PROCEEDINGS OF
Workshop on Artificial Reefs for the Enhancement of Fishery Resources

SEAFDEC/FRA Joint Program Regarding Artificial Reefs for the Enhancement of Fishery Resources **4th August 2009, Putrajaya, Malaysia**

Editors
Ahmad bin Ali
Mohamed Pauzi bin Abdullah
Fauzi bin Abdul Rahman
Osamu Abe

Cover photo: A pack of grey bamboo shark, *Chiloscyllium griseum* crowded together in the little available space underneath the tetrapod module, illustrating the success of the structure as a refuge for the species.

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2010

Perpustakaan Negara Malaysia Cataloguing-in-Publication Data

ISBN 983 - 9114 - 45 - 4

Workshop on Artificial Reefs for the Enhancement of Fishery Resources (2009 : Putrajaya).
Proceedings of the Workshop on Artificial Reefs for the Enhancement of Fishery Resources: SEAFDEC/FRA joint program regarding artificial reefs for the enhencement of Fishery Resources 4th August 2009, Putrajaya Malaysia / Editor Ahmad bin Ali ... [et al.].
1. Artificial reefs--Congresses, 2. Fish habitat improvement--Congresses.
I. Ahmad Ali. II. Title.
639.977

Published by: Department of Fisheries Malaysia, Ministry of Agriculture and Agro-based Industry, Wisma Tani, Aras 1-7, Blok Menara 4G2, Presint 4, 62628 Putrajaya.

Produced by : Marine Fishery Resources Development and Management Department, Southeast Asian Fisheries Development Center, 21080 Chendering, Terengganu.
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Available from: Marine Fishery Resources Development and Management Department, Southeast Asian Fisheries Development Center, 21080 Chendering, Terengganu.
Tel: 609-6171543/6175940
Fax: 609-6175136

Citation: Ahmad, A., Mohamed Pauzi, A., Fauzi, A.R. and O. Abe, 2010. (eds). Proceedings of the Workshop on Artificial Reefs for the Enhancement of Fishery Resources 4th August 2009. Department of Fisheries Malaysia, Putrajaya. 189 pp

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FOREWORD

We are delighted at being able to host the first workshop on artificial reefs for the enhancement of fishery resources, in collaboration with the Southeast Asian Fisheries Development Centre (SEAFDEC) and the Japanese Research Agency (JRA). This workshop demonstrate the close cooperation among the three parties in the exchange of ideas, knowledge and experiences on artificial reefs, especially on the design, construction, placement, evaluation and also the socio-economic impacts of these reefs. Indeed, it is in our common interest to see such a cooperation progress further in future, so as to benefit us in managing our resources sustainably through the utilization of management tools such as artificial reefs.

This proceeding is a record of the presentations made during the workshop. The information gathered can be utilized to identify the relevant experts in this field, as well as to foster closer ties among interested parties and individuals. It will also facilitate further exchange of information and ideas among the researchers, managers and other stakeholders in the field of artificial reefs; such as in the design, construction, deployment, and monitoring aspects.

Collaboration works between researchers and marine engineers in the design, construction and deployment of artificial reefs in Japan is well organized compared with other countries. Merging the accumulated knowledge on fish behaviour and its response to man-made structure with scientific understanding of physical processes in coastal waters has provided reef designers with a more rational approach in seeking the optimum harmony between fishes, ambient physical conditions, and structure. Likewise in Malaysia, biologists and marine engineers have been working together to design and fabricate suitable modules best suited for various type of substrates such as muddy soft bottom or hard sandy bottom.

Malaysia recognizes the expertise in artificial reefs that is available in Japan. The Japanese have been successful in the design, construction, deployment and monitoring of large-sized artificial reefs which are currently introduce in Malaysia. Their expertise has not come overnight but has been built over many years, since Japan has been involved in the usage of artificial reefs much earlier than Malaysia. However, Malaysia has also been successful in the design construction and placement of large-sized artificial reefs. We can be proud of our achievements such as the invention of a module release mechanism which has been instrumental in the placement of 20 metric tonnes artificial reef modules. With this mechanism, the deployment of large-sized modules can be carried out safely and with ease within a short period of time.

I wish to thank and congratulate the presenters during this workshop, not only for their excellent presentations, but also for their willingness to share their knowledge and expertise with others. I would also like to congratulate all those concerned who have worked tirelessly to make this workshop a success. It is hoped that we will be able to make good progress with our endeavour to sustainably manage our fishery resources in a holistic manner. Lastly, I wish everyone well in their future undertakings.

Dato' Junaidi bin Che Ayub,
Director-General
Department of Fisheries Malaysia.

REPORT OF THE WORKSHOP ON ARTIFICIAL REEFS FOR THE ENHANCEMENT OF FISHERY RESOURCES

SEAFDEC/FRA JOINT PROGRAM REGARDING ARTIFICIAL REEFS FOR THE ENHANCEMENT OF FISHERY RESOURCES

4th August 2009, Putrajaya, MALAYSIA

I. INTRODUCTION

1. This workshop is one outcome of the Memorandum of Understanding (MOU) that was signed on 16th February 2009 in Bangkok between the Fisheries Research Agency (FRA) of Japan and SEAFDEC. On 17th February 2009, a delegation from FRA visited SEAFDEC-MFRDMD for discussions on potential projects. During that meeting, two collaborative projects were agreed on artificial reefs (ARs) and sea turtles.

2. This workshop is for the exchange of ideas, knowledge and experiences on several aspects of ARs, between scientists and researchers from Japan and Malaysia. The main focuses of the discussions were on the design, construction, placement and evaluation of ARs as well as socio-economic aspects pertaining to these man-made structures. The prospectus of the workshop is as **Appendix A.**

3. The workshop was attended by representative(s) from Department of Fisheries Malaysia; Department of Marine Park, Malaysia; Ministry of Agriculture and Agro-based Industry; Economic Planning Unit, Prime Minister Department; Malaysia Development Fisheries Board (LKIM); University Malaysia Terengganu; University Kebangsaan Malaysia, SEAFDEC-MFRDMD, Terengganu and SEAFDEC-Training Department, Bangkok. It was also attended by resource persons from FRA Japan; SEAFDEC-MFRDMD; SEAFDEC Secretariat; Fisheries Research Institute, Licensing and Resource Management Division, and Engineering Division of the Department of Fisheries Malaysia. The list of participants is as **Appendix B.**

4. The objectives of the workshop were to gather knowledge on better understanding for the placement of ARs among Southeast Asian countries and Japan through sharing information about scientific-based designs, evaluation methods of ARs and to deepen the understanding on the importance of preservation fishing grounds by executing ARs program through cooperation between SEAFDEC and each member country.

II. OPENING OF THE WORKSHOP

5. Y. Brs. Tuan Haji Suhaili bin Haji Lee, the Deputy Director-General, Department of Fisheries Malaysia (Operation) welcome the participants to the workshop and highlight the previous work by SEAFDEC-MFRDMD since 2001 and the current research and development (R&D) program on ARs in Malaysia under the Ninth Malaysia Plan. He

welcomed collaboration work with Japan who is leader in ARs research and development especially on the design, construction and deployment of big size artificial reefs. He briefly outlined the objectives of the workshop and declared the workshop open. His opening statement appears as **Appendix C.**

6. The agenda for the workshop was adopted with inclusion of a brief presentation on Artificial Reefs Software entitled ARPOS (Artificial Reef Position System): A Web Based GIS Visualization System for Managing the Artificial Reefs by Mr. Haji Mohammad Zaidi bin Zakaria from University Malaysia Terengganu. The agenda and time table appears as Appendix D.

III. SUCCESSFUL PROGRAMS OF ARTIFICIAL REEFS

7. Dr. Ichiro Nakayama gave a presentation on the introduction of the ARs and its history in Japan and then presented case studies in shallow and deep waters. Both ARs for shallow and deep waters play important role in resource enhancement especially so for fish resources. Dr. Nakayama also emphasized on the effect of the placement of ARs on the fishery resources by explaining the facets of the aim of ARs placement. Primarily being to complement the natural reefs which in a way promote the efforts to sustainably manage the coastal fishery resources. Further elaboration was on the functions of artificial reefs. One of which was the creation of biological environment around artificial reefs. This was with respect to periphytons, benthos and planktons. Next was the creation of seaweed habitat from a barren underwater seascape. Another new concept put forward by Dr. Nakayama was the use of floating FADs in helping the harvest of migratory species such as skipjack tuna, bluefin tuna and dorado. This concept of fishing has automated sea water and weather parameters information transmitted via telephony system. This system has helped fishermen to save fuel consumption.

8. Mr. Fauzi bin Abdul Rahman presented the status report of ARs programs in the Ninth Malaysia Plan (2006-2010). He explained briefly the history of ARs in Malaysia and then went on to discuss on the double pronged function of the ARs projects in Malaysia. One was to enhance the fishery resources and next was to deter the illegal trawling activities in near shore coastal waters. Mr. Fauzi also highlighted success stories on ARs activities during 2006-2009. He gave details of the recent years government spending on the ARs resource enhancement efforts and went on to explain the benefits of the investment.

9. Mr. Akito Sato presented Japanese experience on the management of coastal fishing ground with the placement of artificial reefs. He introduced many kind of ARs placed on the coastal area of Japan for enhancing of flora and fauna. He stressed that, productivity of coastal fishery resources is governed by productivity of coastal fishing grounds. In Japan, fishers community is directly involved in fishing ground management. He illustrated the plankton swarms at the sheltered place of the ARs under the current. The periphytons which comprises of sessile organisms and crustaceans among others that settled on artificial reefs. All these may differ depending on the environment of the sites, the materials of ARs, etc. He further suggested that the change in distribution of benthos around ARs was strongly related to the change in sediment on the sea bottom.

He categorized artificial reefs functions as feeding grounds, spawning grounds, shelters and resting sites. Mr. Sato illustrated further the newly created habitat in that through an increase in biodiversity around ARs, fish and other marine resources gather, for feeding grounds where their prey can throng, as well as for hiding/resting sites, and spawning grounds.

IV. DESIGN, CONSTRUCTION AND DEPLOYMENT OF ARTIFICIAL REEFS

10. Dr. Yoshihiro Ohmura's presentation focused on the design, construction and placement of huge size ARs and fish aggregating devices (FADs) in Japan. He also presented Japanese experiences on several model of ARs studied in the laboratory. In detail, he explained the hydraulic forces exerted on the ARs modules. These hydraulic forces are determinants on the size and design of the ARs as to ensure the stability and functional shelf life of the artificial reefs. Next he went on explaining the flow of construction and setting of the ARs on site. This was with due regards to stability and safety while deploying ARs at sea.

11. On behalf of other authors, Mr. Zaidil Abdilla bin Haji Ahmad Salehhuddin presented their experiences in the design, construction and placement of ARs from 2006-2009 during the Ninth Malaysia Plan. Six innovations of big size artificial reefs weight between 5 to 19 metric tonnes were materialized namely cube ARs, cuboids ARs, soft bottom ARs, lobster ARs, recreational ARs and tetrapod ARs. He also mentioned on the challenging task for SEAFDEC-MFRDMD and Research Division researchers as well as officers from Engineering Division, from the Department of Fisheries Malaysia to design, construct and placement of new module of the big size ARs for soft and hard bottom area.

V. ENVIRONMENTAL EVALUATION OF ARTIFICIAL REEFS

12. Dr. Ichiro Nakayama presented on the research themes of FRA projects regarding environment of coastal area. His presentation focused on FRA research activities implemented especially for enhancing natural environment in coastal area of Japan.

13. Mr. Akito Sato, gave a presentation on the environmental improvement around ARs and their evaluation. He highlighted the positive view on the placement of ARs for environment improvement as well as the Japanese regulations on artificial reefs. In his concluding remarks, he called for administrators and researchers of the Southeast Asian countries to gather and share information. He opted "Fishery resources management" and "Fishing grounds management" as two wheels of the same vehicle for maintaining productivity of marine resources. He further suggested that ARs could be made as a management tool as proven success experienced in Japan. Mr. Sato also stressed that it is also important that a cultural environment be created where people will familiarize themselves with the sea and marine resources and acquire the habit from childhood of eating fish and shellfish, and supporting efforts to conserve these valuable resources.

14. On behalf of other authors, Mr. Ahmad bin Ali presented fishing ground environment around artificial reefs. His presentation mostly based on their experiences

conducting surveys before and after placement of ARs in Malaysia especially on site selection, development of ARs from concrete blocks to natural habitat as well as success story on habitat mitigation around ARs sites.

15. Mr. Mohamed Pauzi bin Abdullah presented evaluation of ARs in Malaysia on behalf of other authors. He focused mainly on the estimated of fish species aggregated around single module of ARs deployed between 6-12 months. The degree of richness of the species congregating at the ARs was calculated using Simpson's Biodiversity Index. The progressive changes on the index from time to time was hoped to shed some light on the performance of the modules during later monitoring of the artificial reefs under study.

16. Mr. Haji Mohammad Zaidi bin Zakaria presented on the ARs software produced by researchers from University Malaysia Terengganu (UMT). The software is still at developmental stage. Mr. Zaidi described in detail the architecture design of implementing a web based services on the internet using spatial data mapping.

17. Ms. Hajah Mahyam binti Mohd Isa, Chief of SEAFDEC-MFRDMD on her closing remarks mentioned that Malaysia have still a long way to go in developing of ARs program compared with Japan especially in the design and construction of huge size module for resource enhancement. She also stressed on the need to have collaborative work on the design of ARs specific for target marine fauna especially squids and lobsters as well as to deter illegal trawlers encroachment into prohibited areas. She hoped that this workshop will be the stepping stone towards closer cooperation between Malaysia and Japan in ARs implementation program. Her closing remarks appear as **Appendix E.**

APPENDIX A

Workshop on Artificial Reefs for the Enhancement of Fishery Resources

SEAFDEC/FRA Joint Program Regarding Artificial Reefs for the Enhancement of Fishery Resources

4th August 2009, Putrajaya, Malaysia

Provisional Prospectus

1. Background

The utilization of artificial reefs expands in coastal areas these days. In Southeast Asian region and also in Japan, lots of artificial reefs have been placed aiming for the improvement of fishing ground and fishing activities. Varieties of these placement activities have been executed for the purposes of coastal habitat preservation and/or management. In general, artificial reefs has been expected to emulate some functions of natural reefs to such as protecting, regenerating, concentrating, and/or enhancing populations of living marine resources differently in different locations. Those reefs were at first recognized as fish attraction devices or shelters. Recently, artificial reefs are also used for the purpose of protecting marine resources from illegal fishing.

In these seas where a number of small-scale fishing activities are carried on, placements of artificial reefs are expected to be an effective measure toward the aggressive recovery of fishery/marine resources in harmony with other coastal management measures in the future. Installation and management of artificial reefs has been an urgent theme on fisheries policy matters in the region under the circumstances of depressed fisheries resources and increasing concern of marine environmental preservation. Therefore the need to some kind of guideline regarding placement of artificial reefs has been increasing so that marine environmental deterioration will not occur contrary to their positive basic purposes. Particularly as a point of note, artificial reefs should not be used to justify dumping by using inappropriate materials such as waste or used materials.

For these situations, Southeast Asian Fisheries Development Center (SEAFDEC) and Fisheries Research Agency (FRA), Japan, will organize the workshop in collaboration with Department of Fisheries Malaysia, focusing the suitable placement of artificial reefs. SEAFDEC and FRA have signed a MOU to continue scientific and technical cooperation for five years in February 2009. One of the specific themes of the MOU is "cooperating on researching the infrastructure of fisheries for the sustainable utilization of fishing grounds". In this theme, the "SEAFDEC/FRA joint program regarding artificial reefs for the enhancement of fishery resources" will be implemented. This workshop entitled "Workshop on Artificial Reefs for the Enhancement of Fishery Resources" held in Malaysia will be a first step of this joint program, and related workshops will be conducted in the other ASEAN countries for a few years. The outcomes from this workshop would be utilized at the 2nd Regional Advisory Committee (RAC) for Fisheries Management in Southeast Asia (August 2009, Bangkok); one of the main issues to be discussed is the regional approach on enhancing of fisheries resources in the Southeast Asia. Also this workshop would be a forefront of a new Japanese Trust Fund V program which will be started in 2010, in which a project for the rehabilitation of fishing resources and habitat/fishing grounds in Southeast Asia will be implemented.

2. Objectives

- Better understanding for placement of artificial reefs among Southeast Asian countries and Japan through sharing information about scientific-based designs and evaluation methods of artificial reefs executed in these areas.

- To deepen the understanding as to importance of aggressive recovery and preservation of fishing grounds by executing artificial reefs at a global level by cooperation between SEAFDEC and each country which have lots of experiences for appropriate activities.

APPENDIX B

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APPENDIX C

Opening Address

By

(Y. Brs. Tuan Haji Suhaili bin Haji Lee)
Deputy Director-General, Department of Fisheries Malaysia

Chief of SEAFDEC-MFRDMD, Hajah Mahyam binti Mohd. Isa,
Representative from Ministry of Agriculture and Agro-based Industry,
Representative from Economic Planning Unit, Prime Minister Department,
Representative from Ministry of Finance,
Representative from Ministry of Natural Resources,
Deputy Chief of SEAFDEC-MFRDMD, Dr. Osamu Abe,
Representative from Malaysia Development Fisheries Board (LKIM),
Speakers from Fisheries Research Agency, Japan, Dr. Ichiro Nakayama and Dr. Yoshihiro Ohmura,
Speaker from SEAFDEC-Secretariat, Mr. Akito Sato,
Representative from SEAFDEC-TD, Dr. Yuttana Theparoonrat
Representative from University Malaysia Terengganu,
Representative from University Kebangsaan Malaysia,
Division directors and senior officers from Department of Fisheries Malaysia,
Distinguish participants,
Ladies and Gentlemen,

Assalamualaikum and very good morning to all of you.

Ladies and Gentlemen,

On behalf of the Department of Fisheries Malaysia and the Government of Malaysia, I would like to extend our warmest welcome to all distinguished delegates and representatives from various agencies to this Workshop on Artificial Reefs for the Enhancement of Fishery Resources. This workshop was the result of the discussion between SEAFDEC and Fisheries Research Agency (FRA) of Japan with the collaboration of our SEAFDEC-MFRDMD in Terengganu. I believe that this workshop will benefit all participants as it allows us to share and learn from the experience, knowledge, technology and expertise in the field of artificial reefs. This workshop in our judgment is most timely as we are on the verge of forming a committee on artificial reefs at national level to monitor and supervise the implementation of all artificial reefs in the country. I am also pleased to note that experts from Japan and Malaysia will be presenting papers on their experience and knowledge in artificial reefs. I do hope that distinguish participants will make full use of your presence at this workshop to prospect for new knowledge.

Ladies and Gentlemen,

Perhaps at this juncture it is appropriate for me to mention that the Department of Fisheries Malaysia is responsible for the overall development, management and conservation of fisheries in the country. SEAFDEC-MFRDMD being a research arm of the Department has played an active role in conducting research for fisheries resource enhancement, especially in the development of new concepts in artificial reefs. Research on artificial reefs by this organization has begun back in 1996. The collaborative research between SEAFDEC-MFRDMD researchers and lecturers from University College of Science and Technology (now University Malaysia Terengganu) was successfully completed, and a new innovation in artificial reefs fish aggregating device (ARFadS) for recreational fishing was successfully introduced.

In the year 2000 and 2001, through the SEAFDEC Regular Fund under Marine Conservation and Stock Enhancement Program, SEAFDEC-MFRDMD researchers had successfully completed a study on "Construction and setup durable fish aggregating device for coastal fishermen in SEAFDEC member countries". A book entitled "A Guide to Make and Set Durable Artificial Reef Aggregating Devices (ARFADs) for Coastal Areas" was published.

Since 2001, SEAFDEC-MFRDMD has conducted research on artificial reefs as well as fish aggregating devices. Scientific knowledge gathered from these studies as well as experiences of researchers from SEAFDEC-MFRDMD, Fisheries Research Institute (FRI) in Penang, FRI in Sarawak and from Turtle and Marine Ecosystem Centre (TUMEC), through their studies especially in Malaysia, and accumulated from information from researchers from SEAFDEC members countries, as well as references from various sources available locally as well as internationally, were used to formulate the artificial reefs program for the Ninth Malaysia Plan, starting in 2006.

With the intensive work on research and development activities between 2006 and 2009, six innovative, large-sized artificial reefs weighing between 5 to 19 metric tons were developed. These were named cube ARs, cuboids ARs, soft bottom ARs, lobster ARs, recreational ARs and tetrapod ARs.

Ladies and Gentlemen,

The most challenging task for SEAFDEC-MFRDMD and FRI researchers as well as officers from the Engineering Division of the Department of Fisheries Malaysia is to design a new module of artificial reefs for soft bottom or muddy area. After 3 years of intensive research and development, including facing some challenging times, five innovative and appropriate designs of artificial reefs for soft bottom materialized in 2009.

The success story of research and development on artificial reefs in Malaysia will be shown in video presentation after the opening ceremony, as well as during paper presentations. We have to gain more knowledge and experience, especially in stock assessment of demersal and pelagic fish inhabiting the areas around the artificial reefs, especially those which are deployed in muddy areas. We also hope to learn more from our Japanese counterparts on the cheaper and long lasting materials suitable for constructing artificial reefs in tropical waters. We also hope the FRA will collaborate with their Malaysian counterparts to address many issues related to artificial reefs under the Japanese Trust Fund V beginning in the year 2010.

It is well known that Japan is a pioneer in research and development of artificial reefs, especially on the design and construction of huge-sized structures as well as management of fishing community in proximity to the artificial reef sites. We hope to share your experiences during this workshop. We are also looking forward to collaborative work on human resource development, especially in the design and construction of huge-sized artificial reef especially for deeper waters.

Ladies and gentlemen,

On behalf of Department of Fisheries Malaysia, I would like to express our gratitude to Fisheries Research Agency Japan for sponsoring and arranging a technical visit by one of our researcher to Japan to enhance his knowledge on captive breeding of sea turtles. I also take this opportunity to express my thanks to all of you for sparing your valuable time coming to this workshop. I hope the deliberation during the workshop will be useful to the participants and provide an opportunity for everyone to interact with each other and share the rich experiences.

Finally, I would like to record my appreciation and congratulation to all staff from the Department of Fisheries Malaysia and SEAFDEC for making this workshop a reality. I wish you all a fruitful deliberation in this workshop.

Thank you.

