ENHANCING CORAL GROWTH ON ARTIFICIAL REEFSBY

ELECTRO DEPOSITION REEF

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DEDICATION

I dedicate this dissertation to my family, especially to Umi, Wafii and Wafaa……

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ABSTRACT

The global decline in reef health has prompted the need for effective reef management methodologies, including the development of active reef restoration measures. Major causes of coral reefs damage includeuncontrolled tourismand fishing activities. Electro Deposition Reef (EDR) is a technique to enhance coral growth on artificialreefs by using direct current. It hasdemonstrated to be a potential tool for the restoration of marine habitat. The development and installation of EDR test bed was done in2004 atPerhentian Island. The test bed consisting of Cluster A and Cluster B was located in front of the Marine Park Department Jetty. Cluster A includes the EDR setup, while Cluster B acts as control. Cluster A consists of a 10m x 5m x 1.5m PVC frame to support the EDR structure and 10 units of concrete reefs. While, Cluster B as a control test bed consist of 10 units of concrete reefs only. Concrete reefs deployed functions as medium for coral to grow. These dome shaped concrete reefs were developed by a marine contractor Dorken Reefs Resources. Coral and fish species at Cluster A and B were counted, recorded and compared. The fish and coral assemblage on the test bed were found to be abundant and diverse. The most abundant coral species was *Acropora*, and the most numerous fish was *Razor Fish*.The growth rate of *Acropora*recorded showed the growth of88% faster than Control Cluster (B). The coral grew up to 75mm within 18 months compared to control cluster rateof 40 mm for 18 months.The abundance and diversity index of fish were calculated using Shannon Wiener Index and the results show that thefish distribution is more dominant in Cluster Aat 2.77, compared to Cluster B, at2.46.Installation of the solar panel requires the correct position to be achieved to obtain optimum output of voltage and current.Cloudy areas may not get enough sun exposure. Wet climates will corrode exposed parts more quickly and the cost of maintenance must be considered. From the results given,EDRtechnique contributes in enhancing coral growth and created more source of food for the marine habitats.

ABSTRAK

Kemusnahan batukarang di peringkat global meningkatkan keperluan pengurusan karang yang efektif termasuk membangunkan kaedah pemuliharaan batukarang yang aktif. Antara sebab-sebab utama batukarang musnah ialah aktiviti pelancongan dan perikanan yang tidak terkawal. Kaedah"*electro deposition reef*" (EDR) ialah satu teknik untuk meningkatkan kadar pertumbuhan batukarang dengan menggunakan tenaga elektrik arus terus. Ia telah menunjukkan potensi untuk membantu pemuliharaan habitat marin. Pembangunan dan pemasangan lapangan pengujian EDR telah dilakukan pada tahun 2004 di Pulau Perhentian, Terengganu. Lapangan pengujian KlusterA dan Kluster B terletak di hadapan jeti Jabatan Taman Laut, Pulau Perhentian. Kluster A dilengkapi dengan EDR manakala Kluster B pula bertindak sebagai kawalan. Kluster A mengandungi satu rangka PVC bersaiz 10m x 5m x 1.5m bagimenyokon gstruktur EDR dan 10 unit tukun konkrit. Manakala, Kluster B bertindak sebagai kawalan dengan mempunyai 10 unit tukun konkrit sahaja. Tukun konkrit yang dilabuhkan menjadi medium untuk karang tumbuh. Tukun konkrit berbentuk kubah ini dibangunkan oleh sebuah syarikat marin Dorken Reefs Resources. Karang dan spesisikan di Kluster A dan B dikira, direkod dan dibandingkan. Pelbagai sepsis batukarang dan ikan di dapati telah terhimpun di lapangan pengujian. *Acropora* adalah sepsis karang yang paling dominan, manakala ikan yang paling banyak mengunjungi lapangan pengujian ialah *Razor Fish.* Kadar pertumbuhan *Acropora* direkodkan dan keputusannya menunjukkan ianya tumbuh 88% lebih pantas berbanding kadar pertumbuhan di Kluster Kawalan (B). Karang tersebut tumbuh 75mm dalam masa18 bulan manakala kadar pertumbuhan di Kulster Kawalan ialah 40mm selama 18 bulan. Bilangan dan kepelbagaian ikan dikira menggunakan Shannon Wiener Index dan didapati ikan lebih mendominasi Kluster A iaitu 2.77 berbanding Kluster B dengan 2.46. Pemasangan panel solar perlu dilakukan pada posisi yang sesuai bagi mendapatkan nilai voltan dan arus yang paling optima. Kawasan yang dilindungi oleh awan akan kurang memperolehi cahaya matahari. Manakala cuaca yang lembab akan menyebabkan peralatan mudah karat dan kos bagi membaik pulih perlu diambil kira. Daripada keputusan yang diperolehi, kaedah EDR terbukti meningkatkan kadar pertumbuhan karang dan juga sumber makanan kepada hidupan marin.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

