

# SCIENTIFIC REPORT ON AN EXPEDITION TO THE VATU-I-RA/LOMAIVITI PASSAGE

10<sup>th</sup> – 24<sup>th</sup> MAY 2003.



**A collaborative study undertaken by the Wildlife Conservation Society,  
Conservation International, the Namena Reef Conservation Group and  
Nai'a Diving Expeditions.**

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## INTRODUCTION

The Vatu-i-Ra/Lomaiviti region is situated in the centre of the Fiji Island group to the west of Viti Levu and to the south of Vanua Levu. The region contains a vast array of complex marine habitats, including barrier reefs, fringing reefs, patch reefs, seamounts, mangroves, seagrass beds and deep channels between reefs. Most reefs in the group are bathed in strong currents formed by the channelling of the Koro Sea through deep trenches between the islands of Vanua Levu and Viti Levu. These currents deliver large quantities of oceanic plankton to the reefs, resulting in highly productive ecosystems. Vatu-i-Ra/Lomaiviti reefs are typically characterized by a lush growth of colourful soft corals that take advantage of the nutrient rich waters and high currents. These characteristics make the Vatu-i-Ra/Lomaiviti Group one of the most attractive diving destinations in the world.

The productive ecosystems in the Vatu-i-Ra/Lomaiviti area support dense fish and invertebrate populations. This, combined with the location of reefs with respect to current regimes suggests that the Vatu-i-Ra/Lomaiviti area may act as a source-pool of spawning stocks to supply surrounding, more heavily fished reefs in the Fiji Islands. Due to the remote location of the majority of reef systems within the Vatu-i-Ra/Lomaiviti area, the fishing pressure from local communities is minimal. However, recent reports from local fishermen and tour operators, as well as direct observations, suggest that an increasing level of fishing pressure in the Vatu-i-Ra/Lomaiviti region is occurring as a result of the illegal fishing activities of some long-lining fishing vessels. With plans in place to dramatically increase Fiji's long-line fleet, the Vatu-i-Ra/Lomaiviti area is imminently threatened. If these reefs are to be maintained in their present condition, conservation efforts in the region need to increase dramatically.

In order to build a sound conservation strategy for the Vatu-i-Ra/Lomaiviti region, a comprehensive knowledge is required of the marine resources present and the activities of fishing communities that depend upon them. However, relatively few studies have been carried out on the marine resources of the Vatu-i-Ra/Lomaiviti due to the inaccessibility of the majority of reefs and islands. One study that was designed to detail the conservation value of the Vatu-i-Ra/Lomaiviti area was a rapid assessment program carried out by the Worldwide Fund for Nature (WWF) in 2001. The main focus of the WWF (2001) study were the coral communities, particularly the resiliency of corals to bleaching in the aftermath of the 2000 Fiji bleaching event. However, there is still a large gap in knowledge of the condition of fish stocks within the Vatu-i-Ra/Lomaiviti region. Therefore, the focus of the present expedition was to examine the diversity and condition of fish communities in the Vatu-i-Ra/Lomaiviti passage, in order to compliment previous studies and further assess the conservation potential of the region.

Between the 10<sup>th</sup> and 24<sup>th</sup> May 2003, the Wildlife Conservation Society's South Pacific Marine Program, together representatives from Conservation International and the local Namena Reef Conservation Group, conducted preliminary surveys of the reefs of Vatu-i-Ra/Lomaiviti aboard the dive boat, *Nai'a*. The main purpose of this expedition was to provide a preliminary assessment of the status and conservation potential of marine

ecosystems in the region, as well as to provide data specific to guide the development of a marine reserve network for the Vatu-i-Ra/Lomaiviti reefs.

The specific objectives of this expedition were to:

- Assess the intactness of coral reef fish communities.
- Quantify densities of heavily targeted species (e.g. groupers, napoleon wrasse).
- Estimate the intensity of fishing pressure on reefs in the region.
- Identify areas of reefs that appear to be resilient to bleaching.

