

The study of Mexican coral reefs under the threat of climate change: Contributions from XII CMAC–III CPAC

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In 2000, the first Mexican Coral Reef Conference (I CMAC, for its acronym in Spanish) was held in the city of Veracruz and offered 91 presentations. Eleven years later, VI CMAC took place in the city of Ensenada and grew to feature 126 presentations. Over the intervening years, the scope of this conference has been enhanced by the integration of colleagues from other countries in the Americas, giving rise to the Panamerican Coral Reef Conference (CPAC, for its acronym in Spanish), which was held concurrently with CMAC in 2022 and 2024. For the second time, Ensenada was selected to host this conference, with XII CMAC–III CPAC held from 22–26 April 2024.

Notably, XII CMAC–III CPAC, which featured a total of 299 presentations, talks, and posters, was by far the largest gathering to date of researchers, managers, government officials, and students involved in research, management actions, and conservation efforts in the reef ecosystems of Latin America. This important event was organized by the Mexican Society of Coral Reefs (SOMAC, for its acronym in Spanish), with support from the International Coral Reef Society and the local host institutions of *Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California* (CICESE) and *Universidad Autónoma de Baja California* (UABC).

During XII CMAC–III CPAC, the featured presentations covered multiple topics that were categorized into five thematic sessions: (1) genomic sciences and the physiology of reef organisms; (2) the population and community ecology of reef organisms; (3) social-ecological systems; (4) physics, chemistry, and innovation applied to coral reefs; and (5) temperate reefs. As such, the conference, which reflected a diverse array of research approaches and methodologies, covered a wide range of topics related to corals, reef ecosystems, and their associated species, with a strong emphasis on coral health and reef resilience, physiology, restoration, and the impacts of climate change in these ecosystems.

From the 299 presentations, 11 studies were selected for publication (3 research notes and 8 research articles) in a special issue of *Ciencias Marinas* (vol. 50 [1b]). These studies presented novel findings on issues related to coral reef health, growth, and physiology, as well as interactions with other marine organisms and the impacts of environmental stressors and human activities on the resilience of vital coral ecosystems in the seas and oceans of the Americas.

Within the special issue of *Ciencias Marinas*, you will find 2 studies focused on aspects of coral reef health and resilience and the importance of continued monitoring efforts. Correa et al. (2025) explored the value of using the Reef Health

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Index as a tool for regional monitoring and reef conservation under climate change. In this study, the authors assessed the status of 11 reefs in the southwestern Gulf of Mexico and Mexican Caribbean, finding that reefs in the southwestern Gulf of Mexico exhibited better health than those in the Mexican Caribbean. Carreño-Loaiza et al. (2025) noted the rapid recovery of scleractinian corals only 5 months after a bleaching event in the Veracruz Reef System. The long-term data set (2008–2021) revealed that the health of the coral community could be classified as “good” based on the coral index (CI \approx 3.7), indicating resilience and reinforcing the importance of continuous monitoring.

Regarding the physiology of corals and associated species, Trejo-Estrada et al. (2025) studied the physiological acclimation of *Porites panamensis* under high-latitude marginal conditions. The authors found that *P. panamensis* acclimates to seasonal changes in temperature and turbidity by using mixotrophy as a key nutritional strategy to withstand fluctuating environmental conditions, thus allowing this species to distribute throughout the Eastern Tropical Pacific, even in seemingly suboptimal regions. In addition, Rodríguez-Jiménez et al. (2024) explored the immune response of the anemone *Exaiptasia diaphana* and found that immune activity peaked during the daytime and full moon, especially when *E. diaphana* lacked symbionts. The results of these authors provide relevant information on protective immune mechanisms, which is critical for understanding cnidarian resilience under climate change scenarios.

Two articles in the special issue focused on coral restoration and adaptation. Gutiérrez-Coral et al. (2025) found that colonies of *Orbicella faveolata* were nearly able to fully regenerate following the extraction of donor microfragments within 24 months, providing essential information that supports the sustainability of employing this technique in restoration efforts. Lorenzo-Jiménez et al. (2024) assessed the acclimation of *O. faveolata* to light changes resulting from the translocation of coral fragments between different depths and demonstrated the potential for assisted migration in restoration programs.

Five articles focused on biodiversity and ecosystem functions. López-Pérez et al. (2024a) characterized locations in the southern Mexican Pacific and found that up to 10 coral species were present at sites and depths where they had not been reported previously (e.g., at depths of 37 m) and highlighted the need to address local anthropogenic threats to promote species conservation. Focusing on fish communities, Torres-García et al. (2025) explored the taxonomic and functional richness of fishes in the Mexican Pacific, identifying biodiversity hotspots and a regional “backbone” (i.e., common functional groups throughout the study region) composed of 74 species, which likely maintains ecological functions and processes across biogeographic provinces. This fish diversity analysis aimed to provide information for the management and conservation of reef ecosystems. Jáquez-Domínguez et al. (2025) evaluated species richness and the abundance of cryptobenthic reef fishes, exploring the critical role of

