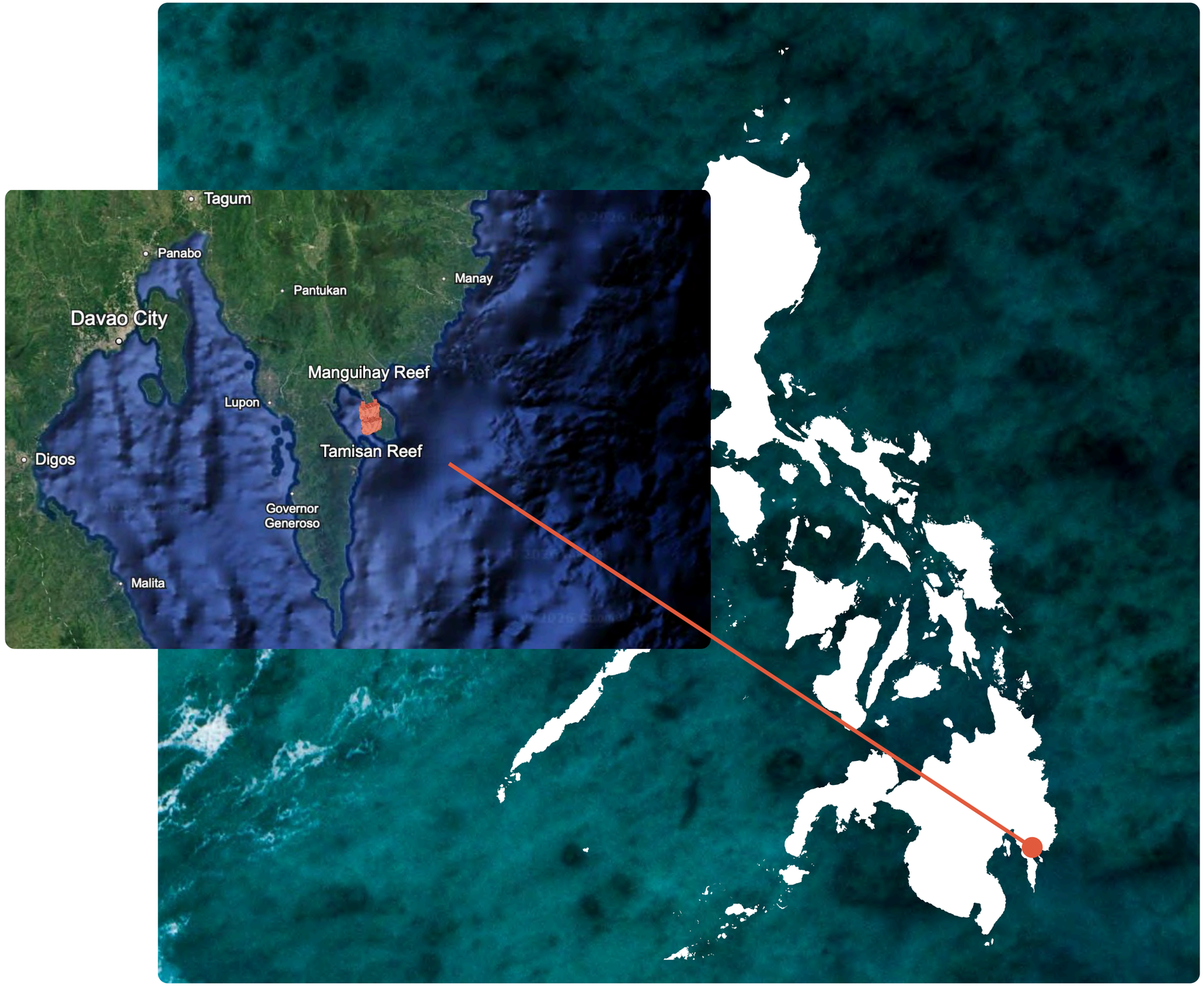

2026 - Pujada Bay, Mindanao, Philippines
rreefs
rethinking
rebuilding
regenerating
impact
report

content


1 pujada bay

pujada bay, mindanao, philippines



Pujada Bay, located on the southeastern coast of Mindanao in the Philippines, is part of the Coral Triangle, which is one of the most biodiverse marine regions on Earth.

Its coral reefs, mangrove forests, and seagrass ecosystems support marine biodiversity, coastal protection, and local livelihoods.

Yet like many regions worldwide, Pujada Bay is increasingly threatened by climate change, destructive fishing practices, sedimentation, coastal pressure, and declining water quality.

Across the Philippines, nearly all coral reefs are considered at risk, highlighting the urgent need for scalable and locally embedded regeneration approaches.

abstract

reviving pujada bay

This report summarizes the ongoing reef regeneration efforts of rrreefs and its partners in Pujada Bay, Philippines, from February 2024 to February 2026.

What began as the pilot reef regeneration initiative **Reviving Pujada Bay** on the site of **Manguihay** – the first project in the bay to simultaneously restore both coral reefs and mangroves, designed as a catalyst for holistic marine ecosystem regeneration – has evolved into a broader socio-ecological framework that combines coral reef rehabilitation, mangrove restoration, scientific monitoring, local production, community engagement, and governance collaboration.

Together with Davao Oriental State University (DOrSU), local fishing community, government agencies, and international partners, the regeneration project aims to strengthen both ecological resilience and local capacity for long-term marine stewardship.

evolution

Since the deployment of our modular clay reef structures (hereinafter the clay reef) and the mangrove planting activities in 2024, the project has grown in several directions: training local reef builders, developing the first 3D-printing clay production facility of its kind in the Philippines, and embedding restoration into local governance and community development.

introducing a new reef site

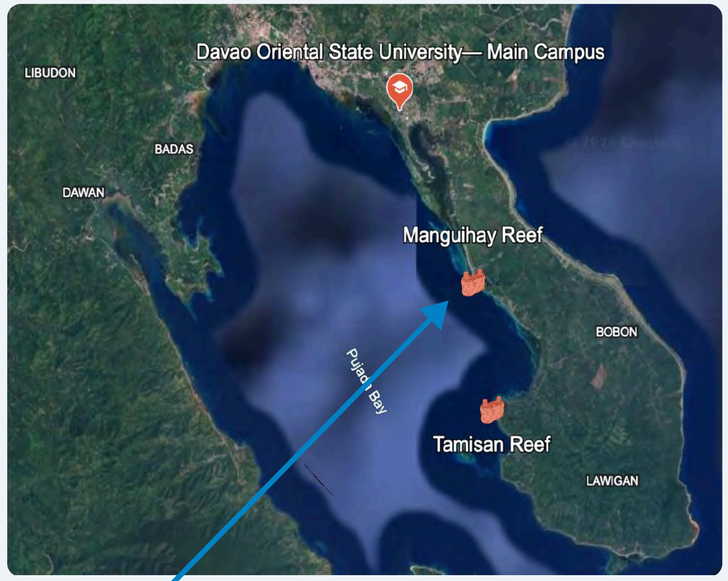
In 2025, as part of the next phase of Reviving Pujada Bay, the project expanded to new sites within the Bay, including the Barangay[1] **Tamisan**.

