

The MAR Insurance Programme: A Nature-based Solution to Enhance Resilience

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Photo: Robert Charland





Photo: Martin Leglize

The MAR Insurance Programme is a regional mechanism that enhances local reef response capacity and provides rapid funding to repair and restore the coral reefs of the Mesoamerican Reef Region (MAR) after hurricane damage. It is the first comprehensive emergency response strategy backed by innovative parametric reef insurance, which addresses the increasing risk of extreme climate events to reef ecosystems across multiple countries. It marks a major advance in coastal resilience, utilizing an innovative financial product to release timely resources for local, community-led reef repair and restoration. Ultimately, reliable reef response boosts reef recovery, enhancing the resilience of the ecosystem, the reef-related economy, and the millions of people that depend on this critical natural infrastructure for livelihoods and coastal protection.

Significant progress has been made to prepare effective response to reef-damaging hurricanes in the MAR, and the MAR Insurance Programme has evolved over the course of its pilot phase. The MAR Insurance Programme is underpinned by investments in local reef response preparedness and a regional parametric insurance instrument, which is designed to “trigger” post-hurricane pay-outs that cover the costs of planned reef response at protected reef sites across the MAR. *Reef Response Coordinating Committees* have organized and planned, *Reef Guardians*, organized into *Reef Brigades*, have been trained and certified, and advances in reef response governance and capacities have been met with expansions in insurance coverage.

The Foundation: Reef Response Preparedness

The **MAR Insurance Programme** builds three pillars of reef response preparedness: Governance, capacities, and finance.

GOVERNANCE: Leadership and plans

- ▶ Each MAR country has developed and formalized reef response governance frameworks—led by *Reef Response Coordinating Committees*—which bring together authorities and local reef stakeholders to coordinate planning, preparedness, and response.
- ▶ Reef emergency response plans have been developed and agreed for insured reef sites.

CAPACITIES: *Reef Guardians* and *Reef Brigades*

- ▶ Local reef responders have been trained and certified as *Reef Guardians* and organized into *Reef Brigades* to conduct emergency reef response throughout the MAR region.

FINANCE: Parametric reef insurance

- ▶ MAR Fund purchases a regionally aggregated reef insurance policy that pre-positions funding for reef response, which is paid-out immediately after hurricanes impact covered reef sites.
- ▶ Pay-outs are distributed through MAR Fund's Emergency Fund, following transparent guidelines that have been developed to deliver resources to local response groups as quickly as possible.

Together, these three pillars of reef response preparedness aim to stimulate a shift to climate resilient and shock-responsive management of the MAR ecosystem, enable the integration of natural capital in emergency response systems, and secure sustainable funding for reef response. Immediate post-hurricane reef response has been demonstrated to boost ecosystem recovery in the face of increasing pressures, protecting biodiversity and enhancing the resilience of the coastal residents, workers, and businesses that depend on a vibrant marine environment for income, food security, and coastal protection.

Furthermore, reef response protects the reef and the reef-related economy while enhancing the direct livelihood opportunities of responders. *Reef Guardians* are paid for their participation in reef response, providing an additional source of income after disruptive hurricanes; they also benefit from enhanced employability as a result of their training and certification.

What is Post-hurricane Reef Response?

Based on the *Early Warning and Rapid Response Protocol: Actions to Mitigate the Impact of Tropical Cyclones on Coral Reefs*ⁱ, rapid response to clean the marine environment, rescue damaged corals, and stabilize the reef can minimize the impacts of hurricanes,

jumpstart ecosystem recovery, and maintain a sustainable and resilient reef-related economy.

Reef Response Committees and *Reef Brigades* are prepared to spring into action when hurricanes occur.

1 Governance and coordination

First, when hurricanes are forecast to impact the reef sites of the MAR Insurance Programme, the relevant *Reef Response Coordinating Committee*—led by local and national authorities—issues a notification of early warning, reviews the agreed reef response plan, and coordinates response with local reef area managers and Reef Brigade leaders.

2 Damage assessment and marine clean-up



Once conditions are safe, *Reef Brigades* assess damage and remove underwater debris and sedimentation harming corals.

3 Reef repair



They stabilize, recover, and re-attach broken coral fragments and repair structural damage to colonies.

4 Coral nurseries and monitoring



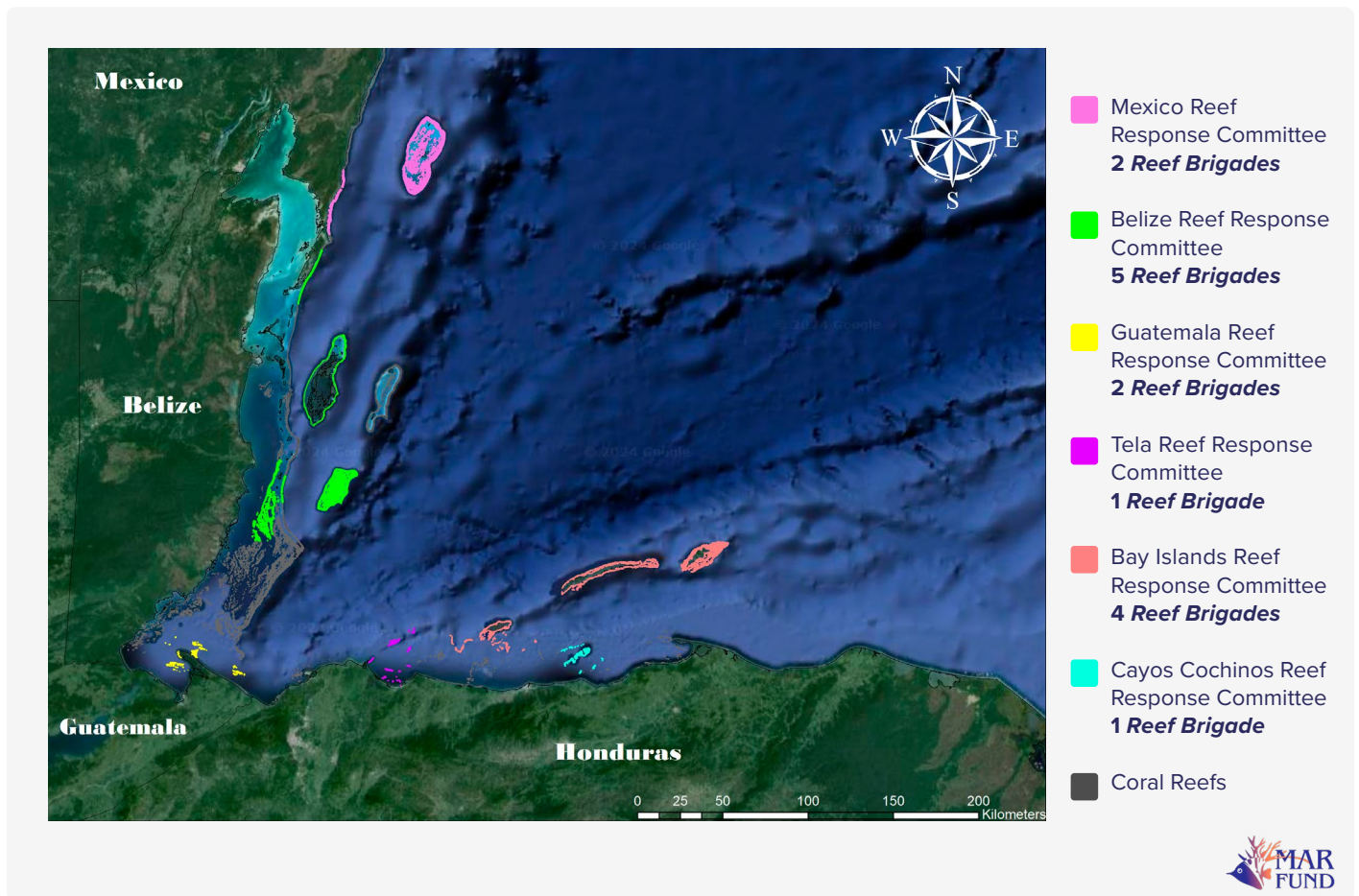
They also collect and transplant viable fragments for care in nurseries and monitor the rescued corals.

