ASSESSMENT OF CLIMATE CHANGE RECOMMENDATIONS FOR ADAPTATION IN MARINE PROTECT AREAS IN THE MESOAMERICAN REEF

ALEJANDRO ARRIVILLAGA

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This assessment includes a revision of the adaptation to climate change strategies included in a series of documents, as requested by MAR Fund. A complete list of documents is included at the end of this report. The objectives of this consultancy are:

- To review the documents provided and to review and prioritize the strategies and recommendations proposed for adaptation to climate change.
- To assess whether the recommendations are sufficient to provide adequate adaptation measures to climate change for the protected areas and/or regions discussed.
- To provide, where feasible, additional recommendations for improved adaptation to climate change in the protected areas and/or regions discussed.

This document also identifies any gaps and opportunities encountered, and a summary of the applicable recommendations related to adaptation to climate change. Finally, recommendations on priority climate change adaptation activities were included.

Main findings in the information included in the documents reviewed:

There is still uncertainty of the combined effects of changes in temperature and precipitation on vegetation (#13), and it is still unknown what critical values of extreme weather and climate may be beyond the ecosystems strength and resilience. Nevertheless, to face climate change impacts, strategies should be based on the precautionary principle and contribute to maintain or increase species and ecosystems resilience in a proactive manner. A good place to start is engaging in the reduction of threats already existing that could worsen with climate change while maintaining sustainable levels of resource use (#1). MPA managers can increase resilience to climate change by managing other anthropogenic stressors that also degrade ecosystems and by protecting key functional groups.

In analyzing this report, it may be useful to have in mind the following definitions (#2):

Climate Change:
Any significant change in climate measures, such as temperature, precipitation, or wind, lasting for an extended period of decades or longer. Changes may result from natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun or from natural processes within the climate system, like changes in ocean circulation. Changes may be due to human activities like burning of fossil fuels or through deforestation, reforestation, urbanization, or desertification, which change the atmosphere's composition and the land surface.

Climate Change Adaption:
The ability of society to plan for and respond to change in a way that makes it better equipped to manage its exposure and sensitivity to climate change. Adaptation is understood as the adjustment in natural or human systems in response to changes, and present and future impacts of climate change in order to reduce their vulnerability.

Adaptation modes for Protected Areas can be twofold (#12). First, natural adaptation or responses to climate change effects, due to changes in individuals, species, communities and ecosystems. Second, assisted adaptation towards favorable conditions to reduce the vulnerability of natural and human systems against current and expected effects of climate change. Support measures for adaptation can be anticipated to occur or circumstantial changes or impacts.

Threats related to climate change can be classified as follows (#2):

a) Existing threats exacerbated by climate change
b) Predicted new threats that might occur in the future, as a result of climate change
c) Maladaptation practices or climate change strategies and policies put into place that will negatively affect the area's ability to adapt to climate change.

Many of the document reviewed start by identifying impacts of climate change to species, ecosystems and resources.

Mangroves, coral reefs and seagrasses are the most threatened ecosystems. Not only they are already being impacted by threats other than change climate, but they also depend on each other (#1). For example, coral reefs rely on mangroves and seagrasses as nurseries for reef fishes, but shoreline modification and erosion, a main threat to mangroves, also affect corals and seagrasses by subsequent sediment deposition. Seawater temperature increases, coral bleaching, and the reduced rate of calcium carbonate deposition due to ocean acidification, are major threats from climate change to marine species. Mangroves are also affected by pollution, deforestation, and tourism development expansion, among others. Climate change strategies for coral reefs, mangroves and seagrasses should help ecosystem connectivity among each other (#1).

Among the predicted climate change impacts to marine resources are sea level rise, sea surface temperature rise, increased intensity of storms, ocean acidification, decreased precipitation, and increase air temperature (#2).

Coral reef are expected to suffer from an increase in sea temperature, which triggers massive coral bleaching events, and magnifies the effects of infectious diseases due to reduced functionality of the immune system, and from a decrease in ocean pH affecting coral growth rate (#10). Under the most conservative IPCC scenarios, models indicate that coral growth will decrease by 50% by 2050 (Clarke et al. 2013). Projected effects on mangroves include increased intensity of tropical cyclones causing an increase the removal of mangroves along the coastline, especially in areas vulnerable to erosion and inundation. Mangroves distribution will change relative to sea level rise as increased sea level will alter the concentration of salt in the soil, and it is expected that mangroves will retreat in response. Seagrass ecosystems are also expected to

suffer the effects of climate, including shift in distribution due to increased ocean temperature with the resulting stress and changes in reproductive patterns, affected growth rates due to increase sedimentation and turbidity from higher intensity and frequency of tropical cyclones, and for some seagrass communities that are carbon limited, increased atmospheric carbon dioxide will promote growth in new areas.

