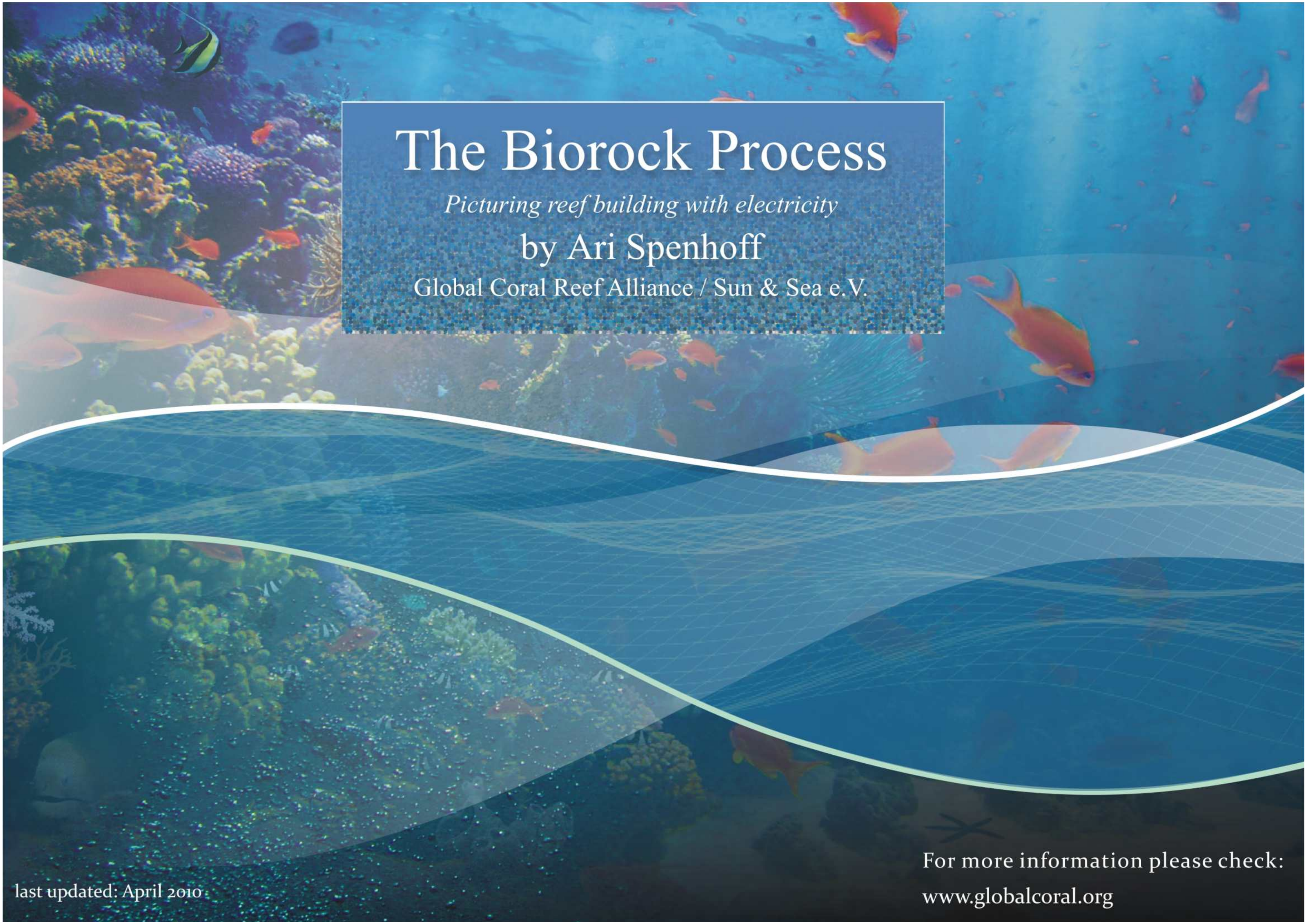

# The Biorock Process

*Picturing reef building with electricity*

by Ari Spenhoff

Global Coral Reef Alliance / Sun & Sea e.V.

last updated: April 2010

For more information please check:

www.globalcoral.org

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**Sun & Sea e.V.**

Sun & Sea's objective is to promote science and arts in the field of mineral accretion (Biorock® Process) on an international level, and exclusively pursues interests of public-benefit. The organization is based in Hamburg, Germany and operating under non-profit status.

**Global Coral Reef Alliance (GCRA)**

GCRA is a non-profit, 501 (c) 3 corporation based in Cambridge Massachusetts, USA. It is a world-wide coalition of scientists, divers, environmentalists and other individuals and organizations, committed to coral reef preservation.

Primary focus is on coral reef restoration, marine diseases and other issues caused by global climate change, environmental stress and pollution.

