NOAA Coral Reef Conservation Program
Project Progress Report FY2011/12

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D. Award Title:	AS Territorial Coral Reef Monitoring Program

Project Background

In 2005 the Department of Marine and Wildlife Resources (DMWR) initiated a comprehensive long-term monitoring program for the reefs in American Samoa, the American Samoa Coral Reef Monitoring Program (ASCRMP). Funding was provided through the Coral Reef Conservation Program (CRCP) of the National Oceanic and Atmospheric Administration (NOAA) and the National Ocean Services (NOS).

Although there have been previous monitoring surveys in American Samoa covering a variety of spatial and temporal scales, the ASCRMP represents the first attempt to annually monitor representative reefs in American Samoa, starting initially around Tutuila and eventually in the Manua islands and the two atolls, Rose and Swains. The program has been set up with long-term government funding, and is therefore capable of accumulating long-term data sets annually over a larger geographic scale.

The primary objectives of the American Samoa Coral Reef Monitoring Program are to: (1) Monitor the status and trends in the distribution and abundance of reef biota on reefs in American Samoa, and (2) Provide environmental managers, as well as other decision makers, with information that is pertinent to managing coral reefs in the territory. As a monitoring program, ASCRMP's goal is to document change - i.e. where, how much, and what kind of changes take place at the various monitoring sites. The ideal is to resolve change at scales which will allow judgments to be made as to which changes are within normal, natural variability, and which are outside it.

The project is coordinated by two staff members that are funded by the program; during FY2011 and FY2012 the Coral Reef Monitoring Benthic Ecologist position was filled by Dr. Doug Fenner and the Coral Reef Monitoring Fish Ecologist position was filled by Ben Carroll. During the last quarter of FY2012. Mr. Benjamin Carroll's contract was not renewed by the then director Ufagafa Ray Tulafono. The DMWR's Chief Fisheries Biologist filled in Mr. Carroll's duties, where possible up until the end of January 2013 when the position was filled part time by DMWR fisheries supervisor Alice Lawrence and part-time by DMWR fisheries technician Saolotoga Tofaeono. The position was filled full-time by Alice Lawrence from the end of January 2014 until the present time.

The program utilizes the DMWR Boston Whaler vessel to access survey sites around Tutuila, however the boat was out of action between January 2012 and October 2012 and between January 2013 and October 2013, and again between January 2014 and November 2014. There were attempts to utilize local fishing boats to conduct surveys with varying success, due to problems with late payments, safety issues and logistics related to the smaller and slower engines used by the local fishing boats.

This report is written in two sections; Section I. Benthic Cover, and Section II. Reef Fish.

I. Benthic Cover

Abstract

In 2011, coral biodiversity data was collected for the first time on reef flats as well as reef slopes. In addition, baseline data was also collected on the reef flat and pools at Ofu. Bleaching data continued to be taken at both the airport and Alofau pools, year-round. Data was also taken from 81 diseased colonies of *Porites* corals in an Ofu pool.

Most indices continue to support the view that the benthic portion of American Samoan coral reefs are in relatively good condition. Mean coral cover in 2011 and 2012 was 31% and 36%, respectively on the reef slope around Tutuila with benthic cover of corals, coralline algae, and turf varying greatly from one site to another. However, as a trend, mean coral cover has increased over the years, and compares favorably to coral cover on the Great Barrier Reef, South Pacific, the whole Pacific, and particularly the Caribbean.

Only one of the fixed monitoring sites showed a decrease in coral cover, Vatia. The decrease recorded at Vatia was due to the tsunami of Sept. 29, 2009, and/or Hurricane Wilma on Jan. 24, 2011. The tsunami badly damaged the inner half of the bay, and the Hurricane damaged the outer half of the bay. In general, encrusting corals dominate the reef slopes with columnar corals second most common. Encrusting species are mainly composed of *Montipora grisea*, *Pavona varians, Montipora informis,* and *Pavona chiriquensis* and columnar/plate colonies are dominated by *Porites rus*, which is actually the single species with the greatest cover. The number of coral species in transects is greater on the South side than the North side, and this has remained so over time. The number of coral species is positively correlated with the amount of coral cover at a site. Coral biodiversity was recorded on roving dives on the slopes, and for the first time, several sites in Pago Pago harbor were included.

On reef flats, mean coral cover was 28.5% in 2011 and 32% in 2012. Again, benthic cover varied considerably between outer reef flat sites. Reef flats on the south side had coral cover equal to that on the north, but north reef flats had more turf and south reef flats had more rubble. Vatia reef flat showed a sudden decrease in coral cover during the time period of the tsunami and Hurricane Wilma. The most common lifeform of corals on the reef flats was encrusting, followed by *Acropora* branching, foliose, branching, and tables. Encrusting corals were the most common lifeform on both the slopes and the reef flats, and *Montipora grisea* was the coral species with the most cover on both slopes and reef flats. The number of coral species found in biodiversity searches varied greatly from one reef flat site to another. Biodiversity searches on the reef flats determined that 10 species were found only on the reef flat and 78 species that were found only on the slope. North side reef flats had considerably more coral species than the south side.

Outer reef flats on Tutuila had more coral cover than on Ofu-Olosega, but inner reef flats on Tutuila had less coral cover than on Ofu-Olosega. In biodiversity searches, there were more coral species in Ofu-Olosega pools than reef flats, more coral species on Ofu-Olosega than on Tutuila, and slightly more coral species on Tutuila reef flats than in pools. Bleaching in the airport pool was less in 2011 than in previous

years. At Alofau, bleaching had decreased in 2010, but then increased in 2011 back toward the levels seen in previous years. A coral disease outbreak in Vatia following Hurricane Wilma killed some corals in the genus *Acropora* and damaged others, but subsided over several months and returned to normal levels. Colonies of *Porites rus* in the pool in front of Vaoto Lodge on Ofu were diseased when observed in 2011, with significant damage from the disease.

Methods

The 12 fixed reef slope sites are shown in the map below (Fig. 1). All are on Tutuila and nearby Aunu'u.

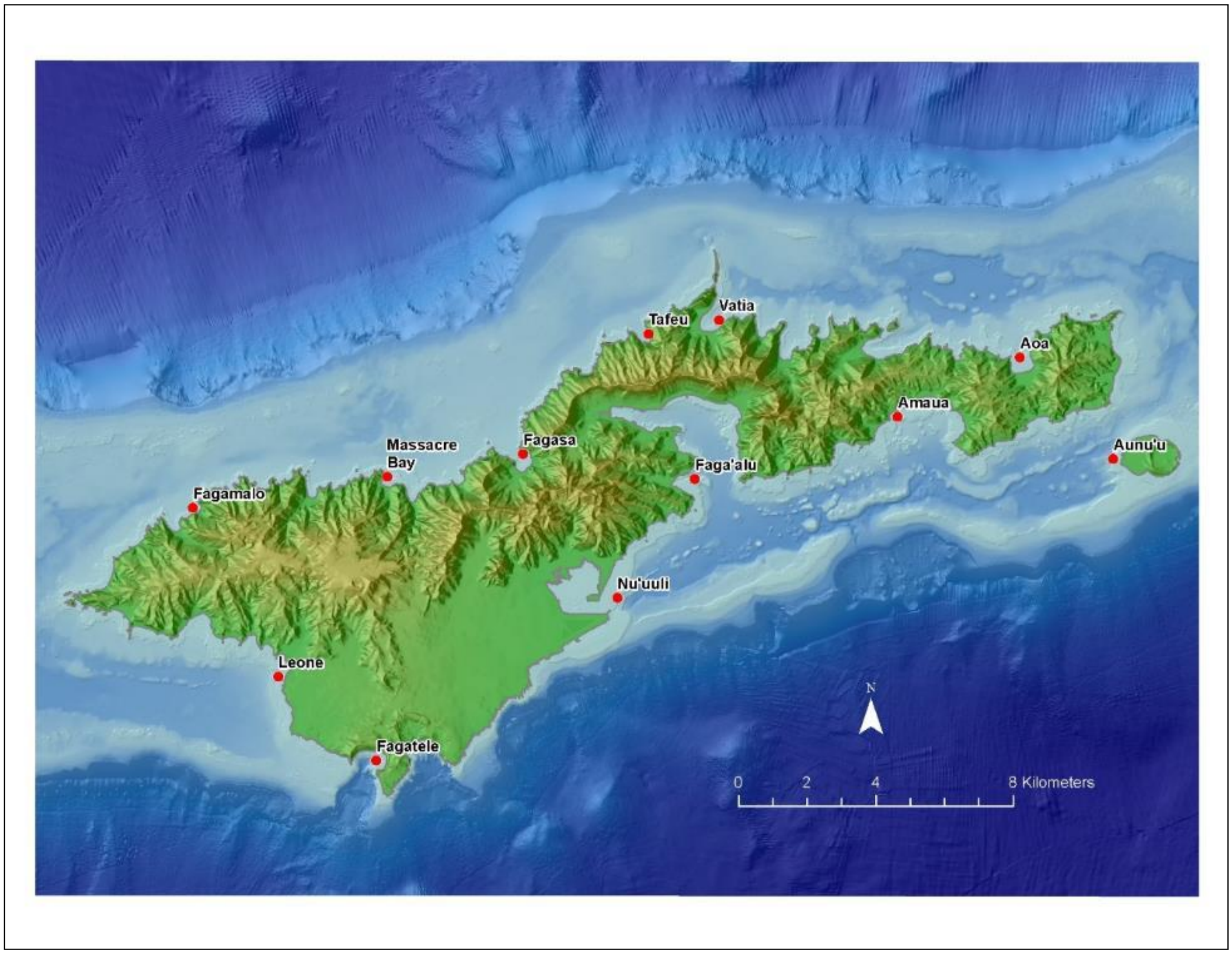


Figure 1. Map of Tutuila with the core slope sites shown.

In the core monitoring, four 50-m tapes were laid on a depth contour between 8 and 10 m deep with a gap of about 5-10 m between transects. 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. Any rock that is not white has turf on it, and was recorded as turf. Corals were identified to lifeform, genus, and species when possible, and soft coral as well as macroalgae were recorded in as much detail as possible (usually genus). Hard coral lifeforms included encrusting, massive, foliose, branching, columnar, submassive, mushroom, *Millepora*, *Acropora* branching, *Acropora* table, *Acropora* digitate, and *Acropora* encrusting. Only the top visible layer was recorded of any multilayer formations such as corals or macroalgae, so all categories of cover add up to 100%. Diurnal, non-cryptic macroinvertebrates were counted in a half-meter wide belt transect beside each 50 m tape. Invertebrates were identified to the most detailed level possible. Spaces between coral branches were not searched. Horizontal visibility was recorded using the tape. The tape was stretched horizontally out from the reef, at the transect depth. Sites were re-located using the GPS and markers as indicated in the 2005 report.

For coral biodiversity, one hour search dives were conducted at each site. The dive begins at the bottom of the reef (but always well above 30 m deep) and continues as a roving dive as the diver ascends up the slope, searching for as many coral species as can be found. The presence of coral species is recorded underwater, and once out of the water, estimates of abundance of each species are recorded on a 0-5 ("DACOR") scale, with the names "not found," "rare," "uncommon," "common," "abundant," and "dominant." Rare was defined as just 1-2 colonies, and dominant was defined as composing more than half of all corals. The other categories were intermediate values, but not defined as individual corals were not counted, since that would greatly slow the survey and reduce the number of species found. This technique compliments the transect tapes since it covers the entire depth range of the slope, and produces a much larger sample that includes much rarer species than the transect tapes.

Data collection on reef flats was continued, using transects. In addition, coral diversity data from roving search snorkels on reef flats was carried out for the first time. The methods for both are similar to that on reef slopes. 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.

Table 1. Reef Slope Monitoring Sites

Site	GPS Coordinates	Survey date 2011	Survey date 2012	Survey date 2013
Fagamalo	-14º 17.872S, -170º 48.726W	NA	NA	3/4/13
Masacre Bay	-14º 17.374S, -170º 45.577W	12/9/11	NA	NA
Fagasa	-14º 17.016S, -170º 43.383W	3/17/11	NA	2/13/13
Tafeu	-14º 15.109S, -170º 41.354W	9/22/11	NA	5/17/13
Vatia	-14º 14.888S, -170º 40.205W	9/29/11	NA	5/15/13
Aoa	-14º 15.474S, -170º 35.332W	5/22/11	NA	2/27/13
Aunu'u	-14º 17.076S, -170º 33.818W	8/5/11	12/10/12	NA
Amaua	-14º 16.418S, -170º 37.312W	3/3/11	11/30/12	NA
Faga'alu	-14º 17.404S, -170º 40.598W	8/3/11	10/12/12	NA
Nu'uuli	-14º 19.287S, -170º 41.850W	1/19/11	11/23/12	NA

Fagatele Bay	-14º 21.859S, -170º 45.753W	2/24/11	11/28/12	NA
Leone	-14º 20.534S, -170º 47.339W	2/25/11 and 8/4/11	11/27/12	NA

Table 2. Reef Flat Monitoring Sites

Site	GPS Coordinates (approximate)	Survey date 2011	Survey date 2012
Fagamalo	-14º 18.2 S -170º 49.4 W	10/5/11	NA
Fagasa	-14º 17.5 S -170º 43.5 W	9/27/11	7/19/12
Vatia	-14º 15.3 S -170º 40.2 W	9/28/11	7/20/12
Aoa	-14º 15.8 S -170º 35.3 W	5/20/11	7/23/12
Alofau	-14º 16.9 S -170º 36.3' W	4/8/11	7/24/12
Amaua	-14º 16.7 S -170º 37.3 W	3/29/11	9/13/12
Gataivai	-14º 17.3 S -170º 40.8 W	9/30/11	7/27/12
Faga'alu	-14º 17.9 S -170º 40.9 W	9/19/11	9/7/12
Nu'uuli, Coconut Pt.	-14º 19.2 S -170º 41.7 W	2/19/11	3/27/13
Fagatele Bay	-14º 22.1 S -170º 45.5 W	4/17/11	1/18/13
Leone	-14º 20.6 S -170º 47.1 W	2/10/11	7/26/12

Table 3. Ofu monitoring sites

Site	Date surveyed
Ofu airport pool	11/15/11
Vaoto Pool	11/8/11
Vaoto Reef Flat	11/8/11
Ofu pool 225	11/11/11
Pool 250	11/10/11
2nd Pool, Ofu 300	11/9/11
Ofu Hurricane House	11/9/11
Ofu reef flat 500	11/14/11
Ofu pool 500	11/14/11

Olosega: bridge-Sili flat	11/15/11
Vaoto Lodge 2	11/18/11
Vaoto Lodge 1	11/28/11

Table 4. Bleaching Monitoring Sites

Site	Coordinates (approximate)
Airport pool	-14º 20' S -170º 42'
Alofau	-14º 16.9 S -170º 36.3'

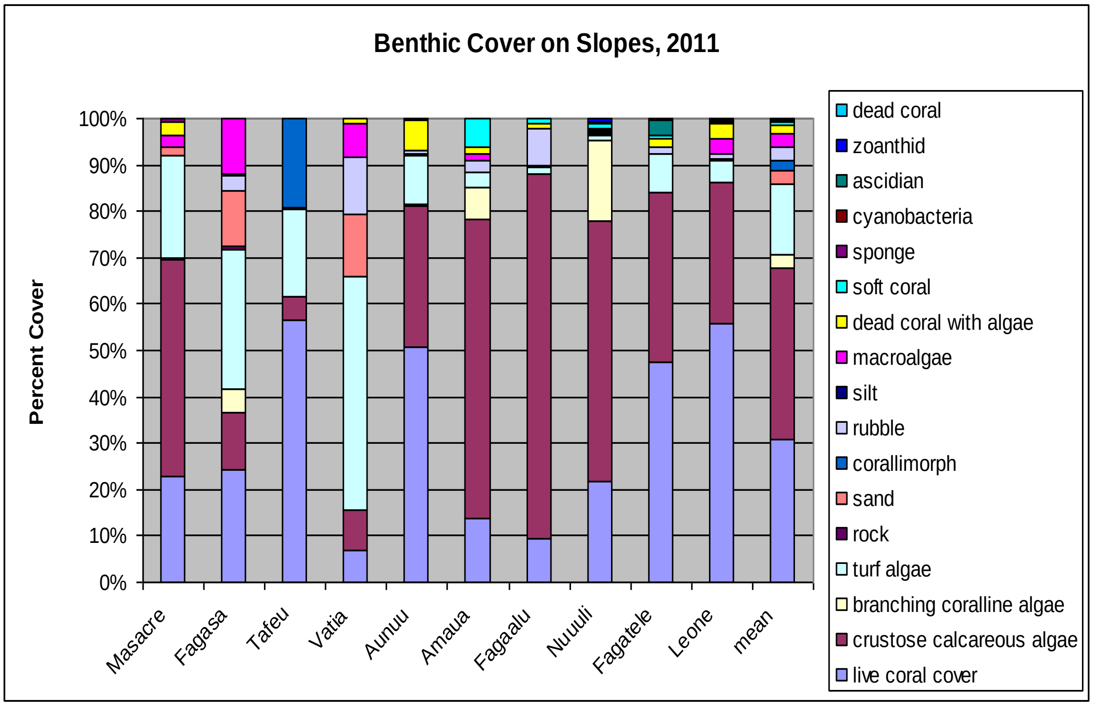
Results and discussion

1. Trends on reef slopes

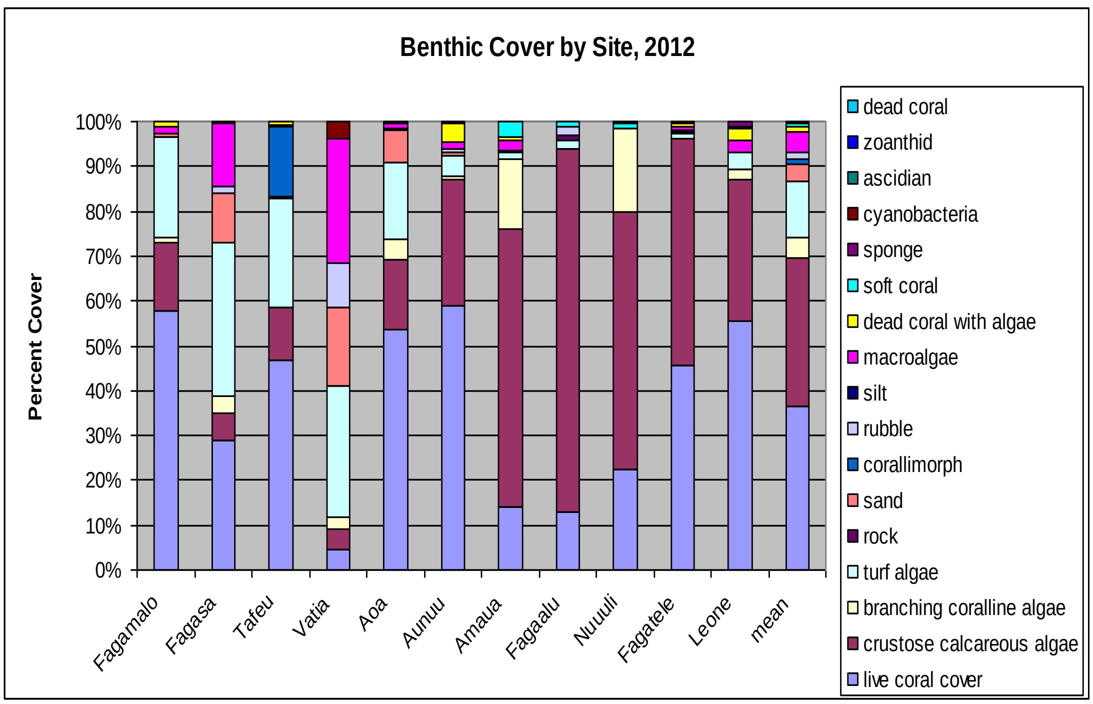
In 2011, average coral cover was 31%. Tafeu, Aunu'u, Leone and Fagatele had the highest coral cover, and Vatia, Faga'alu and Amaua had the lowest cover. Amaua, Faga'alu, and Nu'uuli had the highest cover of crustose calcareous algae. Vatia had the highest turf algae, Tafeu had the only corallimorph cover, Vatia had the highest macroalgae, and Nu'uuli had the most branching coralline algae. Variation between sites was relatively large. "Branching coralline algae" included a soft feathery species that was the most common in that category. That species is *Cheilosporum spectabile* (Fig. 2A).

In 2012, average coral cover was 36%. Coral cover varied largely between sites, with highest coral cover found at Aunu'u, Fagamalo, Leone, Aoa, and Fagatele. The lowest coral cover was observed in Vatia, Amaua, and Faga'alu (Fig. 2B).

Overall, there has been an increase in mean coral cover from 25.5% in 2005 to 36.3% in 2012. There was a slight decrease in the first three years, but steady increase since then (Fig. 3).



A: 2011



B: 2012

Figure 2: Benthic cover at survey sites in 2011 (A) and 2012 (B).

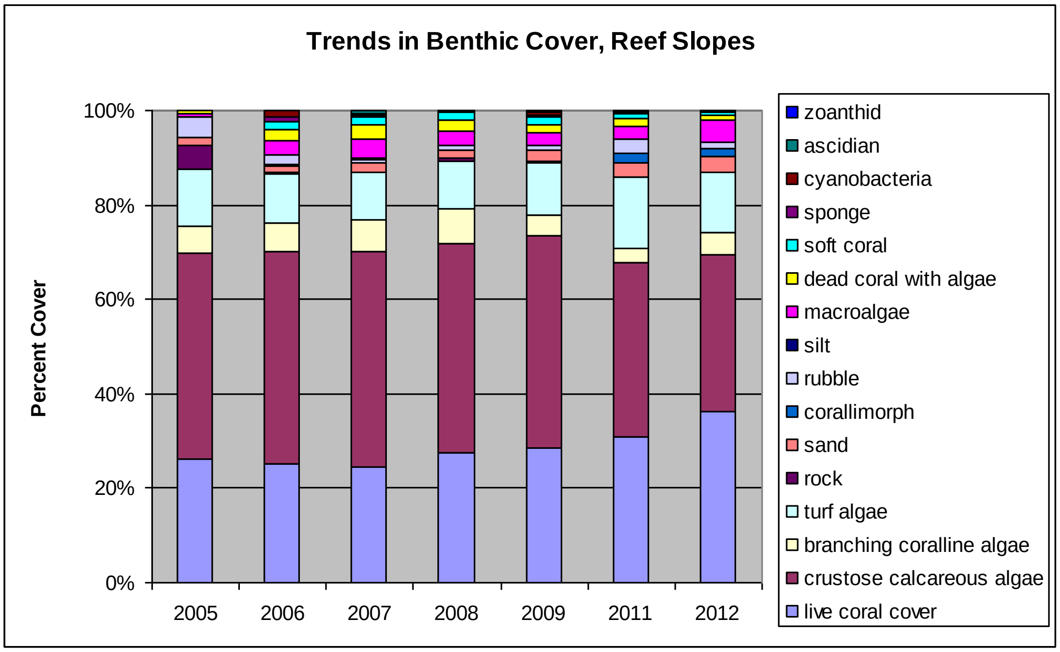


Figure 3. Trends in coral cover from 2005 – 2012.