APPENDIX D

Agenda and Timetable

Tuesday: 4th August 2009		
08:30	Registration	
Agenda 1: Opening Ceremony		
09:00	Welcome Remarks	Chief of SEAFDEC-MFRDMD
09:05	Opening Address	Deputy Director-General of DoF Malaysia (Operation)
09:15	Exchange of Souvenirs	
09:20	Video Presentation: R&D of Artificial Reef in 9th Malaysia Plan	
09:30	Group Photo	
09:40	Coffee Break	
Agenda 2: Successful Programs of Artificial Reefs (Chairperson: Dr. Osamu Abe)		
10:10	Case Studies of Artificial Reefs in Japan	Dr. Ichiro Nakayama (NRIFE, FRA)
10:40	Status Report of Artificial Reefs Programs in Malaysia	Mr. Fauzi bin Abdul Rahman (Licensing and Resource Management Division, DoF Malaysia)
11:10	Japanese Experience on Management of Coastal Fishing Ground with Artificial Reefs	Mr. Akito Sato (SEAFDEC Secretariat)
11:30	Discussion	
Agenda 3: Design, Construction and Deployment of Artificial Reefs (Chairperson: Mr. Abdul Halim bin Marzuki)		
12:00	Case in Japan	Dr. Yoshihiro Ohmura (NRIFE, FRA)
12:30	Case in Malaysia	Mr. Zaidil Abdilla bin Hj. Ahmad Salehhuddin (Engineering Division, DoF Malaysia)
13:00	Discussion	

13:20	Lunch Break	
Agenda 4: Environmental Evaluation of Artificial Reefs (Chairperson: Mr. Abu Talib bin Ahmad)		
14:30	Research Themes of FRA Projects Regarding Environment of Coastal Area	Dr. Ichiro Nakayama (NRIFE, FRA)
14:50	Environmental Improvement Around Artificial Reefs and Their Evaluation	Mr. Akito Sato (SEAFDEC Secretariat)
15:10	Fishing Ground Environment Around Artificial Reefs in Malaysia	Mr. Ahmad bin Ali (SEAFDEC-MFRDMD)
15:30	Evaluation of Artificial Reefs in Malaysia	Mr. Mohamed Pauzi bin Abdullah (FRI, Penang)
15.50	ARPOS (Artificial Reef Position System) A Web Based GIS Visualization System for Managing the Artificial Reefs	Mr. Mohammad Zaidi bin Zakaria (University Malaysia Terengganu)
16:20	Discussion	
Agenda 5: Closing Ceremony		
16:50	Closing Remarks	Chief of SEAFDEC-MFRDMD
17:00	Coffee Break	

APPENDIX E

Closing Remarks by Hajah Mahyam binti Mohd Isa,

Chief of SEAFDEC-MFRDMD

Ladies and Gentlemen,

We have been very fortunate today to have listened to a number of presentations on artificial reefs. This is a subject that many of us have heard of but probably not know the intricacies involved in it. With a total sum of more than RM 8 million allocated for artificial reefs in the Ninth Malaysia Plan, we should pay greater attention towards the relevant projects involving these reefs and ensure maximum benefits are derived from this allocation. I hope today's workshop have been able to enlightened us on this subject.

There have been 10 presentations today, of which 4 presentations are based on experiences gained in Japan; a country that is well-known to be quite advanced in the field of artificial reefs. We have been informed that in Japan, artificial reefs weighting more than 90 metric tons have been constructed. This is more than 4 times the biggest artificial reefs that we have build in Malaysia. Therefore, the physical dimension of some of the reefs in Japan is much bigger than those currently deployed in our waters. The presentations are very interesting and the Department of Fisheries Malaysia will publish it in the proceeding.

Ladies and Gentlemen,

If size is a measure of viability and effectiveness, then we in Malaysia have still a long way to go in developing our artificial reefs. We have heard from our speaker from the Engineering Division of the Department of Fisheries Malaysia about the limitations, issues and constrain in constructing artificial reef in Malaysia. Towards this end, I hope our counterparts from Japan will be able to assist us to overcome at least some of these issues through collaborative projects.

We have also heard how some reefs have been designed for specific marine fauna which are also commodities in capture fisheries, such as lobsters and squids. I hope that further collaborative research will be carried out in future o that more designs can be produced, targeted specifically for other commodities.

A question or query that has sometimes been raised by some parties, including policy makers and stakeholders, is the effectiveness of these artificial reefs. Thus, it is very timely that we start to quantify the contribution of artificial reefs towards resource enhancement, apart from its role as a deterrent to trawler encroachment in prohibited areas. Here again, I hope our Japanese counterparts will be able to share with us in Malaysia, particularly with the Department of Fisheries, their knowledge and experience in addressing this issue.

Ladies and Gentlemen,

The role of artificial reefs as a tool for fisheries resources enhancement has been widely acknowledged and accepted, hence the big funding it has received in Malaysia, and the large expenditure in Japan. This is indicative of the importance attached to these reefs. The willingness of Fisheries Research Agency Japan to carry out collaborative projects in this field is also testament to this fact. Therefore, our workshop today, albeit for only a short period, should be the stepping stone towards closer cooperation between us.

On behalf of the Director-General of Fisheries Malaysia, I would like to take this opportunity to express the Department's appreciation and gratitude to all you for attending this workshop and making it a success, and in particular our guests from Japan and Thailand for being with us here today, in spite of their busy schedule. The credit should also be given to Mr. Fauzi bin Abdul Rahman, Mr. Ahmad bin Ali, Mr. Ahmad Adnan bin Nuruddin, Mr. Abu Talib bin Ahmad, Mr. Norazman bin Zakaria, Mr. Zabawi bin Saad and Mr. Haji Aznan bin Zainal for their tireless work to ensure this workshop materialist as scheduled.

With that, I officially close this workshop.

Workshop on Artificial Reefs for the Enhancement of Fishery Resources

SEAFDEC/FRA Joint Program Regarding Artificial Reefs for the Enhancement of Fishery Resources

4th August 2009, Putrajaya, Malaysia

Tuan Haji Suhaili bin Haji Lee, Deputy Director General (Operation), Department of Fisheries Malaysia and Distinguish Participants

From Left:

First Row: Hajah Mahyam, Farhana, Gulam Sarwar, Tuan Haji Suhaili, Dr. Nakayama, Dr. Ohmura, Dr. Yuttana, Dr. Abe
Middle Row: Akito Sato, Abdul Halim, Prof. Dr. Sakri, Fauzi, Zawawi, Bohari, Ahmad, Azlishah, Abu Talib
Third Row: Jephrin Wong, Prof. Dr. Mazlan, Dr. Mohd. Taupek, Abdul Khalil

Presenters

Mr. Mohamed Pauzi

Mr. Ahmad

Mr. Fauzi

Dr. Ohmura

Mr. Hj. Mohammad Zaidi

Dr. Nakayama

Mr. Zaidil Abdilla

Mr. Sato

SUCCESSFULL PROGRAMS OF ARTIFICIAL REEFS

1. Case studies of artificial reefs in Japan
2. Status report of artificial reefs programs in Malaysia
3. Japanese experience on management of coastal fishing ground with artificial reefs

Case studies of Artificial Reefs in Japan

National Institute of Fisheries Engineering,
Fisheries Research Agency, Japan

Norimasa Takagi
Yoshihiro Ohmura
Ichiro Nakayama

INTRODUCTION

- Changing of global environment and over fishing account for the decreasing of fishery resources.
- For Japan, fishes are one of the most important food resources. And, we think that, keeping and increasing of fishery resources are urgent subject.
- We will introduce about the history and function of artificial reefs in Japan.
- Case study of AR in Japan

Auxiliary Fishing Gears in Japan

Many, many years ago, the history of artificial reefs in Japan starts in the age of primitive fishing. Auxiliary fishing gear, *"zuke"* (piles of natural materials) and *"ishizuka"* (rock mounds) were utilized to lure fish to a specific location.

Auxiliary fishing gear called "zuke", now called "payao"

Source : Artificial fish reef The Japanese Institute of Technology Fishing port ground and communities 2004

Prototype of Artificial Reefs

"Zuke" and *"ishizuka"* are thought to be the progenitors of artificial reefs.

The oldest record of man-made placement of artificial reefs to catch marine life was Kenzan Nonaka (mid-1600 A.D).

Auxiliary fishing gear called "ishigama"

Auxiliary fishing gears called "Takotsubo"

Source : Artificial fish reef The Japanese Institute of Technology Fishing port ground and communities 2004

The History of Artificial Reefs

Auxiliary Fishing Gears (ex. Zuke, Ishizuka)

↓

Prototype of artificial reefs in Japanese history

Piles of Rocks for aggregating fish (mid-1600 A.D)

Piles of Rocks for seaweed propagation (mid-1700 A.D)

↓

Development of apparatus for various purpose

Development of Artificial Reefs(1)

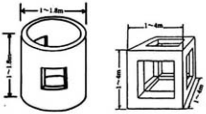
The 1600s; Appearance of Artificial Reefs

The 1900s; Creation of Fishing Ground using Stone of 1-2 ton

The 1930s; Appearance of Concrete Artificial Reefs

The 1950s; Name is from "tukiiso" to "Artificial Reefs"

Early Artificial Reefs



Integrated Artificial Reefs

Development of Artificial Reefs(2)

The 1960s; Upsizing of Artificial Reefs, Progress of Study on Functions of Artificial Reefs

The 1980s; Appearance of Steel Artificial Reefs
The 1990s; Placement of Artificial Reefs in Deep Sea

Recently, in order to conserve, enhance and protect fishery resources, Placement of Artificial Reefs carried out.

Placement of Artificial Reefs

Artificial Reefs Made of Steel

Fishery Effects of Placement of Artificial Reefs in Japan

Aim of Placement

1. **Complement of Natural Reefs**
2. **Sustainable Fish Catches of Coastal Fishery**
3. **Promotion of Reproduction of Fishery Resources**
4. **Creation and Restoration of Coastal Environment**
5. **Protection, Conservation and Growth of small fry, Liberation of Seeding, in Cooperation with Sea Farming**

Functions of Artificial Reefs(1)

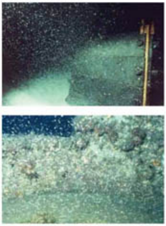
(1) Security of Sustainable Coastal Fishery Catches
(2) Restoration of Coastal Environment

Creation of Biological Environment around Artificial Reefs

(1) Periphytons
(2) Benthos
(3) Plankton

Periphytons

School of small fish around artificial reefs



Planktons inside and outside the artificial reefs

Functions of Artificial Reefs(2)

Construction of Seaweed Bed at Barren Sea Bottom

Barren Ground

Recovery of Fishery Resources

Abundant Seaweed Forest

Block be attached by kelp

School of small fry around algae farming reef

Creation of seaweed bed on sandy beach

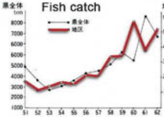
魚礁設置により、根付き魚の漁獲が増える

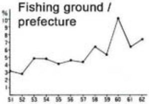
天然礁を補完する人工魚礁を設置

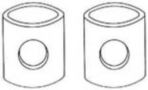
一本釣漁業、刺網漁業による漁獲増加

School of horse mackerel

Site map of fishing reef ground





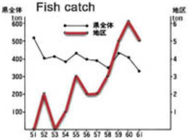


Cylinder type artificial reefs

Data source :The Coastal Fishing Ground Development program (the program of Ensei)

魚礁設置により、根付き魚の漁獲が増える

Flatfish & food organism around artificial reefs

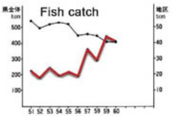


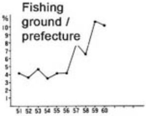
Data source :The Coastal Fishing Ground Development program (the program of Ensei)

魚礁設置により、根付き魚の漁獲が増える

Black porgy around artificial reefs

Site map of fishing reef ground



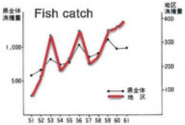


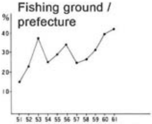
Data source :The Coastal Fishing Ground Development program (the program of Ensei)

魚礁設置により、根付き魚の漁獲が増える

Yellow jack around artificial reefs

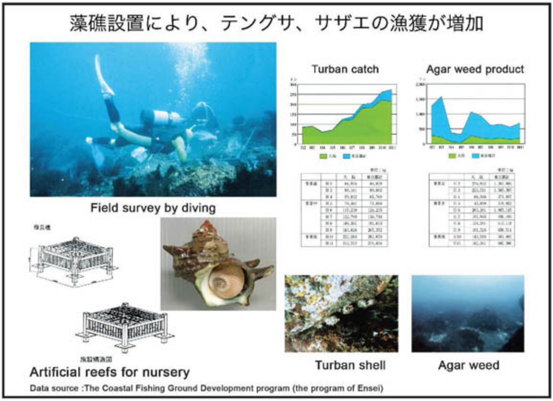
Site map of fishing reef ground





Data source :The Coastal Fishing Ground Development program (the program of Ensei)


Oo-shima,
Tokyo metrop.
1000km


藻礁設置により、テングサ、サザエの漁獲が増加
Turban catch
Agar weed product
Field survey by diving
Artificial reefs for nursery
Turban shell
Agar weed
Data source :The Coastal Fishing Ground Development program (the program of Ensei)

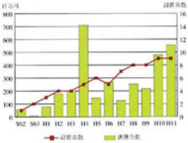
Increase in Migratory Fish, Placement of FADs

Increase in fish catch of migratory fishes such as skipjack tuna, bluefin tuna, dorado.

Steady formation of fishing ground

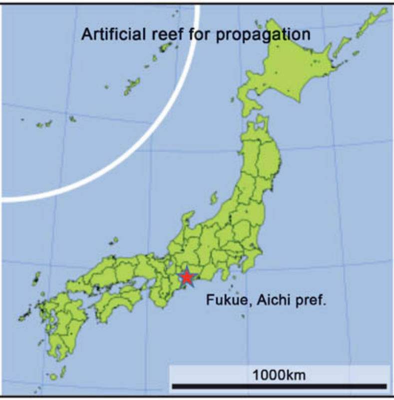
Long-term fishing season

Saving of fuel consumption



FADs called "Kuroboku"

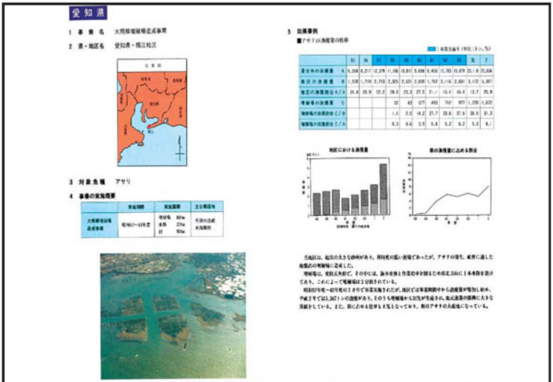
Fishing operation around FADs November,1990



增殖場造成事業

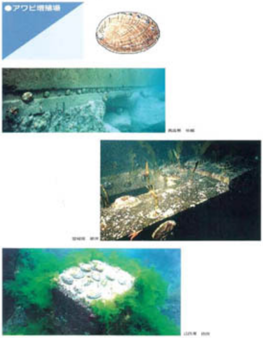
Clams propagation

Data source :The Coastal Fishing Ground Development program (the program of Ensei)

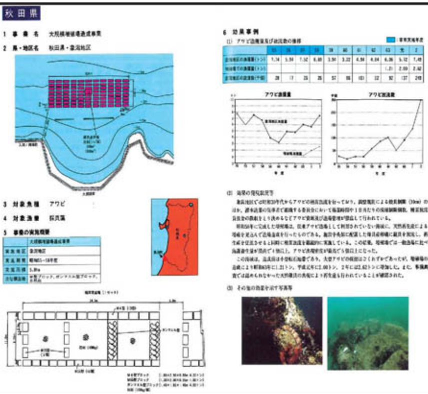


Data source :The Coastal Fishing Ground Development program (the program of Ensei)

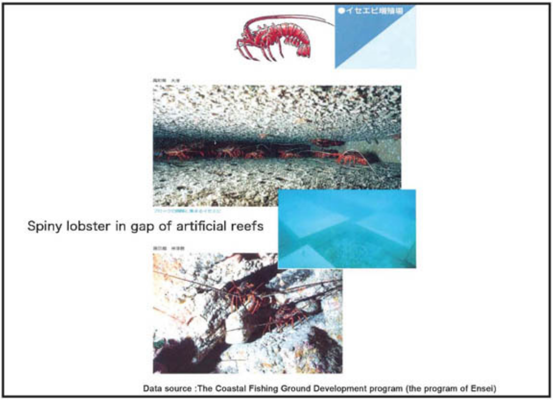
Increase in Abalone, Creation of Seaweed Bed

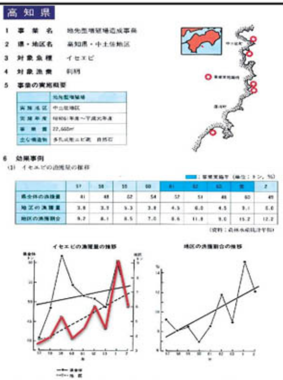


Data source :The Coastal Fishing Ground Development program (the program of Ensei)




Naka Tosa, Kochi pref.
1000km


●イセエビ増殖場
Spiny lobster in gap of artificial reefs
Data source :The Coastal Fishing Ground Development program (the program of Ensei)



高知県

1 事業名 地先型増殖場造成事業
2 県・地区名 高知県・中土佐地区
3 対象魚種 イセエビ
4 対象漁業 刺網
5 事業の実施概要

	地先型増殖場
実施地区	中土佐地区
実施年度	昭和61年度～平成元年度
事業量	22,660㎡
主な構造物	多孔式型エビ礁 自然石

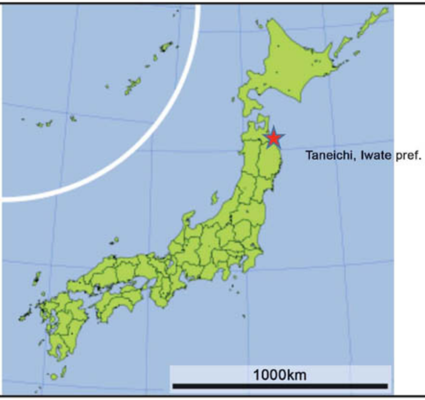
6 効果事例
(1) イセエビの漁獲量の推移

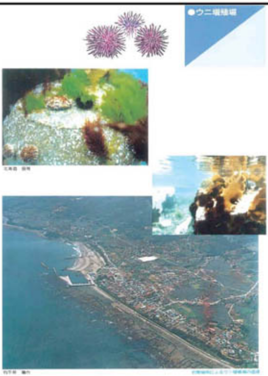
：事業実施年 (単位：トン、%)

	57	58	59	60	61	62	63	元	2
県全体の漁獲量	41	48	62	54	57	51	48	60	49
地区の漁獲量	3.8	3.9	5.3	3.8	4.5	6.0	4.5	9.1	6.0
地区の漁獲割合	9.2	8.1	8.5	7.0	8.6	11.8	9.0	15.2	12.2

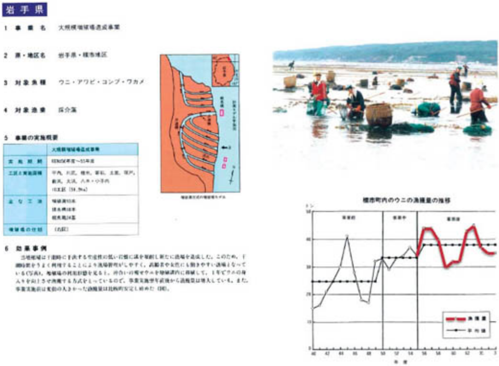
(資料：農林水産統計年報)

Data source :The Coastal Fishing Ground Development program (the program of Ensei)





Data source :The Coastal Fishing Ground Development program (the program of Ensei)



Data source :The Coastal Fishing Ground Development program (the program of Ensei)

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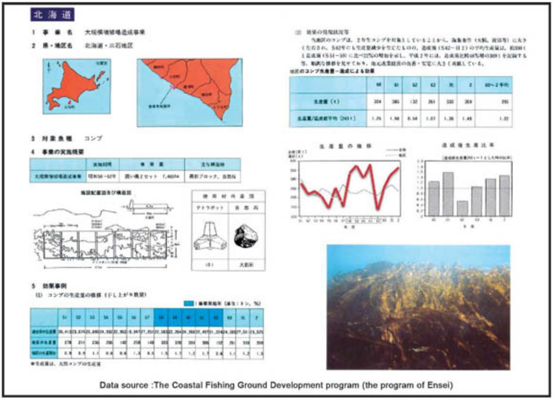
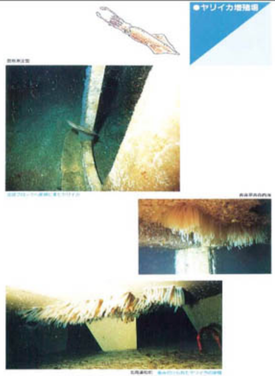

北海道
Data source :The Coastal Fishing Ground Development program (the program of Ensei)


Squid propagation
Matsumae, Hokkaido
Aomori
Shimane, Shimane pref.
1000km



Data source :The Coastal Fishing Ground Development program (the program of Ensei)

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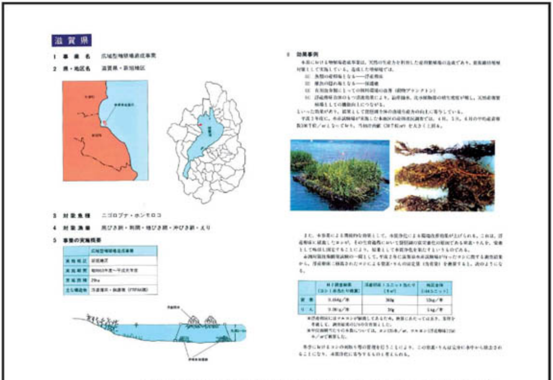
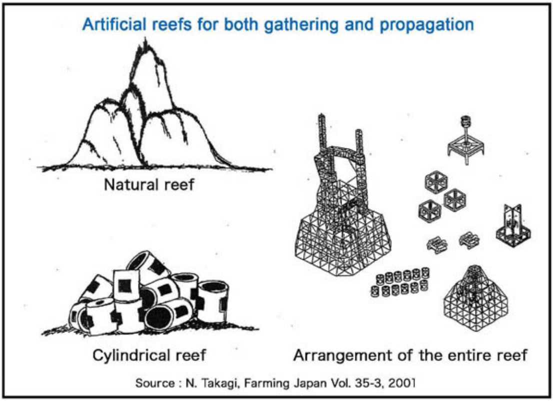
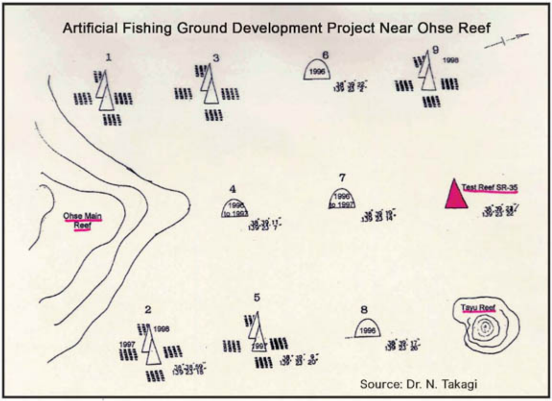


Data source :The Coastal Fishing Ground Development program (the program of Ensei)


Artificial reefs for both gathering and propagation
Natural reef
Cylindrical reef
Arrangement of the entire reef
Source : N. Takagi, Farming Japan Vol. 35-3, 2001


Artificial Fishing Ground Development Project Near Ohse Reef
1
3
6
1996
9
1998
Ohse Main Reef
4
7
Test Reef SR-35
2
1998
1997
5
8
1996
Tayu Reef
Source: Dr. N. Takagi

Sea chub
Ditrema temmincki

Red seabream
Pagrus major

True bass
Epinephelus septemfasciatus

Japanese amberjack
Seriola quinqueradiata

Japanese parrot fish
Oplegnathus fasciatus

Goldeye rockfish
Sebastes thompsoni

Japanese jack mackerel
Trachurus japonicus

Atka mackrel
Pleurogrammus azonus

King fish
Seriola dumerili
カンパチ

Common dolphinfish **(シイラ)**
Coryphaena hippurus

North Pacific bluefish
Thunnus orientalis

Status Report of Artificial Reefs Programs in Malaysia

FAUZI BIN ABDUL RAHMAN
DEPARTMENT OF FISHERIES MALAYSIA

INTRODUCTION

The program on artificial reefs started way back in 1975 with the first module deployed at Pulau Telur, Yan, Kedah.

GENERAL OBJECTIVES

1. To create fishery resource areas in zone A
2. To stop trawlers encroaching into zone A (traditional fishing area) and other areas including turtle nesting beaches
3. To create an area for recreational fishing activities
4. To enhance fishery resources around the artificial reefs

BUDGET FOR DEVELOPMENT OF ARTIFICIAL REEFS PROGRAM (from 7th Malaysia Plan to 9th Malaysia Plan)

- 7th MP (1996 - 2000) : RM 2,751,953
- 8th MP (2001 - 2005) : RM 2,524,344
- 9th MP (2006 - 2010) : RM 8,410,000

Budget From 9th Malaysia Plan

2006*	2007*	2008*	2009*	2010*
RM 1.4 mil	RM 2.0 mil	RM 3.0 mil	RM 1.927 mil	RM 0.083 mil

*Note: Only for Peninsular Malaysia and F.T of Labuan

Objectives of ARs Programs Under the 9th Malaysia Plan

- To develop new sites of ARs and deploy more additional ARs modules at present sites to increase national fishery resources
- To conduct research and survey to compile information on the suitable AR designs, durable materials, suitable sites and local fishery resources.
- To develop new ARs designs which can deter the encroachment of environmental unfriendly fishing gears especially trawlers into traditional fishing ground and specific zones.
- To provide substrate for coral to grow.