ⁱ Available for download at: <https://www.icriforum.org/wp-content/uploads/2020/12/Post-storm-protocol.pdf>

Progress to Date: Reef Response Governance and Capacity

Reef response governance, led by *Reef Response Coordinating Committees* headed by local and national authorities, are now in place in each of the MAR countries. Reef response plans have been elaborated and agreed, with roles for national and local authorities, civil society organizations, and local community members.

More than 160 *Reef Guardians* have been trained and certified in emergency post-hurricane reef response at reef sites throughout the MAR region. These *Reef Guardians* are organized into 16 *Reef Brigades*, ready to rapidly mobilize to implement reef response immediately after hurricanes.ⁱⁱ



Safeguard: The execution of this Programme shall not have any effect with respect to, or in connection with, any sovereignty claims over any territory (land, insular and maritime) claimed by the Republic of Guatemala and/or Belize; nor shall it have any effect over the rights and/or claims of either country over such territory.

ii Note that there are additional reef response capacities in Quintana Roo, Mexico; however, these are not currently covered by the MAR Insurance Programme and therefore not included in this document.

How does the Financial Mechanism Work?

In order to reliably finance post-hurricane reef response on the MAR, MAR Fund and WTW designed a bespoke parametric reef insurance instrument. This insurance secures the timely funding that the *Reef Response Coordinating Committees* and *Reef Brigades* need to repair and restore coral reefs after hurricanes. It is integrated with the nationally and locally coordinated reef response governance, response plans, and capacities that have been developed at reef sites throughout the region.

Who buys the insurance?

MAR Fund purchases a single regional insurance policy, which aggregates reef risk across the four MAR countries. A single administration and placement process minimizes costs, and MAR Fund is a strong policyholder as a private environmental fund with robust governance and administration, strong fundraising capabilities, and relationships, processes, and mechanisms already established to rapidly distribute funds for reef response.

Who pays the premium?

For the first three years of pilot coverage (from July 2021 through May 2024) MAR Fund, in collaboration with WTW, raised ad hoc funds to pay the MAR Insurance Programme premiums.

A significant majority of the short-term pilot premium financing support was contributed by the InsuResilience Solutions Fund (ISF). The Adaptation Fund-European Union-UNDP Innovation Small Grant Aggregator Platform, through the Adaptation Fund Climate Innovation Accelerator (AFCIA/UNDP/ISGAP)ⁱⁱⁱ, also provided premium financing support to expand coverage in Honduras for the 2023-2024 policy year.

This innovative reef insurance is designed to provide post-hurricane pay-outs to cover the costs of planned reef response at different reef sites across the MAR.



MAR Fund is currently developing a sustainability strategy to finance the long-term payment of the annual MAR Insurance Programme premium, in order to secure the long-term reliability of post-storm reef response in the MAR region.

