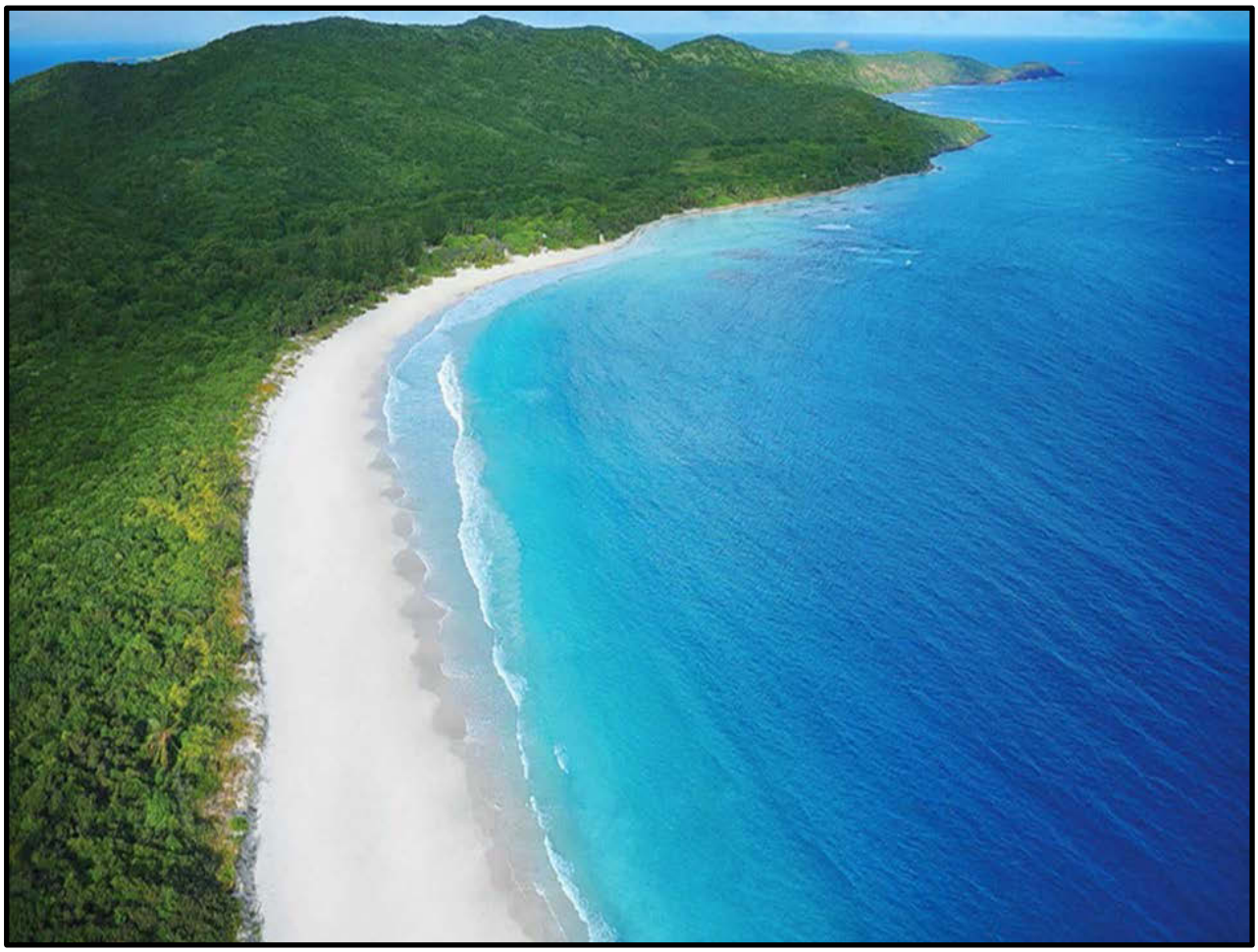
An Implementation Framework for NOAA's Habitat Blueprint Focus Area in the Caribbean - The Northeast Marine Corridor and Culebra Island, Puerto Rico



FINAL

April 2016

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EXECUTIVE SUMMARY

In 2011, the National Oceanic and Atmospheric Administration launched the NOAA Habitat Blueprint to address the growing challenge of coastal and marine habitat loss and degradation by integrating habitat conservation projects throughout the agency, focusing efforts in ten key locations (the Habitat Focus Areas), and leveraging internal and external collaborations to achieve measurable benefits within a short time frame.

In 2014, NOAA selected Puerto Rico's Northeast Marine Corridor and Culebra Island as the Caribbean region's Habitat Focus Area (HFA) to apply the principles of the Habitat Blueprint. The Northeast Marine Corridor and Culebra Island HFA encompasses a wide array of ecosystems in a relatively small geographic area -- coastal forests, wetlands, perennially bioluminescent lagoons, seagrass beds, shallow and deep coral reefs, and miles of pristine nesting beaches for the Leatherback and other sea turtles. Gravely threatened corals, including those protected under the Endangered Species Act (ESA), fringe the island and provide habitat to recreationally and commercially important fish such as grouper.

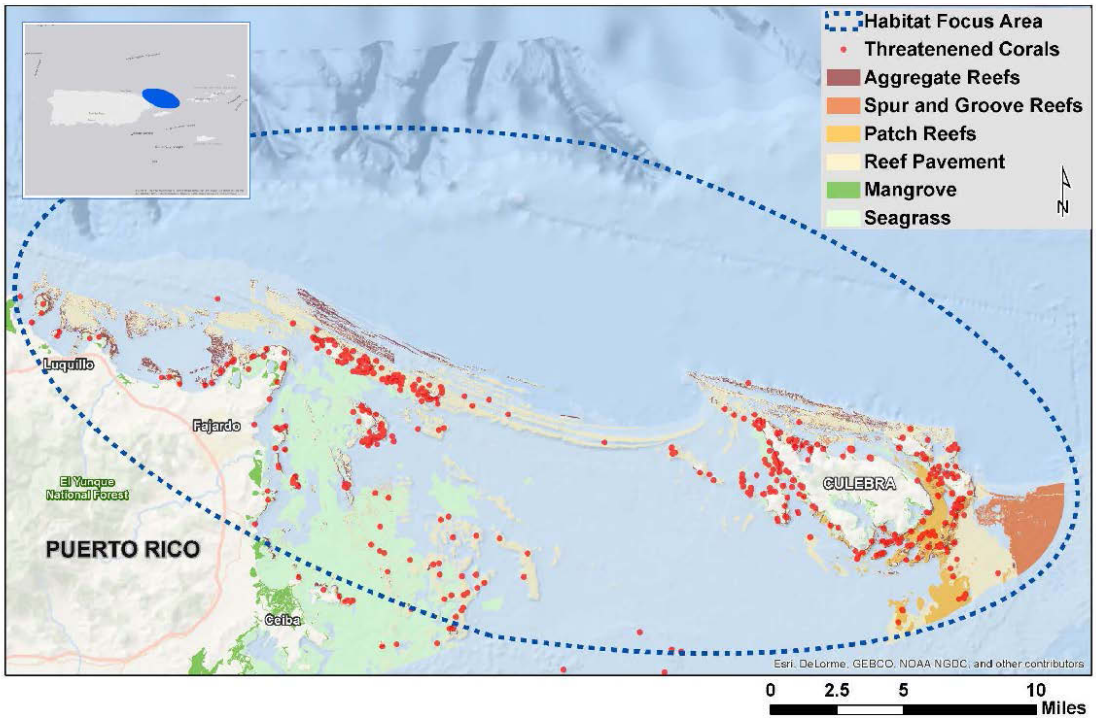
This lush region has experienced significant declines in the quality and extent of mangroves, coral reefs, and seagrass beds due to unsustainable coastal development, over-zealous recreation, land-based sources of pollution, and the effects of climate change such as rising sea surface temperatures. NOAA has brought together a team of experts in weather, satellite data and imagery, fisheries research and management, coastal resiliency planning, coral reef conservation, marine protected area management, social sciences, and habitat protection and restoration to tackle the following four goals:

I. **Habitat Resilience -** Improve management to increase the resilience of coral reefs, seagrass beds, and other coastal habitats.
II. **ESA Coral Recovery -** Increase the population size, abundance, and health of ESA-listed coral species.
III. **Science to Support Marine Resource Management -** Conduct critical research that will enable more informed management of fisheries and protected resources dependent on coral reefs and associated ecosystems.
IV. **Sustainable Recreation -** Promote recreational practices that preserve the ecological integrity of marine habitats.

To achieve these goals NOAA will expand existing partnerships with local residents, Non-governmental organizations (NGOs), academic institutions, and jurisdictional agencies, including Puerto Rico's Department of Natural and Environmental Resources (DNER). In order

to prioritize conservation efforts, this implementation plan contains specific geographic Action Plans for the Culebra Island and Arrecifes de la Cordillera regions of the HFA, in addition to an Action Plan for Management Driven Science that addresses overarching research objectives for the entire focus area. Within these three action plans are 23 priority actions considered to be the foundation necessary for advancing habitat science and conservation in and around the HFA in the near term. Future actions will build on this foundation to achieve the longer-term goals of improving ecosystem conditions. NOAA and partners will support the protection and restoration of coastal habitats and resources within the Caribbean HFA through management driven research and monitoring, on the ground restoration and protection, and training and education to build local capacity.

The Northeast Marine Corridor and Culebra Island Habitat Focus Area



ENVIRONMENTAL THREATS

The lush ecosystems of the Northeast Marine Corridor and Culebra Island have experienced significant declines in the integrity of their mangroves, corals, and seagrasses. Primary environmental threats are detailed below.

- **Land based activities**: Historical mangrove deforestation, coastal erosion, sewage pollution, improper land development and construction practices, and excess runoff are the primary sources of land based sources of pollution (LBSP) in this region. Sewage discharge can cause public health problems when contaminated fish or shellfish are consumed, and also leads to increased nutrient concentrations which increase algal and bacterial growth, degrade seagrass and coral reef ecosystems, and decrease fisheries production. Increased sedimentation screens out light needed for photosynthesis, scouring of coral by sand and other transported sediments, poor survival of juvenile coral due to loss of suitable substrata, and the direct smothering of coral in cases of extreme sedimentation. Nutrient discharges can cause eutrophication that results in decreased biological diversity and community structure, fish kills, and other oxygen depletion events.

