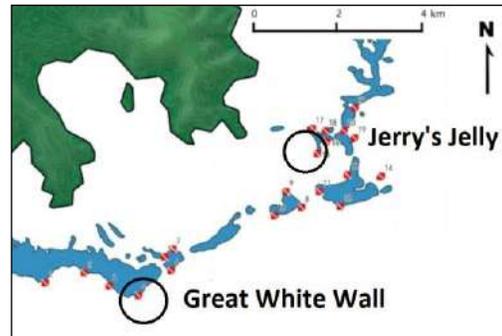


Reef Conditions, Somosomo Straits, Taveuni from 2002 onwards

Background:

Reef Surveys have been carried out at two sites (the Great White Wall on the outer face, and the back of Blue Ribbon Eel / Jerry's Jelly on the inside of the Rainbow Reef) in the Somosomo Straits since 2002, with the exception of 2005 (Rainbow Reef only), 2008 (no surveys), and 2015 – 2017 (no surveys due to poor weather and time constraints).

Figure 1: Map of survey sites on the Rainbow Reef



Surveys have been carried out under the Fiji Coral Reef Monitoring Network (FCRMN) and supported by Coconut Grove Beachfront Cottages, Rainbow Reef Divers at Garden Island Resort and Taveuni Ocean Sports at Nakia Resort.

In 2000 and 2002 Fiji reefs suffered extensive hard coral death from coral bleaching due to exceptionally high water temperatures. However, coral cover recovered to pre-bleaching levels by 2005, much faster than originally predicted. In the Somosomo Straits, cyclones had some impact around 2006 and 2007, but once more the corals recovered very quickly.

High water temperatures threatened coral health in shallow waters in parts of Fiji in 2014 – 2016, but the Rainbow Reef was unaffected. A Crown of Thorns Starfish (COTS) outbreak in 2014 caused widespread coral death but stopped after Cyclone Winston in February 2016. The cyclone caused extensive coral breakage on exposed sites, while others were relatively unscathed, and large numbers of new coral colonies were seen on damaged sites in 2018.

Coral bleaching around Taveuni

Normal water temperature ranges across Fiji waters are between 24 and 30°C (about 76 to 85°F). Coral bleaching happens when the water temperature exceeds **29.2°C (about 83°F)**, leading to coral death if the high temperatures last for more than 6 weeks in a row.

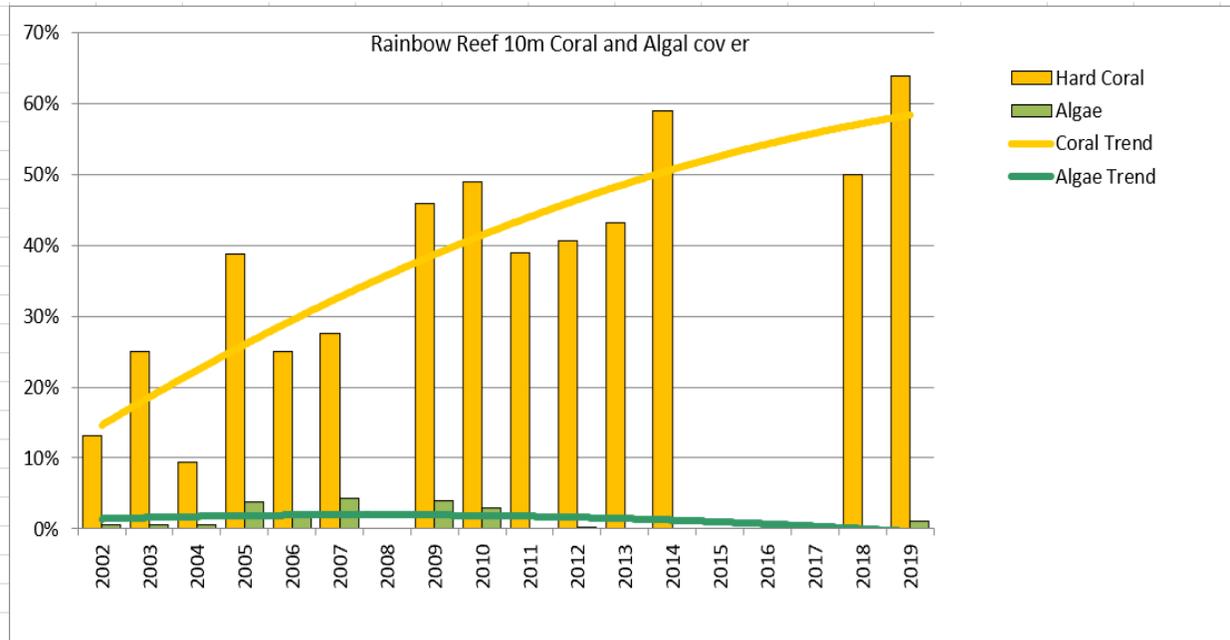
A widespread bleaching event in the years 2000 – 2002 led to mass coral mortality across the Fiji Islands, but most reefs recovered to pre-bleaching levels by 2006, showing the Fiji reefs' high resilience and ability to recover.

A minor bleaching event was experienced in 2014 - 2016, but in Taveuni only affected shallow corals on fringing reef tops. The Rainbow Reef experienced some coral "brightening" but no temperature-related mortality.

