

# Reef surveys, Beqa and Serua, Fiji

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## Introduction

Between 12 April and 11 June 2019, in-water surveys of reefs in the Serua and Beqa Lagoon areas were undertaken. A variety of reef types were studied, mostly at depths of 1 – 4 m (reef flats) or 5 – 12 m (reef slopes). Most areas were open for fishing, for subsistence, small scale commercial, and in some cases, aquarium collection (small ornamental fish or live corals). Four were within protected (no-take) areas, and a few outer reefs were not frequently fished due to rough water conditions.

Standard indicator species used to determine relative coral cover and populations of species targeted by fishers were assessed, and are presented as descriptions of reefs in the area in early 2019, and as a comparison of marine protected areas with open fishing grounds.

## Methods

Over nine days between 12 April and 11 June 2019 (surveys were frequently delayed due to poor weather), 15 sites were selected for study. At each site the following surveys were carried out:

### Water quality:

- Field tests of sea water Temperature, pH, Salinity, Clarity, Presence/ Absence of Coliform Bacteria
- (6 sites): Laboratory tests of seawater Phosphates, Nitrates, quantitative Faecal Coliform Bacteria

**Reef Profile** to at least 10m including identification of main physical substrate type such as hard coral, rubble, rock, sand.

**Detailed surveys** at a variety of depths selected as most representative of fishing depths

- Substrate: 40 points along 20 m line for:
  - Basic substrate cover – Live Hard and Soft Coral, Macroalgae, Rock, Rubble, Sand etc
  - Coral and Algal Lifeform category, including Coralline Algae
  - Bleaching levels
- Invertebrates: 100m<sup>2</sup> belt transects for
  - Giant Clams *Tridacna spp* (Vasua)
  - Triton's Trumpet Shell *Charonia tritonis* (Davui)
  - Diadema Sea Urchins *Diadema spp* (Gasagasau)
  - Collector Sea Urchins *Tripnuestes gratilla* (Cawaki)
  - Pencil Sea Urchins *Echinometridae*
  - Sea Cucumbers *Holothuridae* (Dri, Sucuwalu etc)
  - Lobsters *Panulirus spp* (Urau)
  - Banded Coral Shrimp *Stenopus hispidis* (Ura ura)
  - Crown of Thorns Starfish *Acanthaster planci* (Bula)
- Fish: 100m<sup>2</sup> belt transects for:
  - Butterflyfish *Chaetodontidae* (Tivitivi)
  - Parrotfish *Scaridae* (Ulavi, Bobo)
  - Grouper *Serranidae* (Kawakawa, Donu)
  - Sweetlips *Haemulidae* (Sevaseva)
  - Snapper *Lutjanidae* (Kake, Kabatia)
  - Goat *Mullidae* (Ose)
  - Surgeon and Unicorn fish *Acanthuridae* (Ika Loa, Ta)
  - Jacks/ Trevallies *Carangidae* (Saqa)
  - Rabbitfish *Siganidae* (Nuqa)
  - Angelfish *Pomacanthidae* (Lati ni daveta)

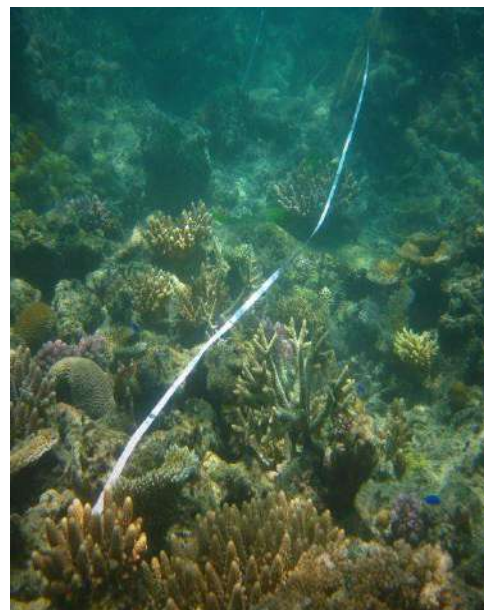


Figure 1: Transect line

## Sites

Sites fell into 3 general areas; Beqa Lagoon West (near Yanuca Island), Beqa Lagoon East (near Beqa Island), and Pacific Harbour (Serua - Navua), plus the fringing reef at Lawaki on Beqa Island.



**Figure 2: Google Earth image showing survey sites**

Two sites are under effective marine protection (Shark Reef Marine Reserve SRMR, and Lawaki MPA), four others are within two declared protected areas, where enforcement is uncertain.