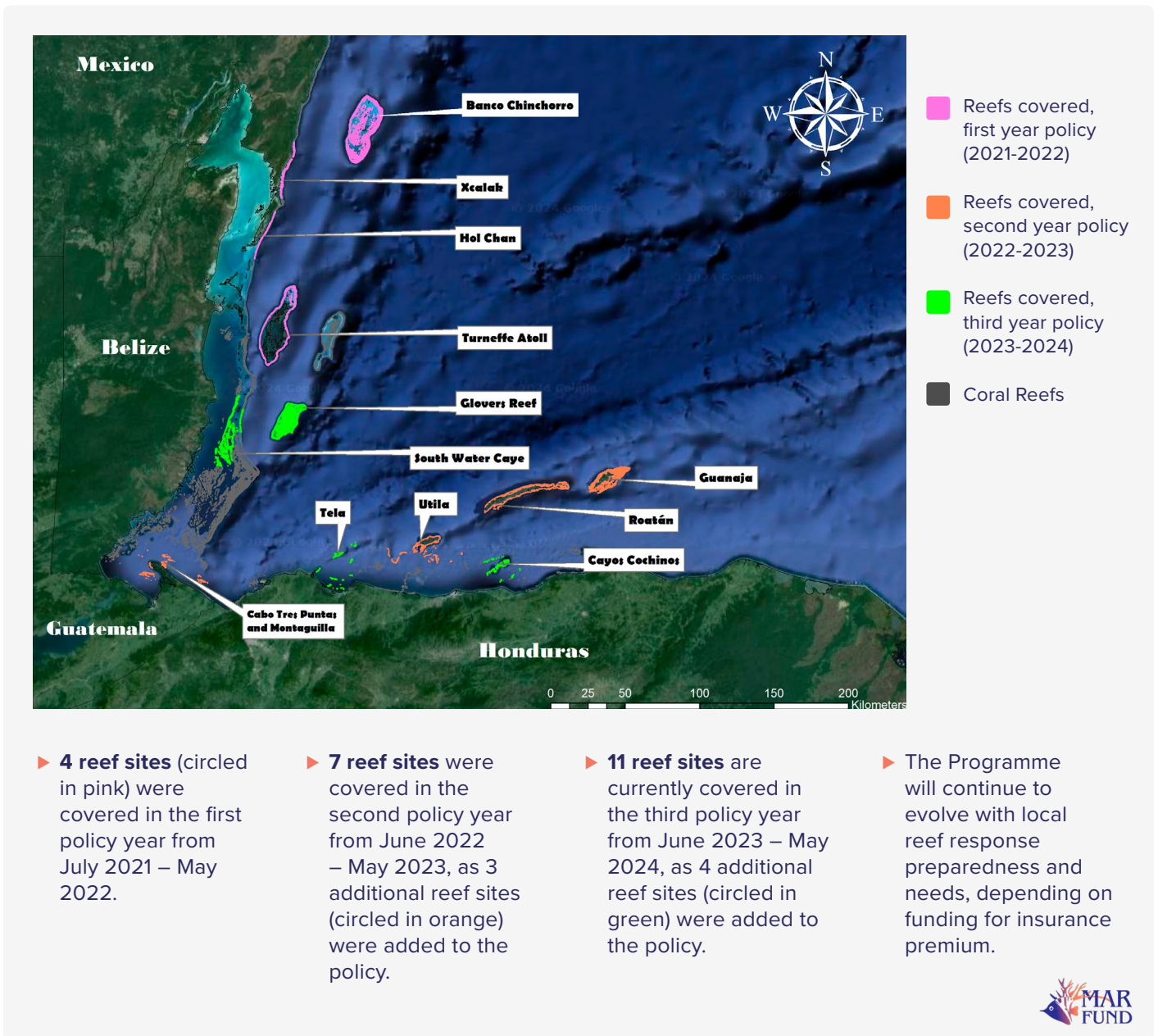
ⁱⁱⁱ Adaptation Fund-European Union-UNDP Innovation Small Grant Aggregator Platform, through the Adaptation Fund Climate Innovation Accelerator (AFCIA/UNDP/ISGAP).

What is covered by the insurance?

This innovative reef insurance is designed to provide post-hurricane pay-outs to cover the costs of planned reef response at different reef sites across the MAR. This encompasses the activities of the *Reef Brigades* (including logistics, planning, and evaluation) to undertake a reef damage assessment, clean the reef and remove debris (including cleaning trash and bulky items, as well as stabilizing loose coral fragments), re-attach fragmented coral, repair structural

fractures / damage, establish *in situ* coral nurseries, and monitor attached corals.

In terms of the area covered, the MAR Insurance Programme has evolved as advances in reef response governance and capacities have been met with expansions in insurance coverage.



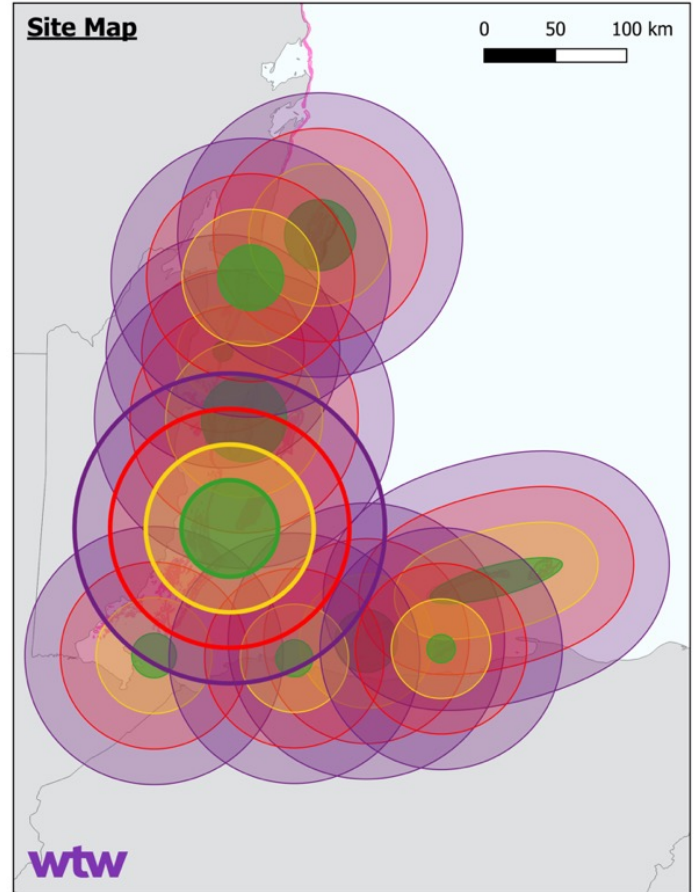
Technical details: How is the coverage designed?

Pay-outs of the MAR Insurance Programme are triggered by hurricanes that reach pre-agreed windspeed thresholds within a pre-agreed area around the covered reef sites. The exact pay-out amount for any given hurricane depends on the location and intensity of the hurricane. Hurricanes with higher windspeeds nearer to covered reef sites trigger higher pay-outs than hurricanes with lower windspeeds, further away from covered reef sites.

The covered geography of the MAR Insurance Programme is a “circular grid” as illustrated in the site map. Each covered reef site has a “reef zone” (in green) which is the smallest circle / oval which can accommodate all of the reef area for that site. There are three successively bigger zones around that, at 25 km, 50 km, and 75 km from the reef zone (in orange, pink, and purple, respectively).

Pay-outs are made based on the location and peak wind-speed of hurricanes within the different zones of the circular grid. Hurricanes trigger different pay-out levels, according to the pre-agreed pay-out matrix below.