P. panamensis as a microhabitat and its influence on the benthic organization of this often-neglected fish group. Cabrera-Rivera et al. (2025) explored the erosive potential of urchins in Campeche Bank and found that it was likely underestimated due to the omission of adequate nighttime surveys in studies, highlighting the scarcity of information despite the important roles these echinoderms play in coral reefs. Lastly, reflecting the ongoing multidisciplinary development of coral reef research, Hernández-Zulueta et al. (2025) studied the bacterial assemblages of *Acropora cervicornis* and identified the associated bacterial genera responsible for vital metabolic functions linked to coral immunity, nutrition, and resilience, such as *Pseudomonas* and *Acinetobacter*, which may influence how *A. cervicornis* responds to environmental stressors that can increase coral vulnerability to bleaching. Such studies are essential for improving our understanding of coral resilience in the face of climate change.

The body of knowledge contained in the special issue of *Ciencias Marinas*, which arose from XII CMAC–III CPAC, attests to the commitment to advance our understanding of coral reef ecosystems and to generate high-quality scientific information that supports the management and conservation of coral reefs in Mexico and the Americas. This commitment is crucial given the recent negative impacts and dire predictions these ecosystems face under climate change (Hoegh-Guldberg et al. 2017, Fabricius et al. 2024).

The year 2023 was especially devastating for coral reef ecosystems worldwide, and the Americas was no exception. The effects of an El Niño event, combined with elevated temperatures due to climate change, resulted in the most intense and prolonged heat wave recorded in recent years (Goreau and Hayes 2024). Along the coasts of Mexico, water temperatures rose above normal causing stress that led to bleaching and massive mortality. This situation was observed in corals on the Pacific coast, as well as those in the Caribbean and the Gulf of Mexico, leading to the death of tens of millions of corals and extensive devastation to reef ecosystems (López-Pérez et al. 2024b; McField et al. 2024).

Members of SOMAC were surveyed regarding the effects of this heat wave on the reefs in their study regions, which were based on the regional definitions proposed by Spalding et al. (2007) and included the Gulf of California, Tropical Pacific, Caribbean, and Gulf of Mexico (Table 1). Based on the survey results, the most affected region was the Tropical Pacific, which lost an average of almost half of its coral cover, although some authors reported sites with coral mortality as high as 93% (López-Pérez et al. 2024b). In contrast, the least affected region was the Gulf of Mexico (5%), followed closely by the Gulf of California (6%) (Table 1).

The current degradation of coral reefs forms part of an ongoing trend that has been documented over several decades. In the Caribbean, the loss of coral cover has been particularly notable and documented since the 1980s (Glynn 1991, Gardner et al. 2003). This loss has been mainly due to poor water quality and coastal development resulting from

Table 1. Average values of coral cover before and after the bleaching event of 2023, prevalence of bleaching, and loss of cover in the geographical ecoregions of Mexico described by Spalding et al. (2007). Data were obtained from an online survey distributed to key senior members of the Mexican Society of Coral Reefs (SOMAC, for its acronym in Spanish) who kindly contributed information. The number of completed surveys is indicated next to each region. Numbers in parentheses are the standard error.

Region	Coral cover before (%)	Coral cover after (%)	Coral cover change (%)	Bleaching prevalence (%)
Gulf of California (<i>n</i> = 3)	18 (6.7)	12 (6.7)	-6	58 (26.7)
Tropical Pacific (<i>n</i> = 5)	63 (9.7)	15 (3.2)	-48	65 (19.0)
Caribbean (<i>n</i> = 1)	15	5	-10	75
Gulf of Mexico (<i>n</i> = 4)	33 (14.4)	28 (13.1)	-5	55 (13.2)

deforestation, land use changes, excessive nutrient inputs, and contamination. In addition to local threats, the effects of climate change have also contributed to the loss of coral cover. Given this context, the current scenario surrounding the coral reefs of the Americas is very concerning.

No easy or simple solutions exist to mitigate these growing threats to corals or to reverse severe reef deterioration. Restoration, given its nature, is costly and has very limited local impacts. More efficient solutions with ecosystem-level effects require proposals that address not only the consequences of reef deterioration, but also its causes. The studies published in the special issue of *Ciencias Marinas* address some of the problems affecting reef resilience, restoration efforts, biodiversity patterns, and microbial communities and offer actionable insights and future research avenues for the coral reef research community of the Americas to foster coral reef conservation in the face of climate change.

DECLARATIONS

Supplementary Material

This work includes no supplementary material.

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Conflict of interest

The authors declare they have no conflict of interest.

Author contributions

Conceptualization: LMC, HPE, GRO, JAZD; Data curation: LMC, HPE, GRO, JAZD; Formal analysis: HPE;

Validation: LMC, HPE, GRO, JAZD; Writing – original draft: LMC; Writing – review & editing: HPE, GRO, JAZD.

Data availability

The data for this study are available from the corresponding author by reasonable request.

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The authors employed DeepSeek V3.2 to translate and improve the grammar of the text. After any portion of text was processed by DeepSeek V3.2, the authors revised and proofread the outputs to ensure accuracy. The authors are fully responsible for the content of this work.

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