CHAPTER 30

# Caribbean Panama

**Authors:** Juan Mate, Judith Lang, Andrea Rivera-Sosa.

**Data contributors:** Marilyn Brandt*, Arcadio Castillo*, Graham J. Edgar, Robert Ginsburg†*, Heather Halter*, Greta Klungness*, Judith Lang*, Yadibaler López*, Eilikipler Martínez*, Juan Maté*, Ryan Moyer*, Lizzi Oh, Felipe Ossandon, Paula Sills, Rick D. Stuart-Smith.

*AGRRA data contributor(s).

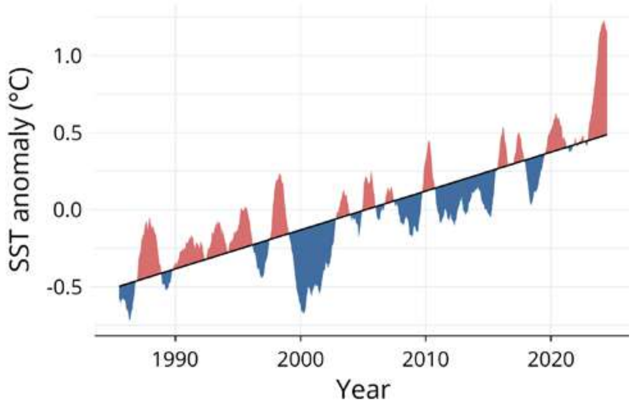
## INTRODUCTION

Panama hosts 1,097 km² of coral reefs, which represent 4.527% of the Caribbean's total coral reef extent. Panama's coral reefs are concentrated on the Caribbean coast, where conditions support extensive fringing, barrier, and patch reef formations. The most developed systems occur in the Guna Yala Archipelago (610 km²) to the East, followed by Bocas del Toro Archipelago on the West, and the Central Caribbean Panamá, which spans the Colón Province, from the eastern entrance to the Panama Canal to Escribanos Bay, West of Guna Yala and is closely linked with mangroves and seagrass beds. These ecosystems host a wide range of Caribbean coral, fish, and invertebrate species, while providing coastal protection, fisheries resources, and a foundation for marine tourism. Reefs in Bocas del Toro and Guna Yala are also integral to the cultural identity and livelihoods of coastal and Indigenous communities.

## THREATS

### Thermal regime

The long-term average in SST from 1985 to 2024 over the Caribbean coral reefs of Panama was 28.16 °C. Over this period, SST increased by 1.10 °C, representing a warming rate of 0.028 °C per year (**Figure 2.30.1**). Coral reefs along Panama's Caribbean coast have been affected by mass bleaching events. The 1998 El Niño caused moderate bleaching linked to regional thermal stress (Wilkinson and Souter 2008). The 2005 event was severe, with widespread bleaching and coral disease outbreaks in Bocas del Toro (Eakin et al., 2010; Wilkinson and Souter 2008). Most recently, the 2023–2024 global bleaching event caused extensive bleaching and mortality across Guna Yala and Bocas del Toro, driven by record heat stress and deoxygenation (Johnson et al. 2021). These recurrent events underscore the increasing vulnerability of reefs to warming seas.

