CORL Coral Farm Project

National Fish and Wildlife Foundation
Final Programmatic Report

Project Name and Number: Community-Based Coral Farming in American Samoa #2008-0061-012

Recipient Organization/Agency: The Coalition of Reef Lovers - American Samoa Branch

Recipient Organization Web Address: www.corl.org

Date Submitted:

1) Summary of Accomplishments

In four to five sentences, provide a brief summary of the project's key accomplishments and outcomes that were observed or measured.

2) Project Activities & Results

If your grant agreement included an approved logic framework, paste the logic framework table here.

Activities →	Project Outputs →	Post-Project Outcomes →	Indicator →	Baseline Value →	Predicted Value of Project Output →	Predicted Value of Post-Project Outcome
1 Place 12 coral trestles 60 coral cages in 2 coral farm areas add 2 to Alofau and 10 to Nu'uuli village*	create coral nurseries in 2 villages Cleanup lagoon areas *	expand nurseries to 50 trestles and 250 coral cages each *	number installed	10	+22 trestles 60 cages	100 trestles 500 coral cages
2 Train 6 villagers in Coral Framing Methodologies *	Teach collection, fragmentation , attachment, and grow out techniques *	Provide training to other Communities with coral farming training*	number of villagers trained	11	17	35
3 propagate and grow out 6,000 corals *	propagate and grow out a total of 6,000 corals consisting of at least 12 different species for	produce a steady supply of 50,000 corals annually for sale to the Marine Ornamental	number of corals sold to the MOI	0	6,000	50,000

	sale to the Marine ornamental industry *	Industry*				
4 Propagate 4 most common species of lagoon corals for rehabilitation areas*	propagate 6,000 corals to place in targeted rehabilitation areas 5 corals per square meter 100 meters% of villages*	increase coral cover .5% during project period in targeted areas plant 3,000 corals per village 5/sq meter restore 600sq meter per village *	corals planted onto the reefs and % coral cover	0	6,000	100,000
5 **Collect mortality data on propagated coral species from collection to post planting in rehabilitation areas***	increased scientific knowledge on coral rehabilitation efforts*	a better understandin g about true cost of coral farming and reef rehabilitation efforts*	% of coral mortality	20%	20%	<10%
6 Water Pollution identification track sources of pollution entering lagoon areas*	decrease nutrient pollution*	Reduction in the sources of nutrient pollution entering the lagoons*	actual water analysis measurement s nutrients	1 base line establishe d Alofau Village	2 base lines establishe d	20% reduction in nutrient pollution
7 Find buyers for the Maricultured corals*	Develop a green MOI product from American Samoa*	decrease demand of wild collected corals in the MOI deter any wild collection and export of corals from American Samoa*	Number of buyers, Number of aquacultured corals sold	0, 0	5	20

Activities

- Describe and quantify the primary activities conducted during this grant (refer back to your approved logic framework, if applicable).

Activity 1: Place 12 coral trestles 60 coral cages in 2 coral farm areas add 2 to Alofau and 10 to Nu'uuli village. A total of 16 coral trestles were made out of 3/8" – ½" rebar, 6 were 1st added to Alofau lagoon each holding 5 cages (30 cages total) and 6 trestles holding 20 cages have been placed in Nu'uuli. After the Tsunami of 9/29/09 four trestles were deployed in Alofau. In addition to the trestles added to Nu'uuli's coral farm 42 cages for zoanthid colonies were created on the seafloor to grow donor colonies for sales of aquacultured zoanthids to the Marine Ornamental Industry. Enough donated materials are still on hand to make an additional six to eight more trestles and 15-20 cages are still in storage and will be placed as needed at the coral farms..

Activity 2: Train 6 villagers in Coral Framing Methodologies. This activity had three main components; 1. Three workshops were held in the participating villages of Alofau, Nu'uuli and Amouli. 2. In the water training was conducted at the Alofau and Nu'uuli coral farms, and 3. Additional "hands on" coral farm training was conducted at the land based Coral farm in Amouli village. Three workshops were held to introduce community members to the project and its goal of coral reef rehabilitation using coral farming technologies. A total of 52 community members from Alofau, Nu'uuli, and Amouli attended the workshops five residents from other villages attended. Of those attending the workshops three community members from Alofau, four from Nu'uuli, three from Amouli, and one from Auto village were taught simple coral fragmentation, attachment, grow out and planting techniques. Five volunteers also spent time at the Amouli coral farm learning how to propagate corals, tank maintenance and equipment upkeep. Many of the school children of the neighboring families have also learned about coral farming stopping by nearly every day to look at the corals in the stock tanks.

Activity 3: propagate and grow out 6,000 corals for sale to the Marine Ornamental Industry.

The total number of corals propagated for sales to the Marine Ornamental Industry during the project period was 3,361. The goal of 6,000 was not reached due to the Tsunami damage and post Tsunami water quality issues. The needed supplies to collect, fragment, attach and grow out and ship up to 7000 individual corals was acquired. The Amouli Land Based Coral Farm was the main coral farm to produce the corals for sale to the MOI. This coral farm was running very well with minimal losses (11%) before the Tsunami. On September 27th the Amouli land based coral farm had 1,892 propagated corals of 16 different species in the tanks targeted for sales to the MOI. The Amouli coral farm was running at about 30% of its capacity. Two CORL volunteer's could fragment and attach at a rate of 50-75 corals an hour, The project director Mike King can fragment and attach 200/ hour. The project target of 6000 aquacultured corals for sale to the MOI by projects end October 2009* was expected to be met by the end of the funded project period. On September 29th 2009 American Samoa was shaken awake by an 8.0-8.3 earth quake and minutes later by a Tsunami which caused much coastal damage throughout the Island. The Alofau coral farm was almost totally destroyed and the Nu'uuli coral farm partially damaged. At the Amouli land based coral farm the main problem was the loss of power, this problem and other mechanical failures in the temporary system caused the loss of 75% of the MOI destined corals. The Tsunami also was the most likely cause of the decrease in water quality at the Amouli coral farm which caused additional mortalities that exceeded 50% upon which the system was shut down and filtration modifications were undertaken to increase water quality.

