

Action Plan for Coral Reef Restoration in American Samoa

Draft Plan March 2021

[Plan developed by DMWR-CRAG; NMSAS; NPSA; DMWR; NFWS; ASCC; USFWS]

Project Description

Reefs provide important ecological and social services to American Samoa, and it is important to maintain the function of these ecosystems. For example, fisheries productivity, ecosystem function, biodiversity and coastal protection are very important for social / human well-being objectives. This project (Goal 1) and its associated objectives will assist the restoration of reef function in American Samoa to ensure our reefs can survive for future generations.

This Pilot Project (Goal 1) will assist the restoration of reef function through direct transplantation of corals of opportunity and selected fragments, in conjunction with field-based asexual coral propagation and outplanting. One key focus will be to improve the resilience of reefs throughout American Samoa. American Samoa has experienced numerous coral bleaching events in the past 20 years, and some of the corals have demonstrated resilience to these thermal bleaching events. For example, the reef-flat pools of Ofu and Airport Pools in Tutuila bleach and recover on an annual basis. Thus, these resilient corals continue to provide opportunities for resilience studies and have large implications for coral restoration efforts in the territory as a 'seed' source.

Over the past 50 years, American Samoa has experienced a number of acute disturbance events. This includes ship groundings, cyclones, storms, crown of thorn starfish outbreaks, and algal competition and overgrowth. Further, there is also a need for coral restoration in areas where chronic stressors have been mitigated. For example, efforts may prove beneficial in Faga'alu, where sediment pollution has been reduced through mitigation efforts at the quarry. In addition, human waste impacts may be reduced in Aua where sewage treatment infrastructure has recently been installed. Therefore, the Pilot Study and Goal 1 will be aimed at recovery of losses from acute disturbance events. Restoration from acute events will support the ecological and human/social priorities.

Finally, community involvement and engagement is a high priority, particularly in American Samoa where natural resources are managed through traditional tenure systems, but is not the primary objective of these initial efforts until the team determines technical aspects for successful restoration in American Samoa. Although, it will be a key component of any priority process from the beginning.

Priority Restoration Goal

The priority goal selected for Goal 1 of the restoration action plan is:

Reefs that are acutely impacted or where a chronic stressor has been removed will be restored to recover reef function. This goal addresses the need to respond to threats such as physical damage from ship groundings, storms, tsunamis; mortality from corallivore predation; and mortality and biodiversity loss as a result of algal overgrowth and/or aggressive species' outbreaks. Restoration efforts will focus on the recovery of reef structure, biological communities, physical characteristics, and ecosystem services (including but not limited to fish production, wave attenuation, biodiversity, and socio-cultural links with healthy reefs) to a previous baseline or state using available data.

Sites Selected for Restoration

Below is a brief description of the priority site(s) in priority order selected for restoration intervention.

Site 1 Aua; SE sector; -14.27723, -170.66897:

Rationale: Site with chronic watershed issues due to lack of contained sewage system until 2019. Major upgrades for half the village to be on sewage system began in 2019 and are continuing. Village is a territorial priority watershed. Reef has good coral cover and fish life.

- a. *Buy-in/Support/Stakeholder Engagement:*
Great community support and local buy-in, including from leadership (Mayor Muaiavaona Fofoga Pila); good volunteer capacity
- b. *Potential to provide benefits:*
Good fish nursery site with high diversity; potential to provide shoreline protection from waves; logistically easy site to access all-year round; 9 vessel groundings in adjacent harbor area (all removed)
- c. *Regulatory constraints/Management:*
Currently undergoing Government-funded sewer line upgrade and enhancement
- d. *Values (ecological, cultural, commercial):*
Site of long-term scientific interest as longest surveyed coral transect in the world; supports and provides ecosystem services to a large community.
- e. *Connectivity (i.e., sources):*
Larger bay area and potentially self-seeding; data lacking
- f. *Human impacts:*
Sewer partially connected; possible seawall extension; main stream (has 6 smaller stream outflows feeding it) has highest annual nutrient concentrations according to survey of Tutuila (2016/17), with high pollution levels- note that this was pre-sewer installations

Site 2 Leone; SW sector; -14.34224, -170.78898:

Rationale: High coral cover, with presence of ESA species and vulnerable acroporid communities. Site is exposed and faces seasonal damage from storms/cyclones. A ship ran aground in 2018 causing damage to the reef crest and flat. This was removed in early 2020.

