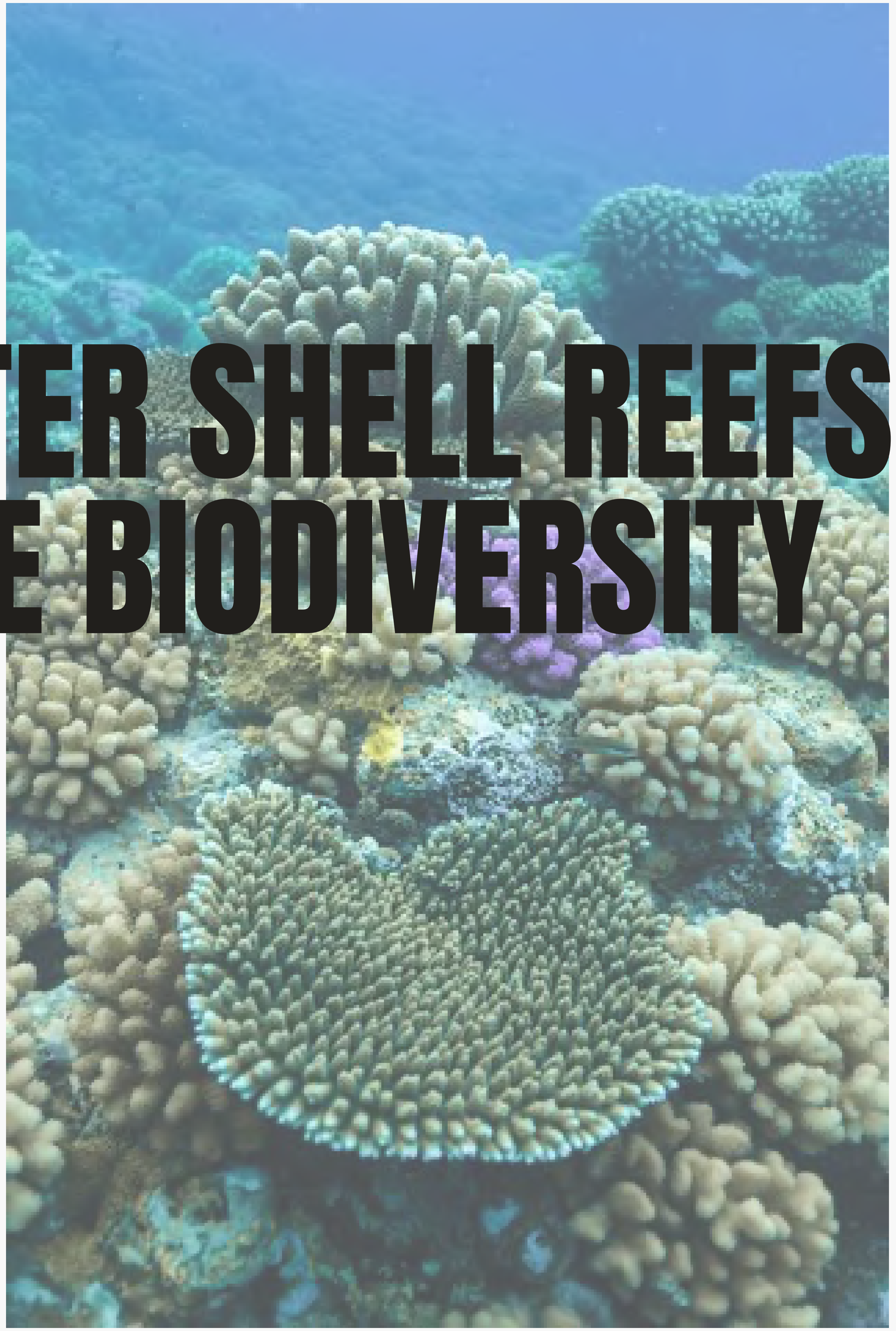
# 3D PRINTED CLAY & OYSTER SHELL REEFS FOR ENHANCING MARINE BIODIVERSITY



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[1] Coral Gardeners

# OVERVIEW

**Key Words:** Bioremediation | 3D Bioprinting | Biocalcification | Regenerative BioDesign | Conservation | Living Structures

Using digital fabrication technology and bio-fabrication techniques to design a 3d bio-printed coral reef structure  for use in conservation which is formed from the calcium carbonate binding between a living microorganism and natural pollution filtering bio-materials.

[1] Coral Gardeners

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# WHAT

[1] 3D Printed Clay Tile Coral Reef

3D bio-printed coral reef using living materials and biomaterials to **enhance** the reef structure, enabling processes such as **biocalcification** and **bioremediation** to occur, pulling pollution from the marine environment.

This design provides a **more hospitable** living environment for marine life and allows for a **self-healing living structure** which closely imitates coral reefs. The hope is to cultivate cyanobacteria or marine fungi that are **adapted to survive** in the harsh and changing conditions to create a stronger reef scaffold.