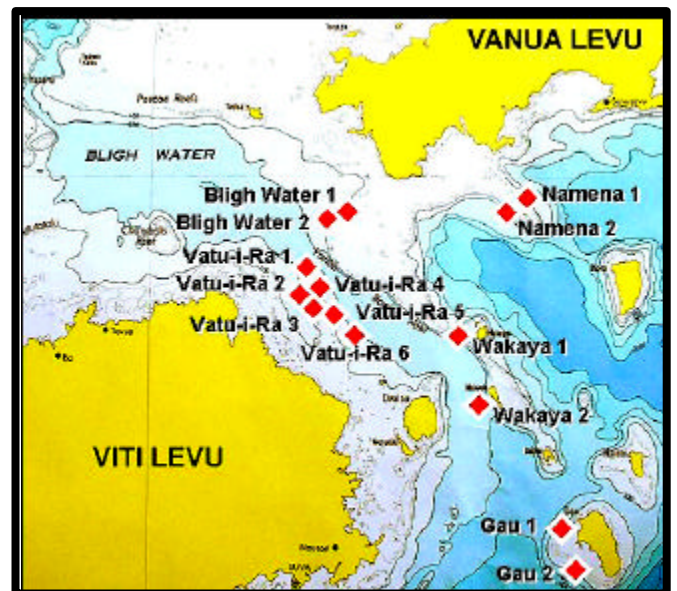
## METHODS

### Study sites

This study was carried out at representative and spatially separated reefs within the Lomaiviti/Vatu-I-Ra passage (Fig. 1). A range of reef types was examined, including the windward and leeward edges of barrier reefs, seamounts and patch reefs. All sites had moderate to high current conditions. Sites were mostly characterized by a shallow reef flat (0 – 5 metres depth), and steep vertical reef walls descending to a rubble base at between 12 and 45 metres. Most reefs were open to fishing activities, however, three sites: Nigali Passage at Gau Island, and the two sites at Namena Reef, were located within marine reserves.

*Figure 1. Sites examined by WCS during Vatu-i-Ra/Lomaiviti Expedition*

Site	Position
Namena 1	17 <sup>o</sup> 04.24S 179 <sup>o</sup> 06.10E
Namena 2	17 <sup>o</sup> 06.80S 179 <sup>o</sup> 03.62E
Gau 1	18 <sup>o</sup> 04.99S 179 <sup>o</sup> 15.71E
Gau 2	17 <sup>o</sup> 58.66S 179 <sup>o</sup> 13.46E
Wakaya 1	17 <sup>o</sup> 26.94S 178 <sup>o</sup> 54.38E
Wakaya 2	17 <sup>o</sup> 34.96S 178 <sup>o</sup> 58.88E
Bligh Water 1	17 <sup>o</sup> 08.22S 178 <sup>o</sup> 31.40E
Bligh Water 2	17 <sup>o</sup> 07.84S 178 <sup>o</sup> 30.84E
Vatu-i-Ra 1	17 <sup>o</sup> 16.67S 178 <sup>o</sup> 29.00E
Vatu-i-Ra 2	17 <sup>o</sup> 16.81S 178 <sup>o</sup> 28.34E
Vatu-i-Ra 3	17 <sup>o</sup> 16.42S 178 <sup>o</sup> 27.72E
Vatu-i-Ra 4	17 <sup>o</sup> 17.69S 178 <sup>o</sup> 26.89E
Vatu-i-Ra 5	17 <sup>o</sup> 16.81S 178 <sup>o</sup> 28.58E
Vatu-i-Ra 6	17 <sup>o</sup> 20.77S 178 <sup>o</sup> 31.37E



## **Survey Methods:**

### **Substratum composition**

The reef substratum was surveyed along four depth contours where available (3m, 7m, 12m and 20m). At sites where the reefs did not break the surface, it was sometimes not possible to sample either or both of the 3m and 7m contours, and only the deeper contours were sampled. At each site, substratum composition was estimated along 10 m transects using standard line-intercept methods (McClanahan and Shafir 1990). Between 3 and 6 transects were sampled at along each depth contour at each site. All transects were laid parallel with the reef crest. The type and length of substrate underneath the transect tape was recorded. All hard corals (including the octocorals *Heliopora*, *Millepora* and *Tubipora* spp.) were recorded to lifeform, based on the descriptions and nomenclature of Veron (2000). Corals in the Genus *Acropora* were recorded separately to the level of life-form. Other substrate categories recorded were sponge, soft coral (alcyonaceans), sea-grass, gorgonians (gorgonaceans), zooanthids, anemones, ascidians, bryozoans, turf-algae, encrusting red algae, coralline algae and sand.

Underwater digital video footage was used to supplement line-intercept data at sites where strong currents precluded the laying of line-intercept transects. Footage was gathered by swimming slowly along the substrate for a distance of approximately 50 metres following a set depth contour. The camera was positioned approximately 50-70 cm from the substrate during filming. Video footage was analysed by playing back tapes for each transect on a high definition monitor and stopping at random intervals to record the category of substratum underneath 5 random points placed on the screen. At least 500 points were analysed for each transect.

