Results of the Territorial Monitoring Program of American Samoa for 2010, Benthic Section.

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Contents

Acknowledgements

Thank you to boat captain Mika Letuane. Thanks also to Ekueta Schuster for filling tanks and other support, and for DMWR enforcement for the use of their giant pickup to pull the boat over the very steep pass to the boat ramp at Fagasa on the north side of Tutuila. Special thanks go to the Fagatele Bay National Marine Sanctuary, for the use of the Sanctuary boat when the DMWR boat was not available, which was most of the time.

Abstract

Because the tsunami in Sept 29, 2009 not only destroyed the boat ramps at Pago Pago Harbor and Fagasa, and damaged almost all DMWR vehicles beyond repair by immersion in saltwater, plus all three DMWR boats were inoperable almost the entire year, only a small amount of data was collected. Only 2 sites on the reef slopes were surveyed in 2010. Coral cover for the two sites has not shown any trend over the last 6 years, and in 2010 was 32%, very similar to that of the average of all 12 sites in previous years. The live coral index remains very high compared to other reference averages such as those for the Pacific, South Pacific, Indo-Pacific, and world. The most common coral lifeform remains encrusting, and *Acropora*, *Montipora*, and *Pavona* are the most common genera. The number of genera per site in these two sites has remained stable over the last 6 years. Encrusting *Montipora* is the most common species at Aunu'u and *Pavona varians* the most common at Faga'alu. Aunu'u had more coral species than Faga'alu. The number of species was steady at Faga'alu but increased in the last two years at Aunu'u. Algae and other categories did not show trends over years except that coralline algae increased in 2010 in Faga'alu.

There were very few invertebrates, with the orange sponge *Stylissa* being the most common, sets of small worm holes being second most common, and grooves made by

alpheid (snapping) shrimp being third most common. There was no clear trend in the number of kinds of invertebrates.

Cover was also measured on outer reef flats at four sites. Coral covered an average of about 35%. There was no clear trend in reef flat coral cover. The live coral index was high and showed no trends.

Staghorn corals in the backreef pools bleached in the austral summer season (December to May) as they had in the previous 6 years in the airport, but may have been less at Alofau (or the higher levels may have occurred during a gap in monitoring).

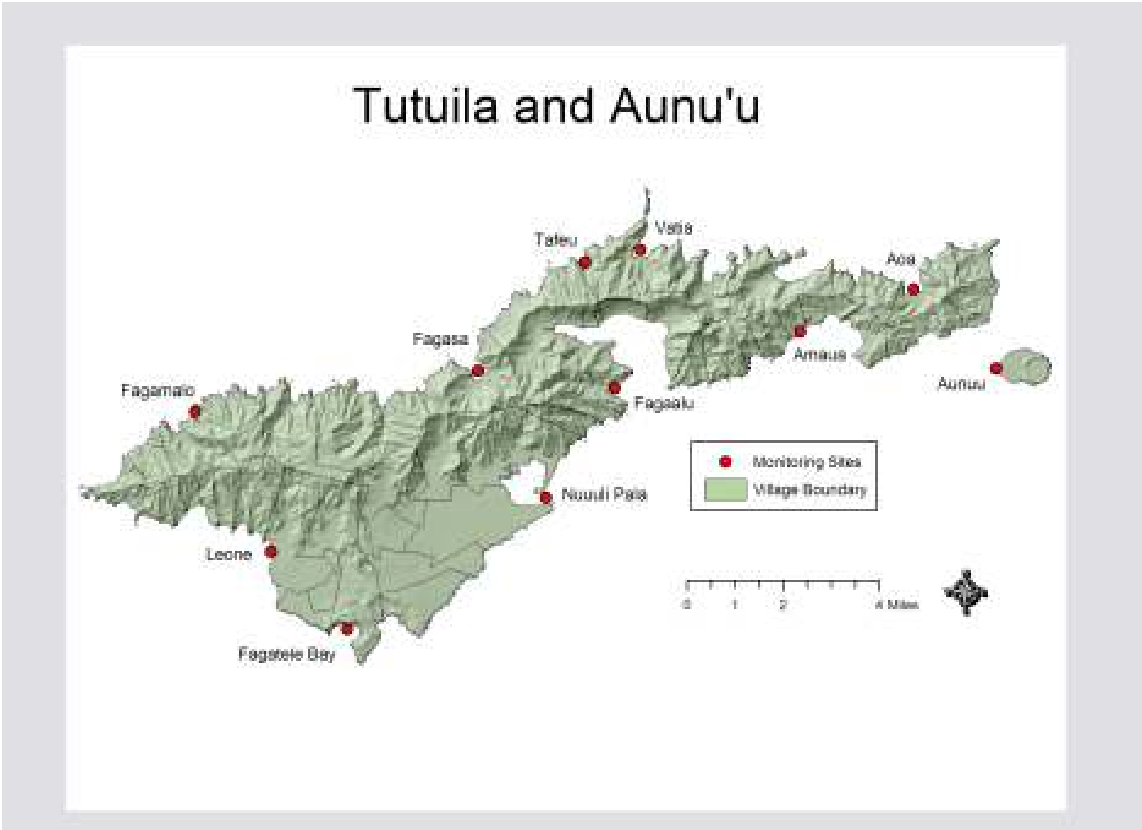
Quantitative data are now available after the tsunami for a few sites. Coral cover did not decrease at Faga'alu or Aunu'u at 9 m depth or at Faga'alu at 4 m depth, but decreased at 18 m depth at Faga'alu from 60% cover to 28% cover. At 18 m depth at Faga'alu the transect was on a delicate plate coral community. There was a sharp line below which all plates were removed by the tsunami, and above which the plates were all intact. The dividing line between these two zones was shallower than the transect in some areas and deeper in others. A transect placed deeper would likely produce very low coral cover, and a transect placed shallower but still in the plate zone might produce near 60% coral cover. Coral cover did not decrease at Nu'uuli at 4 m but did decrease from 30% to 18% cover at 18 m deep. There was no visible sign of damage at this location, so that change is most likely due to a small change in transect location.

In Appendix 1, a short essay on the state of coral reef habitat written for the Fisheries Council concluded that while the reefs are not perfect, most variables indicate they are relatively healthy. Coral cover and the live coral index are higher than the average for the Pacific, South Pacific, and particularly the Caribbean (coral cover). Water clarity is good, coralline algae cover high, and macroalgal cover is low. There are few filter feeders, bioeroders, or introduced species and no invasive species known. Sedimentation has damaged only small areas, and nutrients have only produced small areas of macroalgae blooms. The harbor is heavily impacted. Habitat quality outside the harbor provides little support for suggesting that the lower fish biomass or low large fish abundances we have are due to poor habitat quality.

This report is 44 pages long and includes 34 figures.

Methods

The original 11 core sites are shown in the map below. All are on Tutuila and nearby Aunu'u.



The benthic methods were the same as in 2009. In the core monitoring, four 50-m tapes were laid on a depth contour between 8 and 10 m deep. A space between them of about 10 m was kept. Benthic categories were recorded under each 0.5 m point on the tape. Benthic categories included live coral, dead coral, dead coral with algae, crustose calcareous algae, branching coralline algae, fleshy macroalgae, turf algae, rock, sand, rubble, soft coral, and sponge. "Branching coralline algae" included a soft feathery species that was the most common in that category. That species is *Cheilosporum spectabile*. Any rock that is not colored white has turf on it, and was recorded as turf. Corals were identified to lifeform, genus, and species when possible, and if the macroalgae was *Halimeda* or *Dictyota*, or something else that was identifiable, that was recorded. Soft corals were recorded to genus when possible. Hard coral lifeforms included encrusting, massive, foliose, branching, columnar, submassive, mushroom, *Millepora*, *Acropora* branching, *Acropora* table, *Acropora* digitate, and *Acropora* encrusting. Horizontal visibility was recorded using the tape. Two transect tapes were done on the first dive, and an additional two tapes were done on the second dive. Invertebrates were recorded on a return pass. Sites were re-located using the GPS and markers as indicated in the 2005 report. One day was required for each site. In 2008, a total of 12 sites were recorded, including the original 11 plus Masacre Bay. For 2010, however, the lack of operating boats and boat ramps meant that only two sites were monitored in the calendar year. The tsunami made the boat ramps inoperable at Pago Pago and Fagasa for the entire year.

As in 2007-2009, the rugosity measurements were omitted, because a third team member was not available and when included it lengthened dive times to the point where running out of air was a distinct possibility, thus reducing the margin of safety. Further, it appears that the measurement depends primarily on exactly where the chain falls, and that changes in rugosity caused by coral growth will take quite a few years before they would be detectable. A hurricane could make changes in rugosity quickly by removing corals, and if significant hurricane damage occurs, the rugosity measurements can be repeated. Until changes in coral cover or other rugosity changes are apparent, repeating the measurement of rugosity is not worth the increased risk of running out of air. In future years it is hoped that an additional team member can record the rugosity measure, or additional boat dives are available to take the rugosity measure. In the meantime, it will be considered a lower priority item, and will be done on an opportunistic basis.

When laying the tape, the primary consideration is to keep the tape between 8 m and 9 m deep. The tape is passed along the sides of projections, including live corals such as *Pocillopora* and table corals, which usually have an overhanging side. If it is passed around first one side of one projection and then the other side of another, it is anchored securely from wave action moving it either way at that point. An attempt is made to anchor the tape in this fashion as often as possible, but in some areas there is little to anchor the tape on. A continuing problem is what to do about clefts in the reef. A cleft that is narrow and deep is crossed straight to an anchoring point on the other side. If it is large, then the tape may be laid along one side of it, going up toward shallower water but staying at 8-9 m depth, and then when the bottom rises to that depth, crossing to the other side and continuing on that side out of the canyon. The principle problem with that is finding an anchoring point near the head of the canyon that can hold the tape at the head. The tape is read at each point by reading the substrate under the point at the time at which the diver is directly above the point. A string and weight are not used, as surge and the movement of the tape in the surge makes that a much more difficult and slow procedure. If the tape is stretched between two points far apart and the surge is heavy, the tape can move a meter or more in either direction with each wave. This opens up an opportunity for bias, as the point on the tape sweeps across a variety of benthic patches. If the point on the bottom is recorded that is first seen from a vertical viewpoint, then bias is minimized. An attempt is made to minimize bias in laying the tape by choosing a route based on depth and anchoring points for the tape, not the substrate.

The direct observation underwater of what is under points makes it easier to identify species, and so allows greater taxonomic resolution than video techniques.

GPS of the locations of the 12 sites are listed below in Table 1.

Table 1.

Site	GPS Coordinates
Fagamalo	-14º 17.872S, -170º 48.726W
Masacre Bay	-14º 17.374S, -170º 45.577W
Fagasa	-14º 17.016S, -170º 43.383W
Tafeu	-14º 15.109S, -170º 41.354W
Vatia	-14º -14.888S, -170º 40.205W
Aoa	-14º 15.474S, -170º 35.332W
Aunu'u	-14º 17.076S, -170º 33.818W
Amaua	-14º 16.418S, -170º 37.312W
Faga'alu	-14º 17.404S, -170º 40.598W
Nu'uuli	-14º 19.287S, -170º 41.850W
Fagatele Bay	-14º 21.859S, -170º 45.753W
Leone	-14º 20.534S, -170º 47.339W

Dates of collection of data are shown in Table 2-4.

Table 2. Dates of collection of benthic transect data for each site, reef slope.

Location	**Date**
Aunu'u	9/1/10
Faga'alu	8/18/10

Table 3. Dates of collection of transect data at 4 m and 18 m depth.

Amaua	8/31/10
Faga'alu	3/26/10
Nu'uuli	7/15, 23/10

Table 4. Dates of collection of reef flat transect data.

Fagasa	6/223/10
Vatia	7/1/10
Utulei	7/2, 6/10
Fagatele	8/30/10

Coral diversity data was collected from Fagafue Bay, on the north side, not a normal monitoring site, on 7/12/10.

Monitoring of bleaching continues as before, with visual estimates of the amount of staghorn bleached in different areas of the airport and Alofau pools, about biweekly. Bleaching on the reef flat and slope are also recorded at Alofau each time data is taken.

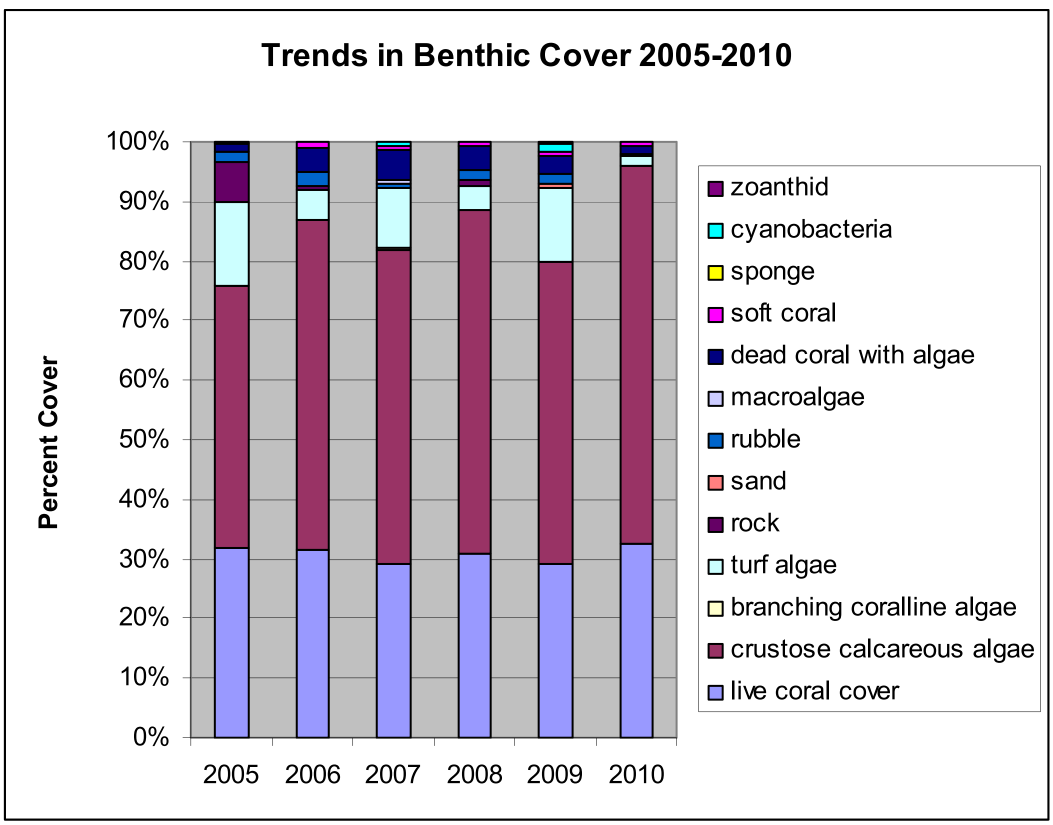
Results

For background information on the coral reefs of American Samoa, see Wells (1988), Craig et al. (2005), Sabater and Tofaeono (2006, 2007), Whaylen and Fenner (2006), Fenner (2008a,b), Fenner et al. (2008), Birkeland et al. (2008), and Brainard et al. (2008), Craig (2009) and Fenner (2009; 2010, 2011).