Currently (2/28/10) there are 1467 corals of 27 species growing out for MOI sales at Amouli CF, 500 have are sold and will be shipped in April-May 2010. There are enough supplies on hand to propagate, grow out and ship over 7,000 more.

(* original project completion date extended to 3/28/10 after Tsunami of 9/29/09.)

Activity 4: Propagate 4 most common species of lagoon corals for rehabilitation areas. The most common lagoon hard corals in both Alofau and Nu'uuli are *Acropora formosa, Porites cylindrica* and *Acropora nobilis* these three coral species make up over 30% of hard coral cover on both lagoons (DMWR Monitoring surveys). Other corals that made up a large percentage (> 10%) of total coral cover are *Pollicopora damacornis, Acropora hyacinthus, Pavona decussate* and *Pavona frondifera.* Both *Pavona decussate* and *Pavona frondifera* are very common in Nu'uuli's lagoon in some areas making up to 60% of all coral cover, but both are rare in Alofau's lagoon), Other somewhat common corals 2-5% cover are; *Acropora teres, Porites rus, Porites lobata, Acropora asperia and Montpora sp.*

The main coral species and numbers that were placed into rehabilitation areas are shown in table below

Village	*Acropora formosa*	*Porites cylindrica*	*Pollicopora damacornis*	*Acropora nobilis*	*Pavona frondifera*	*Acropora aspera*	*Acropora Sp #2*	Totals
Alofau	1,661	1213	211	385	120	0	320	3,225
Amouli	774	0	0	0	0	394	0	1,168
Nu'uuli	50	0	0	25	0	0	0	75
	2,950	1,050	211	410	120	394	320	4,468

Table 1 Corals planted in Rehabilitation target areas

In addition to the hard corals three types of soft corals *Cladella sp, Lobophytum sp*. and several *Zoanthid* sp .were also propagated and placed upon the reef in Alofau and Nu'uuli lagoons for future donor colonies.

Activity 5: Collect mortality data on propagated coral species from collection to post planting in rehabilitation areas.

This activity tracked the mortality of different species to determine best aquaculture methods.

The mortality was tracked for each coral species batch fragmented for restoration activities and for each colony propagated for sales to the Marine Ornamental Industry (MOI). For the restoration corals the mortalities were to be recorded in two separate periods; From fragmentation to the point they were planted in the targeted restoration area. And mortalities from planting to 6 months post planting. Unfortunately the post planting mortality tracking was not possible due to the tsunami and landslide events.

The mortalities for species were also broken down by three event periods.
1). the time preceding the Tsunami of 9/29/09.

2). the period after the Tsunami up to the shutting down of the Amouli coral farm for filtration upgrades on 12/3/09.
3). the mortality after the filtration upgrades were complete.

Overall mortality pre tsunami was found to be 11%, with *Porites cylindrica* having the lowest mortality of 4.1%. and *A. formosa* had the highest at 14.3%.

Losses due to the Tsunami, power outages and mechanical failures are not included in these figures. The losses due to the Tsunami for the MOI corals were over 75%. The high MOI corals mortality was due to shock from transferring them for the High flow raceway to the stock tanks (thermal, lighting intensity, and water quality changes).

After the Tsunami mortality increased to an overall 37.4%, the restoration species that had the greatest losses were *Polliciopora damicornis* up to 71%, *A. formosa* up to 66%, and *A. nobilis* up to 24% mortality. *Porites cylindrica* had the lowest mortality of 5-12%

After the new filtration system was added mortality decreased by a substantial amount, the overall mortality being 2%. Mortality by species was *A. formosa* 8%, *Pollicopora damicornis* 5%, *Porites cylindrica* 0.1%.

Activity 6: **Water Pollution identification track sources of pollution entering lagoon areas**

Water quality testing was conducted on three streams, the Nu'uuli stream near the coral farm, Alofau's Eastern Stream, and the stream adjacent to the Amouli coral farm.

Parameter	Nu'uuli	Alofau	Amouli
Reactive Phosphate	0.72	0.52	0.41
Nitrates	0.2	0.47	0.05
Nitrites	0.012	0.012	0.009
Ammonia	0.1	0	0.2
DO	6.1	5.6	5.2
ORP	220	225	200
pH	7.6	7.4	7.5

Table 2 Water quality averages three streams

The sources of pollution were investigated and determined to be Piggeries, and several Tilapia pond(s) (Photo 4), The grey water lines found did not look like they were still in use. There was also a large amount of agricultural area near the stream and fertilizers could also be another source of nutrients.

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Activity 7: Find buyers for the Maricultured (aquacultured) corals

Several stores and two wholesalers have been contacted and have shown interest in purchasing the aquacultured corals. Currently a CD is being compiled that shows samples of the products. Upon completion copies of the CD will be sent to these stores and wholesalers. A small photo sampling will also be sent to additional stores via email when the 6,000 piece supply goal is reached.
In addition to the MOI market several scientist have asked CORL to produce specific aquacultured corals for scientific studies. One order has now been placed for 1,000 corals by Dominican University for a coral bleaching study.

- **Briefly explain discrepancies between the activities conducted during the grant and the activities agreed upon in your grant agreement.**

Due to the Tsunami of 8/29/09 and landslide in Alofau Village on 1/26/ 2010 some activities fell short of their projected goals.

