Proceedings of

The 2nd Regional Workshop on Enhancing Coastal Resources : Artificial reefs in Southeast Asia

9-12 November 2004, SEAFDEC/TD, Samut Prakan, Thailand

SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER
TRAINING DEPARTMENT

PROCEEDINGS OF THE 2 nd REGIONAL WORKSHOP ON ENHANCING COASTAL RESOURCES : ARTIFICIAL REEFS IN SOUTHEAST ASIA

9 - 12 NOVEMBER, 2004

THAILAND

Organized by
Training Department (TD)
Southeast Asian Fisheries Development Center (SEAFDEC)

in Collaboration with
The Government of Japan
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FOREWORD

As was determined at the 1st Regional Workshop in 2004 the decline in coastal fishery resources has continued but the provision of alternative habitats and marine protected areas are showing promising results.

At this, the 2nd Regional Workshop the member country representative reports indicated that while the work is proceeding there are areas where little or no progress has been made for various reasons including a lack of technology and that of no financial support. In the areas where the work has proceeded the reports and stock assessments after the various proving periods show an increase in abundance of stock and a marked reduction in illegal fishing activities, particularly in the presence of artificial reefs. The use of various waste products of everyday life ashore as artificial reefs indicated a difference of opinion where old car and truck tyres were used. The general opinion of the workshop suggested that they could be a liability rather than an asset as the tyres can cause toxicity in the long term. Concrete pipes show some promise as alternative habitats and glass fibre structures attract new coral growth and soon become excellent reefs in their own right. The meeting was also advised that while the provision of artificial structures are viable the formulation of good fisheries policies by national and local authorities was also essential.

The content of this workshop not only serves to highlight the general understanding of coastal fisheries operation it also serves to highlight the separation of coastal fisheries operation from marines fisheries operation more profoundly. Although the two studies are inextricably linked through recruitment, the fundamental studies greatly differ. The methods by which success or failure can be measured are also in doubt in terms of quantitative assessment of resources and species, what goes on beneath the water surface is very much out of sight, but can never be out of mind. The use of questionnaires and fisherman surveys is equally a doubtful starter as, at least locally, it is known where the individual fishermen fishes, if he discloses his actual catch this might well encourage competition.

The need for concerted fisheries policies was also clear during this workshop, it the regional problems in fisheries are to be solved there must be clear-cut guidelines as to permissible methods of stock enhancement and fishing.

In closing these few words on this workshop and it gives me the greatest pleasure to congratulate the presenters on their presentations and to offer my sincere thanks to all that have taken part and made their contributions to this workshop.

Niwes Ruangpanit
SEAFDEC Secretary-General and
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Report of the Workshop

REPORT OF THE REGIONAL WORKSHOP ON ARTIFICIAL REEFS IN SOUTHEAST ASIA

SEAFDEC/TD, Samut Prakan, Thailand
9–12 November 2004

I. INTRODUCTION

1. The workshop is pursuant to the last meeting on Enhancing Coastal Resources: Artificial Reefs, Fishing Gear Design and Construction and Marine Protected Areas. However, this workshop focuses more on Artificial Reefs in Southeast Asia.

2. The workshop on Artificial reefs in Southeast Asia was organized by SEAFDEC, Training Department from 9th-12th November 2004, at Samutprakan, Thailand.

3. The workshop was attended by representatives from Southeast Asian countries, namely: Brunei Darussalam, Cambodia, Malaysia, The Philippines, Singapore, Thailand and Vietnam, it was also attended by resource persons from Japan, SEAFDEC/ Secretariat, TD, MFRDMD, AQD and other international organizations. The list of participants appears as Appendix A.

4. The objectives of the Workshop were to review the existing regional and national programs/projects related to artificial reefs and to discuss artificial reef issues. Also to promote the establishment of a technical support group to work as resource persons/coordinators on the issues related to artificial reefs, to evaluate, promote and encourage the use of artificial reefs for coastal resources enhancement in the light of the environment and to work in close cooperation with Southeast Asian member countries through technical assistance in research and development programs for artificial reefs.

II. OPENING OF THE WORKSHOP

5. Mr. Niwes Ruangpanit welcomed the participants to the workshop and highlighted the aspects of responsible fishing technologies and practices concept in which resource enhancement is a major component in providing alternative habitats. He briefly outlined the objectives of the workshop, and then declared the Workshop open. His opening statement appears as Appendix B.

6. The agenda for the Workshop was adopted and is appended to this report as Appendix C.

III. INTRODUCTION OF THE PROJECT PROPOSAL BY SEAFDEC/TD

7. Dr. Yuttana T., the project leader, introduced the background and objectives of the project. He then pointed out the recommendations of the last workshop held at SEAFDEC/TD, between 30th September – 3rd October 2003. Dr. Yuttana further proposed the resource enhancement program for the year 2004 that will focus on experiments for the design of the artificial reefs/fish shelters for particular species, that will be set up in the waters of Prathew, Thailand.

IV. REVIEW ON SEAFDEC ACTIVITIES RELATIVE TO ARTIFICIAL REEFS

8. Dr. Yuttana T. presented the past activities and results from the artificial reefs project sites including; environmental survey studies (like benthos, fish larvae, phytoplankton, zooplankton and water current measurements), Fishing operation surveys

(operation of fish traps, squid traps, bottom gill nets, collapsible crab traps). He then concluded that the artificial reefs could induce many fish species both pelagic and demersal to feed and stay around the project site. The duration of 3 months was considered too short to make an evaluation at the moment. He further explained that project site selection is under the departmental program and should be made in collaboration with other proposed programs in Chumporn province. Mr. Aussane gave some additional comments that the installation was at the community's request, to serve the purpose of making a barrier against the illegal fishing gear and operations (EP 01).

9. Discussion

The discussion on the opening points reported a decrease in the size of fish seen during the 2nd trip of the survey, but that detailed data should be collected to give further information. The number of species and length should be included with this data for further comparison. Another way to solve this problem is by making use of artificial reefs as barriers against illegal fishing gear, like trawling for example.

V. REVIEW WORK ON THE CURRENT SITUATION OF ARTIFICIAL REEF ISSUES IN THE SOUTHEAST ASIAN REGION

5.1. Brunei Darussalam

10. Mr. Idris Haji Abd. Hamid, the representative from Brunei gave an introduction and listed the objectives for the artificial reef project in Brunei that focused on the concrete design, use for protection and as a barrier against illegal fishing gear. He further explained the size and design of the ARs and the impact of the reefs on the ecosystem. He concluded that the triangular pyramid type is suitable for the deeper water areas (CP 01).

5.2. Cambodia

11. Mr. Prum Sitha gave information on the current situation and evolution of coral reefs in Cambodia. Artificial reefs in Cambodia were first implemented in 2003, and is still in the preparation stages, the project objective is to use ARs in the protection of the coastal areas and also to enhance the biodiversity of the area. He also mentioned that there are some ongoing activities to attempt at fresh water species enhancement by putting rock and tree trunks in the Great Lakes (CP 02).

5.3. Malaysia

12. Mr. Zaidnuddin I. gave the background and introduction of the artificial reefs deployment in Malaysia. He highlighted the objectives and types of artificial reef used and mentioned that the coral reefs in his country can be divided into 2 groups; one is less than 40 feet of water depth and the other group is more than 40 feet. He then concluded that the ARs leads to an increase in fish stock and a decrease in illegal encroachment, however some points need to be considered like suitable site selection, design of ARs etc. (CP 03).

Discussion

a) The terminology of Artificial Reefs must be clearly defined
b) The study on the comparison of the type of artificial reefs is good and can be used as a sample case study for other areas as an information base.
c) MPAs can greatly enhance the coastal resources in terms of bio-density and diversity.
d) The impact and effect of using tyres as artificial reefs need to be carefully taken in the consideration, otherwise the reef will be useless and become a problem for the environment in the future.

5.4. Myanmar

13. Mr. Han Win introduced the present situation of Marine Fisheries Resources, Conservation and rehabilitation of resources. The Artificial Reefs and/or MPAs in Myanmar have not been established yet because of a lack of technology and financial support (CP 04).

5.5. The Philippines

14. Mr. Pierre Easter L. Velasco presented an overview of the factors attributed to the destruction of coral reefs and the status of the Philippines marine resources including the need to establish Artificial Reefs. He also presented the coral garden and rehabilitation project and components that are carried out by BFAR, the components are on the site selection and the design of Artificial Reefs, The establishment of Marine Reserves, the monitoring of the project was done after 9 months of the AR installation. He concluded that the concrete artificial reef module was most effective in terms of fish abundance per unit volume (CP 05).

5.6. Singapore

15. Mr. L. M. Chou introduced the study of the Artificial reefs program in Singapore using different kinds of materials like tyres, concrete, fiber-glass, and also different constructions, he highlighted that from the survey observation and data collection it was apparent that there is an increase in density, and abundance of aquatic species (both juvenile and adult) around the Artificial Reefs, thus enhancing the resources in the areas of ARs. The experiments on using fiberglass had the result that after 4 months the hard coral settled on them (success in coral recruitment).
Tyres can cause toxicity in the long term of utilization and also can become a waste and pollutant of the sea if they become loose from the main module (CP 06).

5.7. Thailand

16. Mr. Suchat Sangchan presented an evaluation of artificial reefs in Phang nga bay, he mentioned the objectives and methodologies of the program and concluded that 2 years after the Artificial Reef construction there was an increase in aquatic resources (CP 07).

17. Mr. Amnaj Siripech, presented the work on the Artificial Reef installations in the Southern of Gulf of Thailand project that is under the Royal Initiation of Her Majesty the Queen. The materials used for the construction of the ARs are used goods wagons, concrete blocks, concrete pipes. He concluded that the ARs are useful for fish school aggregation (CP 08).

5.8. Vietnam

18. Mr. Nguyen Quang Hung, presented the coastal resources situation in Vietnam and pointed out the current situation of resource enhancement and artificial reefs. ARs are recognized to play very important role in resource enhancement but progress is very slow. He highlighted that the resource protection and fisheries policies are major tasks for the sustainable development of marine fisheries (CP 09).

VI. POTENTIAL AND CONSIDERATION OF ARTIFICIAL REEFS FOR RESOURCE ENHANCEMENT

6.1. Case study from Japan

19. Mr. Yasushi Ito gave a presentation on the introduction of the artificial reef, its use and function, then presented two case studies of Artificial Reefs in shallow and deep waters. He concluded that both ARs in shallow and deep waters play very important roles in increasing the habitat and food-web for the bio-organism around them and serve as a tool for the proper management of marine organisms (EP 02).

6.2. Artificial Reefs; a rewarding attempt?

20. Dr. Jurgenne H. P. resource person from AQD presented a case study of the project in Malalison on an MPA in which some artificial reefs were deployed inside the area. She mentioned that the project is very successful in the fisheries aspects especially in increasing fish diversity and density. She highlighted that Artificial Reefs are effective tools to enhance the marine environment (EP 03).

6.3. Information collection for the evaluation of artificial reefs

21. Mr. Ahmad Ali the resource person from MFRDMD presented that the information collection for the evaluation of artificial reefs is considered to be an important process to monitor the effectiveness of the Artificial Reefs after deployment. The information that should be collected are the biological, geological, oceanographic, engineering, and socio-economic information (EP 04).

22. Discussion. In the case of the effectiveness of AR monitoring, it should be considered on using the simple and cheap methods, aside from diving and using under water cameras, it also can be used some questionnaires to ask and gather information from the fishermen around that area.

6.4. Fish Visual Census Technique

23. Mr. Ukkrit Satapoomin mentioned that the ARs have been used for Coastal Resource Management, but the limited understanding of the biology and ecological effects of ARs is still a problem for use as a tool for management. He then described the visual census techniques using belt-transects and experimental plots for the predetermination the biomass of fish around the ARs, including the advantages and disadvantages of the techniques. He also presented the sample design for reef-fish surveys in the Andaman and Coastal Resource Rehabilitation projects in Pattani and Nararhiwat provinces (EP 05)

6.5. Investigation onthe biological aspects

24. Dr. Hansa Chansang described the objectives for Artificial Reef construction, biological evaluations of the Artificial Reefs for visual purposes including the common topics for monitoring, qualitative surveys, quantitative surveys, some factors to be considered for choosing methods for assessment like manpower, budget, time, then she mentioned about the ARs for coral reef restoration. She gave some recommendations that at present we need to consider and focus also on the research activities in terms of understanding more on the whole environment and those will be useful tools in an information database for future management in the region (EP 06).