Reef Slopes

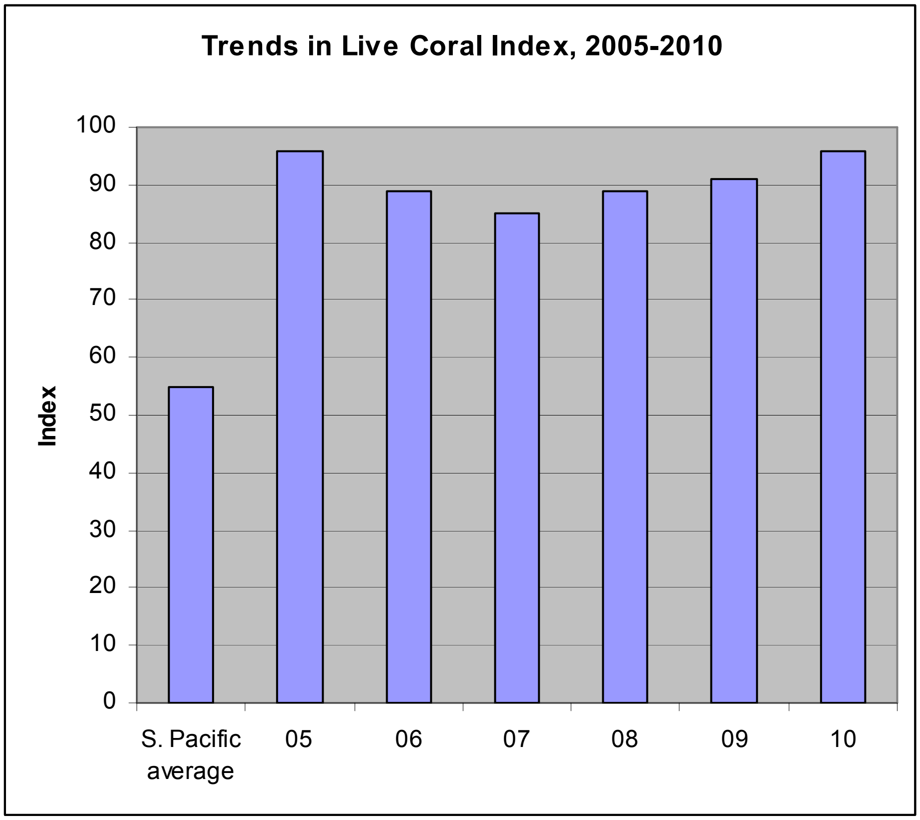
It was only possible to collect transect data at two sites, Aunu'u and Faga'alu. In order to look for trends and include the 2010 data, it is necessary to compare the 2010 data with just the Aunu'u and Faga'alu data from previous years. The small number of sites increases the amount of variation between years and decreases the ability to detect changes. As seen in Figure 1, live coral cover was very steady over the six years of monitoring, with no trend. Turf decreased in 2010 and was replaced by crustose calcareous algae. Since there was no trend before 2010 and variation in turf has been high, this may not be a real trend. These two sites just happen to average about the same coral cover as the whole island (all 12 sites).

Figure 1. Trends in benthic cover for the two sites surveyed in 2010.



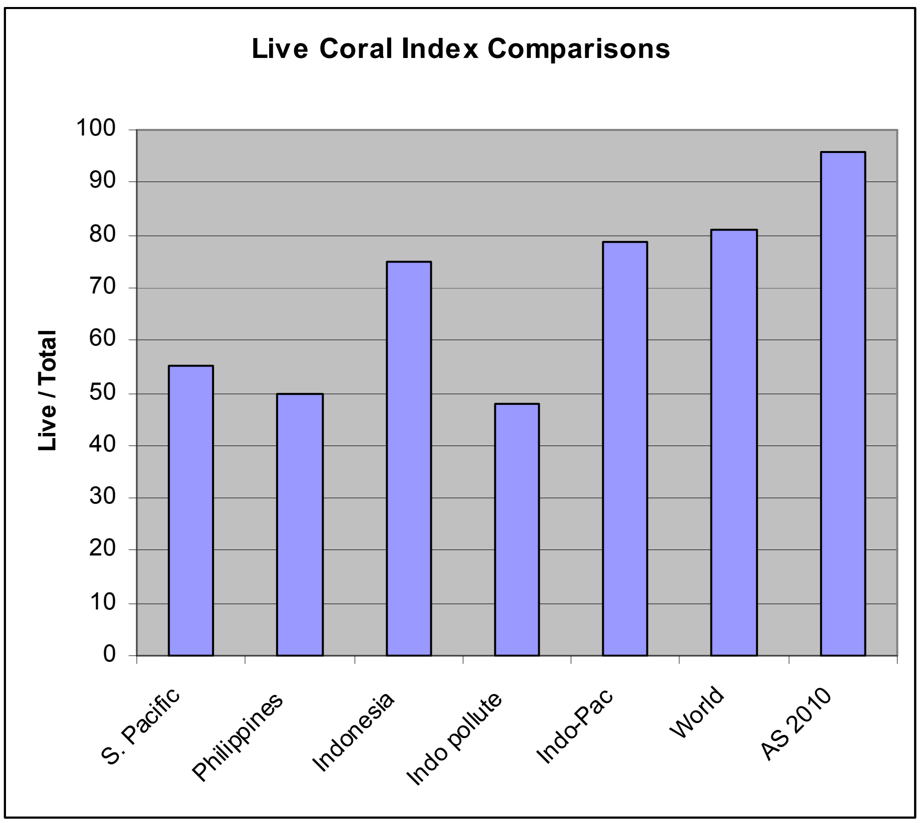
The live coral cover index (live coral/(live coral + dead coral) was high, with no trends apparent. It was calculated for just the two sites for all years, so they are comparable between years. The live coral index remains well above the PROCFish average for the South Pacific (Secretariat of the Pacific Community, 2005). High values are good.

Figure 2.



The proportion of corals that are alive is an important measure of reef health. There is very little dead coral around Tutuila currently. The PROCFish program based at SPC in New Caledonia surveys coral reefs in many Pacific countries. They have devised a “live coral index” which is the ratio of live coral to all coral (live and dead). A reef where most corals are alive is healthy compared to a reef where most corals are dead. Their index averages about 55% in the South Pacific (Secretariat of the Pacific Community, 2005), but the index averages about 93% here in Tutuila (Figure 13). In the Philippines, 48% of 844 reefs had an index below 50% (Gomez et al. 1994a,b). In Indonesia, unpolluted reefs had an average of index of 75% while polluted reefs averaged 48% (Edinger et al. 1998). The Reef Check program also has reported an index that can be converted to the live coral index, which turned out to be just below 80% for the Indo-Pacific and just over 80% for the world (Hodgson, 1999). Thus, Tutuila has a higher (better) live coral index than the South Pacific average, the Philippines, Indonesia, the whole Indo-Pacific, and world.

Figure 3.



Coral Life forms

The life forms of corals are their shapes. The mean cover of the different coral lifeforms is shown in Figure 4. Encrusting continues to be the most common lifeform, followed by branching, column, and table.

Figure 4.

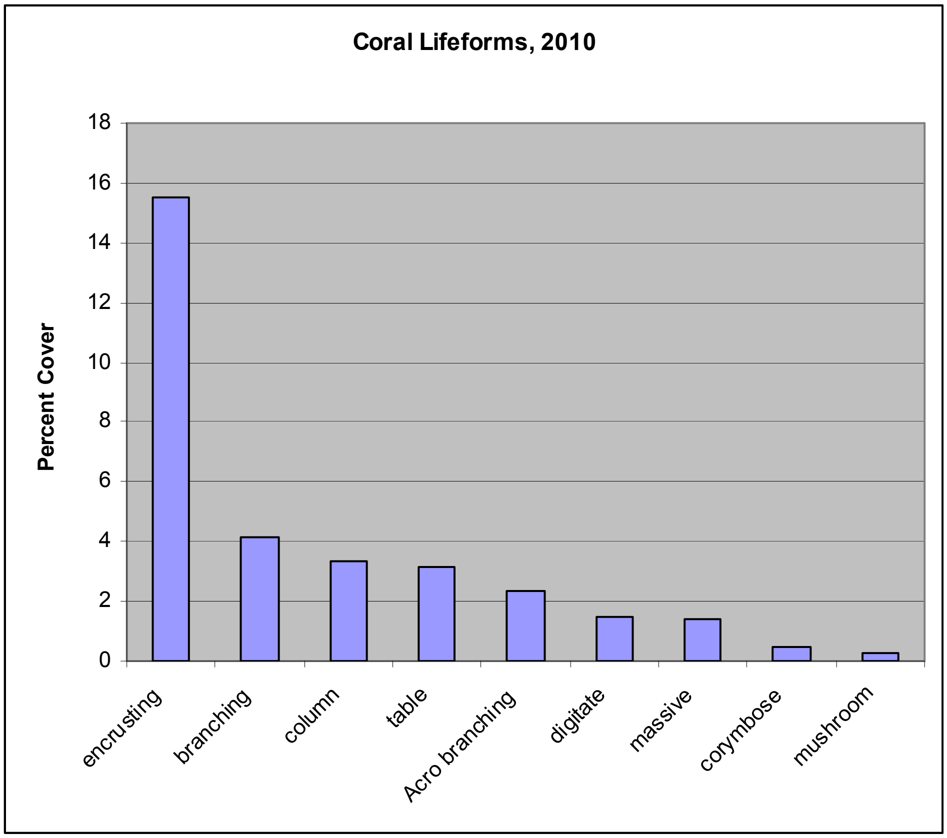
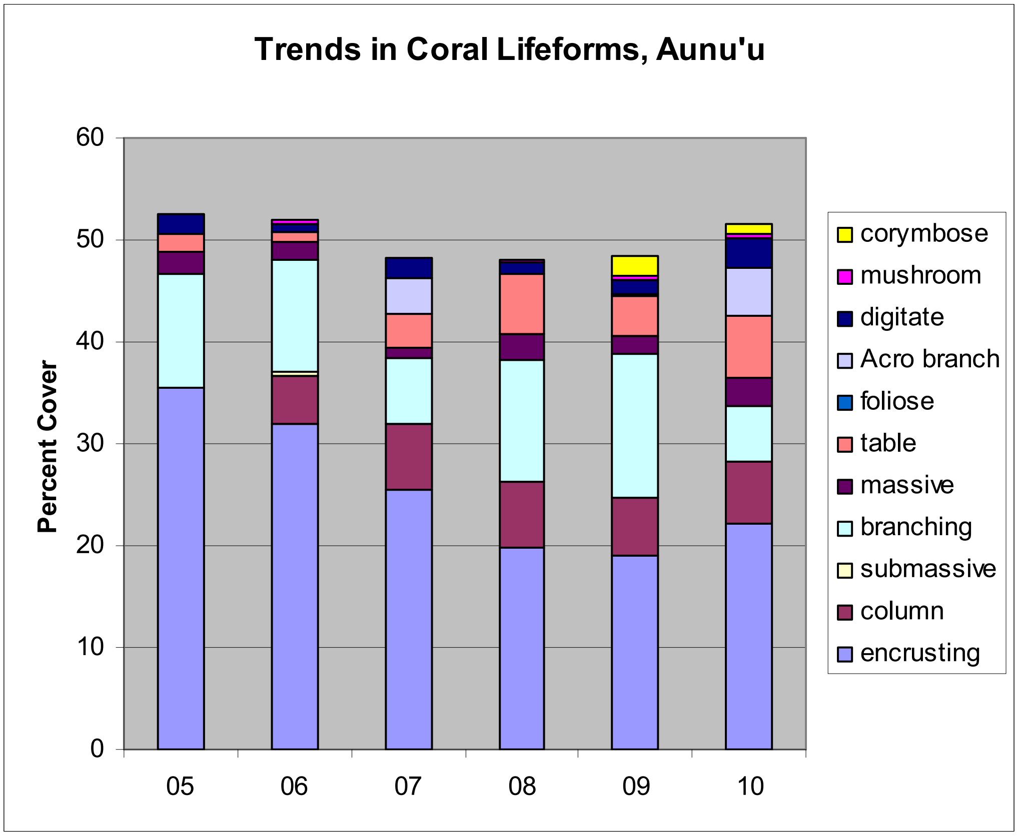


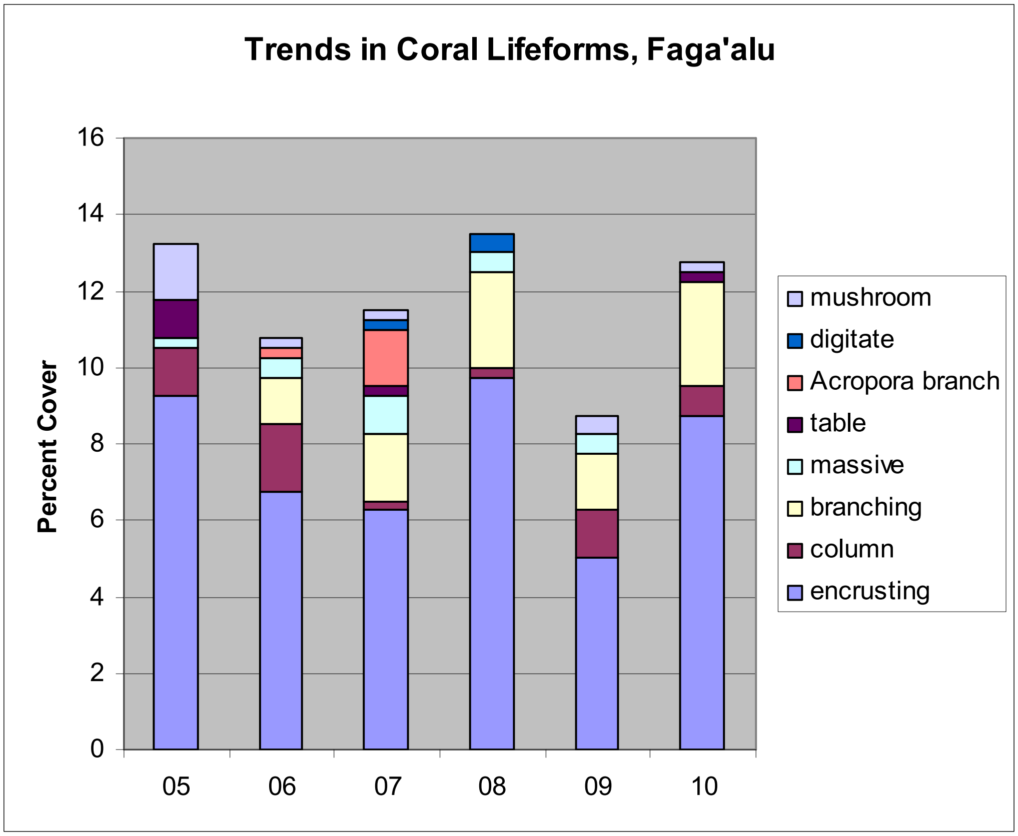
Figure 5 shows the trends in coral lifeforms at Aunu'u. Th e amount of encrusting corals decreased steadily over the first four years and then reached stability. The cause of this is not clear, and the site did not look obviously different.