Materials Used To Construct Artificial Reefs

Before 2006	2006-2009
• Tyres • Old/confiscated fishing vessels • Concrete • PVC • Ceramic	• Old/confiscated fishing vessels • Concrete

TYPES OF ARTIFICIAL REEFS (BEFORE 2006)

TYRES

OLD/CONFISCATED FISHING

TYPES OF ARTIFICIAL REEFS (BEFORE 2006)

CONCRETE

PVC

TYPES OF ARTIFICIAL REEFS (2006-2009)

CUBOID ARs

RECREATIONAL ARs

TYPES OF ARTIFICIAL REEFS (2009-2009)

LOBSTER ARs

TETRAPOD ARs

TYPES OF ARTIFICIAL REEFS AFTER 2006

CUBE ARs

SOFT BOTTOM ARs

Status of Artificial Reefs Deployed in 2006

	State	Type of ARs	No. Site	Area	No. Module
1	Selangor	Soft Bottom	1	Kuala Langat	14
2	Kedah	Soft Bottom	2	Teluk Singapore	12
				Teluk Singapore	21
3	Terengganu	Tetrapod	1	Paka	17
4	Pahang	Tetrapod	1	Cherating	17
	TOTAL		5		81

Status of Artificial Reefs Deployed in 2007

	State	Type of ARs	No. Site	Area	No. Module
1	Selangor	Soft Bottom	3	Kuala Langat	14
				Sabak Bernam	14
				Kuala Langat	14
2	Johor	Tetrapod	1	Pulau Tinggi	20
3	Kedah	Soft Bottom	1	Kuala Triang	16
4	Terengganu	Tetrapod	1	Ma' Daerah	17
5	Pahang	Tetrapod	1	Cherating	17
6	Kelantan	Tetrapod	1	Semerak	20
	TOTAL				132

Status of Artificial Reefs Deployed in 2008

	State	Type of ARs	No.Site	Area	No. module
1	Selangor	Soft Bottom	1	Kuala Langat	10
2	Kedah	Soft Bottom	1	Kuala Chenang	10
			1	Yan	12
3	Negeri Sembilan	Soft Bottom	1	Port Dickson	14
4	Melaka	Soft Bottom	1	Pulau Besar	14
5	Perak	Soft Bottom	1	Pulau Sembilan	14
6	Labuan	Tetrapod	1	Labuan	14
		Lobster	1		20
7	Johor	Tetrapod	1	Pengerang	14
8	Pahang	Tetrapod	1	Sg. Miang	16
			1	Cherok Paloh	16
9	Kelantan	Soft Bottom	1	Pasir Putih	14*
	TOTAL		12		168

* Deployment posponed

Proposed Artificial Reefs Site in 2009 (9th Malaysia Plan Budget)

	State	Type of ARs	No. Site	Area
1	P. Pinang	Soft Bottom	1	Pulau Kendi
2	Perak	Soft Bottom	1	Segari
3	Negeri Sembilan	Soft Bottom	1	Port Dickson
4	Melaka	Soft Bottom	1	Pulau Besar
5	Pahang	Cube	1	Sungai Ular
6	Johor	Lobster	1	Mersing
7	Labuan	Cube	1	Labuan
	Total		7	

Artificial Reefs Program for Recreational (2007 – 2009)

	State	Type of ARs	Area			No. Area
			2007	2008	2009	
1	Pahang	old design	Rompin	-	-	1
2	Terengganu	old design	Teluk Ketapang	-	-	1
3	Johor	old design	-	K. Sedili	-	1
4	P. Pinang	old design	-	P. Kendi	-	1
5	Perak	old design - P. Rumbia new design-P.Sembilan	-	P. Rumbia	P. Sembilan	2
6	F.T Labuan	old design-Pulau Daat new design- Labuan	-	Pulau Daat	Labuan	2
7	Perlis	Soft bottom		-	Sanglang	1
TOTAL						9

Old Design Recreational ARs (2006-2008)

New Design Recreational ARs (2009)

ARTIFICIAL REEFS – 2nd ECONOMIC STIMULUS PACKAGE

Budget Approved for 2009 and 2010: RM 15.0 million

Allocation for 2009 - RM 7,520,100.00

Allocation for 2010 - RM 7,479,900.00

Artificial Reefs – 2nd Economic Stimulus Package 2009

	State	Type of ARs	No. Site	Area
1	Pulau Pinang	Soft Bottom	1	Pulau Kendi
2	Perak	Soft Bottom	1	Segari
3	Negeri Sembilan	Soft Bottom	1	Port Dickson
4	Selangor	Soft Bottom	1	Tanjung Karang
5	Melaka	Soft Bottom	1	Pulau Besar
6	Pahang	Cube	1	Pulau Tioman
7	Labuan	Cube	1	Labuan
8	Johor	Lobster	1	Pulau Tinggi
9	Kelantan	Soft Bottom	5	Bachok, Tumpat, Pasir Putih, Kota Bharu
10	Kedah	Soft Bottom	5	Pulau Payar, Pulau Tuba, Pasir Hitam, Jerlun, Kuala Triang
11	Terengganu	Soft Bottom	1	Besut
		Cube	5	Kemaman, Dungun, K. Terengganu, Marang, Setiu
12	Sarawak	Soft Bottom	1	Lawas
		Recreational	1	Miri
		Cube	1	Mukah
13	Sabah	Recreational	8	Kota Belud, Sandakan, Kota Marudu, Pitas, Papar, Sipitang, Beufort, Kuala Penyu.
	Total		35	

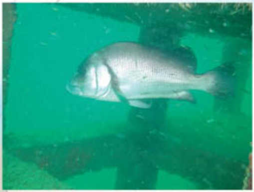
CUBOID and SOFT BOTTOM ARs
Funded by State Gorvernment of Terengganu

District	Type of ARs	Allocation	No of ARs Module
Besut	Soft Bottom	RM 1,000,000	75
Setiu	Cuboid	RM 1,000,000	128
Kuala Terengganu	Cuboid	RM 1,000,000	128
Marang	Cuboid	RM 1,000,000	128
Dungun	Cuboid	RM 1,000,000	128


Soft Bottom ARs


Cuboid ARs

Success story 2006-2009
(Artificial reefs as nursery and breeding ground)


Juvenile and adult fishes inside the structure of soft bottom ARs after 7 months of deployment.


Squid eggs on tetrapod ARs after 12 months of deployment

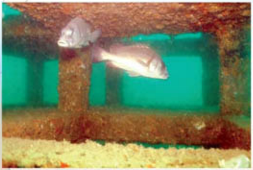
Success story 2006-2009
(Artificial reefs as nursery and breeding ground)

Soft bottom ARs after 16 months at Pulau Payar, Kedah

Fish juveniles (left) and adults (right) inside the structure. This proved that the structure has been accepted as their new habitat.

Success story 2006-2009
(Artificial reefs as breeding ground)

Soft bottom ARs after 18 months at Pulau Payar, Kedah



Aggregation of adults fish inside the structure suggest that it is indeed a preferred breeding ground.

Success story 2006-2009
(Artificial reefs as breeding ground)

Adult female crab at tetrapod ARs, Ma' Daerah, Terengganu

Adult female lobster found at cuboid ARs, Marang, Terengganu

Gravid crustaceans (crab and lobster) found these AR structures as a suitable habitat to release their offsprings

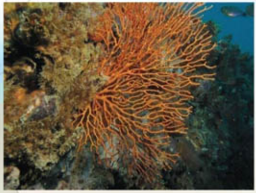
Success Story 2007-2009
(Artificial reefs as nursery ground)

Cuboid ARs after 23 months at Kuala Terengganu


Encrustations on the ARs attract multi species of juvenile fishes near the structures.

Success Story 2007-2009
(Artificial reefs as substrate for coral to grow)

Cuboid ARs after 11 months at Setiu, Terengganu



Gorgonion seafan is known to be a niche for sea horses

Soft corals, Octocorallia a distant relative of the Scleractinia, hard corals

Success Story 2007-2009
(Artificial reefs as substrate for coral to grow)

Cuboid ARs after 23 months at Kuala Terengganu

Nudibranch with their breathing gills on the back

A refreshing sight on the ARs. Octocorals with eight tentacles waving with rhythm.

Success Story 2007-2009
(Artificial reefs as substrate for coral to grow)

Tetrapod ARs after 23 months at Ma' Daerah Terengganu

Tetrapod ARs acting as an Octocoral farm. Prolific growth Octocorals is an indicator of rich plankton ground

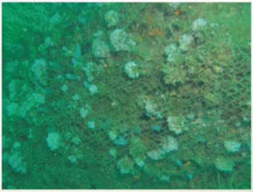
Success Story 2007-2009
(Artificial reefs as substrate for coral to grow)

Tetrapod ARs after 23 months at Ma' Daerah Terengganu


Spotted moray eel taking refuge in the octocoral farm

Success Story 2007-2009
(Artificial reef as substrate for sponges to grow)

Tetrapod ARs after 23 months at Ma' Daerah, Terengganu

Sponges are known to survive by filter feeding. Their presence in high number of individuals suggested that this site is rich with their food planktons

Success Story 2008-2009

(Artificial reef as substrate for flora to grow)

Lobster ARs after 11 months at Labuan

Cluster tunicates, *Sycozoa* sp. taking advantage of the location underneath the ledge of the artificial reef module. Getting food and plenty of oxygen from the current flow.

Success Story 2008-2009

(Artificial reefs substrate for flora and fauna to grow)

Lobster ARs after 11 months at Labuan

Crinoid perching on the ARs taking advantage of the height to filter plankton from the flowing current

Hanging at the corner is dendronepthya soft coral a member of the Octocorallia of the family Alcyoniidae.

Success Story 2007-2009
(Artificial reefs as fish aggregating devices)

Cuboid ARs after 11 months at Setiu, Terengganu

A host of coral fishes has found the AR modules as a niche of their very own

Success Story 2007-2009
(Artificial reefs as fish aggregating devices)

Cuboid ARs after 23 months at Setiu, Terengganu

Coral fishes, Chromis and Anthias

Commercial species *Lutjanus russelli*

Success Story 2007-2009
(Artificial reef as natural habitat)

Cuboid ARs after 11 months at Setiu, Terengganu

Two species of Echinoderms grazing in the vicinity of the AR modules

Success Story 2007-2009
(Artificial reef as natural habitat)

Cuboid ARs after 11 months at Setiu (right) and tetrapod ARs at Mak Daerah, Terengganu after 2 years (left)

Grey bamboo sharks, *Chiloscyllium griseum* utilising under side of the AR modules as a safe refuge. A consideration for future AR design for this family of sharks.

Success Story 2007-2009
(Artificial reef as natural habitat)

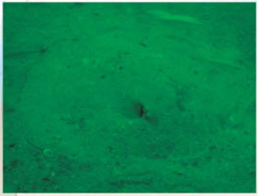
Tetrapod ARs after 23 months at Ma' Daerah, Terengganu

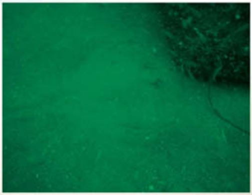
Coral groupers in between the sponges growing on the AR modules.

Flamboyant and bright color nudibranch has toxic chemical defense to survive the hostile predators.

Success Story 2007-2009
(Artificial reef as natural habitat)

Tetrapod ARs after 23 months at Ma' Daerah Terengganu





Stingray camouflages itself under the sandy seabed near tetrapod ARs taking advantage of the position to ambush unsuspecting food prey

Success Story 2007-2009
(Artificial reef as natural habitat)

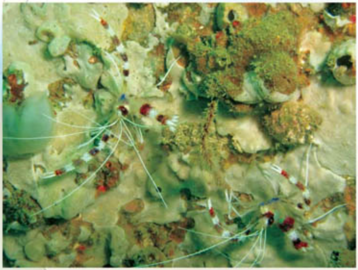
Lobster ARs after 11 months at Labuan

Catfishes preferred the lower part of the module as their home

Coralivores butterfly fishes from the family Chaetodontidae as an indicator of the performance of the ARs modules as substrate for the attachment of corals

Success Story 2007-2009
(Artificial reef as natural habitat)

Tetrapod ARs after 23 months at Ma' Daerah, Terengganu



The presence of banded shrimps at the ARs modules is a sign that the place is being frequenlty "visited" by large fish such as groupers and snappers to get their external parasites and dead tissue cleaned by these 'cleaners"

Success Story 2007-2009
(Artificial reef as natural habitat)

Cuboid ARs after 23 months at Setiu, Terengganu


High commercial value groupers swimming inside the ARs structure that has already transformed from bare concrete block to natural habitat

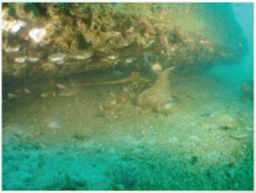
Success Story 2007-2009
(Artificial reefs as natural habitat)

Tetrapod ARs after 23 months at Cerating, Pahang


A familiar scene around matured ARs structures. An assorted coral fishes and octocorals that has grown into bush-like vegetation.

Success Story 2007-2009
(Artificial reefs as natural habitat)

Lion fish at cuboid ARs at Setiu, Terengganu



Lobster and bamboo shark under cuboid ARs at Marang

Success Story 2007-2009
(Artificial reefs as natural habitat)

Cuboid ARs after 2 years months at Setiu, Terengganu

Molting crabs often do find ARs as good refuge.

Success Story 2007-2009
(Artificial reefs as natural habitat)

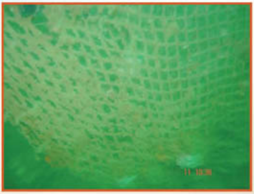
Cuboid ARs after 23 months at Kuala Terengganu

Lobster ARs after 11 months at Labuan

An illustration of the relationship between immersion duration and the encrustation maturity of the created habitat.

Success Story 2007-2009
(Artificial reefs as habitat protection)

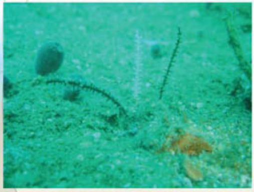
Tetrapod ARs after 3 months at Ma' Daerah, Terengganu



One of those unlucky illegal trawler gotten his cod end torn on the unmovable tetrapod ARs

Success Story 2007-2009
(Artificial reefs as habitat protection)

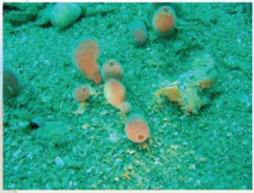
Cuboid ARs after 23 months at Kuala Terengganu



Unidentified marine organism are plentiful growing on the undisturbed sandy bottom near cuboid ARs

Success Story 2007-2009
(Artificial reefs as habitat protection)

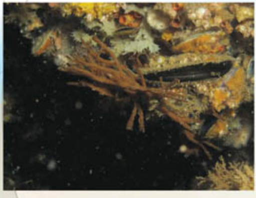
Cuboid ARs after 23 months at Kuala Terengganu



Tunicates (left) and nudibranch (right) participating on the sea floor near the cuboid ARs. A testimony of the success of the newly created habitat.

Success Story 2007-2009
(Artificial reefs as habitat protection)

Cuboid ARs after 23 months at Kuala Terengganu




A compendium of marine life in, on and around typical ARs module

Success Story 2007-2009

Recreational ARs after 3 months at Kuala Penyu, Sabah


Sampling harvest of bucket size red snappers

Conclusion

Based on information those I was presented just now it can be conclude that all the four objectives targeted under the Ninth Malaysia Plan has already been achieved

To develop new sites of ARs and deploy more additional ARs modules at present sites to increase national fishery resources

To conduct research and survey and to compile information on the suitable AR designs, durable materials, suitable sites and local fishery resources.

To develop new ARs designs which can deter the encroachment of environmental unfriendly fishing gears especially trawlers into traditional fishing ground and specific zones.

To provide substrate for coral to grow.

THANK YOU

Japanese Experience on Management of Coastal Fishing Grounds with Artificial Reefs

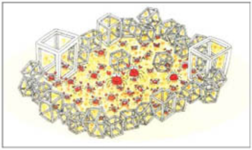
～Workshop on Artificial Reefs for the Enhancement of Fishery Resources～

4th August, 2009

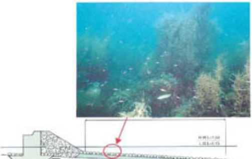
Akito Sato
SEAFDEC Secretariat
Assistant Trust Fund Manager

photos; Fisheries Agency in Japan

(1) A variety of Artificial Reefs



To protect marine resources



To create seaweed beds

To promote coastal fishing activities

To propagate marine resources

photos; Fisheries Agency in Japan

(2) Management of Artificial Reefs

(Purposes and Types of Management Activities)

1) Management of Facility

To conduct the full effect of artificial reefs through maintenance, repair and improvement of artificial reefs.

2) Fishing Ground (biological environment) Management

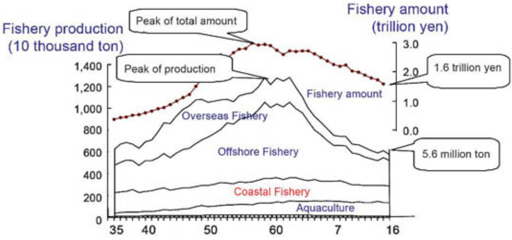
To enhance the stock and to stabilize the settlement of marine resources by securing optimum biological environment for the target species.

3) Fishing Operation Management

To maintain stabilized production by coordination of fishing operation.

(3) Importance of Fishing Ground Management

(a) Fishery Production in Japan



Source: Annual Fishery White Paper;
The Ministry of Agriculture, Forestry and Fisheries (MAFF)

(b) Productivity of Coastal Fishing Grounds

In many cases, productivity of coastal fishery resources is governed by productivity of coastal fishing grounds.

Fishery resources management

Two wheels of the same vehicle

Fishing ground management

To support fisheries and fishing ground management activities by fishermen

⬇

Utilization of various types of artificial reefs for enhancing productivity of coastal fishery resources

(4) Examples of Japanese Fishing Ground Management

(1) Laminaria Kelp ("Kombu" in Japanese) fishing grounds (Hidaka Waters in Hokkaido)

【in the Edo era】

・During 1860's, improvement works by throwing stones into water were started for "KOMBU" fishing ground expansion. Before the works started, "Kombu" production was 50 GOKU (about 75 ton) , but production increased to 200 GOKU after 3 years, 560 GOKU after 5 years, and 700 GOKU after 6 years.

【in the Showa era and recently】

・Cleaning fishing grounds and renewal of stone grounds continue by fishermen or fishery cooperatives supported by local governments in the regions.

⇒Contributing to stable "Kombu" production
("Kombu" production: 3,500ton～6,500ton from 1870's)

Source: editing the "Kombu" dictionary by Japanese Kombu Association(1986)

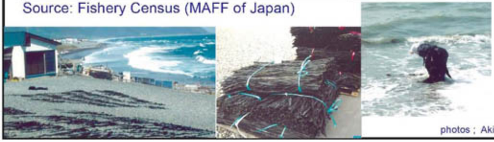
【A feature of “Kombu” fishing rules】

Fishermen in each village have “Kombu” fishing regulations and rules among themselves including self-obligation of cleaning each fishing ground.

【Number of fishery establishments of Hidaka Waters(2004)】

Seaweed fishing (Kombu)	1,094	72.7%
Gill-net Fishing	119	7.9%
Long-line Fishing	95	6.3%
Gathering shellfish	45	3.0%
Large Fixed Netting	41	2.8%
TOTAL	**1,506**	–

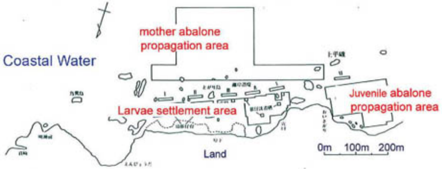
Source: Fishery Census (MAFF of Japan)



photos ; Akito SATO

(2) Improvement of abalone fishing grounds

(Case1: Taro Waters in Iwate Prefecture)



Layout Map of abalone propagation grounds

Source: IWATE Prefecture Fishery Technology Center

【 Ecological Features of Abalones

1) Settlement of drifting larva:

Rock and rolling-stone areas of tidal waters or about 3m in depth

Remark) Crustose coralline algae is also important for abalone larva settlement.

2) Feeding habit：

a) Small algae up to 1～2cm

b) Large-scale seaweeds according to size

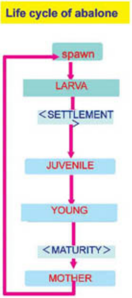
3) Living depth of mother abalone

Differ species of abalones

4) Reproduction

Mother abalones mainly more than three year old

Remark) Environment for high density of mother abalones is necessary for reproduction.



Source: Hiroshi YAMAKAWA (Tokyo University of Marine Science and Technology)

- Density of Abalone in TARO Propagation Grounds

(unit; per 1m^3)

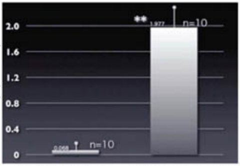
Year	Juvenile abalone propagation area		Mother abalone propagation area		Propagation area (total)	
	Number	g	Number	g	Number	g
Oct. 1986	1.29	173.4	1.49	181.1	1.43 (0.77)	178.8 (130.7)
Oct. 1987	0.91	93.8	2.07	310.2	1.73 (1.26)	246.5 (222.8)
Oct. 1988	1.01	70.0	0.79	124.5	0.85 (0.52)	108.5 (93.1)
Oct. 1989	1.54	115.9	0.28	25.2	0.65 (0.22)	51.9 (36.6)
Oct. 1990	3.75	273.4	1.14	92.4	1.91 (0.57)	145.7 (87.2)
Oct. 1991	2.75	153.8	1.58	123.6	1.92 (0.54)	132.5 (81.9)
Oct. 1992	2.27	132.4	1.31	67.0	1.59 (0.23)	86.3 (36.3)
Oct. 1993	2.38	178.8	0.81	74.2	1.27 (0.32)	105.0 (48.3)
Oct. 1994	2.68	223.0	2.13	139.9	2.29 (0.70)	164.3 (98.3)
Oct. 1995	3.88	203.1	2.96	211.4	3.23 (0.84)	208.9 (125.6)
Oct. 1996	2.30	146.6	2.02	177.6	2.10 (0.51)	168.4 (118.0)
Oct. 1997	3.75	274.7	3.87	341.2	3.83 (1.48)	321.7 (221.7)
Oct. 1998	4.67	355.4	4.84	476.1	4.79 (2.09)	440.6 (320.1)
Oct. 1999	3.08	167.5	3.37	270.4	3.28 (0.91)	240.1 (135.7)
Oct. 2000	3.40	173.2	2.91	185.0	3.05 (0.63)	181.5 (91.4)
Oct. 2001	5.72	401.9	3.97	147.3	4.48 (0.72)	222.3 (101.0)
Oct. 2002	6.32	306.8	2.98	85.2	3.97 (0.42)	150.5 (53.8)
Oct. 2003	4.80	209.5	3.68	94.9	4.01 (0.36)	128.7 (47.8)
Oct. 2004	2.85	120.8	3.11	39.7	3.04 (0.18)	63.5 (21.9)

Source: IWATE Prefecture Fishery Technology Center

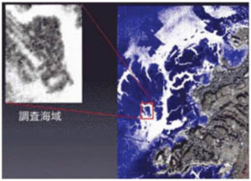
(Case2: Nagai Waters in Kanagawa Prefecture)

(Type of sea bottoms in the site)
- Thrown stone areas: 3,263m²
- Rocky reef areas: 3,517m²
- Sandy/muddy areas: 2,213m²

(Density of abalones in the site)
- Thrown stone areas: 1.98 Ind./m²
- Rocky reef areas: 0.07 Ind./m²



Rocky reef area Thrown stone area
Densities of abalones (in Nagai waters)

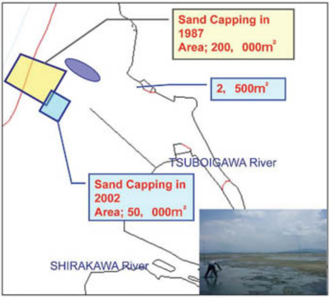


Investigation Areas (in Nagai waters)

Source: Kanagawa fishery research center annual report (2003)

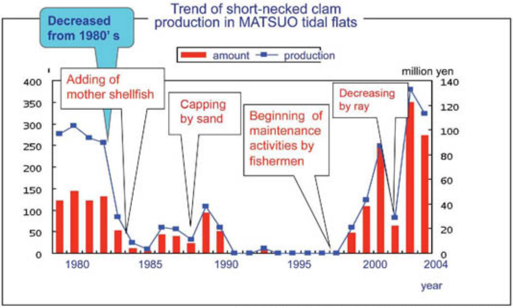
(3) Management of short-necked clam fishing grounds
(Matsuo Waters in Kumamoto Prefecture)

○Matsuo fishing grounds: where short-necked clams were unable to survive mainly due to the piling up of excessive floating mud



Source and photos; Kumamoto city and Matsuo fishery cooperative

【History of fishing ground management for short-necked clams by fishermen in Matsuo Waters】



Source ; Kumamoto city and Matsuo fishery cooperative

【 Fishing ground management activities by fishermen 】



Bamboo fence installed to promote settlement of drifting larva

Covered net to protect the juvenile short-necked clams




Left photo: Caught rays and their stomach contents
Above photo: Transplantation of short-necked clams
Right photo: The group leader with a big smiles

Photos ; Kumamoto city and Matsuo fishery cooperative

【Following resource management activities in Matsuo Waters】

Every year after executing on-site investigations, the fishing policies are decided through consensus-building among all fishermen based on results.

