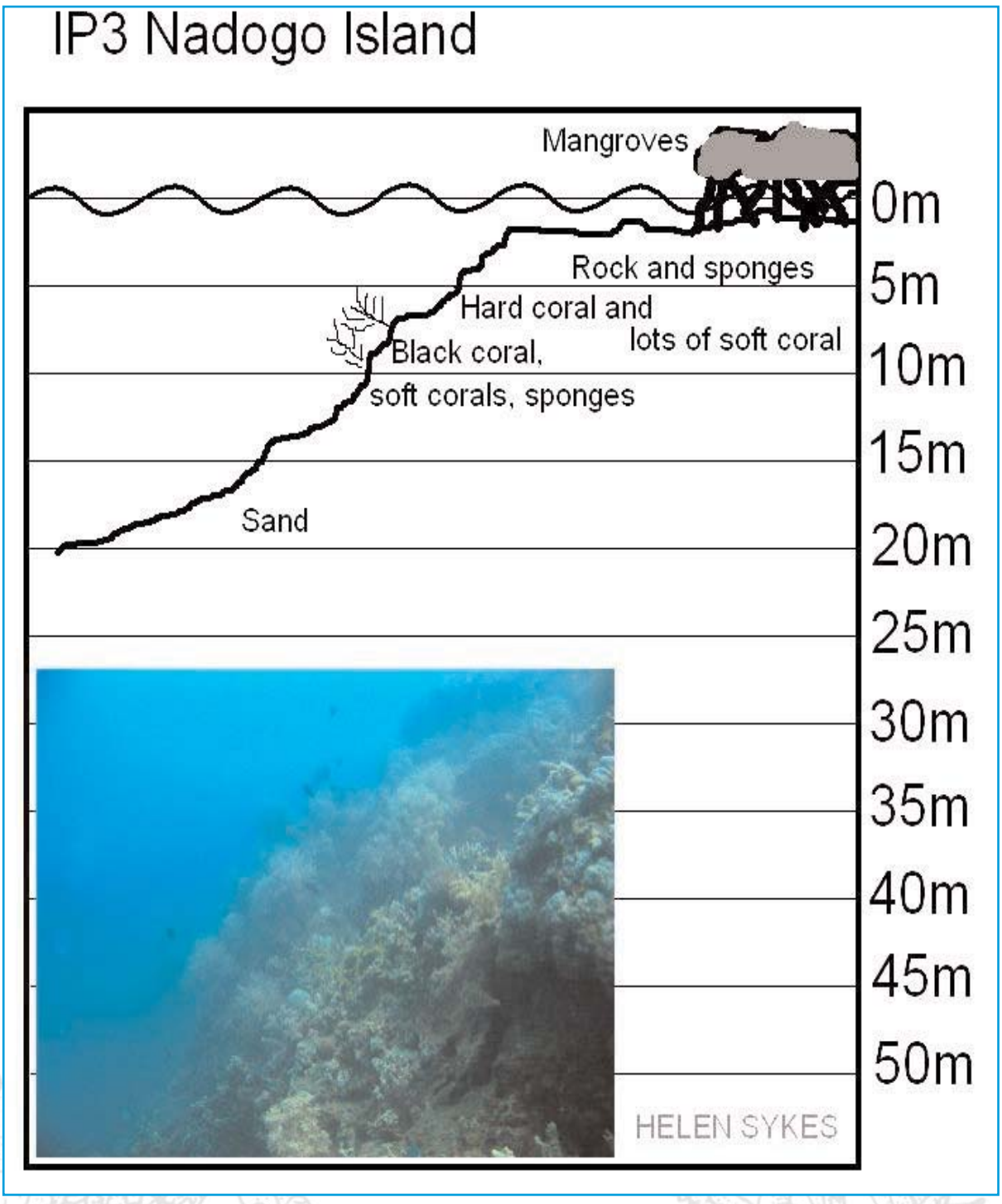


**Table 17.**
Coral Reef Fish Diversity Index (numbers of species) for Nadogo Island compared on national, regional and global scales.

| FAMILY | NADOGO ISLAND | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 14 | 79 | 350 | 402** |
| Damselfish | 15 | 63 | 274 | 330 |
| Butterflyfish | 14 | 35 | 105 | 122 |
| Angelfish | 2 | 14 | 69 | 82 |
| Parrotfish | 4 | 23 | 64 | 83 |
| Surgeonfish | 5 | 27 | 63 | 71 |
| Total (CFDI) | 54 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

This flat mangrove island is locally known as Nadogo, but on the map as Cukini Island west of Labasa. It has a silty sloping reef fringing the mangrove edge with an abundance of black coral, Dendronepthea soft corals and sponges. Visibility is low. An algae snorkel survey of the Nadogo-Sasa mangroves was also made. Rhizophora stylosa is the dominant species. A short reef flat from the mangroves ca. 20 m long gently sloping at around 3m depth. Coral communities abundant near the edge of the reef flat. The substratum on the reef flat was consolidated calcium carbonate with coarse sand. Silt in the water column reduces the visibility. A moderate current flowed towards the inner part of the mangroves at the time of the survey. Algae were common on the reef flat, mainly Padina, Sargassum, Turbinaria ornata, Bornetella nitida and cyanophytes.

## ALPHA DIVERSITY

### FISH

The diversity of fish around Nadogo island is low with a total recorded fauna of 119 species (see complete species list in Appendix C). CFDI families represented 45% of the visible community of fish. Nadogo island reefs possesses 40% of the know Butterflyfish of the Fiji islands (Table 17). About 5% of the worlds known fish diversity within the CFDI families are found at this site.

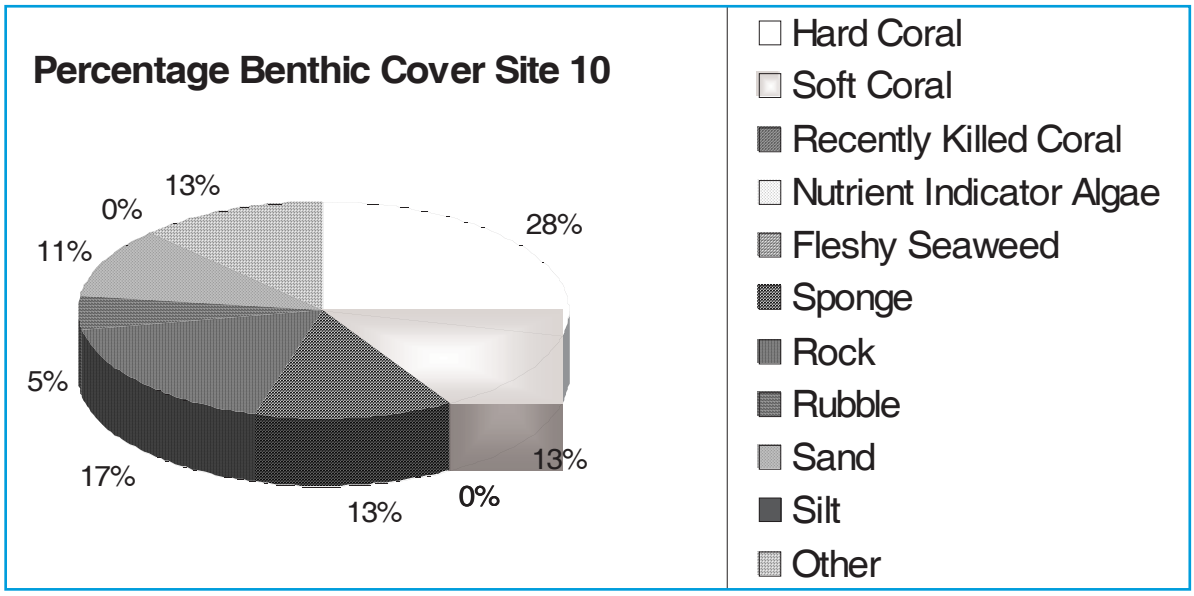
### CORALS

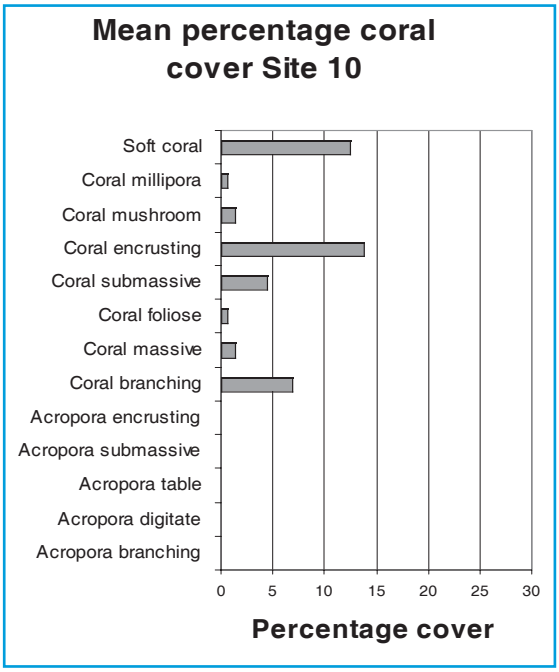
The reef drops off steeply to a depth of 18m where a mud bottom with minimal coral cover occurs. Goniopora lobata and Antipathes spp. are common near the base at >15m. At >8m there is approx. 10% coral cover. Sinularia spp. is dominate at <8m. A large colony of Pavona clavus occur with common species Goniastrea retiformis, Diploastrea heliopora, Pachyseris speciosa Elongate yellow sponges were abundant. The reef flat is largely characterised by Porites lobata, sub tidally Pavona clavus, Canthrellus jebbi, Porites rus, P. cylindrica and P. annae evident. Few Acropora were present though small colonies are evident. A. millepora was dominant.

### MARINE FLORA

Thirty four species of marine flora were recorded around Nadogo island (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS



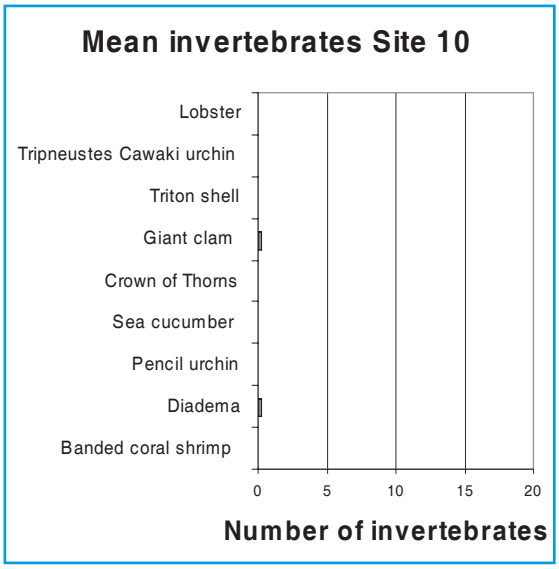



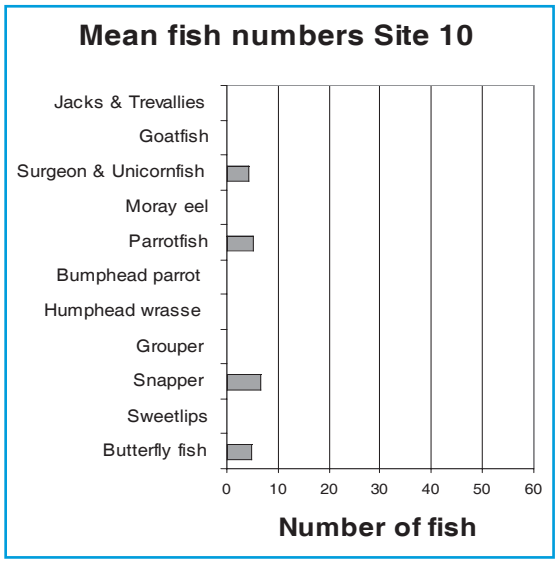

This is a sloping reef in very silty waters, consisting mostly of dead coral boulders and sand with a fine layer of silt. Porites and montipora corals dominate the live hard coral component, in encrusting and branching forms. There are high numbers of Antipatharians (Black Corals) and Dendronepthea soft corals in the shallow waters.

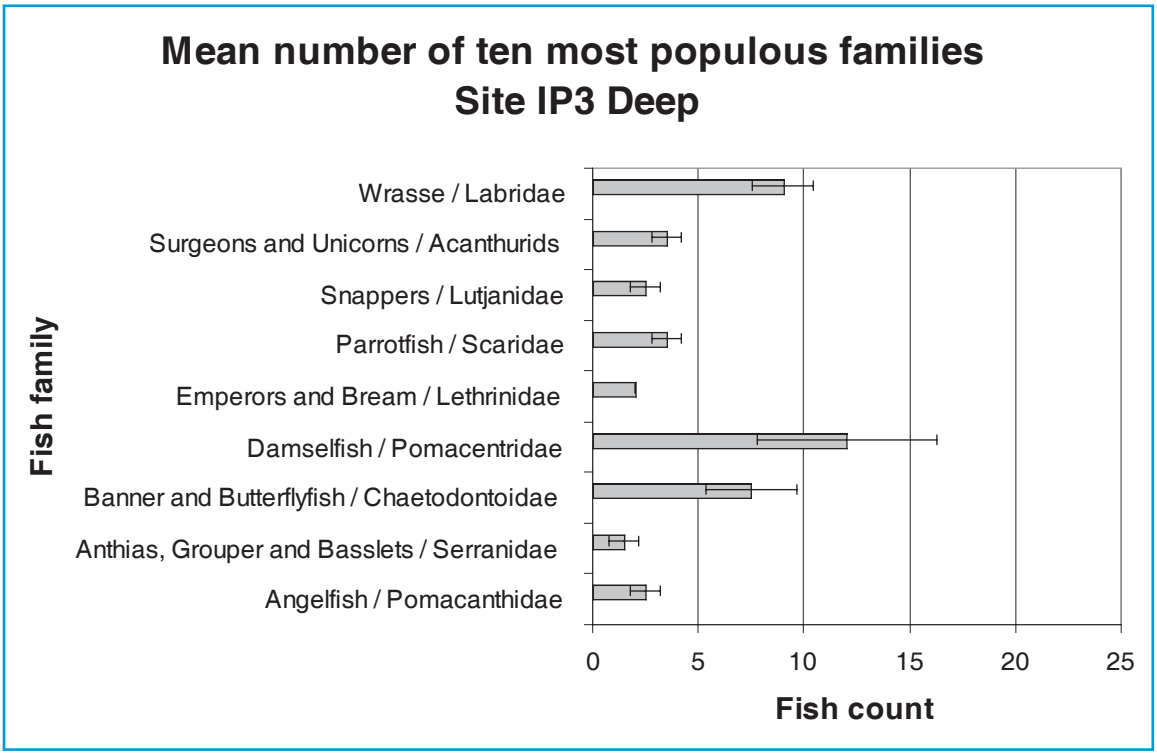
Very few invertebrates were found, specifically a Diadema urchin, and a Tridacna giant clam.

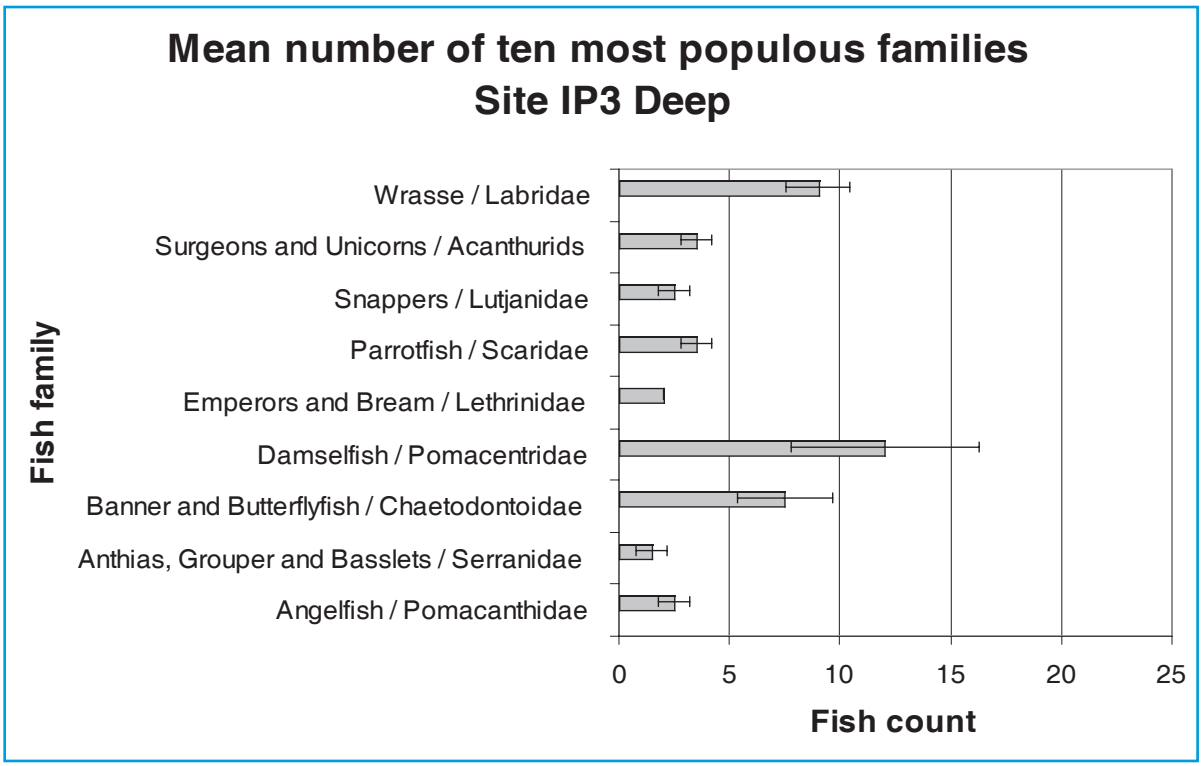
There were not many fish at this site, those present being a few small snapper, surgeon, parrot, and butterfly fish.

## FISH ABUNDANCE AND SIZE CLASS


Mean invertebrates Site 10
Lobster
Tripneustes Cawaki urchin
Triton shell
Giant clam
Crown of Thorns
Sea cucumber
Pencil urchin
Diadema
Banded coral shrimp
0
5
10
15
20
Number of invertebrates


Mean fish numbers Site 10
Jacks & Trevallies
Goatfish
Surgeon & Unicornfish
Moray eel
Parrotfish
Bumphead parrot
Humphead wrasse
Grouper
Snapper
Sweetlips
Butterfly fish
0
10
20
30
40
50
60
Number of fish


Mean number of ten most populous families
Site IP3 Deep
Fish family
Wrasse / Labridae
Surgeons and Unicorns / Acanthurids
Snappers / Lutjanidae
Parrotfish / Scaridae
Emperors and Bream / Lethrinidae
Damselfish / Pomacentridae
Banner and Butterflyfish / Chaetodontoidae
Anthias, Grouper and Basslets / Serranidae
Angelfish / Pomacanthidae
0
5
10
15
20
25
Fish count




This reef had low fish numbers, dominated largely by small wrasse, damselfish and Butterflyfish. There were small numbers of small snapper, emperor and groupers.

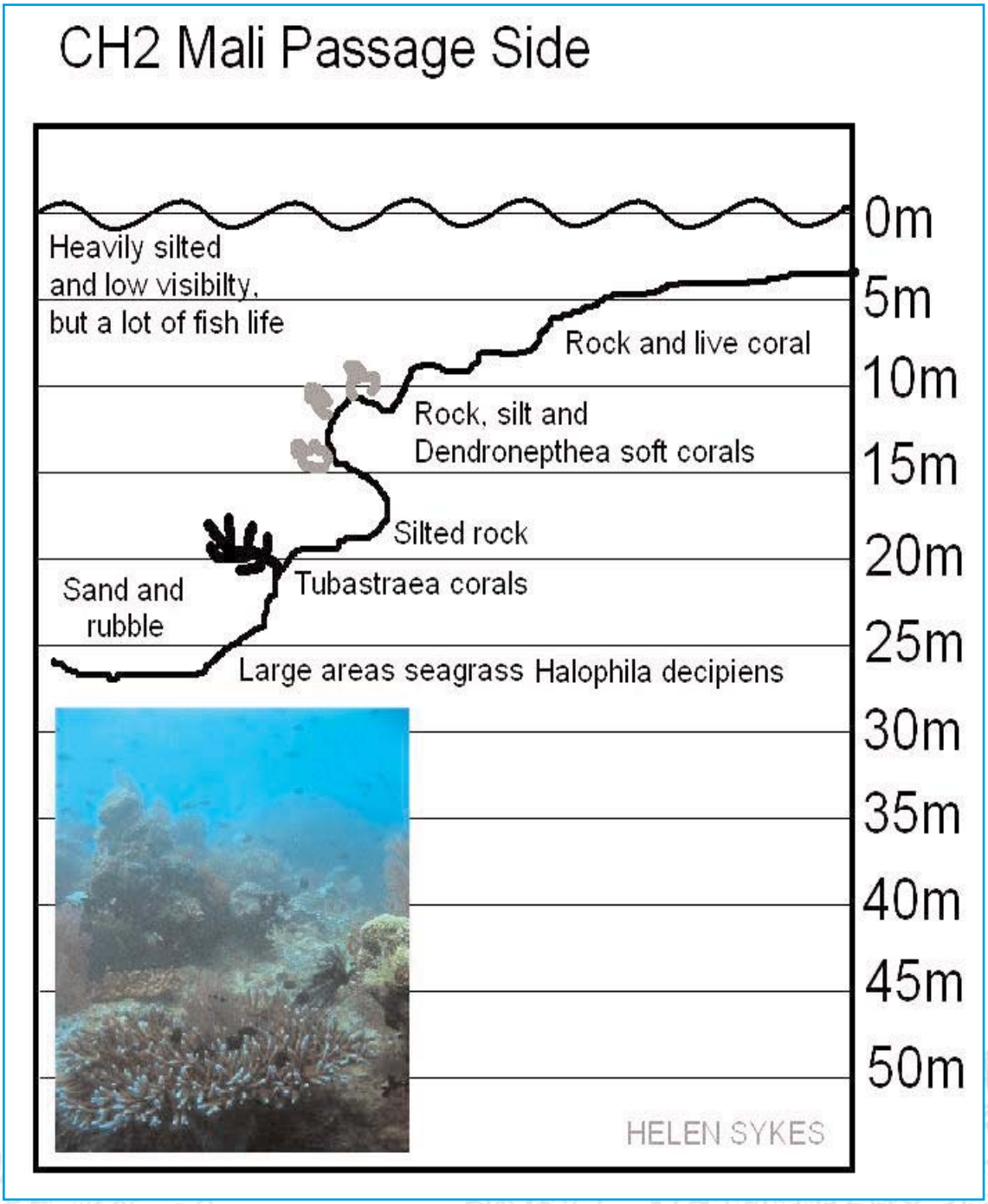
## MALI PASSAGE

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 11 | 10.12.04 | 10.20 | 10.50 | CH2 | Deep | Mali Passage | Passage in barrier |
| 12 | 10.12.04 | 13.20 | 13.50 | CH2 | Shallow | Mali Passage | Passage in barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o18.924' | 179o16.723' | 11m | 4m | Mild incoming, slight surge | Low to Rising | 27.5 |
| 16o19.253' | 179o16.893' | 6m | 10m | Moderate incoming | Rising 3 Hours after Low tide | 28 |

### 7.10 MALI PASSAGE



| FAMILY | MALI PASSAGE | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 33 | 79 | 350 | 402** |
| Damselfish | 26 | 63 | 274 | 330 |
| Butterflyfish | 21 | 35 | 105 | 122 |
| Angelfish | 9 | 14 | 69 | 82 |
| Parrotfish | 5 | 23 | 64 | 83 |
| Surgeonfish | 8 | 27 | 63 | 71 |
| Total (CFDI) | 102 | 241 | 925 | 1090 |

**Table 18.** Coral Reef Fish Diversity Index (numbers of species) for Mali Passage compared on national, regional and global scales.

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

Mali passage is a break in the barrier reef opposite Lautoka town, to the east of the reef outcrop around Kia Island. It is much closer to the mainland than the channels to the west of Kia. The main channel (survey 11) is a silty and rocky edge with lots of fish life and low visibility. There were some very active white-tip reef sharks around, and the local people say that this is a dumping ground commercial fishing boat waste. The inside of the barrier reef (survey 12) is a shallow rubble slope. Notable algae species include Hydrolithon reinboldii, Peyssonnelia inamoena, Portieria hornemannii, Udotea glaucescens and Chlorodesmis fastigiata. A small patch of Halophila decipiens was also found. See Table 14 for more species found at this site. The second algae survey was undertaken towards the outer mouth. The reef slope was more pronounced (45-90o angle). Large boulders and consolidated carbonate structure provided habitats for many organisms, of which a yellow soft-coral (Scleronephthya sp.) dominates. Up to eight 5-m long white-tip sharks were observed displaying a fairly aggressive behaviour, often coming close to where the survey was undertaken. Depauperate communities of Halophila decipiens were found scattered between large boulders.

## ALPHA DIVERSITY

### FISH

The diversity of fish in Mali Passage is moderate with a total recorded fauna of 179 species (see complete species list in Appendix C) however it contains a high number of IUCN Redlisted species. CFDI families represented 57% of the visible community of fish. Mali passage reefs alone possesses 64% of the known Angelfish and 60% of the known Butterflyfish of the Fiji islands (Table 17). About 9% of the worlds known fish diversity within the CFDI families are found at this site. This site also supports populations of six IUCN Redlisted species; Humphead Wrasse (Chelienus undulatus), Giant grouper (Epinephalus lanceolatus), Estuary Grouper (Epinephalus coioides), Leopard Coralgrouper (Plectropomous leopardus), Grey reef shark (Carcharhinus amblyrhyncos) and White-tip reef shark (Triaenodon obesus).

### CORALS

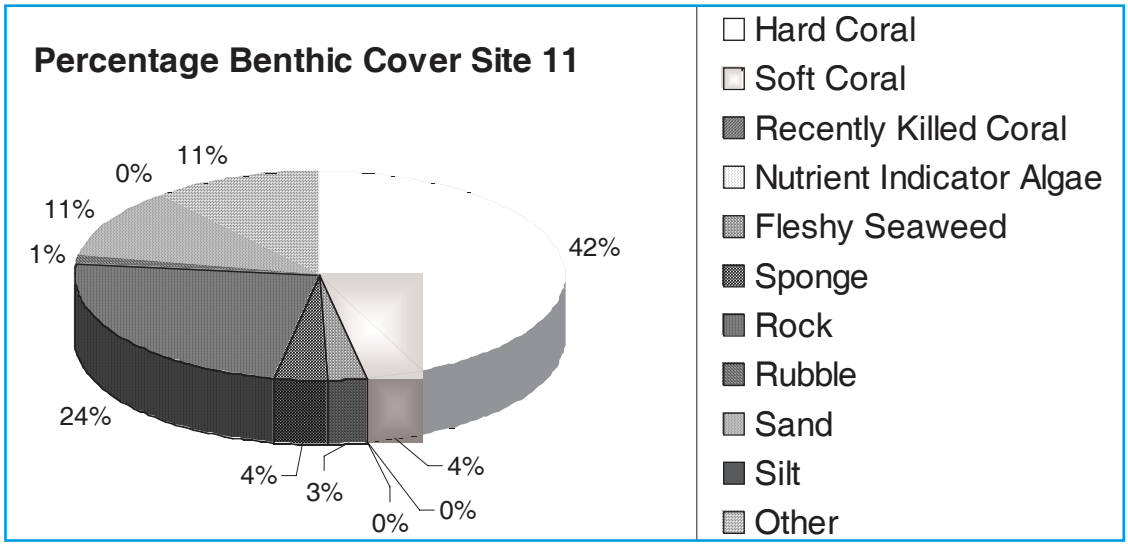
Terraces 5m, 7m, 13m, and 20m as it descended from the reef flat to the channel bottom. Encrusting forms (Leptoseris incrustans, Echinophyllia aspera, E. orphiensis) on the terrace slopes < 8m due to vertical relief and overhangs. Canthrellus jebbi was found at 20m as is an abundance of Tubastrea micrantha. Large silty surfaces are present on the terraces with coral cover <5%. Common species at the site: Acropora divaricata, A. sarmentosa, Pavona clavus, Pocillopora verrucosa, Diploastrea heliopora, Favia stelligera, Euphyllia glabrescens, Oxypora lacera, Stylophora pistillata, Millepora tenella.

