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Ono Development Committee

THE ONO-I-LAU CLUSTER OF ISLANDS: MARINE BIOLOGICAL SURVEY 2008 REPORT

This report is a summary of findings for marine biological surveys led by WWF South Pacific Programme and trained community PADI Open Water Divers of Ono-i-Lau.

SGP The GEF Small Grants Programme

GEF

UNDP

Cousteau

Citation: Fiu, M.Tokece,M. and Areki, F. (2010). The Ono-i-Lau cluster of islands. Marine Biological Survey 2008 Report. Suva, Fiji, WWF South Pacific Programme

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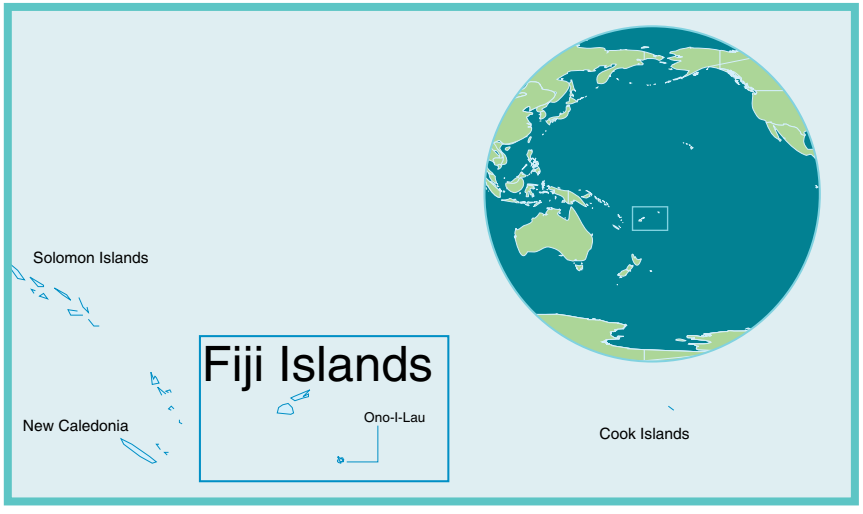

The main Ono-i-Lau Island cluster is located at 20.80º S and longitude 178.75º W. Ono-i-Lau is located at the southern tip of a chain of scattered islands making up the Lau archipelago in eastern Fiji. The main Ono-i-Lau Island cluster is made up of six islands that are part of a remnant volcanic arc.

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LIST OF ACRONYMS

AIMS Australian Institute of Marine Science
ASEAN Australia Living Coastal Resources
CITES Convention on International Trade in Endangered Species of Wild Fauna and Flora
COTS Crown of Thorns
FIME Fiji Islands Marine Ecoregion
FLMMA Fiji Locally Managed Marine Area Network
GEF Global Environment Facility
GCRMN Global Coral Reef Monitoring Network
GDP Gross Domestic Product
MPA Marine Protected Area
NBSAP National Biodiversity Strategy and Action Plan
NGO Non Government Organisation
SCUBA Self Contained Underwater Breathing Apparatus
UNDP United Nations Development Programme
USP University of the South Pacific
WWF World Wide Fund for Nature

ACKNOWLEDGEMENT

WWF South Pacific Programme wish to thank the people of Ono-i-Lau for the hospitality and assistance during the period of marine biological surveys for the Ono-i-Lau cluster. A special thank you to the Matavuvale Navaka, Filipe and his family for looking after the dive teamand opening their home to us.

REPORT AT A GLANCE

WWF South Pacific Programme in partnership with UNDP GEF Small Grants Programme, Lau Provincial Office, Department of Land Use and Planning and the Ono-i-Lau Tikina Development Committee conducted the first community marine biodiversity status survey of the carbonate low islands of the Ono-i-Lau cluster.

The marine ecosystems of Southern Lau, hold some of the most significant marine biodiversity in the world, a region of isolated limestone and oceanic atoll islands with a range of habitats including seagrass, oceanic patch reefs and extensive barrier reef systems. Human communities in this region depend almost entirely on marine resources for their livelihoods in terms of subsistence, tradition and culture. At present, these marine areas are in relatively good condition and present examples of some of the most intact, globally representative habitats of their kind.

These marine systems are currently under threat from a number of factors, including unsustainable patterns of resource use, island and external pressures on key resources and general environmental degradation. These trends threaten not only marine biodiversity, but also undermine food security and economies of these remote island communities.

This report describes the status of key marine habitat types based on standardised health indicators for the varied reef zones, seagrass areas, soft shores on the principal island of Ono and surrounding limestone islets. Based on a 2.5 week stay on Ono-i-Lau, a remote region that is clearly unexplored, the snorkelling and diving team conducted fish visual census of key functional fish groups, surveys of invertebrate taxa, key algal, seagrass (and seaweed) growth. The isolated oceanic conditions create a distinct range of species composition and habitats which provide important breeding, nesting, aggregation sites for keystone species like humphead wrasse, green and hawksbill turtles and the endemic clam species found in Ono-i-Lau waters.

The report highlights potential threats to marine resources, mainly overharvesting for sale and illegal fishing from outside the area including foreign fishermen within the pelagic waters. Modified reef check surveys recorded 68.5% coral cover and describing the reef to be in good condition. Invertebrate and fish counts were high with indicator species recorded to be abundant and healthy in size. In consideration of coral bleaching, ocean acidification, economics and social characteristics of Ono-i-Lau, the challenges of marine resource use management will increase. Therefore, it is crucial for the island community to engage proactively in the decision making process for resource use and management. Ultimately, climate change will undermine any management response affecting ecosystems and livelihoods, thus it is imperative for stakeholder involvement in the reduction of any threats to maintaining the integrity of Ono-i-Lau's island biodiversity.

Report compiled by:
Monifa Fiu and Metui Tokece

Island Dive Team:
Api I(Scuba Bula-Dive Safety), Senibua Tikotaveuni (Lovoni), Iliesa Malani (Doi), Motikiai Vata (Nukuni), Solomone Colati (Matokana), Vilisono Yadrasiga (Lovoni), Mosese Sereivalu (Doi), Peni arawa(Nukuni), Sekope Lutumailagi (Matokana).

INTRODUCTION

ONO-I-LAU District is one of thirteen that constitute the Lau Province. Vatoa Island, an upraised limestone island with volcanic outcrop is a dependency of Ono-i-Lau and located 1.5 km to the north-east whilst the uninhabited Tuvana Islands is located 0.75 km south. The entire resident district population as of March 2009 was registered at 599 individuals, with a total of 149 households and a significant proportion of the Ono-i-Lau population residing in areas outside the district, predominantly on the main island of Fiji, Viti Levu. These non-resident community member, however, still retain customary ownership and user rights to natural resources in the district itself.

Community administration and governance is traditional, where decisions regarding community development and natural resources are still made by the village chief and elders that constitute the village council. The village headman (Turaga-ni-koro), nominated by the village community and endorsed by the council, reports to the district representative (Mata-ni-tikina), who then reports to the provincial council, the latter being the implementing arm of the government within provinces. Community requests for assistance to government ministries or relevant agencies are engaged via this channel. Each of the four village communities on the principal island of Ono-i-Lau have clearly demarcated traditional boundaries regarding their land and fishing grounds. Villagers will not encroach upon another's fishing area deliberately and should disputes arise in regard to infringement, this is resolved by the district council. Other functional social bodies' existent on the island includes the Ono Women's Committee, Ono Youth Association, School Committee, Nursing Station and the Church Committee, each linking back to the district Council.

Subsistence living still predominates much of the islands economy, however in recent years commercial activity in terms of fisheries has been slowly developed with government assistance. The major income sources on the island are derived from intermittent export of fish and sea food to urban centers, seaweed cultivation, pearl shell harvest, production of coir or sinnet as well as cutting copra, to a minor extent.

The target of this community initiative spearheaded by the Ono Development Committee with due funds from GEF Small Grants Programme Secretariat, to conduct the first comprehensive survey of Ono-i-Lau island marine environment, both for the purpose of improving the knowledge base of a region highly regarded to be of national biodiversity significance as well as provide information for island elders in their sustainable island development planning. This first phase of activities is to build and enhance the Ono-i-Lau community's capacity for self management and long term sustainability of their natural resources within the context of an integrated ecosystem based management, strong links to community development and sustainable livelihoods. Specific objectives of this marine biological survey report includes:

- **Ono-i-Lau region's historical climate trends based on 1971-2000 period sourced from local weather monitoring station (FMS)**
- **Description of overall reef health of the main Ono-i-Lau islands' cluster identified by a list of standard indicators-invertebrate taxa, fish families, benthic composition**
- **Seagrass health cover and faunal biodiversity within the meadows**
- **General island ecology i.e. littoral and island native forests are still intact. These islands support a number of sea bird species and undisturbed sizeable sea bird colonies, such as those of the red footed booby**
- **Comparison of reef zones between control managed areas and reef sites classified as open access for fishing by the villagers**

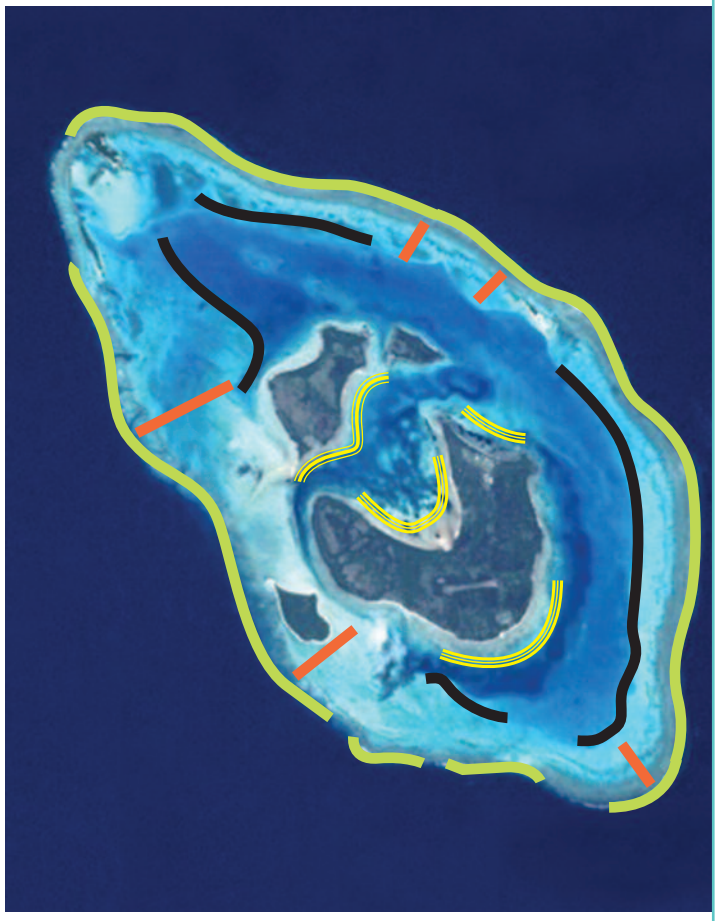
THE ONO-I-LAU SURVEY REGION

Ono-i-Lau is located at the latitude 20.80º S and the longitude 178.75º W, the southern most tip of the Fiji group.