6.6. Investigation on the fishing operation aspects

25. Dr. Mala Supongpan briefly presented the background of ARs installation, considering points for ARs installation as materials used and design and site selection etc. She described the steps to implement ARs in Thailand. Then she presented the types of fishing gear commonly used in ARs areas, fish species caught, data collection for research work to understand the ecology and environment surrounding the ARs, ARs in the function of enhancing activities and the community based fishery management approach after the installation (EP 07).

VII. CONSIDERATIONS FOR DEVELOPING ARTIFICIAL REEF GUIDELINES FOR THE REGION

Working Group Sessions:

1. Investigation guidelines for artificial reefs from the biological aspect
2. Investigation guidelines for artificial reefs in the fishing operation and socio-economic aspects

VIII. CONCLUSIONS AND RECOMMENDATIONS FOR THE PREPARATION OF DRAFT GUIDELINES FOR ARTIFICIAL REEFS FOR THE SOUTHEAST ASIAN REGION

8.1 Introduction (TD's responsibility)

8.2 General Principles Objectives: (TD's responsibility)

8.3 Definition of the Terminology

ARs "Any man made structure placed in a water body to provide shelter, habitat or breeding areas (for aquatic organisms) which at the same time have an effect to exclude some fishing operation from the area"

- Resource Enhancement
- Stakeholder (excluding government, local government involvement must be considered)
- Indicators
- Fishing Effort

8.4 Guidelines for Artificial Reef

Installation Review of the current situation of Artificial Reefs in Southeast Asia

Design (including arrangement the number of modules) and construction of ARs Materials Used for ARs, (Used tyres as a material of ARs should be carefully investigated by TD.)

Transport and deployment Location and Environment

- Guidelines for ARs installation should not only reflect member countries status but include any technique innovation and conclusions to effectively promote future ARs installations
- (It is a strongly suggested that the experience and know how of marine engineering for the installation of ARs especially on a muddy bottom and in the deeper areas should be enhanced through cooperation with appropriate Japanese technical institutions)
- (Concern on the use of toxic material of ARs or toxic substances derived from the used material should be avoided in ARs installations)

8.5 Guidelines for Artificial Reefs operation and maintenance

8.6 Guidelines for Artificial Reefs Evaluation (The Guidelines will be developed by objectives)

1. Evaluation on the Biological Aspect

- The benefit of the ARs should not be limited to fisheries but should include the restoration of habitat and ecosystem functions
- Fisheries management is a critical factor for the successful implementation of ARs. Quantitative data is necessary for fisheries management
- Periodic and the standardized sampling of fisheries resources should be conducted to assess the impact of ARs for aquatic and fisheries resources.
- Biological indicators can be used based upon the respective objectives of ARs to assess the impact of ARs on both fishery resources and the ecosystem.
- A biological research program should be conducted. It is important to include the following topics: community structures (species composition, food-web, stomach content of target species), replenishment of juveniles, epifauna succession, seasonal variation of commercial fishery resources.
- Sampling protocols for the evaluation and monitoring of the impact of ARs should be identified based upon the objective(s) of the ARs development program.
- Simplified survey methodology can be conducted by stakeholders, which contribute to the research activities undertaken by government researchers/ institutions to understand the impact of ARs on fisheries and ecosystems.
- Visual Census Technique (VCT) should be conducted to evaluate the biological status in AR areas and the methodology can be simplified for fishers to conduct such surveys.

Purpose	Evaluation/Success indicators	Sampling protocol
Restore degraded habitats	Increase in species diversity/complexity	Biological /ecological, physical, chemical, water quality parameters.
Increase fishery production	Spawning and nursery ground, target commercial species	CPUE, Species composition
Reduce fishery conflicts	Reduction of encroachment and illegal fishing	Interview, number of fishing boat caught
Recreational activities -Diving -Sports fishing	Increase in species diversity/ complexity Increase number of tourist	Biological/ecological, physical, chemical, water quality parameters. CPUE, Species composition
Mari-culture /marine ranching development	Harmonization with ecosystem, productivity	Chemical, water quality parameters, Growth parameters of cultured species.

2. Evaluation on the Fishing Operation Aspect and
3. Evaluation on the Socio-economics Aspect

*Remarks:

1. Gill net (Surface, Bottom, Drift, Trammel net)
   CPUE: Weight/m^2/hr

2. Traps (Fish, Squid, Crab)
   CPUE: Weight/unit/day

3. Hand line
   CPUE: Weight/line/hr

4. Trolling line
   CPUE: Weight/line/hr

Recommendations for surveys

1. Each monitoring survey should follow using the same material and method in the same location as the baseline survey
2. Surveys should be conducted periodically especially during the first few years of installation of ARs
3. Socio-economic surveys should be conducted once every two years

8.7 Guidelines for the stakeholder and consultation

8.8 Areas of Consideration and Improvements

IX. CLOSING OF THE WORKSHOP

26. The SEAFDEC Deputy secretary-general, Mr. Junichiro Okamoto on behalf of the workshop organizer expressed his appreciation for all the valuable contributions, and shared experiences through the presentations and discussions, and then declared the workshop closed (Appendix 19).

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OPENING ADDRESS

MR. NIWES RUANGPANIT
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Firstly, I should like to extend a very sincere welcome to all of you. Also I should like to thank you for taking the time to come here and to share your knowledge and experience with us at this workshop.

As you will know, SEAFDEC is dedicated to the concepts of Responsible Fishing Technologies and Practices where resource enhancement is a major component. From the resources enhancement point of view the provision of alternative habitats and the use of Fish Attracting Devices are important factors. It is these aspects that we shall discuss during the period of this workshop.

The objectives that we shall address are to review existing regional and national programs and projects relative to artificial reefs. To discuss artificial reef issues. To promote the creation of a technical support group to work as resource persons or coordinators on issues related to artificial reefs. To evaluate, promote and encourage designs and use of artificial reefs and coastal resources enhancement in environmentally friendly climates and to work in close cooperation with the Southeast Asian member countries through technical assistance, research and development programs on artificial reefs.

The restoration and where appropriate enhancement of the coastal fisheries resources is becoming an urgent and immediate problem facing the departments of fisheries in all our member nations. It is our task here, not only to talk about the problems but to suggest and develop solutions in the light of our collective knowledge. Beyond our existing knowledge is the acquisition of a deeper understanding through more extensive baseline research and investigation.

Thank you for your attention, I look forward to the report of a successful workshop.

PROVISIONAL AGENDA AND TIMETABLE

1) Background and Rationale

The quality of coastal and inshore ecosystems has deteriorated significantly as a result of continued and increasing human activities. These areas are critical to a broad range of aquatic organisms during their life cycles including spawning, nursery areas and feeding zones and many of these species are of economic importance. The areas serve as important sources of recruitment to, and the sustainability of, commercial fisheries. It is suggested that the productivity of these ecosystems can be enhanced through human intervention leading to improved livelihoods for coastal communities.

In many areas, the introduction of man-made structures, including Artificial Reefs, Aquaculture Facilities, Breakwaters, Stationary Fishing Gear (SFG) and Jetties are shown to enhance local populations of aquatic organisms, provided that there are sufficient numbers of structures to have a significant and positive impact on ecosystem productivity and that they are integrated into coastal zone management regimes. These structures can enhance fisheries resources. To optimize the results of such initiatives, careful impact assessment and planning procedures are required.

Re-stocking may be an effective component in the enhancement of marine resources in inshore waters. Juveniles and seeds produced by hatcheries or collected from the wild in other areas will be removed rapidly from the ecosystem by destructive fishing gears such as push nets or small-mesh trawl nets. Furthermore, in order to retain the released stocks within the immediate vicinity and minimize losses through out-migration, suitable habitat must be available to them. Therefore, habitat restoration and/or enhancement and establishment of exclusive fishing right may be necessary prerequisites for any marine restocking exercises.

Immediate action is required to prevent further loss of habitat and damage to fish stocks. A range of effective community-level mechanisms must be developed to assist fishers to restore habitats and rebuild stocks. These mechanisms are likely to be specific to different stocks and habitats. Habitat creation and the establishment of artificial reefs, the use of fish attraction devices and predator removal all has potential in the region.

In most ASEAN countries, artificial reefs development have been carried out with very little baseline data on which to base assessment of impact and benefits accruing from artificial reefs, Considering the above factors, ASEAN countries in collaboration with each other, need to initiate systematic baseline studies for potential artificial reefs, This should cover aspects such as biological, ecological, oceanography, engineering, socio-economic, political and gear technology.

Currently, efforts at monitoring productivity and evaluating the impact of artificial reefs be it for resources enhancement or habitat rehabilitation have been diverse. A uniform and systematic methodology for an objective assessment should be adopted for this region. This is to enable the easy comparison of data. Evaluation and monitoring should include also technical and economic viability.

2) Objectives

2.1 To review the existing regional and national programs/projects related to artificial reefs
2.2 To discuss on artificial reefs issues
2.3 To promote the establishment of a technical supporting group for working as resource persons/ coordinator of the issues related to artificial reefs
2.4 To evaluate, promote and encourage the use of artificial reefs or coastal resources enhancement in light of environment
2.5 To work in close cooperation with Southeast Asian member countries through technical assistance in research and development program for artificial reefs

3) Time table

Date/Time	Programme
9 November 2004 (Tuesday)	
08:30-08:45 hrs.	Registration
08:45-09:00 hrs.	Arrival of guests and participants
09:00-09:20 hrs.	AGENDA 1 • Opening address by the SG/TDC • Adoption of the Agenda by chairperson
09:20-09:45 hrs.	Introduction of the project proposal by SEAFDEC/TD
09:45-10:10 hrs.	Group Photo Coffee break
10:10-10:45 hrs.	AGENDA 2 • Review on SEAFDEC activities in relation to artificial reefs
11:45-12:00 hrs.	AGENDA 3 • Review works on the current situation of artificial reefs issues in the Southeast Asian region K Brunei Darussalam K Cambodia K Indonesia
12:00-13:30 hrs.	Lunch break
13:30-15:10 hrs.	Continue AGENDA 3 • Review works on the current situation of artificial reefs issues in the Southeast Asian region K Malaysia K Myanmar K The Philippines K Singapore
15:10-15:30 hrs.	Coffee break
15:30-16:45 hrs.	Continue AGENDA 3 • Review works on the current situation of artificial reefs issues in the Southeast Asian region K Thailand K Vietnam • Discussion and conclusion
18:30-20:30 hrs.	Welcome dinner hosted by SG/TDC

Date/Time	Programme
10 November 2004 (Wednesday)	
09:00-10:00 hrs.	AGENDA 4: Potential and consideration of artificial reefs for resources enhancement • Case study from Japan (Mr. Yasushi Ito) • Re-stocking in artificial reefs (Dr. Jurgenne H.P.)
10:00-10:20 hrs.	Coffee break
10:20-12:00 hrs.	Continue AGENDA 4: • Information collection for evaluation of artificial reefs (Mr. Ahmad Ali)
12:00-13:30 hrs.	Lunch break
13:30-14:30 hrs.	Continue AGENDA 4: • Case study: Fish visual census techniques (Mr. Ukkrit Satapoomin)
14:30-15:30 hrs.	AGENDA 5: Artificial reefs evaluation guideline
15:50-16:30 hrs.	• Investigation on fishing operation aspect (Dr. Mala Supongpan)
11 November 2004 (Thursday)	
09:00-10:00 hrs.	Continue AGENDA 5: • Introduction to working session: Considerations for developing artificial reefs guideline for the region (Dr. Yuttana Theparoonrat)
10:00-10:20 hrs.	Coffee break
10:20-1200 hrs.	Working Group Sessions: 1. Investigation guideline for artificial reefs on biological aspect 2. Investigation guideline for artificial reefs on fishing operation aspect
12:00-13:30 hrs.	Lunch break
13:30-16:00 hrs.	Continue AGENDA 5: Working group sessions
12 November 2004 (Friday)	
09:00-10:00 hrs.	AGENDA 6: Conclusion and recommendation for the further promotion of artificial reefs in the region
10:00-10:20 hrs.	Coffee break
10:20-11:00 hrs.	AGENDA 7: Closing
18:30-20:00 hrs.	Dinner Party

CLOSING ADDRESS

MR. JUNICHIRO OKAMOTO
Deputy Secretary General and Deputy Chief of the Training Department
Southeast Asian Fisheries Development Center (SEAFDEC)

As we come to the end of this workshop we can take the time to review what we have discussed over this period that we have been together. The coastal fisheries management aspect of the use of artificial reefs is a management concept that has consequences far outside the purposes of providing safer habitats for juveniles and the immature fish of our target species. Artificial reefs, particularly the permanent types give a foundation for zoning and the award of fishing rights for specific groups and areas at the same time serving to reduce the incidence of conflict because of the incursion of outside fishing vessels and damaging fishing gear.