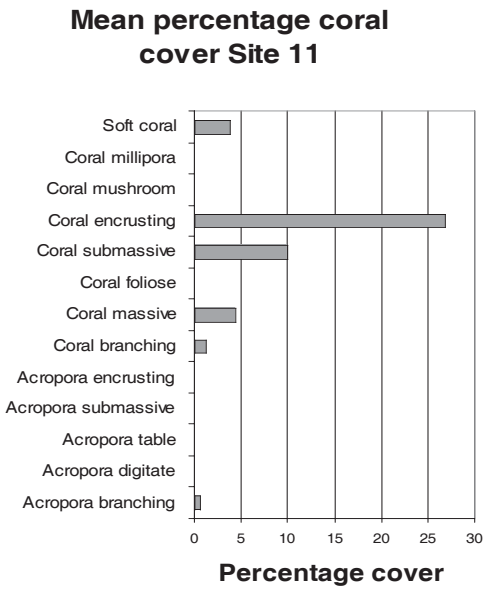
Mali Passage (west side, deep)
Location: 160 18.724S; 179016.596E
The reef profile drops vertically from the reef flat to a large undercut overhang. The channel depth at base is 17m. At 3-5m depth, there is 25% coral cover. Species recorded were Pocillopora verrucosa, Acropora nasuta, A. granulsoa, A. austere, A. robusta, A humilis; A. crateriformis, A. valida, Favites pentagona, and Lobophyllia corymbosa. At 5m, common species were Porites nigrescens, Diploastrea heliopora, Acropora nobilis, A. hyacinthus Goniastrea edwardsi and Montipora tuberculosa. At 17m, the bottom is composed of sand and boulders. Common species were Favites pentagona, Goniastrea minuta, G. edwardsi.

## MARINE FLORA

Nineteen species of marine flora were recorded around Mali Passage (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS

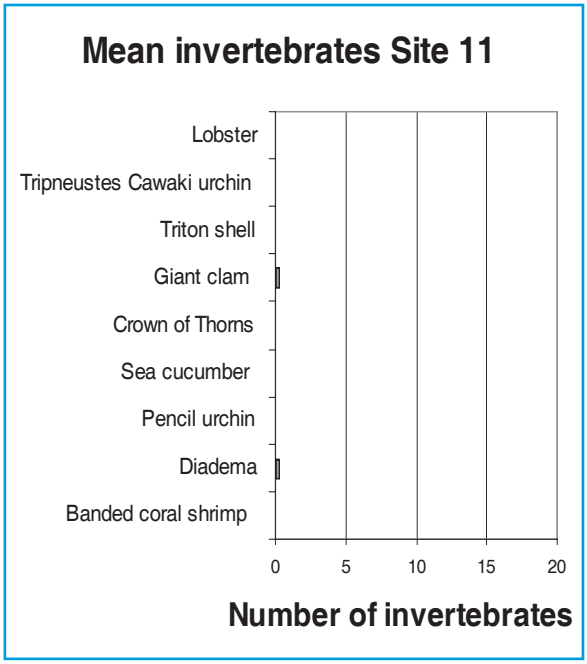


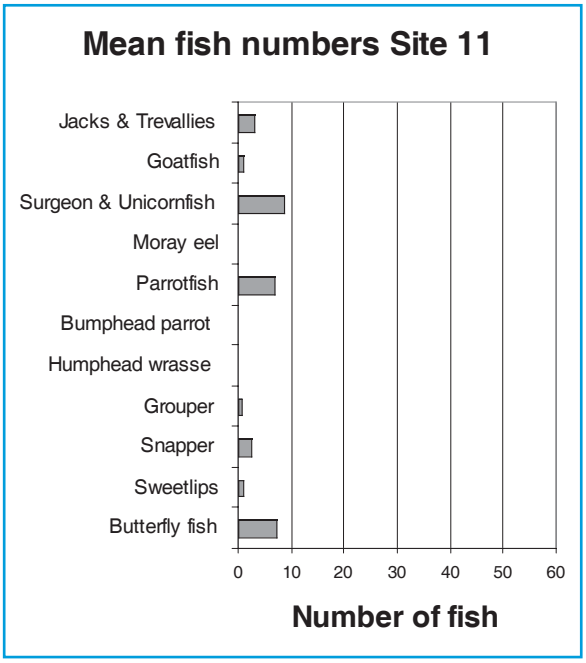



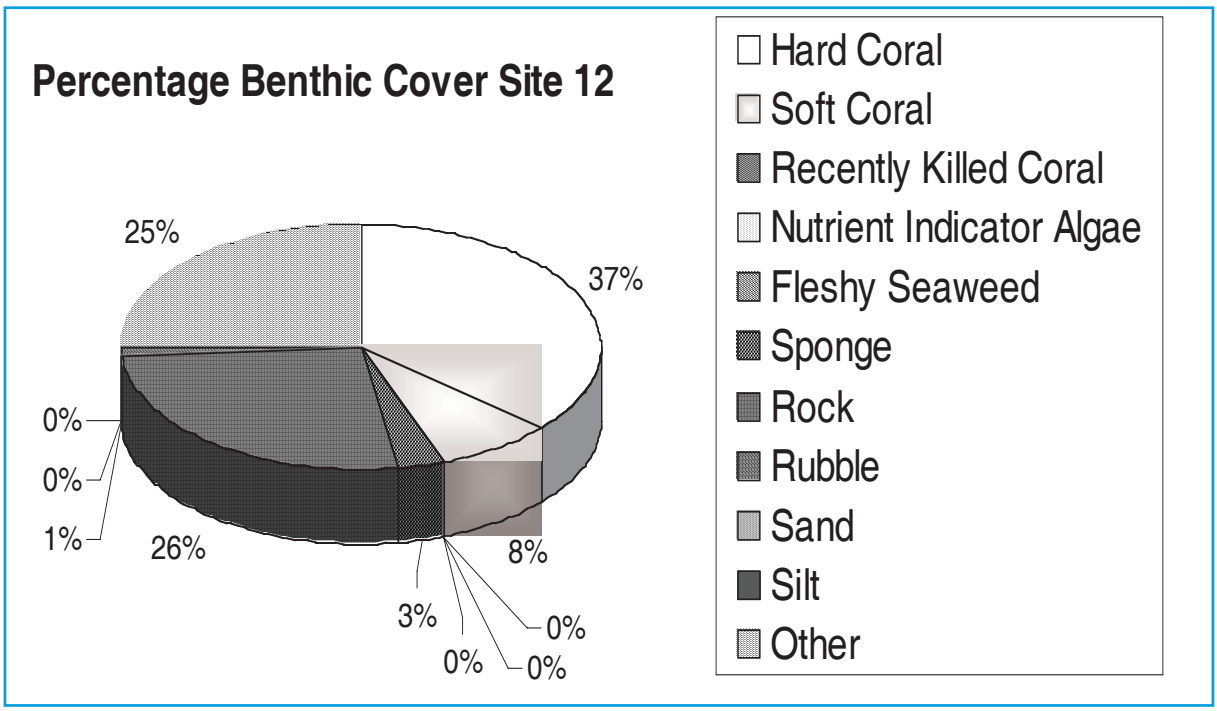

The deeper reef wall had a fairly high level of hard coral cover mostly of non-Acropora encrusting and submassive corals, with the remainder rock and dead corals with a fine layer of silt. There were many large Tubastrea corals which did not appear on the survey line.

Very few invertebrates were found, specifically a Diadema urchin, and a Tridachna giant clam.

There were not many fish at this site, those present being a few small snapper, surgeon, parrot, and butterfly fish.



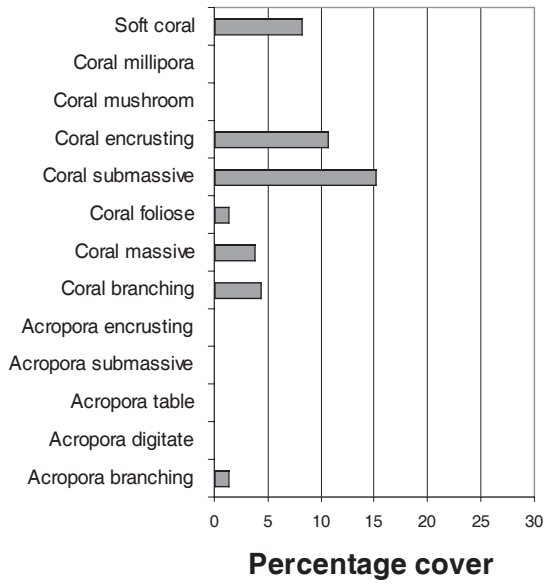




## FISH ABUNDANCE AND SIZE CLASS

Although the fish numbers here were relatively low, and dominated by small damselfish and butterflyfish, the parrotfish, snappers, groupers and surgeons seen were large ones.

## Mean percentage coral cover Site 12

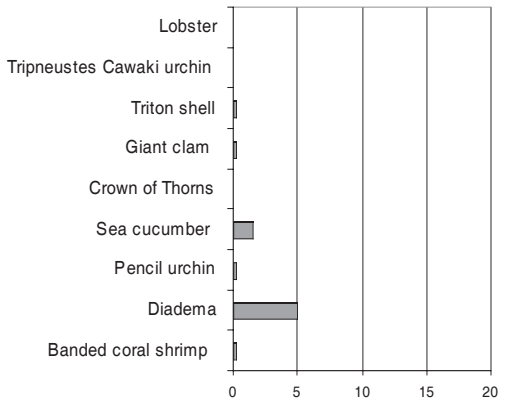



The shallow back reef inside the passage is mostly made up of rock and Non-Acropora encrusting and submassive corals.

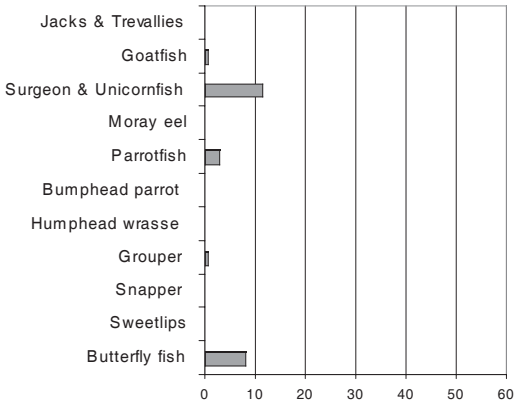
More invertebrates were found than in the main passage, with several Diadema urchins, a few sea cucumbers, and a single Tridachna giant clam and Charonia Triton's Trumpet shell.

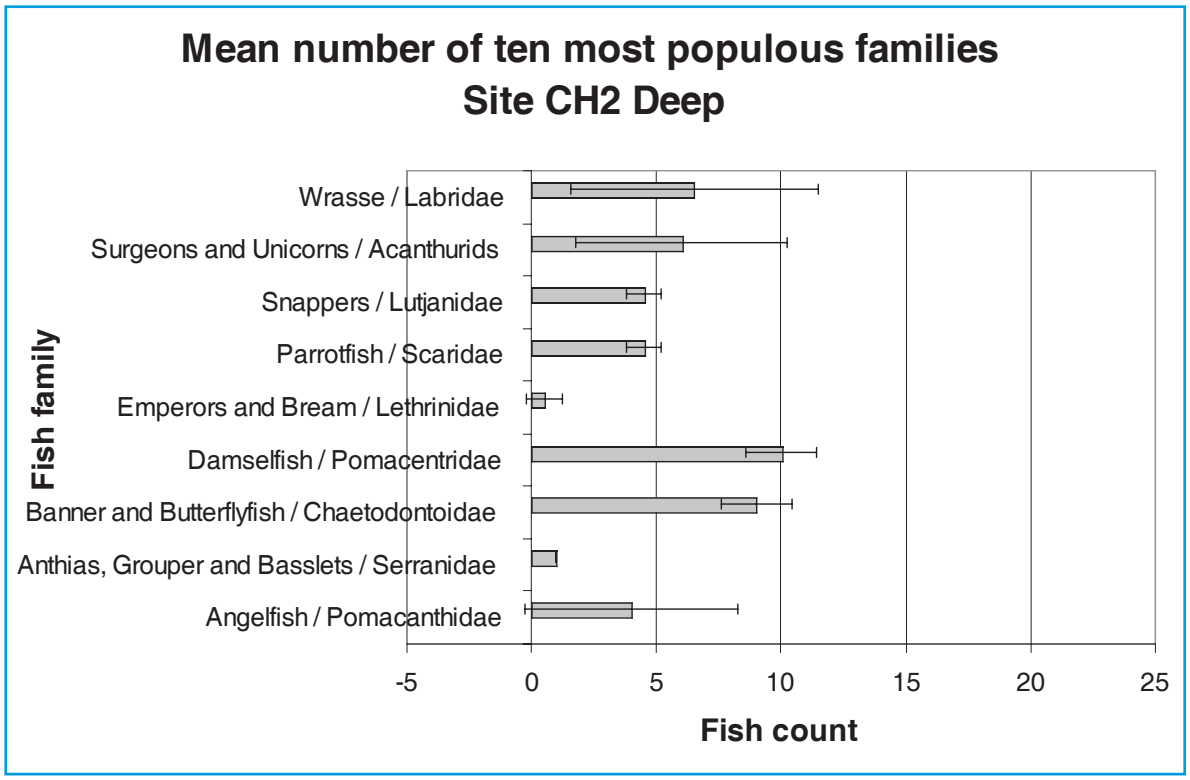
There were not many fish at this site, mostly surgeon, parrot, and Butterflyfish, and small wrasse and damselfish species.

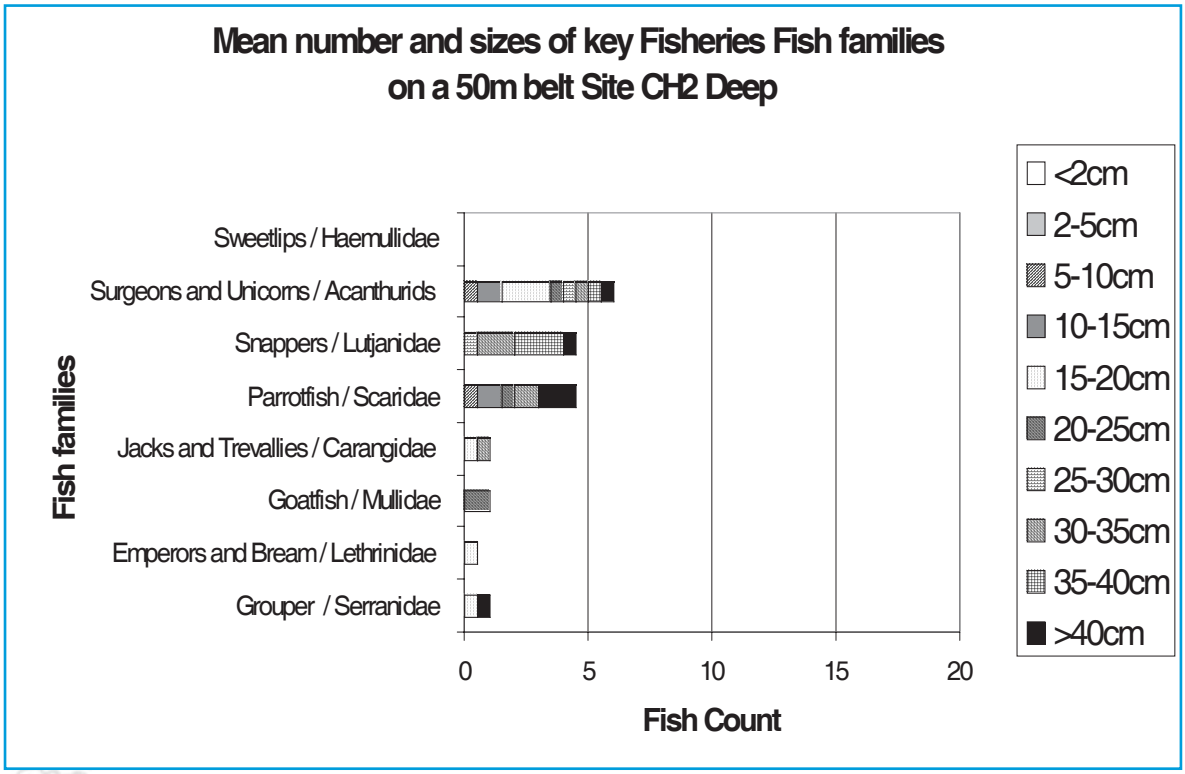
## Mean invertebrates Site 12



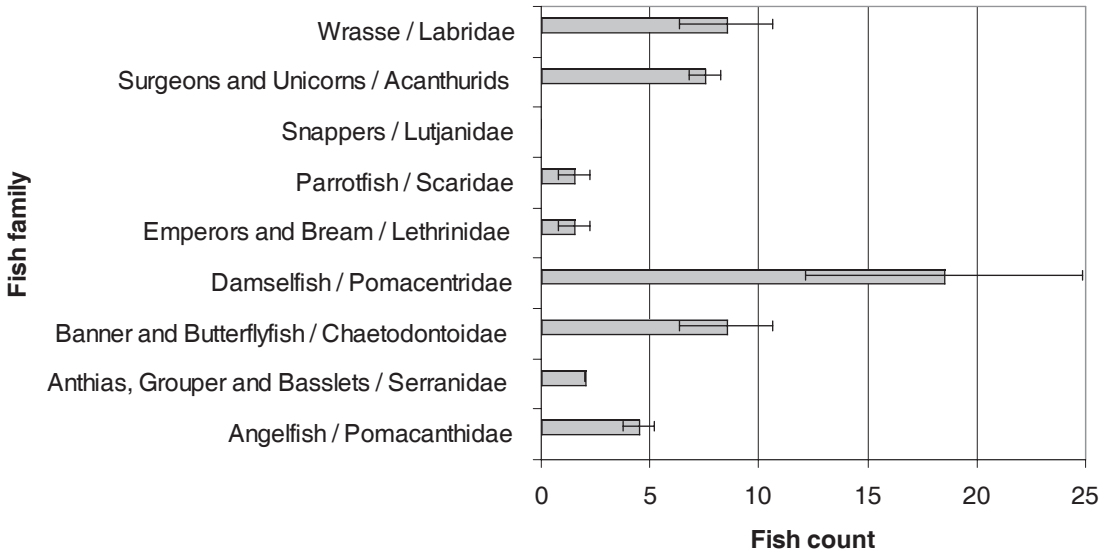

## Mean fish numbers Site 12



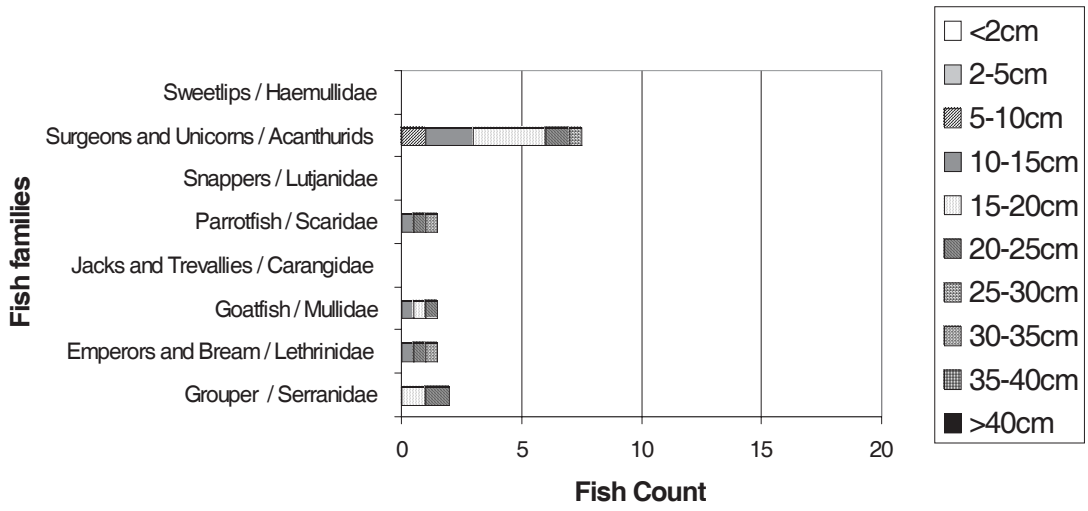

Mean number of ten most populous families
Site CH2 Deep
Fish family
Wrasse / Labridae
Surgeons and Unicorns / Acanthurids
Snappers / Lutjanidae
Parrotfish / Scaridae
Emperors and Bream / Lethrinidae
Damselfish / Pomacentridae
Banner and Butterflyfish / Chaetodontoidae
Anthias, Grouper and Basslets / Serranidae
Angelfish / Pomacanthidae
-5
0
5
10
15
20
25
Fish count


Mean number and sizes of key Fisheries Fish families
on a 50m belt Site CH2 Deep
Fish families
Sweetlips / Haemulidae
Surgeons and Unicorns / Acanthurids
Snappers / Lutjanidae
Parrotfish / Scaridae
Jacks and Trevallies / Carangidae
Goatfish / Mullidae
Emperors and Bream / Lethrinidae
Grouper / Serranidae
0
5
10
15
20
Fish Count
<2cm
2-5cm
5-10cm
10-15cm
15-20cm
20-25cm
25-30cm
30-35cm
35-40cm
>40cm

## Mean number of ten most populous families Site CH2 Shallow




## Mean number and sizes of key Fisheries Fish families on a 50m belt Site CH2 Shallow



## NANANU ISLET - INNER PATCH REEF

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 13 | 11.12.04 | 9.05 | 9.45 | IP2 | Deep | Nananu | Inner island near Labasa river |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o21.393' | 179o19.804' | 9m | 2m | Mild | Rising | 28 |

### 7.11 NANANU ISLET - INNER PATCH REEF

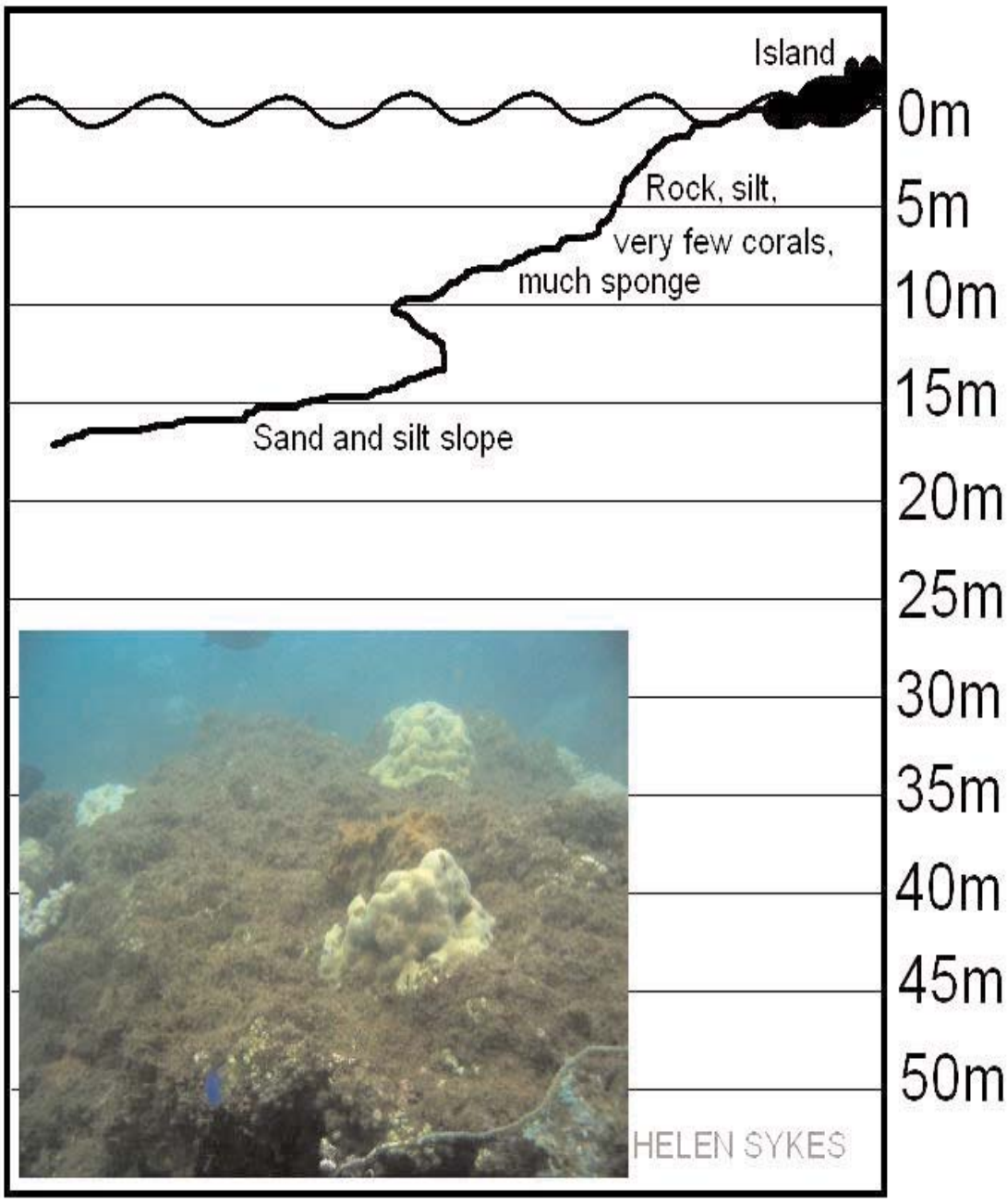


**Table 19.** Coral Reef Fish Diversity Index (numbers of species) for Nananu Islet compared on national, regional and global scales.

| FAMILY | NANANU ISLET | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 7 | 79 | 350 | 402** |
| Damselfish | 10 | 63 | 274 | 330 |
| Butterflyfish | 8 | 35 | 105 | 122 |
| Angelfish | 2 | 14 | 69 | 82 |
| Parrotfish | 1 | 23 | 64 | 83 |
| Surgeonfish | 4 | 27 | 63 | 71 |
| Total (CFDI) | 32 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

Locally known as Yanu Somila, this island is marked on the map as Nananu Island off the south tip of Mali Island, directly opposite the river mouth near the town of Labasa. Heavy siltation was expected and observed in this area due to nearby development and river run off. The reef is a shallow sandy slope off the shore of a rocky islet. It showed an extremely high level of brown silt. Visibility rapidly deteriorated as soon as the bottom was disturbed. The marine flora survey and sponge collections were carried out in the passage between Nananu islet and the main Mali Island. The visibility was again very poor (barely 5 m). At below 5 to 10 m depths algal communities were common, dominated by green algae (Caulerpa and Halimeda species).

## ALPHA DIVERSITY

### FISH

The diversity of fish around Nananu islet is very low compared to other sites in the region with a total recorded fauna of 71 species (see complete species list in Appendix C). This site had the lowest recorded diversity of any site surveyed in the GSR and is clearly degraded by siltation, poor water quality and high levels of pollution (Figures 15,16). Despite this, on a global scale, about 3 % of the worlds known fish diversity within the CFDI families are found at this one site.

### CORALS

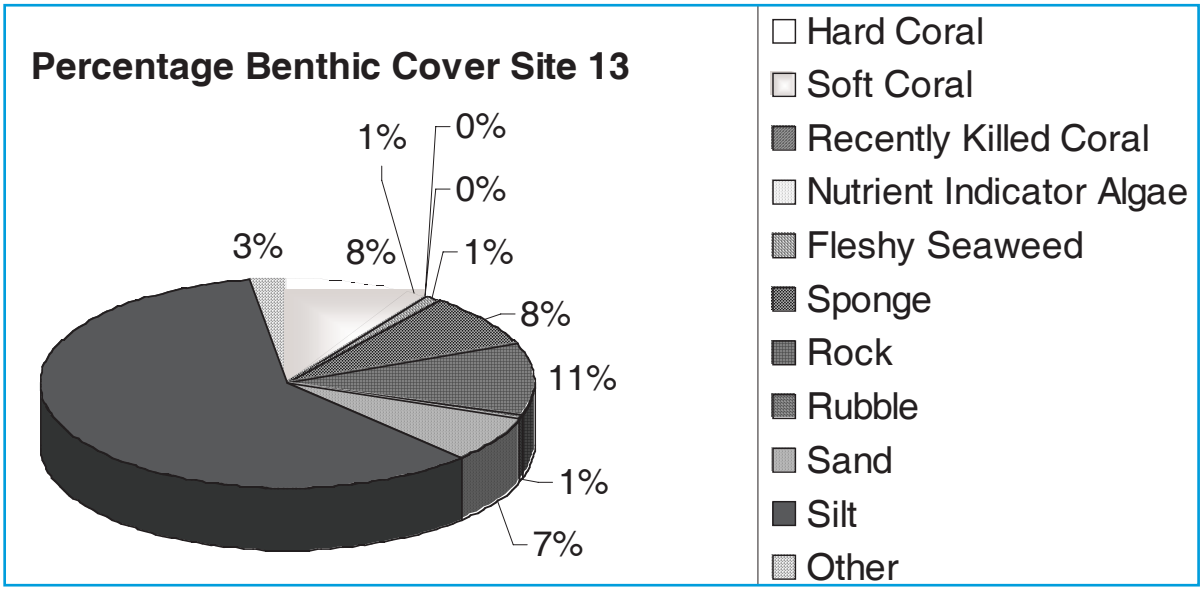
The substrate was characterised by brown silty soft bottom sediments with silt covering all surfaces. Very fine silt occurred at 7m, descending a horizontal bottom at 12m depth.

