Supporting Organizations

CTI
Indonesia National Secretariat of CTI

INCRES
Indonesian Coral Reef Society

Indonesia Association of Oceanologist

Proceedings of Coral Reefs Management Symposium on Coral Triangle Area

Proceedings of
Coral Reefs Management Symposium on Coral Triangle Area



CORAL REEF AND FISHERIES HABITAT RESTORATION IN THE CORAL TRIANGLE : THE KEY TO SUSTAINABLE REEF MANAGEMENT

By: Thomas J. Goreau, Ph.D.[47]

Abstract

So much Coral Triangle reef habitat is now severely degraded that conservation alone is inadequate to preserve the ecosystems along with the species and people who depend on them. Only active, large-scale coral reef and fisheries habitat restoration can maintain fisheries, shore protection, ecotourism, and biodiversity ecosystem services of the Coral Triangle. Turning fisher folks from hunters into sustainable reef farmers will be essential to maintain fisheries and biodiversity in the future. The techniques to do so have been developed in Indonesia, but large-scale investment by governments and funding agencies is needed for training and application of new technologies within the context of community-based restoration and management programs.

INTRODUCTION : THE CORAL TRIANGLE CORAL REEF AND FISHERIES CRISIS

The Coral Triangle contains the world's largest and richest area of coral reefs. Yet around 95 percent of the coral reefs are so severely damaged as to have lost most of their ecosystem function, biodiversity, fisheries, shore protection, sand supply, and ecotourism potential. Seventy percent of the region's protein intake comes from fish, mostly dependent on healthy coral reefs. As the coral reefs are destroyed and vanishing the fish habitat, fish stocks, fish catches, and the food supply for hundreds of millions of people. As the corals die so does the protection of low lying shorelines from flooding by tsunamis and storm waves, the potential for keeping up with global sea level rise, the new sand to maintain beaches, the hopes of ecotourism development, and the potential for new pharmaceuticals from the richest marine biodiversity on the planet. These irreplaceable natural services can only be maintained if the damaged reefs are restored to health.

The stunning beauty and variety of the Coral Triangle's marine life was early noted by observers, looking into clear water that was then typical in places like Ambon [1-2] and from samples hauled up in dredges and fishermen's nets. Yet the first effort to describe the reefs discussed only a handful of places [3], and was based entirely on geomorphology, with no insight from direct first hand observation. The use of diving as a research tool was pioneered in the Caribbean [4] and only in Jamaica did diving researcher scientists explore coral reefs before spear-fishermen had over-exploited them. By the time the first underwater researchers studied the Coral Triangle, the large fish were already largely gone [5-6]. Sport

[47] President, Global Coral Reef Alliance; President, Biorock SA; Scientific Advisor, Yayasan Karang Lestari, Bali; Scientific Advisor, Gili Eco Trust, Lombok; Coordinator, UN Commission on Sustainable Development Partnership in New Technologies for Small Island Developing States; Email: goreau@bestweb.net

divers have a far better sense of the condition of the reefs in this part of the world than scientists do, because scientific study of these reefs has been far too little and far too late.

The late Larry Smith was the most experienced live-aboard boat dive master in Indonesia, with around 50,000 dives on remote reefs from one end of Indonesia to the other. In 1998 I filmed him as he stood in front of a map of Indonesia and described his observations, right across the entire archipelago, searching for the finest coral reefs in the world, in order to bring high-end paying sport divers [7]. Almost everywhere he went the reefs were already destroyed. When he would find untouched reefs in perfect condition and note them as places to return to, he would almost inevitably find the following year that fishermen had bombed these reefs into rubble.

Study of the reefs now amounts to finding the last disturbed remnants, since no part of the region is out of reach of fishermen's boats, bombs, and cyanide, or the escalating threats of global warming, new diseases, land-based sources of pollution, and sedimentation from deforested lands. Consequently, it is largely futile to now start extensive monitoring of these remainders in order to try to find out if the reefs as a whole are deteriorating, yet this has remained the focus of the international funding agencies. What is really needed is not more study but large scale ACTION, training local students in the arts of ecosystem restoration, and funding them to work with communities to restore their vanishing marine habitat. Hundreds of Indonesian students have been trained in coral reef restoration over the last nine years at six Indonesian Biorock Reef Restoration Workshops [8], yet there remains no funding for them to use their knowledge and skills professionally. Even though Indonesia has the world's largest coral reef restoration projects, it proved impossible to find any funding at all to restore coral reefs in the areas affected by the tsunami in Sumatra, despite intense efforts by our Sumatran students. Until policymakers and funding agencies place priority on training, developing, nurturing, and maintaining endogenous restoration skills, and then making sure those who have them can make a living from their knowledge, large-scale pro-active management of the Coral Triangle reefs will be impossible.