Figure 5.



Trends in the coral lifeforms at Faga'alu are shown in Figure 6. There was large variation from year to year yet no clear trend.

Figure 6.



Genera

Figure 7 shows the mean cover of the most common genera. *Acropora* was the most abundant because only two sites are represented, and one of those is Aunu'u, with a high abundance of *Acropora*. The order would be different if all 12 sites were represented.

Figure 7.

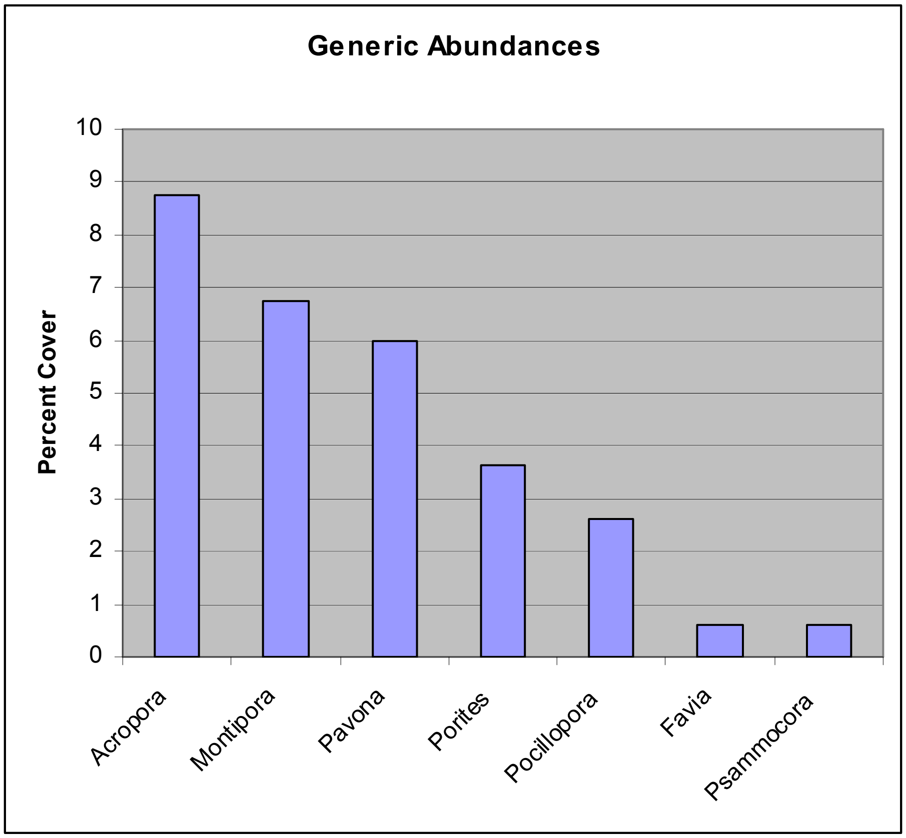


Figure 8 shows the number of genera by site.

Figure 8.

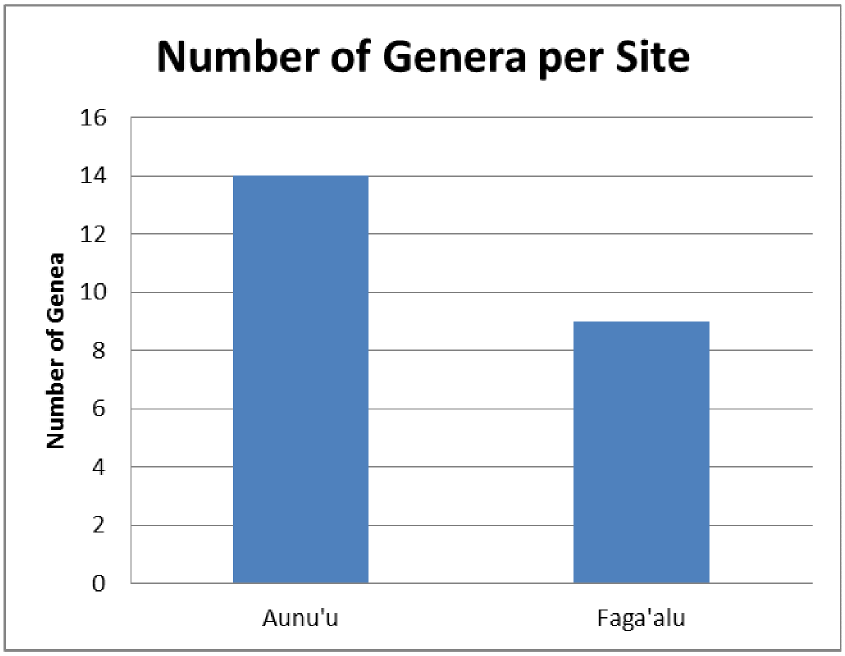


Figure 9 shows trends in the numbers of coral genera per site for the two sites. There is no trend in the mean number of genera.

Figure 9.

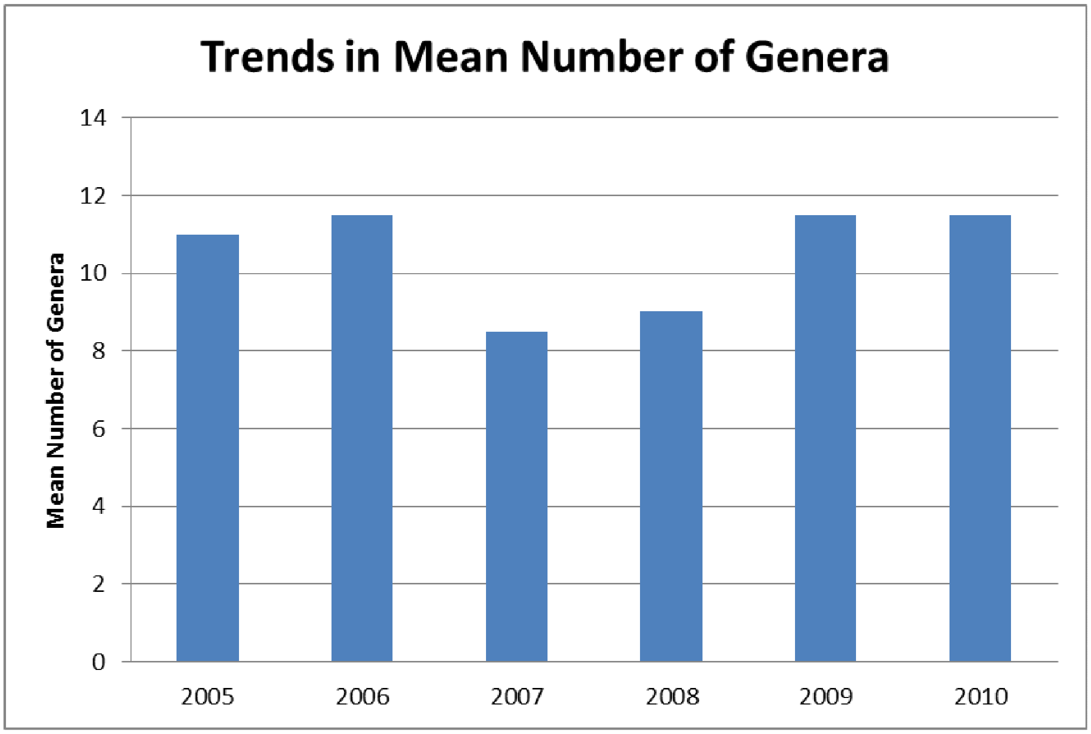
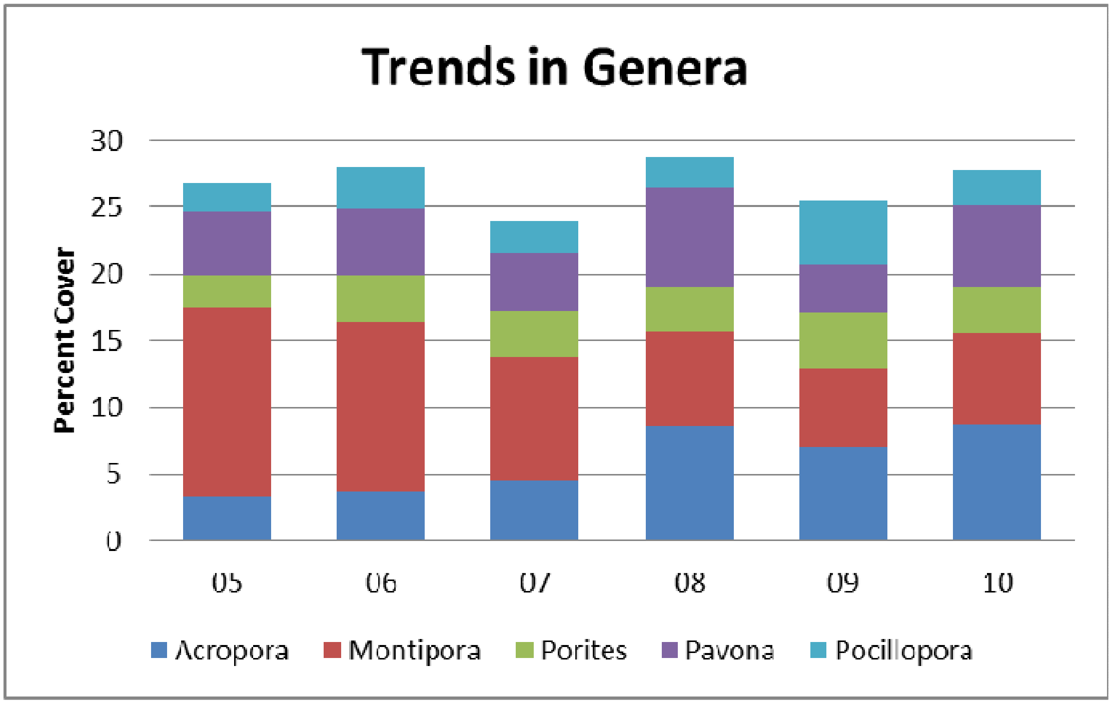


Figure 10 shows the trends in generic composition in transects in the two sites. The amount of *Acropora* increased at the expense of *Montipora* for these two sites between 2006 and 2008, for unknown reasons.

Figure 10.



Coral Species

Figure 11 shows the most common coral species by site. *Montipora* encrusting was the most common species at Aunu'u and *Pavona varians* was the most common species at Faga'alu.

Figure 11.

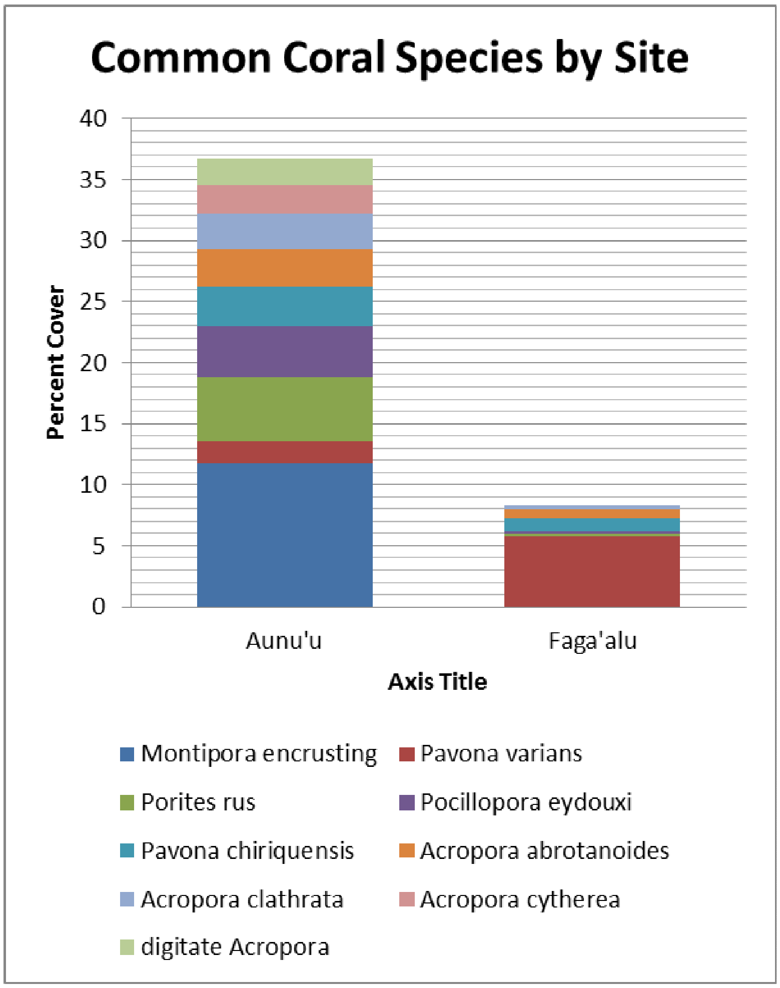


Figure12 presents the mean cover of the most common coral species. *Porites rus* was the most common, followed by encrusting *Montipora*, *Acropora clathrata*, and *Pavona varians*.