Fisheries are also expected to suffer from climate change impacts. For example, coral bleaching and mortality may affect economically important fish species such as lobster, snappers, conch, and other finfish species, that rely habitat provided by coral reefs, leading to lowered fish stock. Decreased ocean pH can also reduce the ability of species with exoskeletons to form shells sine the amount of available calcium carbonate will decrease. Impacts to mangroves and sea grass beds due to sea level rise may threat the nursery value of these ecosystems for many commercial fish species (#10).

An analysis of vulnerability for some Marine Protected Areas (#4) indicates that they will be greatly affected, primarily by changes in rainfall and increase in sea surface temperature, and to a lesser extent by rising sea levels and hurricanes. Exposure of coastal areas and islands to increases in sea level will affect several locations. An analysis of the impacts of increased frequency and intensity of hurricanes in the Caribbean coast of Honduras, show little increased impact and non-significant exposure to hurricanes and storms in the Cayos Cochinos area.

Classification of climate change adaptation strategies in terms of subject, scope, time frame, applicability and geography:

The numbers in parenthesis after each strategy refers to the list of documents reviewed, and that are listed at the end of this assessment. Subject refers to one of eleven subject matters a strategy could be classified in. Scope refers to whether the strategy refers to specifically to climate change (32 strategies) or to general management (87 strategies). Time frame was classified as short-term for strategies that could be implemented in 3 to 5 years (37 strategies), mid-term in 6 to 10 years (52 strategies), and long-term in 11 or more years (30 strategies). Feasibility in the region was rated high (44 strategies) if the strategy or similar strategies have already been successfully applied in the MAR or are considered relatively easy or conveniently; low feasibility (27 strategies) was rated if similar strategies have not produced encouraging results, have never been tried in the region, or current regional capacities (financial, human resources, policy, etc.) preclude them from being applied. Medium feasibility (48 strategies) was assessed in between the two ends. It is vital to keep in mind that this classification is from an overall perspective and it should be re-assessed when selecting strategies for a specific site or geographic area.

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Integrate climate change concept in all planning efforts and establish regional development plan that includes climate change adaptation and strengthens local government and organizations to reduce urban development expansion (1,4)	Policy and planning	CC specific	Mid-term	High	Cayos Cochinos, Mexican Caribbean
Develop a national adaptation plan and policy incorporating considerations for major sectors like tourism, coastal development, agriculture, fisheries, etc. (5)	Policy and planning	General management	Mid-term	High	BZ, GT, HN
Develop adaptation plans at municipal and city levels and implement adaptation plans in priority and demonstrative communities (5)	Policy and planning	CC specific	Mid-term	High	BZ, GT, HN
Implement regional development and management plans incorporating the adaptation to climate change criteria, creating an enabling institutional framework for coastal management (5)	Policy and planning	General management	Mid-term	High	BZ, GT, HN

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Establish coastal management and urban development plans for coastal municipalities to reduce infrastructure built in exposed areas (5)	Policy and planning	CC specific	Mid-term	High	BZ, GT, HN
Develop marine spatial planning for fishing, transportation, and tourism, and strengthen the implementation of Coastal and Marine Policies (5)	Policy and planning	General management	Mid-term	High	BZ, GT, HN
Strengthen Climate Change Observatory Centers, by enactment of new coastal legislation (Coastal Marine Area Framework Law) and institutional strategy, to reduce the threat of sea level rise and urban growth and development (6)	Policy and planning	CC specific	Mid-term	Medium	Honduras
Incorporate climate change adaptation criteria in regional thematic discussion forums and into regional and municipal infrastructure and development management plans to mitigate the threat of increased extraction of ground water and salinization of aquifers (6)	Policy and planning	CC specific	Short-term	High	Honduras
Implement coastal zoning and management plans to reduce threat of sedimentation to seagrasses (8)	Policy and planning	General management	Mid-term	High	Sandy Bay-West End
Diagnose and design concurrent programs for capacity building that meet technical and financial assistance needs related to mitigation and adaptation (13)	Policy and planning	General management	Mid-term	High	Mexico
Policy development and implementation for the protection of critical habitat types and areas with key ecological processes or high diversity of species of special value (nurseries, spawning aggregations, endemism, high productivity, upwelling, apex predators and reef building coral species) for the resilience of human and natural communities (1)	Protection of critical areas and habitat types and connectivity	General management	Long-term	Medium	Mexican Caribbean

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Promote restoration of live and natural infrastructure (1)	Protection of critical areas and habitat types and connectivity	General management	Long-term	Low	Mexican Caribbean
Establish policies and instruments that encourage the protection of critical habitats such as payments for environmental services (5)	Protection of critical areas and habitat types and connectivity	General management	Mid-term	Medium	BZ, GT, HN
Establish policies and instruments to encourage the protection of critical habitat for connectivity and resilience, through a system of payment for environmental services and other instruments including the concept of integrating climate change into planning exercises (7)	Protection of critical areas and habitat types and connectivity	CC specific	Long-term	Low	Mexican Caribbean
Promote connectivity through biological corridors to ensure genetic flow (1)	Protection of critical areas and habitat types and connectivity	General management	Long-term	Low	Mexican Caribbean
Establish policies and instruments to promote and link the protection of critical habitat for connectivity and resilience with an integrated coastal and watershed management approach, including fisheries replenishment zones (7)	Protection of critical areas and habitat types and connectivity	General management	Mid-term	Medium	Mexican Caribbean
Policy development and implementation of systems of payment for ecosystem services for critical habitat types (1)	Protection of critical areas and habitat types and connectivity	General management	Mid-term	Medium	Mexican Caribbean
Establish payments or subsidies for environmental services as economic incentives to improve practices in tourism and fisheries and to promote conservation of critical habitats, including conservation and	Protection of critical areas and habitat types and connectivity	General management	Long-term	Low	BZ, GT, HN