- a. *Buy-in/Support/Stakeholder Engagement:*
Continuous interest in implementing restoration projects (despite failed restoration initiative in 2012); cooperation from local Village Council; the village previously permitted DMWR activities during periods when ocean access is banned (e.g., funerals); women's group continues clean-up of shoreline and reef area
- b. *Potential to provide benefits:*
Good fish nursery site; removal of shipwreck results in high potential to replace coral lost during grounding; logistically easy site to access but very tide dependent
- c. *Regulatory constraints/Management:*
Lack of enforcement on permitting (PNRS, EPA) for building, dumping etc.
- d. *Values (ecological, cultural, commercial):*
Tourist visitation might increase now that shipwreck is removed; supports and provides ecosystem services to a large community; mangrove swamp (21 acres area; 2.8 acres represents open water during high tide) and acts as an important nursery area and aids in water quality).
- e. *Connectivity (i.e., sources):*
Data lacking
- f. *Human impacts:*
Not connected to a sewer line; piggery waste; heavy flooding occurs during rainfall and input from adjacent streams results in pollution (includes batteries, oil, scrap metal, agricultural run-off etc.); increased development and building occurring resulting in reef sedimentation; different sides of the bay are impacted differently

Site 3 Faga'alu; SE sector; -14.290138, -170.67666:

Rationale: USCRTF and local priority watershed. Quarry impacts were mitigated (BMP improvements pending in late 2020).

- a. *Buy-in/Support/Stakeholder Engagement:*
High diversity of stakeholders might make consensus and buy-in challenging; lack of good relationships previously with leadership
- b. *Potential to provide benefits:*
Good fish nursery site; best relative reef resilience; logistically easy site to access all-year round
- c. *Regulatory constraints/Management:*
Central location and proximity to main road makes this easier to enforce and view

- d. *Values (ecological, cultural, commercial):*
National (USCRTF) and local priority watershed; recent assessments of ecological status conducted by NOAA;
- e. *Connectivity (i.e., sources):*
Data lacking; large bay so may self-seed
- f. *Human impacts:*
Quarry impacts have been mitigated; 2020 large seawall constructed around entire bay; recent *fale* developments adjacent to reef; easy access increases change of tampering but could be opportunity for community engagement/outreach

Site 4 Fagasa; NW sector; -14.28320, -170.72336:

Rationale: Large scale COTS outbreaks and physical storm damage have caused losses in coral cover and overall habitat degradation.

- a. *Buy-in/Support/Stakeholder Engagement:*
Community have expressed interest in restoration; growing positive relationship with community and leadership
- b. *Potential to provide benefits:*
Good fish nursery site; logistically easy site to access all-year round (although no boat ramp as of 2020)
- c. *Regulatory constraints/Management:*
NPS are actively involved with this community; difficult to enforce and this enforcement must originate from within the community and its leadership; community sa for the akule harvest might pose limitations
- d. *Values (ecological, cultural, commercial):*
Culturally important for the annual akule harvest; community with good local marine management strategies
- e. *Connectivity (i.e., sources):*
Data lacking; large bay so may self-seed; some potential information on directional currents
- f. *Human impacts:*
Not connected to sewer line; seawall surrounds majority of bay; high nutrient concentration in both major streams that feed directly into the bay

Site 5 Fagamalo; NW sector; --14.29719, -170.81168:

Rationale: Large scale COTS outbreaks and physical storm damage have caused losses in coral cover and overall habitat degradation.

- a. *Buy-in/Support/Stakeholder Engagement:*
Fewer community volunteers due to small population but the Community Fisheries Management Program (CFMP) is still active within the site

- b. *Potential to provide benefits:*
Good fish nursery site; long drive from Pago Pago
- c. *Regulatory constraints/Management:*
CFMP priority area; hard to enforce due to geographic location (and hard to access due to difficult environmental conditions, wave action etc.)
- d. *Values (ecological, cultural, commercial):*
ecologically important as a source of larvae for NW and W sides of Tutuila
- e. *Connectivity (i.e., sources):*
Data lacking; potential larval source for Amanave (due to westward current); some information exists on the directional currents; ecologically important as a source of larvae for NW and W sides of Tutuila
- f. *Human impacts*
Not connected to sewer line but low human population (10-20 residents)

Rationale for Site Selection

The rationale behind determining these sites as the highest priority sites includes:

Three Priority Sites:

1. **Aua** – Good level of community buy-in and support from community members and leadership. The site is highly accessible and offers a good potential as a pilot study site. The location of the village, adjacent to other villages, and along one of the main island roads makes this site and project highly visible with a good potential for transfer and interest from additional communities. Watershed issues (i.e., sewer lines) are complete for half of the village (as of late 2020).

