Text by Gillian Fagan, Photographs by Michael AW

What resembles a giant underwater jungle gym, is as robust as concrete, is sparked to life by the same power source as Frankenstein and has the ability to heal itself?

biorock
the electric advantage

Biorock – the underwater life support system for the ailing reefs of the world.

The brainchild of marine scientist Tom Goreau and professor Wolf Hilbertz, this novel technology of mineral accretion grows limestone rock on artificial reef frames and increases the growth rate of corals and other reef organisms.

With pilot projects in such diverse countries as Jamaica, America, Mexico, Venezuela, Seychelles and the Maldives it is in the small village of Pemuteran, on the island of Bali, that the largest Biorock project is alive and well.

With 450 species, Indonesia possesses the richest assortment of corals on the globe. Covering 85,700km², its reefs constitute 14% of the world's total. Sadly, only 6% of these reefs are in healthy condition.

Amidst the relentless and rapid destruction of these coral reefs from dynamite and cyanide fishing, pollution, global warming, increased turbidity, over-exploitation and environmentally unfriendly tourism, the story of Pemuteran is one of hope. It goes a little something like this…

Once upon a time there was a beautiful place, isolated from the hustle and bustle of tourism, its name – Pemuteran. Too dry for the irrigated rice that is the focus of Balinese agriculture its people were extremely poor and traditionally lived from the sea.

But Pemuteran had an untapped natural treasure – the largest area of shallow coral reefs in Bali, free from strong currents and waves. The thriving coral thickets, swarms of fish and idyllic beaches attracted Mr Agung Prana, a hotelier and Mr Chris Brown, a diver.

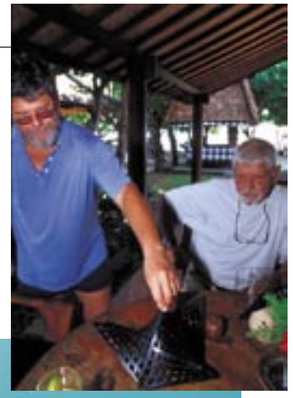
Soon a small network of hotels and dive shops had developed creating, for the first time, jobs other than subsistence fishing, greatly improving the local's standard of living. The village soon grasped that a fish had more value in the sea than in a net or at the end of a line. They declared the bay a no-fishing zone and the tourism industry flourished.

Then, in 1998 a crisis engulfed Indonesia. Following the El Nino induced drought the exchange rate plummeted, banks closed, inflation soared and violence rocked the capital. With their own reefs void of life and over-exploited, desperate fishermen came to the bountiful reefs of Pemuteran and plundered everything they could.

The voluntary ban on the use of dynamite and cyanide collapsed and soon, reefs once replete with fish and vibrant with colour were reduced to a barren wasteland of rubble. Faced with such destruction, Yos Amerta, President of the Bali Branch of the Indonesian Dive and Watersports Federation Gahawisri, asked Hilbertz and Goreau for their help.

Rumour spread quickly through the village that their invention, Biorock, could restore life to their desolate bay.

The villagers, fishermen, divers, hotels and scientists united in their efforts, creating the Pemuteran Coral Reef Protected Area. Within two years, fifty coral nurseries have been brought to life in this area.