CONSERVATION OR RESTORATION

The standard strategy of governments, international funding agencies, and big international NGOs (BINGOs) has been to declare marine "protected" areas (MPAs). It is claimed that by preventing fishermen from fishing in these areas, the damaged coral will spring back by themselves (the so-called "resilience" hypothesis), will become packed with schools of fish, and these benefits will spread out to envelop surrounding areas. But if all of the 5 percent or so of reefs left in good condition are strictly protected, what will happen to the fishermen who are forced to fish in the 95 percent of reefs whose ecology has collapsed? Without prime quality habitat providing the shelter and food they need, the fish populations cannot possibly recover. Starving fishermen will have no choice but to invade the little good reef left if they want their children to eat. Without restoration of the already damaged habitats, there will be no hope of maintaining the fisheries and other ecological services that only healthy and diverse coral reefs can provide. Conservation alone is completely insufficient to meet the urgent survival needs of the people of the Coral Triangle: 100 percent of the fishermen cannot possibly become tour guides in percent of the area. Therefore, while those reefs still in good condition certainly need to be protected from further damage, the vast bulk of the funds generated by the Coral Triangle Initiative should be used for large-scale ecosystem restoration, if sustainable development of the region is to result. Conservation is necessary, but it is just not sufficient by itself to do the job needed, without large-scale investment in restoring the roughly 95 percent of reefs that are already degraded. Yet restoration has been almost totally ignored by policy makers and funding agencies.

CORAL RESTORATION METHODS: OLD AND NEW

Natural recovery of damaged coral reefs occurs faster in the Coral Triangle than any place on earth, because the strong currents provide rich plankton food for corals and transport their larvae. Nevertheless, few of the damaged coral reefs of the Coral Triangle have recovered. Corals settle on loose dead coral rubble, only to die when they are turned over in the monsoon season waves. It is clear that active restoration is needed. Yet for the last decade the scientifically baseless and irresponsible claim that coral reefs are “resilient” ecosystems, able to bounce back all by themselves from any damage, largely promoted by the US and Australian governments, has been used to prevent funding for restoration. After the Tsunami, the International Coral Reef Initiative and the World Bank Expert Group on Coral Reef Restoration announced that countries affected by the tsunami “should do nothing at all. They should simply wait and the reefs will recover all by themselves”. But in all the areas worst affected by the tsunami the reefs had already been long dead, and had failed to recover.

The people of the Coral Triangle have known since ancient times that they could actively create habitat for fish by piling rocks and sticks in the sea, allowing corals and other marine organisms to settle in them, and building up dense fish schools. After a few years, the structures would be surrounded by nets, the structures dismantled, the fish caught, the structures rebuilt, and re-harvested again a few years later. We call this ancient tradition, “First Generation” artificial reefs [9]. In the 1830s loose corals were fixed in place by wooden stakes, and continued to grow as long as water quality was good [10]. Later these methods were adapted to use cement or glue instead of wooden stakes, and artificial substrates like cement, rocks, rubber tires, old cars, ships, and airplanes were used [11]. We refer to these exotic materials as “Second Generation” artificial reefs. These can provide habitat for fish if placed in locations where there is little natural shelter, such as sand and mud bottoms, but in general they succeed only if water quality is excellent, and rarely resemble the diversity of natural coral reefs. They are usually dominated by sponges and stinging hydroids, since most corals require clean limestone rock for settlement, and are not fooled by exotic substrates.