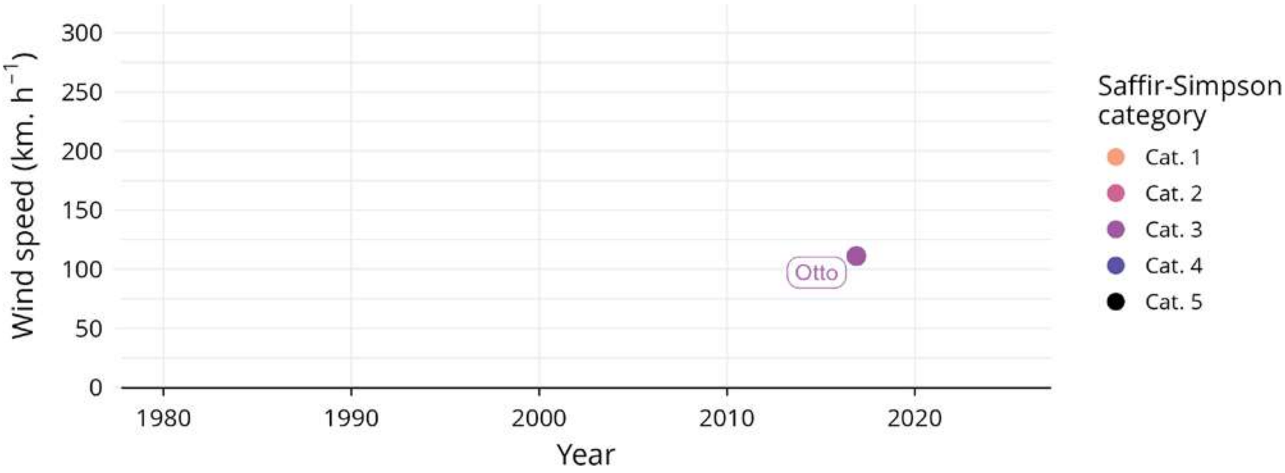



↑ **Figure 2.30.1.** Average Sea Surface Temperature (SST) anomaly from July 1985 to July 2024 over Panama's Caribbean coral reefs. The black line is the long-term trend in SST anomaly, values below this line are negative SST anomalies (*i.e.* cooler than long-term trend), and values above this line are positive SST anomalies (*i.e.* warmer than long-term trend).

## Hurricanes

Between 1980 and 2024, a total of 2 tropical storms passed within 100 km distance of a Panamanian coral reef, and one of these e was characterized by sustained wind speed greater than 100 km.h$^{-1}$ (**Figure 2.30.2**). The hurricane with the highest sustained wind speed over the studied period was the hurricane Otto, in 2016, which passed 86 km from a coral reef with sustained wind speed of 111 km.h$^{-1}$.

↓ **Figure 2.30.2.** Maximum sustained wind speed of tropical storms passing within 100 km of a coral reef between 1980 and 2024 in the Panamanian Caribbean. Colors correspond to the cyclone's Saffir-Simpson category along its entire track. However, the values of sustained wind speed are extracted from the nearest tropical storm position from a coral reef. For this reason, some sustained wind speed values are below the lower threshold of category 1 Saffir-Simpson scale (*i.e.* 119 km.h$^{-1}$). Note that cyclones passing more than 100 km away from coral reefs of Panama are not represented, although they could have had an impact.




## Other threats

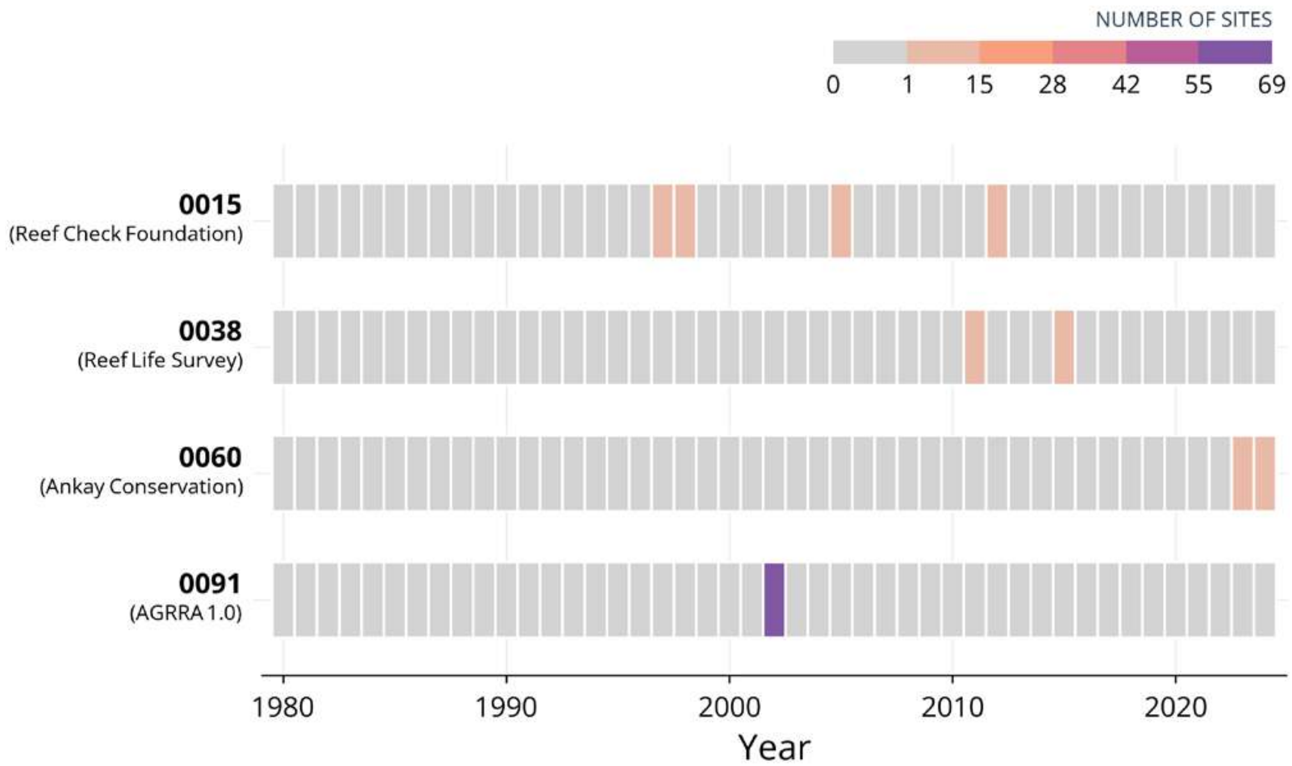
Coral reefs in the Panamanian Caribbean are under growing pressure from local and regional human activities that threaten their ecological health and recovery capacity. Coastal development, deforestation, and land-based runoff are major drivers of sedimentation and eutrophication, reducing light penetration and smothering reef organisms, particularly in areas such as Bocas del Toro (D'Croz et al., 2005; Guzmán and Jiménez, 1992). Pollution from sewage, agriculture, and heavy metals has degraded water quality and altered benthic communities, while nutrient enrichment favors algal proliferation that competes with corals for space and resources (Guzmán et al., 2003). Overfishing and the removal of key herbivores have disrupted trophic dynamics, reducing the natural control of algae and weakening reef resilience. Additionally, unsustainable tourism, including anchor damage and physical trampling, further exacerbates reef degradation in popular coastal and island destinations. Emerging stressors such as ocean acidification and deoxygenation pose long-term threats by impairing coral growth and reef framework stability (Johnson et al., 2021). Low dissolved oxygen levels (hypoxia) has been reported for Almirante Bay in Bocas del Toro resulting in widespread bleaching and mortality of other organisms such as sponges, crustaceans, gastropods and echinoderms (Altieri et al. 2017). To ensure the persistence of Panama's reefs, it is essential to strengthen marine protected areas, enforce sustainable fisheries, improve watershed management, and foster community-based stewardship that integrates local livelihoods with conservation.