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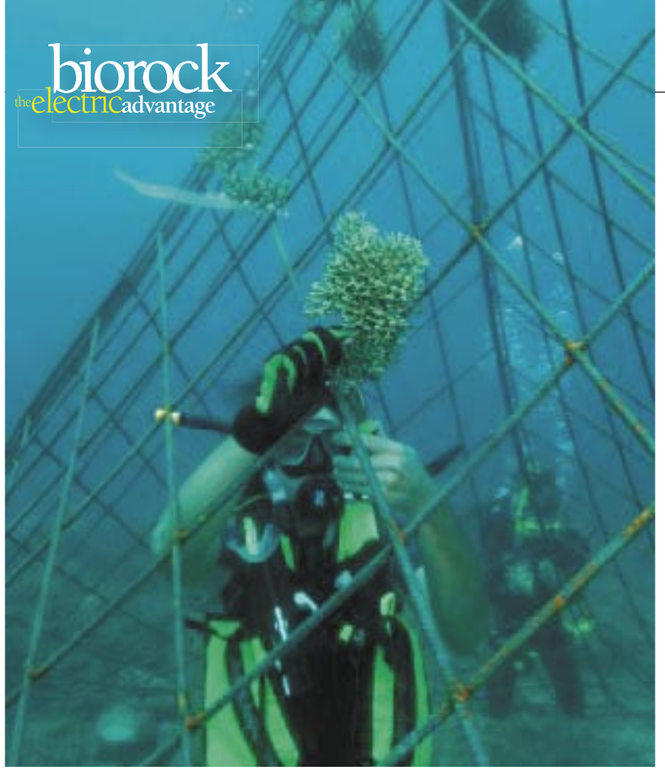
Largely dead reefs have been restored. With an electrical advantage, corals on the Biorock structures grow 3-5 times faster than normal, have brighter colours and are more adventurous - extending their tentacles to feed more often.

Attracted to the electrochemically-altered conditions, crabs, clams, octopi, lobsters and sea urchins have rapidly colonises these authentic coral reef habitats. Juvenile reef fish shelter in the coral, dense schools of snapper crowd into the structure using it as a hotel during the day, batfish and their curiosity make them locals, while damsel and cleaner fish quickly establish their territory.

Likened to an underwater Disneyland, the 300m long reef has become a tourist magnet. There are long caterpillars, ellipsoidal pyramids, funnels, pockets and arcs, all buzzing with life. "Whenever we get a chance to get back and work on our projects we are besieged by divers and snorkellers eager to learn more about the methods," says Goreau of his newfound fame.

Even the spinner dolphins, which abandoned the area during the bombing, have returned to fill the bay with their sweet songs. The village has set up dolphin watching and snorkelling trip with all income going straight back into the community.

Of this modern day fairytale, Goreau says, "this was a bottom up community effort, not one imposed and funded from the outside and therefore is a pioneering model for all of Indonesia."



The Biorock project is both simple and inexpensive, making it suitable for the smallest and most remote communities, to the largest. “Biorock is viable wherever coral reefs have deteriorated and are no longer able to recover naturally.”

The structure is built from ordinary construction steel. Welding is done on the beach by the local blacksmith or if there is no electricity or welding machine it is wired together by hand. “It is fun to watch the shapes emerging as the construction proceeds, so passers-by often get involved,” bubbles Goreau.

The atmosphere is festive, as the floats are attached and the structure is carried ceremoniously down to the water. “The site is amazing and everyone gets involved, locals, fishermen, tourists and children.”

It is then towed out to sea and released into its watery abode.

Using battery chargers a low-voltage direct current is charged to the structure – which serves as a cathode *(negatively charged electrode)*. A length of titanium mesh, which serves as an anode *(positively charged electrode)*, is attached to the battery charger and submerged to complete the circuit.

Electrolysis at the cathode causes minerals naturally present in seawater to build up. Soon after it charged with life hydrogen bubbles miraculously appear on the structure and begin dawdling towards the surface. Within hours a white sedimentation can be observed, indicating calcium carbonate settlement.

Like Victor Frankenstein, the scientist who plundered graveyards in search of body parts from which to create his monster, divers collect broken coral fragments from nearby damaged reefs. These coral pieces, which would die if not transplanted, are then attached to the structure with wires or wedged between steel bars.