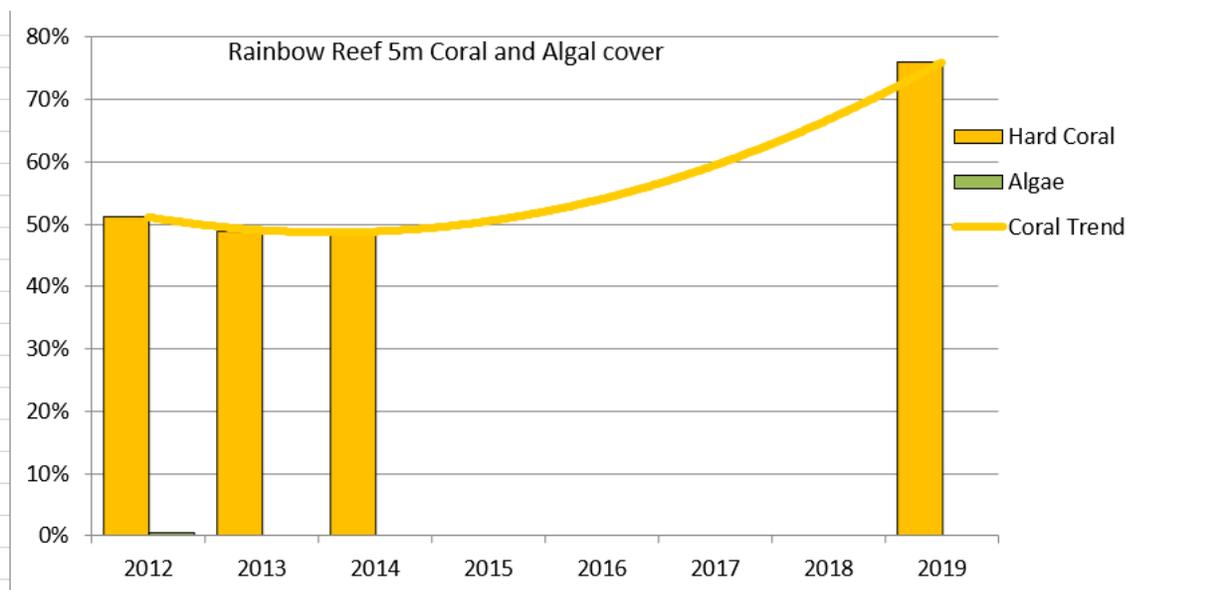
In 2019 temperature-related bleaching started to affect some shallow reefs in the north of Fiji as water temperature rose to over 29°C in March. The Rainbow Reef experienced very little bleaching and minimal brightening.

Hard Coral Cover:

At a depth of 10m, on the **Rainbow Reef at Jerry's Jelly**, hard coral cover rapidly increased from the lowest level recorded (12%) after the bleaching of 2002 – 2002, to over 60% in 2019. Apparently the two major most recent coral damaging events in this area (Cyclone Winston in 2016, and the COTS outbreaks between 2014 and 2016) did not adversely impact hard corals in this area, as cover has remained higher than the Fiji average of around 45%, and coral colonies were large and mature, not small re-growing colonies. Algal cover was very low.



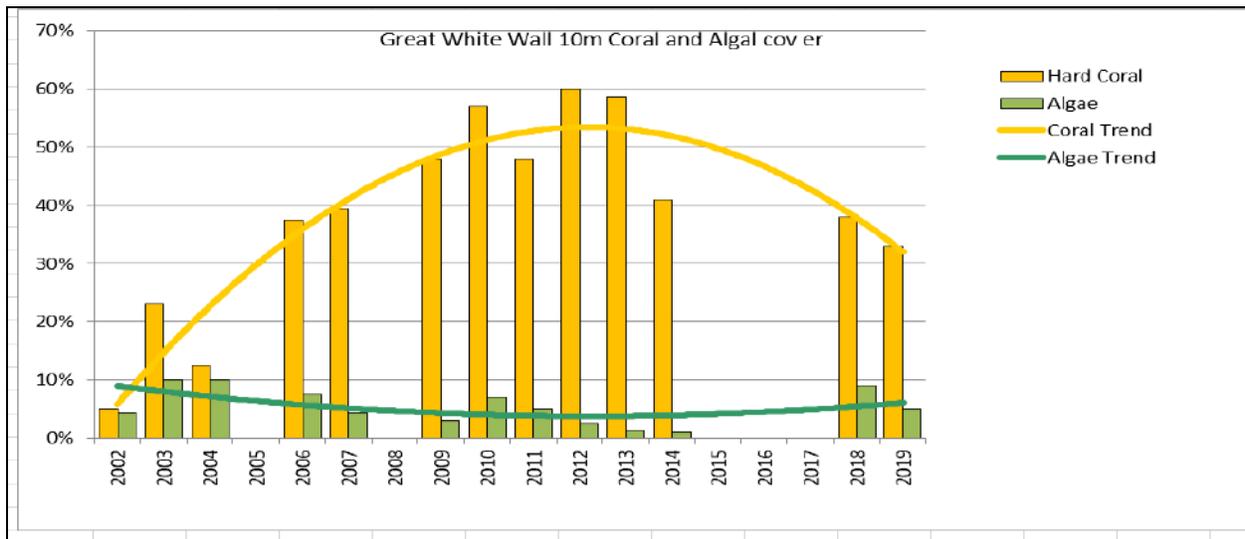
At 5m depth, an area that cannot always be surveyed due to weather considerations, coral cover in 2019 was even higher, at 76%.



