



COCOS LAGOON ABANDONED TIRE REEF REMOVAL PROJECT

PRINCIPAL INVESTIGATORS:
GUAM ENVIRONMENTAL PROTECTION AGENCY
AND
GUAM DEPARTMENT OF AGRICULTURE

Funded by NOAA Marine Debris Grant (NA19NOS9990031)

Project Introduction

The Government of Guam, through the Guam Department of Agriculture, Division of Aquatic and Wildlife Resources (DAWR) and the Guam Environmental Protection Agency (EPA), received a FY19 Marine Debris Removal Grant from the National Oceanic and Atmospheric Administration (NOAA) to expand the local



General view of CARB. (Photograph courtesy of GEPA).

government's abilities to address marine debris issues on island through community-driven and cost-effective removal projects. The project Award Number is NA19NOS9990031.

The awarded project was the removal of one of two artificial tire reef projects piloted by government of Guam fisheries scientists in the 1970's. The main objective of these artificial tire reefs were to increase fish populations through artificial fish shelters and to improve the habitat of inshore lagoon areas. This project was initiated in 1969 but was then discontinued in 1973, after fisheries scientist concluded that the artificial tire reefs were not recruiting enough fish populations to be effective. The tire reefs were abandoned in place and eventually forgotten.

The two tire reefs that were constructed were labeled Cocos Artificial Reef A (CARA) and Cocos Artificial Reef B (CARB). Both artificial tire reefs are located in the center of the Cocos Lagoon. The Cocos Lagoon is an atoll-like coral reef lagoon that borders the Manell-Geus watershed to the north-east and the Achang Reef Flat Marine Preserve to the east in the village of Merizo. The Manell-Geus watershed is a Habitat Focus Area for NOAA's Habitat Blueprint and Cocos Lagoon is a part of the NOAA Coral Reef Conservation Program Priority for Guam. Cocos Lagoon is a very rich and diverse marine habitat that supports cultural and subsistence harvests, as well as tourism operations. Cocos Lagoon is home to extensive seagrass beds, mangrove forests

and patch reefs, which provide important habitats for a variety of vertebrate and invertebrate species. Live coral cover in Cocos Lagoon has been documented at approximately 30% (Burdick et al., 2008). The lagoon also provides important habitat for sea turtles, including Endangered Species Act (ESA)-listed green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles (Hartwell et al., 2017). Cocos Island is also being used as an introduction site for the Guam rail, *Ko'Ko'* bird, (*Gallirallus owstoni*), an ESA-listed species endemic to Guam.

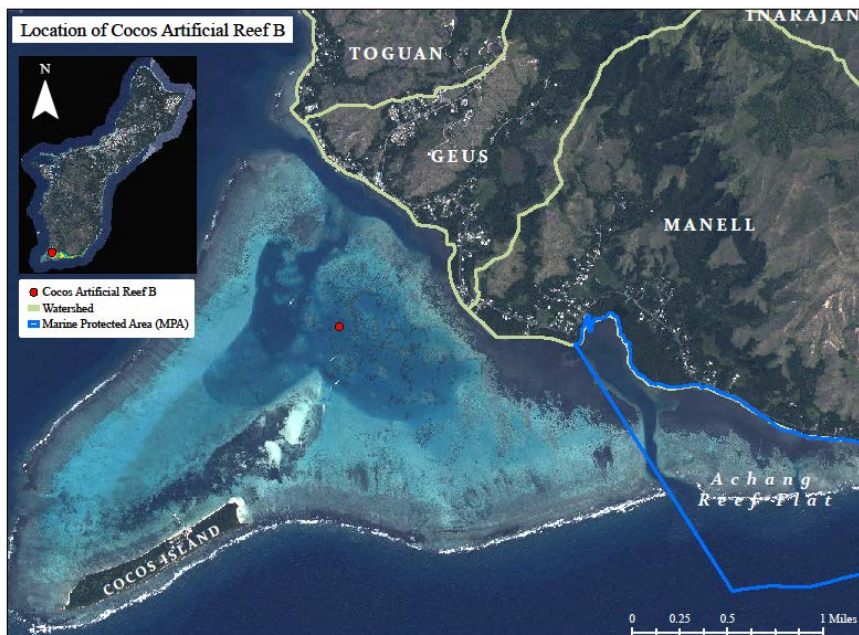


Figure 1. Location map of Cocos Artificial Reef B, the proposed project site.