Table 1: List of coral reef survey sites

Description of marine habitat locations surveyed:

Ono-i-LAU Fringing reefs: Ono_F	
Ono_F1	Adjacent to Nukuni village
Ono_F2	Yao Bay adjacent to Nawatu seagrass area
Ono_F4	Adjacent to Matokana village
Ono_F5	Adjacent to Udui Is. & Matokana MPA seagrass area
Ono_F6	Doi fringing reef
Ono_F7	Adjacent to Muiqalau Pt (Doi Is. leeward)
Ono_F8	Udui Is. leeward
Ono_F9	Udui Is. windward
Ono_F10	Davura Is. leeward
Ono_F11	Davura Is. windward
Ono-i-LAU Outer barrier reef slope: Ono_OB	
Ono_OB1	Outer reef barrier slope adjacent to Mana Is.
Ono_OB3	Outer reef barrier slope-Daku submerged reef @ Matokana
Ono_OB4	Outer barrier reef slope adjacent to Matokana, Vadugu Pt.
Ono_OB5	Outer barrier reef slope adjacent to Matokana MPA
Ono_OB6	Outer barrier reef slope adjacent to Doi submerged reef
Ono_OB7	Outer barrier reef slope adjacent to Yanuya Is.
Ono-i-LAU Inner barrier reef slope:	
Ono_IB1	Inner barrier reef flat/fringing Mana Is.
Ono_IB3	Inner barrier reef slope adjacent to Ono_OB3 @Daku reef
Ono_IB4	Inner barrier reef slope adjacent to Ono_OB4
Ono_IB5	Inner barrier reef slope adjacent to Ono_OB5 @Matokana reef
Ono_IB6	Inner barrier reef slope adjacent to Ono_OB6
Ono_IB7	Inner barrier reef slope adjacent to Ono_OB7
Ono-i-LAU Reef flats of barrier reef:	
Ono_RF1	Inner reef flat adjacent to Mana Is.
Ono_RF3	Inner reef flat adjacent to Ono_OB3, Daku
Ono_RF4	Inner barrier reef flat adjacent to Ono_OB4, Vadugu Pt
Ono_RF5	Inner barrier reef flat adjacent to Ono_OB5, Matokana MPA
Ono_RF6	Inner barrier reef flat adjacent to Ono_OB6, Doi
Ono_RF7	Inner barrier reef flat adjacent to Ono_OB7 @Yanuya Is.
Ono-i-LAU Channel site @Vakasovika Pass near Yanuya Is. (bird rookery)	
Ono-i-LAU Seagrass watch areas:	
Nukuni_ONOSG01	Adjacent to Nukuni village, along Musuiudu and Muanivatu Pt.
Yao_ONOSG02	Yao Bay- extensive sand flats (seaweed aquaculture) 3X50 transects x 3 replicates, 150m perpendicular to shoreline.
Muanivatu_ONOSG03	Muanivatu Pt. 3x50m transectsx4 replicates (T1R1, T1R2; T2R1; T3R1), at least 50-100m perpendicular to shoreline.
Doi_ONOSG04	Adjacent to Doi village 2x50m transects x2 replicates (T1R1,T1R2; T3R1, T3R2), 100m perpendicular to shoreline.
Matokana_ONOSG05	Adjacent to Mana Is. 3 x50m transects (T1R1-T1R3; T2R1-T2R3; T3R1-T3R3) 150m perpendicular to shoreline.
Dromoninuku_ONOSG06	3x50m transects (T1R1;T2R1; T3R1) 50m perpendicular to shoreline.
Yanua_ONOSG07	3x50m transects (T1R1, T2R1, T3R1), 50m perpendicular to shoreline.



ONOI-I-LAU HISTORICAL CLIMATE BASELINE

The climate in the Ono-i-Lau region is fairly cool with an annual average air temperature of 24.7 ^{0}C measured during the period 1971-2000. The air temperature range is 22.3 - 27.2^{0}C with the highest temperatures between November until April, coinciding with the hurricane season. Overall reef health is dependent on both natural influences i.e. the climate variability and how people interact with their local marine environment in extraction of resources.

FIGURE 2. **Monthly air temperature averages for Ono-i Lau based on 1971-2000 period**

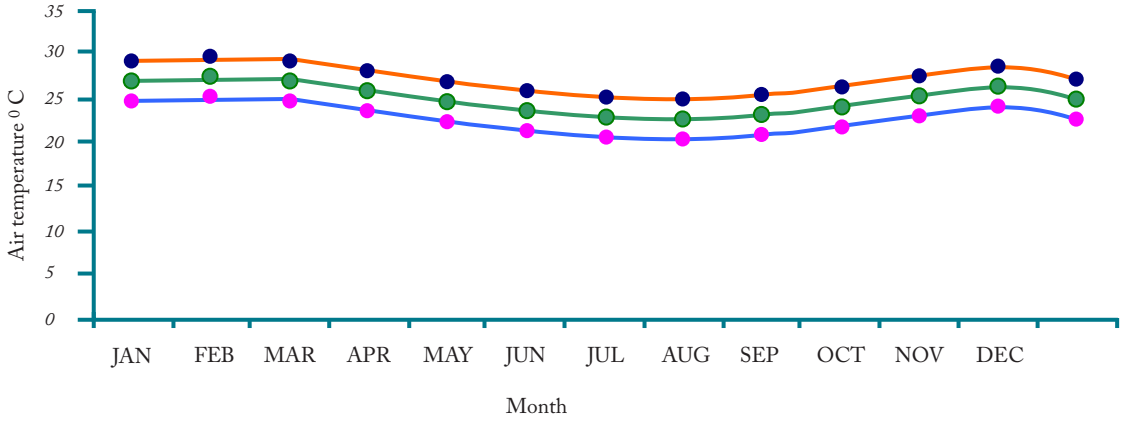


FIGURE 2. Monthly air temperature averages for Ono-i-Lau based on climate averages recorded at Ono-i-Lau climate station from the 1971-2000 period.

Annual average rainfall is 1643mm compared to the annual Fiji rainfall of 1882mm. Relative humidity is 75.7% expressed in percent, of the amount of atmospheric moisture present relative to the amount that would be present if the air were saturated; a function of both moisture content and temperature. Patterns of marine resource use by the island community can be understood from the island's historical timeline of events including extreme natural effects, climate baseline trends that provides insight into the past condition of environment and its remote location provide some measure of control to human disturbances except for the local populace.

TABLE 2. **Monthly averages of climate variables for Ono-i-Lau region**

Ono-i-Lau	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Annual
Max air T(^{0} C)	29.2	29.8	29.3	28.2	26.7	25.9	25	24.9	25.4	26.4	27.6	28.7	27.2
Min air T (^{0} C)	24.2	24.6	24.4	23.6	22.1	21.4	20.2	20	20.4	21.4	22.6	23.5	22.3
Mean air T (^{0} C)	26.7	27.2	26.9	25.9	24.4	23.6	22.7	22.5	22.9	23.9	25.1	26.1	24.7
Rainfall(mm)	179	194	253	157	103	89	92	118	108	86	115	149	1643
Relative humidity, %	78.4	78.9	79.6	77.1	74.9	76	72.3	74.1	73.7	73.2	74.9	76	75.7

METHODS

SURVEY LOGISTICS proved challenging with transportation of key dive equipment and gear to a remote location i.e. high costs for maintenance and hire of dive equipment from a dive facility. Most importantly, the emergency response protocol for this expedition was almost non-existent due to the remoteness of the dive location to the nearest treatment chamber. The emergency/first aid kit contains an oxygen cylinder with a mask and regulator which serves at most 2 hours worth of oxygen treatment, therefore, caution was taken with each dive profile daily. The experience of the dive safety/master and expedition leader spans 25 years of diving and reef research.

