Action Plan for Coral Reef Restoration in American Samoa

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[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 is being 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, tsunami; 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 are descriptions of the priority sites in order selected for restoration intervention.

Site 1 Avau; SW sector; -14.312225, -170.697516:

Rationale: Easily accessible sandy pool with community support and proximity to Seahawk ship grounding site.

a. Buy-in/Support/Stakeholder Engagement:
Community members have shown interest; a coral nursery was established there before and failed due to a lack of continued maintenance. However, the corals on the structures thrived while the structures were standing.

b. Potential to provide benefits:
Good coral nursery site as some nursery structures succeeded in the area previously; logistically easy site to access from the main road and possessing large deep sandy pools.

c. Regulatory constraints/Management:
This area is close to the main road and village and may get a lot of recreational traffic.

d. Values (ecological, cultural, commercial):
Ecologically and recreationally important as a barrier reef for Coconut Point. Turtles graze and thrive in the calm waters of the lagoon formed by this reef.

e. Connectivity (i.e., sources):
Adjacent to a large reef flat with lots of rubble, much of which is free-living coral or fragments of living coral; data lacking

f. Human impacts:
Watershed outflow from the village is nearby and occasionally flows over the reef/pools in this area; Seawall surrounds most of the coastline of the area; Seahawk shipwreck nearby in Pala Lagoon.

Site 2 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 chance of tampering but could be an opportunity for community engagement/outreach

Site 3 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 4 Alofau; SW sector; -14.273936, -170.605085:

Rationale: Large protected bay, accessible during trade wind season, village support needs to be renewed as they formerly managed their reef through the local marine protected area program.

a. Buy-in/Support/Stakeholder Engagement:

Community support existed previously and needs to be renewed. Village used to be part of the MPA program but fell off several years ago.

b. Potential to provide benefits:

Good coral nursery site as some nursery structures succeeded in the area previously; Easy to access from the main road with a broad reef flat and lots of areas that could receive restoration work. Protected from the Southeast swell that's typical during trade season.

c. Regulatory constraints/Management:

May pose a challenge getting village approval due to lack of relationships.

d. Values (ecological, cultural, commercial):

Some areas of reef have high coral cover and resist/recover from stress events well.

e. Connectivity (i.e., sources):

Part of a large, wide reef flat with significant rubble; Some areas of reef have high coral cover; data lacking.

f. Human impacts:

Lightly populated village away from the main population centers. Human waste is managed with septic systems.

Site 5 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 members 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 6 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)

Site 7 Aua; SE sector; -14.27723, -170.66897:

Rationale: Site with chronic watershed issues due to lack of contained sewage system. Major upgrades for half the village to be on sewage system began in 2019. 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

Rationale for Site Selection

The rationale behind determining these sites as the highest priority sites

includes: **Four Priority Sites:**

1. **Avao** – 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. Moreover, a shipwreck with long-term impacts on the reef flat is adjacent to this site, and removal projects will create an opportunity for active restoration nearby.

2. **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).

3. **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.

4. **Alofau** - A small-scale restoration project was conducted here in the past and showed moderate success. This site offers good protection from the Southeastern swell that characterizes the windy season in American Samoa, and is easily accessible from the main road. This village also has good potential for community buy-in as it was formerly involved in the MPA program.

Avao 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.

3. **Aua** - As of 2024, Aua's watershed issues have continued to worsen due to septic system leakage and the degradation of old infrastructure projects. These issues are continually being addressed, but the impacts on water quality have made Aua an unsuitable site to receive restoration work for the time being. For that reason, Aua has been renamed a "Future Priority Site" as of 2024.

   An Army Corps of Engineers mitigation project to remove remnants of a former fuel depot is underway to help improve levels of fuel and heavy metals in the water, and the village is actively converting from a septic to a sewer system to manage human waste entering the watershed. Water quality will continue to be monitored in Aua, and plans for restoration will be reconsidered as conditions improve.

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-Avao L-Leone F-Faga'alu U - Alofau

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

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 toward 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 one field-based nursery with a target of 80% survival rate of fragments one year after installation. Rubble fields adjacent to nurseries will be stabilized in preparation for future outplanting, and effort will expand to additional nurseries as resources allow.

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 is dedicated to resilient broodstock corals, and approximately half of propagated corals have been outplanted at the impact area. Survival rate within each transplant site will be monitored at regular intervals, or immediately following a disturbance event, for two years.

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 at least two suitable additional sites pending village and regulatory approval.
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 the 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

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 at least one field-based nursery 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.
- Survival rate or propagated and transplanted fragments.

Activities		Sites(s)	Lead	Partners	Timeframe
A.1	Develop propagation, direct transplantation, substrate stabilization and outplanting protocol	Avao	DMWR CRAG, DMWR, NMSAS	Community NOAA CRCP NMSAS	Year 1
A.2	Obtain permits for field activities	Avao	DMWR DMWR CRAG	NOAA CRCP NOAA PIRO NMSAS USACE	Year 1
A.3	Conduct monitoring of potential nursery sites & identify source populations	Avao	DMWR CRAG NMSAS	DMWR	Year 1
A.4	Establish at least one nursery and develop and test propagation protocol	Avao	DMWR CRAG NMSAS DMWR	NOAA CRCP	Year 1 – 2
A.5	Conduct trial substrate stabilization and direct transplantation techniques and test protocols	Avao	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 develop maintenance protocol	Avao	DMWR CRAG NMSAS	DMWR NOAA PIRO NOAA CRCP	Year 1 – 3
A.7	Conduct comprehensive review of the pilot study with technical advisory group and make any adjustments in coral species, outplanting techniques, and sites	Avao	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:

- Number of coral fragments propagated.
- Number of coral fragments transplanted.
- Percent cover of competing macroalgae on fragments, transplants and nursery structures.
- Survival rate of propagated and transplanted fragments.
- Percent cover, diversity, and survival of coral recruits.

A.8	Refine propagation and outplanting protocol and schedule	Avao	DMWR CRAG NMSAS DMWR NPSA	NOAA CRCP	Year 3
A.9	Develop and implement long-term monitoring and evaluation plan	Avao	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)	Avao	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)	Avao	DMWR CRAG NMSAS DMWR NPSA	ASCC Communities	Year 4
A.12	Begin outplanting	Avao	DMWR CRAG NMSAS DMWR NPSA		Year 2 – 5
A.13	Implement algal removal program if necessary, to support coral transplant growth and improve recruitment success.	Avao	CRAG NMSAS DMWR NPSA	ASCC Communities	Year 2-5

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 site protocols and procedures	Avao	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 learned 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

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