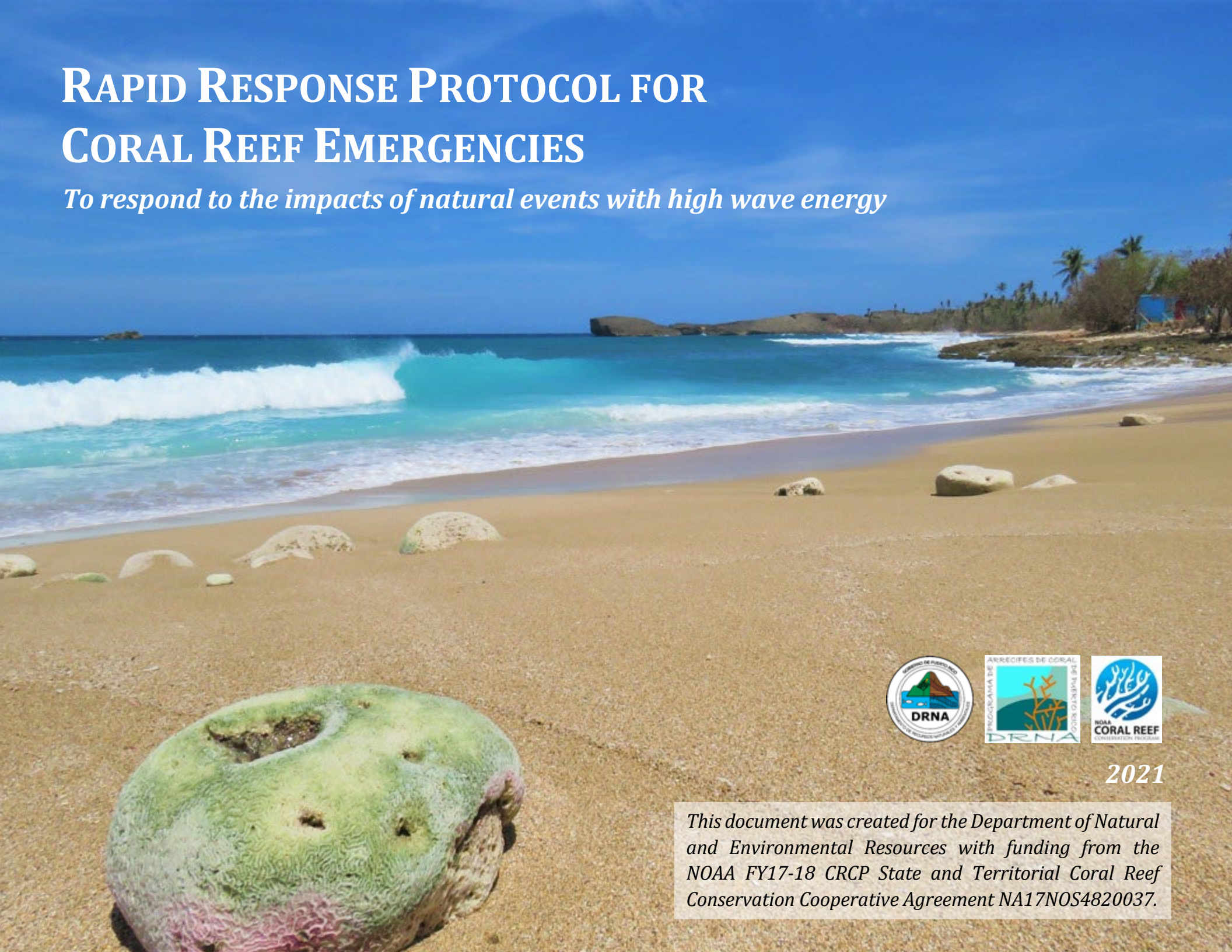
RAPID RESPONSE PROTOCOL FOR CORAL REEF EMERGENCIES

To respond to the impacts of natural events with high wave energy



2021

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POINTS OF CONTACT TO REPORT ALTERATIONS AND/OR DAMAGE TO CORAL REEFS IN PUERTO RICO

Information updated on 11/2019

CORAL REEF INCIDENT OR EMERGENCY

Ranger Corps Command Center, DNER
(787) 724-5700 / (787) 771-1124 / (787) 230-5550

Alternative
Nilda Jiménez, DNER Marine Ecology Division
(787) 230-5555
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Coral Reef Conservation and Management Program, DNER
(787) 999-2200 ext. 2406
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NOAA Restoration Center, Puerto Rico

Sean Griffin
(787) 667-7750
sean.griffin@noaa.gov

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(787) 658-7154
michael.nemeth@noaa.gov

GROUNDINGS, POSSIBLE OIL SPILLS, AND ILLEGAL ACTIVITY

Ranger Corps Command Center, DNER
(787) 724-5700 / (787) 771-1124 / (787) 230-5550

United States Coast Guard (USCG) Command Center
Sector San Juan Command Center
(787) 289-2041

OIL OR CHEMICAL SPILL EMERGENCIES FROM RADIATION OR BIOLOGICAL DISCHARGES

Environmental Protection Agency (EPA) National Response Center (NRC) and the **USCG**
1 (800) 424-8802 *(English only)*

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ACRONYMS

CREC	Coral Emergency Response Committee (Comité de Respuestas a Emergencias de Coral, *in Spanish*)
CRCP	Coral Reef Conservation Program (NOAA)
DNER	Department of Natural and Environmental Resources
EREA	Reef Emergency Response Team (Equipo de Respuesta a Emergencias de Arrecife, *in Spanish*)
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
GIS	Geographic Information System
GOES	Geostationary Operational Environmental Satellite
JCA	Environmental Quality Board (Junta de Calidad Ambiental, *in Spanish*)
LAS	Local Action Strategies
NFWF	National Fish and Wildlife Foundation
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NOAA RC	National Oceanic and Atmospheric Administration Restoration Center
NRC	National Response Center
NWS	National Weather Service
NGO	Non-Governmental Organization
SJBEP	San Juan Bay Estuary Program
POC	Point of Contact
PR	Puerto Rico
PRIDCO	Puerto Rico Industrial Development Company
RRF	Resource Request Form
USACE	United States Army Corps of Engineers
USCG	United States Coast Guard
USCRTF	United States Coral Reef Task Force
USFWS	United States Fish and Wildlife Service
WebEOC	Web Emergency Operations Center

DEFINITIONS

These definitions are taken directly from the Glossary of Terminology from the NOAA Coral Reef Information System, unless otherwise noted.

Climate change: The long-term fluctuations in temperature, precipitation, wind, and all other aspects of the Earth's climate. It is also defined by the United Nations Convention on Climate Change as "change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods"; an observed change in the prevailing or average weather conditions.

Climate change adaptation: Actions taken to help society, communities, and ecosystems moderate, cope with, or take advantage of actual or expected changes in climate conditions. The adaptation or capacity of change can reduce vulnerability, both in the short and long term. (*Slightly adapted from the NOAA Coral Reef Information System by Alfredo Montañez, DNER)*

Coral: A general term used to describe a group of cnidarians; indicates the presence of skeletal material that is embedded in the living tissue or encloses the animal altogether.

Coral bleaching: The process in which a coral polyp, under environmental stress, expels its symbiotic zooxanthellae from its body. The affected coral colony appears whitened.

Coral reef: A wave-resistant structure resulting from cementation processes and the skeletal construction of hermatypic corals, calcareous algae, and other calcium carbonate-secreting organisms.

Damage: For the purposes of this document, damage is defined as a physical disturbance to a reef that is suspected to have been caused by an extreme natural event. Examples of physical disturbance include broken, loose, turned over, or fragmented corals, which could cause mortality of the colony (*definition by the authors of this Protocol).*

Natural disaster: For the purposes of this document, a natural disaster is defined as a natural event that can adversely affect coral reefs, including hurricanes, tsunamis, storm surges, high winds, and similar events. (*definition by the authors of this Protocol).*

Ocean acidification: Ocean acidification occurs when CO_2 from the atmosphere is absorbed into the ocean and reacts with water to create carbonic acid. This decreases both ocean pH and the concentration of the carbonate ion, which is essential for calcification by calcifying marine organisms such as corals.

Rehabilitation: The recovery of specific ecosystem components in a degraded ecosystem or habitat (*Note: Many documents that refer to coral reefs use the term restoration, however, based on NOAA definitions, the correct term for the actions in this Protocol is rehabilitation).*

Restoration: The return of an ecosystem or habitat to its original community structure, natural complement of species, and natural function.

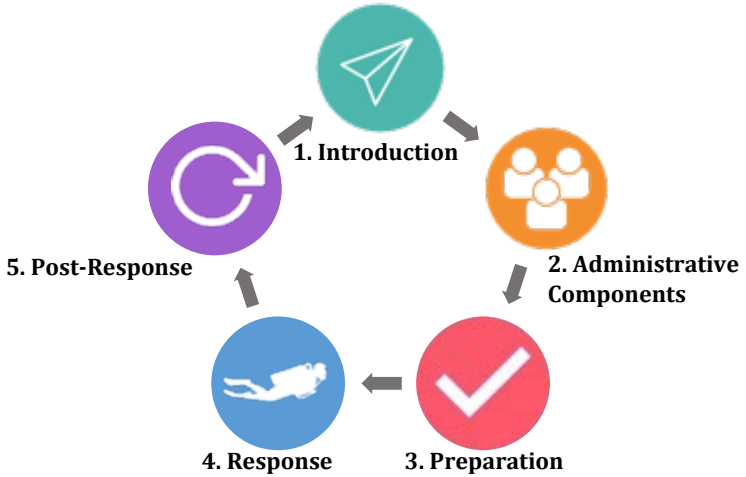
Triage: The process of stabilization and/or readjustment of damaged, broken, or fragmented corals to the substrate [1].