Figure 12.

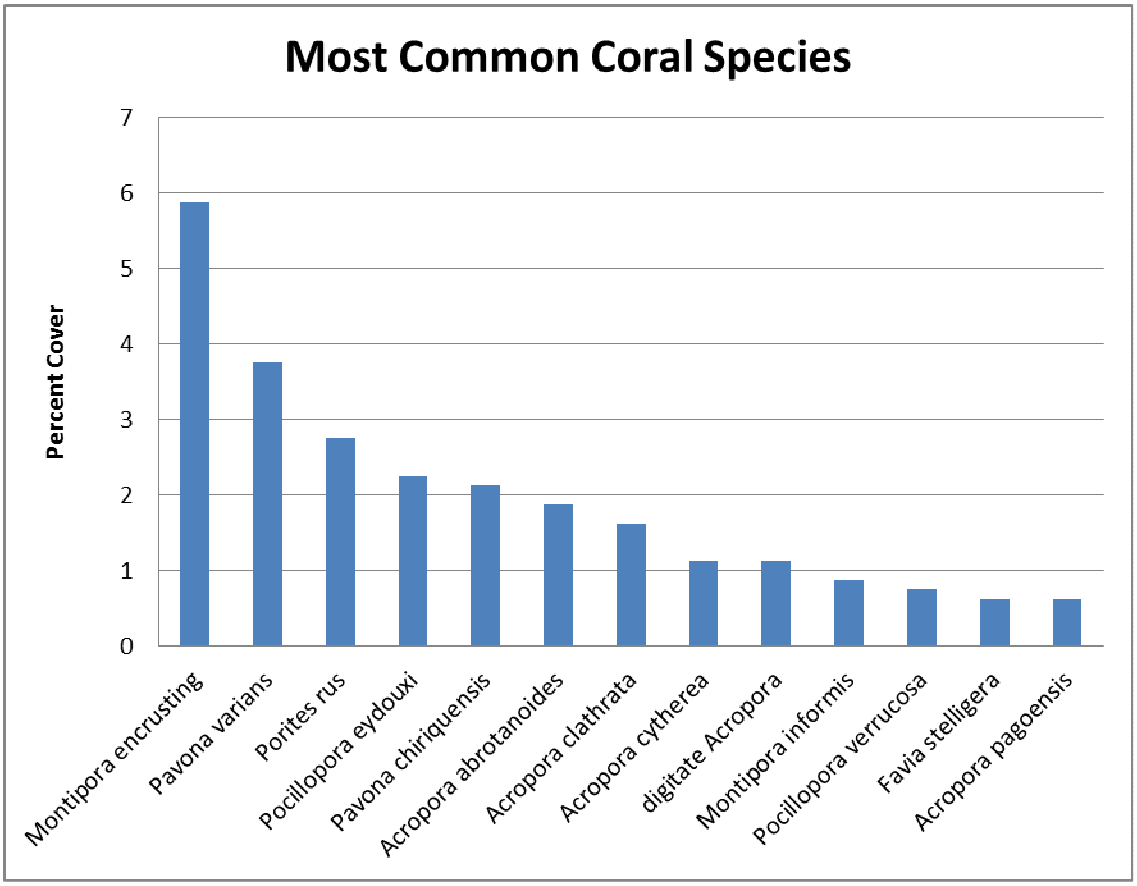


Figure 13 shows the number of species per site. Aunu'u has more species than Faga'alu.

Figure 13.

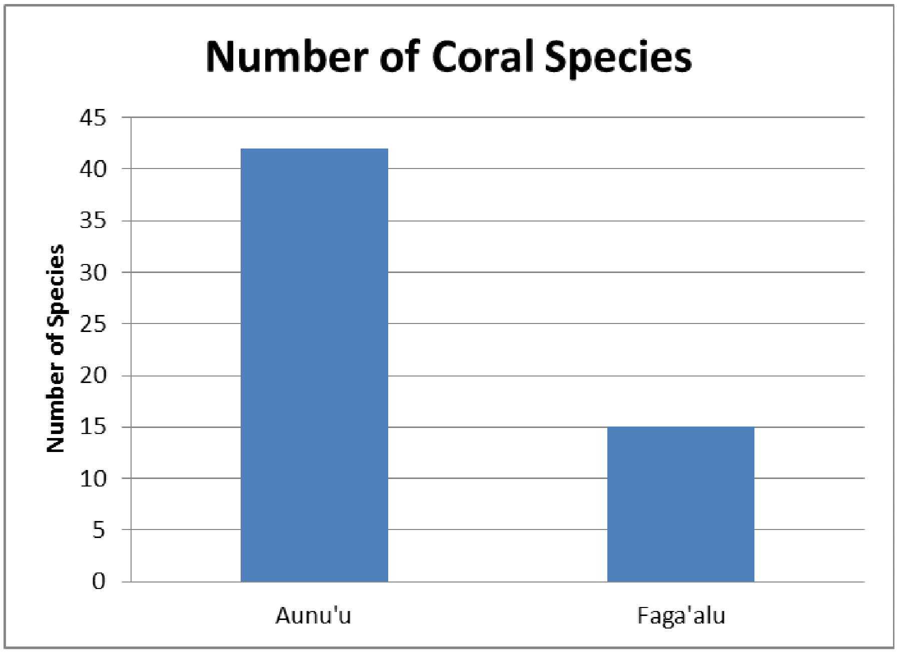
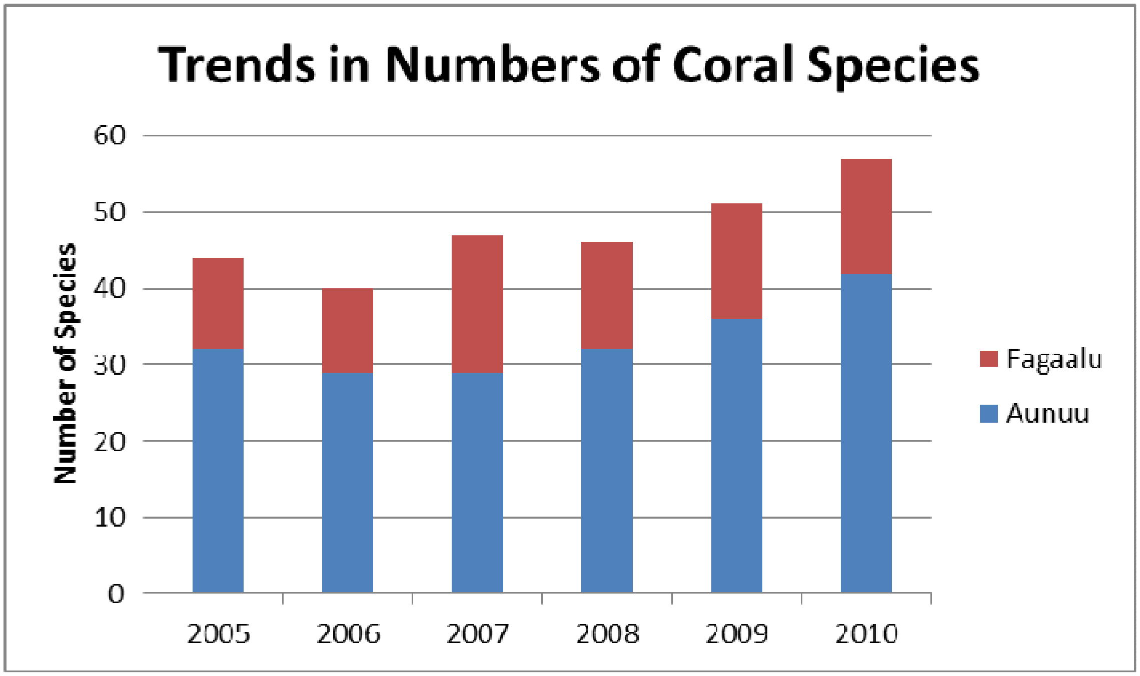


Figure 14 shows trends in the number of species at each site. The number of species at Aunu'u increased in the last couple of years but the number of species at Faga'alu has been steady.

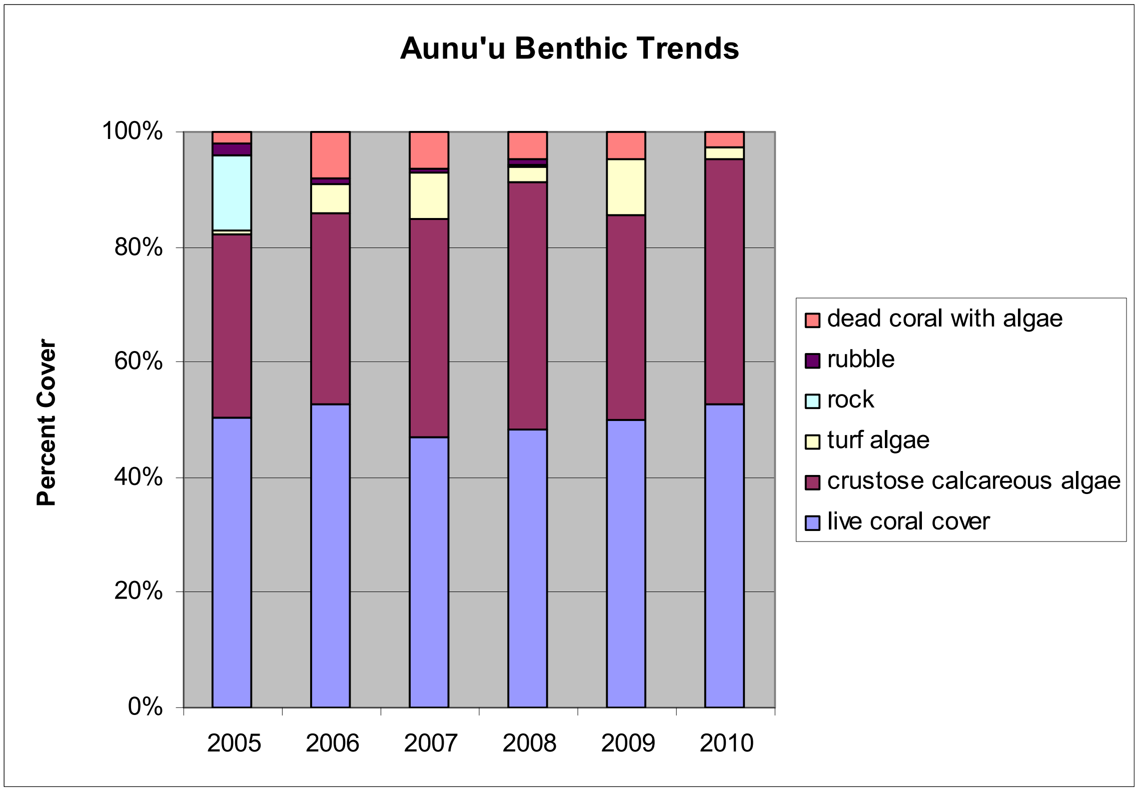
Figure 14.



Trends at Individual Sites

Data in 2009 was gathered from Aunu'u before the Sept 29 tsunami. The six years of records in Figure 15 show no clear trends and no evidence of any effect of the tsunami. The reef at Aunu'u in 2010 looks just like it did in 2005.

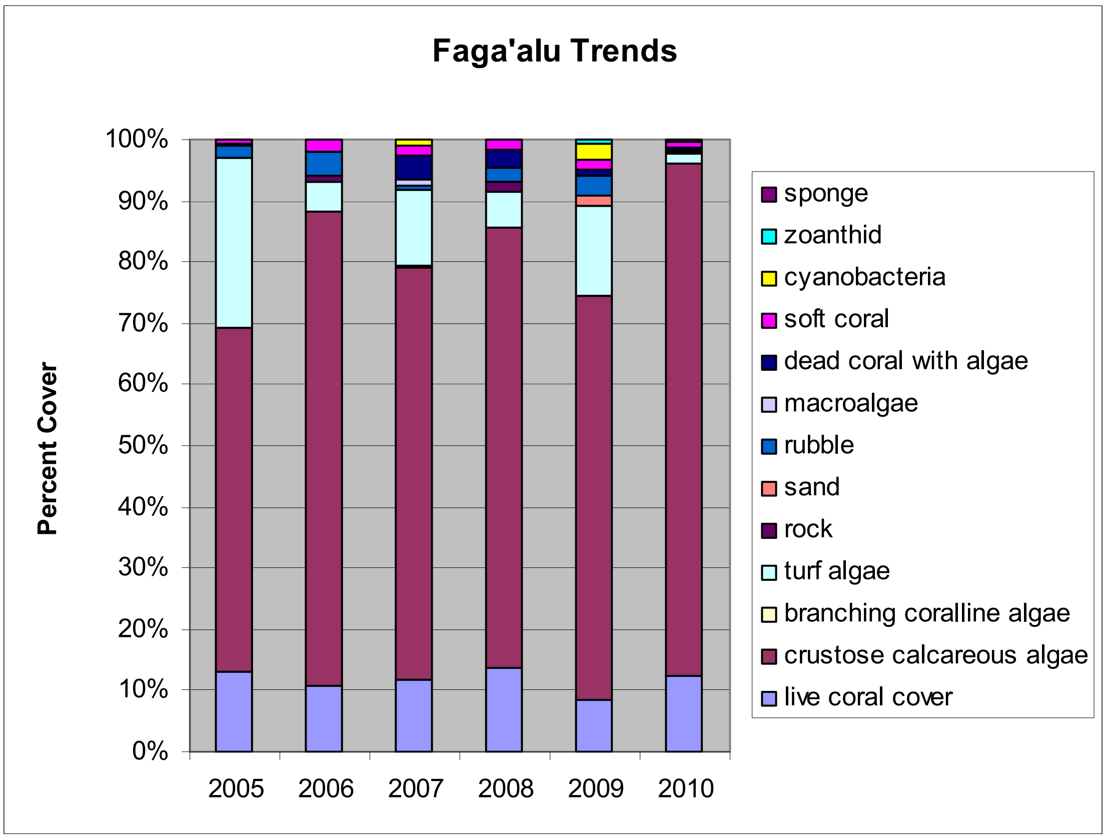
Figure 15.



