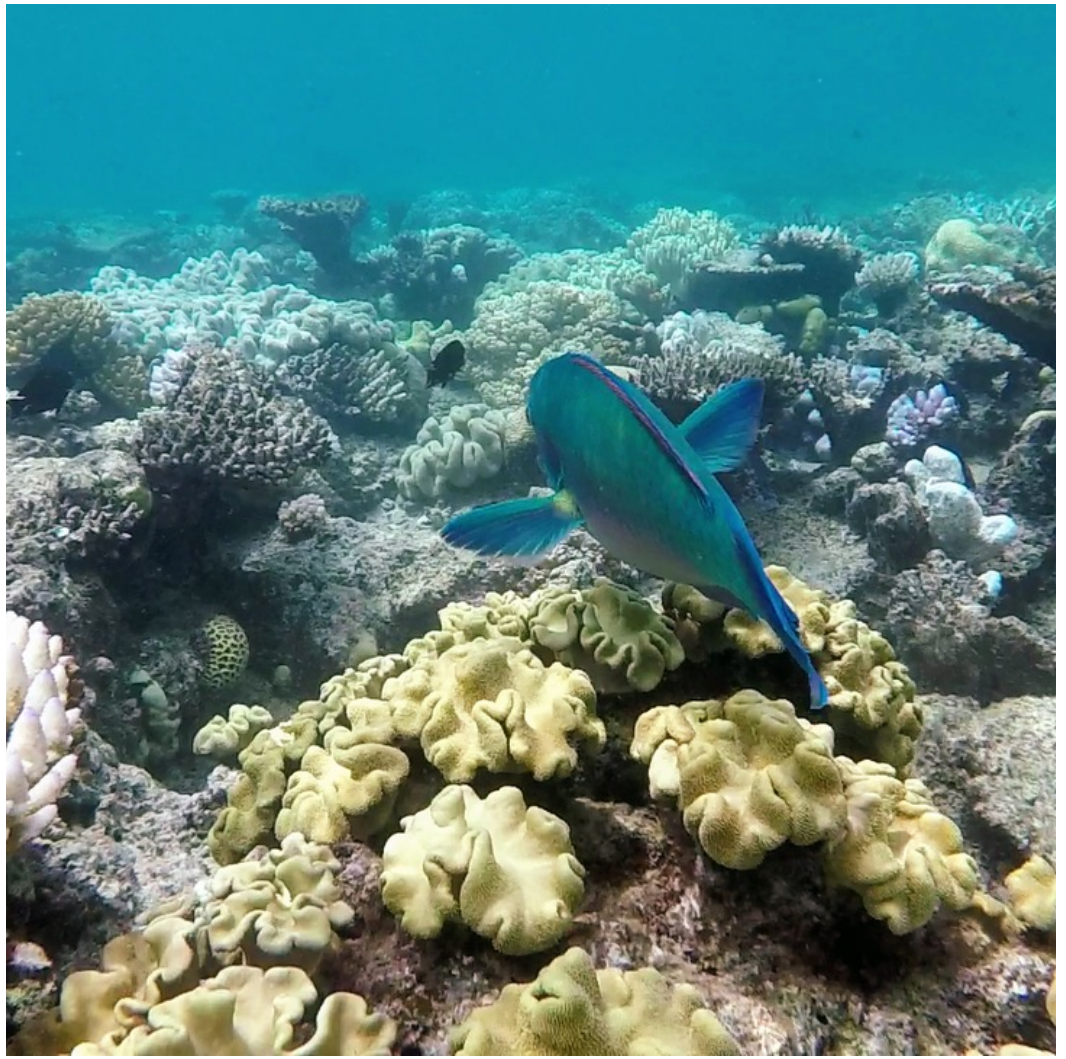
Singapore's High Relief Artificial Reef



Presented by
Dr. Santosh Kumar
HSL Constructor Pte Ltd, Singapore.
Date: 22-Oct-2021

Co-Presenter:
Prof. Chou Lok Ming
National University of Singapore, Singapore.