Windspeed (kn)	Purple zone	Pink zone	Orange zone	Reef zone
0 – 63	0	0	0	0
64 – 82	0	0	Level 1	Level 2
83 – 95	0	Level 1	Level 2	Level 3
96 – 112	Level 1	Level 2	Level 3	Maximum
113 – 136	Level 2	Level 3	Maximum	Maximum
≥ 137	Level 3	Maximum	Maximum	Maximum



The amount of funding that is needed / triggered at the four pay-out levels (Level 1, 2, 3, and Maximum) is set for each reef site, depending on the estimated costs of four levels of response, which are calculated based on the duration of response, the number of *Reef Guardians* mobilized and site-specific characteristics such as size and remoteness, response plans, and prices.

- ▶ The Maximum pay-out amount for each site is set at the estimated cost of mobilizing a full 60 days of emergency reef response at that site.
- ▶ The Level 1, 2, and 3 pay-out amounts for each site area set as a proportion of the Maximum, to fund three lower levels of response to less impactful hurricanes.



Photo: Martin Leglize

How is the coverage structured?

The MAR Insurance Programme's structure for the 2023-2024 policy year utilizes three different types of "insurance limit"—i.e., maximum pay-out amounts.

- ▶ Each site has a unique "site event limit", which is the maximum event pay-out amount for that site, set at the estimated cost of mobilizing all available *Reef Guardians* at that site for 60 days of emergency reef response. This determines the maximum pay-out amount for each hurricane event at each site.
- ▶ Each country also has a "national event limit", which determines the maximum pay-out amount for each hurricane event in each country.

This national event limit applies when a single hurricane event impacts more than one site in the same country, since *Reef Guardians* are shared between sites within the same country. In other words, the national event limit is calculated by estimating the cost of mobilizing all the *Reef Guardians* in each MAR country for a hurricane event impacting every site within that country.

- ▶ The overall MAR Insurance Programme also has an annual programme limit, which determines the maximum pay-out amount across all sites and all events within the policy year.

This annual programme limit applies when multiple hurricane events trigger event pay-outs within the policy year. For example, during the 2023-2024 policy year, event pay-outs would be made for all hurricanes

passing through the circular grid, depending on their location and intensity, up to the site / national event limits, until the programme limit is exhausted.

Note that the coverage terms of the MAR Insurance Programme—including the pay-out matrix and insurance structure—are updated every policy year, based on the most up-to-date assessment of reef response needs and the premium budget available. Each year, MAR Fund works with WTW to design a financially efficient instrument to transfer hurricane risk, achieving effective coverage at the best price possible.

How are pay-outs calculated?

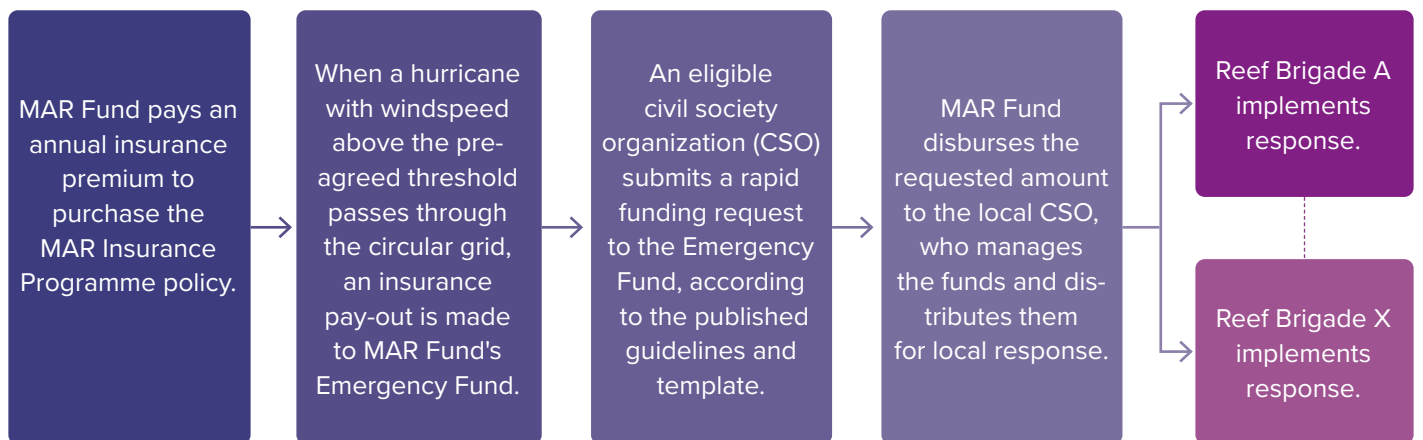
For any given hurricane event during the 2023-2024 policy year, the total pay-out amount was calculated in three steps.

- 1 The **maximum event pay-out amount for each site** is calculated by applying the event pay-out matrix to the hurricane's location and windspeed;
- 2 The **maximum event pay-out amount for each MAR country** is calculated by adding the maximum event pay-out amounts for each site within that country and applying the national event limits.
- 3 The **total programme event pay-out** is calculated by adding all the maximum event pay-out amounts for each MAR country and applying the annual programme limit. This is the total pay-out amount for any given hurricane.

How are pay-outs distributed for response?

Pay-outs are received by the MAR Fund’s Emergency Fund, which provides existing financial infrastructure and transparent fund distribution processes to implement hurricane response. The Emergency Fund is a tried and tested mechanism, which enables MAR Fund to rapidly disburse funding in the immediate aftermath of hurricanes. This rapid and transparent disbursement, which is made according to a pre-agreed process, is essential for reef response effectiveness—when time is of the essence to rescue viable corals and clean the marine environment to reduce mounting impacts.

The Emergency Fund is managed according to MAR Fund’s *Operation Guidelines for the Emergency Fund*, which detail the procedure to access funding. Local non-governmental organizations (NGOs) are eligible to apply for, receive, and manage funds, and they coordinate with the *Reef Response Coordinating Committees* and *Reef Brigades* to distribute funding to implement the reef response plans at each site. NGOs are encouraged to prepare funding request templates before hurricanes occur, so they are ready to apply for and receive funding as quickly as possible.



The Emergency Fund is a tried and tested mechanism, which enables MAR Fund to rapidly disburse funding in the immediate aftermath of hurricanes.