Activity 1: Place 12 coral trestles 60 coral cages in 2 coral farm areas add 2 to Alofau and 10 to Nu'uuli village: The placing of trestles and cages had a project output of creating two coral nurseries in two villages. Actually three coral nurseries were either created or expanded upon. The two new coral nurseries that were created were installed in the Villages of Nu'uuli and Amouli. The Coral nursery at Alofau which was started with funding provided by the Center for Tropical and Subtropical Aquaculture was expanded in size.
The number of trestles listed in project outcomes in activity one is incorrect as the 50 trestles and 250 cages shown should have been a long term post project outcome. This post project outcome should have been the same as the Predicted value of project output, 22 trestles and 60 additional cages as there were already 10 existing trestles and 60 cages already at Alofau's coral farm. Six additional trestles were added to the Alofau coral farm bringing the total to 16; all but three of these were destroyed or damaged and unusable along with 35-40 coral cages on September 29 2009 by the Tsunami. After the Tsunami three new trestles were installed and new 10 cages bringing the total in Alofau up to 6 trestles and 30 cages. Plans were made to create and install an additional 6 trestles and 30 cages but on January 26 2010 a large land slide occurred along the Eastern stream in Alofau that deposited tons of debris, sand and silt into Alofau's lagoon. The sediment in the lagoon was up to 4" in areas near shore, and about 1" at the coral farm. Two weeks after the event turbidity was still so high it reduced visibility at the coral farm to less than two feet. Due to the land slide and resulting sedimentation all Alofau coral farming and coral reef rehabilitation activities were halted. As of February 22, 2010 the visibility has improved to about 3-4 feet. Post event monitoring at the coral farm and surrounding reef areas show a high amount of bleaching and coral mortality.

The Nu'uuli coral farm was created at the old Department of Marine and Wildlife Resources Giant Clam grow out and brood stock area. The Clam farm was shut down in 2004 and abandoned. At this site six trestles were installed along with 20 cages, an additional 42 cages were installed on the sea floor to use for the aquaculture of *Zoanthid sp*. Two trestles were damaged by the Tsunami and removed to be repaired. In addition to the trestles being damaged 25 of the cages were either damaged or lost from the waves.

Activity 2: Train 6 villagers in Coral Framing Methodologies: This activity was achieved no changes occurred. Some additional benefits were realized. Five volunteers also spent time at the Amouli coral farm learning how to propagate corals, tank maintenance and equipment upkeep. Two class field trips and one youth group tour were held at the Amouli coral farm.

Activity 3: propagate and grow out 6,000 corals for sale to the Marine Ornamental Industry. With the Tsunami and its aftermath this activity was the hardest to achieve.

As this project was designed, the aquaculturing of corals for sale to the Marine Ornamental Industry (MOI) was to be conducted at the Amouli coral farm where mortality tracking by CORL and inspections by the Department of Marine and Wildlife Resources personnel could be easily done. The actual setup of this land based coral farm took longer than expected due to difficulties in the shipping of supplies, needed ground leveling for tanks, and plumbing installation problems. Even with these problems the goal of producing 6,000 pieces for the MOI was within reach and would have been met had the Tsunami not occurred. The restocking effort of corals for the MOI has been slow due to nutrient pollution issues post Tsunami. The post Tsunami nutrient and bacterial levels near shore where the intake line is located most likely caused the very high mortality rates experienced. Corrective measures were taken and a filter system was added to the system along with an Ultra Violet Sterilizer this greatly improved the survivability of the corals at the Amouli coral farm. The filter system was completed on January 14th 2010. By February 28th the system contained 1467 corals of 27 species.

It is expected that at the current production goal of 6000 corals will be reached before May15 2010 at the very latest.

Activity 4: Propagate 4 most common species of lagoon corals for rehabilitation areas. As written this activity was surpassed as 7 of the most common lagoon corals were propagated. The project outputs of producing 6,000 aquacultured corals however were not reached due to the Tsunami and aftermath.

Activity 5: Collect mortality data on propagated coral species from collection to post planting in rehabilitation areas. This activity again was only partially reached due to the Tsunami. The mortality tracking after fragmentation and for several weeks following provided good data for determining the overall survivability of corals by species. Due to the Tsunami and following nutrient problems the tracking was broken down into three periods which were linked to water quality issues. The tracking of mortality after planting the corals in the ocean was not possible due to the Tsunami and land slide in Alofau.

Activity 6: Water Pollution identification track sources of pollution entering lagoon areas. This activity was completed without any changes. One additional stream was included.

Activity 7: Find buyers for the Maricultured (aquacultured) corals. This activity was completed; the only change was the availability of the aquacultured corals will be set back a few months.

Results

- Describe and quantify progress towards achieving the project objectives or outcomes described in your grant agreement. (Quantify using indicators from your

approved logic framework, if applicable, or by using new indicators not included in the application.)

Coral Farms Created

This project resulted in the creation of three coral farms (coral nurseries) within the villages of Alofau, Nu'uuli and Amouli. The number of trestles at the end of the project period was to be 22 and the number of cages to hold aquacultured corals was to be 60. These targeted quantities were reached within the project but losses during the project led to only ten trestles and 80 cages being at the coral farms at the projects end on February 28th 2010.
The Land based coral farm set up in Amouli village assisted the Alofau village ocean based coral farm very well. Being located ¼ of a mile from Alofau (there was no suitable land available for rent in Alofau) its location made the transfer of collected and propagated corals very easy between the two Eastern coral farms. The Amouli coral farm being 35-40 feet above sea level also protected it from the Tsunami on 9/29/09.

Training Community Members in Coral Farming and Reef Restoration

The training of community members using three workshops and onsite training at the coral farms proved very successful with a total of 52 community members from Alofau, Nu'uuli, and Amouli attended the workshops, five residents from other villages attended these workshops. Of those attending the workshops 12 were taught collection, fragmentation, attachment, and grow out techniques. Of these twelve, three community members were from Alofau, four from Nu'uuli, three from Amouli, one from A'asufou, and one from Auto village. In addition five volunteers who missed the workshops spent time at the Amouli coral farm learning how to propagate corals, tank maintenance and equipment upkeep. As of date 28 American Samoan's (11 during the CTSA project and 17 during this project) and two non-residents (island visitors) have learned fragmentation, attachment, and grow out techniques for corals.

Propagating corals for Sale to the Marine Ornamental Industry

The propagation of corals for sale to the Marine Ornamental Industry insures a source of funding to continue the coral reef restoration and rehabilitation efforts and also helps decrease the demand of wild coral collection. The total number of corals propagated for sales to the Marine Ornamental Industry during the project period was 3,359. A total of 31 species (estimated as some corals propagated could be the same species with different morphological differences) have been propagated that are commonly acquired by hobbyist. Because of the Tsunami and losses due to water quality issues afterward there were only 1467 corals of 27 species available for sales to the MOI on 2/28/10. Post project work is currently producing 200 to 500 additional corals a week.