In general, the north side has higher coral cover than the south side, the south side has more crustose calcareous algae (CCA) than the north side, the north side has more turf than the south side, the south side has more branching coralline algae (BCA) than the north side, the north side has more sand than the south, the north has more corallimorph than the south side, and the north has more macroalgae than the south side (Fig. 4).

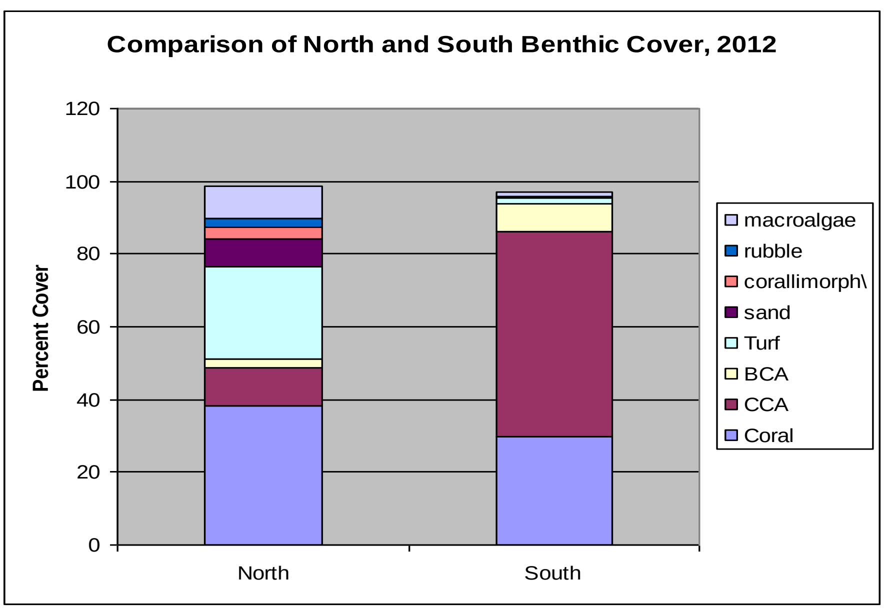


Figure 4. Trends in benthic cover between the north and south side of Tutuila.

1.1 Trends at individual reef slope sites

A. Fagamalo: Coral cover has increased steadily and strongly since 2005. The increase in coral cover came at the expense of crustose calcareous algae (Fig. 5A).

B. Massacre Bay: This site was added to the original 11 sites in 2007, and we were unable to collect data from it in 2012. Coral cover was higher in 2011, but this may be because the transect tape was not in exactly the same location (Fig. 5B).

C. Fagasa: Coral cover has increased very steadily at Fagasa. The increases in coral cover came at the expense of decreasing turf algae (Fig. 5**C**).

D. Tafeu: There was a small increase in coral cover over the years until 2012, when coral cover decreased to near the original levels. Initially corallimorph cover increased along with the increasing coral cover, and both increases were at the expense of turf algae. It appears that over the long term, Tafeu has been relatively steady with high coral cover, and the corallimorph has now stabilized (Fig. 5D).

E. Vatia: The site is on the middle of the east side of the bay. The graph shows a decline of coral cover over the period of the program, with the largest decrease between 2008 and 2011. The inner part of the bay was damaged very heavily on the east side in the tsunami of Sept. 29, 2009. The outer part of the bay was heavily damaged by Hurricane Wilma in 2010. The transects span the area from the inner bay to the outer bay, so the decrease in coral cover recorded most likely reflects the damage done by both events, and unfortunately data was not taken between the two events that could document how much of the change came from each event. The graph also shows a smaller decline over the four years before these events, and a decline in the two years since the events. The decline before coincided with a large increase in macroalgae as seen in the graph (dark purple), mainly due to an increased in *Dictyota*. It is a genus that has been reported to be one of the algae that take over when there is a phase shift from corals to algae, thus it can be considered a problem alga. The bay has fairly murky water, which is murkier near the head of the bay than the mouth. Water clarity is one of the best indicators of water quality, and low clarity indicates low water quality. A narrow bay like Vatia or the harbor has less water circulation at the head and better flushing near the mouth. Nutrients or other pollutants in runoff which enters the bay builds up near the head of the bay, but is flushed out near the mouth of the bay. It is highly likely that nutrients have built up at the head of the bay. The shallow part of slope on the east side of the inner bay was heavily damaged by the tsunami, and immediately a dense cover of green filamentous algae covered everything, and has continued since then, with no sign of recovery beginning the last time it was examined. The green filamentous algae along with the *Dictyota* brown algae point to a buildup of nutrients near the head of the bay which needs to be addressed. The lack of recovery at the head of the bay indicates that the reef there is not resilient. Near the mouth of the bay, there is little filamentous algae or *Dictyota*, and it appears that recovery has begun, indicating resilience (Fig. 5E).

F. Aoa: Coral cover did not show much change until between 2007 and 2008, at which an increase to a new higher level occurred. This is a pattern that could be produced by a change in transect location, but there is no clear evidence of such a shift. Coral cover at Aoa is now quite high at over 50%, one of the highest of the sites in the monitoring program. The increase in coral cover came at the expense of crustose calcareous algae (Fig. 5F).

G. Aunu’u: Coral cover has been high and steady through the years of the monitoring program but coral cover is not as high everywhere around Aunu’u (Fig. 5G).

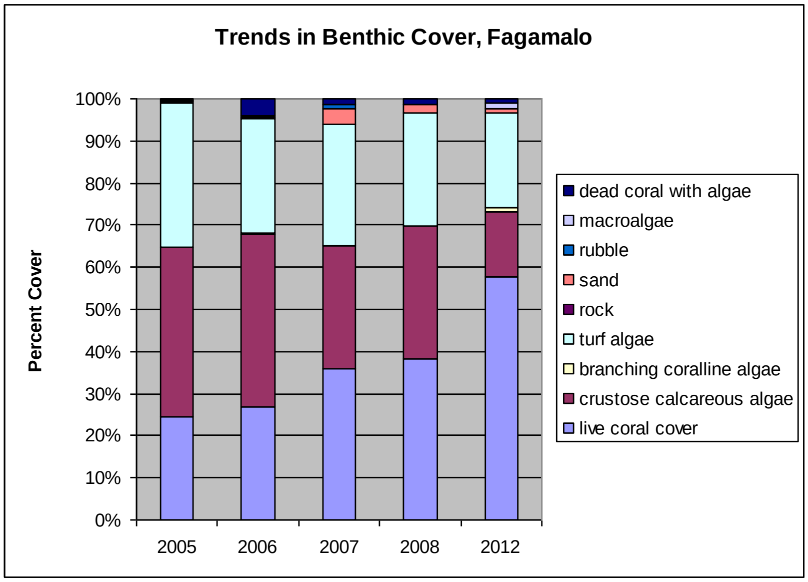
H. Amaua: This site has had low, steady coral cover over the years of the monitoring program. Although crustose calcareous algae cover is high on this steep slope, which should indicate conditions that are good for coral, coral cover has not increased over time (Fig. 5H).

I. Faga’alu: Coral cover has been low and very steady at Faga’alu for the duration of the monitoring program. Crustose calcareous algae has increased at the expense of turf, though turf has varied unsystematically, suggesting that small changes in transect tape locations hit or missed patches of turf. The transect area on the mid-slope of Faga’alu is on a large area of rubble covered with encrusting calcareous algae. The rubble is composed of cylindrical sticks which are clearly from some type of branching *Acropora*, most likely *Acropora intermedia* but possibly *Acropora abrotanoides* or a mixture of species. The corals were all dead, collapsed rubble when first seen, identical to how they look now. Thus it seems likely they were killed well before monitoring began. There is no sign of recovery. Interestingly, deeper on the slope, down at 18 m depth, there is a luxurious, high cover community of plate corals. Cover at 18 m was about 65% live coral before the tsunami. Thus, it would seem that water quality conditions were good for coral. It is not known what killed the *Acropora*, since *Acropora* are among the most sensitive genera of corals to bleaching, coral disease, hurricanes, and crown-of-thorns. It is not clear why there has been no recovery (Fig. 5I).

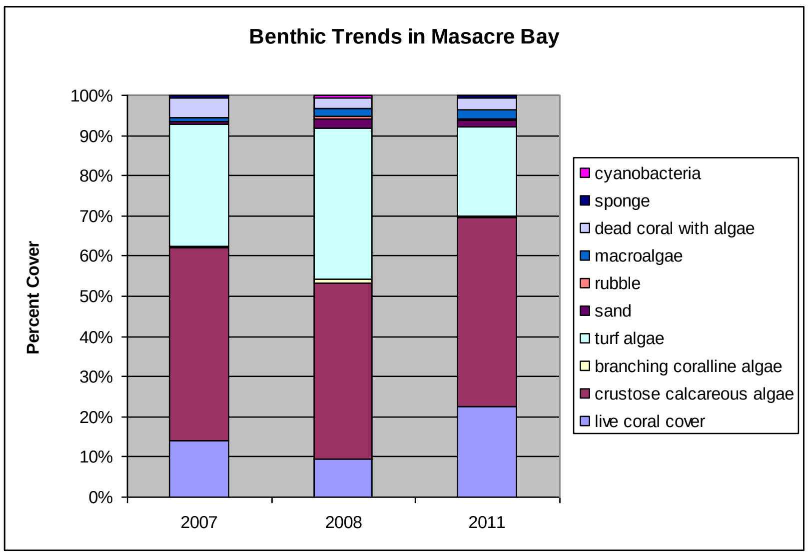
J. Nu’uuli - Coconut Pt.: Coral cover is moderate-low and steady. Branching coralline algae increased initially on this steep slope, then decreased and is now steady. It grew over and covered crustose calcareous algae which remained alive underneath it, and so when it decreased, the crustose coralline algae was again revealed (Fig. 5J).

K. Fagatele: Coral cover has been steady, except during 2006 and 2007, when lower coral cover were recorded. It seems likely that in those two years the transects were not in the same location as in the other years. Coral cover is relatively high at this location on the slope at Fagatele Bay. This location is on the outer edge of the very gently sloping platform, just above the steep drop-off that goes down to about 30 m depth. It is not in one of the areas damaged by the tsunami in 2009. Coral cover in shallow areas is now lower due to the damage from the tsunami, however there was little or no damage in deeper areas such as the transect site (Fig. 5K).

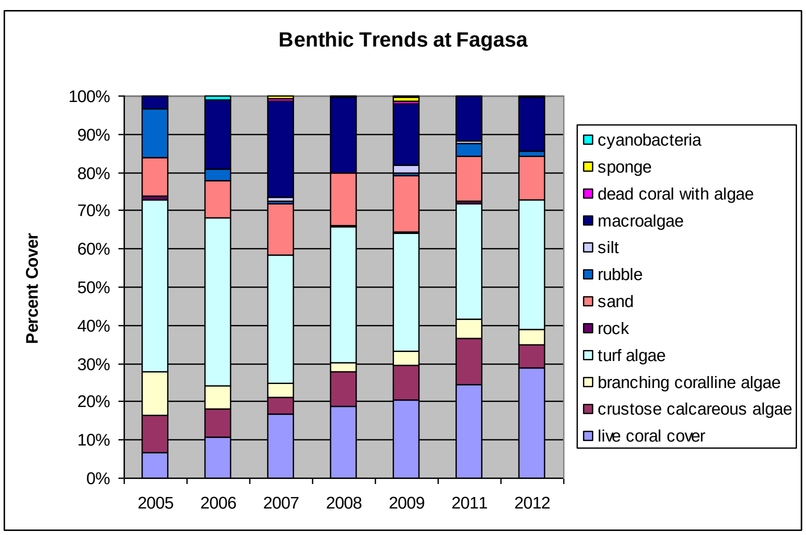
L. Leone: Coral cover was initially steady, then increased, and now is stable at the higher level (Fig. 5L).



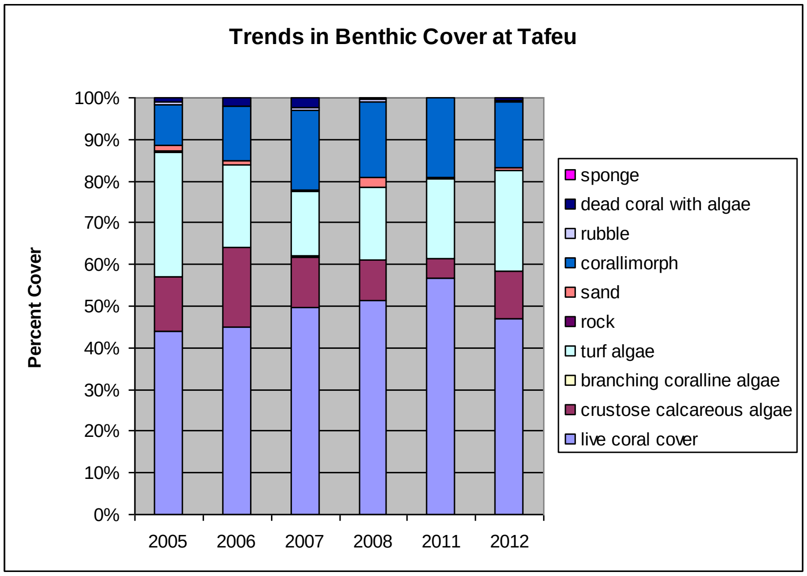
A: Fagamalo



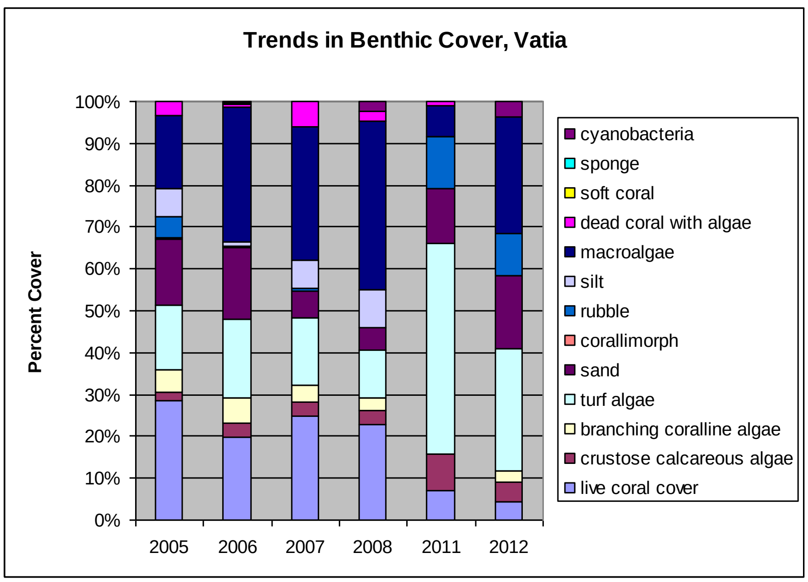
B: Massacre



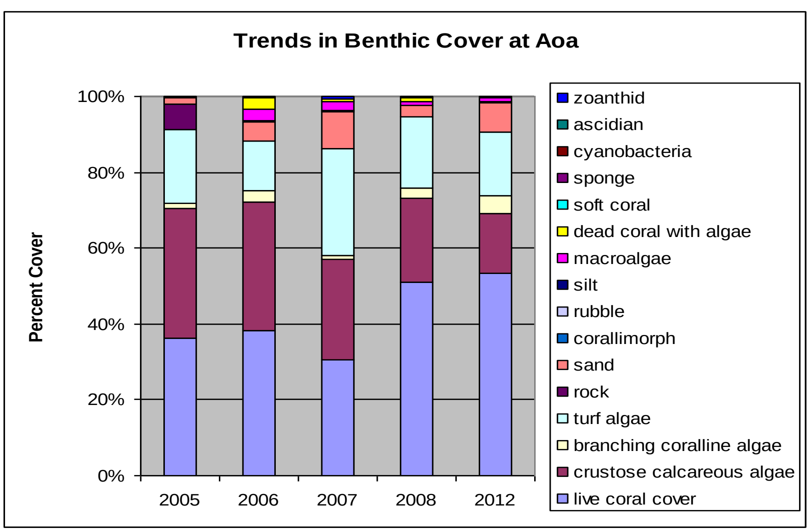
C: Fagasa



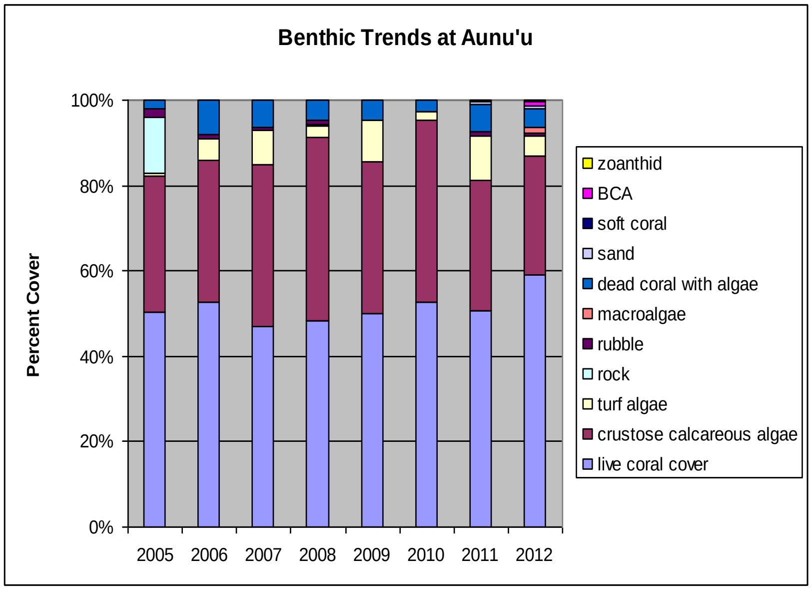
D: Tafeu



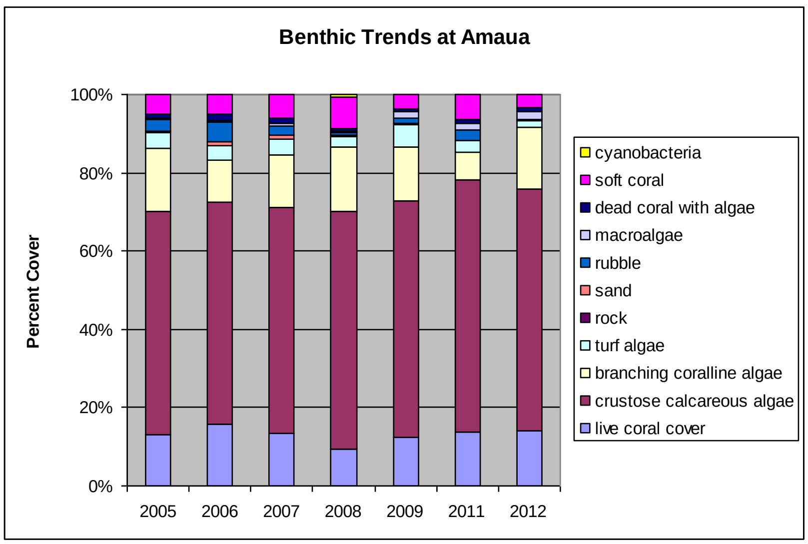
E: Vatia



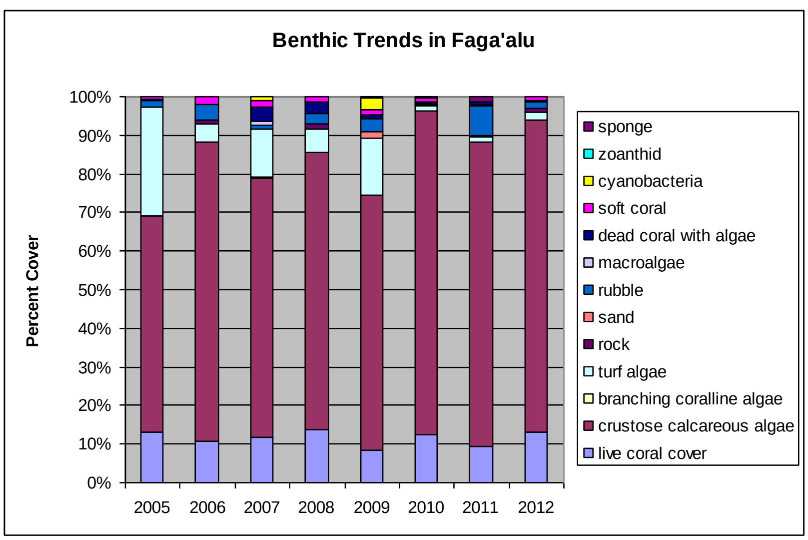
F: Aoa



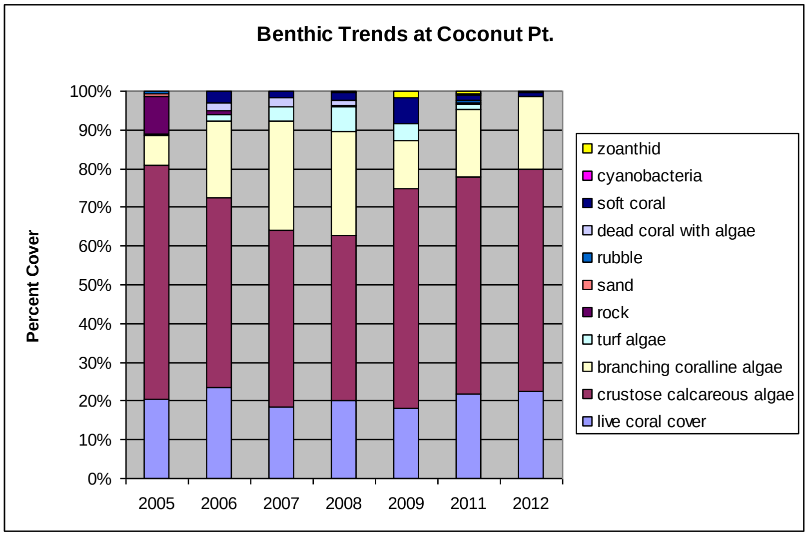
G: Aunu'u



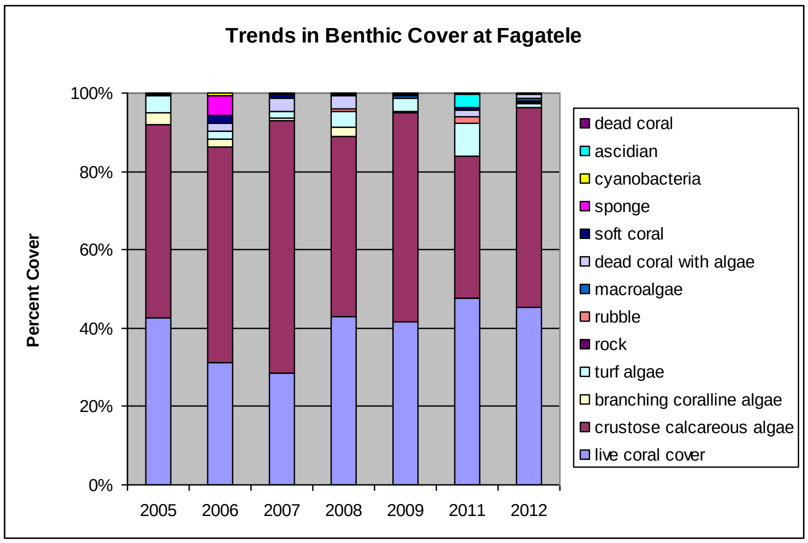
H: Amaua



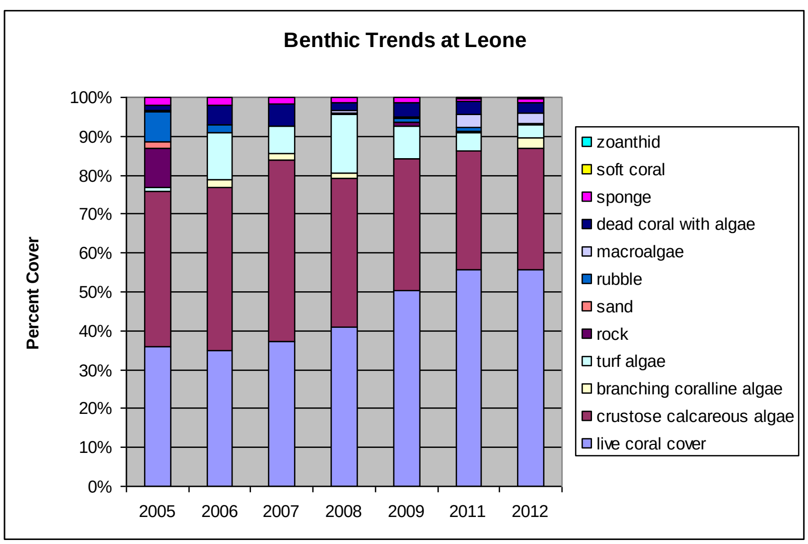
I: Faga'alu



J: Nu'uuli – Coconut Point



K: Fagatele



L: Leone

Figure 5: Trends in benthic cover at all monitoring sites (A-L)

In summary, coral cover at individual sites show either an increase over the study period, are steady, or show a decrease. Table 5 summarizes the different trends at different sites. The trends were based on the difference between the 2005 and 2012 coral cover. Just one site showed a decrease, five sites were steady, and five sites showed increases. This indicates that while average coral cover is increasing, some sites show increases and others no change. Reefs on the Great Barrier Reef show a similar pattern (Sweatman, 2011). That seems more likely there, where reefs are much farther apart and events that affect one site seem less likely to affect other sites.

