new wave coral reef rejuvenation

– the ihuru island barnacle reef project

Ihuru Island, North Male Atoll – one of the few tourist islands in the Maldives to have been preserved in its natural state.

The environmental policy at Ihuru goes beyond a simple "don't touch" rule. Ihuru's attitude, standards and contributions to environmental research, make the island a role model for others to follow.

The hole in the ozone layer, El Niño and global warming are household names today – phenomena with which we are all familiar and which are known to be playing havoc with the natural environment. One effect believed to be caused by such phenomena is the gradual rising of sea temperatures.

text and photographs by **michael aw**

The devastating effect that rising sea temperatures can have on coral reefs was witnessed in the Maldives in 1998 when a sudden spike in sea temperature inflicted significant damage to what were some of the most magnificent coral reefs of the world. While scientific opinion remains divided as to exactly what caused the temperature spike, its effects were immediately visible even to non-scientists. The good news is that today the reefs in the Maldives are well on their way to recovery and there is strong hope that new technologies currently being tested in the Maldives will play an important role in assisting the rejuvenation of the coral reef systems.

In early April 1998, while working on a music documentary in the atolls of the Maldives,

OceanNEnvironment visited over 30 reef sites, some remote and some exposed to marine tourism. We were delighted to find live coral coverage averaging from 75% to 95% on most reefs. In terms of fish and invertebrate density it was also the best we had seen in the Indo-Pacific region. Resident marine biologists told us that the coral coverage was at its peak based on 20 years of observation. On some reefs in the southern atolls, we found hard coral meadows extending uninterrupted for over two kilometres. We recorded some plate colonies to be over three metres in diameter. Little did we know that the images we shot during that expedition would become an historical record of the state of the reefs before a coral-bleaching catastrophe, the worst ever recorded in the region, struck the Maldives in its entirety including the Chagos and Laccadives Islands. Almost on the wake of our departure, water temperatures to a depth of 30 metres rose to 32ºC, up from a previous average of 27ºC. The sea was mirror-flat and scientists and divers watched helplessly as hard corals and anemones perished.

When corals are stressed by high water temperature, the zooxanthellae — the life-supportive symbiotic algae that provide them with nutrients — are voluntarily expelled from their tissues. Initially the process will only weaken the coral, but if warm water conditions persist the corals will eventually die. Affected corals turn stark white as the life-giving zooxanthellae are lost and the coral polyps cannot survive — scientists therefore commonly refer to this phenomenon as "bleaching".

Fringing reef, South Male Atoll, after the bleaching event of April 1998.

All the atolls of the Maldives were affected by the spike in water temperature and reports confirmed that around 80% of corals on back reefs were wholly bleached. Dive centres from resorts in North Male, South Male and Ari Atolls soon reported that 95% of Acropora (staghorn coral) communities were dead. In just two weeks, the holocaust wiped out a century of coral growth.

Dead corals do not simply return to life. The recovery process is dependent on successful annual spawning by surviving coral colonies in the vicinity. If the conditions are right, tiny coral polyps may be seen growing on dead coral structures after a year or two. Based on scientific data, it may take a minimum of 10 years for affected reefs to return to their former glory. Though some marine scientists will not conclusively attribute the rise in sea temperature to the effects of global warming, it seems only common sense that further environmental stress caused by increased solar radiation and pollution will significantly hinder the natural recovery process of coral reef.

During 1999 OceanNEnvironment revisited the Maldives and we were extremely encouraged to observe that the recovery process was well on its way. Live five centimetre-sized Acroporas could already be sporadically found on severely damaged reefs at a depth of 12 metres in April 1999 and, by August 1999, at a depth of 8 metres. In the course of our monitoring, our attention was drawn to an artificial reef project being undertaken at Ihuru Island in the North Male Atoll. This project, which was initiated by two marine scientists, Wolf Hilbertz and Thomas Goreau, may well produce a reef rejuvenating technology that will greatly enhance the recovery process of coral reefs.