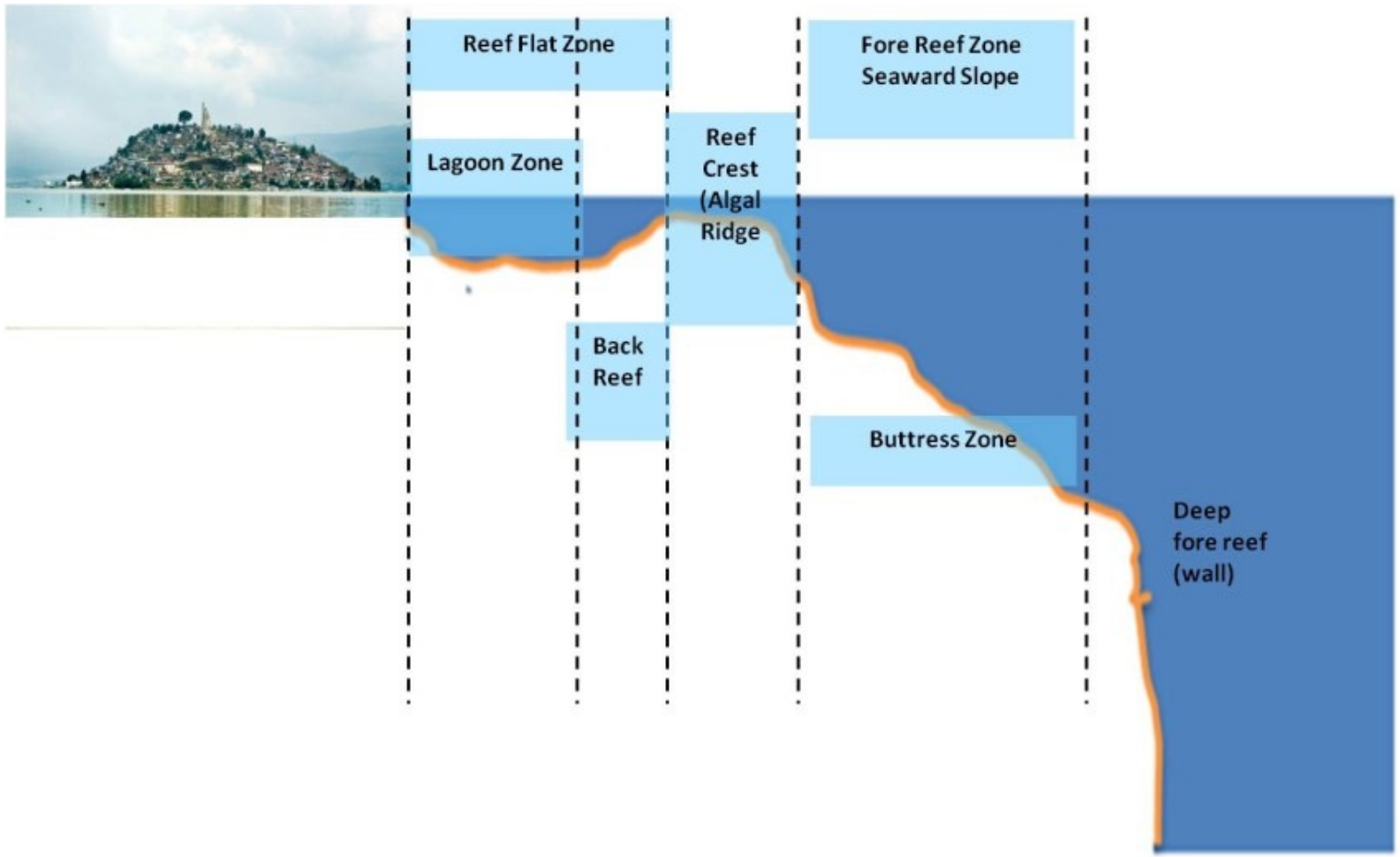
HSL Sustainability

Pivoting to Water, Energy Food and Environment (WEFE) to tackle the global climate crisis

As an infrastructure construction company, HSL executes economical and efficient engineering solutions that address the rising need for **water and food security, flood mitigation** and **cleaner energy**. These are all issues exacerbated by the intensity of climate change.

WHERE CAN WE FIND REEFS?

- In nature, reef slopes extend from seafloor to intertidal zone
- Reefs support biodiversity across all depth zones of water column



TYPES OF REEFS

Fringing reefs – support biodiversity and reduce erosion & wave energy

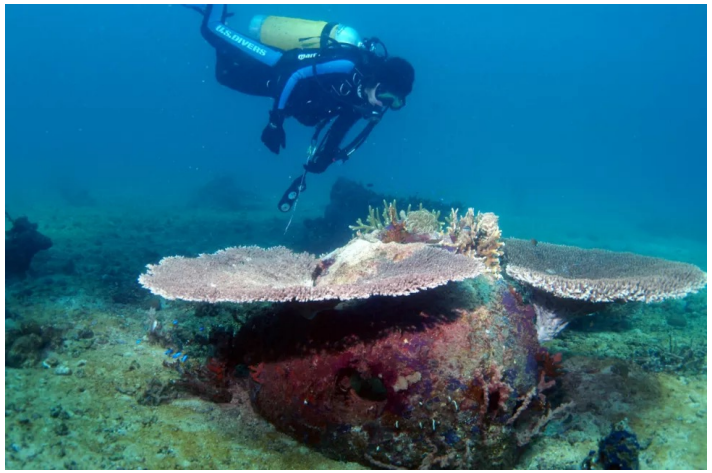
Barrier reefs – support biodiversity and reduce wave energy

Atolls – support biodiversity and reduce wave energy

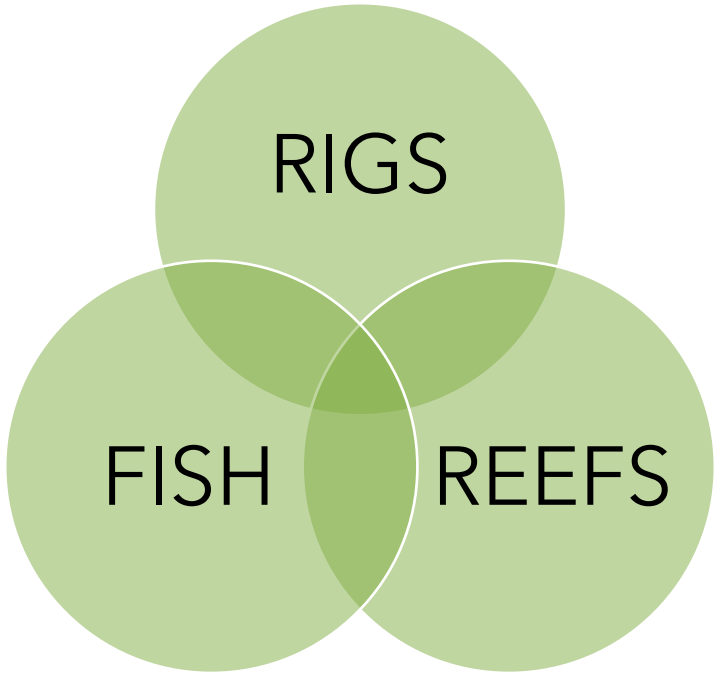
WHAT ARE ARTIFICIAL REEFS?