In the last few decades a completely new approach, the Biorock® method, has been developed, which uses safe low voltage electrical currents to grow natural limestone rock out of the sea on steel structures of any size or shape [9]. This provides the same natural material that coral skeletons are made of, and on which baby corals prefer to settle. The Biorock processes provides the only marine construction material that gets stronger with age and are self-repairing, with damaged areas growing back preferentially. They can be designed to create denser and more varied hiding places for fishes than even a natural reef, and rapidly build up large and diverse fish populations. Corals growing on them grow two to six times faster than normal, have sixteen to fifty times higher survival from severe high temperature stress caused by global warming, recover from physical damage, and spontaneously settle on them, many times faster than normal. As a result reefs can be kept alive where they would die, and reefs grown back in a few years in places where little or no natural recovery is taking place. These reefs have turned severely eroding beaches into growing beaches in a few years, which survived the tsunami that passed over the islands where they were located. We call these Biorock reefs “Third Generation” artificial reefs [9]. In a world where water quality is steadily deteriorating from out-of-control global warming and pollution, Biorock reefs survive stresses that kill all the corals on conventional artificial reefs [12]. Not only do they provide benefits that conventional reef restoration methods cannot, they cost far less [13]. In addition these methods can be used not only to grow new reefs on shallow banks, but also can be used to grow floating coral reefs in deep water, providing habitat for open ocean food chains such as tuna and squid. They are therefore the only practical interim solution to maintain reef ecosystem services until global climate change and pollution are reversed.

SUSTAINABLE FISHERIES RESTORATION

Just as active restoration of coral reefs using Biorock methods can quickly generate complex reefs in places where little or no natural recovery has taken place, the same can be done with many fish species. Simply declaring marine areas “protected” does not restore the fish stock unless prime quality habitat is preserved, or is restored. The Karang Lestari Biorock project in Pemuteran, Bali, worked together with the Gondol Research Institute for Mariculture (GRIM) [14], in Gerokgak, Buleleng, Bali about 5 years ago, releasing three species of grouper hatchlings into the projects. The young groupers hung around for about three year, steadily growing, and then vanished, probably for deeper water, when they were spontaneously replaced by young groupers of different species. GRIM is now producing 8 different grouper species hatchlings, and is planning to release these into the projects and follow their growth, survival and control populations on nearby reefs.

Another major new method for restoring coral reef fisheries is use of the Post Larval Fish Capture and Culture (PLFCC), as developed by the French group, Ecocean [15]. Huge numbers of post larval reef fish are found in the open sea, but almost all of these baby fish are eaten before they can find shelter and food in a coral reef. By collecting them at night using lights and special nets, the natural genetic diversity of larval fish populations can be collected, preserved, and released into Biorock juvenile fish habitat, short-circuiting the predators, allowing the fastest recovery of coastal fisheries. This combination of PLFCC and Biorock is certain to be the fastest way to restore and manage coastal fisheries, and should transform coastal fisheries productivity.

These approaches form a new paradigm for sustainable mariculture that is very different from those now commonly used. Conventional mariculture is almost entirely based on dense cultivation of a single species, usually a single clone, and thus replaces complex ecosystems with extremely simple ones, eroding genetic diversity. Because of their dense populations, they become breeding grounds for parasites and disease, which they pass on to native wild populations, and because of the lack of genetic variety, when one fish or shrimp dies, often they all do. These systems rely on expensive imported feeds, and the rotting food and excrement severely pollutes surrounding ecosystems. Such mariculture is rarely sustainable, causes more harm than benefits, and destroys diverse artisanal fisheries, replacing them with fisheries lacking in diversity, which is so expensive that usually only the richest fishermen can apply the methods, and often only a high priced export crop is produced that locals can't afford to eat, thereby accentuating economic inequality.

In sharp contrast, Biorock reef fisheries restoration promotes highly diverse ecosystems and does not use any external food additions. Biophysical energy is introduced in the form of safe, low voltage electrical currents, which are converted into Biochemical energy by the organisms themselves. This therefore is a highly diverse, productive, sustainable, natural system, lacking the specific drawbacks of conventional mariculture, and costing far less than conventional mariculture facilities. By restoring habitat, fishermen can turn degraded habitat back into high levels of sustainable production.