Photo Credit: NOAA

- **Recreational pressure**: Coral reefs and seagrass beds are degraded by the heavy traffic of recreational and large boats which cause anchor damage, seagrass scarring, groundings, and a trail of litter and pollution. Frequent small vessel groundings further degrade shallow habitats, and damage is exacerbated when grounded vessels remain *in situ*. Impacts of improper recreational practices during snuba, scuba, and snorkeling are incompatible with long term ecological integrity and may result in harassment of endangered species.

Photo Credit: Alida Ortiz

- **Fishing impacts:** Excessive and illegal fishing of important finfish and shellfish populations by commercial, recreational, and subsistence fisheries is a perennial issue. Loss of grazers, in

particular, can reduce the health and abundance of coral populations. Fishing plays a central social and cultural role in many island communities and can represent a critical source of protein, but coral reef fisheries may have disproportionately large impacts on the ecosystem if conducted unsustainably. Rapid human population growth, demand for fishery resources, use of more efficient fishery technologies, and inadequate management and enforcement have led to the depletion of key reef species and habitat damage in many locations. Specific impacts of fishing on reefs are: 1) direct overexploitation of fish, invertebrates, and algae for food and the aquarium trade; 2) removal of a species or group of species impacting multiple trophic levels; 3) by-catch and mortality of non-target species; and 4) physical impacts to reef environments associated with fishing techniques, fishing gear, and anchoring of fishing vessels.

Illegal catch of lobsters with eggs and illegal harvest of undersized Queen conch
Lobster Photo Credit: Paco López; Conch Photo Credit: unknown

- **Climate change**: Thermal stress causes coral bleaching and contributes to increased rates of coral disease. Ocean acidification makes it more difficult for corals to secrete calcium carbonate, inhibiting coral growth. Extreme weather events and sea level rise lead to vulnerable coastal communities and associated ecosystems.

- **Unexploded ordnance**: The Army Corps of Engineers in consultation with NOAA is conducting studies to determine the extent of unexploded ordnance in Culebra to determine the threat they pose to underwater habitats and visitors. Other than potential for explosion and resultant physical damage, unexploded ordnance can cause chemical contamination affecting fish and habitat quality.

The cumulative effects of these threats lead to reduced resilience, coral reef habitat degradation, loss of reef building species, declining coral health and coral-dependent resources, and threatened resource sustainability and economic livelihoods. Limited infrastructure and economic strain in Puerto Rico have exacerbated these environmental impacts.

WHAT CAN NOAA DO?

Although the threats in this region present a suite of diverse challenges, they are balanced by an informed, engaged community with a long history of conservation successes - including the designation of several natural reserves established to conserve entire ecosystems. This dichotomy presents an opportunity for NOAA, working together with its partners, to effect measurable change in a relatively short time period. To combat the identified threats, we have set four long-term, overarching goals for the Northeast Marine Corridor and Culebra Island HFA, and specific supporting objectives have been identified that will help achieve those goals:

I. **Habitat Resilience -** Improve management to increase the resilience of coral reefs, seagrass beds, and other coastal habitats.
   - Support management decision-making by improving our understanding of the ecological dynamics in coastal habitats (primarily coral reefs and seagrass beds).
   - Reduce Land-Based Sources of Pollution (LBSP).
   - Increase response and restoration to physical impacts on coral reefs (i.e. vessel groundings).

II. **ESA Coral Recovery -** Increase population size, abundance, and health of ESA-listed coral species.
   - Improve understanding of abundance and distribution of ESA-listed corals.
   - Increase population size and health of acroporid corals.
   - Improve understanding of non-acroporid coral restoration techniques.

III. **Science to Support Marine Resource Management -** Conduct critical research that will enable more informed management of fisheries and protected resources dependent on coral reefs and associated ecosystems.
   - Advance research and monitoring on fisheries stocks and protected species.
   - Improve coordination and outreach with fishers and fisheries managers.
   - Advance research on fish habitat and relationships between habitat and fishery productivity.

IV. **Sustainable Recreation -** Promote recreational practices that preserve the ecological integrity of marine habitats.
   - Promote interagency partnerships to enhance enforcement of regulations and increase user compliance.
   - Improve understanding of recreational impacts on marine resources.
   - Improve engagement with local recreational users and the tourist community.

These goals and objectives were delineated to maximize habitat restoration and conservation success, while encompassing activities that NOAA can lead by working collaboratively across various Line Offices and Programs. Scientists and representatives from all NOAA Line Offices -

National Environmental Satellite, Data, and Information Service, National Marine Fisheries Service, National Ocean Service, National Weather Service, and Ocean and Atmospheric Research – have been working for several years to protect and restore coastal communities, habitats, and resources within and around the Northeast Marine Corridor and Culebra Island. Past, current, and ongoing conservation projects, monitoring,, training and education programs, and improved weather forecasting all led to the HFA's designation.

Some of these recent and on-going NOAA-led projects are listed below. Many of these efforts are being performed in conjunction with Puerto Rico's DNER, who has local jurisdiction over state-wide natural resources extending offshore up to nine nautical miles. Additionally, efforts to strengthen habitat and fisheries management in coastal and offshore environments have improved the health of protected resource populations - especially through the conservation of critical seagrass habitats for sea turtles, and protection of offshore habitats that support marine mammals and threatened fish and invertebrate species. *For more detailed descriptions of recently completed and on-going projects, please refer to Appendices I and II.*

Coral Reef Conservation Program (CRCP)

- Development of the Northeast Marine Corridor Management Plan
- Watershed Management Plans for Culebra and Río Fajardo
- Hydrodynamic model to forecast waves and coastal circulation in Northeast Puerto Rico
- Multi-agency management support group for the Northeast Marine Corridor
- The National Coral Reef Monitoring Plan for biological, physical, and socioeconomic monitoring throughout all U.S. coral reef areas

NOAA Fisheries - Office of Habitat Conservation - Restoration Center

- Priority watershed restoration actions and installing aids to navigation in Culebra
- Erosion and sediment control trainings
- Protocol on assessment of vessel groundings and follow-up actions
- Conducting emergency restoration of vessel impacts on marine habitat
- Developing Best Management Practices for vessel removal
- Identifying potential areas of impacts from vessels
- Determining climate resistant acroporid coral genotypes
- Enhancing recoverability of non-acroporid ESA-listed species

National Ocean Service - National Centers for Coastal Ocean Science

- Mapping the benthos of the Northeast Marine Corridor and Culebra Island
- Spatial characterization to support development of an Integrated Management Plan for Puerto Rico's Northeast Marine Corridor
- Documenting distribution of threats to corals

NOAA Fisheries - Southeast Fisheries Science Center

- Improved understanding of grouper spawning aggregation sites and dynamics
- High-resolution stock abundance surveys of queen conch, spiny lobster, parrotfishes, snappers, and groupers
- Collecting commercial fisheries landings and effort, and recreational fishing data
- Analyzing fisheries status and development of management recommendations
- Collecting and analyzing fishing communities' socio-economic data,
- Improving characterization of commercial, recreational, and subsistence fisheries by increasing spatial and temporal resolution of fishing effort, fishing community demographics, and catch data

National Environmental Satellite, Data, and Information Service

- Satellite-based estimates of historical and future coral-bleaching risk
- Field surveys during thermal stress events

National Weather Service: Extending present wave/surge operational forecasting capability from mild-sloped coastal areas to steep-sloped (such as those in the HFA).

Oceanic and Atmospheric Research - Atlantic Oceanographic and Meteorological Laboratory: Establishing a subsurface temperature baseline to respond quickly to effects of thermal stress in the region.

NOAA's Role Moving Forward in the Short Term - *A Geographically Focused and Action Oriented Strategy*

Designating the Northeast Marine Corridor and Culebra Island as the Caribbean Habitat Focus Area gives NOAA the impetus to forge new, and strengthen existing, relationships internally among our programs -- one of the primary missions of the Habitat Blueprint Initiative. In the Caribbean HFA, these collaborations are already leading to more effective decision making - for example, incorporating satellite-based bleaching risk predictions from Coral Reef Watch into siting decisions for acroporid outplanting.

Given the size and complexity of this region, the HFA goals delineated are appropriately ambitious yet achievable - working toward improvements in ecosystem function and resilience over a 10 year time frame. Considering the geographic area, diverse threats, and the need for a long-term, systematic approach, the implementation team decided to develop a suite of three Action Plans - two that are geographically based, and one that outlines broad priority research

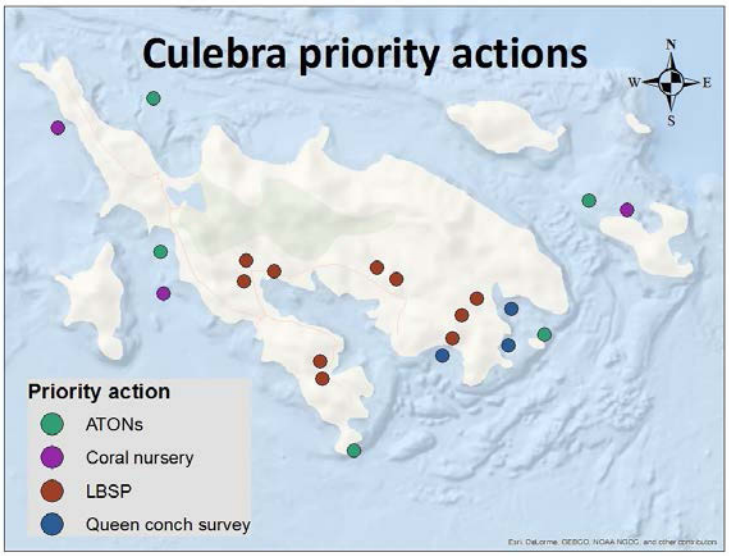
needs. This will allow NOAA's efforts to be focused and demonstrate measurable results within a 3-5 year time frame, while working toward long-term improvement in ecosystem functionality.