CARA consisted of 351 tires that were tied together using nylon rope to form a “Y” shape, known as a “triad”, and were placed flat on the sediment floor within a 75 foot by 75 foot grid at a depth of 25 feet. CARB consists of approximately 2,482 tires that sit atop a sandy, silty substrate



CARB (SIDE VIEW). (Photograph courtesy of GEPA).

at a depth of 20 feet, and is located at the coordinates 13.255248N, 144.665588E. CARB was constructed to test the vertical placement of the artificial fish shelters. At this site, tires were tied together in groupings of five using nylon rope to create tire tubes. The tire tubes were dumped randomly on top of each other



Groups of tires buried under sediment at CARB. (Photograph courtesy of GEPA).

to achieve a 15 foot vertical tire reef mound. Recent assessments show that the current state of this site is about 5 feet shorter than its initial installation in the 1970's. Approximately one tire tube layer appears to be buried underneath the sediment surface.

In old project reports, CARA was described as being

three different distances west of CARB. The Government of Guam attempted to locate CARA twice using the given information, but have not been successful. It is suspected that due to the high sedimentation rate within Cocos Lagoon, CARA may be buried. Search efforts of CARA continued throughout the duration of the removal project and was still not found. CARB is located within the central part of the Cocos Lagoon approximately 0.85 miles south of the Merizo Pier and public boat ramp.



Close-up of CARB. (Photograph courtesy of GEPA).

Reconnaissance Phase

CARB sits atop a sandy, silty substrate at a depth of 20 feet,

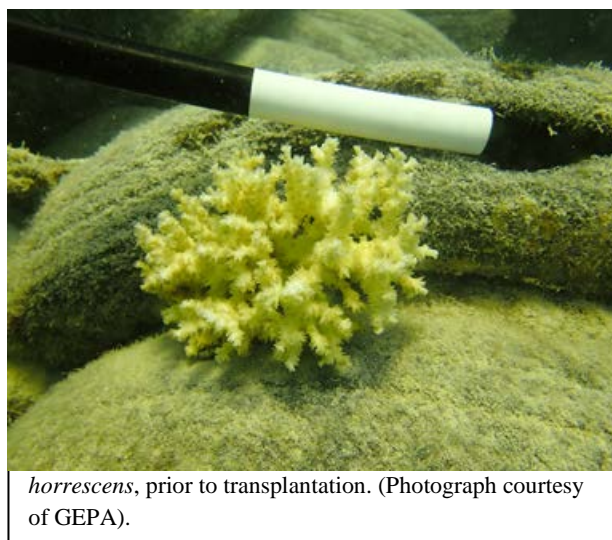
and is located at the coordinates 13.255248N, 144.665588E with a current estimated volume of 21,531 ft³ (48.5 x 45.3 ft x 9.8 ft). Original documentation states that it was constructed with approximately 2,482 tires

After 45 plus years underwater, only minor coral recruitment was observed during site inspections of CARB. A total of sixty-nine (69) “coral features” were identified. Small coral heads of *Pocillopora damicornis*, *Porites cylindrica* and *Porites lutea* were observed, along with small encrusting colonies of *Porites rus*, *Pavona sp.*, *Favia sp.* A coral transplanting plan was created to transplant/relocate as many features as possible. A small amount to no fish stock species was observed aggregating around the structure. Observed fish species were aggregating on the larger-sized coral features.