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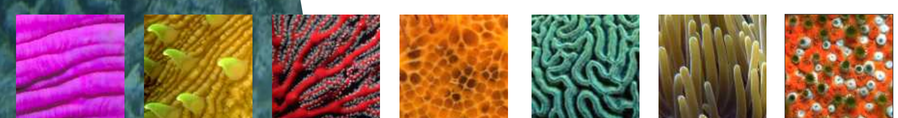


# Coral reefs are...

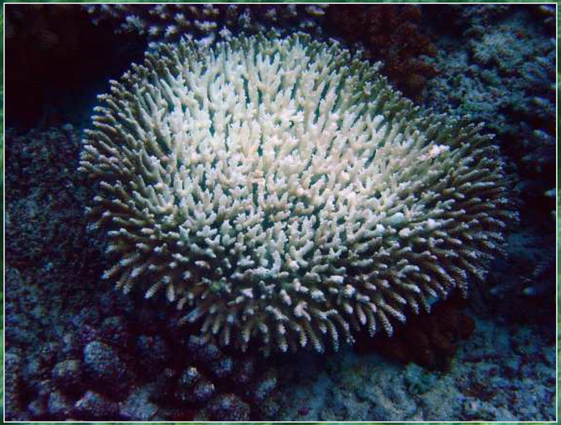
the largest biological structures on earth
found in 109 countries
one of the Earth's most beautiful ecosystems
part of our heritage
a vital source of food
home to 25% of all marine species
hot spots for biodiversity
lush gardens in the sea
highly complex
crucial to the health of oceans
among the most vulnerable habitats
evolutionary cradles
spectacular to behold
unique
the canary in the coalmine
much more than a pretty picture
fundamental to the fabric of local communities
a major tourist attraction
well known to protect the coast from storm waves
sensitive to human activities
becoming less productive just when we need them the most
facing a spiral of decline
the most sensitive of all ecosystems to global warming
dying
damaged beyond repair
being destroyed faster than the rainforests are being cut down

# Action needed

"Coral reefs face many threats. Some are natural stresses, such as hurricanes or plagues of coral-eating predators - about which we can do little. Really healthy reefs will recover from them over time.

In a completely different category are the human caused stresses to reefs. These stresses are persistent and constantly intensifying. Coral reefs cannot recover from such ever-present, worsening stresses. The end result of this human-impacted stress is that reefs now have trouble recovering from natural stresses which they otherwise would be able to bounce back from."

*Dr. Thomas Goreau, Dec. 2008*



Latest coral reef assessments (2009) estimate that 25 percent of the world's coral reefs are dead. A large fraction has been killed by warming sea-surface temperatures linked to global warming. In spite of an increase of heat-trapping gases, global temperatures have been relatively stable for the past decade. Recent studies attribute the stagnation to the so-called Pacific decadal oscillation (PDO). This phenomenon in the Pacific Ocean allows a larger volume of cold deep-sea water to rise to the surface at the equator. Accordingly, this has a significant cooling effect on the Earth's atmosphere.

Another explanation might be reduced solar activity as the radiation of the sun is currently at a minimum, as evidenced by the small number of sunspots on its surface.

For sure, currents in the world's oceans and solar activity are subject to natural cycles. Based on past experience, both factors will shift again soon and warming will resume. Experts warn: "That resumption could come as a bit of a jolt." Dr. Thomas Goreau fears it will be likely killing most of the remaining coral reefs.

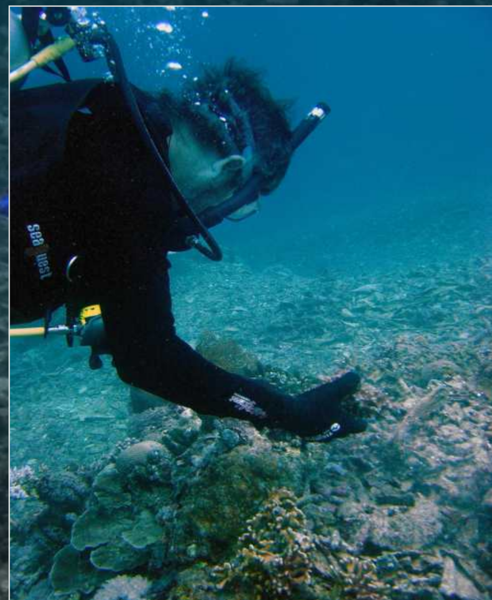
It looks as time for acting is becoming short!