In spring

In autumn

Resources estimation survey before beginning	Beginning of short-necked fishing with securing next year resources	Suspended period (spawning in spring)	Restarting of short-necked fishing after confirming resource situations	Suspended period (spawning in autumn)
		Settlement situation survey	Juvenile shellfish situation survey	

Yearly

Source; Kumamoto city and Matsuo fishery cooperative

5 Support for fishing ground management

(An example of support programs by Fisheries Agency of Japan)

Environmental Conservation Activity Support Programs

Implementing Body

While fishermen should play the core role as implementing body, various people such as local residents can participate according to the type of conservation activities.

Activities Supported

Planning: Discussions, goal setting, plan formulation, dissemination and awareness-raising activities, etc.
Monitoring: Investigation of the current status, investigation of effects
Conservation activities: Placing of mother algae, production/scattering of algae seeds, (examples: seaweeds) transplantation, supply of nutritive salts, removal of herbivores, etc.

Source: Committee on Environment/Ecosystem Conservation Activity Support Projects by Fisheries Agency

6 Target Goal for Fishing Ground Restoration

【Long-term Plan on Improvement of Fisheries Infrastructures】 (2007-2012)

- The plan clearly indicates the implementation target and the scale of projects for each of the three priority subjects to be tackled over a five-year period starting in fiscal year 2007.

[The three priority subjects to be tackled]

1. Improving the productivity of fishery resources in the waters surrounding Japan
2. Strengthening international competitive of fisheries and fish markets
3. Creating safe and secure fishing communities that support stable provision of fishery products

[Target] (regarding the first priority subject)

- Increasing production by about 145,000 tons through the development of fishing grounds in approximately five years

[Scale of total projects] (regarding the first priority subject)

– Development of fish reefs and propagation/farming sites for fishery resources
: approx. 75,000 ha
– Removal of sediments, etc. for restoring the proper function of fishing grounds
: approx. 250,000 ha
– Conservation and restoration of seaweed beds and tidelands
: approx. 5,000 ha

7 Closing Remarks

1. It is important for administrators and researchers of Southeast Asian Countries to gather and share information. Such cooperation among administrators and researchers should be expected to continue in the future.

2. "Fishery resources management" and "Fishing grounds management" are the two wheels of the same vehicle for maintaining productivity of marine resources.

3. Japanese fishermen have used and managed their fishing grounds with artificial reefs, showing that the presence and activities of fishermen are indispensable for fishing ground management.

4. It is also important that a cultural environment be created where people will familiarize themselves with the sea and marine resources and acquire the habit from childhood of eating fish and shellfish, and supporting efforts to conserve these valuable resources.

DESIGN, CONSTRUCTION AND DEPLOYMENT OF ARTIFICIAL REEFS

1. Case in Japan

2. Case in Malaysia

Contents

(1) Shape and Materials of Artificial Reefs

(2) Design Condition of Artificial Reefs

(3) Hydraulic Forces Exerted on Artificial Reefs

a) Morison Formula

b) Physical Model Tests of Artificial Reefs

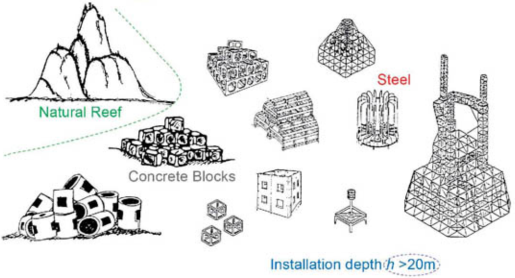
(4) Stability of Artificial Reefs

(5) Construction and Deployment of Artificial Reefs

(1) Shape and Materials of Artificial Reefs

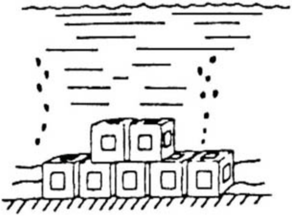
Fisheries Agency of Japan (2003): Design manual for fishing ports and fisheries grounds facilities, 1008p. (in Japanese)

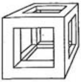
Various Types of Artificial Reefs for Fishes



The greatest steel reef's height reaches up to 40m in Japan.

Various Types of Artificial Reefs for Fishes





Cubic type
'Dice block'
(1-5 m cube)

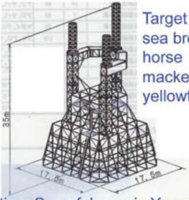
Cylindrical type
'Tube block'

Steel Artificial Reefs Called SR35

型式	空m3	魚礁サイズ			設置履歴						
		底面幅	底面奥行	高さ	設置年月	設置場所	事業名	基数	設置水深	対象魚種	漁法
SR−35−2型	3,947	17.5m	17.5m	35m	H7.[illegible]	山形県[illegible]町沖	試験礁設置工事	1	63m	マダイ・アジ・ブリ	延縄
					H8.[illegible]	山形県[illegible]町沖	人工魚礁漁場造成事業	2	62m	マダイ・アジ・ブリ	延縄
使用起重機台船	250ton吊り以上				H10.10	山形県[illegible]町沖	人工魚礁漁場造成事業	4	62m	マダイ・アジ・ブリ	延縄
開発者	水工研・日鐵建材・広和・中山製鋼所				H11.10	山形県[illegible]町沖	人工魚礁漁場造成事業	4	62m	マダイ・アジ・ブリ	延縄
特長	・魚礁下段部は複雑な構造で底棲魚の蝟集効果があり、魚礁中段部に鋼製パネルを設け、産卵場や餌場を狙った構造。 ・魚礁上段部にリングタワーを設け、回遊性魚の蝟集効果を促進する構造。 ・漁港、港湾等の工事で一般的に使用されている起重機船(250t)で設置作業が可能な形状および構造。										

Water depth: 62-63m

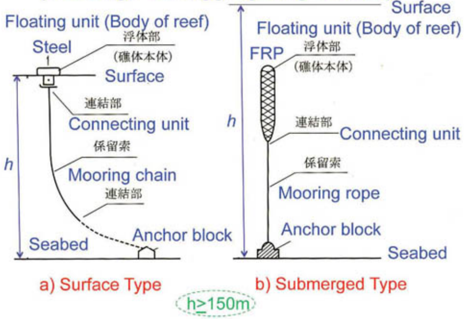
Expected weight (30 years later): 69ton, Weight (in air): 92ton



Target fishes:
sea bream,
horse
mackerel,
yellowtail

Location: Sea of Japan in Yamagata Pref.

Floating Artificial Reefs
(Floating Fish Aggregating Device)

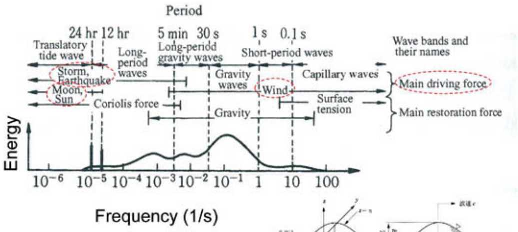


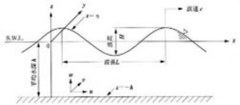
(2) Design Condition of Artificial Reefs

Design Condition

1. Waves: Significant wave height $H_{1/3}$ (m)
   Significant wave period $T_{1/3}$ (s)
   Design waves with probable peak wave height during 30 years are calculated by wave hindcasting and statistical analysis. Wave deformation such as refraction, diffraction and wave shoaling should be considered.
2. Ocean and Tidal Currents: Observed maximum current velocity (If necessary, wave induced current and wind induced current should be considered)
3. Sea Level: H.W.L. to L.W.L.
4. Wind: Observed maximum wind velocity (If there is no wind data, then design wind speed at yard is chosen 50 m/s.)
5. Seabed Condition: Sand, Gravel, Rock, Mud, Flat ,Slope
6. Materials of Artificial Reefs: Concrete(RC), Steel, FRP

Waves Including Ocean and Tidal Currents





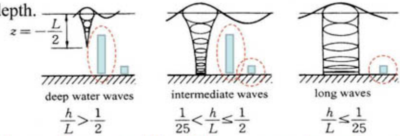
In the case of design of artificial reefs, we should consider the waves with the periods of several seconds or longer in the engineering point of view.

Waves Motion

Equation of dispersion relation

$$\left(\frac{2\pi}{T}\right)^2 = g\frac{2\pi}{L}\tanh\left(\frac{2\pi}{L}h\right)$$

where T is the wave period, g is the gravitational acceleration, π is the circular constant, L is the wavelength, h is the water depth.



If the reef locates within $L/2$ from seawater surface, then we should take into account the influence of surface waves.

Corrosion Rate of Steel

Artificial reefs except floating type are required to have a durability for 30 years.

	Circumstance 腐食環境	Rate of erosion (mm/yr) 腐食速度（mm／年） One side	
Seaward 海側	H.W.L.以上	0.3	
	H.W.L.~L.W.L.－1.0m	0.1~0.3	
	L.W.L.－1.0m~ h =20m	0.1~0.2	
	h =20-50m	0.06	1.8 mm/30yr
	h >50m (h :Water depth)	0.045	1.35 mm/30yr
	Seabed	0.03	
Landward 陸側	Air	0.1	
	Soil (over residual water level)	0.03	
	Soil (under residual water)	0.02	

In the case of steel reinforced concrete (RC), concrete margin surrounding the steel should be chosen greater values of 20mm or diameter of steel (factory made). If RC is not made in factory, concrete margin should be more than 25mm.

(3) Hydraulic Forces Exerted on Artificial Reefs
a) Morison Formula

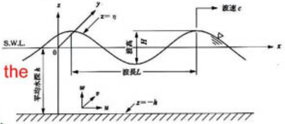
Morison Formula

Drag force dF_D — Inertia force dF_M

$$dF = C_D \frac{w_0}{2g} D_p |u_n| u_n ds + C_M \frac{w_0}{g} A_p \frac{\partial u_n}{\partial t} ds$$

where dF is the incremental wave forces perpendicular to the pile element of lengths ds, C_D and C_M the drag coefficient and inertia (or mass) coefficient, g the gravitational acceleration, w_0 the unit volume weight of sea water, D_p the pile diameter, A_p the cross-sectional area of the pipe, u_n and $\partial u_n/\partial t$ the wave particle velocity and acceleration components perpendicular to the axis of the pile, respectively, t the time.

Horizontal Velocity Component Due to Waves



Horizontal velocity based on the small amplitude theory

$$u = \frac{\pi H}{T} \frac{\cosh k(h+z)}{\sinh kh} \sin(kx - \sigma t) = u_m \sin\theta$$

Horizontal velocity component u_m

where u is the horizontal velocity due to waves, H is the wave height, T is the wave period, h is the water depth, π is the circular constant, k (=$2\pi/L$, L is the wavelength) is the wave number, σ (=$2\pi/T$) is the angular frequency, x and z is the horizontal and vertical coordinate, θ is the phase of waves.

Horizontal Velocity Component Due to Currents

Horizontal velocity component at z

Correction term by fluctuation of currents

$$u_z = u_H \sqrt{\cos\alpha + 1.5} \left(\frac{z}{h}\right)^{1/7}$$

Correction term by water depth

where u_z is the current velocity at z, u_H is the maximum current velocity at sea surface, α is the angle between the direction of the maximum current and the direction of design current, h is the water depth, z is the vertical distance from seabed.

Horizontal Hydraulic Forces Exerted on Reefs

When the reef's height D is smaller than the value of $h/10$, z may be taken the top of the reef. We should pay attention to the uplift force exerted on the reefs, if the reefs are relatively high or huge.

$$u = u_m \sin\theta \qquad u_m = \frac{\pi H}{T}\frac{\cosh 2\pi D/L}{\sinh 2\pi h/L}$$

$$F = F_D + F_M \qquad F_D = C_D A \frac{w_0}{2g} u_m^{\ 2} \qquad F_M = C_M V \frac{w_0}{g}\frac{2\pi}{T} u_m$$

where A is the total shadow area of vertical surface of reef, in which perpendicular to direction of progress of waves, V is the net volume of reef

Expression for waves and currents co-existence

Component due to waves

$$F = C_D A \frac{w_0}{2g}\left(u_m \sin\theta + u_z\right)^2 - C_M V \frac{w_0}{g}\frac{2\pi}{T} u_m \cos\theta$$

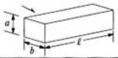
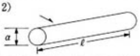
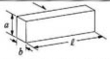
Component due to currents

$$= F_D\left(\sin\theta + u_z / u_m\right)^2 - F_M \cos\theta$$

It is needed to find the phase of wave θ, which gives the maximum value of hydraulic forces F_{max}.

Drag and Inertia Coefficient

Shape of member

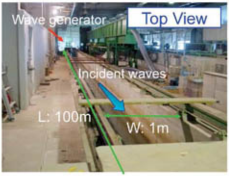
	1) 							2) 						3) 						
l/a	1	2	4	5	10	20	∞	1	2	5	10	20	40≦	1	2	4	5	10	20	∞
C_D	1.05	1.08	1.13	1.14	1.25	1.50	2.0	0.63	0.68	0.74	0.82	0.90	1.0	1.12	1.15	1.19	1.20	1.29	1.50	2.0
C_{MA}	1.0							1.0						1.0						
A	al							al						al						
V	$ab\ell$							$\frac{\pi a^2 \ell}{4}$						$\frac{\pi a^2 \ell}{4}$						

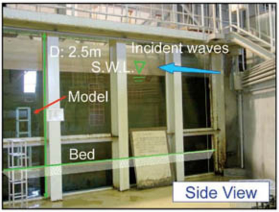
where C_D is the drag coefficient, C_{MA} is the added mass coefficient , C_M (=1+C_{MA}) is the inertia (mass) coefficient, A is the total shadow area of vertical surface of member, in which perpendicular to direction of progress of waves, V is the net volume.

(3) Hydraulic Forces Exerted on Artificial Reefs
b) Physical Model Tests of Artificial Reefs

A Long Wave Flume Used in the Experiments

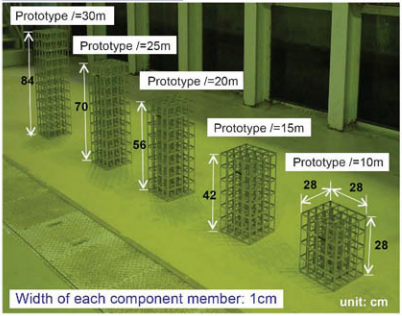
A long wave flume at National Research Institute of Fisheries Engineering (Length:100.0m, Width: 1.0m, Depth: 2.5m)





Sample of the Models of Artificial Reefs

Model Scale: 1/36

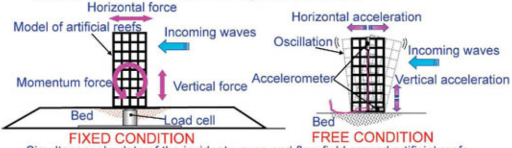


Typical Measurement Items

Physical model tests of artificial reefs are usually carried out in a wave flume by using both regular and irregular waves according to Froude similitude. Tests are also conducted for the uniform flow.

Typical measurement items:

- Surface elevation by capacitance type wave gage
- Velocity by electromagnetic velocity meter
- Wave forces exerted on artificial reefs by load cell
- Acceleration of artificial reefs by accelerometer



Simultaneously, data of the incident waves and flow field around artificial reefs is also measured.

(4) Stability of Artificial Reefs

External Forces Exerted on Artificial Reef

1) Gravity:
2) Impact force at seabed:
3) Hydraulic forces due to waves and currents including buoyancy:

It is needed to check the bending moment, axial force and shearing force exerted on component member of artificial reefs during construction at yard, transportation, installation by crane and after installation.

Seabed reaction force should have taken into account adequately considering the dynamic characteristics of rock, gravel, sand and soft mud.

Impact Load at Seabed

$$\hat{\sigma}_G = \frac{R}{V} = \frac{K\varepsilon^2}{V} \qquad k = \frac{\hat{\sigma}_G}{\sigma_G}$$

R : seabed reaction force,

K : foundation reaction coefficient in seabed

ε : maximum displacement in seabed

V : net volume of reef

$\hat{\sigma}_G$: impact load (equivalent static weight $k\sigma_G$)

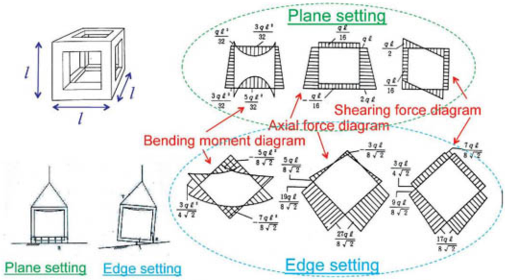
σ_G : unit volume weight of reef materials.

Cubic equation: $L\varepsilon^3 - M\varepsilon - N = 0$

$$L = \frac{gK}{3w_0V} \quad M = g\left(\frac{\sigma_G}{w_0} - 1\right) - \frac{C_DA}{4V}v^2 \quad N = \left(\frac{\sigma_G}{w_0} + C_{MA}\right)\frac{v^2}{2}$$

In the case of sand or gravel seabed, *K* takes 30,000-50,000kN/m². In the case of rock seabed, adequate value of *K* should be chosen.

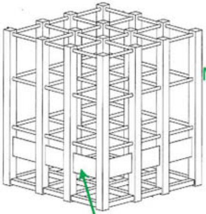
Component Member Strength of Dice Block



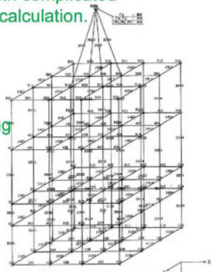
q: equivalent static load exerted on the reef member

Component Member Strength of Steel Reef

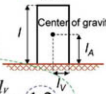
Structural analysis on artificial reef with complicated members is conducted by numerical calculation. (Ex. Finite Element Method)



Modeling



Preventing Sliding and Overturning



Safety factor for preventing sliding

$$S_{FS} = \frac{W\mu(1 - w_0/\sigma_G)}{F} \geq 1.2$$

Safety factor for preventing overturning

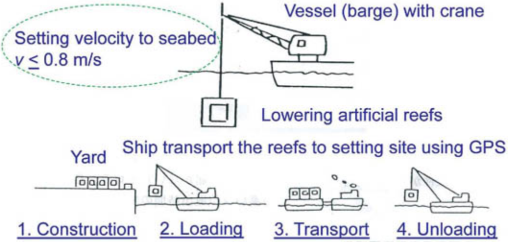
$$S_{FS} = \frac{W(1 - w_0/\sigma_G)}{F}\frac{l_V}{l_A} \geq 1.2$$

where S_{FS} is the safety factor, W is the weight of reef in the air, μ is the friction coefficient between reef and seabed, w_0 is the unit volume weight of sea water, σ_G is the unit volume weight of reef materials, F is the wave and current forces exerted on reef, l_v is the distance from the center of gravity to the nearest side of reef, l_A is the distance from seabed to the center of gravity of reef.

In the case of sand or gravel seabed, μ *often takes* 0.6. Adequate value of μ should be taken in considering seabed conditions and reef footing .

(5) Construction and Deployment of Artificial Reefs

Deployment of Artificial Reefs



Flow of construction and setting the artificial reefs

Design, Construction and Deployment of Artificial Reefs in Malaysia

By
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Safari bin Haji Mat Desa[2],
Ahmad bin Ali[3] ,
Mohd Ridzuan bin Mohamed Alias[4]
Abdul Rauf bin Musleh[1]

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2. National Hydraulic Research Institute Malaysia
3. SEAFDEC-MFRDMD
4. Licensing and Resource Management Division, Department of Fsheries Malaysia

CONTENTS

- The Task
- Introduction
- ARs Construction Stages
- Issues & Problems
- Suggestions
- Conclusion
- Recommendations

THE TASK OF ENGINEERING DIVISION

- To design big size artificial reefs (ARs) for soft and hard bottom sea bed
- To monitor the construction work and deployment of ARs
- To identify the issues and problems regarding the construction and deployment of ARs
- To come out with suggestions and recommendations for improvement

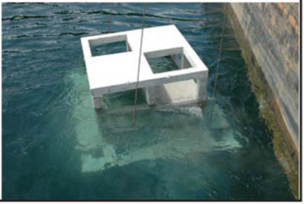
Introduction

- Collaboration work on Research and Development program of ARs between Engineering Division, SEAFDEC-MFRDMD, and Licensing and Resource Management Division of DoF started since 2006
- Six innovations of big size ARs weighting between 5 to 19 metric tonnes was materialist between 2006-2009 namely Cube ARs, Cuboids ARs, Soft Bottom ARs, Lobster ARs, Recreational ARs and Tetrapod ARs
- The first design was materialist with the construction of Soft Bottom ARs and Tetrapod ARs in 2006
- Construction of Cuboids ARs started in 2007 in collaboration with State Government of Terengganu
- In 2008, Lobster ARs was introduced in Federal Territory of Labuan and Recreational ARs in Sabah
- Construction of Cube ARs started in 2009 in Terengganu, Pahang, Sarawak and F. T. of Labuan

FIRST DESIGN OF SOFT BOTTOM ARs (2006)

Specifications

- 3 m x 3 m x 3.6 m (height)
- Total weigh: estimated 14 metric tonnes
- Thickness of column: 20 cm
- Thickness of floor: 15 cm
- Without base beam →
- Concrete mixture: Grade 30



MODIFIED SOFT BOTTOM ARs (2007, 2008)

Slight modification on basement beam

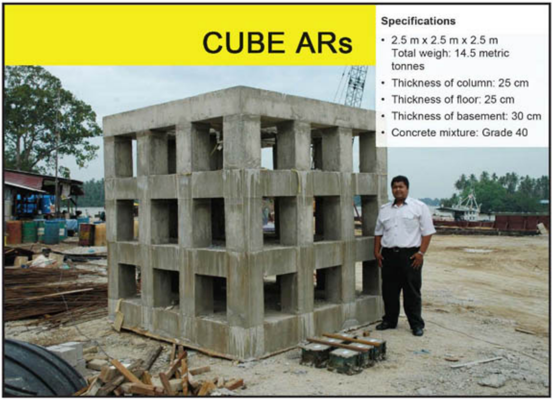
Specifications:

- Total weigh: 19 metric tonnes
- Thickness of column: 25 cm
- Thickness of floor: 20 cm
- With basement beam: →
- Concrete mixture: Grade 50
- 3.0 m x 3.0 m x 3.6 m (height)

LATEST DESIGN OF SOFT BOTTOM ARs (2009)

Minor modification on the first floor with two opening to provide more roaming area for fishes within the structure.

