"Cayman Crown: support conservation of the jewel of the MAR through solid science, Phase I"

FINAL REPORT

Small Grants Program – Mesoamerican Reef Fund

Project number: GUA 11-005
Project name: "Cayman Crown: support conservation of the jewel of the MAR through solid science"
Grantee: Fundación Mundo Azul/ Healthy Reefs Initiative
Authors: Ana Giro, Healthy Reefs Initiative and Angela Mojica, Pixan'Ja
Address: Boulevard Rafael Landivar, Edificio D1, Oficina 202. Paseo Cayala zona 16. Ciudad de Guatemala, Guatemala.
Period of the report: March 15th, 2019 to July the 31st, 2020
Report date: August 15th, 2020

Table of Contents

1. Executive summary

Briefly describe activities and results to date. Complete executive summary for final report.

This proposal addressed the lack of scientific knowledge, protection and management of the Cayman Crown reef through the generation of science and the use of innovative assessment tools.

During the duration of the grant (March 2019, 2020 through July 30th, 2020), we were able to further investigate and monitor the Cayman Crown reef beyond earlier explorations (those developed prior to this grant) to better understand its health and ecological composition. Two sites were selected within the reef system as permanent study sites for this project; their selection was made using biological and physical parameters such as coral cover, diversity, reef rugosity, depth and location. Coral reef rugosity is a measurement of the surface roughness or substrate complexity, which is considered a key ecological feature promoting biodiversity. On these sites we conducted biological monitoring of reef health using the AGRRA methodology, coral bleaching and disease monitoring.

Biological and health indicators included:

- **Coral cover (%)**: it is a measure of the proportion of reef surface covered by live stony corals, principal reef builders.
- **Fleshy macroalgae cover (%):** it is a measure of the percentage of reef surface covered by fleshy macroalgae or simply what is known as "algae". They are data collected in the same benthos transects, where the number of algae and its height is measured to determine the percentage of coverage.
- **Herbivorous fish biomass (g/m²)**: measured biomass (total weight of fish per unit area) of surgeonfish and parrotfish.
- **Commercial fish biomass (g/m²)**: measured biomass (total weight of fish per unit area) of commercially important fish, such as groupers and snappers.
- **Corals affected by bleaching (%)**: it is a measure of the proportion of corals impacted by warmer waters causing different degrees of bleaching impacts (pale, partially bleached and bleached corals) and how this affect their health (bleached, early mortality, old mortality)
- **Coral diseases (presence or absence)**: it is a measure of the presence or absence of diseases affecting corals.

We conducted photomosaic monitoring on these two sites to evaluate species composition and cover of the benthos, as well as to document the health state

of the reef system. This is the first time this technology is used in Guatemala and we are still learning and improving the data processing.

Biophysical indicators such as water temperature and pH were measured since the beginning of the grant with *in-situ* permanent loggers. The information on local temperature and pH variations are key aspects to develop a better understanding of how corals are responding to these variables, which are directly linked to climate change. One temperature logger and one pH/temperature logger were installed in two different sites on the Cayman Crown Reef; these loggers have been recording data since May 29th through October 19th, 2019, and where reinstalled on October the 20th. The final trip to recover the loggers was planned for February 2020; however, they are still deployed given the COVID19 pandemic and the consequent travel restrictions. It is expected that data were recorded until May 2020 (based on the capacity to store data under the current set up). Loggers are expected to be recovered as soon as travel restrictions are lifted, and conditions are suitable for the researchers to travel to the study site.

The following report presents information on site characterization of the Cayman Crown reef using the AGRRA protocol, determining the health of the reef through the analysis of four major indicators which are: percent live coral and macroalgal cover, herbivorous and commercial fish biomass. Development of photomosaics that serve as baseline information to be able to have a visual image of the current state of two sites within the Cayman Crown reef area. Analysis of the local effects of climate change (both temperature and pH), coral disease, bleaching and its impacts on the Cayman Crown reef.

2. Objectives

Include the objectives of the project, as established in the approved proposal.

General objective:

Generate a solid scientific knowledge baseline to support protection of the newly discovered Cayman Crown Reef in the Caribbean coast of Guatemala.

Specific objectives:

Objective 1. Increase the conservation and protection of Cayman Crown through the design and implementation a biological monitoring plan and the development of a site characterization document.

Objective 2. Analyze the local effects of climate change and its impacts on the Cayman Crown reef.

3. Project progress

- *Clearly indicate progress on the project, and results/products to date for each objective and planned activity.*
- *Indicate the progress of the project in relation to the original timetable and explain the reason for any delays there may have been.*
- *Indicate if the originally planned methodology still applies or if it has been modified. In case of the latter, explain why and what the changes are.*

The project was implemented as planned in terms of the proposed activities and methodologies; the original timetable was followed without a problem until February 2020 when the last trip had to be postponed due to rough weather conditions. As a result, a first extension was granted until June 2020; the trip was rescheduled for the last week of March. Due to the global health COVID19 crisis, the trip was originally postponed and then cancelled under this grant; this activity will be developed under the second phase of the grant. Results presented on this report include field data collected from May 2019 through October 2019. The acquired results reflect the overall implementation of the project activities under the two main objectives of the grant:

Objective 1. Increase the conservation and protection of Cayman Crown through the design and implementation a biological monitoring plan and the development of a site characterization document.

Result 1.1 Implementation of a biological monitoring plan and a site characterization document.

Activity 1.1.1 Exploration of the Cayman Crown reef to better understand the reef composition and to select two permanent monitoring sites.