### **Reef Fish Species Richness**

The species richness of reef fishes was estimated at each site using the Coral Fish Diversity Index (CFDI) methods, developed by Allen (1998). Whilst this method was developed for Papua New Guinean fish assemblages, it has since been found to be suitable for Indo-Pacific reefs outside of PNG and was assumed to be suitable for use as an indicator for Fijian reefs. The same observer was used throughout the surveys to maintain the consistency of data. At each site, all families of reef fishes and reef-associated fishes encountered during a one-hour timed swim on SCUBA were recorded, except for some cryptic families, namely: Gobiidae, Blenniidae, Apogonidae and Tripterygiidae. The dive path followed a haphazard, zig-zag pattern on the reef and included all reef zones from the reef base to the reef flat (encompassing a total area of approximately 3 to 4 hectares). Sampling effort was increased in the depths of 3 m to 12 m, where the greatest diversity of fish species usually occurs.

Species were identified based on the descriptions and nomenclature of Allen and Swainston (1993), Randall et al. (1997), Myers (1999), and the ICLARM Fishbase2000 database (Froese and Pauly 2000). Species that could not be easily identified from

reference material were photographed with an underwater digital camera and the images were shown to relevant authorities for identification. Any species still not positively identified were excluded from analyses. From this data, the number of fish within six common and visually apparent families of reef fishes (Acanthuridae, Chaetodontidae, Labridae, Pomacanthidae, Pomacentridae and Scaridae) were summed to provide a species richness index for the site (Coral Fish Diversity Index – CFDI; Allen 1998). An estimate of local species richness at the site was then obtained using the formula: Local species richness =  $3.39 \times \text{CFDI} - 20.595$ . Average values of local species richness for the Lomaiviti/Vatu-I-Ra region were compared to those obtained for Papua New Guinea and Indonesia (WCS unpublished data).

### **Heavily Targeted/Rare Species of Reef Fishes**

Fish species that are considered rare or heavily targeted in other regions, including reef sharks, groupers (Serranidae), napoleon wrasse (*Cheilinus undulatus*) and bumphead parrotfish (*Bolbometapon muricatum*) were recorded during 1-hour timed swims at the same time, and along the same path, as species richness estimates (previous section). Any heavily targeted/rare species encountered within 5 m either side of the swim path were recorded, along with an estimate of their total length. The path covered by timed swims was calibrated and estimated to be approximately 800 m. Therefore, the total area within which heavily targeted/rare species were recorded was estimated to be approximately 0.8 ha.

### **Reef Fish Abundance, Biomass and Population Size Structure**

Abundance and biomass estimates were calculated by recording the size and frequency of fishes within all reef fish families along three 50 meter transects at the 3-4 m and 7-8 m depth contours (where available) and the 11-12 m depth contours. Transects surveyed were 2 m wide for fish less than 10 cm in length and 5 m wide for fish greater than 10 cm. The average size of species commonly targeted by coastal fishing communities in the Indo-Pacific region (determined from fisheries landings – WCS unpublished data) was used to determine an average size of fishes available to the fishery for the Vatu-i-Ra/Lomaiviti region.

The overall biomass (estimated weight of fishes) was calculated by converting size-frequency data to biomass data using representative length-weight conversions for each family acquired from the FishBase2000 database (Froese and Pauly 2000). The same observer was used for all sites within the Vatu-i-Ra/Lomaiviti and sites within PNG and Indonesia to maintain the consistency of data. Abundances of individual species will be presented in later reports. However, biomass estimates will be presented here for comparison with other regions.

### **Indicators of Fishing Pressure**

The abundance of discarded fishing gears on reefs has been found to be a good indicator of local fishing pressure. The abundance of discarded fishing gears (e.g. lines, spears,