Vulnerability: The exposure to the possibility of being damaged (adapted from Oxford Dictionaries). The use of this term in the Protocol relates the vulnerability of corals to their level of exposure to threats and changes in conditions that are potentially harmful to their health and survival.

EXECUTIVE SUMMARY

The Rapid Response Protocol for Coral Reef Emergencies was created to guide the process of responding to damage to corals from high wave energy events. With projected increases in storm intensity and frequency in the future, the DNER recognizes the importance of having a Protocol to respond efficiently to these types of coral emergencies collaboratively, in coordination with the existing Reef Emergency Response Team (EREA, or Equipo de Respuesta a Emergencias de Arrecife, *in Spanish*).

Each extreme event has distinct causes and effects, so this Protocol is a guide that can be adapted according to the circumstances. The year 2017 was one of the most active and destructive Atlantic hurricane seasons on record, and its impact on coral reefs, in addition to the 2018 storm surge, evidenced the need to create this Protocol. The experiences after facing these events were used as a reference in this document. The following is a summary of the sections in this Protocol and the steps for planning and responding to extreme natural events with high wave energy.



1. INTRODUCTION

A summary of the events that led to the creation of this Protocol, as well as the purpose, goals, and relevant laws and documents

2. ADMINISTRATIVE COMPONENTS

The components necessary for the implementation of a rapid response

- Create a **Coral Emergency Response Committee**
- Develop an effective **communication system and plan**
- Expand the **response network**
- Prepare the **necessary materials** for the implementation of the Protocol

3. PREPARATION

Annual activities for preparedness to respond to specific coral reef emergencies and actions to be taken once an alert or warning is issued for an extreme natural event

- Meeting with the Coral Emergency Response Committee - *First Friday of each May*
- Meeting with the response network - *Second Friday of each May*
- Train and certify new participants in the response network
- Outreach aimed at fishermen, boat owners, and the general public on preparation
- Track weather reports throughout the year
- Collect and distribute GIS information

Preparation during an alert of an extreme natural event:

48 hours or more before the event

1. Continually follow weather reports and share this information
2. Distribute available materials in areas of possible damage and identify where to obtain missing materials
3. Share preparedness information with the media for public dissemination

36 hours or more before an event

4. Prepare materials and information necessary to respond
5. Establish communication with the Coral Emergency Response Committee (CREC, for its acronym in Spanish) and the response network, and establish contact with stakeholders

4. RESPONSE

Sequence of actions to follow after extreme natural events with possible major impacts (estimated damage of 10% or more) to a reef site:

- **Initial Response**
  - Prioritize areas to conduct assessments
  - Take into consideration steps for a safe response
- **Assessments** using the methodology and appropriate datasheet in *Appendix IV*
  - Prioritization of areas for rehabilitation
- **Rehabilitation** and data collection using the datasheet in *Appendix VI*

5. POST-RESPONSE

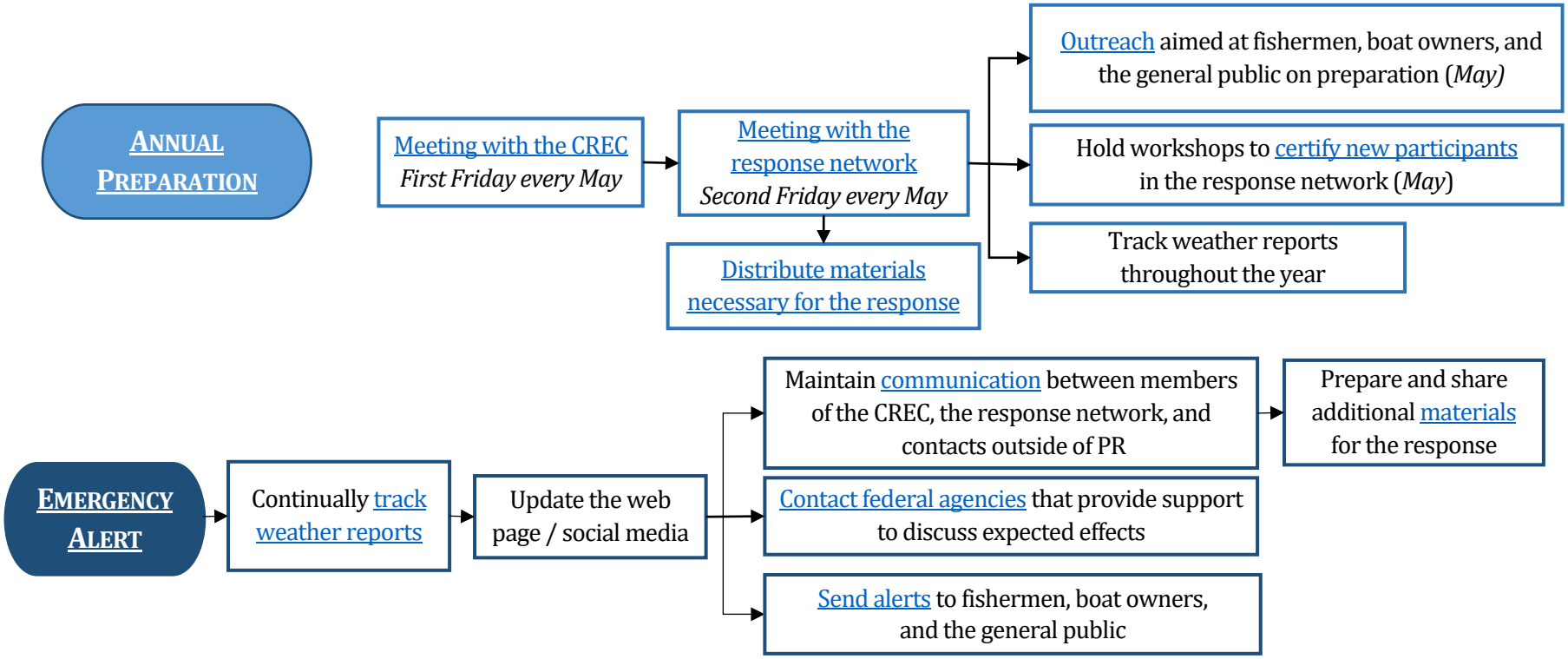
- Hold a debriefing session with the CREC and the response network
- Integrate lessons learned into the Protocol
- Conduct additional rehabilitation, if necessary
- Monitor rehabilitation efforts using the datasheet in *Appendix VIII*

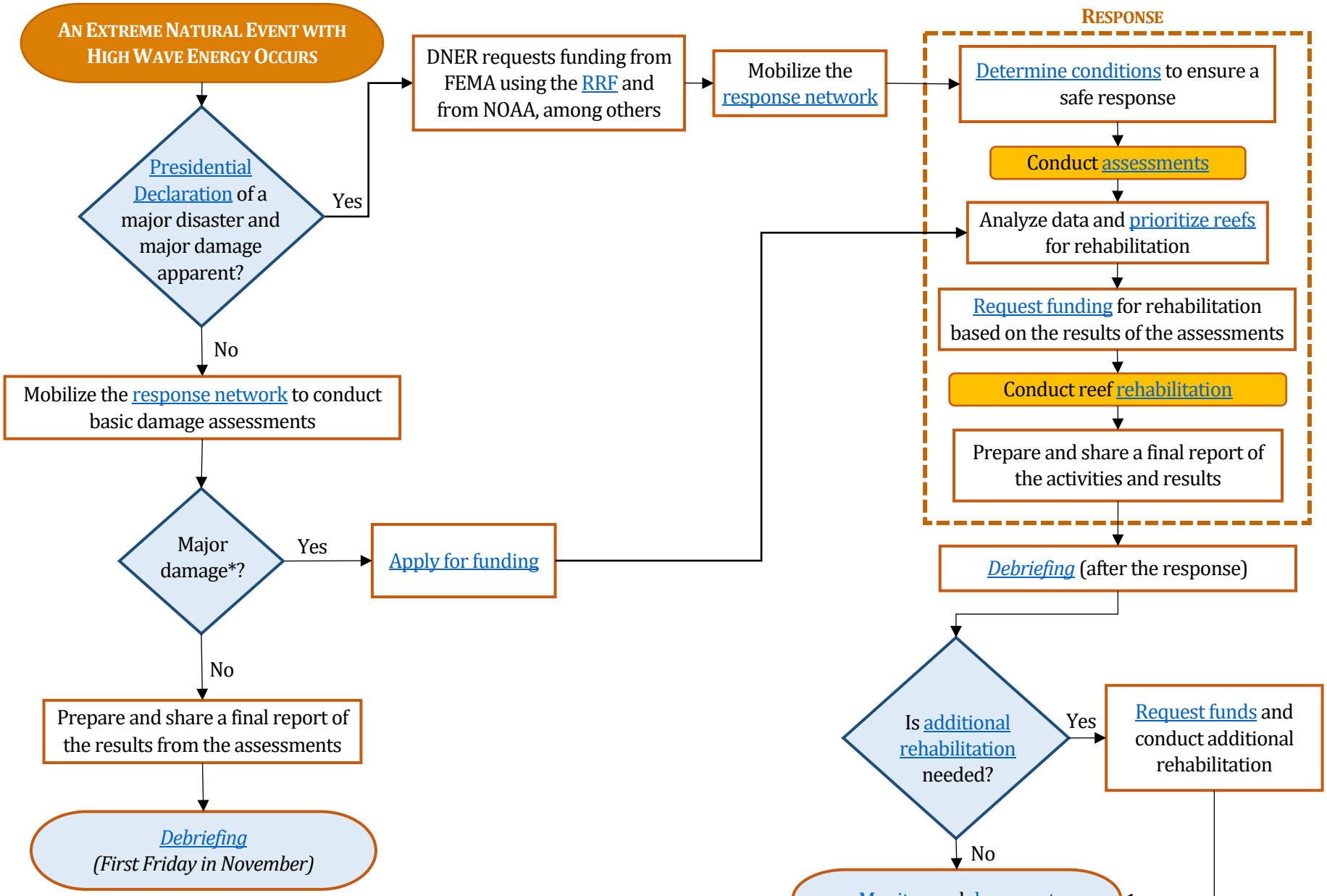
FUNDING

Identification of funding sources to support coral damage assessment and rehabilitation efforts, included in *Appendix X*