**Table 1: Details of survey sites**

Area	Reef name	Waypoint	MPA	Date	Survey Depth
Beqa West	Nayamotu	309		14-Apr-19	5m
Beqa West	Kaiviti	310	X	14-Apr-19	3m
Beqa West	Bird Island	311		17-Apr-19	5m
Beqa West	Kaiviti Back Reef	312	X	17-Apr-19	1m
Beqa West	Frigate's Pass outer wall	313	X	18-Apr-19	6m
Beqa West	Frigate's Pass side reef flat	314	X	18-Apr-19	1m
Beqa West	Nayamotu back reef flat	315		18-Apr-19	1m
Beqa West	Between Yanuca and Bird Island	318		28-Apr-19	17m
Beqa East	Suliyaga Back	304		13-Apr-19	11m
Beqa East	Suliyaga Side	305		13-Apr-19	9m
Beqa East	Inner reef sand slope south of Suliyaga	323		29-Apr-19	8 and 2 m
Beqa East	Outer slope near Storm Island	324		29-Apr-19	5m
Serua	Nasorowaca reef top	361		11-Jun-19	1.5m
Serua	Combe Reef top	340		1-Jun-19	1.5m
Serua	Shark Reef Marine Reserve (back reef)	360	X	11-Jun-19	2m
Beqa	Lawaki MPA		X	2-Apr-19	3m

## Marine Protected Areas (MPAs)

Six of the survey sites fell within four MPAs.

- Shark Reef Marine Reserve, patch reef off Serua reef (site 360). Established 2004, gazetted as legal statutory reserve 2014. Managed and enforced by tourism dive operator.
- Kauvala Tabu at Lawaki Beach House, established 2004, expanded and recognized as traditional “Tabu” area 2010. Managed and enforced by tourism accommodation operator.
- Cavity MPA, from the west coast of Yanuca Island to the outer reef slopes (sites 310 and 312). Established traditional “Tabu” 2009. Management by local community. Enforcement uncertain.
- Navata-i-Lulu MPA, the barrier reef west and south of Frigate’s Passage (sites 313 and 314). Established traditional “Tabu” 2012. Management by local community. Enforcement uncertain.

## Results

### Water Quality testing

These surveys were broken up over a 2-month time frame due to unusually heavy rainfall in April and May 2019, which affected water clarity over all of the survey period, as well as reducing salinity and temperature of the surface waters.

Samples of water were taken at the sites where surveys were carried out, as well as some non- survey sites to establish the extent of rain-water influence from the mainland.

- On-site field tests for temperature, salinity, pH and water clarity were carried out at 21 sites.
- Field tests for presence/absence of coliform bacteria were carried out at nine sites.
- Laboratory tests for nutrients (phosphates and nitrates) and faecal coliform bacteria were carried out by the IAS laboratory of the USP from six sites.

Water temperature was normal for the time of year, generally warmer on the eastern side of the lagoon than in other areas. Acidity was normal for seawater at all sites. Water turbidity was higher, and visibility lower, on shallow inner reef slopes than in the channels and outer reefs.

There were few signs of nutrient enrichment, but the sites closest to the river outlets (316, 321 and 320 near Storm Island) did have slightly elevated levels of nitrate. General and faecal coliform bacterial levels were higher near Pacific Harbour than out in the Beqa Lagoon, suggesting that the Deuba and Navua rivers are washing water contaminated by sewage into the marine environment as far out as the north-eastern reefs of Beqa Lagoon.

Water quality in the **Pacific Harbour (Serua – Navua)** area, close to the shore of Viti Levu, is often affected by rainfall and run-off from the Deuba and Navua rivers, the smaller Qaraniqio river at Pacific Harbour, and several smaller riverlets and creeks. The water in these areas was very muddy and had high bacterial levels immediately after rainfall.

On the **East side of the Beqa Lagoon**, water clarity and salinity were lower closer to the Viti Levu coast than further out in the Beqa Lagoon, but poor visibility and low salinity extended out as far as Waypoint 320, near Storm Island immediately after heavy rainfall. Sites 318 and 318, the furthest away from the coast, were the least affected.

On the **West side of the Beqa Lagoon**, surface water salinity was reduced to less than normal sea water (34 - 38 PPT) at many sites due to recent heavy rainfall, even as far out as Frigate's Passage, more than 30 Km from the mouths of the Deuba and Navua rivers.

### Substrate Cover

In Fiji, long term studies have shown that reefs have an average live coral cover of around 45%, and algal cover of less than 5% (Sykes and Morris 2007). Other categories such as Dead Coral or Silt can be measures of damaging factors.