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
management of riparian vegetation, mangroves and forests cover in critical steep areas where climate threats to human populations are important (5)					
Develop valuation studies of goods and services of coastal and marine ecosystems (5)	Protection of critical areas and habitat types and connectivity	General management	Short-term	High	BZ, GT, HN
Promote stakeholders involvement and participation in MPAs and resource management, and strengthening, financing and capacity building of fisher co-management (1, 2, 7)	Fisheries	General management	Short-term	High	Port Honduras, Mexican Caribbean
Continue and expand research and monitoring of fisheries and fish population using both fisheries dependent and independent methods, through the strengthening or creation of a system to monitoring catches and fish stocks (2,5)	Fisheries	General management	Short-term	High	Port Honduras, Mexican Caribbean
Improvements in fishing technology and identification of destructive fishing techniques to discourage its use (1,2)	Fisheries	General management	Mid-term	Medium	Port Honduras, Mexican Caribbean
Promote alternative sources of income in fishers, including new fisheries products and seaweed and sea cucumber farming, fisheries products value added alternatives, and land based activities like farming (2)	Fisheries	General management	Mid-term	Medium	Port Honduras
Implement a sustainable management approach to fisheries, looking at alternative livelihoods and investing in fishing gear and equipment to explore new fishing grounds, and create a strategy to capture and commercialize lionfish (4, 11)	Fisheries	General management	Mid-term	Medium	Cayos Cochinos. Bay Islands HN

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Maintain and improve enforcement of fisheries regulations, focusing on the protection of herbivorous fish, and promotion of banning herbivore fishing were still permitted (4)	Fisheries	General management	Short-term	Medium	Cayos Cochinos, BZ, GT, HN
Create and maintain a network of fisheries replenishment zones (no-take areas), and reinforce management of protected areas (1, 5)	Fisheries	General management	Short-term	Medium	MAR region
Establish systems for managing critical habitats outside protected areas and establish areas to exclude trawl fisheries (5)	Fisheries	General management	Long-term	Medium	BZ, GT, HN
Develop a bill and enact the Fisheries Act, considering measures of adaptation to climate change (5)	Fisheries	General management	Long-term	Medium	BZ, GT, HN
Restoration and conservation of fisheries resources habitat, including wetlands and mangroves to protect and maintain fish populations (7)	Fisheries	General management	Long-term	Medium	Mexican Caribbean
Strengthening fisheries management authorities and local fishermen's organizations (8)	Fisheries	General management	Short-term	High	Sandy Bay-West End
Improved understanding of existing fisheries response mechanisms to climate variability, to assist in planning adaptation, recognizing and responding to new opportunities brought about by climate change (10)	Fisheries	CC specific	Mid-term	High	Belize
Establish community based sustainable fisheries management programs, including self-adopted regulations for fishing practices and the creation of legally organized fishers groups (12)	Fisheries	General management	Short-term	High	Bay Islands HN
Capacity strengthening for public use planning and adaptive management of tourism and tourism development in and around MPAs (1)	Infrastructure / public use / tourism / land use / zoning	General management	Mid-term	High	Mexican Caribbean

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Development and implementation of policies, codes and regulations for land use and management construction of infrastructure and design and promote a guide of best construction practices considering the possible effects of the climate change on tourism projects and real estate developments, and incorporating climate change adaptation measures (1, 4, 5)	Infrastructure / public use / tourism / land use / zoning	CC specific	Mid-term	High	Cayos Cochinos, MAR Region
Create landfills or relocate tourism development areas on the shoreline (2)	Infrastructure / public use / tourism / land use / zoning	CC specific	Long-term	Low	Port Honduras
Conduct assessment of impacts and causes for erosion in human populated areas (2)	Infrastructure / public use / tourism / land use / zoning	General management	Short-term	High	Port Honduras
Develop and implement land use plans, secure agreements among stakeholders, and create a communications and awareness raising campaign for communities and decision makers, related to land use decisions and best environmental and climatically viable agricultural practices and forest protection (4)	Infrastructure / public use / tourism / land use / zoning	General management	Long-term	Medium	Cayos Cochinos
Develop and implement zoning plans for coastal development to promote building of infrastructure in areas less exposed along the coast (5)	Infrastructure / public use / tourism / land use / zoning	General management	Mid-term	Medium	BZ, GT, HN
Develop national standards and tools to guide planning at municipal, city and community levels, and develop, approve and implement the Coastal Zone Management Plan (5)	Infrastructure / public use / tourism / land use / zoning	General management	Mid-term	High	BZ, GT, HN

