

# KOGAMI

*Komunitas Siaga Tsunami* Tsunami Alert Community, Padang, Sumatra

The changing climatic conditions have a direct and critical impact on coastal regions around the world. The unpredictability of events and the prohibitive costs of traditional coastal defense systems demand a new strategy to mitigate the impact on the fragile but invaluable communities that exist in these locations.

This proposal explores the developing technology of cathode accretion, a process in which calcium carbonate suspended in all seawater may be continuously accreted onto conductive forms in the presence of very low electrical charge. It is the goal of the proposal to utilize this easily applied, adaptable, and economically advantageous process in a holistic and mutually beneficial system of strategies.

The central strategy is the construction of new and robust warm water coral reefs using old shipping containers as their conductive armature. These would enhance the local economy and reduce the power of waves approaching the coast through a combination of induced shoaling, increased seabed friction, redirection of storm surges and gradual coastal shallowing.

The complementary strategy is that the process be used to 'grow' a system of construction elements that might be assembled into coastal structures operating as everyday community locations, and as refuges. The flexibility of possible forms that can be created by this process can be designed to have a structural profile that makes them uniquely resistant to the hydrostatic and hydrodynamic damage that climatic and tectonic events cause to other building typologies.

This proposal was initially developed to mitigate the tragic effects of tsunami along the coasts of Indonesia but it is envisioned that such a simple and comparatively inexpensive process might be applied more extensively, binding together the potentials of the world's seas and oceans and the communities that surround them in a mutually beneficial relationship that both protects threatened marine ecosystems and the communities that rely upon them. The process is not limited to warm or shallow conditions and may with further research but without great modification be applied to coastal regions around the world.

## LOCATION

Site: Padang, Western Sumatra  
(0° 57' 0" S / 100° 21' 0" E)  
- though the system may be  
equally applicable other coastal  
environments at risk from storm  
surges and tsunami inundation.

Container  
Reef Systems

Structure  
Plantations

Coastal  
Refuges

Safer  
Communities

Why not just build a  
seawall?

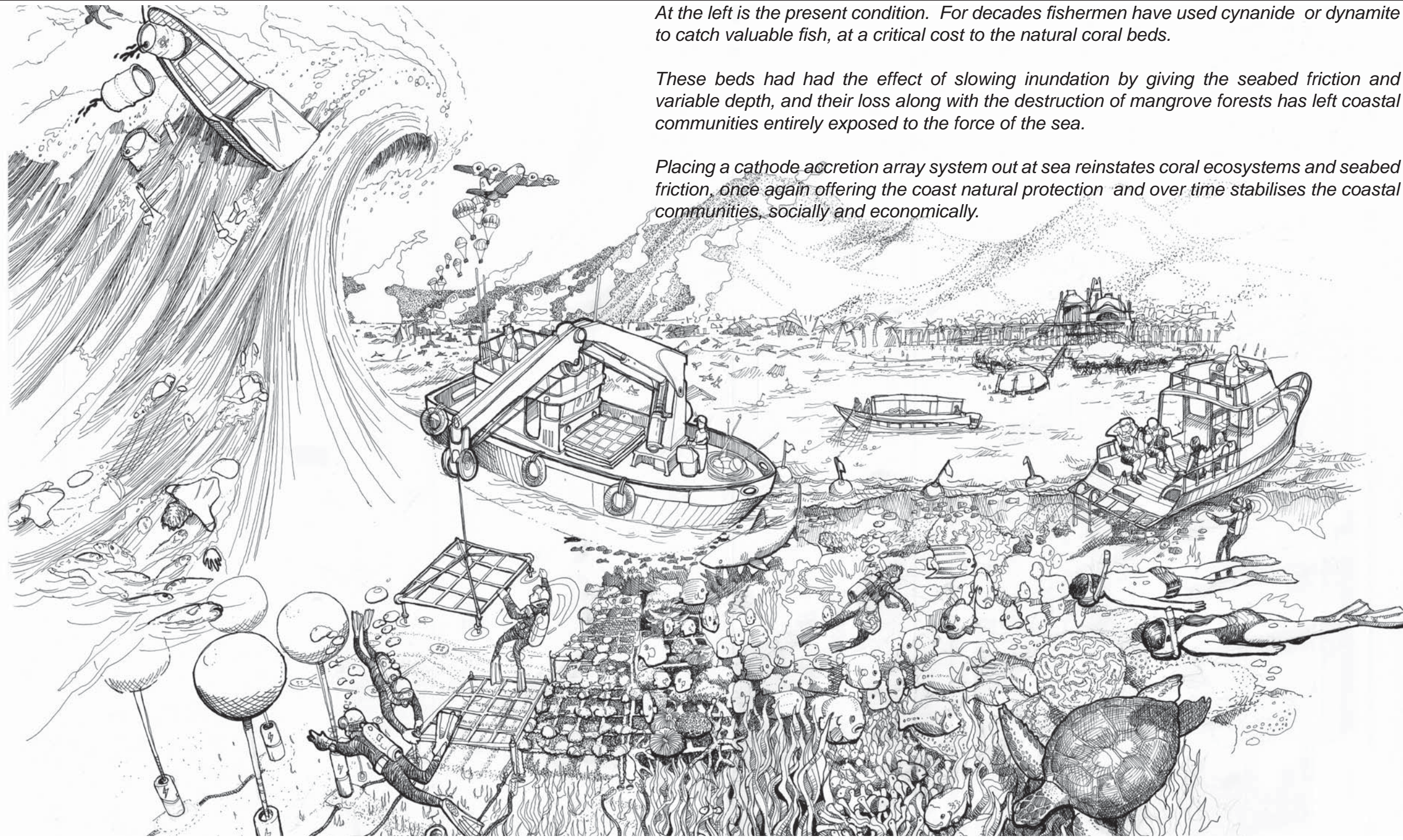
Massive civil engineering  
projects like sea walls  
are ruinously expensive,  
consume vast quantities of  
concrete (with associated  
CO<sub>2</sub> impact), permanently  
separate land from sea,  
and have an effectiveness  
limited to their height and  
location.