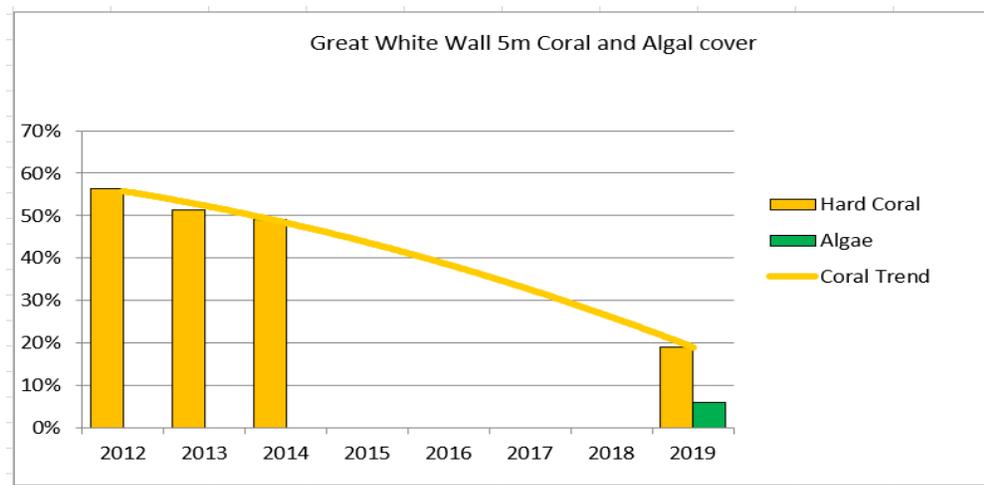
Hard coral cover at 10m on the top of the **Great White Wall** reached 60% in 2012, but started to decline slightly in 2013, when small amounts of COTS were seen. By February 2014 COTS were seen in outbreak numbers and coral cover declined sharply. This outbreak ceased after Cyclone Winston in 2016. The top of the reef suffered a great deal of coral breakage in the cyclone, but deeper corals and soft corals were not affected.

In 2019 hard coral cover was slightly lower than in 2018 and most colonies were small, under 20cm, indicating either recent growth, or slower growth than is normally seen, as the expected increase in hard coral cover over the 2018 results did not eventuate. Soft corals are not included in these charts, but are discussed in the following section on coral types.

Red filamentous algal cover was found in areas where coral had died, (as was seen after the 2000 – 2002 bleaching events) but was decreasing by 2019.



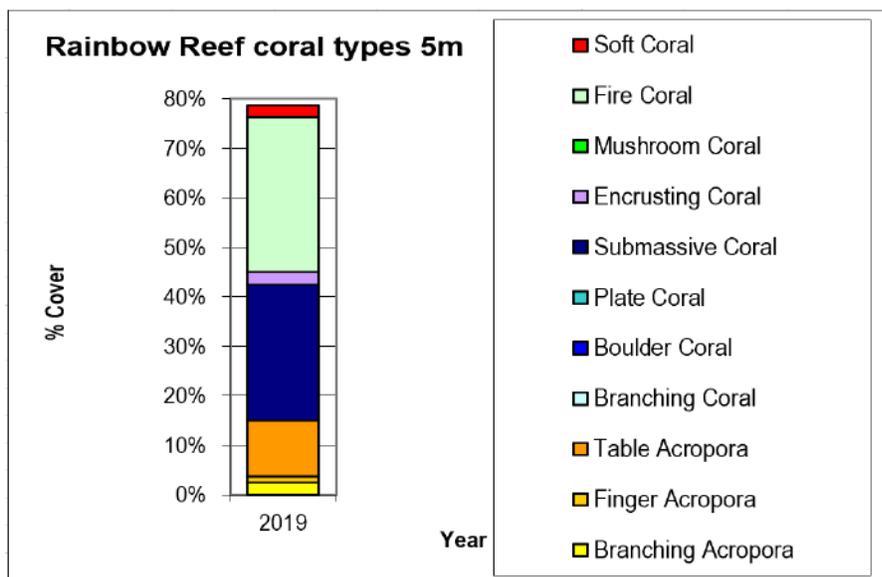
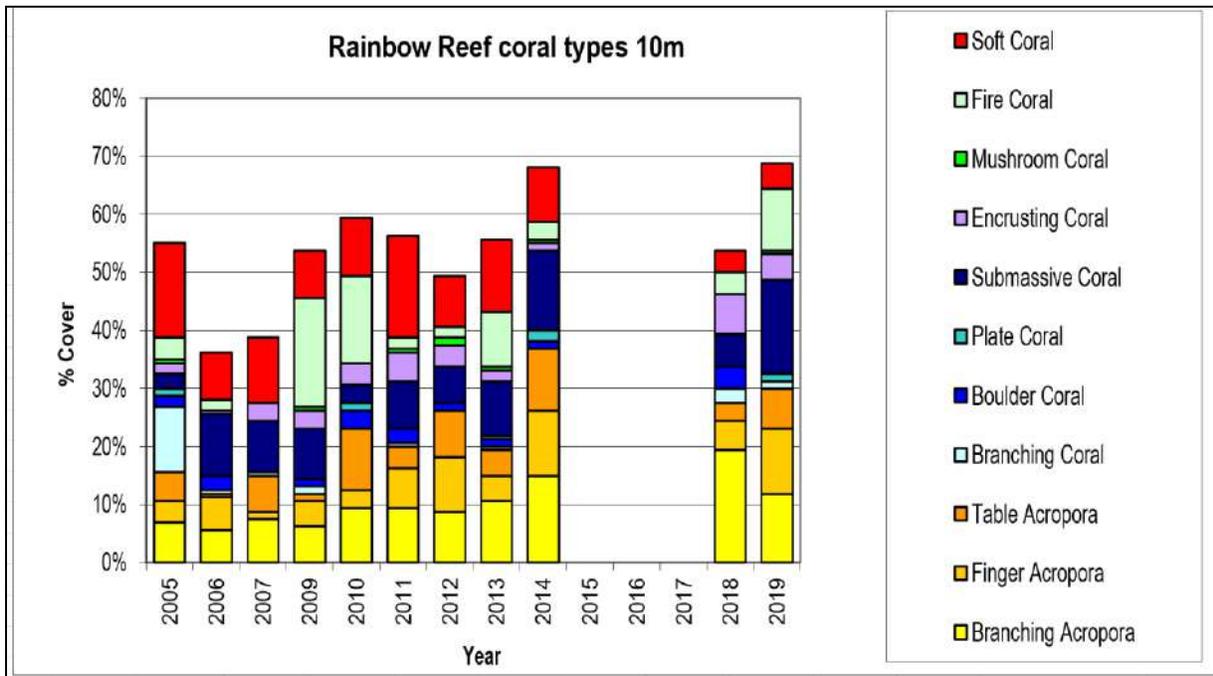
The Great White Wall had not been surveyed at 5m since 2014, due to weather conditions, but in 2019 hard coral cover was considerably lower than in 2014. The shallow area of reef was one of the hardest hit by Cyclone Winston in 2016. Recovery is happening, as can be seen by the large number of small corals on the reef, but it is likely to take a few years.