# Coral rescue

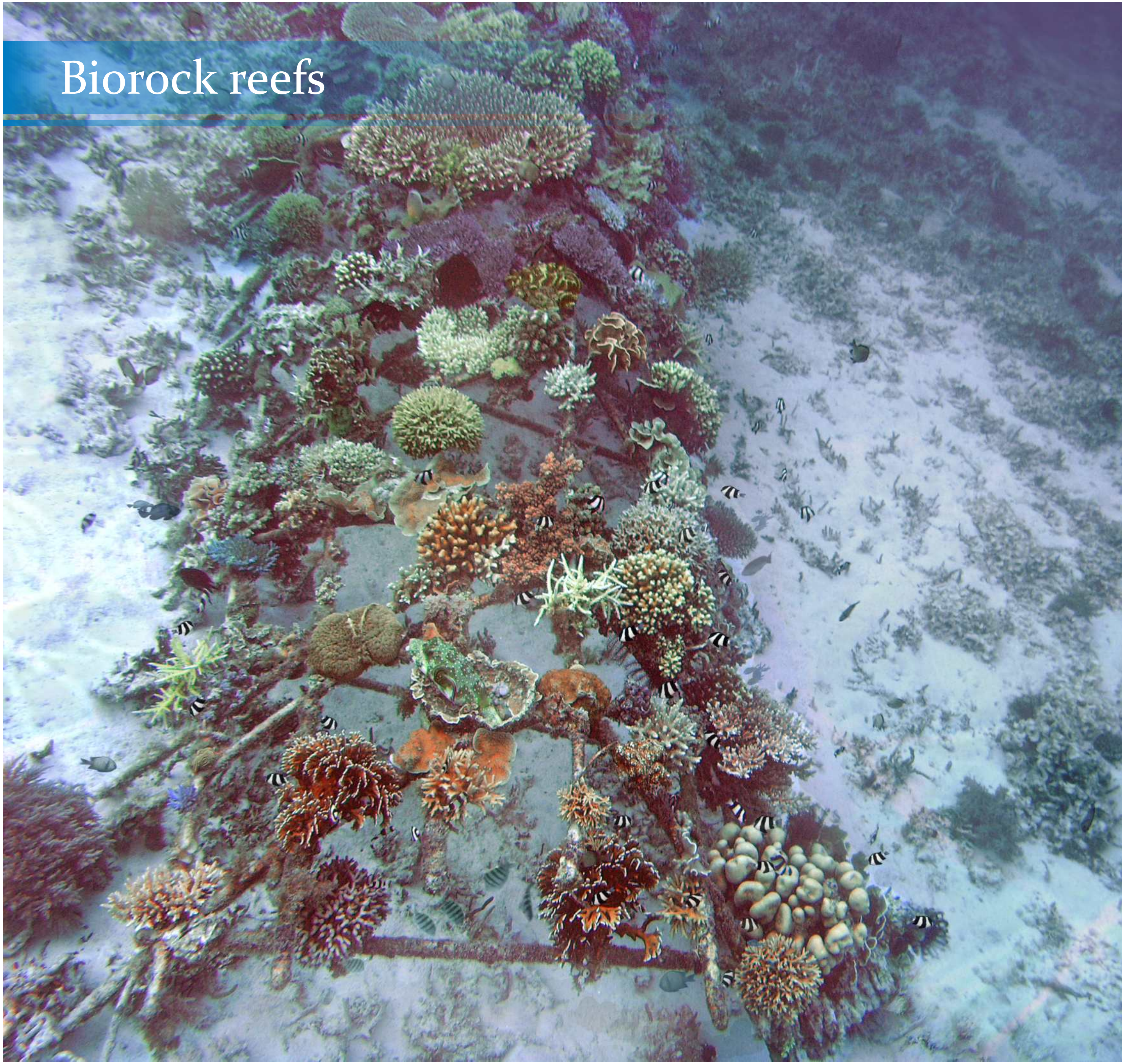
Large numbers of corals can be found loose, damaged by waves or human activity, often having had their bases undermined by boring worms, clams, and sponges. Many of these corals have been damaged by abrasion or burial, often with significant fractions dead.

These damaged fragments almost always soon die as the result of physical injury.

If a small fraction of the coral tissue is left alive these living portions proceeded to grow well after the attachment to Biorock® reef structures.



# Biorock reefs



Biorock reefs have proven to be effective worldwide in creating new habitat for marine life where none existed before, or where the natural habitat has been destroyed.

Although it is not possible to directly restore the ecology of all the damaged coral reefs in the world, it is possible, with enough dedication, to help repair the ecology of specific reef sites at various points along selected reef tracts. These ecologically maintained reefs will have a positive effect on surrounding reef areas through increased coral reef health and abundance at these sites, which will result in increased coral larvae recruitment to the area and increased survival of juvenile corals, and fish at that location.

Unlike artificial reefs made of artificial materials, the Biorock® process stimulates coral growth and produces the natural limestone materials that make up coral reefs, on which reef organisms prefer to settle. Because of their much higher coral survival following severe stress we call them "Coral Arks".