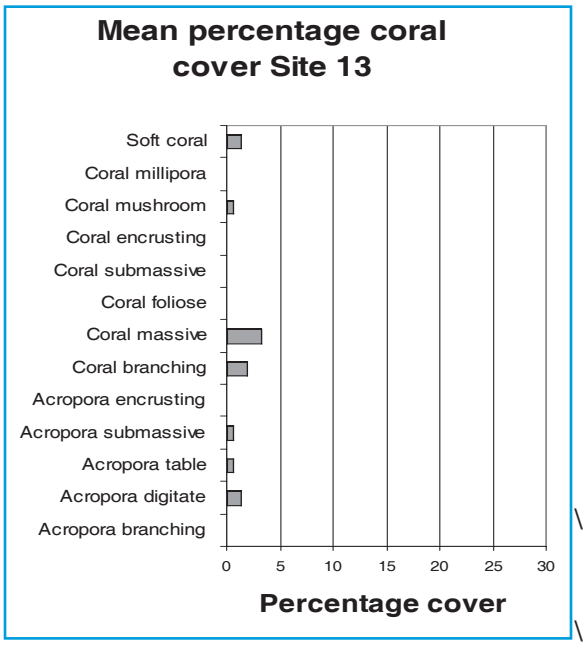
Mixed assemblage of the genera of Favia, Montipora and Porites. Many small colonies on the silty surface indicating periodic mortality probably related to flooding. Larger Acropora colonies were present comprising silt resistant species such as A. vaughani, A. echinata, Favites halicora, Favia pallida, Goniastrea aspera, G. minuta, Poritesrus, Cyphastera serailia, Leptastrea purpurea. There was 5% coral cover above 3m with abundant small Pectinia paeonia, Symphyllia recta, Echinopora horrida, abundant Anacropora sp., Pavona cactus, Hydnophora rigida, H. exesa, Tubastrea aurea, Echinophyllia echinata , Favia rotundata.

### MARINE FLORA

Fifteen species of marine flora were recorded around End of the Earth (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS

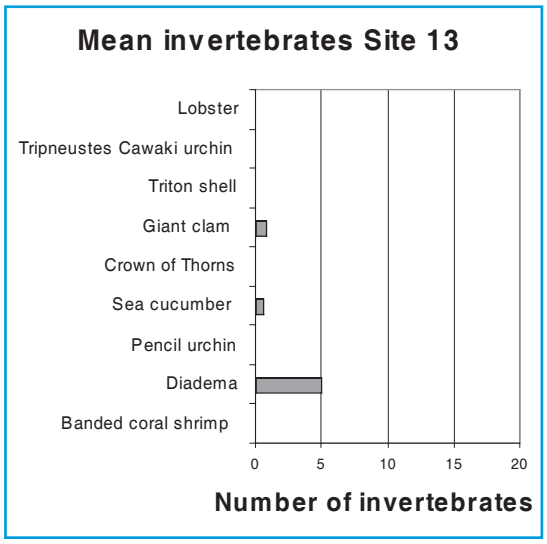


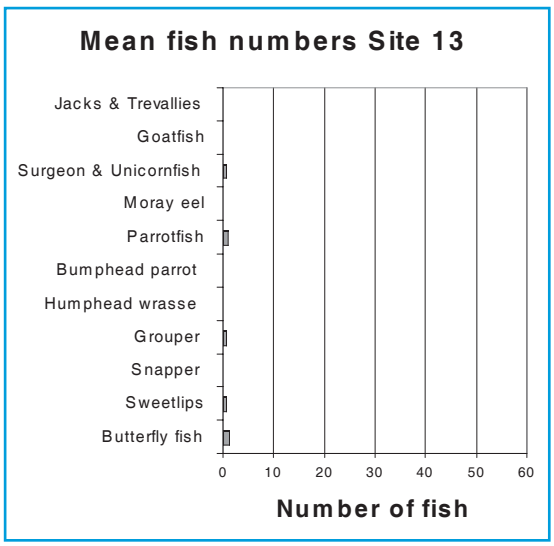




This reef had the highest siltation level of any of the reefs surveyed, with over 60% covered in deep brown silt. Small Porites corals were struggling to survive, but being slowly buried, and the dominant biotic cover was sponges.

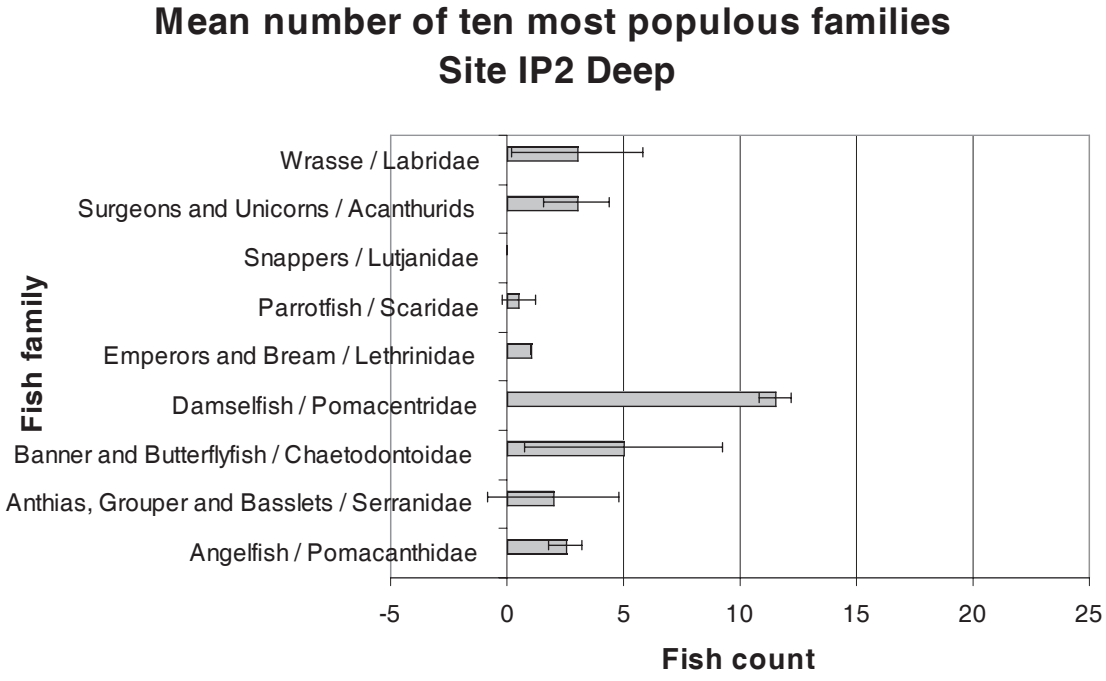
Some Diadema urchins were found in rocky overhangs, and a small Tridacna giant clam and a sea cucumber, but no other invertebrates.

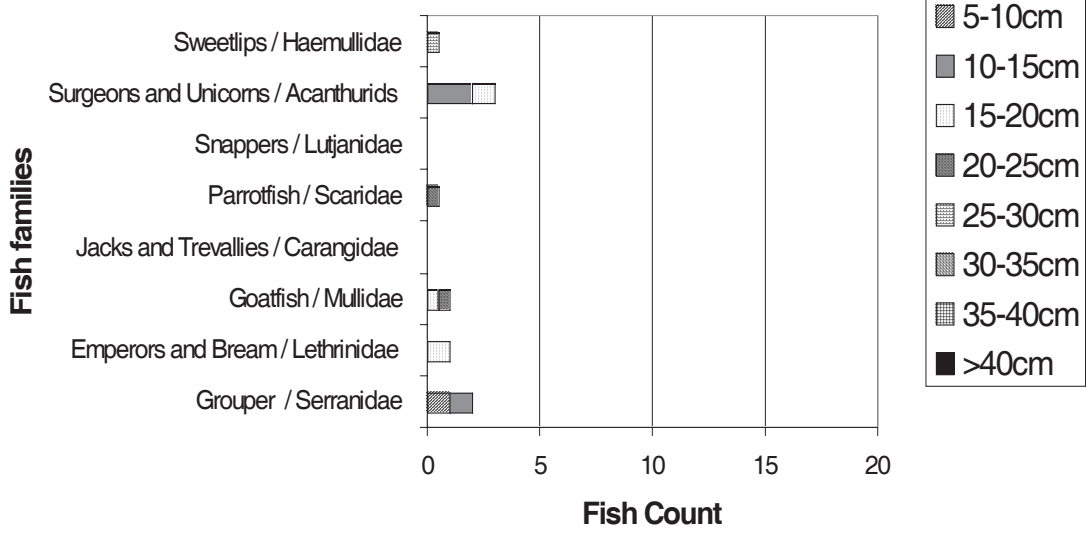
There were hardly any fish on the site, most found were small or juvenile. Fish fauna was dominated by gobies.




## FISH ABUNDANCE AND SIZE CLASS






This site has the smallest number of fish seen on any of the sites surveyed, by a large margin. Only damselfish were found in any number, and all fish found were of a small size. Practically no parrotfish were present, and no large fisheries fish were found at all.

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 14 | 11.12.04 | 13.20 | 14.05 | IB2 | Shallow | Mali Island | Barrier reef inside outer barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o19.462' | 179o17.860' | 4m | 10m | None on top, Mild on slope | Rising | 27.5 |



## 7.12 MALI PASSAGE - INNER DOUBLE BARRIER REEF

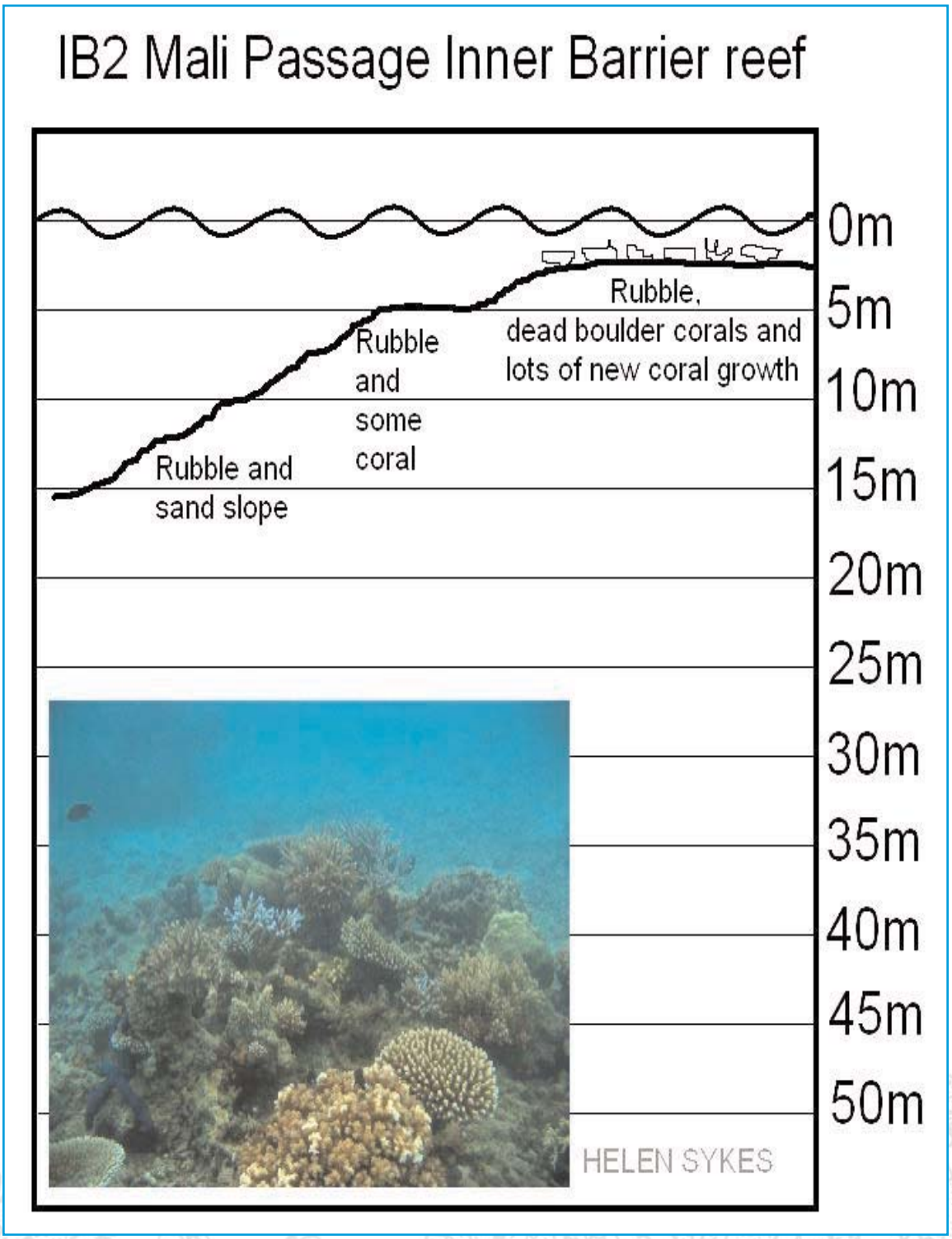


**Table 20.**
Coral Reef Fish Diversity Index (numbers of species) for Mali Passage Inner barrier compared on national, regional and global scales.

| FAMILY | MALI PASSAGE INNER BARRIER | FIJI ISLANDS* | NDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 20 | 79 | 350 | 402** |
| Damselfish | 26 | 63 | 274 | 330 |
| Butterflyfish | 13 | 35 | 105 | 122 |
| Angelfish | 4 | 14 | 69 | 82 |
| Parrotfish | 5 | 23 | 64 | 83 |
| Surgeonfish | 7 | 27 | 63 | 71 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

## ALPHA DIVERSITY

### FISH

The diversity of fish in Mali Passage Inner Barrier is moderate with a total recorded fauna of 143 species (see complete species list in Appendix C). CFDI families represented 52% of the visible community of fish. About 7% of the worlds known fish diversity within the CFDI families are found at this site. This site, while of moderate diversity had notably high numbers of juvenile and sub-adult grouper of the genera Variola and Cephalopholis while other sites tended to be dominated by the groupers of the genus Epinephalus. This site had a higher number of grouper than observed at any site.

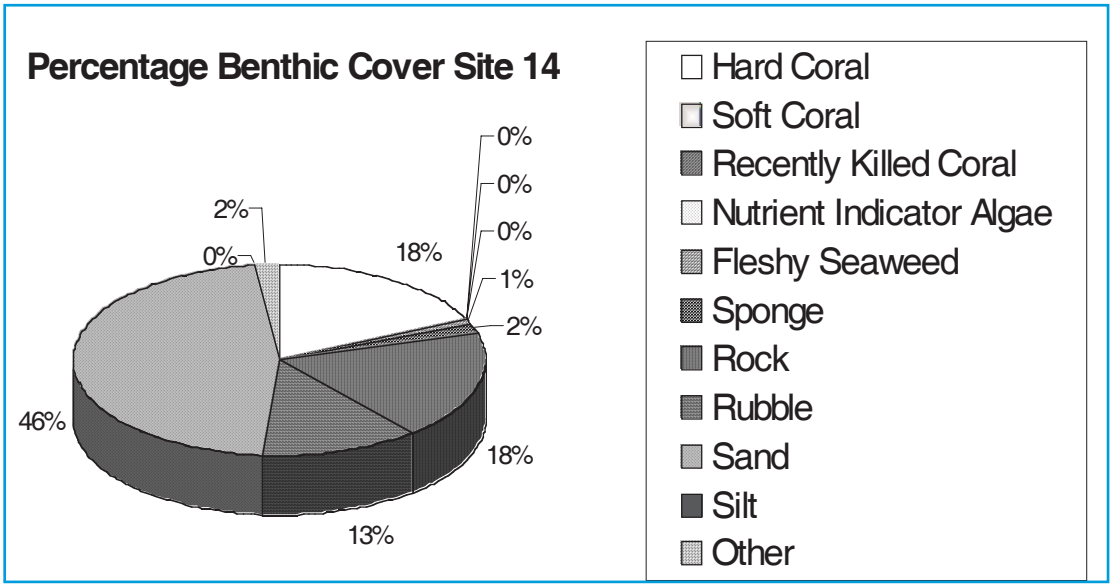
### CORALS

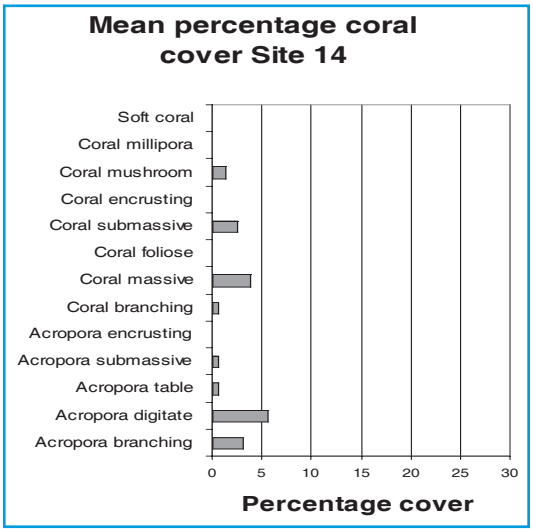
On the south side of the barrier reef slope drops to 34m as a rubble or sand slope with a sand base. The reef has a luxuriant assemblage as it is removed from shore influences. There is good flushing from seaward with wave action and good tidal current. Mali I., to the south, diverts floodwater out of the channel limiting the effect of flooding. The reef top (3-5m) is composed of a sand substrate with some rubble. Reef isolates of reef rock hosting luxuriant coral cover. It is Acropora dominated with plates and branching colonies. Large Porites colonies up to 3m height were evident. Reef patches vary in size but usually with plates, branching colonies and various other genera. Species noted were Acropora sarmentosa , A. intermediate , A. spatulas, A. cytherea, A. humilis, A. nasuta, A. micropthalma, A. aspera, A. divaricata, A. palifera , Pocillopora damicornis, P. verrucosa, Goniopora minor, G. tenuidens, Favia pallida, Gardineroseris panulata, Goniastrea russeli, Porites rus, Montastrea curta, Favites halicora, Favia pallida, F. matthai.

### MARINE FLORA

Sixty five species of marine flora were recorded around Mali Passage Inner Barrier which is the highest recorded algae diversity of any site surveyed (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS

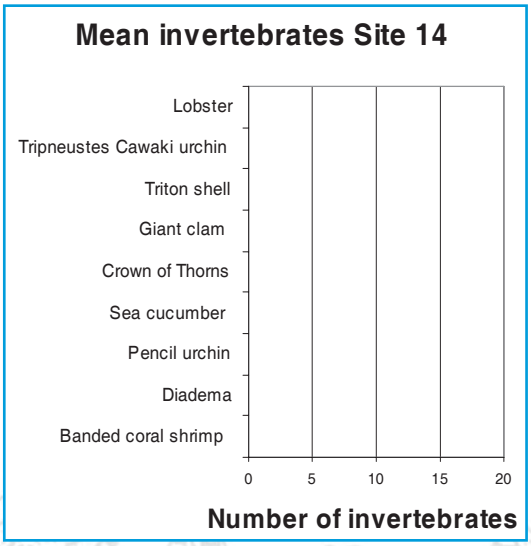


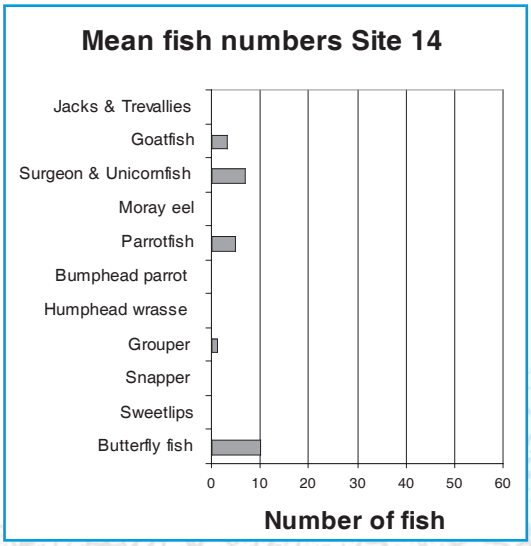




Although the reef is largely dead substrate, rock, rubble and sand, the top of the reef had high growth of small hard corals, often on overturned dead coral pieces, dominated by branching and digitate Acroporas.

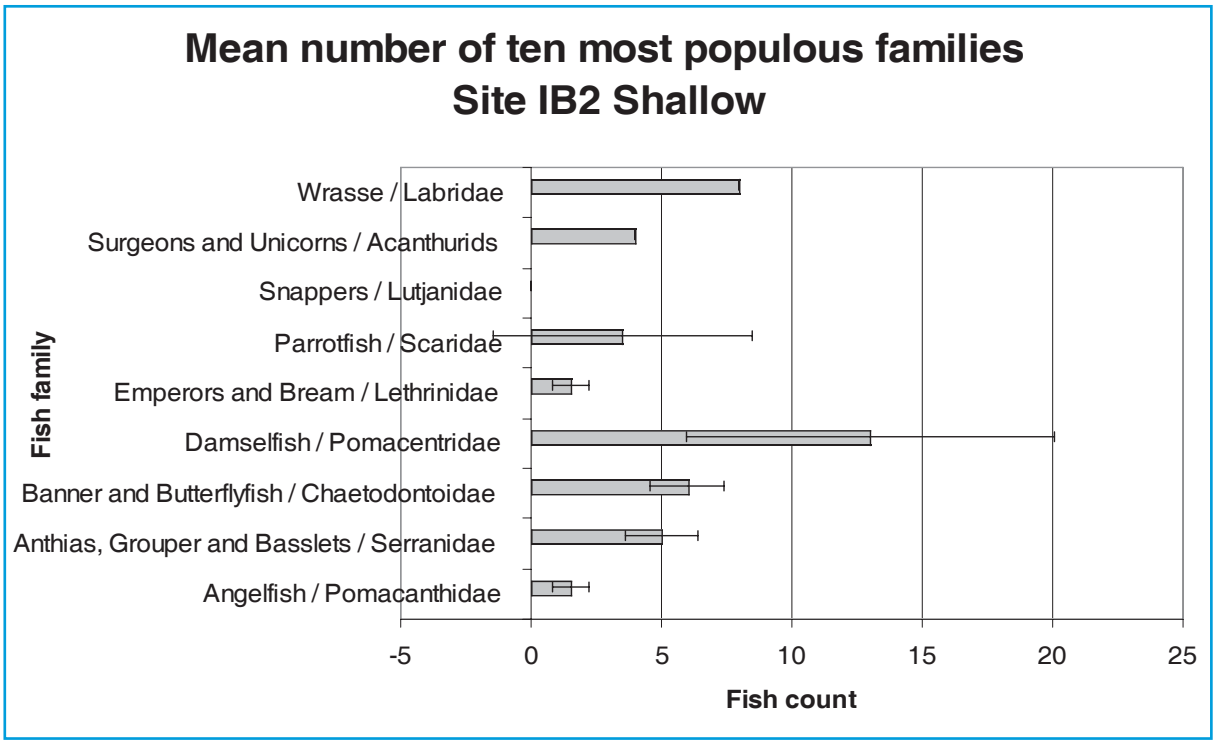
No invertebrates were seen at all.

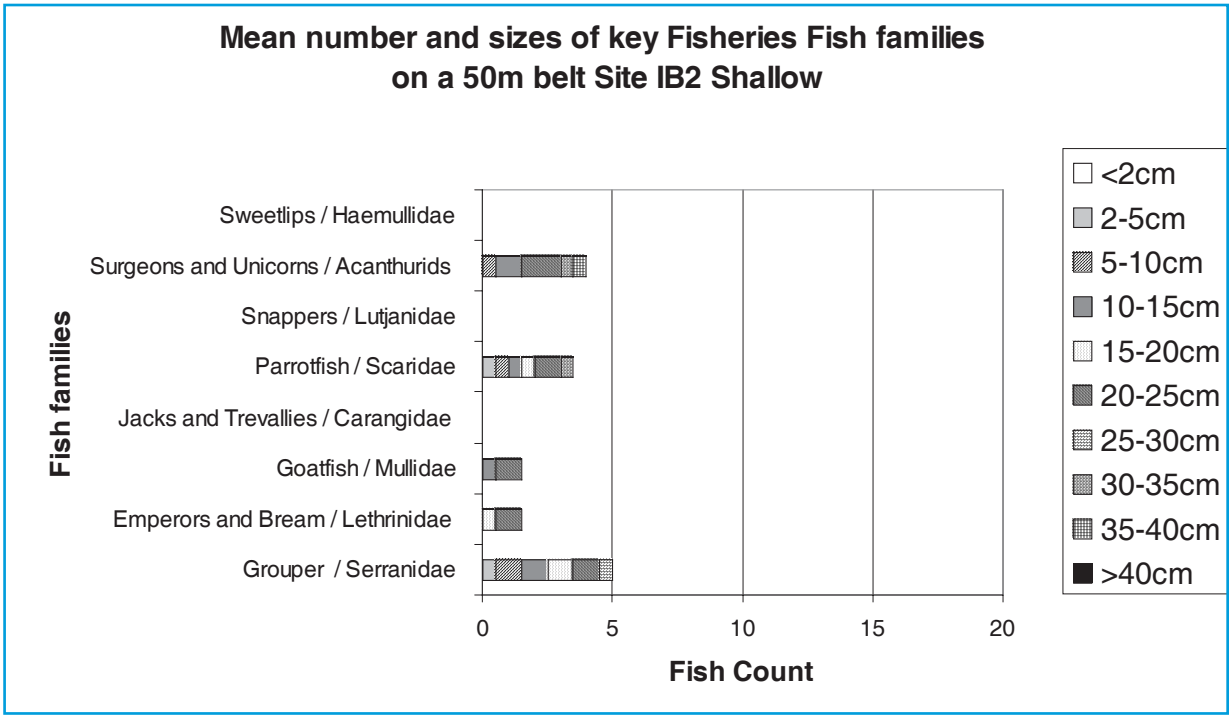
There were few fish, mostly small surgeons, parrot and butterfly fish, small wrasse and damselfish.



## FISH ABUNDANCE AND SIZE CLASS




The relatively low fish numbers at this shallow rubble site were dominated by damselfish and wrasse, but grouper numbers were exceptionally high in comparison with other sites. The groupers seen were of the genera Variola, Cephalopholis and also many Highfin grouper, Epinephelus maculatus. This grouper reaches a maximum size of 54 cm (Myers, R, 1999), and was seen here in a range of sizes, many in the 5-25 cm categories, and none larger than 30cm.