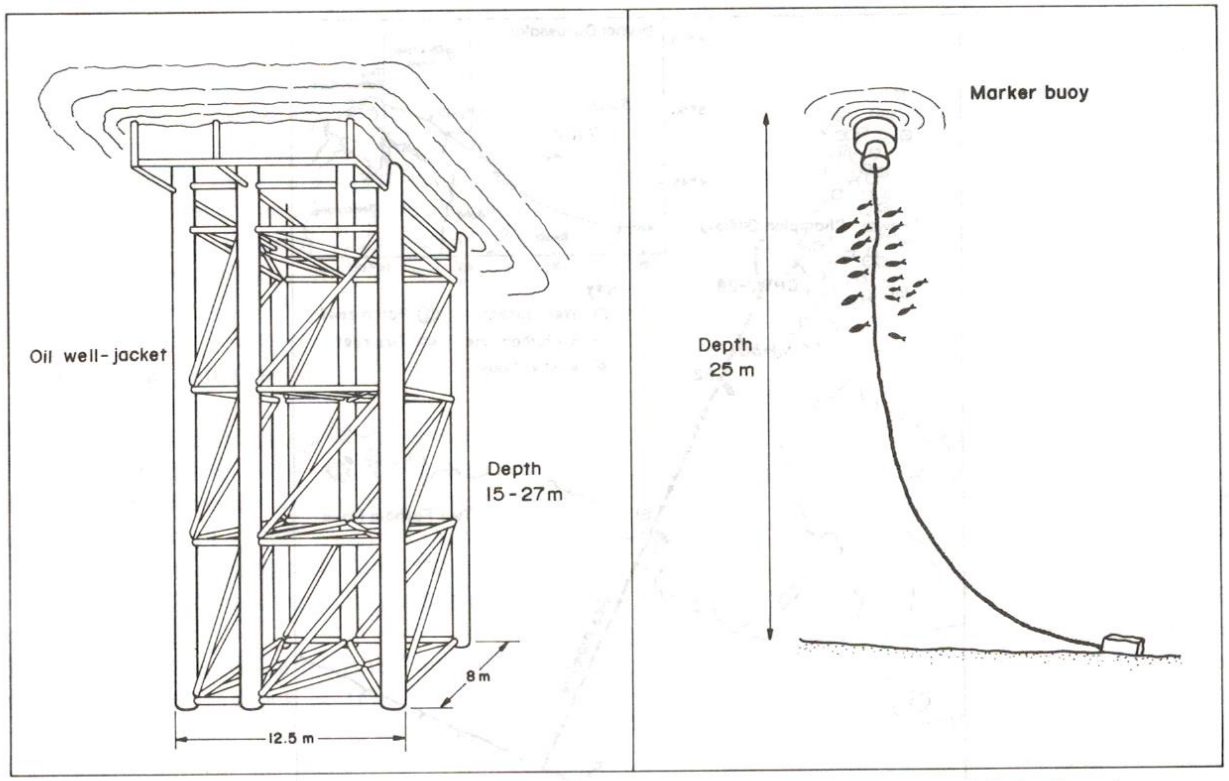
High-relief artificial reefs - structures that extend entire or almost entire water column

Low-relief artificial reefs – structures that cover the seabed and extend minimally into water column.



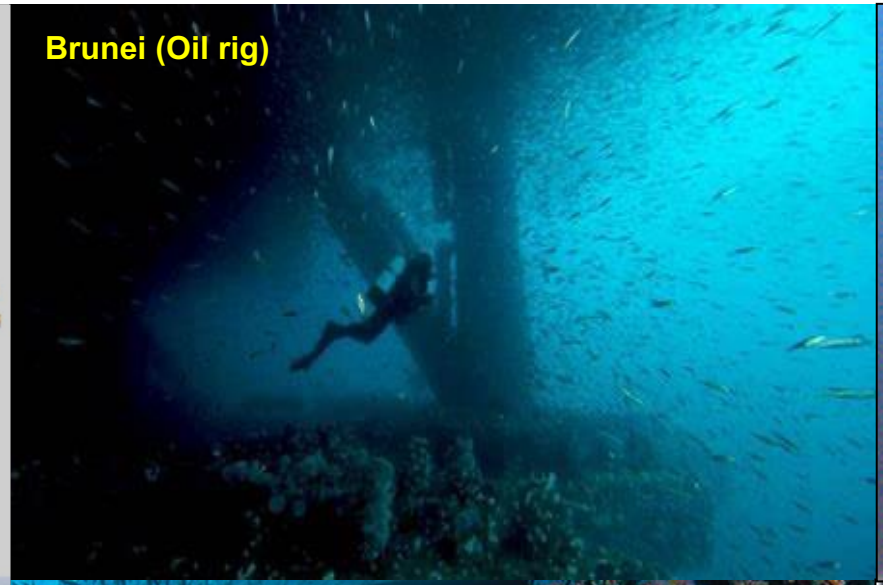
ARTIFICIAL REEFS

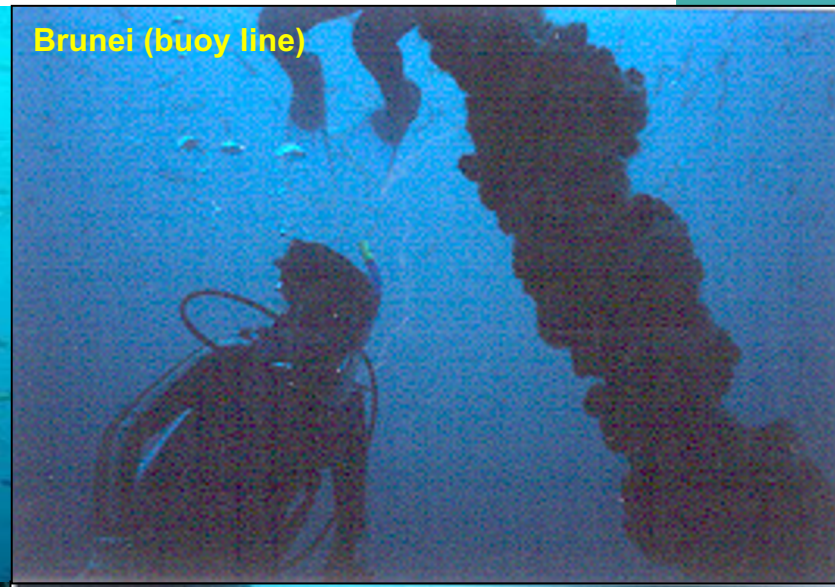




- Dis-used Oil rigs can function as effective biodiversity enhancers and contribute ecosystem services
- Decommissioning = $$
- $$ better spent on managing disused rigs to provide ecosystem services