The usual method of creating an artificial reef is to sink a man-made object in the sea, and

then allow it to become part of the ocean's ecosystems. This concept is traditionally employed to enhance recreational fishing and sport diving opportunities in coastal waters, and to increase the amount of productive hard-bottom habitat. Most business enterprises in the marine tourism and fisheries industries are supportive of the creation of such additional man-made reefs. Done properly, the reef is created using long-life, stable and environmentally safe materials (usually steel or concrete) on a selected area of ocean bottom. However, artificial reef installations are sometimes convenient excuses to use the sea as a dumping ground for unwanted automobile tyres, cars, boats, even planes, or to construct pylon jetties, haphazardly placed for economic gain, with little regard for marine ecology.

Once the material is in place, the intention is that it will act in the same way that naturally occurring rock outcrops do by providing the hard substrate necessary for the basic formation of a live-bottom reef community. Though many structures are successful in attracting a myriad of living organisms to settle, just as many remain as a junkyard beneath the sea. The resulting habitats, though serving as fish aggregation devices, far from resemble coral reefs and contribute little or nothing to the regeneration of coral reefs. Thomas Goreau refers to these as "first generation" artificial reefs.

"First generation" artificial reef – rather than becoming part of the organic marine environment, these structures will always remain foreign objects.

In the last two decades specially engineered reefs have been used by the aquaculture industry for the cultivation of fish, bivalves, and crustaceans in hundreds of bays and estuaries throughout the world. The construction materials used to create these more technologically advanced "reefs" include plastics reinforced with fibreglass, concrete made with hydraulic cement and steel. These structures are vastly improved versions of their predecessors. Together with effective anchoring techniques they are professionally and publicly viewed as the state-of-the-art in artificial reefs.

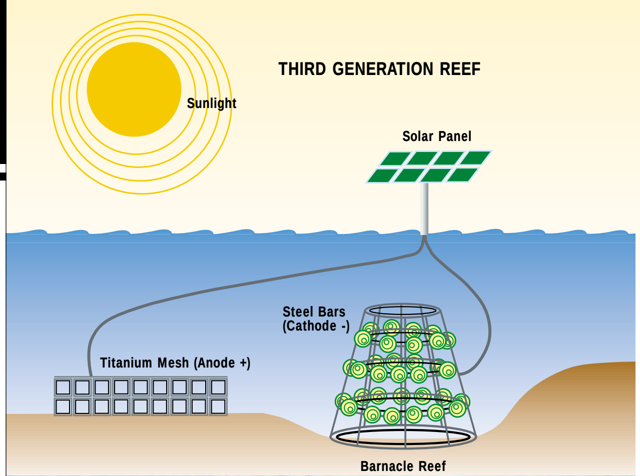
One of the most popular designer reef systems is the Reef Ball system which is used extensively in Asia and the USA to restore both ailing coral reefs and to create new fishing and scuba-diving sites. The moulded balls used in this system are made of concrete and are designed to mimic natural reef systems. However, the balls mainly act as fish aggregation devices, providing diving sites for sport divers, with little contribution to reef restoration. Inherent limitations prevent the balls from resembling natural reef communities thus they do not support the wonderful manifold functions of coral reefs, the most intricate and productive marine ecosystems. Rather than organically becoming part of the marine environment, these structures will always remain foreign objects. These are best regarded as "second generation" artificial reefs.

The methodology used in the Ihuru Island project has little in common with other artificial reef predecessors. The project initiators, Thomas and Wolf, therefore refer to their system as a "third generation" reef system. By means of a novel technology called "mineral accretion", the Ihuru Island method uses electricity to "grow" limestone rock on artificial reef frames and to increase the growth rates of corals and other reef organisms.

To set up the Ihuru Island artificial reef system two structures were constructed from industrial steel in the shape of giant five metre-high“barnacles”. The steel structures were then submerged onto the house reef, sitting at six metres and eight metres respectively.

A set of eight solar panels – costing about US$200 – is used to power the “barnacles”.

Using six solar panels, low-voltage direct current is charged to each 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 solar panel and is also submerged to complete the circuitry. Electrolysis at the cathode causes minerals naturally present in seawater, primarily calcium carbonate and magnesium hydroxide, to build up. At the same time a wide range of organisms on or near the growing substrate are affected by electro-chemically changed conditions, shifting growth rates. Reefs of any configuration and size can then be grown for the purposes of reef restoration and shore protection.