Table 3 shows species collected, numbers propagated and observed mortality since the Amouli coral farm was restarted after filter upgrades. Most corals were collected from broken colonies that were laying loose on the reef or sand or harvested from colonies that had already been planted by CORL. Others were collected from imperiled colonies (corals that were being overgrown or dying), some were trimmed off of living colonies where no more than 10% of any colony was trimmed and then from the outer edges where growth is the fastest.

Species / Variety	pcs/meth	collected & fraggmented	#	Mortality 1-14 days	Mortality 15-24 days	Mortality 25-60 days	Total	% mortality species
Montipora sp 1 "neon green star"	3/trim	1/2/10	25	1	0	0	1	4.00%
*Montipor*a sp 2 "purple haze"	5/trim	1/2/10	50	0	1	0	1	2.00%
Montipora effusa	5 trim	2/7/10	50	2	0	0	2	4.00%
Montipora nodosa	5/ trim	2/16/10	45	1	0	0	1	2.22%
Montipora capricornis orange	5 lg/ imperiled	2/16/10	100	2			2	2.00%
Montipora danae	7/broken	2/16/10	50	1			1	2.00%
Zoanthid Red	8/ harvest	2/3/10	120	0	0		0	0.00%
Zoanthid Red #2	1/ harvest	2/3/10	27	0	0		0	0.00%
Zoanthid green/ blue center	7/ harvest	2/16/10	100	0			0	0.00%
Pollicopora eydouxi	3/ broken	2/3/10	25	0	0		0	0.00%
Pollicopora verrucosa	4/broken	2/3/10	75	1	1		2	2.67%
Pollicopora damicornis pink	4/broken	1/12/10	100	5	3		8	8.00%
A. nobelis green	10/ broken	2/16/10	62	0			0	0.00%
A. robusta	2/ trim	2/16/10	15	0			0	0.00%
A. grandis	3/trim	2/16/10	10	0			0	0.00%
A. nana	20/broken	1/2/10	50	1	1		2	4.00%
A. gemmifera	1/ broken	2/3/10	25	0			0	0.00%
A. cytherea	1/ harvest	2/3/10	25	0			0	0.00%
A. sp encrusting yellow	10/trim	2/16/10	35	0			0	0.00%
Psammocora contigua green	20/broken	2/3/10	25	0	0		0	0.00%
Pavona decussata	1/ broken	2/3/10	50	0	0		0	0.00%
Pavona fondifera	1/ broken	2/3/10	50	0	0		0	0.00%
Galaxea astreata	2/ broken	2/3/10	50	0	0		0	0.00%
Galaxea fascicularis	1/broken	1/2/10	28	0	0	0	0	0.00%
Turbinaria pelata	5/ broken	2/3/10	50	0	0		0	0.00%

Turbinaria reniformis yellow	2/ broken	1/16/10	75	0	0	0	0	0.00%
Porites cylindrica yellow	50/ broken	1/11/10	150	0	0	0	0	0.00%
							20	
		Total #	**1467**			**Average % species mortality**	**1.40%**	

Table # 3 Coral Species propagated for sales to the Marine Ornamental Industry, Number of aquacultured corals produced, and Mortality.

Coral Reef Rehabilitation and Restoration

The Propagation and planting of the four most common lagoon corals to increase coral cover .5% in Alofau was a major objective of this project. A total of 4,468 corals of the most common seven species were planted in Targeted rehabilitation areas in Alofau's lagoon (see Table 1. This amount fell short of the activities predicted output vale of 6,000 corals planted. The two main species planted were *Acropora formosa* 2,950 colonies 2-4" and *Porites cylindrica* 1,050 2"-3" colonies. In addition to the *A.formosa* and *A. nobilis* two other species of corals were planted in Alofau's lagoon; 1,050 Polliciopora damicornis and 120 *Pavona fondifera* were planted in dead coral thickets adjacent to the two coral farm areas. In Amouli Village 394 *Acropora aspera* were planted in front of the coral farm (photo 3). The Nu'uuli coral farm was mainly used for growing out of Zoanthid colonies and as a backup brood stock area for the Temperature bleaching resistant *A. formosa* and *A. nobilis*. Thousands of *Zoanthid sp* were propagated without a grow out holding period and placed directly within the cages that were located in a bare sandy area (see photo2).