Detailed below, the Action Plans developed for the geographical areas of Arrecifes de la Cordillera and Culebra Island outline specific conservation actions that will be undertaken in key habitats over the next three to five years, and provide NOAA with strategies to build upon current regional infrastructure and formalize local partnerships. These geographically based Action Plans capitalize on existing management opportunities that are ripe for NOAA's engagement and leadership. They include priority actions and the most specific methods and performance metrics that are available to address these goals, as scientific developments and research opportunities continue. The 'Additional Opportunities' sections highlight projects that fall outside of NOAA's direct purview, where NOAA would be interested in partnering. Where existing management opportunities are not known, or additional research or monitoring is needed to refine management techniques, an Action Plan for Management Driven Science has been developed. This Action Plan addresses priority research projects that will lead to improved marine resource management for the entire HFA, and sets a framework for NOAA's cross Line Office collaboration with local scientists and partners.

For example, LBSP threats are pervasive throughout the entire HFA; however, at this time, NOAA's LBSP management actions are primarily focused on Culebra Island. This is largely because the LBSP threats on Culebra are well-known and restoration opportunities have been clearly articulated in the Culebra Watershed Management Plan. LBSP threats on Culebra are focused in a small enough region, and existing habitat and resource quality is good enough that with modest NOAA investments and partnerships we anticipate measurable benefits within 10 years. On the other hand, while LBSP threats throughout the Northeast Marine Corridor (including Cordillera) are known, restoration opportunities have not been clearly articulated. Furthermore, the mainland watersheds (e.g., Río Fajardo) are larger comprising multiple land types - agricultural, forested, and urban, which fall under various management authorities (USDA, USFS, EPA, DNER, and local municipalities). This mixed use area offers a wonderful opportunity for NOAA to partner with these agencies to enhance LBSP management for habitat and resource conservation. NOAA will continue to engage in on the ground projects throughout the entire HFA, beyond the two geographic areas currently identified in the Action Plans, as management plans are finalized and conservation opportunities develop.

CULEBRA ISLAND ACTION PLAN

Why Culebra Island?



Culebra Island and its associated cays are located 23 miles off the northeast coast of Puerto Rico. The 12 square mile island's white sandy beaches, fringing coral reef habitats, seagrass and mangrove habitat are popular tourist destinations, and are also important feeding and nesting grounds for sea turtles and 13 species of seabirds. The coral reef ecosystems of Culebra are some of the more pristine in the region and support abundant marine life. However, between 1997 and 2003 coral cover in some nearshore locations of Culebra declined by 30 percent, suggesting the need for enhanced coral reef management (Hernández-Delgado 2010). As a result, Culebra is one of the top priorities for NOAA, DNER, and USFWS for coral reef protection and coastal management.

Numerous protected habitats are found throughout Culebra and its associated islands. The Culebra archipelago, consisting of the main island and 23 smaller islands, makes up the *USFWS Culebra National Wildlife Refuge*, which contains one of the oldest bird sanctuaries in United States territory, home to an estimated 50,000 seabirds. Just to the southwest of this region is the *Canal de Luis Peña* Natural Reserve, which is the first established permanent no-take marine reserve in Puerto Rico. The reserve was established in 1999, and is managed by DNER to protect and conserve the area's seagrass and coral reef resources, and recover commercially and recreationally important fishery species. Lastly, in 2010 NOAA's CRCP, together with DNER, identified Culebra Island as a priority for coral reef conservation which has spurred recent NOAA investments in the region.

What Can NOAA Do on Culebra Island?

Since 2010, NOAA and its partners have invested over $1.3 million to reduce local threats and enhance recovery of Culebra's coral reef habitats. Threats to the island's coral reef habitats can be effectively managed due to its relatively small size, existing management efforts, and conservation partnerships. Habitat restoration can be expected to provide significant benefits in as little as five years. Furthermore, through strategic identification of

conservation actions, NOAA can leverage additional or enhance existing partnerships to expand conservation efforts. The following actions were identified as priority opportunities for NOAA to expand existing habitat and marine resource conservation efforts.

Culebra Priority Action 1: Implement Watershed Restoration Projects to Reduce Threats from Land-based Sources of Pollution (LBSP).

- Ten projects in the Culebra Watershed Management Plan have been identified as having potential to reduce significant amounts of LBSP at five sites in Culebra. Projects will generally consist of erosion and sediment control practices and/or installations of green infrastructure to intercept stormwater runoff, reduce erosive flows, retain sediments and nutrients on site, and reduce LBSP threats to seagrass and coral reef habitats. Example projects include: unpaved road stabilization in the Fulladoza, Puerto Manglar, and Mosquito subwatersheds; and green infrastructure initiatives to reduce sediment and nutrient loads from the airport and Coronel subwatersheds, and treatment wetlands to reduce nutrient loads from the Cabra subwatershed.
- These projects will be utilized as demonstration sites to train local builders and contractors on better development practices to expand local capacity for watershed restoration and protection.
- Project outcomes will be rigorously monitored to evaluate the performance of land-based pollution reduction actions.
- *Funding*: Funded for FY15; $150,000/yr needed.
- *Performance metrics:* Number of projects completed from approved Watershed Management Plans (WMPs) and Coastal Action Plans (CAPs) to reduce LBSP in priority coral reef areas; Decrease and/or prevent terrigenous sediment load (metric tons/year) in target watersheds.

Photo Credit: NOAA

Culebra Priority Action 2: Recover threatened *Acropora* coral populations.

- Increase population resilience and recovery potential by repopulating reefs with genetically diverse corals propagated utilizing *in-situ* coral nurseries.
- Outplant 6000 corals annually for 5 years (will achieve the ESA Species Recovery Criteria for abundance at three reef sites).
- Maintain existing nurseries, relocate a second nursery to Luis Peña Natural Reserve, and establish new coral nurseries at Culebrita and Carlos Rosario reefs.
- *Funding:* 50% funded for FY16, $80,000/yr needed.
- *Performance metrics:* Number of coral colonies propagated in nurseries and outplanted to selected reefs; Acres of coral reef habitat restored to meet ESA recovery criteria.

Photo Credit: NOAA

Culebra Priority Action 3: Support Caribbean Fisheries Management Council and PR DNER decision-making by advancing critical science.

- Conduct fishery-independent surveys to assess current distribution and abundance of juvenile and adult queen conch in nearshore habitats.
- Conduct acoustic tracking of juvenile and adult queen conch in the bays of southeastern Culebra, e.g., Bahía Mosquito, Bahía de Almodóvar, and Puerto del Manglar, to verify habitat use and movement patterns.
- Analyze benthic parameters in the southeastern bays, such as habitat type, depth, sediment grain size, and seagrass type and shoot density, to understand the effects of terrestrial run-off on conch populations.
- *Funding*: FY15 partially funded; $120,000/yr needed
- *Performance metrics:* Number of fish stocks with completed surveys, % of fish stocks with adequate data for status analysis, number of publications/presentations completed (target 2 by 2017).

Conch with acoustic tag (black dot)
Photo credit: NOAA

Culebra Priority Action 4: Identify nursery habitats for key fishery species.

- Survey, identify, and map nursery habitat for key fishery species, such as queen conch, snapper, grouper, grunts and lobster, in shallow waters where habitat degradation is common.
- Use nursery habitat locations along with Culebra Watershed Management Plan and other resources to prioritize habitat conservation actions.
- Monitor status and condition of nursery habitats over time.
- *Funding:* FY15 partially funded; $65,000/yr needed
- *Performance metrics:* Number of nursery habitats identified and mapped; number of nursery habitats with improved habitat conditions.

Photo Credit: NOAA

Culebra Priority Action 5: Reduce boating, diving, and snorkeling impacts.

- Utilize social marketing campaigns to document how marine and coastal recreational users and ecotourism operators impact the coastal resources; obtain public perceptions in this matter; and educate the public and operators on these impacts in Culebra and the Northeast Marine Corridor.
- Provide the expertise of a part-time outreach specialist to advocate for recreational practices that preserve the ecological integrity of Culebra's ecosystems, and engage the community and the Canal de Luis Peña Natural Reserve Management Board on recreational issues, among other environmental needs.
- Conduct a characterization project in the NE Marine Corridor that addresses human uses and use patterns, user knowledge and perceptions and use conflicts to address data gaps essential to effective management from a Limits of Acceptable Change framework.
- *Funding:* Funded for FY15-16; $15,000 needed in FY17
- *Performance metric:* Number/proportion of users observed engaging in environmentally aware recreational behavior who indicated exposure to one or more social marketing campaigns; Pilot Limits of Acceptable Change scientific study.

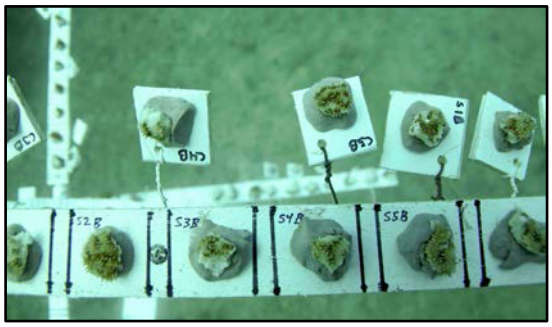
Culebra Priority Action 6: Install mooring buoys and aids to navigation (ATON) to reduce small vessel navigation impacts.

- Install mooring buoys and assist Puerto Rico's DNER in identifying new anchoring areas to protect coral nurseries and reef rehabilitation sites at Bahía Tamarindo and Punta Soldado.

- Three coral reefs have been identified for ATON installation where frequent groundings occur - Las Pelas, Culebrita, and Flamenco.
- *Funding*: Partially funded for mooring buoys FY15-16; $48,000 needed for ATONs at three sites.
- *Performance metrics:* Number of ATONs and mooring buoys installed and number of reefs marked to prevent groundings.

Culebra Priority Action 7: Implement population enhancement methods for non-acroporid ESA corals.