Two reef sites were selected as permanent sites for the project. The selection of the sites was made using parameters such as coral cover, diversity, reef rugosity and location. Coral reef rugosity is a measurement of the surface roughness or substrate complexity. This is an important ecological parameter: the high complexity or rugosity allow corals to attach and grow on higher substrata not influenced by sand and sediment movement along the bottom; they also provide more places for corals to attach, more cover for reef fish and habitat for many sessile invertebrates.

The sites were selected using information that has been previously generated by the Healthy Reefs Initiative (HRI). HRI has been conducting reef monitoring in two sites of the Cayman Crown reef and has a basic bathymetric map with shallow sites (average depth: 10.5 m). This information was used as baseline information for site selection. With this baseline information we explored three different sites on the shallow reef area. In order to select the sites, site explorations were done

by swimming over the reef for 15 – 20 minutes to look at coral composition and rugosity (Rover Diver method[1]), this method can only be used when water conditions are optimal (good water quality and calm sea). From these three sites, two sites were selected based on differences in location, as well as coral composition and depth. An estimation of the area explored (m^2) was not developed, we mainly focused on finding an adequate site to conduct monitoring, photomosaics and deploying the sensors.

- **Selection of permanent monitoring sites**: The map of the study area and the selected sites, as well as a technical data sheet selected can be found on the characterization document within the introduction section (product 1).

Activity 1.1.2. Reef Health Monitoring on two sites of Cayman Crown, using the AGRRA protocol.

The two sites selected were monitored in May 2019, using the Atlantic and Gulf Rapid Reef Assessment (AGRRA[2]) methodology to determine the health of the reef system. This monitoring provided information on reef health based on the Reef Health Index (RHI) Threshold Values made by the Healthy Reefs Initiative and AGRRA (Table 1). The indicators measured include: 1) coral cover, 2) macroalgae cover, 3) commercial fish biomass and 4) herbivorous fish biomass. With the analysis of these four main indicators we are able to say what is the current condition of the reefs monitored. Even though the Cayman Crown reef has been surveyed in the past, it's the first time that the two sites selected were surveyed. The information gathered serves as a solid baseline for future monitoring activities.

Table 1. Threshold values for determining the stare of the reef (McField *et al.*, 2020).

Threshold Values for Indicators | Valores de los Indicadores (ASSIGNED THE HIGHEST RANK MEETING THESE MINIMUM VALUES) *(SE ASIGNA EL RANGO MÁS ALTO QUE CORRESPONDE A ESTOS VALORES MÍNIMOS)*				
Grade *Rango*	**Coral Cover** *Cobertura de Coral*	**Fleshy Macroalgae Cover** *Cobertura de Macroalgas Carnosas*	**Herbivorous Fish Biomass** *Biomasa de Peces Herbívoros*	**Commercial Fish Biomass** *Biomasa de Peces Comerciales*
Very Good | *Muy Bien*	40%	1%	3,290	1,620
Good | *Bien*	20%	5%	2,740	1,210
Fair | *Regular*	10%	12%	1,860	800
Poor | *Mal*	5%	25%	990	390
Critical | *Crítico*	<5%	>25%	<990	<390

[1] Roving Diver survey method: https://www.reef.org/programs/reef-volunteer-fish-survey-project
[2] AGRRA methodology: https://www.agrra.org/coral-reef-monitoring/

- **Reef health biological monitoring:** The data gathered during the biological monitoring was analyzed through the HRI and AGRRA online platform. The HRI and AGRRA have an online data entry system that once the data is set to be analyzed a program runs and analyses the data. The products of the analysis are over fifty different analysis that we have reduced to show the major findings through the four main indicators- Reef Health Index (Products of the analysis can be found in the following Dropbox link[3]).

The main results show that the sites surveyed are in **Poor and Fair condition** (Tables 2 and 3). This is mainly due to the critical condition of commercial fish biomass on both sites and the poor biomass of herbivorous fish (product 2).

Table 2. Reef Health of the two sites monitored using the AGRRA protocol.

Site Name	Site Code	Coral Cover %	Fleshy Macroalgae Cover %	Herbivorous Fish Biomass (g/m^2)	Commercial Fish Biomass (g/m^2)
Site 1- 13 Cayman Crown	13CCNRC	77	5	1178	41
Site 2 – 11 Cayman Crown	011CCNRC	47	25	1131	162

Table 3. Reef Health Index of the Cayman Crown Reef based on the monitoring of two sites.

Site Name	Site Code	Coral Cover	Fleshy Macroalgae Cover	Herbivorous Fish Biomass	Commercial Fish Biomass	RHI
Site 1- 13 Cayman Crown	13CCNRC	5	4	2	1	**3**
Site 2 – 11 Cayman Crown	011CCNRC	5	2	2	1	**2**

Activity 1.1.3. Conduct Photomosaic monitoring to evaluate species composition and cover in two sites of Cayman Crown.

A photomosaic is an image comprised of multiple individual and overlapping images that are digitally stitched together. In various disciplines of marine science, photomosaics are a critical scientific tool that helps in mapping and tracking the health of specific areas on a reef. For the project two photomosaic images were developed, one for each site. The images serve as baseline information to track the overall health of the reef and of individua colonies, and

[3] AGRRA Biological Monitoring Products Dropbox link:
link:https://www.dropbox.com/sh/bxj3t4o97immpr0/AACtlkO-XOoaXs8cDI3RRoLaa?dl=0

to evaluate species composition. The methodology was adapted from the Photomosaic Manual form the Coral Restoration Foundation, Guidelines for handheld image acquisition and personal indications and support provided by Dr. Arthur Gleason [4].