FLOW CHARTS

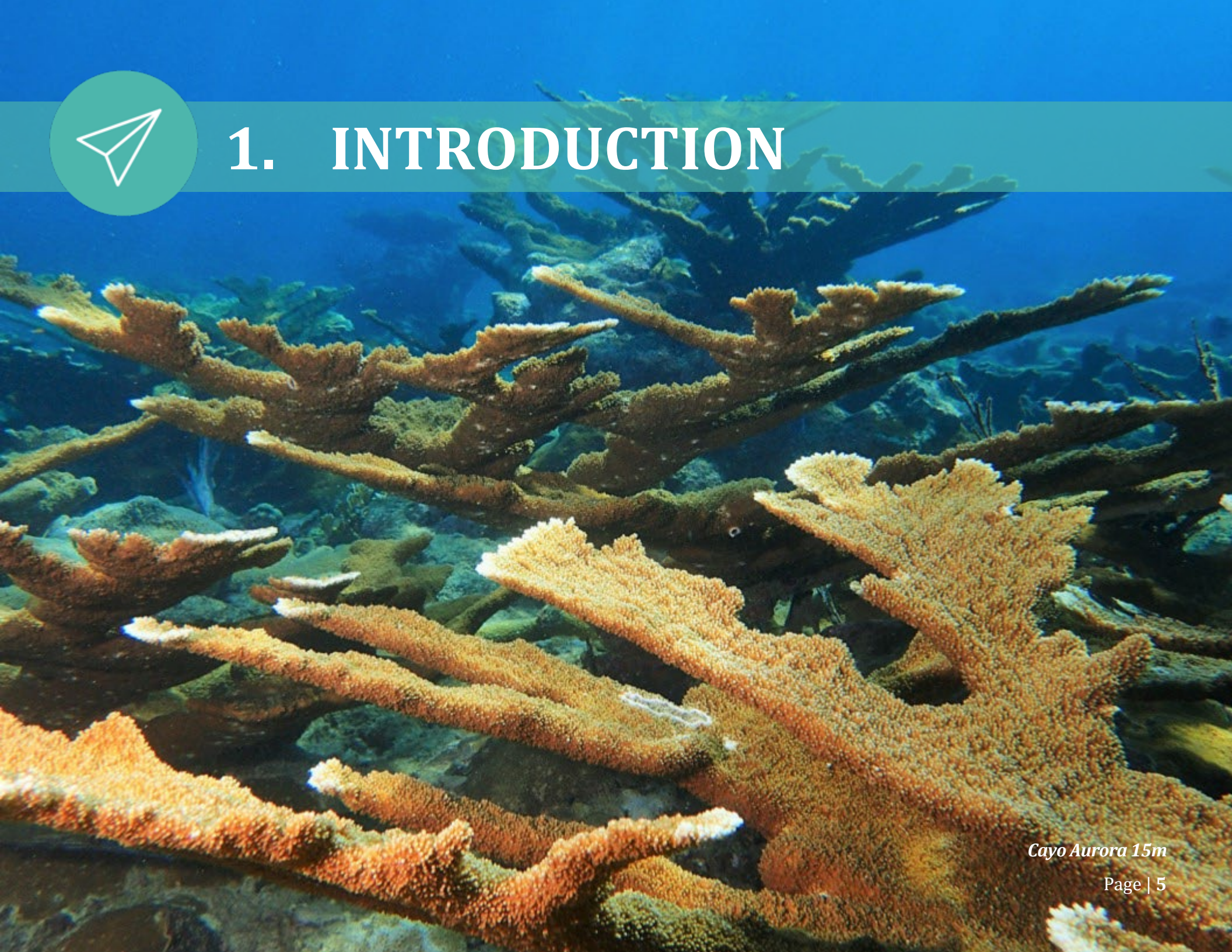
GENERAL ACTIONS TO TAKE IN PREPARATION FOR RESPONSE TO A CORAL REEF EMERGENCY WITH HIGH WAVE ENERGY





*Major damage = 10% or more damage to the corals and reef

1. INTRODUCTION



Cayo Aurora 15m

Puerto Rico contains approximately 756 km^2 of coral reefs and hardbottom habitat in shallow waters[2], the majority of which are fringing reefs[3]. In the Caribbean, reefs are exposed to chronic and local threats, which increases their vulnerability to regional disturbances such as hurricanes and bleaching events[4].

Corals have evolved and adapted to the impacts of extreme natural events such as hurricanes and storm surges. However, increases in pressure at local and global scales, such as groundings and poor water quality (e.g. land-based sources of pollution, global warming, and acidification) augment the level of stress on corals. The average live coral cover in the Caribbean is estimated to be reduced by approximately 17% in the year following a hurricane impact, and recovery to its pre-hurricane state can take at least eight years after the impact[5]. Annually, more coral cover is lost at sites impacted by a hurricane than at sites not impacted by a hurricane (6% versus 2%)[5].

1.1 HURRICANES IRMA AND MARIA IN 2017

In September 2017, Puerto Rico was impacted by hurricanes Irma and Maria, severely affecting coral reefs throughout the archipelago. Following these hurricanes and the storm surges from winter storm Riley in March 2018, the damage assessments and rehabilitation efforts conducted by NOAA in 2018 revealed that an average of 11% of Puerto Rico's shallow coral reefs were impacted[6]. Following a rehabilitation effort funded by NOAA, NFWF, and FEMA, 15,336 coral fragments were attached at 57 sites around Puerto Rico (Sean Griffin, *personal communication)*.

The DNER Puerto Rico Long-Term Coral Reef Monitoring Program (PRCRMP) documented an average of 22.50% coverage of live hard coral at the 21 monitored sites in 2018[7]. The results also showed an average loss of 15% hard coral cover in 19 sites since the last time they were monitored, probably due to the effects of the 2017 hurricanes and 2018 storm surges.

1.2 PROTOCOL PURPOSE

This Protocol details the steps to follow when there is a possibility of damage to coral reefs due to impact from high wave energy events. Its use could help improve the response after these events, prevent further coral loss, and increase coral reef collaboration throughout the Puerto Rican archipelago. Rapid assessment, reef prioritization, and rehabilitation processes can make a significant difference in coral survival and long-term ecosystem recovery. In addition, this Protocol recommends steps to take in case of coral reef emergencies and outlines preparedness efforts before an event occurs. By following this Protocol, more organizations, groups, and agencies will be able to get involved in preparedness to mitigate the impact of extreme events on coral reefs and reduce the cost of replacing the ecosystem services that corals provide.

This document was created from the lessons learned after the 2017 hurricane season, many of which were collected during a meeting on August 3, 2018. Representatives from 10 organizations attended the meeting and information on strengths and weaknesses were collected in response to coral assessments after the 2017 and 2018 extreme events, as well as the opportunities and threats to responses in future events. This Protocol is a dynamic document, which should be adapted with consideration to the lessons learned and successes after each emergency response.

Additionally, the Protocol will guide coral reef conservation leaders from agencies, organizations, and groups before, during, and after extreme natural events that cause high wave energy. The actions outlined below should work in tandem with, rather than replace, existing coral reef rapid response efforts, especially with the Reef Emergency Response Team (EREA, *for its acronym in Spanish*).

This document is based on Goal 8, Objective 3 of Puerto Rico's 2011-2015 Local Action Strategies for Coral Reef Conservation[8].

Goal 8 - Promote recovery of reefs from natural stressors, atmospheric phenomena and invasive species

Objective 3 - Strengthen response capability when natural disasters occur

1.2.1 Protocol Goals

Involve and integrate more organizations, agencies, groups, and individuals interested in expanding coral reef conservation efforts in Puerto Rico

Implement actions that help reduce damage to coastal ecosystems before and after extreme natural events with high wave energy

Minimize the time required to implement response actions to reduce damage and loss to coral reef ecosystems

Provide updated information on the impact and recovery of coral reefs

Identify funding sources and facilitate the process of requesting assistance for coral reef assessment and rehabilitation when there are potential impacts from extreme natural events

1.3 LAWS AND RELEVANT DOCUMENTS

Federal Executive Order 13089 of 1998 on the protection of coral reefs established the United States Coral Reef Task Force (USCRTF) to lead interagency efforts in the preservation and protection of coral reef ecosystems; in the creation of maps; in monitoring, research, conservation, mitigation, and rehabilitation; and in international cooperation. This order was the impetus for the creation of the Coral Reef Conservation Act of the United States, which was passed in the year 2000 to preserve, sustain, and restore the condition of coral reef ecosystems. In 2002, the USCRTF developed the National Coral Reef Action Strategy, which includes 13 goals to respond to global threats to coral reefs. Goal 9 is to restore damaged reefs, which is specifically addressed in the implementation of the Protocol.

Local laws directly related to coral reef conservation are:

- Law No. 147 of 1999 for the Protection, Conservation, and Management of Reefs in Puerto Rico
- Regulation No. 8809 of 2016 on Coral Reefs

The DNER Coral Reef Conservation and Management Program was created in response to Law No. 147. Regulation No. 8809 establishes the Coral Reef Advisory Committee, which promotes communication between stakeholders that have jurisdiction over coral reefs and provides technical advice to the DNER Secretary on the implementation of Law No. 147.