Coral Types

Studies of different types of corals on the **Rainbow Reef at Jerry's Jelly** show that Table and Finger forms of *Acropora* (orange in the graph below), and Submassive forms of *Pocillopora* (dark blue) decreased between 2014 and 2018, presumably broken by Cyclone Winston.

However, very large colonies of Branching *Acropora* (yellow) and other corals, had survived the storms and by 2019 had reached total coral cover of almost 70%, well above the national Fiji average (45%). Diversity of coral types was high, with the commonest corals being *Pocillopora*, *Acropora* and *Millipora* hard corals, and *Dendronepthea* soft corals.



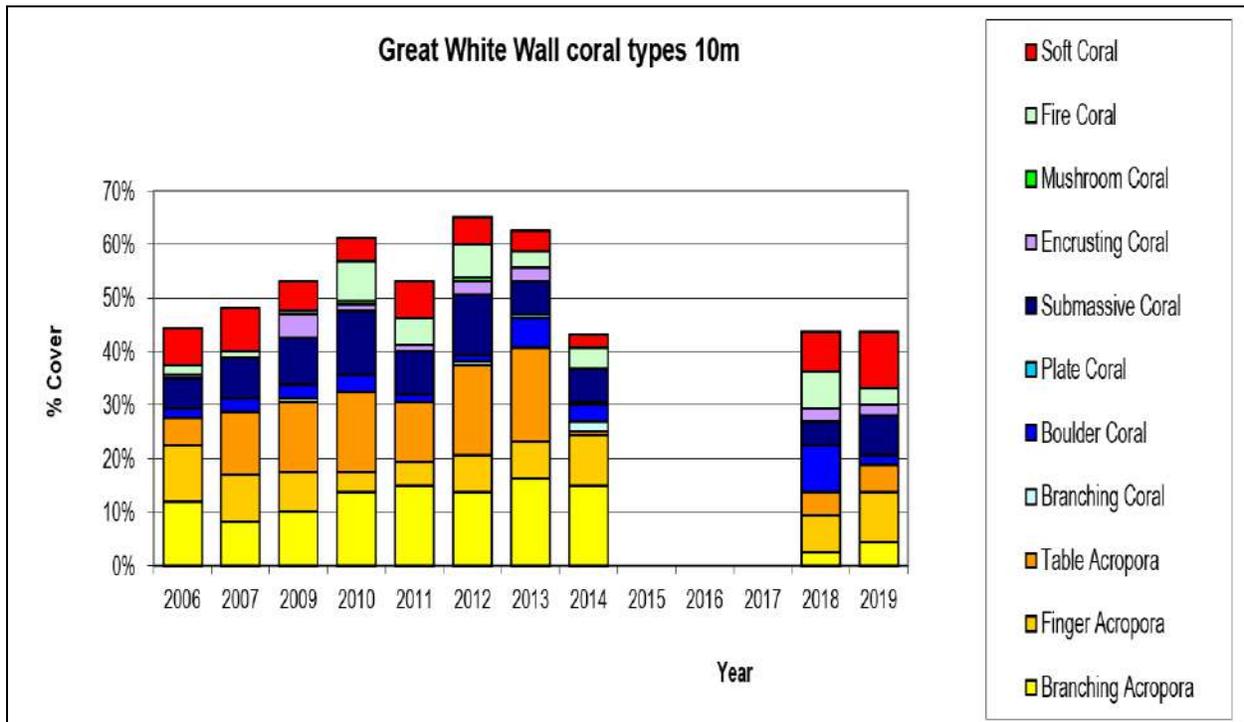
For the first time, the Rainbow Reef was surveyed to coral type at 5m depth in 2019.

Coral cover was exceptionally high at almost 80%, predominantly a mixture of Fire coral (*Millipora*) and Submassive coral (*Pocillopora*)

On the **Great White Wall**, the impacts of Crown of Thorns outbreaks between 2014 and 2016 were most apparent in the reduced amount of Table *Acropora* (dark orange in the graph below). Cyclone Winston in February 2016 damaged the more brittle *Acropora* colonies (yellow to orange) but did not affect cover of other corals as badly.

However, coral colonies were much smaller than those seen at Jerry’s Jelly, suggesting that there had been more coral death at this site in the years between surveys, but that the reef is in recovery, with many new colonies forming since the cyclone. Most of the new, smaller colonies were fast-growing *Acropora* or *Pocillopora* species, which, as long as other stresses do not occur over the next few years, should result in much higher hard coral cover over the next few years.