# Reef therapy

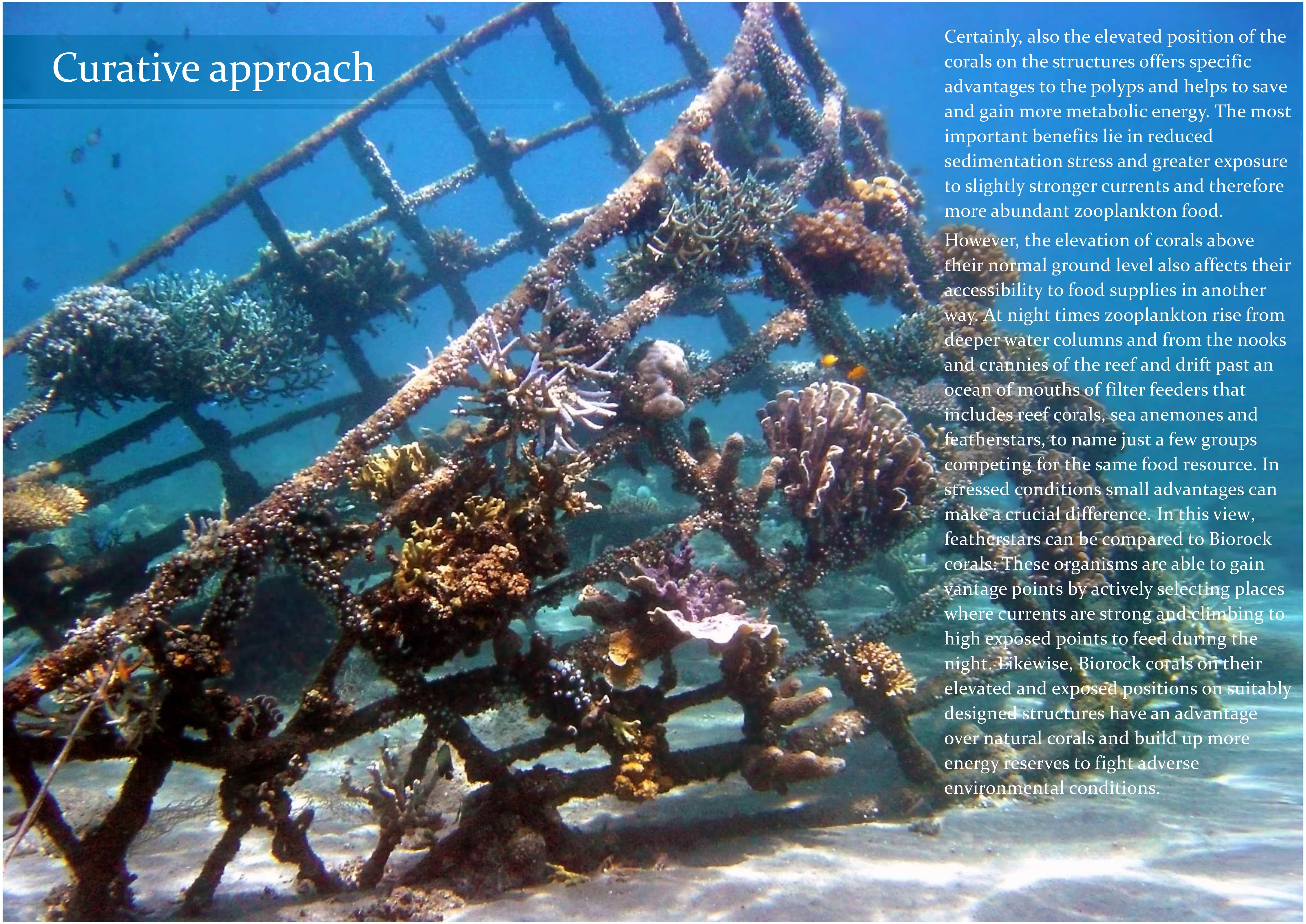
Due to the environmental changes at the steel frame, corals on the Biorock® reef structures grow typically faster than under normal conditions. Furthermore, observations and studies have shown that corals growing on correctly installed and operated Biorock® structures heal faster from damages and are more resistant to various stress factors.

Different explanations for these observations are being discussed:

One theory argues that the coral polyps' exoskeletons might be affected by the electricity similar to human accelerated bone fracture healing by electrical stimulation, which is a well known fact in human medical science.

Another explanation for the phenomenon is that the electric current lowers the acidity of the seawater, causing dissolved limestone to crystallize in close proximity of the frame and be used for coral skeleton growth. Under natural conditions, coral polyps must expend their own energy to create these conditions. With the Biorock grid doing the work, polyps can devote their energy to growth, reproduction and resisting environmental stresses like rising ocean temperatures.

# Curative approach



Certainly, also the elevated position of the corals on the structures offers specific advantages to the polyps and helps to save and gain more metabolic energy. The most important benefits lie in reduced sedimentation stress and greater exposure to slightly stronger currents and therefore more abundant zooplankton food.