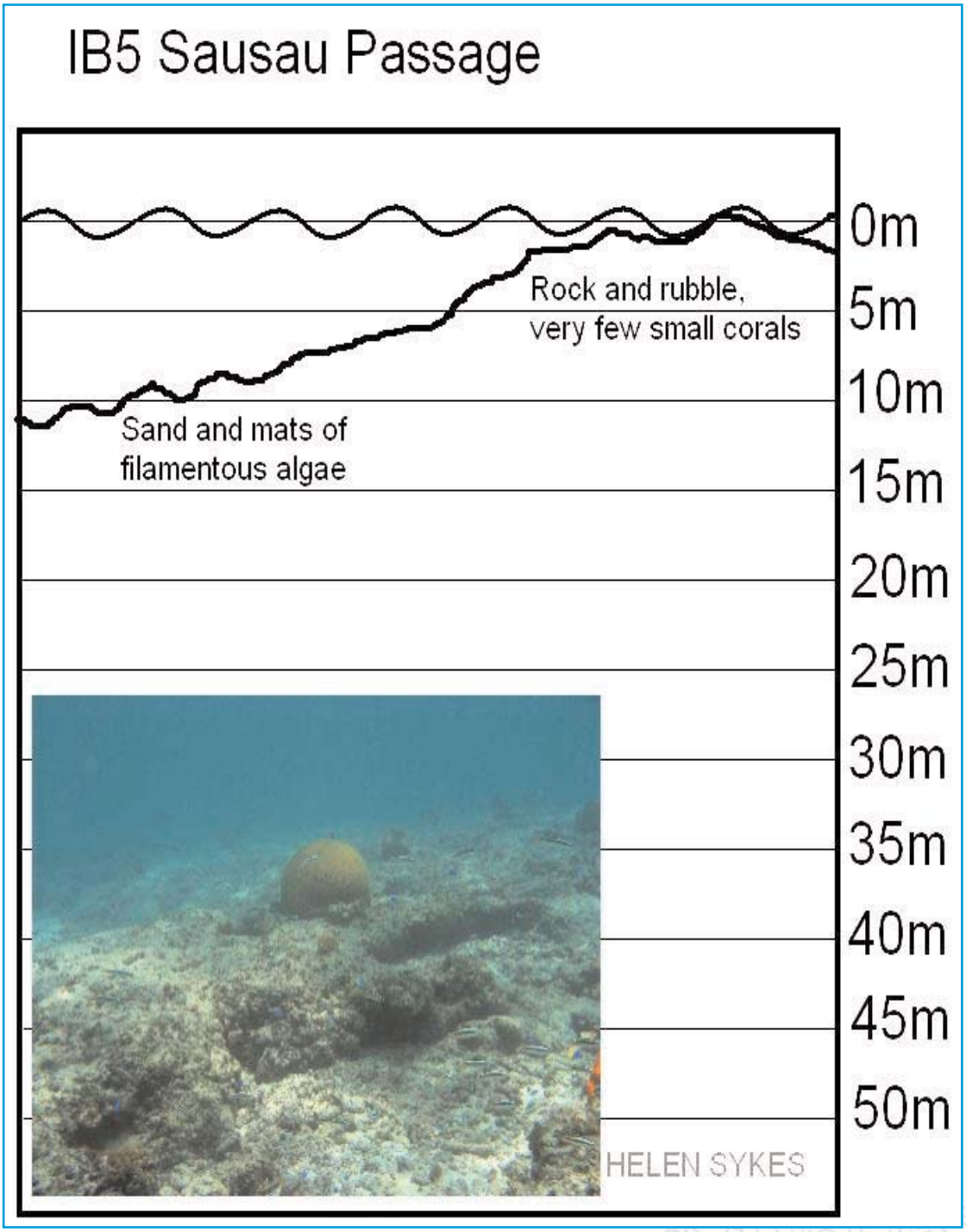
# SAUSAU PASSAGE - INNER BARRIER REEF

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 15 | 12.12.04 | 10.25 | 10.55 | IB5 | Shallow | Sausau Passage | Back of barrier reef |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o10.471' | 179o29.954' | 3m | 10m | Little surge | Falling | 29 |

## 7.13 SAUSAU PASSAGE - INNER BARRIER REEF




This is a wide passage toward the eastern end of Cakau Levu reef, opposite Vago Bay. The survey was done on the back reef behind the inner edge of the passage, a long flat rubble and rock slope. Deeper areas are sand covered with mats of filamentous algae.

## ALPHA DIVERSITY

### FISH

This site was not surveyed for overall diversity of fish.

### CORALS

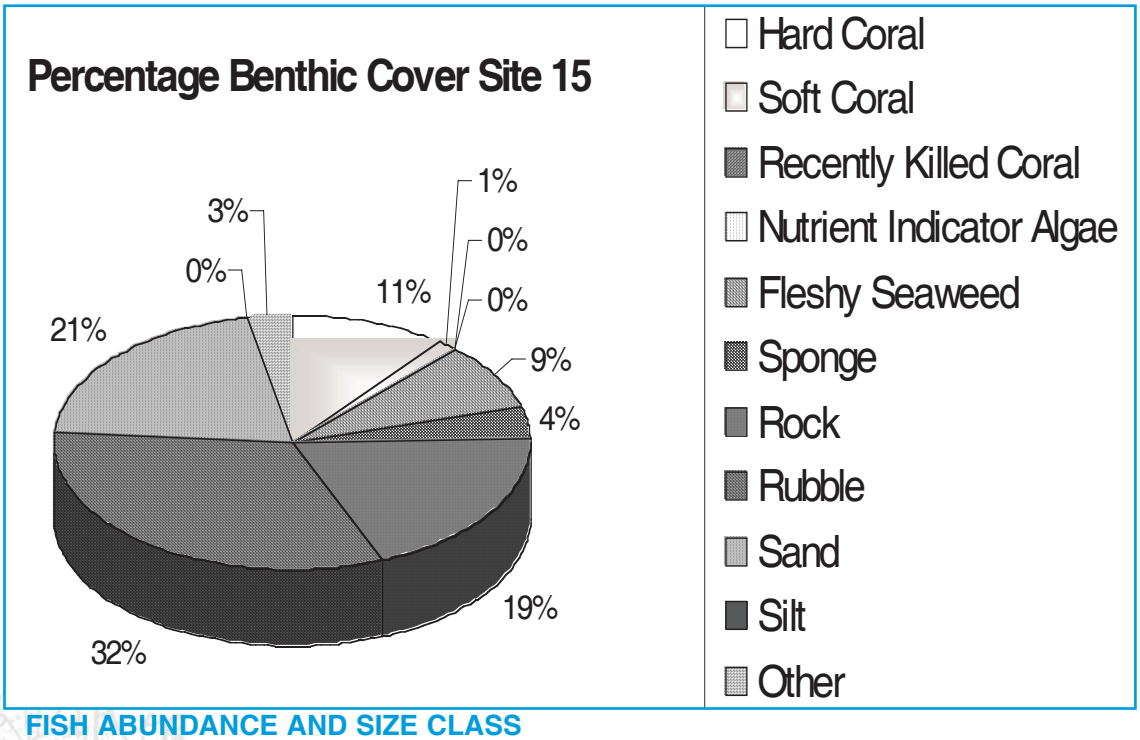
A sand slope is the result of the transport of material by wave action over the barrier reef. Slope descends from back of the barrier with a shallow slope forming a wide apron on the lagoon side of the reef extending along the southern margin. Coral reef ridges extend around the deeper sand areas. Colonization of the reef rock is primarily on the vertical margin surfaces with little colonization on the silt covered horizontal surfaces.

There is evidence of bleaching with recovery through overgrowth in the genera Platygyra and Diploastrea. These genera characterised the deeper sand and rubble expanses. In the shallows Porites spp. and Acropora spp. predominate with Acropora sarmentosa and A. humilis common. Species noted were Pocillopora damicornis, P. eydouxi, Hydnophora microtones, Favia pentagona, F. species, Goniastrea retiformis, and Platygyra daedalea.

### MARINE FLORA

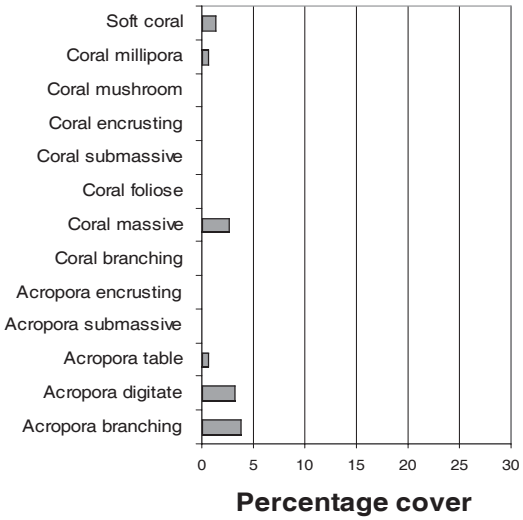
Fifteen species of marine flora were recorded around Sausau Passage Inner Barrier which is the highest recorded algae diversity of any site surveyed (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS




## FISH ABUNDANCE AND SIZE CLASS

### Mean percentage coral cover Site 15



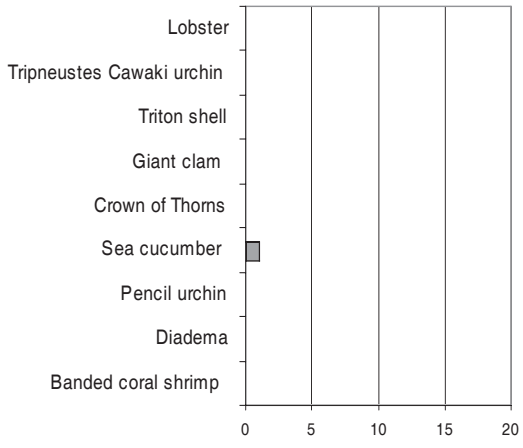

Most of this area is dead coral rubble, rock and sand, with a little hard coral cover mostly consisting of small digitate and branching Acropora colonies.

The only invertebrates counted were a few sea cucumbers.

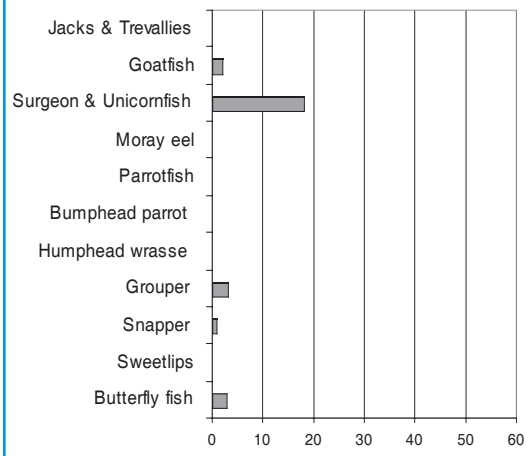
Although there were generally few fish, several small surgeonfish were found.

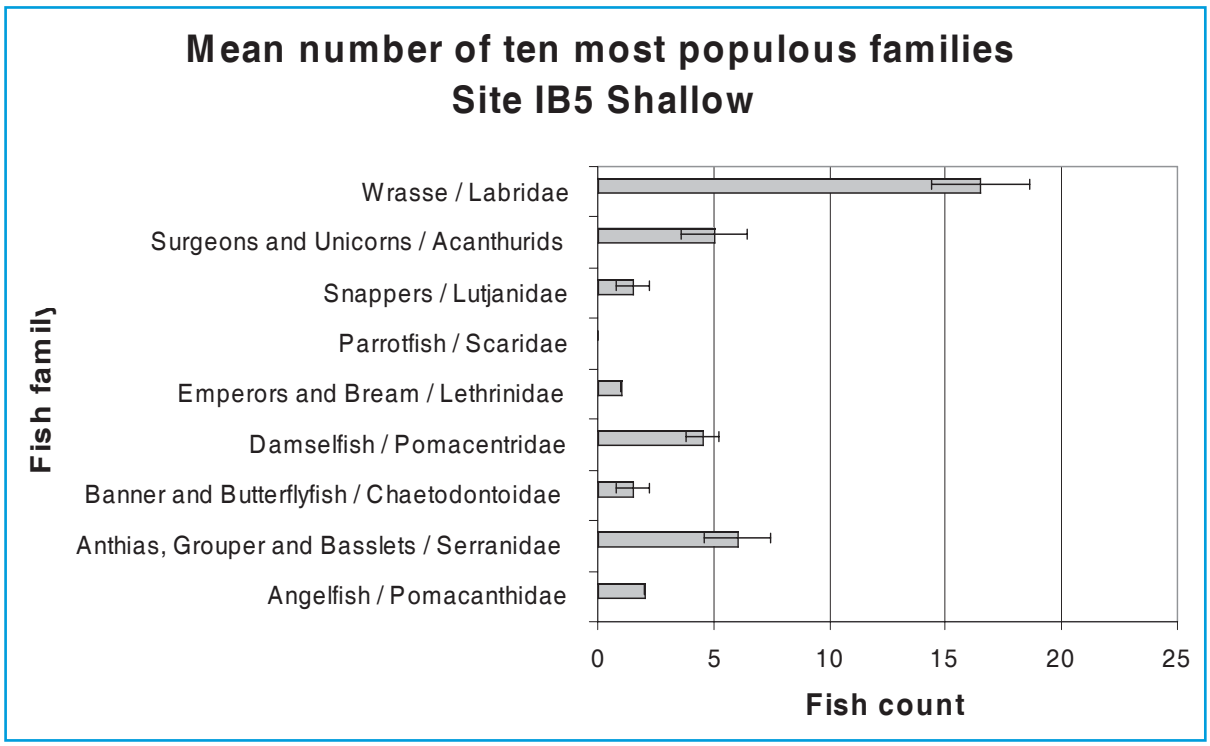
The grouper seen were all of one species, Epinephelus maculatus, (the Highfin grouper), and this may be worth investigating as a potential spawning site for this species.

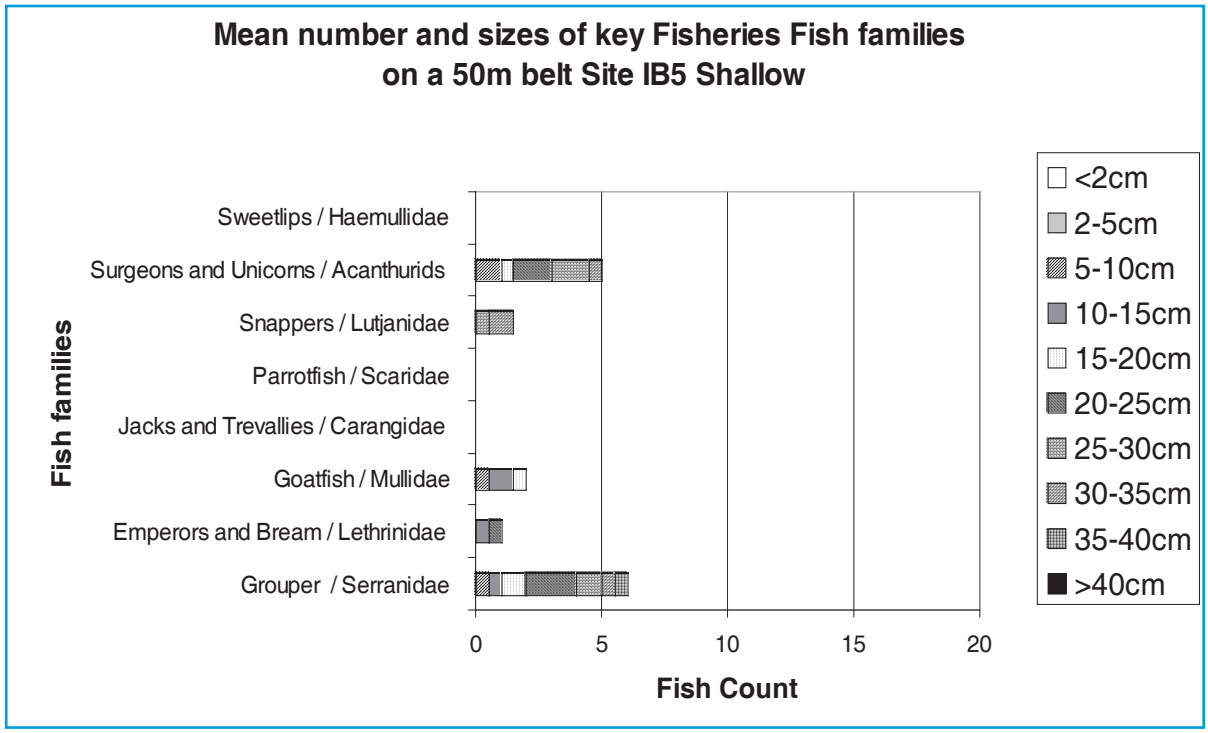
### Mean invertebrates Site 15




### Mean fish numbers Site 15






This site has low numbers of fish, mostly wrasse, but exceptionally high numbers of groupers in comparison to those found on other sites. Most of those were the Honeycomb Grouper or "Kawakawa" Epinephelus merra, a small species which reaches a maximum size of 31cm (Myers, R, 1999). A range of sizes were seen here, but many were adults in the 20-30cm range. Although small, this species is important in local subsistence fishing, and this site may be a spawning area for this species.

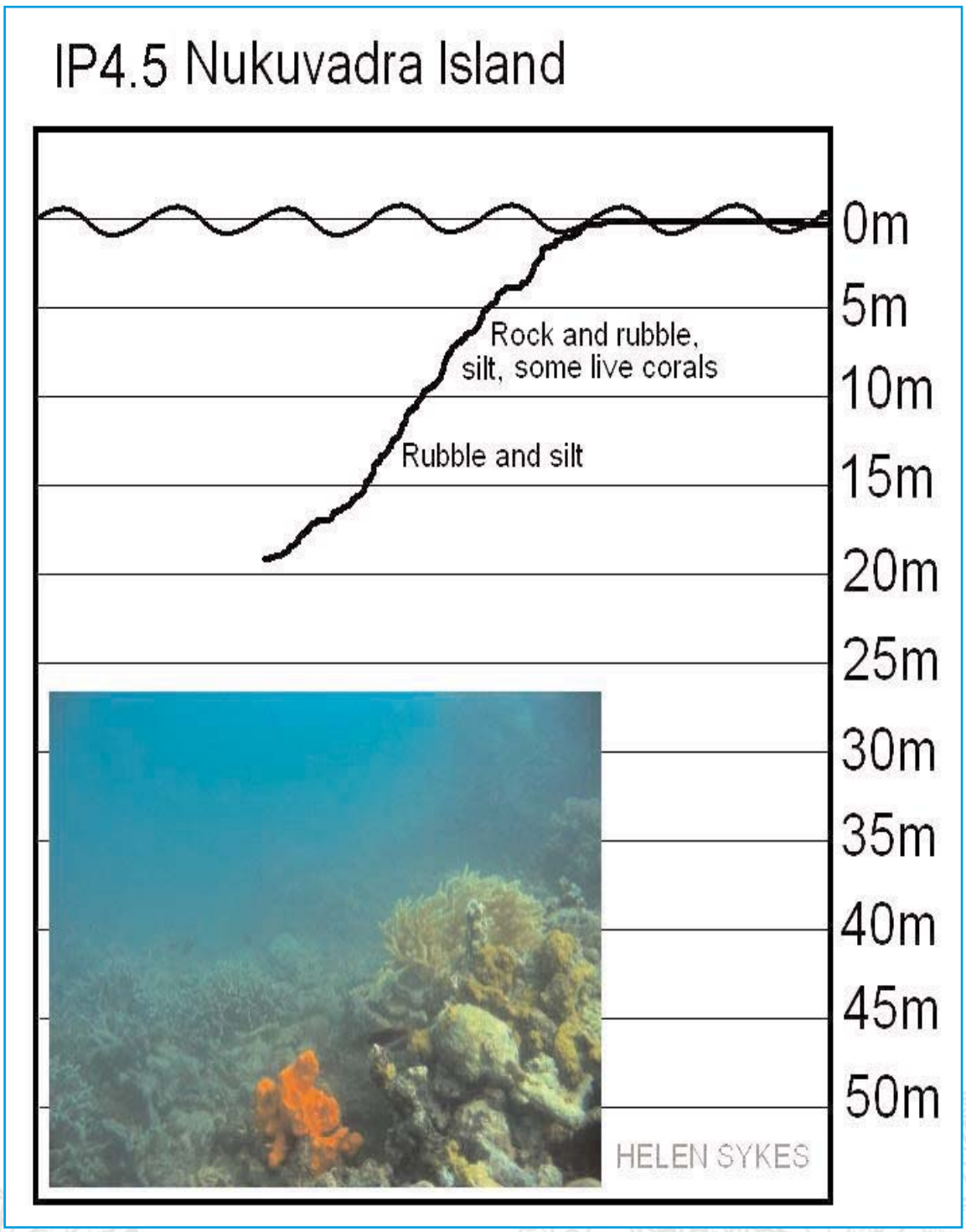
## NUKUVADRA ISLAND - MANGROVE ISLAND FRINGING REEF

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 16 | 12.12.04 | 12.05 | 12.55 | IP4.5 | Shallow | Nukuvadra Island | Mangrove island |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o12.913' | 179o33.040' | 5m | 3m | Mild | Dead Low | 28 |

### 7.14 NUKUVADRA ISLAND - MANGROVE ISLAND FRINGING REEF



This reef fringes a small island inside a silty lagoon area opposite Sausau Passage, near Vago Bay ,and several river outlets in the east of the coastline. It is a sloping reef of dead rubble and silt.

## CORALS

The depth at the base of the hard reef with a transition to a 450 slope of reef sediments is 8m. The slope terminates on a horizontal sand bottom at 18m. The slope was composed of loose rubble and boulder material with coral attached or as loose living fragments or whole colonies. Several specimens of Cycloseris (C. vaughani, C. patelliformis, C. costulata) were collected. The foliose coral Pachyseris rugosa and Oxypora lacera were common, Canthrellus jebbi is present. There was <3% coral cover on the slope and 25% coral cover on the reef top. A diversity of Fungid species occurred on the slope. On the reef crest, Porites cylindrica, P. annae, and P. lobata were present. Acroporaspresent included Acropora millepora, A. subglabra, A. rosaria, A. nasuta, Montipora foveolata, Favites abdita, F. halicora, Echinopora gemmacea, Merulina ampliata, Pachyseris speciosa Tubastrea micrantha, Diploastrea heliopora, Symphyllia, Goniastrea retiformis, Psammocora contigua, Hydnophora rigida, Echinophyllia echinata and Tubipora musica.

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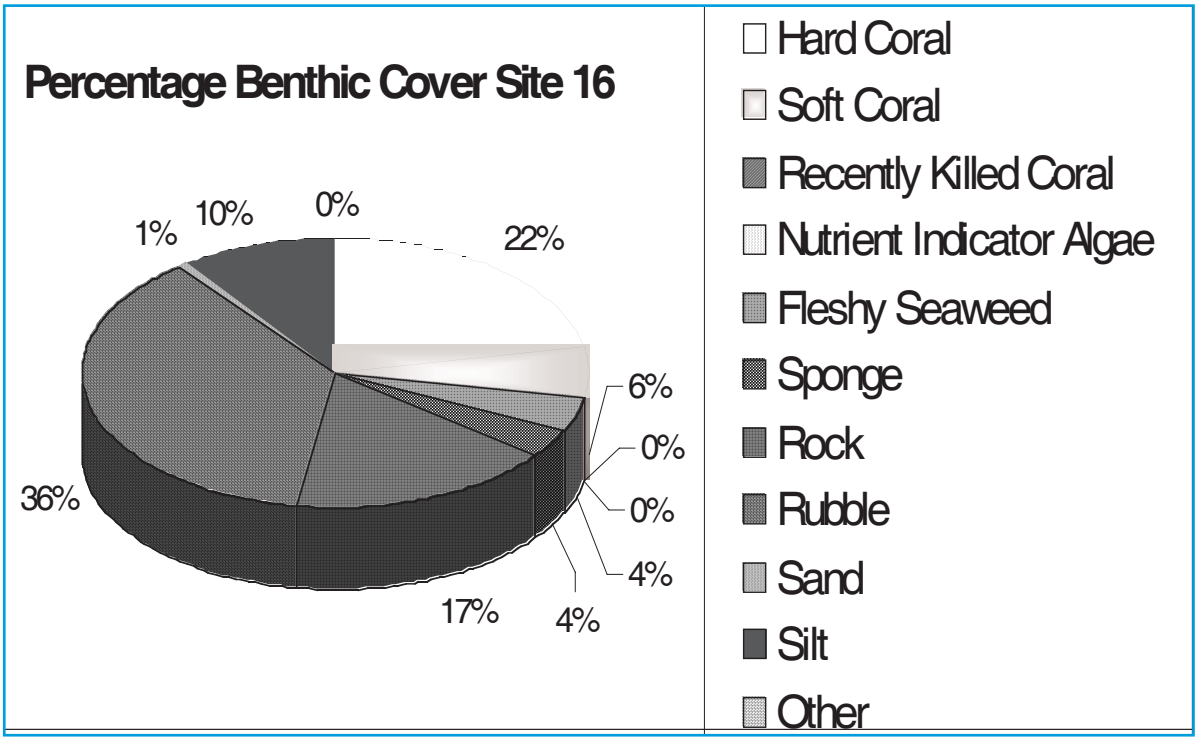
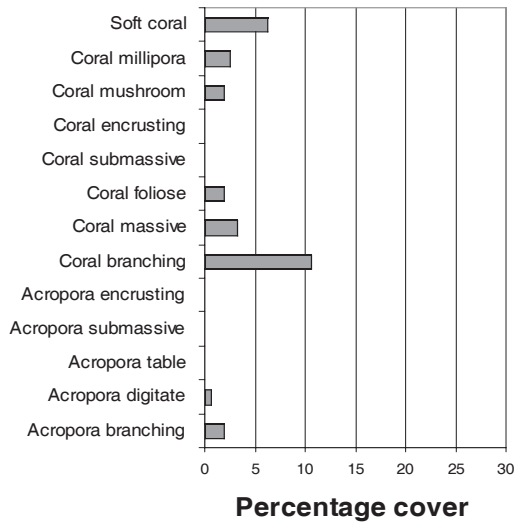
## SITE CHARACTER AND POPULATIONS



## Mean percentage coral cover Site 16

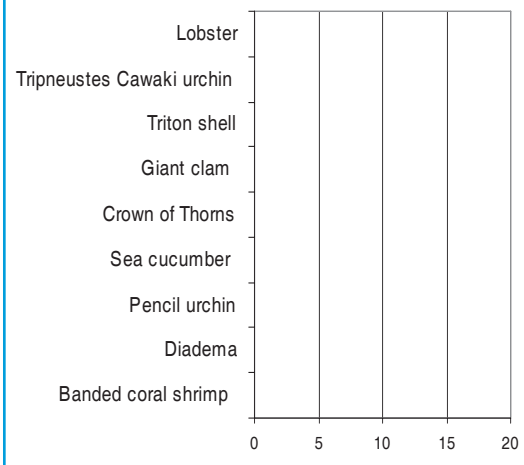



Most of this area is silted dead coral rubble, and rock, with some hard coral cover mostly consisting of branching non-Acropora corals such as Porites cylindrica. Silt levels are the second highest found during these surveys.

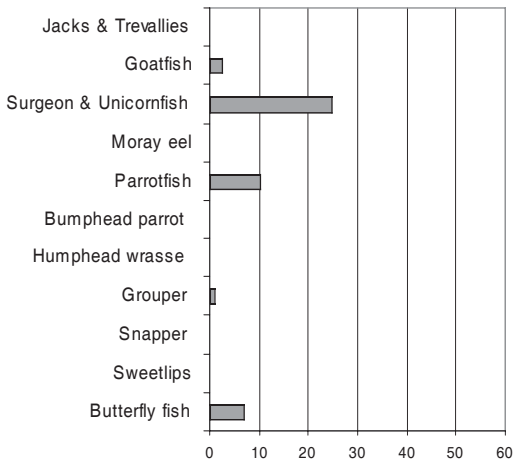
No invertebrates were found at all.

Although there were generally few fish, several small surgeonfish and parrot were recorded.

