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# Coral Matters

THE CORAL REEF RESEARCH HUB MAGAZINE

## CORAL RESTORATION SPECIAL

Can Restoration Efforts Save Coral Reefs?

Also in this issue: Freezing Time for Coral Reefs: Cryopreservation as a Conservation Tool; Restoration or simplification? Avoiding functional erosion in coral reefs

Regulars include: Reef roundup; photography feature; stories from the field, coral career column; get the right gear

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# Coral Matters
# Magazine

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# CoRR Hub News

Welcome to *Issue 2* of Coral Matters, and a warm welcome from all of us at The Coral Reef Research Hub!

In line with our exciting roadmap for 2026, we are delighted to begin rolling out a new series of courses, starting in April with *Essential ID Skills for Coral Reef Scientists*. This course introduces the fundamental principles of identifying reef fish and corals, covering taxonomy to a level appropriate for most high-level field studies. It provides a strong baseline skillset that can be developed over time, ultimately enabling identification to species level. In addition, the course includes key introductions to sponges, other invertebrates, plants, and algae — equipping novice field researchers with the core knowledge needed before entering the field. This course will be complemented by future ID-focused modules designed to further develop these skills. Together with other courses currently in development (Introductions to QGIS, R Studios and more), these will form a comprehensive library of learning resources to support coral reef scientists at every stage of their careers.

And there's more to come! We are also excited to share that development of our mobile app is progressing well, and we are now past the halfway point, with all core frontend systems and base infrastructure in place. In preparation for launch, we will also be integrating Stripe across both our website and app to provide a smoother, more flexible subscription experience for our members.

As part of this next phase, we will be implementing some important updates to the structure of our website to better align with the app's navigation and functionality. One key change is that the resource dashboard will no longer be available to Basic Members. From 1st April, Basic Members will have access to the news feed, networking features, and profile pages only.

Further updates are on the way, and we encourage you to join our website or subscribe to our mailing list to stay informed. Enjoy!

The CoRR Hub Team

# GET CONNECTED

# *Reef Roundup: Around the World*

## Noteworthy coral news from around the world:

1. **Florida Keys, USA:** Recent U.S. policy rollbacks under Trump are weakening climate protections and scientific capacity, which scientists warn could accelerate coral reef collapse already driven by warming oceans and environmental stressors. (Mother Jones, 2026)
2. **Great Barrier Reef, Australia:** Citizen scientists discovered and mapped what is believed to be the largest known coral colony on the Great Barrier Reef, spanning over 110 m. (Oceanographic Magazine, 2026)
3. **Dubai, UAE:** Dubai is using innovative coral nurseries and large-scale artificial reef projects within man-made and coastal environments to actively restore marine habitats and boost biodiversity. (Condé Nast Traveller, 2026)
4. **Caribbean Basin:** Scientists exploring remote Caribbean waters near UK overseas territories discovered previously unseen coral ecosystems and marine species, highlighting both the richness of these reefs and the importance of protecting them from growing environmental threats. (BBC, 2026)

5. **Moorea, South Pacific**: A study has revealed that coral reefs in Moorea remains physically intact after bleaching, although its recovery has stalled because dead coral structures are now dominated by algae and ecological conditions no longer support natural regeneration. (Phys.org, 2026a)

6. **Florida and Wider Caribbean:** A recent study found that applying a topical antibiotic paste to corals affected by stony coral tissue loss disease is both safe and highly effective, significantly improving survival without disrupting coral microbiomes or increasing antibiotic resistance. (News Wise, 2026)

7. **Indopacific and Worldwide:** Heat-tolerant corals may allow some reefs to persist under climate change, but most reefs are still expected to shift toward net erosion, meaning they will degrade faster than they can grow despite these adaptations. (Pys.org, 2026b)

## In more detail: Roundup 7

This global study examined how some coral species that show increased tolerance to higher ocean temperatures may help reefs persist in a warming climate, as these corals are more likely to survive repeated bleaching events. By shifting toward communities dominated by heat-tolerant species, certain reef systems may avoid total collapse and maintain some level of ecological function, at least in the short to medium term.

However, the research also finds that this apparent resilience comes with a significant trade-off: even where corals survive, reef growth is expected to decline while erosion increases. This means that reefs may continue to physically degrade over time, losing their structural complexity and ability to support biodiversity, protect coastlines, and sustain fisheries, ultimately transforming into less functional ecosystems despite the presence of living corals.

# Can Restoration Efforts Save Coral Reefs?

Coral reef restoration has rapidly become one of the most visible responses to the global decline of coral reef ecosystems. Across tropical regions, divers carefully attach coral fragments to degraded reefs, underwater nurseries cultivate juvenile colonies, and scientists increasingly refine techniques to enhance coral survival and growth. These efforts are often presented as a hopeful counterbalance to widespread reef degradation. However, beneath this optimism lies a more complex and uncomfortable reality: many restoration projects struggle to achieve long-term success. The fundamental issue is not a lack of scientific innovation or commitment, but rather a failure to address the underlying causes of coral mortality. In many cases, corals are being reintroduced into environments that remain fundamentally unsuitable for their survival.

Coral reefs are among the most biologically diverse ecosystems on the planet, supporting approximately 25% of all marine species despite occupying less than 1% of the ocean floor (Spalding *et al.*, 2001). They provide critical ecosystem services, including fisheries production, coastal protection, and tourism revenue. Yet these ecosystems have experienced dramatic declines, with more than half of global coral cover lost in recent decades (Hughes *et al.*, 2017). The drivers of this decline are often framed in terms of global stressors, particularly rising sea surface temperatures, which disrupt the symbiotic relationship between corals and their zooxanthellae and lead to bleaching events (Hoegh-Guldberg, 1999). While this mechanism is well established, it represents only part of a broader and more complex picture.

Coral mortality rarely results from a single stressor acting in isolation. Instead, reefs are subjected to multiple, interacting pressures that collectively reduce their resilience. Local stressors such as nutrient enrichment, sedimentation, pollution, and overfishing frequently play a critical role in weakening coral health prior to bleaching events. Elevated levels of nitrogen and phosphorus, for example, have been shown to disrupt coral physiology, promote algal overgrowth, and increase susceptibility to disease (Bruno *et al.*, 2003; Vega Thurber *et al.*, 2014). These localised pressures often determine whether corals can recover from thermal stress or succumb to it. Despite this, they are frequently underemphasised in both public discourse and management strategies.