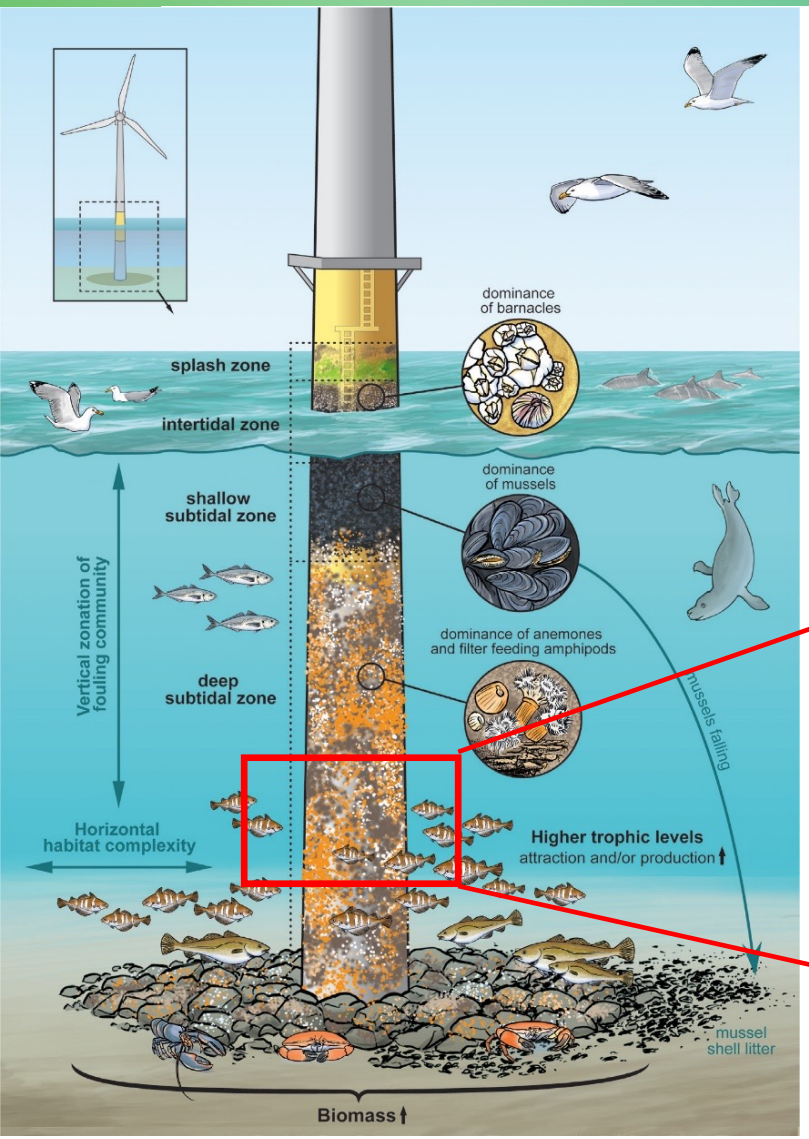
Can Disused Oil rigs function as high-profile artificial reefs?





How about Off-shore Wind turbine towers?

Serves as ‘living’ support structure for clean energy generating infrastructure



Offshore Wind Farm Artificial Reefs Affect Ecosystem Structure and Functioning: A Synthesis. Steven (2020). Degraer, Drew A. Carey, Joop W.P. Coolen, Zoë L. Hutchison, Francis Kerckhof, Bob Rumes, and Jan Vanaverbeke, Vol 33, No.4, pp. 49-57.

Artificial Coral Reefs

Sisters' Island, Singapore

DHI

NUS National University of Singapore

jtc Breaking New Ground

NATIONAL PARKS LET'S MAKE SINGAPORE OUR CITY IN NATURE

HSL

Owners & Developers

jtc
Breaking New Ground

NATIONAL PARKS
LET'S MAKE SINGAPORE OUR CITY IN NATURE

Consultants

NUS
National University of Singapore

DHI

Contractor

HSL

(I) Project Origin & Objectives

Main Objectives

- To have a sustainable solution to enhance marine ecosystem and biodiversity in Singapore Waters
- To offer opportunities in marine biodiversity research and leisure

(I) Project Origin & Objectives

Ecology Aims

- Attracting Epibenthos/ coral species/ fishes within shortest time frame
- Substrate provision
- Ecological connectivity

(I) Project Origin & Objectives

Roadmap

2010	2011-2012	2013	2014-2016	2017	2018	2019	2020-2022
Conceptualization by multi ministry task force	• Feasibility study • Identifying suitable locations	• Engagement of stakeholders, • Securing funding • Securing location	EIA, SI and Concept design	Procurement of D&B Services by JTC and Project Award/Commencement	Project Completion	Small scale coral transplantation	Monitoring programme