As I said at the beginning of this workshop, the restoration and enhancement of the coastal fisheries resources is an urgent and vital issue in the future of fisheries and from what has been discussed here I know that this is well understood. Thus, I should like to offer you all a most sincere vote of thanks for your efforts not only during this meeting, but your efforts in travelling long distances to give us the benefit of your wisdom.

As you leave SEAFDEC you take with you not only our thanks but our wish that your journeys home will be comfortable and speedy.

Thank you all for your attention.

LIST OF DOCUMENTS

Country Papers

SEAFDEC/ECR-2/CP 01 Artificial Reefs Current Situation in Brunei Darussalam (Idris Haji Abd Hamid)
SEAFDEC/ECR-2/CP 02 Status and Evolution of Coral Reefs in Cambodia (Prum Sitha)
SEAFDEC/ECR-2/CP 03 Status of Artificial Reefs in Malaysia (Zaidnuddin Ilias and Ahmad Ali)
SEAFDEC/ECR-2/CP 04 Country Report of Myanmar (Han Win)
SEAFDEC/ECR-2/CP 05 Coral Garden and Reef Rehabilitation Project of the Bureau of Fisheries and Aquatic Resources (Pierre Easter L. Velasco)
SEAFDEC/ECR-2/CP 06 Artificial reef Programmes in Singapore (Chou Loke Ming, Ph.D.)
SEAFDEC/ECR-2/CP 07 Evaluation of Artificial Reefs in Phangnga Bay (Suchat Sangchan)
SEAFDEC/ECR-2/CP 08 Artificial reef instalation in the Southern Gulf of Thailand (Amnaj Siripeah)
SEAFDEC/ECR-2/CP 09 Country Report of Vietnam (Nguyen Quang Hung)

Experience Papers

SEAFDEC/ECR-2/EP 01 Report of environmental survey studies on artificial reefs at Chumporn province, Thailand (Yuttana Theparoonrat, Ph. D.)
SEAFDEC/ECR-2/EP 02 Potential of Artificial Reefs for Enhancement of Fisheries Resource - Case Study From Japan (Yasushi ITO and Hiraaki Terashima, Ph.D.)
SEAFDEC/ECR-2/EP 03 Artificial reefs - a rewarding attempt (J.H. Primavera & K. - J. Kuhimann)
SEAFDEC/ECR-2/EP 04 Information Collection for Evaluation of Artificial Reefs (Ahmad Ali and Mahyam Mohd.Isa)
SEAFDEC/ECR-2/EP 05 Fish visual census technique - an alternative method for the assessment of fish assemblages on artificial reefs (Ukkrit Satapoomin)
SEAFDEC/ECR-2/EP 06 Investigation on Biological Aspect (Hansa Chansang, Ph.D.)
SEAFDEC/ECR-2/EP 07 Fishing operation and fisheries surrounding the artifiaial reefs (Mala Supongpan, Ph.D.)

Country Papers

ARTIFICIAL REEFS CURRENT SITUATION IN BRUNEI DARUSSALAM

Idris Haji Abd Hamid

ARTIFICIAL REEFS –

CURRENT SITUATION IN BRUNEI DARUSSALAM

by

IDRIS HAJI ABD HAMID
Fisheries Department
Brunei Darussalam

1. Intro

The Fisheries Department had been deploying Artificial Reefs (AR) since 1985. Various types have been deployed, including used tyres, decommissioned offshore oil structures, steel pipes, concrete piles and prefabricated structures. The present artificial reef project concentrated on the concrete prefabricated pyramidal structures.

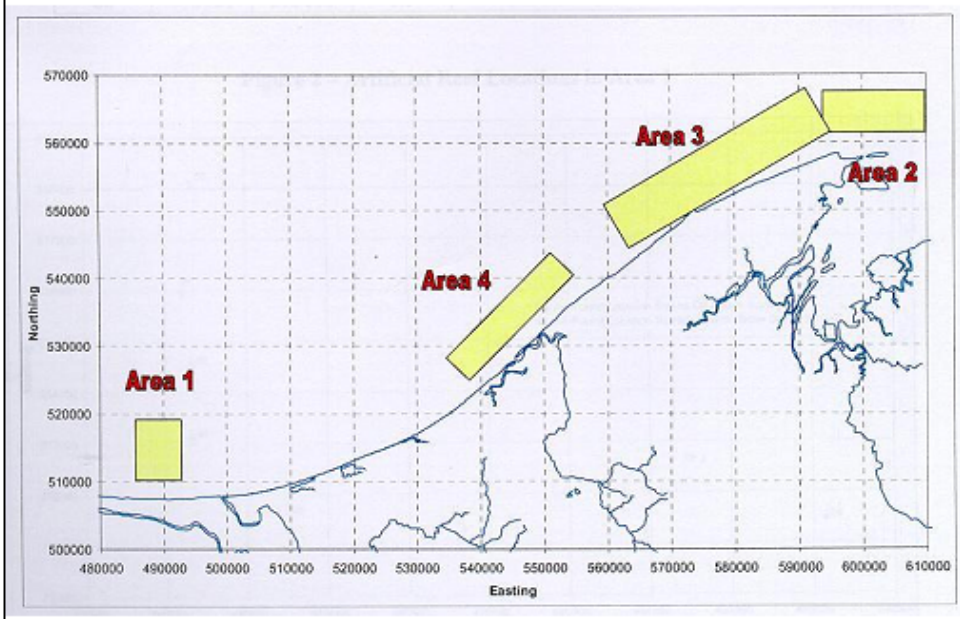
2. Objectives of AR Project

- Provide protection to restricted / prohibited areas from encroachment by fishing trawlers;
- To enhance the productivity of the Coastal Waters;
- To provide alternative sites for the rapidly expanding eco-tourism industry.

3. The Reef Units

- Smaller tetrahedron measuring 2.5m x 2.5m for shallow areas;
- Larger triangular pyramid, 6m x 4m for deeper water;
- Made up of concrete;
- Cluster of 6 – 10 reef units per location;
- Area of deployment – from Kuala Belait in the west to Muara in the east;
- Phase I – 81 locations;
- Phase II – 85 locations;
- Phase III – to be decided, probably including deeper zones.

LOCATION OF ARTIFICIAL REEFS PHASE 1



4. Findings (Grp 64, Area 1, 12m depth)

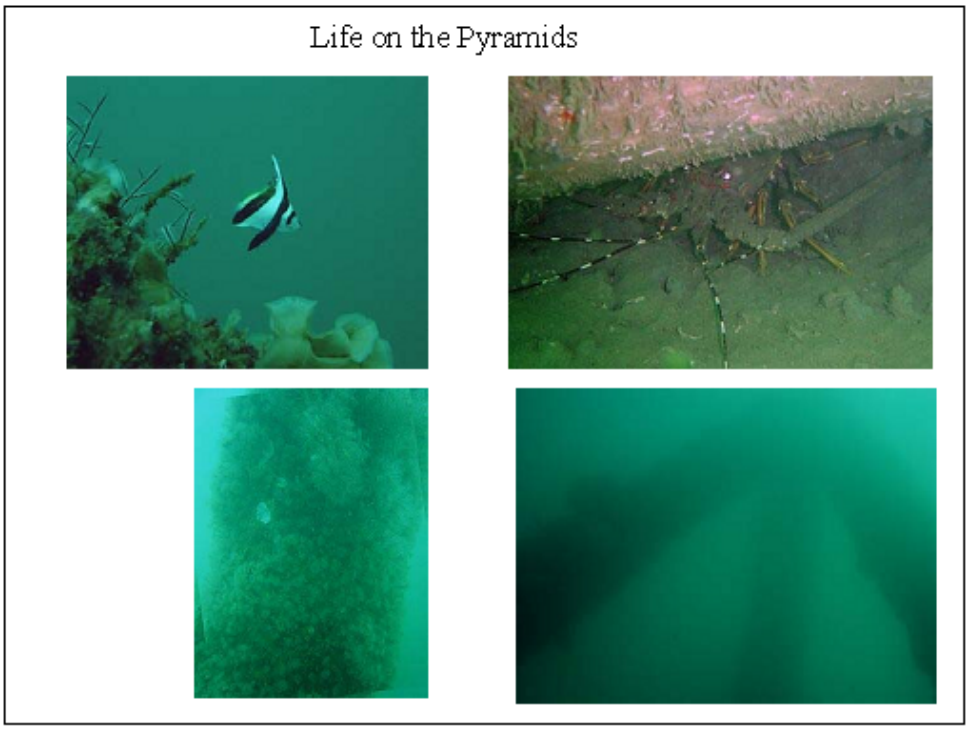
- Majority of the pyramids visited have fishing net ramnants caught on them !
- Dense marine growth of soft corals (*Acanthagorgia sp.*) algae, barnacles, bryozoans and small anemones. Stinging hydroids were also abundant;
- All the surfaces of the structures are covered;
- Lobsters, snappers, carangids, groupers, pinjalo, selar, mackerels, small tunas and sharks are present;
- On every pyramid visited (within 20 metres of each others), the distribution of species seemed similar;
- Only one genuine reef fish, the Banner fish, *Heniochus acuminatus*, present during that dive.

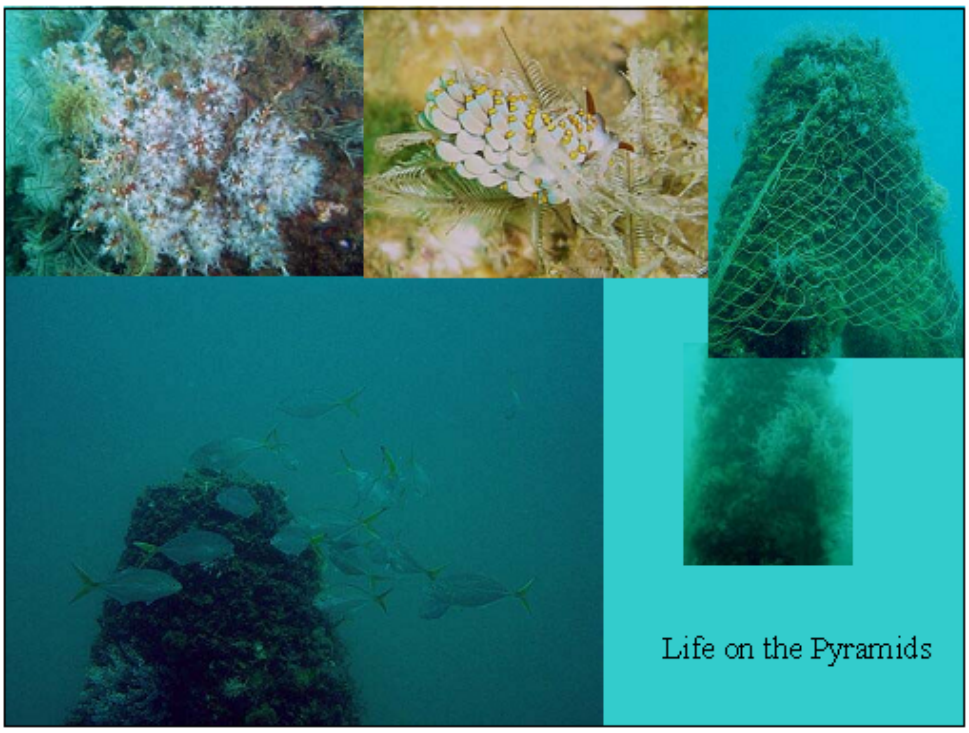
5. What need to be done

- Continuous monitoring which will include oceanographic and fisheries surveys;
- Fishing and socio-economic surveys;
- Proper management plan – to include AR areas as MPAs.

The Mould

The Pyramids


Life on the Pyramids


Life on the Pyramids

Marine growth at one of the pyramid leg

Thank You
Terima Kasih

STATUS AND EVOLUTION OF CORAL REEFS IN CAMBODIA

Prum Sitha

STATUS AND EVOLUTION OF CORAL REEFS IN CAMBODIA

Prum Sitha
Department of Fisheries
P.O. Box 582, #186, Preah Norodom Blvd., Phnom Penh, Cambodia

■ INTRODUCTION

Cambodia is located between latitudes 10° and 15° north, and longitudes 102° and 108° east, forming part of southwest portion of the Indochina's peninsula. It is situated within Southeast Asia, and covers an area of 181,035 Km^2. Its 435 Km long coastline lies within the Gulf of Thailand, with a total of two coastal provinces and two coastal municipal cities, namely the provinces of Koh Kong and Kampot, and the municipal cities of Sihanouk Ville and Kep.