- **Photomosaic analysis:**

Photomosaics were developed in the same area where the biological monitoring for the sites took place. The total area analyzed varied between sites because of the reef composition and structure at each site. Both sites are characterized for having spur and groove reef areas with high rugosity; these sites also had variations between the width of the spurs selected (Site 1: 30 x 20 m^2; Site 2: 18 x 30 m^2). This type of detailed graphic analysis provides a baseline to observe changes over time on these specific areas; this is also the first time such type of analysis and technology is employed to study Guatemalan reefs.

The full resolution photomosaic images can be found as a complementary file to this document given its large size; it can be access through the Dropbox link[5] (product 3).

Figure 1. Photomosaic of Site 1.

[4] Photomosaics methodology used and video guidelines:
https://www.dropbox.com/s/xjnlruwjkmobqq2/Photomosaic%20video_guidelines.pdf?dl=0
https://www.dropbox.com/s/txnltc47scivdtl/CRF%20Reef%20Restoration%20Concepts%20%26%20Guidelines.pdf?dl=0

[5] Photomosaic images Dropbox link:
https://www.dropbox.com/sh/je85escn2rd9x8d/AACbgsKI17zGxunamrGuUM4ta?dl=0

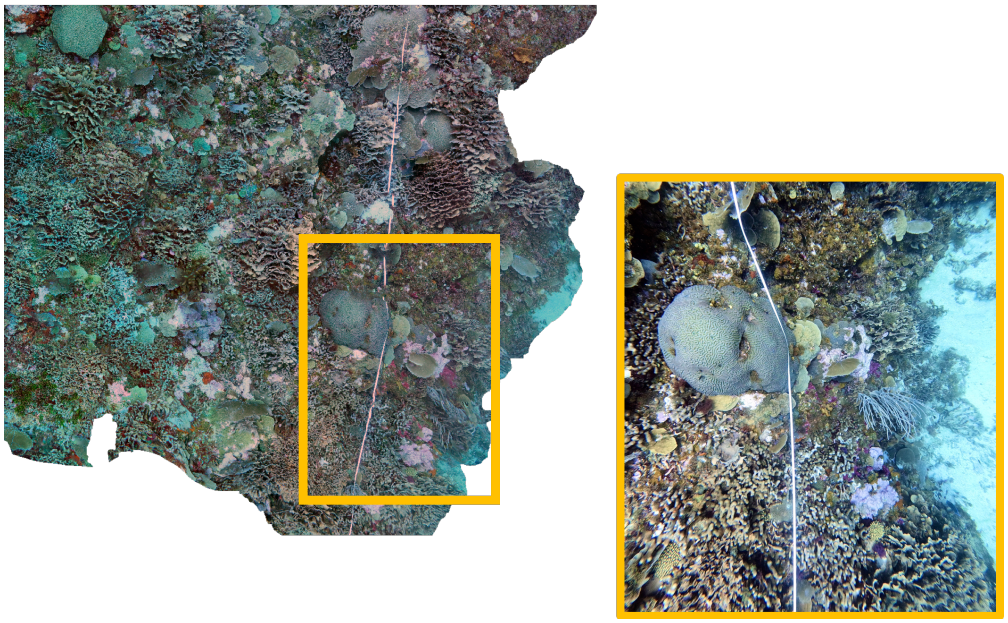

Figure 2. Example how we can track specific coral colonies over time with the photomosaic on Site 1.

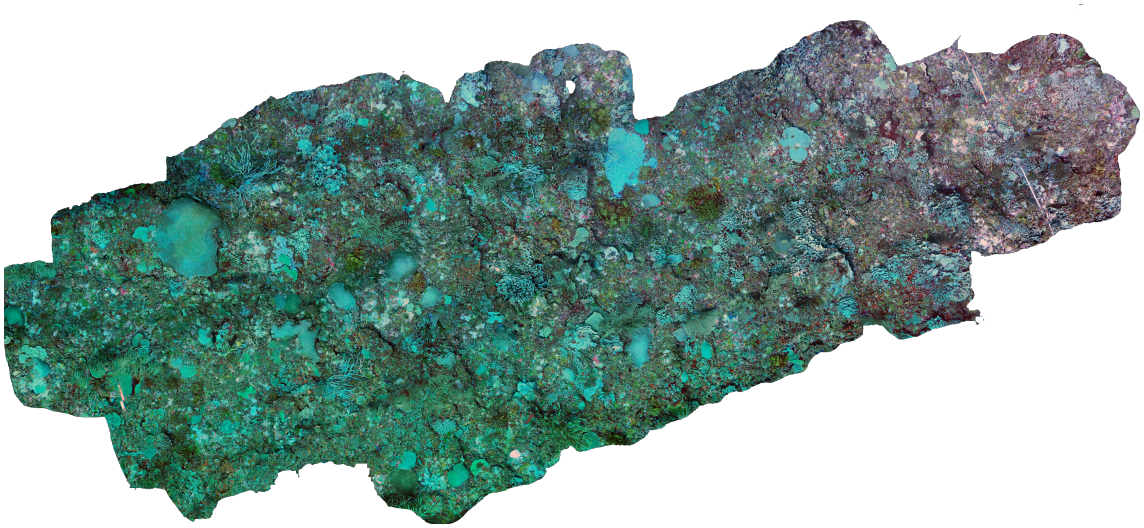

Figure 3. Photomosaic of Site 2.