# TRENDS IN BENTHIC COVER

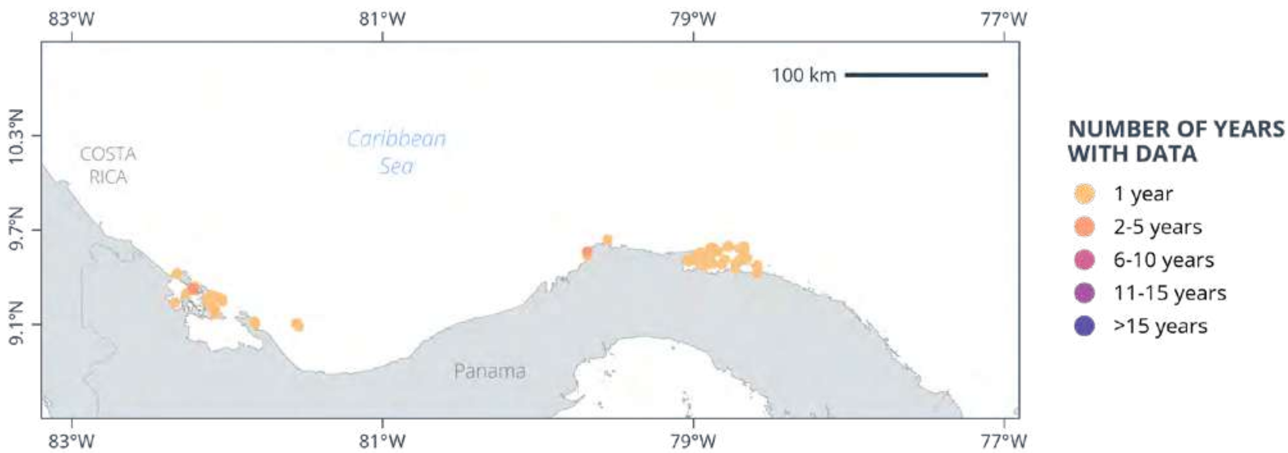
Temporal trends in the percentage cover of benthic categories from 1980 to 2024 were estimated using data from 4 datasets (**Figure 2.30.3**) encompassing 92 monitoring sites. These data were collected through 184 surveys conducted between 1997 and 2024. Long-term monitoring and historical reconstructions reveal pronounced declines in hard coral cover and increases in macroalgal dominance across Panama's Caribbean reefs over the past four decades which differ from the low macroalgae cover earlier reported in **Figure 2.30.5**. (Shulman and Robertson, 1996; Guzmán, Guevara and Castillo, 2003).