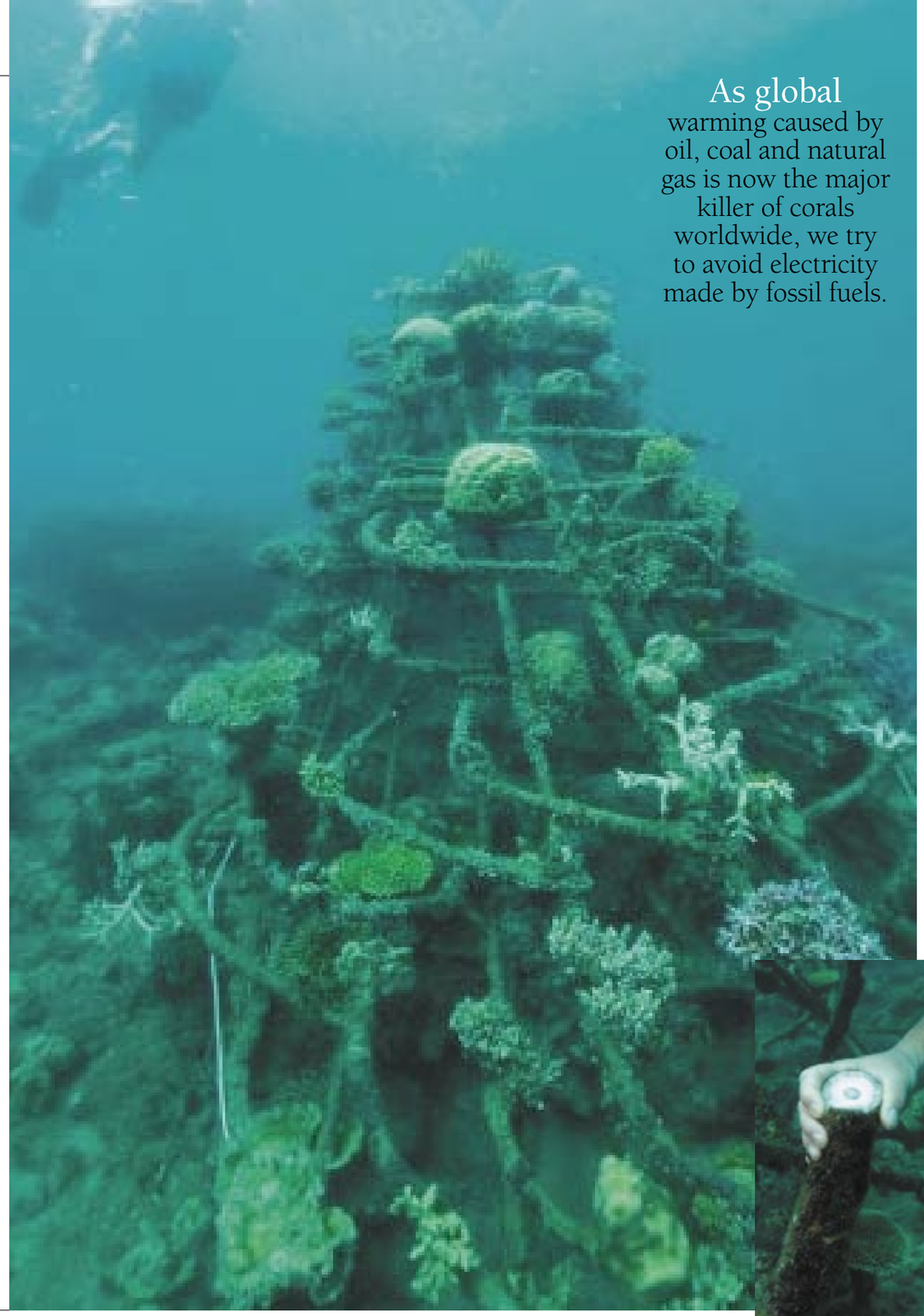
To date, this is the only method which produces natural limestone - the key constituent of coral skeletons, reefs and sand. The transplanted corals grows at exceptionally fast rates and reproduce prolifically as they no longer need to expend their own energy creating this limestone. Young coral that will only grow on clean limestone, readily settles on Biorock’s substrate.

Biorock has the strength of concrete, its corals continue to grow when stressful conditions kill surrounding reefs and it can heal itself with renewed deposition of minerals at the point of impact.

While it may seem like these structures are invincible, unfortunately they are not. Things that eat corals such as Crown of Thorns starfish and snails seem to smell that these corals are tastier, and while the skills to maintain and repair the structures are easily acquired, vigilance against such voracious predators must be upheld.