Table 5. Summary of Coral Cover Trends at individual sites.

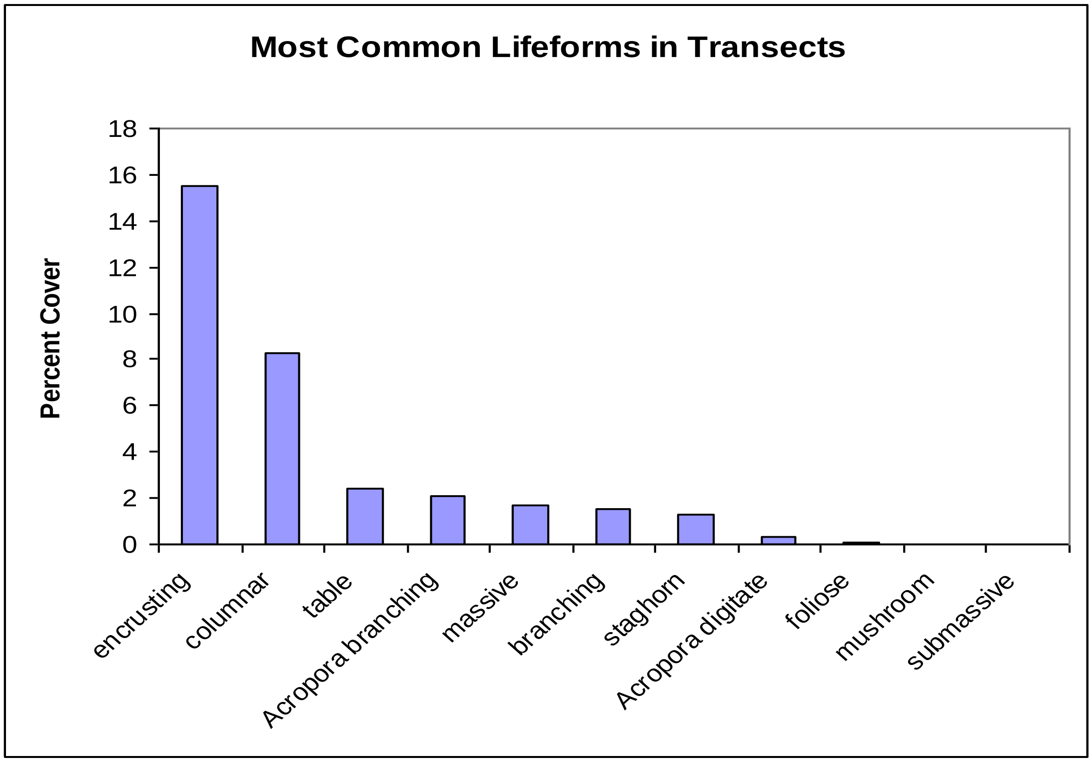
	decrease	steady	increase
Fagamalo			X
Fagasa			X
Tafeu		X	
Vatia	X		
Aoa			X
Aunu'u			X
Amaua		X	
Faga'alu		X	
Nu'uuli		X	
Fagatele		X	
Leone			X
Total	1	4	6

1.2 Trends in coral composition on reef slopes

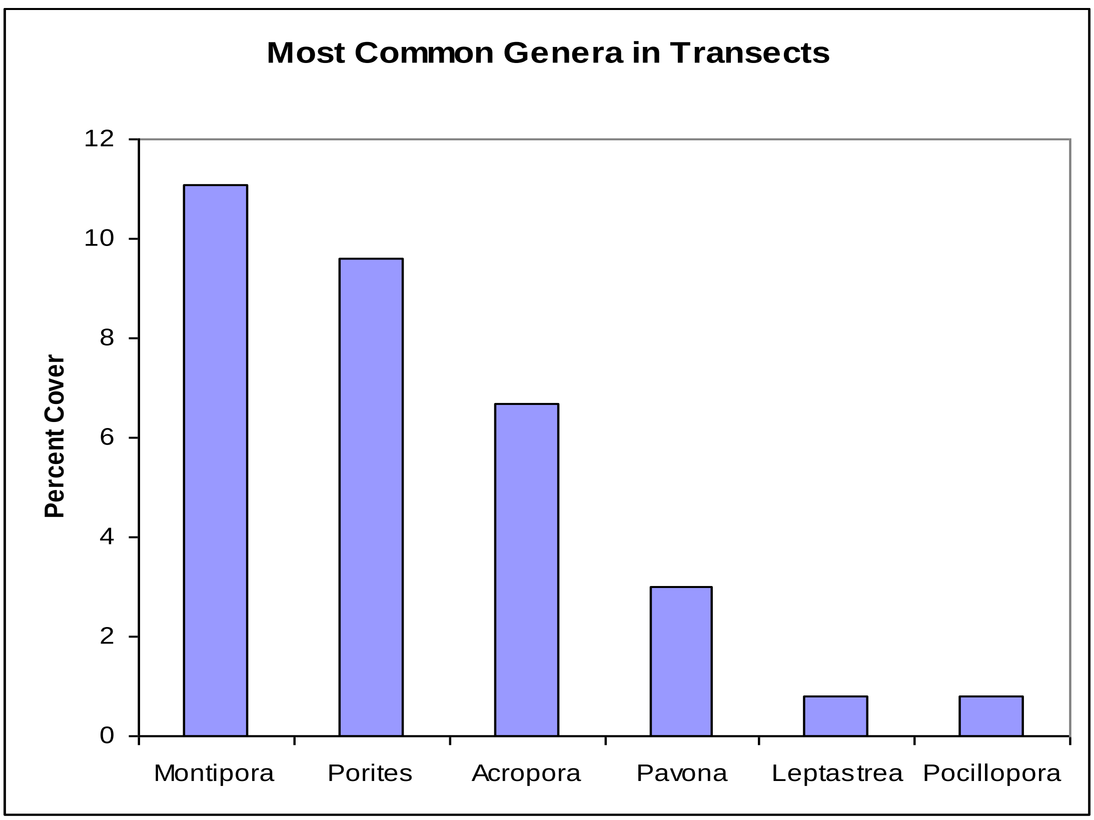
Lifeforms: Encrusting corals have the most cover by far, followed by columnar, and then table, *Acropora* branching, massive and staghorn. Other lifeforms have very little cover. This is a typical pattern that is repeated every year. Encrusting is always the most common lifeform, followed by columnar (Fig. 6A).

Genera: The pattern is similar to that of previous years. *Montipora* has the most cover, followed by *Porites*, *Acropora*, and *Pavona*, and other genera have less cover (Fig. 6B).

Species: *Acropora* has the most species by far, followed by *Porites*, *Montipora*, *Goniastrea*, *Pavona*, *Leptastrea*, and other genera with less cover (Fig. 7A). *Montipora grisea* has the most cover, followed closely by *Porites rus*, which is followed by *Pavona varians* and *Acropora intermedia* (usually referred to as *A. nobilis*), and other species have less cover (Fig. 7B).

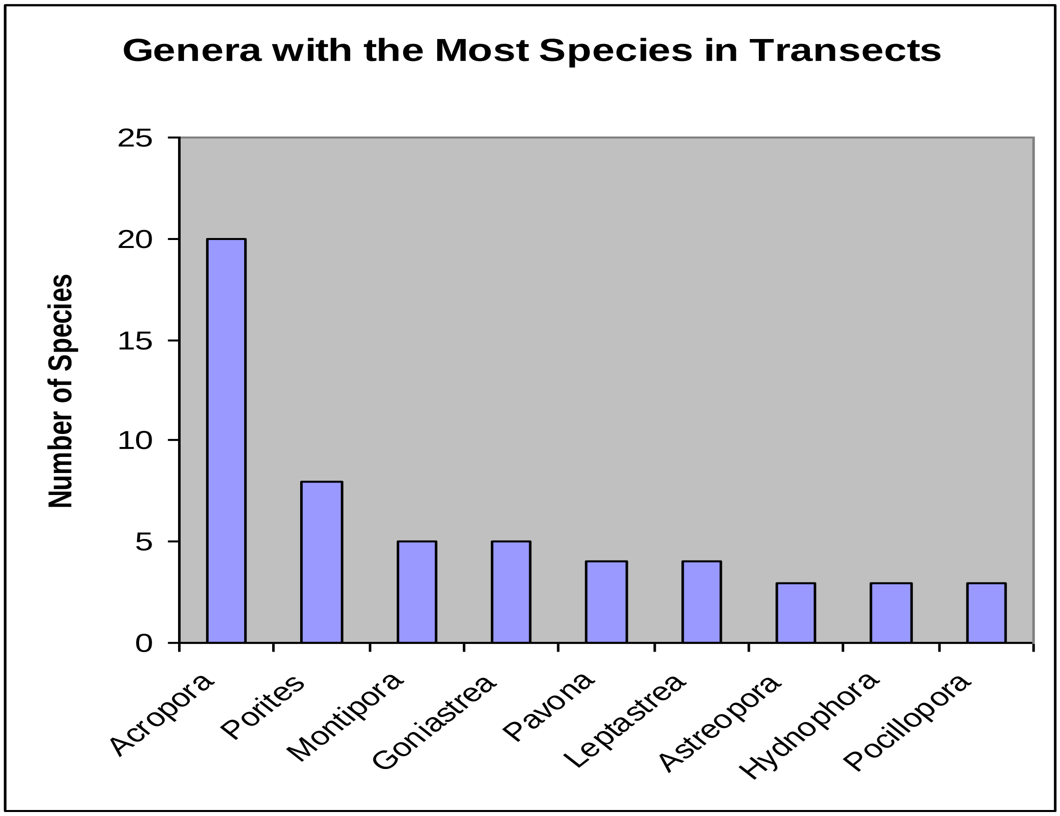


A: Lifeform

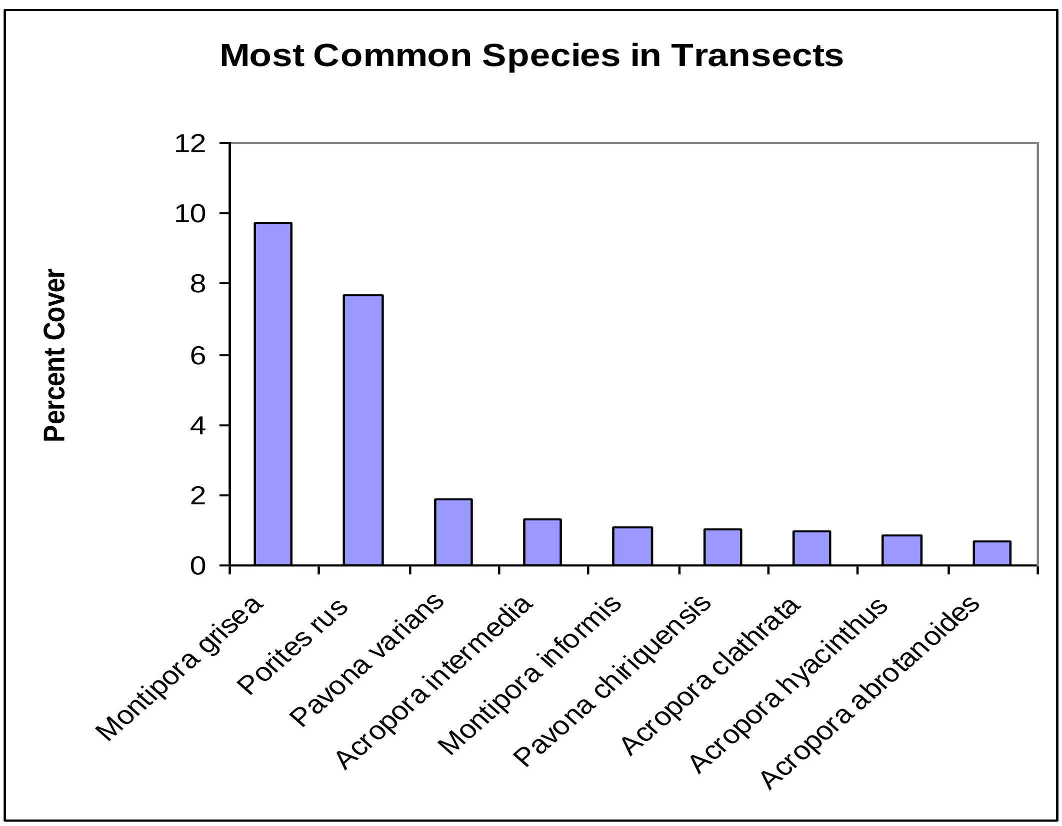


B: Genera

Figure 6: A: Percent cover of different coral lifeforms (shapes). B: Percent cover of coral genera.



A:
Genera/Species



B: Species

Figure 7: A: Number of coral species within genera. B: Coral cover of the most common coral species.

2. Trends on reef flats

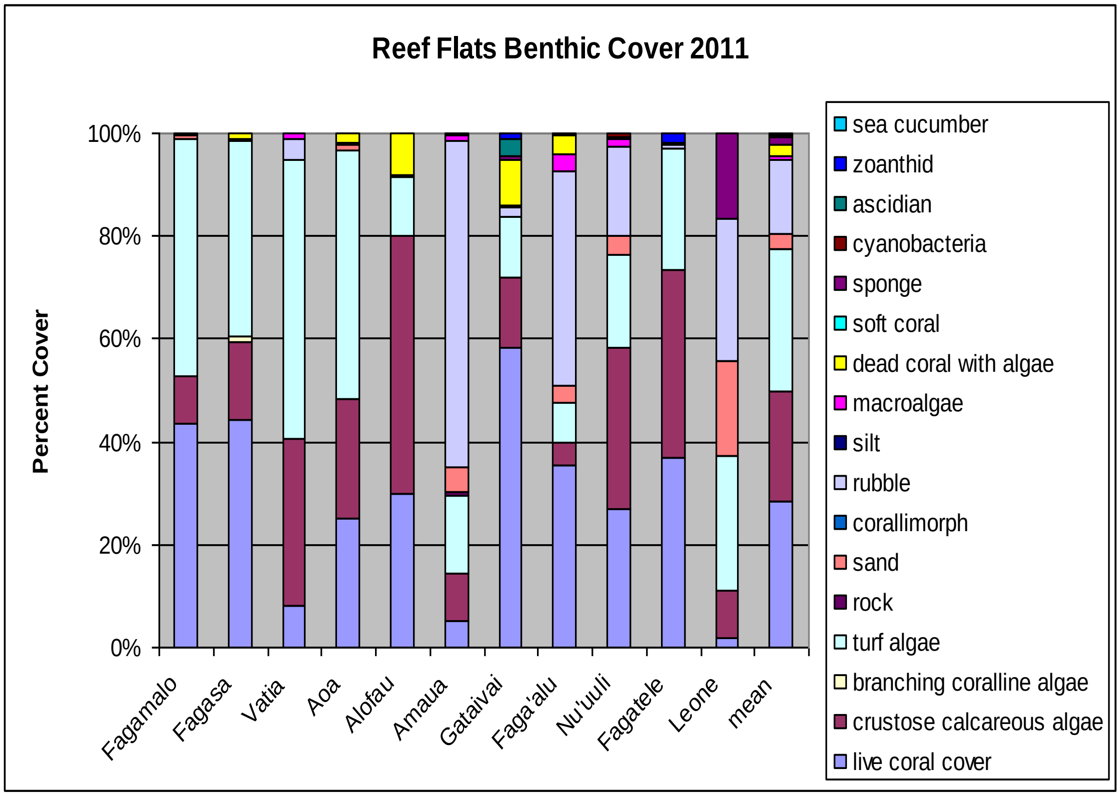
The first scientists to study coral reefs, such as Charles Darwin, could walk on reef flats but could not dive on reef slopes, and had few other ways of studying reef slopes. So the earliest studies of coral reefs were generally carried out on reef flats. After SCUBA began to be used for scientific reef studies, most of the studies have been carried out on reef slopes, and fewer on reef flats, with reef flats often forgotten. The area of reef flats can be readily measured from satellite photos, while the area of reef slopes cannot. Estimates of reef slope area based on typical slopes and maximum depths have shown that reef flats are far larger in area than reef slopes (Vesci, 2004). Thus, reef flats are important for coral reefs in general. Reef flats generally have less coral than reef slopes, because coral growth is limited by exposure to air during low tides. Low tides kill coral that grow above a certain level, due to exposure to air, much like a lawnmower cuts grass blades that grow above a certain level. This effect is why lawns and reef flats appear relatively flat. Low tides also usually restrict coral cove on reef flats to low levels. Reef flats are exposed to different disturbance events and so may have different trends in their communities, so it is important to monitor reef flats as well as reef slopes.

In general, coral cover is lower on inner reef flats than outer reef flats. Therefore, all sites are outer reef flat, except at Amaua, where surf makes it too dangerous to record benthic cover.

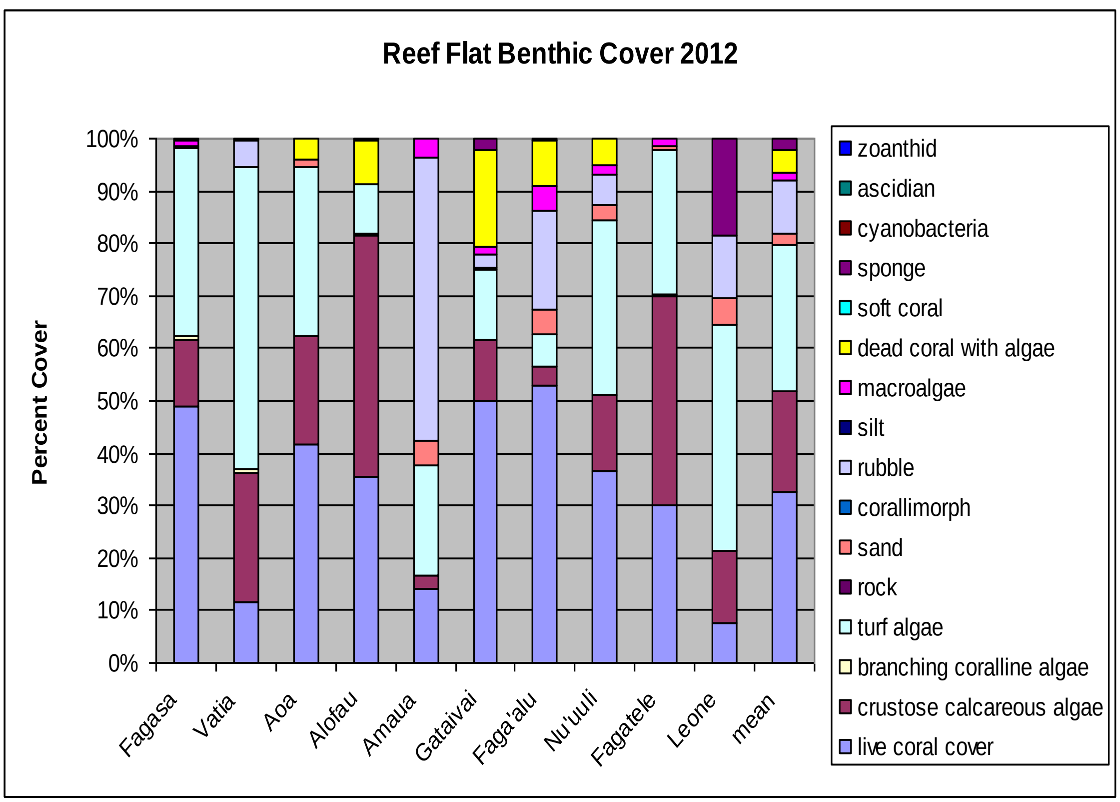
Mean coral cover was 31% in 2011, the same as on the reef slope. The highest cover was at Gataivai, followed by Fagamalo and Fagasa, and the lowest cover was at Leone, followed by Amaua and Vatia (Fig. 8A). In 2012, coral cover ranged from 7% to 51%, with a mean of 32.7%. As on the reef slopes, there was a considerable amount of variation from site to site (Fig. 8B).

Overall, coral cover increased steadily over the period that the reef flats were monitored. Turf decreased considerably, while crustose calcareous algae and rubble increased slightly (Fig. 9A).