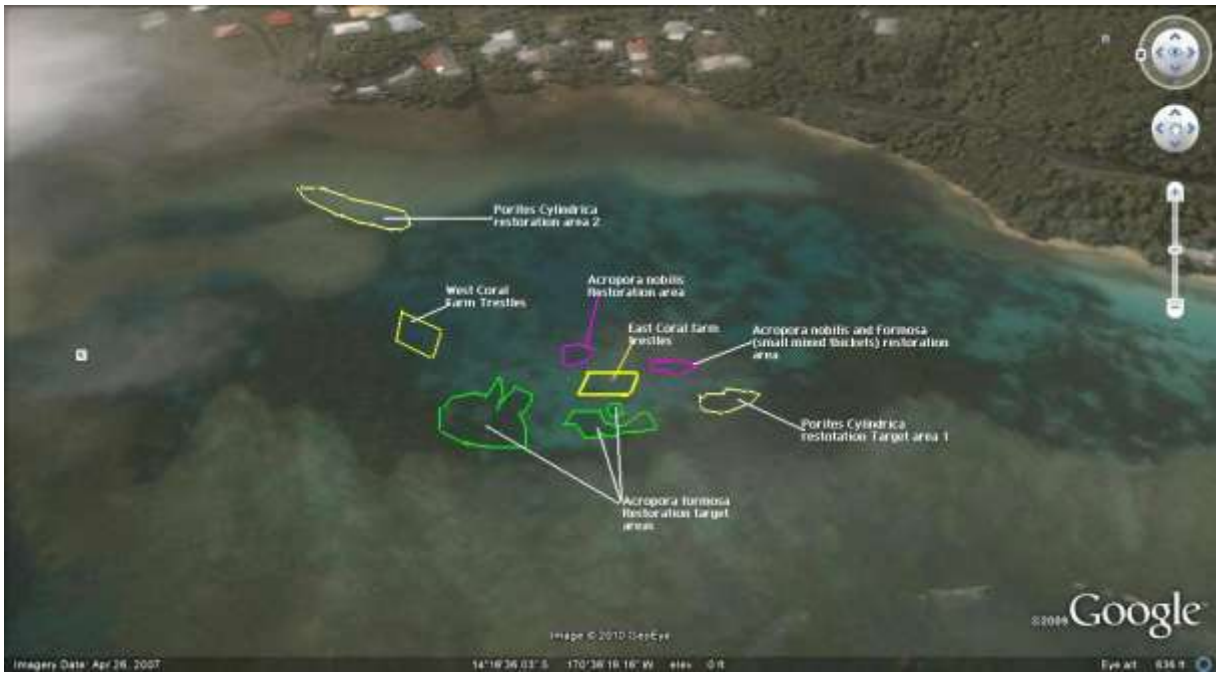

Photo 1. Location of Trestles and restoration areas in Alofau Lagoon

Photo 2. Location of coral farms in Nu'uuli Lagoon and targeted restoration areas.

Photo 3 Amouli Land Based Coral Farm and Restoration area.

The first restoration areas planted in Alofau directly west of the Eastern Coral Trestles were done at a density of 10 *A. formosa* colonies per square meter. The first batch of corals were placed upon the dead coral thicket when they reached 3"-4" in April of 09. Basically because the coral thicket was completely dead the % live coral cover was increased almost .05% upon planting. Unfortunately the Tsunami destroyed all the restoration areas and no actual measurements were conducted using the Point Count methodology which would have given % coral cover using underwater video. The corals planted post Tsunami only had a few weeks of growth before the landslide in Alofau occurred. The Amouli restoration work with *A. formosa* and *A. aspera* is only a few weeks old as of 2/28/10.

After the Tsunami CORL volunteers spent time in Alofau up righting and attaching broken coral pieces to suitable substrates, Monitoring showed that many of these corals did survive one species in particular *Acropora hyacinthus* attached to the substrate it was placed on within 3-4 weeks. Many pieces of this coral were picked up off the seafloor and wedged onto the large overturned heads of *Porites cylindrica* recent monitoring swims have reviled that these corals placed off the seafloor have survived the high sedimentation that occurred in January and are still doing quite well, while the larger colonies of *A. hyacinthus* that were only up righted have bleached, died back or are now completely dead. One note of interest on this species is that it is one of the most difficult corals to propagate and grow out. It is very susceptible to bleaching and disease when placed in land based coral farms.

Mortality Study

The first corals that were propagated were done at Alofau where a small holding tank was set up along the shore and filled with near shore water using buckets. These first *Acropora formosa* corals had a mortality rate of 28.8% When the *Acropora formosa* corals were taken to the land based coral farm and propagated the mortality dropped to 5.3%. This large reduction was most likely attributed to the improved water conditions during fragmentation

and recovery at the Amouli coral farm. The initial overall mortality was 10.2% before the tsunami event.

The MOI corals were held in high flow raceways which had a totally separate filter system from the outside coral tanks. The water quality parameters in this system were kept very constant and near optimum values for coral growth. Mortalities in this system pre Tsunami were below 2%. After the tsunami the aquacultured corals for the MOI sales had a mortality of 74.5%, this was attributed to the moving of the MOI corals from the High Flow Raceways to outside stock tanks. The rapid temperature increases and water quality changes cause most to bleach overnight and then many died from tissue regression where the flesh just fell off the skeleton.

The Tsunami destroyed the Alofau coral farm and just about all of the corals that it held along with most of the planted corals this made the mortality monitoring of both the coral farm and planted areas impossible.

After the tsunami power outages and reduced near shore water quality led to the rise of overall mortality which reached 37%. The two restoration corals that had the highest mortalities were *Acropora formosa* (33.5% to 65%) and *Polliciopora damicornis* (29% to 71%) The *Porites cylindrica* proved to be a very hardy coral with a mortality range of 5% to 39%. The actual mortality of the *P. cylindrica* was actually lower as one batch of fragmented corals was from a salvaged colony that was in very poor shape, mortalities from this colony were at the upper range (39%).

The Amouli coral farm was shut down on December 3, 2009 in order to make changes to the filtration system. A large 900 gallon filter box was made that consisted of three 100 micron sock filters, and a secondary filtration area consisting of a filter pad and chemical treatment area. In addition a 400 watt Ultra violet sterilizer was added in line with the circulating pumps. Afterwards the mortalities of those corals propagated dropped to 2% for the restoration corals. By late December the power situation had become stable and the High Flow Raceways were refilled with corals for the MOI. Mortalities in the Raceway system after the filter was added were 1.4% (see Table 3).

Stream Pollution Tracking

Water quality testing was conducted on three streams, the Nu'uuli stream near the coral farm, Alofau's Eastern Stream, and the stream adjacent to the Amouli coral farm. The results from water testing (Table 2) show elevated levels of nutrients. Previous pollution source tracking show that the main sources of nutrient pollution in Alofau are bad septic systems, grey water lines, and piggeries located too close to the stream. Tracking the pollution sources in Nu'uuli stream reviled that the main pollution sources were Tilapia fish ponds and a piggery. Active agricultural land is also present along the stream but no farmers were on hand to ask if fertilizers were commonly used. Some old grey water lines were observed but they were no longer in use as Nu'uuli village has been hooked up to one of the waste water treatment plants. The stream in Amouli has numerous grey water discharge lines and washing areas next to the stream, most of the houses along the stream also have septic systems without proper drain fields.