Briefing on the specification of soft bottom ARs to visitors from FRA, Japan, SEAFDEC-TD and SEAFDEC Secretariat at construction site in Malacca on 3rd August 2009


CUBE ARs
Specifications
• 2.5 m x 2.5 m x 2.5 m
Total weigh: 14.5 metric tonnes
• Thickness of column: 25 cm
• Thickness of floor: 25 cm
• Thickness of basement: 30 cm
• Concrete mixture: Grade 40


Four holes on each floor to provide more roaming area for fishes to swim within the structure

CUBOIDS ARs (in collaboration with State Government of Terengganu)

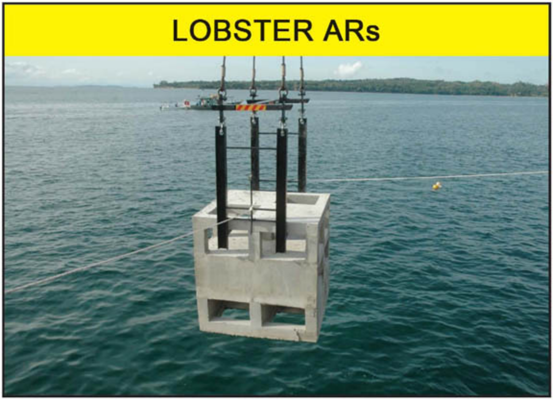
Specifications

- 2.0 m x 2.0 m x 3.0 m (height)
- Total weigh: 10 metric tonnes
- Thickness of column: 25 cm
- Thickness of floor: 25 cm
- Thickness of basement: 30 cm
- Concrete mixture Grade 40

Construction site of cuboids ARs at Chendering, in Terengganu


TETRAPOD ARs
1


KOBELCO
Specifications
• 2.655m x 2.655m x 2.385m height
• Weight : 8 tonnes
• Concrete mixture : Grade 40


LOBSTER ARs


11
12
7
Specifications
• 1.65m x 1.65m x 1.65m
• Weight: 5 tonnes
• Concrete mixture: Grade 40

Recreational ARs

DESIGN AND CONSTRUCTION

- SEAFDEC-MFRDMD provided sketch and measurements of ARs
- Engineering Division come out with details drawing
- Constructed by selected contractor(s)
- Deployment
- Evaluation
- Acceptance

WORKING SCHEDULE

	Scope of Jobs	1st Month				2nd Month				3rd Month			
1	Whole construction work	■	■	■	■	■	■	■	■	■	■	■	■
2	Preparation of logistics, financial, etc	■	■	■									
3	Construction of formwork		■	■	■								
4	Preparation of steel bar frame			■	■	■	■						
5	Concreting.					■	■	■	■	■	■	■	
6	Deployment											■	■
7	Evaluation and acceptance												■

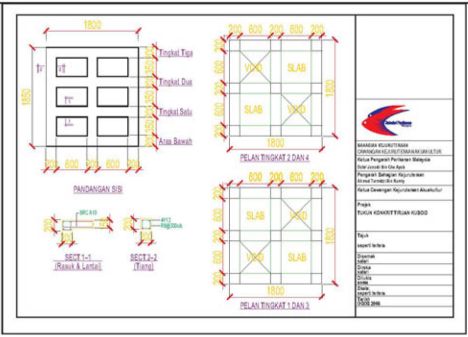
PREPARATION OF ARS DETAILS DRAWING

Input from SEAFDEC-MFRDMD

i. Sketch of ARs (shape, type, dimension)

Output from Engineering Division

i. Final and detail technical drawing (after several consultatios with SEAFDEC-MFRDMD).



Design of ARs:

- Using Computer Aided Design
- Friendly user; easy to use and less time consuming

PREPARATION OF TENDER/ QUOTATION DOCUMENTS

- Followed the British Standard 8110
- Column and beam rebar – Y12 x 4
- Link – R8 @ 200mm c/c
- Slab reinforcement– BRC A10
- Concrete cover – 50mm
- Ready-mix concrete from batching plant – (grade 50 for soft bottom ARs and grade 40 for other types of ARs)
- Cube test after 7 and 28 days age of construction

Construction Stage

- Construction site proposed by contractors
- Construction work started with the preparation of formwork and cutting of steel bar, link etc,
- Monitored by officers from Engineering Division, SEAFDEC-MFRDMD, State Fisheries, and Licensing and Resource Management Division.

Suitable Construction Site

- Closed to deep water jetty
- Near to deployment site
- Near to batching plant
- Easy to hire big crane, truck and pontoon
- Easy to upload the ARs
- Easy to get workers
- Have water supply and electricity
- Road for heavy vehicle
- .....and other supporting facalities

Construction of formwork and rebar

- Column and beam rebar – Y12 x 4
- Link – R8 @ 200mm c/c
- Slab reinforcement– BRC A10

Ready-mix concrete from batching plant

The used of vibrator is mandatory

Construction of beam, column and 1st platform

Column and 1st platform completed

Final step is the rest of top level

**Completed Modules of Soft Bottom ARs
(curing for at least 28 days after construction)**

Monitoring of Construction Work

- Construction work must adhered to specifications written in tender document/quatations and technical drawings
- Comply to British Standard 8110
- Monitoring led by Engineering Division of the DoF and supported by officers from SEAFDEC-MFRDMD, State Fisheries Office and Licensing and Resource Management Division, of the DoF Malaysia
- Cube Test conducted at private or government laboratory after 7 and 28 days after concrete
- Constructors submitted the reports of cube test to Engineering Division of the DoF.
- ARs approved by Eng. Div for deployment if all specification has been met
- If the structure produced not in accordance with the specification, the structure has to be repaired
- The product will be rejected should the product did not comply with the specification

- **Completed soft bottom AR modules**

- **Transportation of ARs to jetty**

Direct loading ARs from construction site onto the barge/pontoon

Barge size: about 120' x 80' with tug boat
If use landing craft –more easier, self propelled
Crane – minimum work load capacity of 50 tonnes (Depend on type of ARs.)
Divers – certified and experiences

- Enroute to deployment location

- **Detail briefing to workers before deployment**

- **DoF officers directly involved during placement of ARs to ensure all Standard Operation Procedure (SOP) is being complied.**

Placement Method

1. Cables released by divers (not practical for water depth more than 5 meters)
2. Mechanical released from the surface (more practical at any depth)

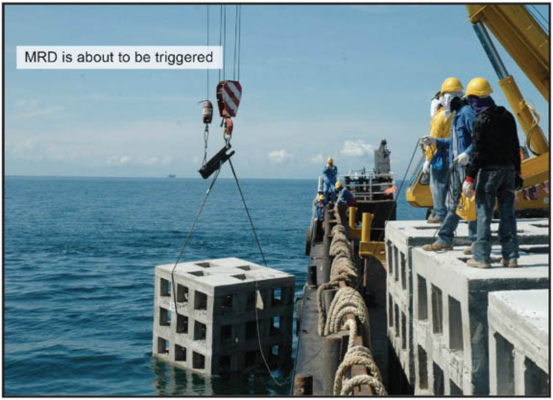
- **Mechanical release device (MRD)**

Wire rope tighten to bollard on barge

MRD (70 cm x 25 cm x 6 cm thickness)

Usage of shackle and strong cable

Unloading of ARs modules for eventual placement on the sea bed



Once the module is completely submerged, the weight is partly reduced by its buoyancy, the MRD is than triggered.

The module was released to make its way to the sea bed

Divers check the position of ARS: standing upright or inclined

Each ARs was marked with a buoy and the position recorded using GPS

ARs Image on the echo sounder screen

Cost of construction-in percentage

1. Preliminary work: 15%

2. Construction: 50%

3. Deployment: 35%

Percentage cost of material /module

1. Formwork: 50%

2. Reinforcement: 25%

3. Concrete: 25%

Major Issues and Problems

- Shortage of raw materials especially cement and steel.
- Limited number of batching plant
- Limited number of steel factory
- Limited number of experiences and skill workers
- Inexperience constructors
- Limited number of suitable construction site
- Limited number of suitable jetty for loading the big size ARs
- Unexpected weather change
- Limited number of big pontoon and crane
- Drastic increase of raw material price especially cement and steel

THESE PROBLEMS OFTEN GIFE RISE TO WORK BEHIND THE SCHEDULE

SUGGESTION

- Continue R&D to produce cost effective and easy to construct ARs
- Increased number of ARs Research and Development (R&D) personnel through human and resource development program (HRD)
- Participate in training course on the design, construction and deployment of big size ARs at regional and international level
- Involve in collaboration work with foreign expertise on ARs research and development

CONCLUSION

- ARs program is important for resource enhancement and habitat protection
- DoF Malaysia has to review the present design to reduce the cost of construction and deployment in order to increase number of modules and to reduce construction time
- DoF should seek for collaboration work with other international organisations which has vast experience in design, construction and deployment of big size ARs


Thank You

ENVIRONMENTAL EVALUATION OF ARTIFICIAL REEFS

1. Research themes of FRA projects regarding environment of coastal area
2. Environmental improvement around artificial reefs and their avaluation
3. Fishing ground environment around artificial reefs in Malaysia
4. Evaluation of artificial reefs in Malaysia
5. ARPOS (Artificial Reef Position System) : A Web Based GIS Visualization System for Managing the Artificial Reefs

Research Themes of FRA Projects Regarding Environment of Coastal Area

Ichiro Nakayama
Director, Aquaculture and fishing port Div. NRIFE

FRA
Fisheries Research Agency

History

FRA
Fisheries Research Agency

April 1st, 2001
Following the reorganization of the central government ministries, the Fisheries Research Agency was established as a new, independent administrative organization by consolidating nine former National Fisheries Research Institutes.

October 1st, 2003
The FRA takes over the duties of the Japan Marine Fishery Research Center and the Japan Sea-Farming Association.

April 1st, 2006
The FRA consolidates the National Salmon Resources Center, another incorporated administrative agency.

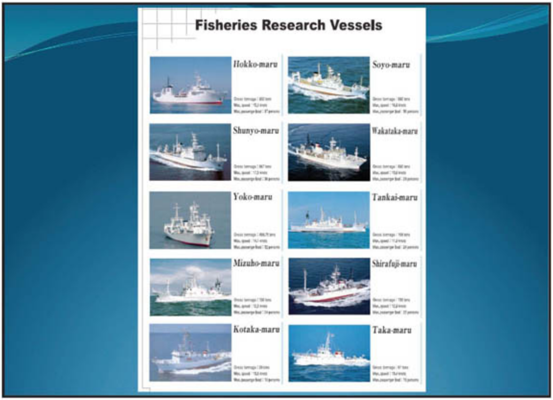
Mission

The Fisheries Research Agency (FRA), an incorporated administrative agency, conducts a wide range of research and development activities on fisheries, from basic research and application to practical use. Furthermore, the FRA conducts the hatching and releasing of salmon fry to maintain their population. Based on these activities, the FRA contributes to achieve the policy targets of "securing the stable supply of fishery products" and "promoting the sound development of the fisheries industries," as stipulated by "the Basic Plan for Fisheries Policy (in 2002 by the Fisheries Agency, Ministry of Agriculture, Forestry and Fisheries)". The FRA promotes efficient and effective research and development, disseminates the results and encourages the practical use in their respective fields.

FRA Structure

Organization


Location
FRA
Fisheries Research Agency
National Salmon Resources Center
Japan Sea National Fisheries Research Institute
Hokkaido National Fisheries Research Institute
National Research Institute of Fisheries and Environment of Inland Sea
Tohoku National Fisheries Research Institute
National Research Institute of Fisheries Engineering
Marine Fisheries Research and Development Center
Headquarters
National Research Institute of Fisheries Science
National Research Institute of Aquaculture
National Research Institute of Far Seas Fisheries
Seikai National Fisheries Research Institute
Research Institute
National Salmon Resources Center
Marine Fisheries Research and Development Center
National Center for Stock Enhancement


Fisheries Research Vessels
Hokko-maru
Soyo-maru
Shunyo-maru
Wakataka-maru
Yoko-maru
Tankai-maru
Mizuho-maru
Shirafuji-maru
Kotaka-maru
Taka-maru

職員数
Number of staff

・一般職	Administration	299
・研究職	Researcher	415
・技術職	Technician	7
・船舶職員	Vessel Crew	177
・調査技術職	Investigate Researcher	111
	Total	1009

The Three Pillars of the FRA's Research and Development

1. Research and Development for Securing the Stable Supply of Fishery Products
2. Research and Development for the Sound Development of Fisheries Industries, and the Safe and Highly Reliable Supply of Fishery Products
3. Basic and Advanced Research, Development and Monitoring that Serve as the Basis of Research and Development


The Three Pillars of the FRA's Research and Development
I. Research and Development for Securing the Stable Supply of Fishery Products
1. Fisheries Resources Management
2. Fisheries Stock Enhancement and Aquaculture
3. Conservation of the Fishing Ground Environment


The Three Pillars of the FRA's Research and Development
II. Research and Development for the Sound Development of Fisheries Industries, and the Safe and Highly Reliable Supply of Fishery Products
1. Stable Management of Fisheries Industries
2. Revitalization of the Local Fishery Community
3. Fishery Product Functions
4. Safe and Highly Reliable Supply of Fishery Products

FRA projects regarding environment of coastal areas

Introduction of Isoyake Recovery Guideline (Fisheries Agency, Japan)

National Research Institute of Fisheries Engineering

Incorporated Administrative Agency

Fisheries Research Agency

Hisami KUWAHARA

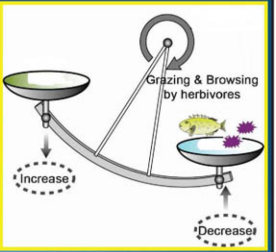
Main theme of this guideline

・In this guideline, we targeted on fishermen. Of course, we expect this guideline will be convenient for administrators, researchers, citizens and volunteer who have willingness to work with fishermen.

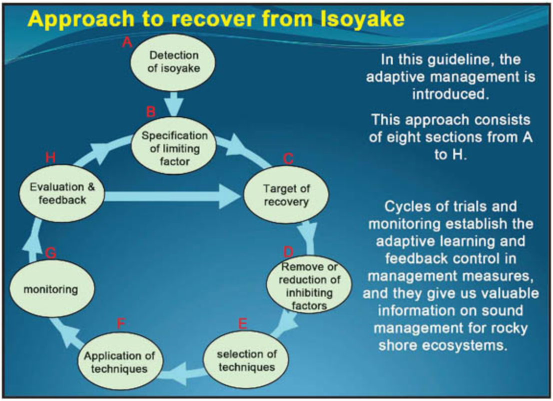
・Grazing on seaweeds by herbivores is greater than growth of seaweeds, the balance will incline clockwise leading to Isoyake.

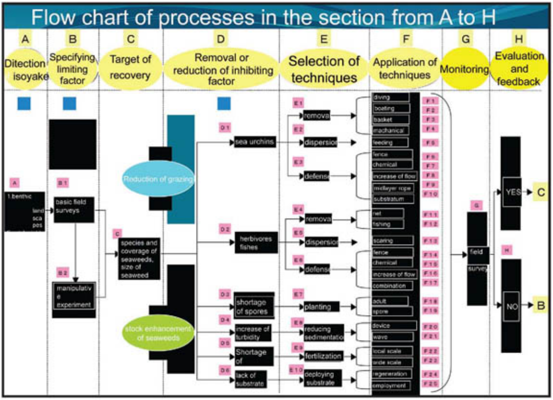
・The clockwise moving of the balance may be strengthened by other changes in backgrounds such as global warming and so on.

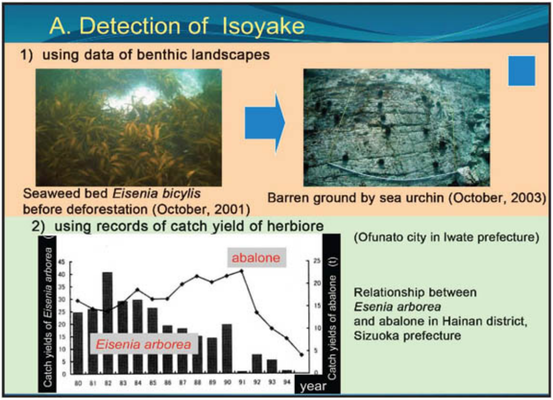
・Basic ideas of this guideline is to recover the balance by decreasing herbivores and by increasing

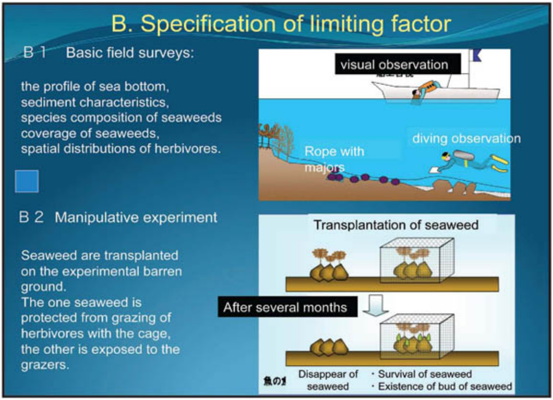


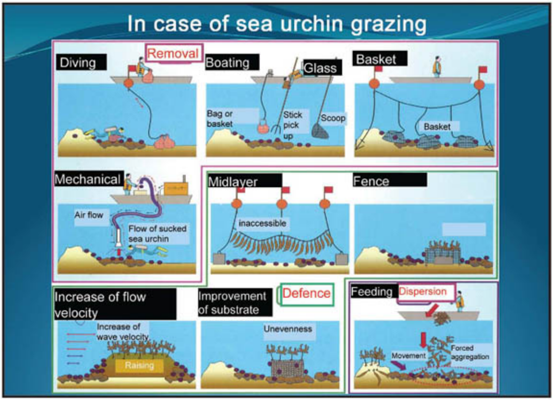
Situation of Isoyake in Japan.

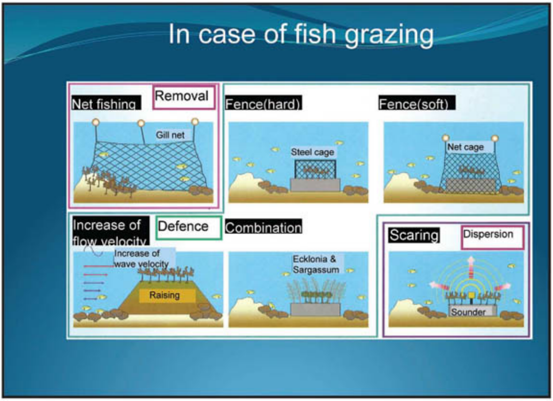

Approach to recover from Isoyake
A
Detection of isoyake
B
Specification of limiting factor
C
Target of recovery
D
Remove or reduction of inhibiting factors
E
selection of techniques
F
Application of techniques
G
monitoring
H
Evaluation & feedback
In this guideline, the adaptive management is introduced.
This approach consists of eight sections from A to H.
Cycles of trials and monitoring establish the adaptive learning and feedback control in management measures, and they give us valuable information on sound management for rocky shore ecosystems.

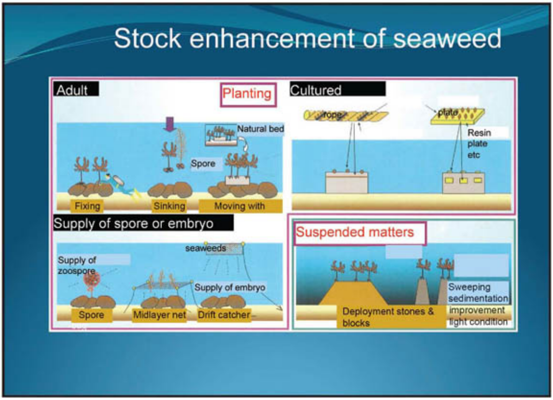

Flow chart of processes in the section from A to H
A
Ditection isoyake
B
Specifying limiting factor
C
Target of recovery
D
Removal or reduction of inhibiting factor
E
Selection of techniques
F
Application of techniques
G
Monitoring
H
Evaluation and feedback
1.benthic land sca pes
basic field surveys
manipulative experiment
species and coverage of seaweeds, size of seaweed
Reduction of grazing
stock enhancement of seaweeds
sea urchins
herbivores fishes
shortage of spores
increase of turbidity
Shortage of
lack of substrate
remova
dispersio
defens
planting
reducing sedimentatio
fertilization
deploying substrate
diving
boating
basket
mechanical
feeding
fence
chemical
increase of flow
midlayer rope
substratum
net
fishing
scaring
combination
adult
spore
device
wave
local scale
wide scale
regeneration
employment
field survey
YES
C
NO
B


A. Detection of Isoyake
1) using data of benthic landscapes
Seaweed bed Eisenia bicylis
before deforestation (October, 2001)
Barren ground by sea urchin (October, 2003)
2) using records of catch yield of herbiore
(Ofunato city in Iwate prefecture)
Catch yields of Eisenia arborea
abalone
Eisenia arborea
Catch yields of abalone (t)
year
Relationship between
Esenia arborea
and abalone in Hainan district,
Sizuoka prefecture


B. Specification of limiting factor
B 1 Basic field surveys:
the profile of sea bottom,
sediment characteristics,
species composition of seaweeds
coverage of seaweeds,
spatial distributions of herbivores.
visual observation
diving observation
Rope with
majors
B 2 Manipulative experiment
Seaweed are transplanted
on the experimental barren
ground.
The one seaweed is
protected from grazing of
herbivores with the cage,
the other is exposed to the
grazers.
Transplantation of seaweed
After several months
Disappear of
seaweed
· Survival of seaweed
· Existence of bud of seaweed

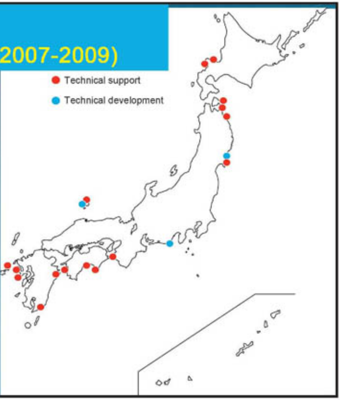

In case of sea urchin grazing
Diving
Removal
Boating
Glass
Basket
Bag or basket
Stick pick up
Scoop
Basket
Mechanical
Air flow
Flow of sucked sea urchin
Midlayer
inaccessible
Fence
Increase of flow velocity
Increase of wave velocity
Raising
Improvement of substrate
Defence
Unevenness
Feeding
Dispersion
Movement
Forced aggregation

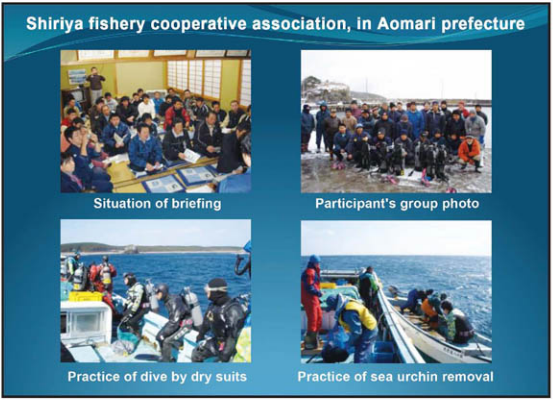

In case of fish grazing
Net fishing
Removal
Gill net
Fence(hard)
Steel cage
Fence(soft)
Net cage
Increase of flow velocity
Defence
Increase of wave velocity
Raising
Combination
Ecklonia & Sargassum
Scaring
Dispersion
Sounder

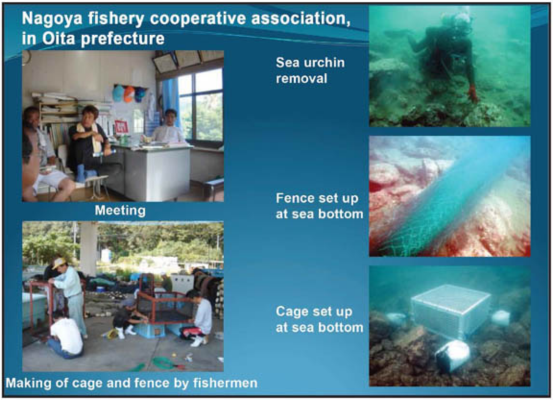


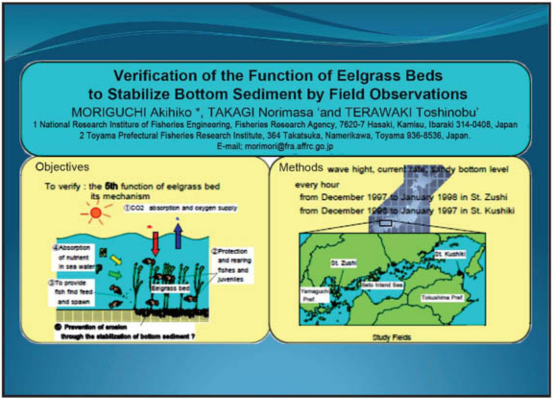
Actual project (Fishery Agency, 2007-2009)

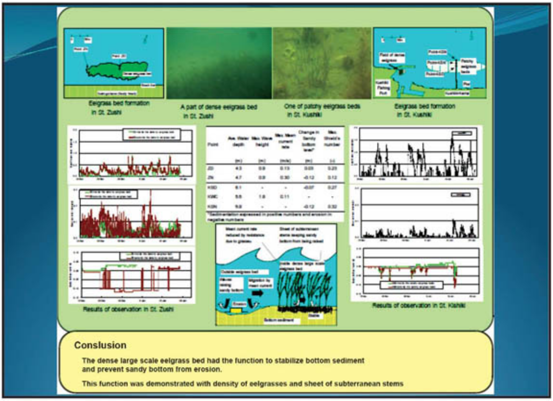
- The core of this activity is giving adequate technical supports to fishermen who are trying to start countermeasures for Isoyake.
- In each area, a local consultation group that was organized to decide the plan of measures for Isoyake. In this group, practitioners of local government, and scientific experts were included.
- We started new attempts that fishermen work together with people in other sectors such as citizens, university and high school students.




