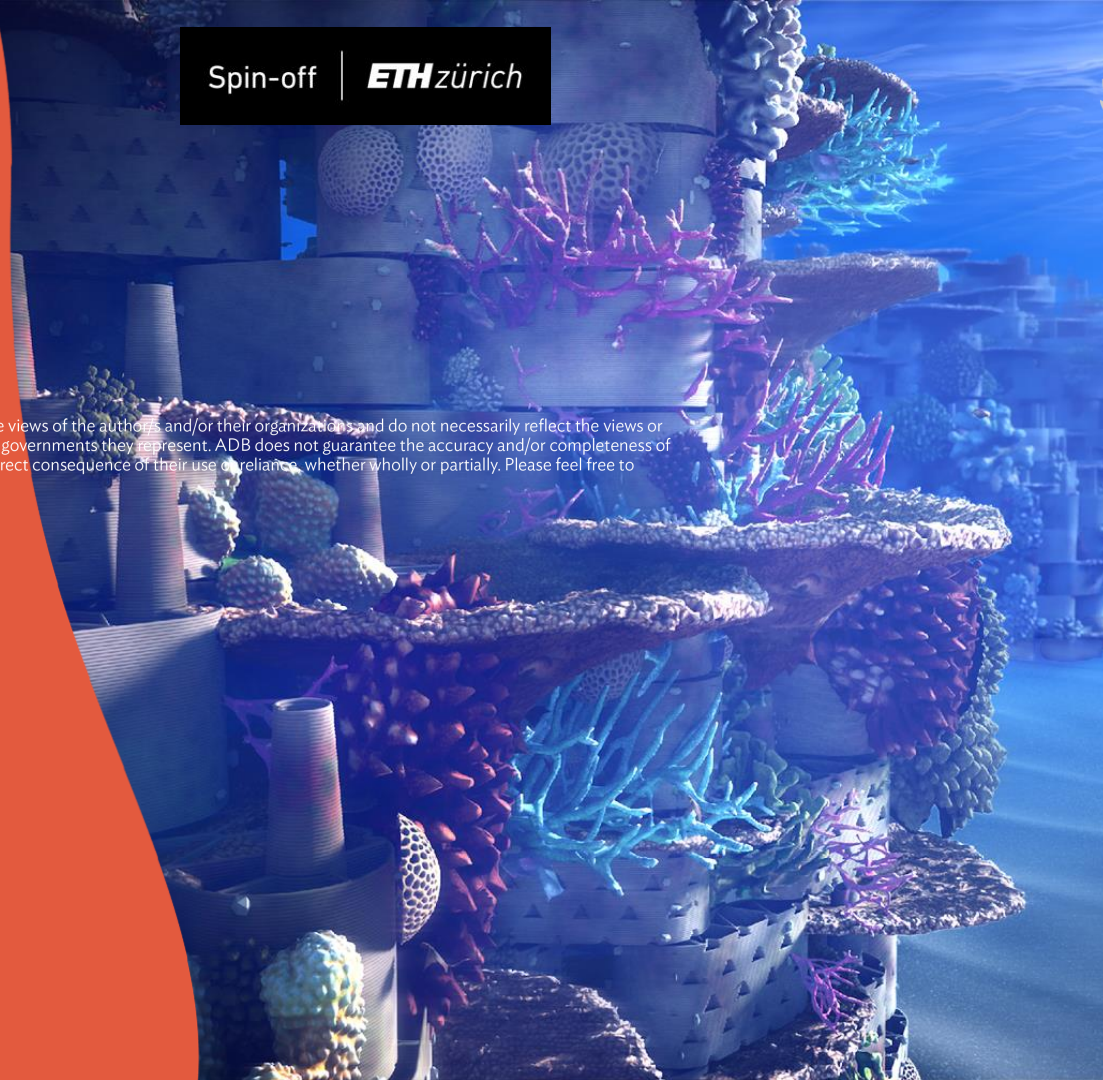
rreefs

Spin-off | ETH zürich

This is not an ADB material. The views expressed in this document are the views of the author/s and/or their organizations and do not necessarily reflect the views or policies of the Asian Development Bank, or its Board of Governors, or the governments they represent. ADB does not guarantee the accuracy and/or completeness of the material's contents, and accepts no responsibility for any direct or indirect consequence of their use or reliance, whether wholly or partially. Please feel free to contact the authors directly should you have queries.

3D CLAY REEF SYSTEM

an innovative approach to structural enhancement and habitat rehabilitation



Hochparterre Design Award
Gold 2021

planethero Award
Winner 2021

Falling Walls Venture
Finalist 2022

The Ocean Exchange Neptune Award
Finalist 2023

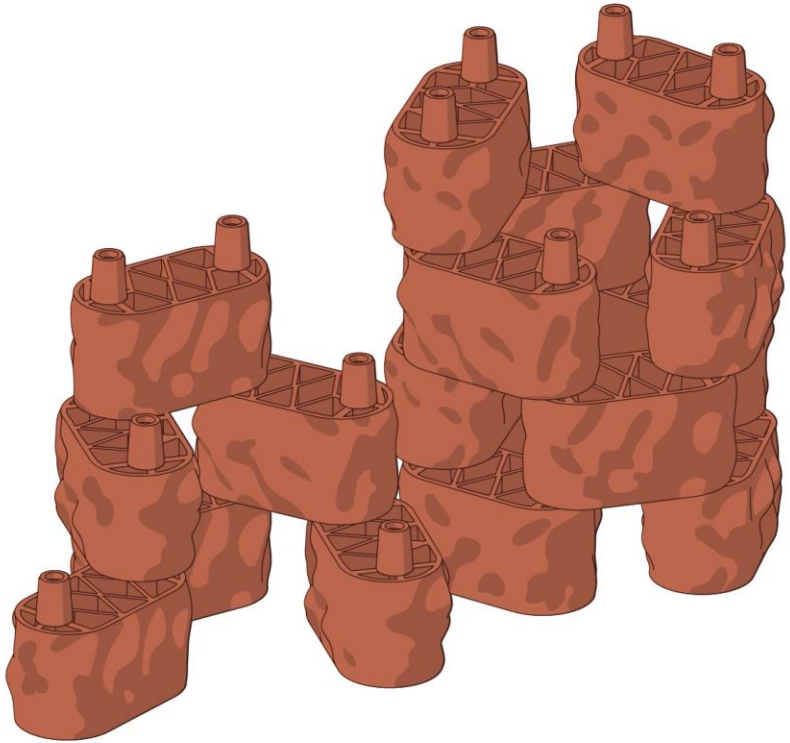
The Earthshot Prize
Nominee '23

Economist Impact Ocean Changemaker
Winner '24

Green Business Award CH
Winner '24

Natural recruitment! Let nature take back!

Scan me to watch the video!



A global biodiversity crisis

rrreefs

> 41 k
species are threatened with extinction

55 %
of global GDP depend on high-functioning biodiversity

Coral reefs are likely to be the first ecosystems to disappear on our planet due to numerous anthropogenic drivers including climate change


rreefs
Up to 95% of corals worldwide are
expected to be dead by 2050.

Coral reefs are dying worldwide

Coral reefs are regarded as one of the earliest and most significant ecological casualties of global warming. Without action, 99% of corals worldwide will likely die by 2050.

Coral reefs are dying at an alarming rate - as much as 50% have already been lost in the past 30 years due to climate change, overfishing and pollution.

Dead reefs quickly lose their structure and break down to rubble – leaving **reef fauna without habitat** and changing the **hydrodynamic properties** of the reef.

25 % of marine species depend on reefs

up to 97% of wave energy are reduced by reefs

> 71'000 km of coastlines are protected by reefs

~ 1 billion people rely on reefs for food, protection, & tourism

At rrreefs, we rebuild degraded reef structures, giving corals and reef animals a chance to grow back and adapt.

Impact of regenerating 1% of coastal coral reefs by 2034

Coastal protection

710 km coastline protected

Social impact

10 million people secured livelihood

Coral regeneration

home for 280 M corals

Marine life

home for 1.4 B large reef animals

Environmental change leads to a socio-economic change

Socio-economic change

Business and livelihood opportunities are disappearing

Decreasing revenue and incomes in fishery and tourism, rising financial efforts related to environmental damages (repair, protecting...)

Anthropologically environmental change

- Climate change
- Deforestation, irresponsible harvesting of mangroves
- Overfishing, destructive fishing methods
- Irresponsible tourism, coral wild catch and coral mining

Increasing sedimentation, limiting freshwater discharge, decreasing larvae exports, die of coral, fish and further species population...


Seafood
1 t per year
Tourism
$ 16.000 per year
1 km
Natural breakwater
worth $ 1-4 million
New sand
100 t per year

Our mission is to revive 1% of coastal coral reefs on Planet Earth by 2034.