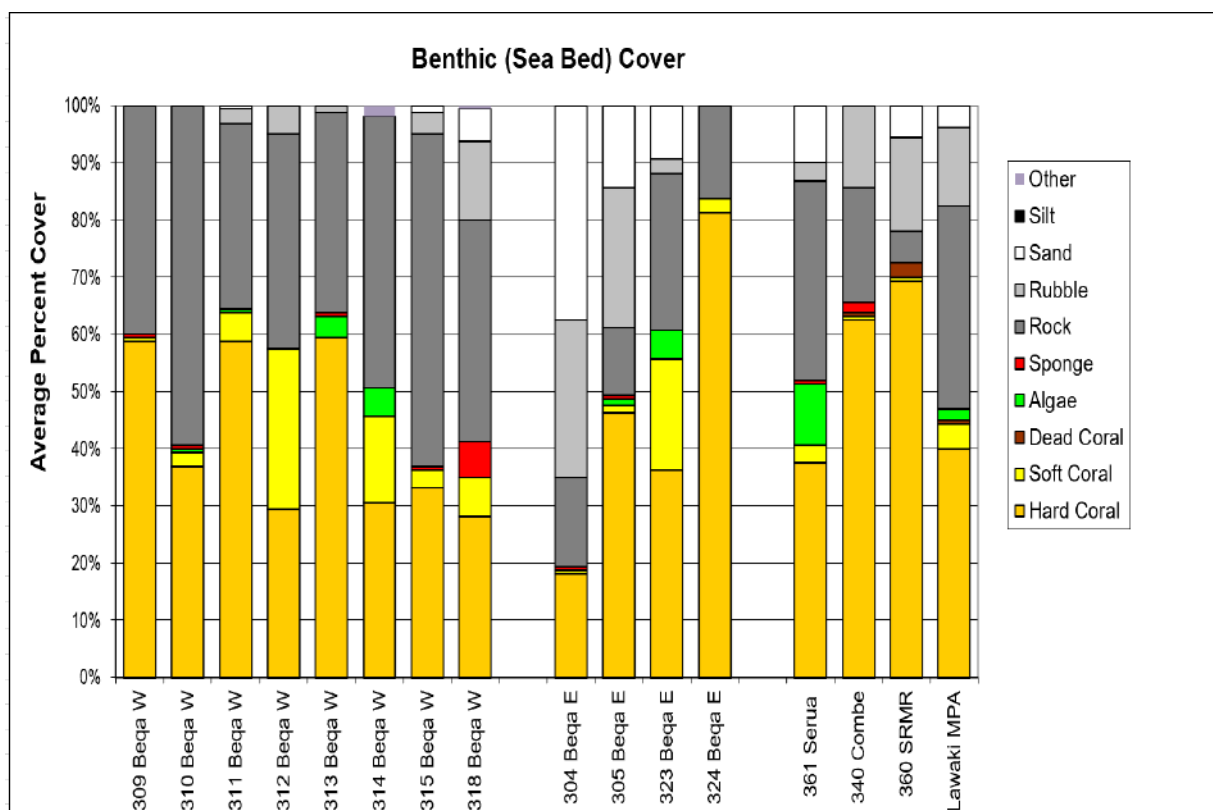


Figure 3: Bar Chart showing Substrate Cover of reefs at survey locations

Most of the Beqa reefs surveyed had hard coral cover between 30 and 60%, and algal cover less than 5%. The highest level of coral cover was seen at sites 324, the outer reef slopes near Suliyaga village on the eastern side of the Beqa Lagoon (over 80% hard coral cover); and 360, the shallow back of the Shark Reef Marine Reserve (almost 70% hard coral cover).

The lowest amounts of hard coral cover were found at sites 304, the sand and rubble slope of the inside of the reef near Suliyaga village (under 20%); and 318, the deeper rubble slope between Yanuca and Bird Islands (under 30%).

Soft coral was highest at sites 312 and 314, the shallow reef tops at the back of Kavuti reef and the side of Frigate's Pass (over 15% soft coral); and 232, the inner sandy slope south of Suliyaga village,

Algae cover was low on most reefs, apart from the shallow near-shore reef at site 361 which had 11% brown macroalgae, primarily *Turbinaria* and *Sargassum* species, typical of overfished near-shore reef flats along the Coral Coast.

Half the sites had coral cover around 60%, considerably higher than the Fiji average of 45%. There were no overall apparent differences between protected and non-protected sites.

## Coral Types

Coral Lifeform categories give a measure of diversity of coral types and habitats available on reefs.

Most sites showed a wide diversity of coral lifeform types. *Acropora* corals dominated, with an average of 22% total substrate cover across all the survey sites, followed by Submassive corals such as *Pocillopora*, *Montipora* and *Porities* species.

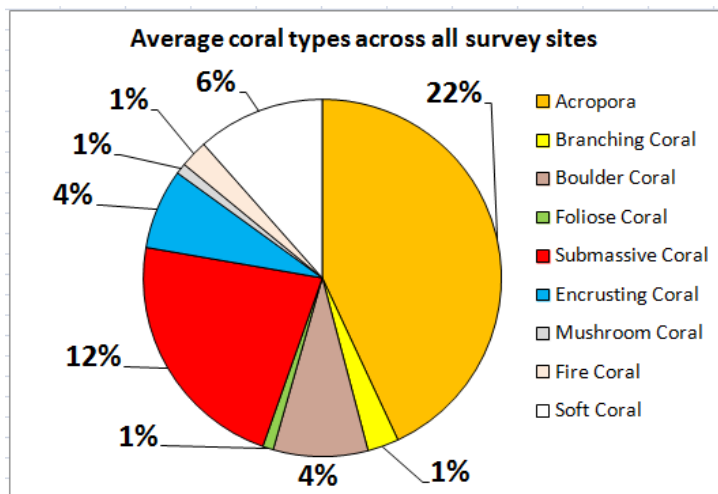


Figure 4: Pie Chart showing average substrate cover of Coral Lifeforms across all survey sites