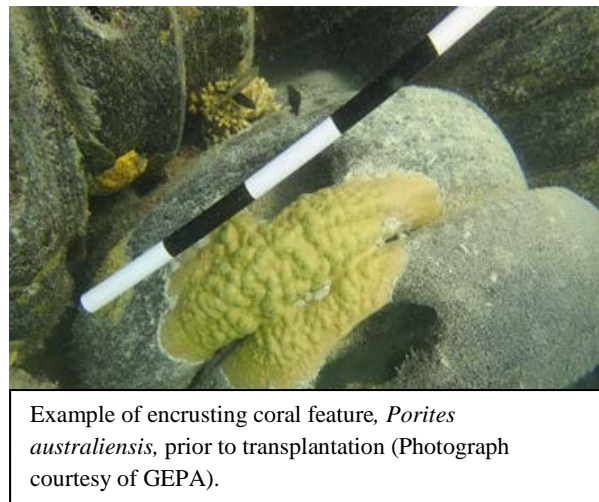
Coral Transplant Phase

Guam EPA attempted a coral transplant of the sixty-nine (69) identified coral features to several suitable sites shoreward of CARB (Attachment B). A breakdown of those coral features are:

- 69 features observed
 - 35 features measuring <10cm
 - 33 features measuring >10cm
 - Total number of species ten (10)
 - No Guam or federally rare, threatened, or endangered (RTE) species were observed on or near the CARB.



Coral heads and encrusting colonies suitable for transplant were identified, and removed from the tire substrate. Corals were removed by chipping off the living portion of the colony from the point of attachment on the tire using a chisel and hammer. All encrusting species (e.g. *Leptastrea purpurea*, *Pavona chiriquiensis*, *P. varians*) suffered damage (split and shattered) when removed from the tire substrate. Small non-encrusting species were relocated if all or a significant portion of the colony can be removed from the tire intact.



A coral transplant site was identified and prepped for the new coral colonies to be transplanted.



Largest Non-encrusting coral feature, *Porites cylindrica*, prior to transplantation (Photograph courtesy of GEPA).

The criteria developed for the transplant site were an:

- Area that is in close proximity to the tire reef;
- Area with an abundance of hard bottom substrate with enough space to accommodate transplants;
- Area that is protected or within an actively managed reef;
- Area with similar conditions as the transplants;
- Area that has low hydrodynamic condition, low turbidity and sedimentation.

The Transplant site 1 is located approximately 87 meters shoreward (13.25602N and 144.66573E) of CARB at a depth of 5 meters. Transplant site preparation entailed removing any type of sand, sediment, or biological growth with scrapers or wire brushes right before transplanting to ensure the maximum effectiveness of concrete or other adhesive materials. The adhesive mixture was prepared and mixed topside in a vessel. The adhesive mixture was then placed into large re-sealable bags, dispensed onto the cleaned substrate by divers and then the coral colony was placed into the adhesive mixture. Cable ties, concrete nails, or rebar was not needed as all transplanted corals were fragments. Transplanted coral fragments will be monitored as described below.



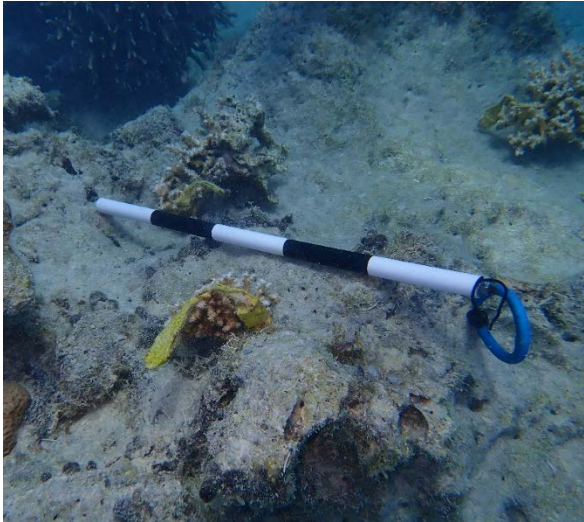
Example of coral feature, *Platygyra sp.*, prior to transplantation (Photograph courtesy of GEPA).



Example of encrusting coral feature, *Leptoseris incrustans*, prior to transplantation (Photograph courtesy of GEPA).



Divers collecting Coral fragments for transplanting (Photograph courtesy of GEPA).