Regenerate degraded coral reefs

Elevate corporate sustainability action

Build global movement of local reef builders

Founding team & Advisory Board

Founding team

Dr. Ulrike Pfreundt
Co-CEO, Head of R&D
Ulrike is an expert in tropical ocean ecosystems, with a PhD in Microbial Oceanography & Genetics.

Josephine Graf
Co-CEO, Head of Business Development
Josephine has a background at the intersection of International Relations and business.

Marie Griesmar
Head of Product & Marketing
Marie is an artist & material specialist with experience on aquatic ecology for over 7 years.

Hanna Kuhfuss
Head of Field Operations & Scientific Partnerships
Hanna is a marine scientist with broad experience in ecosystem conservation and applied marine sciences.

Advisory board

Andreas Feller
Head of Swiss Onshore
Rothschild & Co

Jasmin Khalifa
Founder Guidance4good, previously Head of CSR PwC

Prof. Roman Stocker
Chair Hydromechanics
ETH Zürich

Dr. Phanor Montoya-Maya
Program Manager Coral Restoration Foundation

Petra Riga-Müller
Head Commercial Insurance Zurich Insurance

Stephan Hillert
Global Head Distribution, Customers & Growth
Zurich Insurance

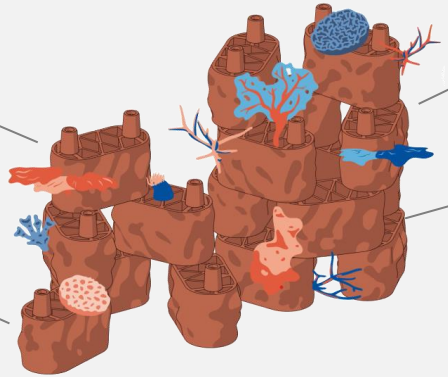
Barbara Truyers
Global Head Strategic Partnerships, Climeworks


Scan me to watch the video!

Innovation

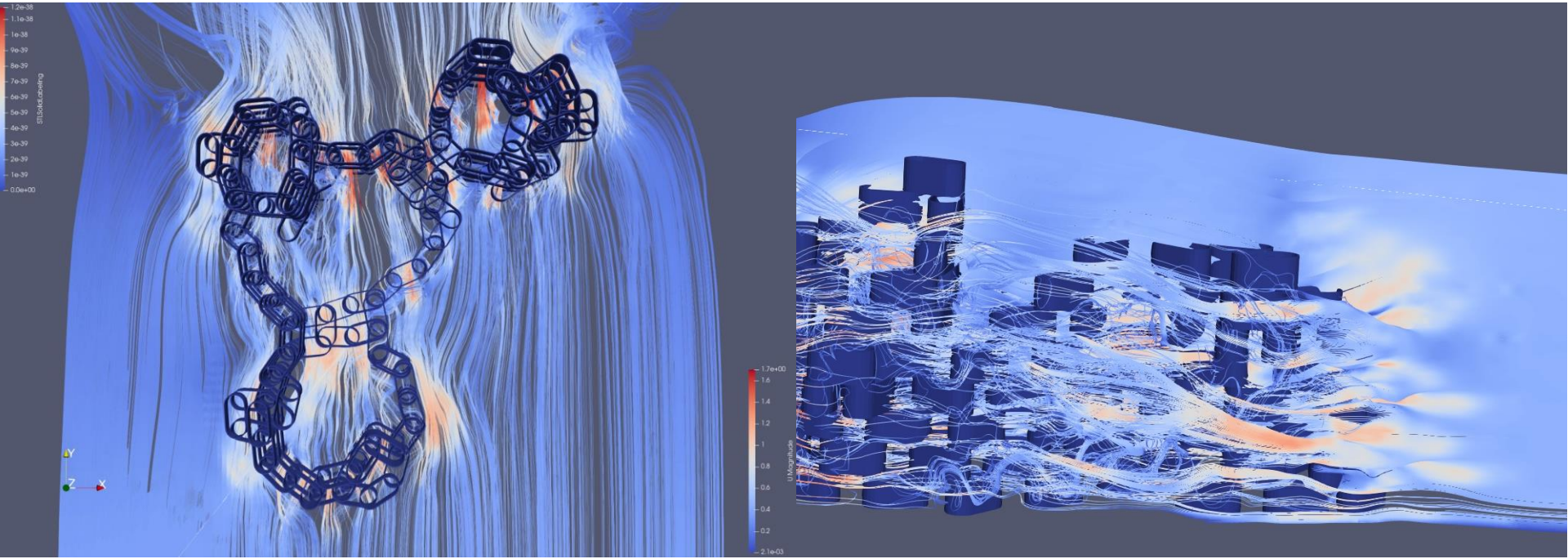
Combining cutting-edge 3D printing technology with science and arts, our modular reef systems turn into resilient and self-sufficient coral reefs.

The biodiversity-enhancing surface structure of our modules is designed to help corals settle and grow, promoting coral reproduction and resilience. Made of pure clay, our reefs offer a durable and natural substrate for coral recruitment and marine life.



Free-flow 3D printing with clay

Hydrodynamic reef design for better circulation and storm resilience



The rrreefs story

4-YEARs MALEDIVES EXPERIMENT

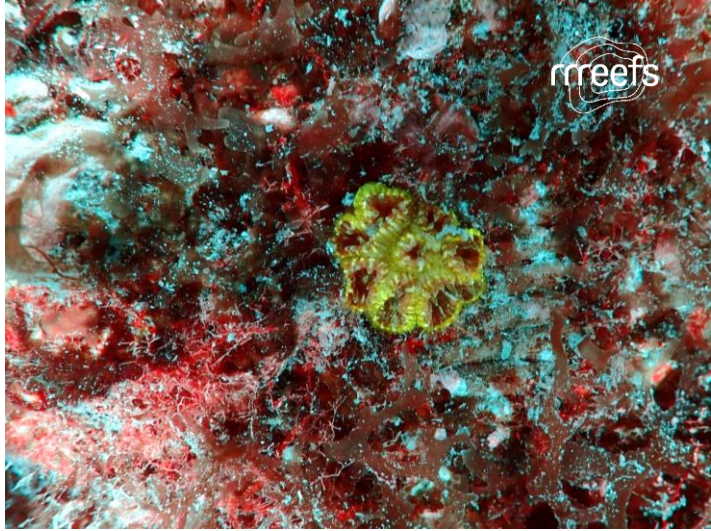
–> Prove of material suitability for natural coral recruitment