## THE SIMPLE MIRACLE OF THE PROCESS

At the left is the present condition. For decades fishermen have used cyanide or dynamite to catch valuable fish, at a critical cost to the natural coral beds.

These beds had had the effect of slowing inundation by giving the seabed friction and variable depth, and their loss along with the destruction of mangrove forests has left coastal communities entirely exposed to the force of the sea.

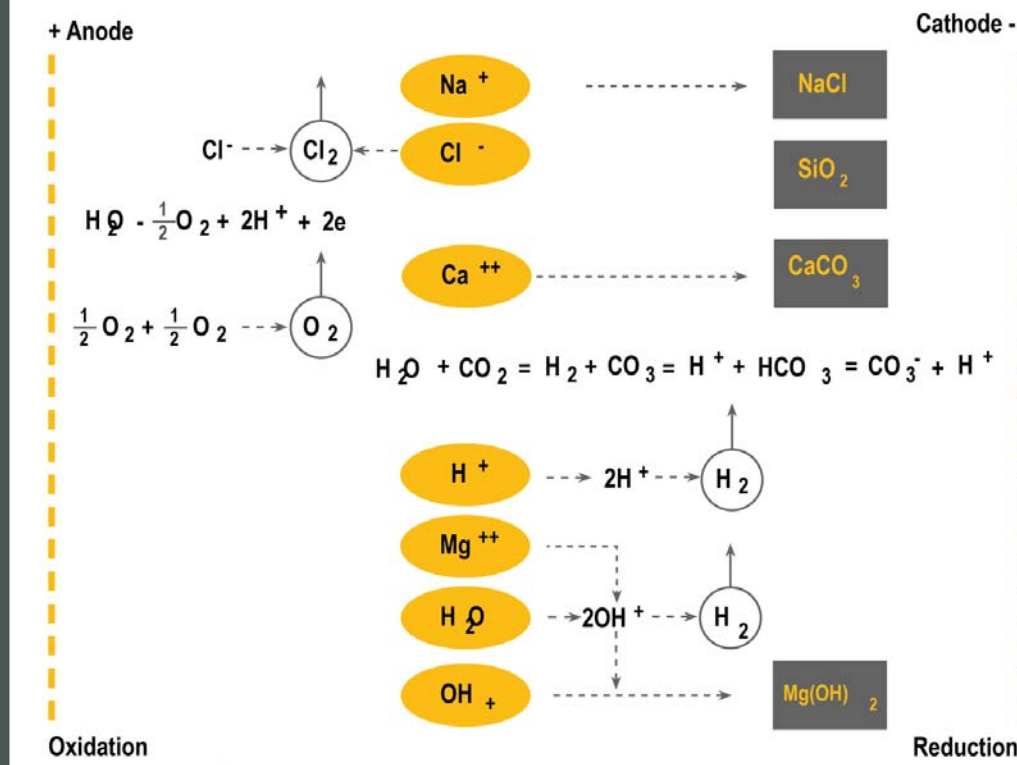
Placing a cathode accretion array system out at sea reinstates coral ecosystems and seabed friction, once again offering the coast natural protection and over time stabilises the coastal communities, socially and economically.