Coral reef restoration aims to accelerate natural recovery processes by increasing coral cover, enhancing structural complexity, and restoring ecological function. Among the most widely used techniques are larval propagation, microfragmentation, and the transplantation of so-called “corals of opportunity.” Larval propagation involves collecting gametes during spawning events, fertilising them under controlled conditions, and settling larvae onto substrates before outplanting them onto reefs. This approach has the potential to enhance genetic diversity and scale restoration efforts, but survival rates remain highly variable, particularly in degraded environments. Microfragmentation, in contrast, involves cutting corals into small fragments that grow rapidly and can fuse together, allowing for the accelerated growth of massive, slow-growing species (Forsman *et al.*, 2015). The use of corals of opportunity - naturally detached fragments collected after disturbances - provides a low-cost and immediate method of transplantation, but does not address the conditions that led to their detachment in the first place.

Despite the development of these increasingly sophisticated techniques, the long-term success of restoration projects is often limited. A key reason for this is that restoration efforts frequently focus on replacing lost corals without addressing the environmental conditions that caused their decline. Transplanted corals are commonly returned to reefs where water quality remains poor, nutrient levels are elevated, and disease pressures persist. Under such conditions, mortality rates remain high, and restoration becomes a repetitive cycle of planting and loss rather than a pathway to recovery (Edwards, 2010). This highlights a fundamental mismatch between restoration interventions and the ecological realities of degraded reef systems.

One of the most significant and underappreciated drivers of coral decline is nutrient enrichment, particularly from anthropogenic sources. Elevated concentrations of nitrogen and phosphorus are associated with a range of negative outcomes, including increased algal competition, reduced coral calcification, and heightened disease prevalence. Phosphorus, in particular, has been implicated in the disruption of coral-associated microbial communities and the enhancement of pathogen virulence, leading to more frequent and severe disease outbreaks (Vega Thurber *et al.*, 2014). In this context, coral mortality cannot be understood solely in terms of bleaching; it is also the result of compromised biological function and increased vulnerability to infection.

The emphasis on climate change as the primary driver of coral reef decline, while scientifically valid, may inadvertently obscure the importance of these local stressors. Climate change operates at a global scale and requires coordinated international action, making it difficult to address directly through local management. As a result, it can become a dominant narrative that overshadows more immediate and manageable factors such as water quality. This framing risks creating a perception of inevitability, where reef decline is seen as largely beyond human control. However, research has demonstrated that improving local environmental conditions can significantly enhance coral resilience to thermal stress, suggesting that local interventions remain both relevant and necessary (Anthony *et al.*, 2011).

The situation in Florida Bay provides a compelling example of how local factors can drive coral decline. Water management practices in the Everglades have altered natural hydrological patterns, resulting in periodic flushing events that transport nutrient-rich freshwater into coastal systems. These inputs introduce elevated levels of nitrogen and phosphorus, fundamentally altering water quality (Szmant, 2002). The consequences for coral reefs are profound, including increased algal growth, higher disease prevalence, and reduced coral survival. Phosphorus enrichment, in particular, has been strongly linked to coral disease dynamics, further compounding reef degradation (Vega Thurber *et al.*, 2014). While coral loss in this region is often attributed primarily to rising temperatures, the role of chronic nutrient enrichment suggests a more complex and locally driven process of decline.

This raises an important question about the role of restoration in coral reef conservation. While restoration can play a valuable role in supporting recovery, it is not a substitute for addressing the underlying causes of degradation. Without improvements in water quality, reductions in nutrient inputs, and effective management of local stressors, restoration efforts are unlikely to achieve lasting success. Instead, they risk becoming symbolic interventions that demonstrate action without delivering meaningful ecological outcomes.

Coral reef restoration should therefore be understood as one component of a broader conservation strategy rather than a standalone solution. Effective reef management requires a dual approach that combines global efforts to address climate change with targeted local interventions to improve environmental conditions. By prioritising water quality, reducing nutrient pollution, and addressing disease dynamics, it is possible to create conditions in which restoration efforts can succeed. Without such measures, the continued focus on restoration alone may offer the appearance of progress while failing to halt the underlying processes driving reef decline.

Ultimately, the future of coral reefs depends not only on our ability to restore what has been lost, but on our willingness to confront the factors that caused that loss in the first place. Restoration can only be effective if it is grounded in ecological reality. Without addressing the root causes of coral mortality, it remains an incomplete and ultimately insufficient response to one of the most pressing environmental challenges of our time.

# Freezing Time for Coral Reefs

## Cryopreservation as a Conservation Tool

By Nayan Kulshreshtha

Ocean warming, mass bleaching, disease, and habitat loss are all posing increasing risks to coral reefs, forcing conservation scientists to consider alternatives to conventional defenses. Although preserving reefs in their native habitat is still crucial, it might not be enough on its own anymore. Coral cryopreservation, or the long-term storage of live coral material at extremely low temperatures, is a new strategy. Studies have demonstrated that it is not only feasible to freeze coral life, but that frozen material can be grown, resurrected, and possibly reintroduced into reefs, as evidenced by the pioneering work conducted in Taiwan by Dr. Chiahsin Lin's lab (Lin *et al.*, 2023; Loeslakwiboon *et al.*, 2024).

### Banking Biodiversity

The capacity to preserve biological material from a variety of coral species has been one of the most significant developments in coral cryobiology. Researchers have shown that somatic cells and sperm from dozens of reef-building corals can be isolated, cryoprotected, and preserved in liquid nitrogen while retaining quantifiable post-thaw viability (Toh *et al.*, 2022). Large-scale coral cryobanking was made possible by this effort, which turned cryopreservation from a small-scale experimental tool into a conservation strategy at the biodiversity level.

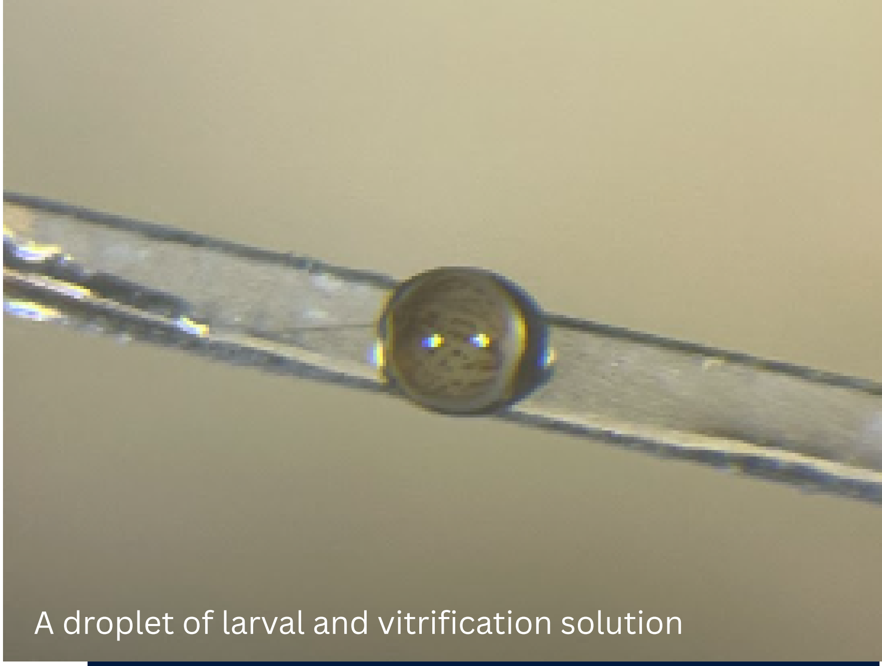
Cryorepositories serve as biological insurance plans, protecting genetic variety that may otherwise be lost from reefs impacted by recurrent bleaching events by banking cells rather than depending solely on living colonies (Loeslakwiboon *et al.*, 2024).