Close up view of one of the artificial reef “barnacles” sitting at eight metres on the house reef of Ihuru Island.

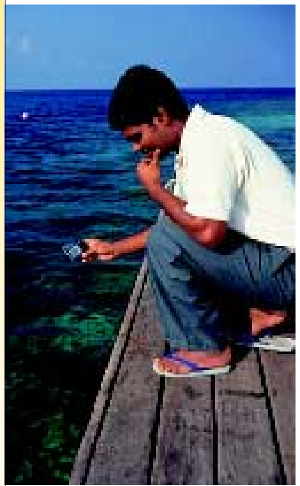
Naturally settled corals, attached corals, coralline algae, bivalves and other organisms thrive on the “barnacle” reef.

Using this method, four hours after submersion, white sediment can already be observed on the steel structure, indicating calcium carbonate settlement. Subsequently, small coral colonies are transplanted from a nearby reef onto the structure and attached with wires or wedged between steel bars. Very quickly, calcium carbonate will naturally reinforce the attachment. Since the contraptions are charged by the solar panels, the cycle of life on the structure resembles that of a natural reef. At night, the interior of these man-made giant “barnacles” soon becomes a “hotel” for many reef animals. Rather than being mere agglomerations of deteriorating shapes they are growing life-support systems, bringing about rich and natural ecologies.

Once the growth on a “barnacle” becomes stable, after approximately 3-4 years, the solar panel and titanium mesh can be recycled to support another installation. Initial cost of production of 2-3 structures is only US$1,000, which can be maximised for at least 10 years of use.

Apart from the project on Ihuru Island, third generation artificial reef projects have also been set up using shore power, wind-driven generators and photo-voltaics in diverse locations including Texas, the U.S. Virgin Islands, Louisiana, California, British Columbia, Cayman Islands, Mexico, Colombia, Venezuela, the Turks and Caicos Islands, Jamaica, Panama, Japan, Corsica, on Saya de Malha Bank in the Indian Ocean, and in the Seychelles. Most of these are smaller pilot projects, submerged in water between one metre and 14 metres in depth. Larger artificial reef systems, up to 630 metres in length and 20 metres in width, are also in the planning stages.

Every two hours, day and night, Ihuru staff lower a thermometer to check and record the water temperature on the house reef.



advantages of the mineral accretion artificial reef system

1. To date this is the only method which produces natural limestone, which is the natural constituent of coral skeletons, reefs, and sand.
2. Young corals and other marine organisms readily settle on the substrate.
3. Naturally settled corals, attached corals, coralline algae, bivalves, and a host of other organisms grow at exceptionally fast rates.
4. Rapid growth of calcareous algae supplies sand for beach nourishment.
5. Corals on these artificial reefs thrive even when water quality conditions have deteriorated to the point of killing surrounding corals.
6. As the reefs grow they cement themselves in place, either to the sea floor or vertical rock or coral formations, contributing to permanent shore protection.
7. Should damage be inflicted to these structures, renewed application of electricity readily facilitates repair.
8. Reefs can be grown and maintained using energy derived from solar panels, wind turbines, or energy plants drawing on the natural power of saline gradients, ocean currents or waves — avoiding the release of greenhouse gases from burning fossil fuels for the generation of electricity and the chemical decomposition of calcareous raw materials for cement production.
9. Artificial or natural components of accreting structures can be harvested in controlled, sustainable ways to provide building materials for terrestrial use in regions which have to import aggregates and cement.
10. Hydrogen gas, bubbling from the cathode, can be collected for use as a non-polluting energy carrier.

Mineral accretion was first developed by architect Wolf Hilbertz in order to provide alternative construction materials, and he and Thomas Goreau of the Global Coral Reef Alliance developed its use for reef restoration and shore protection. They hold a patent on such applications. They have recently joined forces with Professor Alexander Gorlov, the inventor of a remarkable new electrical generator which can be powered by ocean tidal currents that holds great promise with typical tidal flows found around oceanic islands. They are seeking to develop projects using mineral accretion for reef restoration, shore protection, and renewable energy development with interested groups around the world.

Magnificent Acropora colonies measuring up to three metres in diameter which thrived in the Felidhoo Atoll perished during the El Niño year of 1998.