Faga'alu shows no trend in coral cover, with low coral cover continuing (Figure 16). Crustose calcareous algae cover was the highest yet and the turf algal cover the lowest yet. However, these two show strong random variation over the years with no clear sign of an overall trend. It may be that turf growing over crustose coralline algae at the site makes the distinction difficult, or that the exact location of the tapes makes a big difference.

The reef slope at Faga'alu at the study site consists of a large field of rubble consisting of cylindrical branches, covered with coralline algae. The coralline algae have cemented the rubble together enough that the tsunami did no damage to the rubble field, even though there was dramatic evidence of damage deeper on the slope. The rubble is clearly from a staghorn species, and since some branches are large diameter it seems most likely that they are from *Acropora nobilis*. The field looked identical to the present when it was first surveyed in 2005. Whatever killed it, did so well before 2005, because it was all collapsed in 2005, none of it was standing. It could have been broken by a hurricane, or eaten by crown-of-thorns starfish, or killed by mass coral bleaching, or killed by disease. *Acropora* is one of the most vulnerable genera to all of these. So the cause of their death is not known. But the lack of any increase in coral cover is consistent with the observation of no signs of recovery, including no signs of new recruits. There are more corals on the shallower part of the slope, and a dense community of living plate corals deeper, but in a wide depth band around medium depths, the community is dominated heavily by coralline algae-covered rubble with no signs of change. Obviously at one time this area supported a lush coral community, and in spite of probably 10 or more years since their death, there is no sign of recovery underway. Why there is no sign of recovery is not at all clear.

Figure 16.



Invertebrates

Figure 17 shows the number of invertebrates at each site. For each of the three most common species, the species was common at one site but rare at the other. Stylissa is a sponge.

Figure 17.

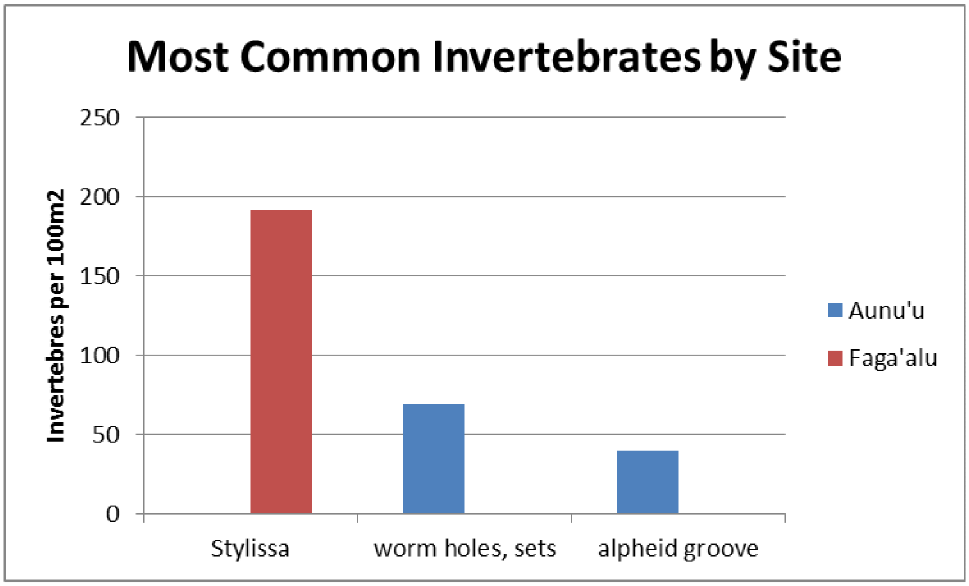


Figure 18 shows the mean number of each species of invertebrates in the two sites. Stylissa is a sponge.

Figure 18.

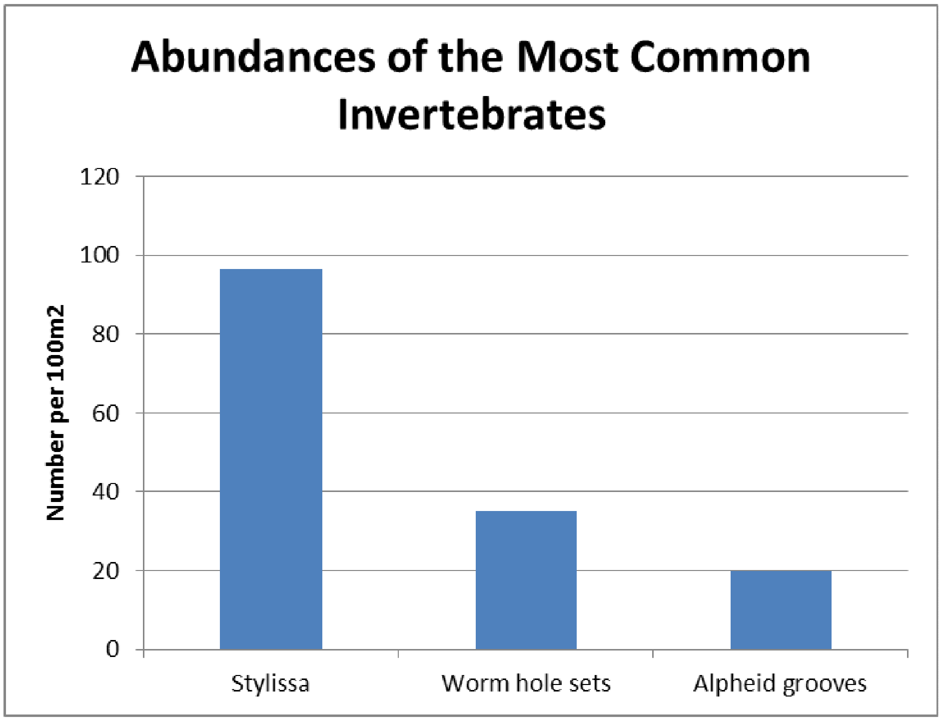
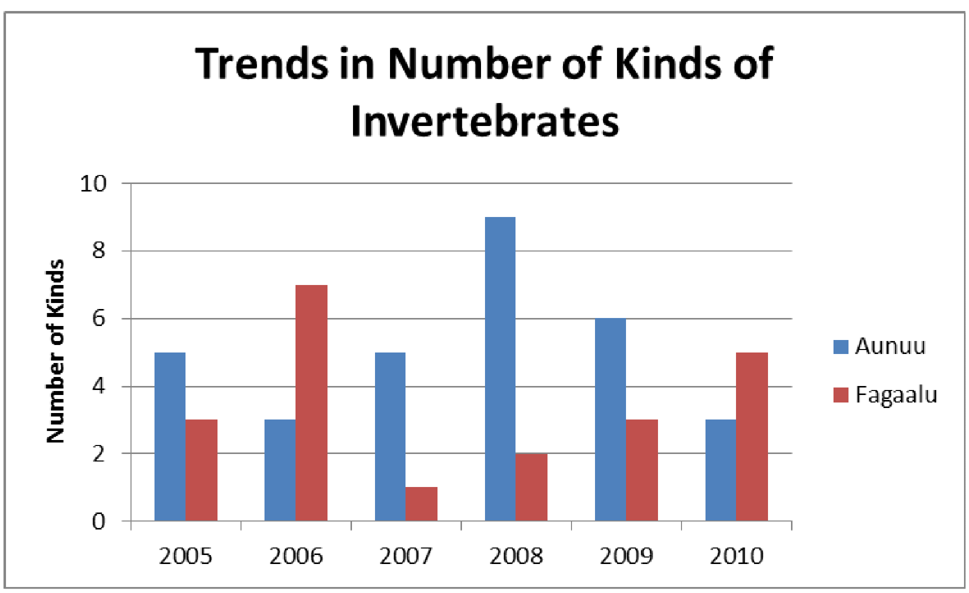


Figure 19 shows trends in the numbers of different kinds of invertebrates at each site. There are no clear overall trends.

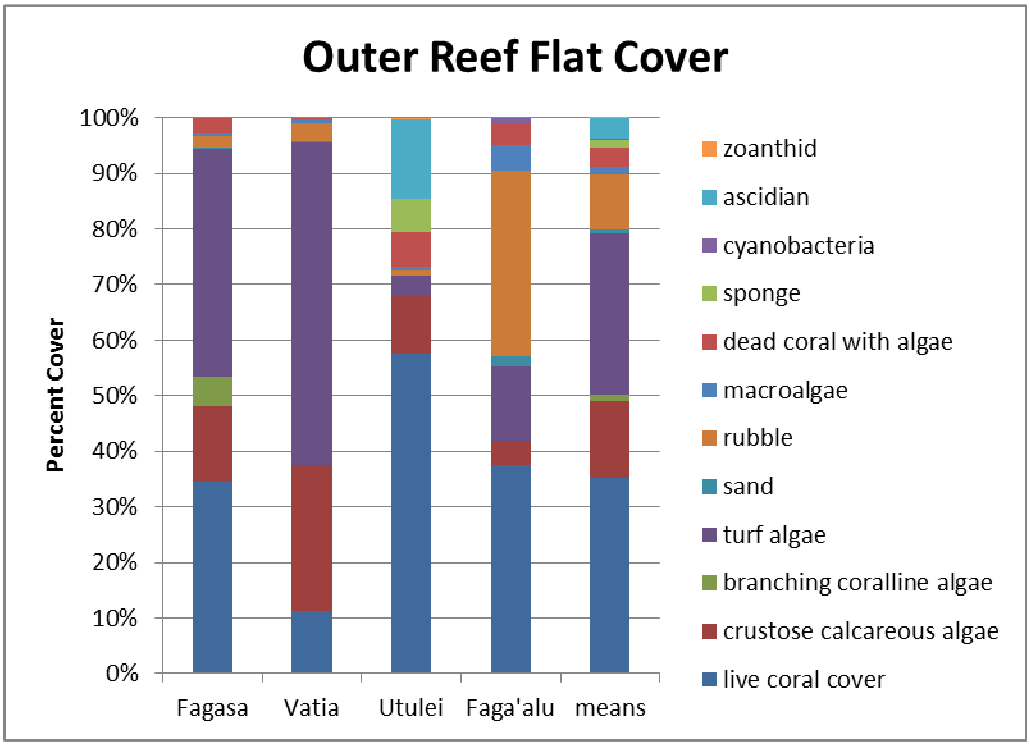
Figure 19.



Reef Flats

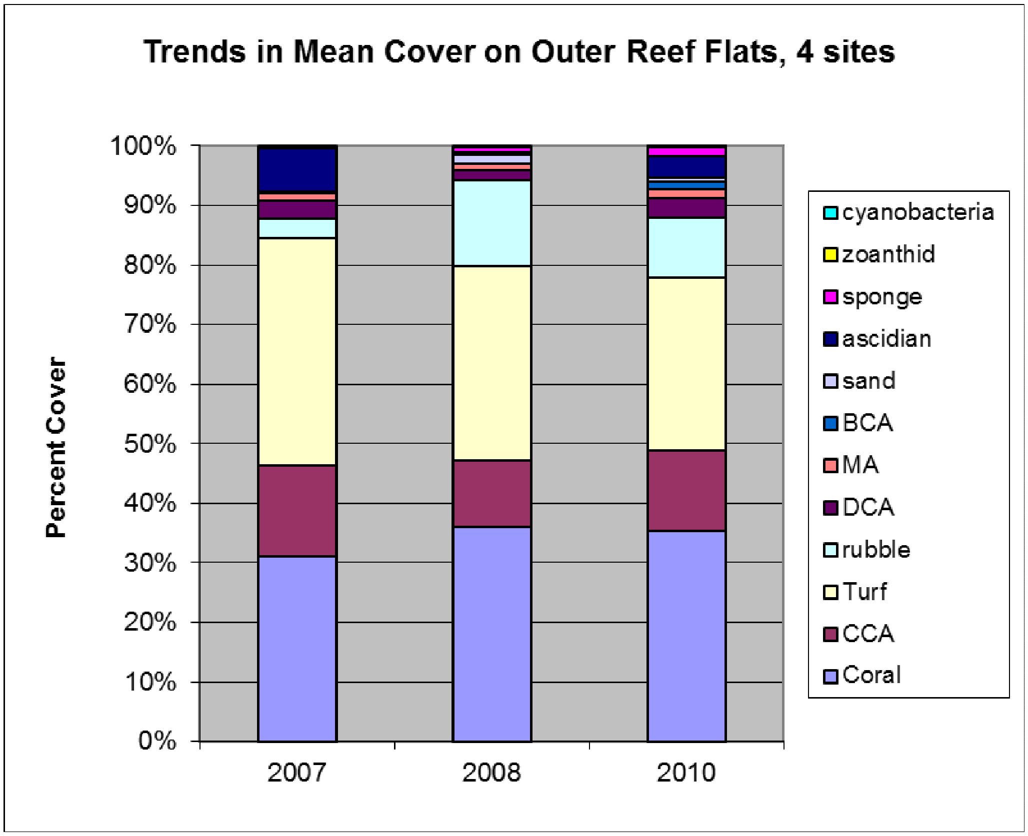
The cover of benthic organisms was measured at 5 sites. The results are shown in Figure 20. As on reef slopes, there are large differences between sites.

Figure 20.