- NOAA Restoration Center will expand production scale propagation techniques for framework building threatened coral species to increase species diversity in restoration.
- The number of corals at the existing Culebra nursery will be increased and outplanting methods will be tested.
- *Funding*: Partially funded FY15; $20,000/yr needed.
- *Performance metrics:* Number of corals grown in the nursery. Effectiveness of the different propagation and outplanting methods.



Experimental coral fragments
Photo credit: NOAA

Culebra Priority Action 8: Conduct emergency restoration in the aftermath of physical impacts from storms and vessel groundings.

- Ameliorate the effects of large wave events and vessel groundings by increasing response and restoration capacity.
- *Funding*: Partially funded for FY15; $60,000/yr needed.
- *Performance metrics:* Number or proportion of incidents where response and restoration occurs. Number of corals saved and reattached.

Photo Credit: NOAA

Table 1: How do priority actions in Culebra relate to the overall HFA Goals?

Culebra Actions	Habitat Resilience	ESA Coral Recovery	Fishery Management	Sustainable Recreation
Culebra Priority Action 1: Implement Watershed Restoration Projects	X	X		
Culebra Priority Action 2: Recover threatened Acropora coral populations.	X	X		
Culebra Priority Action 3: Support fisheries management decision-making	X		X	
Culebra Priority Action 4: Identify nursery habitats for key fishery species			X	
Culebra Priority Action 5: Reduce boating, diving, swimming, and snorkeling impacts	X			X
Culebra Priority Action 6: Install Aids to Navigation	X	X		X
Culebra Priority Action 7: Implement population enhancement methods for ESA-listed corals	X	X		
Culebra Priority Action 8: Conduct emergency coral restoration	X	X		X

Additional Opportunities for NOAA on Culebra Island

While the eight priority actions identified above highlight NOAA-led opportunities to enhance conservation efforts, the actions below highlight priority partnership opportunities to improve habitat and resource conservation on the island.

Fisheries: Assess and quantify connectivity pathways between habitats that are essential to rebuilding or sustaining fishery populations, *e.g.*, between spawning sites and nursery habitats, habitats used by successive life stages (ontogenetic shifts), linkages between Arrecifes de la

Cordillera and Culebra and fishing grounds, etc. Additionally, ensure that enough habitat of adequate quality exists, to support the vital needs of dependent reef fishes (*e.g.*, snapper, parrotfish, grunts, Nassau grouper, red hind, yellowfin grouper, and other groupers). Working closely with the Caribbean Fishery Management Council, DNER, and members of the Caribbean Coral Reef Institute will help to advance these efforts.

LBSP: Coordinate with EPA and regional scientists to develop place-based watershed restoration targets for Culebra Island, and coordinate with Culebra municipal agencies and Clean Water Act (CWA) regulatory authorities (i.e., EPA, Puerto Rico Environmental Quality Board - EQB, USACE) to identify opportunities to improve enforcement of the CWA.

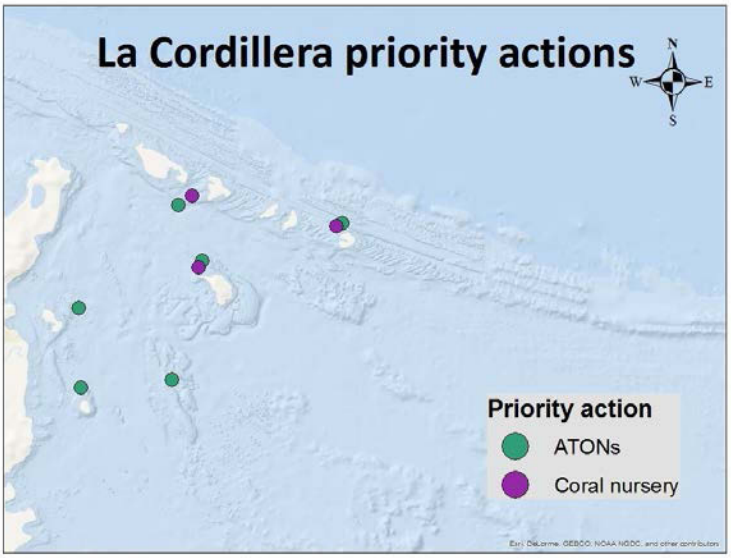
Unexploded ordnances: Coordinate with US Army Corps of Engineers and Department of Defense to explore the removal or remediation of unexploded ordnance in and around Culebra to minimize impacts to ESA listed species and Essential Fish Habitat. NOAA will develop best management practices for coral restoration work that is conducted in areas where unexploded ordnance are known to be present.

Enforcement and compliance: Enhance enforcement by providing support to DNER in implementing priority enforcement projects of the Ranger Corps Strategic Plan. Ensure that fishers are engaged and educated about the laws and regulations.

Measuring size of conch to ensure legality of catch
Photo Credit: DNER

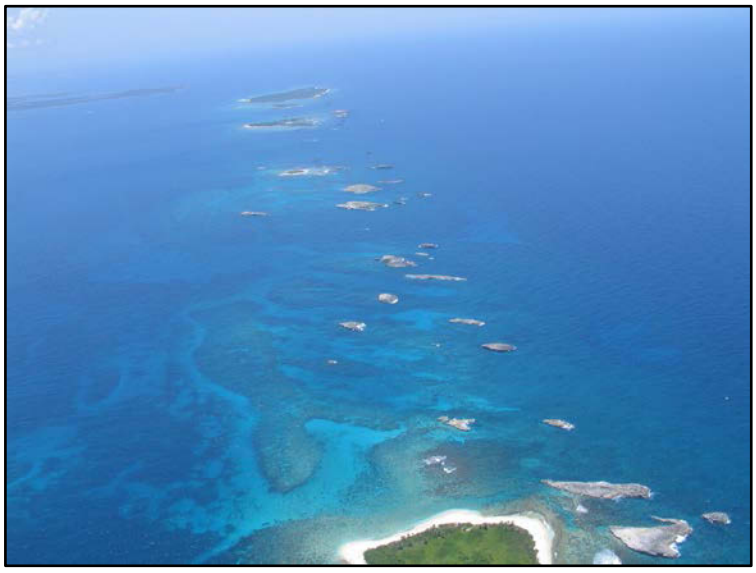
ARRECIFES DE LA CORDILLERA ACTION PLAN

Why Arrecifes de la Cordillera*?*



Extending off the municipality of Fajardo and the Cabezas de San Juan Natural Reserve are multiple chains of islands, reefs, and cays that make up the Cordillera coral reef region between the main island of Puerto Rico and Culebra Island. This area encompasses the Arrecifes de la Cordillera Natural Reserve, which extends 18 miles east-southeast from Fajardo, and covers a total surface area of 46 square miles. The reserve is surrounded by extensive oceanic habitat throughout the northeast Puerto Rican insular platform. In deeper habitats grouper spawning aggregations have historically existed, in addition to mesophotic reef habitat and offshore waters that are important habitat for pelagic sportfish.

This uninhabited region contains coralline sandy beaches, diverse plants, and abundant terrestrial and marine wildlife. Ecosystems throughout the reserve include terrestrial sub-tropical dry forests, fringing coral reefs, rock and hard-ground reefs, and seagrass beds, which provide habitat for a variety of reef fishes and invertebrates. The reserve provides habitat for thousands of aquatic and migratory birds, and a suite of reptiles and amphibians, including hawksbill and green sea turtles that nest in reserve islets.



Arrecifes de la Cordillera aerial view
Photo Credit: A. Ortiz

What Can NOAA Do in Arrecifes de la Cordillera?

Since 2012, NOAA has been evaluating habitats and resources in Arrecifes de la Cordillera to identify threats and associated conservation actions needed to enhance habitat and resource resiliency in this region. Land based sources of pollution, mainly due to improperly treated sewage and improper coastal development practices, threaten the Arrecifes de la Cordillera reefs. They are also impacted by both localized threats, such as unsustainable recreational use and fishing pressure, and global threats, such as increased sea surface temperature. The cumulative effects of these threats have led to degraded coastal and marine habitats with reduced resilience abilities, loss of reef building coral species (especially acroporids), declining coral health and coral-dependent resources, and threatened resource sustainability and economic livelihoods. To combat the above threats the following priority actions are proposed.

Cordillera Priority Action 1: Recover threatened *Acropora* coral populations.

- Increase population resilience and recovery potential by repopulating reefs with genetically diverse coral propagated in *in-situ* coral nurseries.
- Outplant 6000 corals annually for 5 years to achieve the ESA Recovery Criteria for abundance at 3 reefs.
- Establish new coral nurseries at three cays (Palominos, Diablo and Lobos).
- *Funding:* 10% funded FY16; $140,000/yr needed.
- *Performance metrics:* Number of nurseries established, number of coral colonies propagated and outplanted to selected reefs; Acres of coral reef habitat restored to meet ESA recovery criteria.

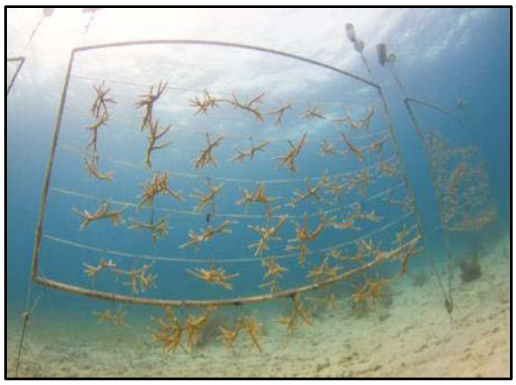


Photo Credit: NOAA

Cordillera Priority Action 2: Reduce recreational impacts on coral reefs.

- Utilize social marketing campaigns to document how marine and coastal recreational users and ecotourism operators impact the coastal resources; obtain public perceptions in this matter; and educate the public and operators on these impacts in the NE Marine Corridor.
- Provide the expertise of a part-time outreach specialist to advocate for recreational practices that preserve the ecological integrity of Cordillera's ecosystems, and engage the community and the reserve's management board on recreational issues, among other environmental needs.