Within a marine area of 55,600 Km^2, there are a total of 64 islands and a reef area covering 28,065 Km^2. Koh Sdach and Koh Rong are spectacular archipelagos of the southwest coast of Cambodia with a total of 16 islands of tropical forest surrounded by ancient corals. These archipelagos are also home to species of fish, crustacean, and Hump- backed dolphin. Because of Koh Sdach and Koh Rong's unique biodiversity and the intense fishing pressure threatening to destroy it, the Department of Fisheries (DoF) and several non-government organization (NGO) have joined forced in an effort to protect it. The Technical Working Group, including DoF, FAO, DFID, WildAid and National University of Singapore (NUS) have participated in a planning process to design a marine sanctuary management system that will effectively protect the fragile ecosystem of Koh Sdach and Koh Rong archipelagos.

Throughout the Koh Sdach and Koh Rong archipelagos, and the coastline from Sihanouk Ville to Koh Kong province, the drastic reduction in small fish and the shrinking of coral reefs are of great concern. Illegal fishing is causing major destruction of the marine fauna and flora with complete lack of coastal protection at this time.

■ ARTIFICIAL REEFS (ARS)

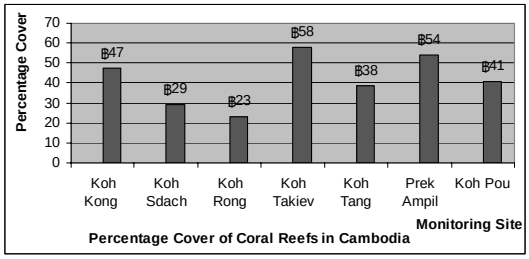
Artificial reef program were initiated in Cambodia in 1991, 1997 and 2002 using concrete modules and base/log of trees. In 1991, 300 units of concrete were deployed, and in 1997, 700 units of base/log of trees were used with a further 100 units deployed in 2002. These were deployed at depths less than 10m into fish sanctuaries in the Great Lake Tonle Sap (inland water) and were aimed to provide habitats and improve fish stock. In the past there was less concern about artificial reefs in marine waters. Traditionally, fishermen use tree branches, bushes or/and water hyacinth to make a brush park or bundles to attract and collect fish and shrimp. These fishing methods provide habitat, improve fish stock and also constitute a type of ARs.

■ MARINE PROTECTED AREAS (MPAS)

MPAs were established in 2002, implemented by DoF and funded by ICRAND project under the United Nation Environment Program in Koh Rong archipelago of Sihanouk Ville. Their focus is on the protection and management of the sea for spawning, feeding and nursing grounds for marine living resources to ensure their long-term viability and to maintain genetic diversity. Management are includes promoting compliance with MPAs regulations by increasing income for local fishers through enhancement of local fisheries, training of alternative livelihood, and promotion of eco-tourism, to protect coral reef and other diversity within the MPAs.

In recent years, DoF was interested in promoting coastal and marine fisheries management. What is required is long-term collaboration with donors to help conduct

natural resource assessments. Information on the extent and present health of coastal and marine ecosystems such as coral reefs and mangroves is needed to provide the basis for the formulation of development of marine fisheries management policies. To utilize the natural resources for the promotion of coastal and marine fisheries management for over the long term, proper management and continued monitoring of the resources are essential. The assessments will provide the information that is necessary for the development plans.



Benthos Cover

The Technical Working Group, including DoF, FAO, DFID, WildAid and NUS have participated in a planning process to design a marine sanctuary management system in Koh Sdach and Koh Rong archipelagos. The project aim is to assure effective protection. This translates into measurable objectives:

1) Regenerate coral
2) Reduce non indigenous species and their relative impact on coral and other marine biodiversity
3) Reduce illegal fishing (dynamite, cyanide and mosquito netting fishing)
4) Local communities effectively develop sustainable fisheries and produce sufficient food supply
5) Restore the small fish population

The main element related to marine fisheries/coral reef is:

- Start up with national policy and plan of action for coral reef monitoring and sustainable use of the reef ecosystem
- To determine the general distribution of coral reefs within archipelagos, and to conduct baseline quantitative surveys to determine the abundance and distribution of the coral reef benthos and reefs fish and invertebrates
- To determine the general condition of the coral reefs in terms of visible impact
- To identify areas with good coral reefs for possible management and conservation efforts in view of the interest to develop the area for coastal tourism.
- To make aware and understood the significance of coral reef ecosystem among all stakeholders at all levels
- To understand coral reef biodiversity, and to get reliable assessment of changes in reef health
- Provide job opportunities and improve livelihood of the people in rural communities
- To improve the access to and distribution of fisheries benefits including export earns
- To extend the institutional responsibilities of fisheries management to the fishing communities
- To improve the protection of fisheries resources in sanctuary way; and
- To encourage the integration of fisheries resource management with rural development in fishing communities. (Nowadays, DoF, local communities and authority are now working together to manage fisheries resources in the coastal of Cambodia).

Strengthen role in conservation and management of fisheries resources:

- DoF have drafted and submitted a Royal Decree on Protection of Coral Reefs in Koh Sdach and Koh Rong archipelagos to the ministry of Agriculture Forestry and Fisheries and the Council Ministry.
- DoF have drafted and submitted the new Fisheries Law to the Council Ministry under support of APIP

(Agriculture Productivity Improvement Program) by World Bank project. However, the Fisheries Law No. 33 passed in 1987 is still in the enforcement that defines fisheries and categorizes fishing areas. Its states that all entities or persons who fish in either freshwater or seawater must contribute to the state, except fishing for household subsistence. Fisheries exploitation and aquaculture in fishing areas are permitted but must be determined by regulation of the government of Cambodia. The Fisheries Law aims at being sustainable of exploitation of fisheries resources which include permission addressing access control, gear restrictions, closed season and the designation of fishing sanctuaries and also support to the management of fisheries coastal resources and coastal environment as well as all type of inland water. The management and administration of coastal fisheries is mentioned in Fisheries Law as the following:

1) Fishery resources are comprised of living animals and plants found in the fisheries domain (Chapter 1, Article 1). Marine fisheries domain extends from the coastline to the outer boundary of the exclusive economic zone (EEZ). Fisheries domain is property of the state.

2) Fishery exploitation, aquaculture and processing in Cambodia's marine fisheries are allowed upon government permission except for small scale family fishing, small scale family fishing gear and other fishing gear permitted in the marine fisheries of Cambodia must be defined by the proclamation of the Ministry of Agriculture. However, this law was not directly mentioned about the coral reefs and seagrass management within marine water (Chapter 3, Article 22).

3) Commercial fishing group or enterprise must obtain the following additional license: a fishing boat or vessels license allowing them to operate in the sea which is to be issued by the fisheries authority after technical control, and a license from the police for administration control (Chapter3, Article 23).

4) The fishing activities of foreigners in Cambodia's marine fisheries domain must have approval from the Council Ministry (Chapter 3, Article 24).

5) Fishers who are permitted in the marine fisheries domain must respect the order or act mentioned in the fishing license. Records must be kept on the daily catch of fish and other organisms, and reported monthly to the provincial municipal fisheries authority (Chapter 3, Article 25).

6) All kinds of fishing gear, extending across a stream, inlet or navigable channel of coastal zones, must have a free space of one-third of it's width during low tide to enable the navigation of vessels (Chapter 3, Article 26).

7) Trawling in shallow waters (depth less than 20m) is prohibited, except where special permission is granted by the DoF for scientific research (Chapter3, Article 28).

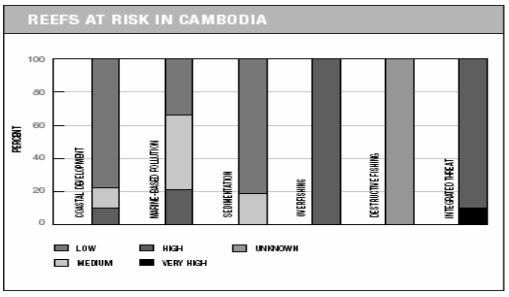
8) Using electro-fishing gears and all kinds of explosive or modern fishing gear, which are not mentioned in the proclamation of the Ministry of Agriculture, are absolutely prohibited (Chapter 3, Article 29).

- Improve the current legislations to make them applicable for coral reef management and conservation
- Capacity Building/provide training on Community Fisheries Management to Fisheries Officers and fishing communities
- Help to develop sustainable livelihood to Community Fisheries

- Enhance dialogue between fishing communities, officials and other stakeholders
- Research the danger arising from resident communities, illegal fishing, and development
- Conduct outreach program locally and on the mainland, highlighting these threats to the islands
- Develop cooperation with the communities to adopt environment friendly practices that reduce pollution and waste
- Working with politicians to gain support for the marine sanctuary and develop strong protection policies.

■ THREATEN TO CORAL REEF/ COASTAL AREAS:

1. Sewage and waste disposal: There is no sewage and waste disposal system in many public gathering places. Everything from sewage, garbage and oil gets dumped into the sea.



Reefs at Risk Indicators 2002, oversfishing and destructive fishing are high in 2004 (Estimated Change)

2. Fishing and fishing methods: The fish catch is worse than before with catch is declining, and more effort needed to catch the same amount of fish. The catch was still good in the 1980's, but started declining from 1995; catch is not enough for the locals survive on. It is due to big fishing boats use commercial fishing techniques like net trawling, dynamite fishing, using electricity to stun and kill fish that flout the rules and destroy the environment. Dynamite fishing was previously a big problem but has since been clamped down on and is now a manageable. However net trawling is still a major concerns. Some of the trawlers are small boats not equipped to go out to deep sea, and use their nets in shallow waters of depths less than 20m, which cause extensive damage to the reefs. The fishermen are able to fish all year round, they fish both during day and night, except when the weather gets too stormy, particular during the rainy season.
3. Corals, which used to be a booming trade in Sihanouk Ville, Kampot and Kep, no longer have a market there.

■ FURTHER ACTION PLANS:

A threat assessment of coastline and archipelagos will identify illegal fishing and destructive activities; identity the factors involved to focus the direction of patrol plans; and promote capacity building and alternate livelihood programs for communities on the coastline.

- To develop small-scale aquaculture, to determine priority areas for installation of anti-trawlers barriers such as artificial reefs along the coast, buoys, to stop trawlers approach the coastline, to conduct participatory appraisal to find alternative sources of food and income for communities' fisheries. Billboards will be placed offshore to instruct on fishing rules and regulations and delineate clearly the marine sanctuary borders. DoF will interface with local fishermen to monitor their fishing activities and insure no illegal and destructive actions are taken. Foreign fishing trawler companies will be dissuaded to fish Cambodian waters through direct action on the sea.
- Education of local fishing communities on sustainable management of fisheries resources will include a combination of training in participatory

assessment and consultation of local needs. Other stakeholders will be educated on the value and fragility of marine life, mangrove forest, coastal and marine conservation component. Nationwide campaigning will be undertaken, in order to reach all stakeholders at all levels as well as foreign industrial trawlers to gain support for marine sanctuary and raise awareness on the destructive impact of mass industrial, dynamite and chemical fishing.

- A baseline biodiversity survey to evaluate the status of conservation of marine fauna and flora is needed.

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2) DoF 2003, Statistic of Fisheries, Phnom Penh.

3) Deap, L., P. Degen and N. van Zalinge 2003, Fishing Gears of the Cambodian Mekong, Phnom Penh.

4) Ministry of Economic and Finance & MoE 2003, National Report on Protected Areas and Development, Phnom Penh, Cambodia.

5) DoF 2004, Poster " Coral Reefs in One of the Poorest Developing Countries ", Phnom Penh.

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7) Chou, LM; K P P Tun and Chan T C 2002, Status of Coral Reefs and Socio-economic Evaluation of the Koh Sdach group of islands, Koh Kong province, Cambodia, Phnom Penh.

8) Chou, LM; T L Loh and K P P Tun 2003, Status of Coral Reefs of the Koh Sdach group of islands, Koh Kong province, Cambodia. Part II, Phnom Penh.

9) WildAid 2003, Creating a marine sanctuary in Koh Kong province, Cambodia, Phnom Penh.