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# WHY

The **rapid decline** of coral reefs has increased the necessity of exploring interdisciplinary methods for reef restoration. There is an urgency to invest in technology that can help reach **ecosystem-scale.** [1]

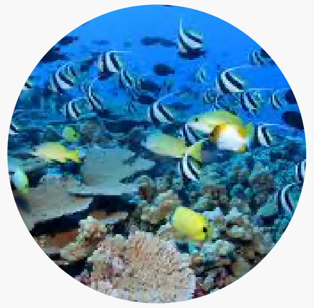
Current Problems with Restoration Techniques:

- difficulty replicating the **3D complexity** of coral habitats
- difficulty **scaling** them to larger areas
- **pollution** from toxic objects such as sunken ships or concrete

Coral Reefs:

are the **most vulnerable** ecosystem to climate change - declined **50%** since the **1950s**, **90%** of coral ecosystems will be severely degraded by **2050** [1],[5].

are a sink for approximately **29%** of all CO2 absorbed by the ocean [4]



support **25%** of marine life [2]

provide food, coastal protection, and revenue for **millions** of people [3]

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[1] Emerging 3D technologies for future reformation of coral reefs
[2] World Corals Are Bleaching
[3] Coral Reef Ecosystems
[4] Ocean Acidification

# RESEARCH

Academic References

## “EVALUATION OF THE EFFECTIVENESS OF 3D-PRINTED CORALS TO ATTRACT CORAL REEF FISH AT TAMARINDO REEF, CULEBRA, PUERTO RICO“

- fish were **more abundant** in corals with the **highest levels of complexity.**

- findings suggest that 3D-printed corals can serve as a **complementary** tool to improve the ecosystem function of degraded coral reefs.

## “REEF REVOLUTION: HOW IMPLEMENTATION OF 3D PRINTING CAN PROMOTE SUSTAINABLE CORAL RESTORATION”

Example of successful 3D printed reefs:
- Archireef - Hong Kong, **95%** coral survival rate

Complexities of design:
- reefs need to be designed for the **particular location, environment and organisms**

- selection of **durable** and **strong** materials e.g clay

## “ARTIFICIAL REEFS: WHAT WORKS AND WHAT DOESN’T”

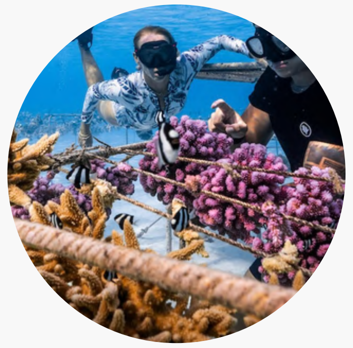
Doesn’t work:
- trash and toxic materials
- small unsecured structures

Does work:
- wrecks and steel structures
- concrete structures
- **modular units**
- mineral accretion devices

# RESEARCH

Organisations

Current innovative methods for reef restoration include propagating coral polyps on frames and 3D printing; while traditional methods sunk objects such as ships or concrete blocks.



## CORAL GARDENERS

Growing coral fragments on rope to revive ecosystems and providing live coral growth tracking information.

## REEFCYCLE

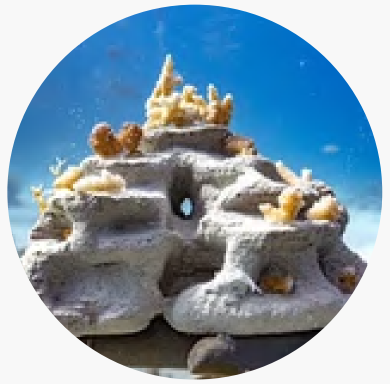
use plant enzymes to mimic shell formation and create bio-cement. Resulting in marine-safe material that can be produced in situ without heat, energy, or resource depletion

## REEF DESIGN LAB

3D printed reef structures made from eco-concrete, oyster shells or other recyled materials.

## RRREEFS

3d printing customisable clay reef structures, and empowering communities through science, art and education.



## COASTRUCTION

3d printing using natural materials aiming for the lowest CO2 footprint possible. Ideally, local materials such as beach sand or recycled concrete.

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# WHERE

Artificial reefs are very **location** and **ecosystem** dependent. When designing a reef these factors should be considered:

- local marine ecosystems and biodiversity
- water depth, light levels and temperature
- hydrodynamics (waves, current and sedimentation)
- seafloor characteristics
- human and environmental impact

ReefScapers

I will use **open access resources** of downloadable **3D photogrammetry models** of coral reefs to identify which part of the world I will study. Such as:

- The Hydro
- VISEAON -Treibitz Marine Imaging Lab
- SketchFab

# HOW

## RELEVANCE/NEED

Problems with current/3D printed reefs methods:

- concrete based designs are still **pollutants** in the marine environment and the industry is one of the **largest producers of $CO_2$** [1],[2]
- artificial reefs may not exist **symbiotically** with the marine life [1]
- molded reef structures have **less complexity** and don't mimic the natural environment well

The solution:

→ biomaterials won't release **microplastics** or pollutants into the water.