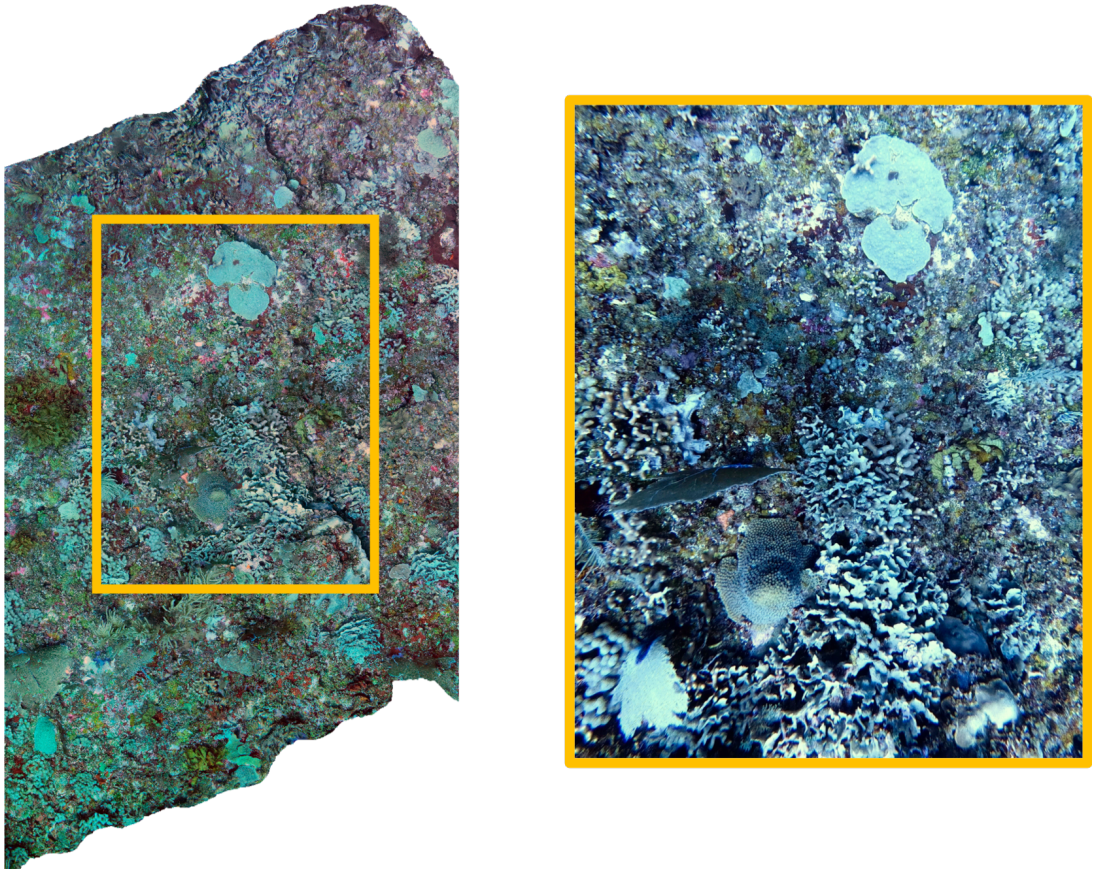

Figure 4. Example how we can track specific coral colonies over time with the photomosaic on Site 2.

Activity 1.1.4 Implementation of a biological monitoring plan and development of a site characterization document.

The biological monitoring as stated before was done using the AGRRA[6] methodology. This protocol is used throughout the Mesoamerican Reef and Caribbean region to gather information about reef health.

- **Site characterization document**: It describes the current state and composition of the Cayman Crown Reef based on the two monitoring sites studied (product 4) and the monitoring trips developed in May and October 2019. It also integrates key information analyzing local effects of climate change and its impacts of the reef developed under the second objective of the project (e.g., changes in sea water temperature and pH, bleaching events and coral disease).

[6] AGRRA methodology: https://www.agrra.org/coral-reef-monitoring/

Result 1.2 Using scientific data to promote the conservation of Cayman Crown.

Activity. 1.2.1 Dissemination of scientific information to Guatemalan decision makers justifying and supporting conservation measures to protect Cayman Crown.

This project has been key to continue with the monitoring and gathering of important data to support conservation. The Healthy Reefs Initiative has contributed to the process of exploring and characterizing the site, providing scientific data geared towards conservation in both Belize and Guatemala.

In Guatemala, the HRI has been actively involved in different meetings to support the declaration of the Cayman Crown Reef area as a temporal space closure zone (No- take zone, Replenishment zone) since 2018. The HRI Guatemalan coordinator has been invited through the Fisheries Department (DIPESCA) to give several presentations to high level authorities, where she has highlighted the biological importance of the reef and the need to protect it.

A technical justification document that supports the importance of the reef and why protection is key, was first presented on November 2019 to DIPESCA, a follow-up document was handed in on February 2020. This document was drafted by the HRI with the support of FUNMZ. After several follow-up meetings with authorities the Ministerial Agreement 85-2020 was published in the official gazette on May 22, 2020. The agreement highlights the importance of the Cayman Crown Reef and justifies its protection. The agreement declares the Cayman Crown Reef as a temporal space closure zone (No-take zone) for 10 years, prohibiting any kind of fishing in these waters[7]. It is important to highlight that this is a remarkable accomplishment for Guatemala, as it is the first No-take zone declared on a reef area and the biggest replenishment area within the country. The newly declared area totals 202 km^2 which rises the percent of full protection of Guatemala's territorial sea from a low 0.6% to 13.1%,

In Belize, the minister of fisheries, forestry, environment and sustainable development, Omar Figueroa, signed a statutory instrument that authorizes the expansion of the Sapodilla Cayes Marine Reserve to include the Cayman Crown reef ecosystem. The newly expanded Sapodilla Cayes reserve now totals an area covering more than 500 square miles, with a strictly protected area in Belize's deep-sea totaling more than 350 square miles.