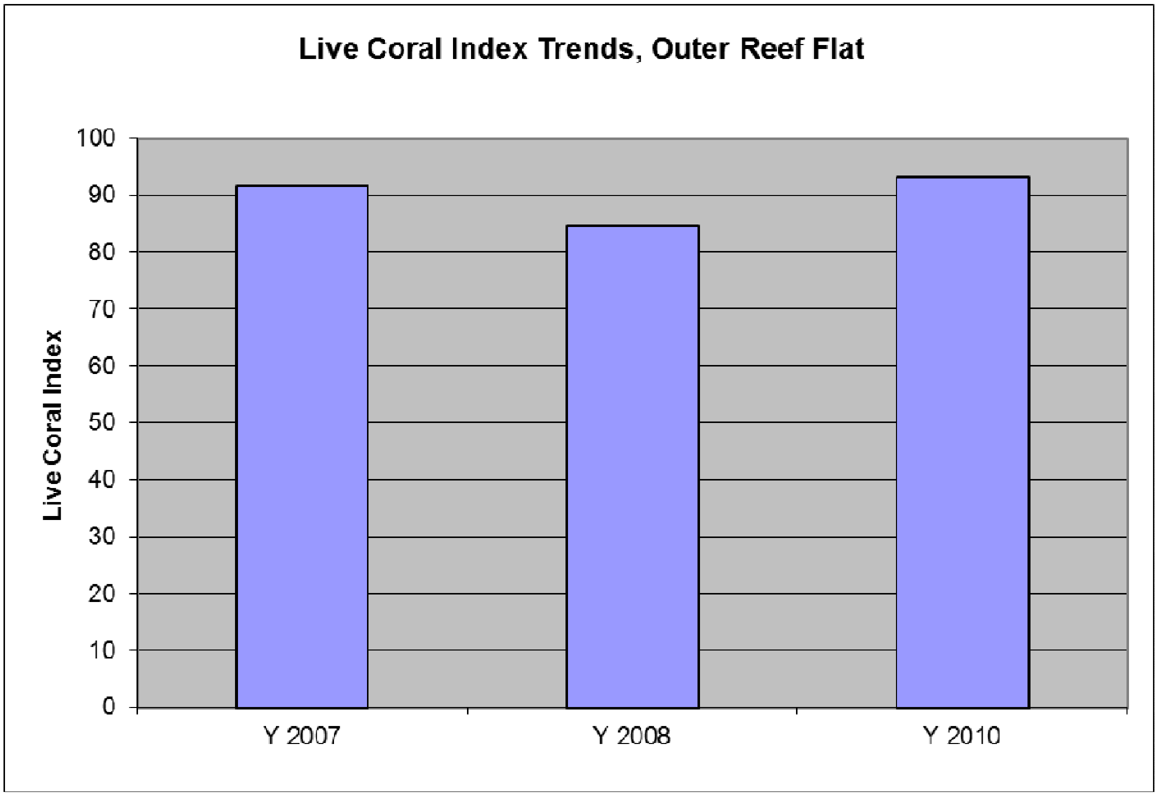
The trends in cover for the average of just the same four sites that were surveyed in 2010 are presented in Figure 21. There is a suggestion of an increase in coral cover, but it depends on just one point, that for 2007. There appears to be a small downward trend in turf.

Figure 21.



The live coral index was calculated for the reef flat just as on the reef slope. Figure 22 shows the trends in the live coral index on the outer reef flat. The live coral index was high like on the reef slopes, and there was no trend.

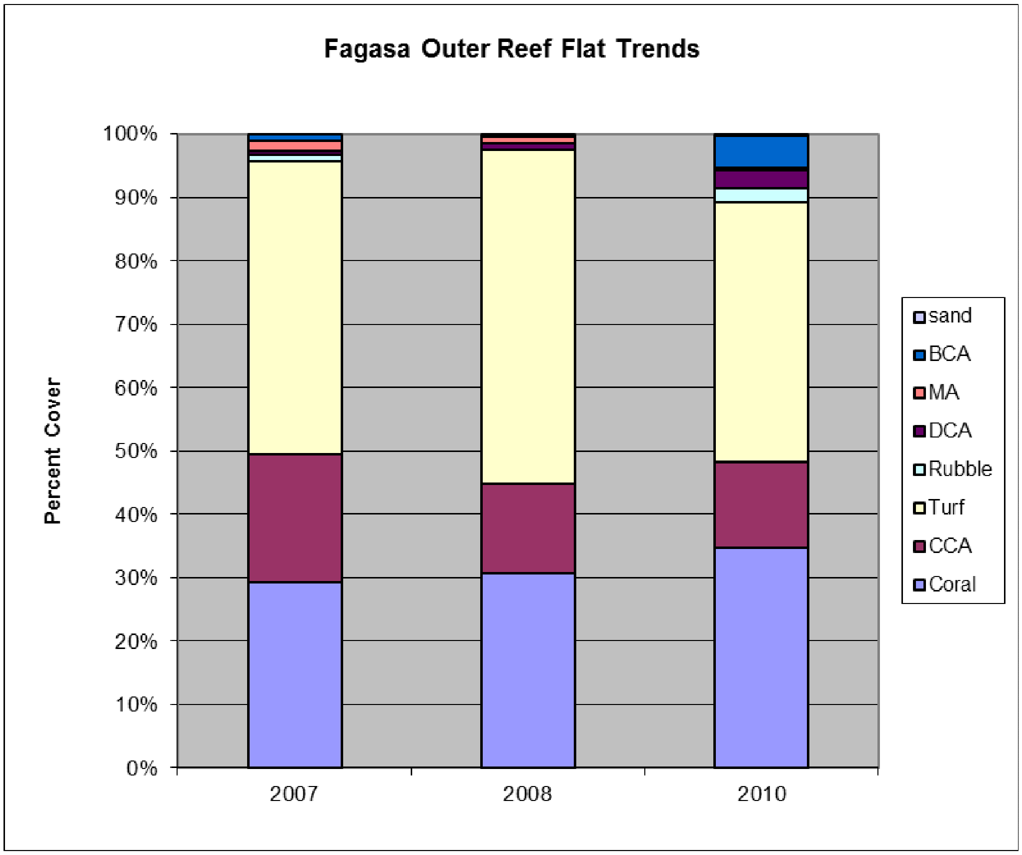
Figure 22.



Trends for Individual Sites

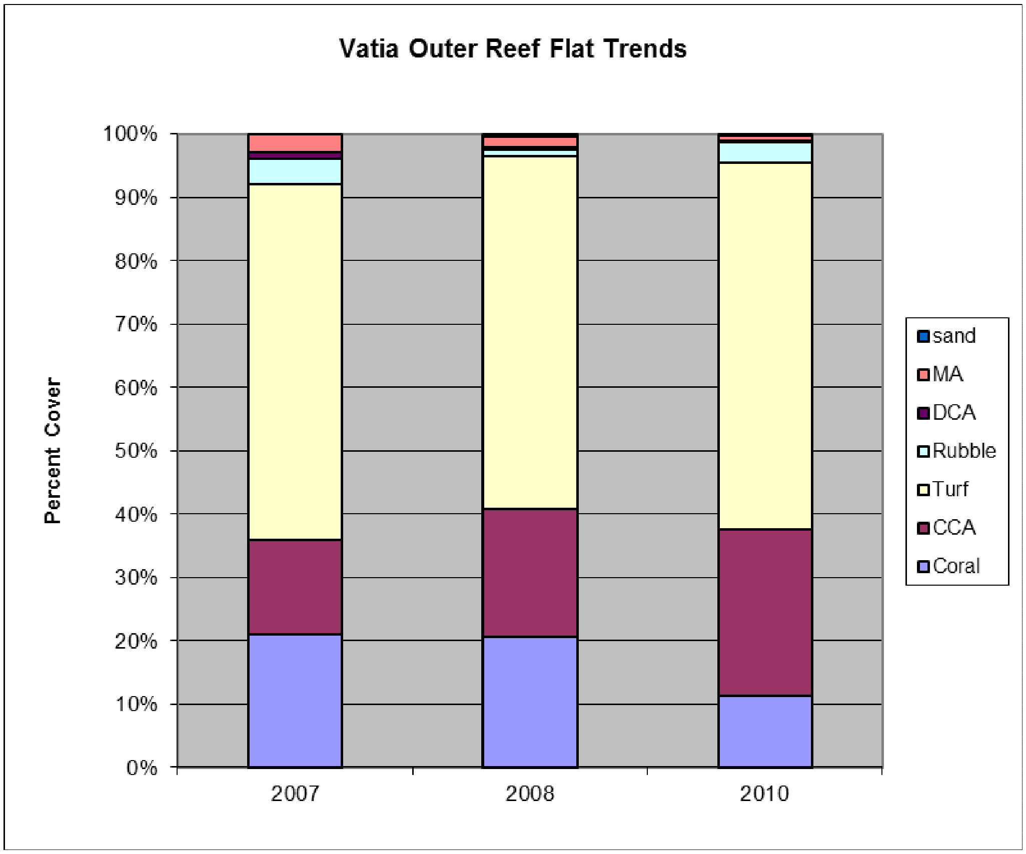
Trends for the outer reef flat at Fagasa are shown in Figure 23. There is an indication of an increase in coral cover but it is small and depends on just one point, so it is likely not real. There appears to be no trend in turf, and a downward trend in coralline algae depends on just one point and is likely not real.

Figure 23.



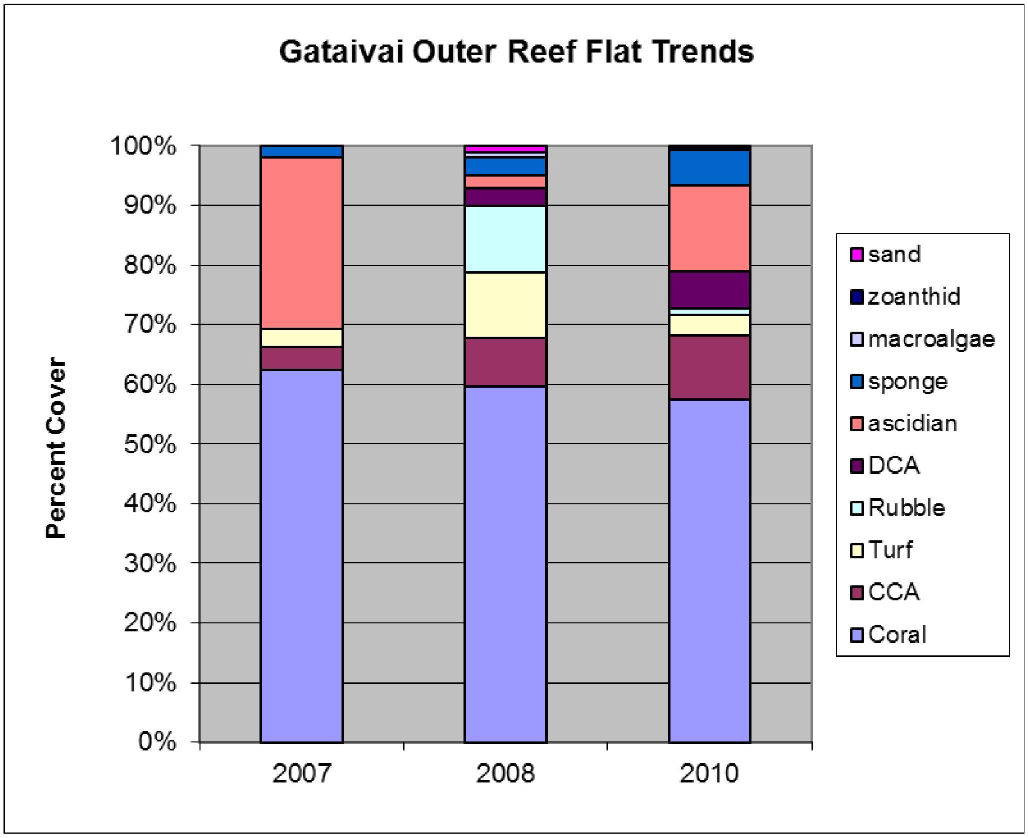
Trends in the cover of the outer reef flat at Vatia is shown in Figure 24. There is a downward trend in coral cover, but it depends on only one point, 2010, so it may not be real. There is an increasing trend in coralline algae that may be real as it is shown by all three points.

Figure 24.



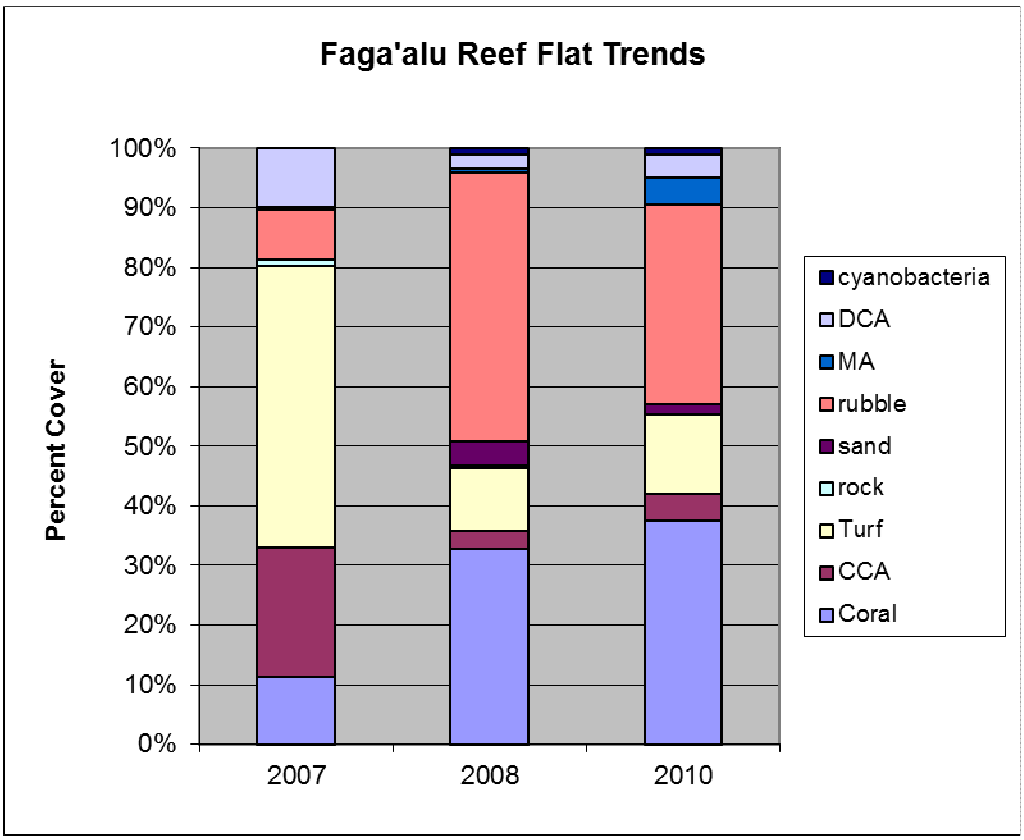
Trends in cover on the outer reef flat at Gataivai in the harbor is shown in Figure 25. Coral cover shows a small decrease over the three points, so the decrease may be real, but coral cover remains quite high at about 58%. Coralline algae increased steadily, but ascidian, turf and rubble had strong, inconsistent changes. It is uncertain whether those changes are real or due to small changes in the location of the transect tapes.