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Develop local plans for infrastructure development considering the impacts of climate change (5)	Infrastructure / public use / tourism / land use / zoning	CC specific	Mid-term	High	BZ, GT, HN
Establish municipal infrastructure development plans that consider the effects of climate change, and design and promote a guide of best building practices considering the effects of climate change on tourism projects and real estate developments (5)	Infrastructure / public use / tourism / land use / zoning	CC specific	Mid-term	Medium	BZ, GT, HN
Establish a training program for professionals, developers, community builders, investors and builders on best practices, building codes and construction regulations for coastal real estate and tourism development, to control beach erosion, and strengthen municipal units of urban design and construction (5, 8)	Infrastructure / public use / tourism / land use / zoning	General management	Short-term	Medium	Sandy Bay-West End, BZ. GT, HN
Promote good practices in tourism operations to maintain well preserved natural tourist attractions, and identify and develop management plans for new sites diversify and expand the tourism attractions offer (5)	Infrastructure / public use / tourism / land use / zoning	General management	Short-term	High	BZ, GT, HN
Carry out vulnerability studies and contingency plans for tourism infrastructure and attractions, and propose management measures (5)	Infrastructure / public use / tourism / land use / zoning	CC specific	Short-term	High	BZ, GT, HN
Establish coastal zone land planning to reduce the threat of substandard coastal infrastructure planning, deforestation, and climate events influenced by global change (6)	Infrastructure / public use / tourism / land use / zoning	CC specific	Mid-term	Medium	Honduras

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Assess and establish limits of carrying capacity for major tourist attraction sites, to reduce the threat of increasing tourist pressure on sites with good health (6)	Infrastructure / public use / tourism / land use / zoning	General management	Short-term	High	Honduras
Strengthen the agencies and improve interagency cooperation for those in charge of threats associated with poorly planned coastal development and substandard infrastructure (6)	Infrastructure / public use / tourism / land use / zoning	General management	Long-term	Low	Honduras
Strengthen management of Municipal infrastructure Development Plans taking into account climate change impacts, to reduce the threat of un controlled coastal development and poorly built infrastructure for protection (6)	Infrastructure / public use / tourism / land use / zoning	CC specific	Mid-term	Medium	Honduras
Restoration of coral reefs, mangroves, seagrasses, and dune vegetation for coastal and tourist infrastructure protection (7)	Infrastructure / public use / tourism / land use / zoning	General management	Long-term	Low	Mexican Caribbean
Establish guidelines for coastal real estate development and construction and tourism operation best practice codes (8)	Infrastructure / public use / tourism / land use / zoning	General management	Short-term	High	Sandy Bay-West End
Construction of sea defenses and reinforcement of shoreline to protect against beach losses and coastal erosion with the appropriate design so that they would not be easily overtopped by storm surges, taking into consideration that hard structures can lead to beach loss as rigid structures cause scouring of beach sand through backwash of waves (2, 10)	Infrastructure / public use / tourism / land use / zoning	General management	Mid-term	High	Port Honduras, BZ
Installation of soft defenses such as the planting of mangroves, or the use of Pimento tree limbs, which	Infrastructure / public use /	General management	Short-term	Medium	Belize

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
allow for wave energy dissipation while retaining most of the sand during backwash (10)	tourism / land use / zoning				
Secure funding to build new houses and raising existing ones on pylons, planting mangroves as natural barriers, and relocating communities to a safer area, to deal with the threat of sea level rise and increased wave size (11)	Infrastructure / public use / tourism / land use / zoning	CC specific	Mid-term	Low	Bay Islands HN
Use existing organized groups to secure funding for enforcing regulations related to building on slopes, deforestation, and leveling of slopes, and promote reforestation, and deny construction permits on high-risk areas due to landslides resulting from heavy rains (11)	Infrastructure / public use / tourism / land use / zoning	General management	Long-term	Medium	Bay Islands HN
Build shelters for use during storms and hurricanes (11)	Infrastructure / public use / tourism / land use / zoning	General management	Short-term	High	Bay Islands HN
Design a management plan for micro-watersheds including restoration and a program to monitor physical, chemical and biological parameters of the hydrological resources (44)	Watersheds / reforestation / freshwater / wastewater	General management	Short-term	High	Cayos Cochinos
Install wastewater treatment plants in coastal communities and in the keys to help reduce algae in reefs and for areas with limited freshwater sources (1, 4)	Watersheds / reforestation / freshwater / wastewater	General management	Long-term	Low	Cayos Cochinos, Mexican Caribbean
Awareness raising campaign on importance of reducing deforestation to control sediments for marine ecosystems, and a restoration campaign to help reduce coral disease related to sedimentation (4)	Watersheds / reforestation / freshwater / wastewater	General management	Short-term	High	Cayos Cochinos