- Conduct a characterization project in the NE Marine Corridor that addresses human uses and use patterns, user knowledge and perceptions and use conflicts to address data gaps essential to effective management from a Limits of Acceptable Change framework.
- *Funding:* Funded for FY15-16; $15,000 needed in FY17
- *Performance metric:* Number/proportion of users observed engaging in environmentally aware recreational behavior who indicated exposure to one or more social marketing campaigns; Pilot Limits of Acceptable Change scientific study.

Cordillera Priority Action 3: Support Caribbean Fisheries Management Council and PR DNER decision-making by advancing critical science

- Conduct fishery-independent surveys to assess current distribution and abundance of key fishery species, including conch, lobster, snappers and groupers in nearshore habitats.
- Acoustically track queen conch to verify habitat use and movement patterns.
- Analyze benthic parameters (habitat type, sediment grain size, seagrass shoot density) to understand the effects of terrestrial run-off on conch populations.
- *Funding:* Partially funded FY15; $120,000/yr needed
- *Performance metrics:* Number of fish stocks with sufficient data to assess current status within HFA.

Cordillera Priority Action 4: Identify nursery habitats for key fishery species.

- Survey, identify, and map nursery habitat for key fishery species, such as queen conch, snapper, grouper, grunts and lobster, whose juveniles use shallow waters where habitat degradation is common.
- Use nursery habitat distributions to identify and prioritize conservation efforts.
- Monitor nursery habitats over time to document changes in habitat conditions.
- *Funding:* Partially funded for FY15; $65,000/yr needed
- *Performance metrics:* Number of nursery habitats identified and mapped; number of nursery habitats with improved habitat conditions.

Cordillera Priority Action 5: Develop population enhancement methods for non-acroporid ESA-listed corals.

- Establish a coral nursery to develop production scale propagation techniques for framework building, ESA-listed coral species (e.g. *Orbicella annularis*).
- *Funding*: Partially funded FY15; $20,000/yr needed.
- *Performance metrics:* Number of corals grown in nursery; effectiveness of different methods for propagation and outplanting.

Photo Credit: NOAA

Cordillera Priority Action 6: Install mooring buoys and aids to navigation.

- Install aids to navigation (ATONs) where frequent groundings occur to reduce small vessel navigation impacts- Cayo Largo, Isla Ramos, and Cayo Roncador.
- Assist Puerto Rico's DNER in identifying new anchoring areas for additional mooring buoys to protect coral nurseries and reef rehabilitation sites. in
- DNER will install mooring buoys in Palominitos, Icacos, and Lobo.
- *Funding*: Fully funded for mooring buoys FY15-16; $48,000 needed for ATONs at three sites.
- *Performance metrics:* Number of ATONs and mooring buoys installed and number of reefs marked to prevent groundings.

Cordillera Priority Action 7: Conduct emergency coral restoration

- Ameliorate the effects of storms and vessel groundings by increasing response and restoration capacity.
- *Funding*: Partially funded for FY15; $60,000/yr needed.
- *Performance metrics*: Number or proportion of incidents where response and restoration occurs; Number of corals saved and reattached.

Table 2: How do priority actions in the Cordillera region relate to the overall HFA Goals?

Cordillera Action	Habitat Resilience	ESA Coral Recovery	Fishery Management	Sustainable Recreation
Cordillera Priority Action 1: Recover threatened *Acropora* coral populations	X	X		
Cordillera Priority Action 2: Reduce recreational impacts on reefs	X	X		X
Cordillera Priority Action 3: Support fisheries management decision-making	X		X	
Cordillera Priority Action 4: Identify nursery habitats for key fishery species			X	
Cordillera Priority Action 5: Develop population enhancement methods for other ESA-listed corals	X	X		
Cordillera Priority Action 6: Install aids to navigation	X	X		X
Cordillera Priority Action 7: Conduct emergency coral restoration	X	X		X

Additional Opportunities for NOAA in the Arrecifes de la Cordillera Region

Fisheries: Assess and quantify connectivity pathways between habitats essential to rebuilding or sustaining fishery populations, e.g. between spawning sites and nursery habitats, and between reserves and fishing grounds. Ensure that enough habitat of adequate quality exists to support the vital needs of dependent reef fishes (*e.g.*, snapper, parrotfish, grunts, Nassau grouper, red hind, and yellowfin grouper). Improve data collection (commercial, recreational, and subsistence) on key fisheries, including number and type of fishers, areas fished, and improved estimates of landings, effort, and bycatch. Working closely with the Caribbean Fishery Management Council, DNER, and members of the Caribbean Coral Reef Institute will help to advance these efforts.

LBSP: Given the range of land use practices in this region (e.g., agriculture, preserved rain forest, urban development) and associated federal and jurisdictional authorities, this area poses a multitude of opportunities to form partnerships that will support LBSP management. Some of these opportunities are to:

- Coordinate with EPA and regional scientists to develop place-based watershed restoration targets for the Río Fajardo, Río Grande, and Luquillo Watersheds.
- Identify opportunities to improve Clean Water Act (CWA) enforcement by coordinating with Fajardo, Ceiba, Rio Grande, and Luquillo municipal agencies and CWA regulatory authorities (e.g. EPA, PR EQB).
- Coordinate with USDA-NRCS to identify opportunities for implementation of agricultural conservation practices to reduce LBSP threats from agriculture.
- Identify opportunities to expand partnerships with US Forest Service within the Rio Grande, Fajardo, and/or Luquillo watersheds.

ACTION PLAN FOR MANAGEMENT-DRIVEN SCIENCE

NOAA has a decades-long history of studying the coral reefs, seagrass beds, mangroves, and coastal forests of northeast Puerto Rico and Culebra Island. Together with the University of Puerto Rico, the Department of Natural and Environmental Resources of Puerto Rico (DNER), and many others, NOAA has mapped much of the benthos, initiated coral reef ecosystem monitoring survey efforts, and investigated the behavior and habitat requirements of key fish species. While this body of work has aided local resource managers, more work is needed to refine our understanding of threats, identify conservation needs, and/or adapt conservation actions. The identification of research gaps is a key first step to preserving the integrity and planning for the resilience of these ecosystems and the human communities that depend on them. However, certain priority science needs are already known for the Northeast Marine Corridor and Culebra Island, and are listed below.

Photo Credit: NOAA

Science Priority Action 1: Protect commercially important fish stocks through the identification of grouper spawning aggregations.

- Use stakeholder input to identify grouper spawning aggregation sites.
- Deploy passive acoustic (sound) recorders to confirm whether a site is viable for active spawning and to map the aggregation.
- Monitor spawning activity to understand temporal and spatial variation and effectiveness of spawning at sustaining local populations.
- Present results to stakeholders and fishery managers to inform decision making on resource protection measures.
- *Funding*: FY15,16 partially funded; $150,000 needed for future years
- *Performance metrics:* Number of viable

Nassau grouper in spawning coloration at aggregation site.

spawning aggregations located, mapped, and assessed; number of spawning aggregation sites highlighted for management and enforcement agencies (i.e., presentations and reports).

Science Priority Action 2: Apply climatic information to management actions.

- Assess and map reef resilience and develop guidance for conservation actions, such as coral outplanting, using available data from past surveys, historical thermal stress risk indicators, and new indicators of climate stress. Overlooking the significant threat posed by climate change places some planned actions at risk of failure.
- Expand the suite of tools available to assess climate threats to coral reef ecosystems, including development of new indicators and expanded analysis of historical thermal stress risk indicators and past survey data.
- Preferentially grow corals surviving thermal stress events in nurseries to enhance the likelihood of outplant survival.
- Conduct d focused surveys and analyze data to track health and survivorship of coral recruit from the time they are reared in the nursery and extending until after they have been outplanted.
- Build upon and complement the results and recommendations of a Climate Change Community Adaptation Plan recently developed for Culebra by the Puerto Rico Coastal Zone Management Board.
- *Funding:* Development of version 1 thermal history maps was funded by the Coral Program; $60,000/yr needed for development of version 2 from new satellite data and application to nursery efforts as well as efforts to track thermal stress impacts on nursery and outplanted corals.
- *Performance Metrics*: Percentage of nursery sites evaluated for thermal stress potential based on past climate variability; Percentage of nursery and outplant corals tracked for potential resilience to thermal stress.

Photo Credit: NOAA

Science Priority Action 3: Establish water quality targets to inform LBSP management targets.

Develop a cost-effective approach for establishing LBSP management targets to inform conservation actions, evaluate performance, and inform adaptive management needs. This action will be building off existing efforts (e.g., EPA Biological Condition Gradient, NOAA RC's nearshore water quality monitoring) and regional science, utilizing Culebra Island as a test bed to define place-based water quality thresholds for seagrass and coral reef habitats.

- Establish additional data collection/modeling programs, including continued monthly *in situ* monitoring of nearshore water quality parameters, additional seagrass monitoring to characterize habitat quality and extent, simulate rainfall events to quantify pollutant loads associated with varied land covers/uses.
- Calibrate/validate model estimates of pollutant loads to refine our understanding of management priorities and assist in development of management targets.
- Use data-driven analysis to link land cover and use with nearshore water quality, habitat quality, and habitat extent.
- *Funding*: $120,000/yr needed

Science Priority Action 4: Improve characterization of fishery impacts on managed resources and habitats.

- Improve accuracy and coverage of the monitoring of extraction of key species. Integrity of coral reef ecosystems depends on interactions between fish, corals, and other organisms within a healthy environment. Excessive removal of fish biomass can degrade reef conditions.
- Characterize in greater detail recreational, commercial, and subsistence fishing statistics (e.g., fishing focal areas, landings, efforts) and socio-economic status of the fishing communities within the HFA to enhance management capabilities.
    - A current project is documenting the recreational sectors for conch and lobster fisheries in Puerto Rico, including within the HFA.
    - Information will be analyzed to assess conditions of fishery populations, habitat conditions, and dependence of stakeholders on HFA marine resources.
    - Characterizing the fishing sectors will assist with stakeholder engagement phases of management and planning.
- *Funding*: Partially funded; $120,000/yr needed for future years

Science Priority Action 5: Develop and implement reef resilience surveys to inform management decision-making.