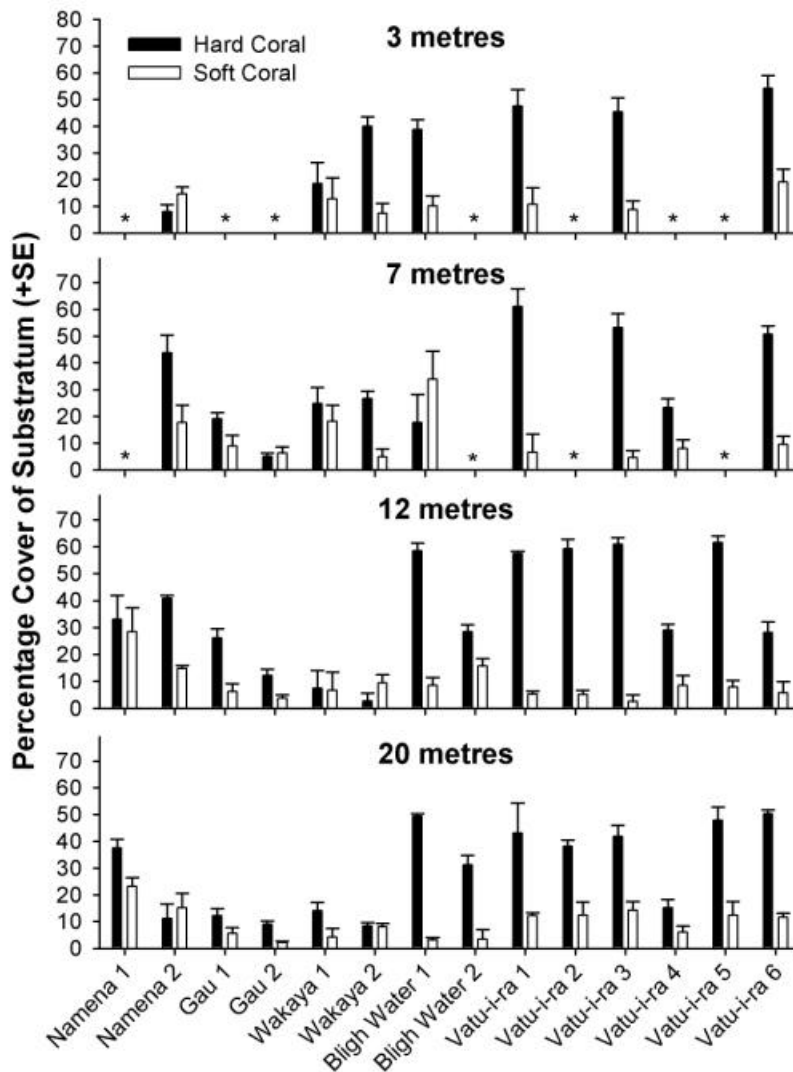
nets, traps) found discarded on reefs was shown to correlate significantly with the intensity of fishing pressure throughout 27 sites examined in PNG and Indonesia (WCS unpublished data). In order to rapidly assess the impact of fishing activities on the reefs of the Vatu-i-Ra/Lomaiviti region, the presence of discarded fishing gears was recorded within a 2m wide belt along each side of transect tapes used for fish biomass surveys (3 x 50 m transects at the 11-12 m depth contour at each site). The mesh sizes of pieces of net and thickness of fishing lines encountered were recorded to provide a gross, general indication of the size of target species.

## RESULTS

### Coral Cover

The coral cover on most reefs within the Vatu-i-Ra/Lomaiviti area was moderate to high (Fig.2). Hard coral cover was generally in the vicinity of 40-60% and this was characteristic of all of the depth contours examined (3m to 20m). Soft coral cover was also relatively high (up to 34%). Additional observations suggested that high coral cover persisted to depths of up to 40 metres. On the whole, reefs appeared to have either suffered little bleaching, or recovered well from bleaching events. However, a few sites had relatively low coral cover and may have been affected by the 2000 bleaching event. The worst affected sites examined were at Gau Island, where a large coverage of dead coral skeletons was present from shallow reefs to depths of more than 20 metres.

**Figure 2. Live hard coral and soft coral cover at each site within the Vatu-i-Ra/Lomaiviti area.**



\* sites where data was unavailable (deep reefs or conditions unfavourable for surveys)