The protection of this incredible reef ecosystem contributes not only to the full protection of Belize and Guatemalan waters but it also contributes to the overall connectivity and protection of the Mesoamerican Reef.

[7] Ministerial Agreement Dropbox Link:
https://www.dropbox.com/s/8e65lwjc7gtlap6/GU1b.8%20Acuerdo%20Ministerial%2085-2020.pdf?dl=0

Objective 2. Analyze the local effects of climate change and its impacts on the Cayman Crown reef.

Result 2.1 Database on coral reef condition, water temperature and pH and coral disease has been developed.

Activity 2.1.1 Install two loggers: one temperature logger and one pH/temperature logger on the two permanent monitoring sites of the Cayman Crown Reef.

One water temperature and one pH/temperature loggers[8] were installed on the Cayman Crown Reef to begin collecting *in situ* real time data (10min interval) since May 2019. The pH/temperature logger was installed on the most well-developed reef, this being the reef with the highest coral cover (80% approx.) and high rugosity (Site 1). The temperature logger was installed on the other selected site (site 2) that has also a high coral cover (50% approx.), but it is located near one of the reef walls (vertical drop) on the general area. The loggers were retrieved once during the one-year study (October 2019) to collect and secure the information, monitor its permanence on site, prove its correct functioning, and provide maintenance to the exterior equipment carcase. Currently the loggers are still deployed given that the last field trip planned for March 2020 had to be cancelled due to travel restriction generated by the COVID19 pandemic.

Activity 2.1.2 Conduct Bleach Watch monitoring to evaluate reef condition and disease in two sites on Cayman Crown.

The HRI has been leading a MAR-wide Coral Bleach Watch Network since 2015, mobilizing a coordinated network of trained surveyor teams to evaluate the extent of bleaching throughout the Mesoamerican Reef by using a systematic protocol called the Drop Bar[9] methodology. The Bleach Watch monitoring gets activated once there is an alert issued by NOAA through the Coral Reef Watch[10], mainly due to the increase in water temperature due to heat stress[11] (usually happens during the hurricane season, from June through November). During October 2019, an alert was issued from NOAA due to the rise in water temperatures; this alert was issued globally, and the MAR was no exception. A second field trip was carried out to visit the two sites and collect data on the bleaching event employing the Drop Bar methodology, this monitoring was

[8] Technical loggers' description and use directions: temperature logger: https://www.onsetcomp.com/products/data-loggers/utbi-001/ ; temperature and pH logger: https://www.onsetcomp.com/products/data-loggers/mx2501/

[9] Drop bar methodology: http://www.ecomarbelize.org/uploads/9/6/7/0/9670208/coral_bleaching_plan_final_2008_2013.pdf

[10] NOAA Coral Reef Watch alert for the Caribbean: https://coralreefwatch.noaa.gov/data/5km/v3.1/current/animation/gif/baa-max_animation_30day_crb_930x580.gif

[11] NOAA Satellite Coral Bleaching Heat Stress Alert https://coralreefwatch.noaa.gov/product/5km/index_5km_baa_max_r07d.php

important to be able to register the bleaching extent on the Cayman Crown Reef. This indicator is directly related to water temperature and the resilience capacity of coral reefs to recover from these stressful events.

Activity 2.1.3 Development of a database with analyzed information.

- **Generation of a temperature and pH data base for the two permanent monitoring sites**: the results of the five month data collection are integrated into the characterization document and are also included as part of the characterization document on section two.; an Excel data base was created as a complementary document to this report, to facilitate future ongoing analysis (product 5).

- **Coral disease monitoring**: A section on observed coral diseased is included in the characterization document and a list of the observed disease and health conditions observed on the two sites was integrated on a technical disease data sheet included in the characterization document (section 2) as a baseline on this topic (product 6). Results indicated that no coral diseases were observed during the monitoring period, just bleaching at different stages; however, bleaching is not a disease but a condition when corals expel their symbionts due to the thermal stress. Bleaching can cause coral mortality (partial or total) if corals do not recover their symbionts due to the extended starvation periods; they can also lead to coral diseases, likely link to a reduced health condition of the organism.

- **Bleach Watch monitoring**: A coral bleaching monitoring was developed during the month of October 2019, after receiving a bleaching alert from NOAA; results indicated that 36.5% to 38.6% of the surveyed corals were fully bleached, 16.5% to 22.2% were partially bleached, 18.3% to 21.5% were pale and 21% to 25.5% show no bleaching signs (Table 4, characterization document section 3). The bleaching data were included in the characterization document; an Excel data base for coral bleaching was created as a complementary document to this report, to facilitate future ongoing analysis (product 7). It is important to highlight that 2019 has been the worse year for bleaching on the Cayman Crown Reef compared to 2016 and 2017 data (based on HRI Bleach Watch monitoring data). A comparison graph with bleaching data collected at Cayman Crown from 2016 and 2017 is included in the characterization document (section 3) and it shows that bleaching impacts have increased in recent years.

Table 4. Coral bleaching monitoring results at sites 1 and 2, Cayman Crown reef.

	Site 1	Site 2
Monitoring date	October 2019	October 2019
Bleached	38.6%	36.5%
Partially bleached	22.2%	16.5%
Pale	18.3%	21.5%
Normal	20.9%	25.5%

4. Obstacles

Indicate if there have been any obstacles to the development of the project that have prevented achieving the planned goals or complying with the timetable, and how you have solved or plan to solve the situation.