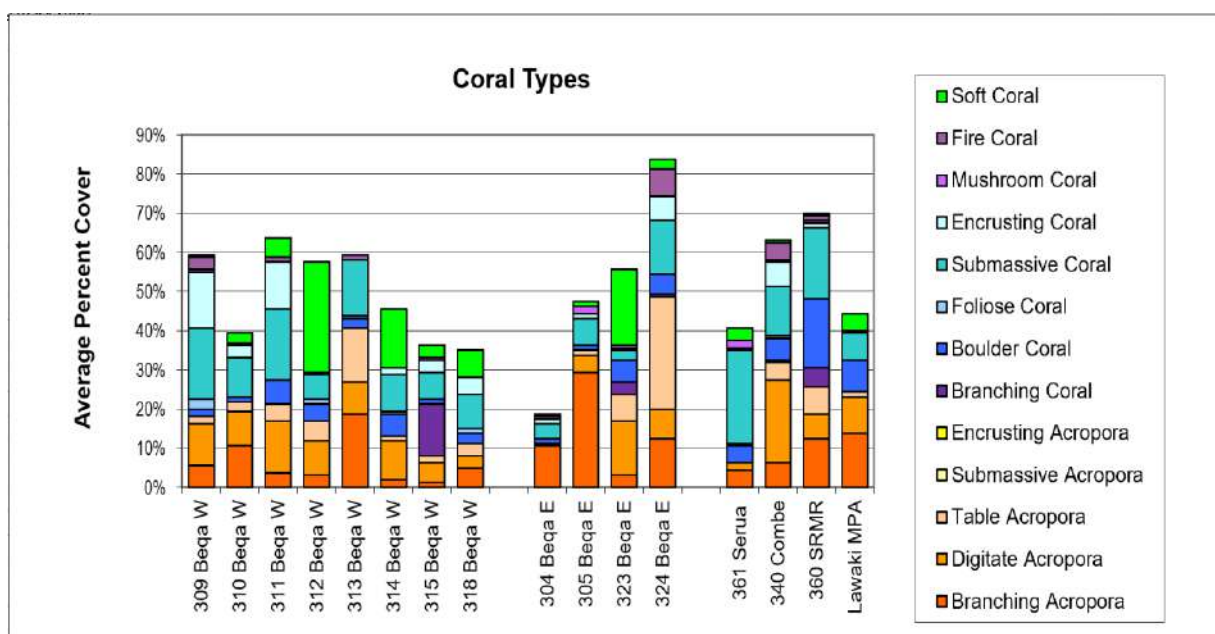


Figure 5: Bar chart showing Coral Lifeforms on reefs at survey locations

*Acropora* forms dominated 4 sites, forming more than 30% of total substrate cover, at 305, Suliyaga, 313, Frigate's Pass outer wall, 324, outer wall near Suliyaga and Storm Island and 340, Combe Reef.

340, Combe Reef and 310, Kauviti had average to above average levels of *Acropora* corals.

Sites 312, Kauviti back and 314, Frigate's Passage side, had 28% and 15% soft coral cover respectively, much greater than the all-sites average of 6%, and in the same range as 323, the inner sand slope at Suliyaga (19% soft coral).

Certain sites such as 315, Nayamotu, had high cover of specific types of branching corals such as *Stylophora* and *Seriatophora*, considerably higher than the average of 1%.



## Algal Types

Macro Algae are split into 4 main categories for the purpose of reef description:

- *Halimeda* is considered a normal component of coral reefs, and not an indicator of poor reef health
- Turf or mixed Macro Algae overgrowths may reflect either a reduction of algal grazers such as surgeonfish or sea urchins, or the effects of sedimentation and nutrient run off, and can result in retarded coral growth due to lack of clean substrate.
- Coralline algae is the hard “reef cement”, an important part of coral reef stabilisation, which provides good substrate for new coral re-growth.