Shiriya fishery cooperative association, in Aomari prefecture
Situation of briefing
Participant's group photo
Practice of dive by dry suits
Practice of sea urchin removal


Nagoya fishery cooperative association, in Oita prefecture
Meeting
Making of cage and fence by fishermen
Sea urchin removal
Fence set up at sea bottom
Cage set up at sea bottom


Verification of the Function of Eelgrass Beds
to Stabilize Bottom Sediment by Field Observations
MORIGUCHI Akihiko *, TAKAGI Norimasa 'and TERAWAKI Toshinobu'
1 National Research Institute of Fisheries Engineering, Fisheries Research Agency, 7620-7 Hasaki, Kamisu, Ibaraki 314-0408, Japan
2 Toyama Prefectural Fisheries Research Institute, 364 Takatsuka, Namerikawa, Toyama 936-8536, Japan.
E-mail; morimori@fra.affrc.go.jp
Objectives
To verify : the 5th function of eelgrass bed
its mechanism
①CO2 absorption and oxygen supply
④Absorption of nutrient in sea water
②Protection and rearing fishes and juveniles
③To provide fish find feed and spawn
Eelgrass bed
⑤ Prevention of erosion through the stabilization of bottom sediment ?
Methods wave hight, current rate, sandy bottom level
every hour
from December 1997 to January 1998 in St. Zushi
from December 1996 to January 1997 in St. Kushiki
St. Zushi
St. Kushiki
Yamaguchi Pref.
Seto Inland Sea
Tokushima Pref.
Study Fields


Eelgrass bed formation in St. Zushi
A part of dense eelgrass bed in St. Zushi
One of patchy eelgrass beds in St. Kushiki
Eelgrass bed formation in St. Kushiki
Results of observation in St. Zushi
Results of observation in St. Kushiki
Conslusion
The dense large scale eelgrass bed had the function to stabilize bottom sediment and prevent sandy bottom from erosion.
This function was demonstrated with density of eelgrasses and sheet of subterranean stems

Isolation of a virus infectious to the harmful bloom causing microalga, Heterosigma akashiwo.

Development of a technique for eliminating *Heterocapsa circularisquama red tides by use of lytic viruses*

Dr. K. Nagasaki,
Harmuful Algae Control Section, Harmful Algal Bloom Division
National Research Institute of Fisheries and Environment of Inland Sea (FEIS)
FRA

http://feis.fra.affrc.go.jp/HABD/HACS/english/engmain.html

Development of Hydraulic and Primary Production Model for evaluating Ecosystem-Network in Large region

FRA
Fisheries Research Agency

Fisheries Reseach Agency
National research institute of fisheries engineering
National research institute of inland sea

Back ground and Plan

1. Coastal region – High Bio-Productivity, Important region for larvae and juveniles of many fishery resources
2. Environment and fisheries resources in coastal region getting worse,
3. Improvement, restoration and preservation of coastal environment for sustainable fisheries development
4. Needs for developing a basic model for evaluating physical and biological environment
5. Consideration of network on aquatic species which change the location of their habitat at their life stage
6. For developing an evaluation model, field surveys, numerical development have been carried on ,especially targeting the larvae stage of some kinds of important fisheries resources in open sea region and inland sea region.

Thank you for your attention.

FRA
Fisheries Research Agency

Environmental improvement around artificial reefs and their evaluation

～Workshop on Artificial Reefs for the Enhancement of Fishery Resources～
4 August, 2009

Akito SATO
Assistant Trust Fund Manager
SEAFDEC Secretariat

photos; Artificial reef, The Japanese Institute of Technology on Fishing Port, Ground and Communities (JIFIC)

1. Introduction

【 Definition of An Artificial Reefs 】

An artificial reefs is a submerged structure deliberately constructed or placed on the seabed to emulate some functions of a natural reef such as protecting, regenerating, concentrating, and/or enhancing populations of living marine resources.

Source: Guidelines for the Placement of Artificial Reefs (IMO/UNEP)

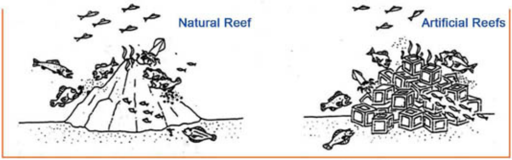


Fig. : Fisheries Agency of Japan

2. Environmental Improvement by Artificial Reefs

If artificial reefs are placed on sea beds, the biological environment on and around them would be enhanced through interactions among the schooling marine life.

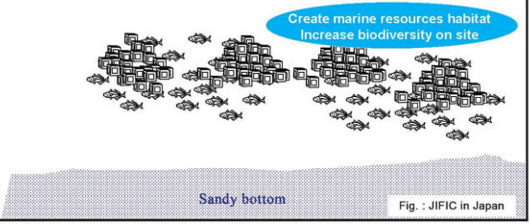


Fig. : JIFIC in Japan

2-1. Distribution of Marine Life around Artificial Reefs

(1) Plankton

Plankton swarms at the sheltered place of the artificial reefs under the current.

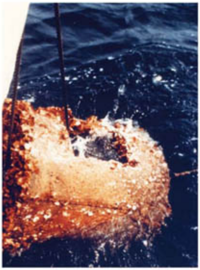
Copepods ; Depth;25m

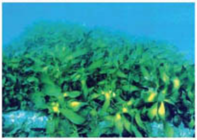
Mysidacea ; Depth 32m

photos : Artificial reef, JIFIC in Japan

(2) Periphytons

The sessile organisms, crustaceans and other periphytons that settled on artificial reefs differ depending on the environment of the site, the materials of artificial reefs, etc..





photos : Artificial reef, JIFIC in Japan

(3) Benthos

The change in distribution of Benthos around artificial reefs was strongly related to the change in sediment on the sea bottom.



Experiment of littoral current (left)
Sediment change by bottom flow (right).

photos : Artificial reef, JIFIC in Japan

2-2. Artificial reefs as living environment for marine resources

The functions that artificial reefs provide for marine resources such as fish and shellfish can be categorized into mainly following types:

1) **feeding grounds**
2) **spawning grounds**
3) **shelters and resting sites.**

(Background of these functions)

1) **Periphytons attached to artificial reefs feeding on the nutrient salts or suspended solid, etc, where they cannot be easily pulled off by waves and can effectively feed off of those nutrient salts (or SS) in the water.**
2) **Plankton swarms around artificial reefs in waters.**
3) **A various kind of benthos appear around artificial reefs.**

(Through an increase in biodiversity around artificial reefs, fish and other marine resources gather around artificial reefs, for feeding grounds where their prey can throng, as well as for hiding/resting sites, and spawning grounds.

sources : Hiroshi Kakimoto, JIFIC in Japan

(1) Function as Feeding Grounds

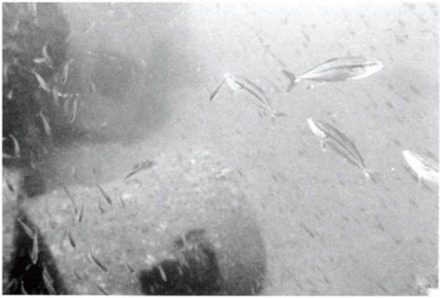
Black scraper, *Thammaconus modesutus* pecking attached animals on an artificial reefs

Common octopus, *Octopus vulgaris* catching Mysidacea around artificial reefs

Flatfish pecking benthos on sea beds around artificial reefs

School of Black spinefoot, *Siganus fuscecens* pecking attached marine life on an artificial reefs

photos : Artificial reef, JIFIC in Japan

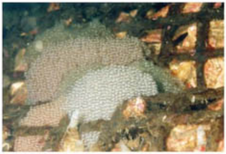


School of predators, *Seriola quinqueradiata* around artificial reefs and prey, young Horse-mackerel, *Trachurus trachurus*

photos : Artificial reef, JIFIC in Japan

(2) Function as Spawning Grounds

Adult Scopion fish, *Sebastiscus marmoratus* in a spawning season around an artificial reefs



Eggs of Greenling, *Hexagrammos otaki* on an artificial reefs

Common octopus, *Octopus vulgaris* and its eggs in an artificial reefs

Spawning and spawned eggs of Arrow squid, *Loligo bleekery* on artificial reefs

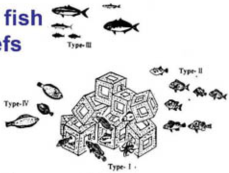
photos : Artificial reef, JIFIC in Japan

(3) Functions as shelters and resting sites

Young Red –spotted grouper *Epinephelus akaara* among narrow space of artificial reefs (upper-left)
A school of Cardinal fish *Apogon lineatus* in a hollow of artificial reefs (upper-right)
Black porgy *Acanthopagrus schlegelii* in a hollow of artificial reefs (lower-left)

photos : Artificial reef, JIFIC in Japan

2-3 Distribution Patterns of fish schools around artificial reefs



Type I: Species that bring a significant portion or certain parts of their body into contact with artificial reefs

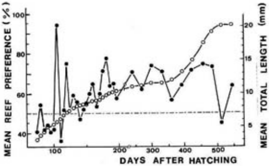
Type II: Species that rarely bring their body into contact with artificial reefs but position themselves very close to artificial reefs

Type III: Species that position themselves primarily in the surface to middle layers away from artificial reefs

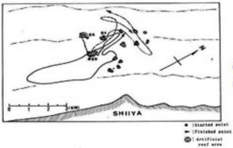
Type IV: Species that position themselves on the sea bottom near artificial reefs

photos : Artificial reef, JIFIC in Japan

2-4 Fish school behaviour around artificial reefs



Change of mean reef affinity of Black sea bream *(Acanthopagrus schelegeli)* with their growth



Three cases of daily migration of Bastard halibut around reefs for 40(B6), 60(B5), 65(B4) hours

sources and Fig.: Hiroshi Kakimoto, JIFIC in Japan

2-5 Summarized Evaluation of Artificial Reefs

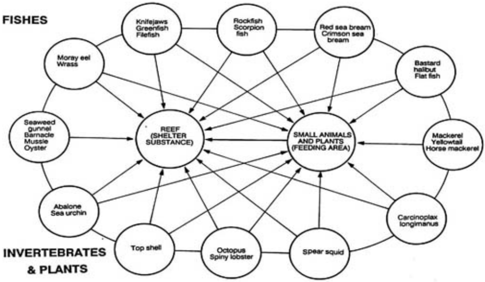


Fig. Schematic presentation of aggregating structure of animals and plants to artificial reefs

Fig.: Hiroshi Kakimoto, JIFIC in Japan

3. Guidelines for the Placement of Artificial Reefs (London Convention and Protocol / UNEP)

The "Guidelines for the placement of artificial reefs" by IMO/UNEP was adapted in the 30th LC & the 3rd LP Meeting in London, 27 – 31 October, 2008.

- **(purpose and scope)**
- **Although the guidelines have been developed within the context of the London Convention, they are not legally binding on any country, whether or not it has existing national regulations.**
- **The purpose of the Guidelines is to assist those countries that have recognised the need to assess proposals for the placement of artificial reefs on the basis of scientifically sound criteria, as well as to develop an appropriate regulatory framework; etc.**

Source ; Guidelines for the Placement of Artificial Reefs

3-1 Table of Contents

Source ; Guidelines for the Placement of Artificial Reefs

3-2 National/Local Policy, Legislation and Decision-making for the Construction/Placement of Artificial Reefs

The construction or placement of artificial reefs is still a relatively minor activity in many countries, and, in such cases, can probably be adequately regulated on the basis of existing ocean dumping legislation.
However, where the activity is sufficiently common to warrant a more specific and rigorous approach such as a regulatory framework,
it should ideally include:

-A formally adopted policy;

-Legislation to provide a basis for implementation of that policy;

-An institutional structure with the mandate and mechanisms to enable it to operationalise the policy and supporting legislation;

-Strategies and Action Plans or Operational Arrangements to facilitate the implementation of the policy and legislation.

Source ; Guidelines for the Placement of Artificial Reefs

3-3 TECHNICAL CRITERIA FOR THE ASSESSMENT OF ARTIFICIAL REEF PROJECTS
(1) General Criteria

- Legal criteria:

  The purpose of the proposed reef should be credible and compatible with government policy, national legislation and the international obligations of the country.

  an artificial reef comprising waste materials or previously used materials or structures – including obsolete vessels – should ensure that the use of the materials is consistent with the provisions of the London Convention and Protocol.

- Technical criteria:
  - Feasibility
  - Functionality
  - Environmental Compatibility
  - Durability and Stability
  - Suitability of proposed monitoring programs
  - Suitability of proposed dismantling arrangements

Source ; Guidelines for the Placement of Artificial Reefs

(2) Specific and Function Specific Criteria

These sections include a general description of the main elements to be considered for:

- **Design and Materials**

  The most important part of the artificial reef planning process is the design – including the selection of materials and the exact location and structure.

- **Location**

  The placement of any artificial reef should only be undertaken once there is a thorough understanding of the local environment, including waves and currents, sediment transport, the seabed, water and sediment quality, biological communities, and other beneficial uses.

- **Function specific criteria for:**
  - Reefs for enhancement of productivity and/or biodiversity.
  - Reefs for ecosystem/resource protection.
  - Reefs for leisure or recreational purposes.

Source ; Guidelines for the Placement of Artificial Reefs

Overview of materials and designs for artificial reefs MATERIALS

General Criteria:

- **Function:** *The selection of the appropriate materials is vital to ensure that an artificial reef meets its objectives.*

- **Environmental compatibility and durability:** *The materials used for the construction of an artificial reef should minimise risks to the environment and possible conflicts between users.*

  Stability: *The materials used to design an artificial reef should be sufficiently stable to the impact of waves and tidal currents, so that they are not tipped over, rolled or fractured.*

Source ; Guidelines for the Placement of Artificial Reefs

4. Japanese Regulations of Artificial Reefs

It is an urgent issue, in a sustainable manner with resource management, to enhance the marine environment and utilize fisheries resources. Artificial reefs have been placed in accordance with the regulations and technical standards issued in accordance with the Fishing Ports and Fishing Grounds Improvement Law enacted in 1950.

Fishing Ports and Fishing Grounds Improvement Law, 1950

↓

1) Basic Policy on Promotion of Fisheries Infrastructures, 2007

2) Regulations for the Evaluation of Fisheries Infrastructures Project, 1999.

3) Standards for Planning for the Improvement of Artificial Reefs, 2000.

4) Guidelines to Design Fishing Ports and Fishing Grounds, 2003.

5) Guidelines for the Artificial Reefs with Obsolete Ship and Vessels, 1982.

etc.

4-1. Basic Policy on Promotion of Fisheries Infrastructures, 2007

This basic policy shows basic matters to be considered for the planning, designing, construction and placement of the artificial reefs:

(a) Appropriate planning and designing by taking into account:
- Natural conditions
- Socioeconomic conditions
- Influence on the natural environment, fisheries activities, and living environment
- Accurate quality/sanitary management of fishery product
- Ecology of targeted living resources and current status of fisheries
- Effective usage and accurate management

(b) Harmonization with environment by taking into account:
- Improvement of fishing grounds with securing harmonization with the marine environment at the site and surrounding areas
- Restoration and enhancement of marine environment

4-2. Guidelines for Evaluation of Artificial Reef Projects

(a) **Evaluation before setting up the projects:**
- Necessity of placement
- Impact on the areas including the environment
- Consistency with political goals
- Promotion of fisheries for securing resource management and propagating and culturing
- Restoration and enhancement of environment
- Economic effects on the areas through cost/benefit analysis etc.

(b) **Evaluation during the construction:**
- Change of fisheries activities, environment and social situation in surrounding area
- Progress of projects
- Efforts for appropriate cost reduction etc.

(c) **Evaluation after the construction:**
- Achievement of project goal
- Management scheme
- Environmental impact
- Effect on socioeconomic factors etc.

4-3. Guidelines for applying the new-type structures"

This Guideline provides technical instructions for applying new-type structures for the improvement of the artificial reefs. ***The Guidelines require that , prior to execution of projects, small-scale studies should be undertaken to examine the following:***

(a) Negative scientific/physical impacts on living resources near the reefs

(b) Sufficient durability

(c) Narmonization with an effect to the fishery living organisms.

(d) Suitability of materials through solution testing

(e) Security of physical stability

(f) Safety during construction

Thank you for your attention.

Fishing Ground Environment Around Artificial Reefs in Malaysia

By

Ahmad Ali [1]
Mohamed Pauzi Abdullah[2]
Daud Awang[3]
Raja Bidin Raja Hassan[1]

SEAFDEC-MFRDMD [1],
FRI, Batu Maung, Penang[2],
FRI, Sarawak Branch[3]

Contents

INTRODUCTION

A few publication of coastal resource surveys off the coastal area of the Peninsular Malaysia conducted by FRI and SEAFDEC-MFRDMD

1. Pathansali, D., Ong, K.S., Latiff, S.S. and Carvalho, J., 1966. Preliminary Results of Trawling Investigations off Penang. Proc. Indo-Pacific Fish. Coun., 12 (11):181-201
2. Pathansali, D., Rauck, G., Jothy, A.A.,Mohd. Shaari b. S.A. Latiff and Curtin, T.B. 1974. Demersal Fish Resources in Malaysian Waters (Trawl Survey of the Coastal Waters off the East Coast of West Malaysia). Fisheries Bulletin 1:46 pp.
3. Lam, W.C., Weber, W., Lee, A.K., Ong, K.S. and Liong, P.C. 1975. Demersal Fish Resources in Malaysia Waters- 7. 3rd East Coast Trawl Survey off the East Coast of Peninsular Malaysia (14th August - 20th September, 1972).
4. A.A. Jothy, G. Rauck, Mohd. Shaari bin S.A.Latif, Ong Kah Sin, Liong Pit Chong and J.L. Carvalho, 1975. Demersal Fish Resources In Malaysian Waters. Second Trawl Survey of the Coastal Waters Off the East Coast of Peninsular Malaysia (March-May, 1971).
5. Mohammed Shaari, S.A.L., G.Rauck, Ong, K.S. and Tan S.P. 1974. Demersal Fish Resources in Malaysian Waters. 2nd Trawl Survey of the Coastal Waters off the West Coast of Peninsular Malaysia (12th December 1970 - 22nd January 1971. Fisheries Bulletin No.3: 41

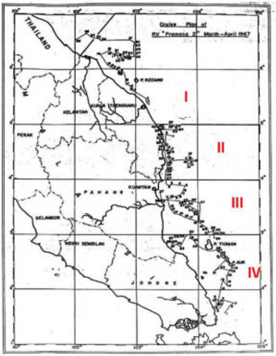


Figure 1. A cruise plan of the Thai-Malaysian-German joint trawling survey off the east coast of Malay Peninsula undertaken by "Pramong 2" from March 1 to April 11, 1967.

Cruise track of resource survey (1967)

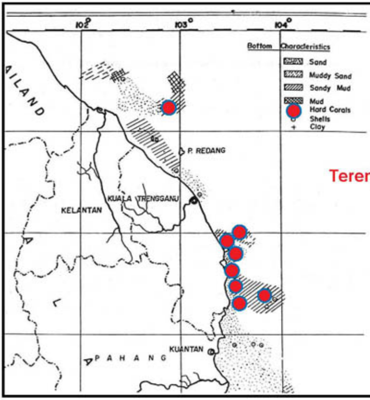
: Thai-Malaysia –German joint trawling survey off east coast of Peninsular Malaysia undertaken by "Pramong 2" from 1stMarch 11thApril 1967

Result of 1970 survey

- **Kelantan (Sub-Area I):** Predominantly of muddy sand with isolated patches of pure sand or clay. Isolated coral beds were also found in the deeper part of sub-area I. Gigantic cup sponges, *Potherion* sp abundant.

.....Result of 1970 survey

- **Terengganu (Sub-area II):** Muddy area in northern part, the rest is dominated by coral, both soft as well as hard. Wire coral available from depth 20-40 meter (occasional severe damage to the net)



Terengganu (1970)

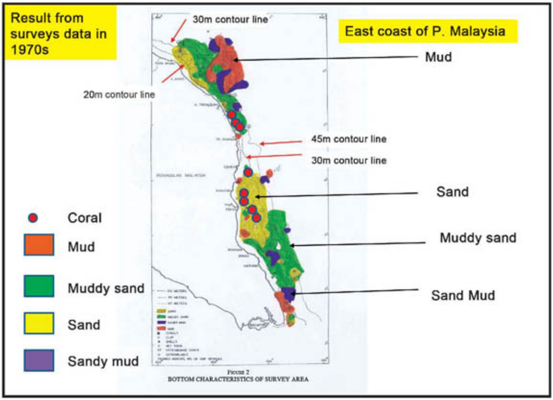
Result of 1970 survey

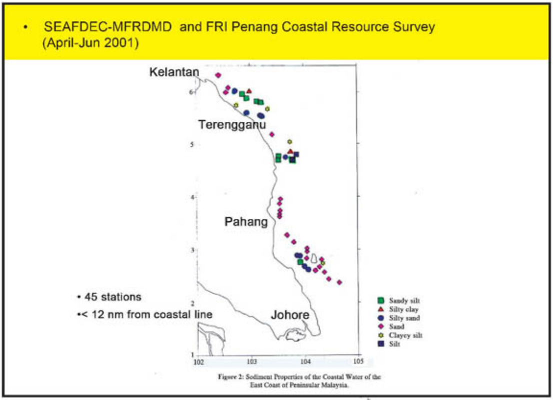
- **Pahang (Sub-area III).** The greatest part of Pahang is sandy with an extensive tract of muddy sand from Johor (sub area IV) bordering the southern edge. Isolated coral beds were also found in the deeper part of sub-area III (off Pekan).