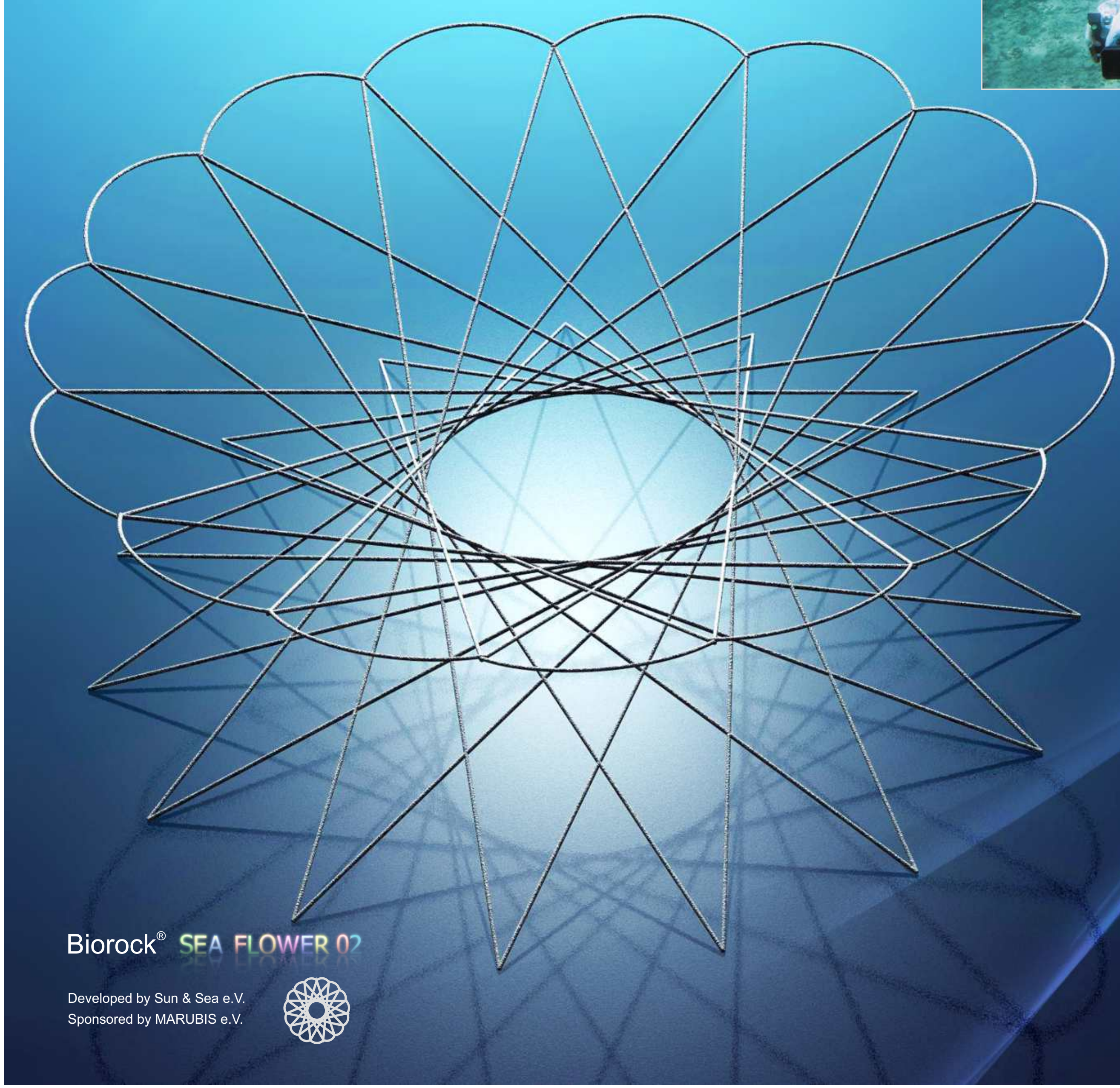
However, the elevation of corals above their normal ground level also affects their accessibility to food supplies in another way. At night times zooplankton rise from deeper water columns and from the nooks and crannies of the reef and drift past an ocean of mouths of filter feeders that includes reef corals, sea anemones and featherstars, to name just a few groups competing for the same food resource. In stressed conditions small advantages can make a crucial difference. In this view, featherstars can be compared to Biorock corals: These organisms are able to gain vantage points by actively selecting places where currents are strong and climbing to high exposed points to feed during the night. Likewise, Biorock corals on their elevated and exposed positions on suitably designed structures have an advantage over natural corals and build up more energy reserves to fight adverse environmental conditions.

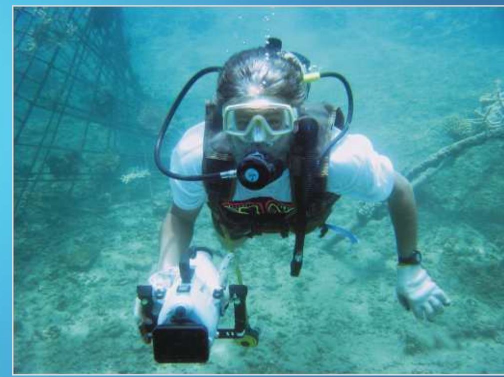
# Crutches for reefs

In many places natural reef recovery is impossible because the natural reef has turned to loose dead rubble that shifts during strong wave conditions. Under such conditions Biorock structures provide the crucially needed hard bottom substrate for coral larvae to settle and survive on.

Furthermore, it seems plausible that the structures provide the corals growing on them with an additional degree of safety from predation by certain coralivorous animals like crown of thorns starfish.

# Seascape design



Biorock projects can be of any size or shape. They generally require a formal set of construction plans and specifications for implementation. Therefore, the first step is to assess the physical and biological characteristics of the project site. Based on the results of a site assessment, engineering drawings and models are a useful tool to visualize the physical structure of the project and locate features such as species plantings and monitoring stations.