Purchase of equipment abroad before and after COVID19 pandemic: Given that the specialized research equipment needed to develop the project had to be purchased abroad (we found only two Guatemalan companies selling diving equipment in the country, unfortunately with higher prices in most cases and a reduced selection of merchandise in terms of technical specifications, quality and brands), the process of purchase internationally, shipping and payment, took longer and costs were higher than expected, because of taxes and weight of each piece of equipment. Of the six shipping companies consulted, only one was able to offer Guatemalan accounting invoices which is required by FCG and Fundación Mundo Azul, the project administrator. The shipping process of the equipment bought after COVID 19 was even slower given the logistical limitations.

Logistics for field expeditions: Both local logistic providers in the Sapodilla Cayes (a) Reef Conservation International ,Tom Owens which is located 7 miles north of Lime Caye; b) Dennis Garbutt, Lime Caye, closest caye to Cayman Crown reef study sites) are unreliable and it is extremely hard to communicate with them; therefore, planning the field trips, guaranteeing the availability of the basic services (accommodation, food, diving tanks), and estimating the costs (there is a considerable difference in prices between the two providers) is a continues challenge.

Weather conditions: The third and final field trip (changes and saving on the proposed budget allowed us to do an additional fieldtrip) of the grant was planned for February but had to be postponed due to rough weather conditions in the region. Given that the field sites are considered remote reefs and our operation base (Sapodilla Keys) is isolated too from mainland Belize, dangerous weather conditions are of great concern for safety reasons. An extension to finalize the implementation of the project was granted by MAR Fund until July 30th, 2020. The fieldtrip was initially rescheduled for the end of March 2020.

COVID19 pandemic: The third field trip had to be cancelled due to the global COVID19 health crisis we are experiencing. Given the uncertainty regarding when the last field trip could be developed, it was decided in agreement with the donor to cancel this activity and allowing the use of these funds to purchase much needed diving security equipment. Taking advantage of the approved grant financing the 2nd phase of this project, the last field trip will be pursued under the 2nd phase of the project once traveling conditions inside and outside Guatemala improve (decrease risk of contracting the coronavirus and faceable transit conditions between countries). The water temperature and pH loggers are still deployed; the second set of data collected from October 2019 through May 2020 are expected to be downloaded as soon as the loggers are recovered.

5. Links with other organizations

Describe any alliances established as a result of the project development.

Climate change data analysis:

PhD. Fabio Cresto Aleina: We established a collaborative relationship with Dr. Fabio Cresto Aleina, an Italian climate scientist based in Guatemala, with the objective of enriching the analysis of the data collected for this project given the experience of Dr. Cresto using innovative modeling tools. This relationship is a collaboration in process. Initial results of the climatic model were presented during the webinar we organized to share initial results of this project. It is important to remember that these are not definitive given the current short data set we have. We expect to continue this relationship once we can retrieve the sensors.

Scientific webinar:

PhD. Patricia Kramer – scientific coordinator of HRI and AGRRA: Patricia provided strategic feedback for the design of the webinar, the connection with some of the guest speakers, as well as the dissemination of the event.

Ileana López - Programme Officer for the Specially Protected Areas and Wildlife Sub-programme (SPAW) for the Cartagena convention Secretariat: We invited Ileana to join us during the technical webinar as a strategic opportunity to socialize our work at Cayman Crown, to maximize the event sharing the stage with a well-known international program as the SPAW protocol focusing on marine conservation in the Caribbean and start forging new professional relationships with influential partners. Ileana is also Guatemalan, adding an additional interest in our interest to reach out to her.

PhD. Craig Dahlgren – Director, Perry Institute for Marine Science: Craig participated in the webinar as one of the guest speakers, sharing the results recently published in the Bahamas Coral Reef Report Card 2020 and sharing their

expertise using photogrammetry as a new technology to monitor coral reefs. The Perry Institute of Marine Science is an organization committed to protecting our oceans through research that both informs the public and encourages action. This is a good connection for our project to further explore scientific exchanges to learn about new technology and tools that they are using for marine conservation like photogrammetry and heat tolerant reefs.

PhD. Mark Eakin- Coordinator, NOAA Coral Reef Watch, National Oceanic and Atmospheric Administration: Mark is key person in NOAA and a renowned expert in coral reefs, using satellite data and the BleachWatch monitoring system; he participated in the webinar as one of the guest speakers providing the latest information regarding the BleachWatch forecast for 2020 and about the latest findings linked to climate change impacts on the Caribbean coral reefs.

Conservation actions:

Lic. Bryslie Cifuentes – Legal consultant for FUMNZ: Bryslie provided legal support drafting the ministerial agreement proposal that was presented to the fisheries department and the ministry. She is an expert in Guatemalan environmental law who has supported other conservation initiatives involving legal matters.

Lic. Carlos Marín - DIPESCA: As explained earlier in the report, the relationship HRI developed with DIPESCA was instrumental in the process of reviewing the proposal to designated as a No-take zone and granting conservation to Cayman Crown Reef.

6. Description of activities for next period

Briefly describe the activities that will be undertaken in the next period.

Activities proposed for the current grant were completed with an extension through July the 30th, 2020 to finalize implementing additional activities including a webinar to share preliminary results gathered in this project and the purchase of security and specialized diving and the gear. A second phase of the project, *Phase II - Cayman Crown: support conservation of the jewel of the MAR through solid science*, also financed by the MAR Fund Small Grant Program, is providing funding to continue and expand the current activities on the Cayman Crown Reef system through March 2021. Monitoring activities for the next period covered under phase II are the same as the ones proposed for this grant with the following additions: a) Two new monitoring sites will be selected and added to expand our current understanding of the Cayman Crown system, and b) an acoustic hydrophone will be installed on one site to document megafauna and fish assemblages present on the reef. Given than the 3rd trip under the current

grant had to be cancelled, it will be developed under the second grant as part of the first expedition.