Importantly, *Reef Guardians* are expected to be paid a daily fee for their work: *Reef Brigade leaders* and *Reef Responders* should receive payment based on the response plan budget elaborated by the *Reef Response Coordinating Committee*. Additional eligible cost categories include

meals for responders, the transportation costs of response (including boat rental with a captain and deckhand, as well as fuel), necessary equipment such as compressed air tanks, cement, coral nurseries, and tools, diving insurance for the *Reef Guardians*, and fees and expenses for planning and evaluation meetings. These categories are not meant to be overly prescriptive, as every response is different and *Reef Response Coordinating Committees* and managers must have flexibility to adapt to circumstances; therefore, please refer to the site emergency response plan and the Operation Guidelines of MAR Fund’s Emergency Fund for more information on the activities and cost categories that are eligible for funding.

Impact of the MAR Insurance Programme

The MAR Insurance Programme is the first comprehensive emergency response strategy backed by innovative parametric reef insurance, which addresses the increasing risk of extreme climate events to reef ecosystems across multiple countries. It marks a major advance in coastal resilience, utilizing an innovative financial product to release timely resources for local, community-led reef restoration. It currently covers the costs of planned reef response across 186,917 km² of ocean, contributing to the adaptive management of 10 marine protected areas and protecting 1,680 km² of reef area across 11 reef sites.

Six *Reef Response Coordinating Committees* have been formed, and six reef response plans have been formally adopted, creating accountability for response. More than 160 *Reef Guardians* have been trained, certified, and organized into 16 *Reef Brigades* to conduct emergency reef response. Certification provides *Reef Guardians* with enhanced livelihood opportunities, and they are expected to be paid a daily wage for reef response, which provides an additional source of income after hurricanes. Additionally, the MAR Insurance Programme supports an estimated 2,149,774 people that live in communities that depend on the maintenance and sustained health of the covered reef sites, enhancing their resilience to extreme climate events on their reefs.

In 2022, Hurricane Lisa impacted the Turneffe Atoll Marine Reserve (TAMR), triggering USD 175,000 for reef response. TAMR's co-manager received funding for adaptive management covering 221 km² of reef, and 14 responders received supplementary income to implement response.

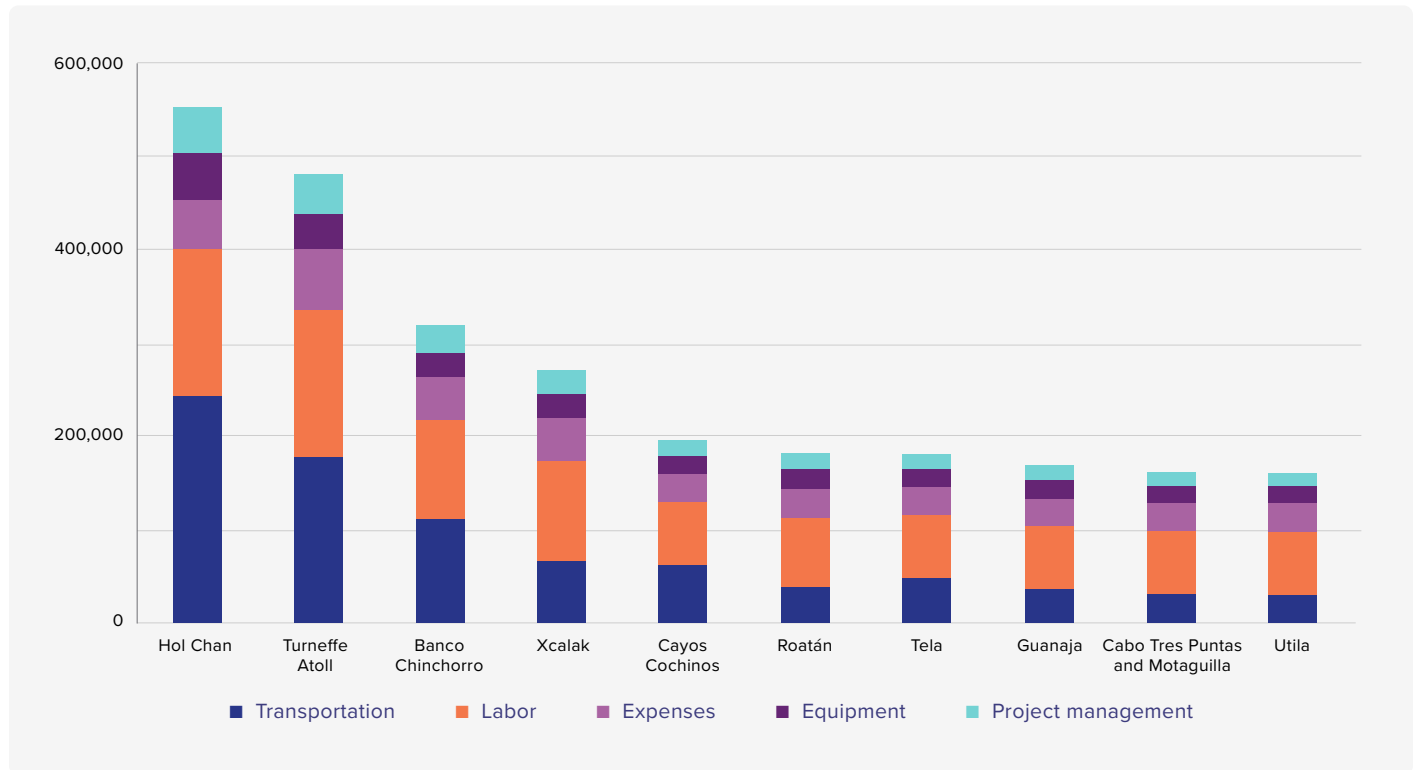


More than 160 *Reef Guardians* have been trained, certified, and organized into 16 *Reef Brigades* to conduct emergency reef response.

Post-hurricane Reef Response without Insurance?

The budgets required to implement post-hurricane reef response have been estimated for sites across the MAR, where *Reef Response Coordinating Committees* and reef response plans are in place and *Reef Brigades* are ready to respond. The costs of reef response are driven by the number of *Reef Guardians* that participate, transportation needs, and the price of labor, meals and meeting expenses, transportation (boats and fuel), equipment such as a drone for the damage assessment, compressed air tanks, cement, coral nurseries, and tools, and diving insurance.

