



**A PRELIMINARY ASSESSMENT
OF THE IMPACT OF THE
TSUNAMI ON THE CORAL REEFS
OF TUTUILA ISLAND**



**Department of Marine and Wildlife
Resources**

**Report Prepared by:
Douglas Fenner, Lucy Jacob,
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This report is a preliminary assessment of the impact of the tsunami that hit American Samoan coral reefs on September 29, 2009. The rapid assessment survey was intended to cover large areas of accessible reefs around Tutuila Island. The semi-quantitative survey involved a series of 5-minute timed swim transects, each covering approximately 30 m in length and 5 m in width (total of 150 m²). For each transect, percentage cover of live coral, rubble, broken corals (branching corals with broken branches and any breakage of submassive and massive corals), overturned corals and debris were recorded. The survey covered the deep (30 - 15m) reef slopes, middle fore reef slope (15 - 5m), crest and reef flats. A general description of the reef was also conducted by one of the divers (Dr. Fenner). A total of 13 reefs were surveyed. Thirteen were reef flats with two sites having crest and slope sites surveyed. Eight of the reef sites had semi-quantitative surveys and the remaining five have a general description of damage.

No 'unusual' or massive fish kills were observed. There were very occasional reports of fish carried inland and one fish observed to be dead with bruising. On average, the major impact of the tsunami was coral breakage (36%). Large amounts of rubble cover were also recorded on the surveys (43%) composed of newly formed and existing coral rubble. Roughly 11% of coral colonies were overturned. The impact of the tsunami was variable from reef to reef and within a reef itself. Coral reefs within bays were the most impacted, consistent with oceanographic data and models indicating these sites had the highest wave height due to shoaling and funnelling effects. Based on the preliminary survey, the reef flats appear to have suffered the most impact. The reef flats in Leone, Poloa and Alofau was the most and equally impacted in terms of coral rubble and breakage. Leone also received the most terrestrial impact based on physical damage and human mortalities. The reef flat in Onesosopo had the lowest impact with less than 1% coral breakage. Initial anecdotal reports also indicated that it had one of the lowest wave heights (3 m). Terrestrial debris were present at all site but the extent ranges from minimal for most sites to significant on three sites. Preliminary observations indicated that the onshore wave force was dominant due to the inshore movement of coral colonies.

It is suggested that research and rehabilitation programs need to be established and/or enhanced in order to determine the long-term impacts of the tsunami and to attempt to



mitigate for these. Recommendations include immediate coral damage mitigation through the removal of debris such as clothing and ropes that have attached to living corals especially in the reef flats. This could be done by community members and other volunteers but assistance and leadership from Government agencies. The provision of snorkelling equipment would greatly help. Live coral rubble and fragments could also be reattached (e.g. using wire frames and cement) to the substrate similar to previous coral reef rehabilitation techniques. However, this would need to be done as soon as possible. At the minimum, growth and mortality of affected coral colonies need to be monitored. To facilitate coral reef recovery, potentially damaging activities such as destructive fishing practices should be avoided and marine pollutants managed effectively. Watershed management and the establishment of marine protected areas have become imperative. Long-term surveys on the impact of the tsunami on coral reefs in American Samoa are critical especially in terms of fisheries loss due to coral damage. Fortunately, baseline data have been well-established so future surveys will be important in deriving insights on the ecological impact of the tsunami.



Table 1. Semi-quantitative assessment of the impact of the tsunami on coral reefs in Tutuila Island, American Samoa.

	Percent cover, live coral	Percent cover, rubble	Percent broken corals (includes any type of breakage)	Number overturned corals	Number debris
Fagasa	16	0	73	1	34
Leone	10	53	72	43	18
Poloa	17	50	52	7	18
Alofao	30	70	25	20	
Vatia	30	49	18	6	3
Fagaitua	30	45	5		
Fagaalu	18	34	4	5	2
Onesosopo	75		1	1	
Over-all	28	43	31	12	15

Table 2. Rating of the severity of tsunami impact at each site
(0 = no impact, 1 = minimum, 2 = medium, 3 = major)