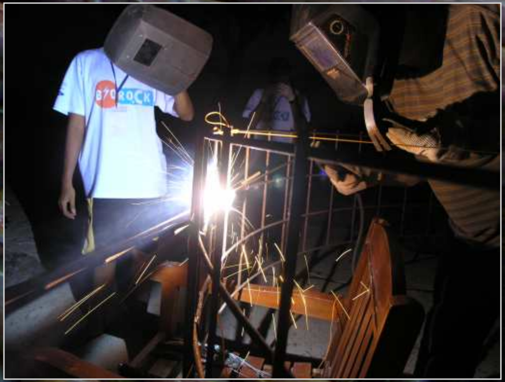
They can be designed with many layers of holes of various sizes that different fishes, lobsters, and other organisms prefer, leading to much higher population densities than natural reefs where the number of suitable holes are limited.

# Reef construction

To build a Biorock reef, an electrically conductive frame, often made from construction grade rebar, is welded together, submerged and anchored to the sea bottom.

The Biorock method is well suited for remote sites where exotic building materials, construction equipment and highly skilled labor are non-existent.

One great benefit of Biorock technology is its adaptability to a wide scope of situations and environmental conditions. If required, the resulting forms can be designed to be highly robust and are well suited even for high wave energy shores and reef crests. This is because they don't block the water movement and reflect the waves but act as permeable barriers.

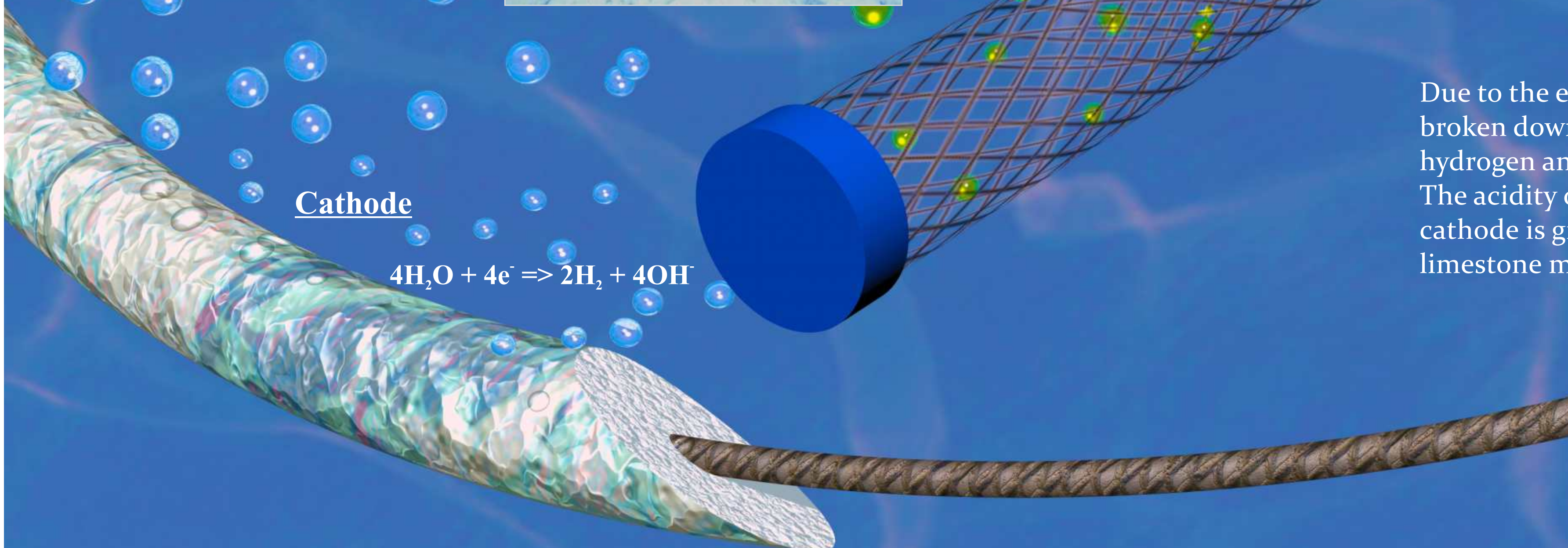


# Placing the new reef

Current Biorock reef construction sites range from small areas to one hectare in size, with many reef structures placed next to each other. Most sites are located on flat featureless sand or unconsolidated rubble bottom which offer little ecological significance or interest to divers compared to thriving coral reefs. Selecting reef construction sites also takes into consideration to avoid any possible conflicts with other reef users. Reef sites should be buoyed to assist in their location and make them visible for vessel traffic.

# Electric reefs

Low voltage direct current is applied. This initiates an electrolytic reaction causing dissolved chemicals naturally found in seawater, mainly calcium carbonate and magnesium hydroxide, to grow on the structure and form a mineral rock similar to that of natural coral reefs. The steel is protected against corrosion and over time the structures gain in strength.




Due to the electrical current water is broken down at the cathode to form hydrogen and at the anode to form oxygen. The acidity of the water around the cathode is greatly decreased, causing limestone minerals to grow on the steel.