The estimates shown in the figure below include the expected resources needed to mobilize a full-capacity, 60-day emergency reef response at each site. Please note that these budgets reflect the expected costs of mobilizing the *Reef Guardians* that are currently trained, certified, and expected to be available in each reef site, and they are sensitive to changes in the number of available *Reef Guardians*.^{iv}



The above budget estimates are considered the “*maximum absorbable rapid reef response budgets*” for each reef site. However, as discussed in the description of the insurance structure above, it is not expected that every hurricane will necessarily require every available *Reef Guardian* for a full 60 days to effectively clean the ecosystem, stabilize the reef, and rescue damaged corals. Rather, reef response needs are expected to vary, depending on the characteristics of each particular hurricane event and the impacts on the reef ecosystem, which will likely influence the number *Reef Guardians* that are actually mobilized and the length of response. Concretely, it is expected that more intense hurricanes nearer to the reef sites will cause more severe impacts, requiring

higher levels of response and therefore demanding more resources; conversely, it is expected that further away, less intense hurricanes will cause less reef damage and therefore incur lower response requirements and costs.

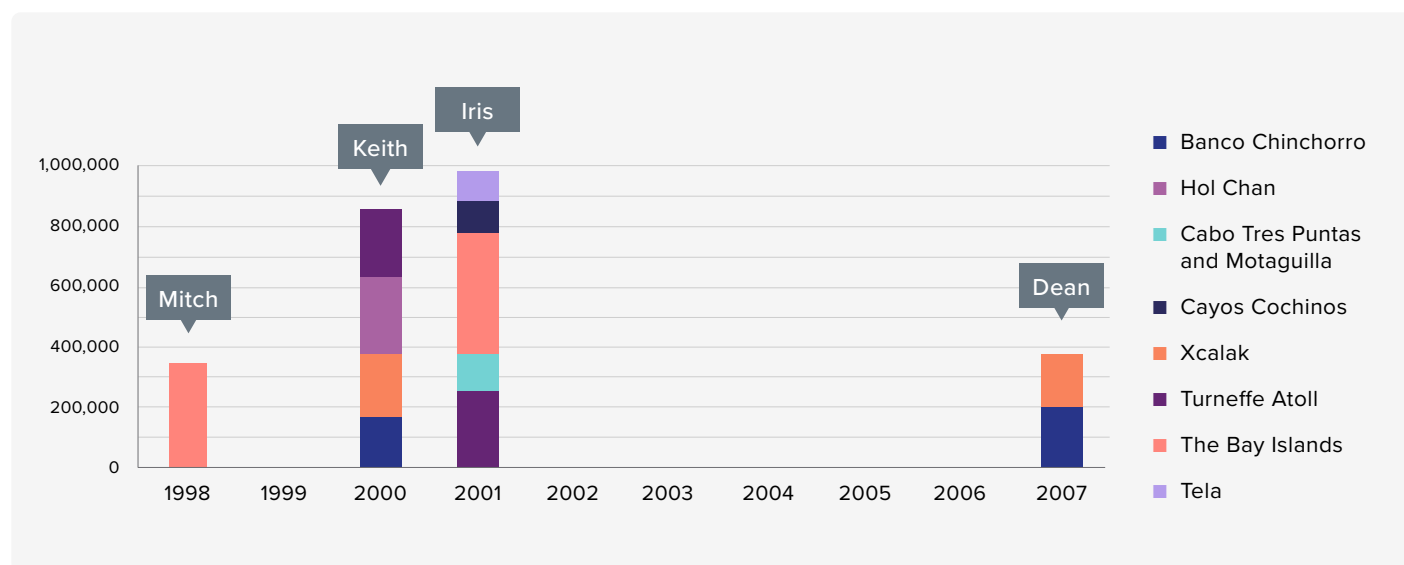
Hurricanes are natural events, and their occurrence is variable in frequency and intensity; therefore, it is impossible to predict exactly when and at what intensity they will occur. Consequently, post-hurricane response needs are likewise unpredictable. It is the year-on-year variability of hurricane events and corresponding reef response costs (in frequency and amount), and the importance of funds being immediately available after a storm, that makes proactive budgeting and resource mobilization so important, yet difficult.

^{iv} Please also note that **reef response** does not include **other** hurricane response activities and, therefore, the *maximum absorbable rapid reef response budgets* are not expected to cover these other activities.

While there are many factors that influence the level of reef damage after hurricanes, research shows that damage intensifies when winds reach hurricane-strength speeds over the reef area, and the MAR is particularly vulnerable to hurricanes rated Category 3 and above on the Saffir-Simpson Hurricane Wind Scale.^{v,vi} Assuming that the full *maximum absorbable rapid reef response budget* for each covered reef site should be available whenever a hurricane rated Category 3 passes directly over the reef area, a hurricane rated Category 4 passes within 25 kilometers (km) of the reef area, or a hurricane rated Category 5 passes within 50 km – while a proportion of that maximum should be available to respond to less intense hurricanes – the potential

resource requirements of reef response can be estimated over time.

For example, from 1998 – 2007, four hurricane events impacted the covered reef sites of the MAR Insurance Programme. If the current reef response capacities had been prepared and mobilized for different levels of response during that decade, it is estimated that post-hurricane response to repair the reef and its ecosystem services at these sites would have cost more than USD 2.5 million, with response to each event costing between USD 100,000 and USD 397,000 per site / USD 126,000 to USD 605,000 per country / USD 350,000 to USD 984,000 across the MAR region.