Cryobanking of Coral Larvae

### From Frozen Larvae to Living Reefs

Long-term reef recovery ultimately depends on complete creatures, even though cell preservation is useful. The discovery that coral larvae can withstand freezing and maintain the capacity to settle after thawing, a crucial biological stage necessary for reef formation, was a significant advance (Cirino *et al.*, 2019). Significantly, these larvae were able to continue their symbiotic association with dinoflagellate zooxanthellae, proving that freezing did not irreversibly break this vital alliance.

This landmark was further pushed by later efforts. Successful development of cryopreserved larvae resulted in the production of fully developed adult corals (Narida *et al.*, 2023). This accomplishment demonstrated that cryopreservation can sustain the whole coral life cycle, from frozen larvae to reproductive adults, significantly increasing its applicability for assisted breeding and restoration projects.


A droplet of larval and vitrification solution

## Preserving the Coral–Algal Partnership

Corals depend on symbiotic microalgae for growth, energy, and stress tolerance; they are not solitary organisms. Coral symbionts themselves have been the subject of cryopreservation initiatives in recognition of this. Studies have demonstrated that thermotolerant strains of reef-dwelling dinoflagellates can be successfully frozen and recovered without compromising their viability (Lin *et al.*, 2019). By keeping these heat-resistant symbionts alive, future corals may be paired with algae better adapted to warmer waters.

There are several technical difficulties when freezing living things, especially when it comes to damage from ice crystals that form during cooling and warming. These restrictions have been lessened because of developments in vitrification, a process that solidifies cells into a glass-like state without ice formation. By avoiding recrystallization during thawing, quick laser warming has further increased survival and increased the scalability and dependability of long-term storage (Lin *et al.*, 2023). For coral cryopreservation to go from lab experiments to a reliable conservation infrastructure, these improvements are crucial.

The creation of specialized cryorepositories marks a significant change in the concept of coral conservation. Dr. Chiahsin Lin's team has established repositories that are intended to preserve viable material for future generations by methodically gathering, freezing, and storing coral larvae (Loeslakwiboon *et al.*, 2024). Even if natural reefs continue to deteriorate, these facilities guarantee that coral diversity will be available for upcoming studies, restoration projects, and aided evolution initiatives.

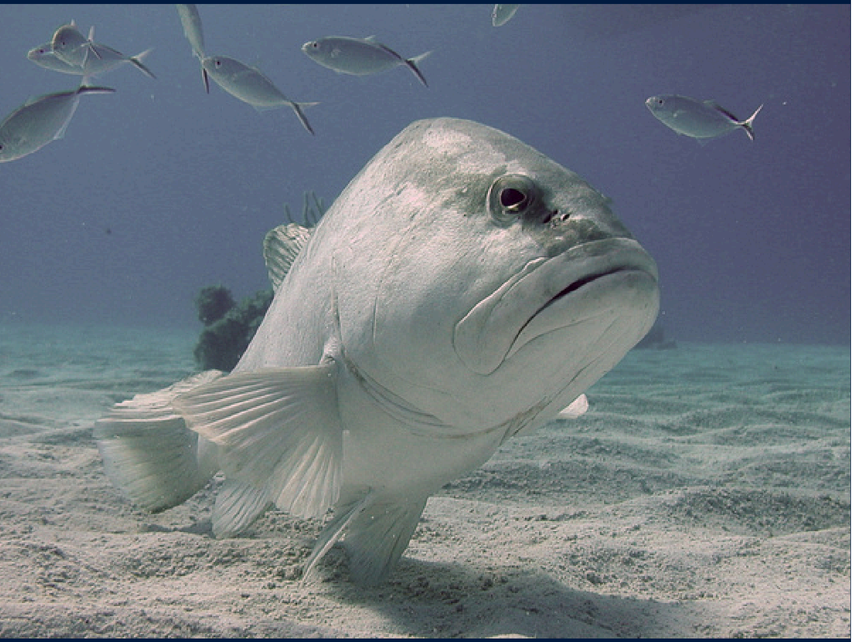
## Buying Time for Coral Reefs

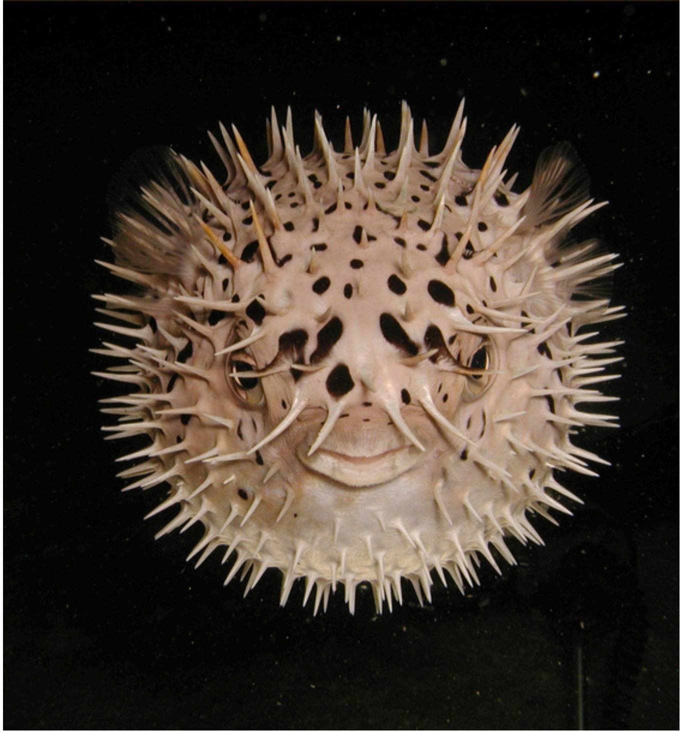
The urgent need to preserve reefs in the wild cannot be replaced by cryopreservation, nor can it stop climate change. Rather, it provides something just as important: time. Conservation science is protecting future alternatives by storing coral cells, larvae, symbionts, and future adults in frozen archives. These cryobanks might eventually enable coral life to recover from ice back to the reef in a period of swift environmental change (Buttari *et al.*, 2025).