Coral fragments reattached at transplant site with concrete. (Photograph courtesy of GEPA).

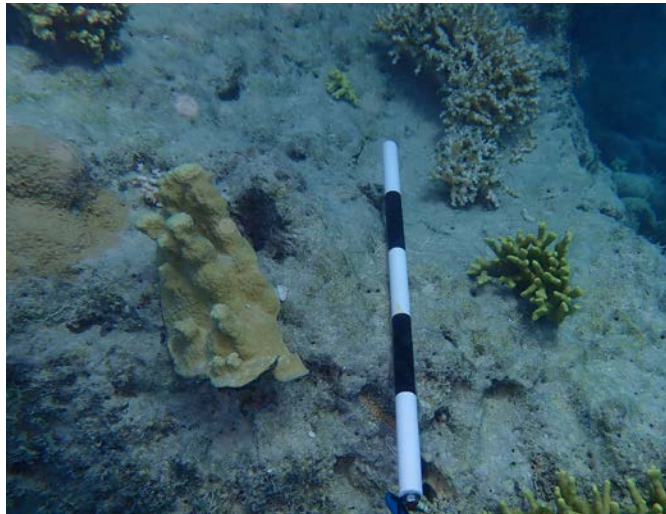
Coral Transplant Monitoring Phase

The Government of Guam monitoring team will be monitoring the transplanted corals for a duration of 3 years. Transplanted corals will be monitored and documented for growth, diseases, bleaching or mortality rates. Monthly monitoring will occur for a duration of 6 months after the corals have been transplanted. After 6 months, coral monitoring will be performed quarterly for the remaining two and a half years of the project period. A total of sixteen coral transplant site visits will be performed for the post-transplant monitoring effort. Monitoring teams will survey the transplanted corals through the use of photo documentation and proper survey tools (i.e. meter sticks, scales). Monitoring teams will also collect the following data on the provided field sheets (found in the appendix): location, date, time, samplers, colony code/tag number, photo number, and health status (e.g. dead, alive, or bleached; see table below).

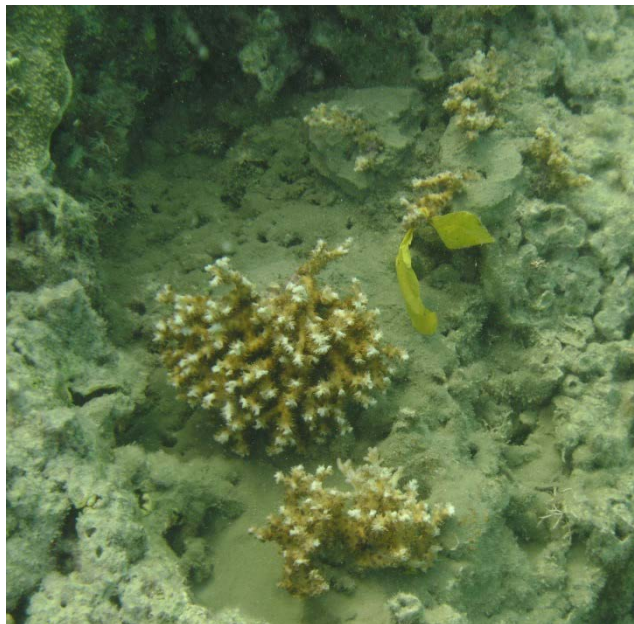
Survivorship monitoring will be performed on each individual colony.

Denotation	Description
Healthy	Living tissue on the fragment 100%
Dead % 50>	More than 50% living tissue left on the fragment
Dead % 50<	Less than 50% living tissue left on the fragment
Dead	No living tissue present on the fragment
Pale	Discoloration of the tissue towards pale
Bleached	Polyps still alive and fragment “looking” fluorescent white

A report documenting the transplant and monitoring phases will be produced separately at the conclusion of the monitoring and will be made available to the public.



Coral fragments reattached at transplant site with concrete.
(Photograph courtesy of GEPA).



Coral fragments reattached at transplant site with concrete.
(Photograph courtesy of GEPA).