# Jump-starting a reef

The electric energy used in the Biorock Process increases growth and coral health, allowing the reef's key organisms to survive adverse conditions, and allowing reefs to be restored where they cannot recover naturally.

The structures form ideal foundations on which attached and naturally settled corals grow and flourish. Robust coral formations, along with the natural protection from the Biorock structure, soon attract a wide variety of fish and other aquatic life, making the site also ideal for snorkelers and divers.

This method is notably suited to address some of the predicted large-scale environmental perturbations which will be effected by global climate change in the near future. Marine ecosystems will be among the first to be radically altered by increased sea temperatures and other oceanic disruptions (e.g. more frequent storm events, sediment runoff after heavy rainfall, eutrophication, new pathogens, ocean acidification).

# Fishhunters to fishfarmers

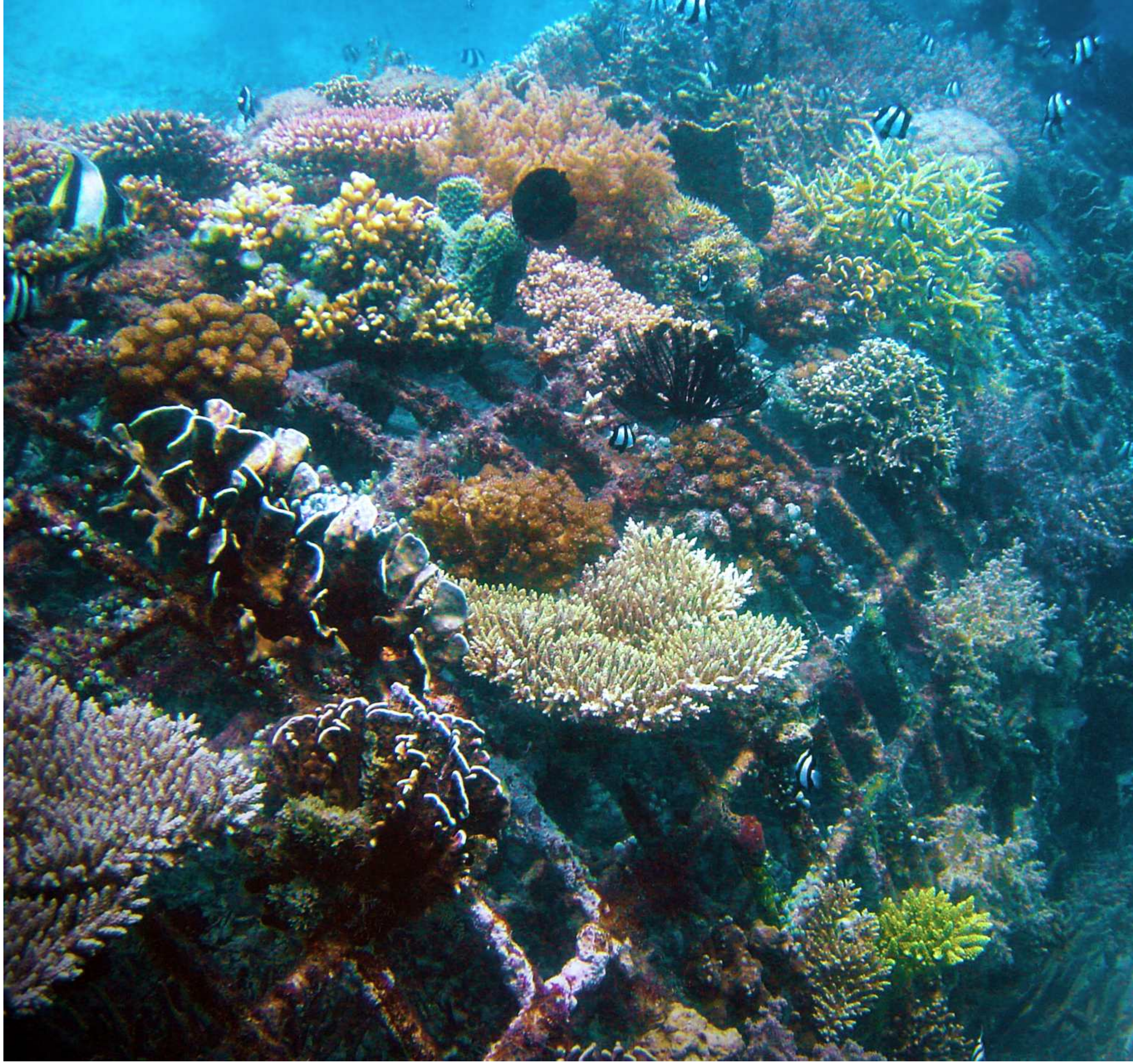
In many tropical coastal communities two critical issues are persistent: the depletion of natural resources and pervasive poverty. These two issues are closely interlinked in a vicious cycle whereby poverty drives the coastal communities to increase fishing pressure and the use of harmful fishing practices, that, in turn, leads to further depletion of coastal fisheries resources and as a result: even more poverty.