Developed together with DOrSU, the Fourfold Foundation, local fisherfolk organisations, and community stakeholders, this new endeavor aims to regenerate reef habitat and strengthen local ownership and long-term restoration capacity.

The Tamisan reef site has become a platform for creating a community-centered regeneration model. Alongside reef deployment activities, the initiative focuses on training local reef builders, strengthening partnerships with LGUs (Local Governmental Units), and establishing the foundations for a regional reef regeneration network.

[1] A barangay (abbreviated as Brgy. or Bgy.) is the smallest administrative division in the Philippines.

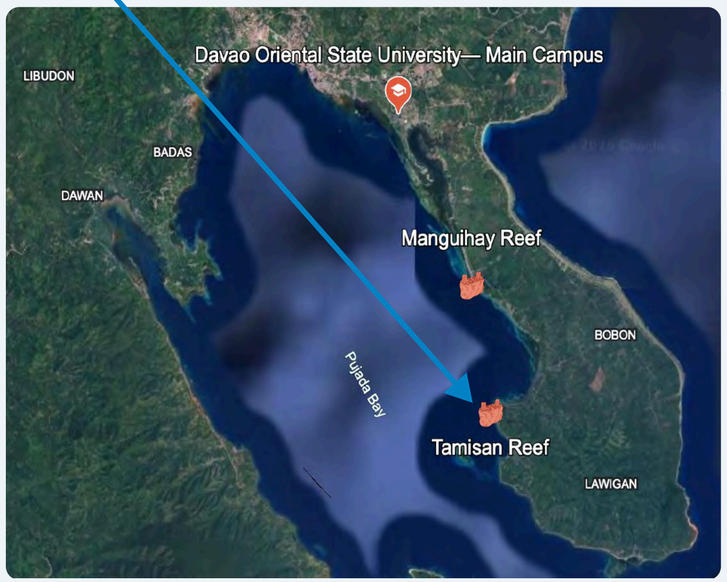
pujada bay: manguihay reef



Enablers: Zurich Gruppe Deutschland, Team Malizia, Mama Earth Foundation, Aqua Solar, VitaBad, Wild Foods

Est. **February 2024**
Lat. **6°52'54.90"N**
Long. **126°16'39.36"E**
Depth **4.5 m**
Bricks **822**
Size **100 m²**

pujada bay: tamisan reef



Fourfold

Geistlich Pharma

TEAL

creaholic

Enablers: FourFold, TEAL, Creaholic, Geistlich

Est. **October 2025**
Lat. **66°50'36.70"N**
Long. **126°17'01.80"E**
Depth **4.5 - 9 m**
Bricks **312**
Size **80 m²**

2 reef health

coral reefs

a threatened ecosystem

Coral reefs are among the most diverse and most fragile ecosystems on the planet. Climate change, overfishing, pollution, and coastal development are causing dramatic degradation of coral reefs worldwide.

Global living coral cover has already declined by more than half since the 1950s.[1] Without rapid and sustained reductions in greenhouse gas emissions and effective local action, the situation will worsen dramatically: at 1.5°C of warming above pre-industrial levels, projections indicate a loss of 70–90% of tropical coral reefs; at 2°C, virtually all (>99%) would be lost.[2]

a vital ecosystem

Although coral reefs cover less than 1% of the ocean floor, they support around 25% of all known marine species and provide food, livelihoods, and coastal protection for up to one billion people worldwide.[3]

Reef-building corals are the architects of these extraordinary ecosystems. Over time, they create the complex three-dimensional structures that provide shelter, breeding grounds, and feeding areas for countless marine animals from – colourful reef fish to sea cucumbers, sponges, shrimps, clams and nudibranchs.

[1] Eddy et al. (2021). "Global decline in capacity of coral reefs to provide ecosystem services." One Earth, Cell Press. doi.org/10.1016/j.oneear.2021.08.016
[2] IPCC (2018). Special Report on Global Warming of 1.5°C, Summary for Policymakers, B.4.3. ipcc.ch/sr15/chapter/spm
[3] NOAA Coral Reef Watch (coralreefwatch.noaa.gov); Reef Resilience Network (reefresilience.org/value-of-reefs); Smithsonian Ocean (ocean.si.edu)

measuring reef resilience

When corals decline, the intricate habitat of corals reefs is gradually lost, and many of the species that depend on it disappear as well. Restoring coral reefs therefore means much more than helping corals recover – it means rebuilding an entire ecosystem.

By monitoring the fish, invertebrates and young corals that colonise our reef structures, we can track how biodiversity develops over time and measure the success of our restoration efforts.

why biodiversity matters:

