

The cities beneath the sea

Written by Karely Jaimes Ramos - HOPE researcher (Vic)

The world beneath the surface

Beneath the surface of the ocean lies a world full of colour and life; coral reefs may appear to be underwater landscapes, but they are much more than just beautiful structures. Some of them are built over hundreds or thousands of years by tiny marine animals; these ecosystems provide shelter, food, and breeding grounds for a variety of species. The complex structures of the coral reefs support marine life while creating a whole essential environment that interconnects with each other and the overall health of the ocean.

Beyond their natural beauty, the coral reefs play an important role in human life, helping protect coastlines from waves and storms, supporting fishing and tourism, and providing food and livelihoods for millions of people. The coral reefs also have a deep cultural significance for Indigenous communities, including Aboriginal and Torres Strait Islander peoples. The importance of coral reefs reaches far beyond the underwater itself, linking marine biodiversity with economies, cultures and communities.

Despite this, coral reefs face growing and continuous pressures from human-related activities and environmental changes. Pollution, coastal development, raising ocean temperatures, and other threats put these ecosystems at risk. Yet, understanding those challenges also raises an important question: can coral reefs recover, and what can be done to protect them? Exploring how reefs function, why they matter, and how they respond to these pressures helps reveal why their protection requires a broader understanding of the ecosystems and communities connected to them.

A city built by tiny animals

First, let's look at the biological story of corals: what they are and how they support each other and the ecosystem. According to the Great Barrier Foundation, corals are invertebrate marine animals that are made of hundreds or thousands of polyps -tiny living organisms- (2023), which allow corals to digest food and capture and ingest prey as well as to protect themselves from predators (Coral Guardian Org, n.d.).



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There are two types of corals: soft corals and hard corals. Hard corals form coral reefs, while soft corals are often fleshy and resemble trees or fans (Loiacono, 2024). Furthermore, corals have existed for more than 400 million years; these invertebrate animals are colonial organisms that grow individually while remaining connected to one another, and this connection allows the formation of coral reefs.

Coral polyps in a symbiotic relationship with a microscopic alga called zooxanthellae build hard calcium carbonate skeletons that ultimately form coral reefs; this relationship is based on the zooxanthellae, which live in the polyp's tissues, providing 90% of the coral's energy through photosynthesis. At the same

time, this energy allows polyps to create the calcium carbonate skeletons that, over the years, form reef structures. Coral reef formation takes hundreds to thousands of years, and they are the largest structures on Earth of biological origin. In fact, the largest coral reef in the world is Australia's Great Barrier Reef (Van Aalst, 2026; Coral Guardian Org, n.d.; Loiacono, 2024).

Furthermore, there are three major types of coral reefs: fringing reefs, barrier reefs, and atolls. Fringing reefs are the youngest type of coral reefs, growing seaward from shorelines or islands; in comparison, the barrier reefs are larger and older formations that run through the coast but are separated by a deeper and wider lagoon; and atolls are circular-shaped reefs that encircle a central lagoon (NOAA, 2026).

The coral reefs are not only a colourful and beautiful landscape of sea life but also function as superorganisms; no single polyp is truly independent, and they depend on each other for food, protection, and shelter, working as a unified whole that supports marine life.

More than a beautiful reef

Coral reefs play a crucial role in protecting coastlines from storms and erosion, providing habitats for marine life, and serving as a source for new medicines. Coral reefs are a diverse ecosystem and are home to more than 4000 species of fish, corals, and other marine life, providing them food and breeding grounds; without them, it would be hard for many marine species to survive (Van Aalst, 2026; NOAA, 2026).

Additionally, coral reefs are a protective barrier during storms and prevent natural damage, as well as providing jobs for local communities. A large number of people depend on them for food, income, and protection, or recreational activities such as fishing, diving, and snorkelling that is a reason why the coral reefs are important for the well-being of the ocean and survival and the wellness of more than hundred million of humans (NOAA, 2026; Loiacono, 2024; UN Environmental Programme, 2026).



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Besides that, according to the United Nations, the economic value of coral reefs ranges from 100,000 to 600,000 US\$ per square kilometre per year across two categories: direct use values such as fisheries and the tourism industry, and indirect use values as benefits from their coastline protection. Even though the coral reefs cover just 0.1% of the ocean floor, they are home to 25% of all marine species (ICRI, 2025; Colognoli, n.d.).