- Develop annual monitoring program with capabilities to also assess stress events to monitor parameters predicting resistance and resilience in coral reef ecosystems. Various factors that provide differential resilience to climate change include local oceanography, differential bleaching resistance among coral species, coral genets, or zooxanthellae clades, and among areas with different management systems.
- Develop a monitoring plan and conduct surveys to assess resilience to stress events (including thermal stress-induced bleaching and disease, severe runoff, storms, etc.) modeled on the Florida Reef Resilience Program. This will include annual monitoring and event-based volunteer and professional surveys in response to acute stress events.

- *Performance Metric:* Percentage or area of coral reefs exposed to thermal stress capable of causing coral bleaching or mortality; maps of exposure to thermal stress

Science Priority Action 6: Model connectivity and apply remote sensing tools to target LBSP reduction efforts

- Hydrodynamic studies have begun to establish a better understanding of the potential connectivity between the reefs and threats from land-based sources of pollution. However, additional research is needed to better understand these linkages. NESDIS is developing ocean color products to measure sediment and nutrient inputs into coral reefs around Puerto Rico using NOAA satellite instruments.
- *Funding*: Funded for FY16; $250K/yr needed
- *Performance Metric:* Remotely-sensed products to detect LBSP in HFA developed and used

Science Priority Action 7: Characterize the spatial distribution of vessels in Northeast Marine Corridor to predict impact of human-use.

- The HFA is highly frequented by commercial cruise ship, tourist boating operators, and cargo traffic, yet little contemporary empirical data is available on the amount and type of vessel traffic or the spatial and temporal usage patterns. NOAA is acquiring satellite imagery that will be used to characterize the spatial distribution of vessels in order to help develop vessel-use zones. The resulting map products will depict vessel size, type, location, and activity at various times throughout the month and year, and will help predict human-use impacts on coral reef ecosystems.
- *Funding*: Funded for FY15-16.

Science Priority Action 8: Predict storm surge in real time to protect life and property and for better assessment of coastal resilience.

- NOAA's National Weather Service (NWS) and partners are improving the resolution of real-time, live guidance on storm surge during hurricanes, and other extreme wave and coastal inundation events in Puerto Rico (and U.S. Virgin Islands), for use by emergency management officials and other decision makers. This real-time guidance enhances the web-based maps developed by the Department of Natural and Environmental Resources of Puerto Rico that illustrate the predicted likelihood of storm surge impact. National Weather Service ran a storm surge model retroactively with a large number of storms, creating a surge envelope for PR. This work can be extended to develop a real-time probabilistic model capability with added resources and effort.
- *Funding:* Funded for FY15, 1 FTE needed for FY16

Table 3: How do these science actions relate to the overall HFA Goals?

Science Action	Habitat Resilience	ESA Coral Recovery	Fishery Management	Sustainable Recreation
Science Priority Action 1: Protect commercially important fish stocks through the identification of grouper spawning aggregations.	X		X	
Science Priority Action 2: Apply climatic information to enhance management actions.	X	X		
Science Priority Action 3: Establish water quality targets to inform LBSP management targets.	X		X	
Science Priority Action 4: Improve characterization of fishery impacts on managed resources and habitats.	X		X	
Science Priority Action 5: Develop and implement reef resilience surveys to inform management decision making.	X	X		
Science Priority Action 6: Model connectivity and apply remote sensing tools to target LBSP reduction efforts	X	X	X	
Science Priority Action 7: Characterize distribution of vessels to predict human-use impact.	X		X	X
Science Priority Action 8: Predict storm surge in real time	X		X	

APPENDIX I - RECENT AND ONGOING NOAA EFFORTS

The following section presents ongoing and/or recently completed NOAA projects in the area of study, as organized by Lead Programs or Offices:

NOAA's Coral Reef Conservation Program (CRCP) is currently supporting several projects to strengthen scientific knowledge and management within the region including:

- **Development of NE Marine Corridor Management Plan -** NOAA, together with DNER, is working on the development of a management plan for the NE Marine Corridor. A completed plan, including a list of priority marine conservation actions for the area is anticipated in Fall 2016.

- **Watershed Management Plans for Culebra and Río Fajardo -** Together with DNER, NOAA has recently funded the development of these two watershed management plans (WMPs), and is supporting the development of another plan for the Northeast Ecological Corridor Reserve. All completed plans will meet EPA's A-I criteria for the subwatersheds in the HFA. *Status: completed*

- **Northeast Corridor Hydrodynamic Modeling Efforts -** Hydrodynamic models via CariCOOS (http://www.caricoos.org) are focused in the Northeast Marine Corridor, for which oceanographic data are available from regional buoys and sensors.

- **Hydrodynamic Model to Forecast Waves and Coastal Circulation -** NOAA is involved in the development of a hydrodynamic model with custom graphical products to forecast waves and coastal circulation, through CariCOOS. These efforts will assist in determining larval and ecological connectivity and geographic patterns of pollution in the NE Marine Corridor and Culebra Island.

- **Management Support Group -** NOAA is in the process of creating a management support group for the NE Marine Corridor, comprised of local and federal agencies, NGOs, and the municipalities. These efforts will allow for enhanced inter-agency conservation partnerships.

- **The National Coral Reef Monitoring Plan (NCRMP) for biological, physical, and socioeconomic monitoring throughout the U.S. Pacific, Atlantic, and Caribbean coral reef areas.** The overarching goal of this effort is to collect the information needed to gauge changing conditions of U.S. coral reef ecosystems, including the NE Marine Corridor and

Culebra. The focus is on four monitoring themes: benthic community structure, fish community structure, climate impacts, and socio-economic condition.

NOAA Fisheries - Office of Habitat Conservation - Restoration Center (RC), together with NOAA CRCP and DNER, has a strong history of working toward priority watershed and marine habitat restoration efforts throughout Northeast Puerto Rico and Culebra Island. Funded and ongoing projects include the following:

- **Priority watershed restoration actions** - Since 2012 and through 2016 NOAA has funded watershed restoration projects in Culebra.

- **Erosion and sediment control trainings** - NOAA provided funding to DNER to couple watershed restoration efforts with trainings to control erosion and sediment primarily during construction.

- **Protocols for vessel groundings** - Together with DNER and CRCP operational procedures and protocols are being developed to assess vessel groundings, establish follow-up actions, and collect penalty fees from offenders. This will include educating stakeholders on Best Management Practices for minimizing impacts during vessel removal.

- **Conducting emergency restoration of vessel impacts on marine habitat** - Together with DNER and CRCP, responses to anthropogenic physical impacts to marine habitats and emergency restorations are being conducted. Coral fragments are being stabilized and reattached.

- **Best Management Practices for vessel removal** - RC with NCCOS is using spatial information on vessel traffic and previous grounding locations to develop a BMPs for vessel removal which will be used to educate stakeholders.

- **Identify potential areas of impacts from vessels** - RC along with NCCOS is identifying regions impacted by commercial and recreational vessels through analysis of aerial photographs, stakeholder information, and spatial information on vessel traffic and previous grounding locations.

- **Install Aids to Navigation (ATONs)** - NOAA and DNER recently installed ATONs in Las Pelas, Culebra to prevent small vessel impacts to coral reefs. *Status: completed*

- **Determining climate resistant acroporid coral genotypes to guide propagation efforts -** With genotype data available for acroporid corals from nurseries and wild populations, NOAA is identifying resilient coral genotypes to climate-change related regional warming.

- **Using scientific research to develop strategies to enhance recoverability of non-acroporid ESA-listed species -** Building upon projects to develop coral propagation methods, ongoing scientific research, and successful acroporid restoration efforts, NOAA is develop strategies to improve restoration techniques for non-acroporid ESA listed species to promote their growth and survival.

NOAA Fisheries - Office of Protected Resources - Section 6 of the Endangered Species Act of 1973 (ESA) provides a mechanism for cooperation between NOAA Fisheries and States / Territories in the conservation of threatened, endangered, and candidate species. After agreements are established, Federal funding, provided in the form of grants, can be used to support management, research, monitoring and outreach projects that have direct conservation benefits for listed species.

- **Section 6 Grant for Turtle Conservation -** The latest grant was awarded in FY13 to conduct in-water sea turtle surveys and analyses of hawksbill (*Eretmochelys imbricata*) and green turtle (*Chelonia mydas*) population dynamics for important foraging areas in Puerto Rican coastal waters to inform implementation of recovery plans.

NOS - National Centers for Coastal Ocean Science (NCCOS) has been involved in the development of a hydrodynamic model, benthic habitat mapping efforts of the NE Marine Corridor and Culebra Island, and biogeographic characterization of Essential Fish Habitat (EFH) affected by human activities, whose products will provide DNER managers with information on the extent, health, and composition of marine resources within the NE Puerto Rican platform.

- **Mapping the Northeast Marine Corridor and Culebra Island benthos** - Products will provide DNER managers with information on the extent, health, and composition of marine resources within the NE Puerto Rican platform, and help refine the proposed watershed management plan for the Northeast Ecological Corridor Natural Reserve. These efforts build upon a 2006 U.S. Marine Managed Areas Inventory that assessed benthic habitat cover for natural reserves in the HFA. *Status: completed*

- **Spatial characterization -** NOAA and partners are developing an integrated management plan using spatial data to characterize the area, identify priority biological resources, and highlight potential ocean use conflicts. This will create a map-based tool that will support ecosystem-based marine spatial planning by integrating physical oceanography, biological

patterns of marine fauna and habitats, historical and current human use data, and watershed characteristics. NCCOS is also involved in the biogeographic characterization of Essential Fish Habitat affected by human activities in the entire coastal zone of the Puerto Rico archipelago, where information on EFH characteristics in protected and non-protected marine areas, including components of the HFA, has been compiled.
Partners: DNER, The Nature Conservancy
Status: almost complete

- **Documenting distribution of threats to coral species** - Building upon NOAA's efforts to map local scientific knowledge to prioritize areas for marine spatial planning, NCCOS is identifying optimal locations for coral species where their threats are minimized.