STATUS OF ARTIFICIAL REEFS IN MALAYSIA

Zaidnuddin Ilias.& Ahmad Ali

Status of Artificial Reefs In Malaysia

By

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Turtle and Marine Ecosystem Center
Department of Fisheries Malaysia
23050 Rantau Abang, Dungun Terengganu

Content

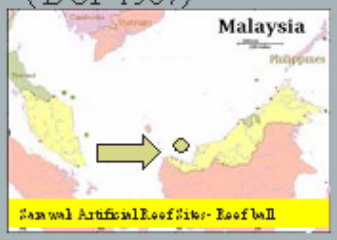
- *Introduction, objectives, aims*
- *Type of artificial reefs*
- *Criteria to determine success*
- *Colonization of hard coral*
- *Recommendation*

Introduction

- Up to the year 1990's Department of Fisheries has deployed 3,000,000 tyres as artificial reefs. Deployment of tyre reefs has stop after the launched of 1987 artificial reefs in Pulau Pisang Pontian Johor.
- 1990-2004 DOFM started to deploy pre-fabricated concrete and PVC reef for special purpose artificial reef for example for Lobster and squid.
- In 2000 Reef ball was promoted to Malaysia

Peninsular Malaysia

(DOF 1987)



Definition

- *Artificial Reefs are man-made structure sunk (accidentally or constructed) underwater to increase fish resources in an area (Ino, 1974)*
- *This includes structures for example fish trap, FAD, Payao, Kelong, wreck etc.*

Aims

- *The primary aims of DOF artificial reef program are;*
  - *to enhance the fishery resources by using artificial reefs*
  - *to use the artificial reefs as a mitigating method to control encroachment by fishermen into fish protected area*

Parties Involved in development of artificial reefs in Malaysia

- *Department of Fisheries Malaysia (officially since 1975)*
- *Local Fishermen- not recorded*
- *LKIM(Fisheries Development Board)- 1990's*
- *Universities and Local governments*
- *NGOs for example diving club*

Objectives of Artificial reef programs

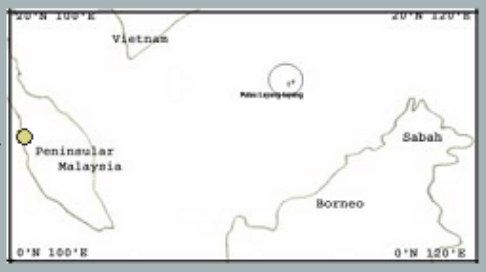
- *To increase fish resources*
- *To stop encroachment*
- *Protection of turtles (Sarawak Islands)*
- *For fishing activities*
- *For target species for example lobster, grouper*
- *For SCUBA diving purposes*

Type of Artificial Reefs

- *Used Materials*
  - *FAD's- bamboo, coconut leaves, sand bags*
  - *Scuttled boats,*
  - *tyres*
- *Pre-Fabricated*
  - *Concrete cubes, pyramids*
  - *PVCs'*
  - *Jetties*
  - *Oil rigs*

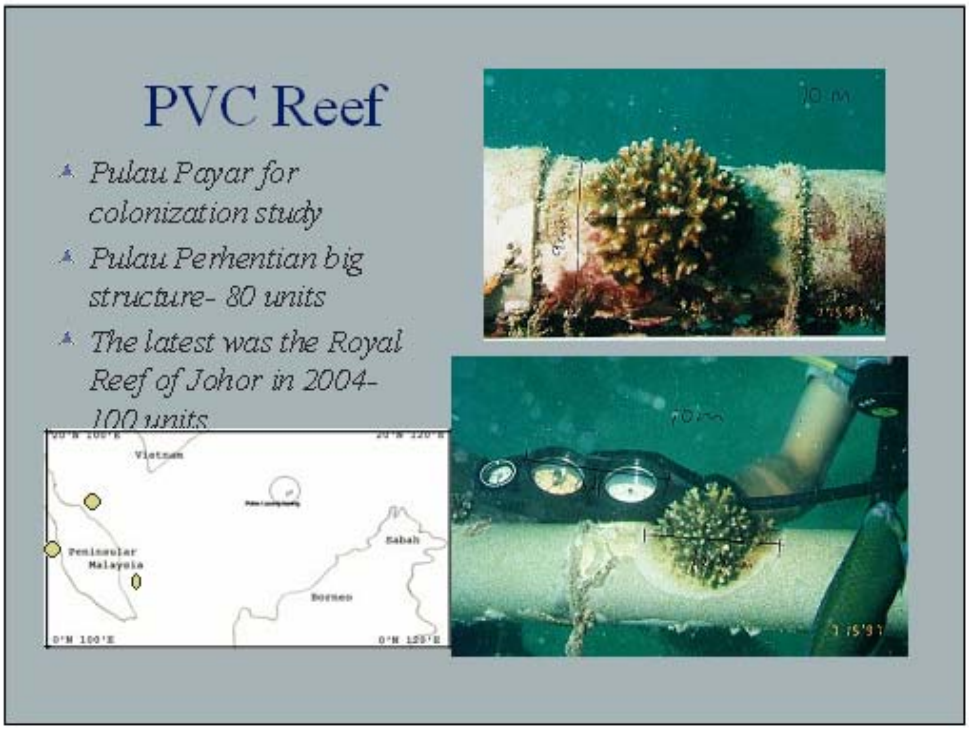
Tyre reefs

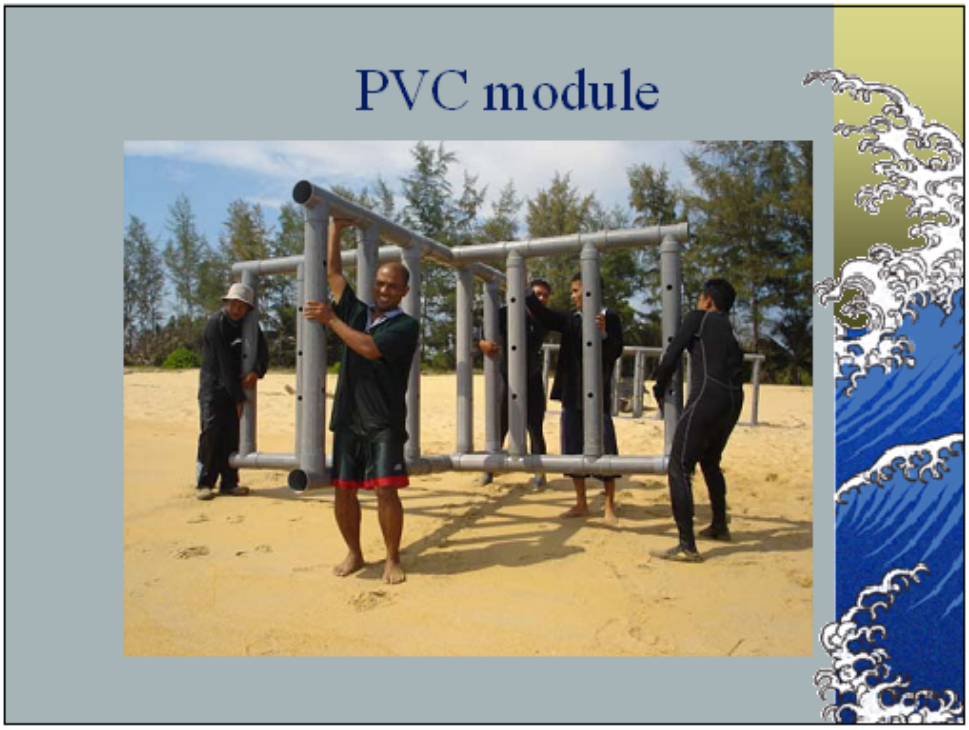
- *First deployed in 1975 near Pulau Telor, Kedah.*
- *Non design modules, only tied together*
- *More at Pulau Payar, Kedah from tied together design to pyramid design*