Coral reefs also play a crucial role in the reduction of greenhouse gases in the atmosphere since they capture and store carbon dioxide CO₂ (Colognoli, n.d.). Moreover, the coral reefs also have strong cultural importance and significant connections with indigenous communities worldwide (Davare, 2022). Notably in Australia, Aboriginal and Torres Islander people have been connected with the Great Barrier Reef for immemorial time, even before the reef formation; Aboriginal and Torres Strait Islander people lived on what is now part of the sea, which gave them enormous cultural and practical knowledge about the area; later, after the Great Coral Reef formation, Aboriginal and Torres Strait Islander people keep a relationship with their Sea Country through interconnecting their cultural identity, traditions and spirituality in correlation with a sustainable use of its resources (Great Barrier Reef Marine Park Authority, 2026).

For Aboriginal and Torres Strait Islander people, the Great Reef is more than an economic or natural resource; it is an essential part of their culture, identity, and responsibilities to the Sea Country, and their traditional knowledge of marine environments continues to be passed between generations. Traditional Owners continue to contribute to Reef's protection through cultural practices, community organisation, and partnership with contemporary marine science. Therefore, the acknowledgement and support of their continuing custodianship is fundamental to protecting the reef's biodiversity and preserving its cultural heritage (Great Barrier Reef Marine Park Authority, 2022).

A reef under pressure

Nowadays, there are various threats affecting coral reefs; these can come from both local and global environments. For instance, the local threats are physical damage, destruction, pollution that starts on land such as sedimentation, pathogens, toxic substances, and rubbish and microplastics, overfishing, and coral harvesting (United States Environmental Protection Agency, 2026)

Global threats to coral include warming temperatures, sea level rise, coral bleaching, strong storms, and ocean acidification. The increase in warming temperatures also affects seawater temperatures, and this places stress on corals and causes the expulsion of microscopic algae that produce the food they need, ultimately affecting their coloration, a condition known as coral bleaching (United States Environmental Protection Agency, 2026; Coral Reef Alliance, n.d.).

Coral bleaching is a sign of corals under stress; changes in temperature and environmental pressure cause corals to lose their algae, losing their brown colour and instead turning white from their skeleton or bright yellow, pink, blue, or purple from the sunscreen chemicals. One of the biggest causes of this bleaching in the past 20 years has been the rising water temperatures. However, this condition is variable to various factors; not all types of coral react the same to the changes in water temperature or sunlight, as exemplified by plate corals, which often bleach first; conversely, the slower-growing boulder corals take longer to bleach and have higher survival rates (Great Barrier Reef Marine Park Authority, 2019).

Correspondingly, Ocean acidification is another global threat to corals, since the ocean absorbs carbon dioxide, including around 48% of fossil fuel emissions, causing the ocean pH to drop and affecting their ability to build

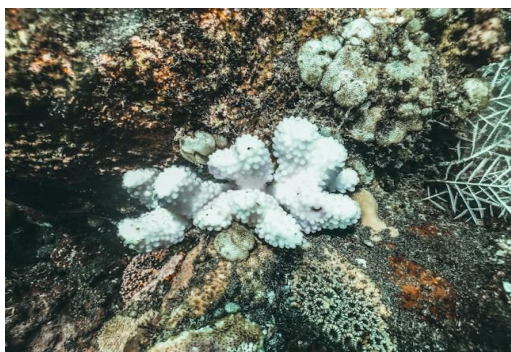


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and grow the skeletons that form the foundation of coral reefs (Coral Guardian, n.d.; Coral Reef Alliance, n.d.; United States Environmental Protection Agency, 2026). Moreover, sea-level rise is also an issue for the growth and conservation of corals; temperature changes not only cause the pH to drop, but the warming also causes sea levels to rise; when coral growth does not keep up with sea-level rise, approximately 200 million people in coastal areas could be displaced (Coral Reef Alliance, n.d.; Coral Guardian, n.d.).

According to the Great Barrier Marine Park Authority (2024), their report on the Great Barrier Reef Outlook found that the reef is under pressure from climate change, poor water quality as a consequence of land-based run-off, coastal development

impacts, and impacts from fishing, as well as the rise above average sea temperatures, cyclones and storms, flood plumes and crown-of-thorns starfish outbreaks. The rapidly changing climate is compounding the stress the Great Barrier Reef faces and reducing its capacity to recover.

Can a reef recover?

After considering the many and different threats to coral reefs, an essential question remains: is it too late to protect them? Although coral reefs face serious challenges, there are opportunities to support their recovery and protect the marine life and communities that depend on them.