In addition to the legal basis to coral reef-related issues, there are several local and national documents that guide the management and conservation of these marine resources, as shown in *Figure 1*.

1.4 LEGAL FRAMEWORK

This Protocol has been prepared in compliance with the mandate of Law No. 147 of 1999 (Law for the Protection, Conservation, and Management of Coral Reefs in Puerto Rico, Article 4), under the authority conferred by Law No. 23 of June 20, 1972, as amended (Organic Law of the Department of Natural Resources) and under Law No. 241 of 1999 (New Law of Puerto Rico Wildlife).

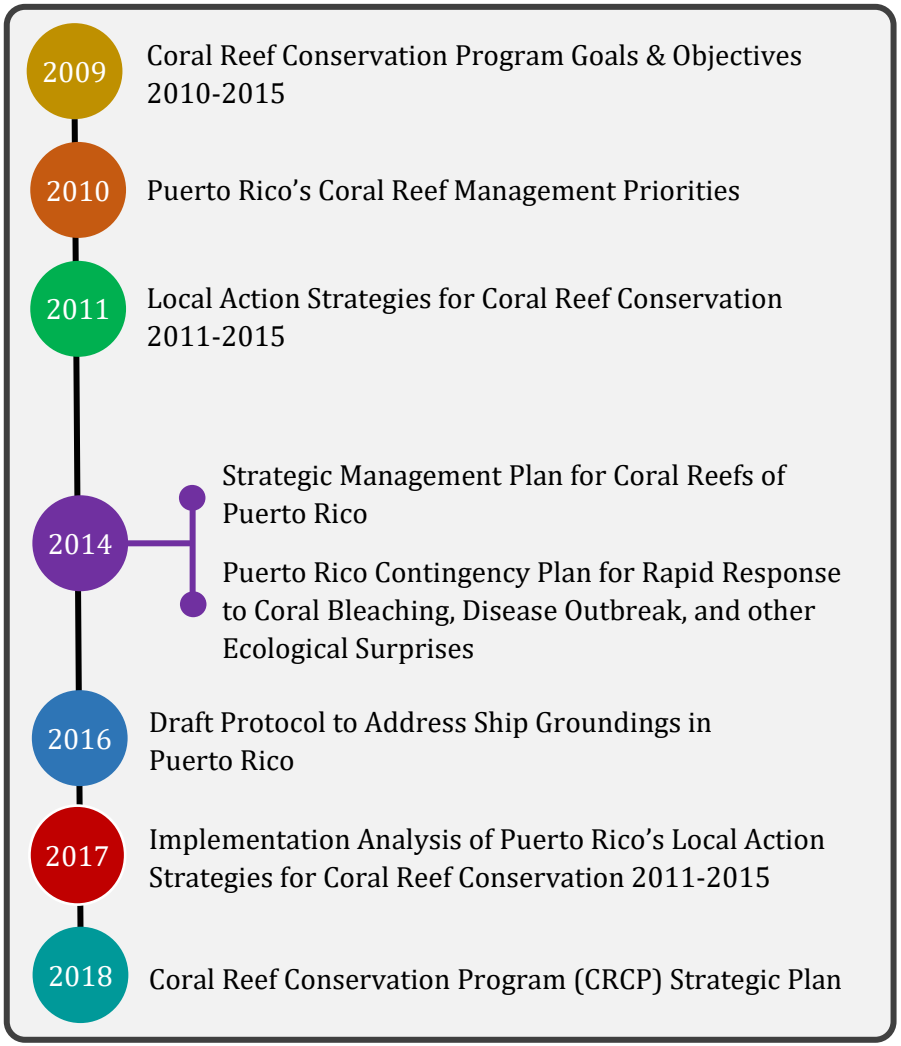


Figure 1. Documents related to coral reef emergency response in Puerto Rico.

2. ADMINISTRATIVE COMPONENTS

Tres Palmas, 20m

The rapid response actions detailed in this Protocol are dependent upon the establishment of the following components as part of emergency preparedness:

1. **Coral Emergency Response Committee**
2. Effective **communication system and plan** with alternatives to respond without electricity or communication services
3. Broad **response network**
4. **Prepare the materials** necessary for response and plan how to acquire missing materials or how to respond without them

2.1 CORAL EMERGENCY RESPONSE COMMITTEE

For the planning and implementation of the response, it is necessary to establish a Coral Emergency Response Committee (CREC, *for its acronym in Spanish*) that promotes receptive leadership and multisectoral communication, including governmental and non-governmental organizations (NGOs), academia, and the private sector, among others. The following lists include essential responsibilities of CREC members, which may change depending on the response and post-response needs. Responsibilities are designated annually by the existing CREC during the first annual meeting (the first Friday in May), detailed in section *3.1 Annual Preparation*.

COORDINATION

- Help connect regulatory agencies and collaborators
- Identify Points of Contact (POC) for the response network at the regional level, including an alternate POC per region
- Keep an up-to-date contact list
- Plan and facilitate meetings and work among members
- Stay up-to-date with weather events
- Activate the Protocol response with the Reef Emergency Response Team (EREA, *for its acronym in Spanish*) and notify stakeholders
- Contact the response network before and after emergencies that require action
- Organize preparation and response activities and meetings, and other events involving the response network
- Implement the communication plan and keep information up-to-date on the social platforms created for the CREC and the response network

TRAINING

- Coordinate and provide training to certify new members of the response network following the EREA protocols
- Prepare official identification for response network members

DATA MANAGEMENT

- Keep the website and social networks updated with useful information for the response network
- Collect and organize assessment and rehabilitation data
- Analyze assessment data to prioritize rehabilitation efforts
- Prioritize areas for rehabilitation

LOGISTICS

- Identify potential funding sources for each emergency
- Maintain contact with the entities that grant funding, including to provide updates on project progress and reporting
- Fill out and deliver documents to request funding
- Apply for permits for activities related to preparation, response, and post-response and coordinate to keep permits up-to-date

LOGISTICS (*CONTINUED*)

- Keep an inventory of available materials and equipment, and coordinate material use and availability to the response network
- Maintain contact with private organizations to request access to necessary materials during an emergency (e.g. fuel, transportation, etc.)

2.2 COMMUNICATIONS

Creating and maintaining an updated list of participant phone numbers and emails for those involved in the response, including alternative means of contact is necessary to facilitate communication. Contact information can also include that of relatives or neighbors with service from a different cell phone company as an option to prepare for service failures from one or more companies. The following communication platforms should be created or updated to facilitate communication between the parties involved in the Protocol:

Website

The EREA website will be used to provide the following:

- Updated information on:
  - How to join the volunteer group
  - Contact information
  - Meetings, workshops, trainings, or other events
  - Additional response activities
- Gather important information (i.e. incident reports, data, photos of damage) for coral reef managers and to use in the decision-making process

Social Networks

Pages or groups on social media, like Facebook and Twitter, help to spread the message. The EREA Facebook will be used to communicate information to the response network.

Message Groups

A quick way to communicate with all the members of a group is through cellphone messages. Other popular options are private programs like WhatsApp or Facebook Messenger. In the event of communication system failures, some of these private communication programs may work better than others depending on the situation.

In addition, information will be shared in the Coral – PR Google Group, which was established to provide a forum that promotes communication and collaboration on coral research, conservation, and education in Puerto Rico.

Points of Contact (POC) by group and/or region

In emergencies where there is a power and/or communications failure, some of the previously discussed communication options will not work. To prepare for this, the CREC must identify POCs by region and alternate contacts, which should include a leader from each group of the response network. Before an extreme natural event, meeting points should be identified with a date and time, in central places in each region, where stakeholders can obtain information and coordinate a response. The meeting points could be the DNER offices in the region, universities, fishing villages, or the office of the regional response coordinator, among others.

To address the scenario in which there is no local communication, the CREC will identify a contact outside the impacted area, for example, a NOAA contact in the United States, who can serve as a liaison as communications are reestablished.

Communications Plan

In addition to the response network, it is important to implement a communication plan to alert boat owners, fishermen, and coastal property owners on how to prepare for these events and prevent their property from becoming a threat to marine ecosystems. At the beginning of the year, the CREC will launch a press release and / or media campaign with recommended practices in the event of an extreme natural event with high wave energy. These actions may be coordinated with the DNER Commissioner of Navigation.

At the beginning of each hurricane season and winter storm season, it is recommended to share at least the following information and/or messages about preparing for extreme natural events:

- Remove your nets, traps, and cages from the water and secure them
- How to properly store your boat
- How to track weather information and use it to know when to prepare and stay safe
- How to prepare your home and belongings to prevent these from becoming marine debris (for the general public)

2.3 RESPONSE NETWORK

Expanding the current response network, created by EREA, is important for this Protocol. This network should be made up of people who can provide information and/or take action when there is a coral reef emergency. These include agency representatives, members of organizations, groups, and individuals with the ability and availability to assist in preparedness and/or response. Ideally, this network should have representation throughout Puerto Rico and, among the groups, decide which areas and reefs to respond to, so as not to duplicate efforts. Participants in the response network can carry out different activities according to their ability and experience.

The response network should also be made up of other stakeholders who have access to coral reefs, such as protected area managers, dive shops, scientists, fishermen, and coastal communities. If any of these sectors are not included as part of the response network, it is recommended to work on expanding their representation. Once created, the response network participant list and information should be reviewed and updated every year to validate the availability of the participants to continue as part of this initiative.