NEED FOR LARGE-SCALE COMMUNITY-BASED RESTORATION AND MANAGEMENT

Biorock reef restoration projects have been built in Bali, Lombok, Sulawesi, Flores, and Sumbawa in Indonesia, in Negros, Panay, and Mindoro in the Philippines, in New Britain in Papua New Guinea, and in Sabah in Malaysia, and around 20 countries across the Caribbean, Pacific, Indian Ocean, and Southeast Asia. Biorock projects at Pemuteran in Bali, and Gili Trawangan in Lombok, are the largest coral reef restoration projects in the world. The projects shown in the slide presentation are right here in North Sulawesi at Pulau Gangga Resort [16], and we invite WOC delegates to see them. These projects have all been done without any funding from governments, large international funding agencies, or BINGOs, being purely supported by small donations, mostly in-kind, from local communities who understand that their reefs are nearly gone, recognize that they must start growing corals immediately if they are to protect their own resources and future, and realize that if they wait for outside funding to start, resources will come too late. All are linked to community-based efforts to protect, restore, and manage local marine resources. Six Biorock coral reef restoration workshops have been held in Indonesia, training hundreds of students, coming from all over the world, but mostly Indonesian, as seen in the accompanying video. But these projects to date are a mere drop in the bucket compared to the need, and it is crucial that these successful techniques be rapidly transferred to bottom-up community-based programs to restore and manage damaged coral reefs and fisheries [17].

Coral reefs fisheries remain big game hunting, not farming. The Neolithic revolution of ten thousand years ago, when our ancestors had killed the big animals and had no choice but to put seeds in the ground and wait for them to grow, if they wanted to eat, is only now starting to reach the oceans. Overfishing, coupled to destruction of habitat, means that fisheries will not recover even if all fishing stops. Only active restoration of coral reef fisheries habitat will allow us to restore our fisheries. Our children cannot be fish hunters in the future like their grandparents were when there were many corals and fish and few people, they will have to become reef farmers. It is our experience living with and working with subsistence fishing communities all around the world for more than 50 years that most fishermen are intelligent people who are fully aware that their struggle to feed their families today means destroying their children's future resources. Almost all of them would rather adopt more productive and less destructive techniques, but governments and funding agencies have failed to provide them the training and tools to do so.

SUBSIDIZING REEF RESTORERS INSTEAD OF PELAGIC FLEETS

Throughout the Coral Triangle fishermen are among the poorest and most politically and economically marginalized communities, being driven further into poverty as fisheries collapse, and seeing few of the benefits of globalization accruing to urban elites. There is little investment in their education or for training them new and superior methods. Every government understands that for subsistence farmers to become cash crop farmers they must have training in more productive methods and access to loans and capital for better seeds, tools, and agrochemicals, and they have developed mechanisms to provide funding. But subsistence fishermen have been largely ignored.

Nevertheless most governments around the world subsidize the big capital-intensive fishing fleets that are destructively over-harvesting the open ocean pelagic fisheries, even while global warming is causing changes in ocean circulation that is resulting in open ocean fisheries to collapse from the bottom-up as well as the top-down [18]. In effect governments have chosen to throw money at their richest fishermen to race each other to destroy the resources of the ocean. These subsidies have been called “perverse” because they reward those who accelerate environmental destruction and punish those who act responsibly. They should be ended, and the funds instead invested in training and financing community-based fisheries habitat restoration by growing coral reefs across the Coral Triangle, thereby maintaining the priceless biodiversity for future generations by making sure that the vast majority of the fishermen have a direct economic stake in growing their resources back instead of destroying them. This should be a policy priority of the governments of the region, which is conveyed to the national and international funding agencies.

LINKS TO SUSTAINABLE ENERGY DEVELOPMENT

Besides education and training in new improved methods to improve production by restoring habitat, fishermen will need secure community-based property rights that ensure that outsiders cannot come in and reap what locals have sowed, access to loans for materials, and low voltage electrical current. Although energy costs are low in Indonesia because they are subsidized, they are still beyond the reach of poor fishing communities, and the petroleum resources are rapidly dwindling. Sustainable energy from renewable sources is needed. The region has significant geothermal resources, but these are highly localized. Wind power is probably not cost-effective because wind speeds are generally fairly low and highly seasonal. Solar power is still extremely expensive, and anyway the high cloudiness of the region diminishes sunlight availability significantly. But there are four potential new sustainable energy resources that could be tapped, and which are not currently being used, but which could play crucial roles in long-term sustainable development of the entire region if they were seriously tackled.