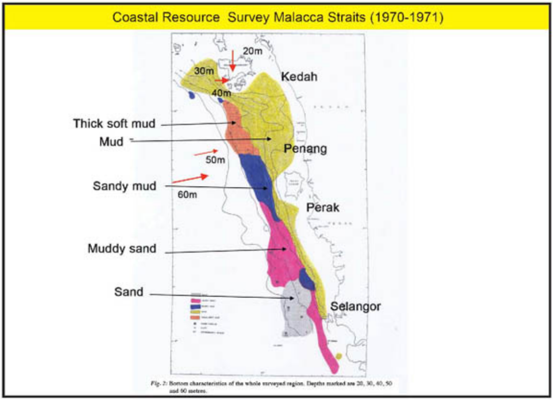
Result of 1970 survey

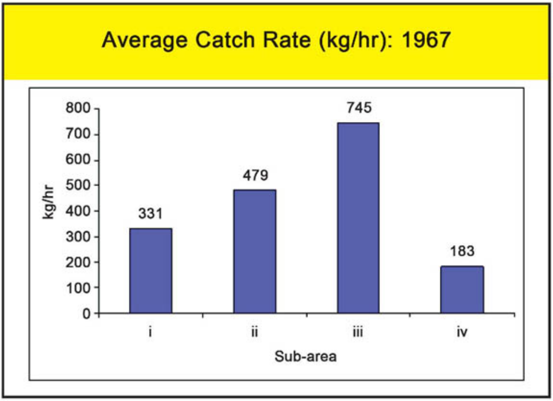
- **East Johor (Sub-Area IV).** Isolated coral beds were also found in the deeper part of sub-area IV (off Pulau Aur). Gigantic cup sponges, *Potherion* sp abundant.

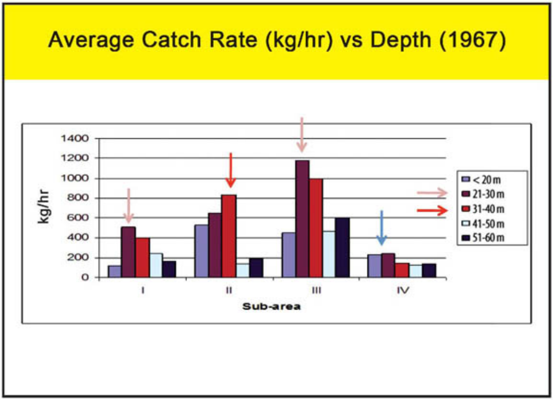
West coast of P. Malaysia: mostly muddy area □

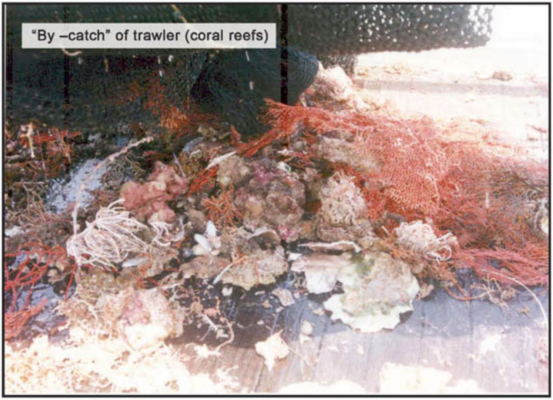

Result from surveys data in 1970s
East coast of P. Malaysia
30m contour line
20m contour line
45m contour line
30m contour line
Mud
Sand
Muddy sand
Sand Mud
Coral
Mud
Muddy sand
Sand
Sandy mud
FIGURE 2
BOTTOM CHARACTERISTICS OF SURVEY AREA


• SEAFDEC-MFRDMD and FRI Penang Coastal Resource Survey (April-Jun 2001)
Kelantan
Terengganu
Pahang
Johore
• 45 stations
•< 12 nm from coastal line
Sandy silt
Silty clay
Silty sand
Sand
Clayey silt
Silt
102
103
104
105
Figure 2: Sediment Properties of the Coastal Water of the East Coast of Peninsular Malaysia.

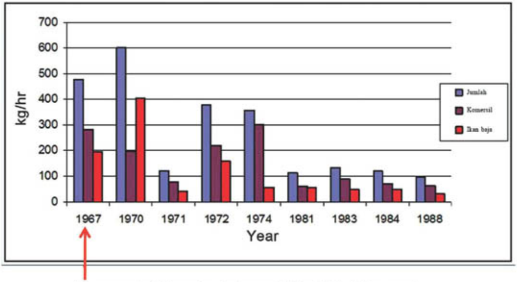

Coastal Resource Survey Malacca Straits (1970-1971)
20m
30m
40m
50m
60m
Kedah
Thick soft mud
Mud
Penang
Sandy mud
Perak
Muddy sand
Sand
Selangor
Fig. 2: Bottom characteristics of the whole surveyed region. Depths marked are 20, 30, 40, 50 and 60 metres.


Average Catch Rate (kg/hr): 1967
kg/hr
800
700
600
500
400
300
200
100
0
331
479
745
183
i
ii
iii
iv
Sub-area


Average Catch Rate (kg/hr) vs Depth (1967)
1400
1200
1000
800
600
400
200
0
kg/hr
I
II
III
IV
Sub-area
< 20 m
21-30 m
31-40 m
41-50 m
51-60 m


"By –catch" of trawler (coral reefs)

Average Catch Rate: East Coast of P. Malaysia (kg/hr from1967-1988). Source DoF Malaysia



1st survey (collaboration between Malaysia/Thai/Germany)

Destruction of Flora by Trawlers

- Quotations from Fisheries Bulletin No 1. Publish in 1974, (Demersal fish resources in Malaysia waters; Trawl survey of the coastal waters off the east coast of West Malaysia)
- .....the trawl net was either damaged by hard corals or entangled with flexible, curly, "wire-like" corals which were extremely difficult to remove
- Other than the corals, the gigantic cup sponges, *Potherion* sp were a hindrance to trawling. They were present in depths ranging from 14 meters to 56 meters. In Sub Area-1 (Kelantan) and IV (East Johore), where they were especially abundance, there were hauls in which catches comprised entirely of these sponges. .....
- .....However, the giant cup sponges, which were recorded in a number of places, **would be a hindrances to trawling in the initial stage of development but with continued trawling there is a possibility that they will be reduced in numbers, as happened in the Gulf of Thailand** *(page 44, 1st paragraph,*

Focus of SEAFDEC-MFRDMD Activities on ARs During the Ninth Malaysia Plan (2006-2010)

- R&D on the ARs design, construction and deployment of big size ARs
- Site selection studies (To find the most suitable sites to deploy difference design of ARs)
- Monitoring activity mainly focus on fish behavior, biodiversity of flora and fauna, stability of ARs after deployment as well as habitat protection
- Up-grade the ARs design from time to time based on information from fish behavior studies

LOCATION OF ARs

Status of ARs sites from 2006- August 2009

Federal Government :	24 sites
State Government of Terengganu :	5 sites
State Government of Sabah:	3 sites
Total:	32 sites

Lobster ARs

Soft bottom ARs

Tetrapod ARs

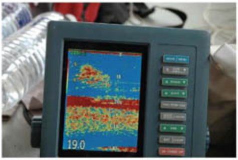
Cuboid ARs

SITE SELECTION

1. Smith Mc Intyre Grab

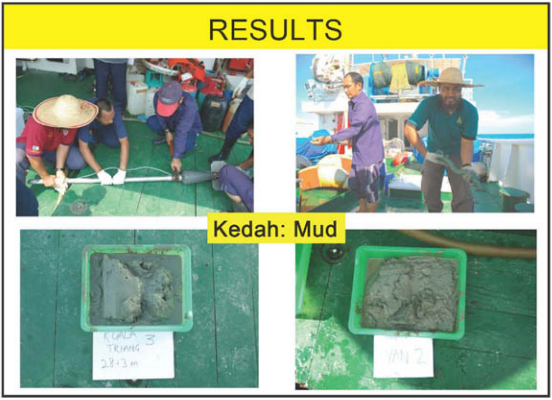
2. Phleger Corer

3. SCUBA



4. Echo sounder

5. Side-scan sonar (for State of Terengganu only)


RESULTS
Kedah: Mud


Selangor: Mud and sand

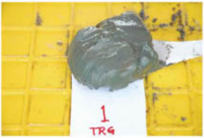
(Hard bottom: Coarse and medium sand)
Marang Terengganu

Medium sand

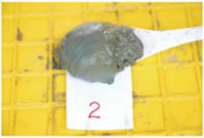
Medium sand

Coarse sand

(Mud)
Besut



Mud



Mud

Mud

Mud

(Medium sand and muddy sand)
Setiu

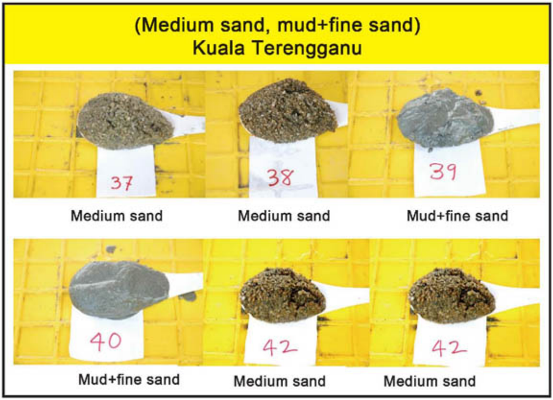
Medium sand

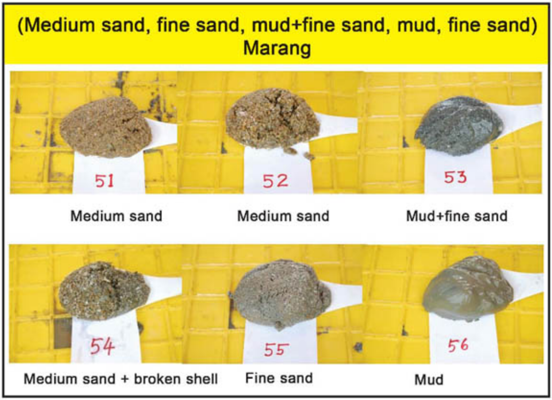
Medium sand

Medium sand

Medium sand

Muddy sand


(Medium sand, mud+fine sand)
Kuala Terengganu
37
38
39
Medium sand
Medium sand
Mud+fine sand
40
42
42
Mud+fine sand
Medium sand
Medium sand


(Medium sand, fine sand, mud+fine sand, mud, fine sand)
Marang
51
52
53
Medium sand
Medium sand
Mud+fine sand
54
55
56
Medium sand + broken shell
Fine sand
Mud

Dungun

Medium sand

Muddy sand

Fine sand+shell

Medium sand + shell

Medium sand+ shell

Medium sand

Kemaman

Medium sand

Medium sand+mud

Medium sand+mud

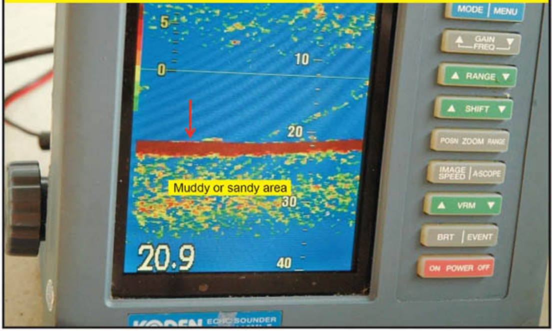
Mud

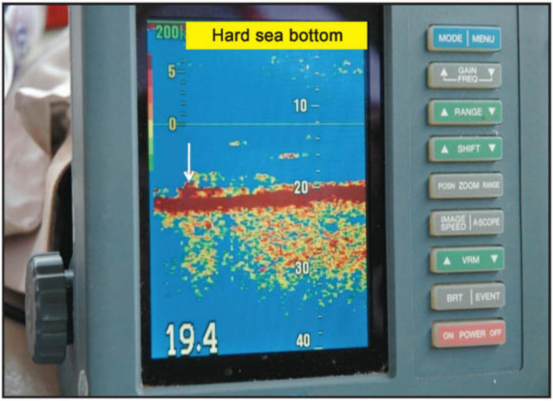
Medium sand+ shell

Medium sand+mud

(Hard sea bottom)
Federal Territory Labuan

Contour of sea bottom from Echo sounder image




Hard sea bottom
200k
5
10
0
20
30
19.4
40
MODE MENU
GAIN FREQ
RANGE
SHIFT
POSN ZOOM RANGE
IMAGE SPEED A-SCOPE
VRM
BRT EVENT
ON POWER OFF

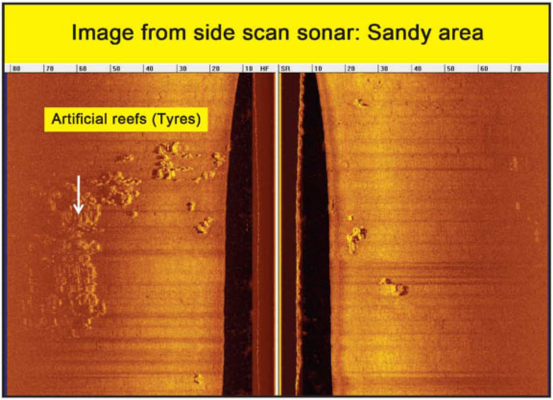


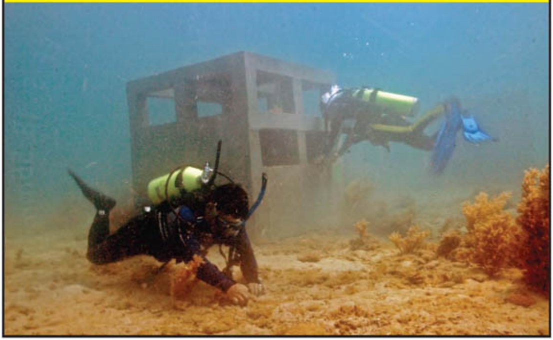
Image from side scan sonar: Sandy area
Artificial reefs (Tyres)

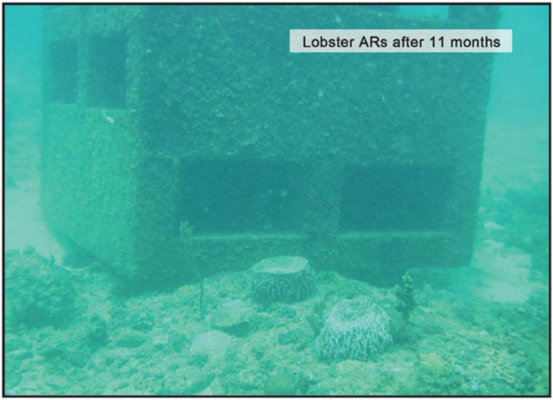
We also conducted benthos study to collect baseline information of sea bottom before deployment of ARs

Monitoring of ARs Stability After Deployment

- Monitoring by scuba diving and echo sounder
- Almost all cuboid, lobster and tetrapod ARs modules deployed on hard sea bottom maintained the position until now (August 2009; after 2 years of deployment)
- Some modules slanted (during deployment) but had maintained the position until now (after 2 years)
- Soft bottom ARs sunk between 50-90 cm during placement process and had maintained the position until now (after 2 years)

Monitoring of Lobster ARs: I[st] day after deployment





Monitoring of Soft Bottom ARs

Image of soft bottom ARs on echo-sounder screen after deployment. Only 60 cm was submerged

Monitoring by SCUBA
(Soft bottom ARs near Payar Island)

Adult snappers around soft bottom ARs. This picture was taken 18 months after deployment

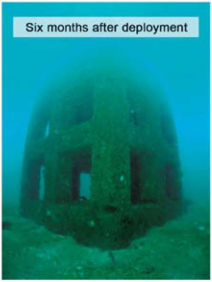
Cuboid ARs

Snappers and juvenile groupers near Cuboid ARs placed on sandy area

Snappers

11 months after deployment

Juvernile groupers



Sweetlips near Cuboid ARs placed on sandy area

Pictures taken 11 months after deployment

Flora and fauna recorded near the cuboid ARs deployed on the sandy area at Kuala Terengganu. These pictures were taken between 1- 2 years after deployment

Flora and Fauna

Pearl oysters

11 months after deployment

Nudibranch

24 months after deployment

Flora and Fauna

11 months after deployment

Echinoderm grazing on the ARs module

Sea fern Hydroids participating in enriching the newly created habitat

Flora and Fauna

11 months after deployment

Murex Shell, *Chicoreus ramosus*

Bushy gorgonions flourishing on the AR modules

Conclusion

- Large size artificial reefs could be used as mitigation of habitat damaged by unfriendly fishing gears
- Development of ARs as natural habitat for most tropical fish species is faster for ARs deployed on the sandy area compared with those on the muddy area
- The present design of large size ARs are suitable for most of tropical fish species to aggregate, as nursery ground, for hiding, visiting as well as breeding
- R&D and monitoring activities should be continued to gain more information for further development of ARs program in Malaysia.

Note: Camouflaged stingray on this slide ! It took advantage of the presence of ARs to ambush upon prey. Here it is safe from trawlers. We hope it can survive to produce its generations of offsprings.

Evaluation of Artificial Reefs in Malaysia

By
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Ahmad bin Ali[2]
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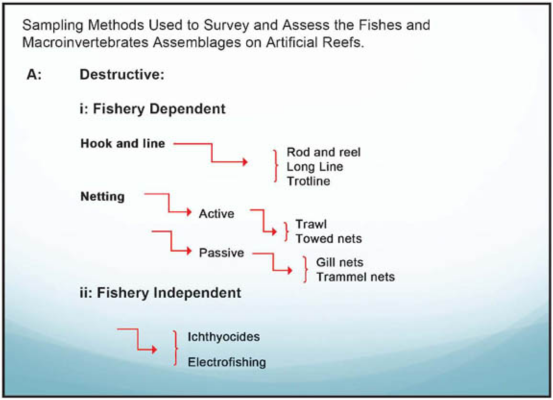
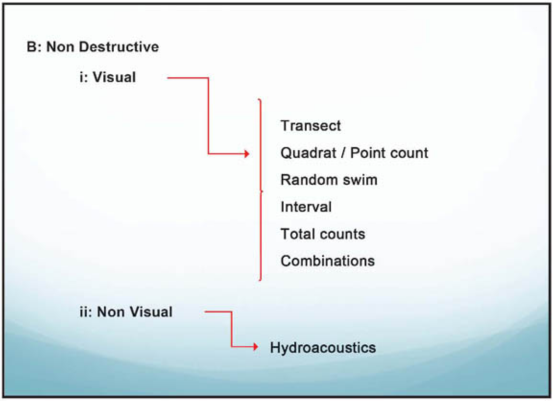
2. SEAFDEC-MFRDMD, Kuala Terengganu, Terengganu
3. Fisheries Research Institute, Sarawak, Branch, Kuching

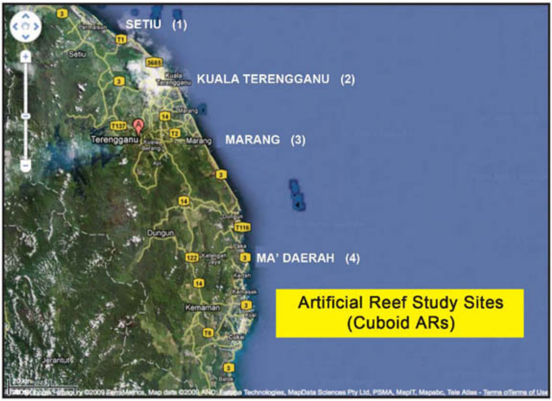
Introduction

There are several methods of evaluating artificial reefs with respect to fish and macro-invertebrates. The Book titled *Artificial Reef Evaluation with Application to Natural Marine Habitats,* Edited by William Seaman Jr. (2000) outlined the methods as being divided into two categories. That is destructive and non destructive.


Sampling Methods Used to Survey and Assess the Fishes and Macroinvertebrates Assemblages on Artificial Reefs.
A: Destructive:
i: Fishery Dependent
Hook and line
Rod and reel
Long Line
Trotline
Netting
Active
Trawl
Towed nets
Passive
Gill nets
Trammel nets
ii: Fishery Independent
Ichthyocides
Electrofishing


B: Non Destructive
i: Visual
Transect
Quadrat / Point count
Random swim
Interval
Total counts
Combinations
ii: Non Visual
Hydroacoustics

We opted for non destructive method in evaluating the artificial reefs. Whereby we involved SCUBA divers to film and take pictures of the ARs, fishes and macro-invertebrates.



CUBOIDS ARs (This project was funded by the State Government of Terengganu)

Specification

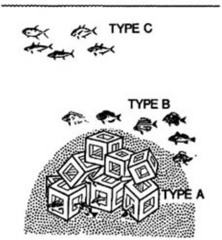
- 2.0 m x 2.0 m x 3.0 m (height)
- Total weigh: about 10 metric tonnes
- Thickness of column: 25 cm
- Thickness of floor: 25 cm
- Thickness of basement: 30 cm
- Concrete mixture: Grade 40

Placement of cuboid ARs at Kuala Terengganu

Three Categories of Target Species for Large Artificial Reefs

- Type A. Resident Species. In physical contact with the reefs most of the time.
- Type B. Visiting species and have some physical contact with the reef.
- Type C. Visiting species and do not have much physical contact with the reef and most of the time hovering in the eddies area.

For example, given a current speed of 5 cm/sec (0.5 kn), the width B of a structural member should be at least 20 cm in order to trigger vortex shedding.



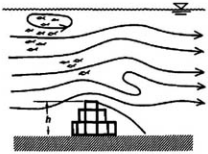


Figure 3. (Left) Three fish types according to their respective positions to the reef.

Figure 4. (Right) Schematic showing the formation of lee wave in the presence of an obstacle in a continuously stratified slow-moving current.

Makoto Nakamura 1985

Lutjanus lutjanus

These lutjanids are small sized visitors which come in a big group. However their larger siblings often come in smaller numbers.

Crab

Crabs are by virtue predators but they are themselves vulnerable during molting stage of their life cycle. Molting crabs often do find ARs as good refuge. Crabs are example of Type A species inhabiting ARs and mostly in physical in contact with the man made reef.

Lutjanus sebae

Type B visitors which often exercise physical contact with the AR modules.

Carangids

Type C visitors which normally seldom physically in contact with the AR modules but rather choose to hover some distance away.