2.4 MATERIAL PREPARATION

The existing or acquired equipment for the implementation of the Protocol should stay with CREC members and be distributed according to the incident or regional contacts. The CREC will conduct an annual inventory of additional resources available in the regions that will facilitate the coordination of the response to an event. This inventory includes available human resources, equipment (boats, vehicles, compressors, etc.) and materials, which do not involve the disbursement of funds. See *0* for a list of general response and post-response materials.

3. PREPARATION

Fajardo, 2018
Photo: Osvaldo Quiñones, DNER Coastal Zone Management Program

3.1 ANNUAL PREPARATION

Preparation for extreme natural events includes identifying material and human resources and planning their use in an emergency. Response planning must consider a range of possible scenarios, including those in which certain resources are not available.

Preparation at the start of each year is useful to reduce time and effort in responding to potential impacts to coral reefs. The following is a list of some of the preparedness activities that should be coordinated each year, ideally beginning in early May, at the end of the winter storm season and one month before the hurricane season begins (June 1).

1. **Coral Emergency Response Committee Meeting**
   First Friday of each May
   - Discuss the lessons learned from previous years and new adaptations to the Protocol
   - Evaluate availability and changes that could affect the coordination of the response (e.g. condition of materials, deterioration of water quality, availability of trained personnel)
   - Identify existing funds for the response or any funding opportunity that may be requested in advance
   - Take inventory and inspect available materials
   - Discuss projections for the upcoming hurricane season
   - Coordinate trainings
2. **Meetings with the response network participants**
   Second Friday of each May
   - Confirm participant registration and contact information, and their availability by region
   - Discuss actions for preparation and adapt the process to the new season
   - Corroborate the inventory of available resources
   - Distribute educational materials, work materials, and equipment, as necessary. The person receiving work materials and equipment must commit to taking responsibility for them.
3. **Train and certify new response network participants**
4. **Conduct a campaign aimed at fishermen, boat owners, and the general public on preparing** for extreme natural events. This should occur annually in May, before hurricane season.
5. **Track weather events**
   The websites found in *Appendix II* are useful resources for monitoring weather-related information and receiving early warnings in preparation for weather events. Some of the important functions are listed below each website. In addition, local news can be used to obtain additional information related to weather and forecasts, areas affected by the event, hazards, government command centers, and more.
6. **Collect and distribute GIS information** to identify response opportunities and constraints

3.2 PREPARING FOR AN EXTREME NATURAL EVENT ALERT

The initial response begins with an alert of an extreme natural event. Tsunami warnings are generally issued right before the event and are therefore not included in this preparation stage.

48 hours or more before an extreme event

The NOAA National Hurricane Center issues watches, for example:

- Storm surge watch
- Tropical storm watch
- Hurricane watch

1. The CREC will continuously follow weather reports and will share this information with the network through different platforms
2. The CREC will distribute available materials to the groups in areas with possible damage and help groups identify where to get missing materials
    - The CREC will print maps of the projected routes of the event that will include the benthic ecosystems that could be affected, boat ramps that could be used, and other useful information to know which groups will be in areas more prone to damage
3. The CREC will share important information from the communications plan with the media so the public can prepare and store anything that could become marine debris

36 hours before an extreme event

The NOAA National Hurricane Center issues warnings, for example:

- Storm surge warning
- Tropical storm warning
- Hurricane warning

4. The Points of Contact (POCs) which are regional leaders, together with the response network groups, will prepare materials and information necessary for the response
5. Communication
    a. The CREC will establish contact between its members
    b. The POCs will establish communication with the response network and will:
        - Ensure that everyone understands their role and has necessary response materials or knows how to obtain them
        - Inspect equipment to ensure it works
        - If any materials are missing, ensure members understand how to respond without it
    c. Confirm one or more contacts outside of Puerto Rico, in case there is no local communication
    d. Contact Federal agencies to discuss the processes if funds need to be requested for rapid assessment and rehabilitation

4. RESPONSE

Cayo Diablo 5m

4.1 INITIAL RESPONSE

After the occurrence of a high wave energy event with major damage to reefs, the initial response should start with the following:

1. The CREC will contact the NOAA Restoration Center (RC) and the NOAA Management Liaison to explore the possibility of receiving funds to finance the post-disturbance assessment efforts. According to the expected damages, additional agencies or organizations can be contacted to request funds.
2. The CREC will conduct a prioritization exercise to identify areas of interest for the response and determine where to initiate damage assessments.
3. Depending on the available funding, the response will be initiated in priority areas. In these areas, response network groups will work on the following tasks:
   a. Determine and review conditions to carry out a safe response (see section *4.1.2*).
   b. Conduct reef assessments.
   c. Submit assessment data and reports to the CREC within two weeks of conducting the assessment. The CREC will analyze the data to determine priority areas for rehabilitation.
   d. Carry out reef rehabilitation efforts in the priority areas.
2. Each group in the response network that responded to the event will prepare a final report of activities and results, which will be sent to the CREC. To facilitate analyses, the table will be submitted in .csv format with the collected data.

4.1.1 Analysis to prioritize response areas

After an emergency event with a possible impact to several coral reefs, it is important to determine which reefs to attend to first, especially when funds and materials are limited. Not all events will affect the same reefs, therefore, a prioritization process for post-disturbance response is crucial and should be developed by the CREC and other stakeholders to facilitate quick and effective action. In the prioritization process, consider the following information:

- The areas affected by the event (e.g. the path of a hurricane)
- The ecosystem value of the reef (e.g. the reef's contribution to coastal protection, if it acts as an important aggregation or spawning area, active rehabilitation areas)
- Coral cover

As an example of reef prioritization during the 2017 hurricane response, NOAA characterized "high value" reefs by 1) coral cover, 2) presence of coral species listed as endangered or threatened, and reef-building species, such as *Diploria labyrinthiformis* or *Colpophylia natans*[6] and 3) contribution to coastal protection[6]. NOAA focused on assessing shallow water reefs (less than 23 feet [7 meters] deep), species listed under the Endangered Species Act (ESA), and reef-building species.

4.1.2 What to consider when planning fieldwork after an extreme event

In planning the damage assessment and / or response to a coral reef emergency, participants must ensure that the weather conditions and water quality are suitable to safely carry out fieldwork. Response efforts should not be conducted in dangerous weather conditions such as strong currents, high waves, electrical storms, etc. Likewise, there should be sufficient visibility both outside and underwater to respond efficiently and avoid accidents.

Water Quality

According to the EPA, a bacteriology test that measures enterococci is the best indicator of health risk in saltwater. If the bacteriological analysis shows that enterococci is greater than 70 colonies per 100 milliliters of water, the parameter exceeds the Beach Action Value and immersion is not recommended[9]. A rapid test measuring enterococci and other parameters can be performed using kits or equipment, for example, those included in *Appendix I*. A reference for these tests could be the parameters used by the San Juan Bay Estuary Program (SJBEP), included in *Appendix III*.

The DNER Beach Monitoring and Public Notification Program publishes water quality monitoring results and whether or not the beach complies with the Beach Action Value, through the DNER Facebook. This information is also published on the CARICOOS website or its Pa 'la Playa cellphone application. For rapid tests that identify sewage contamination, phosphate, nitrite, nitrate, ammonia, and pH, test kits such as the API Master Test Kit can be used.

It is not always possible to sample water quality in advance and / or wait for results from a laboratory. In such cases, responders should review the most basic indicators that reflect possible contamination, for example, floating material, bad odor, poor visibility, or other suspicious conditions. In addition, it is not advisable to swim in bodies of water near urban areas 24 hours after a rain event, due to the possibility of contamination from sewage (Jorge Bauza, *pers. comm*).

Other limitations to consider when planning fieldwork:

- Damaged boat docks and ramps
- Marine debris that inhibits navigation or access
- Lack of essential safety materials (e.g. first aid kit, materials to assess water quality)
- Poor visibility in the water

Unmanned aircraft or drone systems may be used for aerial documentation and evaluation of areas of interest before visiting the reef, as long as the pilot complies with the current Federal Aviation Administration (FAA) regulations.

4.2 CORAL REEF DAMAGE ASSESSMENT

The first aspect to consider after an event is the magnitude of the impact to the reefs. For this, the CREC must evaluate the available information on the route or direction of the event and establish which areas are priority for response. Once the areas with possible impacts are determined, the CREC will communicate with the regional POCs to coordinate the assessment efforts. Assessment participants must have received training prior to this activity.

4.2.1 Methods

Similar to what is detailed in the Puerto Rico Contingency Plan for Rapid Response to Coral Bleaching, Disease Outbreaks and other Ecological Surprises, each group will be made up of snorkelers and/or divers, support personnel, and a group leader who maintains communication with the CREC. The methods for assessment will depend on the available materials, the site conditions, and participant experience. Below, a general methodology is presented that could be adapted depending on the conditions for each effort.

Experienced Participants

Participants in the response network with experience evaluating corals will start with a roving diver survey, which will be conducted by a manta tow survey and / or with scooters or jetskis. This survey will be used to identify suitable areas to place a Band Transect (BT) to assess damage to the coral reef in areas with greater than 10% colonized hardbottom habitat, if possible. The BT should measure 20m x 2m ($40m^2$), with 1m on each side of the main line. Two divers or two snorkelers will conduct

categorical assessments of site damage and damage to corals and / or the reef framework. Each diver will swim on one side of the transect and completes the assessment sheet included in *Appendix IV*. Transect videos and photos should be taken for reference, as well as GPS coordinates to georeference the area investigated.

For each BT, two coral impact assessment sheets should be filled out (one sheet per diver / snorkeler). These data sheets were adapted for this Protocol from the assessment sheet used by NOAA in the 2017 hurricane response. The sheets will be delivered to the CREC, who will analyze the data to complete the prioritization exercise for reef rehabilitation, using available resources and funding.