Without pre-positioned finance, response to each event would have required time-consuming *ad hoc* fundraising efforts in the immediate aftermath of the hurricane, when repairing damage to grey infrastructure and property often takes priority. In these circumstances, it is easy to imagine that even coordinated reef response plans and prepared *Reef Response Brigades* would be difficult to fund and mobilize rapidly, in the critical window of opportunity when corals are still viable for rescue. Furthermore, a lack of predictable, reliable finance compromises response effectiveness and even discourages preparedness—why invest time and money in planning, training, and equipment if you do not believe funding will be available when you need it? Pre-arranged finance is therefore critical to the sustainability of post-hurricane reef response in the MAR; this is the challenge that the innovative reef insurance of the MAR Insurance Programme aims to address.

v Perez-Cervantes, E., Urrutia, F. P., 2019. Análisis: Correlación entre los Daños a Arrecifes Causados por Huracanes y las Características de los Huracanes que Provocan los Daños. MAR Fund Reef Rescue Initiative.

vi Gardner, T.A., Côté, I.M., Gill, J.A., Grant, A. and Watkinson, A.R., 2005. Hurricanes and Caribbean coral reefs: impacts, recovery patterns, and role in long-term decline. *Ecology*, 86(1), pp.174-184.

Background: The Mesoamerican Reef and the Risks of Inaction

The Mesoamerican Reef (MAR) is the largest trans-boundary reef in the world, spanning more than 1,000 kilometers of the Caribbean coastline of Mexico, Belize, Guatemala, and Honduras. The MAR is a unique biodiversity hotspot with a mosaic of distinctive coral reef types, including some of the last healthy staghorn and elkhorn colonies in the Caribbean. Its structure attenuates wave energy, protecting the region's coasts from the impacts of regular wave action and extreme events, such as erosion and flooding. And this vibrant coastal ecosystem provides critical habitat to many endangered and charismatic species such as manatees, whale sharks, groupers, and parrot fish, which draw visitors from around the world.

The MAR is a unique biodiversity hotspot with a mosaic of distinctive coral reef types, including some of the last healthy staghorn and elkhorn colonies in the Caribbean.

A healthy reef underpins an array of economic opportunities in the tourism and fishing sectors, enabling a dynamic blue economy in the region.



Photo: Fundación Albatros

But the MAR and the reef-related economy are at risk. Vital natural assets worldwide are threatened by the effects of climate change, including increasingly frequent and severe extreme weather events as well as both short- and long-term ocean temperature variability and related biological and chemical changes. While the MAR has survived the natural disturbance of storms for eons, natural recovery from storm impacts takes at least eight years, during which time ecosystem functions are impaired. Moreover, global climate change and local stressors reduce coral resilience and amplify storm impacts, and hurricanes are now a leading driver of coral loss in the region.^{vii} Reefs increasingly persist in a degraded state of early recovery and continual decline after

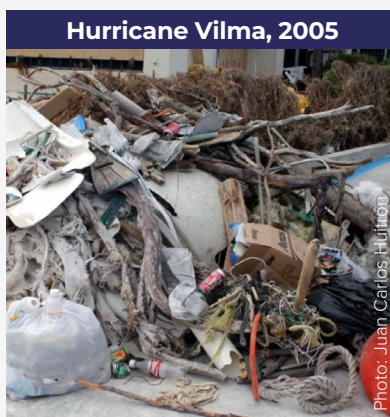
storm-related damage, if they recover at all. Losses of coral and structural complexity lead to reductions in fisheries productivity and biodiversity, coastal protection, and the vibrancy of the ecosystem, threatening all who depend on these benefits for security and prosperity.^{viii}

Global climate change and local stressors reduce coral resilience and amplify storm impacts, and hurricanes are now a leading driver of coral loss in the region.

Entire reef areas have been reduced to rubble by powerful waves, storm surge, and debris burial.



Storms generate powerful waves and surges that break coral tips and branches and can dislodge, flip, and/or bury entire coral colonies.



High winds on land hurl debris onto reefs, and items such as trees, roofs, floating trash, and micro items damage corals until they are removed.



Intense rain and storm-blocked drains lead to run-off, and increased turbidity, as well as wave-transported sediment, can smother corals.

vii Gardner, T.A., Côté, I.M., Gill, J.A., Grant, A. and Watkinson, A.R., 2005. Hurricanes and Caribbean coral reefs: impacts, recovery patterns, and role in long-term decline. *Ecology*, 86(1), pp.174-184.

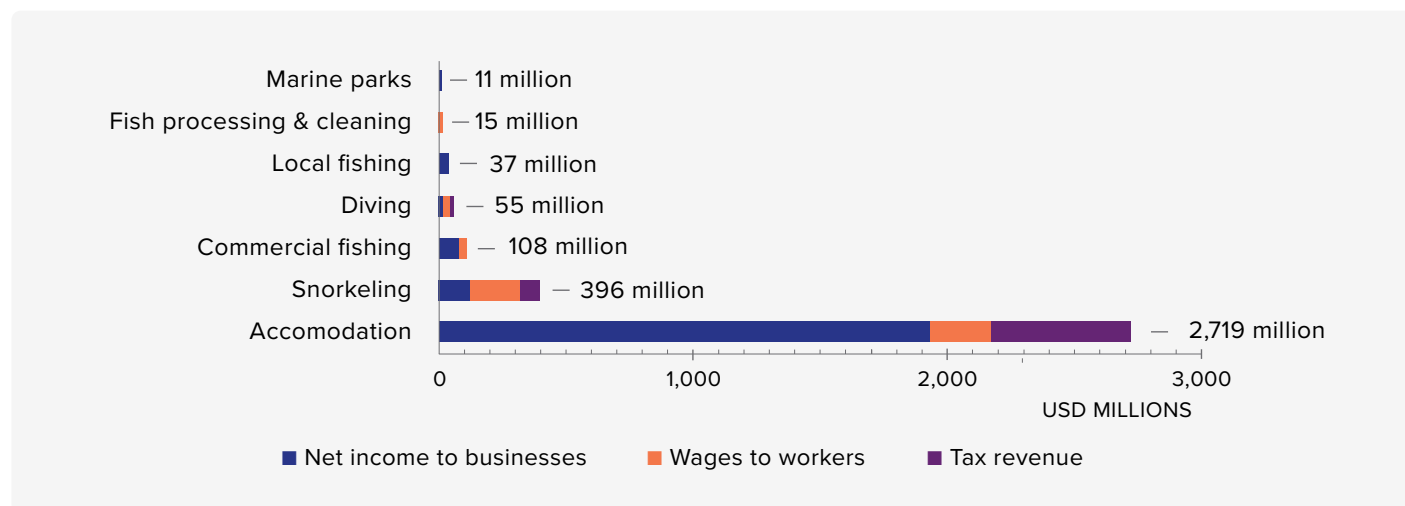
viii Rogers, A., Blanchard, J.L. and Mumby, P.J., 2018. Fisheries productivity under progressive coral reef degradation. *Journal of applied ecology*, 55(3), pp.1041-1049.