Coral reef recovery is possible when surviving corals continue growing and reproducing, allowing new corals to establish themselves in affected areas. Nevertheless, this process takes time and depends on reducing the pressures affecting reef ecosystems. Coral reefs are essential to the world and our ecosystem, and it does not matter if you do not live near the coast; everyone can contribute to their protection. Individual actions count; some things you can do when you visit coral reefs are practicing safe and responsible diving and snorkelling, and using reef-friendly sun protection. Actions at home are also important; for instance, recycling and proper disposal of trash, minimising the use of fertilizers that could affect the quality of water, and reducing stormwater runoff (United States Environmental Protection Agency, 2026).

Nonetheless, while individual actions matter, protecting coral reefs on a broader scale requires coordinated efforts from governments, scientific organisations, and local communities. At the governmental level, protecting coral reefs requires long-term planning. In Australia, the federal government and the Queensland government have the 'Reef 2050 Long-Term Sustainability Plan', which includes a focus on climate change and its impacts; the plan has five priority areas for action: limit the impacts of climate change, reduce impacts from land-based activities, reduce impacts from water-based activities, and protection, rehabilitation and restoration of coral; this plan also includes partnerships with the Traditional Owners of the land, scientists and a diverse range of industries that develop and implement sustainable practices to protect the Reef (Department of Climate Change, Energy, the Environment and Water, 2025; Great Barrier Reef Marine Park Authority, 2025).

In addition to government policies and strategies, the Great Barrier Reef Marine Park Authority uses management programs to protect marine habitats, monitor coral reef health, and address outbreaks of crown-of-thorns starfish that can significantly damage reef ecosystems. Monitoring and management control programs aim to reduce pressure on coral and give affected areas a sustainable opportunity to recover. Another important aspect of coral protection is the involvement and participation of scientists and researchers helping identify changes in coral cover, assess the effects of bleaching events, and understand how reefs respond to different environmental conditions (Great Barrier Reef Marine Park Authority, 2026). This information is essential for determining areas that need additional protection and evaluating the effectiveness of conservation measures.

Furthermore, local communities and Traditional Owners are essential to the ongoing protection of the Great Barrier Reef. As mentioned earlier, Aboriginal and Torres Strait Islander peoples have longstanding connections with Sea Country; their knowledge and cultural responsibilities contribute to the marine environment. Tourism operators, community groups and other industries can also support conservation by adopting responsible practices and participating in the reef initiatives.

Despite these initiatives, protecting coral reefs remains a long-term challenge, and recovery cannot be guaranteed. Government plans, research, and individual actions can help to reduce certain pressures, but the effectiveness of these efforts depends on continuous commitment and the ability to address the different threats

affecting reef ecosystems. Ultimately, protecting coral reefs today is essential to give these ecosystems a better chance of surviving and recovering for future generations.

What happens next?

The future of coral reefs depends not only on the actions taken to protect coral colonies, but also on our ability to understand and manage their wider ecosystems. The Great Barrier Reef is part of an environment which involves seagrass meadows, coastal habitats, and the survival of multiple marine species; these interact with one another, meaning that pressures affecting one part of this system can have consequences for others.

Therefore, protecting coral reefs requires a broader approach that considers water quality, coastal activities, and the impacts of climate change, rather than an isolated approach that addresses threats in isolation. Scientific research, environmental action, and monitoring will remain essential to understand the response of coral reefs to changing conditions. However, the recovery of corals will not happen at the same rate and pace everywhere, and improvements in one area do not necessarily mean a healthy ecosystem. Effective protection requires long-term commitment, cooperation between governments, researchers, local communities and Traditional Owners, and willingness to adapt strategies as new evidence becomes available.

Coral reefs' future will be shaped by the combined effects of global climate action, local management, scientific knowledge and the choices made by the people and industries connected to these ecosystems. The question is not simply if the coral reefs can recover but whether we are prepared to create and maintain the conditions that allow them to do so.

Individual action cannot replace government policies or global efforts to address climate change; however, they can contribute to reducing the pressures on coral reef ecosystems by reducing household waste, responsibly disposing of rubbish, limiting the use of fertilisers contributing to water pollution, and choosing responsible tourism operators and providers when visiting marine environments. People can also support initiatives and advocate for policies addressing climate change and the protection of marine ecosystems. Individual choices can form part of a broader collective effort.

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