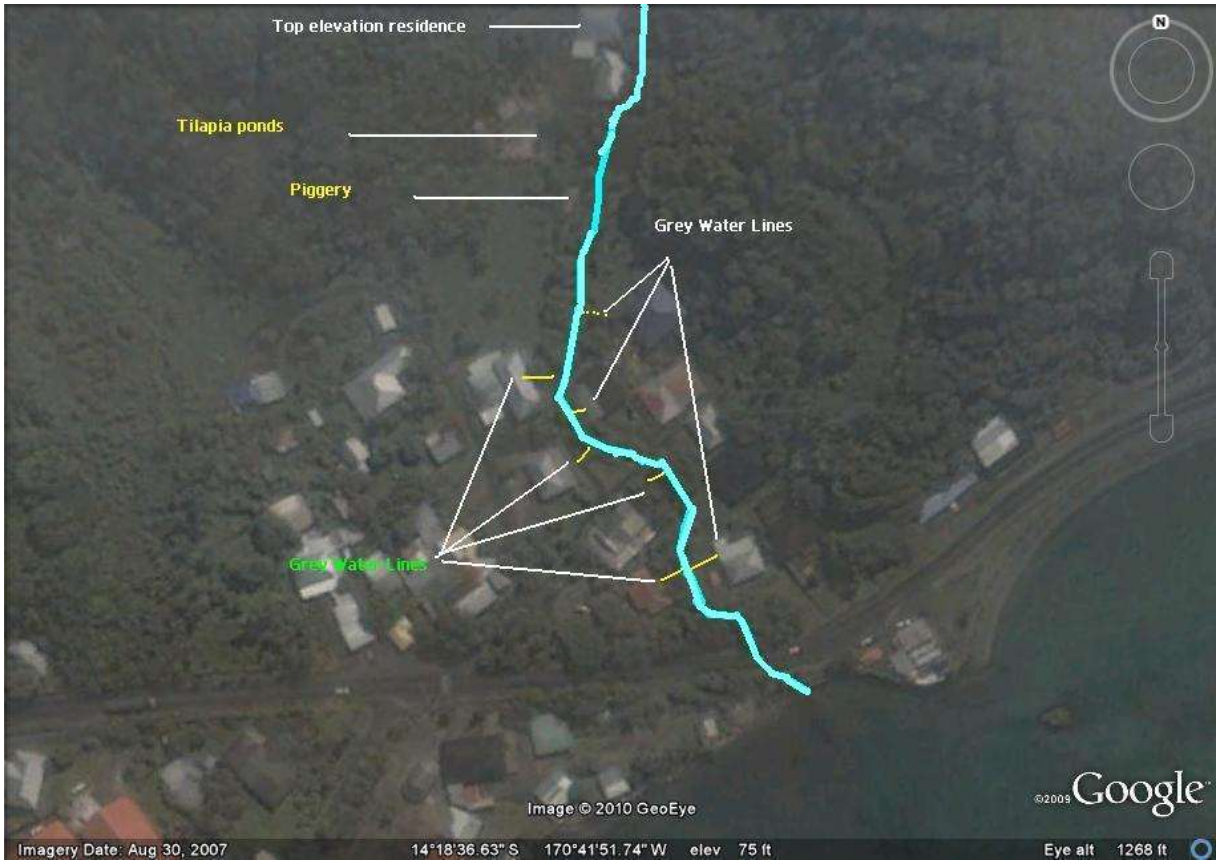

Photo 4. Nu'uuli Ocean side stream near coral farm showing approximate locations of most likely pollution sources.

Obtaining buyers for aquacultured corals

Most potential buyers have asked for photos of the aquacultured corals so they can see the product. To comply photos are being taken of the parent colonies, the mounted fragments grown under natural sunlight, and the fragments after 4 weeks of artificial light (250watt 10,000K metal halide light). In the near future a CD will be created and supplied to wholesalers, retailers, internet stores, and Marine Aquarium clubs to promote additional sales. Several wholesalers have already expressed interest in purchasing our aquacultured products. Due to competition and privacy concerns they will not be listed.
Another potential cliental base has also developed the supplying of aquacultured corals for scientific study. One order has already been placed for 980 pieces from a researcher working on coral bleaching and another researcher has asked for pricing info so he could include the cost in a proposal on effects of ocean acidification on common coral species.

- Briefly explain discrepancies between what actually happened compared to what was predicted to happen.

The main difference between what was predicted to happen and what occurred was in the propagating the planting of 6,000 aquacultured corals in coral reef rehabilitation areas and the propagation of 6,000 sellable corals for sales to the Marine Ornamental Industry (MOI). A total of 4,716 propagated corals were placed onto coral reef rehabilitation and restoration

areas and 3,359 propagated for sales to the MOI of which only 1,467 were available for sales at the project's completion.
The mortality study of corals planted in the lagoon and back reef areas in Alofau was not possible due to the Tsunami and Land Slide. The Overall mortality during the project exceeded the predicted 20%, however the final mortality rate occurring at the end of the project (2%) was far below the 20% expected.

- Provide any further information (such as unexpected outcomes) important for understanding project activities and results.

3) Lessons Learned

Describe the key lessons learned from this project, such as the least and most effective conservation practices or notable aspects of the project's methods, monitoring, or results. How could other conservation organizations adapt their projects to build upon some of these key lessons about what worked best and what did not?

Coral Farming:

The Ocean based coral farms (OBCF) need to be located near the communities they serve and in locations where the coral farm staff can work easily and safely. They need to be installed in an area where there is little or no existing coral cover with suitable water quality and movement (usually these areas are already full of wild corals). The ease of access to the community members who will be operating the CF also has to be considered. The design of trestles and cages needs to be simple and low cost yet durable (Figure 1). The ½ "rebar frames made proved to be much more durable than the 3/8" rebar frames. The metal PVC coated cage material is also more durable but its cost and shipping cost is considerably higher. The plastic mesh cages work fine if an inner support frame is attached to them, ½" PVC pipe worked well for this.

