

Draft Action Plan for Coral Reef Restoration in Commonwealth of the Northern Mariana Islands

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Project Description

The following priority goals were identified to address live coral loss and subsequent decline in reef ecosystem function from ongoing and future threats to CNMI's coral reef ecosystems. The rationale was to maintain and enhance reef ecosystem function with specific focus on coastal protection services through wave attenuation and supporting habitat connectivity and biodiversity for fisheries. Loss of coastal protection services and fisheries habitat were seen as a major concern due to the multiple stressors CNMI's reefs have endured and the impact this will have on the community. These stressors include extensive coral loss from multiple bleaching events and COTS outbreaks, degraded water quality from land-based sources of pollution, as well as damage from more acute disturbances such as storms and ship groundings. Implementing coral restoration within the CNMI is seen as a critical and necessary effort to assist coral recovery from past disturbances, and preserving and enhancing genetic diversity to increase adaptive potential to climate change impacts, which includes: increase in frequency of bleaching events, increasing storm intensity, ocean acidification, and sea level rise. Coral restoration will also compliment watershed management plans to be implemented by multiple government agencies. This includes expanding efforts to improve infrastructure for reduction of storm water runoff and flooding, reducing illicit wastewater discharges, and a NFWF funded project to support wetland restoration. These collective actions will help improve water quality conditions needed for coral recovery, and in preparation for future coral outplanting efforts.

As this action plan is a draft and is intended to be a living document, the goals, site prioritization, and objectives outlined here will be revised as needed to implement an adaptive management strategy that can incorporate lessons learned, latest research, and community priorities. The goals, objectives, and action items outlined within this draft were designed to expand upon current restoration activities, and successful implementation of pilot studies and activities that can set the stage for scaling up restoration interventions. Current restoration activities that are ongoing or in planning stages are summarized in the timeline below.

- 2018 – Funding secured by NOAA to establish a pilot ocean-based nursery in Saipan.
- 2019 – A pilot, ocean-based coral nursery completed by Johnston Applied Marine Sciences and NOAA.
- 2020 – Completed expansion of the pilot coral nursery, and first experimental coral outplanting conducted in Saipan Lagoon.
- 2020 – Financial support secured for the Saipan Coral Nursery Pilot project through 2022.

- 2020 – A NFWF Coastal Resilience grant awarded for coral and watershed restoration to be completed by 2024.
- 2021 – A second, ocean-based coral nursery installed in Saipan Lagoon, managed by the CNMI government.

The action plan was developed in cooperation between local experts, planners, and stakeholders from multiple government agencies and non-profit organizations, which included: Division of Coastal Resources Management (DCRM), Office of Planning and Development (OPD), Division of Fish and Wildlife (DFW), Mariana Islands Nature Alliance (MINA), Johnston Applied Marine Sciences (JAMS), and NOAA. Contribution by these agencies allowed for a comprehensive plan that incorporated multiple restoration projects at different planning stages and levels of implementation, as well as representing a diverse group of community, scientific, and government interests.

The following list are priority goals drafted by the restoration planning team:

Goal 1: Within 10 years, reef structure is restored or enhanced on Saipan's western side to reduce wave energy that threatens coastal infrastructure, improving the CNMI's resilience to sea level rise and increased storm events.

Goal 2: Coral populations are restored to correct habitat gaps created by land-based runoff, shoreline development, and other human impacts, in order to enhance habitat connectivity needed to support coral and reef fish recruitment under changing land and ocean conditions.

Goal 3: Within 5 years, management agencies have the ability to respond to acute reef disturbances through both rapid assessment and mitigation activities to reduce reef damage caused by coral bleaching, COTs outbreaks, storm events, or ship groundings.

Priority Restoration Goal

The priority goal selected for this restoration action plan is:

Goal 1: Within 10 years, reef structure is restored or enhanced on Saipan's western side to reduce wave energy that threatens coastal infrastructure, improving the CNMI's resilience to sea level rise and increased storm events.