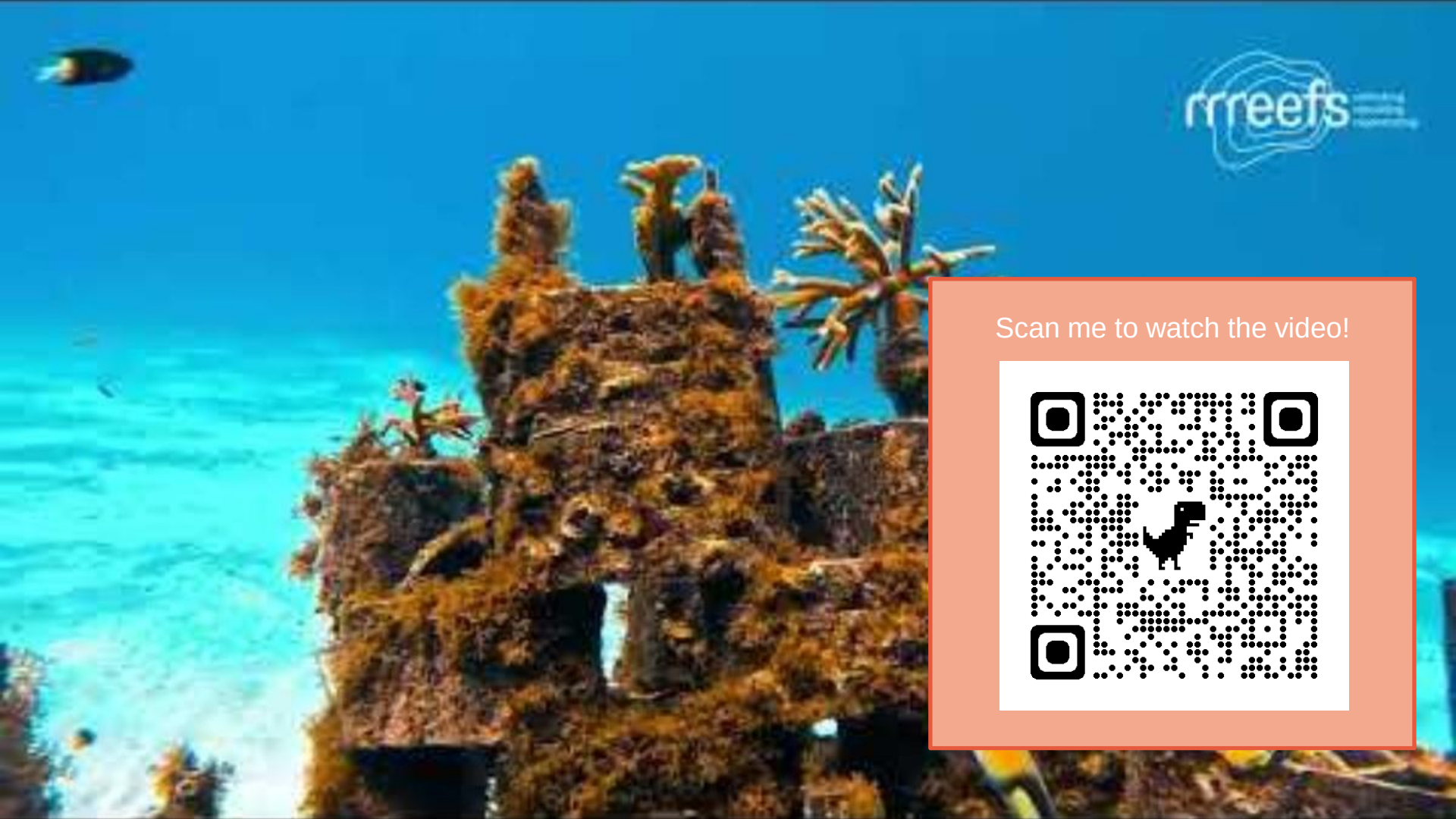
Dec 2019

Nov 2023

FIRST CORAL RECRUITS

PILOT REEF SAN ANDRES AFTER 8 MONTHS, PUJADA BAY **AFTER 3 MONTH**



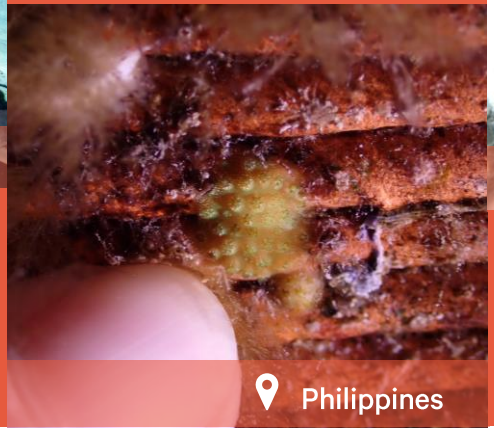

rreefs
Scan me to watch the video!

We have proven that our solution works

We have collected data and analyzed our impact in **2 under-water installations** with our **pilot reef "El Castillo"** in **Colombia** (Sep 2021), and 3D printed clay tiles in the **Maldives** (Nov 2019). We are currently collecting data from our latest projects in the Philippines and BVI.

Increased fish diversity
After only 3 months, our reef has reached similar fish diversity as the natural reefs around.

Regeneration of corals
After one year, we discovered 2 times more baby corals than on the natural reef. Larvae settlement in the first weeks.



Regeneration of corals
After 3 years, 90% survival and growth of baby corals proved long-term suitability of material and structure.

Increased local action
Ten local partner organizations across 5 countries currently work with us. Independent reef builders in the Philippines.

Generating positive social impact

We prioritize social impact by

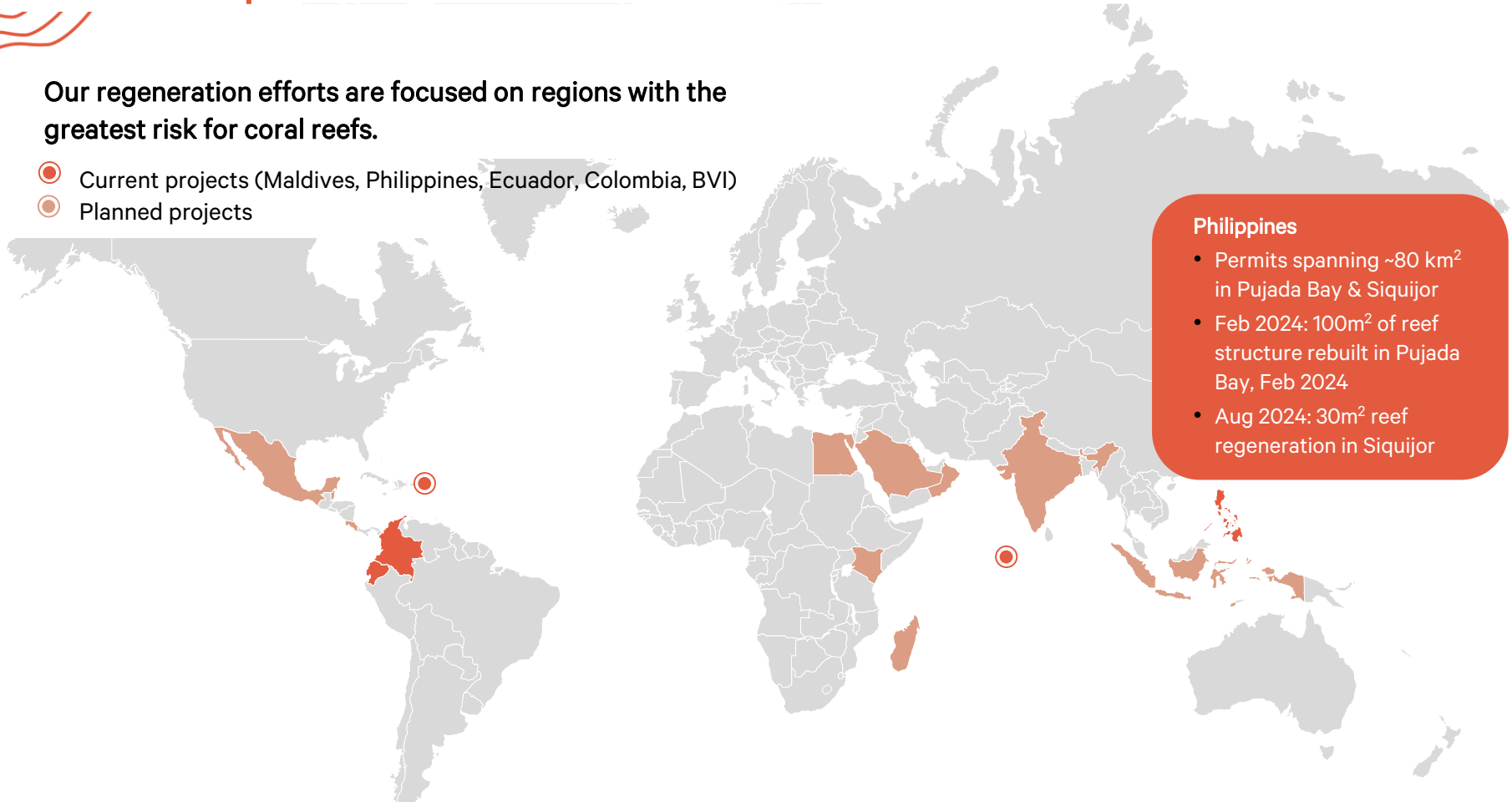
- Actively **involving local communities**, e.g. fisher families, in the process of building, installing, monitoring, and protecting our reef systems
- **Transferring knowledge** to monitor, build and produce the reef modules using innovative 3D printing
- **Providing training and resources** to equip individuals to continue preserving marine ecosystems for future generations
- **Empowering community members** to become **guardians of the marine ecosystem**
- **Collaborating with partners**, e.g. NGOs, LGUs and universities, to promote educartional programs and sustainable practices


Scan me to watch the video!
Machalilla / Ecuador
Empowering women & community

Where we operate

Our regeneration efforts are focused on regions with the greatest risk for coral reefs.