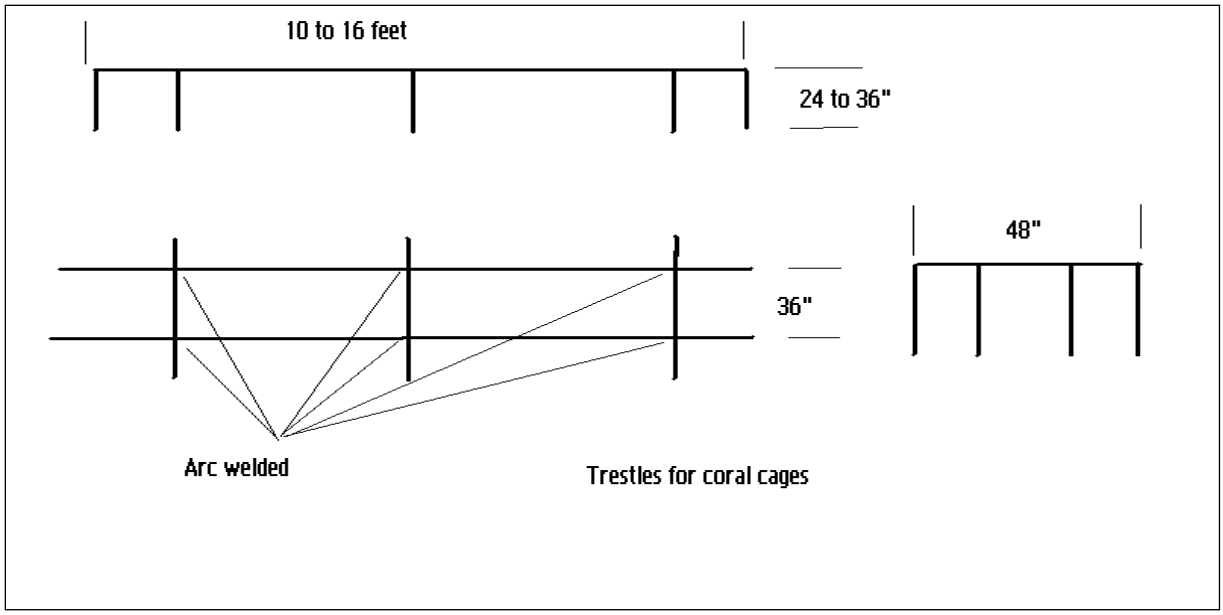

Figure 1 Trestle design.

Simplicity and ease of deployment are very important. Using common rebar that can be arc welded and bent with a piece of steel pipe makes construction of the trestles easy. Using cages allows for easy placement of mounted corals and the cage also serves as a transport carrier as it can be filled on shore and taken out to the coral farm. Black UV resistant zip ties work best for attachment to the trestles.

Creating the molds for the coral plugs is a time consuming task, but a base is needed for many corals to keep them stable during grow out. The propagation of Stag horn type corals can be done by simply gathering up broken pieces and breaking them down into 3-4" branches and sticking them into the coral cages mesh openings, when these unattached fragments reach 6-8" they can be placed in targeted restoration areas, placing within the old dead branches or attaching them with zip ties works well.

Plugs and attachment methods

The determination of what type of artificial substrate to use depends upon what the coral will be used for. MOI destined corals should always be mounted on an artificial base of some kind as required by CITES for aquacultured corals. One of the leading causes of coral mortality at the ocean based coral farm is due to the corals tipping over in the cages. To correct this problem this project created a plug design that could be easily made from common materials and would attach securely to the plastic mesh cages (figure 2.)

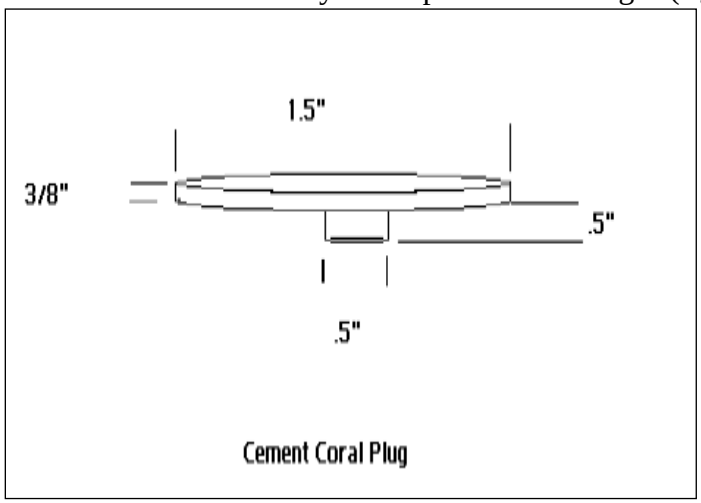

Figure 2 Cement Coral plug.

This base can be used for supplying corals to the MOI and reef rehabilitation and restoration activities. The construction of the mold can be of Marine grade plywood and completed using a drill, 1.5" hole saw and .5" drill bit. Using a wood mold requires 2-3 coats of strong hard polyurethane covering, to ease the removal of the poured cement disk a coating of auto wax followed by a light spray of coconut oil before pouring the mold. The cement should never be left in the mold more than 24 hours or removal of the plugs will be difficult. Total mold size should not exceed 4' by 3' and a flat underlayment of at least ½ inch thickness should be also used. The cement bases should be cured for 30-60 days in running fresh water to lower their pH value. Microsilica additive when added to the cement mix greatly strengthened the coral plugs and reduced breakage during removal. The best mixture used was 2 parts coral sand (one 3gallon buckets of fine beach sand sifted through common window screen) 1 part cement (1.5 gallon bucket) and 2 cups of micro silica.

Unfortunately most hobbyist and many wholesalers don't particularly care for cement bases as they are unsightly and can introduce pest into their aquarium systems. Other commercially produced bases are available made out of PVC, Ceramic, or cement.

Land Based Coral farms:
Land based coral farms are not always needed for coral reef restoration efforts; if water quality is good and a suitable area is available, then only ocean based coral farming is needed. Land Based coral farms are also costly to build and operate. Their use is critical however if the sales of aquacultured corals is to be utilized in funding any restoration efforts. The corals destined for the MOI need to be pest free and of optimum quality, to insure this they should be inspected and held in a controlled environment where conditions can be kept near optimum for several weeks prior to shipment.