Goal 1 was selected based on the current capacity to readily complete restoration work in the CNMI. Focusing on Saipan's western shoreline will serve as the initial staging area, and is logistically feasible due to the close proximity of the ocean-based coral nurseries. Coral restoration on the west side of Saipan will also compliment watershed management actions that will be focusing on the West Takpochao area (Appendix 1). This will include activities to reduce land-based sources of pollution, as well as mangrove restoration for enhancing coastal resiliency. Lessons learned from the initial restoration activities on the western coast of Saipan will help inform future expansion of restoration to Saipan's east coast, or islands to the south, Tinian and Rota.

Sites Selected for Restoration

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

Site prioritization was evaluated for 15 sites on the western side of Saipan, where initial restoration efforts are planned (Appendix 1). Overall, all sites were ranked as high for relevance to the selected restoration goal, which was to provide coastal protection services through attenuation of wave energy for the Saipan coastline. All 15 sites were also considered vulnerable to human impacts, including land-based sources of pollution, and high risk of exposure to future climate stressors. Additional criteria, such as location of essential fish habitat, availability of baseline data from long-term monitoring sites, and currently planned watershed restoration efforts were also included to represent management priorities from Division of Coastal Resources Management, Division of Fish and Wildlife, Division of Environmental Quality, and Office of Planning and Development.

The rankings for future exposure were based on models projecting annual bleaching exposure. The potential restoration sites were projected to have annual bleaching between 2033-37, however the 4-year range is not statistically significant between sites, because it falls within the level of error for climate model output. Therefore, level of future exposure was not found to be relevant in the final prioritization ranking.

The rankings differed among sites for two categories, which included resilience and potential to improve condition. These criteria were evaluated based on changes in coral cover from 2012-18, and were used to select the highest priority areas. However, site selection will be revised with the completion of a more in-depth site prioritization study of Saipan's western reefs in 2021, being conducted by Johnston Applied Marine Sciences and SymbioSeas, in collaboration with NOAA and the CNMI government. This study will assess current reef condition, resilience, and likelihood of short and long-term coral survival based on physical and biological characteristics and future climate projections, at 16 sites along the western forereef of Saipan.

Listed below are the top three priority sites, with location and rankings for a subset of the criteria evaluated.

Chalan LaoLao; west side of Saipan; 145.703287, 15.179089:

- Relevance to Restoration Goal: **High**
- Potential to Improve Condition: **High**
- Future Exposure to Annual Bleaching Conditions: **Med/Low**
- Resilience/Ecological Processes: **High**
- Human Impacts: **Med/Low**

Outside Mañagaha; west side of Saipan; 145.706099, 15.246012:

- Relevance to Restoration Goal: **High**

- Potential to Improve Condition: **High**
- Future Exposure to Annual Bleaching Conditions: **Med/Low**
- Resilience/Ecological Processes: **Med/High**
- Human Impacts: **Med/Low**

Akino Reef; west side of Saipan; 145.699012, 15.223482:

- Relevance to Restoration Goal: **High**
- Potential to Improve Condition: **Med/High**
- Future Exposure to Annual Bleaching Conditions: **Med/Low**
- Resilience/Ecological Processes: **Med/Low**
- Human Impacts: **Med/Low**

Rationale for Site Selection

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

Chalan LaoLao, Outside Mañagaha, and Akino Reef were selected as the top priority sites, because of their top rankings in resiliency and ability to improve condition. Outside Mañagaha and Akino Reef were prioritized because of ongoing watershed management efforts and a planned restoration project within Achugao and West Takpachao watersheds that will help improve water quality for adjacent reef and seagrass habitats (Appendix 1). Chalan LaoLao, located within Saipan Lagoon, was selected as a priority site to help restore Staghorn corals (*Acropora pulchra* and *Acropora muricata*) decimated in the past bleaching events that occurred in 2013, 2014, 2016, and 2017. In Saipan Lagoon, structurally complex staghorn thickets provide important fisheries habitat and coastal protection services.

Ongoing Management

The management actions and regulations already in place at this site are:

All three priority sites selected fall within the DCRM's areas of particular concern (APCs) for lagoon and reef habitat, which require special permitting for any development or activities in the area. In addition, all three sites are surveyed within the long-term marine monitoring program at DCRM. Chalan LaoLao falls within the region covered by the Saipan Lagoon Use Management Plan, which identified stakeholder priorities for improving the environment and management of Saipan Lagoon.