Inexperienced Participants

Participants in the response network will conduct a roving diver survey to identify the general condition of the coral reef site. Each diver should complete an assessment sheet, included in *Appendix IV.* Participants without experience in this type of assessment are recommended to submit photos or videos to validate their findings.

Assessments should start at reefs that are accessible from the shore and have low or no risk to participants. Later/subsequent assessments will determine whether it will be possible to reach distant reefs or those that may present some risk. Given the urgency of rehabilitating impacted corals after an event, the assessment should focus on the condition of the corals. However, any observations on the state of associated ecosystems after the event should be recorded and documented with images and videos, if possible.

4.3 CORAL REEF REHABILITATION

Once reef assessments are completed, rehabilitation activities should be coordinated depending on available materials and funding. Rehabilitation includes removing debris, stabilizing substrate, and stabilizing or attaching coral fragments in suitable areas or in conditions that allow the coral to survive and grow. If coral fragments can be collected and stabilized right after physical impacts, the probability of survival increases substantially, up to more than 90%[10].

Areas with significant damage to coral cover, particularly impacts to reef-building species, should be prioritized and recommended for rehabilitation through triage. In the event that the area with the greatest damage is not suitable for attaching coral fragments due to poor water quality, strong swells, or exposure to continuous stress that could limit the corals' survival, the fragments should be attached in an alternate site, always considering their function in the original reef. Each rehabilitated site will be documented using the coral rehabilitation datasheet, found in *Appendix VI*.

General practices for coral reef rehabilitation

1. Rehabilitation of branched species, such as Acroporids, should be prioritized, since it has been documented that they suffer higher mortality rates when fragmented and / or loose colonies are found in the substrate[11]. Columnar species such as *Dendrogyra cylindrus* may also be a priority due to their conservation status, vulnerability to mechanical damage, and low probability of survival.

   The next priority should be massive coral species, as they tend to withstand longer periods of time in the substrate after breaking or turning over. In the 2017 hurricane response, it was found that slow-growing coral colonies of the *Orbicella, Pseudodiploria, Diploria* and *Colpophylia* genera survived longer than the *Acropora* fragments, with colonies of the first three surviving a year after the impact of the hurricanes[11].
2. To the extent possible, corals should be returned to their original area and depth and fixed at the same ratio (number of corals / reef area) as the pre-disturbance density[12]. If the coral cannot be fixed

in the same area, a suitable site should be identified or they should be taken to a coral farm and later attached *in situ*.

3. To attach corals, different techniques can be used as applicable (e.g. cement, epoxy, zip ties)[12]. The technique used will depend on the type of fragment, substrate, and available materials.
4. The substrate should be scraped and cleaned so that it is free of marine organisms before attaching the coral[12].
5. The place chosen to attached coral should be away from fire coral, sponges, or fast growing algae that can compete with the coral and reduce its potential for survival [12].
6. Attached corals should not be in contact with others[12]. Sufficient space must be left for the growth of the individual. For example, typically 0.5 to 2m distance is left between *Acropora cervicornis* fragments [18].
7. If possible, 10% of fragments or corals should be marked to monitor survival and growth. Data should be collected on the location, species, identification number, size, number of branches (if applicable), and condition (healthy, diseased, bleached, percent live tissue cover, algae cover, etc.). Photographs and / or video should be taken to document all corals and fragments[12]. The data collection sheet is included in *35Appendix VIII*. More details of the coral monitoring process can be found in section *6.5.3*.

5. POST-RESPONSE

Tourmaline 10m

Post-response is long-term and includes those activities that take place after the urgency of an immediate response has passed. The effects of extreme natural events, such as tropical cyclones, can have long-term consequences and coral reef recovery may take years to centuries [13]. This phase includes a meeting with the CREC to decide on the actions to take and to coordinate the continuous monitoring of the rehabilitation work carried out and possible mitigation of the damages caused by the emergency.

5.1 *DEBRIEFING* WITH THE CREC AND RESPONSE NETWORK

The CREC and the response network will meet at least twice a year, even without an emergency affecting coral reefs. The second meeting will be held on the first Friday of each November, unless the response network is responding to an emergency. In that case, the second meeting will be held when the emergency response is completed. In this meeting, the CREC should lead a discussion and include the following:

- A briefing on what was accomplished during the response and current activities from the CREC and the response network.
- Opportunities for post-response activities and details of how and where to implement them.
- Lessons learned and changes in the implementation of the Protocol, as well as other important information to adapt and improve future emergency responses. All of this should be documented and, if relevant to the response, should be integrated into the Protocol.
- Monitoring data from previously rehabilitated corals, successes, challenges, and lessons learned from rehabilitation and additional activities.

5.2 ADDITIONAL REHABILITATION

In cases where the damage to a coral reef is such that there are not enough living fragments or colonies in the area for rehabilitation, corals from coral nurseries can be used for rehabilitation. Another option to consider is the use of artificial reefs as alternatives to rehabilitate some of the coral reef functions in an area that may not be fully restored with other techniques.

5.2.1 Adaptive Rehabilitation

The effects of climate change on coral reefs, including rising sea levels and temperatures, increased intensity of storms, ocean acidification, as well as anthropogenic threats including water pollution, overfishing, and impacts of nautical activity, among others, are aspects that must be considered when planning the long-term rehabilitation of coral reefs. Technology and tools exist to project future oceanic conditions and the potential vulnerability of coral reefs to changes in these conditions. To the extent possible, this information should be integrated when evaluating the rehabilitation measures to be implemented, thus increasing the probability that these efforts will be effective in the long term. Some of the recommended coral reef rehabilitation practices are:

- Diversify rehabilitation efforts with various native coral species and different genotypes of the same species to improve reef resistance. For example, consider that Acroporids are more sensitive than other species to ocean warming [14,15].
- In some coral species, micro-fragmentation and coral fusion techniques demonstrate rapid growth compared to the natural growth rate[16]. These techniques have been successful in the rehabilitation of *Montastrea cavernosa* and *Orbicella faveolata* in the Florida Keys[17].
- Increasing genotypic diversity can reduce inbreeding depression. However, avoid coral movement or mixing gametes from distant

populations to reduce outbreeding depression. Both conditions can be detrimental to the long-term survival of corals[18].

- Consider the three-dimensional structure of coral reefs. For example, stabilizing branched coral fragments close to the same species is recommended to create larger thickets that could help minimize impacts from future waves or storms[11].

5.3 MONITORING

Monitoring rehabilitated reefs helps to determine if rehabilitation efforts were successful. The percentage of attached corals that were tagged and still alive and healthy after a while makes it possible to quantify and compare the rehabilitation strategies carried out. These data also provide the necessary information to determine difficulties or failures in the process and whether corrective action or mitigation may be appropriate at or near the rehabilitated coral sites.

General practices for monitoring

1. In each monitoring activity, data on previously tagged corals should be collected, including the identification number of the tagged coral, size, the number of branches (if applicable), and condition (healthy, diseased, bleached, etc.), the percent of living tissue cover, if it is covered with algae, among other relevant information. Take photographs and / or video to document changes[12].
2. The frequency of coral monitoring should be higher in the first months after rehabilitation. For example, monitoring could be biannual for the first two years and annually thereafter.
3. Coral monitoring data will be stored in a database using Microsoft Excel.
4. Training and involving local user communities to monitor rehabilitation sites can be a cost-effective and viable alternative to this component of rehabilitation. This helps create a sense of inclusion and raises awareness of the importance and vulnerability of coral reefs.

APPENDIX

Appendix I. RESPONSE MATERIALS

It is recommended to determine the availability of the following materials that can be used to facilitate a quick response:

COMMUNICATION AND COORDINATION

- ☐ Satellite telephones
- ☐ *Walkie Talkies* (e.g. Midland – GXT1000VP4)
- ☐ Portable power station (e.g. Goal Zero Yeti - to charge laptops, camaras, GPS, etc.)
- ☐ Solar panels (e.g. Goal Zero Boulder - to charge the portable power station)
- ☐ Printed maps of areas of interest
- ☐ GPS
- ☐ Identify areas to fill SCUBA tanks and gasoline for transportation

ASSESSMENT

Once the reef site is reached, the essential materials for the assessment are each participants diving / snorkeling equipment, a first aid kit, and an emergency oxygen tank. It is also recommended to identify:

- ☐ Generator
- ☐ Air compressor
- ☐ Additional dive tanks and gear
- ☐ Boat or other marine transportation (paddleboard, kayak, canoe, underwater scooter, jetski)
- ☐ Additional gasoline
- ☐ Safety and first aid equipment

Water quality assessment (examples)

- ☐ AMT IB-007 Rapid Bac Test for Enterococcus Bacteria
- ☐ YSI ProDSS Water Quality Meter Digital Sampling System

One option is the use of drones, with a certification from the FAA, to assess inaccessible or unsafe areas.

Reef damage assessment

- ☐ Dive slate or waterproof datasheets, clipboard, and rubber bands to attach the sheet to the clipboard
- ☐ Waterproof pencils
- ☐ Flexible rulers for measuring fragments / colonies
- ☐ Measuring tape
- ☐ Waterproof camera
- ☐ GPS

REHABILITATION – *Includes reef assessment materials, plus:*

- ☐ Gloves
- ☐ Buckets for loading fragments and for mixing cement
- ☐ Cement / Epoxy
- ☐ Tool for mixing cement (e.g. concrete mixer)
- ☐ Large Ziplock bags
- ☐ Mesh bags
- ☐ Lift-bags
- ☐ 14" cable ties (recommended with reinforced steel)
- ☐ Tools: hammer, scissors, knife

MONITORING – *Includes reef assessment materials plus:*

- ☐ Cattle tags, numbered and ideally yellow or a bright color
- ☐ 14" cable ties (recommended with reinforced steel)
- ☐ 3" Cut masonry nails for cement
- ☐ Tools: hammer, scissors, knife

Appendix II. TRACKING WEATHER EVENTS

The following websites are official sources for monitoring weather-related information and receiving early warning in preparation for weather events. Some of the functions relevant to this Protocol are listed below each website. Local news can be used to obtain additional information related to weather and forecasts, areas affected by the event, port openings, hazards, and more.