Aua will be designated as the Pilot Study Site to identify best practices within the nurseries, determine levels of success with species and methods, and develop transferable protocols and procedures. The lessons learned during the Pilot Study will be reviewed and used to determine the next steps and revisions of objectives and plans. Then, restoration activities will be implemented at the additional priority sites.

2. **Leone** – A prior small-scale and community-led restoration project in 2012 was semi-successful (issues arose with poor placement of the nurseries, and lack of monitoring). Other projects, including removal of shipwreck, have improved relationships between the scientific and village communities in this village, and there is now a good level of community buy-in and support for further work in the village.

3. **Faga’alu** – There are a diverse level of stakeholders that utilize the reef within this community, primarily due to its accessibility in most tides and weather conditions, this increases likelihood of tampering with restoration activities. Further, this increases the importance and need for education, and engagement as a key strategy to overcome any associated challenges. Sediment pollution from the Faga’alu Quarry has now been mitigated, through an array of activities. This community and reef have high local and national level buy-in (including functioning as a USCRTF Priority Watershed).

Aua will be designated as the Pilot Study Site to identify best practices within the nurseries, determine levels of success with species and methods, and develop transferable protocols and procedures. The lessons learned during the Pilot Study will be reviewed and used to determine the next steps and revisions of objectives and plans. Then, restoration activities will be implemented at the additional priority sites.

Future Priority Sites- pending stressor management and mitigation

1. **Fagasa** – Currently the stressors are too high and not adequately managed to justify restoration. These stressors, primarily land-based sources of pollution, sedimentation, and poor water quality, must be effectively mitigated before proceeding with restoration.
2. **Fagamalo** – There is existing community buy-in through the CFMP initiative, and the community relationship is good. However, logistically this site poses many limitations. It is difficult to access geographically, with one small road, and boat transits are long. The reef is also exposed and hard to access in poor weather conditions.

Ongoing Management

The management actions and regulations already in place at these sites are:

1. **Aua** – Sewer lines are being completed throughout this village (Government project)
2. **Leone** – Special Management Area
3. **Faga’alu** – US Coral Reef Task Force and local priority watershed

Restoration Interventions

Intervention Options: A-Aua L-Leone F-Faga'alu

1. Direct coral transplantation (A/L/F)
2. Coral propagation and outplanting (A/L/F)
3. Substrate Stabilization (A/F)

We will select a range of species from the impact site, nursery, or from nearby reefs that are more resistant to bleaching and disease while also being robust against wave energy and with faster growth rates to offset sea level rise. For chronically impacted sites, we will prioritize 2 branching, and 2 massive species per site. For acutely impacted sites, we will use available fragments and colonies at the impacted site with a preference to more resilient species. We will begin by sourcing from the impacted sites which infers that we are sourcing tolerant species. Then, using lessons learned, we will begin preferentially sourcing from places that are more bleaching and disease tolerant to build a new, more robust community that is resistant to bleaching and disease. Transplants will be located across a range of depths in the site to account for sea level rise and spread the risk of climate related impacts while also ensuring sufficient depth to avoid extreme low tide exposure. Transplants will be attached using cement, epoxy or fasteners designed to withstand extreme weather events.

Asexual fragmentation and micro-fragmentation with propagation will occur in a field-based nursery. Nurseries will be located across a range of depths to allow coral to acclimatize and spread the risk of climate related impacts while also ensuring sufficient depth to avoid extreme low tide exposure. Appropriate quarantine measures and disease monitoring will be put in place to account for expected increases in coral disease. Propagated corals will be transported to the site and attached to the substrate using cement, epoxy or fasteners designed to withstand extreme weather events.

Manual macroalgae and predator removal will be done to enhance success of transplants and fragments in the nursery with expected increases in macroalgae growth due to warmer waters and nutrient runoff.

Within the Pilot Study and its objectives, physical stabilization techniques will be used to stabilize unconsolidated substrate and facilitate coral and recruitment of crustose coralline algae (CCA). Methods may include mesh, nets, or other materials attached with cement, epoxy or rebar fasteners to stabilize rubble. Methods and materials will be designed to withstand extreme weather events and projects will be located at a sufficient depth to avoid extreme low tide exposure.

Objectives and Performance Metrics

The specific objectives and performance metrics that will be used to assess project progress are as follows. A summary is provided in Appendix 2 of this Action Plan detailing the site(s), lead personnel or agencies, partners, and timeframe to complete each of these activities.

Objective 1.1: Within 3 years of the Pilot Study, 120 fragments each of 5 coral species have been propagated in three field-based nurseries with 80% survival rate of fragments. Rubble fields adjacent to nurseries will be stabilized in preparation for future out planting.