Additional analysis of the water temperature and pH data collected are proposed to be developed in collaboration with an Italian climate change expert, Dr. Fabio Cresto Aleina. A small grant to support fund the development of these analysis and associated activities was submitted by Dr. Cresto to the Sustainable Ocean Alliance (SOA) microgrant program and granted in July 2020.

7. Project development table

Please find the project development table attached as a document and in the following link:
https://www.dropbox.com/s/4d83srekkuce4w3/PDT%20MAR%20%20Fund%20FINAL.docx?dl=0

8. Lessons learned

Emphasize, besides the technical issues, the social and administrative aspects that may be useful in future projects regarding the same topic or developed under similar conditions.

Additional costs associated to the importation process: Given the lack of specialized equipment (e.g., technological equipment to conduct science, diving gear, security accessories, underwater material, etc.) in Guatemala, the majority (almost 100% of it) of the purchases were done internationally. Having guidelines regarding the different options to purchase equipment that satisfice the tax requirements can provide a very helpful support in the planning, budgeting, and implementation of the proposal with less delays and more accurate estimates of the real costs of importing this kind of materials and equipment.

Guidelines for administrative processes when operating outside of the country: Operating outside the country (the closest field station is in Belize; however, our research project is located within the Guatemalan borders) imposes some administrative challenges, given that some of the expenses will be done outside Guatemala and there are some limitations regarding the percentage of the budget that can be expend outside the country. Having guidelines to get familiar with these processes can facilitate the planning and budgeting significantly.

Working in remote locations require specialized security equipment: Accessing and working in Cayman Crown Reef is a challenge and a risk given its isolated location, the long hours required to navigate to the site or to arrive and return to the closest field station in Belize, and the lack of infrastructure in case there is an emergency (there is no phone line and no rescue system in any of the countries). Given the great necessity to improve our safety for this and future field projects, we were able to purchase basic security equipment (including a satellite phone, boat radio, GPS personal trackers and lights for divers) for the research team as a result of changes in activities derived from COVID 19 pandemic. This is a valuable lesson to be considered for other teams and projects if working in remote locations, where the logistics and infrastructure to provide support in case of an emergency are nonexistent or very reduced.

Strengthening local capacities of boat captains and boat assistants for science expeditions: We have observed the significant differences and advantages when working with a trained boat captain, especially in remote and deep areas, where these skills become transcendental in the quality of diving, the support provided to get in and out of the water, the monitoring of the captain while the team is underwater, and the safety measures maneuvering the boat under complex weather conditions. This was one of the main reasons to work from Belize, besides having access to the closest field station. Working with trained and experience boat captains who have previously worked with researchers in scientific expeditions is critical to the success of the project, the efficiency and effectiveness during the field work (hours in the water) and the safety conditions provided during the field work. Providing adequate training to local boat captains for scientific missions should be considered as part of this kind of projects, especially if working in remote or complex areas.

Contingency budget for unexpected expenses: Projects with a strong field component require having a contingency budget for unexpected expenses that difficult to anticipate (e.g., an additional trips, additional gasoline for the boat, additional accommodation expenses, price changes in flight tickets and overweight) and that are not the researchers' responsibility, but that very likely will happen. Having flexibility facilitates the planning and most of all, the adoption of emergency and adaptive management measures.

9. Effects of the project:

Have the results of the project promoted environmental, social or economic changes? How was this determined/measured?

Environmental conservation: Official protection to Cayman Crown Reef by the Ministry of Environment was recently granted as a temporal space fishing closure zone

This document was drafted by the HRI with the support of FUNMZ. After several follow-up meetings with authorities the Ministerial Agreement 85-2020 was published in the official gazette on May 22, 2020. The agreement highlights the importance of the Cayman Crown Reef and justifies its protection. The agreement declares the Cayman Crown Reef as a temporal space closure zone (No-take zone) for 10 years, prohibiting any kind of fishing in these waters[12]. It is important to highlight that this is a remarkable accomplishment for Guatemala, as it is the first No-take zone declared on a reef area and the biggest replenishment area within the country. Guatemala has risen the percent of replenishment zone protection from a 1% of their territorial sea to 13.1%, contributing not only to the full protection of Guatemalan waters, but also rising the percent of No-take zones along the Mesoamerican Reef, contributing to the protection of 20% which is a MAR wide-goal.

Additional efforts are being carried out by us and other partners to grant additional protection to Cayman Crown Reef such as the conversations with National Council of Protected Areas (CONAP) to declare it as marine protected area, actions with the navy and the port authorities to reroute some of the passages for commercial ships further away from the shallow reefs or in deeper zones.

Advances in science

Despite the challenges to continue the monitoring activities, we have a great opportunity to document the before (monitoring baseline May 2019) and after 2019 massive bleaching event (bleaching alert developed in October 2019) impacting the MAR. Having a baseline of the state of the ecosystem previous to the bleaching event will allows us to document and study the recovery process and the resilience capacity of the reef system. Besides the indicators to measure its health state, this is the first time we have water temperature and water pH data to compare with the corals' response to the observed changes in the physical parameters. Being able to scientifically document such an event (2019 has been the hottest year ever recorded for the planet's oceans) in a recently

[12] Ministerial Agreement Dropbox Link: https://www.dropbox.com/s/8e65lwjc7gtlap6/GU1b.8%20Acuerdo%20Ministerial%2085-2020.pdf?dl=0

discovered reef is a unique opportunity to improve our understanding of the reef response to climate change impacts and the resilience of the MAR.