- Current projects (Maldives, Philippines, Ecuador, Colombia, BVI)
- Planned projects

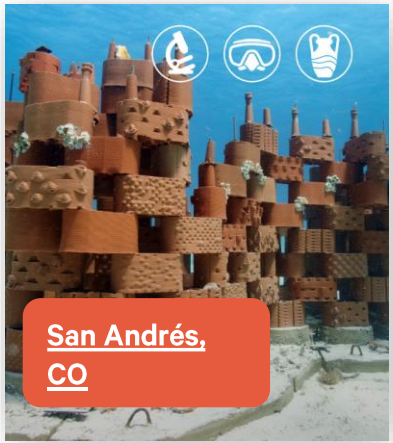


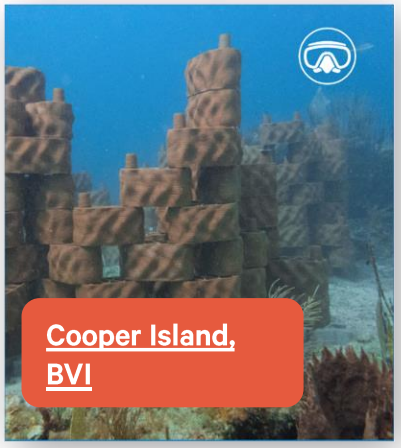
Philippines

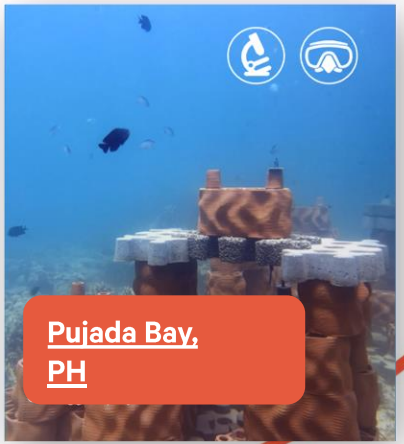
- Permits spanning ~80 km^2 in Pujada Bay & Siquijor
- Feb 2024: 100m^2 of reef structure rebuilt in Pujada Bay, Feb 2024
- Aug 2024: 30m^2 reef regeneration in Siquijor

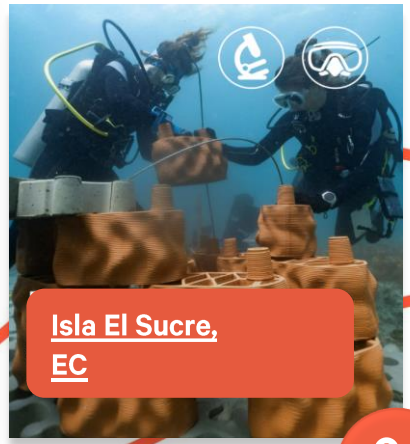
Current projects

Combining cutting-edge 3D printing technology with science and arts, our modular reef systems turn into resilient and self-sufficient coral reefs. Download our latest scientific report here.

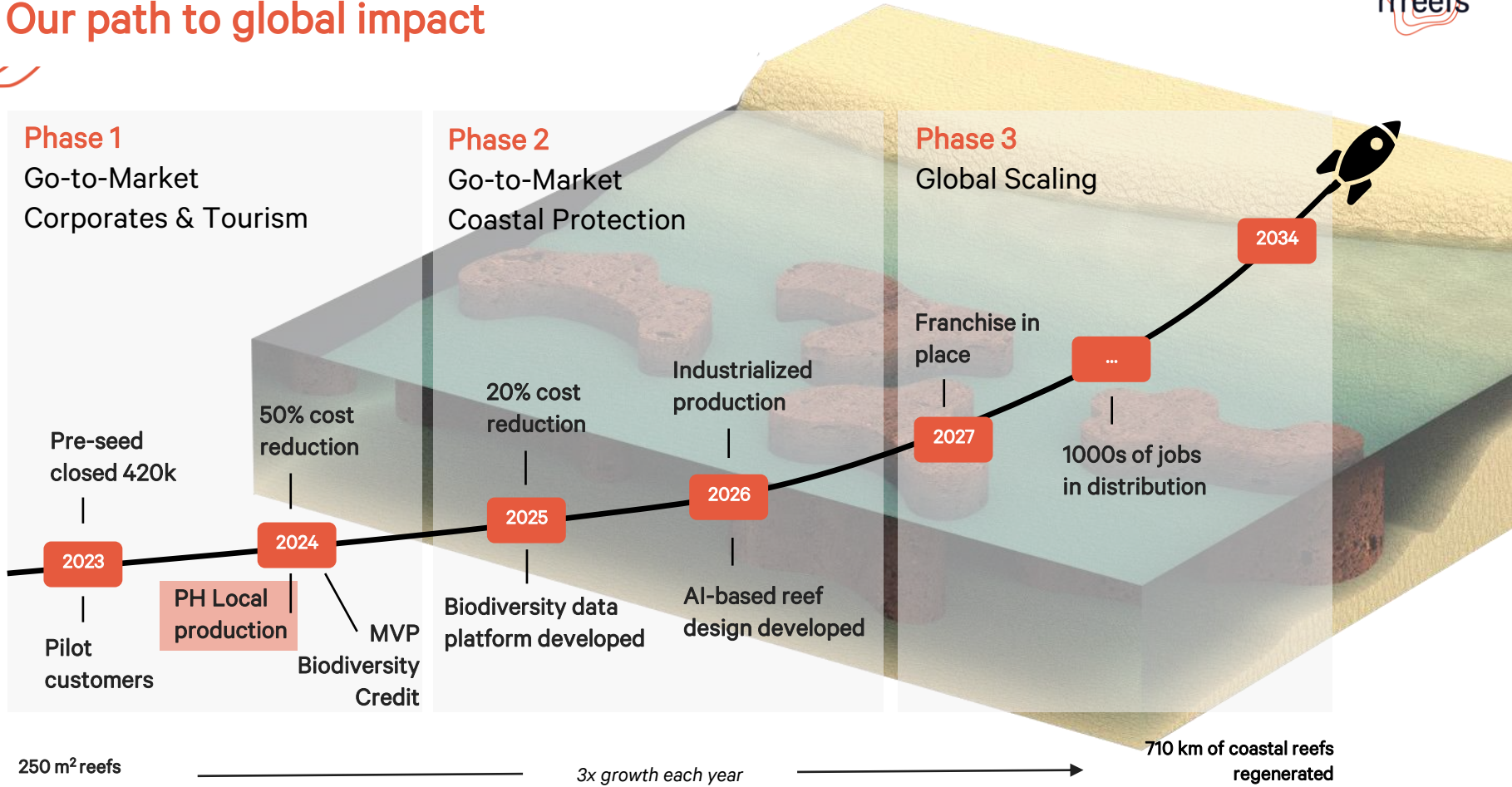








Our path to global impact



Benefits of combined clay reef structure & floating solar installations

most **resource-efficient** reef habitat solution on the market

high coral and other larvae recruitment and **survival rates** of young corals; fast colonialization by any kind of reef-dwelling organisms

hurricane-proof hydrodynamic design reducing currents and wave impact

design is adaptable to local needs through modularity

local added value by outsourcing reef building to local community

by shading the surface water, the solar panels can potentially help the seawater warm up less quickly and thus help protect the corals

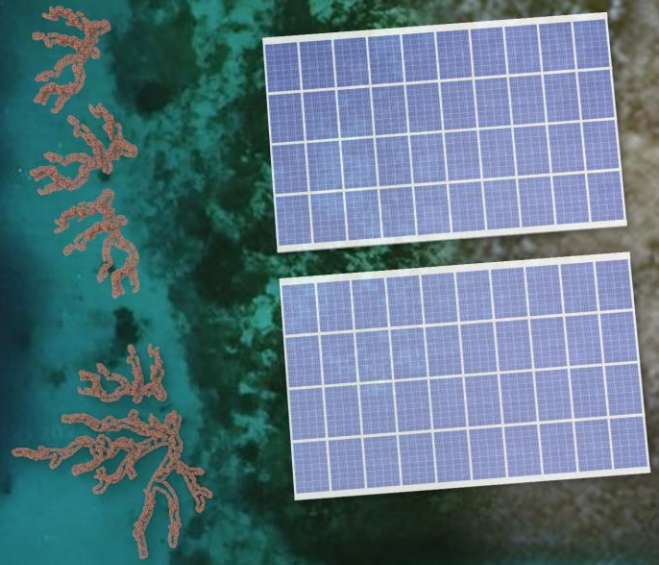
Reef regeneration as part of ADB's floating solar projects

Improve biodiversity and fish stocks, climate resilience, coastal protection & empowering communities by restoring degraded reef ecosystems with rrreefs' innovative nature-based reef solution!

permanent
building sturdy reef systems that last and can easily be enlarged by add on modules

participative
involving local stakeholders & community members throughout all project phases

measurable
precise reporting of how much biodiversity is restored



scalable
natural resources, modular design and low footprint

Grace Baptist Church

rrreefs

Thank you very much
Please get in touch for any further questions

Hanna Kuhfuss
Head of Field Operations &
Scientific Partnerships
hanna@rrreefs.com

+49 177 345 49 52 (WhatsApp)
+41 76 242 55 04 (Call)


Appendix


rreefs
Restoring Degraded Marine Ecosystems
in Pujada Bay, Philippines
ZURICH
vitabad
Ihr Stil. Ihr Pool.
AQUA SOLAR
SCHWIMMBAD- UND FILTERTECHNIK
wild foods

Partners in Pujada Bay

The President & Science Board Members (DOrSU)

Reinforcement Maritime Police & Coast Grades

Freemason supporting scientific analyses

The local government Barangasy & DENR Mati

Davao Oriental State University (DOrSU)

Local main project partners

Davao Oriental State University (DOrSU)

Department of Environment & Natural Resources (DENR-R11 & Mati & PENRO) & Biodiversity Management Bureau (DENR-BMB)

Mama Earth FOUNDATION

Implementation partners in the Central Visayas

CCEF
Sustainable coasts, involved communities.