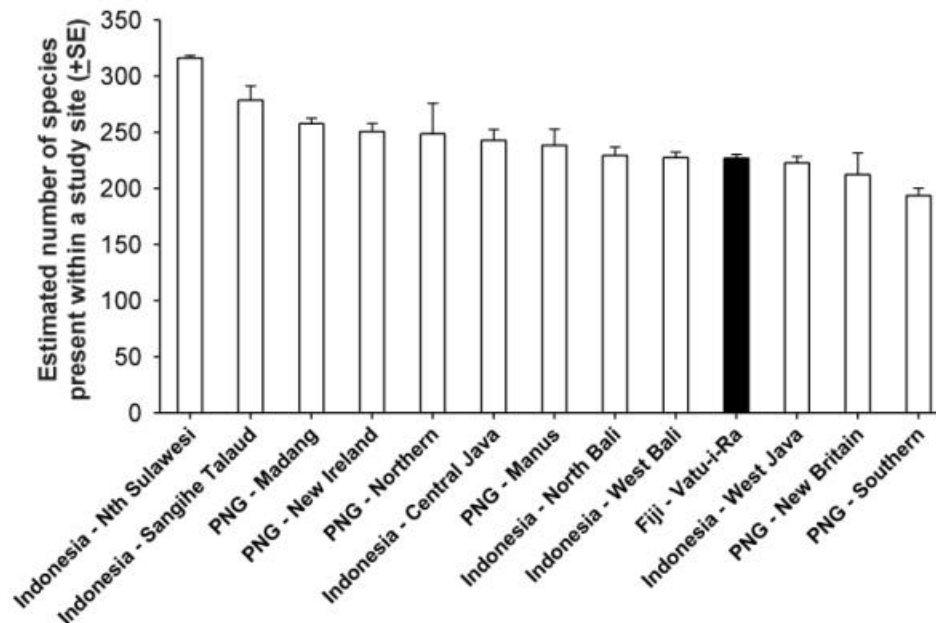
## Fish Species Richness

The fish species richness in the Vatu-i-Ra/Lomaiviti passage was extremely high, considering the distance of Fiji from the centre of diversity in the Indo-Pacific Archipelago. Using CFDI indices, the estimated species richness was uniformly high across all sites examined (Table 2). Vatu-i-Ra/Lomaiviti reefs were found to be higher in species richness than some sites examined by WCS within the “coral triangle”, such as sites in Papua New Guinea (southern mainland PNG and New Britain) and one site in Indonesia (West Java) (Fig. 3).

**Table 2. Coral Fish Diversity Index (CFDI) and estimated local species richness of reef fishes within each Vatu-i-Ra/Lomaiviti study site.**

Site	CFDI	Local species richness
Namena 1	71	220
Namena 2	73	227
Gau 1	75	234
Gau 2	71	220
Wakaya 1	69	213
Wakaya 2	78	244
Bligh Water 1	71	220
Bligh Water 2	65	200
Vatu-i-Ra 1	74	230
Vatu-i-Ra 2	76	237
Vatu-i-Ra 3	69	213
Vatu-i-Ra 4	75	234
Vatu-i-Ra 5	79	247
Vatu-i-Ra 6	76	237

**Figure 3. Species richness of reef fishes within the Vatu-i-Ra/Lomaiviti area compared with WCS study sites in Papua New Guinea and Indonesia.**

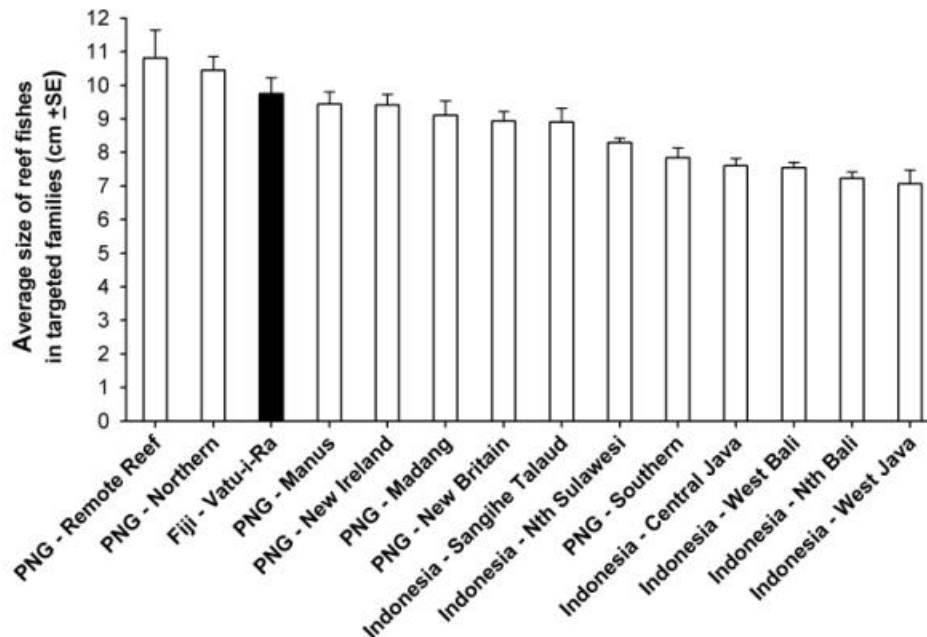




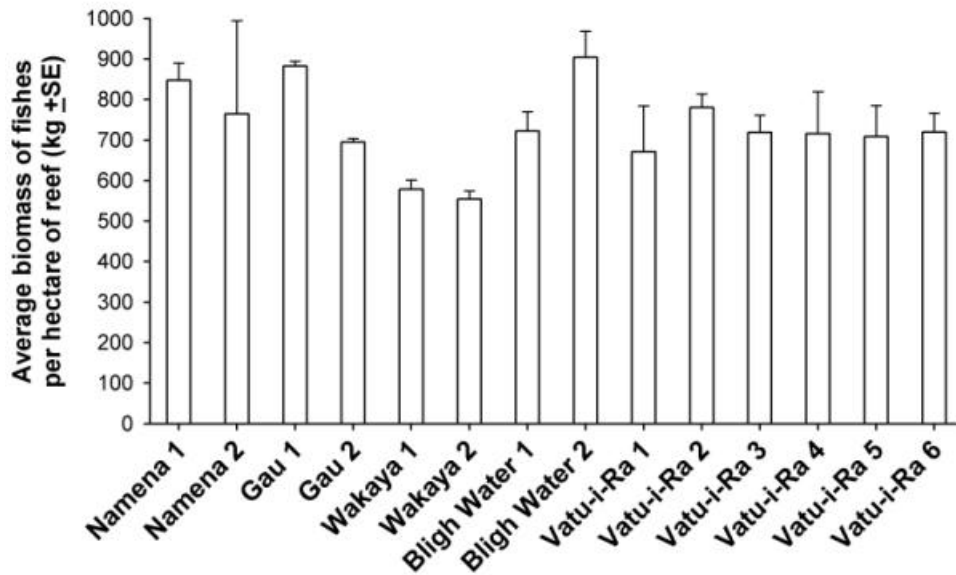
## Fish Community Size Structure and Biomass