Images courtesy of Dr. Chiahsin Lin's Coral Cryopreservation Laboratory, National Museum of Marine Biology and Aquarium, and National Dong Hwa University, Taiwan.

# Photography Feature

Lippold Haken, Florida





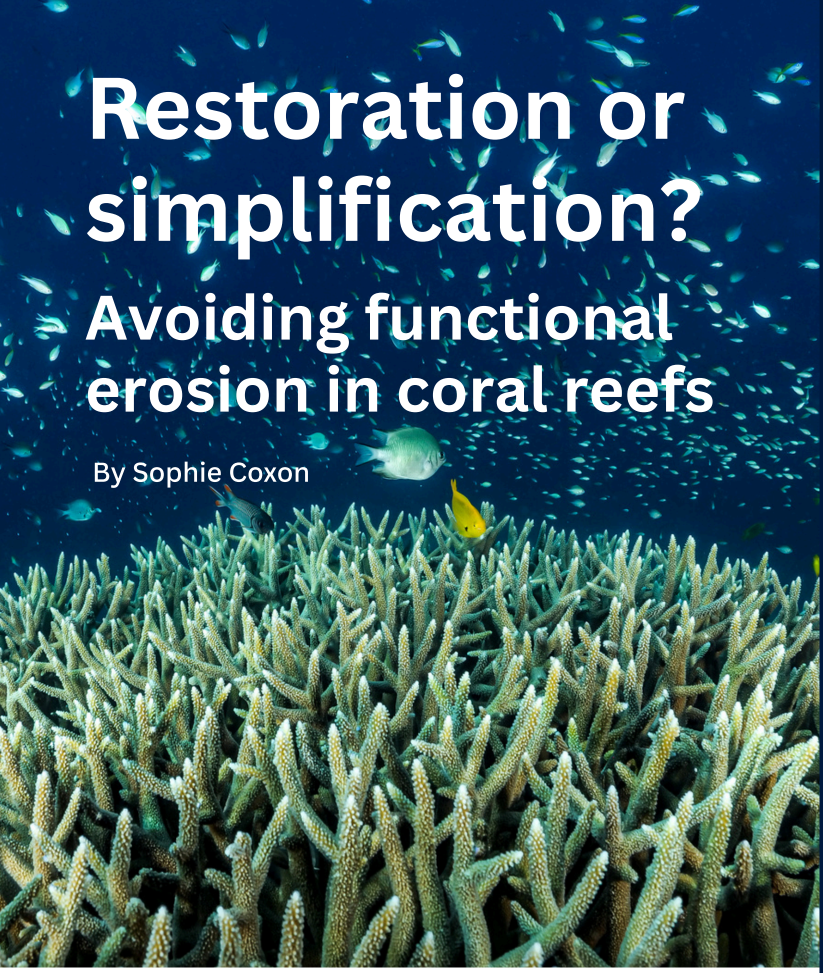
**Clockwise from top left:** A Nassau Grouper (Epinephelus striatus) hovering curiously over a sand patch; a startled balloonfish (Diodon holocanthus) puffed up defensively; a Caribbean reef squid (Sepioteuthis sepioidea) making a swift escape; and a stunning frontal view of a Nassau Grouper (Epinephelus striatus).

**Inset:** Many of Lippolds photographs can be found in the book 'An Underwater Guide to Anguilla, British West Indies (Wynne, 2019).

# Restoration or simplification?

## Avoiding functional erosion in coral reefs

By Sophie Coxon



In a time of global uncertainty across many domains and disciplines, the climate crisis and its plethora of ecological impacts are perhaps shown most starkly in our coral reefs, as the white of surrender sweeps the tropics in another mass bleaching event (Ceccarelli *et al.*, 2026). By now, we are used to the concept of coral bleaching, its causes, and the effects it has on marine ecosystems both tropical and temperate. But an aspect we are still grappling with is its aftermath, and the long-term effects on ecological processes where reefs suffer severe degradation. After being pushed closer to the brink year upon year by warming oceans, pollution, and destruction, a critical tipping point has recently been passed (Gianelli *et al.*, 2026); coral reefs now face a precarious future, teetering on the edge of irreversible loss, with dire consequences for marine and human life alike.

Whilst this may not be the brightest outlook, a remarkable effort has been made collectively across the globe to actively restore coral reefs. From nurturing fragments on rope nurseries to genetically modifying super-specimens in the lab, a variety of techniques have been developed, each with unique benefits and challenges. The natural growth rate of coral is extremely low, with the fastest growing species only managing to increase by centimetres per year, making the rapid expansion of restoration projects and overall coral cover an impressive achievement. However, the field is not without its flaws, and major challenges are emerging as the field evolves. The scalability of current approaches is proving limited (Boström-Einarsson *et al.*, 2020), securing adequate funding for long-term monitoring is arduous, and the underlying threat of total loss in the wake of extreme heat waves, ocean acidification, and mass mortality due to invasive species or disease outbreaks is an ever-present concern, with the potential to wipe out years of work in a matter of weeks or even days.

In an attempt to outpace decline, restoration projects often prioritise the most adaptive, fast-growing coral genera and species, which yield the highest success rate in recolonising degraded areas and withstanding changing environmental conditions. Branching coral, specifically of the Acropora genus, is the most commonly used, due to its unusually high growth rate, finger-like morphology and ease of breakability (Boström-Einarsson *et al.*, 2018). Healthy fragments naturally break off during stormy weather, and can be collected by divers and relocated to rope nurseries or metal frames at restoration sites. The elongated form makes the fragments easy to attach to frames and ropes with simple cable ties, and the rapid growth rate makes positive change visible within a matter of weeks. This makes for an excellent crop of a single coral genera, however the goal of restoration is to restore what has been lost, rather than to replace it with something different. And what has been lost is an entire reef made up of hundreds of species, all of which must be captured in restoration for successful functioning of the ecosystem and sustainable resilience against future conditions (Hein *et al.*, 2021).

In May of 2025, I spent a month in the Maldives, conducting research on reef restoration, looking at an adjacent ecosystem effect - fish. I wanted to compare the fish assemblage found at an established restoration site (5 years old) with that at a natural reef site, to understand how the proportional cover of different coral types influences the associated biota - in this case the abundance and diversity of fish, which are an excellent proximal measure of overall reef health (Samoilys *et al.*, 2025). Due to the tight relationship between reef fish and their coral counterparts, the structure of a fish community and the relative weightings of different species and functional groups paints a detailed picture of the state of a reef. Despite the importance of fish, both for the reef itself and for local fishers, this aspect of the reef system is overlooked in research, more often than not - to the detriment of long term reef management and resilience.