COASTAL CONSERVATION AND EDUCATION FOUNDATION, INC.

Evelyn T. Deguit
Executive Director

Dionel L. Molina
CCEF x rrreefs officer - Coral Reef Rehabilitation and Monitoring Specialists

Nicholson D. Tan
Ecosystems Research and Monitoring Specialist

Atty. Dalton Presle B. Dacal
Senior Coastal Resource Management Officer

Alexis Mae C. Cancino
Project Monitoring, Evaluation and Compliance Officer

info@coast.ph www.coast.ph @ccefoundation @coasts_ccef
3F Rm 302, PDI Condominium, Archbishop Reyes Ave., Banilad, Cebu City, 6000, Philippines

Restoring marine ecosystems together in Pujada Bay, Philippines

In Pujada Bay, Philippines, we work on a project to explore the co-benefits of restoring different marine ecosystems together, namely coral reefs, seagras and mangroves. This includes benefits such as biodiveristy, coastal protection, and blue carbon potential.

Coral reefs

- Habitat for an abundance for marine life
- Physical buffer for waves shoreline
- Providing calm environments for blue carbon ecosystems like seagrass and mangroves to thrive

Mangroves & seagrass

- Carbon sequestration (store up to 10x more CO2 than tropical rainforests)
- Prevents erosion
- Bind sediments / pollution sink
- Maturing fish & crustaceans

Start of project Feb 24:

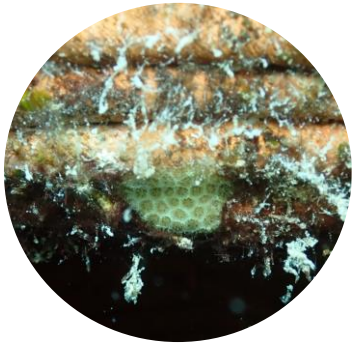
100 m2 reef rebuilt + 9000 mangroves planted

First impact generated in Pujada Bay

Enhanced protection status

- Pujada Bay is a **Marine Protected Area** (MPA), especially dedicated to the protection and maintenance of biodiversity, encompassing around 200km^2
- A **no-take zone**, i.e. a zone where no fishing is allowed, was established around the reef to enhance the protection

First coral settlement

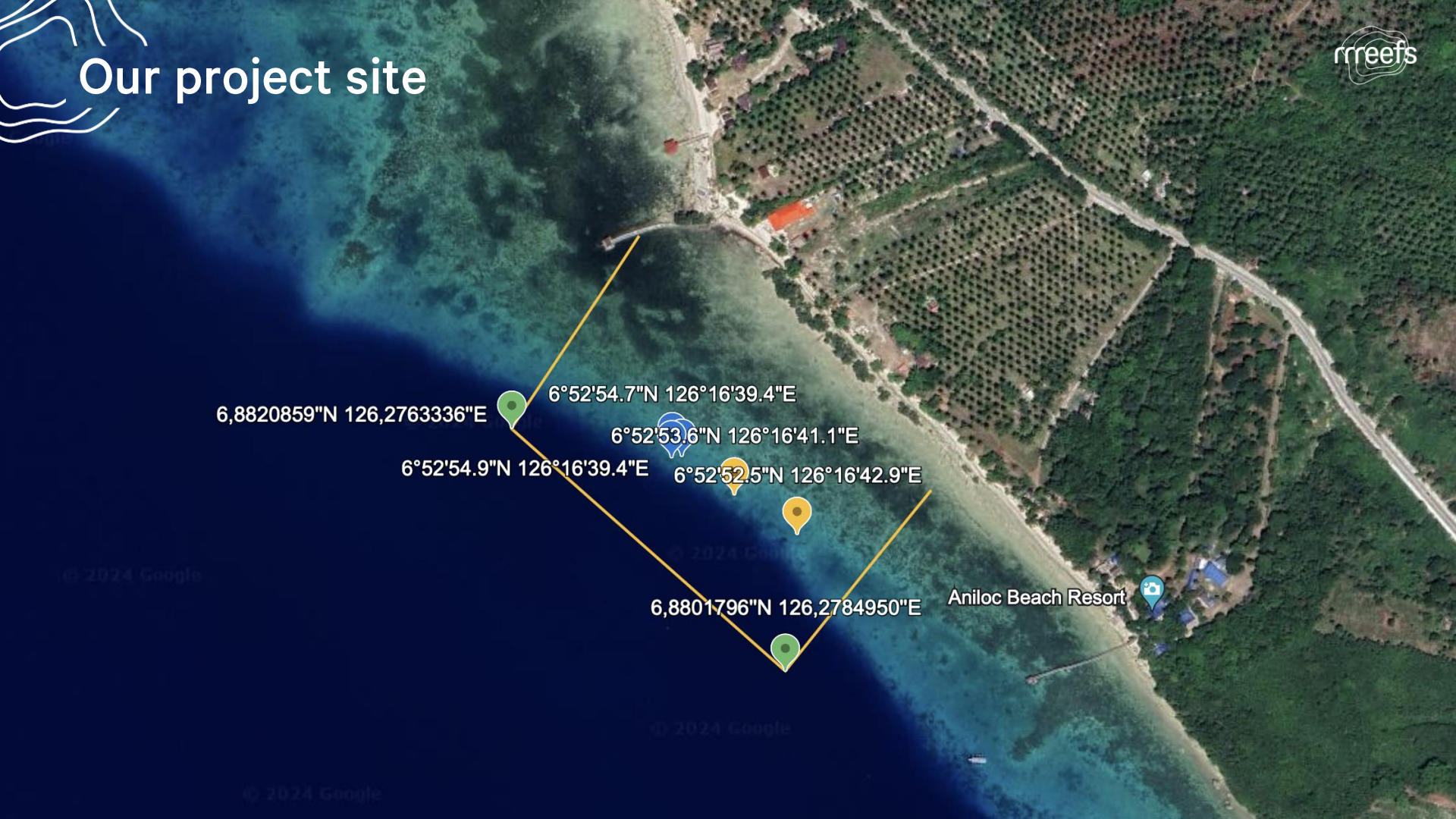


- Marine life adopted the new clay reef structure since implementation and **monthly visual observations** detect a **constant increase in various fish and other reef organisms**
- **First settlement of coral larvae shortly after implementation** of the clay reef structure.

Collaboration & community impact

- The **Davao Oriental State University** (DOrSU) in Mati is conducting scientific monitorings
- The DOrSU Future Thinking Lab explores **alternative livelihoods for fishermen** affected by the no-take zone
- Regular community updates and **educational sessions for children** in the region are held