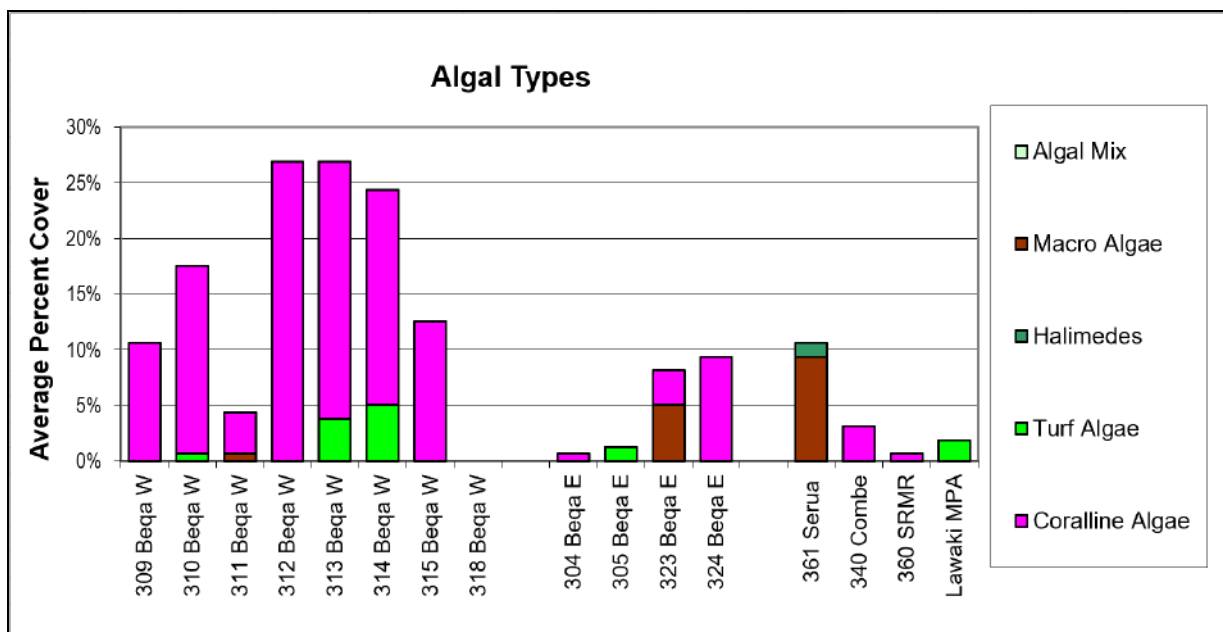


Figure 6: Bar Chart showing Algal Types on reefs at survey locations

Most of the reefs had low (below 5%) Macro-Algal cover, apart from site 362, Nasorowaca, the near-shore reef ay Serua, which had high levels of *Turbinaria* and *Sargassum* brown macroalgae. Coralline algae was found on many sites, and in particularly large amounts at 312, 313 and 314, the side and outer reefs of west Beqa Lagoon, the furthest from the nutrient-rich influences of the river waters.

Although not recorded in these surveys, many of the deeper reef floors, particularly on the west side of Beqa, near Yanuca Island, and off Frigates Passage, were covered with extensive films of red filamentous algae, (possibly *Wranglia sp*). Such algal films are usually indicative of either nutrient enrichment, or overfishing of animals that eat algae, in this case, probably a combination of both.

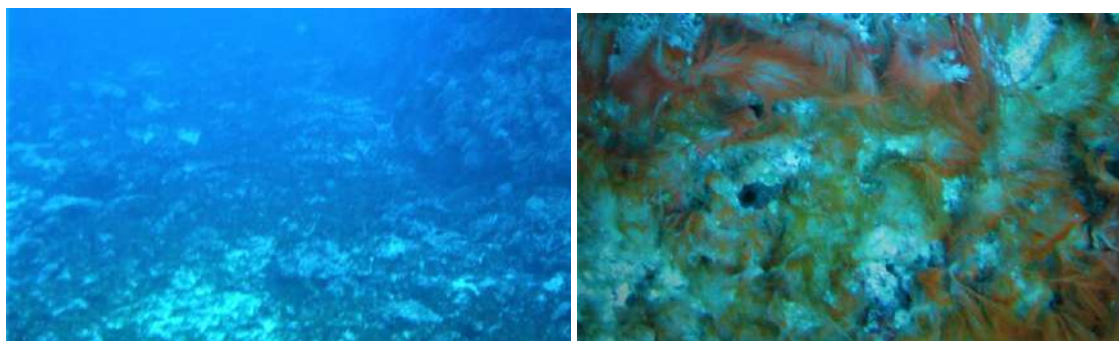


Figure 7: Photos of algal films on reef floor at site 309, Nayamotu reef, on the west of Beqa Lagoon

### Indicator Invertebrates

Most of the invertebrates surveyed as part of standard reef description are chosen as indicators of fishing pressures, or, as with the Crown of Thorns Starfish, have a specific impact on reef health.