“As global warming caused by oil, coal and natural gas is now the major killer of corals worldwide, we try to avoid electricity made by fossil fuels.” According to Goreau, Biorock projects use only renewable energy sources such as hydroelectric power, solar panels and windmills.

The pair are also working closely with Professor Alexander Gorlov, the pioneer in the field of tidal energy. “We are very enthusiastic about tidal energy. It is the largest, untapped, renewable energy resource after direct solar power and unlike unreliable winds and waves, it will always be there.”



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In 2002 the Pemuteran Biorock initiative was named as the best project in the county at the National Coastal Zone Management Conference in Bali. With the community so much a part of the project, it was only natural for local fishermen to be present on stage, in traditional dress, to receive the US $500 grant.

With education a vital ingredient in any conservation effort, Goreau and Hilbertz "believe that training Indonesian students to work with the community to restore their habitat is the single most important contribution we can make to saving the coral reefs."

Two local university students recently completed their research into the Biorock structures, with more projects and thesis on the way. Putra Nyoman Dwija from Udayana University measured the growth rates of staghorn coral on Biorock and nearby controls, finding Biorock coral grew 4 times faster.

Ramadian Bachtiar from Bogor University compared Biorock to conventional artificial reefs. Biorock is a third generation reef, which unlike it's predecessors is not a mere agglomeration of deteriorating shapes, but is a growing life support system.

Prior to Biorock, artificial reefs were biologically impoverished, attracting a myriad of organisms, but not contributing to the regeneration of reefs. Bachtiar concluded that the structures were a very viable solution to restore damaged Indonesian reefs.

Ask Goreau what the greatest achievement of the Pemuteran project is, and his answer is simple – turning a ravaged and empty bay into a lush reef swamped with fish. But there is something missing, an essential part of the equation, a mind-blowing feat – the fact that the project was completed without any funding.

"Money is far and away the major obstacle, since these projects have been done with ZERO funding. This is not for want of trying: we have gone to all the likely sources and they have all told us that they were not interested or that according to their "experts" what we were doing is impossible!"

"All of our support has been from small individual donations, most of them local and in kind like materials, a room and food."

In a world where the Global Coral Reef Monitoring Network predicts that 40% of all coral reefs will be dead by 2010 and 60% lost forever by 2030, how is this lack of support possible?

"People are baffled at why there is not funding to do this on a much larger scale all around the world. Most are amazed that we have done this with no large scale funding and some think we must be really stupid not to be swimming in money!"

In the 1998 coral bleaching catastrophe, 60-90% of the Maldive's coral reefs perished in the high water temperatures and mirror calm seas. Coral, the very pulse of the reef, is a fussy creature able to survive in very narrow ecological limits. When the temperature gets to high the coral becomes stressed and the first thing to break down is the symbiotic relationship between the microscopic single celled algae zooanxthellate and the coral.

Biorock reefs in the Maldives had from 16-50 TIMES higher survival after bleaching than surrounding reefs.

In suitable conditions the algae harnesses the suns energy through photosynthesis converting carbon dioxide into sugars and amino acids. 90% of this energy goes to the coral host. When temperatures exceed 30°C, the zooanthellae is unable to convert the trapped light energy. The coral must make a choice, loose the algae or die. The algae is expelled taking with it its colours, leaving the coral stark white and starving.

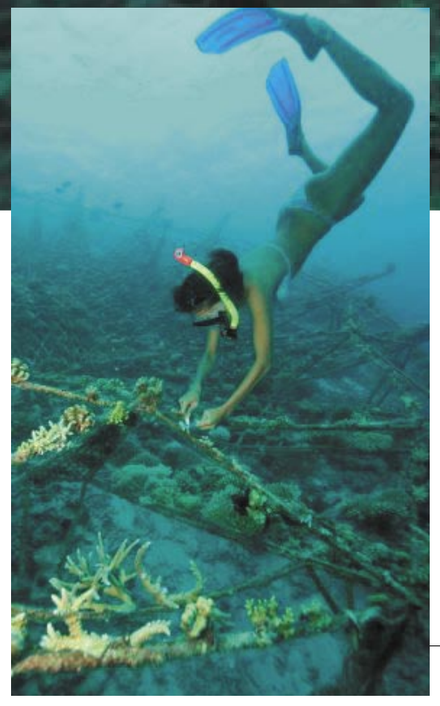
In just two weeks the holocaust wiped out centuries of coral growth. This, however, was not the case around Ihuru Island in North Male Atoll, where Biorock barnacle structures had been acting as an artificial fringing reef for two years. While the bleaching event killed all Acroporas on the artificial reefs, 80% of the Porites coral species survives as compared to 10% on natural reefs.