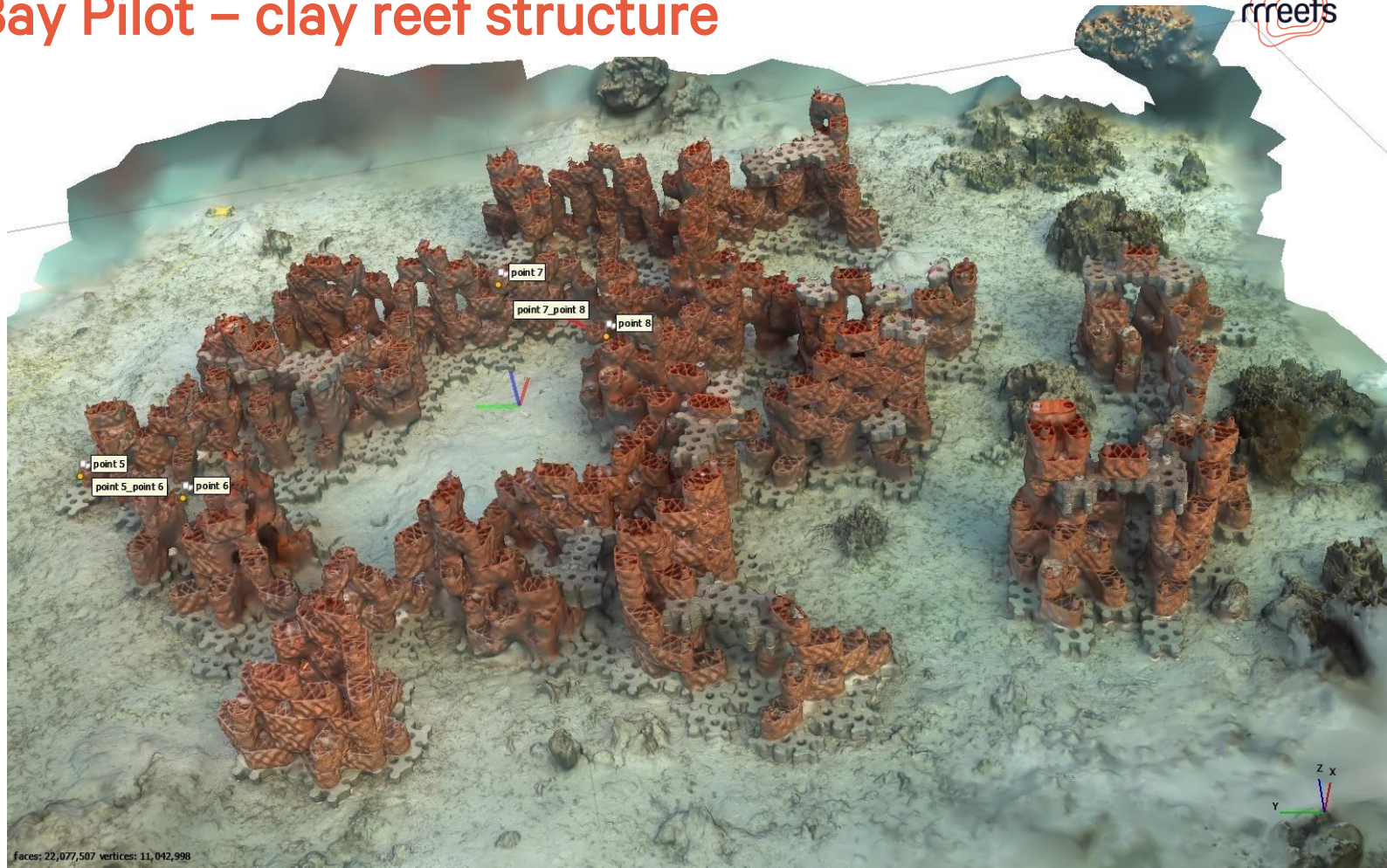
Our project site



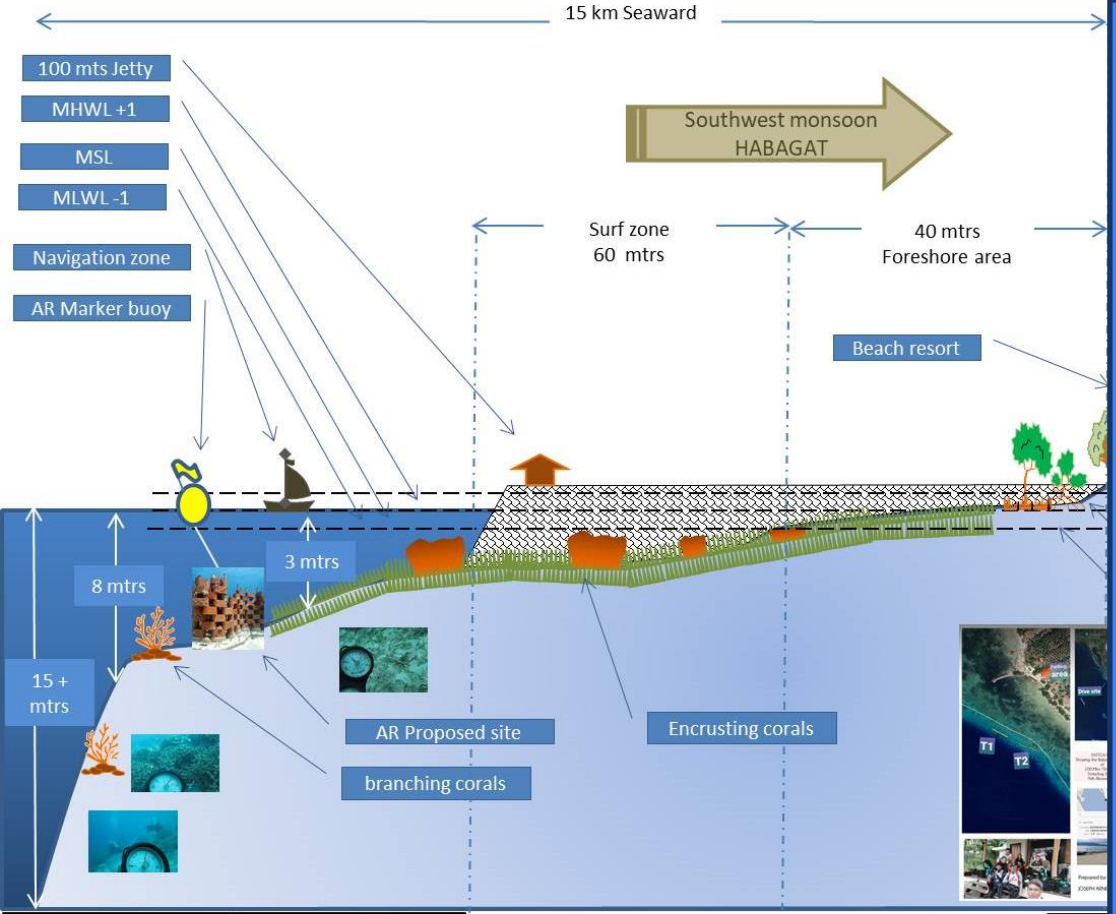
Pujada Bay Pilot – clay reef structure

830 rrreefs' clay bricks in 3 different patches:

- Big reef
  510 bricks
- Medium reef
  230 bricks
- Little reef
  90 bricks



Science Time



Prepared by:	Surveyed by:
_____	_____
January 30, 2024	January 25, 2024

Drawn not scaled

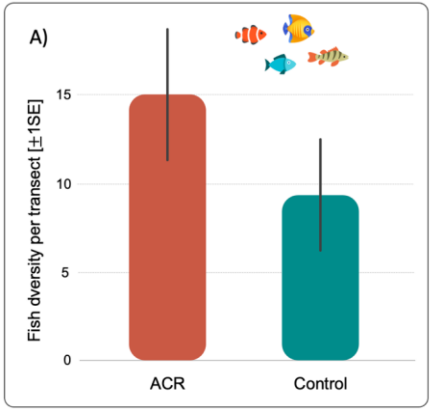
Beach Profile Map

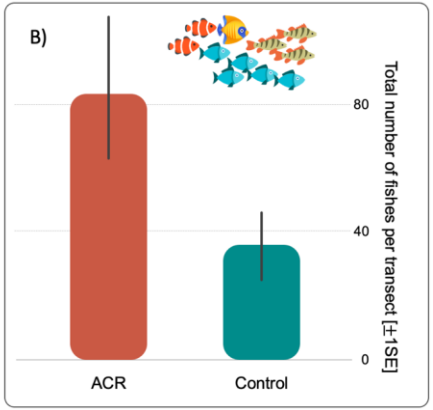
Located in Sitio Manguihay, Barangay Bobon
City of Mati, Province of Davao Oriental
Coordinates
Start- Lat= 6°53'3.63"N, Long=126°16'49.00"E
End-Lat=6°52'56.20"N, Long=126°16'32.49"E

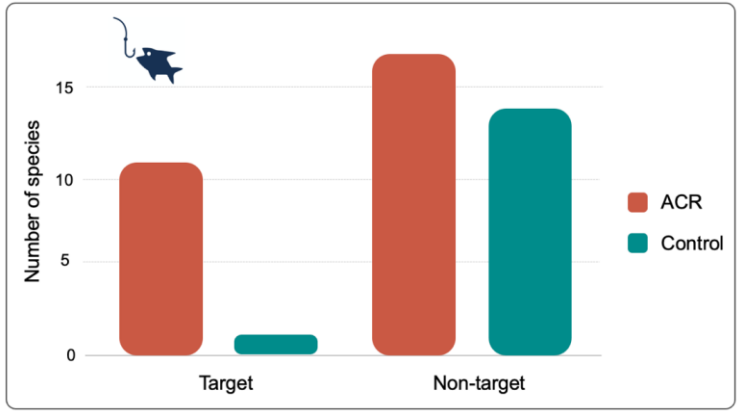
Long-term Monitoring

- **Visual counts:**
  - **Transects** for fish, macro invertebrates (Following the Standard Marine Resource Baseline and Monitoring Assessment, guidelines from DENR, CCEF and additional SOP Monitoring rrreefs)
  - **Defined areas** on substrate for recruitment (SOP rrreefs)
- **Stream Ocean Camera** -> innovative AI fish monitoring test monthly & **Photogrammetry**
- **Visual quartets**: seagrass cover/density (Quarterly by DOrSU) → does the AR change Sg-cover
- **Molecular**: environmental DNA (every 6 month, 4 replicates per site, following Simplex Protocol)
- **mangroves** -> survival rates and growth (DOrSU)
- **Sensors** (physical parameters): HOBO logger for Light + Temp (continuous); Salinity, dissolved O2, pH (every month if possible) → possibility to explain biological effects