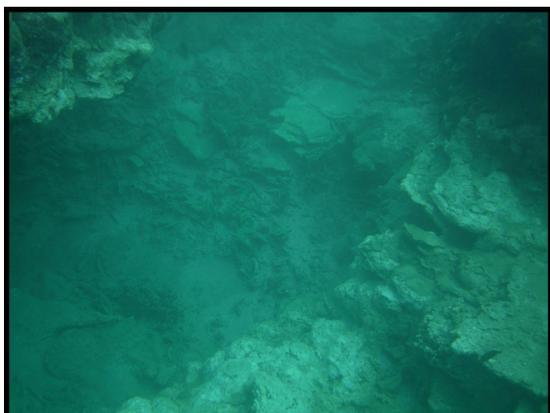
Alofau reef flat	3
Leone reef flat	3
Poloa reef flat	3
Fagaitua reef flat	2.5
Vatia reef flat	2.5
Fagasa flat	2
Fagaalu reef slope	1
Onesosopo reef flat	0
Fagaalu reef crest	0
Fagaitua reef crest	0
Fagaitua reef slope	0
Fagatele	3
Airport pool	1
Nu'uuli pool	1
Gataivai	0
Aua reef flat	0



Preliminary summary descriptions of tsunami damage at coral reef sites in Tutuila, American Samoa

Vatia

Substantial overturned rubble and new chutes scoured into the substrate. There were evidence of broken corals, sedimentation and fresh coral death. However, many corals remained healthy and attached, particularly those that were attached to mounds. Debris was minimal compared to other sites. There was some unusual bleaching of some coral colonies.



Fagasa

Many small corals (*Acropora sp.*) had broken branches and debris (clothing, ribbon, plants) were attached. Large debris included corrugated iron roofing. Encrusting corals were intact.





Faga'alu

Slope: Majority of the damage was found at 20m depth were plate corals (*Mycedium sp*) were broken and overturned. Fungiids were also overturned at this depth. Minimal damage or debris was found in shallower areas. Fagaalu pool: Staghorn coral (*Acropora muricata*) was extensively damaged.



Alofau

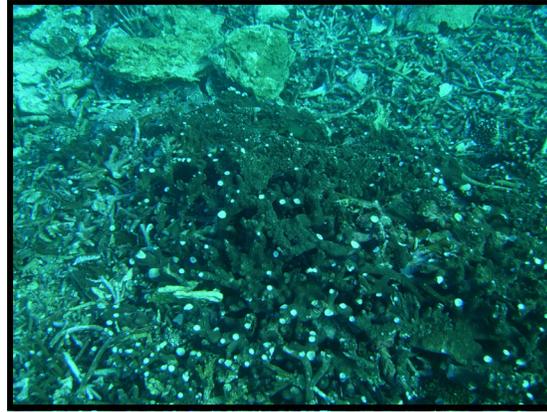
Near shore damage was present but not severe. In certain areas, severe damage included broken massives and staghorn corals. Debris was mostly nearshore and minor.





Fagatele

Extensive damage on the shelf, ridges survived and gullies were filled with freshly overturned rubble. Several large growths of the thin plate coral, *Echinopora lamellosa*, up to about 20 feet across have disappeared. Little damage below 40 feet.



Fagaitua

There were extensive damages to the staghorn coral fields and mixing of rubble. Staghorn corals were reduced to rubble and moved to other parts of the reef. Debris was minimal.





Poloa

Encrusting corals were undamaged but the majority of small branching and table corals had snapped branches. Coral reef is not well developed but the impact on extant colonies was severe. Many corals had debris attached. Large debris was also present including corrugated iron roofing.



Leone

The reef flat was dominated by damaged massive corals. Coral rubble was high. The force of the water in some areas of the reef was apparently very high with massive corals were reduced to pieces. Numerous massive corals were also overturned and in many cases broken. Some coral colonies were moved to inappropriate habitats (sandy and muddy substratum). Some colonies ended on the beach indicating the dominant on shoreward force of the tsunami.





Onesosopo

This shallow and apparently natural pool is located near the Origin gas facility in Onesosopo, and has abundant coral of a number of species in about 3 feet of water. The corals were almost entirely intact, with a very few small colonies that were not attached that were overturned, and at least one colony with broken off branches.



Airport Pool

The near shore coral reef had no detectable damage. In some areas, there were dense staghorn thickets with no breakage, in other areas there were colonies with several branches broken off. There are few table corals in the pool, but one table coral was overturned. Overall, there was damage but it was relatively light.

Nu'uuli Pool

There was lots of sand and medium pieces of dead rubble nearshore that clearly were swept in by currents. Some living large massive *Porites* colonies had damage marks from being hit by rubble or corals. In the deeper part of the pool, there was no sign of any damage. Overall, there was damage but it was relatively light.

Gataivai reef flat near the sewage pipe.

No damage to the reef flat or the corals alongside the pipeline.