1) Biochar energy. Using modern kilns, any plant biomass can be turned into energy for making electricity, while producing biochar, and liquid fuels as well [19]. This process recycles atmospheric CO2 and does not add new CO2 to the atmosphere like fossil fuel combustion does. The biochar, when put into the soil, acts as a fertilizer, retaining soil nutrients and water, and greatly increases agricultural productivity. Furthermore it acts to remove carbon from the atmosphere and permanently buries it in soil, and therefore is a

highly effective carbon sink that should qualify for carbon credits under any scientifically-sound carbon trading scheme. It is the only practical way to stabilize global CO2 levels and reverse global warming [20-21]. Biochar kilns have been successfully used to generate energy and produce soil fertilizer in pilot projects at Bogor Agricultural University in Indonesia. Use of Biochar to improve soil fertility can also be combined with use of the world's best erosion preventing plant, Vetiver grass, *Vetiveria zizanoides*. Vetiver has been used in the East Bali Poverty Project to turn barren eroding hillsides into highly productive terraced agricultural land, halting erosion and transforming the lives of local village farmers [22]. Vetiver is so effective in halting soil erosion that when it was planted on severely eroding hillsides in Vanuatu, whose eroded soils had smothered and killed nearby coral reefs and destroyed their fisheries, the erosion was stopped. After a few years the water on the reef cleared up, and coral and fish have returned, to the delight of local fishermen [23]. By combining Biochar and vetiver, clean energy can be provided without deforestation, damaged hillside land and coral reefs restored to full production, while reversing global warming and earning carbon credits.

2) Tidal energy. The ferocious tidal currents of the Coral Triangle, well known to fishermen, sailors, and divers, make the region practically the Saudi Arabia of tidal energy, yet their vast and clean energy is completely untapped. These currents are driven by the flow of water between the Pacific and Indian Ocean driven by the solar and lunar tides, and are highly reliable and predictable [24-25]. Modern vertical axis tidal energy turbines could provide much of the energy of the region if a crash program for their development was funded [20]. A small tidal energy turbine has been built in Negros Occidental, the Philippines, to power Biorock coral reef restoration projects [26], and could be used in many Coral Triangle Islands to grow back coral reefs and fisheries and provide power for coastal communities using clean, sustainable, inexhaustible, and unutilized, natural energy resources.

3) Wave energy. Like tidal energy, this resource is entirely untapped, can be relied on as long as the sun shines and the wind blows, and only a tiny fraction of it would need to be harvested to meet global energy needs. Most wave and wind energy is found in the areas far from the equator, so efforts to date have focused on very large, technically complex, and extremely expensive devices in cold countries. There are many clever designs being developed to utilize tidal energy, but most have yet to be proven under real-world conditions. One remarkable exception is the SwellFuel wave energy systems, which can make up to kilowatts of energy per square meter in waves as small as 10 cm [27]. These ingenious devices allow energy to be made in most coastal habitats most of the time. It is planned to use these remarkable new power supplies later this year to restore coral reefs for the first time on offshore bank reefs near Pemuteran, Bali. If this pilot project works well, it will open the possibility to restore coral reefs at even remote sites, using widely available and unutilized ocean energy resources.

4) Space based solar power. Since the 1960s it has been technically feasible to use solar panels on satellites above any absorption of sunlight caused by clouds and aerosols in the Earth's atmosphere, and transmit it to the surface using microwave radiation frequencies that are not absorbed by water vapor, and so do not have any of the effects associated with microwave ovens. A pilot project many years ago showed that this was feasible on the Indian Ocean Island of Reunion, using receiving antennas built by local high school students [28]. But until recently such power was unaffordable to any but NASA space missions due to the high cost of photovoltaic panels. A new generation of ultra thin film solar panels, and the

inevitable future rise in petroleum prices as easily tapped reserves are exhausted, will change this situation. Transmission of solar satellite power is proposed in a US-European-Japanese pilot project that plans to orbit a satellite in a figure 8 orbit, with the extreme ends over Tokyo and Australia, passing over the Coral Triangle [29]. The first proposed project using such power will be to grow Biorock coral reefs to protect a low lying atoll in Palau, and save it from disappearing from global sea level rise [30]. If this project happens, it may open tremendous new opportunities for cost-effective space based solar power that could be beamed to any place on the earth.

CONCLUSIONS : CORAL REEFS AND SUSTAINABLE DEVELOPMENT IN THE CORAL TRIANGLE

Coral reefs and fisheries should no longer be regarded as a mere afterthought to national development plans, to be sacrificed to unsustainable fishing practices, soil erosion, mining effluents, sewage, agrochemical pollution, and global climate change. Restoring the world's richest and most productive reefs on a large scale should be the very central focus for planning the sustainable development of the world's largest island nations. Integrated planning to restore the region's collapsing living marine resources, develop their vast untapped marine energy resources, and manage them sustainably, will contribute vastly to the sustainable development of the Coral Triangle by giving the coastal populations a stake in their long-term future, while protecting their resources from the runaway changes of global climate change and population-dependent stresses. Students from the region need training in the art and science of ecosystem restoration and jobs that use their knowledge, and fishermen need training in new techniques and access to capital to employ the new more productive methods. Reversing the current, out-of-control, destruction of forests, soils, coral reefs, and fisheries, would provide the best incentives for the Coral Triangle's farmers and fishermen to play a leading role in sustainable development by restoring the land and the sea.