To break the cycle requires introducing coastal resource conservation and management measures to ensure resource sustainability over the long term, and the introduction of supplementary and alternative livelihood initiatives to raise income levels and improve the living conditions of coastal dwellers.

Building Biorock reefs has proven to be effective in reanimating complex reef ecosystems with predator fish, obligatory reef fish and a wide range of invertebrates.

The re-organization of fisherfolk into fishfarmers that actively regain and tend their coastal resources will empower them to transform into responsible resource managers and users.

# Shore protection



Many beaches worldwide are suffering from accelerating erosion. In the tropics one major factor is the decline of coral reefs. The loss of living corals has a twofold effect on beach erosion: Firstly, coral reefs buffer coastlines from the pounding of waves by absorbing the wave's force simply by their topographic protective elements. Secondly, most carbonate sand ultimately derives from the coral reef ecosystem and thus the loss of thriving coral stands throttles the supply of new sand grains to the beach. Therefore, the sand washed away into deeper waters is lost and cannot be replaced if the surrounding reefs are not thriving.

This combination of conditions is likely to become more important as climate change is predicted to make tropical storms more frequent and destructive. Coastal erosion will be perhaps the largest cost of global climate change as whole countries disappear and hundreds of millions of people are forced from their homes to become environmental refugees.

Specially designed Biorock reefs are a simple, elegant, and highly effective new design for shore protection structures against coastal erosion. Within a few weeks of installation these structures begin to build up sand. These “permeable” barriers are built open rather than monolithically solid. They absorb a portion of the wave energy and allow some to pass through, gradually reducing wave energy so that when the wave reaches the shoreline it has much less force, depositing sand instead of eroding it.

# Tourism and reefs

Artificial reefs are not just for fish or to alleviate erosion problems. They also provide alternate areas for divers and snorkelers to use, reducing the user pressures that natural reefs are exposed to.

The Biorock reef site developed at the Balinese fishing village Pemuteran can serve as a role model to demonstrate the benefits of developing tourist attractions with this technology.

More than sixty Biorock coral nursery structures have been installed since June 2000 in cooperation with local dive shops and hotels, and other local stakeholders. These structures are located in an area parallel to the shore, about 50-100 meters from the coastline, in waters ranging from about 3 to 7 meters depth. They are roughly lined up, forming a snorkeling and diving trail.

(info: www.biorockbali.webs.com )

The restoration of the previously heavily damaged reef with Biorock technology not only refurbished the ecological assets provided by coral reefs in general but also added further recreational and commercial value to the area.

Feedback received from visitors spells out that many had heard of the unique reef site previous to their booking. Because the natural and cultural resources of a destination are often what attract travelers in the first place, it can be assumed that Pemuteran as a tourism destination has been significantly enriched by adding new interests and activities to the core “product”, thus helping to improve its competitive position. The raised demand for the provision of transport, guiding, rent of dive equipment, boarding, lodging etc. helped to increase income to local business and employment. It is also notable that this was made possible in an area located off-route from Bali's mainstream tourism pathways. It appears that the reef restoration effort in Pemuteran made it able to spread the geographical distribution of tourism on Bali and thus contributed to the regional development.

Similar projects are under way in Gili Trawangan, Lombok and many other places around the world.

# Reefs and responsibility

A particular feature of the Biorock approach is the provision of a framework for local stakeholder participation in implementation and decision-making. Experience has shown that development projects imposed on local communities often fail to address issues of local concern and priority, and hence fail to engender a perception of local ownership. Building Biorock reefs facilitates local participation within the project cycle and brings various stakeholder groups together and provides an opportunity to exchange information and build consensus between the groups involved.

# Awards and recognition

1998 Theodore M. Sperry Award for Pioneers and Innovators in Restoration from the Society for Ecological Restoration

2000, Maldives Environment Award

May 2002, National Coastal Zone Management Conference on Bali, selects a Biorock project as the "best coastal project in the country".

June 2002 winner of Indonesia's “Konas Award“ for best community-based coastal management.

Nov. 2002 winner of SKAL International's "Ecotourism Award" for best practices in coastal tourism.

May 2004 winner of „Kalpataru/Adipura Award“presented by the President of Indonesia.

Jan. 2005 winner of “Aseanta's Award for Excellence” for best conservation effort.

April 2005 winner of PATA's “Gold Award for Best Environmental Project”.

2006 winner top award MIT IDEAS Competition.

# The Biorock group


The Biorock® process was invented and developed by the late Professor Wolf Hilbertz, an architect, inventor and founder of the NGO Sun and Sea e.V., together with his research partner Dr. Thomas Goreau, president of the Global Coral Reef Alliance.

The Biorock process is being used by a coalition of scientists, divers, environmentalists and other individuals and organizations, committed to preservation of coastal resources and with a thorough understanding of all aspects related to the application of Biorock technology.

Activities of the Biorock group include the provision of technical support to several community initiatives around the world that aim to restore and protect reefs, fisheries and coastlines in areas where natural recovery is not likely to occur.



For more information please see
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