List of required dive gear and survey equipment:

- Compressor to fill dive tanks + 10 dive tanks
- 6 X (BCD+wt belt with 4 lead units+reg+dive computer+wetsuit+booties)
- 8 x sets of mask+snorkel+pair of fins
- 6x 50m measure tapes+30cm ruler
- 10 x slates +pencils+erasers+board clips+rubber bands
- 2 GPS units + Ono-i-Lau reference map
- Emergency Oxygen Kit (to include mask+reg+O2 tank)
- Seagrass Watch Kit (4x.25sq.m quadrats+seagrass ID/
- Underwater printed data sheets
- Reference Books for fish+seashell+marine algae
- Bird charts+seagrass+invertebrate+coral volume
- Manta tow board +17m (10mm) towing rope +
- Harness rope to attach to rear of boat
- Camera +Housing
- Refractometer + Stopwatch + Compass

MANTA TOWS were completed prior to Reef Check surveys to provide a quick reconnaissance of reef areas and for Reef Check site selection. Methods followed standard manta tow protocol as detailed in Survey Manual for Tropical Marine Resources (English et al., 1997). Hard coral, dead coral and soft coral cover where estimated during the manta tows as well as broad scale topographic and habitat information. Cover estimates were converted into a score on a five – point scale: 1: 0-10% cover, 2: 11-30%, 3: 31-50%, 4: 51-75%, 5: 76-100% and averaged for each tow area (e.g. MT OT 1). Start and end position of each tow were recorded by GPS.

Reef sites further from the main reef passage were prioritized and dived first. There were 2 teams of 4 divers each catered for by 2 motor outboards. A typical day of survey involved 2 tank dives per team of 4 divers, completing at least 2x50m transects along a standard depth profile of 10-15meters. A one hour surface interval on the boats allowed the survey divers enough rest within safety limits during a multiple-dive situation and sorting of field datasheets before the next survey dive.

SITE SELECTION Pre-selection of survey sites were priority ranked according to:

- Unique characteristics documented in literature eg. a foraging site by three turtle species at areas with lush and pristine sea grass meadows; green turtle (*Chelonia mydas*) was recorded to nest on the beaches of the surrounding islands of Mana, Udui and Tuvana. Adjacent deep waters are known pathways for migratory whales; plus Ono-i-Lau was recorded to host Fiji's largest natural occurring colonies of an endemic giant clam species.
- Access to reef area due to good maritime conditions and safety is assured due to the remote location of these surveyed reef sites.
- Local knowledge on the status of specific marine areas key to management measures considered by the community.
- Representation of the diverse range of reef zones accounting for the leeward/windward sides of the island

CORAL REEF SURVEY METHODS were adopted from the global ReefCheck methodology, Seagrass Watch and the standards of the Global Coral Reef Monitoring Network. The standard Indo-Pacific indicator species list (fish) was tailored to the locally significant (subsistence & commercial) fish species.

About Reef Check: *www.reefcheck.org*

- Largest international coral reef monitoring program involving recreational divers and marine scientists
- In 1997, over 750 volunteer sport divers were trained and led by 100 volunteer scientists in surveys of more than 300 reefs in 31 countries
- Today, over 1500 trained volunteer divers are led by 160 scientists in surveys of 250 reefs in 50 countries

Five types of data were recorded via three surveys along each transect line at each depth. Firstly, a site description sheet was completed that included anecdotal, observational, historical, locational and other data. Secondly, a 5 m wide by 50 m long transects (centred on the transect line) were sampled for commercially important fish, for example those typically targeted by mainly fisher-folk. Surveyors recorded data on more fish species than specified by the standard Reef Check protocol. The divers assigned to count fish swam slowly along the transect and then stopped to count target fish every 5 m and then waited three minutes for target fish to come out of hiding before proceeding to the next stop point. Thirdly, 5 m wide by 50 m long transects (centred on the transect line) were sampled for invertebrate taxa typically targeted as food species or collected as curios. Quantitative counts were made of each species. In addition, the invertebrate surveyors noted the presence of coral bleaching or unusual conditions (e.g. diseases) along the transects. Finally, the same 50m transect was point sampled at 0.5 m intervals to determine the substratum types and benthic community of the reef. The diver looked at each point and noted down what lay under each of those points. The standard Reef Check protocol specifies that the categories recorded under each 50 cm point are: hard coral, soft coral, recently killed coral, dead coral, fleshy seaweed, sponge, rock, rubble, sand, silt / clay and 'other'. However, project surveyors recorded hard corals to life form level (along with target species), soft corals and categories of algal cover (mixed assemblage, coralline, Halimeda, 'macro' and 'turf') into non-coral benthos, abiotic categories included the non-living part of the reef surveyed. Finally, the substratum surveyors recorded coral damage from anchors, dynamite, or 'other' factors and trash from fishing nets or 'other'. Divers rated the damage caused by each factor using a 0-3 scale (0 = none, 1 = low, 2 = medium, 3 = high). All data were transferred to specially-designed recording forms (Appendices).

About Seagrass Watch: *www.seagrasswatch.org*

- global scientific, non-destructive, seagrass assessment and monitoring program now occurring at approximately 205 sites globally.
- to raise awareness on the condition and trend of nearshore seagrass ecosystems and provide an early warning of major coastal environment changes.
- educate the wider community on the importance of seagrass resources
- build the capacity of local stakeholders in the use of standardized scientific methodologies and be able to conduct long-term monitoring of seagrass & coastal habitat condition
- support conservation measures which ensure the long-term resilience of seagrass ecosystems

For more information of seagrass watch surveys please refer to this link: **http://www.seagrasswatch.org/guides.html#FIJI1.**

DATA ANALYSIS Manta tow and Reef Check data are summarised graphically and via univariate statistics. Data were either summarised by site or for the whole project area as appropriate. Note that coral cover is generally divided into 'Acropora' and 'other coral'. Such a division is often used in coral reef ecology since *Acropora* is the largest genus of coral within the Indo-Pacific region, with over 160 species (Veron, 2000), and may have distinct ecological properties. For example, it is known to be particularly susceptible to coral bleaching (e.g. Marshall and Baird, 2000). Total coral cover is a sum of these two parameters.

MARKING MPA BOUNDARIES During the course of the survey, the boundaries of Matokana MPA and other village-endorsed MPAs were marked on a Global Positioning System (GPS) unit. It was noted that at least four shipwrecks were counted on the fringes of the barrier reef system.

RESULTS

Level of community knowledge - High (island biodiversity)
Knowledge of marine species diversity - Low
Habitat diversity - oceanic submerged reefs, passages, outer barrier reef slopes, inner barrier reef slopes, seagrass meadows, sand flats, mangroves, fringing reefs.
Special features - seabird colonies, seagrass diversity, seaweed/marine algal & rich diverse benthic communities.

Source: Setting Priorities for Marine Conservation in the Fiji Islands Marine Ecoregion. WWF Publication 2006.

The reef environment were characterized into five major reef zones which includes the outer barrier slope (coded OB), inner barrier reef edge (coded IB, transect parallel to shore), reef flat (coded RF, transects top of barrier reef), fringing reef (coded F, transect parallel to shore) and reef channel (coded CH, 1 transect at Vakasovika Pass).

MANTA TOW A total of 81 manta tow series were conducted spending a total time of 9 hours and 17 minutes spanning an estimated 17.3km of reef towed. The first series (1st day of towing) starting from outer reef slope of Matokana MPA to the patches of reef adjacent to the anchorage located between Udui and Doi. The second tow series (2nd day of towing) continued from outer reef slopes adjacent Doi Island right along to Vakasovika Pass. Manta tow results showed high live hard and soft coral cover of 51-75% with good visibility. The manta tows were conducted over the reef slope, observing the reef at approximately 5-10 m in depth. The shallow reef slope was characterized by a gradual slope from the reef crest to 5-15m depth, changing to a steeper slope and a sandy bottom at least 30m before deep blue. The exposed (windward side) of the outer reef slopes adjacent to Mana Is., from the crest to slope at 5-15m depth the reef is characterized by a homogenous substrate made up of consolidated coral rock with a few shallow drains breaking up the reef structure. Towards the outer reef slopes of Matokana MPA and adjacent to Doi Island, manta tow results showed moderate live hard and soft coral cover of an average 15-40% with a shallower reef slope profile. Fish life is extremely high with observations of substantially sized species of commercial and ecological importance along the outer reef slopes.

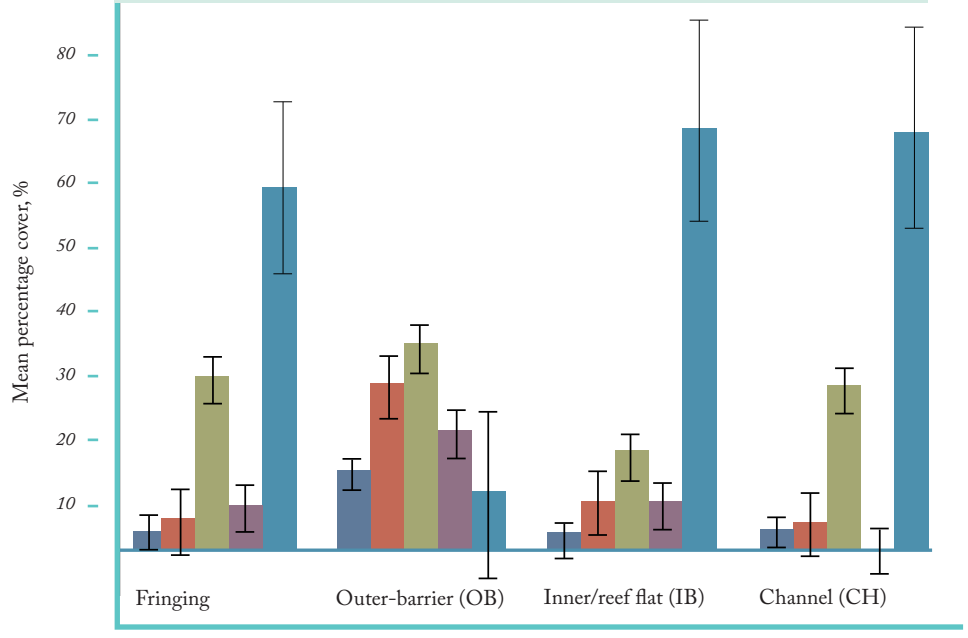
CORAL REEF SURVEYS A total of 29 Reef Check surveys were completed with 10 fringing reef sites, 6 outer barrier reef sites, 6 inner barrier reef sites, 6 reef flat-sites and 1 channel site. The approximate locations of these transects are marked and described in the site descriptions listing. Due to the limited reef development below 5 m on the fringing reef, inner barrier and reef flat complex, most of the transects were completed in the 'shallow' depth band (3-6 m) defined by the standard Reef Check methodology. Deeper transects were generally restricted to the outer barrier reef slope and channel sites where reef development was more extensive.