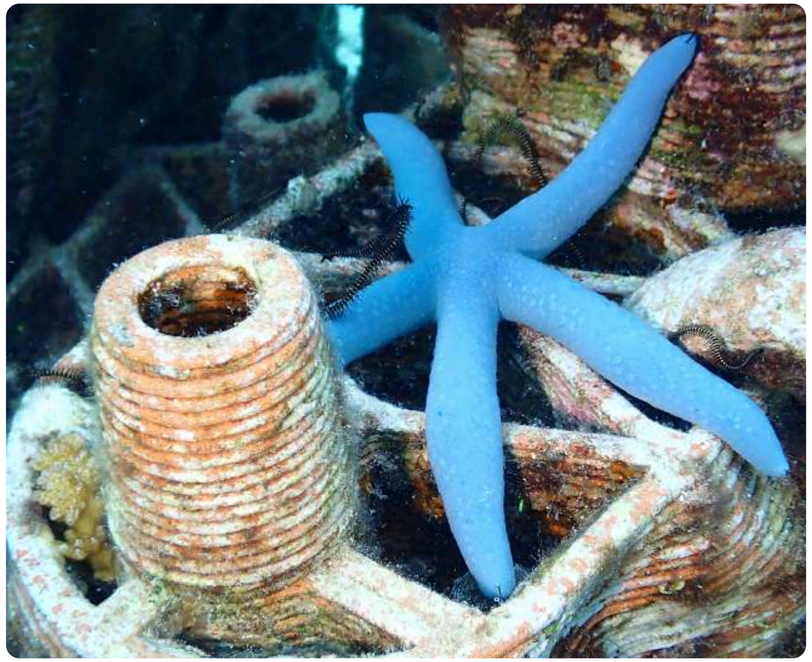
- **biodiversity** is one of the strongest indicators of reef resilience
- **complex habitats** support more species and ecosystem functions
- **healthy reef communities** are better able to recover from disturbances

scientific focus areas

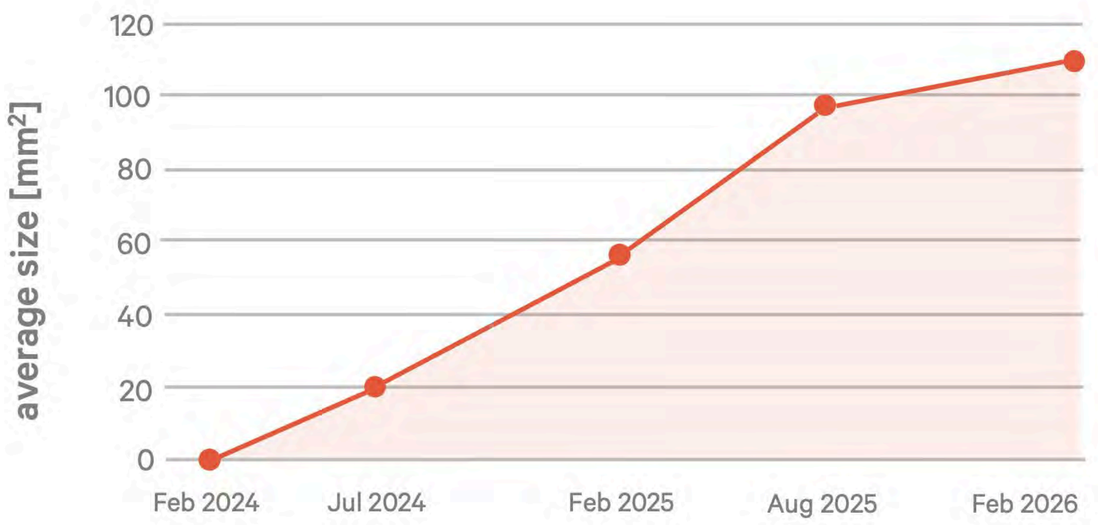
corals

fish

invertebrates



coral recruits – manguihay reef



>380 coral recruits

Since installation of the clay reef, coral recruitment has been strong and continuous, with around 230 recruits estimated after one year and nearly 400 after two years (Fig. 1).

1,138 mm² maximum size

Following installation of the clay reef, coral recruits showed steady and encouraging growth, with the largest ones reaching 1,030 mm² (approximately 3.62 cm in diameter) after one year and increasing to 1,138 mm² (3.81 cm in diameter) after two years (Fig. 2).

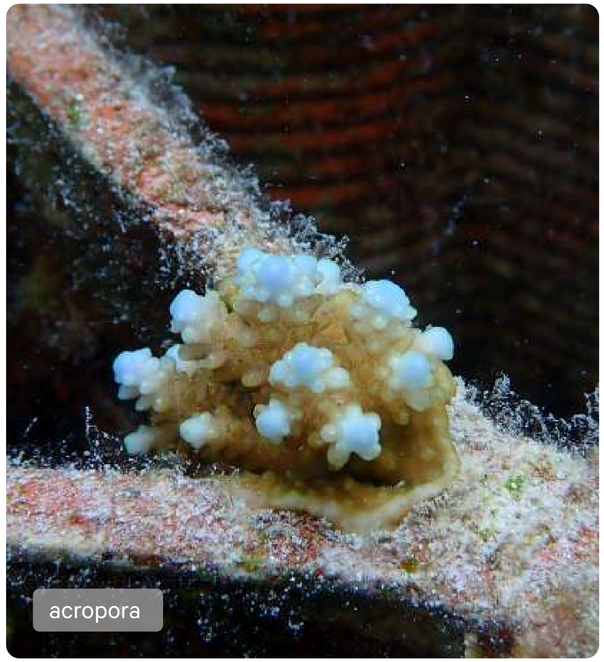
coral recruits

what does it mean?

The data clearly show that both the number of new coral recruits and their average size have increased steadily since deployment. This indicates that the structures are functioning as intended: they **successfully attract settling coral larvae**, and the young corals are not only surviving but **consistently growing over time**. The **continued upward trend** demonstrates **healthy reef development** and confirms that the restoration intervention is creating **suitable habitat conditions for natural coral recovery**.