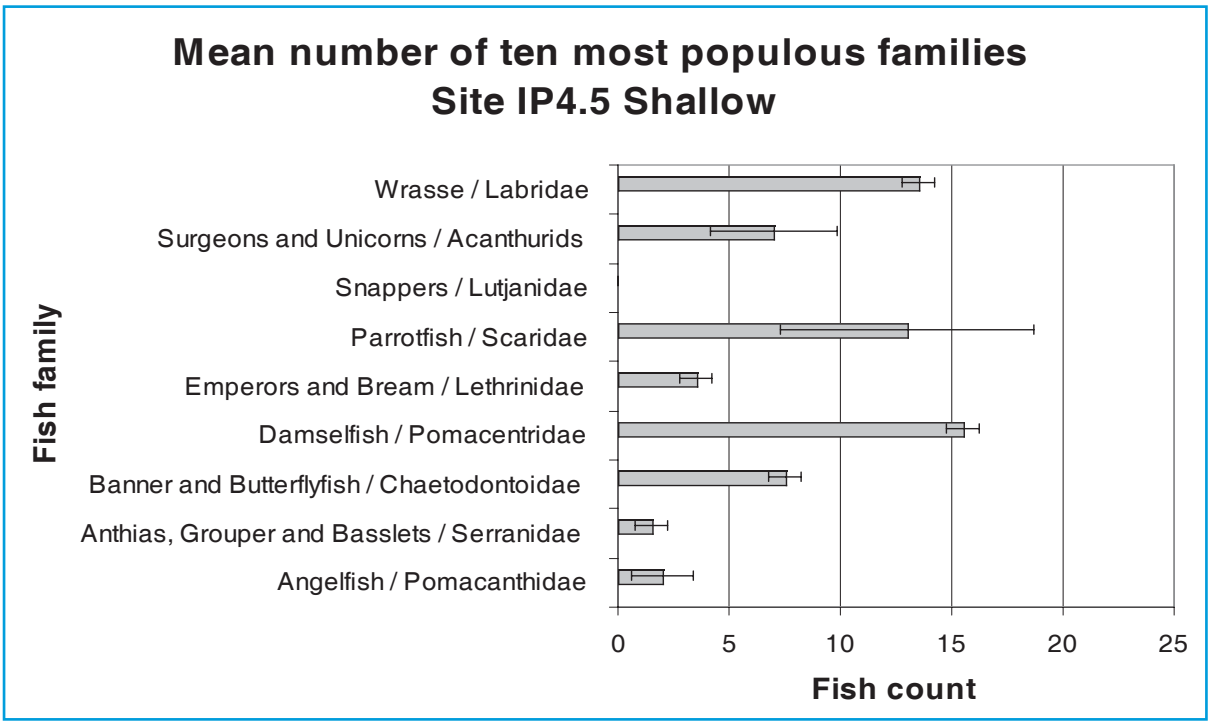
## Mean invertebrates Site 16

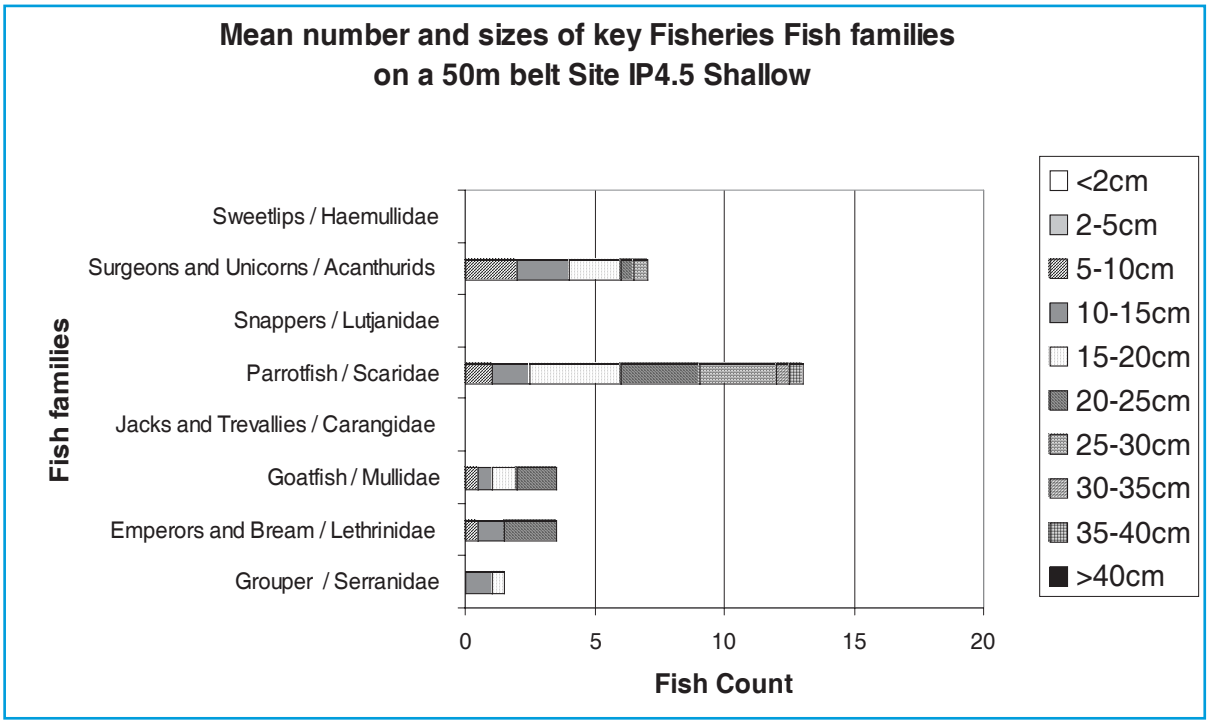



## Mean fish numbers Site 16



## FISH ABUNDANCE AND SIZE CLASS




This mangrove site had an extremely high fish count, the second highest found on all sites surveyed, and the richest in moderately sized intermediate and female parrotfish, which were found in very large schools. This site is probably a parrotfish spawning site. Large Trevallies were also seen, although not during the survey. This site also had several large and small individuals of the grouper species, Specklefin Grouper Epinephelus ongus, although they were very shy and seen after the survey ended.

### 7.15 TILAGICA ISLAND - BACK BARRIER REEF

# TILAGICA ISLAND - BACK BARRIER REEF

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 17 | 13.12.04 | 10.25 | 11.00 | IB4 | Shallow | Tilagica Island | Inner barrier reef slope |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o10.290' | 179o46.081' | 5m | 5m | Slight surge | Falling | 28 |

## IB4 Shallow

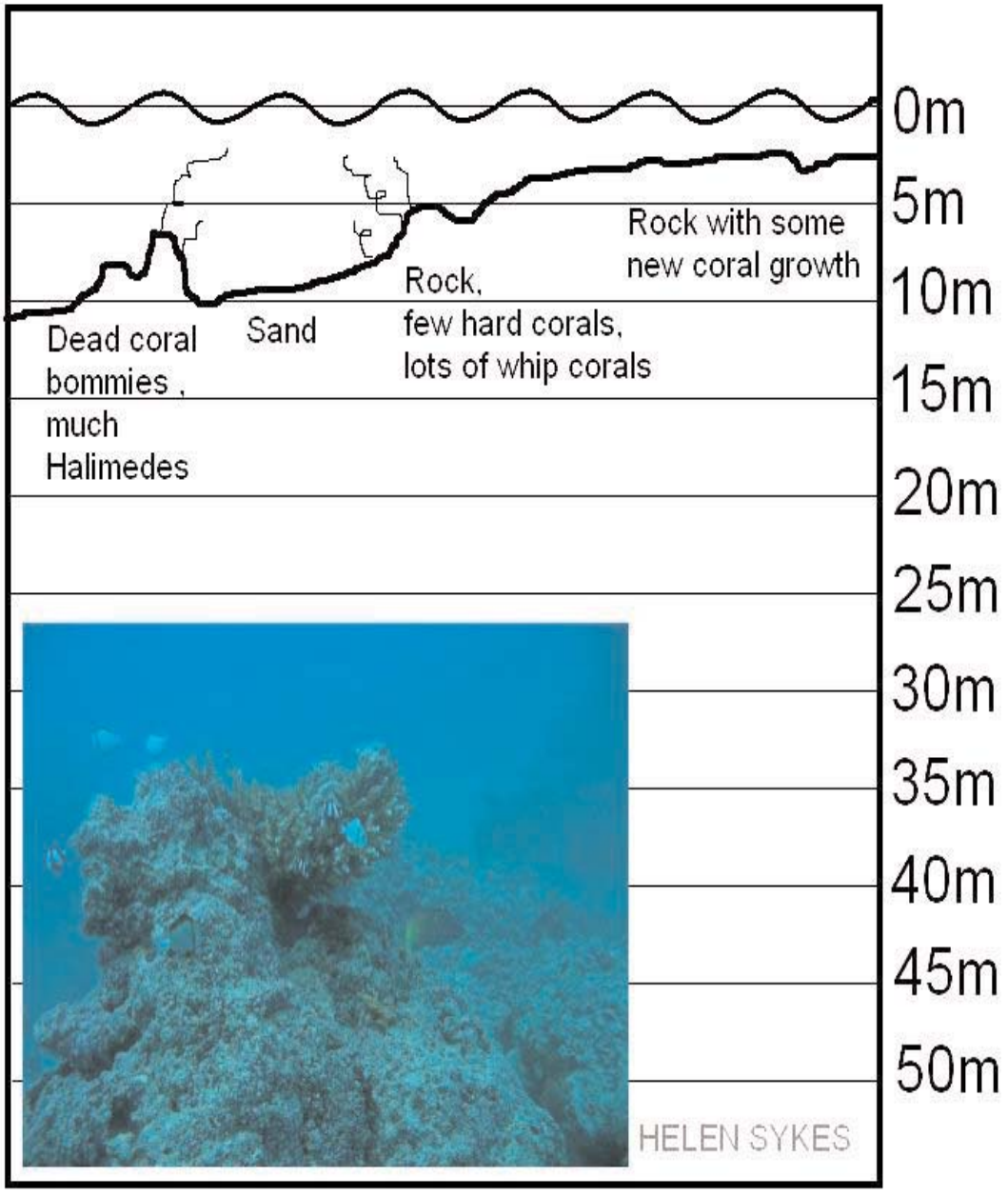


**Table 21.** Coral Reef Fish Diversity Index (numbers of species) for Tilagica Island compared on national, regional and global scales.

| FAMILY | TILAGICA ISLAND | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 20 | 79 | 350 | 402** |
| Damselfish | 20 | 63 | 274 | 330 |
| Butterflyfish | 19 | 35 | 105 | 122 |
| Angelfish | 6 | 14 | 69 | 82 |
| Parrotfish | 3 | 23 | 64 | 83 |
| Surgeonfish | 9 | 27 | 63 | 71 |
| Total (CFDI) | 77 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

The diversity of fish on Tilagica Island is moderate with a total recorded fauna of 143 species (see complete species list in Appendix C) however it contains several IUCN Redlisted species. CFDI families represented 54% of the visible community of fish. Tilagica Island reefs alone possesses 54% of the known Butterflyfish and 43% of the known Angelfish of the Fiji islands (Table 20). About 7 % of the worlds known fish diversity within the CFDI families are found at this site. This site also supports populations of three IUCN Redlisted species; Leopard Coralgrouper (Plectropomous leopardus), White-tip reef shark (Triaenodon obesus) and the Bluespotted ribbontail ray (Taeniura lymma).

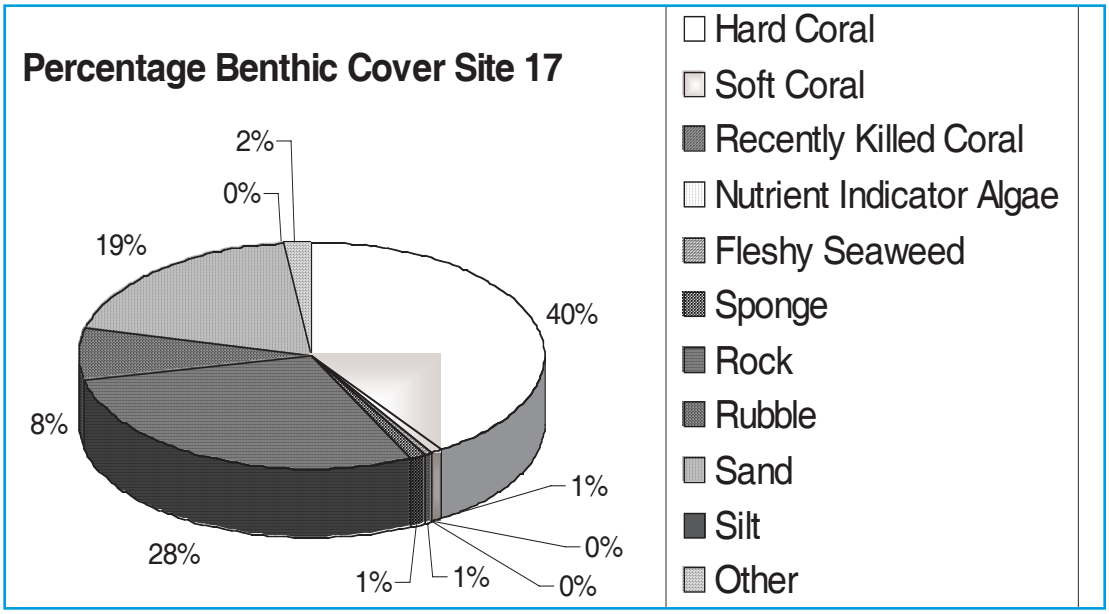
## CORALS

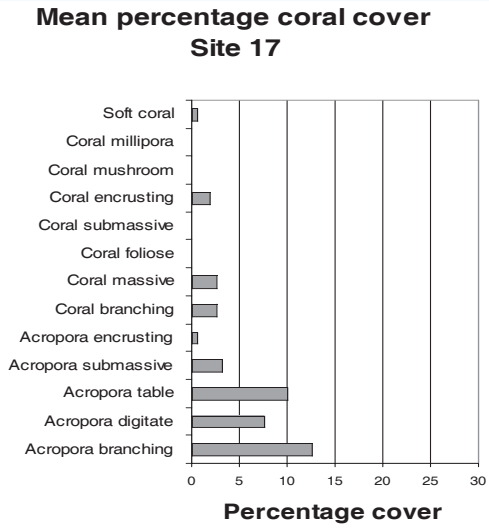
At 6m depth, a sand expanse of abundant seagrass Halodule uninervis occurred. Isolated reef mounds throughout the area. Species noted in area are Galaxea fascicularis, G. astreata, Goniopora lobata, Leptastrea pruinosa, Porites lobata, Echinopora echinata, Cyphastrea serailia, Goniastrea edwardsi, Psammocora sp., Symphyllia spp., clumps of Acropora rosaria, A. sarmentosa, Astreopora listeri, A. gracilis. Habitat is characterised by large boulders (old Diploastrea and/or Porites) which are now covered with algae though many small coral are colonizing the boulder substrate. Estimated 3% coral cover by isolated colonies on the coral rocks. Bleaching occurred in 2002, so growth on these is within 32 months. Earlier environmental change more probably caused the death of the coral which is now in an environment characterised by siltation and limited visibility. Silt is evident on the surfaces. Abundant Halimeda spp. are present. Species noted were Pectinia paeonia, Pachyseris rugosa, Montipora verrucosa, M. grisea, M. danae, Favites halicora, Goniopora tenuidens, Cyphastrea decadia, Pavona clavus, with Fungia danae common as were Acropora carduus and A. echinata.

## MARINE FLORA

Sixty species of marine flora were recorded around Tilagica island and this is the second highest species total for any site (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS



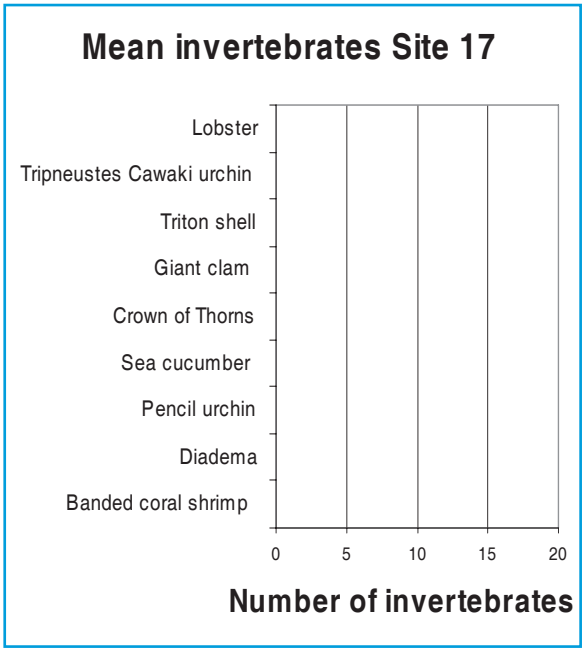



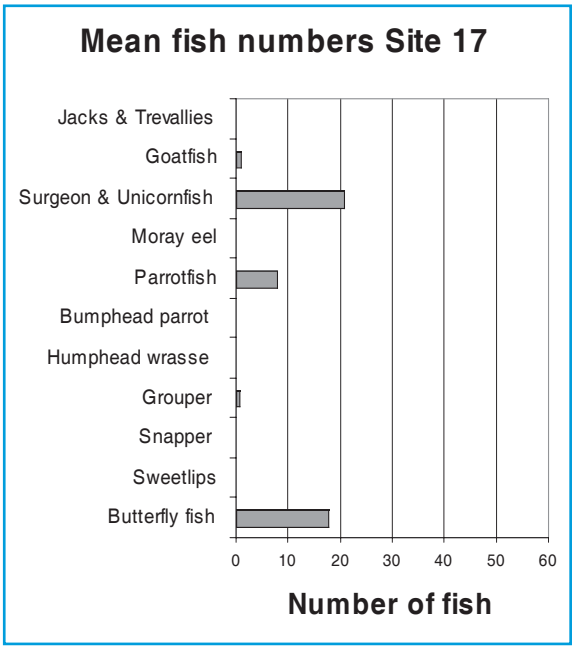

This shoal is mostly dead coral rock and sand, with quite high new hard coral growth in the shallows, mostly Acropora of various types.

High Halimedes algae cover was found below the depth of the survey

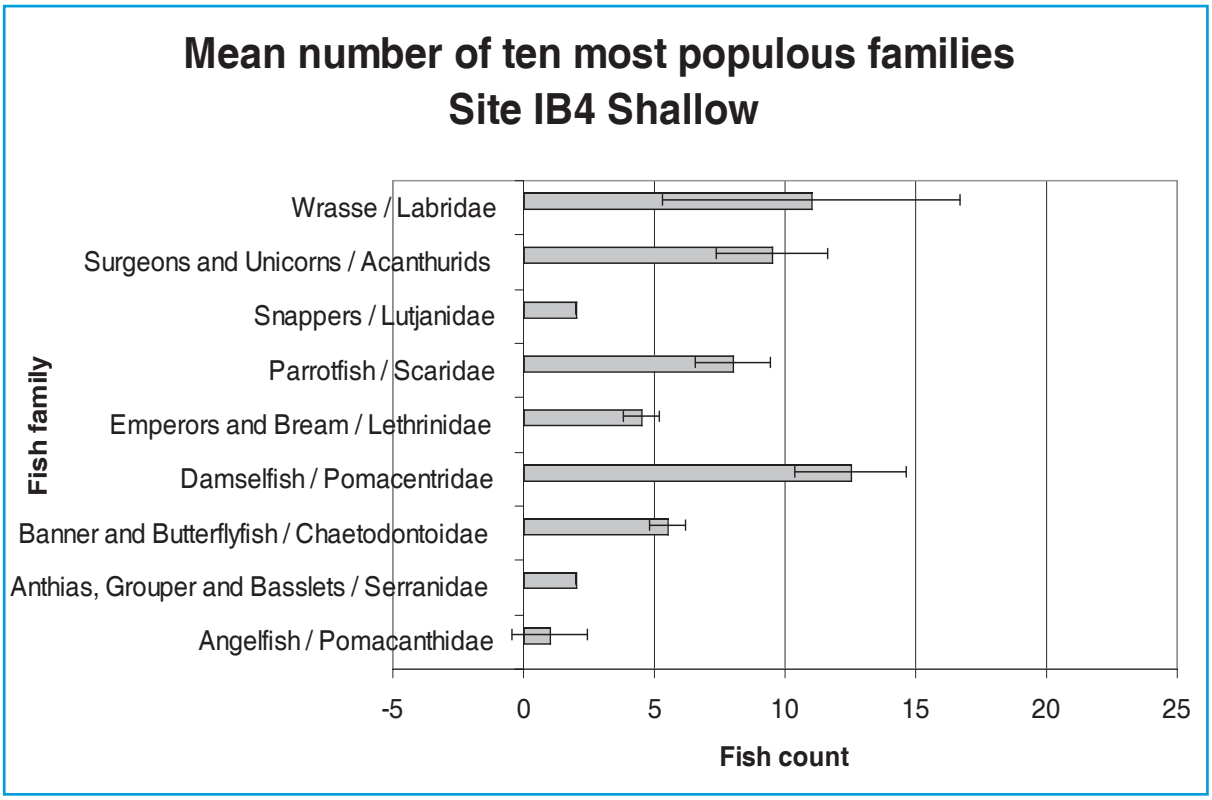
No invertebrates were found at all.

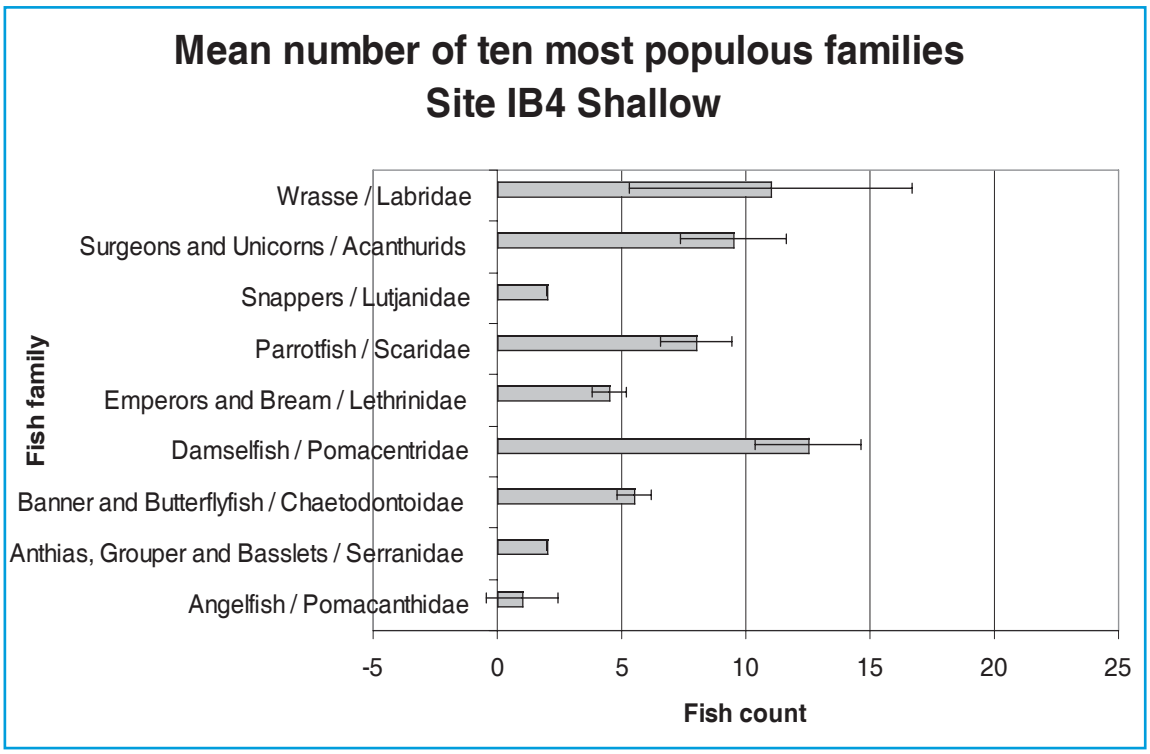
Fish seen were predominantly small surgeonfish, butterfly fish and a few parrotfish.




## FISH ABUNDANCE AND SIZE CLASS






The high fish numbers on this site were mostly of the surgeonfish, wrasse, damsel and parrotfish families. The groupers seen were very small, there was quite a high population of moderately-sized emperors, and a few medium sized snappers.

# TILAGICA PASSAGE - CHANNEL

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 18 | 13.12.04 | 13.10 | 13.45 | CH5 | Deep | Tilagica Pass | Passage wall |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o09.794' | 179o45.240' | 10m | 5m | None to moderate incoming | Dead Low | 27.5 |

## 7.16 TILAGICA PASSAGE - CHANNEL

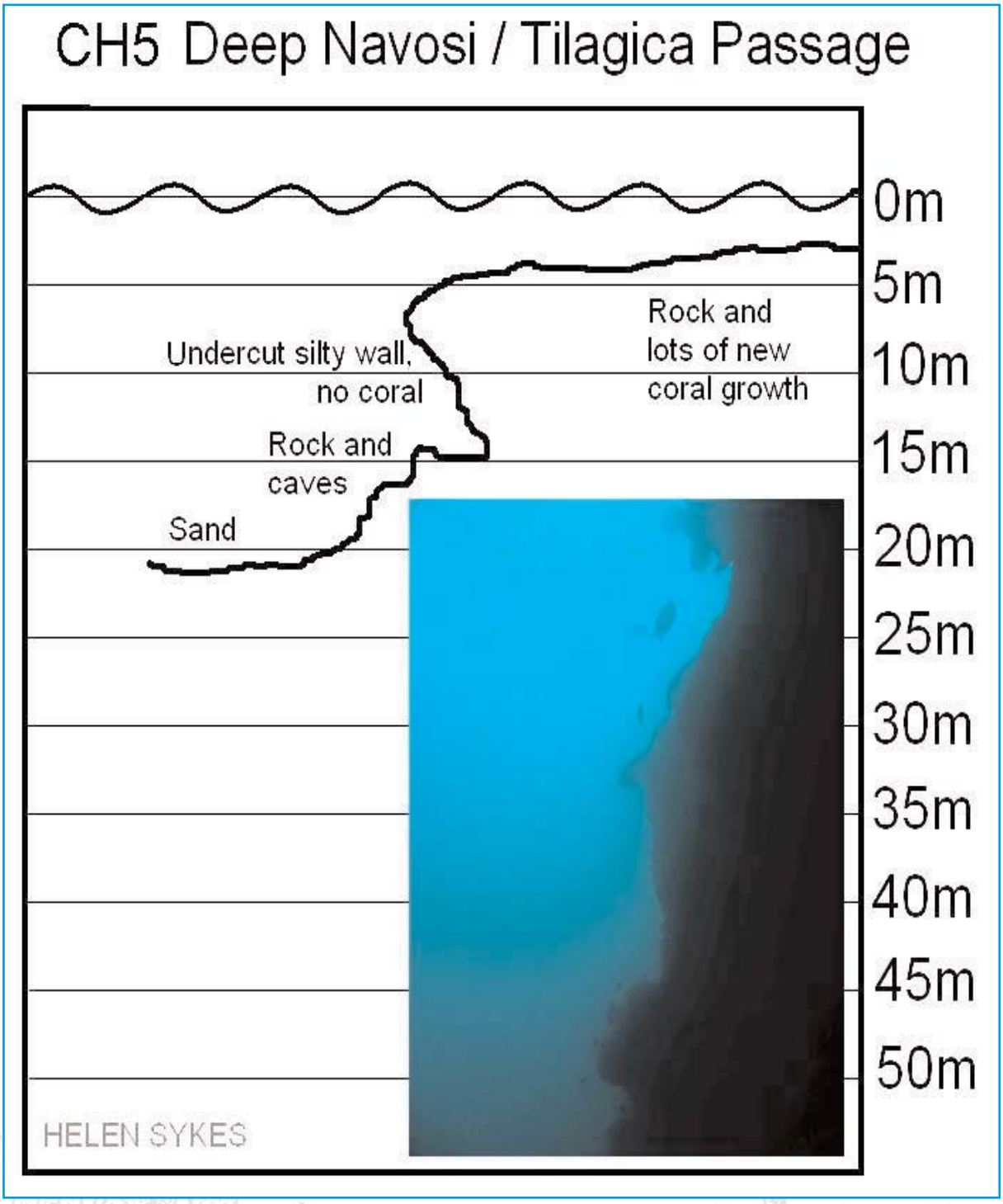


**Table 22.** Coral Reef Fish Diversity Index (numbers of species) for Tilagica Passage compared on national, regional and global scales.

| FAMILY | TILAGICA PASSAGE | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 20 | 79 | 350 | 402** |
| Damselfish | 21 | 63 | 274 | 330 |
| Butterflyfish | 16 | 35 | 105 | 122 |
| Angelfish | 3 | 14 | 69 | 82 |
| Parrotfish | 5 | 23 | 64 | 83 |
| Surgeonfish | 9 | 27 | 63 | 71 |
| Total (CFDI) | 74 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

Tilagica passage is the most eastern of the passages surveyed, close to Udu Point., and the closest passage to land. It has a current-scoured passage wall, very high silt levels and low visibility. Survey was carried out towards the mouth of the channel. The visibility was low (< 5 m). Continuous carbonate structures create a sub tidal bank, where good coral growth is seen in the 3 m depth reef flat plateau. The slope is acute in some places, aligning at a 90o angle. At 10+ meter depth, Callophycus serratus, Caulerpa opposita and Tricleocarpa fragilis dominate.