The average size of species of reef fishes commonly targeted by coastal fishing communities was found to be higher on Vatu-i-Ra/Lomaiviti reefs (9.7 cm) than most sites examined by WCS in PNG and Indonesia (range: 7.1 - 10.8cm) (Fig. 4). The average biomass of fishes (estimated from size-frequency data) was extremely high on all reefs examined within the Vatu-i-Ra/Lomaiviti area. Average biomass values ranged from 554 kg ha<sup>-1</sup> to 903 kg ha<sup>-1</sup> across all sites (Fig. 5). The average fish biomass for all reefs combined (730 kg ha<sup>-1</sup>), was greater than the highest biomass of fishes observed on reefs examined by WCS in Papua New Guinea (maximum 650 kg ha<sup>-1</sup>) and Indonesia (maximum 356 kg ha<sup>-1</sup>) (Fig. 6).

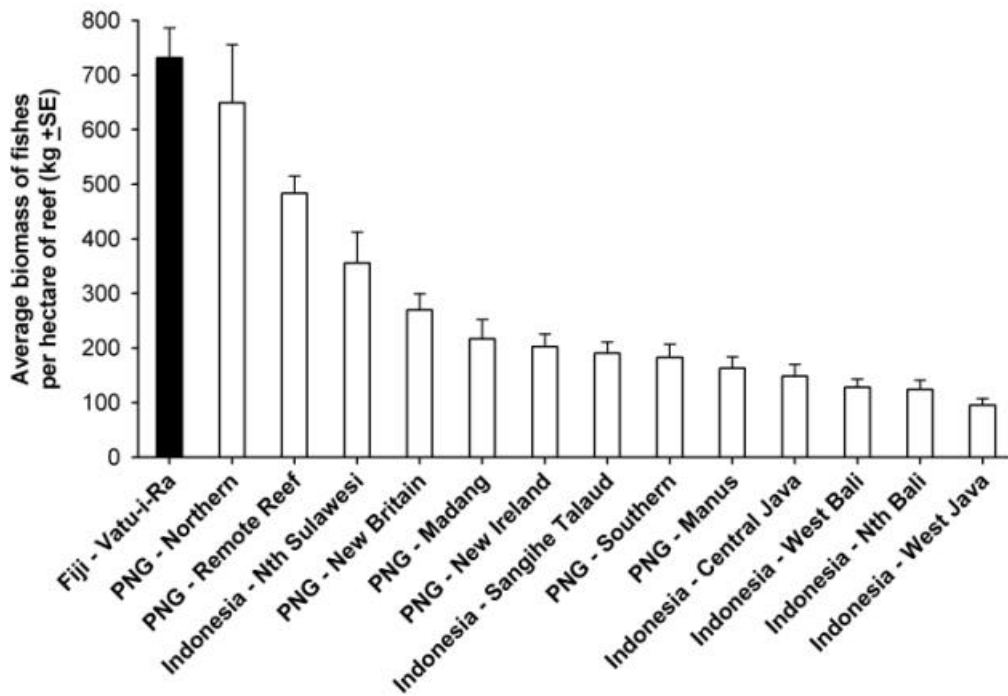
**Figure 4. Average size of commonly targeted species of reef fishes within Fijian sites (Vatu-i-Ra/Lomaiviti) versus sites examined by WCS in Papua New Guinea and Indonesia.**



**Figure 5. Average biomass (estimated weight) of all non-cryptic reef fishes at sites examined within the Vatu-i-Ra/Lomaiviti area.**



**Figure 6. Average biomass (estimated weight) of all non-cryptic reef fishes at Fijian sites (Vatu-i-Ra/Lomaiviti) versus sites examined by WCS in Papua New Guinea and Indonesia.**