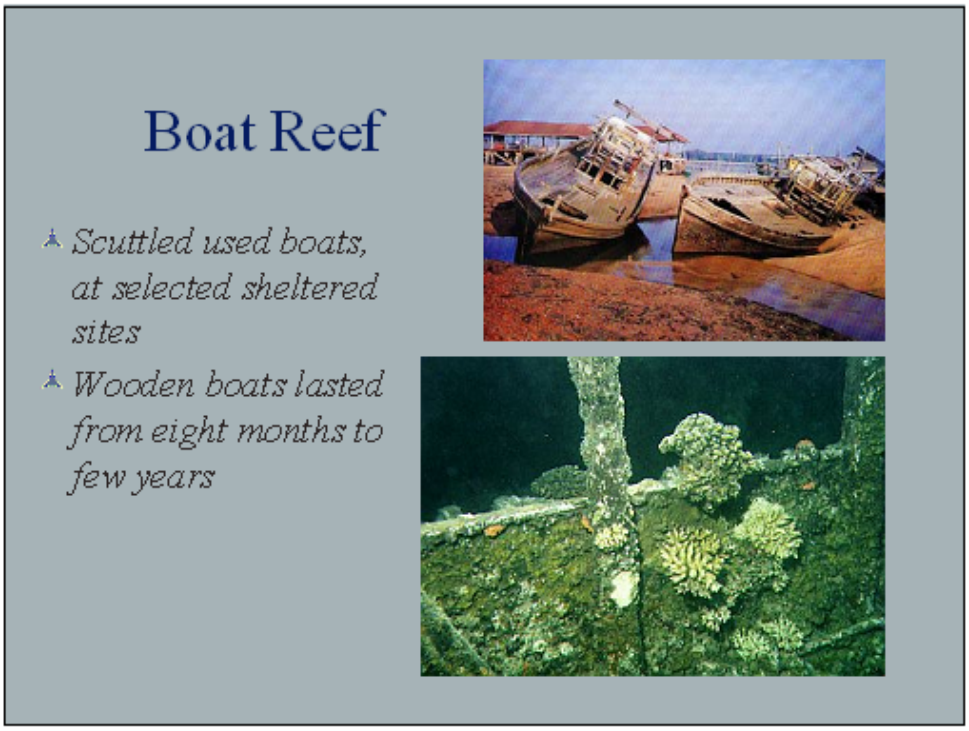


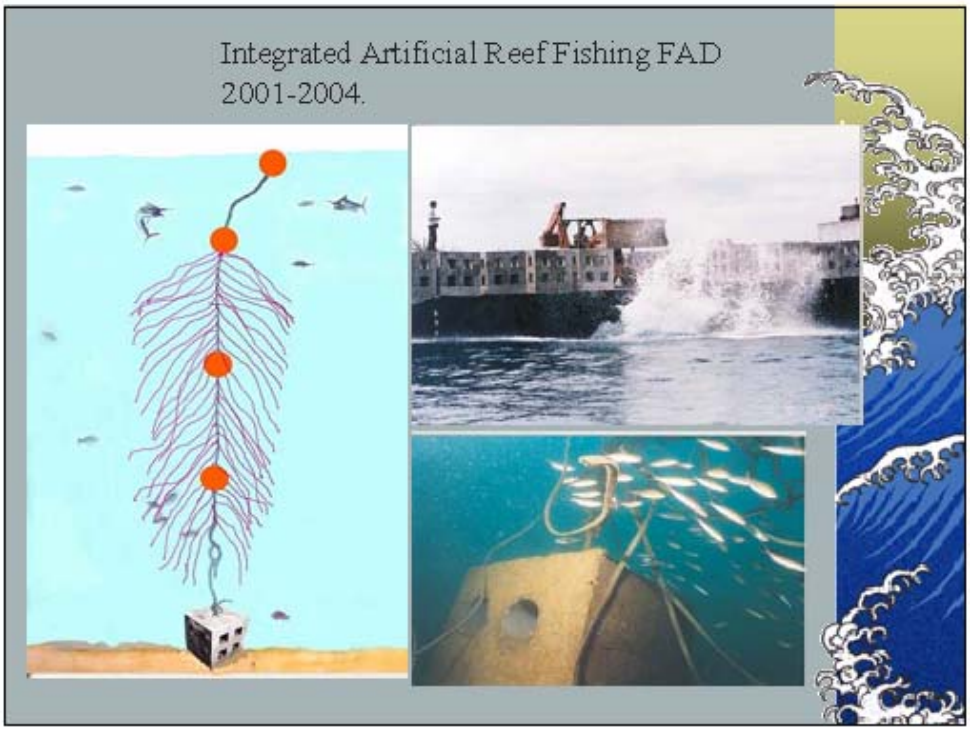
Pyramid Design

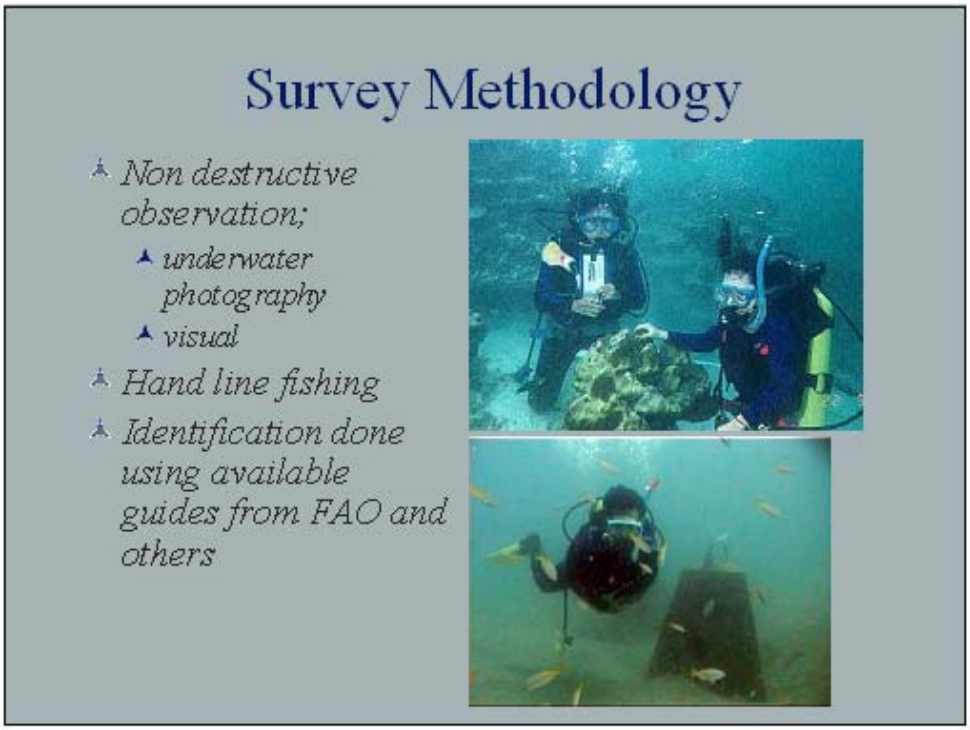

Concrete reef
Pilot project deployed at Pulau Payar in 1988 from culverts
other sites are in Tioman, Terengganu
Vietnam
Peninsular Malaysia
Sabah
Borneo


PVC Reef
Pulau Payar for colonization study
Pulau Perhentian big structure- 80 units
The latest was the Royal Reef of Johor in 2004- 100 units
Vietnam
Peninsular Malaysia
Sabah
Borneo


PVC module


Boat Reef
Scuttled used boats, at selected sheltered sites
Wooden boats lasted from eight months to few years


Integrated Artificial Reef Fishing FAD
2001-2004.


Survey Methodology
Non destructive observation;
underwater photography
visual
Hand line fishing
Identification done using available guides from FAO and others

Deployment depths

Artificial reefs in Malaysia can be divided into two depth groups

-40 feet or less

-more than 40 feet

Deployment Method

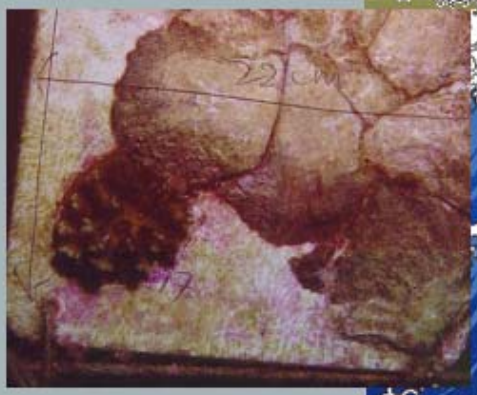

Using Barge and tractor

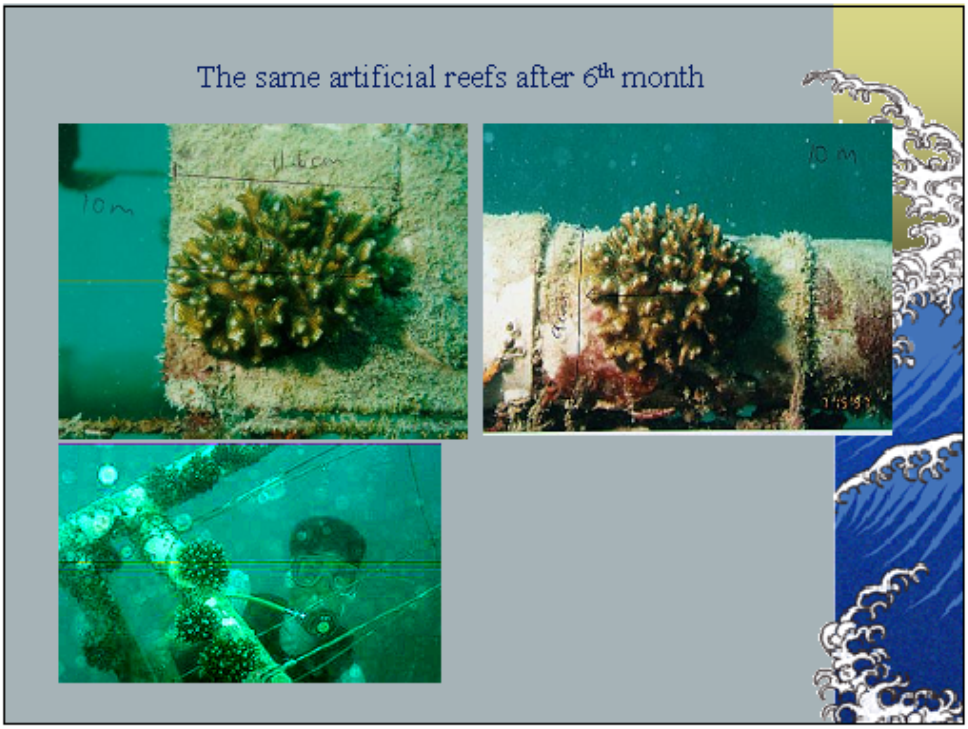

Official marking of artificial reefs

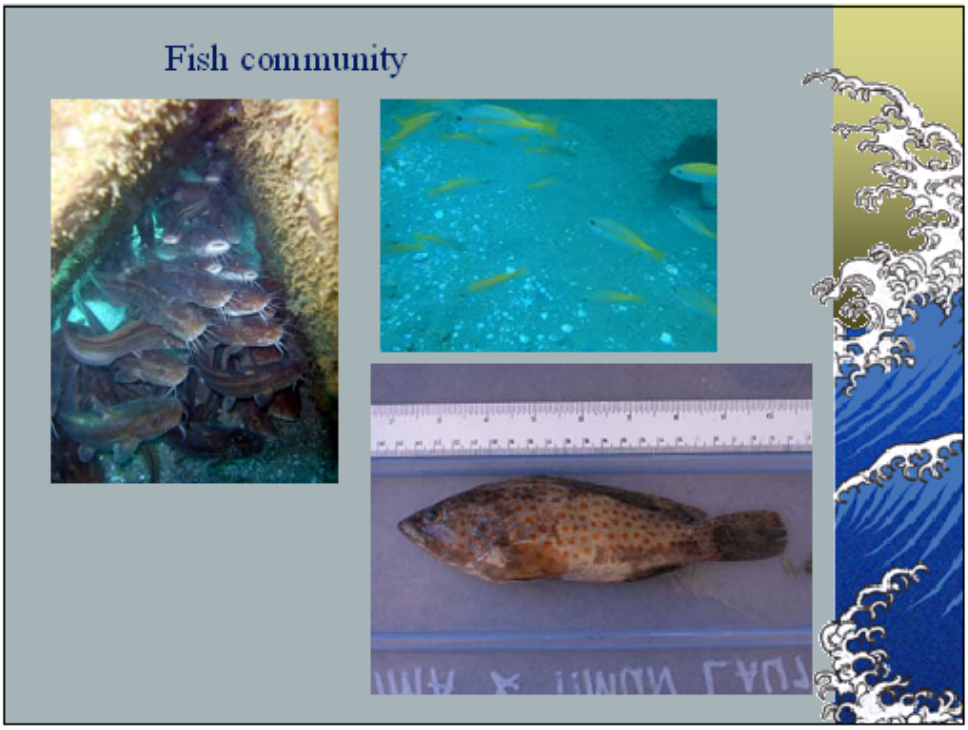
Criteria used to determine success are

- *Increased in fish stock*
- *Increased in catch rates*
- *Increased in colonization of substrates*
- *Increased in overall diversity*
- *Decreased in illegal encroachment*

Artificial reefs deployed less than 40 feet to study colonization, encrustation of oyster after 2 months