Outside Mañagaha falls within the no-take marine protected area, Mañagaha Conservation Area. All three sites benefit from CNMI gear restrictions and take moratoriums including: no harvesting with SCUBA, no use of gillnets, prohibited harvest of sea cucumbers, any and all species of hard Hermatypic reef building corals, soft corals or stony hydrozoans, *Trochus niloticus*, or other invertebrates (CNMI Div. of Fish and Wildlife, 2015).

Complimentary on land management actions benefitting all three sites include the NFWF funded project, Coastal Community Resilience Initiative for Wetlands and Corals in Saipan's Priority Management Watershed, which plans restoration projects within the West Takpochao Watershed. In addition, the Garapan Integrated Watershed Management Plan lists the Garapan (subwatershed of West Takpochao) and Achugao as priorities for improving water quality through initiatives to improve infrastructure and critical habitat, such as mangroves and wetlands.

Restoration Interventions

Restoration interventions to be implemented are listed below.

- Propagate and outplant structure-building corals onto existing and artificial reef structure
- Collect gametes and larvae for settlement onto structures and attachment onto reef
- Crown of Thorns Sea-star Predator Management, with a focus on restoration sites

All three interventions selected received the highest scoring options with respect to effectiveness, flexibility, and urgency. Lower ranking interventions such as direct transplantation will occur as needed in response to acute disturbances such as ship groundings. Interventions implementing algae and disease management are ongoing activities incorporated into standard operating procedures during coral nursery maintenance, donor colony collections, and coral outplanting.

Grant funding, expertise, and personnel are all currently in place to implement coral propagation, scaling up larval settlement, and management of COTS outbreaks. Pilot studies on coral propagation have been completed in the past two years, with plans to expand ocean-based nurseries to stock additional coral fragments and species to be completed in 2021. A pilot outplanting was completed in Saipan Lagoon in 2020, which will help select outplanting methods and/or need for artificial framework to provide structure for coral fragments to grow on.

Pilot studies will be completed in the next two years addressing larval settlement and dispersal. In addition, a Department of Interior grant was awarded in 2020, to support response to COTS outbreaks. This intervention will be addressed under Goal 3: Within 5 years, management agencies have the ability to respond to acute reef disturbances through both rapid assessment and mitigation activities to reduce reef damage caused by coral bleaching, COTs outbreaks, storm events, or ship groundings.

We anticipate that all three sites will have corals outplanted onto existing or artificial reef structure. For Akino Reef and Outside Mañagaha, corals will most likely be outplanted directly to bare substrate with either epoxy/cement, which is advantageous for the habitat type. Akino Reef and Outside Mañagaha have more area with consolidated reef framework that would allow for coral fragments to be directly attached to reef structure. For Chalan LaoLao, located in Saipan Lagoon, coral outplanting may involve attachment to substrate by epoxy/cement, zip ties, or attachment to an artificial structure, such as rebar frame. Due to the location within the lagoon, this habitat type is made up of rubble and sandy areas, as well as dead coral stands that can be overgrown with turf or cyanobacteria. Therefore, priority sites in the lagoon will require flexibility in the attachment type, as artificial frames may be needed to provide a stable structure for outplanted corals to grow on. The pilot outplanting of Staghorn corals conducted in Saipan Lagoon in 2020, will help inform feasibility of attaching coral fragments with zip ties directly to reef structure within the lagoon.

Outplanting activities that involve dispersal of settled larvae, are still within the planning stages, and may be used for all three sites. However, final site selection will be dependent on the target species for gamete collection, the preferred habitat type for settled larvae, and the final design of settlement structures.

Management of the COTs population, will occur for Akino Reef and Outside Mañagaha as these sites occur within the habitat range for the predatory sea star. This intervention will only be applied as necessity arises during large scale outbreaks or for managing higher COTS densities.

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), objectives, specific activities and timeframe for completion, lead personnel or agencies, and partners.

Objective 1.1: By 2023, the CNMI will complete expansion of two ocean-based nurseries with the capacity to hold 5000 coral fragments, representing at least 10 species.