Performance Metrics:

- Number of coral fragments propagated.
- Number of coral fragments transplanted.
- Percent cover of competing macroalgae on fragments and nursery structures.
- Monthly survival rate of propagated and transplanted fragments.

Objective 1.2 At the end of 5 years of the Pilot Study, nurseries and their fragments are maintained, one nursery (of the three) is dedicated to resilient broodstock corals, and 45% of propagated corals have been outplanted at the impact area, with an 80% survival rate within each transplant site.

Performance Metrics:

- Number of coral fragments propagated.
- Number of coral fragments transplanted.
- Percent cover of competing macroalgae on fragments, transplants and nursery structures.
- Monthly survival rate of propagated and transplanted fragments.
- Percent cover per unit area, diversity (Shannon Diversity Index), and survival of coral recruits (outplants).

Objective 1.3: Within 10 years of the completion of the Pilot Study, using the lessons learned, we will scale-up restoration to the remaining two priority sites.

Performance metrics will be determined using these lessons and the data from the Pilot Study, and a revised Restoration Plan will be developed.

A summary of the objectives is provided in Appendix 2 of this Action Plan detailing the site(s), lead personnel or agencies, partners, and timeframe to complete each of these activities.

Stakeholder Engagement and Outreach

Our strategy for stakeholder engagement for this coral reef restoration plan includes:

- Work with community to evaluate nursery and restoration sites.
- Engage community members in nursery / restoration activities – could be monitoring, algal weeding, nursery maintenance, outplanting, science projects for students, etc.
- Report on outcomes to the community and gather feedback on any issues with nursery or restoration activities or suggestions for ways to improve ecosystem service outcomes.
- Develop educational presentations / materials for students, particularly in target villages (i.e. incorporate it into lesson plans / presentations/ activities).

Appendix 1. Map of Priority Sites



Figure 1: Map showing priority sites (red) and future priority sites (yellow) around Tutuila, American Samoa. Marine management areas and boundaries are displayed for reference (SMA; Special Management Area).

Appendix 2. Action Plan Summary Matrix

| Goal: Reefs that are acutely impacted or where a chronic stressor has been removed will be restored to recover reef function. | | | | | |
|--|--|-----------------|----------------------------|--|------------------|
| SMART Objective 1.1: Within 3 years the Pilot Study will be implemented where 120 fragments each of 5 coral species have been propagated in three field-based nurseries with 80% survival rate of fragments. Rubble fields adjacent to nurseries will be stabilized in preparation for future out planting. | | | | | |
| Performance metrics: | | | | | |
| <ul style="list-style-type: none"> • Number of coral fragments propagated. • Number of coral fragments transplanted. • Percent cover of competing macroalgae on fragments and nursery structures. • Survival rate of propagated and transplanted fragments. | | | | | |
| Activities | | Sites(s) | Lead | Partners | Timeframe |
| A.1 | Develop propagation, direct transplantation, substrate stabilization and outplanting protocol | Aua | DMWR-CRAG, DMWR, NMSAS | Community NOAA CRCP NMSAS | Year 1 |
| A.2 | Obtain permits for field activities | Aua | DMWR DMWR-CRAG | NOAA CRCP NOAA PIRO NMSAS USACE | Year 1 |
| A.3 | Conduct monitoring of potential nursery sites & identify source populations | Aua | DMWR-CRAG NMSAS | DMWR | Year 1 |
| A.4 | Establish three nurseries and develop and test propagation protocol | Aua | DMWR-CRAG NMSAS DMWR | NOAA CRCP | Year 1 – 2 |
| A.5 | Conduct trial substrate stabilization and direct transplantation techniques and test protocols | Aua | DMWR-CRAG NMSAS DMWR | NOAA CRCP | Year 1 – 2 |
| A.6 | Monitor coral viability in the nurseries and environmental conditions and conduct routine maintenance at the nurseries to document intervals to develop maintenance protocol | Aua | DMWR-CRAG NMSAS | DMWR NOAA PIRO NOAA CRCP | Year 1 – 3 |