10. Communication of results

What mechanisms have been used or will be used to communicate the results, and to what audiences?

A technical webinar to share the preliminary results of this project with the scientific and marine conservation community was developed in collaboration with multiple scientists working on climate change, reefs, bleaching and reef protection. Given the expected audience is familiar with the topic, it was decided to maintain a technical level in the language. The participation of high level and well recognized scientists and conservationists in the webinar elevated the event by providing different perspectives on how climate change is impacting other ecosystems and reefs in close by geographies, what are the latest predictions for this year's bleaching forecast, and some of the latest methodologies to monitor coral bleaching. 245 people registered for the event, but we had a maximum capacity of 100 attendees. The very high interest was a surprise given the number of webinars offered these months. The webinar invitation, recording link and materials gathered to better respond to some of the questions received can be found on Annex 1.

11. Project continuity

Will the processes established by this project continue operating? How will it be done? Who will provide follow-up?

Phase II - Cayman Crown: support conservation of the jewel of the MAR through solid science: This project will continue under a second phase financed by MAR Fund through the Small Grant Program from March 2020 through March 2021. Since this is the initial phase of a long-term monitoring program for the Cayman Crown reef system, continuing with the existing efforts and adding additional sites and variables will certainly strengthen and complement data bases on coral health, coral disease, bleaching events and reef resilience, as well as megafauna and fish assemblages as a new monitoring variable proposed on phase II.

The implementation of the next phase has been design, proposed and will be carried out by the same team developing the current proposal, HRI and Pixan'Ja with the administrative support of Fundación Mundo Azul. We are looking for strategic collaborations with experts on climate change to enrich the analysis of the climate change related variables as previously mentioned.

Other grants: A small grant to support fund the development of these analysis and associated activities was submitted by Dr. Cresto to the Sustainable Ocean Alliance (SOA) microgrant program and granted in July 2020.
The Healthy Reefs Initiative has a grant through the MAR Fish project that will be helping with the project continuity as well as complementing the Phase II of this project.

12. Annexes

Annex 1. Webinar materials

- **Recording link to the webinar:** https://youtu.be/pLM9sqk095c
- **Resource links that might be of interest linked to the presentation:**

To submit bleaching reports to NOAA:
https://coralreefwatch.noaa.gov/satellite/research/coral_bleaching_report.php

The multi-year plots – NOAA Regional Virtual Stations
https://coralreefwatch.noaa.gov/product/vs/map.php

Sign up for NOAAs Coral Reef Watch's coral bleaching email alerts at:
https://www.ospo.noaa.gov/Products/ocean/cb/alert_system/subscribe_user_VS_5km.html

AGRRA bleaching and other survey materials – (the website is getting updated and materials will be available soon). If needed, you may contact Patricia Kramer perigeeenv@gmail.com
https://www.agrra.org/training-tools/

Mesoamerican Reef Health Report Cards can be downloaded:
https://www.healthyreefs.org/cms/report-cards/

Link to Mesoamerican Reef Explorer:
https://oref.maps.arcgis.com/apps/MapSeries/index.html?appid=9556c100e1d9424fa9b3c1748454e297

Bahamas Reef Health Report Card 2020 can be downloaded:
http://www.perryinstitute.org/coralreefreportcard2020/

Software to analyze photomosaic images
https://www.agisoft.com

Link to webinar- Mapping Reef Health: Using Photogrammetry and 3D Models to Monitor and Visualize Coral Reefs given by the Perry Institute for Marine Science
http://www.perryinstitute.org/photogramwebinar/

Link to webinar- Photomosaics as a Tool for Monitoring Coral Restoration Success
https://reefresilience.org/photomosaics-as-a-tool-for-monitoring-coral-restoration-success/

Information of the Greening of the Earth:
https://www.nature.com/articles/nclimate3004

The Amazon carbon sink decline:
https://www.nature.com/articles/nature14283
https://www.nature.com/articles/s41586-020-2035-0

Changes in species composition:
https://onlinelibrary.wiley.com/doi/full/10.1111/gcb.14413

Permafrost landscape degradation:
https://www.nature.com/articles/ngeo2674?draft=marketing

Carbon release from permafrost:
https://www.nature.com/articles/d41586-019-01313-4

Tipping points in the Earth's System:
https://www.nature.com/articles/d41586-019-03595-0

- **Webinar invitation**

REEF HEALTH AND CLIMATE CHANGE IMPACTS

Caribbean and Mesoamerican Reef Region

WEBINAR

July 28th 11:00-12:30 ET
10:00-11:30 CT/ 8:00-9:30 PT
Via: Zoom

Meeting ID: 817 0105 5500
Password: 615040

How are coral reefs responding to climate change?

Hear about the latest 2020 coral bleaching otulook and regional commitments and policies addressing climate change.
Learn about new technologies, research on heat tolerance, photogrammetry and meteorological models applied to coral reefs.

Speakers:

Ileana López, SPAW Programme Officer, UNEP Cartagena Convention Secretariat

Craig Dahlgren,Executive Director, Perry Institute for Marine Science

Ángela Mojica, Cofounder of Pixan'Ja

Mark Eakin, Coordinator, NOAA Coral Reef Watch

Fabio Cresto, Climate Specialist

Ana Giró, Healthy Reefs Initiative, Guatemala Country Coordinator