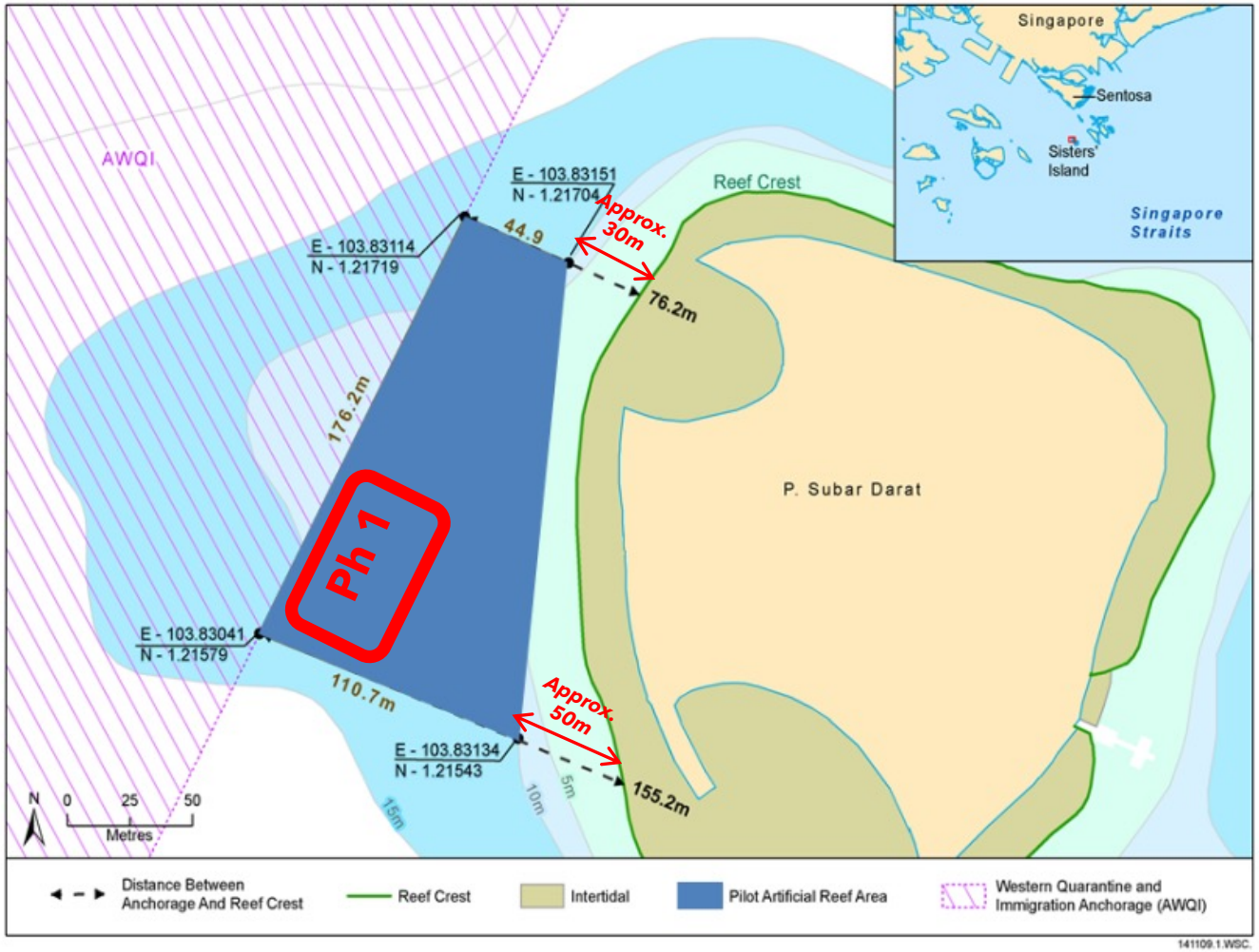

Singapore


Sisters' Islands


Artificial Coral
Project

(I) Project Origin & Objectives

Chosen Location



General Coordinates (WGS84)	
N1° 12.986′	E103° 49.874′

Seafloor Area	Average Depth
Approx. 10,000m²	-7m CD

(I) Project Origin & Objectives

Chosen Location

- Environment Impact Study (EIS)

To determine the impact of artificial coral reef structures on the existing seabed, flora & fauna

- *Suspended sediment*
- *Pollution*
- *Underwater noise*
- *Navigation safety*
- *Recreation*
- *Macrobenthos*
- *Coral reef biodiversity*
- *Currents, wind waves, Ship wake*
- *Seabed morphology*

- Analyses & Models
  - *Bathymetry study*
  - *Ship wake analysis*
  - *Numerical current flow model: currents and water levels in the area*
  - *Numerical sediment spill model: propagation of spilled materials based on construction works*
  - *Numerical mud transport model: transport of cohesive materials based on the flow conditions*

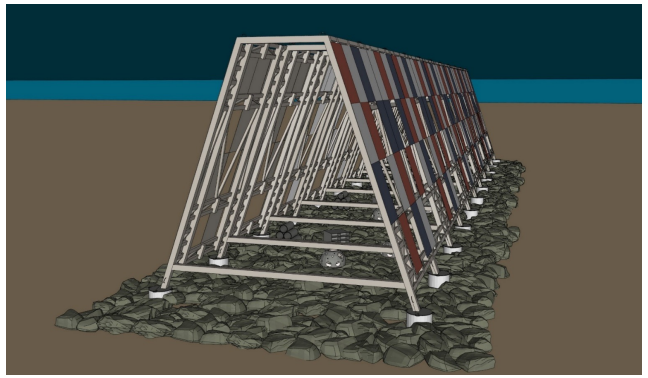
(II) Environmental Consideration

Design Considerations

- Different structural design
  - For Epibenthos + Corals
  - For fish species
- Increased textural complexity of structures
- Openings for current flow and light penetration
- Orientation – Sloping surfaces to minimize sediment accumulation
- Alkaline materials & others like PVC/ Fiberglass that enhance Biofilm formation
- Elimination of piling