NMFS - Southeast Fisheries Science Center (SEFSC) has been involved in several projects throughout the HFA including fishery-independent stock abundance surveys, and efforts to improve characterization of commercial, recreational, and subsistence fisheries for the region.

- **Conduct high-resolution stock abundance surveys -** Fishery-independent stock abundance surveys of queen conch density, habitat use and movements, and of fishing and grouper spawning, off Northeast Puerto Rico and Culebra Island are funded by NOAA Fisheries Office of Science and Technology.
  Partners: This project builds upon Caribbean South East Area Monitoring and Assessment Program (SEAMAP-C) fishery-independent conch surveys that are carried out and assessed by DNER, University of Puerto Rico, and CFMC staff.

- **Improve characterization of fisheries** - Basic surveys are ongoing and build upon a socioeconomic study of trap fishing (Agar et al. 2008) and spatial analysis of recreational fishing (Shivlani and Koeneke 2011) in Puerto Rico, and forthcoming DNER recreational fishing surveys in Puerto Rico and Culebra. Improved characterization of commercial, recreational, and subsistence fisheries will occur as a result of increasing spatial and temporal resolution of fishing effort, fishing community demographics, and catch data (i.e., landings and bycatch) information.

NESDIS, through NOAA's Coral Reef Watch, is currently involved in efforts using satellite imagery to examine risk of HFA coral reef areas to climate-related bleaching and disease during thermal stress events, and to map and survey historical and future at-risk reef habitats through NOAA's Coral Health and Monitoring Program.

- **Satellite-based estimates of levels of risk and areas affected during thermal stress events** - Through use of satellite thermal imagery, NOAA Coral Reef Watch is estimating HFA coral

reef areas at risk for bleaching and disease. These efforts allow for calculation of percent area exposed to thermal stress capable of causing bleaching and/or mortality, and the creation of maps of specific regions exposed to thermal stress.

- **Estimates of historical risk (from satellites) and future risk (from climate models)** - Along with OAR's Coral Health And Monitoring Program (CHAMP), NESDIS is mapping historical and future risk to climate-related bleaching events and climate impacts to coral reef habitats.

- **Field Surveys During Thermal Stress Events** - NOAA is undertaking field surveys during thermal stress events to quantify bleached coral colonies, disease outbreaks, mortality events, and to map impacted areas.

  Partners: DNER, University of Puerto Rico

NWS, through the Office of Science and Technology Integration, the National Hurricane Center and San Juan Weather Forecast Office is involved in an organized effort to improve storm surge modeling for the U.S. Caribbean.

- **Improving storm surge guidance for Puerto Rico and U.S. Virgin Islands -** NOAA NWS is involved in an organized effort to improve storm surge modeling that will identify models or techniques that will extend NHC and local WFO's present wave/surge operational forecasting capability from mild-sloped coastal areas to steep-sloped, such as those in the HFA. These efforts also facilitate high resolution storm surge guidance for decision makers, and improve overall forecasting for the region.

  Partners: National Centers for Environmental Protection (NCEP)/Environmental Monitoring Center (EMC), Sea Grant of Puerto Rico, University of Puerto Rico, Notre Dame University, Caribbean Coastal Ocean Observing System (CariCOOS), U.S. Army Corps of Engineers/Engineer Research and Development (USACE/ERDC)

Oceanic & Atmospheric Research - Atlantic Oceanographic and Meteorological Laboratory is involved in subsurface temperature logging using National Coral Reef Ecosystem Monitoring Program instruments off *Isla Palomino* and Culebra to establish a subsurface temperature network, and work to mitigate and respond quickly to the effects of thermal stress for the region.

APPENDIX II - PARTIAL LIST OF PARTNERSHIPS AMONG FEDERAL AGENCIES & THE PUERTO RICAN GOVERNMENT

Scientists and representatives from NOAA Line Offices are collaborating with state and local agencies (DNER) and federal partners (CFMC, US Fish and Wildlife Service), who are leading habitat and resource conservation, watershed management efforts, and working to enhance environmental sustainability and enforcement of regulations within the Northeast Marine Corridor and Culebra Island. Ongoing research, monitoring, and educational outreach projects are helping to address management needs throughout the region. Details of some of these efforts are below.

The **Caribbean Fishery Management Council (CFMC)** is working with NOAA Fisheries SEFSC and the Southeast Regional Office (SERO) on management of fisheries resources in the HFA region. The Council is responsible for the creation of management plans for fishery resources (FMPs) in the U.S. Caribbean Exclusive Economic Zone, and once implemented Puerto Rico's local government may adopt compatible legislation for fisheries conservation in territorial waters. There is a joint enforcement agreement between NOAA Fisheries and DNER for both federal and territorial jurisdictions and a part-time position exists for coordination between DNER and the Council. Current FMPs for priority fishery species include those for queen conch, Caribbean spiny lobster, reef fishes, and coral and reef associated plants and invertebrate species.

Puerto Rico Department of Natural and Environmental Resources (DNER) is involved in the following regional efforts for the Northeast Marine Corridor and Culebra Island.

- **Coordinate cross-agency effort -** NOAA is leading efforts together with DNER, federal partners, local agencies and municipalities to provide jurisdictional management support for the region, and establish a proposed Northeast Marine Corridor Management Board. These efforts will promote inter-agency conservation partnerships.

- **Developing Watershed Management Plans (WMPs) -** DNER is leading efforts with a NOAA CRCP cooperative agreement to develop a WMP for the Northeast Ecological Corridor Natural Reserve, between the municipalities of Luquillo and Fajardo.

- **Watershed restoration actions in Fajardo -** DNER has designated funds for implementing Erosion and Sediment Control projects as recommended in the Río Fajardo WMP, and is anticipated to participate in the implementation of watershed restoration priority actions identified in approved WMPs in collaboration with the municipality of Fajardo.

- **Developing a framework for streamlined adjudication of anthropogenic physical impacts on coral reefs -** DNER, with support from NOAA (RC and CRCP), is developing a protocol to assess groundings and the proper follow-up actions to these events.

- **External evaluation and development of a strategic plan for the DNER Ranger Corps -** DNER, with NOAA assistance, completed an external evaluation of the DNER Ranger Corps, which is serving as a foundation to develop Standard Operational Procedures and an enforcement strategy.

- **NE Marine Corridor and Culebra Island management-** DNER recently employed a full time manager for this region.

The **U.S. Fish and Wildlife Service** has provided $30K for habitat restoration in Culebra and will be helping to implement watershed restoration priority actions identified in approved Watershed Management Plans.

APPENDIX III – TABLE 4: RESOURCE INVENTORY

Action Plan #	Priority Action	FY14 Expenditure ($K)			FY15 Expenditure ($K)			FY16 Projected ($K)			FY16 Need	Total NOAA FY14-16	Total Match FY14-16	GRAND TOTAL
		NOAA	Match	Total	NOAA	Match	Total	NOAA	Match	Total				
Culebra 1	Building Resiliency in the Puerto Rico Northeast Reserves by Addressing Land-based Sources of Pollution (LBSPs), Restoring Coral Reef Habitat. Site Location: Culebra Island and Northeast Reserves.				226.65	242.33	468.98	132.00	275.58	407.58		358.65	517.91	**876.56**
Culebra 2,7 Cordillera 1,5	ESA Coral Population Enhancement	5.00		5.00	15.00		15.00	20.00		20.00	185.00	40.00		**40.00**
Culebra & Cordillera 3,4	Assessing habitat quality: effects on queen conch density, distribution, and movement				62.12		62.12				99.80	62.12		**62.12**
Culebra 5	Marine resources conservation specialist for management of Luis Peña Channel and Northeast Natural Reserves				50.00	4.80	54.80	50.00	4.80	54.80		100.00	9.60	**109.60**
Culebra 5 Cordillera 2	Reduce boating, diving, swimming, and snorkeling impacts.							69.50		69.50		69.50		**69.50**
Culebra & Cordillera 6	Install aids to navigation and mooring buoys				34.00	12.70	46.70	20.00	2.50	22.50	96.00	54.00	15.20	**69.20**
Culebra 8 Cordillera 7	Emergency coral restoration following storms and vessel groundings	10.00		10.00	10.00		10.00	20.00		20.00	100.00	40.00		**40.00**
Science 1	Grouper spawning aggregations, spawning habitat, and fishing pressure in the NE Reserves and Culebra Island	18.00		18.00	79.10		79.10	45.00		45.00	85.00	142.10		**142.10**
Culebra 1 Science 3	Reduce threats from LBSP and establish WQ targets for LBSP monitoring	345.00		345.00	159.00		159.00	65.00		65.00	143.00	569.00		**569.00**
Science 5	Understanding fisheries impacts on resources	30.00		30.00	35.00		35.00				175.00	65.00		**65.00**
Science 6	Develop and implement reef resilience surveys.													
Science 7	Research on connectivity (e.g. using satellite tools)		37.00	37.00				76.00	20.00	96.00	125.00	76.00	57.00	**133.00**
Science 8	Characterize distribution of vessels to predict human-use impact.							25.00		25.00		25.00		**25.00**
Science 9	Predict storm surge in real time.										1 FTE			
Completed	Benthic mapping of NE and Culebra	225.00	35.00	260.00								225.00	35.00	**260.00**
Parallel project	Northeast Marine Corridor Integrated Management Plan		20.00	20.00	188.80	20.00	208.80		10.00	10.00		188.80	50.00	**238.80**
	Subtotal	**633.00**	**92.00**	**725.00**	**859.67**	**279.83**	**1,139.50**	**522.50**	**312.88**	**835.38**	**1,008.80**	**2,015.17**	**684.71**	**2,699.88**

APPENDIX IV - STAKEHOLDER ENGAGEMENT & COMMUNICATION STRATEGY

The Stakeholder Engagement and Communication Strategy outlines a detailed approach and methodology for involving stakeholders in the NE Puerto Rico Marine Corridor and Culebra Island Habitat Focus Area (HFA). We seek to involve the stakeholders in:

1. The development of the Implementation Plan (IP);
2. Implementation of actions in the HFA Plan in coordination with NOAA;
3. Other activities that indirectly support the successful implementation of the HFA.