EDR	-	Electro Deposition Reefs
LED	-	Light Emitting Diode
Amp	-	Ampere
Volt.	-	Voltage
PVC	-	Polyvinyl Chloride
PWM	-	Pulse Width Modulation
MPPT	-	Maximum power point tracking
EPA	-	Environmental Protection Agency
ORP	-	Oxidation Reduction Potential
TDS		Total Dissolved Solids
EC		Conductivity
DO		Dissolved Oxygen

LIST OF SYMBOLS

m	-	Meter
mm	-	Millimetre
pH	-	Hydrogen ion activity in solution
W	-	Watts
I	-	Current
V	-	Volt
mg	-	milligram
ℓ	-	litre

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

Coral reefs, the rain forests of the sea, are undergoing a worldwide decline. Global changes and continuous intense abuse of reefs by human are the main factors for this decline. Adverse anthropogenic activities such as over-fishing, recreational activities, waste discharge, deforestation, reef mining and dredging have all been listed as primary causes for this degradation. The decline of coral reefs raised the need for adequate restoration methodologies as efforts to conserve degrading reefs have failed to produce significant results and rehabilitation measures have not compensated for the rapid reef degradation.

A World Bank report in 2006 [1] on coral reefs identified this ecosystem as the highest priority area for conservation, especially in countries with an economic

dependence on coral reefs. This concern is further supported by reports discussing the ecological and socio-economic issues of worldwide reef degradation [1].

The fast degradation of coral reefs has prompted greater attention to remediation and restoration activities. In Southeast Asia some of the status of the reef has reached a critical point of reduced resilience forcing active restoration measures. However, established theories and approved management and restoration techniques for marine ecosystems, including coral reefs are still lagging behind and rely largely on those developed for terrestrial habitats [1].

As a result, the principles underlining reef restoration measures have become part of the many ill-defined issues of this discipline. The fast worldwide reef degradation has invoked discussions on suitable restoration measures to be applied as management tools supplementary to the traditional conservation measures [1].

Various approaches have been proposed including construction of artificial reef structures, the transplantation of entire coral colonies or fragments and the concept of ‘‘coral gardening’’ by means of underwater nurseries. Until recently, attempts to restore degraded reef areas were based on whole colony transplantation in which dead coral colonies are replaced with new ones in order to accelerate natural recovery. However, harvesting corals for transplantation usually abuse and inflict trauma to the donor reefs while survival and growth of the transplants are left to the mercy of conditions within the damaged reef site [1]

To alleviate coral reef degradation, a two-type restoration and enhancing coral growth protocol termed ‘‘Electro-deposition Reefs’’ (EDR) is proposed. For the test bed, two clusters of engineered reef were constructed and deployed at the Pulau Perhentian,

Marine Park in Terengganu. Cluster A was installed with Electro deposition Reefs and Cluster B acts as the control unit. All units were deployed at the same water depth of 8m during high tide.