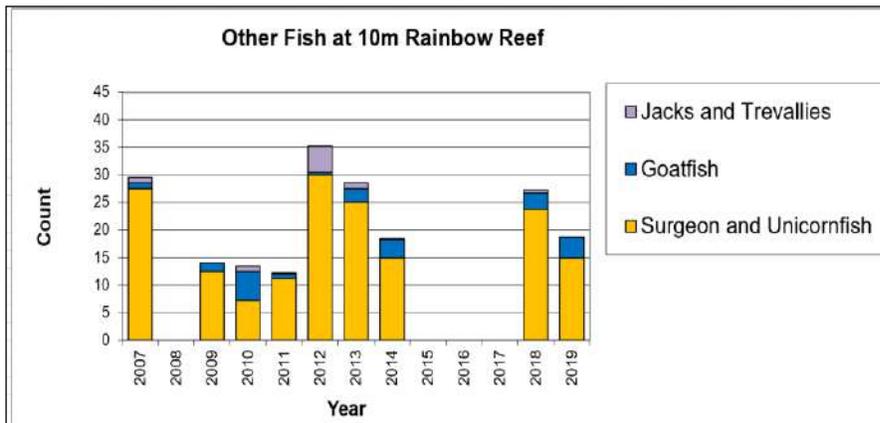
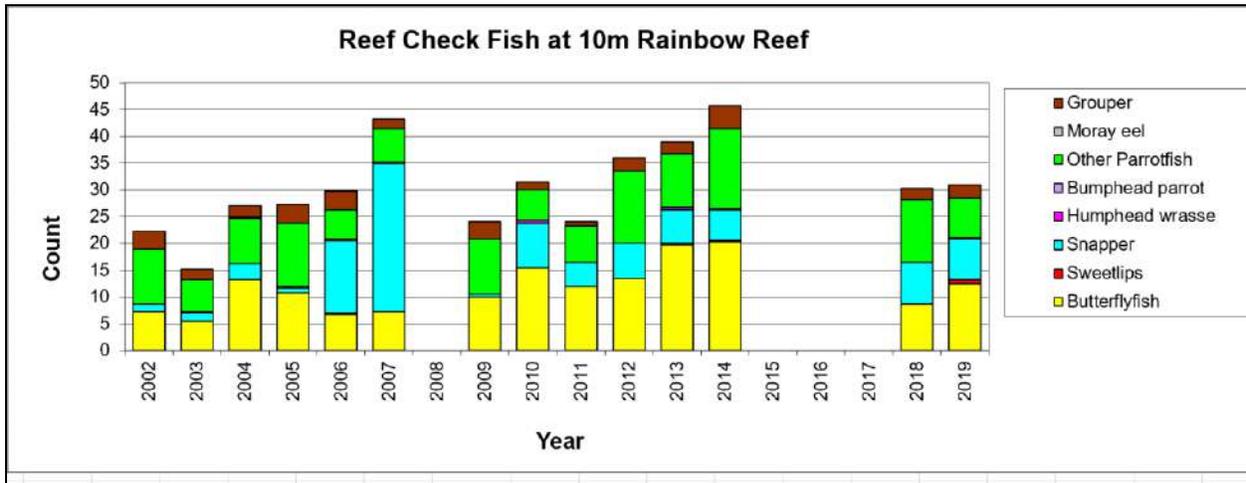
In 2019, a shift from hard coral to soft coral dominance seemed to be appearing, with hard coral cover dropping slightly and soft corals increasing. The deeper walls in this area are famous for *Dendronepthea* soft corals, and it may be that over the long term, these will also come to make up more of the coral cover on the reef flats as well.



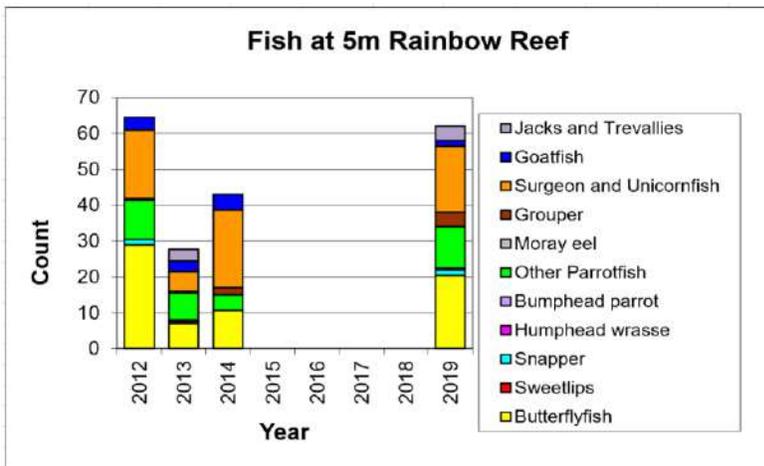
Fish

Since 2002, standard (Reef Check) key groups of fish have been counted at 10m depth, to give a density per 100m² of reef. (Surveys were not carried on the Great White Wall in 2005, or on either site in 2008, and 2015 - 2017). Extra groups of fish were added to surveys in 2007.

On the back of the **Rainbow Reef**, schools of fish are common, particularly of Snappers and Fuseliars (Fuseliars are not counted in this survey). Severely endangered Humphead Wrasse are also sometimes seen at this site (two seen in 2010 and 2013, one in 2014, and two in 2019).



Large schools of Surgeon and Unicorn fish were found most years, with small amounts of Goatfish and Trevallies.