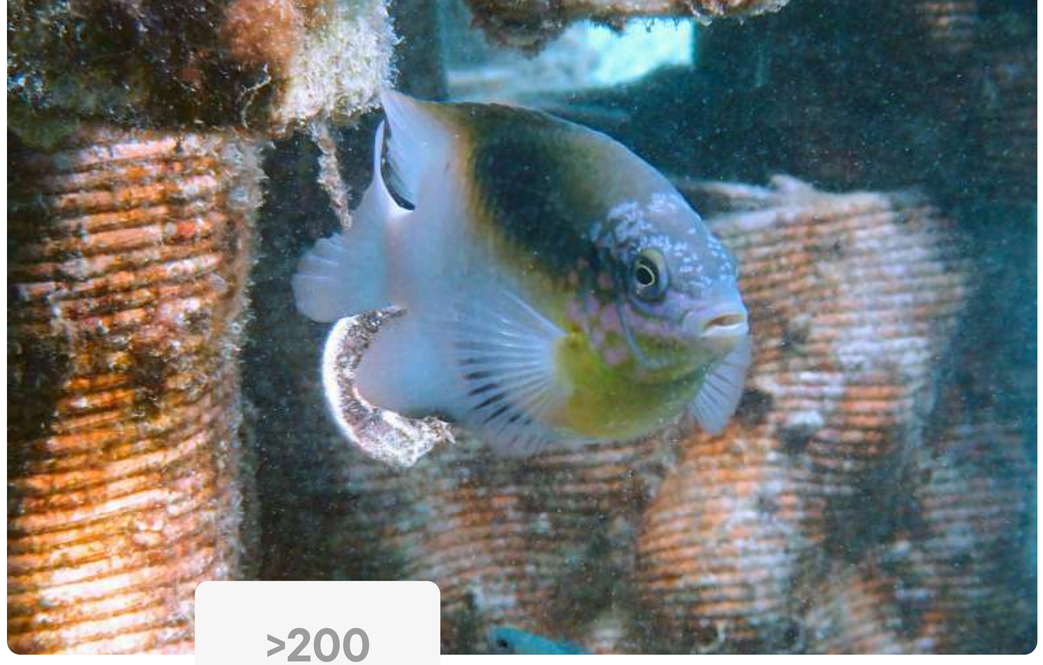
Corals are slow-growing, colonial, jellyfish-like animals with a calcium carbonate skeleton. These colonies begin with a single tiny **polyp**, known as a recruit, which is almost invisible to the naked eye.

To monitor coral recruitment, we typically use **UV-light photography** at night, a technique that reveals the natural **fluorescence** of the polyps and makes these early-stage corals visible for assessment.



corals

fish



>200

fish counted in one survey at the clay reef

the guardians of the reef

Fish and coral reefs depend on each other to survive. Reefs give fish food, shelter, and nurseries, while fish graze algae, cycle nutrients, and keep pests in check, helping corals stay healthy.

Over 4,000 fish species rely on reef habitats.[1] This balance is fragile: overfishing, especially of algae-grazing species, lets algae overrun corals and pushes reefs toward decline.

In Pujada Bay, the Marine Protected Area (MPA) surrounding the reef was elevated to a no-take zone due to the reef-building in 2024, prohibiting all fishing to safeguard the recovering ecosystem. Protecting fish populations is protecting the reef itself.

[1] NOAA Fisheries, "How Are Fisheries and Coral Reefs Connected?" https://www.fisheries.noaa.gov/feature-story/how-are-fisheries-and-coral-reefs-connected

fish population – manguihay reef

measuring fish abundance, diversity and biomass

Monitoring data collected at six-month intervals from February 2024 to February 2026 shows higher abundance and biomass at the clay reef, which suggests the restored habitat offers better shelter and foraging opportunities, supporting the recruitment and retention of fish.

We also saw a gradual decline in diversity, which may reflect ecological succession, with an early phase of colonisation by a broad range of species followed by increasing dominance of a smaller number of abundant taxa as the community matured.

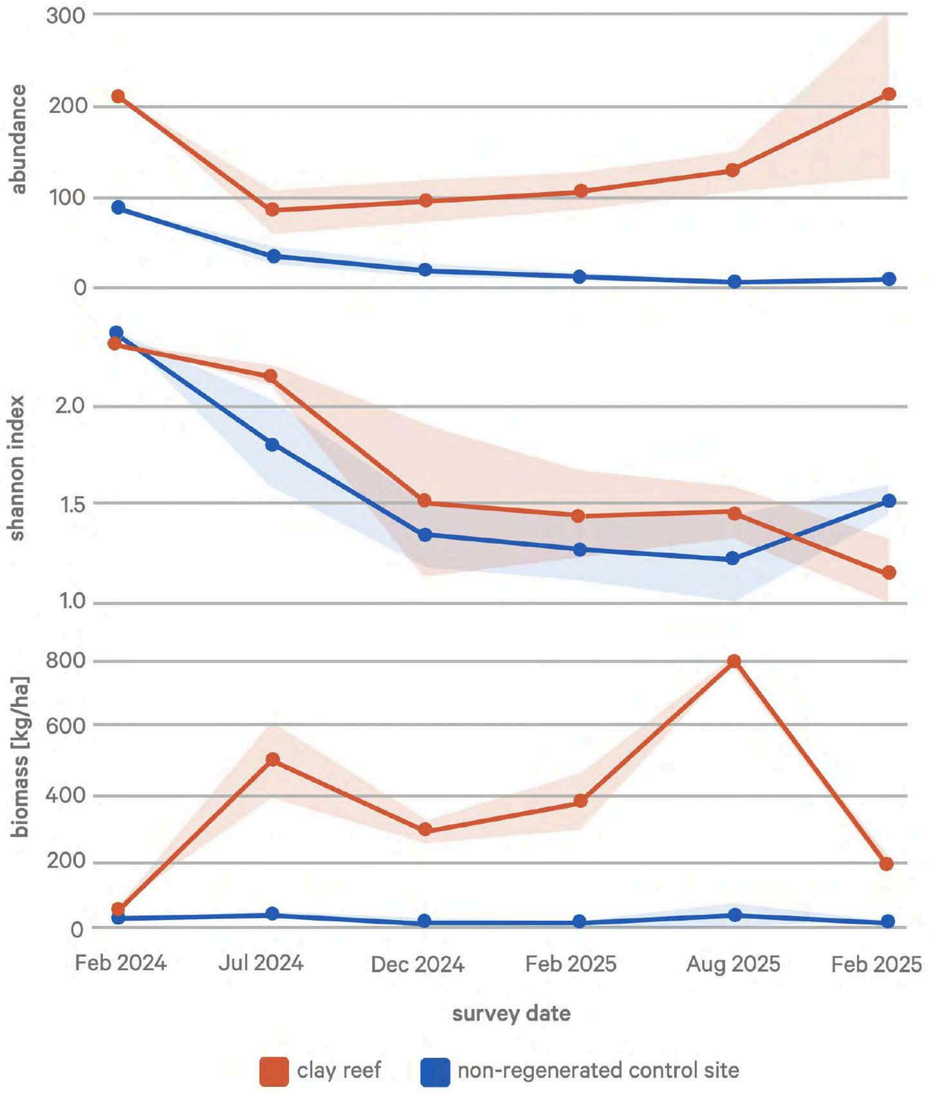
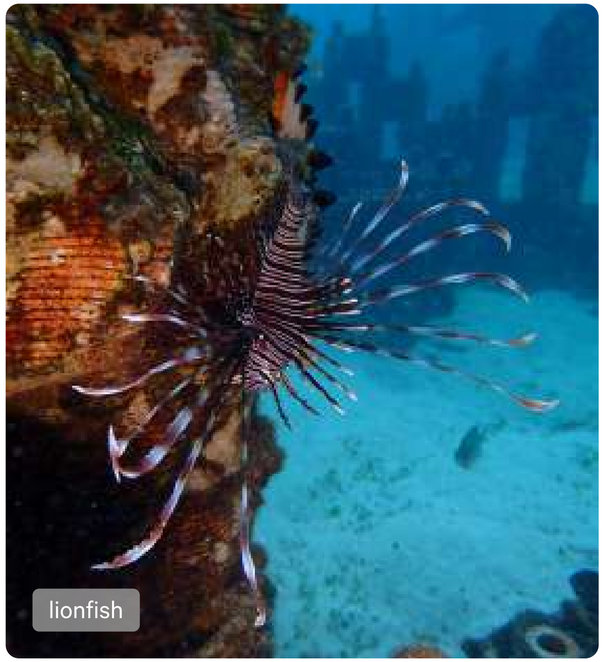