The Biorock® method, invented, developed, and patented by the late Prof. Wolf Hilbertz and Dr. Thomas J. Goreau, uses low voltage direct currents (around 1.4 Volts) to grow solid and resilient limestone minerals (aragonite) on conductive substrates. At these levels of charge an accreted layer of around 10-20mm of material with a compressive strength of up to 80 Newtons per mm<sup>2</sup> will form for each and every year of the charge field being operative. The minerals grown are naturally present in very large amounts in seawater, but electrical charge is necessary for them to be deposited.

The electrical current used is safe to humans, and all marine organisms are seen to be attracted, and none repelled. Corals in particular thrive in the charge with faster growth and increased resistance to bleaching. The cathode accretion process provides a preferential environment for their growth as it supplies the same energy that the corals would otherwise have to expend to create their hard forms.

The low current also completely prevents rusting of steel substrates, indeed as it negatively charged it reverses oxidation that had previously occurred.

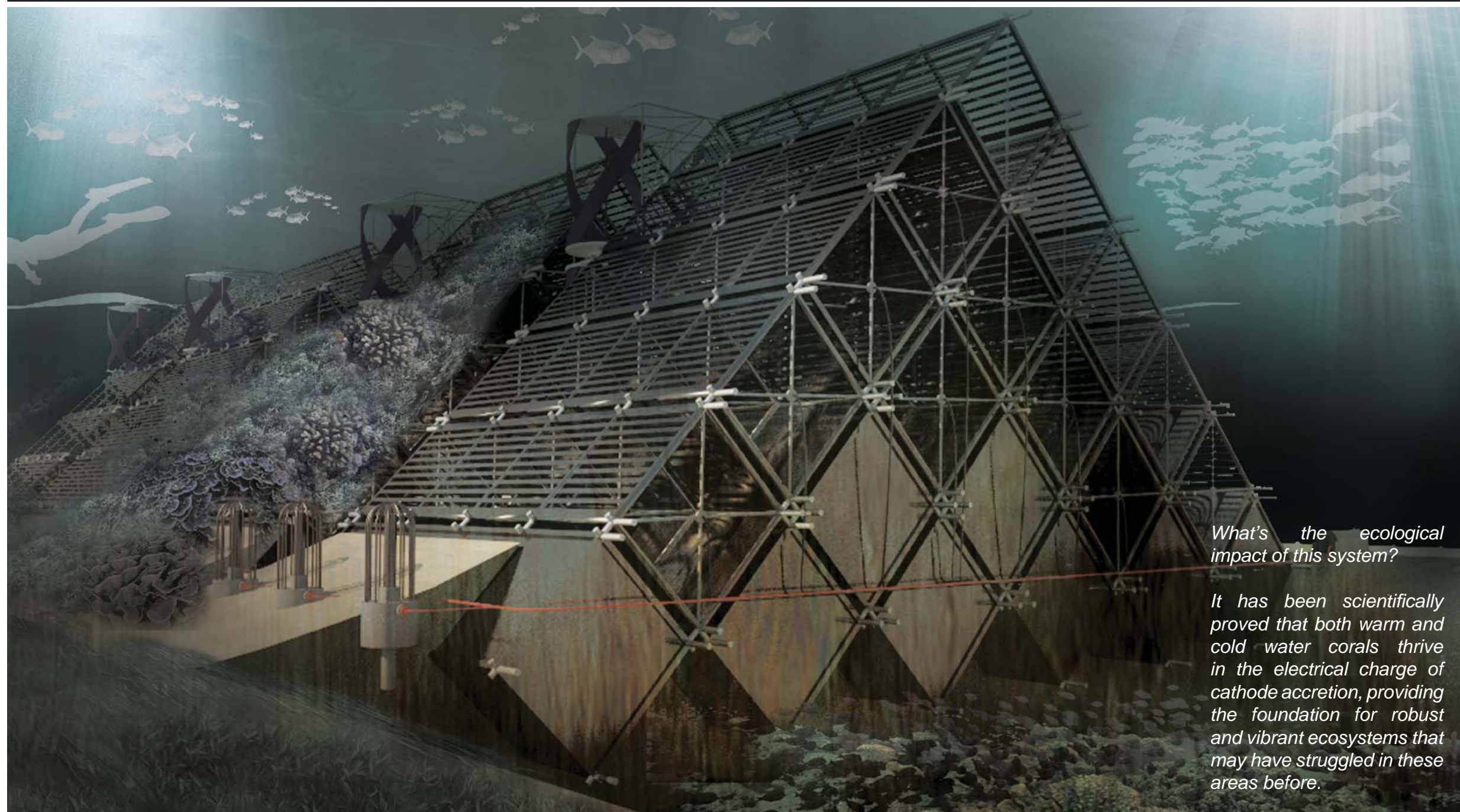


Above left: The simple chemical process by which the cathode accretion occurs in seawater

Above middle: A table-top experiment set up to investigate the process. A tank of estuarine seawater into which metal forms were suspended acting as the cathode and chemically inert graphite sticks at regular intervals as the anodes.