The basic oceanographic and climatic conditions during Reef Check surveys were also recorded. The mean sea temperature recorded during the dives range from 23.5°C and 24.3°C. The mean estimated underwater visibility was between 10-15m. Mean sea surface salinity was found to be 38‰ in the outer barrier reef slope and as low as 35‰ for inshore readings. The impacts recorded on the site description are almost to none except for fishing by the islanders mainly on the closer fringing and inner barrier reefs.

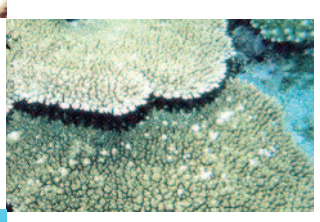
BENTHIC DATA CHARATERISTIC BY REEF HABITAT A graphical summary of all sites are shown in Figure 3 according to 5 key categories: Acropora, other coral types, non coral benthos, dead coral with algae (as an indication of past bleaching severity) and non-living abiotic components of reef (rock, rubble, sand). Bars represent standard deviation.

Reef Check results indicated highest coral cover found at the OB sites with a mean percent cover of at least 40% (sum of Acropora and Other coral cover). In summary, the outer barrier reef sites exhibited a homogenous representation of benthic categories identified for characterization of the reef communities. Representation for the highest Abiotic cover was at IB (<70%), CH (<70%)and Fringing reef (<60%) sites, this category is a combination of rubble, sand and rock (non-living) components of the reef area surveyed. Non-coral benthos mean cover were highest at OB (~32%) Fringing (<30%), CH (<30%) sites. The category DCA (Dead Coral with Algae)mean cover was low across all reef sites (less than 20%).

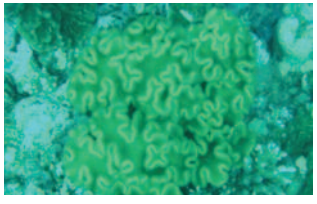
FIGURE 3. **Mean cover of benthic types per reef habitat type**



Acropora

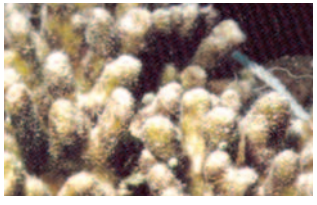


Other coral



Non-coral benthos
Soft coral

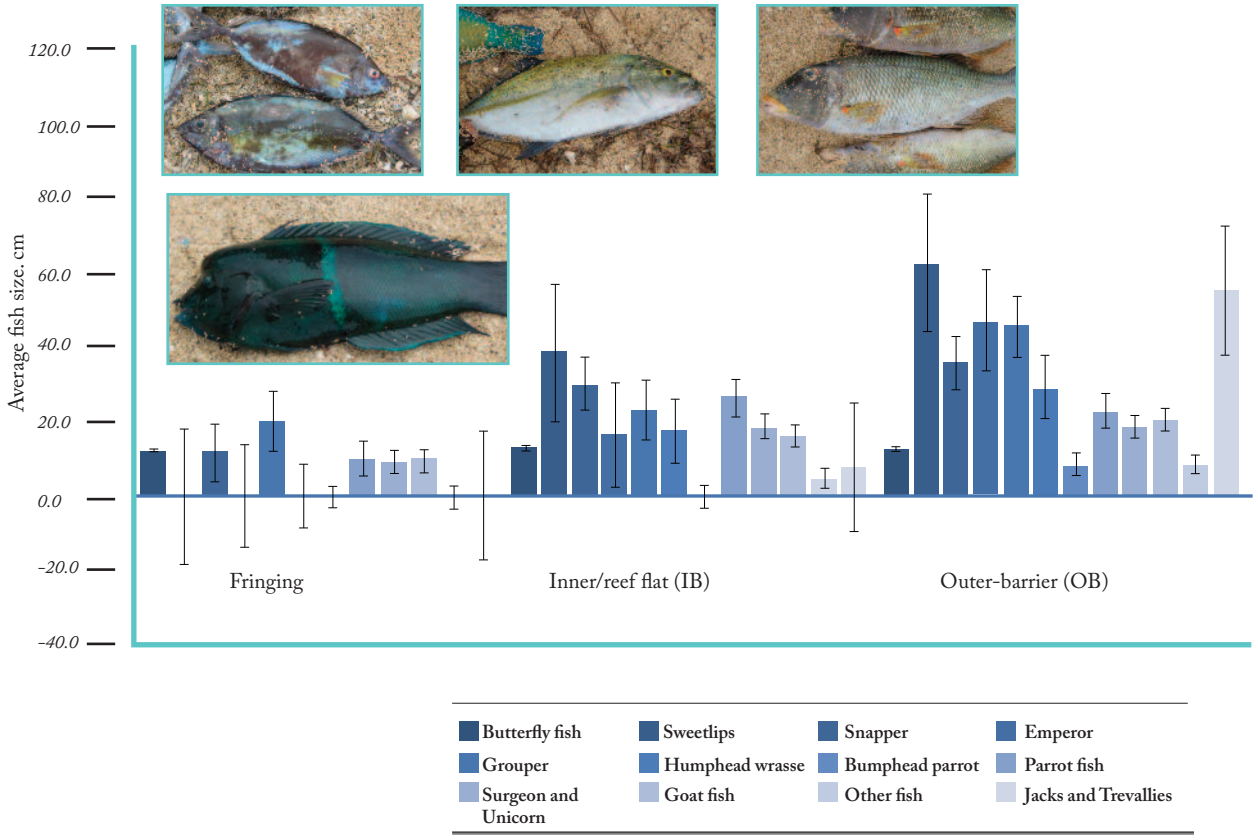
Abiotic
rubble, sand,
rock

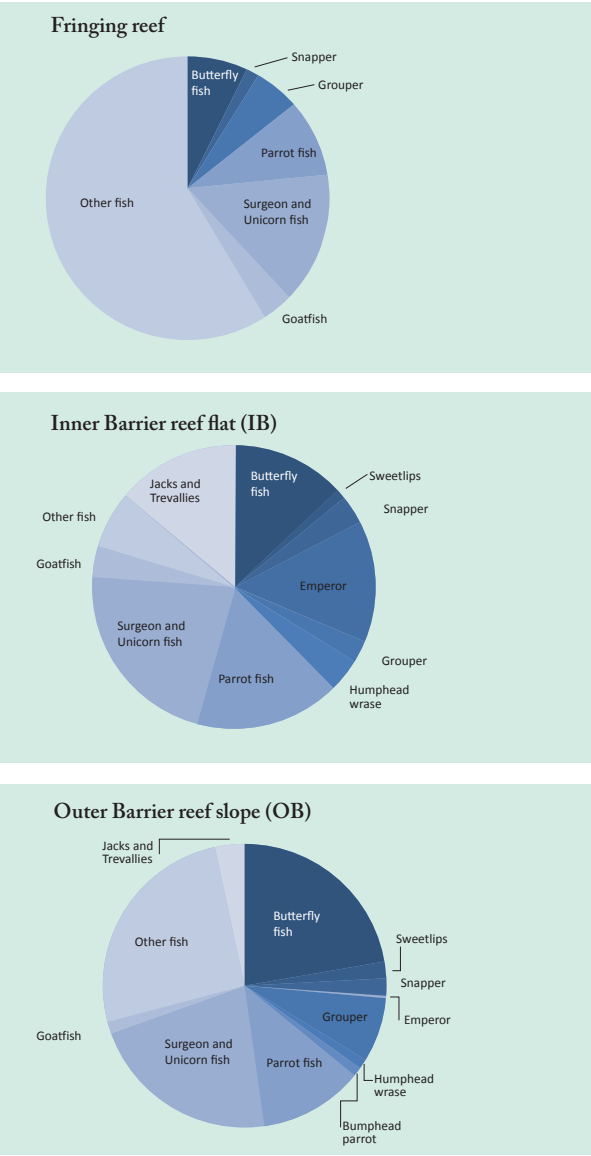


DCA
Dead Coral with Algae

FISH LIFE Twelve fish family groups were highlighted during the analysis based on abundance categories. Representation of fish abundance by family grouping in pie charts showed that Other fish category made up the largest group at Fringing reef sites, IB sites –most abundant fish groups were parrotfish (*Scaridae*)and surgeonfish (*Acanthuridae*). OB sites- high abundance of butterflyfish (*Chaetodontidae*), surgeonfish and unicorn-fishes plus large schools of fish were observed outside of the transect. In overall, the IB sites represented a more diverse range of fish groups observed as compared to the OB and Fringing reef sites. The bar graphs represent the average fish sizes of observations per fish group at each reef habitat type. OB sites' fish size representation across fish groups indicate larger-sized fish (highest >60cm in length) observed on the outer reef slope as compared to the fringing reef sites closer to the island. This observational data can be attributed to the timing of surveys at the shallower reef sites (Fringing and reef flats) and caution on describing the smaller-sized fish distribution at fringing and IB reef sites to fishing pressure. Fish is a highly mobile species moving across reef habitats.