Tire Reef Removal Phase

Guam EPA conducted a Request for Proposal (RFP) for local environmental or salvage companies to conduct the tire removal and disposal work of CARB. The RFP process was initiated in January 2020 and finally concluded in December 2020 due to processing delays associated with the pandemic.

The contract was awarded to Unitek Environmental Guam (Unitek), with the in-water work being performed by Trident, LLC, under contract number GEPA-2019-2200-001.

The primary objective of this project was to safely remove and properly dispose of the visible tires at Cocos Artificial Reef B (CARB). The secondary objective was to remove other waste that existed in CARB as well as waste produced from the removal effort. The field work



Tire retrieval. (Photograph courtesy of Guam EPA).



CARB Work site within Cocos Lagoon. (Photograph courtesy of Unitek).

for this project was completed between July 5, 2021 and July 28, 2021.

Prior to the commencement of in water work, the contractor inspected and cleaned all equipment and materials on land prior to deploying and utilizing them, due to the sensitive nature of the Cocos Lagoon. The equipment consisted of two (2) support boats, two (2) 16' x 16' floating dive platforms (DPs), and all the necessary equipment for tire removal, diver support and turbidity and sedimentation control.

Dive platform (DP) 1 was utilized as the main working platform, with DP 2 as the collection and transport barge. Once DP -2 was loaded to capacity, with approximately 200 hundred tires, it was towed to the temporary staging area within the Cocos Resort parking lot/ramp within the village of Merizo. Tires were then offloaded utilizing a telescopic forklifts, transferred to the secondary containment area, and then finally loaded into standard dump trucks to be transported to the Unitek primary facility in the village of Agat. At this facility, all tires were cleaned with power washers prior to being hauled to the Guahan Waste Recycling Tire Shredding Facility for processing and final recycling/disposal at an off island facility.



First set of tire recovered (Photograph courtesy of Unitek).

Water quality samples for turbidity analyses were collected up-current, from within the turbidity curtain and down-current outside the turbidity curtain to ensure removal operations were within water quality standards. Samples were collected three times a day, once in the morning, afternoon and at the end of the working day. Only three (3) major exceedances occurred during the course of the project and coincided with heavy weather events.



Tires being transported to shore. (Photograph courtesy of Unitek).

Waste water collected during the cleaning and rinsing phase was treated and disposed of through the Unitek NPDES permitted water processing facility (NPDES No. GU0020346). Other solid waste, solids and dry sediment were disposed of at Guam Solid Waste Layon Landfill.



Telescopic forklift offloading Tires. (Photograph courtesy of Unitek).



Removed Tires within temporary containment area. (Photograph courtesy of Unitek).



Recovered tires being cleaned and processed at the Unitek primary facility. (Photograph courtesy of Unitek).



Recovered tires being cleaned and processed at the Unitek primary facility. (Photograph courtesy of Unitek).



Stacked cleaned tires waiting to be shredded at the Tire Processing facility. (Photograph courtesy of Unitek).



Stock photograph of shredded tires containerized for shipping Tire Processing facility. (Photograph courtesy of Guahan Waste).

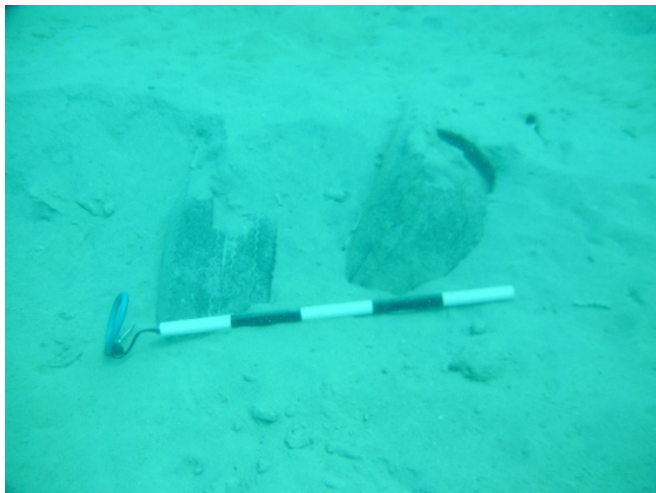


Close-up of Stock photograph of shredded tires. (Photograph courtesy of Guahan Waste).