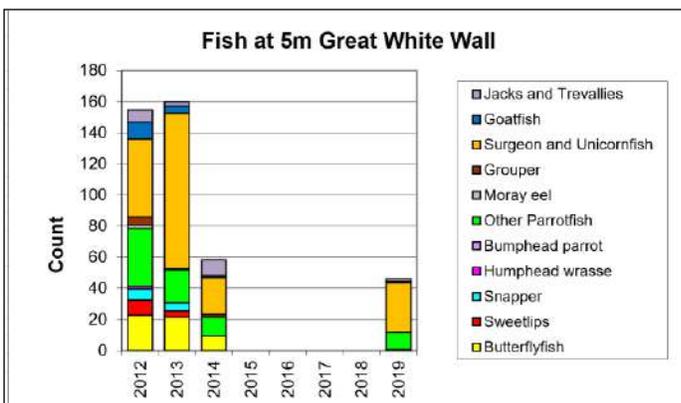
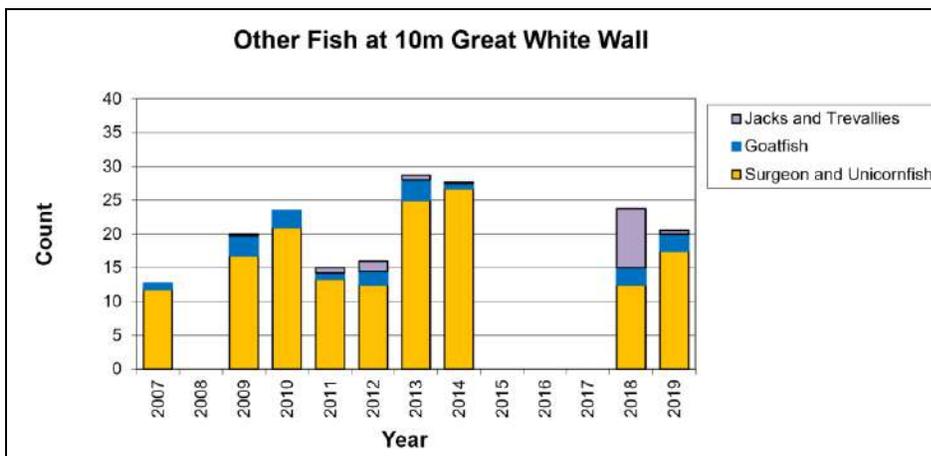
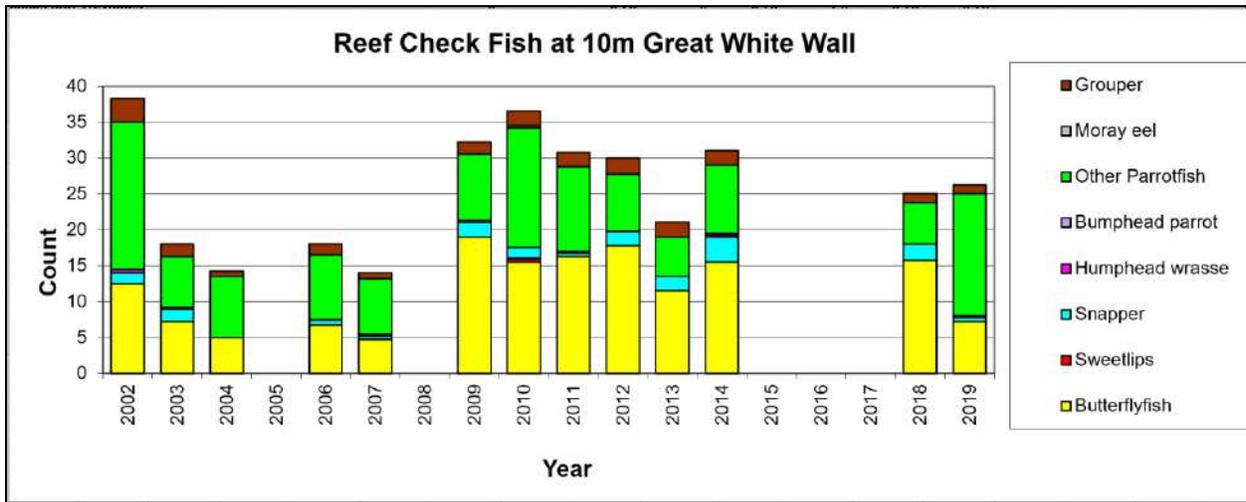


At 5m, key fish types are very similar to those seen at 10m, consisting primarily of Butterflyfish, Parrotfish and Surgeonfish.

At both depths there are no apparent patterns of either decline or increase in key fish density in the long term.

Butterflyfish, Parrotfish and Surgeonfish are very numerous on the **Great White Wall**, Butterflyfish counts were lower in years where hard coral, particularly *Acropora* hard coral, cover fell below 40% (2003 – 2007 and 2019).

Otherwise patterns of key fish numbers are fairlly stable. Small numbers of Groupers and Snappers are consistently seen, and in 2018 a Blacksaddle Coralgrouper *Plectropomus laevis* well over 1m long and several Jacks were seen. In 2014 one Humphead Wrasse and one juvenile (about 50cm) Bumphead Parrotfish were found.

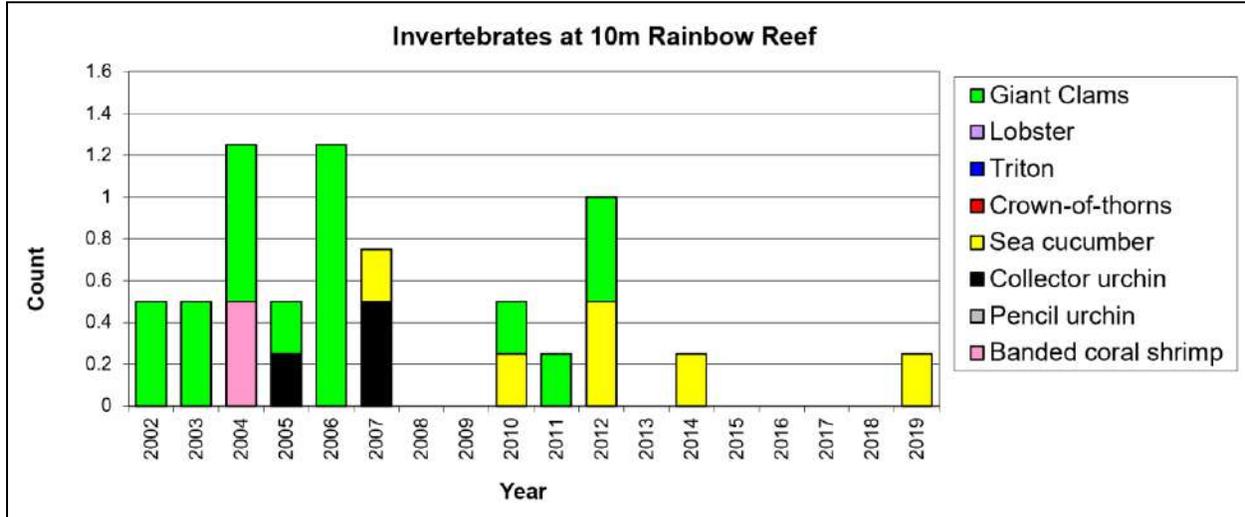


Fish surveys at 5m showed a large drop in Butterflyfish and Surgeonfish in 2014, the year that Crown of Thorns Seastar outbreak caused a drop in hard coral cover, and in 2019 Butterflyfish numbers were exceptionally low, while Surgeonfish numbers were growing.