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| A.7 | Conduct comprehensive review of the pilot study with technical advisory group and make any adjustments in coral species, outplanting techniques, and sites | Aua | DMWR- CRAG NMSAS DMWR NPSA | NOAA CRCP USFWS ASCC NOAA PIRO | Year 3 |
| SMART Objective 1.2: Within 5 years, the Pilot Study nursery is maintained, one nursery is dedicated to identified resilient mother colonies, 45% of propagated corals have been outplanted on existing reef at the Pilot Site, with an 80% survival rate within each site. | | | | | |
| Performance Metrics: | | | | | |
| <ul style="list-style-type: none"> • Number of coral fragments propagated. • Number of coral fragments transplanted. • Percent cover of competing macroalgae on fragments, transplants and nursery structures. • Survival rate or propagated and transplanted fragments. • Percent cover, diversity, and survival of coral recruits. | | | | | |
| A.8 | Refine propagation and outplanting protocol and schedule | Aua | DMWR- CRAG NMSAS DMWR NPSA | NOAA CRCP | Year 3 |
| A.9 | Develop and implement long-term monitoring and evaluation plan | Aua | DMWR- CRAG NMSAS DMWR NPSA | NOAA CRCP | Year 3 |
| A.10 | Identify resilient broodstock colonies (i.e., those that survived or showed resilience to thermal bleaching events) | Aua | DMWR- CRAG NMSAS DMWR NPSA | | Year 1-5 |
| A.11 | Scale-up nursery operations (i.e., increase number of fragments, and expand nurseries based on findings and evaluations) | Aua | DMWR- CRAG NMSAS DMWR NPSA | ASCC Communities | Year 4 |
| A.12 | Begin outplanting | Aua | DMWR- CRAG NMSAS DMWR NPSA | | Year 2 – 5 |
| A.13 | Implement algal removal program if necessary, to support coral transplant | Aua | CRAG NMSAS | ASCC Communities | Year 2-5 |

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|---|--|-------------------|--|-----|------------|
| | growth and improve recruitment success. | | DMWR NPSA | | |
| SMART Objective 1.3: | | | | | |
| Within 10 years of the completion of the Pilot Study, using the lessons learned, we will scale-up restoration to the remaining two priority sites | | | | | |
| Performance metrics: | | | | | |
| Performance metrics will be determined using these lessons, and the data from the Pilot Study. | | | | | |
| A.14 | Conduct final, comprehensive review of the Pilot Study with Technical Advisory Group and make any adjustments in coral species, outplanting techniques, and sites protocols and procedures | Aua | DMWR- CRAG NMSAS DMWR NPSA | | Year 5 - 7 |
| A.15 | Expand Pilot Study to two additional Priority Sites | Leone Faga'alu | DMWR- CRAG NMSAS DMWR NPSA | OSA | Year 8 - 9 |

| Management Activities | | Timeframe |
|--|---|------------------|
| M.1 | Conduct a workshop with multidisciplinary/multisectoral government/nongovernment/academic partners to review the status of non-climate and climate-stressors for nursery and outplanting sites every two years and any assumptions made in restoration planning and design. | Year 1 |
| M.2 | Determine needed requirements to apply for permits (e.g., biological assessments) | Year 1 |
| M.3 | Obtain necessary permits and inform necessary regulation bodies/agencies | Year 1 |
| M.4 | Utilize lessons learnt to scale up restoration efforts around the Territory | Year 3-10 |
| M.5 | Data management and analysis of survey and monitoring results to understand effectiveness, results and lessons learned | Year 3-10 |
| M.6 | Formal reassessment of coral restoration strategy following preliminary results | Year 3-5 |
| Community Engagement Activities | | Timeframe |
| C.1 | Ensure buy-in and support from village leadership through outreach events and community trainings | Year 1 |
| C.2 | Community engagement using student interns and/or village residents | Year 1-5 |
| C.3 | Provide annual update to village leadership on successes and challenges of project | Year 2 – 10 |
| C.4 | Reevaluate project goals based on community needs to align with scaling up operations | Year 5 |
| C.5 | Work with community to identify any additional management measures – i.e., CFMP or herbivore management rules; identifying BMPs to control LBSPs | Year 5 |

Appendix 3. Glossary of terms

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| ASCC | American Samoa Community College |
| BMP | Best management practice |
| CCA | Crustose coralline algae |
| CFMP | Community Fisheries Management Program |
| COTS | Crown of thorns starfish |
| CRAG | AS Coral Reef Advisory Group |
| DMWR | Department of Marine and Wildlife Resources |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| LBSP | Land-based sources of pollution |
| NMSAS | National Marine Sanctuaries of American Samoa |
| NOAA | National Oceanic and Atmospheric Administration |
| NOAA CRCP | National Oceanic and Atmospheric Administration Coral Reef Conservation Program |
| NOAA PIRO | National Oceanic and Atmospheric Administration Pacific Islands Regional Office |
| NPSA | National Park Service of American Samoa |
| OSA | Office of Samoan Affairs |
| PNRS | Project Notification and Review System |
| SMA | Special Management Area |
| USCRTF | US Coral Reef Task Force |
| USFWS | US Fish and Wildlife Service |