## Status Heavily Targeted/Rare Fish Species

Significant numbers of large, predatory fish were sighted in the Vatu-i-Ra/Lomaiviti area (Table 3). On average, at least two to three sharks were sighted on each 1-hour timed swim. These were mostly white-tip (*Triaenodon obesus*) and grey reef sharks (*Carcharhinus amblyrhynchos*). In addition, several hammerhead sharks (*Sphyrna lewini*) were sighted, and observations were made by divers of large schools of hammerhead sharks in deep water (>40 m depth) at some of the seamount sites. Large groupers, most commonly *Epinephalus fuscoguttatus* and species of *Plectropomus*, were prevalent at almost all sites. However, the greatest numbers of these species were observed in reef lagoon entrances/channels, such as the Nigali Passage at Gau Island. Napoleon wrasse (*Cheilinus undulatus*) were recorded on the majority of timed swims, however, these were not common at all sites. Only two schools of bumphead parrotfishes (*Bolbometapon muricatum*) were sighted during this expedition, however, these were large schools (25-35) individuals, of a large average size (~120 cm), and were easily approached by divers.

**Table 3. Sightings of species of heavily targeted/rare reef fishes per 1-hour timed swim (~0.8 ha) at each site.**

Site	Sharks	Groupers (> 50cm)	Napoleon Wrasse
Namena 1	3	3	0
Namena 2	6	4	3
Gau 1	2	3	0
Gau 2	9	38	6
Wakaya 1	2	7	0
Wakaya 2	3	6	2
Bligh Water 1	3	2	1
Bligh Water 2	5	15	0
Vatu-i-Ra 1	0	7	3
Vatu-i-Ra 2	3	3	2
Vatu-i-Ra 3	1	2	0
Vatu-i-Ra 4	3	8	2
Vatu-i-Ra 5	2	8	2
Vatu-i-Ra 6	3	2	1
<b>Average</b>	<b>3.2</b>	<b>7.7</b>	<b>1.6</b>

## New Discoveries

During the two weeks of surveys, a total of seven potentially new species of coral reef fish were discovered. Two of these have now been described. A small, colourful wrasse (pictured on front cover of report) was discovered and collected from deep rubble banks around Wakaya. This species has since been described as *Cirrhilabris marjorie* (Allen, Randall and Carlson 2003). In addition, a new species of flasher wrasse was found on rubble banks in the Vatu-i-Ra passage. This species has since been described as *Paracheilinus rubrocaudalis* by Randall and Allen (2003). A new species of pipefish and damselfish were also found that remain to be described. Two additional species of damselfish and one species of wrasse are also likely to be new, but their status is still under investigation through DNA studies.

## Evidence of Fishing Pressure

Very few discarded fishing gears were found on any of the reefs examined in the Vatu-i-Ra/Lomaiviti passage (Table 4). However, out of those that were found, the majority were heavy-guage, long-line fishing gears. Only three standard fishing lines and two pieces of net, both of large mesh size (15 cm) were found. No discarded spears were found on reefs.

*Table 4. Average number of discarded fishing gears found per 600m<sup>2</sup> of reef at each site.*

<b>Site</b>	<b>Fishing lines</b>	<b>Nets</b>	<b>Long-line gears</b>
Namena 1	0	0	0
Namena 2	0	0	1
Gau 1	0	1	0
Gau 2	0	0	0
Wakaya 1	1	0	0
Wakaya 2	1	1	0
Bligh Water 1	0	0	3
Bligh Water 2	0	0	2
Vatu-i-Ra 1	0	0	1
Vatu-i-Ra 2	0	0	1
Vatu-i-Ra 3	0	0	0
Vatu-i-Ra 4	0	0	0
Vatu-i-Ra 5	1	0	1
Vatu-i-Ra 6	0	0	0

## DISCUSSION

Overall, the reefs of the Vatu-i-Ra/Lomaiviti passage were found to be in a relatively pristine condition. The coral cover of most reefs was extremely high, with sites characterized by a predominance of hard coral (mainly *Acropora* spp.) on reef flats, crests and slopes, and a lush growth of colourful soft coral (e.g. *Dendronephthya* spp.) on vertical reef walls. This rich growth of coral was most likely due to the high currents in the area, which supply the corals with a continual source of plankton. These currents may also be responsible for providing corals with a refuge from warm water events, which have caused more extensive bleaching in other areas of Fiji. Only a few sites had very low live coral cover. Sites at Gua Island had a particularly large cover of dead coral skeletons. These reefs were reportedly affected by the 2000 bleaching event (WWF 2001) and the dead coral skeletons were assumed to be due to this event. These reefs do not appear to have recovered well so far. However, the majority of reefs in the region, especially those within the Bligh Waters and Vatu-i-Ra Passage, appear to have either escaped bleaching completely, or recovered well from bleaching events. This suggests that the Vatu-i-Ra/Lomaiviti reefs, whether because of local current regimes or other factors, may be well placed to survive the effects of climate change.