The NOAA National Hurricane Center (NHC) issues projections, advisories, alerts, and warnings of events with possible impact by winds, rain, and / or storm surge. Tropical climate projections are discussions of areas with potentially hazardous tropical weather, as well as their potential for development over the next five days. During the Atlantic hurricane season, June 1 through November 30, the two-day and five-day projections are issued every six hours. The advisories include a list of all tropical or subtropical cyclone alerts and warnings, and the position, distance from ground, and current movement of the cyclone. Every time a tropical or subtropical cyclone forms, the NHC issues warning information at least every six hours.

Atlantic winter storms are most frequent between September and April. Although these occur in the North Atlantic Ocean, the effects of these storms can cause heavy swells in Puerto Rico. The NWS provides the latest forecasts and warnings for these storms.

National Hurricane Center (NHC)

- Track tropical cyclones and active storms
- Maps of 2 and 5 day Tropical climate projections

National Weather Service (NWS)

- Weather forecast and warmings
- Hazardous weather outlook
- Maps of significant wave height and direction
- Tropical storm and hurricane alerts and warnings

CARICOOS

- Wave height and direction
- Wind speed and direction
- Ocean currents

Pa' la Playa cellphone application

- Water quality
- Weather forecast
- Average wave height

Windfinder

- Wind and weather forecast for up to 10 days in advance

FEMA / FEMA cellphone application

- News of presidential declarations after a disaster

Windy

- Wind and weather forecast

Appendix III. WATER QUALITY PARAMETERS FOR NATURAL BODIES OF WATER

**These parameters were shared by the San Juan Bay Estuary Program (Programa del Estuario de la Bahía de San Juan). These limits are only for use in natural bodies of waters, not for potable water.*

Dissolved oxygen (mg/L)	≥ 4
Turbidity (NTU)	< 10
pH	6.0-9.0
Water transparency (Secchi depth in meters)	≥ 1
Oil and fats (mg/L)	< 1
Kjeldahl nitrogen, total (mg/L)	< 1
Nitrates and nitrites, total (mg/L)	< 1
Total phosphorus (mg/L)	< 0.5
Total organic carbon(mg/L)	< 5
Chlorophyll-a (mg/m3)	< 5
Ammonia (mg/L)	0 is ideal, but ammonia can come from humans and other organisms
Biological oxygen demand (mg/L)	< 5
Fecal coliforms (CFU/100mL)	< 200
Fecal enterococci (CFU/100mL)	< 35

Appendix IV. CORAL IMPACT ASSESSMENT DATASHEET

For band transects

NAME		**DATE**		**TRANSECT #_____ of _____ in the same site** **Width _____(m) Length _____(m)**
SITE		**START TIME**		**LAT LON**
VIS (ft)	**Transect Heading**	**Depth (ft)**	**PHOTO?** Yes No **VIDEO?** Yes No	**Hardbottom in transect _____%**
Habitat type: LINE AGRE PTCH BDRK PVM		**Dominant habitat**		**Dominant habitat in transect _____%**
Damage to: Corals Structure Both		**Rubble in transect _____%**		**Est. # loose corals in transect _____#**

Marine debris: Yes No **Description:** *(hard to remove debris - record coordinates, potential impact, take photos)*

CODE	CORAL STATUS (#)	Total # of each size: MED (20-50cm)	LARGE (51 – 100cm)	XL (101-150cm)	THICKETS/ GIANT (>150cm) Length, Width, % damaged	Additional notes (*coral health, etc.*)
ACER	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
APAL	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
DCYL	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
CNAT	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					

CODE	CORAL STATUS (#)	Total # of each size:			THICKETS/ GIANT (>150cm) Length, Width, % damaged	Additional notes (*coral health, etc.*)
		MED (20-50cm)	**LARGE** (51 – 100cm)	**XL** (101-150cm)		
DLAB	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
MCAV	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
OANN	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
OFAV	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
OFRA	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
PORI SP. **ramificado**	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					
PSTR	Attached - Intact					
	Attached-Broken					
	Upside down /Overturned /Loose					
	Loose frag.					

CORAL IMPACT ASSESSMENT DATASHEET

For assessments conducting a roving diver survey

NAME/BUDDY	**DATE**	**SITE**	
LAT **LON**	**START TIME**		**VIS (ft)**
Habitat type: LINE AGRE PTCH BDRK PVM	**DEPTH (ft)**	**PHOTO?** Yes No **VIDEO?** Yes No	**Hardbottom**_____**%**
Damage to: Corals Structure Both	**Estimate of evaluated area:** _____m^2	**Estimate # loose corals in the area**_____	
Marine Debris: Yes No **Description:** *(for hard to remove medium or large debris, record coordinates, potential impact, and take photos)*			

Coral Type or Species	**Coral Status** Intact, Attached-Broken, Overturned, Loose frag.	**Total # of damaged corals of each size:**					**Additional Notes** *(coral health, etc.)*
		< 20cm	**20 - 50cm**	**40 - 60cm**	**60 - 100cm**	**>100cm**	

Coral Type or Species	**Coral Status** Intact, Attached-Broken, Overturned, Loose frag.	**Total # of damaged corals of each size:**					**Additional Notes** *(coral health, etc.)*
		< 20cm	**20 - 50cm**	**40 - 60cm**	**60 - 100cm**	**>100cm**	

Appendix V. DESCRIPTION OF THE CORAL IMPACT ASSESSMENT DATASHEET

Data	Description
Transect #_____of _____ in the same site	Start with #1 for the first transect in a site. The transect number of the total number of transects evaluated in the site. It is recommended to have a minimum of 3 transects per site.
TRANSECT Width, Length	Total width and length in meters of the transect used for assessment. If possible, it should be 20m x 2m.
VIS (ft)	Water visibility measured in feet
Transect Heading	Transect direction from start point (ex. N, NE, E, SE, etc.)
Depth (ft)	Average depth of the transect
PHOTO? Yes No **VIDEO?** Yes No	Photo documentation: If you took photos, videos, or neither
Hardbottom in transect _____%	Estimated percent hardbottom in the transect area
Dominant habitat	Type of dominant habitat in the transect
Habitat type	Type of dominant reef habitat: linear, aggregated, patch, bedrock, pavement
Dominant habitat in transect_____%	Estimated percent of dominant habitat in the transect
Damage to:	Damage to corals, reef structure, o both (corals y reef structure)
Rubble in transect ____ %	Estimated percent area of rubble in the transect
Est. # loose corals [in transect ____#]	Estimated number of loose corals in the transect
Marine Debris: Yes No	If marine debris is present in or around the transect
Description (marine debris)	Description of the types of debris, quantity, general sizes, potential impact to the coral reef, coordinates, and reference photo codes
CORAL CODE	Species codes: Use codes that consist of the first letter of the genus, the first 3 letters of the species. If you do not know the species, use the following code: The first 4 letters of the genus, a space, SP. (ex. ORBI SP.) and take a photo.
Coral Status (#)	Number of corals of each species that are Attached-Intact, Attached-Broken, Upside Down/Overturned/Loose, or a Loose Fragment
Total # of each size:	**MED:** Number of medium sized corals, size 20 cm to 50 cm
	LARGE: Number of large corals, size 51 cm to 100 cm
	XL: Number of extra-large corals, size 101 cm to 150 cm
	THICKET/GIANT: Number of thickets or giant coral colonies, size 150 cm or larger. Include the length, width, and percent damage, if necessary.
Additional notes	Other important information, for example health of the coral - diseased with abrasions, pale, diseased, or dead

Appendix VI. CORAL REHABILITATION DATASHEET

Adapted from the NOAA datasheets used in coral rehabilitation after hurricane Maria.

NAME/BUDDY	**DATE**	**LAT**	**LON**		
	SITE	**Day #_____ of _____ for rehabilitation at same site**			
Habitat type: LINE AGRE PTCH BDRK PVM		**DEPTH (ft)**	**Est. # of days remaining:**		
Site Damage: Severe (>50%) Moderate (10-50%) Minor (<10%) None		**Area rehabilitated: _____m²**		**Remaining area: _____m²**	
Additional triage potential: High Medium Low None		**Initial #**	**# Reattached**	**# Remaining**	**% Completed**
Rehabilitation site potential: High Medium Low None					
Marine Debris: Yes No **Description:** *(for hard to remove medium or large debris, record coordinates, potential impact, and take photos)*					

CODE	# SMALL (< 20cm)	# MEDIUM (20-50cm)	# LARGE (51-100cm)	# XL (101-150cm)	# GIANT (>150cm)
ACER					
APAL					
DCYL					
CNAT					
DLAB					
MCAV					
OANN					

CODE	# SMALL (< 20cm)	# MEDIUM (20-50cm)	# LARGE (51-100cm)	# XL (101-150cm)	# GIANT (>150cm)
OFAV					
OFRA					
PORI SP. *branched*					
PSTR					
Additional Information ***(Rehabilitation methodology, description of remaining work, etc.)***					