Performance Metrics:

- No. of fragments (5000)
- No. of species (10)
- No. of nurseries ($n = 2$)
- 70% survivorship of coral fragments within the nursery within the first 6 months
- mean productivity/growth of fragments within the nursery measured as cm yr^{-1} (Schopmeyer et al., 2017)

Objective 1.2: By 2024, the CNMI will have developed a restoration strategy to scale up dispersal of coral larvae on settlement substrates across at least 500 m^2 area.

Performance Metrics:

- No. of larvae settled (TBD)
- Gametes collected from no. of species (TBD)

- Range (area) of larval dispersal (TBD)

Objective 1.3: By 2023, phased coral outplanting of restoration sites underway within Saipan.

Performance Metrics:

- No. of outplanting activities (TBD)
- no. of fragments (TBD)
- 70% survivorship within the 1st year versus control sites
- 50-60% survivorship vs control sites over 2-3 year period (Boström-Einarsson et al., 2020)

Objective 1.4: By 2023, the CNMI has developed a data management and reporting plan for restoration activities.

Performance Metrics: N/A

Objective 1.5: By 2025, establish baseline data and support monitoring activities to evaluate coastal protection services by Saipan's coral reefs.

Performance Metrics:

- Shoreline erosion (change in shoreline profile)
- Reef structural complexity (fractal dimension, rugosity)
- Measuring or modeling wave attenuation (TBD)

Management activities that will be supporting the above objectives are listed below:

- The restoration planning team meets quarterly, and is organized by the restoration coordinator to support Obj. 1.1-5.
- An annual report on restoration activities will be drafted by the restoration coordinator. The CNMI Restoration plan will be updated at least every 5 years, and incorporated into CNMI's Comprehensive Sustainable Development Plan and annual report. These activities will help support Obj. 1.4, data management and reporting plan.
- The CNMI restoration team adopts an adaptive management strategy to reevaluate methods, nursery design, outplanting strategies, and interventions every 3-5 years to be revised within the Restoration Action Plan to help complete Obj. 1.1-5.
- Coral restoration activities will be coordinated with on land management actions for a comprehensive ridge to reef restoration strategy to support Obj. 1.1-3. For example, management actions will target priority watersheds to reduce land-based sources of pollution, that can improve water quality for adjacent coral reef sites prioritized for restoration.
- All permits needed for nursery and outplanting activities will be acquired within the next 1-2 years to complete Obj. 1.1-3.

Community activities that will be supporting the above objectives are listed below:

- Continue developing a network of volunteers and interns for assistance with nursery maintenance to support Obj. 1.1.
- Continue developing Eyes of the Reef trainings, a citizen science program training the community to identify and report coral reef stressors/disturbances.
- Engage in training and education opportunities with SeaGrant or other partners, as well as participate in outreach opportunities within the community, such as with Project HOPE, Environmental Expo, SFEC – Schools for Environmental Change, Friends of the Marianas Trench.
- Provide the public information on restoration activities and milestones through various media outlets (i.e., local news organizations, social media) and/or press releases.
- By 2025, PSS and partners have included coral-specific educational resources into the Marianas-wide educational programs and resources that are currently being developed.