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Develop and implement the national policy for land use, and implement watershed management activities in priority watersheds (5)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	High	BZ, GT, HN
Improve agriculture and ranching practices to reduce soil erosion, and establish a program to promote restoration of riparian zones and coastal forest (5)	Watersheds / reforestation / freshwater / wastewater	General management	Long-term	Low	BZ, GT, HN
Enforcement of existing legislation for the protection of the buffer zone (66 feet) along bodies of water (5)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	Low	BZ, GT, HN
Enforce effluents laws for industry, towns & agriculture and regulate water extraction by implementing the water act (5)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	Low	BZ, GT, HN
Regulate and enforcement of tourist development and dredging (5)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	Low	BZ, GT, HN
Establish a prioritized riparian systems restoration program such as payment programs for environmental services (5)	Watersheds / reforestation / freshwater / wastewater	General management	Long-term	Medium	BZ, GT, HN
Reinforce the management of watershed authorities, and reinforce reforestation programs to restore riparian vegetation to reduce sediment erosion (5)	Watersheds / reforestation / freshwater / wastewater	General management	Long-term	Low	BZ, GT, HN
Build a complete system of sewers and treatment plants in coastal cities, starting with the installation	Watersheds / reforestation /	General management	Long-term	Low	BZ, GT, HN

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
of collectors in critical areas prone to flooding, and implement a solid waste management plan (5)	freshwater / wastewater				
Create an environmental auditing mechanism so that civil society can monitor the enforcement of laws and the construction of the sewage system, and influence authorities about the seriousness of the sanitation problem due to climate change (5)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	Medium	BZ, GT, HN
Strengthen coordination between the municipalities and central government to address wastewater projects (5)	Watersheds / reforestation / freshwater / wastewater	General management	Short-term	High	BZ, GT, HN
Implement patrolling and local environmental awareness programs to reduce the threat of pollution from ports and ballast water, and the lack of treatment for waste water and solid waste (6)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	Low	Honduras
Assess aquifer extraction capacity (7)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	High	Mexican Caribbean
Advocacy program and municipal management plan for improvement in solid waste collection and management (8)	Watersheds / reforestation / freshwater / wastewater	General management	Short-term	Low	Sandy Bay-West End
Install waste water treatment plants to reduce threats to coral reefs from pollution from human activities including waste water, oil, ballast water, pesticides and solid waste (8)	Watersheds / reforestation / freshwater / wastewater	General management	Long-term	Low	Sandy Bay-West End
Use funding from the local water funds, municipalities and other projects to drill more water wells, capturing rain water (more and bigger holding	Watersheds / reforestation /	General management	Mid-term	Medium	Bay Islands HN

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
tanks), and improve water quality and the distribution network (11)	freshwater / wastewater				
Increase aquifer infiltration by planting trees and increase Water Board knowledge and technical capacity (11)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	Medium	Bay Islands HN
Increase access to clean water for communities and tourism, through the installation of rain catchment systems, construction of reservoirs and potable water distribution network (12)	Watersheds / reforestation / freshwater / wastewater	General management	Long-term	Low	Bay Islands HN
Improve water management by reforesting micro-watersheds and installing rainwater catchment tanks (12)	Watersheds / reforestation / freshwater / wastewater	General management	Mid-term	Medium	Bay Islands HN
Create family-run productive gardens by composting and recycling organic wastes to reduce erosion and sedimentation form heavy rains (12)	Watersheds / reforestation / freshwater / wastewater	General management	Short-term	Medium	Bay Islands HN
Enforce existing mangrove protecting legislation and mangrove reforestation programs (2)	Mangroves	General management	Short-term	Low	Port Honduras
Establish a mangrove restoration program, and implement a coastal land planning, including the establishment of payment of environmental services mechanisms for mangrove conservation to help protect the coast line (5)	Mangroves	General management	Mid-term	Low	BZ, GT, HN
Implement a coastal land planning mechanisms for economic compensation for the conservation of mangroves (5)	Mangroves	General management	Long-term	Low	BZ, GT, HN
Conserve and restore mangrove forests, swamps and coastal floodplain areas for protections to fishing	Mangroves	General management	Long-term	Medium	BZ, GT, HN

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
habitats, and regulate construction in the coastal zone (5)					
Strengthen monitoring effort to assess effectiveness of climate change adaptation strategies (2)	Monitoring	CC specific	Short-term	High	Port Honduras
Establish a system to monitor climate data and ecosystem dynamics, together with a program to reforest beaches with native species, and design and promote a best practices guide for beachfront development, based on understanding of beach dynamics (4)	Monitoring	CC specific	Mid-term	Low	Cayos Cochinos
Establish a species and ecosystems monitoring program to measure the impacts of climate change (5)	Monitoring	CC specific	Short-term	High	BZ, GT, HN
Establishment of monitoring system for fish stocks and fisheries landings (8)	Monitoring	General management	Short-term	Medium	Sandy Bay-West End
Strengthen climate monitoring programs of impacts of climate change on ecosystems and species (8)	Monitoring	CC specific	Mid-term	Medium	Sandy Bay-West End
Monitoring biophysical, social and economic indicators linked to management and policy responses and adoption of multi-sector adaptive strategies to minimize negative impacts (10)	Monitoring	General management	Short-term	High	Belize
Promote research to increase knowledge for a better understanding and interpretation of climate change and its impacts on biodiversity, and establish climate monitoring networks in protected areas to evaluate and adjust adaptation and mitigation processes in its territory (13)	Monitoring	CC specific	Short-term	High	Mexico
Establish training and credits programs to promote livelihood diversification in coastal communities (5)	Alternative livelihoods	General management	Mid-term	Medium	BZ, GT, HN