My selected reef sites were just offshore from an artificial resort island in the North Male Atoll, within 2km of each other and displaying similar environmental and topographic characteristics. After a pilot dive over the sites to assess conditions, it was already very clear that the restoration site was dominated by branching Acropora coral, and lacked the diversity of the surrounding natural reef which was a mosaic of bouldering, plating, branching and encrusting coral, embellished with rock formations, algae, sponge and areas of densely layered coral rubble. While other genera such as Porites (massive) and Montipora (branching) were somewhat represented within the restoration site, most frames were predominantly Acropora based, a difference visible even to the untrained eye. This pattern was reflected significantly in the benthic survey data collected over the month period, and interestingly, a clear pattern in fish assemblage also emerged.

Collected over 3 weeks along daily transect lines, fish abundance was recorded to species level, with fish later grouped by functional role, based on feeding habits. The restoration site showed an overwhelmingly higher abundance of Dascyllus aruans, a species of damselfish known for their territorial tendencies and aggressive nature. The restoration site was also significantly less diverse in its fish community, showing lower numbers of herbivores and a less balanced assemblage than that seen on the natural reef. Dascyllus are typically associated with Acropora coral, forming resident family groups within a coral colony which they guard fiercely against other organisms (Chase *et al.*, 2020). The prevalence of Acropora at the site likely explains the immensely high numbers of Dascyllus, as once these fish move into a coral, they are staying for the long haul. The lack of diversity in coral types may have also limited the available niche space for other species, causing a simplifying effect as a monoculture of coral emerged from restoration efforts - and in turn reared a monospecific increase in fish.

The numerous technicalities and various confounding factors contributing to this outcome undoubtedly play an important role, however the key takeaway from this study is very simple and is repeated across many habitats and ecosystems: if you simplify the habitat, you simplify the community that depends upon it (Gámez-Virués *et al.*, 2015). And with each species lost from an area or ecosystem, a layer of resilience against adverse events is also lost. In a time such as this, where the list of threats to biodiversity seems to grow by the day, maintaining resilience in ecosystem functions is the most urgent goal of restoration.

If we look at forestry, or agriculture, a similar pattern can be seen - where old growth forests and natural mixed woodland are cleared and replaced with monospecific plantations of a single tree species, biodiversity levels plummet (Wang *et al.*, 2019). Not only because of the direct loss of certain tree species, but also because of the collective loss of nutrient input, cycling, and ecological networks. Where a mixed woodland has multiple tree species which provide different nutrients, services and processes, a mosaic of various undergrowth species, dead wood, fungi, and associated animal life, a plantation forest lacks the natural mess and overlap of life histories, phases and cycles, which provide a buffer of ecological machinery that can fill in where another fails. Reefs are fundamentally the same; where the rubble layer, uneven topography, and vast diversity of niche spaces formed by coral diversity is lost, all the ecological cushioning against adverse events diminishes, leaving the ecosystem exposed and vulnerable to collapse. It is like replacing a flower meadow with a lawn, and then looking for butterflies.

Spending so long on the same patch of coral reef was a valuable experience, in that I came to know what to expect from different fish species, where they would be, and what they would likely be doing. My anecdotal observations were strongly mirrored in my data, which was assuring in itself, and the study unearthed some deeper questions we should collectively ask ourselves as we continue to expand and improve restoration efforts. If we can find ways to increase the establishment and survival of corals with suboptimal morphotypes (such as massive or plating) in restoration methods, and seek to amalgamate at least a minimum percentage of total restoration cover with underrepresented types, this could make a large increase in the diversity of associated species supported. Diversity levels of both the coral substrate and the dependent organisms, particularly fish, are equally important and monitoring these as restoration progresses at a site is essential (Seraphim *et al.*, 2020).

The rubble layer was essentially missing from the restoration site, limiting the grazing and sheltering space for a variety of cryptic and elusive species such as grouper, which we saw very few of compared to at the natural site where rubble was abundant and complex. Removal of rubble and dead coral is basic protocol for many restoration projects, but perhaps we should re-examine the motives behind this. In natural systems, organic detritus forms a crucial component of food webs, acting as a habitat, food source and nutrient buffer, forming the basis of energy flow across trophic levels. Whilst removing this layer may reduce mess and make restoration sites appear more cared for and in better condition, the reality is that natural, wild places are often just that: wild. It is important that we overlook the aesthetic appeal of orderly systems and restore nature by nature’s own terms, rather than our own human perceptions of what looks best.

Overall, the collective effort, time and funding invested in coral restoration is astounding. However, we can always do more, and whilst any coral cover is likely better than no coral at all, where we have the means and knowledge to do so, coral restoration should strive for diversity to establish resilience, stability, and long-term sustainability of reef ecosystems. Using evidence-based approaches and being flexible in our methods and applications is critical to supporting adaptive ecosystems which can function and thrive under increasingly unpredictable and adverse conditions.

# Stories from the Field

## Counting Coral's Gene Banks and Why They're Working

By Brooke True

Conservation begins, and continues, with the 'not-so-simple' act of raising awareness. So, with that, it's a privilege to be able to share what we do. This piece is meant for those encountering coral conservation for the first time, and for those who have been around the coral-restoration block a few times and are curious about why we do things the way we do. So this is my attempt to cover the basics. Conversationally, transparently, and straight from the field!

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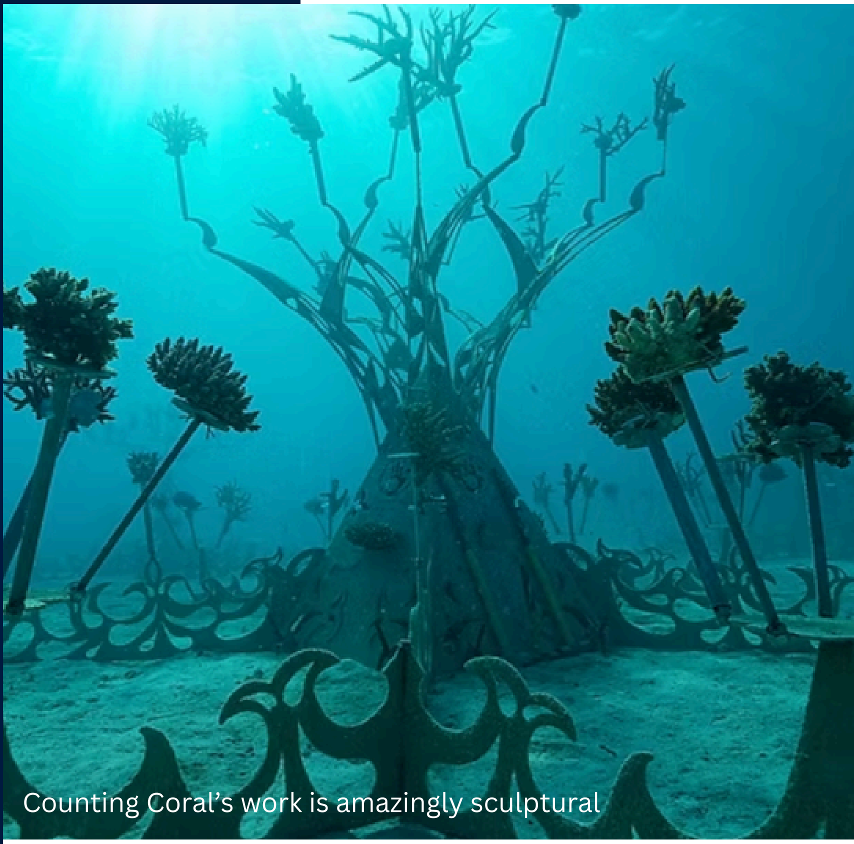
### How It Started