Above right: Two separate steel Meccano elements after two weeks in the tank. The build-up of hard aragonite accretion is sufficient to prevent the two parts from moving.

## PROTECTION BY REEFS MADE OF SHIPPING CONTAINERS

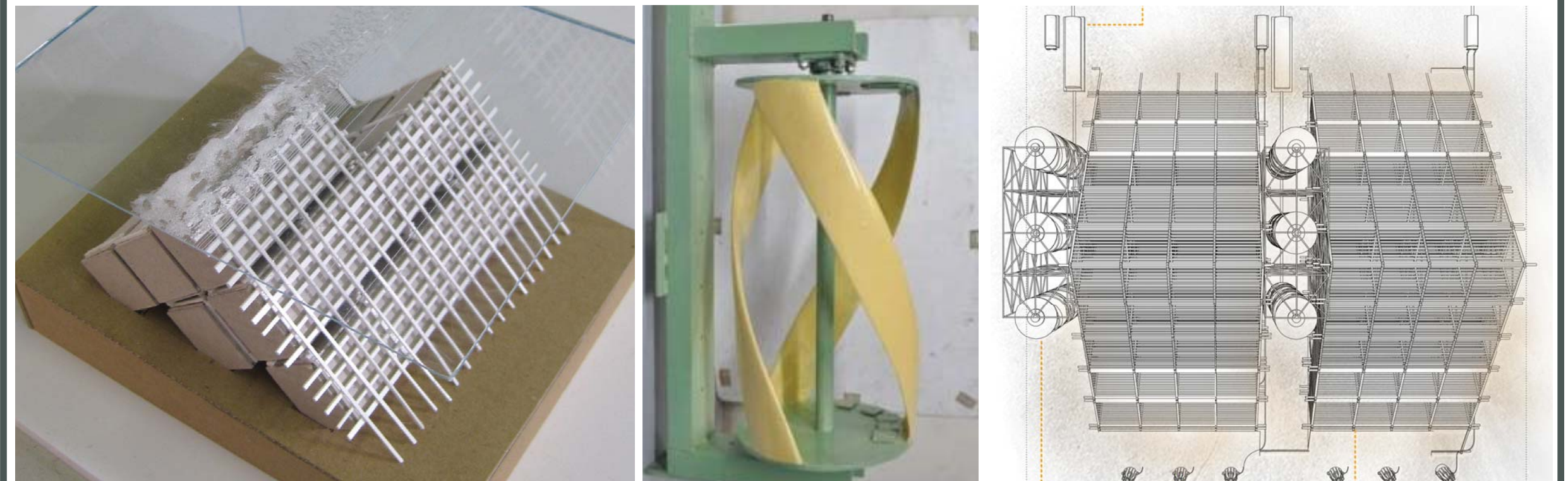


What's the ecological  
impact of this system?

It has been scientifically  
proved that both warm and  
cold water corals thrive  
in the electrical charge of  
cathode accretion, providing  
the foundation for robust  
and vibrant ecosystems that  
may have struggled in these  
areas before.

Used shipping containers filled with sand are secured into the seabed at 45 degrees. Further shipping containers modified to allow sea water to pass through them are lowered on top of this foundation and are welded into place. Once placed, the cathode accretion matrix is activated to turn these structures into ever more coherent and massive reinforced limestone features. The power of the matrix is supplied by Gorlov helical tidal generators placed in focussed positions between the container reef arrays.

These arrays are discontinuously placed broadly parallel to the coastline to provide friction to the seabed to induce wave shoaling and wave re-direction, all with the aim of reducing wave power and its directional identity, but, critically, not acting as a traditional resistant seawall. Arguably, it is futile to try to stop the action of the sea entirely but this system effectively ameliorates its potential to damage coastlines and their communities.

