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Editorial: SeaFlower Biosphere Reserve: New Findings and Trends in the Largest Caribbean Marine Protected Area

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Editorial on the Research Topic

SeaFlower Biosphere Reserve: New Findings and Trends in the Largest Caribbean Marine Protected Area

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The SeaFlower Biosphere Reserve-SFBR is home to the most developed coral reefs in the Caribbean Sea and some of the few atolls and barrier reefs in the Atlantic Ocean (Geister, 1992). In what was perhaps the first scientific study in this area, John Milliman highlighted the prolific development of coral reefs in Albuquerque, Courtown (Bolivar), Serrana, and Quitasueño, the four atolls that surround the islands of San Andrés, Providencia, and Santa Catalina (Milliman, 1969). The archipelago's reefs likely remained in good condition over the following two decades, whether these were relatively remote or close to inhabited islands. The first expeditions led by INVEMAR in the mid-90's revealed both the enormous coral-dominated areas of these structurally complex reefs and their evident deterioration in coral health with the presence of diseases and partially dead corals (Diaz et al., 1996; Zea et al., 1998). People's awareness of these changes and threats was a motivation to establish a reserve. The Raizal community–descending from European, African, and indigenous people that kept their language and culture–together with the local environmental authority (CORALINA), and in collaboration with international scientific institutions, promoted the establishment of the SeaFlower Biosphere Reserve in the year 2000. The Reserve is considered an exemplary case of participatory mapping and zonation worldwide (Friedlander et al., 2003). Today, the SeaFlower Biosphere Reserve management plan remains the roadmap for sustainable development in the archipelago.

This special topic compiles 13 scientific studies conducted by 72 authors, 55 of whom are Colombians. This is a remarkable effort given the remoteness and financial challenges associated with conducting research in the Global South. Collectively, these studies considered biodiversity levels and ecosystem functioning in the Reserve, emphasizing detecting accelerated environmental changes in recent years. Several tropical storms recently impacted the study area, including Iota (2020), a category five hurricane from which its inhabitants are still recovering. Understanding environmental change and strengthening social-ecological resilience are essential objectives for this region to prosper sustainably.

New biodiversity assessments presented in this topic found 263 previously unreported species. The biodiversity knowledge of the SFBR is increasing in numbers, proving to be an important setting for invertebrates and marine fish that requires further exploration. Of the 138 echinoderms found in the Reserve so far, 10 species were new records (Borrero-Pérez et al.). Similarly, Acero et al. reported 220 species of fish for the first time in the Reserve. These add up to 411 species, approximately a quarter of the total species found in the greater Caribbean when added to previous records. In mesophotic coral ecosystems, between 40 and 115 m deep, Sánchez, González-Zapata et al. found a complete replacement of the community of corals, octocorals, and black corals, totaling 33 species, all new records for the area, and in the case of *Stylaster duchassaingi* is the southernmost record of the species. In contrast, some octocorals may be new to science. Alvarez-Yela et al. also contributed with an original aspect of the Reserve's biodiversity, the microbiomes of some corals, sponges, and sediments; a starting point for the study of microbial diversity in the remote Serrana atoll. These contributions identified new knowledge gaps, including the structure, biodiversity, and functioning of deeper reef environments and coral-associated microbiota.

Other contributions focused on ecosystem functioning and large-scale oceanographic processes. Idárraga-García and León found that in a single atoll (Roncador), there are geomorphological features such as canyons that point at previously unknown flows of matter and energy between shallow and deep ecosystems, as well as large landslides. The SeaFlower Biosphere Reserve occupies a prominent area within the Caribbean basin that is characterized by its heterogeneity in connectivity patterns. Lopera et al. demonstrate that some areas within the SFBR act as larval sinks (e.g., Serranilla, Providencia, Quitasueño, and Serrana), whereas the primary larval sources are found in the northern region of the Reserve (e.g., Serranilla, Alicia, and Nuevo). Populations of queen conch at Serrana bank, as presented by Ardila et al., are as numerous as the most preserved areas in the Caribbean (e.g., Bahamas) and sustain a well-managed artisanal fishery. Ramirez-Gallego and Barrientos-Muñoz found that Serrana and Serranilla comprise hope areas for the endangered populations of loggerhead and hawksbill turtles, where they regularly nest. In addition, Barragán-Barrera et al. found that although studies on dolphins of the genus *Stenella* suggest they prefer coastal waters, observations around the Reserve suggest that for *S. attenuata* and *S. longirostris* these remote and oceanic environments are equally important for their populations. These results constitute new knowledge for the management of the Reserve and its marine resources.

In line with global trends, the SFBR changes have accelerated in the last three decades, resulting in severe coral reef degradation. According to Sánchez, Gómez-Corrales et al. the percent cover of reef-building corals and coralline algae in Serrana and Roncador has decreased abruptly while the cover of leafy algae has increased significantly since 1995. In both areas, these changes have been accompanied by an increase in octocoral densities. According to Bernal-Sotelo et al., key species of reef-building corals, such as the pillar coral *Dendrogyra cylindrus* in Providencia, have declined in percent cover and abundance since the beginning of the century, practically in the absence of recruitment. Further, Lizcano-Sandoval et al. recorded reduced skeletal densities in *Orbicella faveolata* over the last decades. A combination of global and local factors may be working in synergy to explain the decline of reef-building corals in the SFBR. Against this concerning backdrop, Guerra-Vargas et al. find that seagrasses in San Andrés hold enormous potential for removing atmospheric carbon dioxide and sustain higher ecosystem service levels when they occur next to coral reefs. There are many reasons to act decisively to halt the sources of coral reef decline in SFBR. The need to mitigate local stressors and continue advocating for reductions in greenhouse gas emissions globally is clear. The SFBR, however, needs further studies addressing social-ecological issues to understand resilience patterns, including timely assessments of coral reef fisheries.

The SFBR is a natural laboratory for the study and conservation of coral and island ecosystems. International scientific support is urgently needed to explore its deep-sea environments, which are practically unknown. This special topic constitutes a milestone in open marine science within a marine protected area in a country with little tradition of sharing raw data. Collectively, it was a great effort for the authors, the FMR team, and the dedication of the reviewers that allowed us not only to maintain scientific rigor but also to improve the quality of the manuscripts.

AUTHOR CONTRIBUTIONS

JS wrote the editorial with inputs from SB and SH. All authors read and approved the manuscript.

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