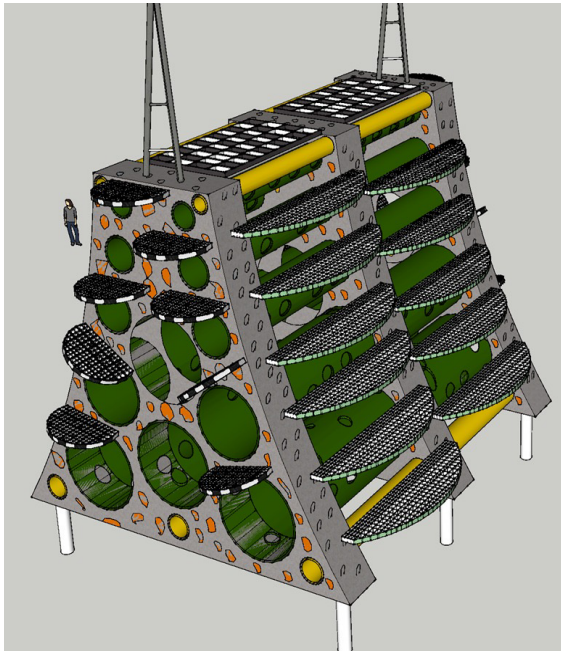
(III) Development of Design

Tender

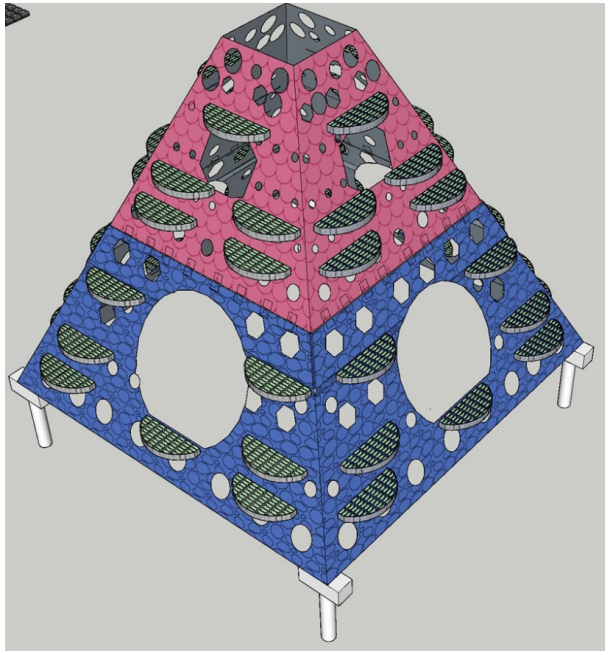


Post Tender

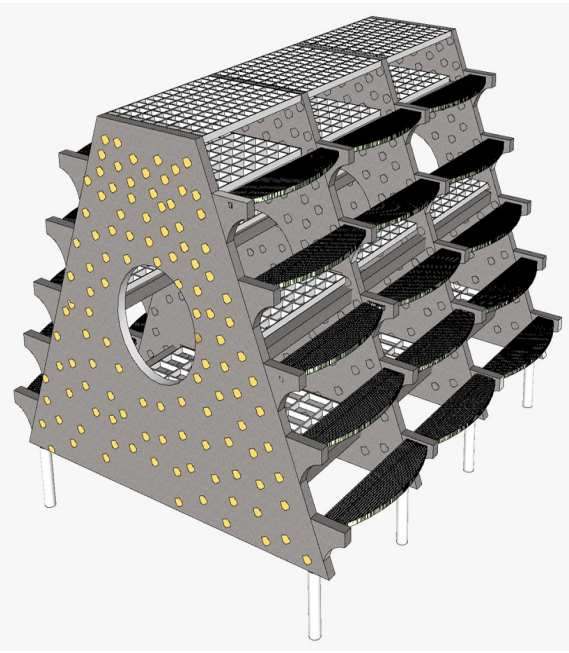
Proposal 1



Proposal 2



Proposal 3



(IV) Construction

Sustainability

- Concrete surfaces are infused with rock obtained from JTC's Rock Cavern in Jurong Island
- GRP pipes and secondary steel members were salvaged from other projects

(IV) Construction

Key Activities

Casting of main wall panel

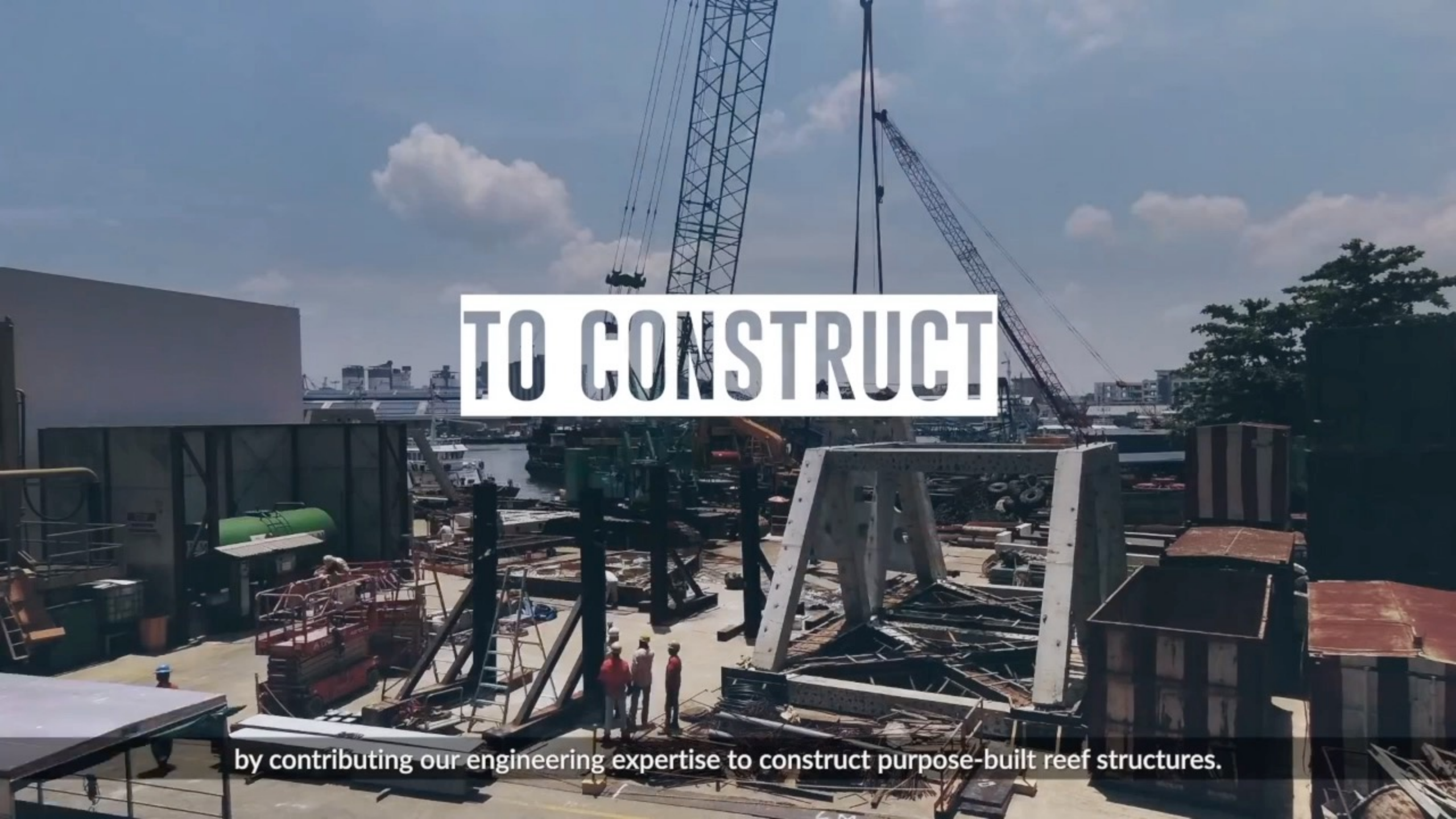

Fabrication of bottom structure


Trial assembly of structure


Transportation by barge


Installation of Artificial Reef


Installation of Artificial Reef


TO CONSTRUCT
by contributing our engineering expertise to construct purpose-built reef structures.