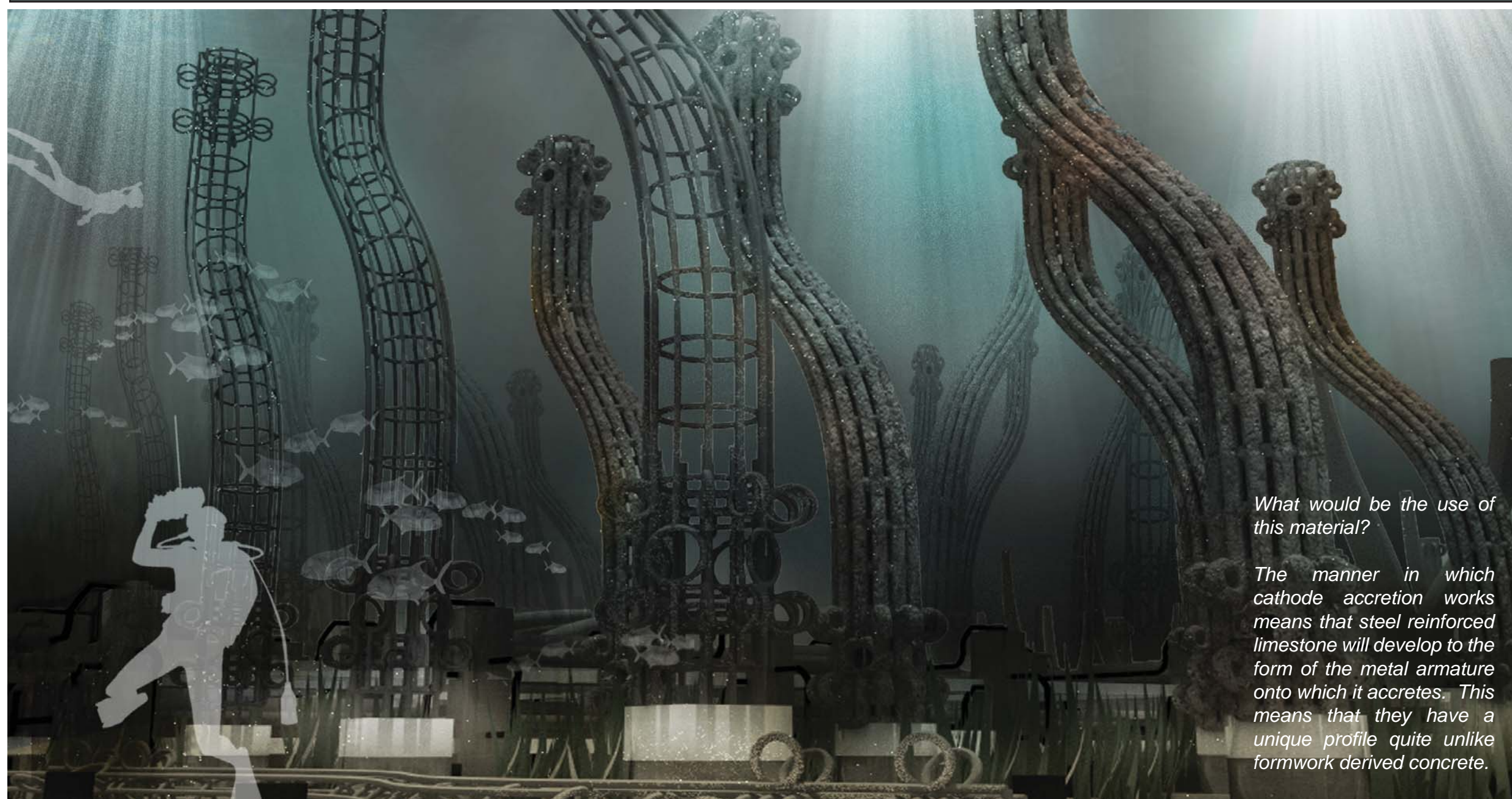


Above left: A simple scale model of the stacked shipping containers, secured a steel rebar reinforcement layer. Creating deeper and shallower zones causes wave energy dissipation by shoaling. Angling the arrays redirect waves against themselves to cause the coast bound tidal forces to reduce their damage potential.

Above middle: A small working model of a helical tidal turbine as developed by Professor Gorlov. Energy is generated regardless of flow direction. This example was constructed by National Institute of Ocean Technology, Chennai.

Above right: The container reefs are arrayed to focus tidal flow through the Gorlov generators to maximise the energy generated to power the accretion systems.