What Value is at risk?

Reef-related income to businesses, workers, and government

A 2021 study commissioned by the Inter-American Development Bank (IDB), *Economic Valuation of the Ecosystem Services of the Mesoamerican Reef, and the Allocation and Distribution of these Values*, estimates the regional economic value of the MAR at more than USD 4.5 billion. Reef-related economic activities include coastal accommodation; marine recreation such as snorkeling, diving, and visiting marine protected areas (MPAs); and fishing, processing, and cleaning of reef-associated species.

Reef-related fishing and tourism in the MAR are estimated to generate more than USD 3.3 billion in reef-related income every year. Two thirds of that (USD 2.2 billion) is net income to reef-related businesses, 15 percent (USD 500 million) is wages to workers in the blue economy, and 19 percent (USD 630 million) is estimated tax revenue to central governments from reef-related activities. This reef-related income is also estimated to generate an additional USD 758 million in indirect economic benefits across other sectors of the regional economy.^{ix}



Income from certain activities of the reef-related economy is particularly at risk to reef degradation. For example, reef degradation is estimated to reduce the productivity of reef-associated fisheries by 35 percent.^x Income from diving, snorkeling, and visiting MPAs may be impacted by reef degradation, as prices and/or the average proportion of tourists that dive, snorkel, and visit MPAs may be sensitive to reef health. And although overall tourism arrivals to the MAR region are expected to increase, certain coastal hotels and hotel workers may experience a decrease in income from reef degradation, and all will be more vulnerable to coastal hazards.

ix Please see the full IDB report, available at <https://publications.iadb.org/en/economic-valuation-ecosystem-services-mesoamerican-reef-and-allocation-and-distribution-these>, for details on the valuation methodology, specific data points, and data sources.

x Rogers, A., Blanchard, J.L. and Mumby, P.J., 2017. Fisheries productivity under progressive coral reef degradation. *Journal of applied ecology*, 55(3), pp.1041-1049.

Reef-related protection from coastal hazards

The MAR is also a nature-based solution to one of the most significant challenges facing the MAR region—the physical and economic impacts of climate change—as it attenuates wave energy and protects against hazards such as flooding and coastal erosion.

2 million people

The MAR protects the safety and property of more than 2 million people who live in areas lower than 10 meters above sea level. This includes 85 percent of the population of Quintana Roo, Mexico, almost half of the entire national population in Belize, and 9 percent of the population of the Department of Izabal in Guatemala. In Honduras, it includes the entire population of the Bay Islands, a third of the population of Atlántida, 10 percent of the population of Colón, and 6 percent in Cortés in Honduras.¹

USD 25.7 million

A healthy, structurally complex reef defends coastal assets from the impacts of coastal hazards by reducing flooding and maintaining shoreline elevation. A resilient MAR reduces the expected average annual cost of flood damage by more than USD 25.7 million.²

USD 350 – 550 million

In economic terms, the MAR's flood risk reduction benefits have a net present value of more than USD 350 million over a 50-year time horizon, assuming a 7% discount rate. A 4% discount rate would give the MAR's role in flood management a net present value of more than USD 550 million.³

- 1 The population within the 10-meter low elevation coastal zone (LECZ) was calculated using the following data:
 - ▶ 2020 United Nations adjusted population data from WorldPop, downloaded from: <https://hub.worldpop.org/geodata/listing?id=79>
 - ▶ LECZ area from the Center for International Earth Science Information Network (CIESIN), Columbia University, and CUNY Institute for Demographic Research (CIDR), City University of New York, downloaded from: <https://sedac.ciesin.columbia.edu/data/set/lec2-urban-rural-population-land-area-estimates-v3/data-download>
 - ▶ Administrative boundaries from GADM, downloaded from: <https://gadm.org/>
- 2 The estimated increase in expected average annual flood damages from reef degradation is calculated by taking the difference between modelled damages to built capital with and without the top meter of reef height. Quantification of the potential increase in damage to built capital is based on the local risk modelling study published by Reguero et al. in 2019, *The Risk Reduction Benefits of The Mesoamerican Reef in Mexico* and a global modelling study published by Beck et al. in 2018, *The Global Flood Protection Savings Provided by Coral Reefs*. In both studies, damage to built capital with and without the top meter of reef height is calculated; Reguero et al. conduct local risk modelling for Quintana Roo in Mexico, and Beck et al. include the Caribbean coastal areas of Belize, Guatemala, and Honduras in their global assessment. The figure cited in this report combines the results of the two studies, reporting the sum of the differences between the damages with a healthy reef and with a degraded reef in each country to give the potential increase in damages for the region. The value used for Mexico is a direct citation of the results of the Reguero et al. study. The values for Belize, Guatemala, and Honduras are based on Beck et al., 2018, the results of which are calibrated using the results of Reguero et al.

The data on the difference in annual expected damages to built capital with and without the top 1 meter of reefs is collected from Beck et al. for the MAR coastline, available from the "Mapping Ocean Wealth Explorer" (accessible at <https://maps.oceanwealth.org/>). Values in Quintana Roo, which are included in Beck et al., but not included in Reguero et al. because the area is not protected by reef (in Cancún and Cozumel) are omitted. The total "difference in annual expected damages to built capital with and without the top 1 meter of reefs" for the adjusted Beck et al. dataset in Quintana Roo is divided by the value for the same area in the Reguero et al. study to get the "calibration factor". The "calibration factor" is applied to the Beck et al. (2018) values for Belize, Guatemala, and Honduras. The Reguero et al. (2019) results for Mexico are summed with the calibrated values for Belize, Guatemala, and Honduras to give the regional figure of USD 25.7 million expected annual flood damages.
- 3 50 years is a standard time period over which to evaluate the benefits of flood mitigation infrastructure—e.g., 50 years is used by the US Federal Emergency Management Agency (FEMA). FEMA also uses a 7% discount rate. A 4% discount rate is also applied, as this is often used by the World Bank.

The MAR Insurance Programme: A Nature-based Solution to Enhance Resilience

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