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Identification of alternative sources of income and valuation of the existing income sources in MPA buffer area to reduce the threat of reduced tourism demand (6)	Alternative livelihoods	General management	Short-term	High	Honduras
Implement management approaches and policies that strengthen the livelihood asset base (10)	Alternative livelihoods	General management	Mid-term	Medium	Belize
Incorporation of climate change in formal and informal education will help society become aware of the impacts of climate change on their livelihoods (5)	Communication and Environmental Awareness	CC specific	Short-term	High	BZ, GT, HN
Disseminate the value of protected areas as carbon sinks and climate change impact reduction alternative (13)	Communication and Environmental Awareness	CC specific	Short-term	Medium	Mexico
Sensitize stakeholders in conservation and restoration processes in protected areas about the impacts related to climate change, to encourage their active participation (13)	Communication and Environmental Awareness	CC specific	Short-term	Medium	Mexico
Encourage behavior changes in urban and rural populations, favoring a reduction of the vulnerability of the ecosystems they inhabit (13)	Communication and Environmental Awareness	General management	Mid-term	Medium	Mexico
Establish communication schemes for early alert and risk management of contingencies resulting from extreme weather events (13)	Communication and Environmental Awareness	General management	Short-term	High	Mexico
Actively participate in forums and collaborative learning networks related to mitigation and adaptation processes in protected areas (13)	Communication and Environmental Awareness	General management	Short-term	High	Mexico

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Establish protected areas in priority zones or watersheds, following the rule of the law (5)	Marine Protected Areas	General management	Long-term	Low	BZ, GT, HN
Strengthen the management of protected areas that conserve critical habitats for healthy and functional fisheries such as lagoons, mangroves and reefs (5)	Marine Protected Areas	General management	Short-term	High	BZ, GT, HN
Develop technical studies and promote the declaration of new protected areas to complete the gaps identified in the National Gap Analysis, and strengthen the management of protected areas, creating a network of well-designed and well managed conservation areas (5)	Marine Protected Areas	General management	Long-term	Medium	BZ, GT, HN
Establishment of a network of coastal protected areas and strengthening existing ones, to reduce the threat of agricultural areas expansion and uncontrolled urban growth and development (6)	Marine Protected Areas	General management	Long-term	Medium	Honduras
Strengthen MPAs capacities for the design, development and implementation of programs of public use, with an adaptive management approach, to address areas of greatest tourism pressure inside and outside MPAs (7)	Marine Protected Areas	General management	Mid-term	Medium	Mexican Caribbean
Expansion of the conservation areas across different categories should be promoted to facilitate natural adaptation and promote connectivity, help to maintain viable populations and ecosystems (13)	Marine Protected Areas	General management	Long-term	Medium	Mexico
To ensure the integrity, functionality and resilience of ecosystems and production systems, protected areas management should be connected with its area of influence, in a scale of landscape planning (13)	Marine Protected Areas	General management	Mid-term	Medium	Mexico
Improve protected areas management effectiveness to reduce the combined impacts of climate change	Marine Protected Areas	CC specific	Mid-term	Medium	Mexico

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
and the pressures of existing environmental degradation (13)					
Strengthen institutional capacity and management of protected area local actors to manage risk and respond to disasters caused by extreme weather events (13)	Marine Protected Areas	CC specific	Mid-term	Medium	Mexico
Develop measures to promote the adaptation of priority species (13)	Marine Protected Areas	CC specific	Long-term	Low	Mexico
Partner with specialized institutions to promote research projects that support planning and management of protected areas and areas of influence (13)	Marine Protected Areas	General management	Mid-term	Medium	Mexico
Establish agreements on priorities for research on climate change and management of protected areas in conjunction with research institutions (13)	Marine Protected Areas	CC specific	Short-term	Medium	Mexico
Strengthen MPA manager's GIS capacity as a tool to guide decision-making processes on mitigation and adaptation to climate change (13)	Marine Protected Areas	General management	Short-term	High	Mexico
Streamline procedures and mechanisms to promote optimal and timely use of information for planning, implementation and evaluation of regional actions related to adaptation and mitigation at regional and individual MPAs (13)	Marine Protected Areas	General management	Mid-term	High	Mexico
Implement a program of strategic positioning about the role of protected areas as cost-effective mechanisms for mitigation and adaptation to climate change to the public and particularly to stakeholders such as entrepreneurs, producers, regulators and other sectors (13)	Marine Protected Areas	CC specific	Mid-term	Medium	Mexico