Figure 25.



Trends in cover on the outer reef flat at Faga'alu are shown in Figure 26. The coral cover at Faga'alu increased strongly, particularly from 2007 to 2008. The fact that the increase was over all three years suggests it may be real. Turf decreased greatly from the first to second year as did coralline algae, but rubble increased greatly after the first year. It may be that the tapes in the first year were at a different location than in subsequent years. The tape nearest shore is lined up with a light pole, but it is difficult to distinguish between two poles and it appears that coral cover near shore is higher near the outer pole than the inner pole, and a change in location which would be quite large may account for the change from the first to second year.

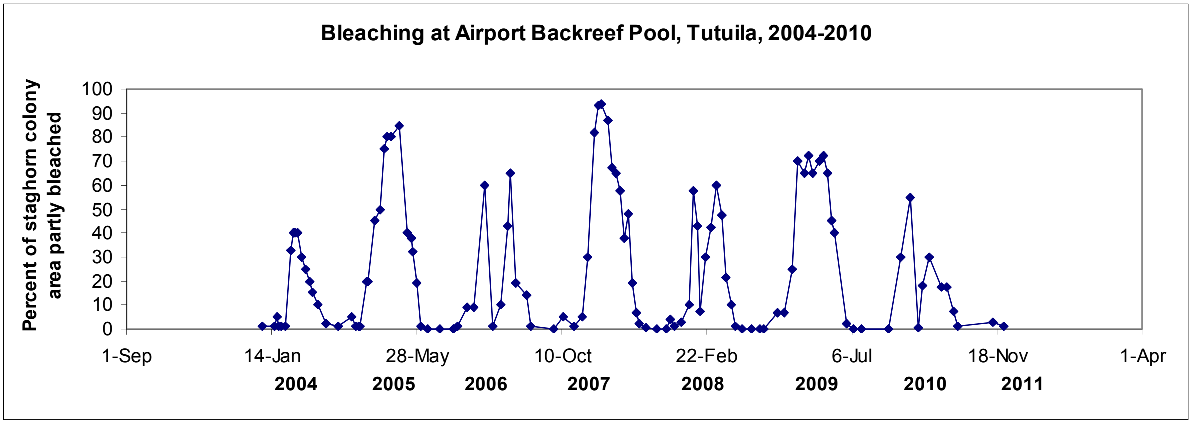
Figure 26.



Bleaching

Bleaching monitoring continued in the airport backreef pool, and the Alofau pool. The annual austral summer bleaching of the staghorns continues, with the graph for the airport through 2010 shown below in Figure 27. The bleaching for 2010 had a notch in

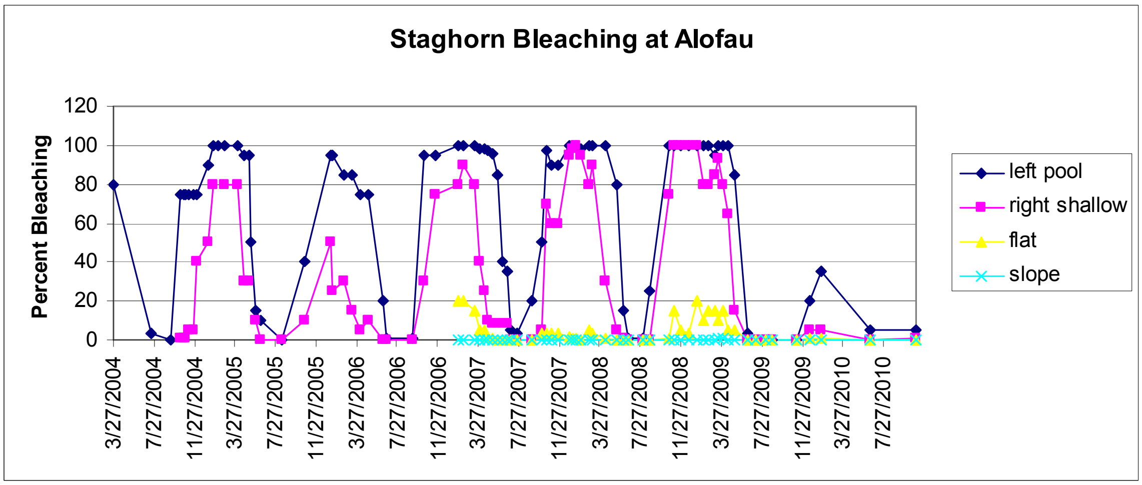
Figure 27.



It, like the notches in 2006 and 2008 due to cloudy, rainy, cool weather. The peak after the notch did not reach as high a level as in those years, perhaps because there was a gap in monitoring which may have missed a peak.

Figure 28 shows the bleaching record at Alofau. The unbleached period in late 2009 was the longest recorded so far, and bleaching in 2010 was the least intense of all the years it has been recorded. A gap in monitoring in 2010 may help explain the low level of bleaching recorded, since it was not recorded at a time when it may have been highest. This was due to the lack of vehicles, since the tsunami had destroyed most of the departmental vehicles and they had not been replaced yet.

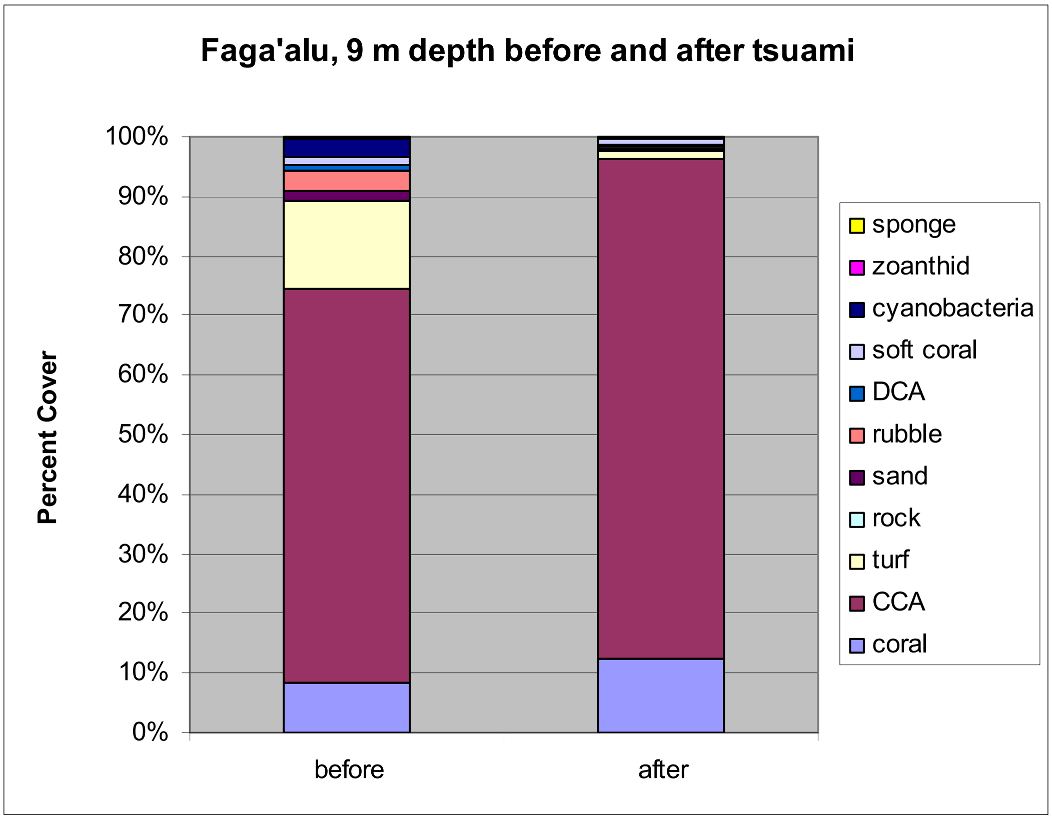
Figure 28.



Effects of the Tsunami

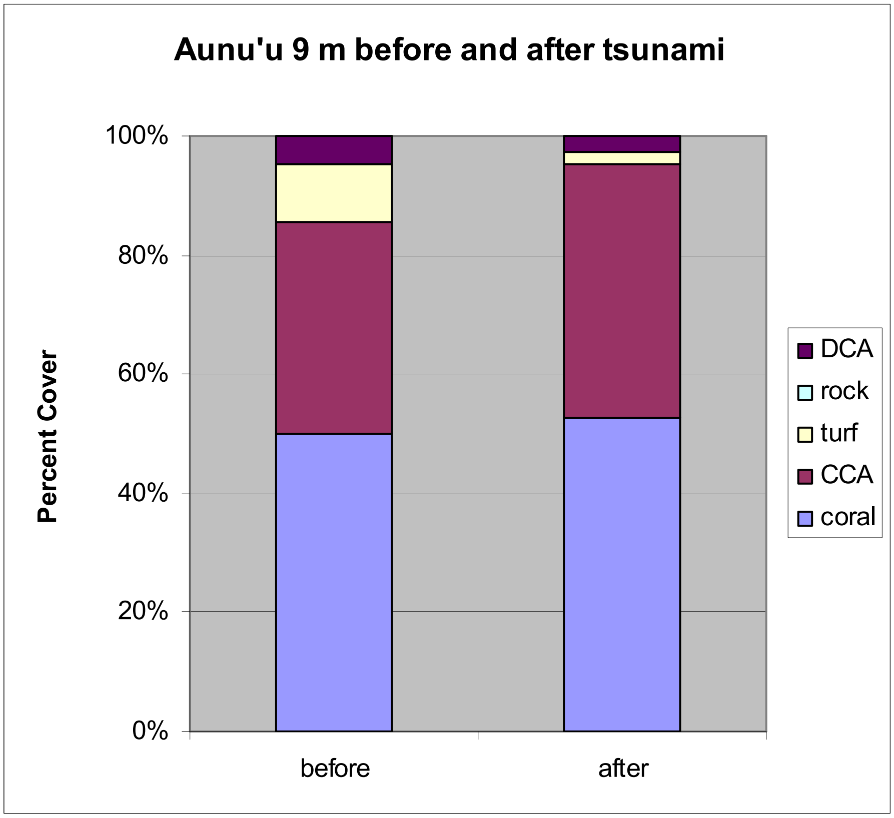
Quantitative data on the effects of the tsunami are now available at the 9 m monitoring depth at two sites, Faga'alu and Aunu'u. At Faga'alu there was a slight increase in the percentage coral recorded, as seen in Figure 29. Likely this is not a real change in the reef, but rather due to slight changes in the exact location of the transects. The main change was a decrease in turf and an increase in crustose calcareous algae.

Figure 29.



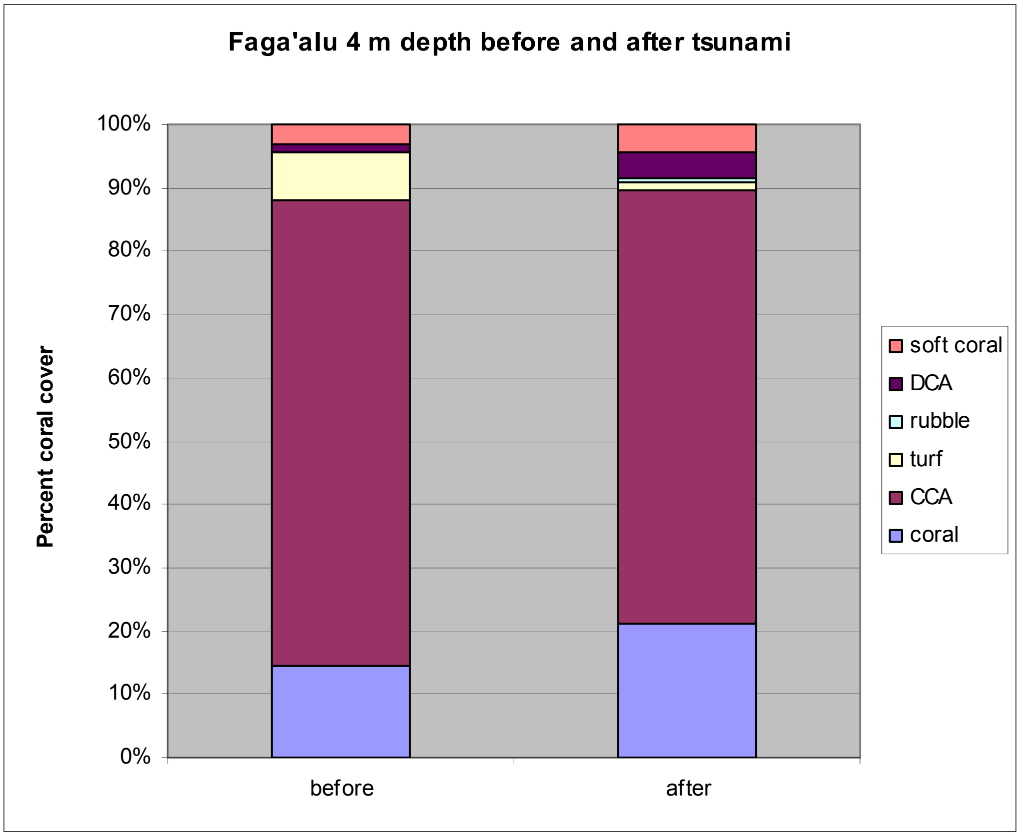
Changes in cover at 9 m depth at Aunu'u can be seen in Figure 30. Again there is a slight increase in coral cover, which is unlikely to be a real change. The main change was a decrease in turf, which was replaced by crustose calcareous algae.

Figure 30.