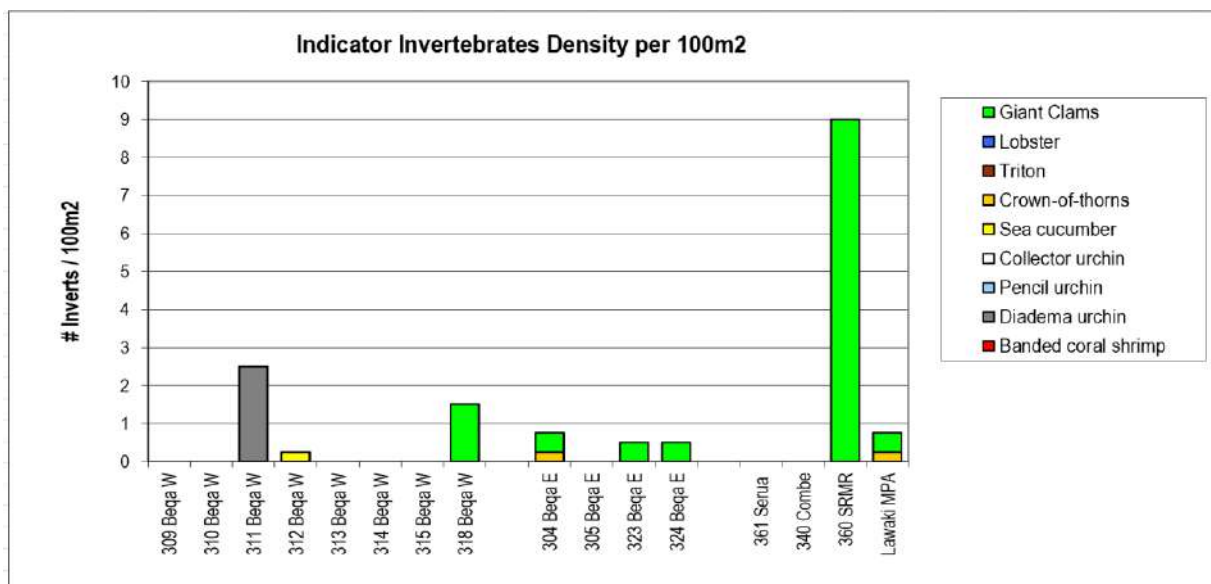


Figure 8: Bar Chart showing density of Fisheries Indicator Invertebrates at survey locations

Very few invertebrates of fisheries importance were seen. A single Crown of Thorns starfish, one Sea Cucumber and ten Diadema urchins (an average of 2.5 per 100 m<sup>2</sup>) were seen during all the surveys. Apart from a single sea cucumber, no invertebrates were found in the MPAs at 310, 312, 313 and 314.

A few Giant Clams were found on some sites, but only in any numbers within the protected area at 360 Shark Reef Marine Reserve. On most of the sites where clams were found, they were between 30 and 50 cm across, adult breeding size. In Beqa East sites, and at the back of Shark Reef Marine Reserve, they were smaller, under 20 cm across, or even under 10cm, indicative of new settlement of clam larvae, probably within the last 2 or 3 years.

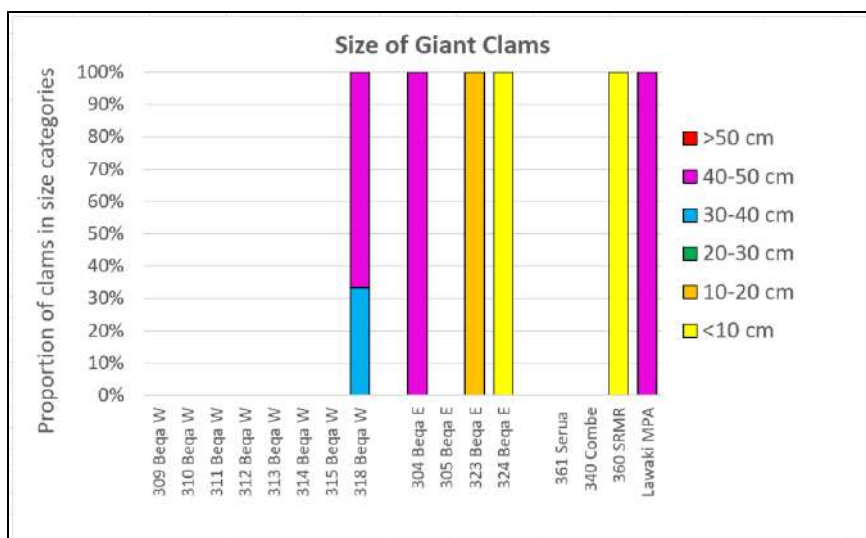
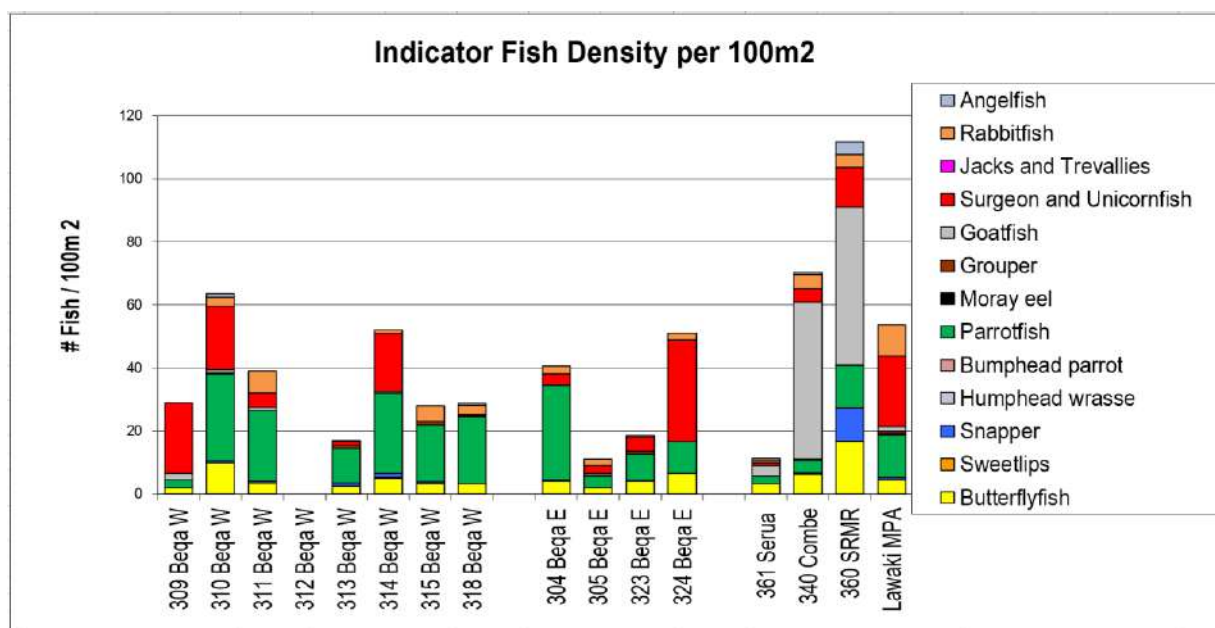