This thesis presents the findings on the performance of the Electro Deposition Reefs where coral growth and fish distribution were recorded over an 18 months period.

1.2 Research Objectives

The objectives of this project are as follows;

1. To investigate the effectiveness of ‘‘Electro-deposition Reefs’’ to accelerate coral growth.
2. To monitor the coral growth rate and fish distribution at two clusters of test bed installed at site.

1.3 Scope and Task

This research works involve:

1. Development and deployment of “Electro-deposition Reefs technique’’ at the research site for the coral to grow.
2. Monitoring and comparing the rate of coral growth between the EDR Cluster and the Control Cluster.
3. Observing and recording the fish distribution at the EDR Cluster and the Control Cluster.

The prototype and test bed for concrete reef with EDR method was developed and deployed at Pulau Perhentian in April 2008. The EDR method setup uses solar panel at 12 volt and 0.4 Ampere and connected to the concrete reefs copper cage and titanium as conductor. Comparison for the rate of acceleration will be quantified. Data collection on the effectiveness of the EDR method to enhance self accretion and act as substrate for coral growth will be recorded. Diversity including type, number of coral and fish around the test beds will be observed and recorded.

1.4 Significance of the study

Expected findings from this research are:

1. A novel way of using EDR technique to enhance coral growth. EDR setup expected to propagate coral growth especially *Acropora sp* which the structure construct by calcium carbonate. The growth rates of this species will be recorded along the project.
2. Recommendations of suitable electrochemical reaction series of metal for deployment of manmade coral habitat. From the series, improved method can be suggested for future project. The test bed developed using the suitable electrochemical series expected to be a sustainability food chain for marine life.

1.5 Thesis Outline

This thesis is organized into 5 chapters to completely cover the whole research works that have been conducted covering the development, deployment and monitoring of an “Electro-deposition Reefs system ’’ to accelerate coral growth.

Chapter 2 reports on the literature review of the EDR method. There is a need for extensive and continuative investigation either via laboratory or experimental approach. Chapter 3 provides a description of the experimental testing on site. The experimental facility, setup and procedures for this study are described.

Results of this study are reported in Chapter 4, including the observations recorded, assessment of the test results and assessment of the particular factors that influence acceleration rate for coral growth using the “Electro-deposition Reefs system”. Finally, in Chapter 5 the contribution of this thesis are summarized and recommendations for future works are given.

REFERENCES

1. Schubert, R. The Future Oceans, Warming Up, Rising High, Turning Sour. *German Advisory Council on Global Change (WBGU)*, 2006, Vol. 2 : 111-117

2. Pandolfi, J.M. Global trajectories of the long-term decline of coral reef ecosystems. *Science 301*, 2003, 955–958

3. Bellwood, D.R. Confronting the coral reef crisis. *Nature*, 2004, 429: 827–833.

4. International Coral Reefs Report, Diagnostic Monitoring & Assessment of Coral Reefs: Studies from Around the World, *10th International Coral Reef Symposium*, 2008, Vol. 3.5: 355-358

5. Wilson, S.K. Multiple disturbances and the global degradation of coral reefs: are reef fishes at risk or resilient? *Global Change Biol*ogy, 2006, 12 : 2220–2234

6. Munday, P.L. Climate change and the future for coral reef fishes. *Fish*, 2008, 9: 261–285

7. NODC (National Oceanographic Data Center) 2001, *World Ocean Database 2001*. NODC, Silver Spring MD.

8. Pratchett, M.S. Effects of climate induced coral bleaching on coral reef fishes; ecological and economic consequences. *Oceanography Marine Biology*, 2008, 46 : 251–296

9. Levin, S.A. and Lubchenco, J. Resilience, robustness, and marine ecosystem-based management. *Bioscience*, 2008, 58,:27–32

10. Wilkinson, C.R. Status of the coral reefs of the world: 2008. *Global Coral Reef Monitoring Network and Australian Institute of Marine Science, Townsville*, 2008,

11. Baruch, R. Management of coral reefs: We have gone wrong when neglecting active reef restoration, *Marine Pollution Bulletin*, 2008, Volume 56 :1821–1824

12. Zac, H. F, Baruch, R, and Cynthia L. H. Investigating fragment size for culturing reef-building corals (Porites lobata and P. compressa) in ex situ nurseries Aquaculture, 2006, *Oceans* 2006, 261: 89–97.