Early surveys in the 1980s documented high coral cover in the San Blas Archipelago (currently known as Guna Yala), averaging 31–45%, which dropped to 12–26% by 1990, while macroalgae rose from ~2% to nearly 30%, largely due to the *Diadema antillarum* die-off, sedimentation, and nutrient enrichment (Shulman and Robertson, 1996).

Similar declines were recorded along the Guna Yala coast, where coral mining, land-based runoff, and local disturbances contributed to a ~79% loss of coral cover between 1970 and 2000, accompanied by a marked increase in algal and rubble substrates (Guzmán, Guevara and Castillo, 2003).



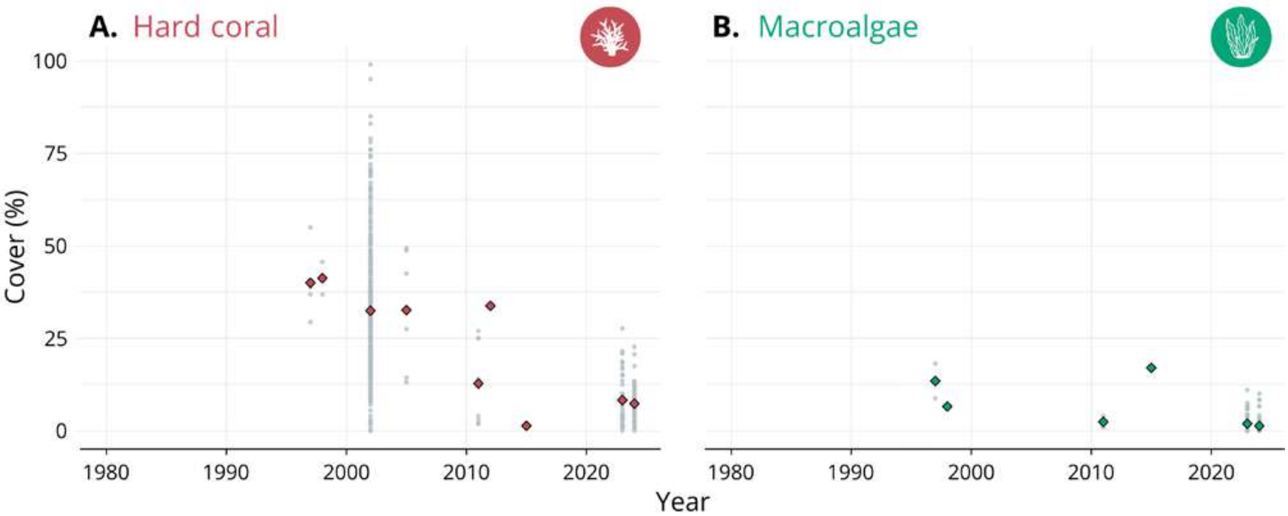

↑ **Figure 2.30.3.** Temporal distribution of surveys from datasets included in the analyses to model temporal trends of the three benthic categories in Panama's Caribbean coral reefs. The y-axis numbers denote individual dataset identifiers, and the text below, shown in parentheses, specifies the corresponding dataset names as defined in gcrmndb_benthos (see Materials and Methods).




↑ **Figure 2.30.4.** Spatio-temporal distribution of benthic cover monitoring sites across the Caribbean coast of Panama. Sites monitored for the greatest number of years are displayed above those monitored for fewer years. For the purposes of this report, a site is defined as a unique set of GPS coordinates. Consequently, small year-to-year variations in these coordinates may have resulted in lower "number of years with data" in this figure compared to those reported in other publications based on the same dataset.

Regionally, these trends mirror Caribbean-wide declines of 50–80% in live coral cover since the 1970s, attributed to cumulative chronic stressors—overfishing, pollution, and disease outbreaks—that reduced reef-building coral abundance and favored opportunistic macroalgae (Cramer et al., 2021). The 2005 mass bleaching and disease event further exacerbated coral loss in Panama and would have slowed recovery trajectories (Eakin et al., 2010).