Figure 9: Bar Chart showing size of Giant Clams at survey locations

It has long been recognised that the waters around Beqa and Pacific Harbour have been extensively fished by both local and non-local fishers, and the distinct lack of edible or commercially important invertebrates is indicative of those fishing and collection pressures.

### Indicator Fish

As with the reef description invertebrates, Indicator Fish are selected, for the most part, as those likely to be reduced by local fishing activities, or for their environmental significance, for example butterflyfish, which relate to coral cover.



**Figure 10: Bar Chart showing density of Fisheries Indicator Fish at survey locations**

As discussed in the indicator invertebrate section preceding, Beqa Lagoon and Pacific Harbour reefs have been, and still are, under a great deal of fishing pressure from local and other subsistence and small-scale commercial fishers.

The most targeted groups, Groupers and Sweetlips, were hardly seen during surveys, and Goatfish, were only seen in any large numbers on the Serua reefs; Combe and the Shark Reef Marine Reserve. Goatfish were exceptionally low on all the Beqa reef sites, both inside and outside MPAs, but this may be more habitat related than affected by fishing, as Goatfish prefer sandy habitats and most Beqa surveys were on solid reef substrate.

The only reef surveyed with any great number of indicator fish was site 360, the back of the reef within the Shark Reef Marine Reserve (SRMR), which was also the only site with more than a few snappers.

The largest number of rabbit fish were seen within the Lawaki MPA.

There were quite high numbers of parrotfish and surgeonfish at site 310, within the Cavity MPA behind Yanuca Island, but no indicator fish at all at the other site within that MPA (312).

Sites 313 and 314, within the Navata-i-Lulu did not have different patterns of indicator fish from the open areas.

Outside the SRMR and the Lawaki Tabu, all fish seen were small and not the types most targeted by commercial fishers, such as snapper, grouper or sweetlips. Even on deeper outer reef walls no trevallies or large predators, except for white tip reef sharks, were seen.

Many of the reefs had fewer fish than are normally seen in Fiji, even in regularly fished areas, and there is a very strong indication of overfishing.

## Discussion

### General reef condition in the area

Overall, from the perspective of coral cover and diversity, most of the reefs in the Beqa and Serua area are in good condition, and have both a history, and the future prospect, of having some of the highest coral cover in Fiji, showing resilience to, and swift recovery from, crisis events such as elevated water temperatures and cyclones.

However, the numbers of fish and macro-invertebrates targeted by the subsistence and small-scale commercial fishing industries are much lower than seen in many other comparable areas of the country, and, particularly on the west side of Beqa, near Yanuca Island, were quite starkly low, some of the lowest populations this surveyor has seen in over 20 years of carrying out reef surveys in Fiji.

Algal cover on the reef floors of the west Beqa reefs also correlates with the extremely low number of herbivorous animals such as sea cucumbers, surgeonfish and parrotfish. Such algal films can retard new coral settlement, and suggests that the extreme levels of overfishing in Beqa may very soon be at the point where the overall health of the reefs may become impacted in an irreversible way.

### Effects of Marine Protected Areas

There were four MPAs within the surveyed reefs, of which two are regularly patrolled and enforced (Shark Reef Marine Reserve SRMR, and the Kauvala Tabu at Lawaki Beach House). The other two are larger, and more distant from the managing communities, so the level of observation and enforcement is uncertain.

Coral cover and diversity did not seem to be affected by marine protection over fished reefs. Fish and invertebrate levels were low at all sites except the SRMR and, to a lesser extent the Lawaki MPA and one of the two survey sites within the Cavity MPA behind Yanuca Island. The other three MPA survey sites were no better, or in one, case worse, than fished sites, indicating the importance of proper management and enforcement on the success of marine protection.

### Comparison of Shark Reef Marine Reserve with neighbouring Combe reef

The sites in this survey were physically quite varied. The most similar reef to the SRMR is neighbouring Combe reef, approximately 7 Km away within the same reef system off Pacific Harbour, which is outside the officially protected MPA.

Coral cover at Combe Reef was within 10% of that at SRMR, with similar proportions of coral types, although more boulder coral at SRMR than at Combe.

The largest differences were in invertebrate and fish populations. No invertebrates were seen at Combe reef, while several small juvenile Giant Clams were found at SRMR. Fish numbers on Combe reef were higher than those seen on the other sites, but even higher on SRMR. In particular, Snappers and Parrotfish were found in higher numbers at SRMR than at Combe.