Stakeholder Engagement Goal

The overall goal of stakeholder engagement in the HFA is to establish a foundation of support and sustained acceptance and understanding of the Implementation Plan, which is designed to build on existing NOAA programs, prioritize activities, and guide future actions.

Stakeholder Identification and Involvement

NE Puerto Rico and Culebra relevant stakeholders were identified and categorized as federal, territory, non-governmental, and business entities. They were selected based on their current involvement in natural resources conservation efforts in NE Puerto Rico. The primary stakeholder is the Puerto Rico Department of Natural and Environmental Resources (DNER) since one of their direct missions is to manage Puerto Rico marine resources. The Environmental Quality Board and the Planning Board are also considered key partners because they enforce the water quality standards and the Land Use Plan.

Methodology

Periodic email communications, social media, phone calls and group meetings in Puerto Rico have been utilized to obtain input and keep stakeholders informed about progress on IP development. PR DNER has provided some feedback throughout the process of developing the goals and objectives for the IP. We have also received some feedback on our initial work from a University of Puerto Rico-Mayagüez representative. Information about the HFA was uploaded to the Coral Reef Conservation Program's Facebook page. Public roll out of three Action Plans was achieved at the October 2015 U.S. Coral Reef Task Force for members and the public including handouts of the three Action Plans. Progress on the HFA was also presented at the *Climate Change in the Caribbean Conference 2015* held in San Juan, Puerto Rico on November 17th-18th, 2015.

Two meetings were held for stakeholders in Puerto Rico to present the first Implementation Plan draft. One was held in Fajardo on February 3, 2016 and the second one in Culebra Island

on February 8. The meetings were widely attended by representatives of local agencies, federal agencies, academia, municipalities, and NGO. Overall, the Plan was well received. Many specific comments about the priority actions and other pertinent issues were received and recorded. The HFA team worked to incorporate as many suggestions as possible and a separate spreadsheet will be prepared for the stakeholders to respond to each comment as many cannot be directly incorporated in the Plan. Many issues were discussed, for example, enforcement and specific land-based sources of pollution activities that cannot be addressed by the HFA's Implementation Plan. However, we will develop a strategy to facilitate addressing the issues with local, NOAA, and other federal agency resources.

Our future methodology will include the same type of activities mentioned above with added emphasis on 1) Providing regular updates biannually or any time there is a major development; 2) Announcing updates to the HFA website; 3) Sharing a funding opportunities document as well as timely notifications of current opportunities; 4) Reaching out to potential applicants about specific opportunities that may enhance the implementation of the IP; and individual in-person meetings and teleconferences with key stakeholders who have jurisdiction over the HFA region. We also plan to collaborate with the NOAA funded NE Marine Corridor Management Plan initiative to coordinate stakeholder participation and communications.

Table 5: Upcoming stakeholder engagement and communication activities:

Date	Activity
February 2016	Incorporate stakeholder suggestions and ensure performance metrics are appropriate
March 2016	Submit final implementation plan to the NHCT; provide responses to all individual stakeholders comments; provide information about funding opportunities that may be appropriate for the HFA or the IP's priority actions
April 2016	Coordinate with other federal agencies and stakeholders about how best to address non-IP issues of concern
May 2016	Roll out final IP; Highlight IP at NOAA in the Caribbean meeting in Puerto Rico; conduct individual in-person follow up meetings with key stakeholders in Puerto Rico to coordinate leverage for IP actions.
June 2016	Begin formal implementation of Plan and regular contact with stakeholders

Other ongoing activities:

- Update the fact sheets periodically
- Complete the translation of fact sheets
- Coordination with the CRCP communications liaison to disseminate news in social media

APPENDIX V - LIST OF PARTNERS

Regional partners have been engaged in conservation work for many years in Culebra and the DNER Natural Reserves located in Northeast Puerto Rico. This work culminated in DNER's establishment of the first marine corridor that will be managed as an ecosystem. The partners joined NOAA in the designation of the region as an HFA to emphasize coordinated management efforts. The list of partners has grown since the HFA designation process and the list below contains the current partners.

Non-governmental organizations
Abbie's School of Culebra
Asociación de Pescadores de Culebra
Asociación de Pescadores de Las Croabas
Asociación de Pescadores de Maternillo
Asociación de Pescadores de Sardinera
Asociación de Pescadores de Ucares
Caribbean Landscape Conservation Cooperative
Centro para la Conservación del Paisaje
Consultores Educativos
CORALations, Inc.
Culebra Foundation
Escuela Ecológica de Culebra
National Fish and Wildlife Foundation
Northeast Ecological Corridor Coalition
Pew Conservation Trust
Protectores de Cuencas
Puerto Rico Climate Change Council
Puerto Rico Conservation Trust
Puerto Rico Sierra Club
Ridge to Reefs
Sociedad Ambiente Marino
The Nature Conservancy

Federal agencies
Caribbean Fisheries Management Council
Environmental Protection Agency
NOAA Coral Reef Conservation Program
NOAA National Environmental Satellite, Data, and Information Service
NOAA National Weather Service

NOAA Office of Atmospheric Research
NOAA Restoration Center
San Juan Bay National Estuary Program
US Army Corps of Engineers
US Coast Guard
US Dept. of Agriculture-Natural Resources Conservation Service
US Fish and Wildlife Service
US Forest Service

Puerto Rico government
Aqueduct and Sewer Authority (PRASA)
Authority for the Development and Conservation of Culebra (ACDEC)
Culebra Municipality
Department of Agriculture
Department of Natural and Environmental Resources (DRNA)
Energy and Power Authority (PREPA)
Environmental Quality Board (JCA)
Fajardo Municipality
Luquillo Municipality
National Parks Company (CPN)
Planning Board (JP)
PR Tourism Company (PRTC)
Río Grande Municipality
Solid Waste Authority of Puerto Rico (ADS)

Universities
Caribbean Coral Reef Institute, UPR-Mayagüez
Caribbean Coastal Ocean Observing System (CariCOOS), UPR-Mayagüez
Center for Applied Tropical Ecology and Conservation, UPR-Río Piedras
Interamerican University-Fajardo
Seagrant of Puerto Rico

Private
GESCICA LLC (Grupo Estudios Científicos del Caribe)
Horsley Witten Group

APPENDIX VI - TABLE 6: IMPLEMENTATION PLANNING TEAM

Member		
Mark Eakin	NESDIS	Center for Satellite Applications and Research (STAR), Satellite Oceanography and Climatology Division (SOCD), Marine Ecosystems and Climate Branch (MECB)
Leslie Craig	NMFS	Office of Habitat Conservation / Restoration Center
Lisa Vandiver	NMFS	Office of Habitat Conservation / Restoration Center
Michael Nemeth	NMFS	Office of Habitat Conservation / Restoration Center
Tom Moore (co-lead)	**NMFS**	**Office of Habitat Conservation / Restoration Center**
Tali Vardi	NMFS	Office of Science & Technology
Tony Marshak	NMFS	Office of Science & Technology
Ron Hill	NMFS	Southeast Fisheries Science Center
Chris Jeffrey	NOS	NCCOS Biogeography Branch
Simon Pittman	NOS	NCCOS Biogeography Branch
Antares Ramos	NOS	Office for Coastal Management / Coral Reef Conservation Program and Coastal Zone Management Program
Eileen Alicea	NOS	Office for Coastal Management / Coral Reef Conservation Program
Jen Koss (co-lead)	**NOS**	**Office for Coastal Management / Coral Reef Conservation Program**
Rob Ferguson	NOS	Office for Coastal Management / Coral Reef Conservation Program
Peter Edwards	NOS	Office for Coastal Management / Coral Reef Conservation Program
Carlos Anselmi	NWS	NWS / Southern Region / Weather Forecast Office
Daniel Melendez	NWS	Silver Spring Headquarters
Ernesto Rodriguez	NWS	NWS / Southern Region/Weather Forecast Office
Derek Manzello	OAR	Atlantic Oceanographic and Meteorological Lab
Ian Enochs	OAR	Atlantic Oceanographic and Meteorological Lab
Ruperto Chaparro	OAR	Sea Grant Puerto Rico
Jim Hendee	OAR	Atlantic Oceanographic and Meteorological Lab
Lew Gramer	OAR	Atlantic Oceanographic and Meteorological Lab
Jen Lechuga	SO/PPI	Program Planning & Integration

REFERENCES

Agar, J.J., Waters, J.R., Valdes-Pizzini, M., Shivlani, M., Murray, T., Kirkley, J.E., and Suman, D. 2008. US Caribbean fish trap fishery socioeconomic study. *Bulletin of Marine Science* 82(3): 315-331.

Hernández-Delgado, E.A. and A.M. Sabat. 2000. Ecological status of essential fish habitats through an anthropogenic environmental stress gradient in Puerto Rican coral reefs. *Proceedings of the Gulf and Caribbean Fisheries Institute* 51: 457-470.

Hernández-Delgado, E.A. 2010. Thirteen years of climate-related non-linear disturbance and coral reef ecological collapse in Culebra Island, Puerto Rico: A preliminary analysis. In, E.A. Hernández-Delgado (ed.), Puerto Rico Coral Reef Long-Term Ecological Monitoring Program, CCRI-Phase III and Phase IV (2008-2010) Final Report. Caribbean Coral Reef Institute, Univ. Puerto Rico, Mayagüez, PR. pp. I.1-
I.62.

Shivlani, M. and Koeneke, R. 2011. Spatial characterization of artisanal fisheries in Puerto Rico: Geographic information systems (GIS) approach for assessing the regional effort and landings." *Proceedings of the Gulf and Caribbean Fisheries Institute* 63: 60-66.

NOAA Coral Reef Conservation Program: Fishing Threats:
http://coralreef.noaa.gov/threats/fishing/

An Overview of Land Based Sources of Marine Pollution, Caribbean Environment Programme
http://www.cep.unep.org/issues/lbsp.html#Land