Aua Transect (reef flat)

The borrow pit near shore is sandy bottomed and showed no sign of disturbance, with some of the best seagrass beds on the island intact. The reef flat is all loose stick rubble, and only a small percentage of the surface rubble had been moved at all. At the reef crest, there was very little damage to any corals, including *Acropora nana* which has very thin branches about 5 mm thick. There were a very few pieces of colonies loose or overturned on the rubble near the reef flat, or colonies that had any branches broken off.



Appendix 1

Detailed descriptions of each coral reef site surveyed and described by Dr. Fenner.

Reef Damage Rapid Assessment, Tsunami of 9/29/09 Tutuila, American Samoa

Douglas Fenner

Summary:

No effects: 2 sites

Minor effects: 5 sites

Medium effects: 1 site

Major effects: 5 sites

No effects: Gataivai reef flat, Onososopo Reef Flat

Minor effects: Airport pool, Coconut point Pool, Fagasa Crest, Alofau slope and outer reef flat, Aua Transect Reef Flat

Medium effects: Fagaalu slope

Major effects: Fagaalu Park Pool, Fagatele Bay Slope, Vatia Bay Slope, Fagaitua Bay Reef Flat, Alofau Pool and Inner Reef Flat

Very little debris from on land has so far been found on the reefs in our surveys.

Descriptions:

1. Airport pool: 9/30/09. Nearshore there was no detectable damage. On the ocean side of the pool, there were areas where there were the white disc on a staghorn where a branch had been broken off. In some areas, there were dense staghorn thickets with no breakage, in other areas there were colonies with several branches broken off. In some areas, it appeared that the strong current had rolled and mixed the living staghorns from the surface of the thicket with many dead branches from below that. The dead branches had patches of coralline algae on them, dark pink, but no filamentous algae. The dead branches predominated in these areas. The living staghorns were in a variety of orientations. There are few table corals in the pool, but one table coral was upsidedown, and two others had sand on the lower parts of their surface. So quite a bit of sand may have been flying along in the current. The nearshore part of the reef flat was checked, and showed signs of strong current- lots of sand and pieces of coral rubble that had been turned over or tumbled. Overall, there was damage but it was relatively light.



2. Nu'uuli pool: 9/30/09. Nearshore at the stairs of the grocery store, there was lots of sand and medium pieces of dead rubble, none of which was there before. I clearly had all that sand and rubble swept in by currents. A bit farther out there is an areas with some living large massive *Porites* colonies. Some had damage marks from being hit by rubble or corals. Some had chips knocked out of them, the largest chip being about 4 inches diameter. Two coral heads of about 1 m (3 feet) diameter each had been moved and were leaning against other corals or upsidedown. Those would be way to heavy to lift. Seaward of the stream delta there used to be an area of soft mud with some *Halimeda* that had very large plates. Some of the *Halimeda* could be found, but the bottom was now covered with sand with some rubble. In the deeper part of the pool, there was no sign of any damage. Where the reef flat meets the pool, there were in places a number of pieces of rubble or live coral, on the order of 1-2 feet diameter that were clearly moved and deposited there.

On the reef flat, there was evidence of strong current, with sand and small corals that were loose moved along. In the pool, one massive *Porites* had sand in dips in its surface, which when removed revealed living coral that was starting to bleach. Overall, there was damage but it was relatively light.

3. Rock wall between DMWR and the docks: 10/1/09. Corals are fine where the rock substrate was not moved, but 2/3 or more of the rocks underwater were moved or removed, and on any moved rocks there was no sign of corals. One 20-30 foot section was completely removed, with nothing left under half of the sidewalk.

4. Gataivai reef flat near the sewage pipe: 10/1/09. No damage to the reef flat or the corals alongside the pipeline.

5. Fagaalu at the park: 10/1/09.

Only minor damage to *Porites cylindrica* (finger coral). A few branches were broken off in a few places, a few small colonies thrown around. But damage to the staghorn (*Acropora muricata* = *formosa*) was extensive. There are large areas in which the staghorns were moved and broken and jumbled up with the dead staghorn that was beneath the living staghorn. The dead staghorn was light colored, had some coralline algae on it, but no filamentous algae. There are also smaller places that look like a bulldozer went through, with nothing but sand and rubble. In one spot, large amounts of sand were removed, leaving white reef rock that had been covered by sand. A depth of over 5 feet of sand had been removed from that channel through the reef.

6. Fagatele Bay: 10/1/09.

Extensive damage on the shelf, ridges survived and gullies were filled with freshly overturned rubble. Several large growths of the thin plate coral, *Echinopora lamellosa*, up to about 20 feet across have disappeared. Little damage below 40 feet.