You don't need a degree, formal training, or even a grand plan to begin contributing to conservation. What you need first is something much simpler: an inability to ignore that the natural world is quietly unraveling. That's where this began for me.

My name is Brooke, and I'm the Executive Director of Counting Coral, and we're a small but very determined 501(c)(3) nonprofit. We're fully volunteer-based, entirely donation-driven, and gratefully, what started as a simple "let's just try" moment has grown into something we're immensely proud of. Now, 5 years in, we have created a global community of collaborators, restoration systems thriving underwater, and real, visible impact on the reefs surrounding the islands we work with.



Counting Coral's work is amazingly sculptural

### Coral Conservation: One Goal, Many Approaches

Coral conservation takes many forms, but at their core they all aim, or should aim, to protect reef ecosystems and promote their long-term resilience. Some initiatives focus on establishing marine protected areas, improving water quality, or conducting long-term monitoring to better understand reef health and reduce human pressure on these ecosystems. Others take a more hands-on approach through active restoration, collecting coral fragments, growing them in nurseries, and later transplanting them onto degraded reef areas. Some projects also experiment with artificial reef structures that provide new surfaces for coral growth, while emerging research explores techniques such as larval propagation and assisted evolution to help reefs adapt to changing ocean conditions.

Counting Coral works within this restoration space through a genetic coral bank system built around a three-stage propagation model. Our approach is designed to maintain coral biodiversity while producing a steady and sustainable source of corals for reef restoration.

*The Three Stages in Question:*

**Primary culture** – coral fragments from the reef are placed onto a permanent structure, creating a protected gene bank where colonies are maintained as long-term parent stock for propagation.

**Secondary nurseries** – fragments taken from these parent colonies are grown out on dedicated nursery structures, where they can mature and multiply.

**Out-planting** – once established, these nursery-grown corals are transplanted back onto nearby reefs. Because the parent colonies remain protected within the gene bank, there is no need to repeatedly collect coral from natural reefs.

This approach significantly reduces how often coral must be collected from natural reefs, as well as improving propagation efficiency and creating a steady supply of coral ready for restoration. In many ways, it functions like what we like to call a conveyor belt or a closed-loop system.

We noticed several gaps within coral conservation that weren't being addressed. So we took this already effective framework and pushed it further.

## The Materials

One of the most overlooked questions in restoration is surprisingly simple: What are we actually putting into the ocean?

Many coral restoration structures are built with materials that are convenient or inexpensive, but not always ideal for the ocean long term. Anything placed underwater interacts with the ecosystem around it, sometimes in ways we don't immediately anticipate. Unfortunately, some commonly used materials, including certain metals, ropes, pipes, cement structures, and plastic will degrade and introduce harmful elements into reef environments over time.

To avoid this, every structure and element used by Counting Coral is built from marine-grade stainless steel, a material valued for its strength, corrosion resistance, and chemically inert behavior in seawater. It can withstand extreme ocean conditions, support coral growth over centuries, and importantly does not introduce harmful compounds into the surrounding environment. This material choice forms the foundation of our restoration systems.

Top view of a Counting Coral sculptural gene bank

## The Engagement

The second gap we encountered is less scientific and more human.

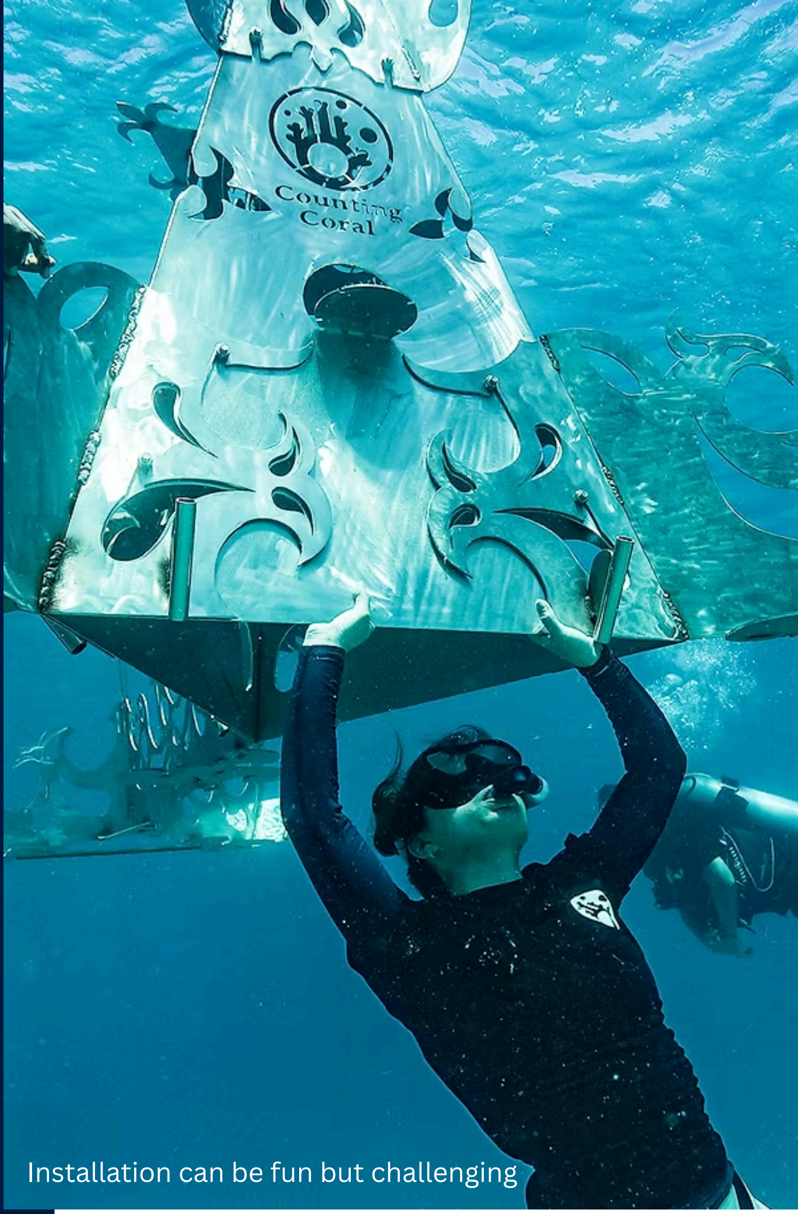
Unfortunately, or perhaps fortunately, people’s attention spans are short, and before something can matter, it usually has to catch their eye. Nonprofit work is challenging enough to begin with, but when you get as niche as coral conservation, it becomes a real battle for eyes and ears. We knew that efforts that people can see, experience, and feel connected to often lasts longer and grows stronger.