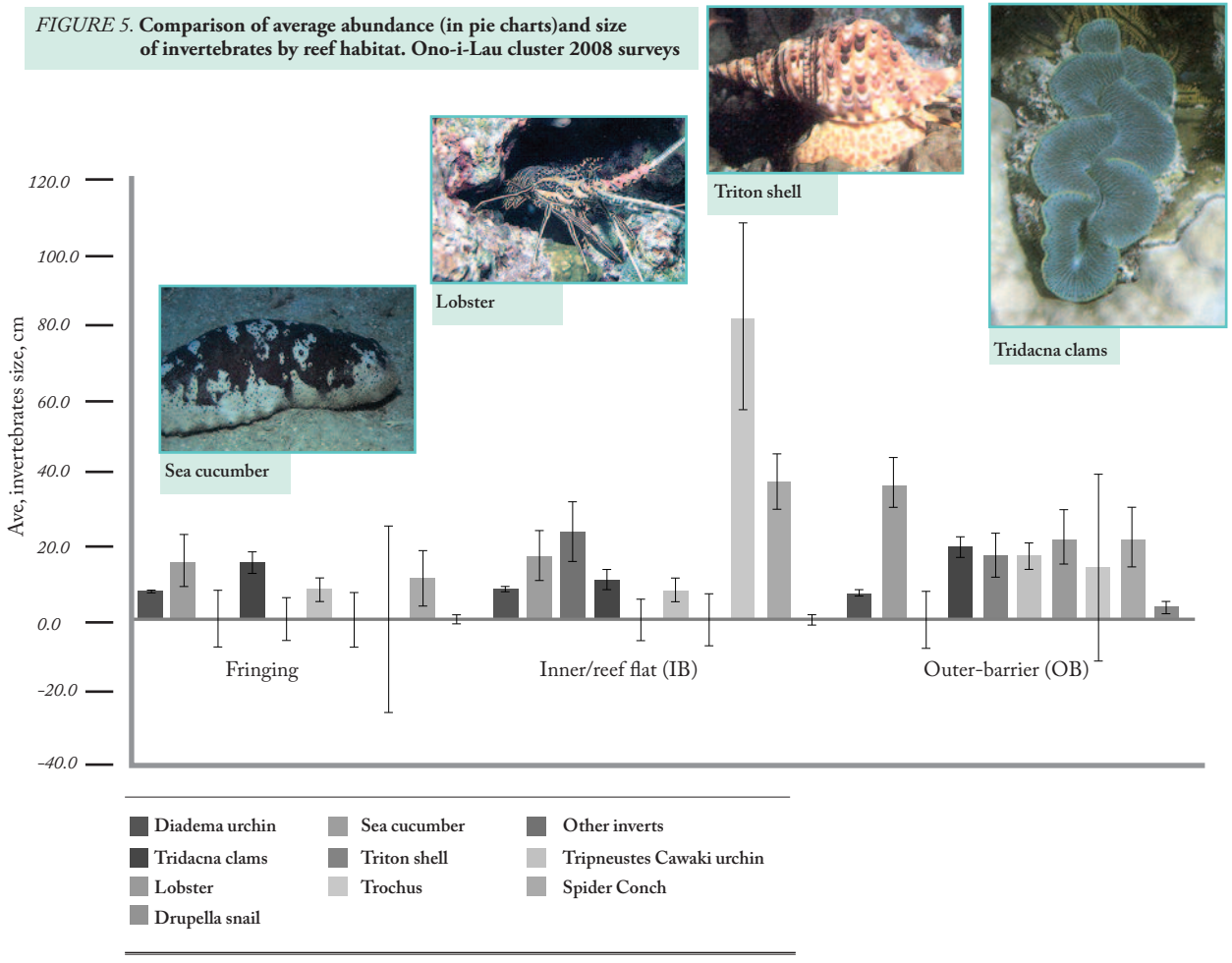
FIGURE 4. **Comparison of average abundance (in pie charts)and size of fish by reef habitat. Ono-i-Lau cluster 2008 surveys**





INVERTEBRATES A relationship exists between invertebrate taxa found and the type of benthic composition of a reef. Pie chart representation of invertebrate counts on Fringing reefs show *Tridacna* clams most abundant, *Diadema* most common on IB sites plus a diverse range of invertebrate taxa in OB sites with *Triton*, *Tripneustes* urchins, sea cucumbers and spider conch shells recorded. The bar graph represented the invertebrate sizes (in cm) of species counted and trends show that OB sites recorded sizes of invertebrates in the range of 10cm to at least 35cm in length. The spider conch recorded at the IB reef site skewed invertebrate length sizes for the sum of inner barrier reef sites.

FIGURE 5. **Comparison of average abundance (in pie charts)and size of invertebrates by reef habitat. Ono-i-Lau cluster 2008 surveys**



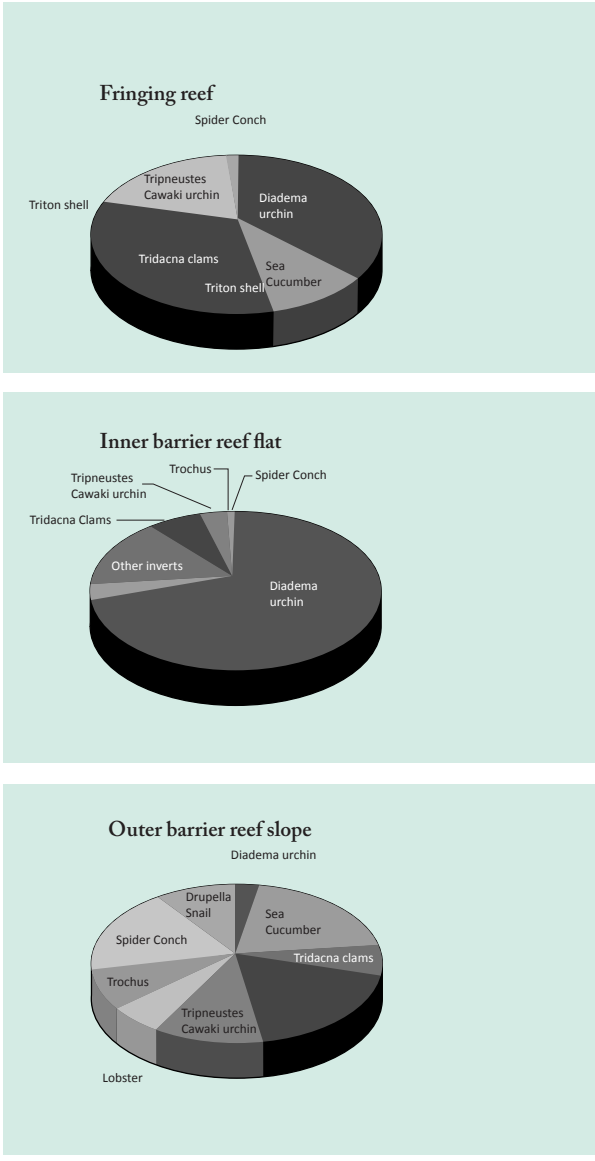
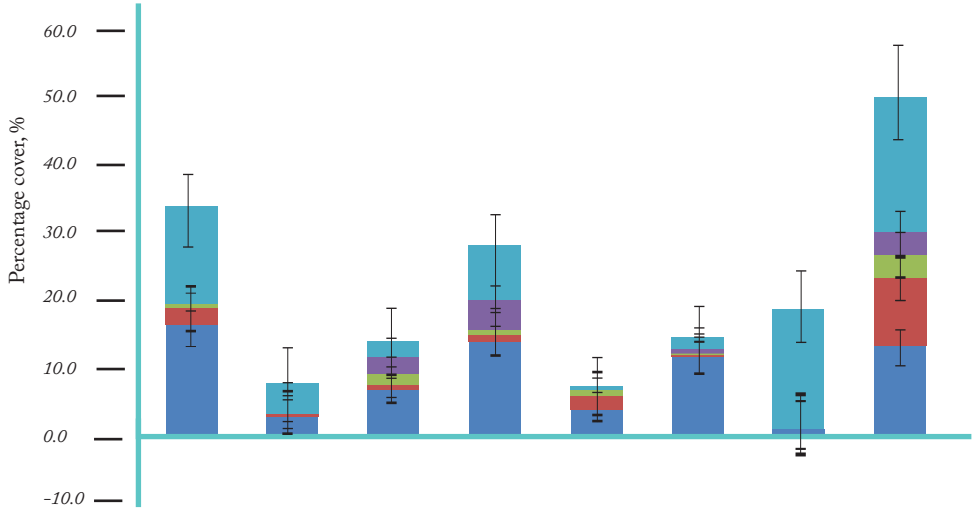


TABLE 3. **Description of seagrass cover and fauna distribution across seagrass sites**

Site	Mean canopy height (cm)	Mean seagrass cover (%)	Average # of organisms
Nukuni	7.2	19.1	43.7
Yao Bay	3.8	3.1	63.4
Muanivatu	4.9	11.4	24.3
Doi	6.1	19.3	39.5
Matokana	4.7	6.3	83.4
Dromoninuku	6.7	12.5	51.8
Yanua	3.9	0.8	3
Davura	12.3	29.5	4.3

FIGURE 6. **Graph illustrates the mean algae and seagrass cover, its species diversity along Ono-i-Lau's coastline during seagrass watch surveys from the period 27th September-6th October, 2008**



	Nukuni	Yao Bay	Muanivatu	Doi	Matokana	Dromoninuku	Yanua	Davura
Algae	14.1	4.5	2.3	8.5	0.8	1.8	17.7	20.5
SI	0.0	0.0	2.9	1.3	0.0	0.5	0.0	3.3
HO	0.3	0.2	1.5	0.5	0.8	0.2	0.0	3.2
HP	2.4	0.1	0.3	0.7	1.8	0.2	0.0	9.5
HU	16.4	2.8	6.7	13.8	3.7	11.6	0.8	13.5

SEAGRASS WATCH A total of 36x50m transects across 7 seagrass watch sites were established for assessing the extent of seagrass growth and species diversity. Four seagrass species were identified: *Syringodium isoetifolium* (SI), *Halophila ovalis* (HO), *Halodule uninervis* (HU) and *Halodule pinifolia* (HP) on Ono-i-Lau soft shores. The main areas of seagrass beds are located in the inter-tidal and adjacent subtidal zones in Yao Bay, Nukuni, Lovoni, Matokana and Doi. Scattered patches of seagrass and algal assemblages are found elsewhere on the surrounding islets like Yanuya, Davura and Mana where a major algal bed of Caulerpa. sp. is found.