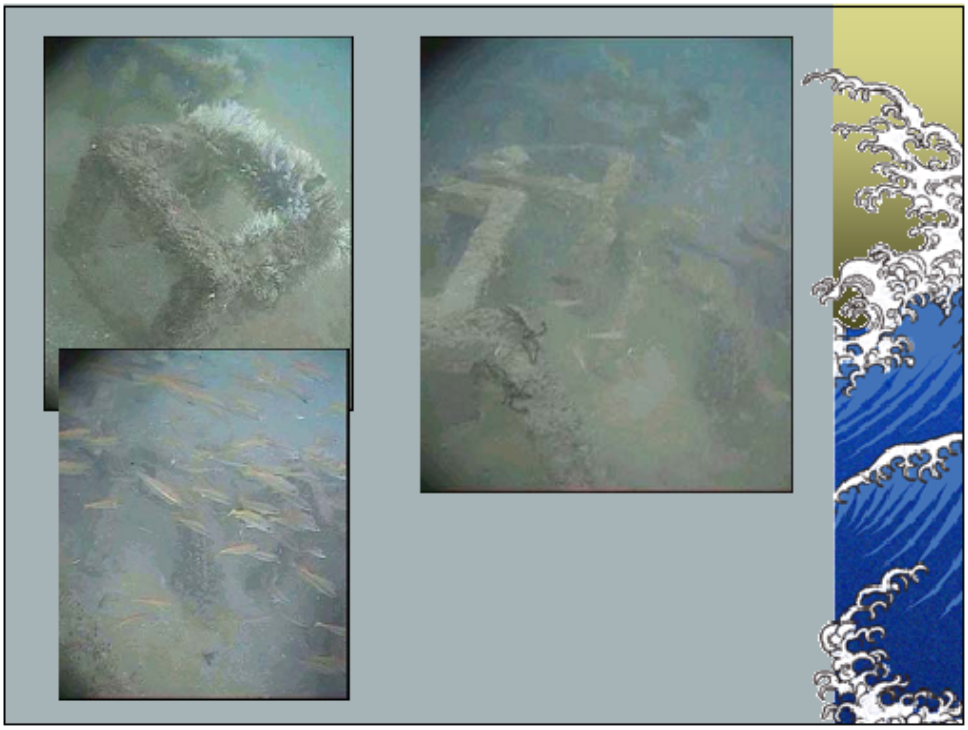

The same artificial reefs after 6th month

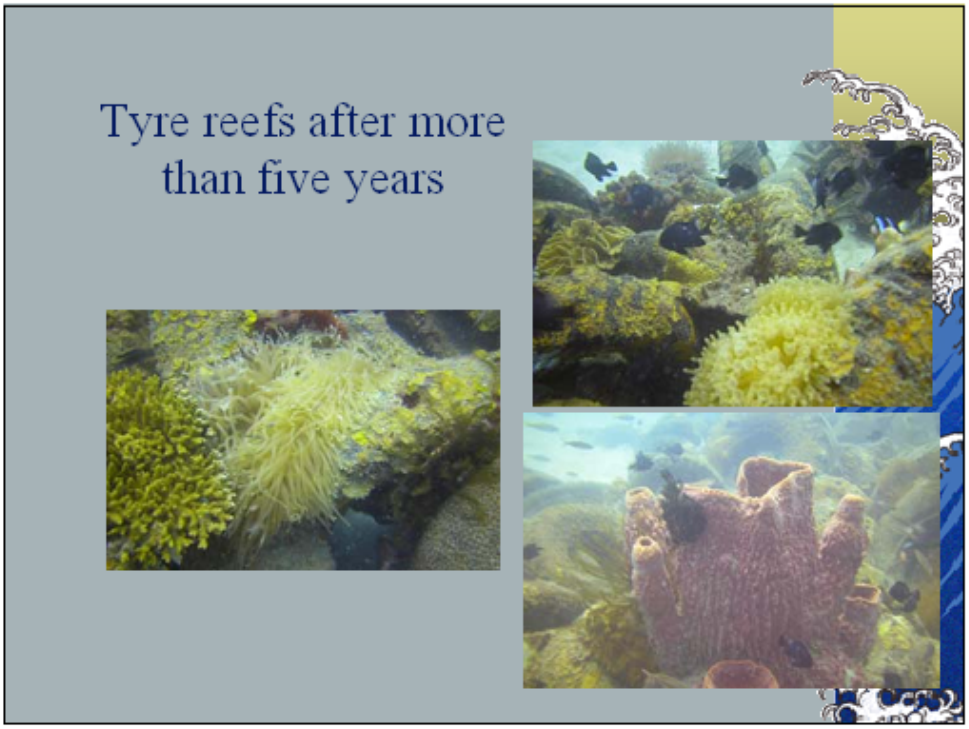

Fish community

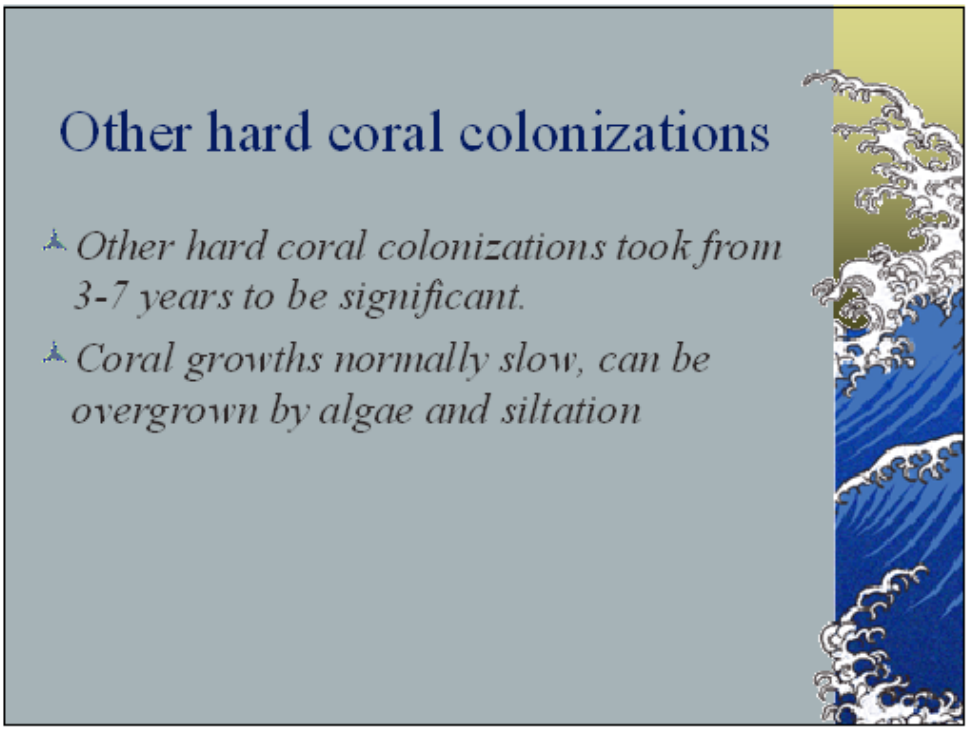

Fish species
Chromis sp.
Snappers and others


Reef Ball, two month after deployment

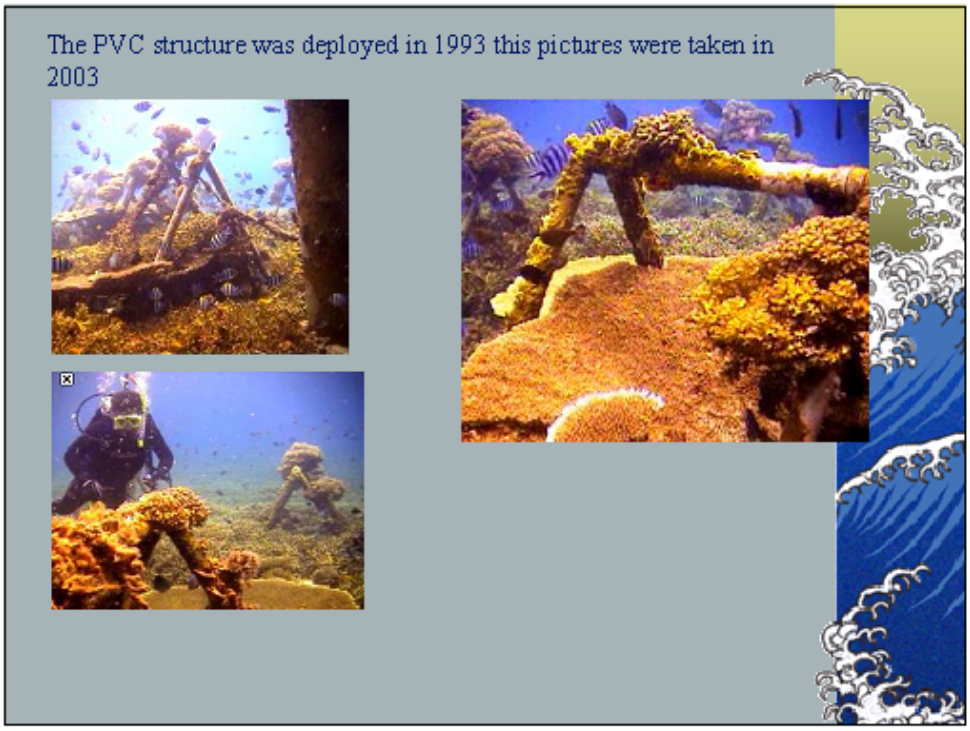

ARS at 70 feet, sandy bottom, deployed more than five years




Tyre reefs after more than five years


Other hard coral colonizations
Other hard coral colonizations took from 3-7 years to be significant.
Coral growths normally slow, can be overgrown by algae and siltation


Concrete pillar of Pulau/Koh Tioman Marine Park Jetty

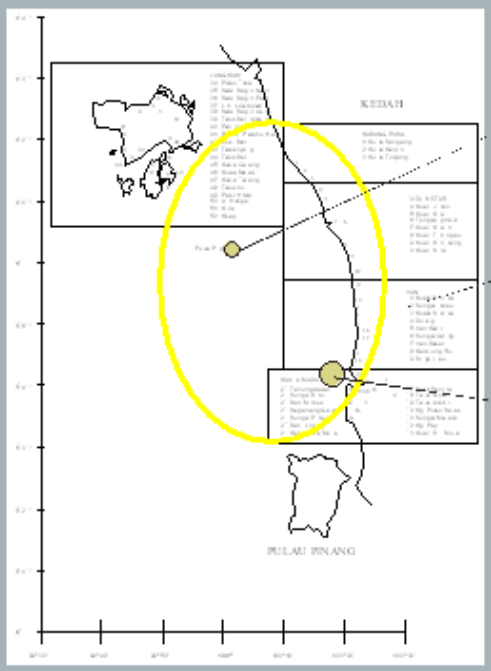

The PVC structure was deployed in 1993 this pictures were taken in 2003

Success on a large scale ecosystem

Success in increasing fish resources of a large area was difficult to determine as most of artificial reef program were small and patchy.

Other influencing factors cannot be easily single out to show the success of the artificial reefs

One example of analysis of resource data was carried out on the coastal hand line fisheries in Kedah State, to determine the usefulness of artificial reef program.

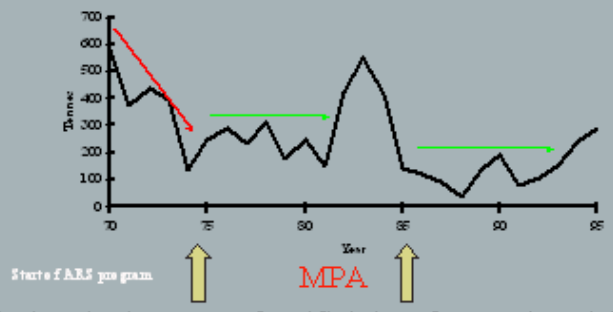


Artificial Reef Site 1

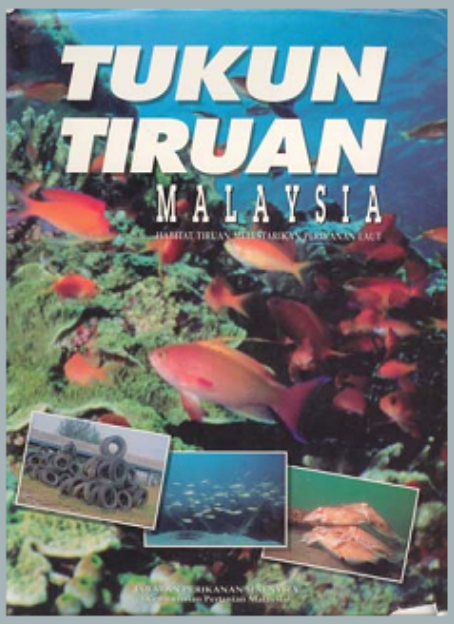
Fish landing area

Artificial Reef Site 2

A case study

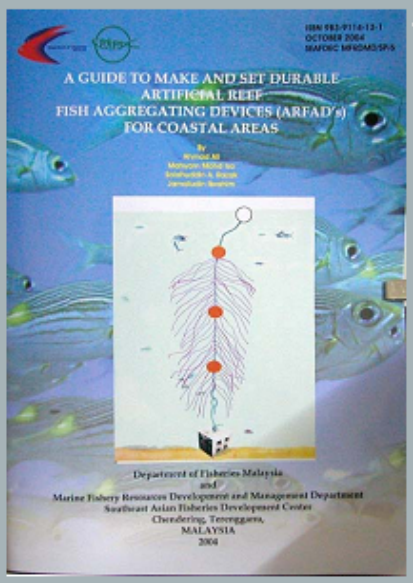


- First deployment of artificial reef around Kedah waters (1975)
- The trend of handline fisheries of Kedah State, there is an increase in catch between the year 1982-1985 (Alias & Mohd-Saupi, 1998).
- Pulau Payar gazetted as Marine Park- 1989 may give more impact to the stabilization of resources



In 1994, Department of Fisheries Malaysia produces a book on artificial reef program named TUKUN TIRUAN, Malaysia

A guide produced by Mr Ahmad Ali in October 2004



In Future, DOFM is aiming for larger and bigger artificial reefs. These reefs must be able to give enough spaces for fish on muddy bottom. One of the design is using decommission oil rigs as artificial reefs

Recommendation/Observation

- *Site selection is the most important aspect in artificial reef building.*
  - *Success in fish colonization*
  - *Success in encrusting organisms colonization*
- *Depth determine which organisms to flourish either photosynthetic or non/low photosynthetic.*
- *Size and availability of hiding places determine the number of resident type fishes*
- *In one of the study sites fish juveniles recruitment occur after north-eastern monsoon*

Recommendation/observation

- *Any nontoxic material can be used to construct Ars but consideration should be given on available spaces, variation of space size and the Ars purpose*
- *Larger and higher profile reef can contribute more to enhance fish resources especially the pelagics*

COUNTRY REPORT OF MYANMAR

Han Win

COUNTRY REPORT OF MYANMAR

Han Win
Assistant Fishery Officer
Marine Fisheries Resources Survey & Research Unit, Department of Fisheries

■ INTRODUCTION

Myanmar has a long coastline of nearly 3,000 kilometers and the continental shelf covers an area of 230, 000 square kilometers with a relatively wider portion in the centraland southern parts. The territorial sea of Myanmar extends 12 nautical miles and EEZ extends 200 nautical miles from the baseline towards the sea. The total area of Myanmar marine fisheries waters, which include territorial sea and exclusive economic zone (EEZ),is 486,000 square kilometers.

Myanmar's coastline can be divided into three coastal regions: the Rakhine Coastal Region (from the mouth of Naff River to Mawtin Point, about 740 km in length), the Ayeyarwady Delta and the Gulf of Mottama Coastal Region (from Mawdin point to the Gulf of Mottama, about 460 km in length) and the Tanintharyi Coastal Region (from Gulf of Mottama to the mouth of Pakchan River, about 1200 km in length) in the Bay of Bengal and the Andaman Sea.

With a coastline of nearly 3,000 km, Myanmar possesses a considerable diversity of coastal habitats, including coral reefs, mangroves, sandy beaches and mudflats. Corals are important coastal resource for sustaining coastal fisheries. Myeik Archipelago along the southern coast, where the majority of Myanmar coral reefs is found. Myanmar has 1,686 sq. km. of coral reef area (WRI, 2002).

■ MARINE FISHERIES RESOURCES

A "Marine Fisheries Resources Survey and Exploratory Fishing Project" was carried out with the assistance of FAO during 1979-83 Project activities consisted of acoustic experimental fishing surveys with R.V. Dr. Fridtj of Nansan and trawl survey with M. F.V 525 and others vessels from Myanmar contribution. It is to be mentioned that the survey was conducted only within 200-meter depth.