Development of fish community after 5.5 months at the Pujada Bay site



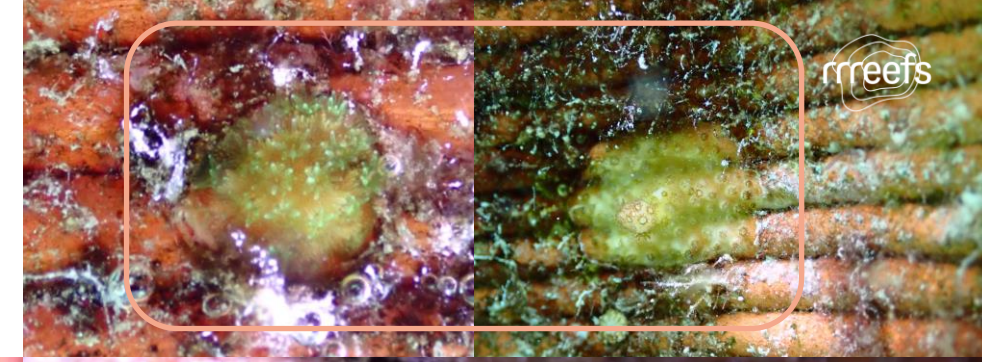


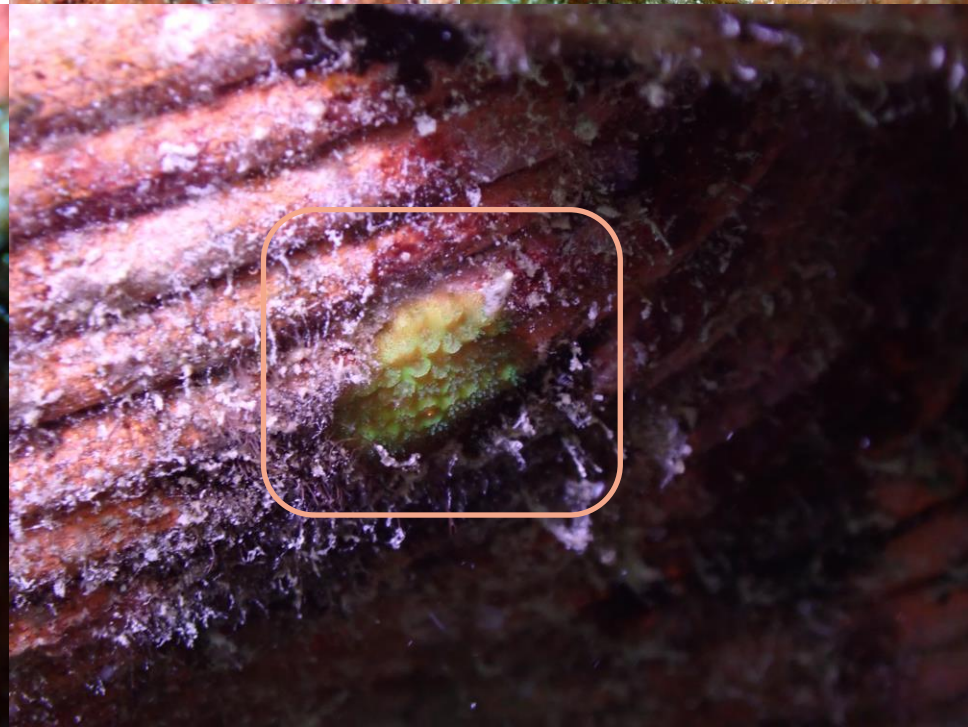


Natural recruitment

coral spat after 5.5 months

settlement directly after implementation





Establishing a local 3D-printing production facility

We aim to build the first 3D-printing clay production facility in Mati, Philippines – a blueprint for scaling up the production of resource-efficient reef structures around the world:

- Partnering with **Davao Oriental State University (DOrSU)**, which will host the facility
- This facility will also promote **knowledge sharing** and **capacity building**, fostering innovation and sustainability
- Expertise of our **Swiss partner coeurdeterre**, to implement with the engineers of DOrSU a functioning facility
- Local production will reduce logistical costs and environmental impact, enhancing project efficiency

Rebuilding 10’000 ha reefs in the Philippines

Phase 1
Pilot projects together with local partners

Phase 2
Large-scale projects

Permit Pujada Bay

Partnership CCEF, DOrSU, Mama Earth Foundation

2023

Permit Siquijor

Feb: 100m² reef rebuilt Pujada Bay

Jul: Onboarded CCEF country manager

2024

Aug: 30m² reef rebuilt in Siquijor

Asia Blue Project start
-> goal: 10k ha marine ecosystem regeneration

Production partner Philippines for casted bricks

2025

3D-Printing Production facility in Mati is running

2026

1 ha of coral reefs restored

10 ha reefs in Philippines restored

2027

2035

10k ha reefs in Philippines restored

120 m² reefs → 10’000 ha of reef structure regenerated

Building climate-resilient reef structures

Climate change, ocean acidification, and other environmental stressors pose ongoing threats to coral reef ecosystems, impacting the success of restoration efforts. We focus on the following three pillars to create climate-resilient reef ecosystems:

Advancing natural coral larvae recruitment

Our focus lies on facilitating natural coral recruitment and the proliferation of genetically robust corals, which are more likely to survive and adapt to changing climatic conditions. To date, coral larvae are often offspring from climate-resilient corals that survived environmental stresses. By mimicking the natural reef complexity and offering microhabitats that provide shelter, our structures present optimal settlement substrate for coral larvae.

Providing a long-lasting foundation

We construct durable and ecologically suitable reefs using terracotta clay . Our reefs resemble stable structures that do not degrade over time as they can endure storm surges and temperature fluctuations. Even in the case that corals die due to climatic conditions, our reefs will endure and continue to provide a settlement foundation for more climate-resilient corals and an abundance of other marine life which depends on reef structures for shelter and food.

Combining different coral restoration approaches

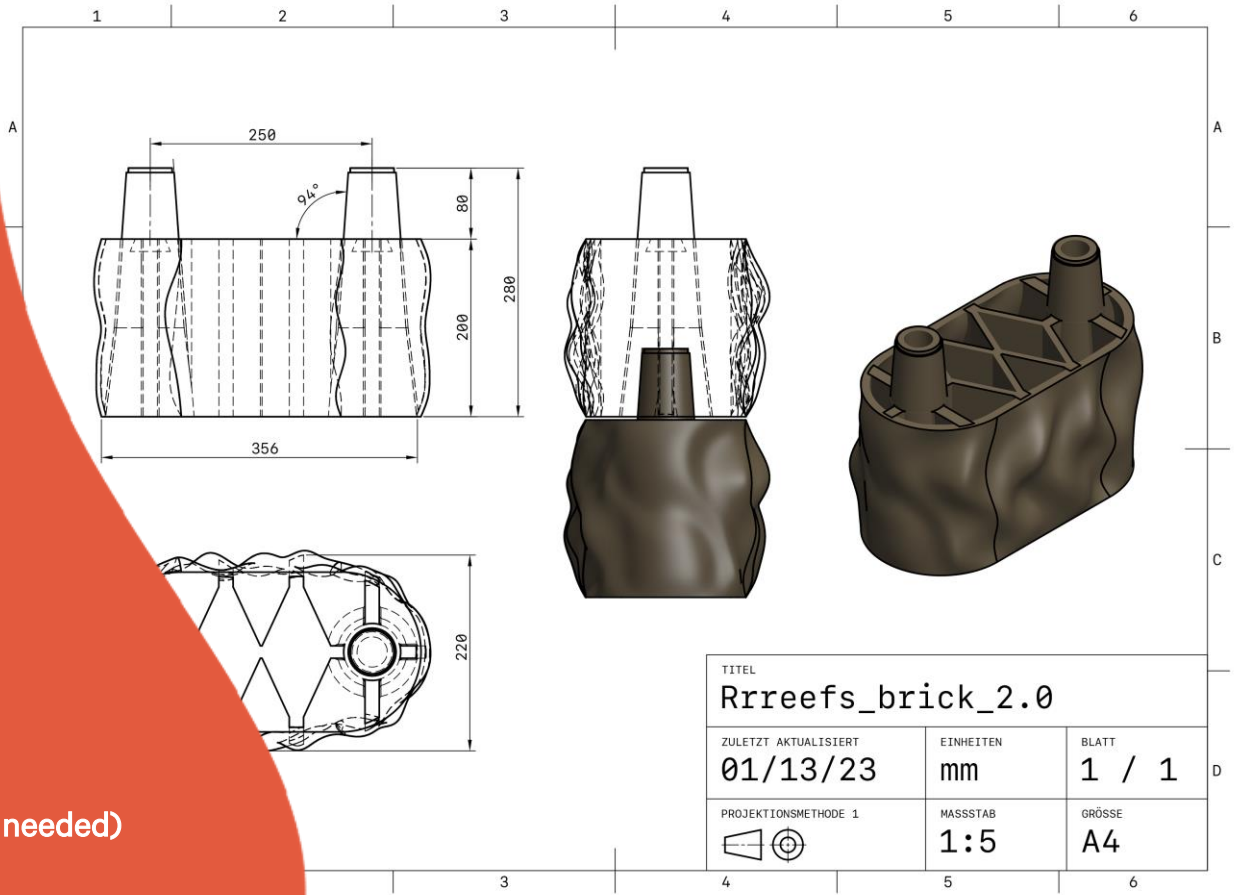
Working together with partners, we can integrate a variety of coral restoration techniques, including coral gardening, and microfragmentation to maximize restoration success. This multifaceted strategy allows us to address different environmental challenges and adapt to site-specific conditions.