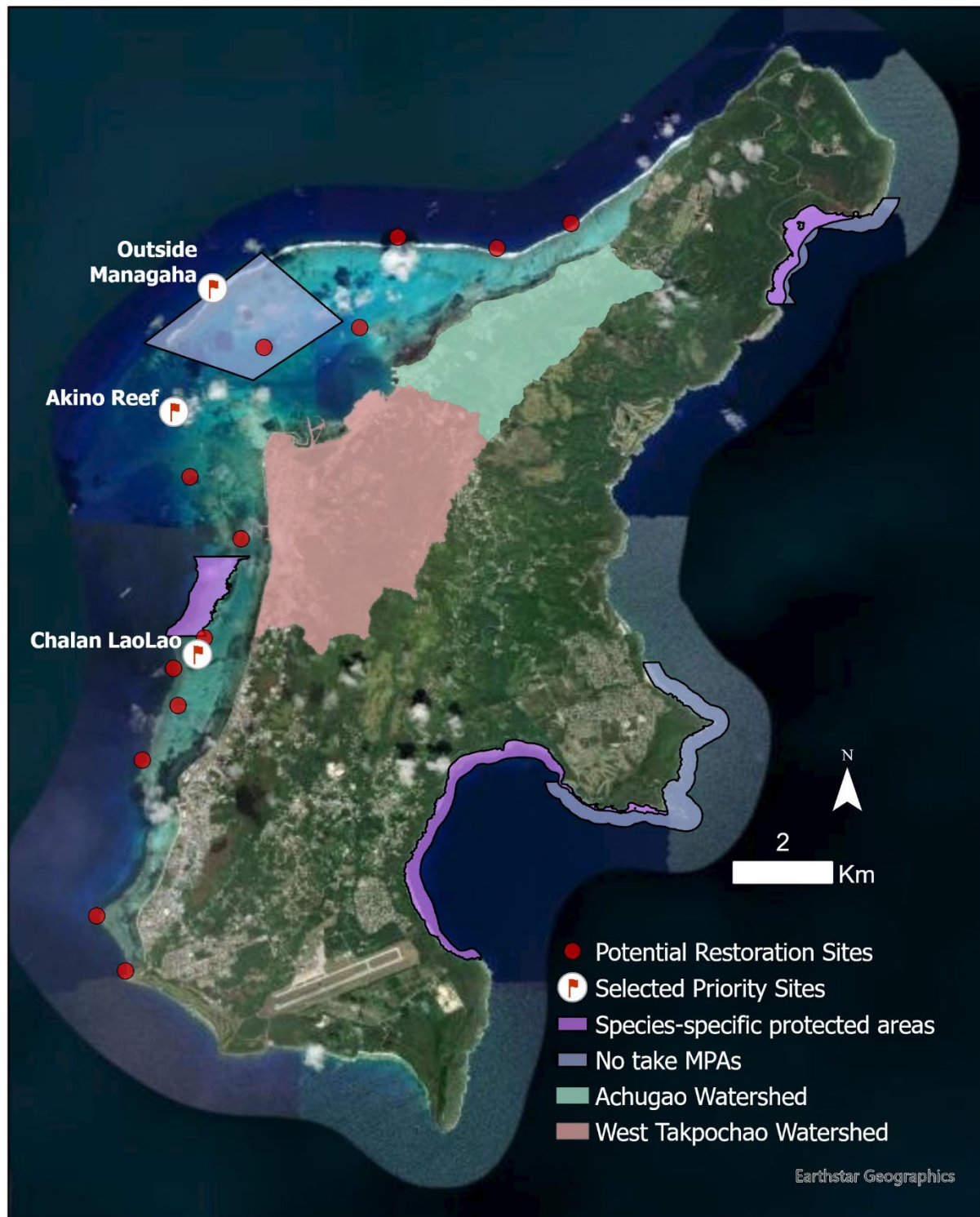
Stakeholder Engagement and Outreach

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

The draft action plan, once completed, will be presented to the natural resources planning taskforce led by the Office of Planning and Development. Presenting to the interagency taskforce will provide opportunity for stakeholders to provide comment and feedback for finalizing the plan.

Once the restoration plan is complete, the document will be made available online for the public to access, and will be announced through various media outlets (i.e., local news organizations, social media).