## A NEW TYPOLOGY - SEA STONE 'FORESTRY'

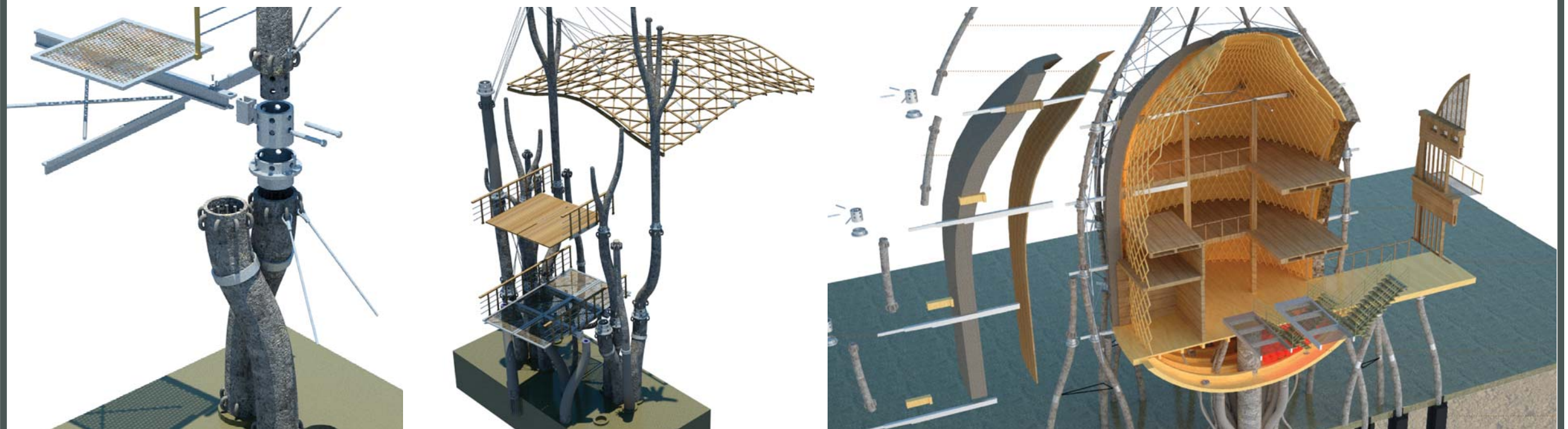


What would be the use of  
this material?

The manner in which  
cathode accretion works  
means that steel reinforced  
limestone will develop to the  
form of the metal armature  
onto which it accretes. This  
means that they have a  
unique profile quite unlike  
formwork derived concrete.

In the shallow waters between the container reefs welded rebar forms are set into a low charge matrix arranged on the sea-bed. Over time, and with minimal maintenance these elements accrete limestone at about 1 radial centimeter per year. Once sufficiently accreted to be structurally robust as reinforced limestone these elements can be harvested and brought ashore to be used in the construction of coastal structures. In the meantime more steel forms can replace them in the matrix for continued generation of construction elements.

The tubelike forms combine the strength of bones with the low resistance profile to tides of mangroves, giving them the strength to safely support gridshell forms above the height of inundation without the risk of hydrodynamic or hydrostatic damage or collapse. They support lightweight gridshell volumes, within the base of which are stored sufficient materials to support a large number of people in the event of a disaster.

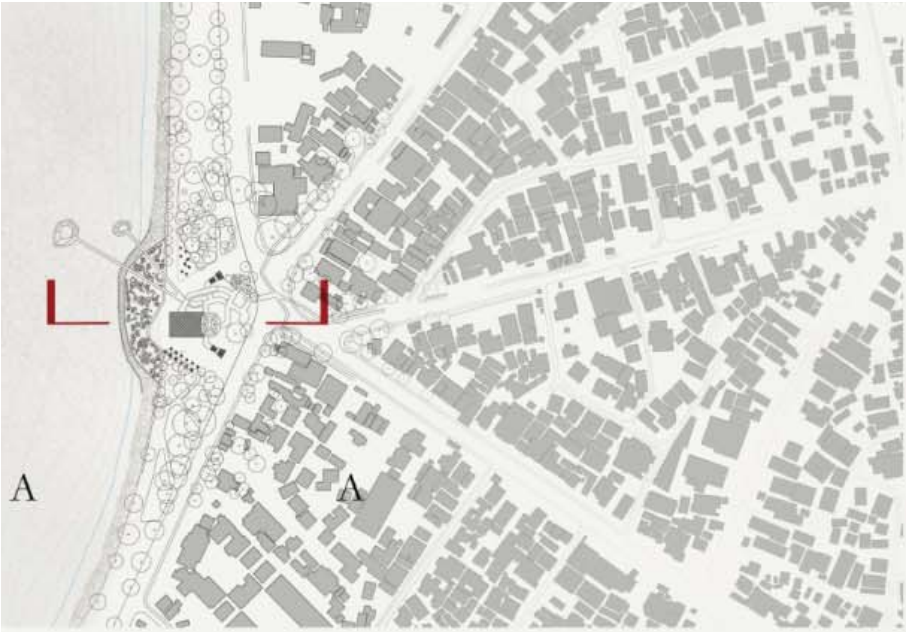


Above left: The assembly system is intended to be simple and flexible but structurally resilient. As such it relies on a balancing of compressive and tension elements to create a mutually reinforcing matrix within which the habitable volumes and platforms are supported.