With this, we leaned into the unexpected blend of art and conservation. Our sculptural pieces, both individually and as a collective park, are designed to be visually striking, unique, and inviting.

It’s not uncommon for people to see our work and feel mesmerized, puzzled, or even skeptical that something so artistic could help a reef. Fortunately, beneath the aesthetics of our work lies a great deal of engineering, science, and reef-forward design.

## The Design

Every curve and hand-cut opening is intentional. The intricate cut-outs and sweeping forms are designed to work with the ocean itself, guiding water flow through the structures while creating pockets of habitat for fish and marine life. The sculptural geometry stabilizes each module on sandy seabeds while allowing natural currents to move freely through the system. Built from marine-grade materials and engineered for harsh ocean environments, the structures are designed to withstand storms and cyclones, with a projected lifespan of up to 500 years underwater.



Installation can be fun but challenging

The multi-tiered levels allow corals to grow at different depths, letting us experiment with variations in temperature, light exposure, and environmental conditions, while keeping colonies close enough together to support growth and propagation.

Each structure is also part of a mapped and coded system. Every arm, module, and coral attachment point is logged and tracked. A simple code such as M1-A12 refers to a precise coral location within the system, allowing us to monitor growth, survival, and propagation over time. What appears artistic on the surface is, underneath, a carefully organized restoration infrastructure.

## A Zero-Impact Design

We're happy to class our work as zero-impact. I shall explain.

Our systems are installed exclusively on soft sandy substrates, avoiding live reef or rock structures entirely. They are secured using removable anchoring pins designed to withstand storms and cyclones, while still allowing complete removal of the installation if necessary.

Our Gene Bank's and coral nursery structures are positioned adjacent to reef systems, allowing natural marine life movement and ecological connectivity, while remaining strategically placed to avoid direct impact on existing reef habitat. The structures themselves can be lifted from the seabed with minimal disturbance to the surrounding environment.

Additionally, the stanchions used to hold parent corals are removable, allowing corals to be repositioned within the system if environmental conditions shift, or removed entirely if needed. Given the number of restoration projects that have been abandoned over time, we are intentional about not placing structures in the ocean unless they are beneficial and actively maintained. Ultimately, every component is designed with reversibility in mind. Everything we install assumes the possibility that one day it may need to be removed without leaving a trace.

## The Conveyor Belt of Coral

Now, back to the restoration system itself.

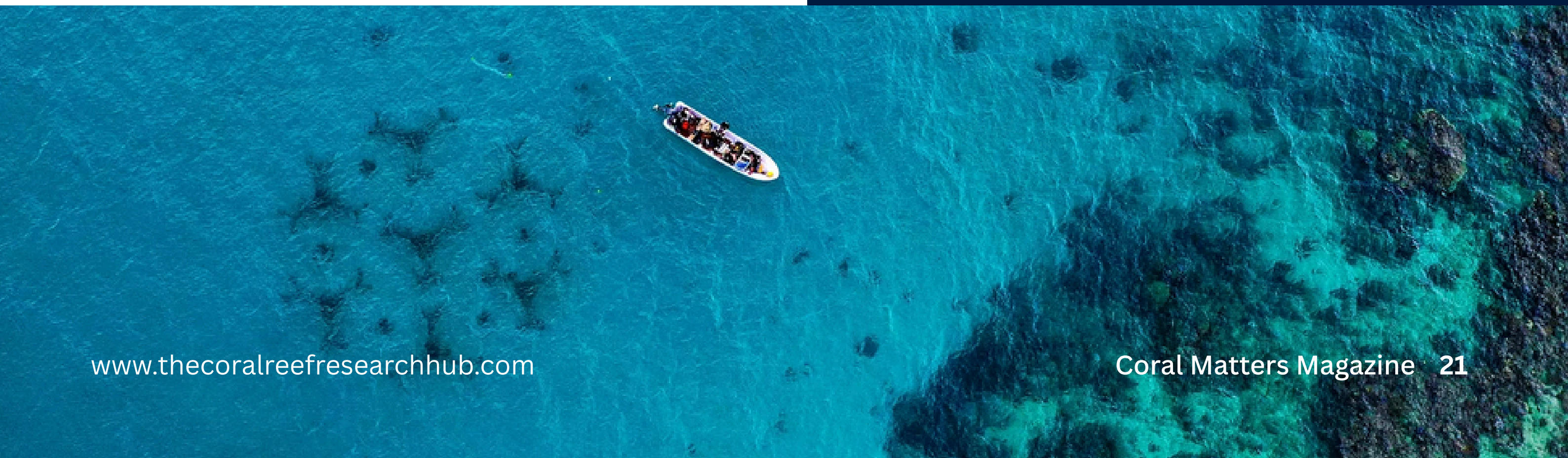
Gene bank → nursery → reef.

Parent corals are chosen with biodiversity in mind to avoid creating monocultured reefs. We focus on three categories: corals of opportunity (naturally broken fragments that would otherwise be lost), resilient corals that appear well adapted to harsh local conditions, and rarer species that will help strengthen overall reef diversity.

After these colonies have been established and monitored for over a year, fragments are transferred to secondary nurseries, where they are grown and tracked until they reach a size suitable for restoration.

Once mature, these nursery-grown corals are out-planted onto nearby reef systems, helping rebuild coral cover and biodiversity. Because the parent colonies remain protected within the gene bank, the system creates a sustainable source of coral fragments without repeatedly harvesting from natural reefs.

Over time, the process begins to function like a conveyor belt of coral, continuously growing, fragmenting, and returning corals to the reef while preserving the genetic diversity needed for long-term resilience.



## Saving the World's Reefs? Not Quite.

Claiming to save the world's reefs is unrealistic for any single team. What we can do, however, is focus on protecting and strengthening specific reef systems, especially those connected to the communities and local establishments that rely on them, often more than they realize.