REFERENCES

Photos and Videos presented at this talk can be seen as on-line appendices at www.globalcoral.org

[1] Rumphius, G. E., 1705, The Ambonese Curiosity Cabinet, 1999 Edition, Yale University Press, New Haven

[2] Wallace, A. R., 1869, The Malay Archipelago, 1962 Edition, Dover, New York

[3] Umbgrove, J. H. F., 1947, Coral Reefs of the East Indies, Geological Society of America Bulletin, 58: 729-778

[4] Goreau, T. F., 1956, A study of the biology and histochemistry of corals, Yale University, New Haven

[5] Tomascik, T., A. J. Mah, A. Nontji, & M. Kasim, 1997, The Ecology of the Indonesian Seas, 2 Volumes, Oxford University Press, Oxford

[6] Edinger, E. N., J. Jompa, G. V. Limmon, W. Widjatmoko, & M. J. Risk, 1998, Reef degradation and coral biodiversity in Indonesia: effects of land-based pollution, destructive fishing practices and changes over time, Marine Pollution Bulletin, 36: 617-630

[7] Smith, L., 1998, Condition of coral reefs in Indonesia, Personal Communication, one hour filmed by T. Goreau at Lembeh Resort, North Sulawesi

[8] Goreau, T. J., T. Sarkisian, & D. Robbe, 2009, 6th Indonesian Biorock Training Workshop Report, Gili Trawangan, Lombok, December 1-7, 2008, 28p., http://www.globalcoral.org/WORKSHOP%20REPORT%202008,2.pdf

[9] Hilbertz, W. & T. J. Goreau, 1998, Third generation artificial reefs, Ocean Realm, Summer Issue, p. 45-48

[10] Darwin, C., 1842, On the Structure and Distribution of Coral Reefs, 1890 Edition, Ward, Lock, and Co., London

[11] Rinkevich, B., 2005, Conservation of coral reefs through active restoration measures: Recent approaches and last decade progress, Environmental Science and Technology, 39: 4333-4342

[12] Goreau T. J. and Wolf Hilbertz, 2007, Reef Restoration as a Fisheries Management Tool, in Fisheries and Aquaculture , [Ed. Patrick Safran], in Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford ,UK, [http://www.eolss.net]

[13] Goreau T. J. & W. Hilbertz, 2005, Marine ecosystem restoration: costs and benefits for coral reefs, World Resource Review, 17: 375-409

[14] Sim, S. Y. & A. Hanafi, Grouper Hatchery Production Training Course, Gondol Research Institute for Mariculture, 2002, 13 p., http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=8&lid=89

[15] Ecocean, 2009, Post Larval Capture and Culture, http://www.ecocean.fr/en/presentation.html

[16] http://www.ganggaisland.com/info.html

[17] Goreau, T. J. & W. Hilbertz, 2008, Bottom-up community-based coral reef and fisheries restoration in Indonesia, Panama, and Palau, P. 143-159 in R. France (Ed.) Handbook of Regenerative Landscape Design, CRC Press, Boca Raton

[18] Goreau,T.J., R.L. Hayes, & D. McAllister, 2005, Regional patterns of sea surface temperature rise: implications for global ocean circulation change and the future of coral reefs and fisheries, World Resource Review, 17: 350-374

[19] D. Day, R. J. Evans, J. W. Lee, & D. Relcosky, 2005, Economical CO2, SOx, and NOx capture from fossil-fuel utilization with combined renewable hydrogen and large-scale carbon sequestration, Energy, 30: 2558-2579

[20] Goreau, T. J., 2007, Global warming, coral reefs, and tropical islands; Why immediate action is essential and how it can be achieved, Briefing for Small Island Developing States delegations, United Nations Convention on Climate Change, Bali, 45p., http://globalcoral.org/Global%20Warming%20Coral%20Reefs%20and%20Tropical%20Islands.1.pdf