The species richness of fish communities was found to be much higher than initially expected for Fijian reefs, with richness estimates exceeding those obtained for some sites sampled by WCS in Papua New Guinea and Indonesia. This result was surprising, considering the distance of Fiji from the centre of diversity and from the equator. It is likely that the diversity of habitats, high currents and relative intactness of reef systems in the Vatu-i-Ra/Lomaiviti region is responsible for the maintenance of this high biodiversity. Fiji is a well-known site for endemism and local colour morphs of reef fishes, as well as other marine organisms. This was evidenced by the discovery of at least four (Allen *et al.* 2003, Randall & Allen 2003, G.R. Allen unpublished data), and potentially as many as seven new species of fishes within only a two-week period. Most of these species have not been sighted elsewhere and may be restricted in range to this area. The high species diversity of the Vatu-i-Ra/Lomaiviti reefs, coupled with a relatively large proportion of regionally endemic species suggests that this area is likely to play an important role in the maintenance of a unique marine fauna. These findings also illustrate the need for a much more comprehensive inventory of species (both vertebrates and invertebrates) within the Vatu-i-Ra/Lomaiviti area.

Reef fish stocks were found to be in relatively good condition at all sites. The average size of targeted reef fishes was found to be at least as large, if not larger than stocks examined in PNG and Indonesia. The size structure of reef fish stocks has been found to correlate strongly with the level of fishing pressure (WCS unpublished data). Because the largest individuals are usually the first targeted in the fishery, the size structure of stocks is often the first variable to be affected by changes in fishing pressure. However, the large average size of fishes on Vatu-i-Ra/Lomaiviti reefs suggests that the fish communities are still relatively intact. The biomass of fishes in the Vatu-i-Ra/Lomaiviti area was also found to be exceptionally high. High fish biomass may also be caused by the productivity resulting from strong currents in the area. Alternatively, the high standing biomass of

fishes may be maintained due to the low level of fishing pressure present within the region. In either case, this high standing biomass of fishes represents a significant source of gametes and larvae to supply surrounding areas. This is particularly true for large, heavily targeted species, such as groupers and napoleon wrasses, which are being driven to local extinction in other areas due to their high economic value. The relatively high densities of large, predatory fishes on reefs of the Vatu-i-Ra/Lomaiviti passage was reassuring, and suggests that this is an important area, which should receive protection before fishing efforts begin to increase.

The low number of discarded fishing gears found on Vatu-i-Ra/Lomaiviti reefs further supports the observation that the area receives little fishing pressure. However, the evidence of long-lining gears on reefs was alarming, and supports claims by local communities that long-line vessels are operating illegally in close proximity to reefs at night. The activity of long-line vessels fishing close to reefs has been implicated in the rapid decline of reef-associated sharks and large predatory fishes in South-east Asia. The imminent threat to Vatu-i-Ra/Lomaiviti reefs is of particular concern since the Fijian long-line industry is presently going through a rapid expansion phase.

The high densities of reef sharks observed in the Vatu-i-Ra/Lomaiviti area suggests that the shark fishery had not yet had a major impact on these reefs and populations were still largely intact. Reef sharks are rapidly disappearing from reefs in the Asia-Pacific region due to the shark-fin and shark meat trades. Since sharks have life histories that predispose them to over-harvesting (long life-spans, low fecundity, high age of maturity) they are among the first groups to be depleted on reefs under heavy fishing pressure. In many parts of South-east Asia, reef shark populations have been decimated almost to the point of local extinction, and the same process is beginning to occur on reefs of Pacific Islands in order to meet market demand. The Vatu-i-Ra/Lomaiviti area may be an important refuge for sharks, however, protection for these reefs should become a priority before major shark fishing activities spread to the area.

Although the corals and fish stocks of the Vatu-i-Ra/Lomaiviti reefs appear to be in good condition at present, there are a number of immediate threats to the region which place these ecosystems at great risk. This study suggests that the Vatu-i-Ra/Lomaiviti region has a very high and immediate conservation potential. The region contains a diverse array of reef communities and habitat types and a number of regionally endemic species. The reefs have relatively intact fish communities (something that is rare to find so close to human population centres), which could potentially act to re-supply surrounding, depleted reefs. Conservation work has already commenced to build a network of community reserves on inshore reefs. However, it appears critical to include offshore reefs in this network to include areas that have some resilience to bleaching. Local fishing communities appear to have very little dependence on offshore reefs at present, suggesting that large areas could potentially be designated marine reserves with little, if any, economic loss to these communities. This expedition has highlighted the value of the Vatu-i-Ra/Lomaiviti Reefs in terms of maintaining biodiversity and providing a refuge to large breeding populations of reef fishes. However, it is crucial that immediate action be taken to conserve this unique region whilst it remains intact.

## ACKNOWLEDGEMENTS

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