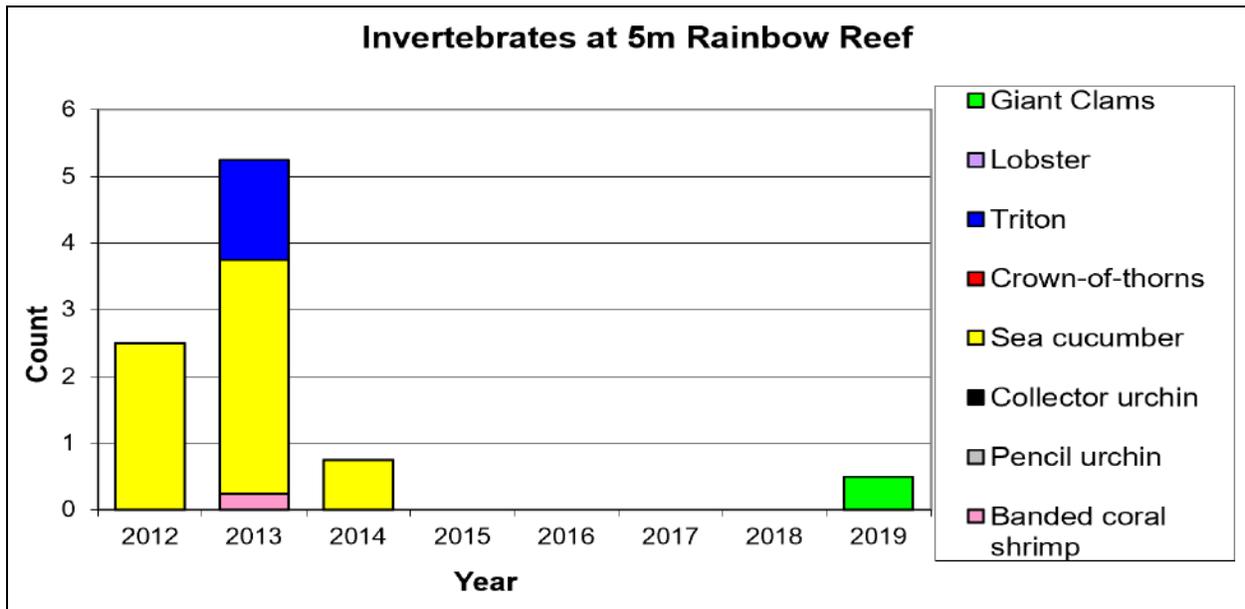
This may reflect the falling amount of hard coral and the rising amount of algae at this site.

Invertebrates

Giant Clams (green in the graph below) and Sea Cucumbers (yellow) have always been the main key macro-invertebrates found at **Jerry's Jelly on the Rainbow Reef**, although numbers are very low. No Giant Clams have been recorded since 2012, but given the low numbers, it is hard to say whether this is due to over-fishing or simply due to variation in survey placement.

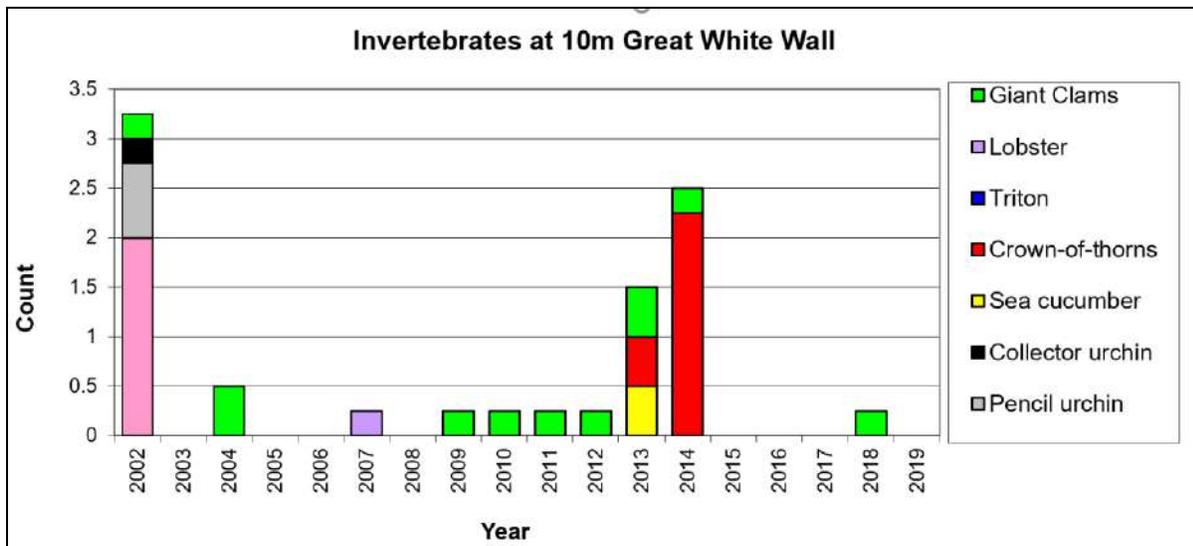


The reef has only been surveyed at 5m occasionally, but larger numbers of macro-invertebrates have been found in the past at this shallower depth than at 10m.