STRATEGY	SUBJECT	Scope	Time frame	Feasibility in the region	Specific geographic areas
Develop institutional capacity to strengthen communication and outreach campaigns on the issues of climate change on protected areas (13)	Marine Protected Areas	CC specific	Mid-term	Medium	Mexico
Generate and develop opportunities for technical collaboration with other institutions to develop mitigation and adaptation projects in protected areas and areas of influence (13)	Marine Protected Areas	General management	Short-term	High	Mexico
Cost – benefit analyses of inaction to justify public sector and fishers investment in conservation and restoration (1)	Odds but important	CC specific	Mid-term	High	Mexican Caribbean
Involve non-traditional sectors including marine aquaculture (1)	Odds but important	General management	Mid-term	Medium	Mexican Caribbean
Establish the National Adaptation Fund for Marine Protected Areas (Reef for Life) as a financial mechanism to support conservation of functional coastal and marine ecosystems (5)	Odds but important	General management	Long-term	Low	BZ, GT, HN
Governments pursue financing from UNFCCC Adaptation Fund to revitalize and upgrade coastal protection, and land drainage and irrigation, to promote adaptation of key sectors such as agriculture, water resources and tourism, and human settlement health and well-being (10)	Odds but important	CC specific	Long-term	Low	Belize
Develop a strategy for procurement of funds to allow access to human, technical and financial resources needed for the implementation of climate change adaptation strategies, and tag federal funding for initiatives to address climate change in protected areas (13)	Odds but important	CC specific	Long-term	Medium	Mexico

Gaps and opportunities related to strategies for adaptation to climate change:

It is evident from the revision of the submitted reports that there is more information and knowledge available on vulnerability and impacts that on specific adaptation strategies for the Mesoamerican Reef MPAs. Some of the strategies that are not mentioned and that may be worth considering include:

Protection of key ecosystem features

- Promote connected landscapes to facilitate species movements and gene flow, and sustain key ecosystem processes.
- Remove barriers to upstream migration in rivers and streams like the use of nets that cover the width of the river, and maintain natural flow regime through dam flow releases.
- Design protected areas with dynamic boundaries and buffers to protect breeding and foraging habits of highly migratory and pelagic species.
- Monitor ecosystems and have rapid-response strategies to assess ecological effects of extreme events.
- Identify ecological connections among ecosystems and use them to inform the design of MPAs and management decisions such as protecting resistant areas to ensure sources of recruitment for recovery of populations in damaged areas.
- Manage functional species groups necessary to maintaining the health of reefs like herbivores and reef building corals

Reduce anthropogenic stresses

- Use early detection and rapid response to non-native invasive species.
- Develop storm water infrastructure to reduce severe erosion.
- Conduct integrated management of nutrient sources and wetland treatment of nutrients to limit hypoxia and eutrophication.
- Prohibit bulkheads and other engineered structures on estuarine shores, and remove structures that harden coastlines.
- Manage excessive inputs of nutrients, sediments and pollutants.

Promote representation and replication of ecosystems and habitat types in networks of protected areas

- Expand the boundaries of protected areas to increase variation in species.
- Increase physical habitat heterogeneity in channels to support diverse biotic assemblages.
- Include entire ecological units to maintain ecosystem function and resilience.
- Spread risks by increasing ecosystem redundancy and buffers.
- Replicate reefs along a depth gradient to allow fish and crustaceans to survive when depth-dependent environmental degradation occurs.
- Maximize habitat heterogeneity within MPAs and consider protecting larger areas to preserve biodiversity, biological connections among habitats, and ecological functions.

- Include entire ecological units (e.g., coral reefs with their associated mangroves and seagrasses) in MPA design to maintain ecosystem function and resilience.
- Ensure that the full breadth of habitat types is protected (e.g., fringing reef, fore reef, back reef, patch reef).
- Replicate habitat types in multiple areas to spread risks associated with climate change.

Restoration

- Restore important native species.
- Direct estuarine restoration to places where the restored ecosystem has room to retreat as sea level rises.
- Consider mangrove restoration to protect shoreline, expand nursery habitat, and release tannins and other compounds that may reduce photo-oxidative stress in corals.
- Following extreme events, consider whether actions should be taken to enhance natural recovery processes through active restoration.

Refugia

- Identify and protect areas observed to be resistant to climate change effects or to recover quickly from climate-induced disturbances.
- Plant riparian vegetation to provide fish and other organisms with refugia.
- Create side-channels and adjacent wetlands to provide refugia during droughts and floods.
- Establish dynamic Marine Protected Areas defined by large-scale oceanographic features such as oceanic fronts where changes in types and abundances of organisms often occur.