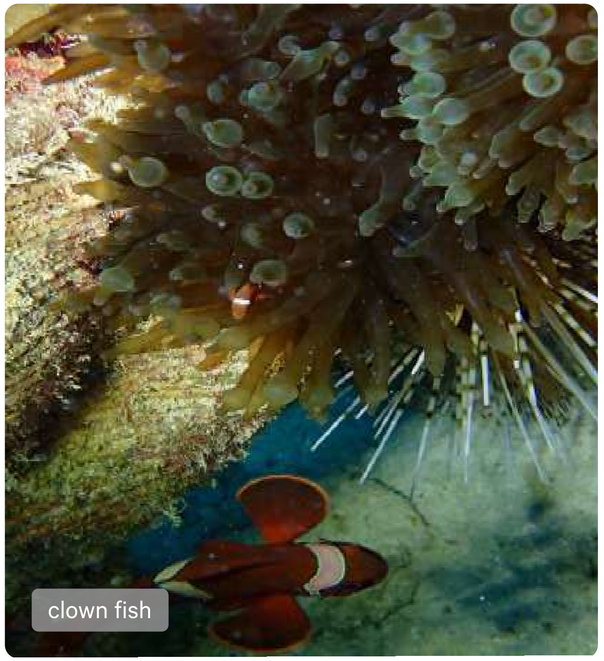
Fig. 1: Temporal changes in fish abundance, diversity (Shannon index), and biomass at the clay reef and non-regenerated control site between February 2024 and February 2026. Values represent mean (±SE) from replicated transects.

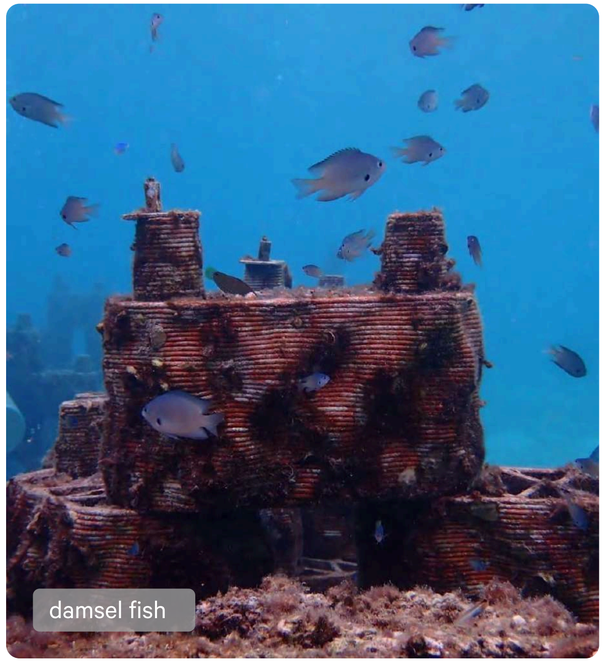
Fish abundance (total number of individual fish recorded) remained consistently higher at the clay reef throughout the monitoring period and increased markedly after an initial decline, while abundance at the control site decreased steadily and stayed low.

Fish diversity (number of different species present) declined over time at both sites but remained generally higher at the clay reef until the final survey, when the control site slightly exceeded it.

Fish biomass (combined weight of all fish recorded) increased substantially at the clay reef after deployment and consistently exceeded the control site, peaking in August 2025 due to the presence of several large-bodied individuals before declining at the final survey. Biomass at the control site remained low and stable throughout.


lionfish


clown fish


damsel fish


lembeh sea dragon


toby (canthigaster papua)


moray eel

fish communities

invertebrates – manguihay reef

life is flourishing in every corner of the reef

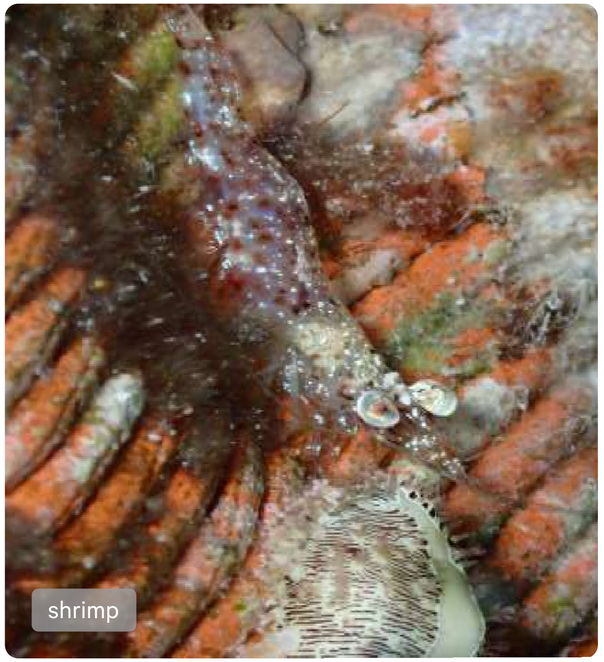
The reef continues to support a diverse range of invertebrates, with around 85% of all bricks occupied by mobile species such as crabs, shrimps and sea cucumbers. Sessile organisms, including tube worms, barnacles and anemones, were found on virtually every brick surveyed.