Coral cover on reef flats was almost the same on the north side and the south. Turf was much higher on the north side, and rubble was much higher on the south side. It is not clear why that is the case, though turf is also higher on the slopes on the north side than the south side (Fig. 9B).

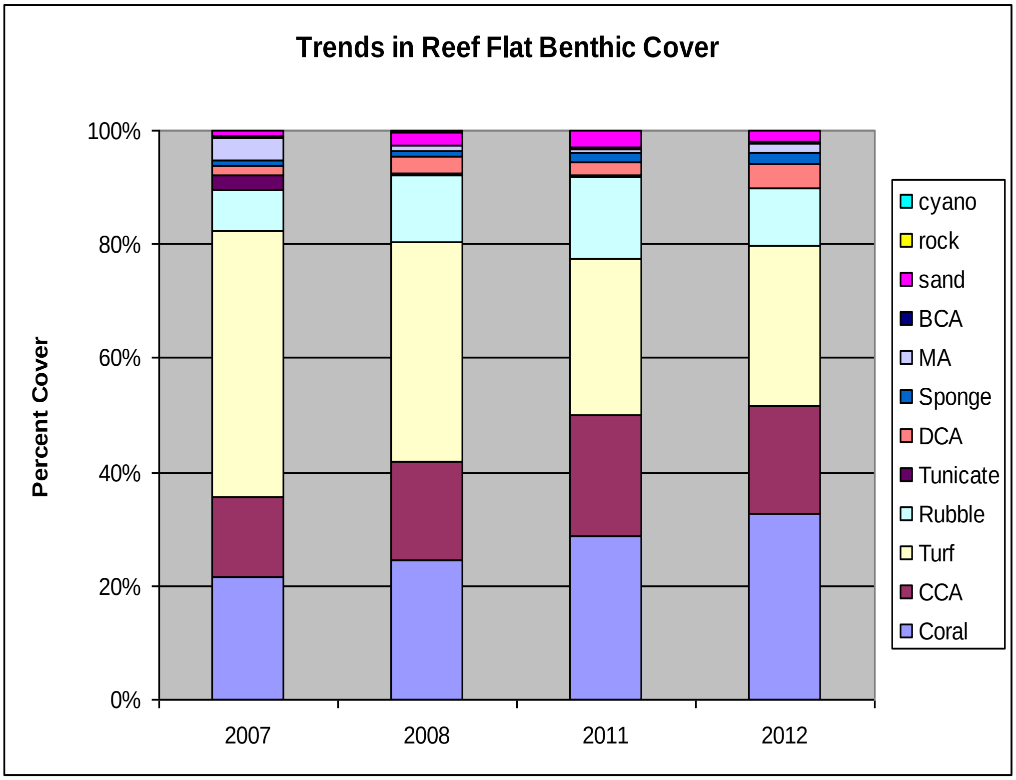


A: 2011

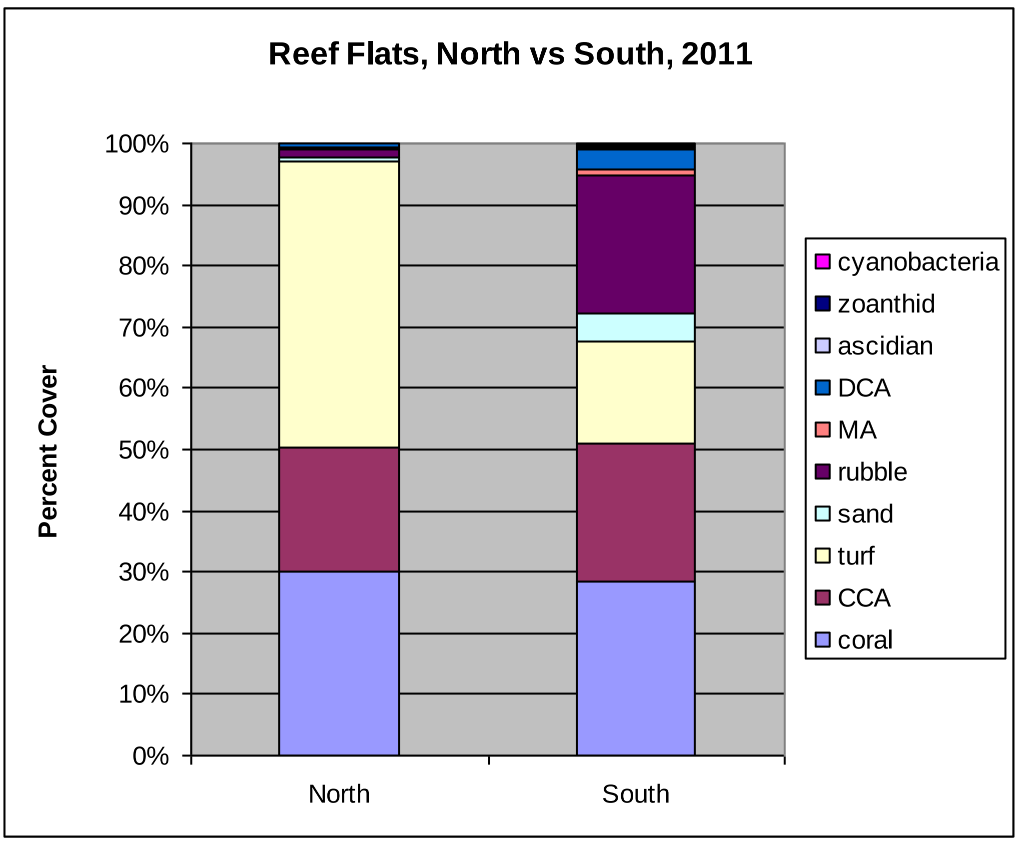


B: 2012

Figure 8: Benthic cover on reef flats in 2011 (A) and 2012 (B).



A: Cover



B: North vs South

Figure 9: A: Trends in reef flat benthic cover. B: Comparison of coral cover on reef flats on the north and south side of Tutuila.

A summary of the trends in reef flat coral cover at individual sites is given in Table 6. Two sites had decreasing coral cover, three had steady cover, and five had increases. This pattern is similar to that on the reef slopes shown in Table 5, but which sites increased and which decreased was not the same. This table supports the view that coral cover has been increasing on the reef flats as well as slopes.

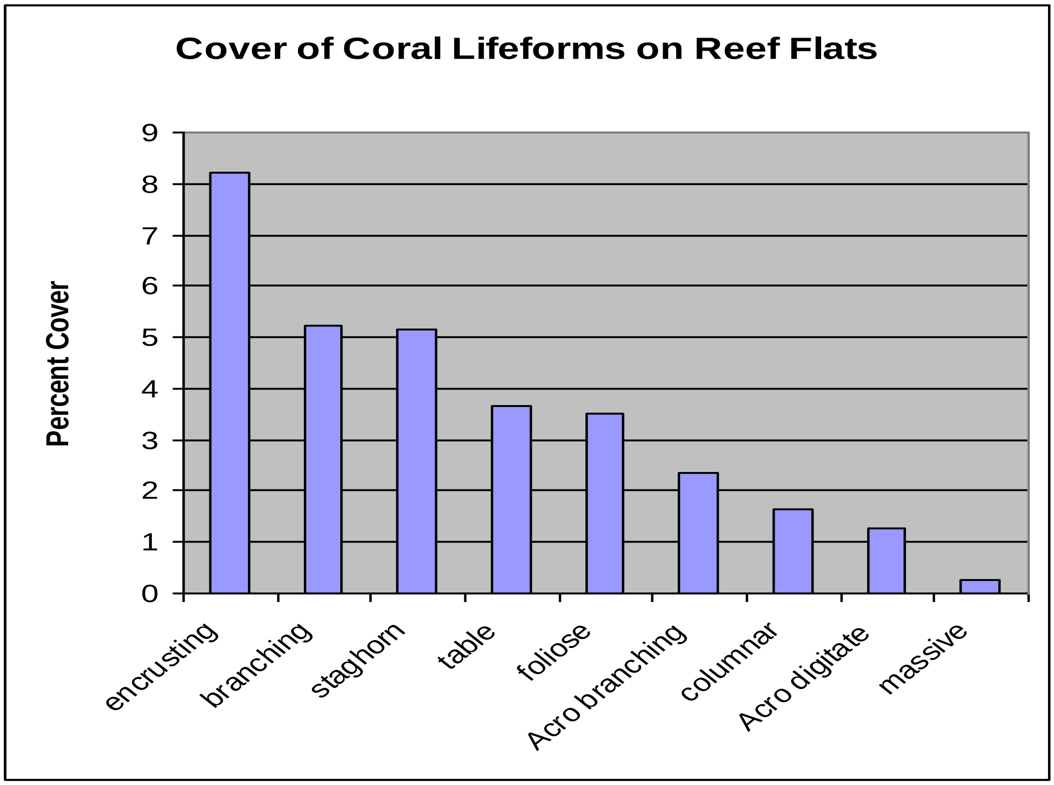
Table 6. Summary of Reef Flat Coral Cover Trends at individual sites.

	decrease	steady	increase
Fagasa			X
Vatia	X		
Aoa			X
Alofau		X	
Amaua		X	
Gataivai	X		
Faga'alu			X
Nu'uuli			X
Fagatele			X
Leone		X	
Total	2	3	5

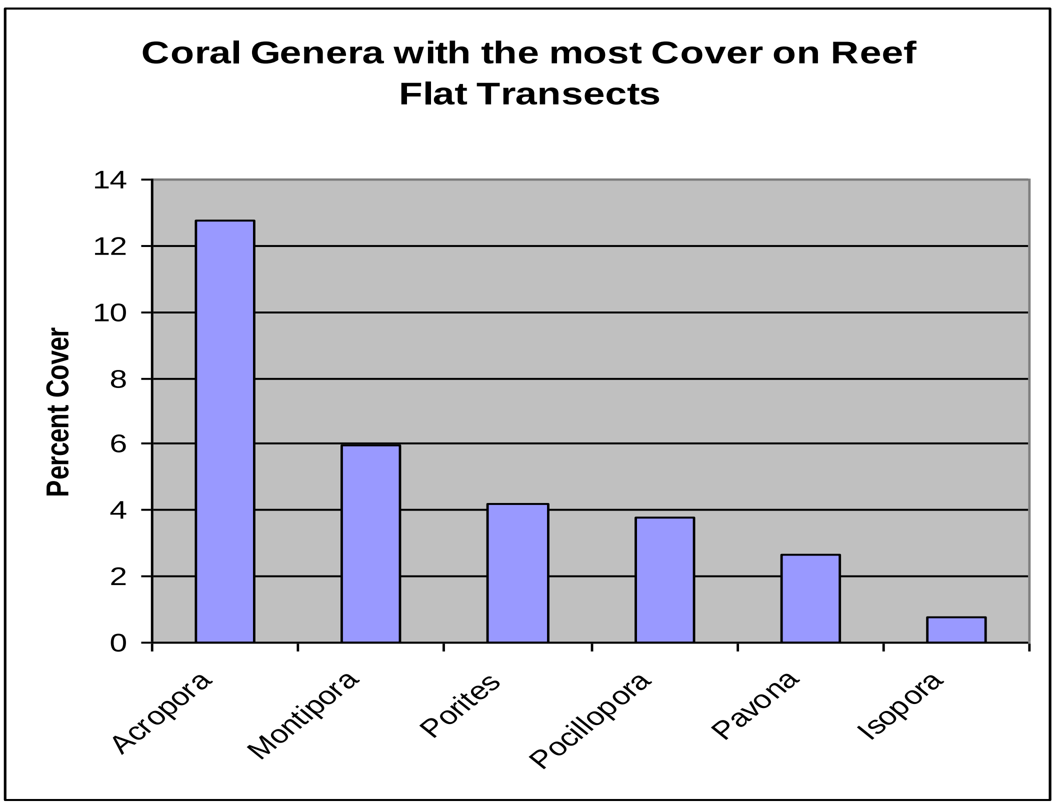
2.1 Trends in coral composition on reef flats

Lifeforms: Encrusting lifeforms have the highest abundance, followed by branching, staghorn, table, foliose, *Acropora* branching, columna, *Acropora* digitate, and massive. On reef slopes, encrusting and columnar were the most common lifeforms (Fig. 6A). Encrusting is therefore the most common lifeform on both slopes and reef flats, but columnar is the second most common lifeform only on slopes, not on reef flats, which show more lifeform diversity (Fig. 10A).

Genera: *Acropora* is the genus with the most cover on reef flats, followed by *Montipora*, *Porites*, *Pocillopora*, *Pavona* and *Isopora*. On reef slopes, the genera with the most cover were *Montipora, Porites*, *Acropora*, *Pavona*, *Leptastrea* and *Pocillopora* (Fig. 10B). *Montipora*, *Porites* and *Acropora* were the three genera with the most cover on both slopes and reef flats, but their order was different in the two zones.

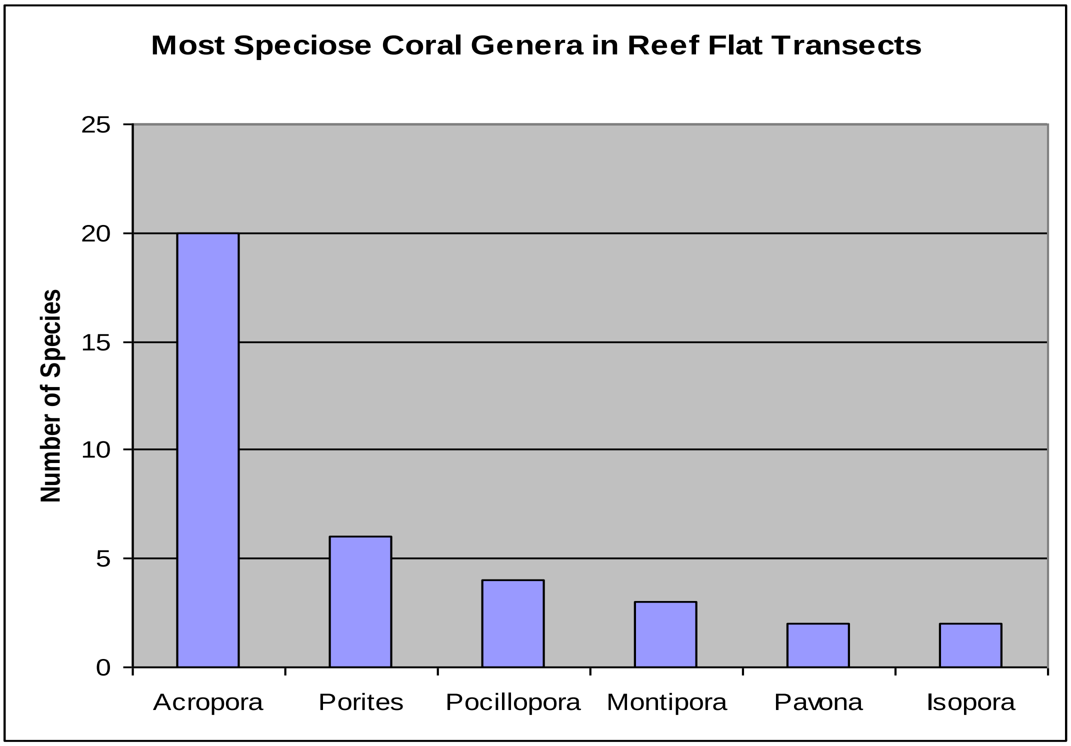


A: Lifeform

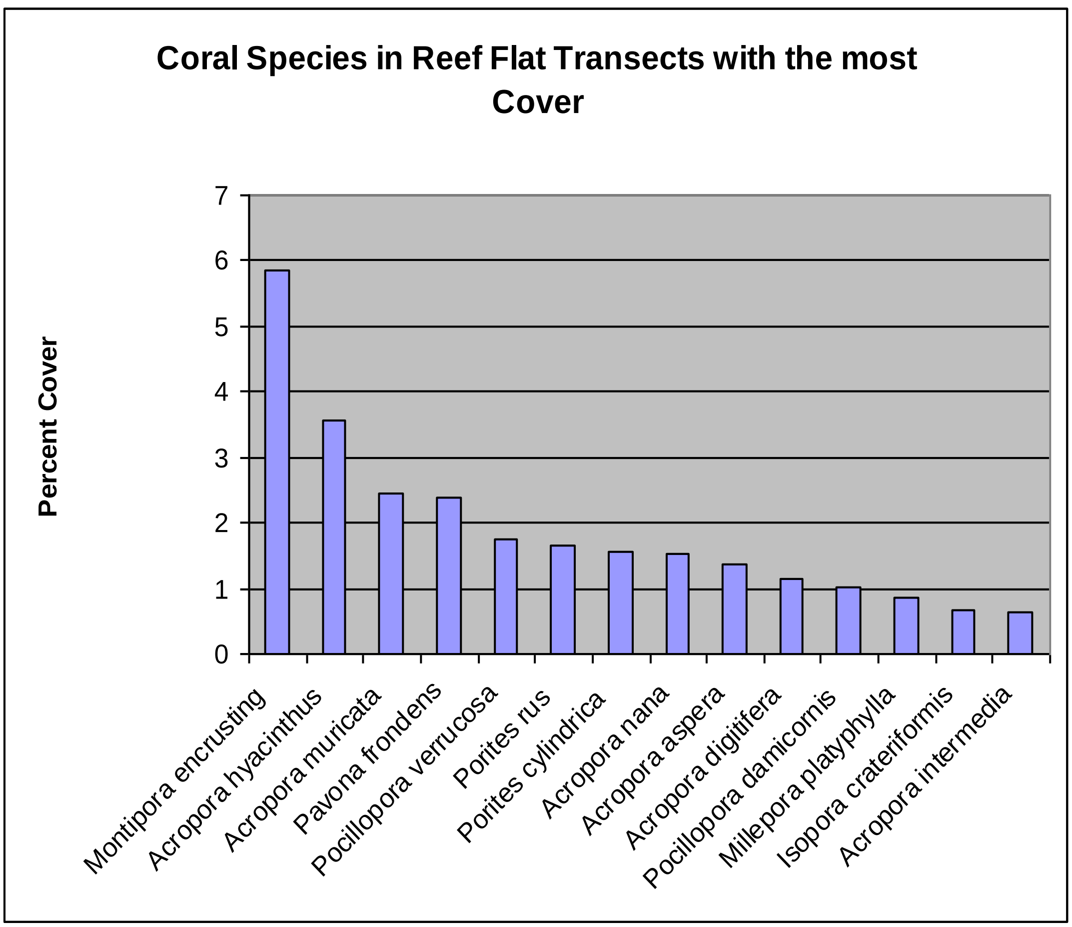


B: Genera

Figure 10: A: Cover of different lifeforms (coral shapes) on reef flats. B: Cover of most abundant genera on reef flats.



B: Genera/ species



B: Species

Figure 11: A: Number of coral species within genera. B: Coral cover of the most common coral species.

Species: *Acropora* had the most species by far, followed by *Porites*, *Pocillopora*, *Montipora*, *Pavona* and *Isopora*. On reef slopes, *Acropora*, *Porites*, *Montipora*, *Goniastrea*, and *Pavona* had the most species. Thus, *Acropora* and *Porites* had the most species on both slopes and reef flats, but the order after that differed. *Montipora* ranked high in both zones (Fig. 11A).

The species with the most cover was an encrusting *Montipora*, followed by *Acropora hyacinthus*, *Acropora muricata*, and *Pavona varians*. On reef slopes, the coral species with the most cover was *Montipora grisea* (an encrusting species), followed by *Porites rus*. All other species had much less cover. Thus, the coral species on the reef flats were quite different from those on the reef slopes (Fig. 11B).

3. Water Quality: Visibility

Visibility is a relatively easily obtained indicator of water quality. Low visibility is caused by sediment, pollution and/or plankton, all of which are indicators of poor water quality. A large study of indicators of water quality on the Great Barrier Reef reported that water clarity is the best single indicator of water quality (Fabricius et al. 2012).

Overall, there is no increasing or decreasing trend apparent. Water clarity is relatively good on the reef slopes, much better than in the harbor, but not as good as out at the banks where influence from the island is much less (Fig. 12).

Leone, Fagatele, Aunu'u and Tafeu had the highest clarity, respectively. Vatia and Fagasa has the lowest visibility, respectively. Coral cover is highest at Leone, Fagatele, Aunu'u and Tafeu and lowest in and Fagasa (Fig. 13A) suggesting a link of coral cover and water clarity, shown by a moderately strong positive correlation between coral cover and visibility, r = 0.7031 which is significant (p < .02) (Fig. 13B).