Relocation

- Assist in species migrations by eliminating barrier such as beach traps and nets across rivers
- Facilitate long-distance transport of threatened endemic species
- Facilitate interim propagation and sheltering of critical species through activities like coral gardens
- Establish programs to move isolated populations of species of interest that become stranded when water levels drop

Strategies for MPAs

- The most effective configuration of MPAs may be a network of highly protected areas nested within a broader management framework.
- Identify and protect ecologically significant (“critical”) areas such as nursery grounds, spawning grounds, and areas of high species diversity.
- Establish dynamic MPAs defined by large-scale oceanographic features, such as oceanic fronts, where changes in types and abundances of organisms often occur.
- Include entire ecological units (e.g., coral reefs with their associated mangroves and seagrasses) in MPA design to help maintain ecosystem function and resilience.

- Ensure that the full breadth of habitat types is protected (e.g., fringing reef, fore reef, back reef, patch reef).
- Consider mangrove restoration for potential benefits including shoreline protection, expansion of nursery habitat, and release of tannins and other dissolved organic compounds that may reduce photo-oxidative stress in corals.

Conclusions:

Evaluation of the adaptation measures, assessment on whether they are sufficient to provide adequate adaptation:

This is potentially the most difficult question to answer, mainly for two reasons. First, the accuracy of the current predictions of climate change impacts is unknown. There is still uncertainty of the combined effects of changes in temperature and precipitation on flora and fauna (#13), and it is still unknown what critical values of extreme weather and climate may be beyond the ecosystems strength and resilience. And second, the adaptation strategies and measures presented in the revised documents are only delineated in a general manner and specific goals, objectives and actions still need to be developed. Moreover, not having a complete knowledge of what strategies have already been tried and their effectiveness precludes one from making a more precise assessment of whether they are sufficient to provide adequate adaptation to the MPAs and the region.

With those two caveats, and taking into consideration that many of the adaptation measures proposed in the revised documents come from participatory workshops and / or from global recommendations, it can be said that these measures are mostly comprehensive and sufficient, particularly if the gaps identified (see item 3 below) are also included.

MPAs with specific recommendations in the documents evaluated are Port Honduras Marine Reserve (#2), Punta de Manabique Wildlife Refuge (#3), Cayos Cochinos Natural Monument (#4), Mexican Caribbean (#7), and the Sandy Bay-West End Special Protection Zone (#8). The rest of strategies are for either the whole MAR region, the Mexican Caribbean, or for the Gulf of Honduras countries (Belize, Guatemala and Honduras).

Priority strategies and gaps:

Priority strategies and gaps to face climate change impacts were identified as those strategies that use the precautionary principle, promote connectivity, and contribute to maintain or increase species and ecosystems resilience in a proactive manner. Most important gaps include the protection of key ecosystem features such as refugia (areas in which populations can survive through a period of unfavorable conditions), the reduction of anthropogenic stresses, the promotion of adequate representation and replication of ecosystems and habitat types in networks of protected areas, and restoration and relocation where needed to assist in adaptation. The following is a list of identified priority strategies and gaps.

- Monitor ecosystems and have rapid-response strategies to assess ecological effects of extreme events.
- Manage functional species groups necessary to maintaining the health of reefs like herbivores and reef building corals
- Use early detection and rapid response to non-native invasive species.
- Restore riparian vegetation to provide fish and other organisms with refugia.
- Focus estuarine restoration to places where the restored ecosystem has room to retreat as sea level rises.
- Create side-channels and adjacent wetlands to provide refugia during droughts and floods.
- Assist in species migrations by eliminating barrier such as beach traps and nets across rivers
- Facilitate interim propagation and sheltering of critical species through activities like coral gardens
- Consider mangrove restoration to protect shoreline, expand nursery habitat, and release tannins and other compounds that may reduce photo-oxidative stress in corals.
- Promote connected landscapes to facilitate species movements and gene flow, and sustain key ecosystem processes.
- Include entire ecological units (e.g., coral reefs with their associated mangroves and seagrasses) in MPA design to maintain ecosystem function and resilience.
- Identify ecological connections among ecosystems and use them to inform management decisions such as protecting resistant areas to ensure sources of recruitment for recovery of populations in damaged areas.
- Spread risks by increasing ecosystem redundancy and buffers through replication
- Establish MPA networks defined by large-scale oceanographic features, such as oceanic fronts.
- Ensure that the full breadth of habitat types is protected (e.g., fringing reef, fore reef, back reef, patch reef).
- Identify and protect areas observed to be resistant to climate change effects or to recover quickly from climate-induced disturbances.
- Conduct integrated management of nutrient sediments and pollutants
- Recommendations on priority climate change adaptation activities and where you recommend they should be undertaken.

A good place to start is by engaging in the reduction of threats already existing that could worsen with climate change while maintaining sustainable levels of resource use (#1). MPA managers can increase resilience to climate change by managing other anthropogenic stressors that also degrade ecosystems and by protecting key functional groups.

A good rule of thumb when implementing climate change adaptation actions for the MPAs and the region is to invest 70% of the financial, manpower, and capacity resources available implementing ‘traditional’ management measures and 30% on ‘new’ specific climate adaptation strategies.

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