All plants on the ground at the base of the rock wall above the beach were removed except the tree. Plants were damaged up to about 20-25 feet above the water level. The stairs were fine. Damage was extensive on the “shelf,” that is the nearly flat slope between about 10 feet deep (at the dropoff from the reef flat) and 40 feet deep. Upward projecting ridges had little damage, with live coral and coralline algae cover as before, though some coral branches were broken. Gullies and flat areas between ridges were covered with debris/rubble, most of which was a light yellow and long dead. Pieces up to about a foot diameter dominated. There is zero live coral in these debris areas. The debris appears to be debris from previous events such as the hurricanes or crown-of-thorns outbreak, which had coralline algae growing over it, but was ripped up by the tsunami and spread around. There were a few larger blocks, the largest of which was about 8 feet by 4 feet. There had been several large growths of the thin plate coral, *Echinopora lamelosa*, up to about 20 feet across, but no trace of any of those growths were found. Below about 40 feet deep it appeared that there was little damage, and most of the damage was to table corals.

7. Fagasa: 10/2/09.

Many small corals (*Acropora* sp.) had branches broken off and debris (clothing, ribbon, plants) were attached. Large debris included corrugated iron roofing. Encrusting corals were in tact.

The rock wall cladding of the shoreline above the waterline was ripped apart with boulders and rocks scattered below the wall and smaller rocks thrown over the road. The ramp was not affected. On the reef flat and upper reef slope, encrusting corals were not damaged. Most *Pocillopora* colonies were fine, though a couple had most of their branches broken off. Most *Acropora hyacinthus* recruits were damaged, perhaps around 80%. Some were broken around the edge of the table top. Others had only the encrusting base and the base of the pedestal left. Many were intermediate with significant damage to the table top. Many had clothes or grass or other human debris caught on the table. A few had dead areas in the center that were covered with dark green turf, and thus that area had died some time prior to the tsunami, probably weeks to months earlier. Many had areas around their edge that did not look healthy. Corals other than table recruits on the slope and reef flat looked healthy, but some other *Acropora* colonies had broken off branches. There were some pieces of corrugated iron roofing on the slope at around 20 feet deep. There was no sand or rubble visible. One area in a crack looked scoured with white rock surfaces. Rocks near the shore had white areas where they had been hit by other rocks. It appears that there may have been a number of rocks moved back and forth over the crest area breaking corals.

8. Vatia Bay: 10/2/09.

The eastern side was examined. There was lots of white or light brown/orange rubble in chutes on the reef slope. Such chutes began in ava-shaped (V-shaped) cuts in the



edge of the reef flat. Near the reef flat they show signs of powerful scouring, with several feet of white reef rock exposed on the lower side of the chute, and no rubble on the bottom. Farther from the edge of the reef flat, the rubble began in the chute, and extended down to around 40 feet or more in some of the chutes. There may have been some sorting so that small stick rubble was nearest the top of the slope, and pieces of table tops were near the bottom of the chute. In between chutes there were steep slopes that had coralline algae and coral and were undisturbed. In some places there were large lumps with coral on their tops and sides. *Porites cylindrica* and *Porites rus* colonies rarely had any damage, though in a few places many branch tips of *P. cylindrical* were broken off. On large colony of *P. cylindrical*, perhaps 8 feet by 4 feet, was tipped on its side, with the live branches pointing toward the center of the bay, as though it had been pushed over by water coming from the direction of the shoreline. Many tables, perhaps 20% of tables, had central areas that appeared to be a light brown and were partly filled between branchlets. Feathering water by hand revealed it was sand that had settled on the table and killed the tissue under it, so the lower sand was often black. These areas ranged from around 10 cm diameter up to nearly the entire surface of large tables over a meter diameter. Nearer to the head of the bay the chutes were larger and more abundant than out closer to the mouth of the bay. The direction of the chute of rubble was straight down the slope toward the center of the bay, so perpendicular to the shoreline, at right angles to a line from the head of the bay to the mouth of the bay. The V-shaped cuts in the edge of the reef flat that led to lower areas of the reef slope than surrounding areas was a pre-existing feature of this reef slope, that somewhat resembles spur and groove formation. The bottom of the grooves had some coral and some sand and rubble. No live coral remains in these rubble fields. It appears that the scoured chute heads were formed by large volumes of water pouring off of the reef flat, when the tsunami had covered the reef flat with a water perhaps 15 feet deep, and then the water level quickly dropped, and the water on the reef flat cascaded over the edge of the reef flat in huge volumes which scoured the head of the chute, removing large amounts of buried rubble from the head of the chute where it had accumulated from prior disturbance events such as hurricanes and/or the crown-of-thorns outbreak of 1978, and moving it down slope. Rubble on the rubble bar in the middle of the reef flat had also been moved such that white and orange rubble that had been buried there were moved to the surface. There are also some microatolls on the reef flat there, and they showed strong scour around them, exposing about 20 cm depth of white rock that had been buried.