## ALPHA DIVERSITY

### FISH

The diversity of fish in Tilagica Passage is moderate with a total recorded fauna of 144 species (see complete species list in Appendix C) however it contains populations of several IUCN Redlisted species. CFDI families represented 51% of the visible community of fish. Tilagica Island reefs alone possesses 46% of the known Butterflyfish and 33% of the known Damselfish of the Fiji islands (Table 21). About 6.7 % of the worlds known fish diversity within the CFDI families are found at this site. This site also supports populations of four IUCN Redlisted species; Humphead Wrasse (Chelienus undulatus), Leopard Coralgrouper (Plectropomous leopardus), White-tip reef shark (Triaenodon obesus) and Manta Ray (Mobula birostris).

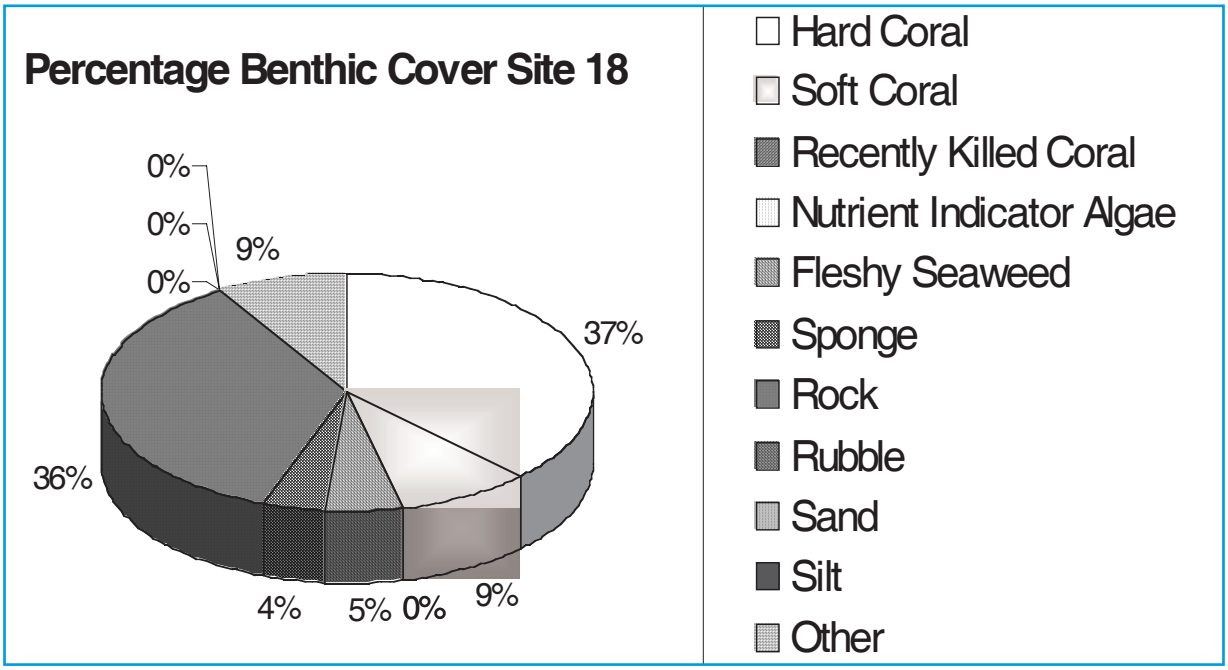
### CORALS

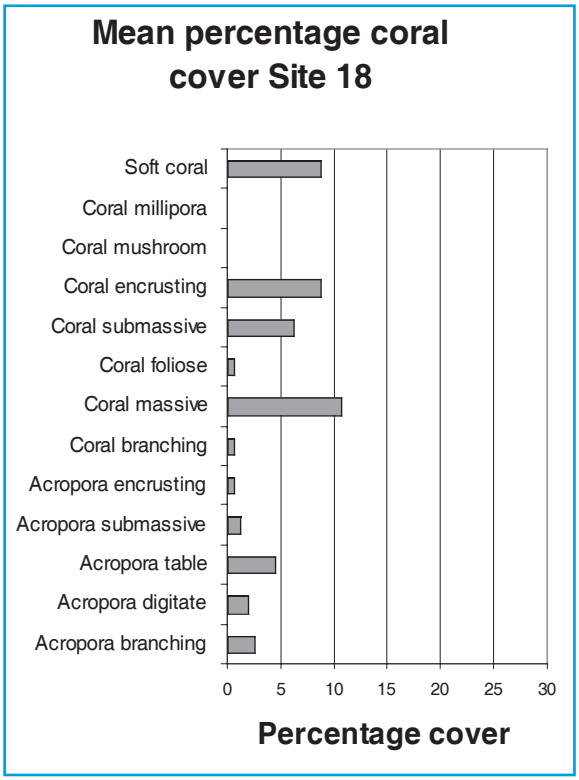
The wall environment is steep with overhangs. This is a high current area during tidal changes. Species noted were Montipora venosa, Acropora granulosa, A aspera, A. speciosa , A. subglabra, A. carduus, A. cerealis, A intermedia, A. hyacinthus, A cytherea, A clathrata, A. valida, A. humilis, A. cerealis, A. granulose, Turbinaria stellulata, T. peltata, Symhyllia recta, Echinophyllia aspera, Astreopora suggesta, Pavona maldivensis, Merulina ampliata. Reef flat crest on channel margin is predominated by Acropora corymbose growth forms at a depth of 5m. Dominant species were Acropora hyacinthus, A. cytherea, A. clathrata, A. selago, A. nasuta, and Pocillopora eydouxi.

### MARINE FLORA

Fifty three species of marine flora were recorded around Tilagica Passage (full species list in Appendix C).

## SITE CHARACTER AND POPULATIONS

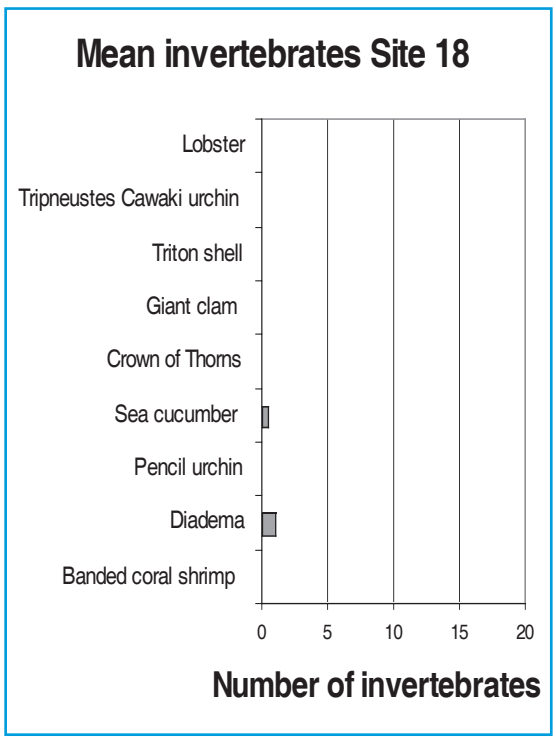


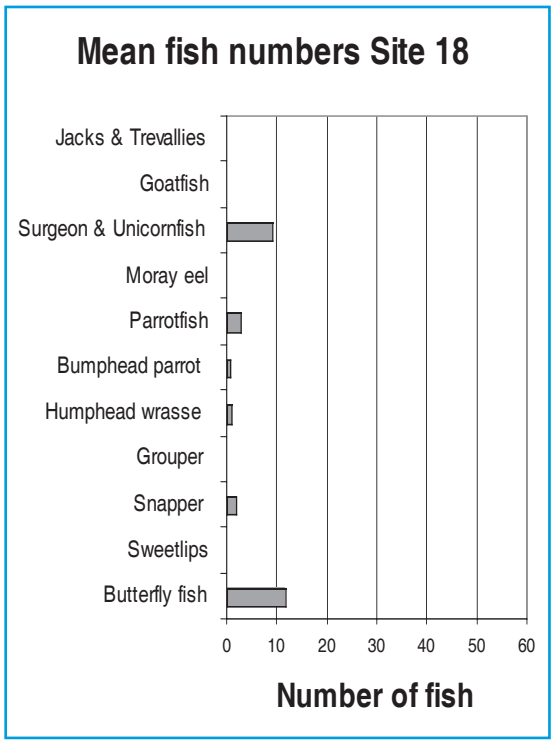




Even though most of the rock walls were covered in a fine layer of silt, many hard and some soft corals were flourishing in the shallower areas of this passage, primarily massive, submassive and encrusting Non-Acropora species.

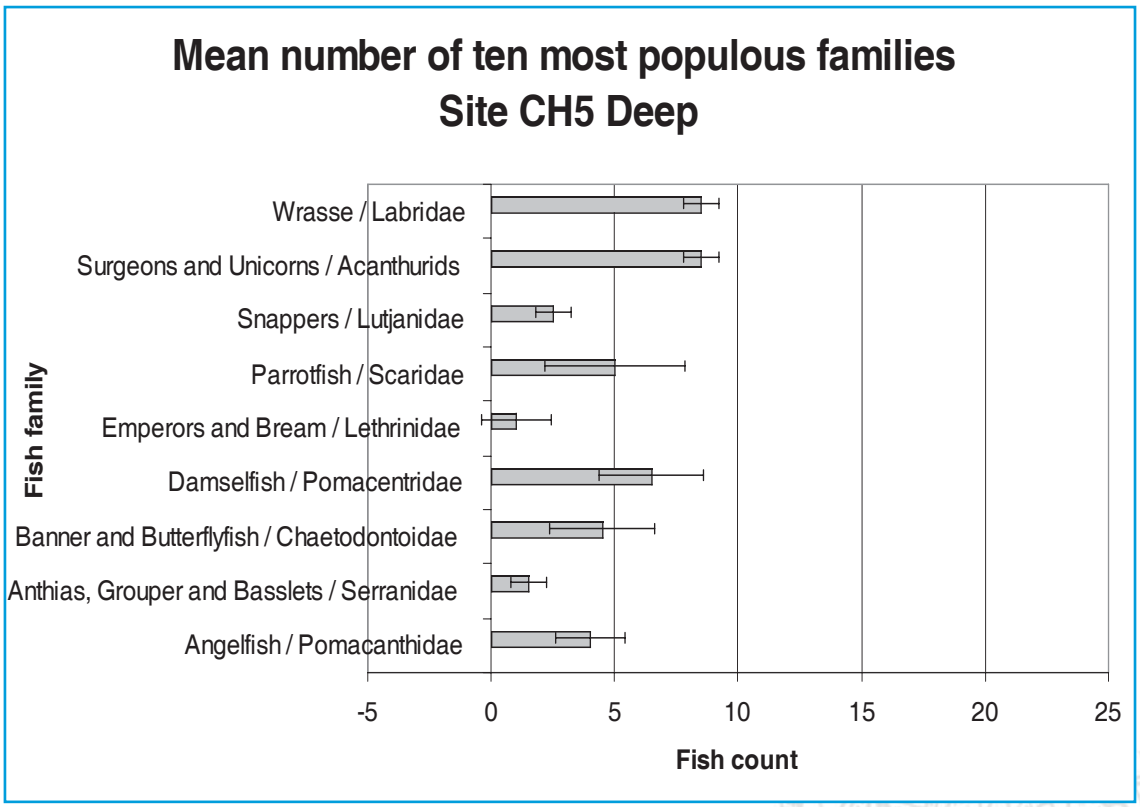
Very few invertebrates were found, a few Diadema urchins and a sea cucumber.

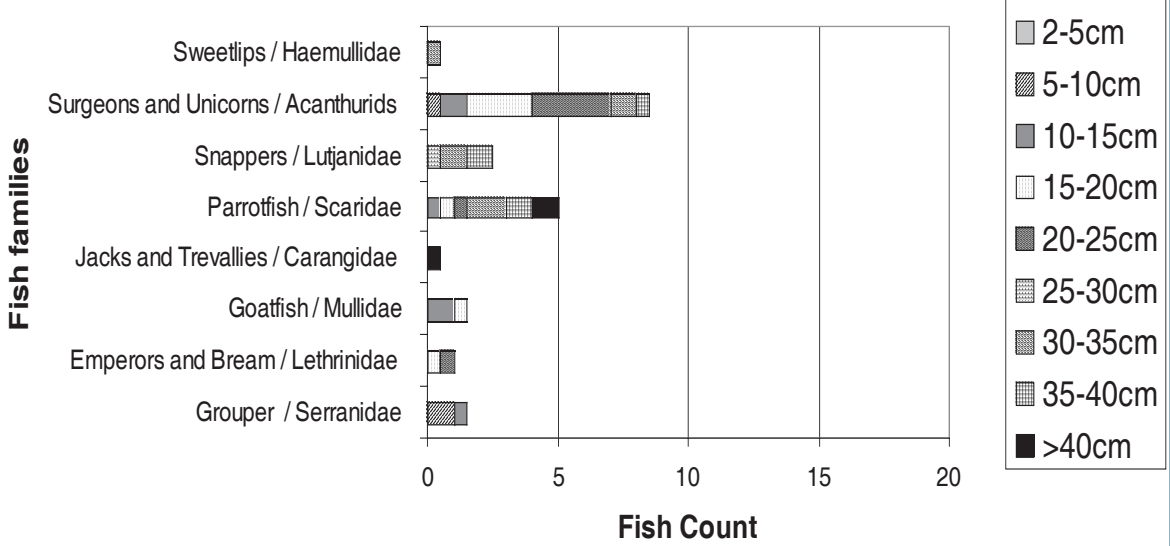
Low numbers of fish were seen, but the low visibility means that there could have been others not observed. Of those counted, the most common were surgeon and unicornfish, and butterfly fish.




## FISH ABUNDANCE AND SIZE CLASS






This passage had relatively low fish numbers, dominated by wrasse, surgeon & unicornfish, and damselfish, but some fairly large fish, including large trevallies and parrotfish. Relatively large numbers of angelfish were seen, unusually equaling the butterflyfish populations.

## 7.17 TALAILAU ISLAND - FRINGING AND PATCH REEFS

## TALAILAU ISLAND - FRINGING AND PATCH REEFS

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 19 | 14.12.04 | 8.40 | 9.35 | IP3.5 | Deep | Talailau Reef | Mangrove island |
| 20 | 14.12.04 | 12.00 | 13.00 | IP3.5 | Shallow | Talailau Reef | Mangrove island |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o22.508' | 179o09.217' | 10m | 10m | None | Falling | 28 |
| 16o22.508' | 179o09.217' | 5m | 10m | None | Low | 29 |

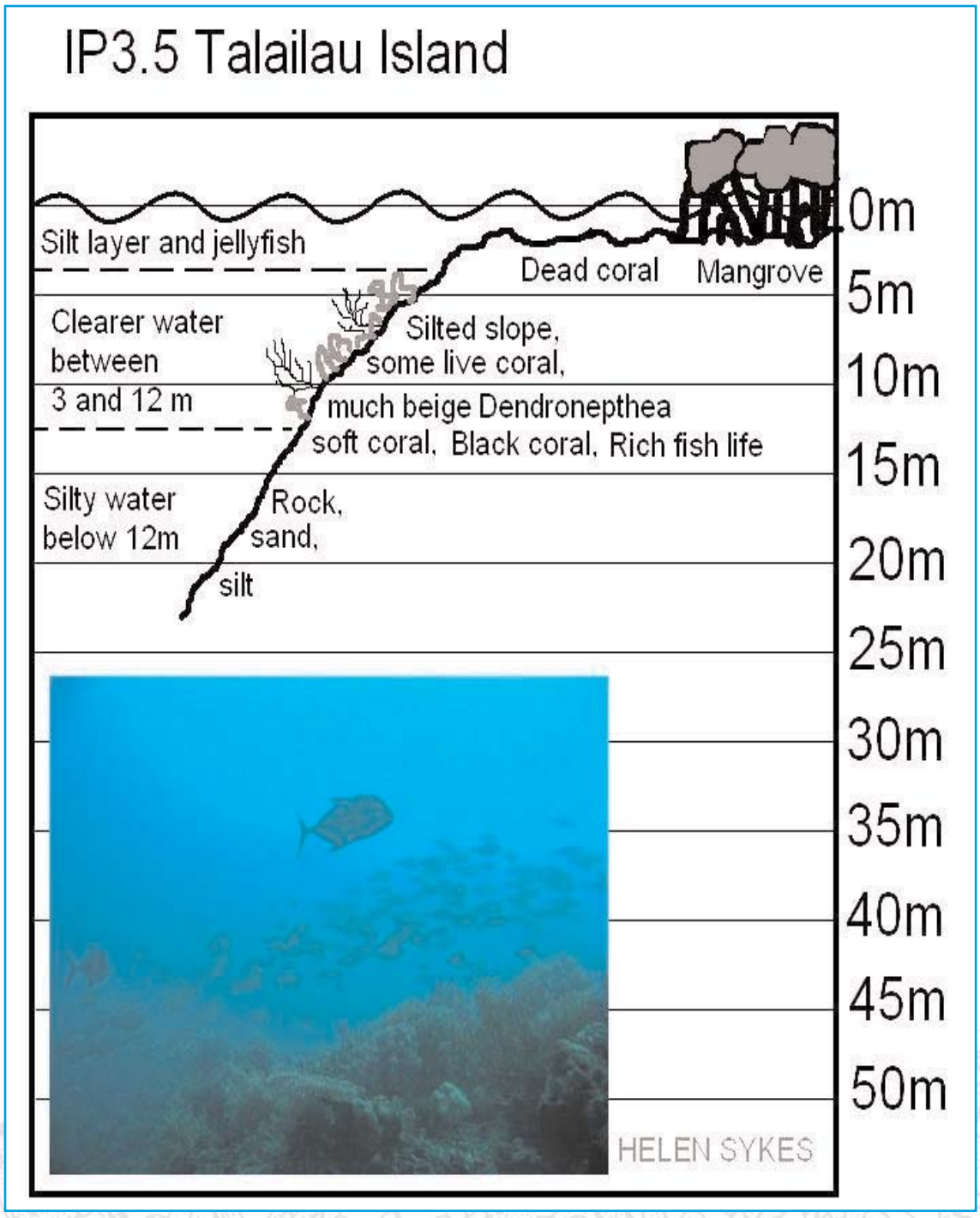


**Table 23.**
Coral Reef Fish Diversity Index (numbers of species) for Talailau Island compared on national, regional and global scales.

| FAMILY | TALAILAU ISLAND | FIJI ISLANDS* | INDO-WEST PACIFIC | WORLDWIDE |
|---|---|---|---|---|
| Wrasses | 22 | 79 | 350 | 402** |
| Damselfish | 24 | 63 | 274 | 330 |
| Butterflyfish | 13 | 35 | 105 | 122 |
| Angelfish | 4 | 14 | 69 | 82 |
| Parrotfish | 8 | 23 | 64 | 83 |
| Surgeonfish | 7 | 27 | 63 | 71 |
| Total (CFDI) | 78 | 241 | 925 | 1090 |

*Sources: GSR-this survey; Fiji - combined species lists of Allen and Jenkins; Indo-West Pacific, Worldwide - Jenkins 1999 **tropical species only*

This reef fringes a fairly extensive mangrove flat near the island of Talailau, opposite Naduri Bay, and below Kia Island. It is a sloping reef with a high level of silt, and poor visibility, dominated by beige Dendronepthea. It has large numbers of fish, and is potentially a very good site for Marine Protected Area development. It was surveyed at two depths, 10m (survey 19) and 5m (survey 20). Survey was carried out on the northern part of the mangrove-islet. A shallow reef flat extends outwards from the mangroves before sloping to 18-20 m depth. The substratum at this depth was of fine muddy sand with very few organisms seen. Algal communities were more common in the shallower part. Tydemania expeditionis and Udotea orientalis were found common at <15 m depth. Coralline algae - usually Hydrolithon species, were also found at this depth as well as Peyssonnelia sp. At 3 m depth, soft corals, hard corals and sponges were found in abundance as well as Galaxaura divaricata. At 3 m depth the topography starts to level off to the reef flat at around less than 2 m, where algae become the dominant organism. Padina was perhaps the most dominant alga.

A small adjacent patch reef was also surveyed for algae and sponge collections. It is approximately 500 m long X 300 m wide; exposed during low tides. The slope is acute in some places and gentle in others, leveling at around 18-20 m depth in the north-eastern side. The substratum at the sea-floor is soft sandy mud at least 20 cm thick. The current was moderately calm and the visibility very low (ca. 5 m) at the bottom becoming slightly better at 10 m depth. High number of clams and oysters was seen and a few holothurians were noted at 3-10 m depths. High fish diversity was noted with bigger sized fish noted at 5-10 m depth. Recently dead and dying soft-corals and othuroids were noted, at 3-5 m depth, near a slope where rubble, sand and sediment were eroded (land-slide) to the bottom. There was very poor algal community at this site, with only an unattached Halimeda macroloba seen at 20-m depth. At 10 m depth, coralline algae were noted as well as other encrusting red algae: Peyssonnelia species. Udotea orientalis was found growing between coral colonies or in places where sediments rest on rock. Towards the shallower depths (<3 m), Actinotrichia fragilis and Amphiroa foliacea dominate and are often seen growing between branching Porites. Some turf algae were also noted growing near the base of Acropora corals.

## ALPHA DIVERSITY

### FISH

The diversity of fish on Talailau island fringing reefs is moderate/high with a total recorded fauna of 161 species (see complete species list in Appendix C) and it contains populations of several IUCN Redlisted species. CFDI families represented 48% of the visible

community of fish. Talailau Island reefs alone possesses 34% of the known Parrotfish and 38% of the known Damselfish of the Fiji islands (Table 22). About 7 % of the worlds known fish diversity within the CFDI families are found at this site. This site also supports populations of three IUCN Redlisted species; Humphead Wrasse (Chelienus undulatus), Leopard Coralgrouper (Plectropomous leopardus) and White-tip reef shark (Triaenodon obesus).

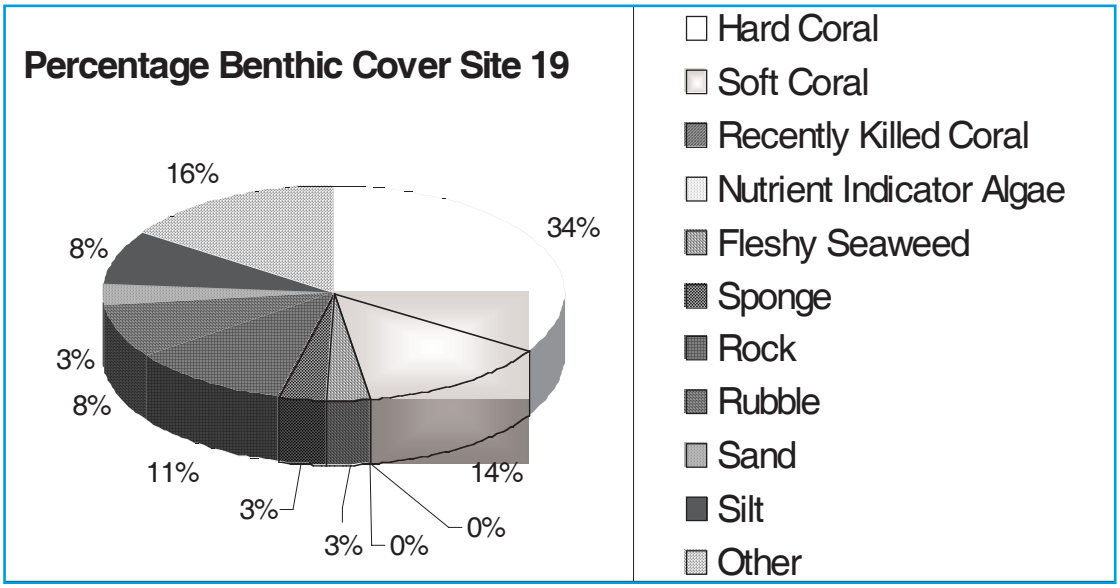
## CORALS

The reef extends from the mangroves as a narrow reef flat margined by Acropora divaricata, and A. nasuta. Porites spp. dominate the reef slopes to 20m where it is margined by a soft silt bottom. The reef is generally very silty. Goniopora lobata with lots of small Pectinia spp. are present. Caespitose and tabulate Acropora colonies were dominant as was Porites rus and P. cylindrica. Acropora subglabra was common. Other species seen were Oxypora glabra, Echinopora gemmacea, Lithophyllon and Stylophora spp., Pectinia paeonia, Ctenactis simplex, Pavona varians, Turbinaria peltata, and T. heronensis.

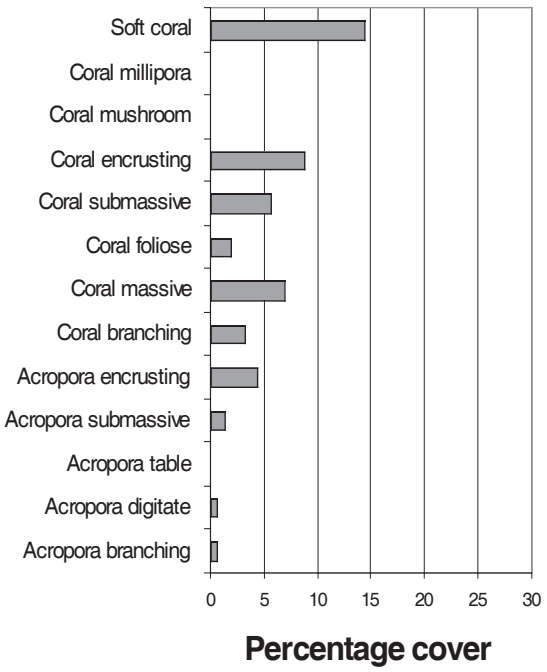
## MARINE FLORA

Twenty seven species of marine flora were recorded around Talailau Island and patch reef (full species list in Appendix C).

## OVERALL SITE CHARACTER AND POPULATIONS



## Mean percentage coral cover Site 19

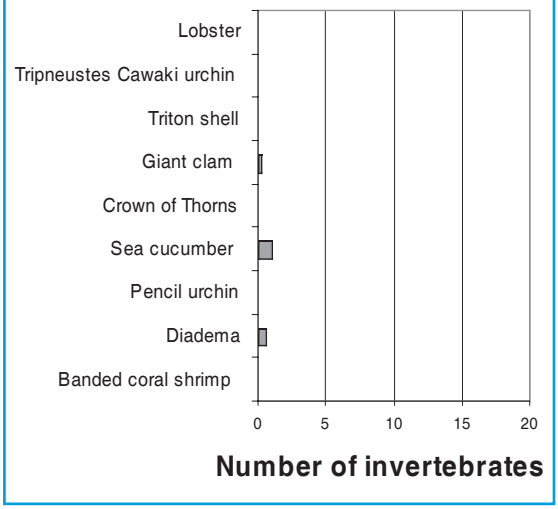



This area had very silty water and considerable amounts of silt on the rock and rubble substrate, but still had high levels of hard and soft coral growth, mostly non-Acropora species, and a single species of beige Dendronepthea soft coral.

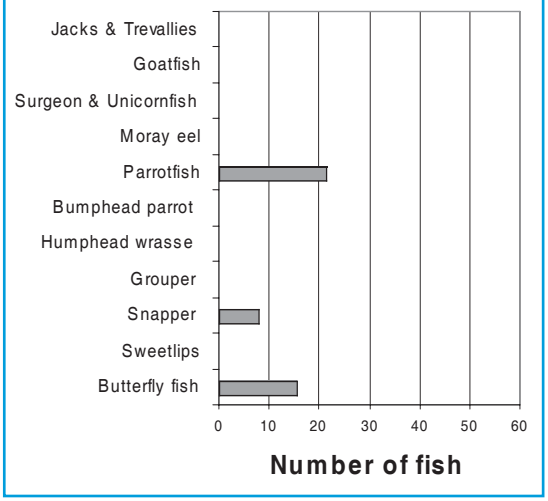
Very few invertebrates were found, a few Diadema urchins sea cucumbers, and a Tridachna giant clam.