Overall, while the two Serua sites seem to be less impacted by overfishing than the Beqa ones, the protection at SRMR has allowed Giant Clams to begin to repopulate the area, and fish populations to increase.

## Appendix

### Descriptions of SRMR and Combe reefs



Figure 11: Location of SRMR and Combe reef

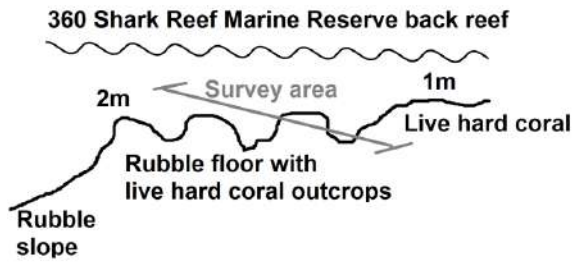


Figure 12: Position of survey site on SRMR



Figure 13: Position of survey site on Combe reef

Reef name	Area	Waypt	Survey depth
Shark Reef Marine Reserve back reef	Pacific Harbour	360	2m



Shark reef is a patch reef, 5 km offshore of Pacific Harbour. It is physically similar to Combe reef (340), and became a statutory marine reserve in 2014.

Shark feeding and tourist SCUBA diving now take place on the front of the reef, approximately 500m away. From the survey site.

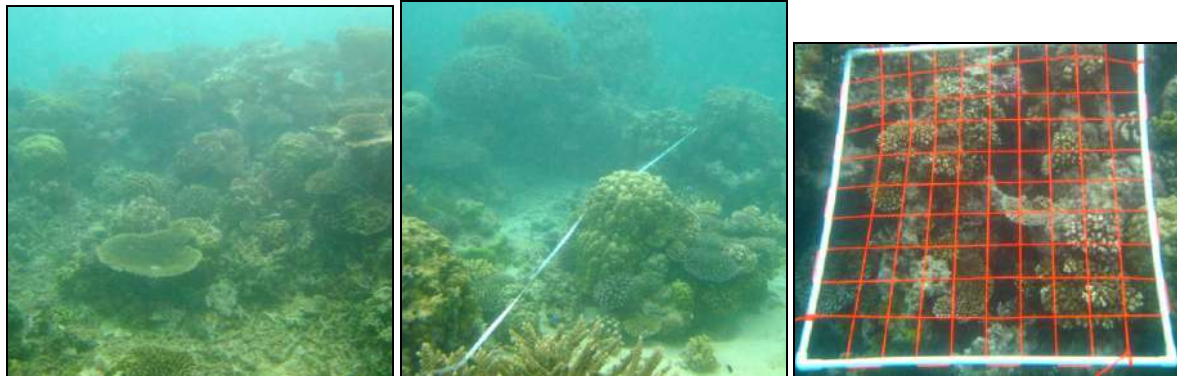
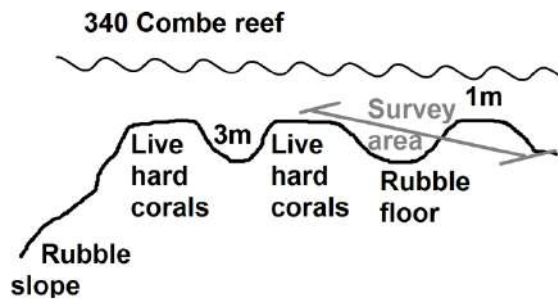


Figure 14: Photos of Shark Reef back reef at 2m: area, transect and quadrat

Reef name	Area	Waypt	Survey depth
Combe Reef	Pacific Harbour	340	2m



Combe is a patch reef 3 Km offshore of Pacific Harbour. The shallow reef top is almost dry at low tide, and 1 - 2m deep at high tide, and consists of a rocky surface with high hard coral cover divided by rubble gullies about 3m deep before it drops to a rubble slope.

There are many smaller *Acropora* colonies in the shallows.



Figure 15: Photos of Combe reef at 2m: area, transect and quadrat

## GPS coordinates of sites

**Table 2: GPS coordinates all in-water survey sites**

304	S18 22.561 E178 11.279	Suliyaga back
305	S18 22.035 E178 11.091	Suliyaga side
309	S18 25.243 E177 56.788	Nayamotu
310	S18 22.622 E177 57.664	Kauviti
311	S18 20.878 E177 59.740	Bird Island
312	S18 22.277 E177 58.172	Kauviti Back Reef
313	S18 28.960 E177 56.017	Frigate's Pass outer wall
314	S18 27.112 E177 56.028	Frigate's Pass side reef flat
315	S18 24.799 E177 57.372	Nayamotu back reef flat
318	S18 21.327 E177 59.578	Fish collection shoal
323	S18 23.560 E178 11.343	Inner reef sand slope south of Suliyaga
324	S18 21.312 E178 10.863	Outer slope near Storm Island
340	S18 17.525 E178 04.748	Reef Top at Combe Reef
360	S18 17.825 E178 01.108	Shark Reef Marine Reserve (back reef)
361	S18 16.092 E177 58.207	Nasorowaca reef top