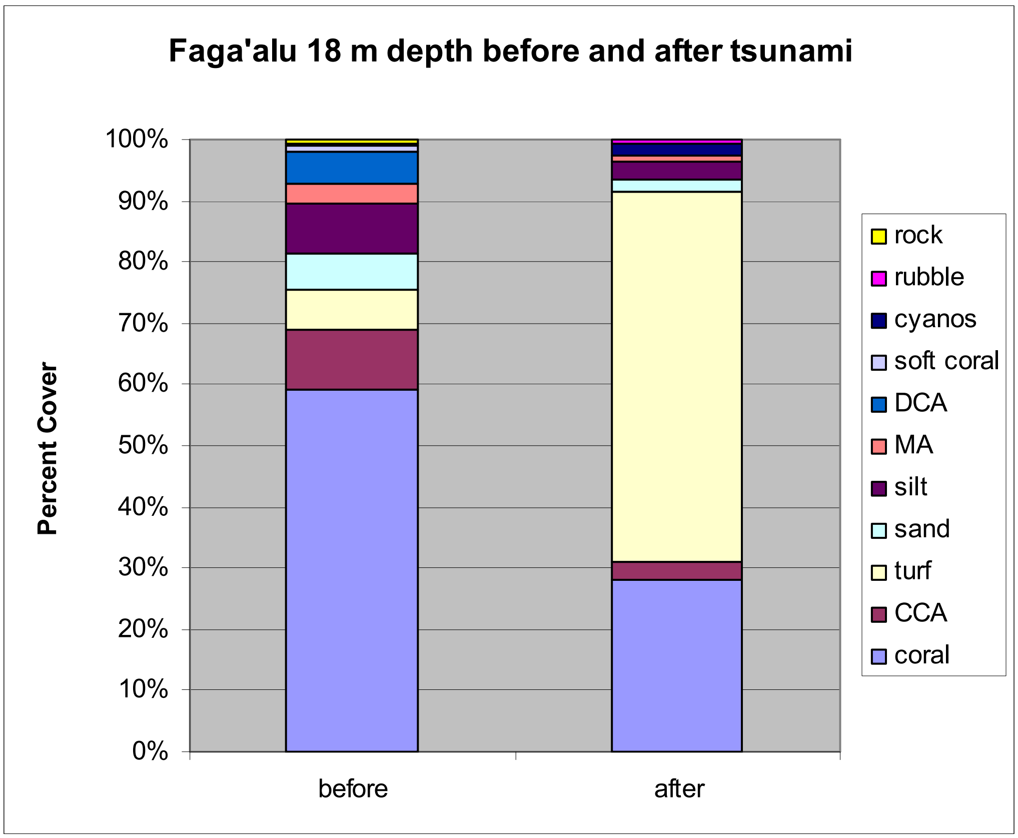
Quantitative transect data was also taken at 4 m depth and 18 m depth at Faga'alu and Nu'uuli. At Faga'alu there was a modest increase in coral cover at 4 m depth, as shown in Figure 31. That increase seems more likely due to a change in transect tape placement than due to a change in the reef.

Figure 31.



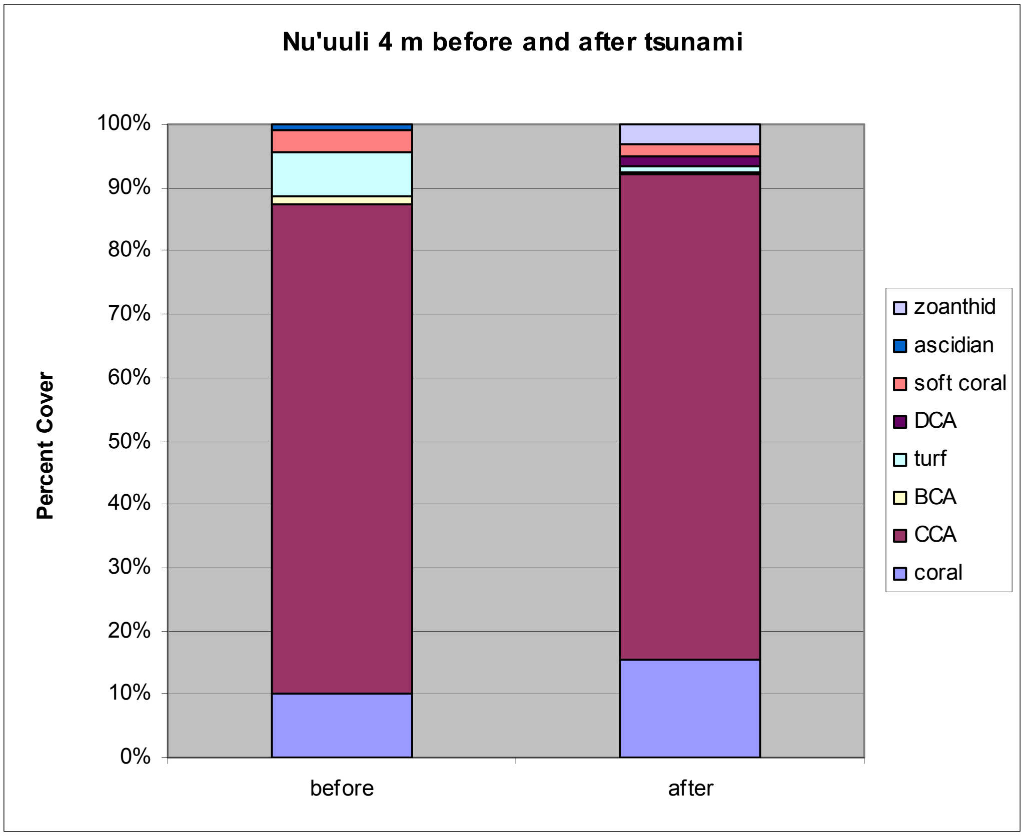
At Faga'alu at 18 m depth, however, there was a large decrease in the coral cover as shown in Figure 32. This documents the change caused by the tsunami, which ripped out all of the plate coral formations in deep water at Faga'alu. If the transect was deeper than 18 m, the coral cover would have been even lower after the tsunami, since in some places the remaining intact plates extended down a bit below 18 m, but not much further. But because the baseline transects were at 18 m, there is no baseline to compare with below 18 m. In fact, it is lucky that there was a baseline at 18 m. The live coral cover was primarily replaced by turf algae on the exposed coral rock.

Figure 32.



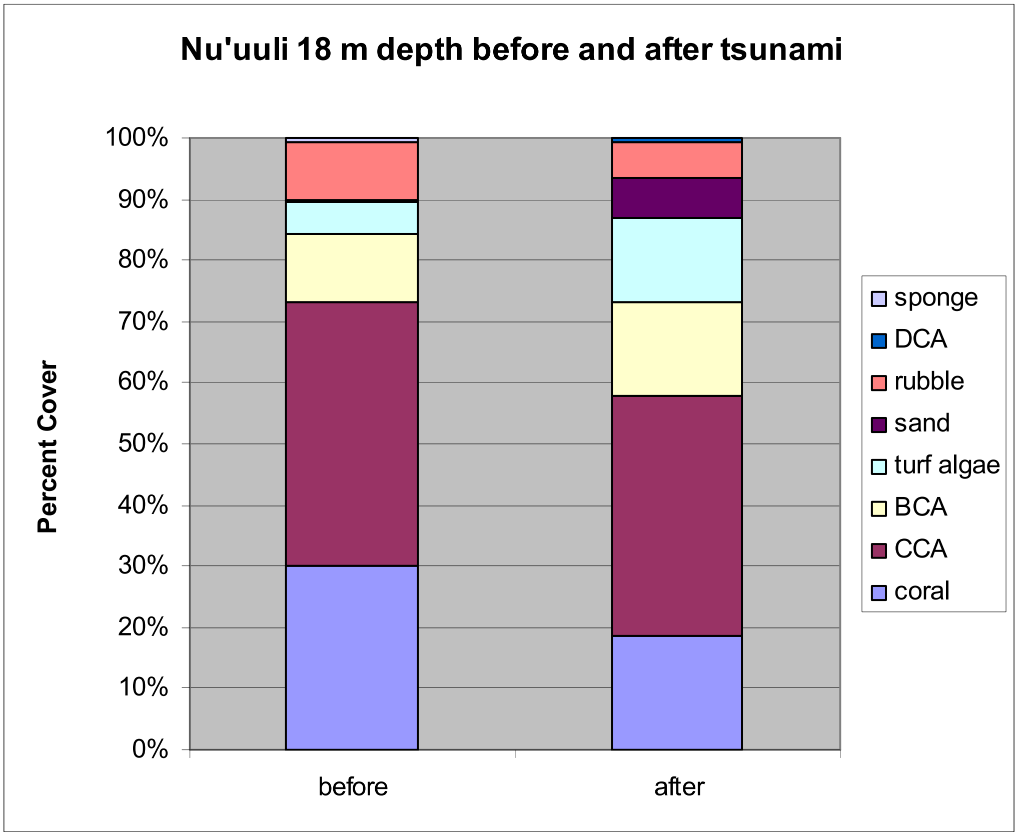
At Nu'uuli, at 4 m depth a small increase in coral cover was recorded, but again this seems unlikely to be real.

Figure 33.



At 18 meters depth, the amount of coral cover recorded had a modest decrease as shown in Figure 34. It is likely that this was due to a change in location of the tapes, since there was no sign of any damage to the reef or broken coral.

Figure 34.



These quantitative results for before and after the tsunami are preliminary. Once additional data is taken after the tsunami it will be possible to get a more accurate reading on whether average coral cover increased or declined. Hopefully that data can be collected in 2011.

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Appendix 1.

The following document was provided as a summary of the condition of the benthic communities of the coral reefs, as habitat, to the Fisheries Council for incorporation into their Coral Reef Plan Team report.

The State of Coral Reef Habitat in American Samoa, 2011 Douglas Fenner, Ph.D.

Vroom (2010) stated, "…all researchers would likely agree that high biodiversity, high fish biomass, intact apex predator communities, low incidences of disease, and the ability to accrete calcium carbonate faster than erosion occurs are among key factors in defining health [23, 26–30]." Biodiversity should be relative to the local species pool. Also, relatively low levels of anthropogenic sedimentation and nutrification are key factors, along with good herbivore stocks and only moderate levels of brown macroalgae.

The submarine slope around Tutuila consists of reef flats, reef slopes, shelf, bank reefs on the shelf, deep escarpment and deep slope. The reef flats, slopes and bank reefs have coral on them. The shelf is the largest component and the reef slopes are probably the narrowest. The reef slope and reef flat are the most studied.

Five different monitoring programs have all reported coral cover of about 30% on Tutuila reef slopes using transects. The Territorial Monitoring Program (TMP) of DMWR finds no downward trends in coral cover in at least 4 years, and maybe a slight increase; both the Key Reef Species and CRED programs show increases. Crustose coralline algae cover is high on reef slopes, particularly on the upper slopes and particularly on the south side of the island. Turf is more abundant on reef flats than coralline algae, and coral is less abundant on reef flats than reef slopes, but is still about 8-21% cover. The predominant cover on the reefs is encrusting, both encrusting coralline algae and encrusting corals. This may provide less hiding cover for fish than would branching coral, though the reef matrix provides many hiding holes most places. The coral cover is higher than current averages for the Pacific and South Pacific and particularly the Caribbean, which has 8% cover. However, it is lower than the coral cover reported from the Pacific and Caribbean from the past, and an estimate of coral cover from Tututila in the past. However, those numbers are higher than the 35-40% cover reported from the most pristine coral reefs remaining around the world. Vroom (2010) reports reefs here have very similar levels of coralline algae and macroalgae to the near-pristine US remote islands, to the north, and slightly lower coral cover here. The rate of coral cover change found by TMP is 1% increase per year, compared to 5-9% annual losses for different regions of the world's reefs. The percentage of corals alive (over 90%) is much higher than for the whole Pacific (55%).

The tsunami of Sept. 29, 2009, did significant damage to reef areas in Vatia Bay, Fagatele Bay, and Leone Bay, and lesser damage elsewhere. Heavily damaged areas were rare, moderately damaged areas more common, and lightly damaged or undamaged areas the most common. Within about 6 months, all the rubble moved in Fagatele Bay was completely covered with coralline algae, while none is at Vatia. Hurricane Wilma did additional damage in Vatia on Feb. 24, 2011, but little elsewhere.

Sedimentation rates near the mouths of streams are much higher than inside bays, which are in turn higher than outside bays. The water on outer reef slopes away from streams is relatively clear, with low nutrient levels. There is damage to small areas near stream mouths, and both Vatia Bay and the reef flat next to Coconut Point have had dense blooms of brown macroalgae. Those are no longer present in Vatia, but persist at Coconut Point. The reef slopes are dominated by calcareous algae, most by coralline algae, but also by the green macroalga *Halimeda*. They contribute to building the reef, and are not known to bloom during phase shifts, unlike brown algae. The reefs have remarkably little brown macroalgae. Reefs in the harbor are in very poor condition.

There are only a few introduced marine species, none of which are invasive. There are very few bioeroders or filter feeders, and calcium accumulation on the reef appears to be very good. Disease incidence is low. Macroinvertebrates, including herbivorous urchins, are in general uncommon to rare, for unknown reasons, but very likely this is natural. Some may be hidden from sight. Macroinvertebrates are food for some types of fish. Hawaii and the Marianas also lack abundant large non-cryptic invertebrates. There have been no bleaching events in the last 7 years, but 3 events before that. Peter Houk reports a negative correlation of human population with coral diversity, but TMP has been unable to replicate that using slightly different variables and different sites.

The largest single disturbance on the territory's coral reefs was the crown-of-thorns starfish outbreak around 1978. Over 90% of all corals were eaten. Observers report that they remember that table corals and staghorns were common, but areas dominated by other corals were not unusual. Most of our reefs are now dominated by encrusting corals and only a few patches have high densities of tables and staghorns, except perhaps the banks where tables are common. Thus the reefs may still be recovering from that event. One reef patch at the mouth of Vatia Bay has shown remarkably rapid recovery, but other areas have recovered slowly. The cause is not known, but does not seem to correlate with human populations.

Benthic reef communities are by no means pristine, but relatively healthy and far healthier than places like the Caribbean. Habitat quality outside the harbor provides little support for suggesting that the lower fish biomass or low large fish abundances we have are due to poor habitat quality.

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