Appendix 1. Map of Priority Sites



Appendix 2. Action Plan Summary Matrix

Goal 1: Within 10 years, reef structure is restored or enhanced on Saipan's western side to reduce wave energy that threatens coastal infrastructure, improving the CNMI's resilience to sea level rise and increased storm events.					
Objective 1.1: By 2023, the CNMI will complete expansion of two ocean-based nurseries with the capacity to hold 5000 coral fragments, representing at least 10 species.					
Performance metrics: No. of fragments (5000), no. of species (10), no. of nurseries (n=2), 70% survivorship within the 1 st year versus control sites, mean productivity/growth of fragments within the nursery measured as cm yr ⁻¹					
Activities		Sites(s)	Lead	Partners	Timeframe
A.1	Expansion of two nurseries will be completed with the capacity to hold 5000 fragments	Mañagaha, Saipan Lagoon	JAMS, NOAA, DCRM, DFW	JAMS, NOAA, DCRM, DFW	2-3 yrs
A.2	10 species representing branching and massive morphologies will be propagated across two nurseries	Mañagaha, Saipan Lagoon	JAMS, NOAA, DCRM, DFW	JAMS, NOAA, DCRM, DFW	2-3 yrs
Objective 1.2: By 2024, the CNMI will have developed a restoration strategy to scale up dispersal of coral larvae on settlement structures across at least 500 m ² area.					
Performance metrics: # of Larvae settled (TBD), gametes collected from # of species (TBD), range/area of larval dispersal					
A.3	By 2023, the CNMI has completed a pilot study testing larval settlement	Saipan	JAMS, NOAA	JAMS, NOAA	2 yrs
A.4	Build capacity for enhancing larval dispersal to promote diversity via sexual reproduction within in-water floating basins	Saipan	JAMS, NOAA	JAMS, NOAA	1 yrs
A.5	Testing new settlement substrates	Saipan	JAMS, NOAA	JAMS, NOAA	1-2 yrs
A.6	Target species will have been identified for collection of gametes, as well as refining spawning windows for selected species	Saipan	JAMS, NOAA	JAMS, NOAA	1 yr
A.7	Identify partnership and funding for on land experimental facility/nursery	TBD	TBD	JAMS, NOAA, DCRM, OPD, DFW, MINA	4 yrs
Objective 1.3: By 2023, phased coral outplanting of restoration sites underway within Saipan.					

Performance metrics: # of outplanting activities (TBD), # of fragments (TBD), 70% survivorship within the 1 st year versus control sites, 50-60% survivorship vs control sites over 2-3 year period					
A.8	Identify grant funding for monitoring outplanting and control sites	N/A	JAMS, DCRM, DFW	JAMS, NOAA, DCRM, OPD, DFW, MINA	1-2 yrs
A.9	Site prioritization study is completed for Saipan	Saipan	JAMS	JAMS NOAA SymbioSeas	1 yr
A.10	Complete artificial reef structure designs for coral outplanting	TBD	DCRM, OPD	JAMS, NOAA, DCRM, OPD, DFW, MINA	3 yrs
A.11	Outplant corals to ten priority restoration sites.	TBD	JAMS, DCRM, DFW	JAMS, DCRM, DFW, NOAA, OPD	4 yrs
Objective 1.4: By 2023, the CNMI has developed a data management and reporting plan for restoration activities.					
Performance metrics: N/A					
A.12	A restoration coordinator is hired to support planning and implementation of restoration activities among CNMI agencies and partners	N/A	DFW	DFW	1 yr
A.13	Identify uniform metrics and methods for monitoring growth, survivorship, disease susceptibility, thermal tolerance by species, genet, and/or symbiont clade for coral fragments within the nursery and at outplanting sites	N/A	Restoration Coordinator	DCRM, JAMS, NOAA, DFW	2 yrs
A.14	Develop a data sharing plan or central repository	N/A	Restoration Coordinator	DCRM, JAMS, NOAA, DFW	2-3 yrs
Objective 1.5: By 2025, establish baseline data and support monitoring activities to evaluate coastal protection services by Saipan's coral reefs.					
Performance metrics: Shoreline erosion (change in shoreline profile), structural complexity (rugosity, fractal dimension), wave attenuation and modeling (TBD)					

A.15	Baseline data and long-term monitoring for reef structural complexity is established for foreereef sites	Saipan, Tinian, Rota, Aguijan	DCRM JAMS	DCRM JAMS	Ongoing
A.16	Continued monitoring shoreline erosion	Saipan, Rota, Tinian	DCRM	DCRM	Ongoing
A.17	Identify methods for modeling or monitoring wave attenuation for Saipan's western coastline	Saipan west coast	TBD	DCRM, NOAA, DFW, JAMS	2-3 yrs
A.18	Identify funding or partners to complete a study modeling risk reduction for the coastline, or modeling coastal vulnerability with sea level rise and/or typhoon activity under different restoration scenarios	TBD	TBD	DCRM, NOAA, DFW, JAMS	2-3 yrs
A.19	Identify methods for monitoring reef accretion and bioerosion	TBD	TBD	DCRM, NOAA, DFW, JAMS	2-3 yrs

References

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