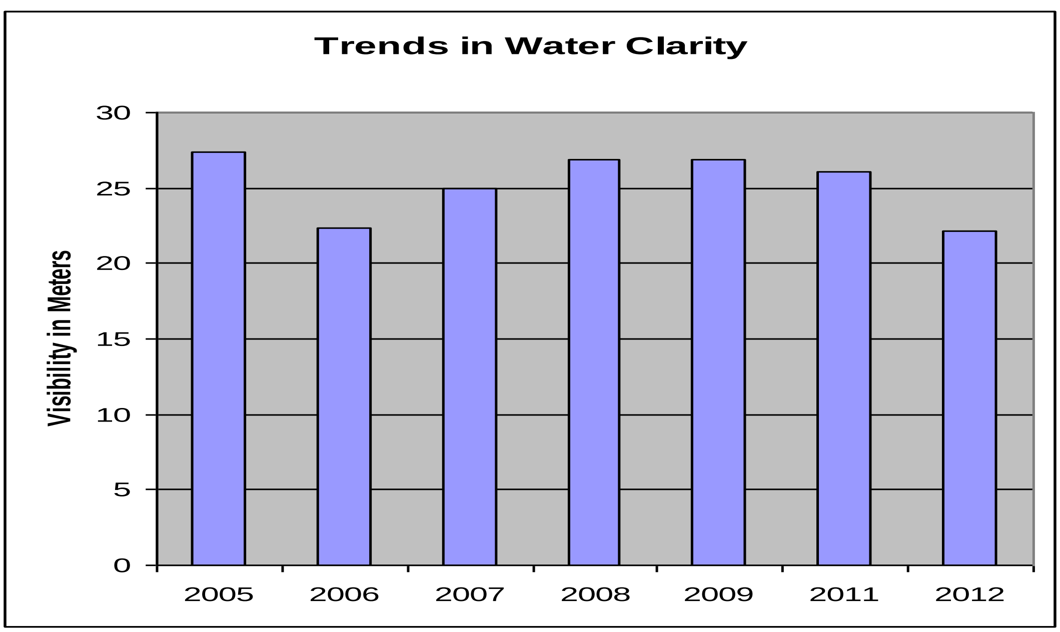
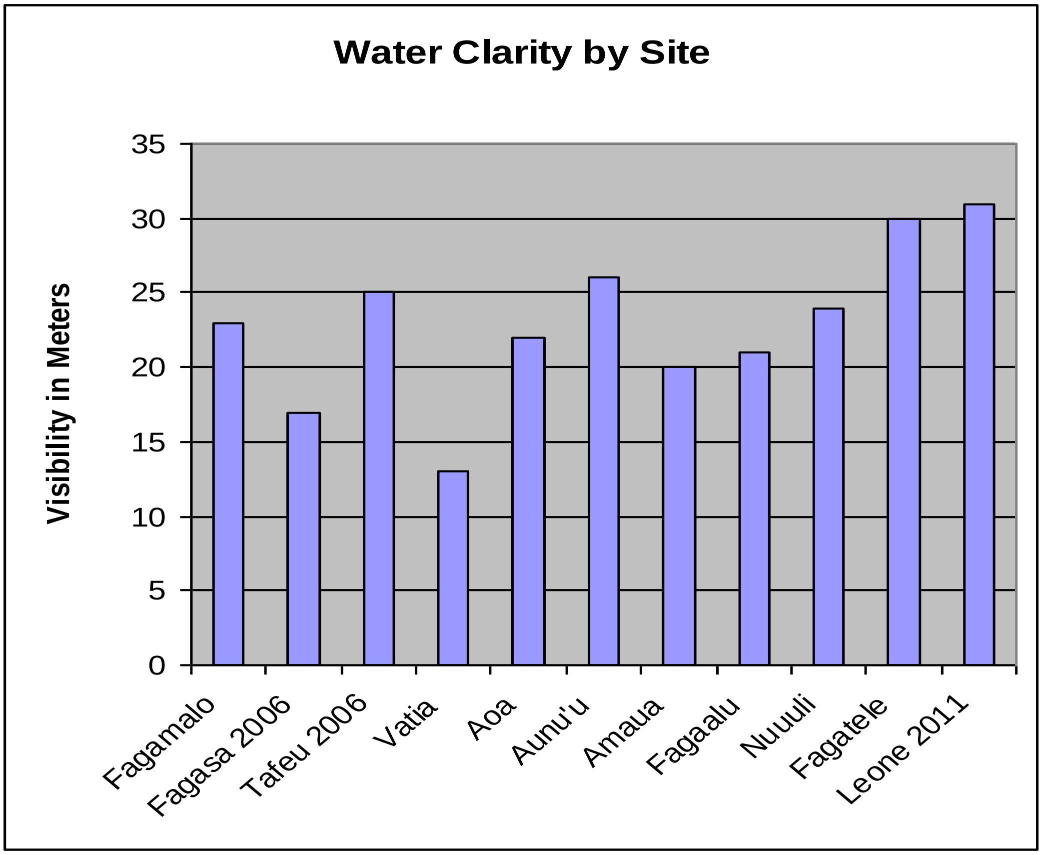
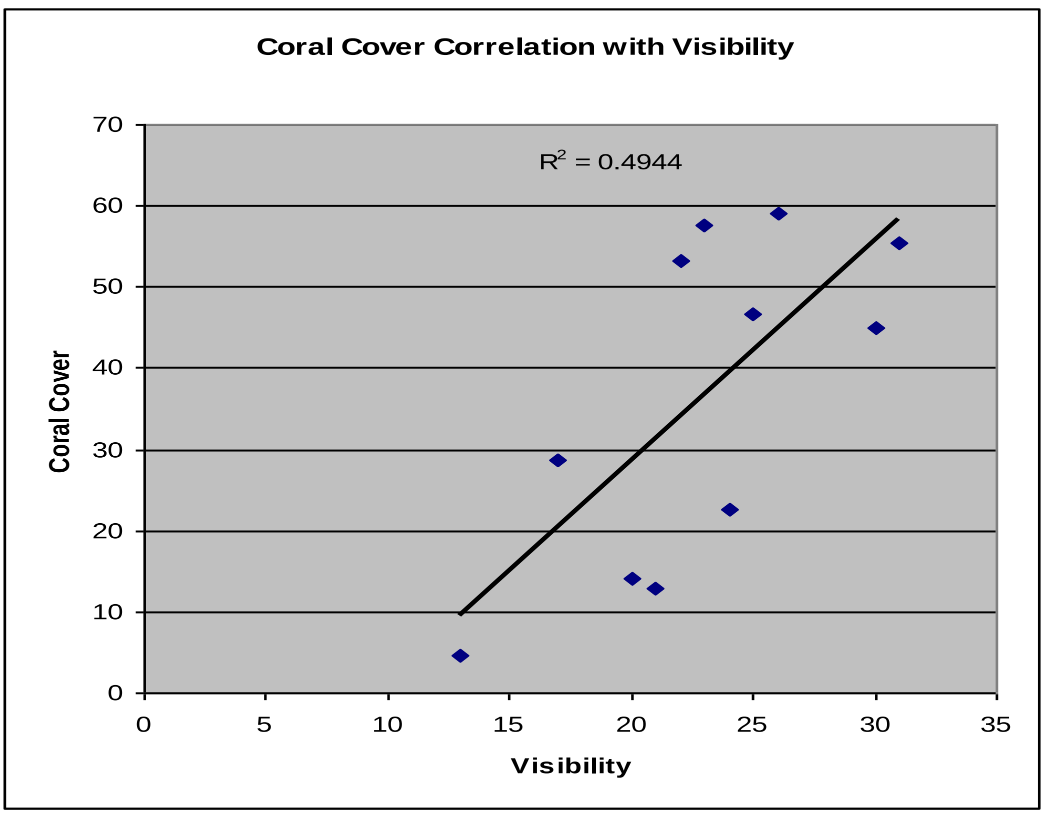


Figure 12: Trends in mean visibility on the reef slopes.



A: By site



B: Correlation

Figure 13: A: Water clarity at each of the reef slope sites. B: Correlation of coral cover and visibility.

4. Ofu-Olosega Reef Flats and Pools

The opportunity arose to collect coral data from reef flats and pools on Ofu and Olosega for the first time in November, 2011. Transects were run on reef flats, but corals in pools were so patchy that transects in the pools were not attempted. Two transects were taken on the reef flat near Vaoto Lodge on the south side of Ofu, one on the inner reef flat and one on the outer reef flat. One transect in each of these two zones was also taken near Pool 500 on the south side of Ofu, and between the bridge and Sili village on the north side of Olosega. Although the two islands are separate (connected by a short bridge) the reef is continuous around the two islands. Coral cover was higher at Sili/bridge on the north side of Olosega than at the Ofu sites, though there was considerable variation. Mean coral cover at the three sites was slightly higher on the inner reef flat than on the outer reef flat. Average coral cover overall was just under 20% (Fig. 14), close to that on Tutuila when reef flats were first surveyed in 2007.

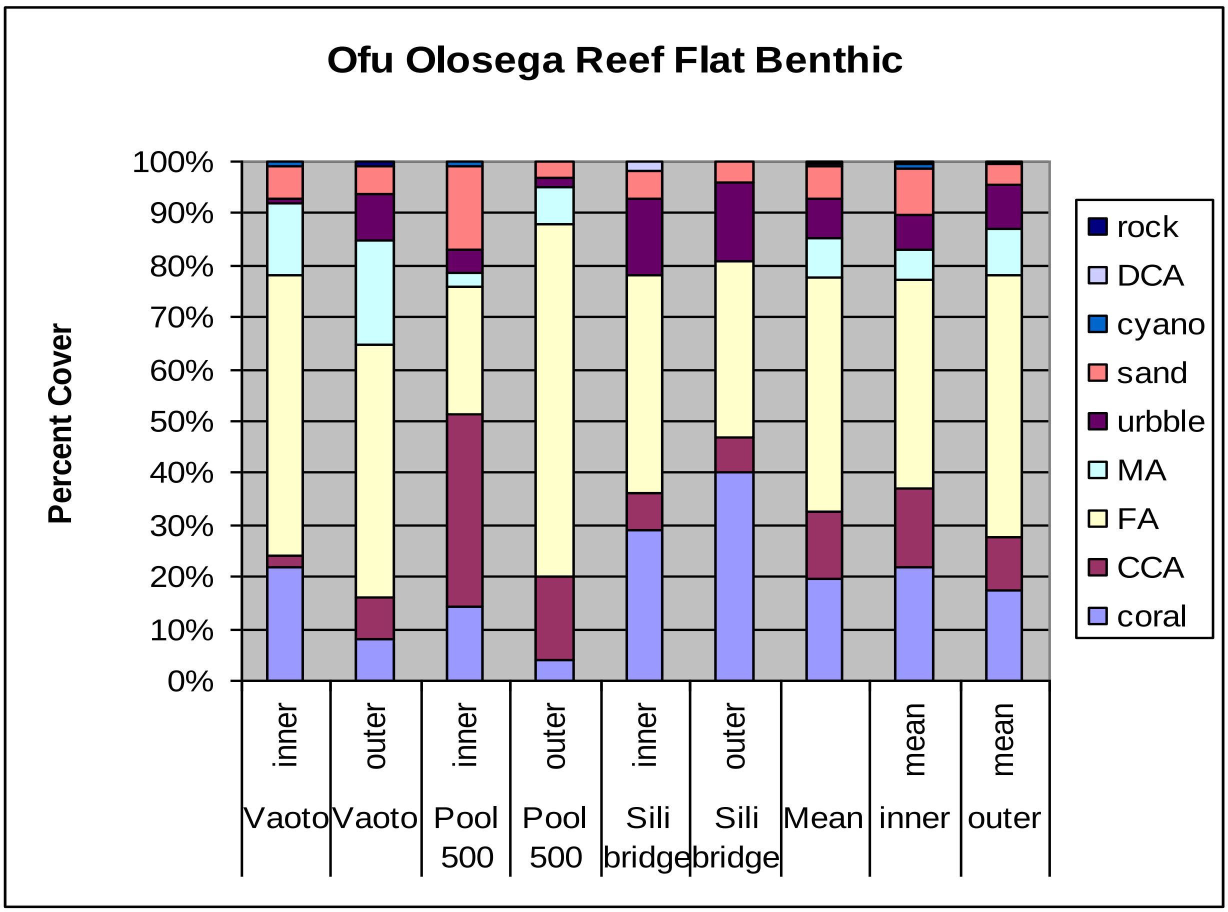
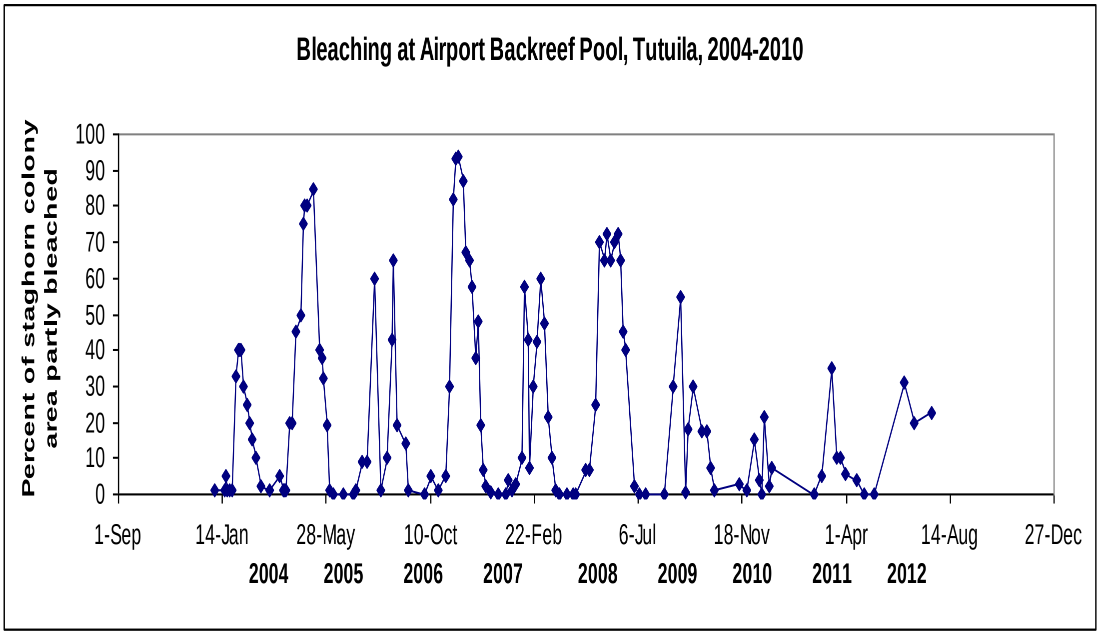


Figure 14: Benthic cover at reef flat sites on Ofu-Olosega.

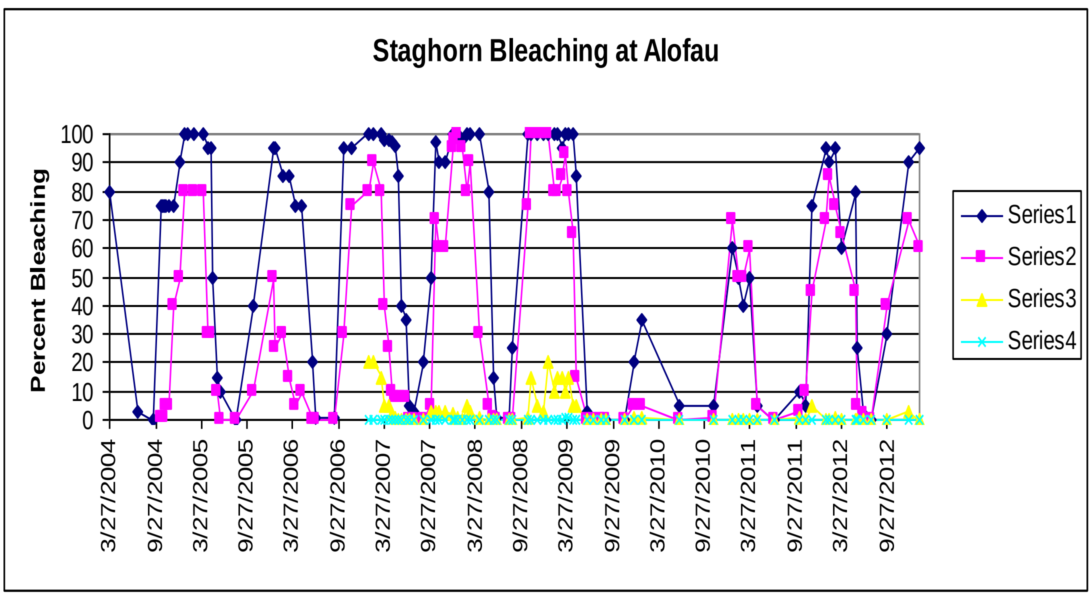
5. Bleaching

Monitoring of bleaching continued in the airport and Alofau backreef pools in 2011 and 2012. Bleaching in the airport pool was less in 2010, 2011 and 2012 than it had been in previous years. The cause of the reduction in bleaching intensity is not yet clear.

At the Alofau pool, bleaching was less intense in 2010, but then increased in intensity in 2011 and 2012 to approximately the intense it was in previous years. The cause of this pattern, and why bleaching in Alofau has returned to previous levels while it has not in the airport pool, is not yet clear.



A: Airport



B: Alofau

Figure 15: Trends in coral bleaching in the airport pool (A) and Alofau backreef pool (B).

6. **Disease**

A disease outbreak was observed in Vatia Bay on 2/19/11 following Hurricane Wilma on 1/24/11. Observations were made along the south side of the bay. The disease observed was areas of white skeleton between live tissue and skeleton which showed progressively darker turf algae with distance from the live tissue. *Acropora abrotanoides, Acropora monticulosa, Pocillopora verrucosa* and *Pocillopora edouxi* were the most commonly affected, and *A. monticulosa* appeared to be the most severely affected. Almost all *A. monticulosa* colonies appeared to be affected and a few were completely dead. Subsequent observations showed that the width of the white area decreased in time, as well as the proportion of colonies that had white areas indicating active disease. The width of the white area is probably an indicator of the speed with which the disease is killing the colony. Observations of other areas following the first observations indicated that the disease was also present on the north side of the bay and that the reduction in disease was a little earlier on the north side than the south side. Observations of other areas indicated that there was a fair bit of white disease on *Acropora nana* near the reef crest at Alofau even though there was no hurricane damage observed at Alofau. Also, heightened levels of white disease were seen on *Pocillopora* at Alofau and some other sites. Fairly low levels of white disease on *Pocillopora* appears to be chronic all over Tutuila, with scattered diseased colonies seen at many sites and over the entire span of the author's observations since 2004. Also, the reefs all have a significant amount of old standing dead *Pocillopora* colonies that are covered with a mixture of turf and coralline algae, indicating significant amounts of mortality over the years. The observed disease on *Pocillopora* after Wilma was greater than this background level, but not all colonies had disease. *Isopora crateriformis* was observed to have a very few diseased colonies on the southwest of Tutuila where they are abundant, the first colonies of that species that the author has ever observed with disease. *Isopora* was previously considered a sub-genus of *Acropora*, but recently has been elevated to genus status. Clearly, *I. crateriformis* is closely related to *Acropora*. Interestingly, no white disease was observed on the staghorn species *Acropora nobilis* in Vatia Bay, nor any of the staghorns (*Acopora muricata*, *Acropora pulchra*, and *A. nobilis*) in any of the backreef pools. Even colonies of *A. nobilis* with damage from the hurricane did not have disease. Thus, although *Acropora* and *Pocillopora* were the only genera affected, not all *Acropora* species were affected. *Acropora hyacinthus* in Vatia had very few affected colonies. Oh the south side, the diseased colonies were all in the mid to outer part of the bay, but then the inner part of the bay had no colonies left due to the tsunami, and some like *A. monticulosa* and *A. abrotanoides* were much more common in the outer bay even before the tsunami.

No outbreak of disease was observed following the tsunami. The fact that the disease was well underway when first observed 26 days after the hurricane, plus the fact that the disease was most intense at the only location where the hurricane did significant damage, suggests but certainly does not prove that the hurricane caused the disease outbreak. Disease outbreaks have been reported following bleaching events (Bruno et al 2007; Wilkinson and Souter, 2008), however this report appears to be the first report of a disease outbreak following a hurricane. Higher temperatures are reported to increase disease such as black band (Boyett et al 2007; Bruno et al 2007), which suggests a mechanism for disease outbreaks to follow bleaching events, since bleaching is caused by high temperatures. However, it is not at all clear how a hurricane might cause a disease outbreak, nor why this relatively mild hurricane would produce disease while disease outbreaks have not been reported following far stronger hurricanes.

Speculative possible mechanisms might include stress on the corals that could make them vulnerable to diseases they could resist otherwise, and the possibility that the heavy surge could disperse diseases.

During the work on Ofu-Olosega in November, 2011, disease was noticed on colonies of *Porites rus* in the Vaoto Lodge pool. The disease produced white areas that graded from white to yellow to normal colony color. Parts of the colonies were dead. There were many large, essentially massive colonies with very lumpy surfaces. The white was not on the upper surfaces of lumps any more than on lower surfaces, and nearby surfaces at the same orientation were not the same shade of color, indicating it was likely disease instead of bleaching. Further, the portions of the colonies that were dead were not restricted to upper surfaces. Also, no other corals nearby or in any of the pools were bleached, and *Porites* is much more resistant to bleaching than *Acropora* and *Millepora*, which were not bleached. Colonies of *Porites rus* in the Vaoto Lodge pool were visually surveyed for percentage of each colony's surface that was diseased, percentage of each colony's surface that was dead, and the diameter of each colony was measured. The mean colony size was 69 cm (Fig. 16). If colonies grew 1 cm a year, such a colony would be 25-35 years old (since the diameter, not the height, was measured, and thus there were two growing surfaces. The largest colony is 300 cm, and if it grew 1 cm a year, would be 150 years old. The mean surface area showing signs of disease was 11.8% (Fig. 17). So only a small proportion of the colony surface was currently diseased.

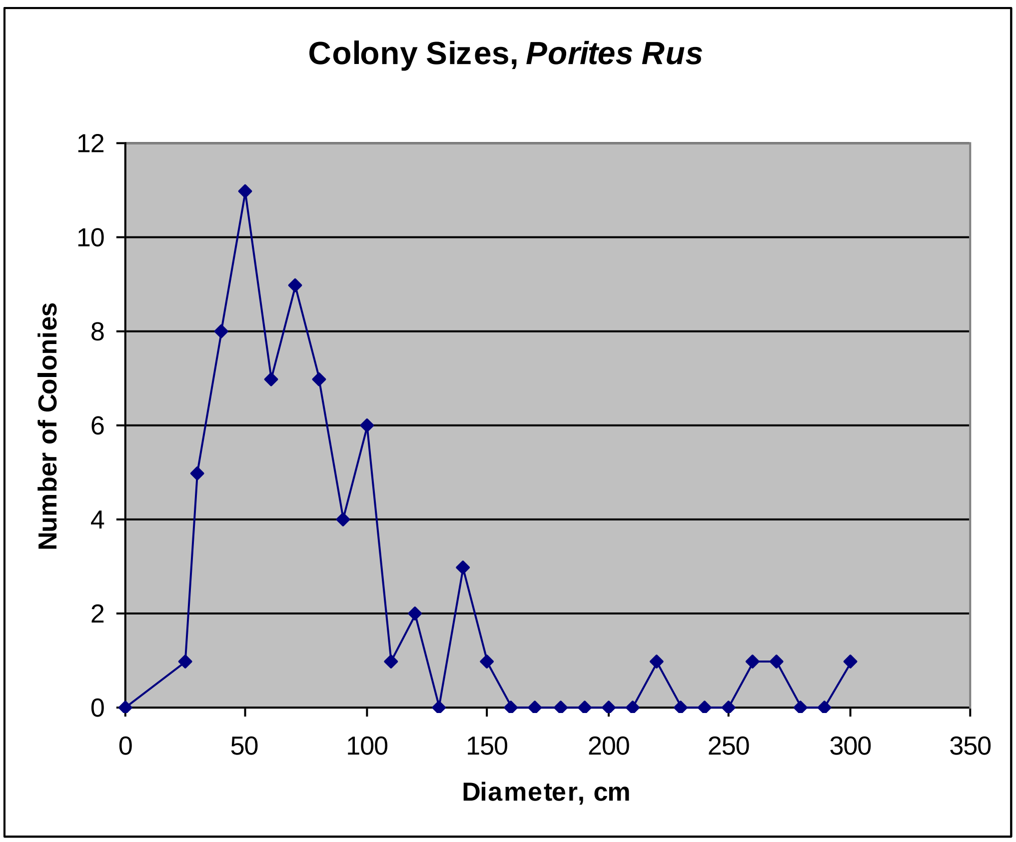


Figure 16: Distribution of colony sizes of *Porites rus* in the Vaoto Pool.