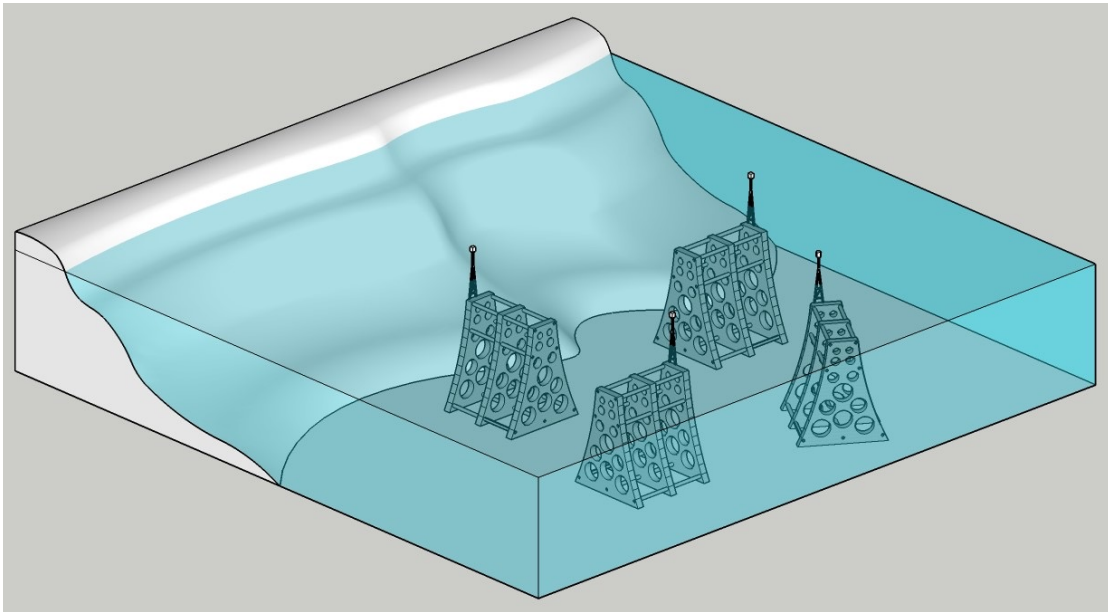
(V) Applications

Reduce Wave Energy

An artificial reef submerged in between the Posidonia oceanica bed - Larvotto Marine Reserve, Monaco

- Saving $9 billion/- of assets along coastal line every year

- 97% - Avg. total Wave Energy Reduction
- 84% - Avg. total Wave Height Reduction



The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. Ferrario, F.; Beck, M.W.; Storlazzi, C.D.; Micheli, f.; Shepard, C.C.; & Airoldi, L.; Nature Communications, 2014. DOI: 10.1038/ncomms4794

(V) Applications

Reduce shoreline erosion

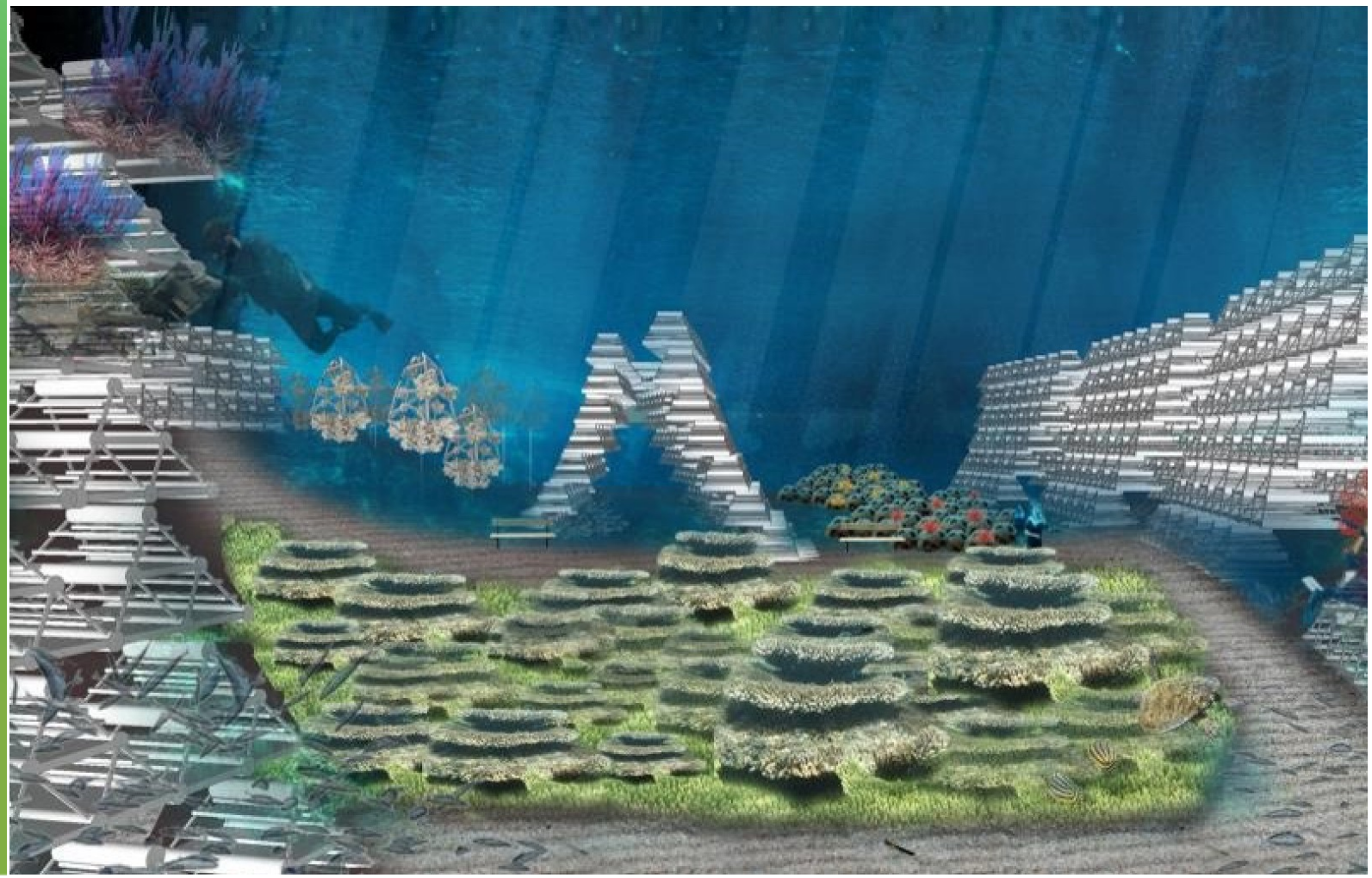
Artificial reef structures built with steel cages and filled with stones and cement, were installed in 2015 in Grenville Bay, Grenada to protect a vulnerable coastline from strong wave action and the impacts from climate change, such as severe erosion.