The bleaching event of April 1998 significantly affected Ihuru Island's artificial "barnacle" reef

but at the same time proved the success of the project. Though all Acroporas on the artificial reef perished, 80% of the Porites coral species survived as compared to less than 10% on natural reefs. Realising the implication of the impact, the resident guardian of the project, Mr. A. Azeez A. Hakeem, immediately went out to collect surviving specimens of hard corals. They were transplanted onto the "barnacles" to monitor for growth rates, as well as to facilitate ongoing assessment. One species of Porites, *Porites rus*, was noted to be the most successful in surviving the warm water conditions. With the absence of Acroporas, the diets of some marine animals were expected to change. Drupella, a marine snail that preys on Acroporas, was found feeding on the Porites species on the "barnacles". With the aid of his staff, Azeez collected over three kilograms of these miniature snails for the Marine Ministry. Parrotfish were also observed to have acquired a taste for Porites.

During OceanNEnvironment's Sea Life Festival in April 2000, we had the opportunity to observe and review the Ihuru Island "barnacle" reef for the first time. We were very impressed. The coral colonies are thriving healthily, much more lavishly, in fact, than on the natural atolls. Apart from the "barnacles", the coral team has also built a huge steel structure with a similar set-up, named the "Ihuru Necklace". The objective of this structure is to deter beach erosion on the island. To enhance growth, the island generator provides low-voltage electricity to the necklace continuously, creating an artificial fringing reef around the island.

A bleached anemone, some have recovered, many have perished.

Since the holocaust of 1998, the Ihuru Island Tourist Resort management has also set up a system of recording the water temperature in the house reef every two hours, creating a temperature database, the only one known to exist in the Maldives. Another on-going exercise conducted by Azeez is monitoring the tolerance of hard coral species which thrive on shallow reef environments between one to one-and-a-half metres. Selected specimens are cemented onto concrete blocks and strategically located in the zone, which is subjected to the harshest environmental conditions. The knowledge acquired from such research contributes to the efficiency of setting up the artificial reef.

The initiatives of Ihuru Island Tourist Resort's management and their scientific team deserve to be applauded and congratulated. Unfortunately, much of the benefit of the regeneration project does not contribute directly to the rejuvenation of Ihuru's reefs. When coral spawns, their larvae are carried by tidal currents to settle on another reef a distance away. If the other 80 tourist resorts in the Maldives were each to invest in their own "barnacle" reef rejuvenation projects, then we would undoubtedly see the recovery process greatly enhanced.

Global warming is very real and coral bleaching events like the event of 1998 are anticipated to occur more frequently than before, and many regions of the world's ocean may become unsuitable habitats for reef-building corals. In the process, other areas, previously offering the right conditions for coral growth, may become too hot or cold to sustain reef builders and their ecologies. Under such circumstances, solar-based third generation artificial reef technology may have a crucial role to play in helping to preserve marine biodiversity, facilitating effective shore protection, providing ecologically sound reef-building materials, and thereby contributing to maintaining the quality of the world ocean.

Lush hard coral meadows in pristine condition were very common in the Maldives prior to April 1998.

how can you help conserve coral reefs?

The bio-diversity of our planet is one massive foundation upon which all life is dependent. We are part of the bio-diversity and preserving its integrity is really preserving our own existence. It is now more vital than ever that we ensure human activity does not interfere, for example, with the annual coral spawning process, thus maximising potential for coral larvae to settle on damaged reefs. However, until now, the coral spawning period in the Maldives is not known. Clearly there is a need for more research in this area.

OceanNEnvironment will be conducting a Coral Reef Survey Expedition in the Maldives in September 2000. This unique expedition will start from Haa Alifu, the remote northern-most atoll of the Maldives, then will proceed through Haa Dhaalu, Shaviyani, Raa, Noonu to the more familiar Baa, Lhaviyani and Kaafu Atolls. The purpose of the expedition is to collect specimens of Acropora (staghorn) corals. The objective of the research is to document surviving species and discover new species that have not been documented in the area before. This is the first such coral reef survey conducted since the bleaching event of 1998. If you are keen to participate in this expedition, please contact oneocean@OceanNEnvironment.com.au