Reefs do far more than enhance your holiday experience. Their true value is far greater than I could fully capture here, from protecting coastlines, sustaining economies and serving as indicators of broader planetary stress. When reefs decline, the impact is felt quickly, both in the ecosystem and in the communities connected to it.

By working with islands and the resorts that operate alongside them, we can help strengthen local reef biodiversity, maintain protected genetic reservoirs through our coral gene banks, and create a steady supply of coral fragments that can be returned to nearby reefs over time.

It is also important that those who benefit from reefs, even indirectly, play a role in protecting them. Tourism, diving, and the experience of reefs are something of a double-edged sword. Greater exposure brings appreciation and awareness, which can inspire protection, but increased human presence can also put additional pressure on fragile ecosystems.

Rather than ignore that reality, we lean into it. Our resort partners become active stakeholders in the health of the reefs around them. Together we establish marine protected areas, support coral propagation, and help introduce visitors to these extraordinary ecosystems in a way that encourages understanding and stewardship. It takes a village.

If nothing else, I hope this gave a small window into the strange, fascinating world of coral restoration. If you're able, please consider supporting the people doing the work — whether that's for reefs or any natural ecosystem that needs a helping hand.

At Counting Coral, we're working to expand and manage long-term reef restoration systems. We're always grateful for support in any form: donations, interest, questions, or simply helping spread the word.

COUNTING CORAL

Learn more here: https://www.countingcoral.com

Interview with Rodrigo A. Nuñez-Inzunza, Builder of MesoReefDAO

# Partnership Feature

## MesoReefDAO

Who are you?

I am Rodrigo Nuñez, a builder, coral reef researcher, scientific diver, and ocean conservation advocate deeply involved in projects across the Mexican Caribbean. Since 2020, I've been a global connector, pioneering blockchain use cases for public goods and the commons in conservation, bridging marine science with Web3 communities worldwide. My work spans environmental education, community-focused citizen science, and hands-on research studying coral reef ecosystems, including herbivory patterns, biodiversity assessments, and restoration techniques.

What is Web3?

Web3 refers to the next evolution of the internet, built on blockchain technology. Think of it as a shared, tamper-proof digital ledger that no single company or government controls. Unlike today's internet (Web2), which is dominated by big tech platforms that own your data, Web3 gives users ownership through digital tokens, decentralized applications, and smart contracts that automatically execute agreements. For everyday users, this means secure, transparent ways to fund projects, verify actions (such as coral planting), and earn rewards directly without intermediaries which is particularly valuable in conservation, where trust and traceability are essential.

What is DeSci?

DeSci (Decentralized Science) represents the next evolution of open science, offering a global, fair alternative to the traditional scientific system using Web3 tools. It enables scientists to raise funding through community-driven mechanisms, conduct research with shared tools, store data openly on blockchains, and receive recognition for their work, while ensuring open access to research. By decentralizing funding, peer review, and data sharing, DeSci removes paywalls, institutional barriers, and risks of censorship, fostering a more transparent, collaborative scientific ecosystem where both researchers and the public can contribute and benefit.

What is MesoReefDAO?

MesoReefDAO is a global collective using DeSci and Web3 to address the coral reef crisis, starting with community-driven initiatives in Latin America (including the Mexican Caribbean) and scaling globally. It is not a traditional NGO, but a cooperative network of scientists, builders, and local stakeholders who collectively govern through token-based systems, making conservation more transparent, results-driven, and community-owned.

What have you built?

We have developed practical tools, secured initial funding, and collaborated across initiatives in multiple sectors to scale impact:

- **Pepo the Polyp Bot:** A coordination tool (similar to a shared knowledge network) that connects coral experts worldwide to improve collaboration and efficiency in reef work.
- **ReefRegen.org:** A global platform to verify, map, and track coral restoration efforts using blockchain technology. Users can log restoration activities and view verified results on interactive maps.
- **c0ralGPT IP Framework:** A developing suite of AI tools designed to support capacity building and help communities learn advanced coral restoration and biotechnology techniques.
- **Coral Restoration Commons Fund:** An active funding pool supporting open-source coral reef restoration projects.
- **Regen Reef Framework:** A system supporting partners through integrated biotechnology, restoration strategies, and community-based solutions, including modular wet labs and AI-driven monitoring.

Drawing on my experience in blockchain-based conservation since 2020, these tools aim to transform fragmented conservation efforts into a coordinated, transparent, and verifiable global movement, where local actions contribute to meaningful global impact.

Socials: https://linktr.ee/mesoreefdao

# Get The Right Gear

**Never be without your (almost) free Coral Quadrat!**

A simple coral quadrat can be made using PVC pipe, making it an affordable and highly practical tool for fieldwork. To build one, cut PVC pipes to your desired size (commonly 0.5 m × 0.5 m or 1 m × 1 m) and connect the corners using elbow joints to form a square frame. Before assembling, drill small holes along the pipes to allow water to enter, preventing trapped air and helping the quadrat become neutrally buoyant underwater. You can also paint marker bands or measurement intervals along the PVC to provide clear reference points during surveys. For added functionality, attach string or fishing line across the frame in a grid pattern to assist with estimating percentage cover more accurately. The result is a lightweight, durable quadrat that is easy to transport, deploy underwater, and reuseable across multiple surveys.

Using a PVC quadrat is an excellent idea because it provides a standardized method for collecting consistent, repeatable data on coral cover, biodiversity, and benthic composition. It is cost-effective, easy to customise, and accessible for students, citizen scientists, and professionals alike. Whether you are conducting formal research or community-based monitoring, a simple PVC quadrat allows you to gather meaningful, comparable data that contributes to a better understanding and conservation of coral reef ecosystems.

# Coral Career Column

**Humility is the key to success**

When starting fieldwork or a new role in a different location, it’s essential to approach your work with humility, respect, and an awareness of the local context. Many communities and organisations have long-standing relationships with their environments and may already be implementing conservation strategies shaped by cultural, economic, and historical realities. Taking the time to listen, learn, and understand local priorities builds trust and ensures your work is relevant and effective. Although it may seem counterintuitive, working at a pace that reflects the local culture and rhythm will often lead to better outcomes than trying to impose a fast-paced, “western” approach.

Arriving with a mindset of “saving” or “fixing” a system can unintentionally undermine local expertise and create resistance. Effective conservation is collaborative, not imposed. Pushing long hours or trying to drive change too quickly can strain relationships and reduce overall impact. By working alongside local stakeholders, respecting existing knowledge, and contributing as a supportive partner, you foster stronger, more sustainable outcomes.

The most effective scientists are those who combine technical expertise with cultural sensitivity, patience, and the ability to adapt to the environments and communities they work within.

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