Above middle: The compressive structure is made up of elements harvested from the sea stone plantations. These are bound together directly and with tension cables.

Above right: The volumes set into this matrix are form-active gridshell constructions designed to be light but very strong, borrowing effective strategies from local vernacular typologies to combat climatic conditions with minimal energy demands.





all site plan  
0



Arrayed concentrically from the coast container reefs cause wave shoaling and seabed friction. Between them are laid out the biocrete 'plantations' in which the structural elements of the system are 'grown' in a system analogous of forestry plantations.

In the shallows are constructed lido platforms where locals are taught to swim, and where the Kogami Organisation can practice drills in preparation for tsunami events. They are lightweight and not expected to survive a tsunami but are directly linked to the safe upper decks in the event of an alarm.

Further shipping containers under slight electrical charge create a strong biocrete reef breakwater to form a last barrage within which mangrove trees are grown. Mangroves have a significant effect on tsunami dissipation, and act as an additional protection for the Kogami.

The manmade mangrove wood is traced with suspended pathways to create a unique public park which combines tsunami protection with leisure, ecological and educational functions.

The pathways of the mangrove wood and ground levels lead up to 4m deck of the Kogami, binding together the structure and the sea to further reinforce the connected functionality of the system.

The Biocrete structural system emulates the dense but flexible matrix of the mangrove to safely support the decks and volumes above the maximum inundation level. Inundations will pass through and round the structure leaving the superstructure safe as a refuge.

The volumes supported by the Biocrete matrix are lightweight gridshell forms designed using the strategies of vernacular architecture to ameliorate the local climate, minimising the energy load as energy may be unavailable in a post tsunami condition.

Buried beneath the Kogami are water cisterns and septic tanks sufficient to provide clean water and waste storage, systems which in a tsunami or storm surge event might otherwise be dislocated. Further emergency stores are packed into the hold-like undersides of the structural volumes

The volumes are linked by extensive areas of open decking to accommodate the people escaping raised sea levels, areas that in are in everyday and familiar use for meetings, ceremonies, education and simple leisure activities.

Seismic shocks travel faster than the tsunami they cause so a tall fine tower structure will be mounted to it acts as a naturally responsive alarm to the local community, the shock causing the bells to ring ten minutes before a possible tsunami.

Raised deck walkways extend into the fabric of the community to provide safe and rapid pedestrian access to the Kogami in the event of an alert, above traffic and the first inundations.