Table 3 describes seagrass cover and fauna distribution across seagrass areas surveyed. Mean canopy height describes the length of seagrass blades which adds to the thickness of the local seagrass area and the highest seagrass cover is observed at Nukuni and Doi. The abundance of organisms found in the seagrass were especially noted in the Matokana (ave. 83.4 organisms), Yao Bay (ave. 63.4 organisms) and Dromoninuku (ave. 51.8 organisms). These were mainly sea shells, brittle stars and edible urchins (cawaki) highlighting the important food links of the seagrass to the surrounding coral reefs also an important gleaning area for the islanders.


divingthegoldcoast.com.au

Halophila ovalis


picasaweb.google.com

Halodule uninervis


teamseagrass.blogspot.com

Syringodium isoetifolium


ceag.phc.edu.tw

Halodule pinifolia

DISCUSSION

Current data collected during surveys are highly qualitative, large scale and dependent on the time of the survey (i.e. they are not systematically collected across the tidal regime). Consequently it is difficult to interpret the current data from the limited data collected during the study. However, there is an indication of currents along the length of the seaward reef moving from the south east. Accurately modelling water movement patterns is vital for conservation since fish and coral larvae are entrained by currents and moved between 'source' and 'sink' areas (e.g. Caley et al., 1996). Therefore, important to place marine reserves in areas that provide larvae (sources) via current flow to other local reefs and, therefore, can replenish fish stocks and regenerate benthic communities after degradation by anthropogenic impacts (Roberts and Hawkins, 2000). However, storm damage play a key role in shaping the environment in which coral reefs develop. The mechanical effects of strong wave damage and periodic cyclones have characterized the seaward reef slope topography and biota.

Past coral bleaching effects on these reef sites can only be described based on the DCA categories on colonies observed mainly on the outer barrier reef slope. Since water temperatures were approximately 23.5-24.3 ^{0}C during the surveys, well below the critical threshold for bleaching (approximately 30 ^{o}C), the historic bleached state presumably represent colonies stressed by the cold temperatures rather than zooxanthellae subjected to warm water. Reef Check surveys results summarised provide a preliminary assessment of reef health for Ono-i-Lau with enough representation of reef habitats except for the channel sites. Overall, Reef Check surveys recorded a coral cover of 65.8% for all reef habitats. Coral cover is often used as a gross surrogate of reef health and the ASEAN-Australia Living Coastal Resources proposed the criteria that: >75% = excellent; 75-50% = good; 50-25% = fair and <25% = poor (Chou et al., 1994). While these classes were designed primarily for Southeast Asia they are also a useful indicator for the South Pacific. The data presented in this report indicate that overall the reefs are currently in 'good' condition. However, it is much more instructive to separately discuss each reef complex, and the natural and anthropogenic influences that shape these reef communities.

Outer barrier reef slope is characterised by wave surge and periodic severe wave action from storms and cyclones. As a result, only close cropped and encrusting life forms are found in the shallow zone of the seaward reef. A band of higher coral cover exists at approximately 5-15 m in depth. Other coral types (non-Acropora) were found to be more dominant on the outer reef.

Fringing reef, Inner barrier and reef flats surrounding the main Ono Levu and other islets were dominated by non-coral benthos mainly algal assemblages and seaweed with a mean cover of 27.6%. Live coral cover is low and comprise mainly of rubble, sand with colonies of *Porites, Favites* and *Pocillopora*. Signs of fishing impact is almost non-existent at these patches of reef except for occasional observation of a fishing line.

Though not of high biodiversity, the stress tolerant coral reef (*Porites* dominated) and disturbance adapted (*Acropora* dominated) reefs are unique areas adapted to specific environmental conditions, with a distinct biota associated with each habitat. Using techniques originating in botany, Edinger and Risk (2000) assigned conservation values to sites based on the proportion of disturbance-adapted (ruderal) Acropora corals, competitively dominant branching and foliose non-Acropora corals and stress-tolerant massive and submassive non-Acropora corals that are present. Reefs dominated (>60%) by stress-tolerators have a low conservation value, reefs dominated (>50%) by competitively dominated or disturbance-adapted corals are assigned medium conservation value and reefs with a mixed community have a high conservation value. This applies to the benthic composition of the outer barrier reef slopes. Edinger and Risk (2000) assigned these conservation values because they showed them to be correlated with coral species richness, number of rare coral species and habitat complexity (which is likely to be linked to fish diversity and abundance). While the stress tolerant and disturbance tolerant corals are not of the highest conservation value due to their relatively low habitat complexity and species richness, the reefs of Ono-i-Lau have significant values for subsistence fisheries with potential for commercial exploitation and should be a priority for management.

Fish and Invertebrates Reef Check surveys also record the abundances of a suite of fish and invertebrate taxa that are indicators of reef health (Hodgson, 1999), although this list was extended for the survey. Abundances of the most commercially important fish families were high (sweetlips, groupers and jacks, trevally) and few numbers of bumphead parrotfish (*Bolbometopon muricatum*) and Humphead wrasse (*Cheilinus undulates*) were recorded during the dive surveys were recorded in the outer barrier reef slopes. The stress tolerant and disturbance adapted fringing reefs have relatively lower species richness and habitat complexity, which is linked to fish diversity and abundance. There is a clear correlation between coral and fish species richness. The increased spatial complexity of coral rich habitats provides a larger variety of niches that support greater diversities of fish at the family and species level (*Luckhurst and Luckhurst*, 1978) via additional food sources (*Thresher,* 1983) and hiding places (*Roberts and Ormond*, 1987). Species of butterflyfish that are obligate corallivores as indicators of reef health. In comparing benthic composition to the fish assemblagees recorded, there is similar counts of butterfly fish at each of the reef habitat type where live coral cover is moderate.

Most of the invertebrate target taxa were found. The most commercially valuable invertebrate species were relatively abundant. Two species of sea cucumbers were noted during the surveys, *Holothuria edulis* and *Bohadschia argus*. Kuster, et.al (2003) reported these species of beche-de-mer that includes: *Actinopyga mauritiana*, *Holothuria fuscogilva*, *Holothuria nobilis*, *Thelenota ananas, Holothuria atra* and *Bohadschia marmorata* found mainly on barrier reef top. There are a few collectors of the targeted cucumber species namely *Stichopus choloronotus*, *Holothuria nobilis* and T*helenota ananas*.

Lobster populations are exceptionally large based on catch whilst being on Ono-i-Lau and can sustain a commercially important fishery with good practice principles and monitoring of collection. The curios trade prizes triton shells were found during transect surveys which indicate good reef health and lack (or limited) of collection for food or curio purpose. However, such removal may have important ecological effects since tritons are known to feed on crown-of-thorns starfish. Based on past surveys (Kuster, et.al 2003), three species of giant clams were noted: *T. maxima, T. squamosa and T. derasa*, and only dead shells of *Hippopus hippopus* and *T. gigas* were found. This survey recorded a high number of clams along the transects with five clam species noted: *T. maxima, T.derasa, Hippopus hippopus and T. crocea* and *T. squamosa.*

Megafauna, such as sharks, tuna (a bluefin tuna), turtles are only loosely correlated with reef health but these top predators and its frequent sighting during reef surveys especially on the outer reef slope indicates a highly productive area of fisheries but also vulnerable to overfishing. Furthermore, megafauna are highly valued by tourists and can be a major attraction to an area.

RECOMMENDATIONS

The information collected during this survey presents more than a snap shot analysis of the coral reef environment of the Ono-i-Lau cluster. It is clear from the results that many indicator species are present in relatively high abundance.

In order to facilitate marine resource use management, the survey design catered for key questions posed by communities for the purpose of assessing the status of their protection effort of their I qoliqoli and setting baseline information of Ono-i-Lau's marine resources for better understanding how these described reef communities will respond to both natural influences and community resource use over time.

A series of marine reserves with small areas as 'no-take' zones (i.e. fishing is banned) should be considered to augment the current MPA at Matokana. No-take zones have the advantage in that they can be effective without requiring growth and mortality statistics for each species that are necessary for conventional management options (Munro and Williams, 1985; see also Mahon, 1997). The placement of these reserves should incorporate both biological data and socio-economic factors and follow extensive discussions with all stakeholders.

Extracted from the Ono-I-Lau Development Plan-Focal Area

Focal Area 14 **Environment-Biodiversity and Natural Resources**
GOAL: To protect Tikina Ono-i-Lau's existing unique environment from further degradation and to promote and encourage sustainable natural resource use and management amongst all Ono-i-Lauans within the district by 2020.
Target 1: Marine To identify existing and potential threats to Tikina Ono-i-Lau's I qoliqoli areas and to have developed key actions for implementation to address and safeguard against these identified threats by 2008.
Activities Consultation, meeting, workshop with Ono-i-Lau villages and those living in urban areas to discuss threats to Qoliqoli.
Target 2: Marine To have a defined percentage of the Tikina Ono-i-Lau's qoliqoli under a community marine protected system, managed by a fully functional Ono-i-Lau Qoliqoli Committee by 2010.
Activities Designation of a common MPA for all the villages in Ono and for the island of Vatoa. (District level MPA for an effective compliance level). Implement, monitor, review and adapt the Qoliqoli Management Plan annually.