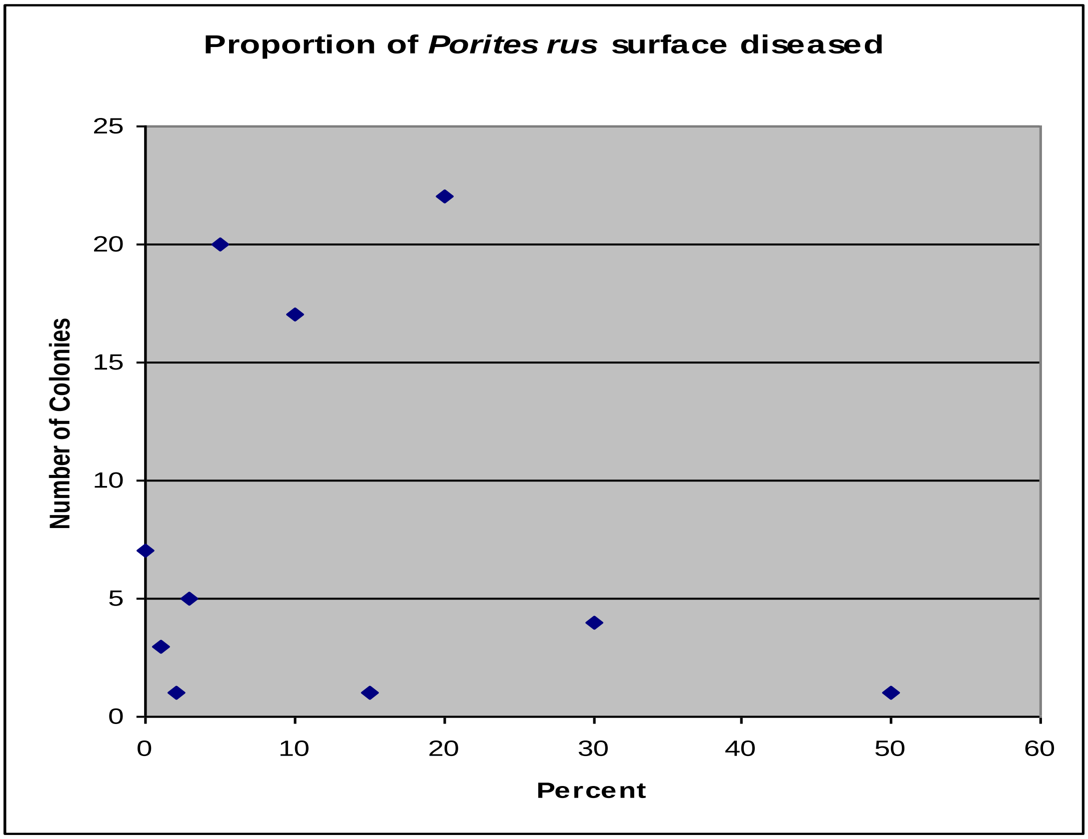


Figure 17: Proportion of the surface showing signs of disease in *Porites rus*.

II. Fish abundance and biomass

Abstract

This section is separated in to 2 sub-sections; the first summarizes the reef fish abundance and biomass data collected during the FY2011 and FY2012 period, and the second which summarizes the reef fish abundance and biomass data collected during the FY2013 and FY2014 period, up until 31st March 2014.

There are some gaps in data collection due to these changes in personnel, from September 2012 when Mr. Benjamin Carroll's contract was not renewed by the then director Ufagafa Ray Tulafono. The DMWR's Chief Fisheries Biologist filled in Mr. Carroll's duties, where possible up until the end of January 2013 when the position was filled part time by DMWR fisheries supervisor Alice Lawrence and part-time by DMWR fisheries technician Saolotoga Tofaeono. The position was filled full-time by Alice Lawrence from the end of January 2014 until the present time.

The main issue responsible for data gaps during this grant period has been that the DWMR boat engines are old and have required servicing on numerous occasions. The servicing has usually taken many months, mainly due to the need for parts to be shipped and paid for through the ASG system, which usually takes many months to process. The boat was out of action between January 2012 and October 2012 and also again between January 2013 and October 2013, and again between January 2014 and November 2014. There were attempts to utilize local fishing boats to conduct surveys with varying success, due to problems with late payments, safety issues and logistics related to the smaller and slower engines used by the local fishing boats.

Following the personnel changes in January 2013, it was agreed by the DMWR Chief Fisheries Biologist and the new Fish Monitoring Biologist that it would be a good opportunity to combine the 4 monitoring programs that were being managed by DMWR.

The report also details grant activities that are related to Technical Assistance work, attendance at regional Monitoring Meetings and Coral Reef Science Meetings, work involving the Local Action Strategy working groups and how the work undertaken has Applications to Management in American Samoa.

Subsection A: FY 2011 → FY2012 activities

Project Background

Eleven sites around Tutuila Island were initially chosen by the American Samoan Governors Coral Reef Advisory Group (CRAG) and a Monitoring Working Group that was established for this purpose. Monitoring sites chosen represented what was thought to be a reasonable sample size around the main island of Tutuila and the nearby small island of Aunu'u, providing a reasonable geographic distribution and some of the variety of reef types and exposures (i.e. windward/leeward). The site plan for the ASCRMP incorporated federal, territory, and community-based MPAs. Three of the 11 monitoring sites are community-based MPAs within DMWR's Community-based Fisheries Management Program (CFMP) (Fagamalo, Vatia, and Amaua) and 2 sites are federal MPAs (Fagatele and Tafeu).

Based on population density and subsequent impacts to the watershed, the ASCRMP incorporated villages in the complete range of the ASEPA watershed classification scale; pristine, minimal, intermediate, and extensive (DiDonato 2004). Three of the 11 monitoring sites (Leone, Nu'uuli and Faga'alu) are categorized as Extensive, three sites are categorized as Intermediate (Amaua, Aoa, and Fagasa), one site is categorized as Medium (Vatia), and three sites are categorized as Pristine (Fagatele, Tafeu and Fagamalo).

In 2007 an additional site, Massacre Bay, was added on the northwest sector to improve north-south/east-west balance, and thereby provided a balance of the four geographical quadrats of Tutuila (NW, NE, SE & SW). In 2009 five sites surrounding Swains Atoll were surveyed for the first time and it is hoped that annual monitoring will continue at Swains. In 2010, sites will be added on Ofu, Olosega, and Ta'u if logistically possible, as well as at Rose Atoll.

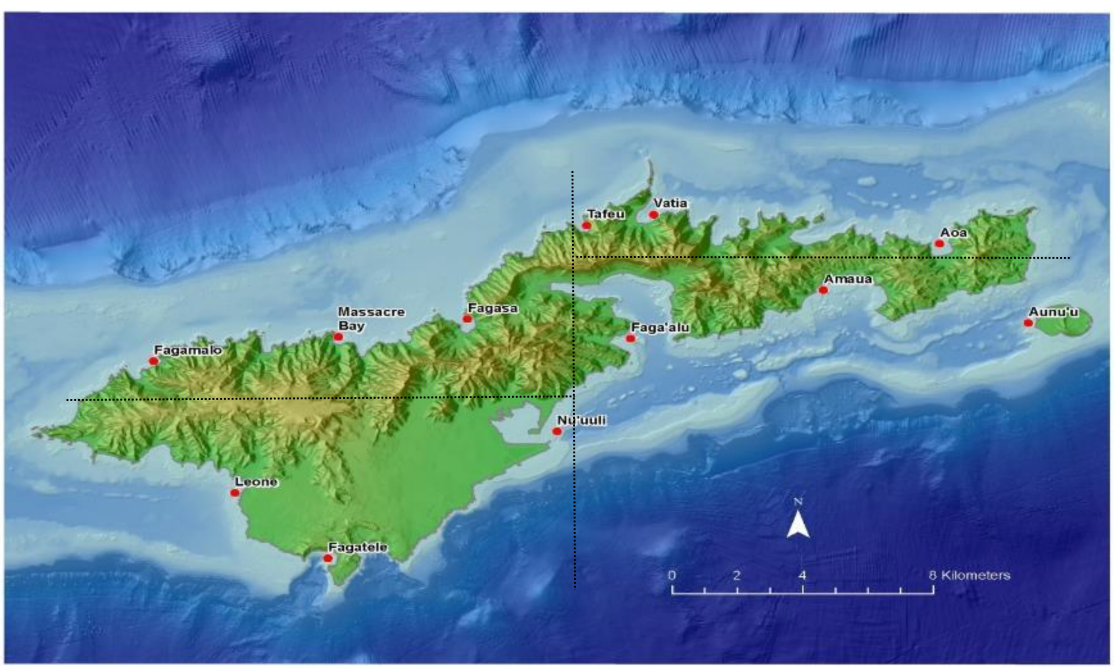


Figure 18: Monitoring sites by 'sector' on Tutuila Island, American Samoa

Monitoring Protocol (FY 2011 → FY 2012)

All diurnally active, non-cryptic reef fish were recorded to species level using belt transects. At each site, 6 replicate 30m transects were sampled with several passes and widths being used to sample different groups. The first pass is used to sample larger, more mobile species 7.5m either side of the transect as the transect is being laid out (groups such as sharks, snapper, jacks, scombrids, kyphosids, large grouper etc). On the second pass parrotfish are recorded 5m either side of the tape. The third pass surgeonfish are recorded 2.5m either side of the tape. Every other species is then recorded 2.5m either side of the tape on the fourth pass, except damselfish, which are recorded on the fifth pass 1m either side of the tape. Each individual fish is counted and a length estimate made so biomass calculations can be performed. Water clarity is measured visually horizontally along the transect tape.

Monitoring Activities

Monitoring surveys conducted during the period FY2011 and FY2012 are listed in Table 7.

Table 7: Reef Slope Monitoring Sites Surveyed in FY2011 and FY2012.

Site	GPS Coordinates	Survey date FY 2011	Survey date FY 2012
Fagamalo	-14º 17.872S, -170º 48.726W	Not completed	*See NOTE[1]*
Massacre Bay	-14º 17.374S, -170º 45.577W	12/9/11	*See NOTE[1]*
Fagasa	-14º 17.016S, -170º 43.383W	3/17/11	*See NOTE[1]*
Tafeu	-14º 15.109S, -170º 41.354W	9/22/11	*See NOTE[1]*
Vatia	-14º 14.888S, -170º 40.205W	9/29/11	*See NOTE[1]*
Aoa	-14º 15.474S, -170º 35.332W	5/22/11	*See NOTE[1]*
Aunu'u	-14º 17.076S, -170º 33.818W	8/5/11	*See NOTE[1]*
Amaua	-14º 16.418S, -170º 37.312W	3/3/11	*See NOTE[1]*
Faga'alu	-14º 17.404S, -170º 40.598W	8/3/11	*See NOTE[1]*
Nu'uuli	-14º 19.287S, -170º 41.850W	1/19/11	*See NOTE[1]*
Fagatele Bay	-14º 21.859S, -170º 45.753W	2/24/11	*See NOTE[1]*
Leone	-14º 20.534S, -170º 47.339W	2/25/11 and 8/4/11	*See NOTE[1]*

NOTE[1]: *The DMWR boat was out of service between January 2012 and October 2012*

Results and discussion

Trends on reef slope sites in FY 2011 and FY 2012

In 2011, Scarids and Acanthurids usually had the greatest biomass at most sites, while Balistids also had a relatively high biomass at a lot of sites including Aunuu, Fagatele and Tafeu. A high biomass of other families/groups was also found at the following sites: Labrids at Fagatele and Amaua, Lutjanids at Aunuu and Nuuuli, and Chaetodons at Aunuu, Leone and Faga'alu.

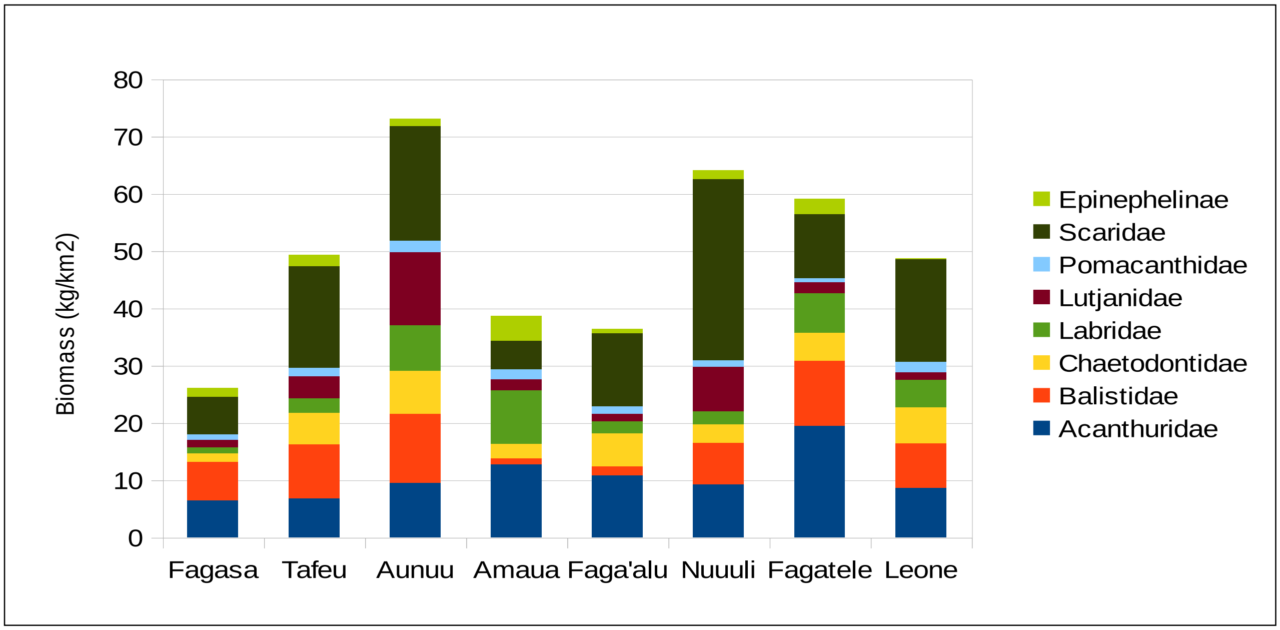


Figure 19: *Average fish family biomass per site (kg/km2) in 2011*

As in previous years, the most dominant surgeonfish at most sites in 2011 in terms of biomass were those from the genus Ctenochaetus. Acanthurus was the second most dominant in terms of biomass except at Leone and Faga'alu where Naso had a slightly greater but similar biomass at Leone and a greater biomass at Faga'alu. Relatively greater biomass of Naso were also found at Fagasa. Zebrasoma were found in low but relatively higher abundance at Fagatele, Leone and Faga'alu.

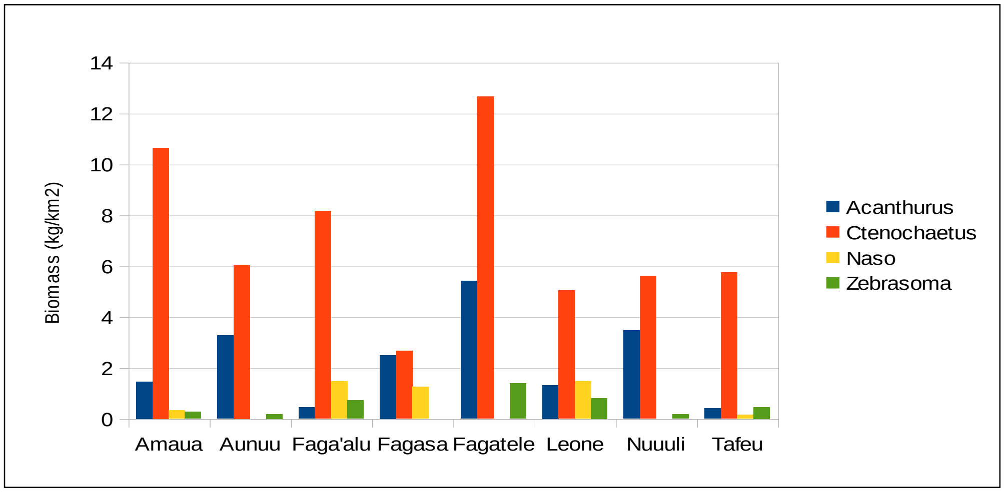


Figure 20: *Average Surgeonfish biomass per site (kg/km2) in 2011*

As in previous years, Acanthurids were easily the most abundant family in terms of numbers across all sites. The only exception was at Nuuuli where Scarids were equally as abundant. Generally, scarids, chaetodons and labrids also had relatively high abundance at most sites. Other family groups were not as abundant and varied between sites.

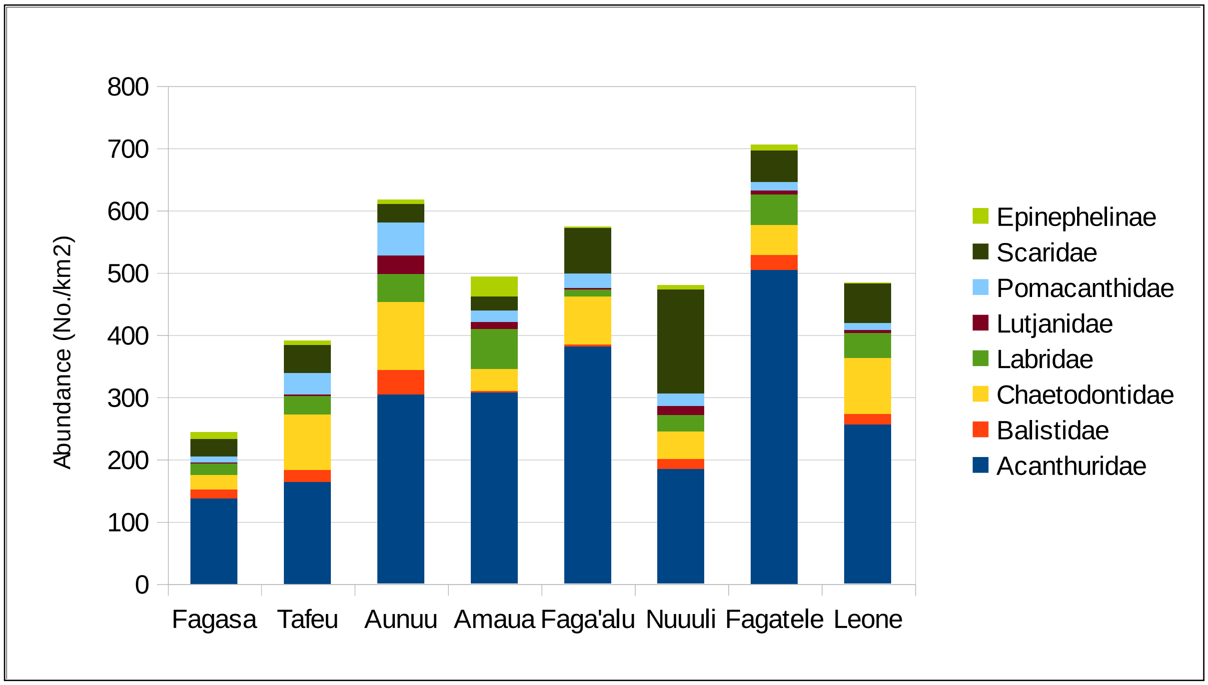


Figure 21: Average fish family abundance per site (no./km²) in 2011

When examining different genus in the surgeonfish family by site, and again similar to previous years, Ctenochaetus were the most abundant at all sites, followed at most sites by either Acanthurus (Aunuu, Fagasa, Fagatele, and Leone), or Zebrasoma (Amaua, Faga'alu, Nuuuli and Tafeu). Naso were either absent or found in very low abundance at all sites.

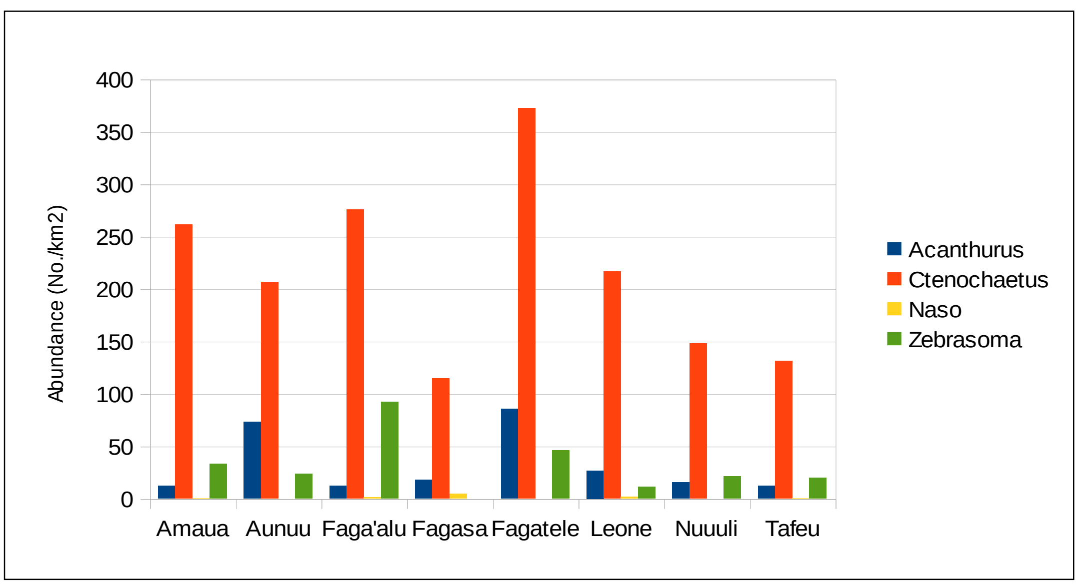


Figure 22. Average Surgeonfish abundance per site (no./km2) in 2011

Biomass values of reef fish remained relatively similar between the years 2006-2010 with most differences being unlikely to be significant. Results indicate that similar fish faunal composition is found around Tutuila especially when comparing between similar sites but also that there were some small differences when comparing between dissimilar sites. These similarities and differences were striking at the species level and also discernible at the family level. Overall, Fagatele appears to have a slightly greater biomass but not abundance of reef fish when compared to other sites suggesting that the fish being observed in Fagatele are generally somewhat larger. Faga'alu also shows a similar pattern having quite a high biomass although abundance varies more throughout the years. There also appears to be at least slight differences between sites located on the northern side of Tutuila compared with sites located on the south. Probably the most obvious difference is that biomass appears to be slightly greater on the north than the south. Some of this difference is attributed to the unique differences at Nuuuli and Aunuu as just described, and both these sites happen to be on the south side of Tutuila. In the same light, it should also be noted most sites on the north are located well within bays where sedimentation can be an issue, where the reefs are generally not as developed, where the reef slope doesn't continue into water that is particularly deep, and where there is more limited water circulation and wave energy.