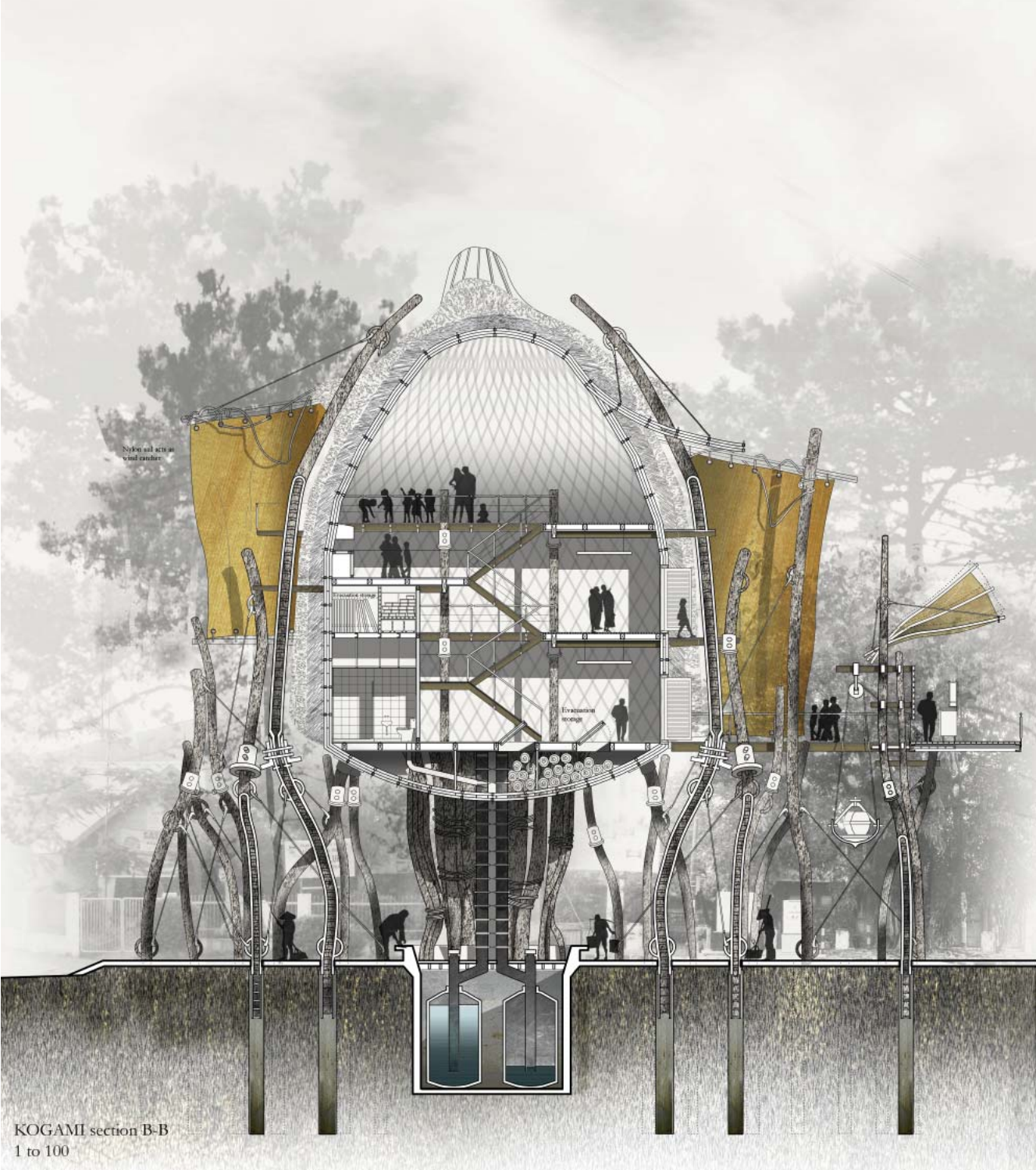
The birock columns are connected by a strong but flexible 'cuff and bolt' system which is kept under tension by cable cross bracing to give excellent compressive and tensile characteristics. The spindle structures allow water to pass through them without critical damage.

The volumes suspended by this system are constructed using form active timber gridshells to minimise compressive loading, and all are heavily insulated by vernacular thatching methods to minimise insolation and associated energy loads to maintain thermal comfort, when energy may be in short supply

Canvas and vines are used to shade the decks of the structure. A secondary function of the operable canvas is to act as deployable wind catchers, directing sea breezes through the volumes in order to maintain internal thermal comfort, and like sails these can be withdrawn in conditions of high wind.

## LONGITUDINAL SECTION

## TRANSVERSE SECTION ID 062



KOGAMI section B-B  
1 to 100



BEFORE

Unlike many existing structures intended as tsunami and inundation refuges the new typology created by cathode accretion has the flexibility to be applied to structures that have everyday utility, whether health centres, junior schools or community halls - that is they become a recognised and appreciated addition to the day to day lives of the coastal communities in which they're embedded. This has a double benefit as their usefulness adds value to the community and their familiarity makes them known as the place to head for in the event of an inundation warning, when time is often of live saving importance.



DURING

Raised walkways and multiple stairways run into the fabric of the coastal communities to make access to the safety of the upper levels as quick and unobstructed as possible. These upper levels are extensive to allow them to accommodate everyone who might seek refuge upon them. The structures are placed at regular intervals along the coast so that no one is ever far from refuge they offer. Under the gridshell volumes are stored all the essential materials that will be required for the immediate care of the people upon them, and surplus stores to continue this care until such time as external help might reach them.



AFTER

Dislocation caused by forced evacuation is a critical problem that this system hopes to overcome by keeping the local population safe in close proximity to their local area. Post inundation they are kept safe and healthy and as soon as it is safe to do so they are able to go out into their familiar location to start the process of tidying up the damage - returning to the nearby refuges to rest safely, or in the event of another inundation warning. This is the key of the proposal, to accommodate the fluctuations of natural forces with minimal damage to the qualities that make coastlines so precious.