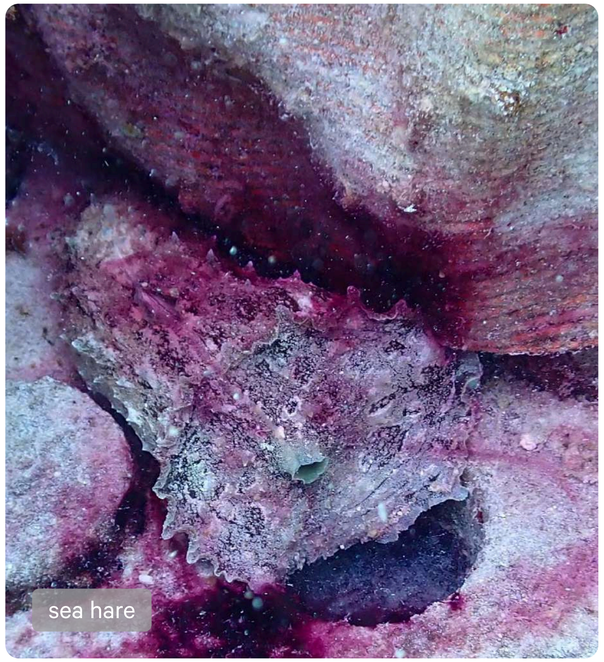
Together, these species form the foundation of a healthy reef ecosystem. By filtering water, recycling nutrients and providing food for larger animals, they help create the conditions that allow the entire reef community to thrive.

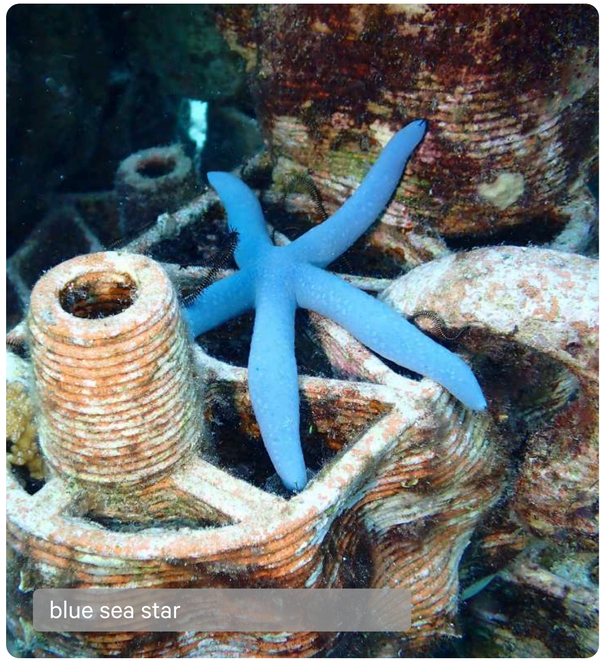
~ 85%

of all bricks occupied by invertebrates

an anemone at the clay reef, Manguihay, Pujada Bay







invertebrates

monitoring 3 methods

scientific monitoring

the importance of research

Scientific monitoring underpins everything we do at rrreefs. It provides the data that allows us to measure the impact of our reefs, comparing it to a control site and tracking how marine life returns over time.

Because our reef structures are small and highly complex, we've developed an adapted monitoring protocol tailored to this unique environment.

comparison is key

Surveys are conducted on both our clay reef structures in Manguihay and a control site located ~100m away, chosen to match the reef site in habitat, depth, and environmental conditions.

Because our reef structures are small and highly complex, we have developed an adapted monitoring protocol tailored to this unique environment.

For this impact report, surveys were conducted on the Manguihay reef at four key time points:

- **baseline** prior to deployment
- **three months** after the clay reef installation
- **six months** after the clay reef installation
- **twelve months** after the clay reef installation

These data points are essential. They help us understand how our reefs develop, how species return, and how we can refine our approach for future projects.

reef surveys

what we survey

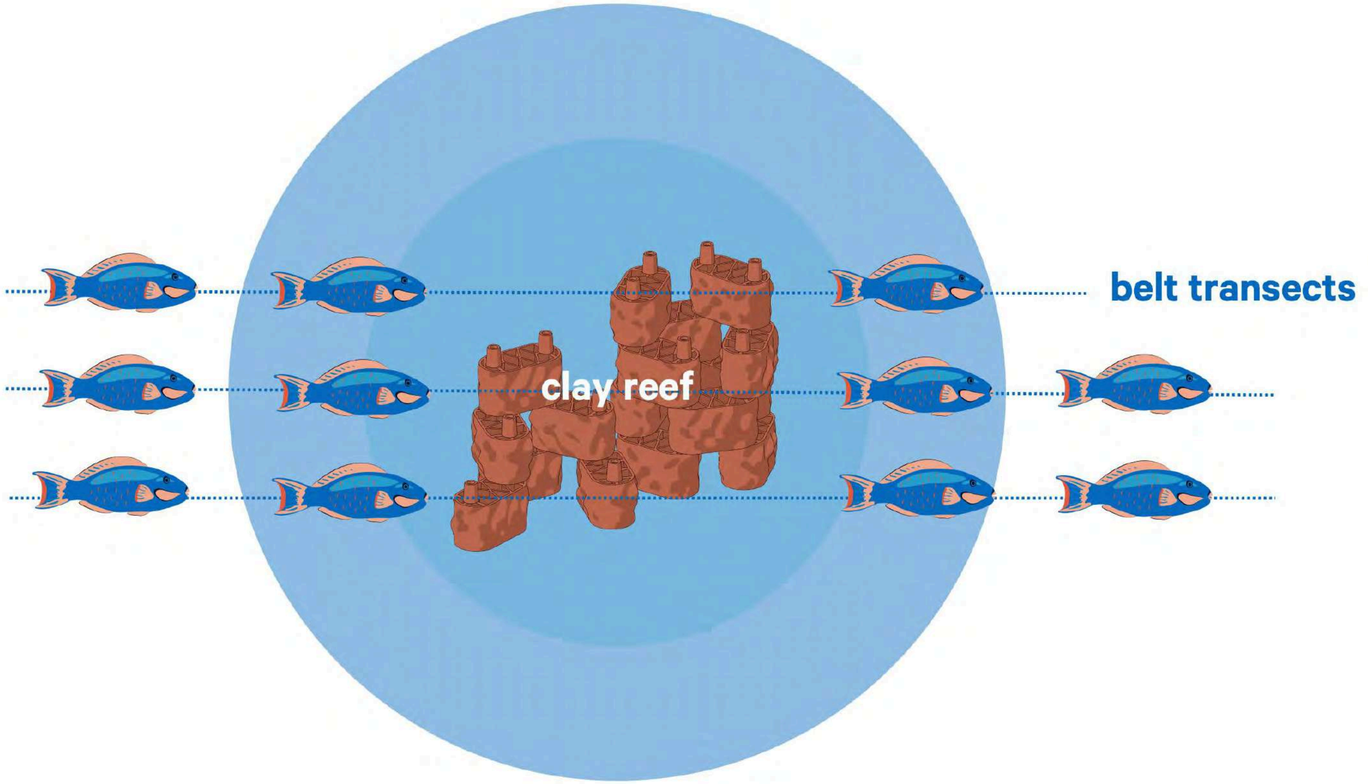
- reef associated fish communities
- mobile invertebrates indicating reef development