- **Preserves substrata**
- **50% - Reduction in Shoreline erosion**

Coral reefs for coastal protection: A new methodological approach and engineering case study in Grenada.
Borja G. Reguero; Michael W. Beck; Vera N. Agostini; Philip Kramer; Boze Hancock.
Journal of Environmental Management, 2018, pp. 146-161.

(V) Applications

Enhance biodiversity including fisheries production



Coral reefs home to 25% of all marine fish species

- *Coral reefs support approximately 4000 species of fish and 800 types of corals*

Globally, net economic benefit of $30 billion/-

- *Fisheries: $5.7 billion/-*
- *Tourism & recreation: $9.6 billion/-*
- *Biodiversity: $ 5.5 billion/-*

Fisheries and Tourism: Social, Economic, and Ecological Trade-offs in Coral Reef Systems
Liam Lachs & Javier Oñate-Casado
The Oceans: Our Research, Our Future, 2019, pp 243-260.

(V) Applications

Coral reefs in Medicine & Pharma

Cancer


Sarcophyton


Lobophytum michaelae


Nephthea chabrolii

Dental care

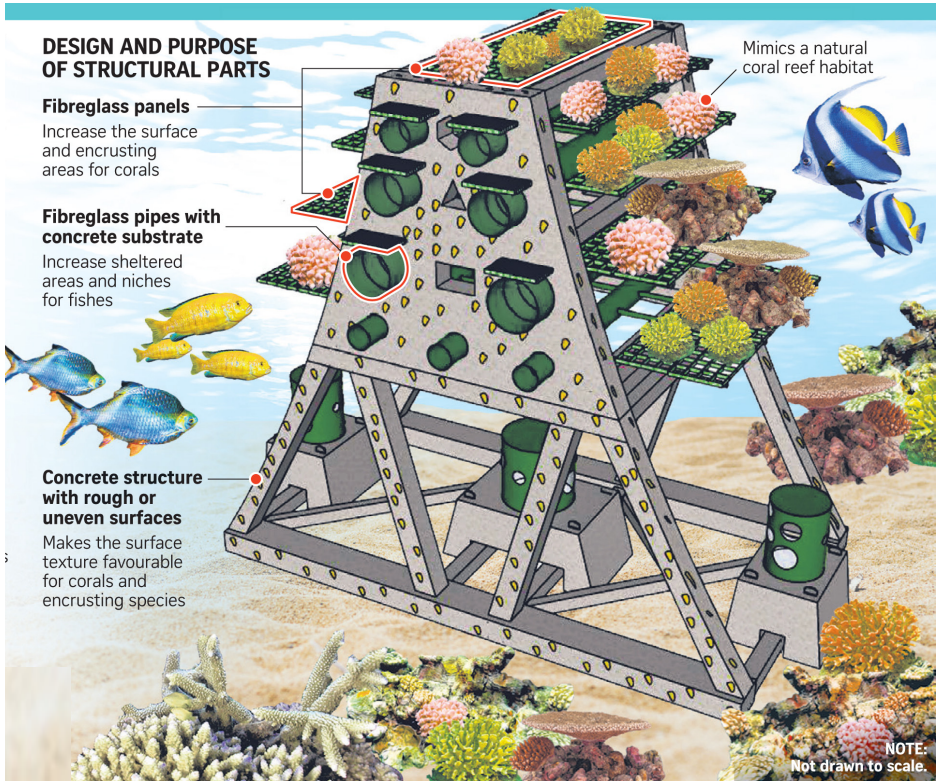
Other Pharma & Medicine use

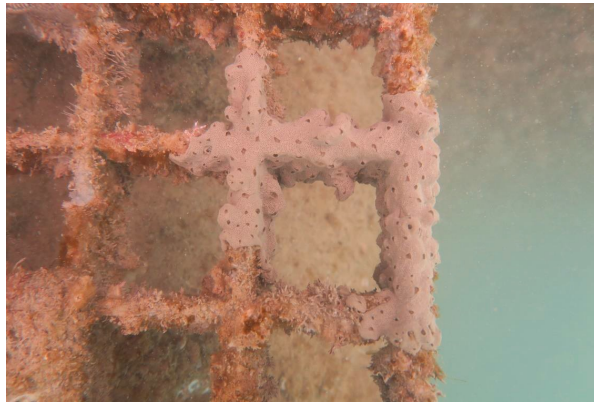
- Inflammatory
- Bones
- Pain
- Parkinson's disease
- Antibacterial effect
- Hypertension
- Cosmetic

Fisheries and Tourism: Social, Economic, and Ecological Trade-offs in Coral Reef Systems
Liam Lachs & Javier Oñate-Casado
The Oceans: Our Research, Our Future, 2019, pp 243-260.

(V) Applications

Improve larval and habitat connectivity





Artificial corals

- provide structural support that could stimulate the recovery of endangered reefs
- provide shelter and fodder for marine organisms
- influence the density of coral larvae which in turn can influence settlement, post-settlement colony abundance and coral cover in larval restoration

Thank You

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