9. Onosopopo pool: 10/3/09. This shallow and apparently natural pool is located near the Origin gas facility in Onesopopo, and has abundant coral of a number of species in about 3 feet of water. The corals were almost entirely intact, with a very few small colonies that were not attached that were overturned, and at least one colony with broken off branches. But the rest of thousands of colonies that were observed showed no damage, and there was no evidence of scour, sand, rubble or anything else indicating damage.

10. Fagaitua Bay, west side. 10/3/09.



Extensive damage to staghorn coral fields and mixing of rubble. Debris was minimal.

This shallow area also appears to be a natural backreef pool, and had extensive beds of the staghorn coral, *Acropora muricata* (= *Formosa*). As of about 2004, this continuous bed of staghorn was all alive with essentially no dead coral. Since then low tide events and bleaching impacted it, with low tides killing the highest growing branches, and bleaching killing some other corals. It had recovered partway when the tsunami struck. Now, the bed has been disturbed heavily, rolled and churned much like the staghorn in Fagaalu. In almost all of the bed, the older dead branches that had underlain the living branches now predominate in a rubble bed, with some branches of living staghorn mixed in. Most of the living staghorn consists of broken branches. There are a few small areas of about 1-2 sq meters that appear much as they did before.

11. Alofau: 10/3/09.

Near shore damage was present but not severe. In certain areas, severe damage included broken massives and staghorn corals. Debris was mostly nearshore and minor.

Near to shore on the sand flat there are several small finger coral heads (*Porites cylindrica*) that were not there before. They appear healthy, but it is not clear whether they can survive near shore. In the deep pool, some of the staghorn on mounds was moved or broken, but some is intact. In the shallow area to the west of the deep pool, damage is severe. Many of the large *Porites cylindrica* mounds were moved or broken or smashed. So much of the staghorn was tumbled, broken, and mixed with rubble that it is hard to find the staghorn areas I used to assess for bleaching. The only small patch of the staghorn *Acropora nobilis* I knew in Alofau was completely missing. Disturbance was so severe that I could not recognize where I was. An area where there was a deeper connection to the next pool to the west was scoured out and much deeper. Approaching the reef flat there is an area of *P. cylindrica* that was in the pool next to the reef flat. This finger coral was very heavily damaged, broken, tumbled, etc. The inner reef flat is unrecognizable, with scour removing considerable amounts of the rubble that was there, perhaps about 30 cm deep. A bit farther out, most of the larger microatolls remain, some with the substrate level around them lowered. A few smaller massive *Porites* heads were overturned. Farther out, a sharp line is reached where the original coralline-algae encrusted rubble bed remains, but at a sharp edge the substrate drops about 20 cm to a white rubble bed of newly exposed rubble that had been previously buried. Farther out the corals on the outer reef flat appear just as they were before the tsunami, with no visible damage. On the upper reef slope the only damage was to table corals. Most tables were undamaged, but a few had pieces broken off of their edges. Farther down the slope there were several large pieces of table corals. One *Pocillopora* had most of its branches broken off. But all other corals appeared untouched.



12. Fagaalu slope: 10/5/09.

Below about 20m, most of the plate corals (*Mycedium*) were flipped and jumbled with plate rubble, all surfaces not alive were covered with brown turf. Some fungoids (mushroom corals) were flipped upside down. In one area, healthy untouched plate *Mycedium* up slope shallower than 18 m had plates close together, and may have been better attached. There was a sharp dividing line between where plates below moved, but above they were untouched. There were some streaks where *Acropora* stick rubble was moved, with brown stick rubble revealed that was below what was removed. Past the bend on the ridge that sticks out, everything was rubble, but most had not been moved. There were a couple of sandy areas. Shallower areas were undamaged except for a few spots where corals or rubble were moved. There was no damage at the crest in just a couple feet of water.

13. Aua Transect (reef flat): 10/5/09. The borrow pit near shore is sandy bottomed and showed no sign of disturbance, with some of the best seagrass beds on the island intact. The reef flat is all loose stick rubble, and only a small percentage of the surface rubble had been moved at all. At the reef crest, there was very little damage to any corals, including *Acropora nana* which has very thin branches about 5 mm thick. There were a very few pieces of colonies loose or overturned on the rubble near the reef flat, or colonies that had any branches broken off.