[21] CNN, 2009, Can Biochar save the planet?, http://edition.cnn.com/2009/TECH/science/03/30/biochar.warming.energy/index.html

[22] Matthews, S., 2005 The Vetiver System and Indonesia's East Bali Poverty Project, http://video.google.com/videoplay?docid=7648948557201400672

[23] Miller, D. E. K. & N. Lambrechtsen. 2004. Solutions to Erosion Problems in Vanuatu. P. 335-342 in: D. H. Barker, A. J. Watson, S. Sombatpanit, B. Northcutt and A. R. Maglinao (eds): Ground and Water Bioengineering for Erosion Control and Slope Stabilization, Science Publishers, www.scipub.net, Enfield, NH

[24] Gorlov, A. M., 2001, Tidal Energy, p. 2955-2960 in Encyclopedia of Ocean Sciences, Academic Press, London

[25] Natural Currents, 2009, About tidal power, http://www.naturalcurrents.com/about.html

[26] First Step Coral Team, 2006, MIT IDEAS Competition, http://globalcoral.org/First-Step-Coral_5-30-2006.pdf

[27] Swell Fuel Ocean Wave Power, 2009, http://swellfuel.com/

[28] Pignolet, G., J. Hawkins, N. Kaya, J.-D. L. S. Luk, F. Lefevre, V. Loman, Y. Naruo, F. Valette, & V. Vanke, 1996, Results of the Grand Bassin case study in Reunion Island: Operational design for a 10 KW microwave beam energy transportation, 12p., Proceedings 47th International Astronautical Congress, Beijing, China, IAF-96-R.2.08

[29] Reed, K., 2008, Ultra-lightweight CFRP boom deployment thin film solar arrays, European Space Agency, http://atlas.estec.esa.int/SPS/images/9/9b/SPS_NetWorkshop_PRE_0208_Reed.pdf

[30] Goreau, T. J., W. Hilbertz, S. Sackarias, & H. Hosei, 2004, Hotsarihie (Helen Reef) Project Report, http://globalcoral.org/Hotsarihie%20(Helen%20Reef)%20Project%20Report.htm

Proceeding of Coral Reef Management Symposium on Coral Triangle Area
Page iv, 303
ISBN : 978-602-8717-56-4

Honorary Member :
Sudirman Saad

Advisors :
Agus Dermawan
Yaya Mulyana

Editor :
Jamaluddin Jompa
Riyanto Basuki
Suraji
Mike Tesoro
Eva Tri Lestari

Cover Design :
Gerald Hudiono

Published by :
Coral Reef Rehabilitation and Management Program Phase II
C O R E M A P II, 2010 (Second Edition)
Directorate General of Marine, Coasts and Small Islands
Ministry of Marine Affairs and Fisheries

Jl. Tebet Timur Dalam II No. 45, Jakarta Selatan – Indonesia
P. +62 21 83783931 F. +62 21 8305120
www.coremap.or.id
www.coremap-2.com

Jl. Medan Merdeka Timur No. 16 Gd. Mina Bahari III lt. 10, Jakarta Pusat
P./F. +62 21 3522045
www.dkp.go.id

Preface

Thirty-two technical papers comprise the Proceedings of the Coral Reef Management Symposium on Coral Triangle Area, held on 12-13 October 2009 at the Hotel Bidakara in Jakarta.

The international symposium succeeded in bringing together scientists, managers, policy-makers, NGO representatives and the private sector in looking for solutions to address the ongoing challenges in coral reef conservation. In relation with this initiative, the proceedings intend to generate exchanges in research results, activities and foster understanding among researchers and observers to the ongoing international efforts to conserve the coral reefs. This also serve as a tool in initiating awareness and sustaining knowledge on coral reef conservation efforts among the general public.

Sincere appreciation also goes to the members of the symposium's Organizing Committee, the COREMAP Phase II, and to the speakers who shared their time and talents in preparing their respective technical papers.

It is envisaged that the proceedings will be beneficial in facilitating the strategic improvement in the future implementation of various coral reef conservation programs not only in Indonesia but also in the rest of the world. Additional inputs and substantive comments from the readers will be highly appreciated to further improve the technical papers.

The development of this proceedings was made possible with the support of the Coral Reef Rehabilitation and Management Program Phase II (COREMAP II) through its National Coordinating Committee.

Jakarta, July 2010
COREMAP II Director

Ir. Agus Dermawan, M.Si

Contents