Fish numbers were high, most noticeably very large schools of parrotfish, and many snappers and it is felt that this is an important spawning ground.
Some large Trevallies were seen off transect.

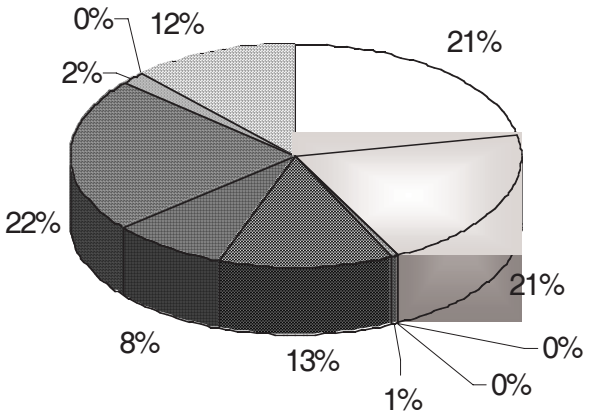
## Mean invertebrates Site 19




## Mean fish numbers Site 19

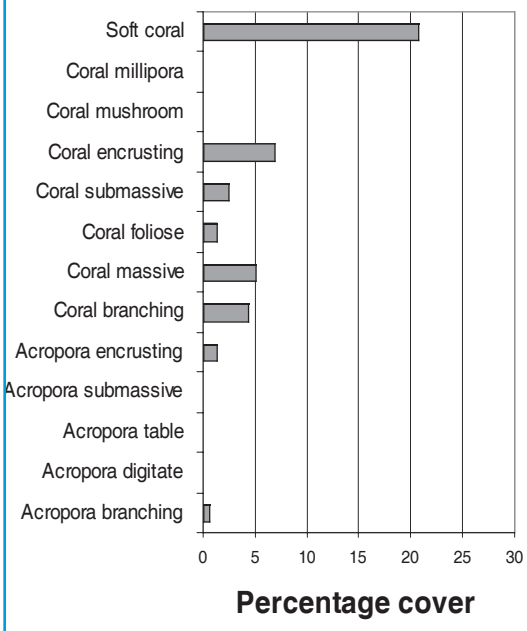


## Percentage Benthic Cover Site 20




- Hard Coral
- Soft Coral
- Recently Killed Coral
- Nutrient Indicator Algae
- Fleshy Seaweed
- Sponge
- Rock
- Rubble
- Sand
- Silt
- Other

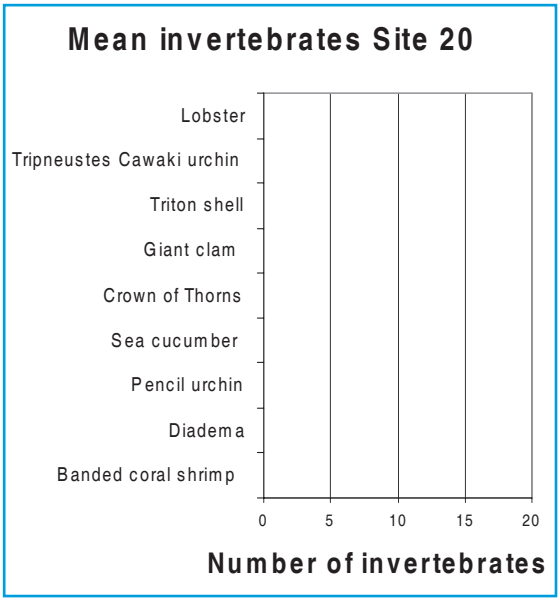
## Mean percentage coral cover Site 20

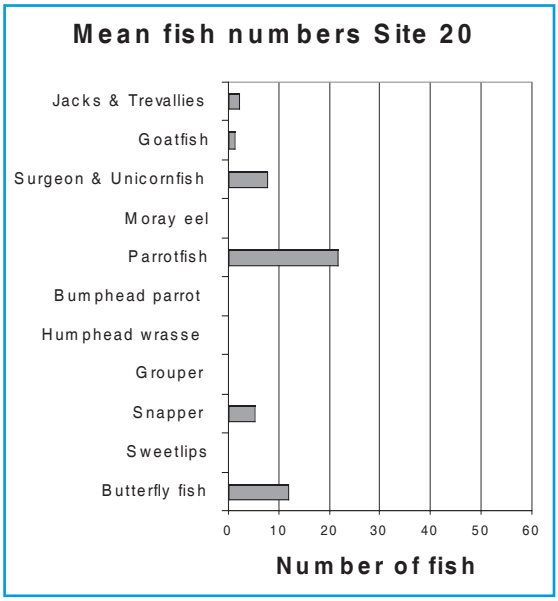



The shallower reef also had very silty water and considerable amounts of silt on the rock and rubble substrate. There were still reasonable amounts of hard non-Acropora corals, and even higher amounts of the single species of beige Dendronepthea soft coral than seen on the deeper slope.

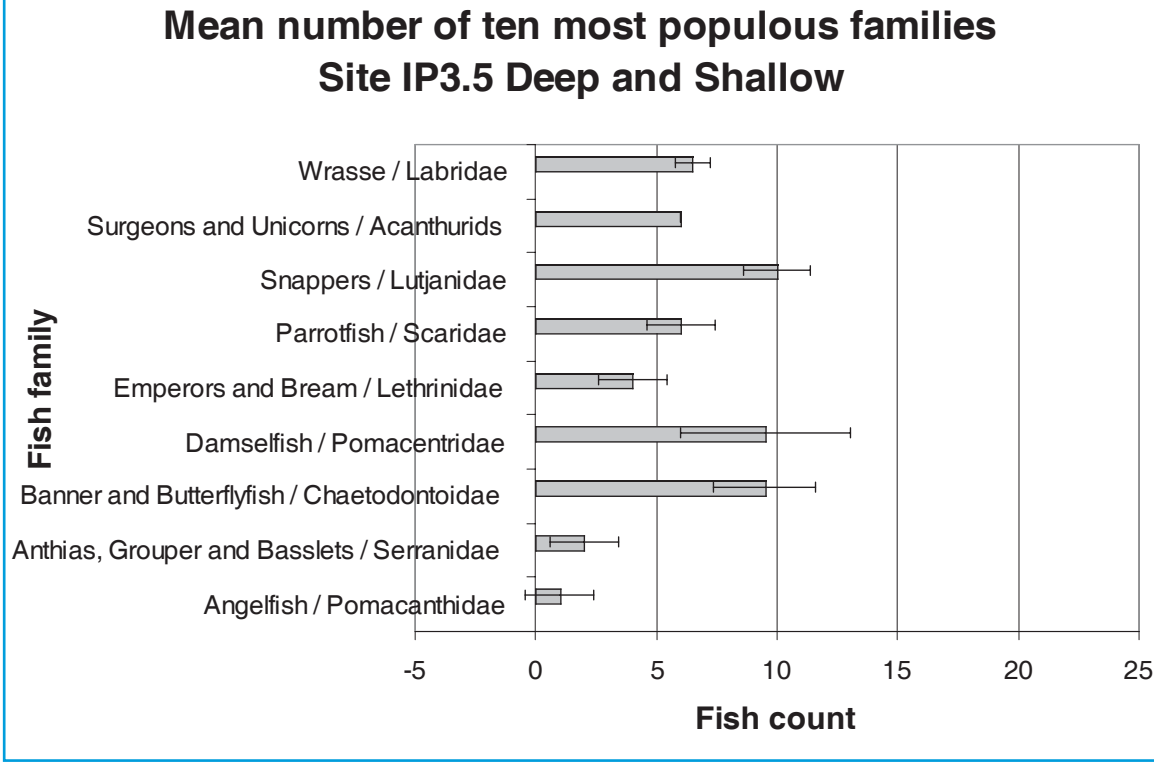
No invertebrates were found at all.

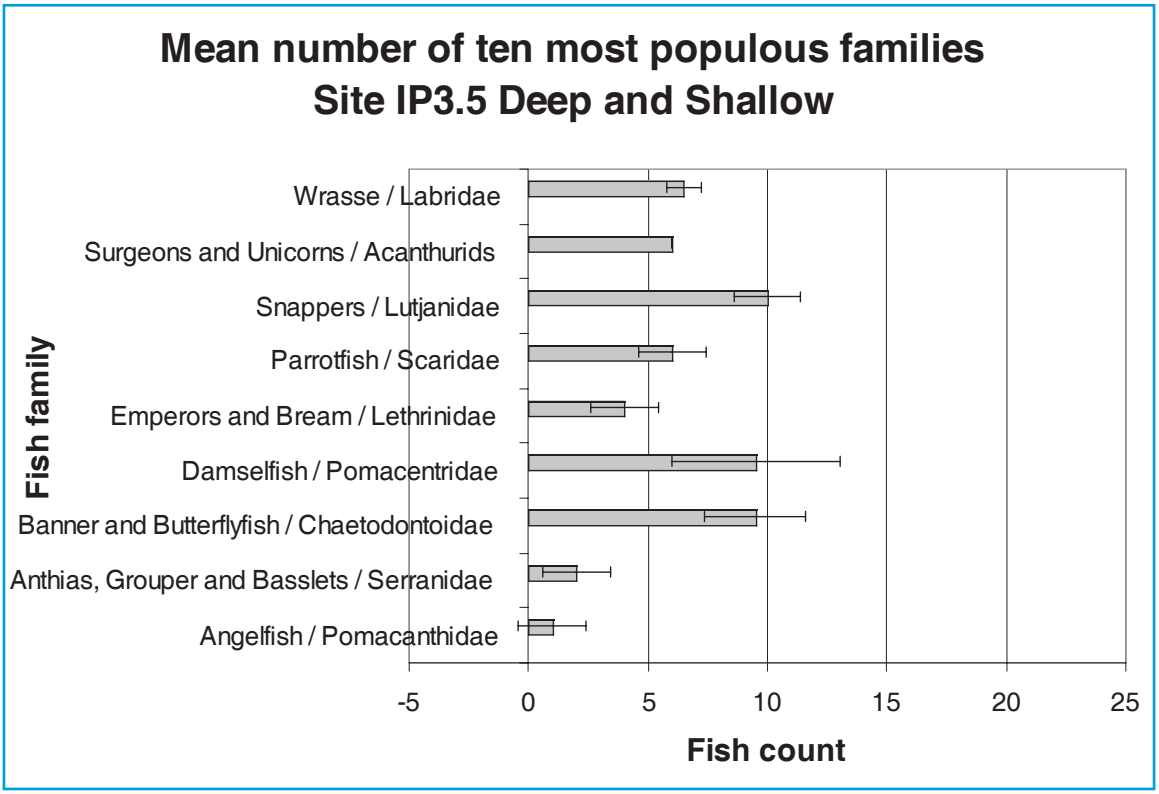
Fish numbers were high, most noticeably very large schools of parrotfish, and many snappers and it is felt that this is an important spawning ground.




## FISH ABUNDANCE AND SIZE CLASS






There were high fish counts at this site, and the highest number of snappers seen on any survey. These snappers were found in a variety of sizes, from 5 - 40cm in length, mostly of the species Black-spot snapper Lutjanus fulviflamma and Flametail snapper Lutjanus fulvus. Several large trevallies were also found, as well as a number of medium sized emperors.

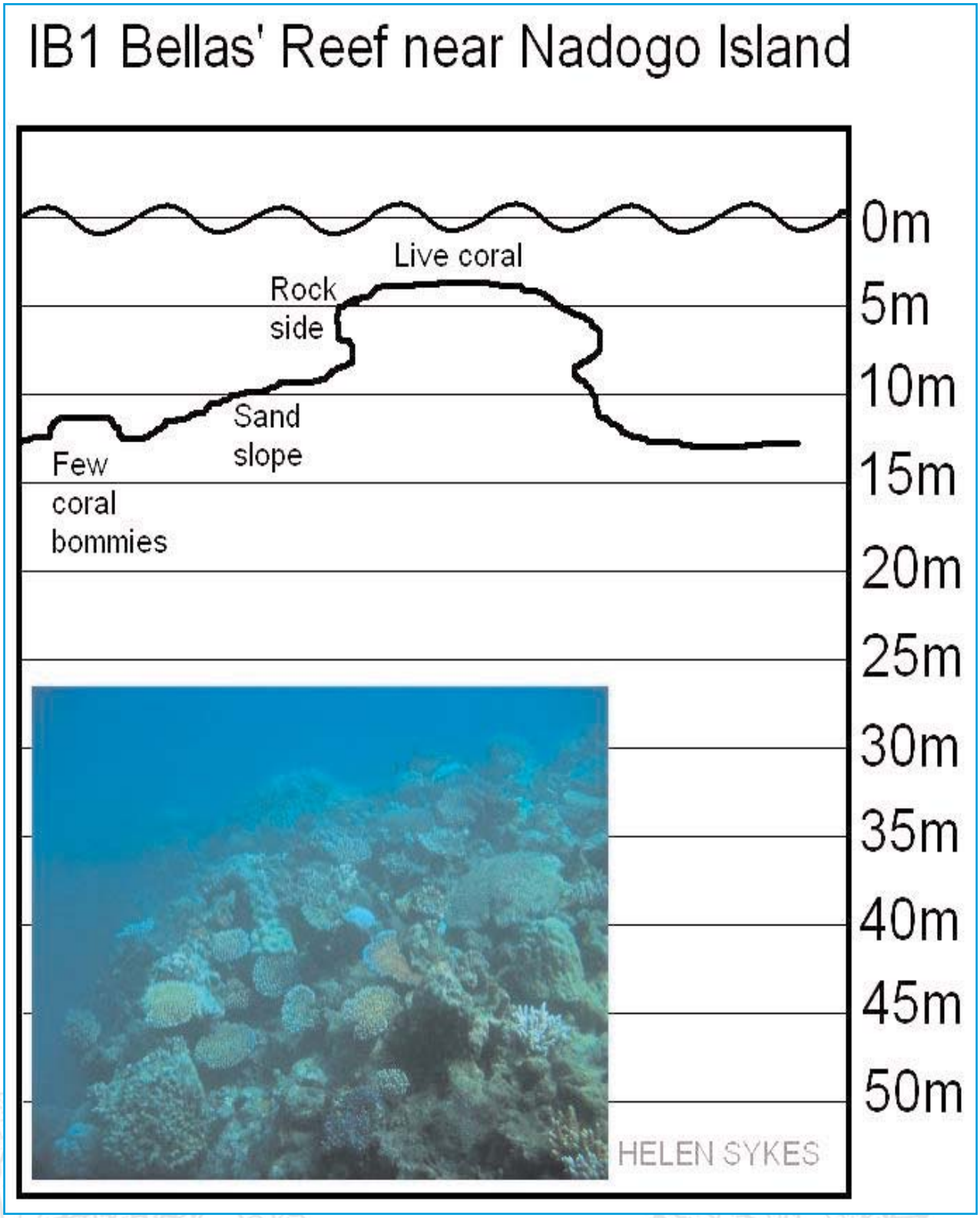
# BELLA'S REEF - SUBMERGED PATCH REEF

Survey details

| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 21 | 15.12.04 | 9.50 | 10.30 | IB1 | Shallow | Nadogo Bella's reef | Ribbon reef inside barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o28.171' | 178o45.091' | 5m | 15m | None | Falling | 28 |

## 7.18 BELLA'S REEF -SUBMERGED PATCH REEF

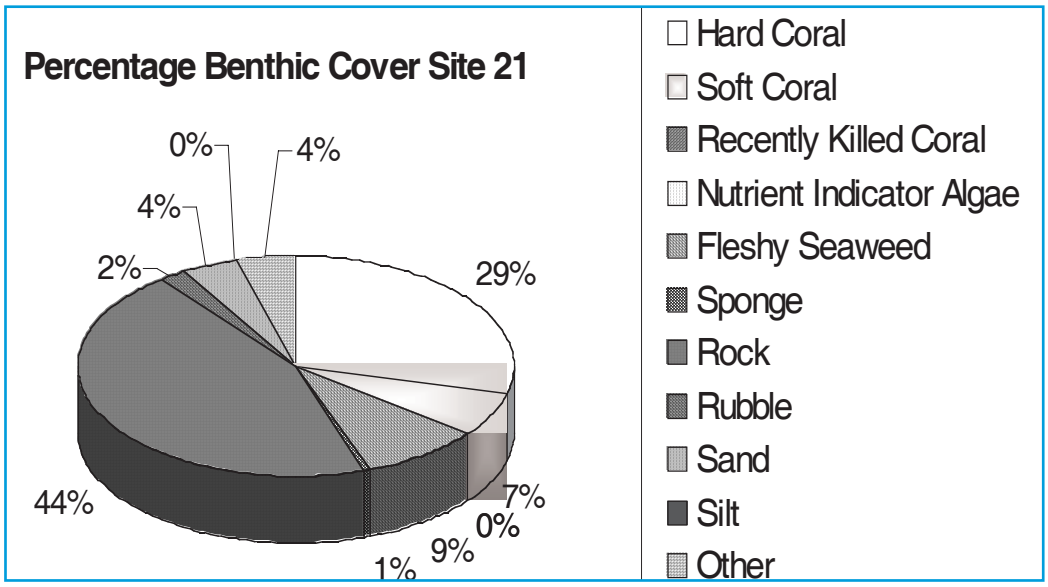


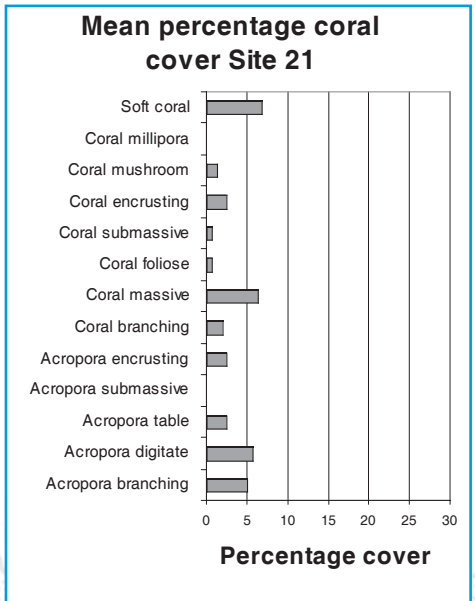
This is an unusual area of ribbon reefs in the middle of the broad lagoonal area opposite Nadogo island at the western extremity of the area surveyed. It has good hard coral cover on the top at 3 to 5 m, less on the deeper sandy bottom around 10 to 12m. It sits in clear waters. A few areas had heavy patches of red or green filamentous algae.

## CORALS

Mid-shelf reef with survey area protected by submerged reef ridge at 8m depth Reef area 5m from top of ridges. Species diversity is high with similarity to the double barrier reef of site IB2. Species noted are Acropora grandis, A. florida, A. loripes, A. muricata, A. samoensis, A. longicyathus, A. sarmentosa, A. carduus, Favia russeli, Favites abdita, Lobophyllia corymbosa, Cycloseris spp., Seriatopora hystrix, Cyphastrea decadia, Porites lobata, Platygyra lamellina and Galaxea astreata.

## SITE CHARACTER AND POPULATIONS

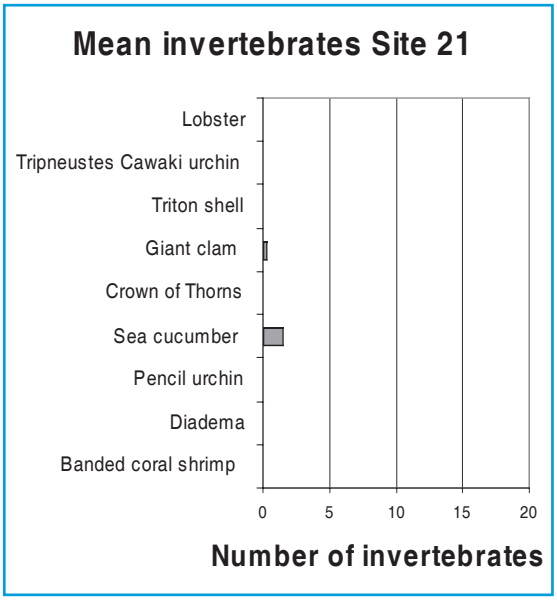


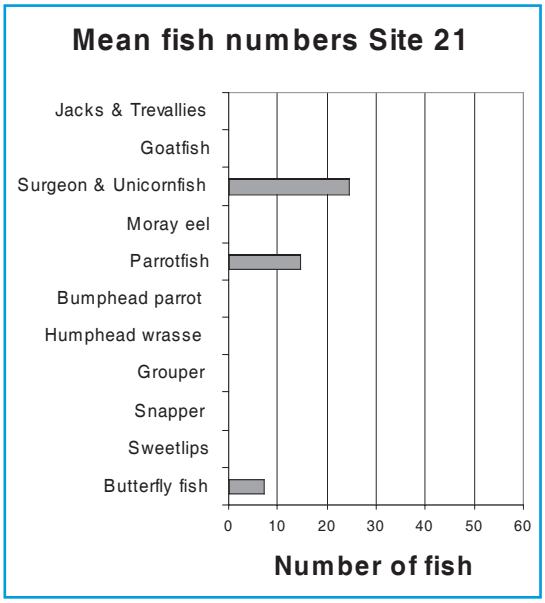




Most of this reef is made up of dead coral rocks with a covering of turf algae where damsel fish are situated. There are patches of rich hard coral growth, and other areas with little coral, but overall there is a good population of a variety of hard corals.

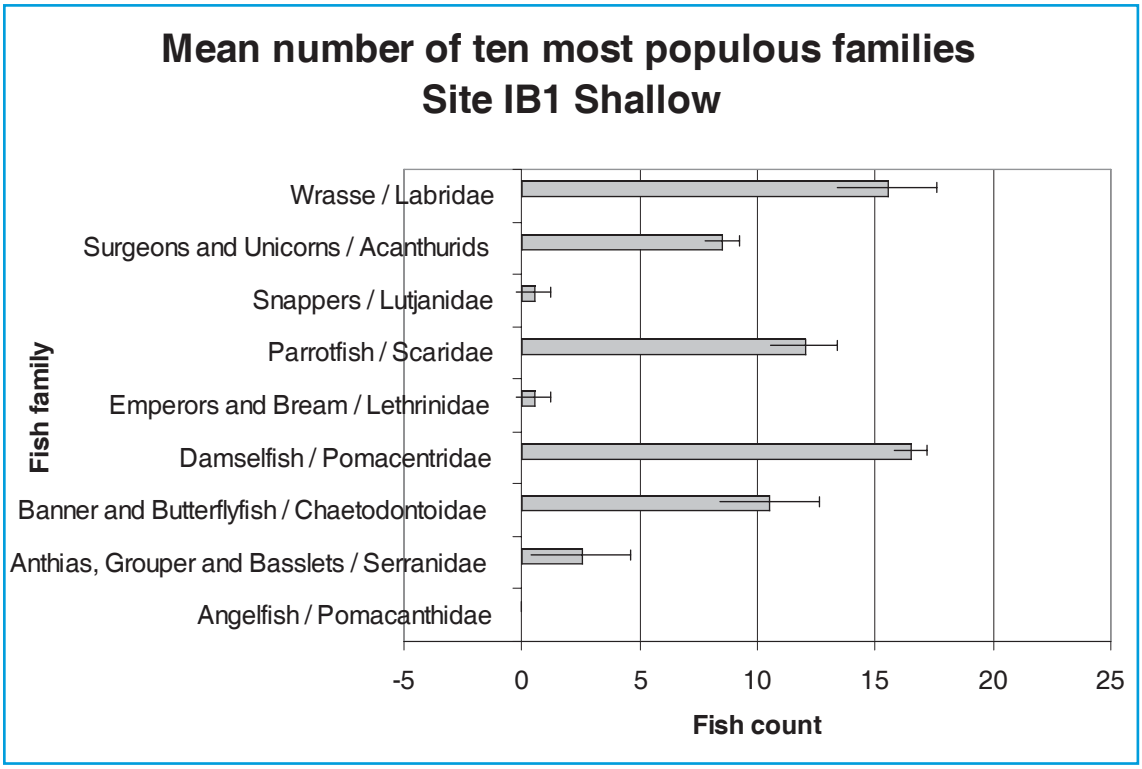
Few invertebrates were found, mostly sea cucumbers and one Tridachna giant clam.

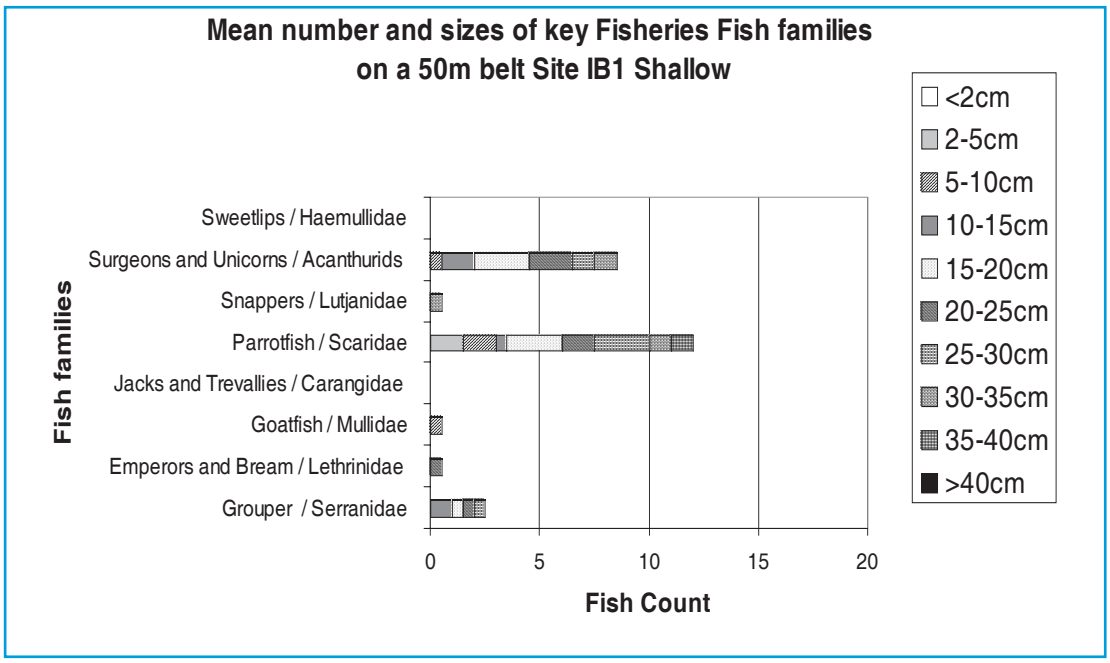
Numbers of surgeonfish were high, with some small parrot and butterfly fish, but no particularly large species. The reef is regularly fished by the local villages.




## FISH ABUNDANCE AND SIZE CLASS






This site had the highest fish count of any site during the surveys, with large numbers of wrasse, damsel, butterfly, parrot and surgeonfish. There were several small grouper (mostly the Honeycomb Grouper or "Kawakawa" Epinephelus merra) but very few large fisheries-important fish.