how surveys are conducted

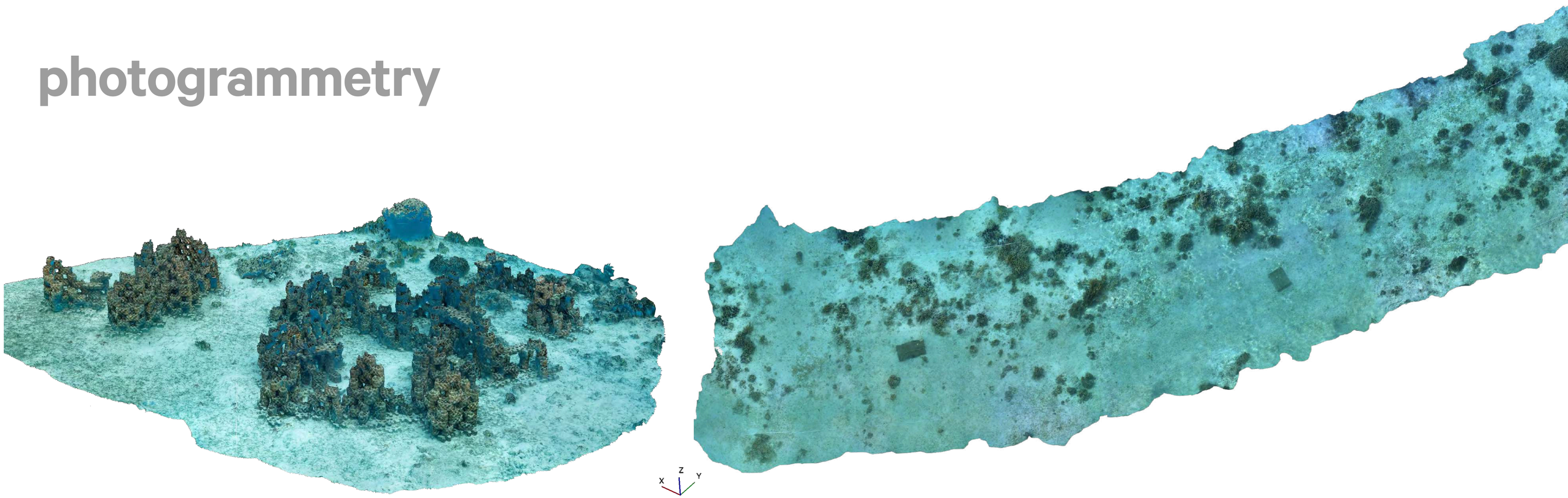
- fish point counts record large and mobile species around the reef
- belt transects quantify fish abundance and size across fixed areas
- mobile invertebrates are surveyed along the same transect
- surveys are repeated at reef and control sites

why this approach works

- fixed survey areas allow direct comparison over time
- methods are adapted to small scale, complex reef structures



photogrammetry



mapping the reefs

Photogrammetry is a method of creating accurate 3D models from a series of 2D photographs or videos. By capturing images from multiple angles, specialized software analyses overlapping details to reconstruct the reef in three dimensions.

This allows us to monitor the structural integrity of our modules and track their development over time. As corals grow, photogrammetry will also enable us to measure coral cover on individual bricks, helping us better understand how marine life colonizes our structures in different environments.

>1’000 pictures taken

We compile thousands of images taken from every angle of our reef structure, which are then processed into detailed 3D models.

Photogrammetry plays a role even before clay structures are installed. It’s an essential tool to document the site where reef regeneration is needed, and help us plan the placement and design of the reef structures.

4 social impact

community builds resilience

Throughout 2025 and 2026, we worked closely with fishing communities, local government units, educators, and other organisations to strengthen local engagement around marine conservation and reef restoration.

Through consultations, workshops, reef-building activities, and public meetings, community members become directly involved in shaping and implementing regeneration efforts. These activities help create stronger connections between scientific restoration work and local knowledge, while increasing awareness of the ecological and economic importance of healthy reef ecosystems.

In 2025 our new training program “The Reef Regeneration Leaders (RRL)” further supported this process by equipping participants with practical restoration skills, reef monitoring knowledge, and leadership experience that can support future community-led initiatives.

local education and engagement

Community engagement remains a central pillar of the Reviving Pujada Bay initiative. Through workshops, consultation meetings, educational activities, and public discussions, the project aims to strengthen awareness around marine conservation and encourage active participation from local stakeholders.

In 2025 alone, more than 416 people participated in community engagement activities across the Pujada Bay region. This included participants from community surveys and think tank workshops, consultation meetings, Protected Area Management Board (PAMB) discussions, and local community update meetings in Tamisan.

Educational activities focused not only on reef ecology, but also on the broader relationship between communities, livelihoods, climate resilience, and marine ecosystems. By combining scientific information with participatory dialogue, the project encouraged stronger connections between local knowledge and restoration science.

These activities help strengthen relationships between fishing associations, local government units (LGUs), academic institutions, and national agencies involved in coastal management and marine protection efforts.

from stakeholders to stewards

The growing participation of local stakeholders reflects an important shift: reef regeneration is becoming a shared responsibility, woven into the social fabric of the coastal communities in Pujada Bay.