Land based coral farms when used in conjunction with Ocean based coral farms can greatly reduce mortality rates when they are used as a temporary holding area for freshly fragmented and attached restoration corals. At the Amouli coral farm the cutting of donor colonies was conducted using a flowing water system where the circulated water passed through a 100 micron filter sock filled with activated carbon this helped reduce mortality from tissue regression.

Water quality at the Land based coral farms is very important, even when the intake water quality is normally good, natural disturbances can cause it to quickly degrade. Land based coral farms need to be designed and set up so they can be run as a closed system if needed, this means that an adequate filter system needs to be utilized. Equipment should be properly sized (oversized is better) and consist of Pumps, Protein skimmer, sock filters (100micron seems good for most parasite control) or other mechanical filter, an activated carbon canister or bag area, and a Ultra Violet light for bacterial disease control. The problem with all of this equipment is in the cost of its operation. I urge any other organization thinking about creating a land based coral farm to incorporate renewable/alternative energy systems into their design doing so will lower the operating cost and lessen your facilities carbon footprint. Such a system would also have a built in back up in case of a natural disaster such as the one that occurred during this project period.

The High Flow Raceways and separate closed circulation filtration system made grow out of many of the more MOI desired corals possible. Many of the corals that the aquarist desires are those that come from higher energy areas or at deeper depths than those located in the lagoon habitats. To propagate these corals their habitat must be duplicated or they must be grown in the ocean where they are found. Areas of high energy are very difficult areas to set up for growing aquacultured corals, deep areas require the training and use of SCUBA gear or boats and hookah apparatus. The Land based coral farm can easily be tailored to duplicate the deeper depths using various shade cloth densities. To duplicate the high energy areas requires more water movement. The closed system high flow raceway is one method for duplicating these higher water currents; another method is in making wave makers many aquaculture facilities utilize both methods in their systems.

Marine Ornamental Industry:
One factor most commonly overlooked in the sales of aquacultured corals to the MOI is color changes that will occur when aquacultured corals are moved from natural sunlight at their collection depth to artificial light in the hobbyist tanks. Many corals change colors, dull brown

corals under natural conditions can become colored under a 14K artificial Metal Halide lamp. Many colorful corals can also turn into a dull brown coral also. The use of High flow raceways can help in determining the color a coral will be by using the different degree K light bulbs in the grow out stage and recording color changes. By doing this and incorporating results (pictures) into promotional materials the hobbyist will have a better idea of what he is getting and there will be a higher degree of satisfied customers.

Coral Mortality:
While the study of coral mortality was hampered by the Tsunami and Land Slide a large decrease was observed when water quality issues were taken care of. The use of a dedicated fragmentation set up with water filtration also helped reduce stresses that were causing mortalities. The use of High Flow Raceways also proved to be very worthwhile in reducing mortalities of MOI corals prone to bleaching as the water temperature could be set below the bleaching threshold.

Natural disaster preparedness:
The Tsunami of 9/29/09 caused a large set back in this project. Damages to the ocean based coral farm and the project's restoration efforts were very high. After the Tsunami the loss of power prevented the circulation of water within the Amouli coral and water temperatures hit 32deg c for several days causing bleaching. Water was pumped up from the ocean using a gas powered pump for several hours a day, this worked until the gas pump failed. The coral farm did have a generator which was donated by Ace industries on Island but due to the emergency it was taken to the only undamaged East side gas station so the emergency vehicles could get fuel. My recommendation to anyone attempting a similar project is be prepared for a natural disaster to occur, and redundancy is a good thing when it comes to being ready.

Reef Restoration:
This project did show the community that they can take an active role in the health of their coral reefs. Community based coral farming of lagoon corals is possible and results can be seen. Natural disasters / events will always occur, the recovery of their reefs and associated fisheries afterward will be influenced by the communities actions to stop what stressing factors they can and their active role in restoring the habitat after the events.

The Stag horn type corals *Acropora formosa* and *Acropora nobilis* and *Porites cylindrica* are easy to propagate and grow fast under the right conditions. The planting of these corals can be as simple as placing broken pieces onto or into suitable substrates. The use of coral farms to propagate these corals works very well and large numbers can be produced in a relatively short period. These three corals make up a large percentage of American Samoa's coral reef lagoons and back reef areas.

4) Dissemination

Briefly identify any dissemination of lessons learned or other project results to external audiences, such as the public or other conservation organizations.

This project along with updates will be posted on CORL's website (www.corl.org) when it is redesigned in the near future.

Additional information on the project along with the restoration and rehabilitation efforts will be provided in a compact disk and DVD that will be supplied to potential buyers of the aquaculture products produced.

A 30-45 minute project video will be created for distribution to other organizations and marine aquarium clubs. This video was to be included as part of the matching funds but has been omitted. The Reason for this omission is the damage that the video editing computer received during the many brown outs and power failures post Tsunami has caused big delays in the production. The rebuilding of the video editing computer has been started a final project video should be completed in the summer of 2010. Upon completion copies will be sent to the NFWF. The NFWF will also be given credits for their funding of the project in the production..

This project will also be the subject of several talks to be given at marine aquarium clubs in the States and possibly at a future Marine Ornamentals conference.

5) Project Documents

a) Include with your report 2-10 representative photos from the project. Photos need to have a minimum resolution of 300 dpi.

High Flow raceway #1 showing corals for shipment to MOI

610 gallon Stock tank

Quarantine system for incoming corals

Village helpers installing intake line through culvert under the road.

Troy Fiuia Mayor of Auto village making coral plugs.

Porites cylindrica parasitic nudibranch

Zoanthid colony ready for propagation.

Acropora formosa showing new growth 4 weeks after trimming.

Volunteer sets coral trays on a trestle.

CORL destined for Marine Ornamental Industry *Montipora species* Two weeks after attachment