In the past decade, reefs in Bocas del Toro and the Guna Yala continue to experience low coral cover (often <15%) and persistent macroalgal dominance, sustained by degraded water quality, eutrophication, and limited herbivore populations. Episodes of deoxygenation and sedimentation have caused localized coral mortality and further shifts toward algal-dominated states (Johnson et al., 2021). Collectively, these temporal trends demonstrate a long-term transition from coral-dominated to macroalgal-dominated reef communities in Panama, driven by the interaction of chronic local pressures and acute disturbances. Strengthened management of coastal runoff, fisheries, and marine protected areas is crucial to reverse these declines and enhance reef resilience.




↑ **Figure 2.30.5.** Annual means of observed data (*i.e.* monitoring data) for hard coral (A), and macroalgae (B) in Panama from 1980 to 2024. Grey dots in the background represent the mean values of individual transects conducted each year.

Case study nº6

# Coral reef fish abundance and reef rugosity in Bocas del Toro, Panama

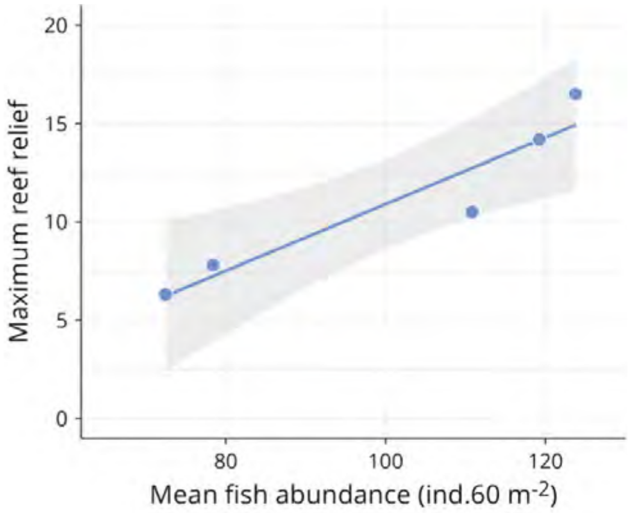
**Author:** Paula Sills[1]

[1] Ankay Conservation

Coral reef ecosystems are highly productive habitats that support diverse fish communities and play a crucial role in marine biodiversity conservation. The structural complexity of a reef, often measured using Maximum Reef Relief (MRR), plays a crucial role in shaping fish assemblages by providing shelter and feeding opportunities. The structural complexity of coral reefs has been declining, primarily due to the loss of framework-building corals, which poses a significant threat to reef-associated biodiversity. (Alvarez-Filip et al., 2009). This study examines the relationship between fish abundance and reef rugosity in Bocas del Toro, Panama, using a belt transect methodology.

Fish surveys were conducted using the belt transect method, covering a 60 m² area per transect (2m width × 30m length). Reef structural complexity was assessed using Maximum Reef Relief (MRR), measured every 5 meters along each transect. The data was collected from five dive sites: Pandora, Grandma's Garden, Manuel's Wall, Casablanca, and Buoy Line.

Analysis revealed a strong positive correlation ($r = 0.95$) between reef structural complexity (MRR) and fish abundance. Sites with higher MRR supported a greater number of fish per transect. According to Gratwicke and Speight (2005), "There is a strong, positive relationship between structural complexity and both species richness and abundance, emphasizing the importance of physical habitat complexity for maintaining fish communities."




↑ **Figure 1.** Relationship between Maximum Reef Relief (MRR) and Fish Abundance in Bocas del Toro, Panama.

The findings confirm the well-documented relationship between reef structural complexity and fish abundance. Higher MRR values provide more shelter and resources, leading to increased fish diversity and biomass. This highlights the importance of preserving structurally complex reef habitats for maintaining fish populations. (Hixon and Beets, 1993; Alvarez-Filip et al., 2009). Predation and the availability of refuge space jointly influence fish community structure, with complex habitats offering more opportunities for prey to escape predators. Higher MRR values reflect more shelter and resources, leading to increased fish diversity and biomass. This highlights the importance of preserving structurally complex reef habitats for maintaining fish populations. Future research should assess long-term trends and potential anthropogenic impacts on reef structure complexity in the region.

↑ **Figure 2.** Spongey Reef, Coral reef with predominance of sponges, April 2024. Location: Bocas del Toro, Panamá. Credit: Felipe Ossandón

↑ **Figure 3.** Bocas del Toro Reef, Coral reef with predominance of Agaricia, September 2024. Location: Bocas del Toro, Panamá. Credit: Paula Sills