Appendix VII. DESCRIPTION OF THE CORAL REHABILITATION DATASHEET

Data	Description
Day #_____ of _____ for rehabilitation at same site	Start with #1 for the first day of rehabilitation in a site. The day number of the total days rehabilitated at this site.
Habitat type	Type of dominant reef habitat: linear, aggregated, patch, bedrock, pavement
DEPTH (ft)	Average depth of the transect
Est. # of days remaining:	Estimated number of remaining days to complete triage and/or additional rehabilitation at this site.
Site Damage:	Percent damage at site: **Severe:** > 50% damage to corals and reef structure **Moderate:** 10% - 50% damage to corals and reef structure **Minor:** < 10% damage to corals and reef structure
Area rehabilitated: _____m^2	Estimated area of reef rehabilitated in m^2
Remaining area: _____m^2	Estimated area of remaining reef to be rehabilitated in m^2
Additional triage potential:	**High:** > 300 corals to be stabilized/attached (> 20 cm); many ESA species impacted **Medium:** > 100 corals to be stabilized/attached (> 20 cm); some ESA species impacted **Low:** < 100 corals to be stabilized/attached **None:** No impact
Rehabilitation site potential:	**High:** significant damage, rehabilitation required for recovery, requires an additional assessment **Medium:** Moderate damage, could require rehabilitation, possibly an additional assessment **Low:** Damage is present but natural recovery is probable **None:** No additional rehabilitation is necessary or recommended
Initial #	Estimated number of initial corals and fragments to be stabilized/attached
# Reattached	Number of corals and fragments stabilized and attached in the dive/snorkel
# Remaining	Number of corals and fragments in the reef that require stabilization, triage, or other methods of rehabilitation
% Completed	Percent of completed rehabilitation up until the present date [# stabilized / (# stabilized + # remaining)]*100
Marine Debris: Yes No	If marine debris is present in or around the rehabilitated area
Description (marine debris)	Description of the types of debris, quantity, general sizes, potential impact to the coral reef, coordinates, and reference photo codes
CODE	Species codes: Use codes that consist of the first letter of the genus, the first 3 letters of the species. If you do not know the species, use the following code: The first 4 letters of the genus, a space, SP. (ex. ORBI SP.) and take a photo.
Total # per size: (Number of corals stabilized, attached through rehabilitation efforts)	**SMALL:** Number of medium sized corals, less than 20 cm
	MEDIUM: Number of medium sized corals, size 20 cm to 50 cm
	LARGE: Number of large corals, size 51 cm to 100 cm
	XL: Number of extra-large corals, size 101 cm to 150 cm
	GIANT: Number of thickets or giant coral colonies, size 150 cm or larger. Include the length, width, and percent damage, if necessary.

Appendix VIII. MONITORING SHEET FOR CORALS AND FRAGMENTS MARKED IN REHABILITATION EFFORTS

Names: _____Date: _____ Site: _____ Habitat: _____

ID number	**Location**	**Species**	**Size** (longest branch in cm)	**Number of branches and sizes** (if applicable)	**Condition** (healthy, diseased, % coverage of living tissue, bleached, covered with algae, etc.) **and other information**

Appendix IX. ADDITIONAL RESOURCES

1. **Boat Ramp Maps:** in Google Maps or Lanchasybotes.com
2. **Gas Stations:** Google Maps
3. **Puerto Rico Industrial Development Company (PRIDCO):** Interactive map to locate public assets, commerce, or industry around Puerto Rico
4. **NOAA Digital Coast Critical Facilities (2016):** Aggregated totals of law enforcement facilities, fire stations, medical facilities, and schools in coastal areas

Appendix X. FUNDING

The costs of implementing this Protocol largely depend on the event and the extent of the damage to coral reefs. Information on the agencies and organizations that could potentially help finance the implementation of this Protocol can be found below.

Potential funding mechanisms

When a natural event occurs that affects coral reefs, some agencies and organizations offer funding opportunities to respond to the needs based on these events. Due to the importance of coral reefs as habitats, sources of income, cultural value, important research sites, and coastal protection mechanisms, some of these funding opportunities are aimed at the rehabilitation of these marine resources.

Below is a list of agencies, organizations, and groups that provide funding or resources opportunities that can be used to support the response to coral reef impacts, in general or after an extreme natural event.

The DNER is the proposing agency in requests for State funds in order to assess or rehabilitate damage to coral reefs. The DNER can channel these requests through the Marine Ecology Division and / or the Office of the Coastal Zone and Climate Change Program, to which the Coral Reef Conservation and Management Program is assigned. The implementation of this Protocol must be coordinated with personnel from these offices that represent the agency. Staff could provide support in coordinating with other groups and agencies, as well as provide fieldwork materials and / or training for these activities.

When there is an emergency in a United States jurisdiction, presidential statements dictate what type of assistance FEMA grants. Currently, only in the event of a major presidential disaster declaration is it possible for FEMA to activate the Hazard Mitigation Grant Program. After the 2017 hurricanes, this program provided assistance in preventing or reducing the risk of coastal properties from natural hazards, considering the importance of coral reefs as marine structures.

In order for the President to issue a disaster declaration for Puerto Rico, the Governor must request the declaration through FEMA within 30 days after the incident. If the President denies the request, the Governor may appeal the determination within 30 days from the date of the letter.

If the President declares a Major Disaster in Puerto Rico, the Resource Request Form (RRF) can be a way to request federal assistance from FEMA. The RRF is the FEMA form used to apply for federal assistance and is completed by an applicant, who would be the DNER in these cases. The applicant completes Sections I and II. The RRF must be signed by the Approval Officer of the delegated State, which includes the territories and their approval delegates, and in the case of Puerto Rico would be the Governor. Requests for assistance are submitted through the Web Emergency Operations Center (WebEOC).

Examples and instructions for filling out the RRF can be found here. The RRF form can be found on the FEMA website, here.

The **National Oceanic and Atmospheric Administration** (NOAA) provides funding, personnel, and materials for coral reef assessment and rehabilitation efforts. After the 2017 hurricanes, the NFWF received funding from NOAA to work with local organizations in the assessment and rehabilitation of Puerto Rico's coral reefs. NOAA Restoration Center (RC) staff in Puerto Rico are a POC to identify available funds and courses of action to respond to the emergency.

NOAA's Coral Reef Conservation Program (CRCP) has several national grant opportunities for working with coral reefs. The opportunities are listed on the NOAA CRCP website and should be monitored to check if an available opportunity can complement conservation and rehabilitation efforts.

The **Environmental Protection Agency** (EPA) is the federal agency with jurisdiction in most cases against companies or individuals that do not comply with environmental regulations. Most of these cases are resolved through agreements where the alleged offender can propose a project that provides tangible benefits to the affected environment. This is a voluntary agreement a called Supplemental Environmental Project (SEP). Projects submitted for an SEP must have a strong connection to the violations that are being resolved. For example, violations affecting the coral reef, such as improper anchoring damage or oil spills, could possibly be mitigated with rehabilitation efforts after a coral reef emergency.

The **Department of Natural and Environmental Resources** (DNER) has a Division of Marine Ecology and a Coral Reef Conservation and Management Program (Program), both of which work to protect the corals of Puerto Rico. NOAA and the DNER have a collaborative agreement that supports coral reef conservation and management activities. At the time of writing this Protocol, the Program has set aside funds to promote the implementation of this Protocol, including the acquisition of materials and to promote the development of the response network.

The **National Fish and Wildlife Foundation** (NFWF) is a nonprofit organization that leads the opportunities for conservation grants in the United States. NFWF has funded coral reef conservation in partnership with NOAA and other federal and non-federal partners for the last 20 years. The primary coral funding comes from the Coral Reef Conservation Fund for awards that range between $60,000-$200,000 on average. The evaluation, restoration, or mitigation parts of this Protocol could be subsidized through these grants. In addition, NFWF administers the National Coastal Resilience Fund with the goal of restoring and strengthening the natural infrastructure that protects coastal communities while enhancing habitats for fish and wildlife. Funding from this program needs to tie directly to a community for increased protection and range between $150,000 - $8,000,000 depending on the proposal category.

NFWF is also called upon to administer emergency funding for episodic events which may or may not be administered through a program cycle like those above. For example, NFWF administered an award to a local company HJR Reefscaping to conduct coral damage assessment and

restoration simultaneously after hurricanes Irma and Maria. This funding may or may not be federal in nature, but all coral efforts are coordinated with the NOAA Coral Program and therefore the contacts for these types of funding should be the NFWF Coral Reef Manager (www.nfwf.org/coralreef) and/or the local NOAA representative.

Other federal funding mechanisms

The Coastal Resiliency Funding Guide[19] presents funding opportunities applicable to different situations. The following funding opportunities come from the Federal Toolkit Matrix and are directly related to the conservation, rehabilitation, and creation of natural coastal barriers, such as mangroves and coral reefs. Some of these opportunities are applicable to response efforts, while others are geared toward post-response efforts.

EPA

- Multipurpose Grants to States and Tribes
- Supplemental Environmental Projects (SEPs) *described above*

FEMA

- NFIP Community Rating System
- Hazard Mitigation Grant Program (HMGP) *described above*
- Pre-Disaster Mitigation Grant Program (PDM)

NOAA

- Broad Agency Announcement
- Coastal Resilience Grants
- Coastal Zone Management Administration
- Community-based Marine Debris Removal
- Community-based Restoration Program Coastal and Marine Habitat Restoration Grants
- Habitat Blueprint Coastal and Marine Habitat Focus Area

USACE

- Section 14, Flood Control Act of 1946, as amended
- Section 103 – Beach Erosion and Hurricane Storm Damage Reduction
- Section 111 – Shore Damage Attributable to Federal Navigation Works.
- Section 204 – Beneficial Uses of Dredged Material. USACE can restore, protect, or create aquatic and wetland habitats in connection with construction maintenance dredging of an authorized federal navigation project.

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*Information provided by Sean Griffin of the NOAA Restoration Center on May 2, 2018 in a meeting with the DNER. These numbers include coral fragments attached with funding from FEMA as well as fragments attached with other funding sources.