A total of one thousand eight hundred twenty-nine (1,829) or 74% of the tires were removed from the CARB site out of a reported 2,482 tires, during the sixteen (16) days of in water work. Post inspections dives were conducted by Guam EPA divers on July 30, 2021, and verified that all project objectives were met and the project was completed. During this post dive inspection, a layer of tires could be made out just under the surface or partially exposed from the removal of upper tire layers. These remaining tires (approximately 653 or CCC, buried within the



Partially exposed bottom layer of CARB not removed.
(Photograph courtesy of GEPA).



Partially exposed bottom layer of CARB not removed.
(Photograph courtesy of GEPA).

sediment were not part of the project objectives due to the high removal cost and the additional impacts from the potential resuspension of large volume of sediment. It is also anticipated that with the current sedimentation rate within Cocos lagoon that the remaining tires will be furthered buried and covered, reducing further exposure. The Government of Guam will continue to research alternative sources of funding and collaborations to remove the remaining tires at CARB and identify and locate CARA and

remove those tires as well.

All recovered tires were shredded to two inch nominal size with an approximate volume of 75 cubic yards at the only tire recycling facility on Guam. All material was containerized and shipped off island to a recycled rubber company in Mumbai, India to be used either as tire-derived fuel (TDF) for the cement industry or as Crumb Rubber Granules for rubberized asphalt or in creating running tracks and other sports surfaces.

Conclusion

In recent years, the Cocos Lagoon has been surveyed for the presence of chemical contaminants due to the operation of a US Coast Guard (USCG) Long-Range Navigation (LORAN) station from 1944 to 1963 on Cocos Island. In studies conducted by USCG contractors, elevated levels of polychlorinated biphenyls (PCBs) were found in the soils on Cocos Island and within the fish in the lagoon (Environet, 2005; Element Environmental, 2008, 2013, 2014). After the results of the first study were released, a fish consumption advisory was put in place for Cocos Lagoon by the Government of Guam in 2006, as a response to the contamination of fish by high concentrations of the PCBs and other heavy metals. In 2015, NOAA's National Centers for Coastal Ocean Science (NCCOS) conducted a separate survey of the Cocos lagoon for chemical contaminants and they also found elevated levels of PCBs and DDT within fish tissues (Hartwell *et al.*, 2017).

A separate finding in this study was that elemental Zinc was the third highest metal concentrated within fish tissues. The government of Guam believes that the artificial tire reefs could have been a source of the zinc and the elevated levels found. As literature searches report that rubber tires are typically comprised of 1-2% Zinc by weight and Zinc is also the main heavy metal within its leachate (Collins *et al.*, 1994).

Removal of the 1,829 tires from CARB is anticipated to reduce and hopefully eliminate any further risk of contamination of heavy metals within the lagoon, specifically Zinc. This effort may also lead to the reduction of the Government of Guam fish consumption advisory for Cocos Lagoon, which will strengthen subsistence and cultural fishing practices. The government of Guam will be looking to conduct additional studies within Cocos Lagoon, regarding heavy metal contamination in the water column, sediment, and fish tissue to continue monitoring contaminant levels after the removal of the artificial reef has been completed.

Also, as part of this project, the principal investigators are planning to create an awareness campaign through the creation of posters, pamphlets, public service announcements, and other outreach tools to help educate the public on the negative effects of marine debris on our environment. The outreach campaign will focus on how to properly dispose of tires and other typical marine debris and the adverse effects of improperly disposed waste on our marine

environment. This portion of the project is currently on hold due to the pandemic restrictions that are in place by the Government of Guam.

The Government of Guam believes that cleaning up the artificial tire reef is an important step to ensure no additional harm to surrounding ecosystems. Removal efforts of the artificial tire reef will help prevent any negative impact on the biological, economic, and cultural importance of Cocos Lagoon.

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