CUBOID ARTIFICIAL REEFS

Estimation of fish density/ARs module, 11 months after deployment at Setiu

Species	Range (tail)	Estimated Mean Weight/tail (gram)	Mean weight / ARs (kg)	Mean Count/ ARs (tails)	Market Price/kg (RM)
Portunus sp (Crab)	0-2	200	0.2	1	12.00
Lutjanus lutjanus	300-700	50	10	500	5.00
Plectorhincus flavomaculatus	2-8	400	2	5	14.00
Epinephelus spp	2-4	500	1.5	3	25.00
Lutjannus russelli	1-4	500	1	2	14.00
Chiloscyllium griseum	0-4	500	1	2	5.00
Siganus spp.	2-8	200	0.8	4	6.00
Total			16.5 kg/ ARs	517tails	

CUBOID ARTIFICIAL REEFS

Estimation of fish density/ARs module, 5 months after deployment at Kuala Terengganu

Species	Range (tail)	Estimated Mean Weight / tail (gram)	Mean Weight / ARs (kg)	Mean Count/ ARs (tail)	Market Price/kg (RM)
Portunus sp. (Crab)	1-3	200	0.3	2	12.00
Lutjanus lutjanus	200-500	40	3	300	5.00
Epinephelus spp	30-60	40	1.8	45	25.00 (big fish)
Arothron stellatus	1-4	150		2	*
Coral Fishes	10-25	10		15	*
		Total Fish Weight/AR	5.1 kg/AR	364 tails/ AR	
					* Not priced

CUBOID ARTIFICIAL REEFS

Estimation of fish density/ARs module 11 months after deployment at Kuala Terengganu

Species	Range (tail)	Estimated Mean Weight/tail (gram)	Mean Weight/ARs (kg)	Mean Count/ ARs (tail)	Market Price/kg (RM)
Portunus sp.(Crab)	0-2	150	0.15	1	12.00
Lutjanus lutjanus	800-2000	50	50	1000	5.00
Plectorhincus flavomaculatus	20-60	400	16	40	14.00
Lutjanus sebae	2-4	600	1.8k	3	14.00
Epinephelus spp	3-9	500	2.5	5	25.00
Carangoides spp.	50-100	200	16	80	10.00
Lutjanus russeli	1-3	600	1.2	2	14.00
Atule mate	500-1000	120	8.4	700	6.00
Siganus guttatus	5-10	80	0.64	8	6.00
		TOTAL	96.7 kg/ARs	1839 Tails/ ARs	

SIMPSON'S DIVERSITY INDEX (D)

$$D = \frac{\sum n(n-1)}{N(N-1)}$$

Where:

- D = diversity index
- N = Total number of organisms of all species found
- n = number of individuals of a particular species

SIMPSON'S DIVERSITY INDEX (D)

(11 months after deployment at Setiu)

Species	Numbers (n)	n(n-1)
Portunus sp.(Crab)	2	2
Lutjanus lutjanus	700	489300
Plectorhincus flavomaculatus	8	56
Chiloscyllium griseum	4	12
Epinephelus spp	4	12
Siganus spp	8	56
Lutjanus johnii	4	12
Total	N=730	4894450
D= 0.9197249		

SIMPSON'S DIVERSITY INDEX (D)

5 months after deployment at Kuala Terengganu

Species	Numbers (n)	n(n-1)
Portunus sp.(Crab)	3	6
Lutjanus lutjanus	500	249500
Epinephalus spp	60	3540
Arothron stellatus	4	12
Coral Fishes	25	600
TOTAL	N = 592	253658
D = 0.725002286551		

SIMPSON'S DIVERSITY INDEX (D)

11 months after deployment at Kuala Terengganu

Species	Numbers (n)	n(n-1)
Portunus sp.(Crab)	2	2
Snappers (Lutjanus lutjanus)	2000	3998000
Sweetlips (Plectorhincus flavomaculatus)	60	3540
Lutjanus sebae	4	12
Groupers (*Epinephelus* spp)	9	72
Carangoides spp	100	9900
Lutjanusruselli	3	6
Atule mate	1000	999000
Siganus guttatus	10	90
Total	N=3188	5010622
D= 0.49316388		

Grouper *(Epinephelus* spp)


Groupers have been observed as the earliest territorial species that patronize newly emplaced structures underwater.

Groupers *(Epinephelus* spp)

These groupers will soon grow to high market value marine produce. Their numbers and the length of time they inhabit any artificial reefs complex may also be an indicator of the success of the man made sunken structures.

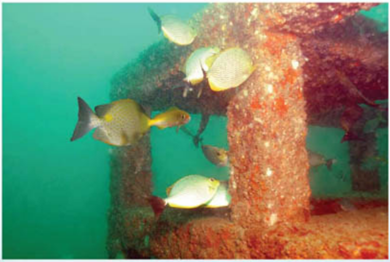
Snapper *Lutjanus ruselli*

The actual dimension of the window in the artificial reef modules has been made narrower by the growth of marine organisms such as oysters and soft corals. Almost imitating the natural habitat preferred by snappers.

Sweetlips, *Plectorhinchus flavomaculatus*

Artificial reef modules emplaced on the sea bottom must not only attract marine life such as these fishes but must also be able to provide them with food organisms. Artificial reefs that are properly sited may contribute to the growth of planktons by altering current flow which in turn causes upwelling and churning up of nutrients required for the propagation on marine plankton.

Rabbitfish *Siganus* spp



Rabbitfishes are grazers and they love biting off budding polyps of corals and other juveniles of encrusting organisms growing on the artificial reef modules. Their presence in numbers can be a rough guide of how the artificial reef is faring in providing them with their delicacies.

Atule mate

Visiting pelagic species often find AR modules as a place to hover and play with the resultant eddies caused by the obstruction of the flowing current.

Pteria sp

The free swimming larvae of these oysters found the AR modules as a suitable substrate to colonize and a base upon which they soon propagate a packed family.

Coral fishes

Cardinal fishes, *Apogon* spp. known to feed on small fishes and crustaceans.

School of damselfishes, *Neopomacentrus cyanomus* and snappers, *Lutjanus lutjanus*.

Conclusion

Material (concrete)	**OK**
Large size ARs	OK
Present design	Need more R&D especially for lobster, squid and cuttlefish

A successful artificial reefs, as put forward by Professor Emeritus Hiroshi Kakimoto is the one that allow marine organisms to "swim through but cannot see through".

ARPOS (Artificial Reef Position System): A Web Based GIS Visualization System for Managing the Artificial Reefs

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Abstract:

New challenges and requirements for the management of artificial reefs data require improved data integration and data sharing. The aim of this paper is to developed a web based artificial reefs management system which is called Artificial Reef Positioning System (ARPOS). The ARPOS Virtual Database consists of a framework for advanced Web based retrieval, analysis, and visualization of spatially related to the artificial reefs distribution data based on the integration of distributed data repositories. This paper described in detail the architectures design of implementing such a web based services on the internet using spatial data mapping. The spatial data mapping used 3-tier architecture specifically to perform context-aware queries and updating the spatial datasets.This situation can provide an aware assistance to web-based users by presenting the right information at the right time, place, and situation using context-associated knowledge. The visualization of the artificial reefs distribution had been done by using Autodesk MapGuide viewer software tools. It can collect and analyze artificial reefs positioning using GIS information consisting of longitude and latitude data. ARPOS can be used in client-server mode, where the interactive client interface can be downloading as a map viewer. Web-based accessibility of the reefs information is becoming important for a timely decision making on the next artificial reefs positioning and distribution. Proper tracking and maintenance activities for the existing artificial reefs are required for their sustainability. ARPOS is particularly suited for Web-based analysis and publication of geo-referenced statistical data. The functionality and user interface of ARPOS is illustrated by some example applications of the population distribution of artificial reefs. The development of this system were based on an open source technology like apache, PHP and MySQL database system.

Keywords: GIS, Internet Mapping, Visualization, Statistical information.

1. Introduction

Understanding the spatial distribution of data from phenomena that occur in space constitute today a great challenge to the elucidation of central questions in many areas of knowledge, be it in agriculture, fisheries, health, environment, geology, among many others. Such studies are becoming more and more common, due to the availability of low cost Geographic Information System (GIS) with user-friendly interfaces. These systems allow the spatial visualization of variables such as photographic identification information (Wong et. al. 2002), quality of life indexes or company sales in a region using maps. To achieve that it is enough to have a database and a geographic base (like a map of the municipalities), and the GIS is capable of presenting a colored map that allows the visualization of the spatial pattern of the phenomenon.

ARPOS Development is Web based application combine with GIS viewing technique. The Web is the most far-reaching and extensive medium of personal exchange to appear on Earth. It has probably allowed many of its users to interact with many more groups of people, dispersed around the planet in time and space, than is possible when limited by physical contact or even when limited by every other existing medium of communication combined. Because the Web is global in scale, some have suggested that it will nurture mutual understanding on a global scale. By definition or by necessity, the Web has such a massive potential for social exchange, it has the potential to nurture empathy and symbiosis, but it also has the potential to incite belligerence on a global scale, or even to empower demagogues and repressive regimes in ways that were historically impossible to achieve.

The development of Artificial Reef Positioning System (ARPOS) is an idea to helps the fisheries managers and industries to gains a quick information retrieval and analysis of the current situation of each individual artificial reef that have been deployed. As the deploying of artificial reef involved a highly cost project and the development of artificial reef to be effective as a fish aggregating devices required a long period of time, the data based should be managed and monitor continuously. Moreover, the project sometimes involved different interest parties and the need of data sharing and integration are solely needed. The main objectives of this studies are to collect and analyze the data requirements needed by the fisheries bodies, to design the Total Spatial Information system on Artificial Reefs positioning system, and to develop a prototype of Spatial Information System on Artificial Reefs positioning System.

2. Problem Statement of Artificial Reefs and GIS Positioning System

Fisheries management is continually frustrated by the lack, or poor quality of critical data which remain an obstacle for meaningful advances in fisheries management. There is a number of aspects to the problem. Poor quality of historic data in many fisheries monitoring program around the world. Much energy is wasted and important opportunities lost because of the uncertainty surrounding crucial historic data. For example, there are typically many factors related to the development and successful of living resources surrounding the artificial reef, to catch-per-unit-effort data, a key index of trends in resource abundance, which are not recorded, and hence cannot be incoperated into statistical analysis. The other problem, include the viewing a location for Artificial Reefs which is crucial to fisheries managers for conservation, monitoring the catch data and species distribution. Current system however does not seem to give a complete information needed by fisheries authorities. The invention of Spatial Information system that can visualize the location in a form of map via online that can help fisheries authorities to locate the Artificial Reefs distribution on their specific area based on longitude and latitudes (Coordinate Data) had been derived . The current system could not display the exact location of Artificial Reefs in term of mapping system, do not have the automatic mechanism to update the Artificial Reefs distribution, unable to access through the online that consist of the timely manner which can suspend the entire decision making on the next Artificial Reefs positioning and distribution and do not have the proper tracking and maintenances activities for the existing Artificial Reefs.

We limit our prototype to displayed and managed the Artificial Reef for the East Coast of Peninsular Malaysia waters. The location viewer is capable of navigating and also selecting the map and shows all information that referred to the Artificial Reef at the selected location. Therefore, developing a location viewer to display a depiction is significant since there is a need to have a system that can help fisheries authorities to managed the distribution of Artificial Reef implementation.

3. ARPOS Design and Methodology

The ARPOS architecture was designed to help the fisheries authority to manage the location of the artificial reefs and related activities. This software consists of the several modules for the fisheries authority staff to insert, deleted, update and modify all the artificial reefs distribution based on longitude and latitude of the artificial reefs. The artificial reef will automatically update through the online application and also automatically display in real time in the mapping by user Autodesk Map Guide software as shown in Figure 1.

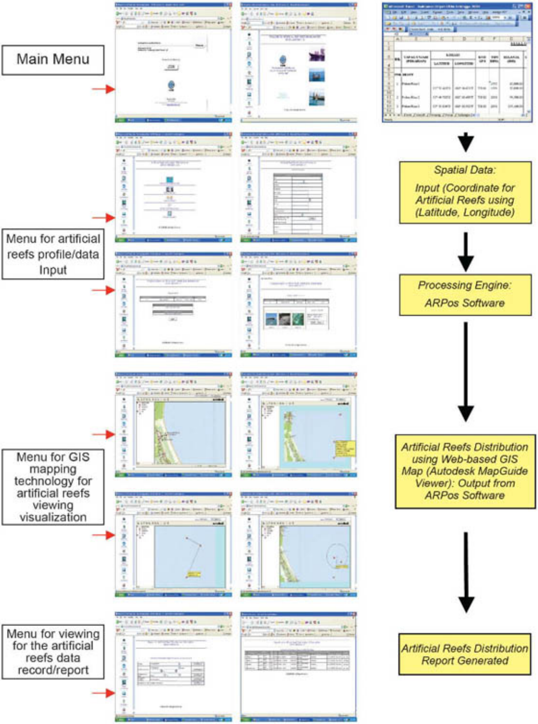

Figure 1: User Interfaces and Process flow for ARPOS Virtual Database System

From the viewing screen of the mapping areas, this software is able to calculate and display the distance between one artificial reef to other artificial reef and can display the radius in order to calculate the area of the artificial reefs via this online software. Zooming technique in this software is a very useful procedure for the fisheries authority to modify and updating the information concerning the individual artificial reefs. Input data on artificial reefs includes the position (longitude and latitude), type of artificial reefs, number of artificial reefs, current status, and owner of the artificial reefs, date developed and other. By using this application, all the information will appear on screen display using the Autodesk MapGuide viewer plug-ins.

3.1 Knowledge Acquisition and Data Analysis

The knowledge acquisition and data analysis were based on two main sources which were classified as the primary data and the secondary data. The primary data consisting of the map and data on the Artificial Reef implementation from fisheries authorities. In data analysis phase, the collected data are analyzed in order to align with the scope of the research. This phase will summarized all data gathered and divided them into various categories based on its similarities and priorities. During this phase, the data needs on this ARPOS system will be verified. The data used in the ARPOS are based on the interviews done on specific topic from the artificial reef authorities at the East Cost of Peninsular Malaysia waters. The result of the findings on the analyzed data will be further used in modeling the knowledge gained.

3.2 Knowledge Modeling and Representation

In this phase, the knowledge gained is modeled into understandable steps to be easily presented. Using the gained data, the spatial information is modeled and appropriate data are being selected for the spatial database. It's important to model the suit data on the spatial database application in order to make sure the application that are being produced are accurately presented the actual position on the real implementation. It is so as it is significant to illustrate concepts and identifying the entities, attributes, attributes domain and others. There are several steps in modeling a database design process. The first step is to identify the conceptual data types, relationship and constraints for ER model. Then, map conceptual model to logical data model. In knowledge representation, the conceptual and logical data model has been designed to represent the knowledge in an illustrative way. This includes the designing of conceptual model. The conceptual model is mapped to the logical data model for relational diagram. The representation involves in the form of ER diagram, relational schema and supporting documents. Each logical model is validated using the technique of normalization to ensure that the model is structurally consistent, logical and has minimal redundancy.

3.3 Design and Implementation of Prototype

Figure 2 shows the methodology used to developed the prototype for demonstrating the spatial information system design on ARPOS. In designing the prototype, all requirements needed are identified. This phase described the desired features and operations in detail, including screen layouts, business rules, pseudo code and other documentations.

At this phase, the real code were written and all the requirements of the technical stuff of the development are being used. For example the language that will be used are PHP and it is integrated with the Map Guide® Autodesk application to present the maps with the help of the Spatial Database Management System (SDBMS) such as MySQL database. The complete prototype were implemented and run through specified configuration and evaluated thoroughly with respect to the requirements defined at the early phase of prototyping. The prototype were installed on suitable platform under a rapid development environment.

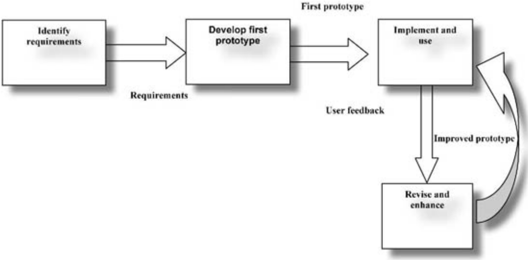

Figure 2: Algorithms used to developed the ARPOS (Artificial Reef Positioning System) software prototype

3.4 Digital Map and Projection of Coordinate System

The maps that are available were not in a form of a digitized format. The digitizing of the map were done by using the GIS software tools such as Arc View GIS and Map Info software in order to produce the maps with the projection of its geo-referencing system. The type of the geo-referencing is the projection of latitude and longitude coordinate system. The type of the geo-referencing system must be compatible with the map in order to produce the accurate position of the distribution of Artificial Reefs.

3.4.1 Data Analysis and GIS Modeling

The data collected were analyzed to suit the research scope. Before all data could be finalized, it will be studied, summarized and divided into several categories based on its similarities and importance. Through the information gained from data collection, the tabulation of GIS method and model are being produced. These refer to the existing implemented of the GIS application in the fisheries activities. The model and method is referred as a framework to the GIS system. The existing model and method may be referred as model to this system development. The spatial analysis were done in order to produce geographic information using existing information and to enhanced the spatial structure or relationship between geographic information. All data related to the Artificial Reef and its geographic information were being identified and classified. The results on the findings of analyzed data will further be used in modeling the knowledge gained.

The analysis were combined with the statistical information stored in the relational database and will be embedded with the spatial data. This combination of data will provide a powerful analysis that represents the distribution of Artificial Reefs. In other hands, if the statistical data have changed, the spatial data that viewed the location of Artificial Reefs also change regards to the changes of data in the statistical data the stored in the database system. This will allow the system to represent the real data and analysis base on the real time information. Table 1 shows the sample of statistical spatial data analysis on Artificial Reefs distribution.

Table 1: Data of Artificial Reefs Distribution

No	Waters	Location		GPS Code	Year Build	Cost	Financial Source	Type	Fisherman/Founder Information				Status
		Latitude	Longitude						Name	Address	Tel No	Boat No	
1	Jambu Bongkok	5°50.423'	102°36.671'	de45	2006	230000	MTD	SERAMIC	MAMAT BIN MAT HASSAN	KG TEBAUK	019678543	TF 5674	ACTIVE
2	Gong Balai	5°49.733'	102°38.695'	123	2006	12	no	KUBOID	ROSLAN MUDA	kg laut	09876542	TAF 6564	ACTIVE
3	sungai tong	5°50.056'	102°38.93'	TB03	2001	179100	IHSAN	KUBOID	MAMAT BIN MAT HASSAN	KG TEBAUK	019678543	TF 5674	ACCEPTED

3.4.2 Global Positioning System Code Conversion

Global Positioning System (GPS) helps us to find exactly location on the surface of the earth. GPS gives position in terms of longitude and latitude coordinate. The longitude and latitude coordinate system are use widely in position or location finding. The GPS unit uses information from a series orbiting 20,200 km above earth. The geographical longitude indicates the angle between the plane of the reference (Prime or Greenwich) meridian and the meridian passing through a point of interest. The geographical latitude is the angle between the normal to the ellipsoid passing through the point of interest and the Equatorial plane (Figure 3). In other words, geographical longitude and latitude represent angular measures of a position on the Earth's surface. A longitude (E or W) defines east-west position with respect to the prime meridian (000 - 180°), while a latitude (N or S) indicates north south position with respect to the equator (00 - 90°) .

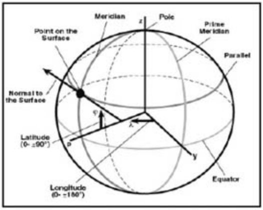

Figure 3: Definition of Geographical Latitude and Longitude

GPS normally used longitude and latitude coordinate system that represent the location in decimal degree and minutes. However the Autodesk MapGuide Server only recognizes the coordinate system in term of decimal degree. In order to make the coordinate workable with the Autodesk MapGuide Server, the conversion has been done from the current decimal degree and minutes coordinate into decimal degree coordinate. The algorithm or formula use in the conversion process is as shown below:.

To convert Decimal degree and minutes to decimal degree;

Example;

$$39° 59.98' = (1.0 \times 39) + (59.98 \div 60)$$
$$= 39 + 0.99967$$
$$= \underline{39.99967}$$

To convert from decimal degree to decimal degree and minutes

$$39.99967 = 39° \text{ and } (0.99967 \times 60)'$$
$$= \underline{39° 59.98'}$$

4. Visualizing the Location of Artificial Reefs

The location of Artificial Reef distribution of Malaysian waters and their related information can be managed and viewed by using the Artificial Reef Positioning System (ARPOS). The ARPOS prototype relies on typical three-tier architecture for enterprise information systems, composed of the client layer, application server layer, and the database layer. This architecture focuses the load on the application server layer of the system, allowing for a thin client necessary context. All communications between the client layer and the database are conducted through the application server layer. With this type of architecture, the processing load is balanced, as each tier of the system resides on a separate computer (Figure 4). Also, this architecture allows for the development of individual components of the system separately, thus maintaining component independence. In this way, different parts of the system can be developed at different stages; some more than others, without affecting the entire system each time a change needs to be made. For example, this architecture has proven ideal for developing Hypertext Preprocessor (PHP), Extensible Markup Language (XML) based applications because all PHP and XML processing is carried out on the middle tier of the system, without affecting client and/or database tier manipulation/development.

Figure 4: Tree-tier Architecture that involved in developing the prototype for ARPOS software

4.1 Client Layer

The client layer of the system consists of a web-based, data-editing tool to provide the officers/user with capabilities to edit and annotate the data in the system. Delivery of data to the client is one of the core aspects of the project. For desktop web-based access, the content delivery is not affected by bandwidth restrictions. In a client-side Internet GIS application, client-side applications require users to install a complete client application. In either case client-side application require software of some kind (other than browser) to be transferred to the user. In client-side Internet GIS, the client is enhanced to support GIS operations. To implement client-side solutions of any kind, software must be transferred to the client. The primary advantages of client-side solutions are the abilities to enhance user interfaces, improve performance and implement solutions using vector data. Client-side solutions can be implemented with all the features and capabilities allowed by a modern graphical user interface (GUI).

4.2 Application Server Layer

In a server-side Internet GIS application, a Web browser is used to generate server requests and display the results. An Internet GIS server usually combines a standard Web (HTTP) server and a GIS application server, and the GIS databases and functionality reside completely on the server(s). A server-side GIS application can be illustrated by a mapping application on any of the major Internet portals. Users type in the address they are looking for (the request), which is transferred to a Web server. The Web server passes the request to a GIS application server, which runs an address matching routine, generates a map graphic, convert the graphic to Web format, wraps the image in HTML and sends it back to the Web server, which then returns the response to the client as a standard Web page. This is an advantage for simplified application development, deployment and maintenance of data. In server-side Internet GIS, usually the application requires proprietary software and the software stay on the server. Map data transmitted to a Web client are in standard HTML formats that can be access through any Web browser, creating significant positive implications for performance, reliability and size of user base.

The application server layer of ARPOS is responsible for formulating all spatial queries, inserts and updates to the system and acts as the main hub between the client and database. The Autodesk MapGuide LiteView servlet accepts HTTP requests for raster images through the Java Servlet API interface of a Web Server is illustrated in Figure 5. To fulfill a request for a raster image, Autodesk MapGuide LiteView will accepts an HTTP request for a raster image of a portion of an MWF file, load the requested MWF file, Zooms to the correct location and scale, generating HTTP requests for a map-layer data to the Autodesk MapGuide Server and returns a raster image in PNG or JPEG format as the HTTP response.

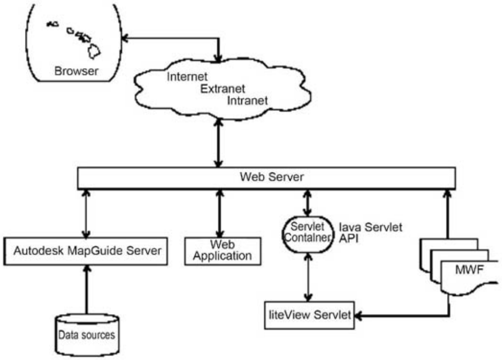

Figure 5: Application Architecture for developing the ARPOS software

4.3 Database Layer

The spatial database layer is responsible for processing all queries, both spatial and transectional, in the system. The Autodesk MapGuide LiteView were used in the system that includes SDO, a spatial extension to SQL or MySQL to developed the software. This database introduces new spatial data capabilities, e.g. geo-coding and topological queries. This tier stores all spatial and non-spatial data including raster (map) data and any metadata as well as the topological properties of these data. Spatial data types can be inserted, stored, manipulated and queried in the database as they are represented in physical space.

5. Conclusion

The Internet Mapping application were able to guide the fisheries authorities to assessed the individual position of previous artificial reefs that have been deployed with all their physical, biological, economical and statistical information. Developing a user friendly and functional application is usually a continuous effort. Though the web-based application discussed in this paper requires maintenance for its long-term operation, improvement o the functionality implemented is expected. A quick glance of all the available information on Artificial Reefs positioning and distribution will provide an understanding of potential use of GIS in Artificial Reefs Positioning and researcher can use the spatial data on presenting information instead of using relational databases.

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