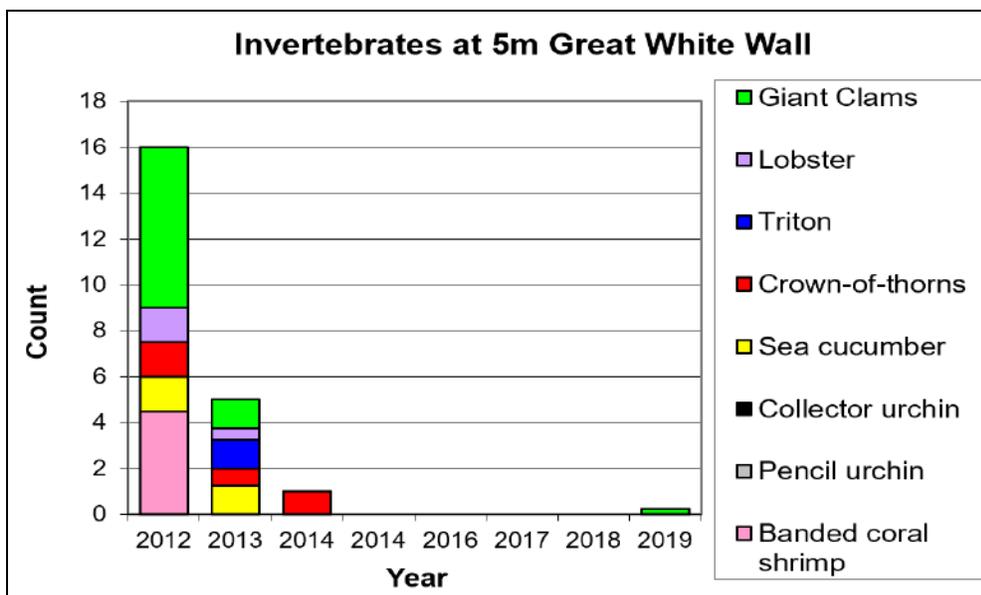


In 2013 and 2014 a Crown of Thorns Starfish (COTS) outbreak was recorded on **the Great White Wall** (red in the graph below) at a density of 0.5 COTS per 100m² in 2013, rising to 2 COTS per 100m² in 2014, more than 200 per hectare, (40 per hectare is considered an active outbreak). Although there were no surveys in 2015 and 2016, dive operators reported that number grew even higher, and considerable damage was done to Table Acropora corals, particularly at the Great White Wall.

No COTS were reported after the cyclone of February 2016, and none, and no COTS scars, were recorded in the 2018 surveys. It is assumed that the cyclone tore the COTS from the reef and previous work suggests that it will be 5 – 8 years before they return.



In 2012, invertebrates were found in quite high numbers at 5m on the Great White Wall, but this has subsequently dropped. No Sea Cucumbers or Giant Clams have been recorded since 2013. This could be due to environmental impacts such as COTS or cyclones, but could also be evidence of over-fishing. One small Giant Clam was found in 2019.



Discussion:

These surveys have provided a picture of fluctuations in reef health on the Rainbow Reef over the past 17 years, and a baseline of indicator animal populations. Full fish species census data is also available from some years.

Over this time the reefs of the Somosomo Straits have demonstrated a high level of resilience, being impacted by bleaching mortality, outbreaks of coral-eating Crown of Thorns Starfish, and breakage due to cyclones, but showing recovery to pre-crisis levels within 4 or 5 years.

The report “Biophysically Special and Unique Marine Areas of Fiji” gives the area a high priority rating of 11/12 for the following reasons:

Geographic coordinates: S16° 50' 55", E180° 0' 0" and S16° 42' 47", E180° 0' 0"

Area (km²): 156.4

Division: Northern

Unique iQoliqoli ID number: Cakadrove_MAP24_FOL42 and MAP30_FOL26

TABLE 144: Details of Site Rating T2

Criteria	Details	Rating (out of 3)
Biophysical Justification	Narrow Strait with high currents and patch reefs, 3 species of whale, sharks, soft corals, fish diversity, humphead wrasse, pelagic fish.	3
Geographic Explicitness	From coastline of Vanua Levu to coastline of Taveuni, including mapped tourism dive sites.	2
Source Number and Type	At least one peer reviewed paper and at least one good report and expert advice available.	3
Obligations (See Appendix C)	Relevant taxa: <i>Carcharhinus amblyrhynchos</i> ; <i>Cheilinus undulatus</i> ; <i>Manta alfredi</i> ; <i>Galeocerdo cuvier</i> ; <i>Stenella longirostris</i> ; <i>Balaenoptera acutorostrata</i> ; <i>Megaptera novaeangliae</i> .	3
Overall Rating (Out of 12)		11

DETAILED DESCRIPTION OF HABITAT / FEATURE

This site has a high overall rating of 11 (Table 144), and includes the Somosomo Straits, (Map 70) which are the narrowest point between the large island of Vanua Levu and the medium sized island of Taveuni, just over 7.5 km wide. There are very deep waters to the north east and south west of the straits, and tidal changes cause strong currents as nutrient-rich water is funnelled up through this constriction, creating an area of rich marine life.

The area is world renowned for the density of, *Dendronephthya* spp., soft corals and schooling fish found on the reef walls and patch reefs, and, known as the "Rainbow Reef", it has been the focus for SCUBA diving tourists for many years¹³⁹. At least five operations regularly offer SCUBA diving in the area, and it is one of the main attractions for resorts on Taveuni (Neubauer, 2011).

Grey reef sharks, *Carcharhinus amblyrhynchos*, and humphead wrasse, *Cheilinus undulatus*, are seen across the reefs, and there are reef manta rays, *Manta alfredi*, cleaning stations. Pelagic fish and tiger sharks, *Galeocerdo cuvier*, are known to frequent the deeper waters¹⁴⁰. Dolphins, *Stenella longirostris*, and minke whales, *Balaenoptera acutorostrata* or *B. bonaerensis*, are often seen, and the straits are on the migratory route for humpback whales, *Megaptera novaeangliae* (Miller et al., 2016).

The reef has been studied since 1999, and has gone through several stress events such as coral bleaching, crown-of-thorns starfish (COTs) outbreaks, and cyclones, but has always returned to high coral cover, and could be considered a centre for coral resilience to climate change, and a potential source of coral spawn to aid the recovery of other, less resilient reefs (Lovell and Sykes, 2008; Sykes and Morris, 2007).

As such, the area is a very high priority for marine protection.