"Biorock reefs in the Maldives had from 16-50 TIMES higher survival after bleaching than surrounding reefs," exclaims Goreau.

Despite these blatant successes, "we work with little or no funding, while vast sums are being wasted by governments, international funding agencies and large conservation groups on methods that are proven failures."

Coral reefs support 500 million people, providing $400 billion a year through industries such as fisheries and tourism. But still we continue to destroy them with over-fertilisation, mining of coral rock and sand, dredging, tropical species aquarium trade, increased bacterial and fungal diseases…and the list goes on.

Biorock technology has the capacity to save whole communities from drowning by growing

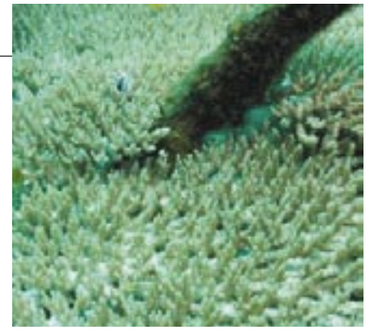


a reef on an eroding beach and turning it into a growing beach. The components of accreting structures can be harvested in controlled, sustainable ways to provide ecologically sound building materials. As the structures grow they cement themselves in place providing permanent and effective shore protection.

In Tulamben, Bali's largest dive destination, Biorock is not only restoring flood-damaged coral gardens, but is ensuring the survival of the worlds most famous shore dive – the Liberty. This WWII wreck, with its record number of fish species, is slowly rusting and collapsing, its lifetime limited. Biorock technology not only completely stops the rusting, it increases the growth and survival of corals and greatly increases the number of fish.

"The dive shops and village of Tulamben are determined to save the Liberty and their economic future. We are very honoured to work with such a dedicated and serious group."

In Pemuteran the fishermen must pass throngs of fish attracted to the artificial reefs en-route to their fishing grounds, where they will spend the day searching in a barren graveyard. Even with conventional management and conservation efforts such as no-take zones, these areas will never recover, as they are no longer able to support fish populations.



Even if I knew that the world would end tomorrow, I would still plant my apple seeds today.

Local fishermen are keen to expand the project to areas on the banks of North Pemuteran and beyond using large, solar powered nurseries. They are eager to restore their fisheries, learn how to become farmers rather than hunters and spread this knowledge to surrounding communities. But it is the same old story – money, money, money.

"Fishermen are intelligent people, but they are usually the poorest of the poor. Having spent my life working with subsistence fishermen, I am confident most would change their ways if they could afford to do so."

"Pemuteran has made dramatic and path breaking steps in the right direction and we hope that they have the strength to stay the course."

This course of restoring reefs is, according to Goreau, more like horticulture than forestry. You can't just throw the seeds on the ground and walk away or you will get weeds, not roses.

We are just starting to discover the art of growing whole complex ecosystems and maintaining their checks and balances. We have been told that what we are doing is dangerous and irresponsible and that by restoring damaged reefs we are implying that it is acceptable to destroy them. This is silly. We MUST restore what we have destroyed, for our children's future."

Martin Luther King said that, "even if I knew that the world would end tomorrow, I would still plant my apple seeds today."

A typical structure at Pemuteran has around US$100 of steel, a battery charger worth $100, $50 worth of cables, around $60 of electrodes and $10 worth of epoxy.

"Our structures are Coral Arks to keep the species from going extinct until the Flood abates. The only thing we can do to really make a difference is to grow as man corals tat are more resistant to environmental stress, in as many places as we can…before the corals are gone." And all this for the bargain price of $320. AG

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