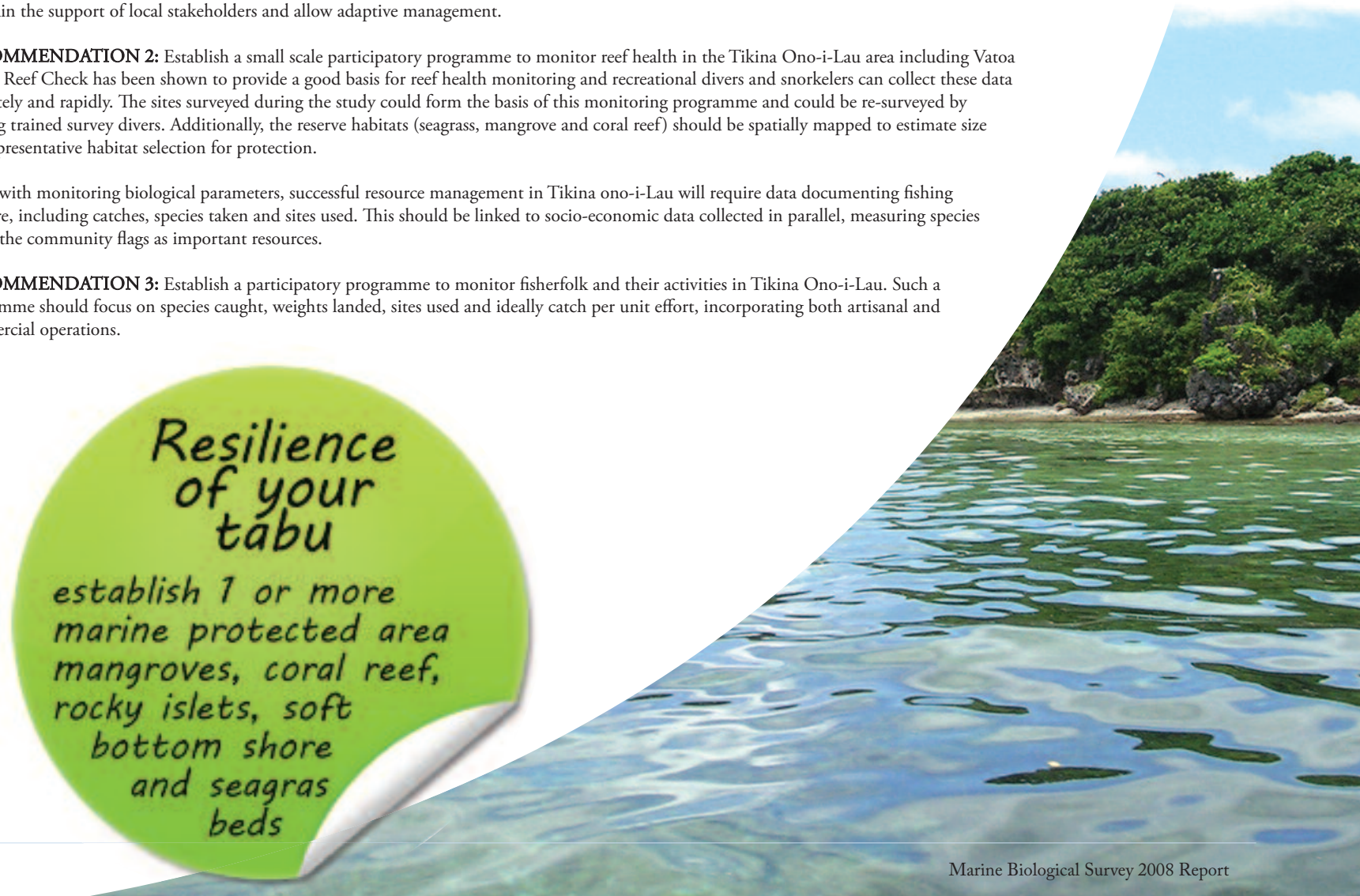
A general principle to guide discussion with the establishment of MPA will emphasise on the island community's understanding " to catch your limit, or limit your catch" with the following recommendations:

- **RECOMMENDATION 1:** Aim to establish one or more marine protected areas in the Tikina Ono-i-Lau expanding on the current reserves at Matukana that covers from the shoreline including seagrass, mangroves, patch reefs and bands of the outer barrier reef slope.
  The establishment of an effective system of marine reserves will require the support of local stakeholders and communities and hence a series of conservation education programmes will be required. This study provides a baseline data set on current reef health and future surveys will allow recovery or further declines to be monitored. Furthermore, monitoring the efficacy of any future programme of marine reserves is vital to maintain the support of local stakeholders and allow adaptive management.

- **RECOMMENDATION 2:** Establish a small scale participatory programme to monitor reef health in the Tikina Ono-i-Lau area including Vatoa Island. Reef Check has been shown to provide a good basis for reef health monitoring and recreational divers and snorkelers can collect these data accurately and rapidly. The sites surveyed during the study could form the basis of this monitoring programme and could be re-surveyed by existing trained survey divers. Additionally, the reserve habitats (seagrass, mangrove and coral reef) should be spatially mapped to estimate size and representative habitat selection for protection.

  Along with monitoring biological parameters, successful resource management in Tikina ono-i-Lau will require data documenting fishing pressure, including catches, species taken and sites used. This should be linked to socio-economic data collected in parallel, measuring species which the community flags as important resources.

- **RECOMMENDATION 3:** Establish a participatory programme to monitor fisherfolk and their activities in Tikina Ono-i-Lau. Such a programme should focus on species caught, weights landed, sites used and ideally catch per unit effort, incorporating both artisanal and commercial operations.



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APPENDIX 1

Ono-i-Lau Cluster EXPLORE EXPEDITION 2008

Broad Objectives of the Ono-i-Lau Cluster Explore Expedition 2008

1. To explore the Ono-i-Lau cluster of islands also known as the eastern archipelago of the Fiji Group.
2. To update the information status for Ono-i-Lau region, first described as an area of national significance during a national marine biodiversity prioritization workshop by WWF in 2003, with the participation of local and international marine experts and scientists.
3. To provide a marine biodiversity baseline assessment of Ono-i-Lau cluster of islands and associated coastal habitats.

Level of community knowledge - High
Knowledge of marine species diversity - Low
Habitat diversity - oceanic submerged reefs, passages, outer barrier reef slopes, inner barrier reef slopes, seagrass meadows, sand flats, mangroves, fringing reefs.
Special features - seabird colonies, seagrass diversity, seaweed/marine algal & rich diverse benthic communities.

Source: Setting Priorities for Marine Conservation in the Fiji Islands Marine Ecoregion. WWF Publication 2006.

SPECIFIC EXPEDITION OBJECTIVES:

1. To assess the reef health status of the Ono-i-Lau cluster and provide a marine biological baseline profile of its marine environment.
2. To conduct interactive island biodiversity education and awareness sessions with the schools and host villages; information sessions will include coral reef ecology; fisheries-related issues and impacts of climate change on resilience of isolated island communities.
3. To determine indicators from marine biological surveys that will contribute to the District Development Plan.
4. To collect and review distributed the fisher log-books given to the trained PADI divers (8) as part of the Catch Per Unit Effort (CPUE).

DIVE TEAM MEMBERS:

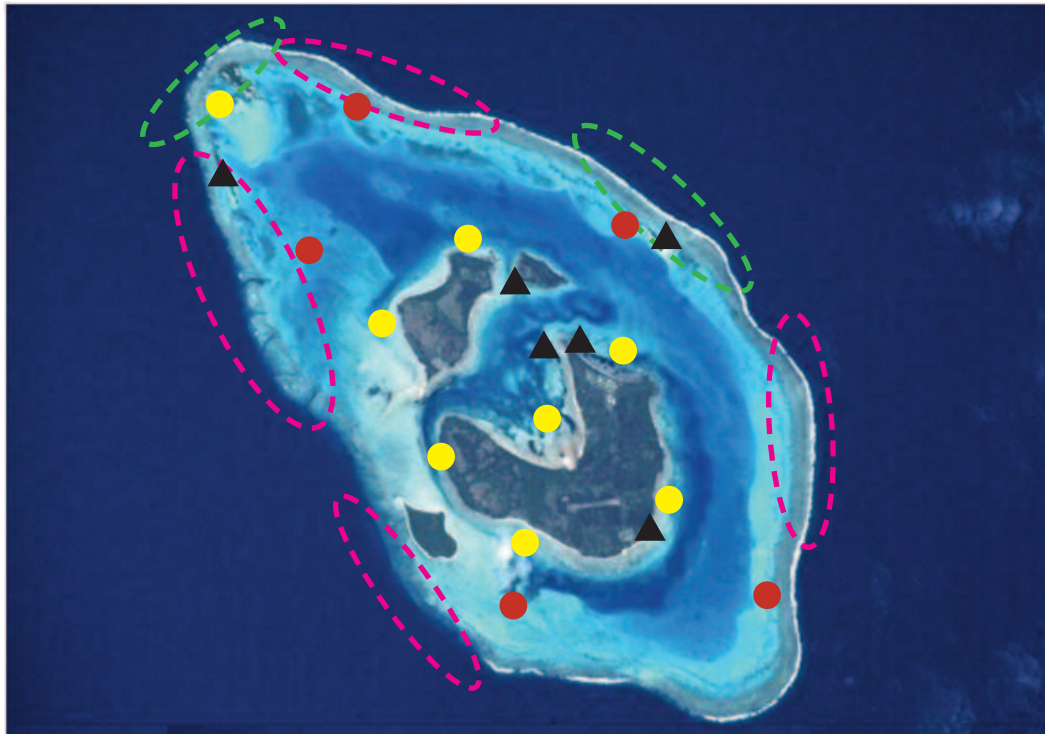
1. Monifa Fiu [Expedition Leader/ Safety]
2. Metui Tokece [WWF Fiji Liaison Officer]
3. Api I- Scuba Bula [Dive Safety/ Expedition]
4. 8 x trained community divers of Ono-i-Lau

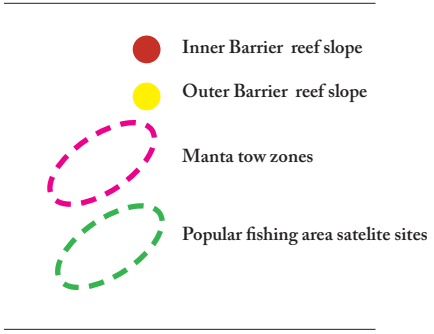
All divers must have valid DAN Diver insurance.