Building materials

Our reef system is made from natural clay. The clay sources we use get tested by certified third-party agencies to not leak any salts or heavy metals or containing other pollutants, and to adhere to the EN 771 norm.

Other building materials depending on the region:

- Stainless steel ropes & press sleeves
- Ground anchors (stainless steel)
- Local concrete mix (foundation, only if needed)



Building materials

Other building materials depending on the region and the type of AR foundation:

For Siquijor we produce locally with LGU Maria.

- The local concrete mix was applied in different coral restoration approaches in Siquijor before.

NOTE: We are developing a platform solution made of clay currently and depending on the sea floor may use different solutions in futur.

WE PROVIDE FAST, VISIBLE IMPACT

We rebuild resilient coral reefs that have the ability to recover and flourish with marine life within a few years. When conditions permit (minimizing water pollution, addressing overfishing, etc.), we believe that healthy reefs can adapt to the effects of climate change.

2 months
site scouting & government permit

1-2 months
production of bricks

~ 1 month
transportation

~ 5 days
building & anchoring reef underwater

3 months
fish biodiversity similar to natural reefs around

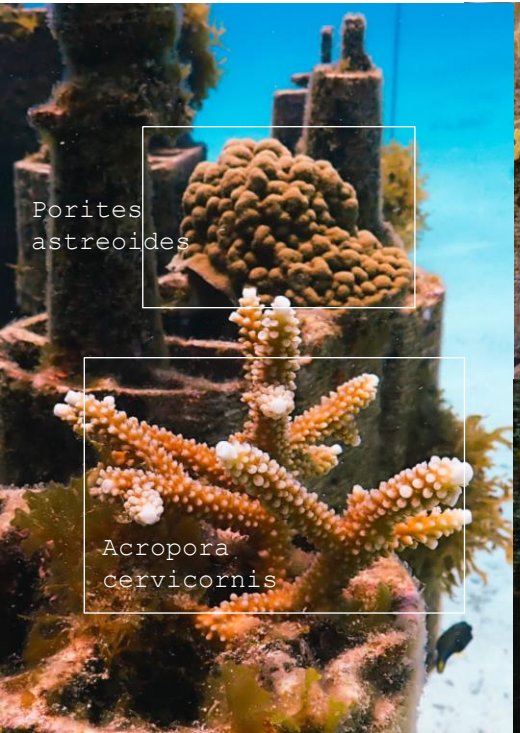
6-9 months
first natural coral settlement

3-4 years
structure is over-grown by corals

preparation | production | implementation | reef development

Measuring and quantifying impact

To assess the **long-term impact** of our reefs, we assess **marine biodiversity** and **coral settlement and growth** using different monitoring techniques. This data is shared with our customers to prove the biodiversity impact achieved over time.



Example Policy Recommendations

- Enforce a no-take zone on the artificial reef (No fishing, mining, drilling, or other extractive activities allowed within the boundaries of a no-take zone. (PAMB)
- Delineate 100 m from the core zone as party of the no take zone and additional 200 meters for the buffer zone (limited activities are allowed such as hook and line for subsistence fishing).
- Selected recreational activities are allowed in the AR such as diving and freediving for education and research only.
- Demarcate the zone with floating buoys (DENR CENRO & PAMB) and signages for awareness and educational purposes. (DOrSU)
- Implace enforcement (Bantay Dagat, DA) in the Artificial Reef for safety and protection. (BFAR, Coast Guard's, Maritime Police)
- Allocate funds for the regular Monitoring of the Artificial Reef. (PAMB)
- Studies on alternative livelihood for the fishermen who will be affected by the no take zone policy on the artificial reef. (future thinking lab from DOrSU)

Example Policy Recommendations

- Conduct regular community updating and educational information about the artificial reef. (DOrSU)
- Sharing of data among stakeholders. (DOrSU, rrreefs, DENR)
- The Protected Area Management Board (PAMB) should create a Technical Working Group (TWG) for the Monitoring of the Artificial Reef which includes:

- DOrSU: main scientific partner of rrreefs and the main responsible for the ecosystem monitoring
- DENR CENRO & PENRO: will support DOrSU-RIC XI team with the ecosystem monitoring
- BFAR: will reinforce the no-take zone and provide buoys to mark the area
- rrreefs: providing monitoring guidelines and training and will take part in the main monitoring when time and travel funds will allow it.

The multiple positive impacts of regenerating reefs with rrreefs

direct increase of habitat for a wide variety of animals, action for the least funded SDG 14

Proven to **restore fish diversity** after 3 months, natural coral settlement after 6 months, coral survival of >50 % in the vulnerable first 6-9 months, and >90 % for corals >1cm.

scaling implementation with people → local added value, alternative income

We will scale reef building by employing thousands of people in coastal communities. This creates **jobs**, creates **ownership**, and improves **socio-ecological resilience**

indirect CO_2 sequestration by improving mangrove and seagrass habitat

An isolated coral reef is net-carbon-zero. Reefs create secondary habitat for **mangroves** and **seagrasses**, which sequester CO_2 much faster than forests. **Increased fish stocks and biodiversity** bind additional carbon and increase CO_2 -binding capacity. Not eligible for CO2 credits.

a lever to widen Marine Protected Areas or improve their management

Community support for a restoration site increases likelihood that this site will be protected to ensure the success of the restoration activities.

protection of coastal infrastructure, settlements, and ecosystems

Our reefs can be hydrodynamically adapted to local needs for coastal protection, reducing storm flood damage, beach loss, and salinization of coastal freshwater ecosystems

The importance of coral reefs for blue carbon

The oceans are the greatest carbon sink on Earth. Around half of all atmospheric CO_2 emissions since the industrial revolution have been absorbed by the ocean. The term **blue carbon** refers to the carbon sequestered in coastal ecosystems and stored in their sediments.

Given their ability to dissipate waves and currents, **coral reefs facilitate the blue carbon potential** of ecosystems like mangroves, seagrass and salt marshes. Consequently, the conservation of coral reefs is increasingly being recognized as an essential asset in blue carbon concepts, **de-risking** the vulnerability of blue carbon ecosystems.

Coral reefs

- Buffering of waves and currents
- Providing calm environments for blue carbon ecosystems like seagrass and mangroves to thrive

Mangroves & seagrass

- Mangroves and seagrass are of enormous importance for reducing CO_2 in the atmosphere balancing climate
- Though blue carbon ecosystems cover far less land area than terrestrial forests, they can store up to 10 times more carbon than tropical rainforests


rrreefs
“Our clients, business partners and employees are thrilled with our collaboration with rrreefs – a strong, passionate team and an innovative and scalable approach to healthy reefs and oceans.”
Dr. Carsten Schildknecht
CEO | Zurich Group Germany
ZURICH
Winner
planethero
Award 2021
by ZURICH

"The award-winning creative entrepreneurs and companies create added value in Germany, but above all they also provide impetus for the urgently needed change in the economy and society as well as concrete and sustainable solutions for the climate and environmental challenges of our time."

Dr. Robert Habeck
Federal Minister for Economics and Climate Protection