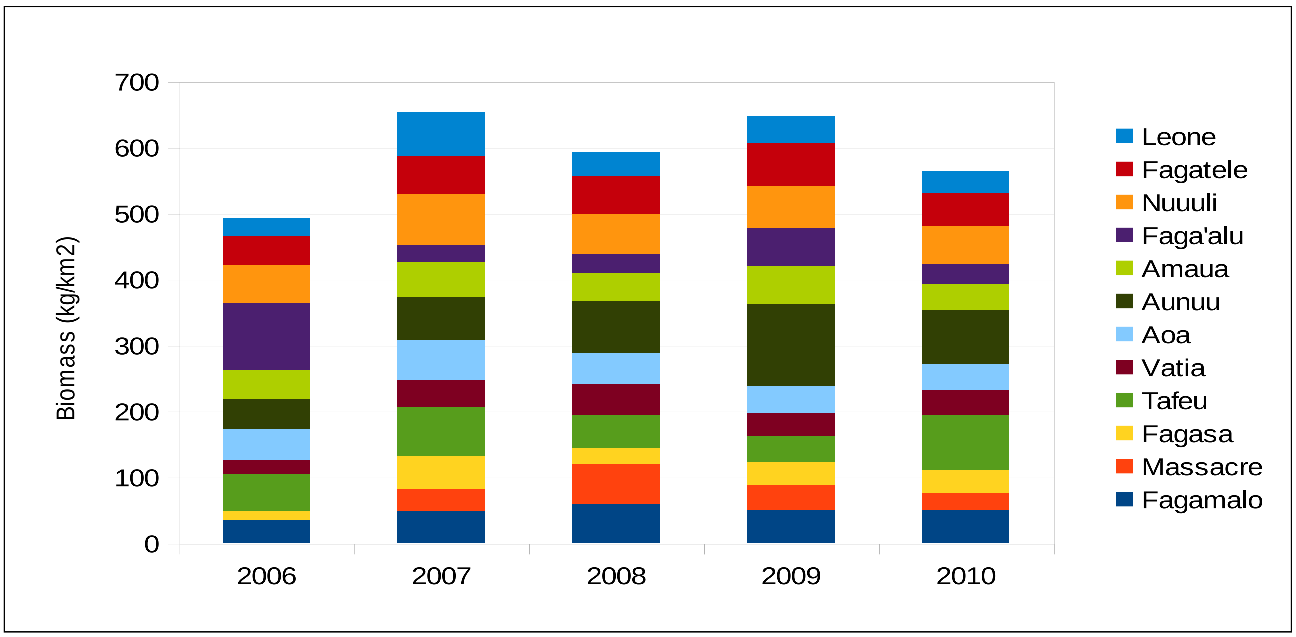


Figure 23 *Average total fish biomass per site 2006-2010 (kg/km2)*

Subsection B: FY 2013 → FY2014 activities

Project Background

In January 2013 the DMWR Fisheries division made a decision to integrate the four biological monitoring programs that had been implemented with varying effort and methods over the previous 6 years. The four programs are:

1. **Key Reef Species Program (KRSP)** – funded by USFWS Sports Fish Restoration Program
2. **Community-based Fisheries Management Program (CFMP)** – funded by USFWS Sports Fish Restoration Program
3. **No-take MPA Program (NTMPA)** – funded by USFWS Sports Fish Restoration Program
4. **American Samoa Coral Reef Monitoring Program (ASCRMP)** – funded by NOAA Coral Reef Conservation Program

The key goal is to monitor the status and trends in the distribution and abundance of biota on coral reefs in American Samoa on a long-term basis, in order to provide information that is pertinent to managing coral reefs in the territory.

The key benefits to an integrated monitoring program include:

- The CFMP program decided to switch from reef flat snorkel surveys to SCUBA surveys on the reef slope. Integrating the four programs will reduce the strain on the boat and staff resources, and reduce duplication of effort where site lists overlap.
- Historically, most programs failed to complete surveys at their designated sites within a 12 month period, mainly due to staff absences and boat availability issues. The integrated effort will ensure that all the sites are completed on time.
- Combining efforts into one program ensures that a total of 30 monitoring sites can be surveyed in one year and therefore more data is available for each program to analyze.
- A team of 8 DMWR staff available to undertake the monitoring surveys, split into 2 teams of 4 staff who will survey on alternative days. This ensures that if monitoring team members are sick or unable to dive on a scheduled day, a backup staff member will be available to step in and enabling the survey schedule to stay on track.
- Monitoring surveys are scheduled for a block of 4-6 months during the period of most favorable weather conditions. This ensures that data is comparable between sites and ensures continuity and motivation within the survey team.
- One main survey protocol, with the opportunity to add extra components depending on program needs, ensures that all data collected is compatible and available for data analysis.
- Monitoring team is trained at the same time and tests are conducted prior to start of monitoring season to ensure quality control of data recorded.

- A total of 30 monitoring sites will be surveyed, creating a larger and more robust data set which will be available for each program to analyze with respect to their program objectives.

New site selection process

Site selection was based on the following priorities:

1. Include all sites where 3 or more years of data have been collected.
2. All Marine Protected Area (MPA) sites.
3. Ensure that each MPA sites has a relatively comparable non-MPA site nearby.

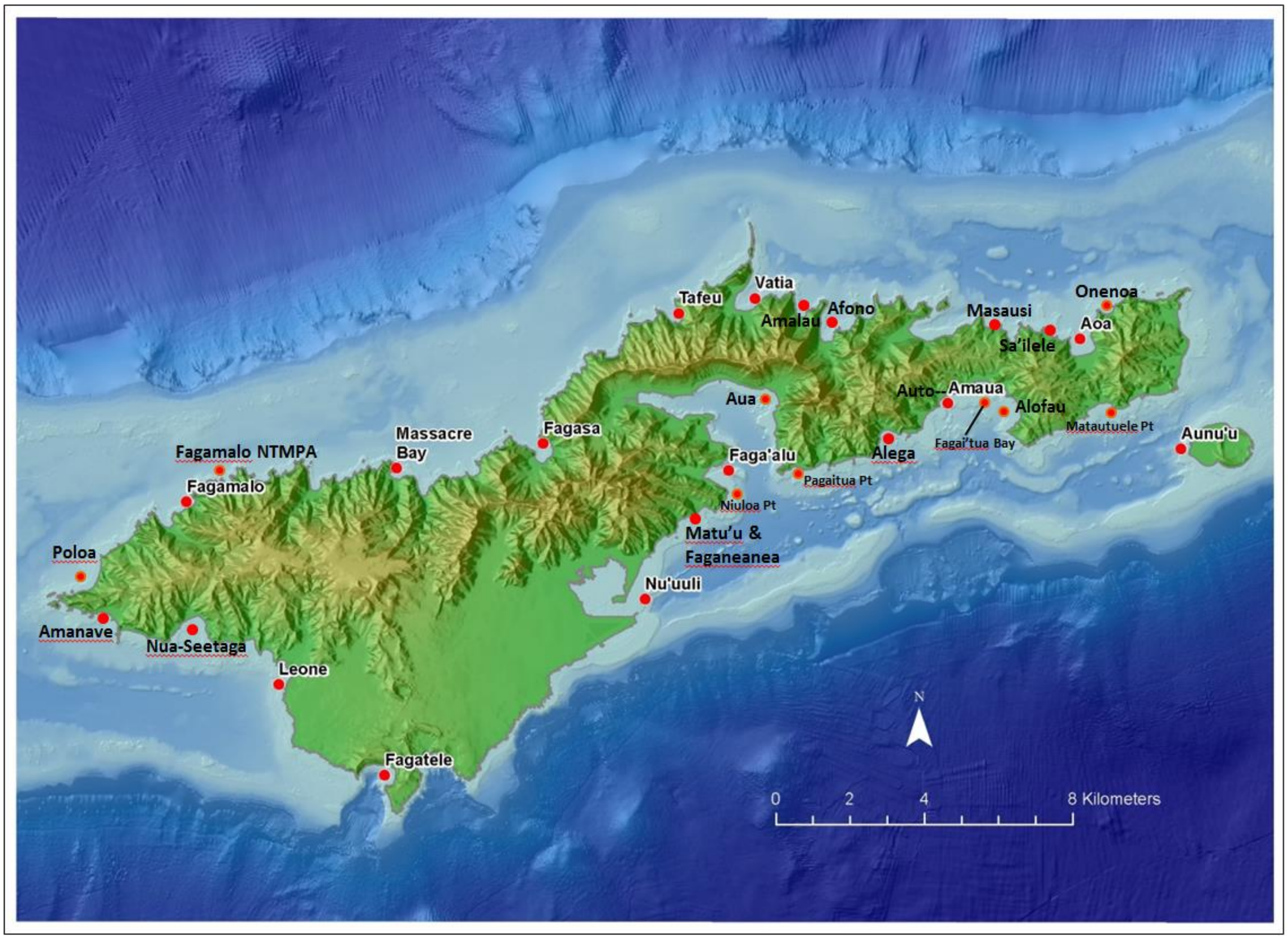


Figure 24: Integrated Coral Reef Monitoring sites on Tutuila Island, American Samoa

Monitoring Protocol (FY 2013 → FY 2014)

The new integrated monitoring protocol didn't differ greatly from the original used by the NOAA program. The main difference was with the fish surveys, where the methods were adapted to enable the local technicians to be able to conduct the surveys in buddy pairs and within the time constraints of tank air usage per dive. Reef flat surveys were also added to monitor trends in fish recruitment events and benthic habitat associations. A summary of the integrated survey methods are shown below:

- **Site location** – GPS Co-ordinates, and metal rebar at MPA sites.
- **Underwater Visual Fish Census** - 4 x 50m-long transects surveyed at each site (total 200m transect length).
- **Transect widths**
    - Large-bodied fish / predators: 20m total width (perhaps too wide? 5 m on each side, 10 m total?
    - Small and Medium sized fish (not including damselfish): 5m total width (2.5m on each side of transect tape) (where do we put the damselfish? Is there a need for this?)
    - Juvenile fish: 1m total width (0.5m on each side of transect tape)
    - Invertebrate Indicators (giant clam, COTS, urchins): 1m total width (0.5m on each side of transect tape)
- **Reef Flat & Bank sites** – sites that are characterized by fast water currents, a timed swim (for 7 minutes) covering the same belt dimensions will be conducted.
- **Fish size measurements** - The Total Length (TL), in cms of the fish is estimated (NOTE: KRSP used to use Standard Length (SL), however TL is easier to estimate underwater, and also the NOAA CRED provide biomass coefficients using TL measurements).
- **Rugosity Index** – calculated using a 15m long rugosity chain.
- **Water clarity** –the horizontal visibility is recorded along the transect tape.
- **Benthic Line Point Intercept** - benthic substrate is recorded at 0.5metre intervals along the 50m transect tape.
- **Photo-quadrat transect** - implemented when the benthic surveyor doesn't have the taxonomic expertise to undertake the LPI. An underwater camera is mounted on a 1m high frame attached to a 0.5m x 0.5m quadrat, to take a high resolution photograph at 1m intervals along the transect tape.
- **Sedimentation** – Sedimentation traps will be deployed in selected sites and regularly retrieved for sediment analyses.
- **Manta tow surveys** – Towed surveys will be regularly conducted to estimate crown-of-thorns abundance. Other modified large scale towed or timed-swim surveys will be conducted as needed, for example, to estimate sea cucumber abundance which is a developing fishery and derive estimates of stock size for fishery management policy purposes.

Monitoring Activities

Table 8 shows the monitoring surveys that were conducted at the original sites and the additional integrated monitoring sites.

Table 8: Reef Slope Monitoring Sites Surveyed in FY2013 and FY2014

Site	GPS Coordinates	Survey date FY 2013	Survey date FY 2014
Fagamalo	-14º 17.872S, -170º 48.726W	3/4/2013	
Massacre Bay	-14º 17.374S, -170º 45.577W	See *NOTE*[2]	
Fagasa	-14º 17.016S, -170º 43.383W	2/13/2013	
Tafeu	-14º 15.109S, -170º 41.354W	5/17/2013	7/15/2014
Vatia	-14º 14.888S, -170º 40.205W	5/15/2013	
Aoa	-14º 15.474S, -170º 35.332W	2/27/2013	8/8/2014
Aunu'u	-14º 17.076S, -170º 33.818W	12/10/2012	
Amaua	-14º 16.418S, -170º 37.312W	11/29/2012	8/15/2014
Faga'alu	-14º 17.404S, -170º 40.598W	See *NOTE*[2]	
Nu'uuli	-14º 19.287S, -170º 41.850W	See *NOTE*[2]	
Fagatele Bay	-14º 21.859S, -170º 45.753W	11/28/2012	
Leone	-14º 20.534S, -170º 47.339W	11/27/2012	
Integrated Monitoring Survey Sites			
Alega (vMPA)	-14.28158333, -170.6378833		10/1/2013
Matu'u (vMPA)	-14.303483°, -170.687318°		10/2/2013
Poloa (vMPA)	-14.31541667, -170.8357667		10/10/2013
Sailele (vMPA)	-14.254883°, -170.597833°		10/8/2013, and 8/13/2014
Amalau (vMPA)	-14.249783°, -170.655483°		7/18/2014
Amanave (vMPA)	14.32613333, 170.8323167		1/23/2014

***NOTE*[2]**: *The fish monitoring position was vacant between September 2012 and January 2013. All FY 2013 surveys not completed due to boat out of service between January 2013 and October 2013, however a local fishing boat was utilized to complete sites where possible*

***NOTE*[3]**: *All FY 2014 surveys not completed due to boat out of service between January 2014 and November 2014, however a local fishing boat was utilized to complete sites where possible (mostly on North side)*

Data Analysis

The data analysis files produced by Ben Carroll were unfortunately not passed on to DMWR, therefore it is difficult to make direct comparisons with the biomass data presented in the previous pages of this report. Data analysis that has been conducted during FY2013 is presented below.

Changes in average length of targeted fish

The top 5 fish species that have been recorded during coral reef monitoring surveys are *Acanthurus nigricans, Ctenochaetus striatus, Naso lituratus, Scarus oviceps,* and *Cholorurus japanensis.* The data for these 5 species were extracted from the coral reef monitoring datasets that were recorded between 2005 to 2012. The general trend shows decreasing size for all 5 of the fish, apart from *Scarus oviceps* which shows an increase in size between 2008 and 2010-2012. The largest change in average length was observed with the two parrotfish species *Scarus oviceps* and *Cholorurus japanensis*. These results could potentially be due to fishing activities, however more work needs to be undertaken to analyze the Commercial Biosampling database to assess the coral reef fish stocks. A workshop was attended by Alice Lawrence and other DMWR staff during the WPRFMC plan team meeting in April 2013 to learn about how use length-based mortality estimation to assess the fish stocks in American Samoa. Further work is being continued by DMWR to follow up with this to assist with informing fish size limits and Allowable Catch Limits.

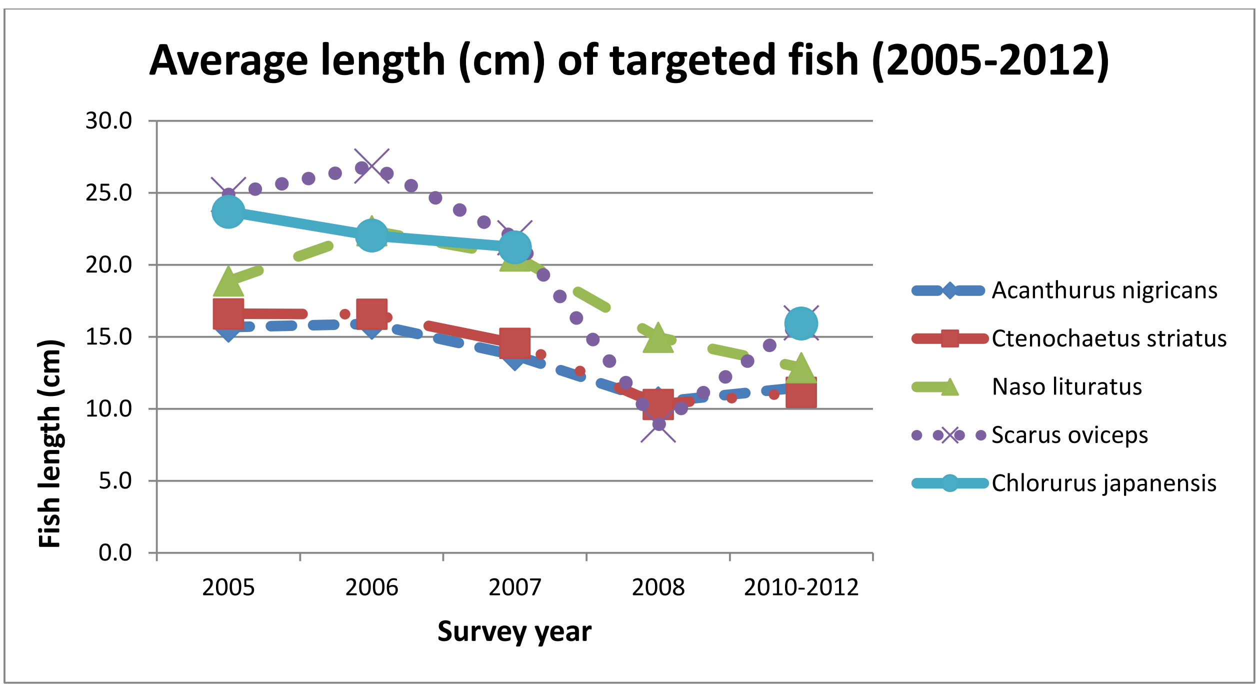


Figure 25: Average length of 5 targeted reef fish as observed by coral reef monitoring surveys (2005-2012)

Commercial Spearfishing effort: An opportunity was provided by the NOAA PIFSC -led Commercial Biosampling Project to analyze spearfishing data with the coral reef monitoring survey data and GIS software was used to present the initial results. The Commercial Biosampling Database provides a wealth of biological information including fish species names, length, weight, sex, and gonad weight, in addition to socio-economic information such as fishermen names, areas fished, number of hours fishing, fishing method, number of fishermen in a boat, and quantities of bait, fuel and ice used. Initial biological data analysis has been undertaken to geographically visualize subsets of the data to determine potential differences between fishing zones in relation to productivity, composition of key fishery species, average fish length and total weight in addition to investigating trends in seasonal spawning patterns. The information provided by the fishermen about the fishing areas usually covers a broad area and therefore the zones depicted are a general estimate of the actual fishing locations.

The fishing grounds were separated into 8 key biogeographic zones, and the data for each of the fishing areas were assigned to the relevant zone. Catch Per Unit Effort (CPUE) for different fish species is calculated within the database by using the total catch weight (in lbs) per fishermen hours, which is represented on a monthly basis. The annual average CPUE for each of the fishing areas was collated into the 8 zones and mapped with the Marine Managed Areas (MMAs) GIS layer.

Average fish biomass: The average fish biomass recorded at each monitoring survey site was calculated and mapped using a blue fish symbol, with the circle sizes representing biomass values. This data was overlaid onto the commercial spearfishing CPUE map using the GIS software, as shown in Figure 26. The sites with the highest biomass are mostly found within MMAs and in areas where the CPUE or fishing effort is lowest, as would be expected, however there are exceptions and no obvious trend is shown with the non-MPA monitoring sites.

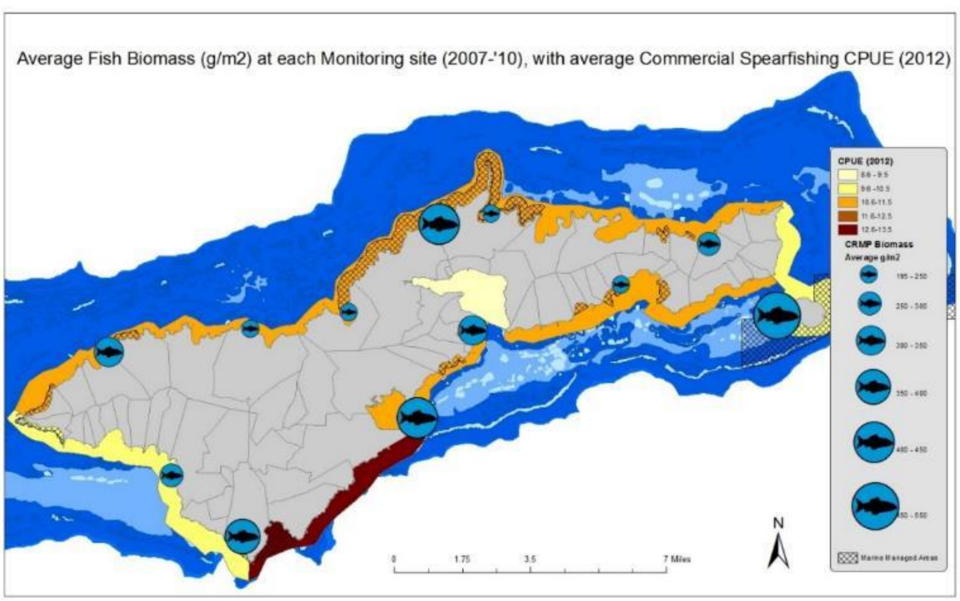


Figure 26: Average fish biomass from coral reef monitoring surveys in comparison to spearfishing CPUE from 2012.

Average Length of species: Figure 27 shows the CPUE in each zone along with data on the average length of *Acanthurus nigricans* as recorded in the coral reef monitoring surveys. The highest fishing effort seems to be in the South-West zone and the lowest in the Harbor area, and on the east and west sides of the island. The larger sized *A. nigricans* were observed all along the north and south coasts which coincides with the relatively mid to high fishing effort in 2012.

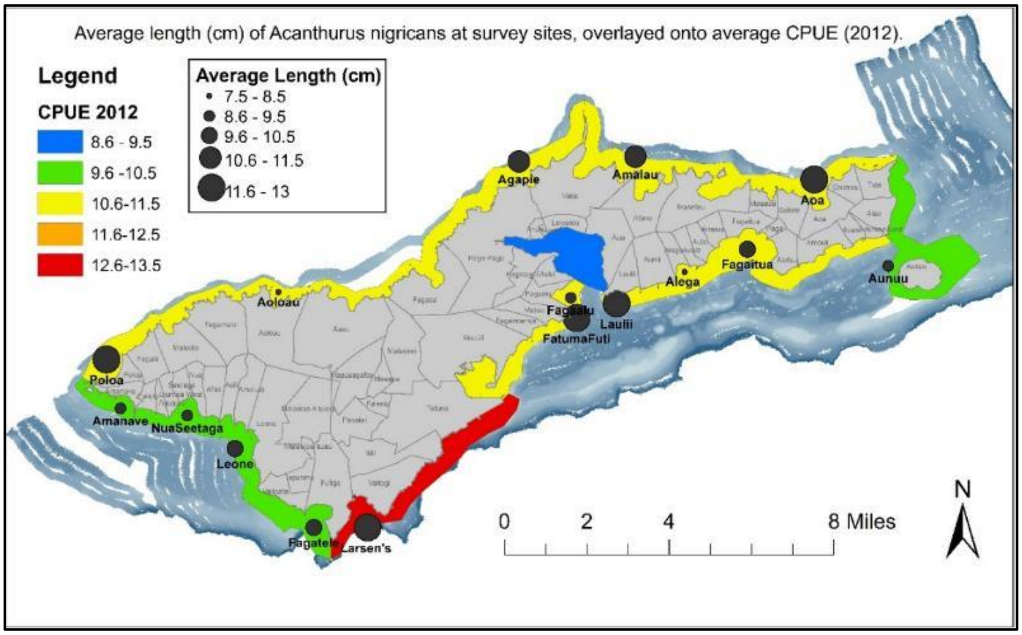


Figure 27: Average length (cm) of *Acanthurus nigricans* at survey sites, overlaid onto average CPUE (2012).