# UNNAMED CHANNEL - BARRIER CHANNEL

Survey details

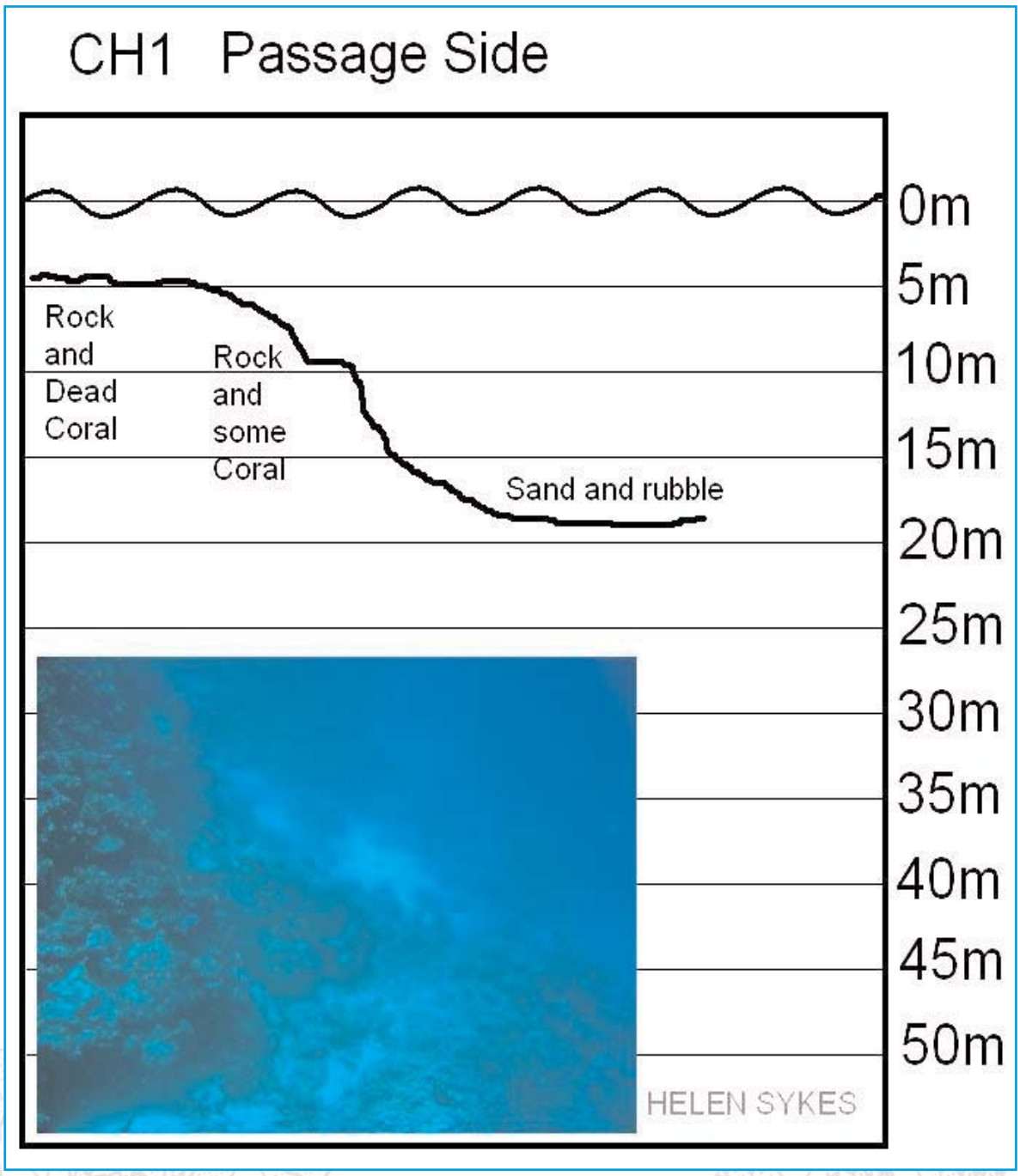
| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 22 | 15.12.04 | 12.15 | 12.30 | CH1 | Deep | No official name on map | Passage in outer barrier |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o19.648' | 178o44.016' | 12m | 12m | Mild outgoing | Falling | 28 |

## 10.19 UNNAMED CHANNEL - BARRIER CHANNEL

**Rapid Assessment Only**

Full surveys were not carried out due to time constraints. This is the result of rapid assessments done by Helen Sykes and Ed Lovell only.



This wide passage opposite Nadogo Island was the most westerly passage in the barrier reef investigated. It has rock and rubble sides dropping to a sandy floor, with low levels of live hard coral. Algal cover is low, and water is clear. There are pinnacle and patch reefs to be found in the deeper waters in the west of the lagoon area behind the passage.

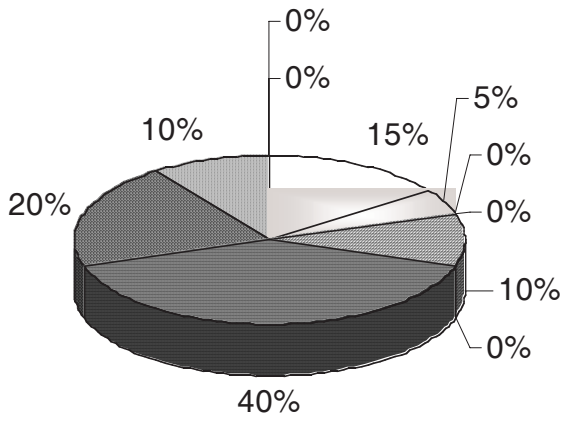
## CORALS

The site location includes the reef slope and reef flat. The visibility was 15m. There was evidence of bleaching death in 2002. Pavona minuta, Acropora valida, A. robusta, A. selago are common on reef slope. On the reef top, dead standing coral is 15-20% of the total coral. Robust forms of Acropora digitifera, A. robusta, Porites spp., F. pallida, and F. stelligera are evident. Abundant soft coral is 15%. Other hard coral species are Acropora robusta, A. samoensis, Hydnophora rigida and Goniastrea aspera. Presence of vertically branched form of an unusual Pocillopora spp.

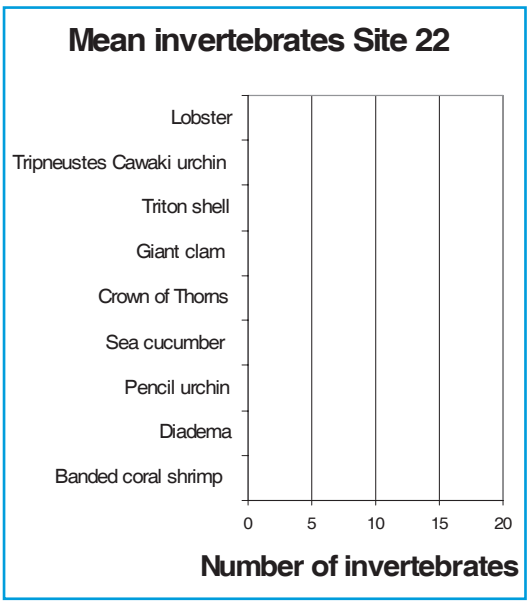
## SITE CHARACTER AND POPULATIONS

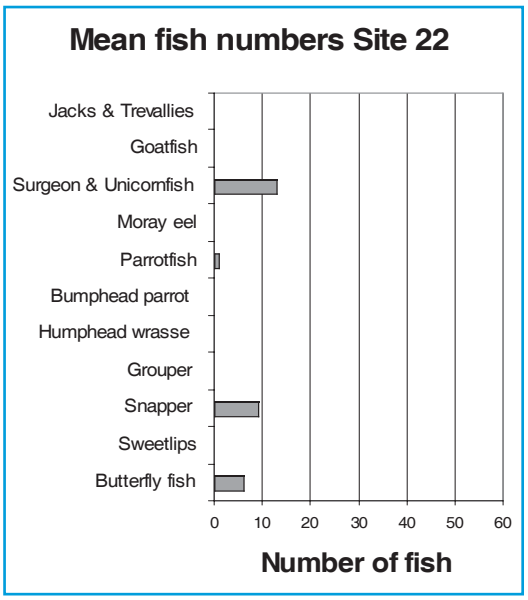
Note: These charts are drawn from estimations made during a 15 minute swim, not from measured transect data as with other sites. No detailed breakdown of coral types is available

**Percentage Benthic Cover Site 22**

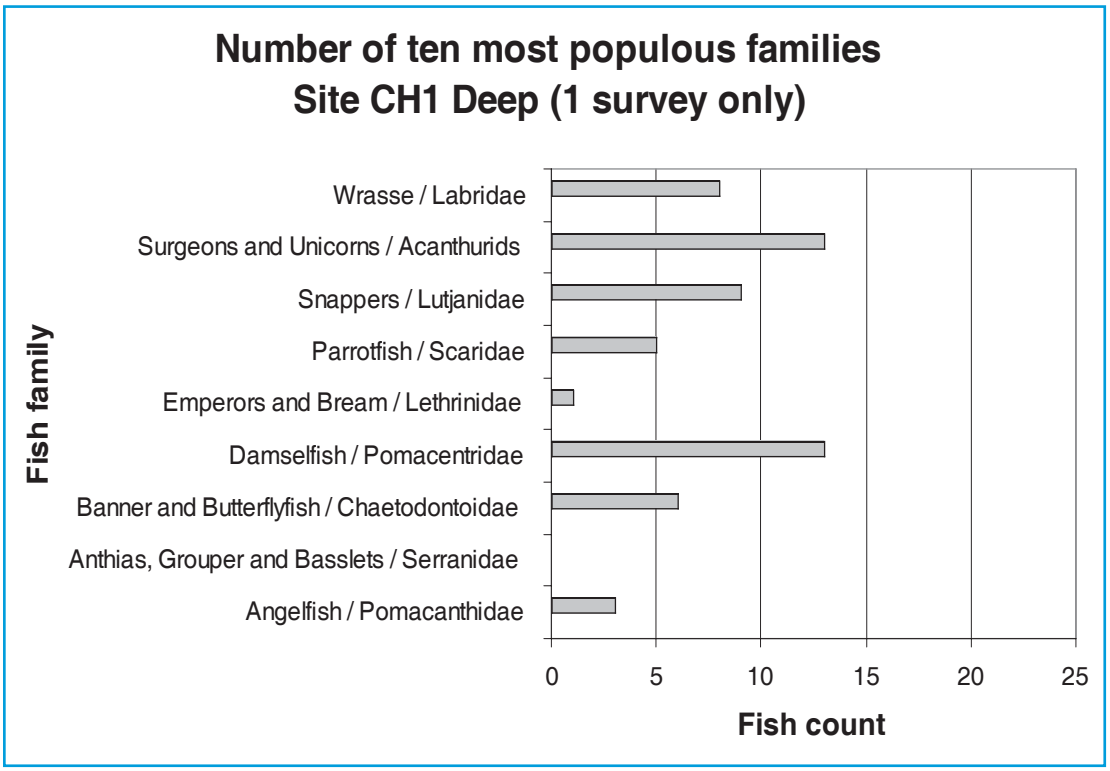


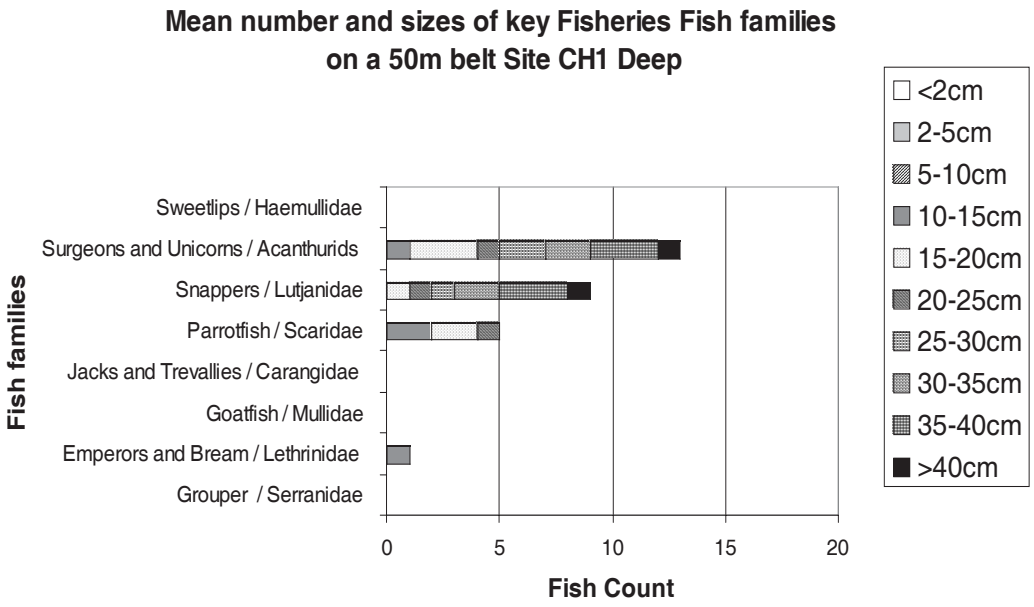

This passage has a sloping side made up of dead coral and rock, and dead coral rubble, with sandy slopes and gullies between coral stands. There is some live coral, largely Acropora, Porites and Pocillopora species, usually in large colonies amongst dead coral. Some of the dead rock in the shallower section is covered in the type of turf algae farmed by damselfish.
No invertebrates at all were seen.
There were not many fish recorded, but fairly large snappers and unicorn fish were seen in the deeper channel, and smaller surgeonfish and butterfly fish around the shallower edge. Unusually few parrotfish were seen.




## FISH ABUNDANCE AND SIZE CLASS






The high fish count in this channel was mostly made up of surgeon and damselfish, but also with large numbers of snappers of length 35cm and above, mostly the Black Snapper, Macolour niger, the Black-and-White Snapper, Macolour macularis, and the Paddletail snapper, Lutjanus gibbus, with a few Smalltooth Jobfish, Aphareus furca

# UNNAMED CHANNEL - BACK BARRIER REEF

Survey details

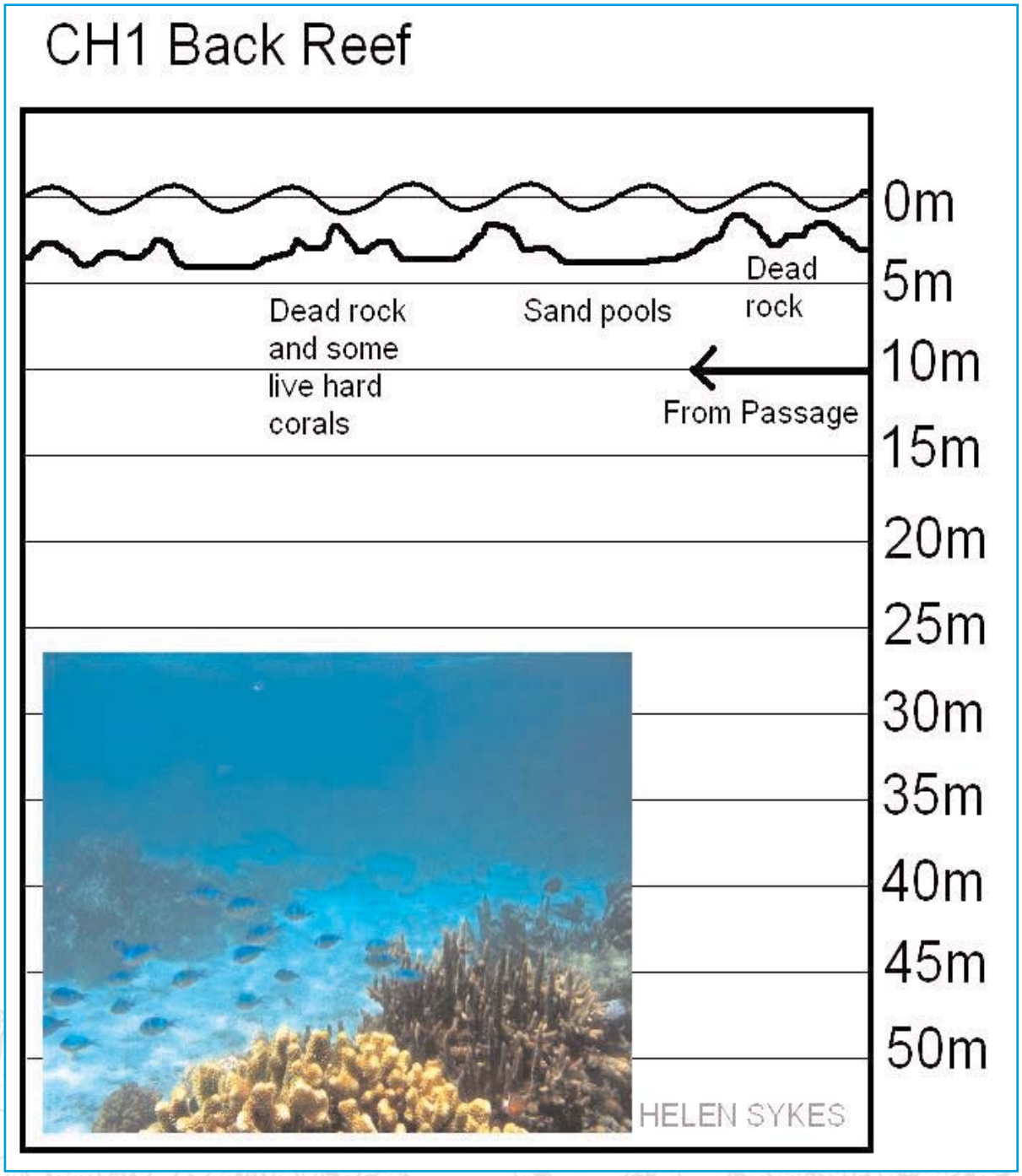
| Dive/Survey number | Date | Time start | Time End | Code | Deep or Shallow | Name | Reef type |
|---|---|---|---|---|---|---|---|
| 23 | 15.12.04 | 12.30 | 12.45 | CH1 | Shallow | No official name on map | Back of barrier reef |

| GPS S | GPS E | Depth | Viz | Current | Tide | Water temp |
|---|---|---|---|---|---|---|
| 16o19.648' | 178o44.016' | 2m | 12m | None | Falling | 28.5 |

## 7.20 UNNAMED CHANNEL - BACK BARRIER REEF

**Rapid Assessment Only**

Full surveys were not carried out due to time constraints. This is the result of rapid assessments done by Helen Sykes and Ed Lovell only.



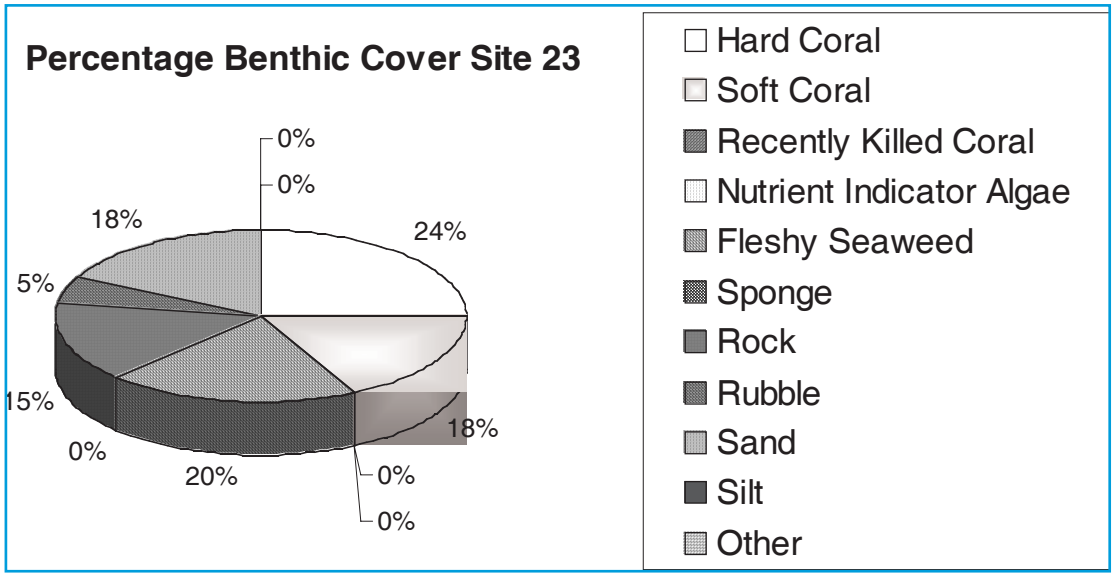
This wide passage opposite Nadogo Island was the most westerly passage in the barrier reef investigated. This is the extensive system of shallow patch reefs behind the barrier reef, in the western side of the lagoon. Algal cover is high in patches on the dead corals, mostly turf algae cultivated by damselfish. Water is clear.

## CORALS

The top of the reef crest is 4m depth with sprawling Pocillopora, Scapophyllia and avona varians. Soft coral cover <2%. Pavona clavus and P. minuta were evident. On the back barrier reef shallow lagoon there is dead standing coral 15-20%. Robust forms of Acropora digitifera and A. robusta, Porites spp., F. pallida, F. stelligera. Abundant soft coral is 15%. Other hard coral species are Goniastrea aspera, Acropora robusta, A. samoensis, Hydnophora rigida. Presence of vertical Pocillopora spp.

## SITE CHARACTER AND POPULATIONS

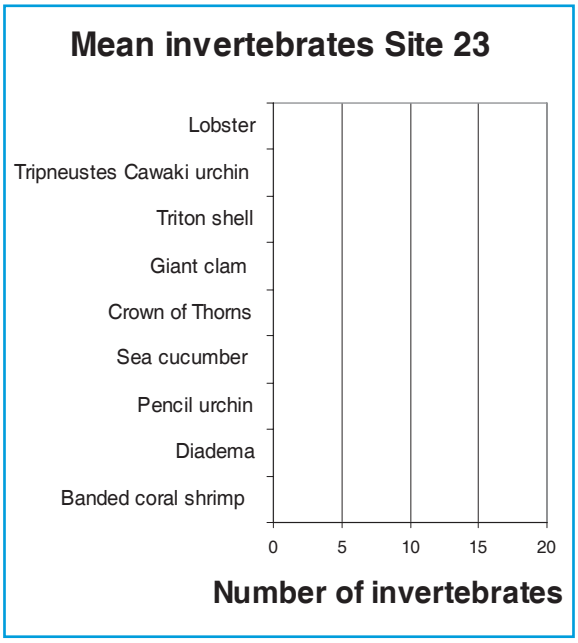
Note: These charts are drawn from estimations made during a 15 minute swim, not from measured transect data as with other sites. No detailed breakdown of coral types is available.

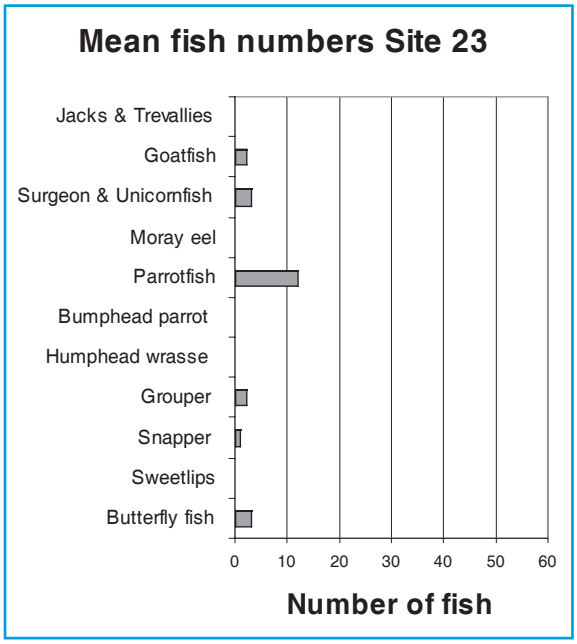



There is a wide flat back reef behind the passage mouth, made up largely of dead coral rocks with white sand pools between them. There are occasional large stands of coral, largely Acropora, Favids or Porites species). Soft coral was more common in the shallow waters. A lot of the rock is dead coral, probably from the bleaching event of 2002, and is now covered in the type of turf algae farmed by damselfish.

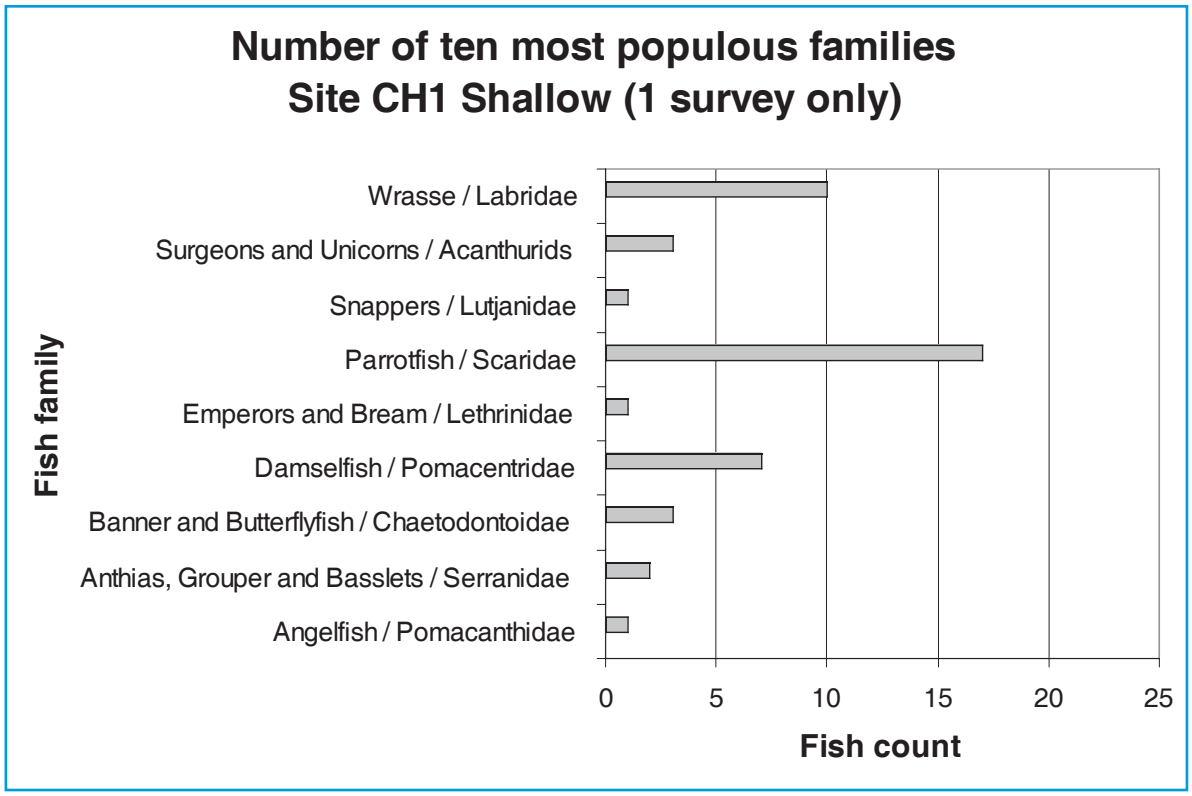
No invertebrates at all were seen.

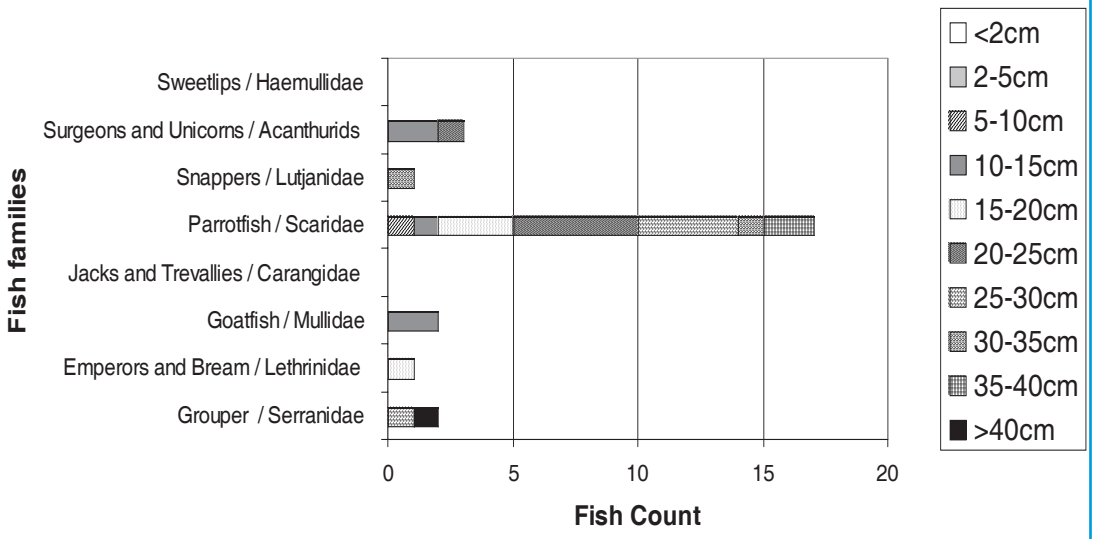
There were quite a few small fish seen in the sandy pool areas, mostly small wrasse and damselfish, but there were also several small parrotfish, and a few surgeon, butterfly and goatfish.




## FISH ABUNDANCE AND SIZE CLASS






The back reef has less fish numbers than the main channel, with large numbers of small to medium parrotfish, but low numbers of butterflyfish. A few large leopard coral groupers, Plectropomus leopardus, and small surgeon and goatfish were also found.

**APPENDIX B** : Reefcheck site description form

APPENDIX C : Species recorded on the survey