13. Walter, C. J. Coral Reef Restoration, *Ecological Engineering*, 2006, Volume 15: 345-364.

14. Terry, P. H, Nicholas A.J ,Graham N , Jeremy B.C, Jackson, Peter J. M and Robert S. S, Rising to the challenge of sustaining coral reef resilience, *Trends in Ecology and Evolution*, 2009, Vol.25 : No.11

15. Hilbertz, W.H, *Biorock Of Minerals In Seawater*, Marine Science Institute The University of Texas Report; 2000, Vol. 5: 48-49

16. Thomas J. G, Global Coral Reef Alliance, Isambridge, Shore Protection, Beach Formation, And Production Of Building Materials And Energy Using Seawater Electrolysis Technology, *Evolution and Zoogeography of Coral Reefs Ecosystems of the World*, 2000, Vol. 25:1-8.

17. Hilbertz, W.H, Minerals in Sea Water: Experiments and Applications, *IEEE, Journal On Oceanic Engineering*, 1979, Vol. 4.

18. Thomas, J. G, Global Coral Reef Alliance, Restoring Coral Reefs, Oyster Banks, And Fisheries By Seawater Electrolysis, *Coastal Zone Management And Tourism Applications*, 2003, OCEANS.

19. Thomas, J. G, Marine Ecosystem Restoration: Costs and Benefits for Coral Reefs, *World Resource Review*, 2005, Vol. 17: 3-4.

20. Lee, S, Gideon L, Edgardo G, Baruch R, Fixed and suspended coral nurseries in the Philippines: Establishing the first step in the "gardening concept" of reef restoration, *Journal of Experimental Marine Biology and Ecology*, 2008, 358: 86–97.

21. Gideon, L, Lee S, Abraham H, Baruch R, Mid-water rope nursery; Testing design and performance of a novel reef restoration instrument, *Ecological Engineering*, 2010, 36: 560–569.

22. T. Yoshida, K. Akagi, T. Toda, M.M.R. Kushairi, A.A.A. Kee & B.H.R. Othman, (2010), *Evaluation of Fish Behaviour and Aggregation by Underwater Videography in an Artificial Reef in Tioman Island, Malaysia*, Sains Malaysiana 39(3): 395–403

23. Shahbudin, S, Haififi, Z, Akhbar, J, Kamaruzzaman, B.Y, and Jalal K.C.A, Distribution and Diversity of Corals on Artificial Reefs at Pasir akar and Teluk Kalong, Redang Island, Malaysia, *Journal of Applied Science*, 2010, ISSN : 1812-5654.

24. Vanysek, P, Electrochemical Series, *Handbook of Chemistry and Physics*, 88th Edition.

25. Tilley, R.J, *Understanding solids: the science of materials*, 2004, John Wiley and Sons, ISBN 978-0-470-85276-7 : 281

26. Werner, Z, Reinhold, W, Chapter 3: “Production of Hydrogen. Part 4: Production from electricity by means of electrolysis" Knowledge , *Hydrogen in the Energy S*ector, 1996, Ludwig-Bölkow-Systemtechnik GmbH.

27. Stelter, M., Bombach, H, Process Optimization in Copper Electrorefining, *Advanced Engineering Materials*, 2004, Vol 6: 558

28. Metal Finishing*: Guidebook and Directory*, Issue 98, 1998

29. Elizabeth, W and Michaeal, A, Reef Fishes Corals and Invertebrates of The South China Sea, *New Holland Publisher (UK) Ltd*., 2002