LIST OF REQUIRED DIVE EQUIPMENT:

1. Compressor to fill dive tanks + 10 dive tanks
2. 6 X (BCD+wt belt with 4 lead units+reg+dive computer+wetsuit+booties)
3. 8 x sets of mask+snorkel+pair of fins
4. 6x 50m measure tapes
5. 10 x slates +pencils+printed underwater datasheets+erasers+board clips+rubber bands
6. 2 GPS units + Ono-i-Lau reference map
7. Emergency Oxygen Kit (to include mask+reg+O2 tank)
8. Seagrass Watch Kit (4x.25sq.m quadrats+seagrass ID/data sheets+50m tape+30cm ruler+compass)
9. Reference Books- Fish+seashell+marine algae+bird charts+seagrass+invertebrate+coral volume
10. MANTA TOW BOARD +17m (10mm) towing rope + harness rope to attach to rear of boat
11. Camera +Housing
12. Refractometer + Stopwatch + Compass

Satellite Image of Ono-i-Lau





Reefs of special interest proposed to visit:

1. Vatoa submerged reef
2. Green turtle nesting areas at Mana, Udui and Tuvana
3. Seabird colony areas - Yanua Island.
4. Potential seagrass watch areas adjacent to schools
5. Visit the reef museums of shipwrecked on the reef.

Site selection of marine habitats (listed according to high priority of exploration).

** Initial efforts will concentrate (weather/currents permitting) on the farther sites from camp site.*

Survey team roles and responsibilities [TENTATIVE]

– fish abundance/biomass

- Document abundance (density) and biomass of a localized indicator fish species list at each site. 50 x 5 meter transects at deep (12-15 m) and shallow (3 -6 m) depths.

- diversity of Algae and seagrasses

- Document different major groups of algae and sea grasses at each site and estimate of percentage cover.

Report to consist of precise methods used, species at each site – estimations of % cover for each species for each site – comparisons to other known sites in Fiji eg. GSR, Kabara, Tikina Wai, Nadroga.

Coral Reef Monitoring Team

- Fishes

- Document reef profile at each site
- Document amount and type of lost/discarded fishing gear at each site
- Fish abundance and size class estimations per survey depth and site

– Sessile Invertebrates

- Document the diversity and abundance of indicator groups of sessile invertebrates. Reef Check methodology. Species level if possible.

– Benthic cover

- Assist documentation of benthic cover using point intercept transect method at each site. 1x50 transects at deep (12-15 m) and shallow (3 -6 m) depths. Special notes on percent bleached corals and crown of thorns cover and damage. Benthic data recording will include resilience variables for coral bleaching monitoring.

Survey dive logistics:

The above teams will ideally be diving off the same outboard.

APPENDIX 2

SEAGRASS WATCH TECHNIQUES adopted from Seagrass-Watch: Manual for Mapping & Monitoring Seagrass Resources by Community Volunteers.
(2nd Edition. Department of Primary Industries, Queensland, Northern Fisheries Centre. April 2003).
Within a seagrass area, 3x50m transects were laid out parallel to each other, at least 25m apart and perpendicular to shore. For every, 5m mark along the 50m tape, a quadrat was placed for sampling according to the following steps:
Step 1- describe the sediment composition by feeling the texture of sediment from the top centimeter of the substrate. Note the grain size in order of dominance e.g. sand, fine sand, mud.
Step 2-estimate seagrass percent cover within the quadrat-use the percent cover photo standards as a guide (Annex___).
Step 3-estimate seagrass species composition by identifying each species of seagrass within the quadrat and determine the percent contribution of each species to the cover (must total 100%). Use seagrass species identification keys provided (Annex ___).
Step 4- measure canopy height, ignoring the tallest 20% of leaves. A 30cm ruler was used to measure from the sediment to the leaf tip of at least 3-5 shoots.
Step 5- Estimate algae percent cover in the quadrat. Algae are seaweeds that may cover or overlie the seagrass blades. Use "Algal percent cover photo guide".
Step 6- Estimate epiphyte percent cover. Epiphytes are algae attached to seagrass blades and often give the blade a furry appearance. First estimate how much of the blade surface is covered, and then how many of the blades in the quadrat are covered.
Step 7- Describe other features and ID/count of macrofauna. Note and count any other features which maybe of interest eg. Number of shellfish, sea cucumbers, sea urchins, evidence of turtle feeding. In this field trip, samples of seagrass and photographs were not taken at each quadrat/transect site. At completion of monitoring, datasheets were checked and filled in completely, i.e. ensure that observers' name, date and site/quadrat details are clearly recorded on the datasheet. Survey equipment were washed with freshwater and let to dry, ready for the next seagrass survey as according to next schedule.

APPENDIX 3

Fish list derived from Ono-i-Lau 2008 survey

Fijian Name	English Name: Kuster,et.al,2003	English Name: WWF survey,2008	Family & Species
Ulavi	Five Banded Parrotfish	Longnose Parrot fish	Scaridae-Scarus ghobban
Cabutu	Yellow Tailed Emperor	Snubnode Emperor	Lethrinidae-L.mahsena
Kabajia	Variegated Emperor	Orange stripe Emperor	Lethrinidae-L.variegatus
Baba	Flutemouths	Keeltail Needlefish	Fistularidae-Fistularia spp
Ose	Yellowfin Goatfish	Yellowstripe Goatfish	Mullidae-M.Vanicolensis
Renua	Rudderfish	Highein redderfin	Kyphosidae-Kyphosus
Dravisau	Sabre squirrelfish	Long-jawed squirrel Fish	Holocentridae-Sargocentron spiniferum
Kerakera	Marbled cod Brown-marbled	Grouper	Serranidae-E.microdon
Meto	Lined bristletooth	Chronixis surgeonfish	Acanthuridae-Ctenochaetus striatus
Kanace	Bluetail Mullet	fringelip Mullet	Mugilidae-Valamugli seheli
Ta	Unicorn Fishes	Bluespine Unicornfish	Acanthuridae-Naso.spp
Bose	Parrotfish	Steephead Parrotfish	Scaridae
Ika Loa	Surgeon Fish	Round spot surgeon Fish	Acanthuridae-Acanthurus sp.
Sai	Thumprint Emperor	Red-Axic Emperor	Lethrinidae-L.harak
Nuqa		Golden rabbitfish	Siganidae
Gugu		yellowbox fish	
Mulu	Forktail Rabbitfish	Dusey Rabbitfish	Siganidae-siganus argenteus
Balagi	Yellowfin surgeon fish	Yellowfin surgeon	Acanthuridae-A.xanthopterus
Sevaseva	Harlequin sweetlips	Spotted sweetlips	Haemulidae-Plectorhinchus
Vunavuna		Arabian Angel fish	
Tete		Puffers	Tetraodontidae
Damu & Kake	Blackspot seaperch	Snapper	Lutjanidae
Salala		Fusilier	Caesionidae
Bakewa		Remoras	Echeneidae
dolokoto	Flounders	Sandperch	Pinguipedidae
Davilai		Left eye Flounder	Bothidae
Kaboa		Catfish	Plotosidae
Qitawa		Terapons	Teraponidae
Cumu	Triggerfish	Triggerfish	Balistidae
Masi		Tile fish	Malacanthidae
Matu		Mojarra	Gerreidae
Sokisoki		Pocupine fish	Diodontidae
Ravo ni Magimagi		Wrasse	Labridae
Guru		Damsel	Pomacentridae
Matale		Sea breams	Sparidae
Dabea		Moray Eel	Muraenidae
Kawakawa,Kasala,Kavu		Groupers	Epinephelinae
Qitawa		Terapons	Teraponidae
Vilu,Saqa		Jacks	Carangidae

Roba,Matu	Pony Fish	Leiognathidae
Damu,Kake,Bati	Snapper	Lutjanidae
Dokoni,Kabatia,Kawago	Emperors	Leethrinidae
Matake	Breams	Nemipteridae
Ose	Goatfish	Mullidae
Jivijivi	Butterfly fish	Chaetodontidae
Guru	Bamselfish	
Dradravikula	Wrasse	Labridae
Bose,Kalia,Kawakawa	Parrot fish	Scaridae
Todo,Utimate	Sandperch	Pinguipedidae
Beli	Gooces	
Lati ni daveta,Vunavuna	Spadefish	Ephippidae
Balagi	SurgeonFish	Acanthuridae
Ta,Macimaci	Unicorn fish	Nasinae
Ogo	Barracuda	Sphyraenidaae
Salala,Walu	Tuna/Mackerel	Sphyraenidaae
Dadavilai	Left eye Flounder	Bothidae
Toatoa	Boxfish	Ostraciidae
Sumusumu	Puffers	Tetraodontidae
Kabua	Catfish	Plotosidae
Yalewa matua	Frogfish	Antennaridae
Kanace	Mullet	Mugilidae
Saku	Needlefish	Belonidae
Corocoro,Damuda	Squirrelfish	Hollocentrinae