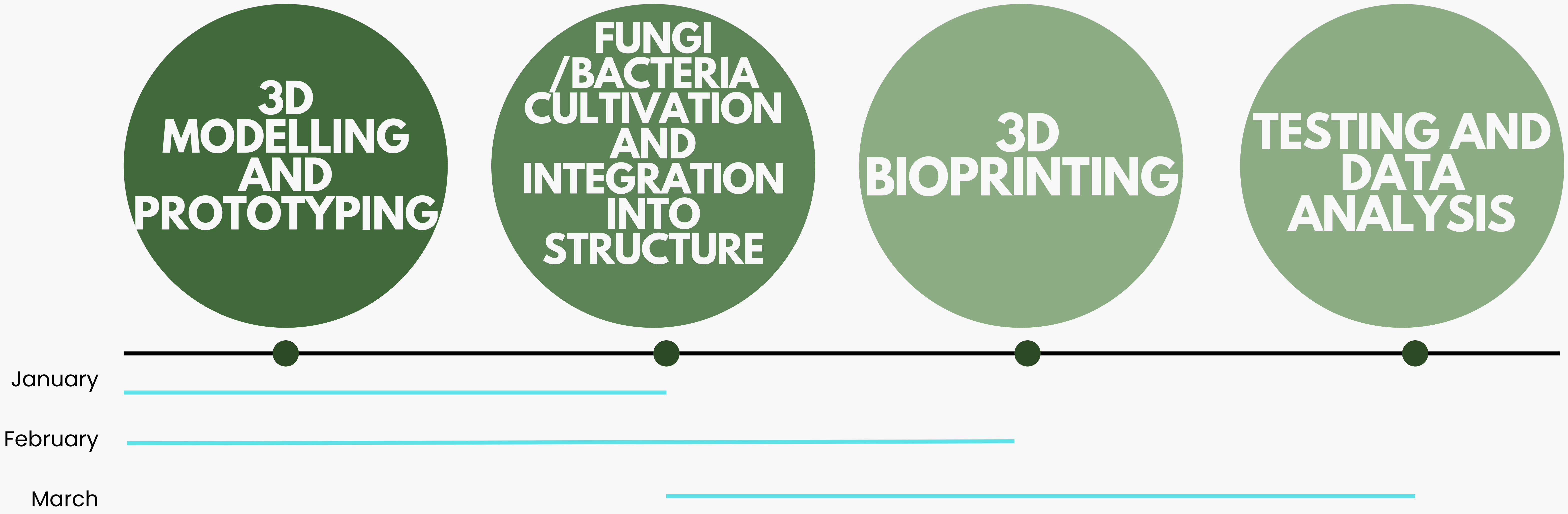
→ creating a living structure with **bioremediation** properties will allow for a **more hospitable** marine environment

→ 3D printing allows for more **complex geometries** and surface areas allowing for more life to form on the structures.

[1] The Eco Friendly Alternatives to Ocean Concrete
[2] Biocement Fabrication and Design Application for a Sustainable Urban Area

# HOW

## PROCESS


3D MODELLING AND PROTOTYPING
FUNGI /BACTERIA CULTIVATION AND INTEGRATION INTO STRUCTURE
3D BIOPRINTING
TESTING AND DATA ANALYSIS
January
February
March

Biomaterial
- CLAY
- SAND
- CRUSHED SHELLS

Living Organism
- MARINE FUNGI
- CYANO-BACTERIA
- MICRO-ALGAE

# MATERIALS

Taking inspiration from design innovations such as **self-healing biobricks** [1] , 3D printed architecture with **living materials** [2], and **bio-cement** I will choose a biomaterial and living organism to build a resilient structure which produces calcium carbonate and filters pollutants from the water.

The living material will either be chosen based on its ability to **survive in aquatic environments** or its ability to **produce calcium carbonate** (i.e it will be baked before being submerged)

**Reinforcement** with steel may be necessary depending on the location.


[1] Self Healing Bricks Eat CO2
[2] ClayCelium - IAAC
[3] BioCement Fabrication and Design Application

# CONCLUSION

*"3D bio-printed coral reef structure enhanced with living organisms and sustainable biomaterials with bioremediation and biomineralization properties for reef restoration and increased biodiversity"*

Coral reefs are the most **vulnerable** ecosystem under threat from climate change and are **unable to adapt** fast enough to become resilient to the changing conditions.

Traditional methods of restoration have proven **unsustainable** and **polluting** to the marine environment.

Modern methods include **propagating** coral fragments on frames, **3D printing** reef structures, and **molding bio-cement** into simple shapes.

- There is little to none of research into 3D bio-printing a living coral structure using e.g **clay** and **cyanobacteria** which would promote biocalcification and bioremediation within the skeleton.
- 3D bio-printing will allow for more **complex geometries**, easier **customisation** with 3D modelling and photogrammetry, and **higher surface area** for larvae attachment

# THANK YOU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