Species composition and coral reef cover: Figure 28 shows how data on fish species composition can be combined with fishery-independent monitoring survey data. *Naso unicornis* dominates out of the 3 species in the north and west zones, whereas *Chlorurus japanensis* dominates in the south central-east areas. Analysis at a finer scale, comparing fishing areas within these larger zones could also be useful to help understand correlations with benthic habitat.

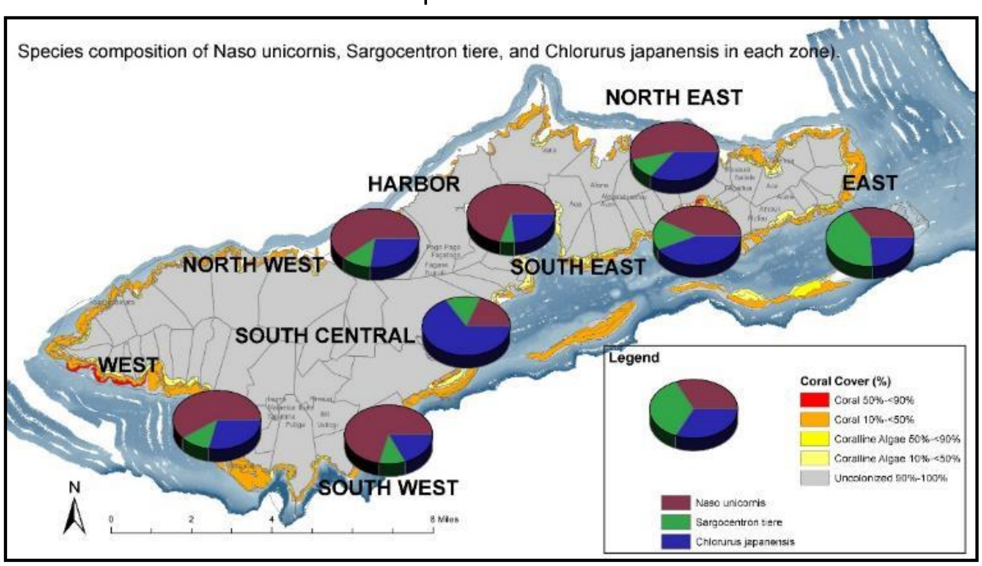


Figure 28: Species composition of *Naso unicornis, Chlorurus japanensis* and *Sargocentron tiere*

Fish Consumer Group composition: Figures 29 and 30 show the composition of each of the 4 consumer groups at each coral reef monitoring site, presented with percentage coral cover and the MMA sites. Numbers on the map represent the average number of fish recorded at each monitoring site. The map shows a similar consumer group composition at each survey site, although slightly higher percentage composition of Piscivores are shown at the survey sites located along the South-east and North-east coastlines. Higher composition of Primary Consumers (herbivores and detritivores) are found on the North-east and North-west coastlines. The highest percent composition of Planktivores are found at the Aunu'u site, which may be explained by its location at an offshore island which is exposed to higher flow of ocean currents. Likewise the slightly higher percentage composition of Planktivores at the 2 South-Westerly located sites, may also be explained by their exposure to prevailing South-Westerly winds.

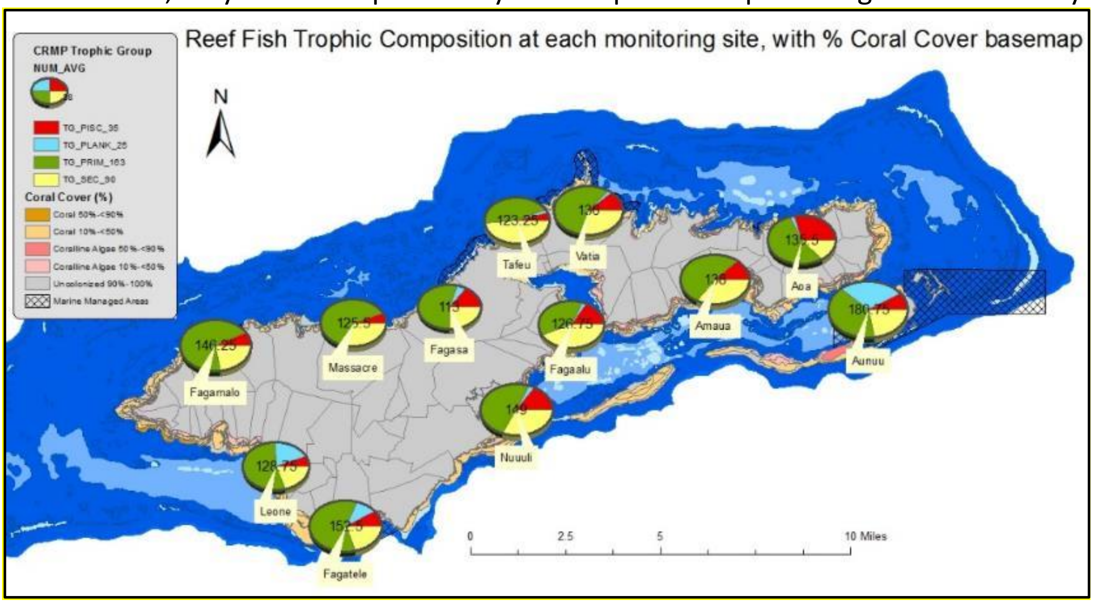


Figure 29: Reef fish trophic composition at each monitoring site, with % coral cover basemap

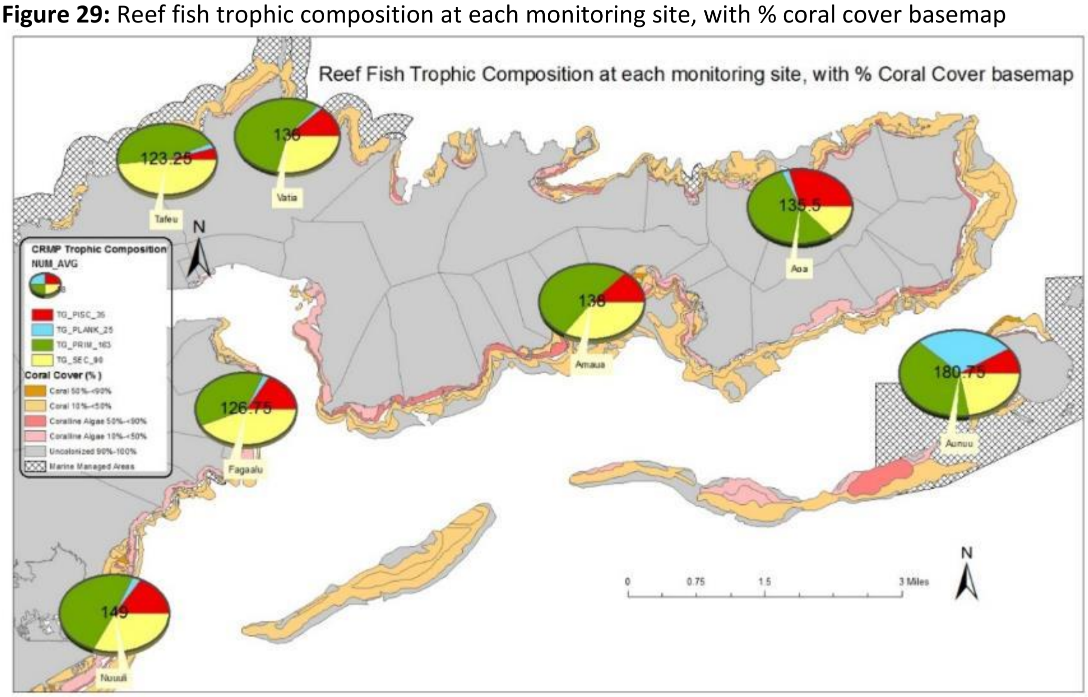


Figure 30: Reef fish trophic composition at each monitoring site, with % coral cover basemap. Zoomed in view.

Seasonal trends in spawning periods: Using the Commercial Spearfishing data the Gonadosomatic Indexes can be calculated using the gonad weight and the total weight of the fish. This is conducted for 10 species as part of the Commercial Biosampling Program. Figure 31 shows the average Gonadosomatic Index (GSI) of *M. murdjun* during the austral summer and winter time, in addition to the differences in average weight (lbs) across the fishing zones. The higher GSI during the summer indicates that the species is likely to spawn during the summer months, however there is no obvious correlation between the spawning areas and the zones with the highest average weight. More work needs to be conducted for the other fish species including parrotfish and grouper species to identify spawning periods in order to consider potential temporal management measures in the Territory.

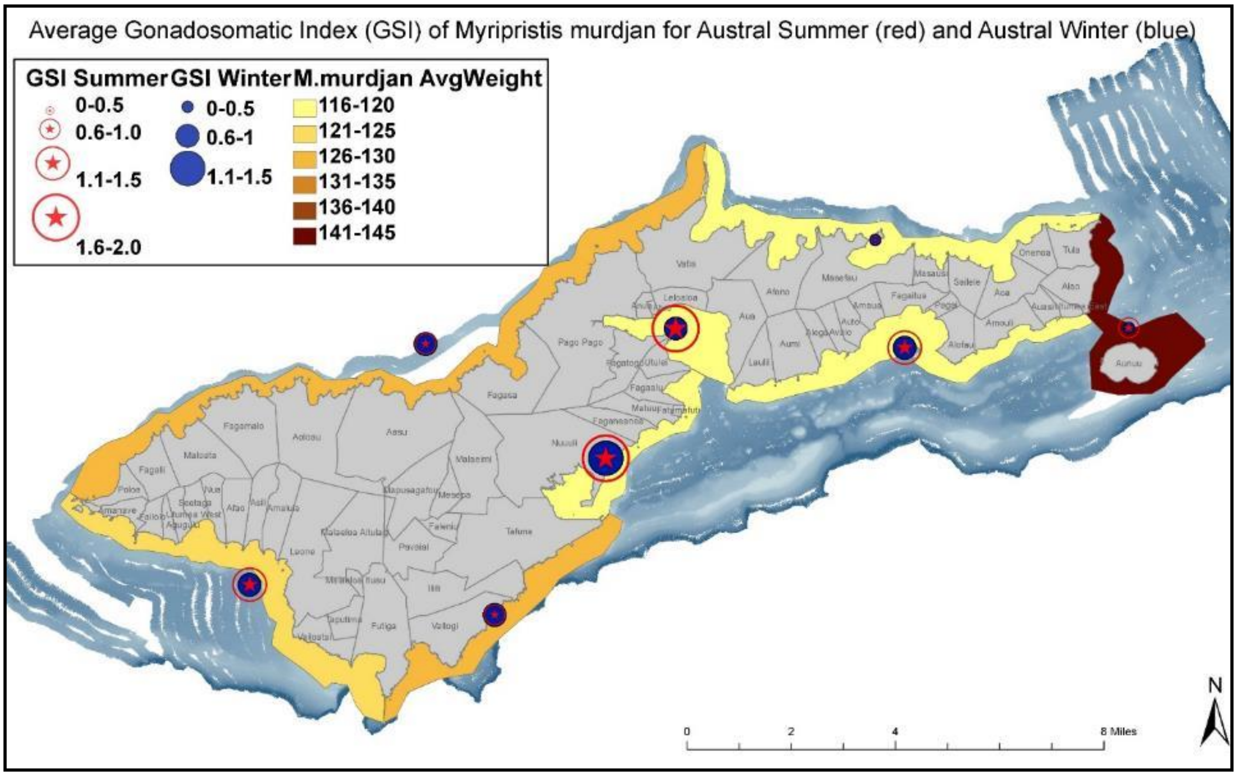


Figure 31: Reef fish trophic composition at each monitoring site, with % coral cover basemap. Zoomed in view.

Technical Assistance

Capacity Building - The integration of the monitoring programs resulted in project staff conducting training workshops for the DMWR technicians, which included fish size estimation, fish coral and invertebrate ID training, survey methods, and dive safety drills and deployment of Surface Marker Buoys (SMBs) and signaling mirrors. Data entry and basic data analysis skills will also be included in addition to training on the use of the Coral Point Count for excel (CPCe) software to analyze benthic quadrat photographs. Program staff have also worked on coordinating training workshops led by offisland organizations including the Coral Finder ID workshop led by Russell Kelley, in addition to a CRAG-funded project in collaboration with Dr. Greta Aeby which aims to train the coral reef monitoring team to competently identify and survey coral diseases. Program staff have also collaborated with NOAA CRED staff Dr. Bernardo Varagas-Angel to conduct a training workshop on coral demographic survey techniques. Program staff have been working with NOAA CRED to fund a monitoring database project which will integrate all the monitoring data and provide a platform for data analysis and reporting as well as effective data entry and quality control procedures. This project will be implemented in FY2015.

Crown of Thorns starfish outbreak - A Crown of Thorns starfish outbreak has been a territory-wide issue since late 2012 and has become a high priority for the coral reef monitoring program. Control efforts have included conducting COTS removal using SCUBA and snorkeling, and working with the National Park Service's 'Submerged Resources Team' by conducting rapid snorkel tow assessments along the 30-40ft depth contour to identify areas with COTS outbreaks. The DMWR monitoring team also conducted DropCam surveys between 50-150ft and on offshore banks and pinnacles along the SW and NW coast of Tutuila with the aim of locating large COTS populations. Program staff have attended the inter-agency COTS working group and a priority list of sites has also been developed which identifies sites which should be checked on a regular basis for COTS outbreaks, with the aim of ensuring that the high biodiversity coral reef communities are protected in the event of a Territory-wide COTS outbreak. A USFWS grant was submitted to request funds for a COTS control program run by DMWR, and staff are continuing to work on the NEPA approvals prior to initiating the project. Further efforts have been undertaken to raise the profile of the COTS issue with the Governor and the ASG leaders through the production of a Statement of Concern and the coordination of VIP field trips to visit the sites affected by COTS. Figure 32 shows the distribution and densities of COTS populations around Tutuila in December 2013.

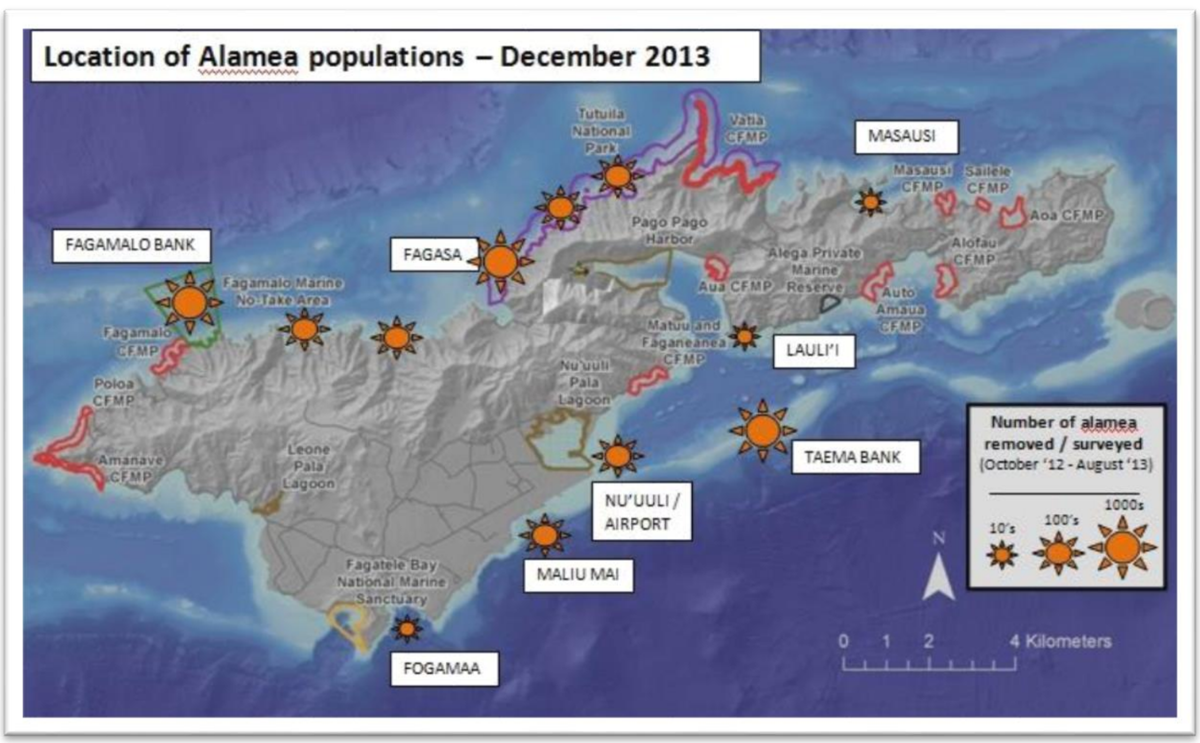


Figure 32: Location of Crown of Thorn Starfish populations as of December 2013

Sea Cucumber Surveys – Since early 2013 an additional problem in the Territory has been the initiation of a large-scale commercial sea cucumber fishery which resulted in local fishermen collecting large quantities of all species of sea cucumbers from the reef flat and reef slope areas around Tutuila and Manu’a. The cucumbers were being removed in large quantities and were being processed and exported to Asia as part of a lucrative commercial operation. Alice Lawrence coordinated DMWR staff to conduct reef flat surveys to determine sea cucumber densities and a Sea Cucumber Health Assessment Report was completed, in addition to working with DMWR staff and agency lawyers to develop and pass a Sea Cucumber moratorium which came into effect on 4th December 2013. Alice also assisted with developing educational materials and participated in a media campaign to raise awareness about the issue, which included participating in a local TV chat show, providing information and interviews for newspaper and radio coverage as well as information for an education workshop with the village mayors. Activities were conducted in collaboration with the DMW enforcement division and staff from the Port Authority to ensure that export of the products were not successful.

Figure 33: Sea cucumber catch confiscated by DMWR in December 2013

Pago Pago Harbor Red Tide events – Program staff coordinated efforts to investigate the red tide event which occurred in September and October 2013. Activities included taking water samples from 12 different sites around the inner, middle and outer harbor which were then analyzed for nitrate and phosphate concentrations. Staff coordinated with Don Vargo at the ASCC Land Grant and microscopic examination revealed the abundant presence of a single-cell organism. A photograph was sent to Dr. Steve Morton, head of the Marine Biotoxins Program based in Charleston, South Carolina. Dr. Morton identified it as *Prorocentrum micans*. Program staff were also involved with sampling dead fish, in addition to producing press releases and conducting TV and radio interviews.

Attendance of Regional Monitoring Meetings and Coral Reef Science Meetings

- Doug Fenner attended the Australian Coral Reef Society conference in August 2011
- Doug Fenner attended the 12th International Coral Reef Symposium held between 9-13 July 2012 in Cairns, Australia.
- Doug Fenner and Ben Carroll attended the Western Regional Fishery Management Council Plan Team Meetings in Honolulu in April 2011 and April 2012.
- Alice Lawrence and Salotonga Tofaeono attended the Australian Coral Reef Society conference in August 2013
- Alice Lawrence attended the Western Regional Fishery Management Council Plan Team Meetings in Honolulu in April 2013 and April 2014.

Local Action Strategy

Temporal monitoring of coral reefs has been identified as a cross-cutting issue for all American Samoa LAS's. For example, in the Fisheries LAS, "Project 4: Improve fisheries and other marine resource monitoring", Action B is to: "Implement a monitoring program to include biophysical (to include fisheries monitoring), socioeconomic and assessment of governance." The present monitoring program will continue the biophysical monitoring, while an MPA Coordinator will lead the socioeconomic monitoring and governance assessment.

Applications to Management

Examples of contributions of the monitoring program to management decisions include:

- Data on fish abundance used along with data from other sources for determining annual catch limits by the Western Regional Fishery Management Council.
- Data on the presence of coral species that have been petitioned for Endangered Species status were provided to the NMFS Biological Review Board for their review of the petition.
- Tsunami damage survey information led to a rapid debris removal effort that removed cloth from many hundreds of live corals in Fagasa. Later survey showed that all corals without cloth survived and the few with cloth remaining died.
- Annual coral bleaching monitoring produced information which showed the location was ideal for bleaching studies, which then attracted research on using cooling and shading to combat bleaching, and subsequent tests of scaling these up to protect corals there from bleaching and ultimately at other locations also.
- All survey and monitoring information from this program was provided to the NOAA Coral Reef Biogeography team for a biogeographic study of the Samoan archipelago and a

subsequent report that is currently being compiled. Similar information provided helped support the choice of expansion sites for the Fagatele Bay National Marine Sanctuary.

- Monitoring data is continually shared and will continue to assist in the establishment of other MPA's in the territory.
- Information on fish abundances from this monitoring program and other sources led to the promise made by the Director of Marine & Wildlife at the Task Force Meeting to protect certain 'large' reef fish species in American Samoa (Humphead Wrasse, Giant Grouper, Bumphead Parrotfish and Sharks).
- The Monitoring Program has been active in working on the territorial priorities on coral reefs. Information from the monitoring program was important in the original decisions to choose Vatia and Faga’alu as the priority sites. The observation during monitoring of green water in Vatia bay along with the observation and measuring of a bloom of brown algae indicated that there was a nutrient problem there. Our observation of sediment-laden water entering Faga’alu and settling on corals in the bay was an important part of the decision to set it as a priority site. Vatia and Faga’alu are two of our regular annual monitoring sites.
- Project staff have coordinated monitoring work with PhD researcher Alex Messina from San Diego State University who is working on sedimentation monitoring in the Faga’alu Watershed. Sediment traps were removed and photo quadrat surveys were undertaken along the NOAA CRED transects, which is a project undertaken in collaboration with Dr. Bernardo Vargas-Angel at NOAA CRED.
- Program staff have been working with NOAA CRED to fund a monitoring database project which will integrate all the monitoring data and provide a platform for data analysis and reporting as well as effective data entry and quality control procedures. This project will be implemented in FY2015.
- Program staff coordinated with DMWR staff to conduct reef flat surveys to determine sea cucumber densities and a Sea Cucumber Health Assessment Report was completed, in addition to working with DMWR staff and agency lawyers to develop and pass a Sea Cucumber moratorium which came into effect on 4th December 2013.
- Participating in the inter-agency COTS control efforts to reduce the impact of the COTS outbreak in Tutuila.
- Coordination of efforts to investigate the Red Tide event in Pago Pago Harbor in September 2013, including taking water quality samples and sampling dead fish, in addition to producing press releases and conducting TV and radio interviews.
- Coordination of a series of marine biological assessments for NEPA assessments which included inside the Manu’a Islands harbor wharves, following a request for assistance from the Department of Port Administration (DPA) of the American Samoa Government prior to planned dredging work. Other projects have included the extension of the service wharf at the Pago Pago container terminal, extension of the alia dock at the cannery and seawall construction projects.

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