Involving the fishing communities is essential to making this work over the long term. Education about the ocean and marine conservation is a core pillar of our work and that of our partners in the Philippines, and regular consultations with community members ensure that our projects reflect local needs and priorities.

reefs made in the philippines

a collaborative effort

The local production facility, established in 2025, marked an important step in turning our reef regeneration work into a locally rooted system. Developed together with DOrSU, local partners, and international stakeholders such as WASP, the 3D-printing clay facility is designed to produce rrreefs structures in the region while creating new opportunities for technical training, employment, and community participation.

Beyond manufacturing reef modules, the facility is a space for knowledge exchange, hands-on learning, and capacity building. Local community members and reef builders are involved at multiple stages, from material preparation and brick production through to assembly, logistics, and reef deployment.

strengthening local ownership

By localising parts of the production chain, we reduce logistical complexity while strengthening regional ownership over marine restoration.

The facility also creates a stronger connection between reef regeneration and the local economy, positioning restoration not only as an environmental effort, but as a community-driven development opportunity.

Together with the Reef Regeneration Leaders (RRL) training programme, the facility contributes to a growing network of locally skilled actors able to support future restoration work across Pujada Bay and beyond.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

the first reef factory in the philippines

The clay is sourced directly in the region and processed on the DOrSU campus in Mati, where 3D printers from the company WASP can produce up to 90 elements per week. Once dried, the bricks are fired in the kiln, then stored and installed on the seabed of Pujada Bay. The whole facility is run by trained local team members.

the reef builders

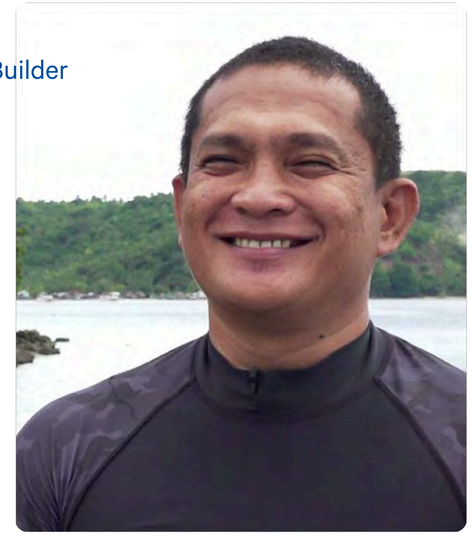
Through our Reef Regeneration Leaders (RRL) training, we have equipped participants with practical rehabilitation skills, reef monitoring knowledge, and leadership experience that can support future community-led initiatives.

Twelve local reef regeneration leaders completed their training last October 2025. Since then, the team has been busy expanding reef regeneration efforts within Pujada Bay by building more clay reefs and continuing scientific monitoring in the areas.

With these efforts, we have strengthened the sense of stewardship these local leaders have toward their local reefs by enabling them to build the foundations of one with their own hands and giving them the opportunity to monitor its growth in the many years to come.

“Every time I dive into the ocean, I feel connected–like it’s my home. When I see that our reefs here have been badly damaged, it breaks my heart. So when we go in and help in regenerating the reef, it feels like healing knowing that we are bringing back life that we can share with our sons and daughters some day.”

Jerson Historia
Freediver and Reef Builder



Fourfold

building reefs, building skills

The Reef Regeneration Leaders (RRL) training certifies participants as reef builders and introduces them to rrreefs' interlocking, modular reef system. Participants first practise on land, starting with small-scale modules before working up to the original size. The training is highly interactive and covers the reef system itself, the clay material, site assessment, and anchoring techniques. In the final step, participants move into the water and build a real reef as the culmination of the training.

acknowledgment

This impact report, and the reef regeneration work behind it, would not have been possible without the dedication and support of the partners listed below.

collaborators

Field, Sciences and Education:
Davao Oriental State University:

- DOrSU-RIC XI team
- Dr. Lea A. Jimenez
- Amy G. Ponce
- Rheacine Polastico
- Dr. Ariel Eballe
- DOrSU President, Dr. Roy G. Ponce
- DOrSU VP for Research, Innovation, and Extension, Dr. Emily S. Antonio
- GreenPulse DOrSU student Organisation

Troy Silverio
SAWOM team
Arnel G. Gayta
Ramil L. Ramos
Hans-Joachim Steudel
Patricia Stöckli
Katharina Kaiser

Governance and other operations:

- PAMB Pujada Bay Protected Landscape and Seascape (PBPLS)
- LGU Mati
- Barangay Tamisan
- BFAR-DA
- DENR RXI, DENR-PENRO, DENR Mati
- Mati CityENRO
- CDRRMO
- DENR-BMB
- DOST
- Philippine Coast Guard Davao Oriental
- Maritime Police Mati
- DOrSU Production Facility Team
- Paul Martin

corporate sponsors

- Zurich Gruppe Deutschland
- Team Malizia
- Vita Bad
- Aqua Solar
- Wild Foods
- Geistlich Pharma
- TEAL
- Creaholic

foundations & philanthropy

- Mama Earth Foundation
- Fourfold Foundation
- Hannover Re Foundation

supporting partners

- SSI Philippines
- Holcim Philippines
- Knipex
- Fourth Element
- WASP

Author: rrreefs

Pictures: Uli Kunz; Hanna Kuhfuss; Stella Könemann; Patricia Stöckli; Lars Weber

earth to reef

This series follows the making of the reef regeneration hub in the Philippines, starting with the production facility.

Episode 1 follows the making of the Philippines' first 3D-printed reef production facility, showing how local teams, fishing communities and partners are building a reef regeneration hub from the ground up.

Episode 2 shows the shift from planning to reality as the 3D printers arrive in Mati and the facility comes to life. We follow engineer Jaypee Cantones, Supervisor of the Production Facility, alongside rrreefs co-founder Marie Griesmar reflecting on the trust and shared commitment behind the collaboration.

earth to reef

Episode 3 explores why clay sits at the heart of the Philippines' reef production facility, following ceramic engineer Artemio Reyes on the science and local relevance of the material and rrreefs designer Mauro Bischoff on refining techniques and ensuring full knowledge transfer to the local team.

Episode 4 follows the journey from digital design and G-code to freshly printed clay reef bricks inside the Philippines' first 3D-printed reef production facility. The episode captures the hands-on collaboration and knowledge transfer between the DOrSU team, rrreefs, and WASP on the production floor.

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