According to surveys, it was noted that about 1.0 million metric ton of pelagic fish and 0.8 million metric tons of demersal fish are exists as biomass in Myanmar marine fishery waters. Out of the total biomass, 0.5 million metric tons of pelagic fish and 0.55 million metric tons of demersal fish, totaling 1.05 million metric ton of marine fish is marked as Maximum Sustainable Yield (MSY).

■ CONSERVATION AND REHABILITATION OF RESOURCES

In many countries, depending on its condition of marine fisheries resources and environment, artificial reefs have been established as a possible tool for fisheries management in maximizing exploiting, resources conservation, habitats rehabilitation, and mitigating the effects of over fishing. In Myanmar marine fisheries water, artificial reefs have not been used yet. It may be attributable that the production in marine fisheries was not reached into its MSY, and there are in abundance of natural reef especially in islands from Tanintharyi Coast. However, the conservation of marine resources and their environment has been always the primary concerned of the Department of Fisheries (DOF). Therefore, intending to remain the undamaging marine environment in perpetuity for future, among the islands in Tanintharyi Coast, Lampi Island had been gazetted as Marine Park and Marine Reserve under the Fisheries Laws as a management measure and resources conservation of DOF. The water around the Island area also has been

announced as Fishery Protected Area, whereby collection of marine fauna and flora is prohibited. Fishing in this area also prohibited unless especially licensed to do so. Public awareness of the need to protect the corals and other marine fauna and flora in the waters surround the islands is being promoted so as to ensure their conservation.

■ MANAGEMENT MEASURES

One of the goals of fisheries management is to achieve sustainable coastal fisheries. In order to achieve this goal, various management strategies have been formulated and implemented to control fishing effort and promote rehabilitation and conservation of marine resources and marine ecosystems. These measures include licensing of the fishing gear and fishing vessels, closed fishing area and season, and enacting laws and enforcement.

■ DIRECT LIMITATION OF FISHING EFFORT

State and Division-wise direct limitation of fishing effort through proper licensing of the fishing gear and fishing vessels. This is to ensure that the current high fishing pressure on the limited coastal fisheries resources will not be increased, and to prevent overexploitation. A person desiring to carry out fishery shall apply for license to his respective DOF office in the prescribed application form. The effectiveness of the fisheries licensing procedures is one year and it must be renew at the end of the year. Conditions for renewal of licenses are laid down annually from 1 September to 31 August of next year for deep-sea fishery and for the coastal fisheries, 1 April to the next 31 March of every fiscal year.

■ CONTROL ON SIZE AND POWER OF FISHING VESSELS

Any attempt by fishermen to change the tonnage or engine power of fishing vessels or to construct fishing vessels, requires permission from the Director-General, Department of Fisheries.

■ REGISTRATION OF FISHERMEN

This program controls entry of new individuals into the fishing industry. Every fisherman is required to register and everybody working, living, staying on the fishing vessel of fleet or any related vessel must have a fishermen registration card.

■ CLOSED FISHING AREA

Commercial fishing vessels, like trawlers and fish purse seiners, are prohibited from fishing in waters less than 5 nautical miles from the shore, which is the nursery grounds of juveniles of shrimp and fish, in order to reduce their fishing pressure.

■ CLOSED FISHING SEASON

Nursery areas are identified to ensure survival of juveniles of commercially important fish species. They are one fishing ground in Rakhine, four in Ayeyarwady, two in the Mon, and three in Tanintharyi region. They have been gazetted as closed fishing area for three months, June to August.

■ MANAGEMENT ZONES

Two fishing zones have been classified through a licensing scheme whereby zones are designated for specific fishing gear, classes of vessels and ownership. These two management zones, Inshore- and Off-shore fishery, can ensure equitable allocation of resources and reduce conflict between traditional and commercial fishermen. Basically they are:

1. Inshore Fishery. Fishing in In-shore fishery (five nautical miles away from shore in Rakhine ten nautical miles in Ayeyarwady and Tanintharyi coast) is done by passive fishing gears without boat or non-mechanized boat or mechanized boat. If the boats are mechanized, the engine should not be more than 12 H.P. and the overall length of the boats should not be more than 30 feet.

2. Off-shore Fishery. In Off-shore fishery (from outer area of demarcated in-shore fishery areas to end of EEZ), active fishing gears are operated with fishing vessels which are more than thirty feet in over all length and engine power more than 12 H.P.

■ MYANMAR'S FISHERIES LAWS

The government promulgated four fisheries laws: "The Law Relating to the Fishing Rights of Foreign Fishing Vessels" in 1989, "Aquaculture Fisheries Law" in 1989, "Myanmar Marine Fisheries Law" in 1990, and "Freshwater Fisheries Law" in 1991.

■ PROHIBITION OF FISHING GEARS

Under the "Law Relating to the Fishing Rights of Foreign Fishing Vessels", "Myanmar Marine Fisheries Law" and related regulations, fishing gear or method that is destructive to the environment and the fisheries resources are banned. These gear includes pair trawl fishing, electric fishing, fishing with poisons, chemicals and explosives, push net and purse seine net (less than one inch in mesh size), trawl net (less than two inches in cod-end mesh size), drift net (less than four inches in mesh size), trammel gill net (less than 1.5 inches in mesh size).

■ MONITORING, CONTROL AND SURVEILLANCE (MCS) PROGRAM FOR FISHERIES MANAGEMENT

MCS program provided for effective and efficient scientific data acquisition for resources evaluation and management of fisheries in Myanmar. It also provides for the design of effective monitoring and control of fisheries enforcement activities to ensure that only authorized or license holder fishing vessels conduct their fishing activities within designated areas in Myanmar's fisheries waters.

■ LAW ENFORCEMENT

Strict law enforcement on fishing activities in Myanmar's fishery waters, is carried out by a number of departments, namely Myanmar Navy, Customs Department, Myanmar Police Force and Department of Fisheries and these departments address the problem of illegal fishing.

■ FUTURE OUTLOOK

The fisheries resources of Myanmar can play a crucial role in production of food, improvement of income, generating of employment and foreign exchange, and fishery is ranked as third in national economy. According to the policy and principle objectives of the livestock and fisheries sector formulated and fisheries economy system in accordance with the market oriented economy, Myanmar fisheries has been gradually growing year by year production in marine fish had grown 1.02 million metric ton in 2001-2002.

In the future, the demand for fish will exceed potential supplies creating over exploitation subject to this, effective appropriate management measure are required to promote objectives for optimum utilization of aquatic resources.

Management should be conceived and understood not as a constraint upon national exploitation, but as an essential tool for the sound, sustained development of fisheries, hence, management of fisheries is an integral part of the development process. There is a need to introduce effective management mechanisms at all stage and particularly at the beginning of fisheries development rather than wait until the effect of over fishing has began to be felt.

DOF has accepted using artificial reefs (AR) for marine aquatic resources restoration and enhancement. DOF has considered to make an effort for being used ARs with suitable materials, design at suitable places in Myanmar marine waters. However, Myanmar marine fisheries were not so developed in the past and, therefore, exploitation on marine fishes has not been reached to unsustainable level. Lack of knowledge on the role of AR among public is a fact to be considered although their participation in establishment of AR is important.

Authorities concerned may consider increasing the number of Marine Park and Marine Reserve, or Marine Protected Area at a place where, especially, corals are abundant. The establishment of an AR is a difficult task in terms of financial and technology.

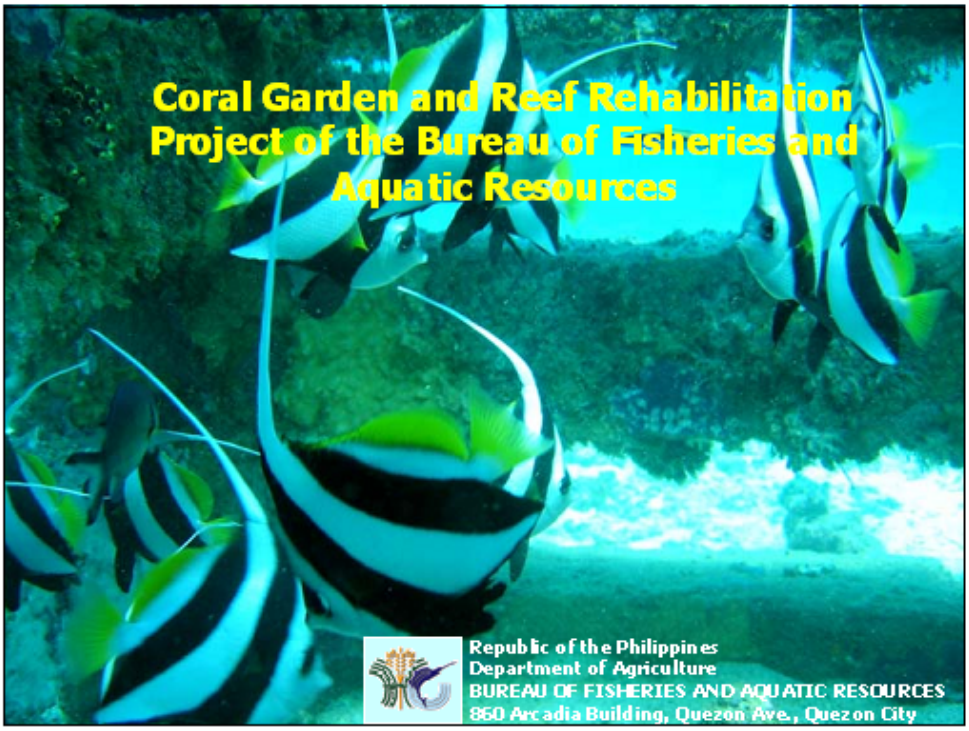
Assistance from international fisheries related agencies, such as FAO, NACA, BOBP and SEAFDEC, is essential for the fisheries development in assessment of fishery resources, development of appropriate technology, training of skilled manpower, identification and preparation of projects, financing of commercial operation.

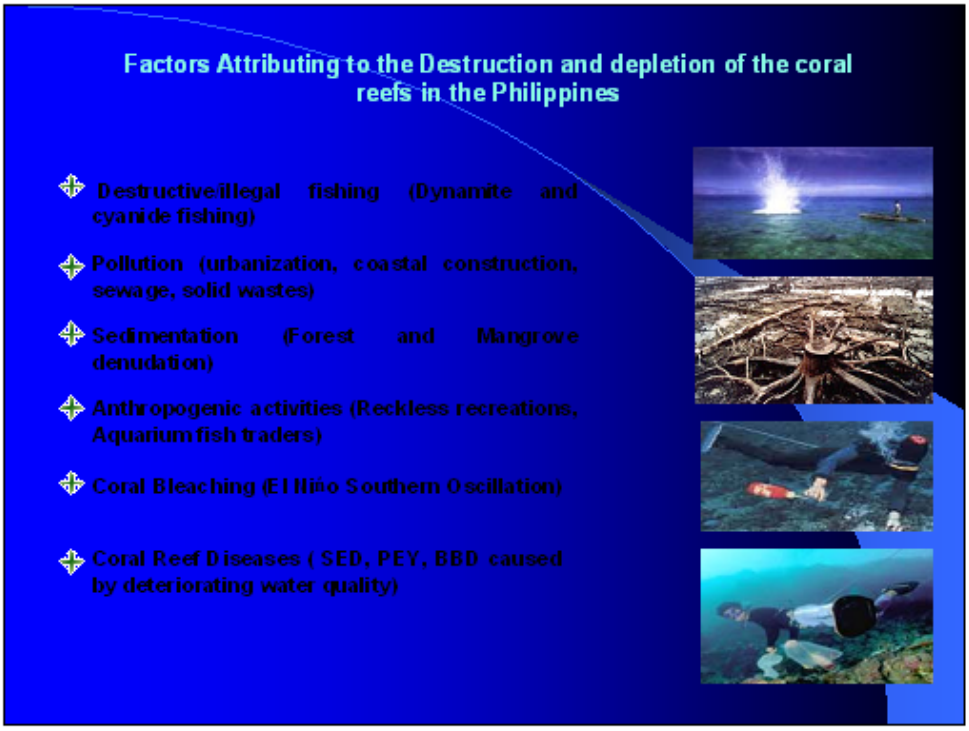
REFERENCE

1) WRI 2002. Reefs at Risk in Southeast Asia. Lauretta Burke (WRI), Liz Selig (WRI), and Mark Spalding (UNEP-WCMC, Cambridge, UK).

CORAL GARDEN AND REEF REHABILITATION PROJECT OF THE BUREAU OF FISHERIES AND AQUATIC RESOURCES

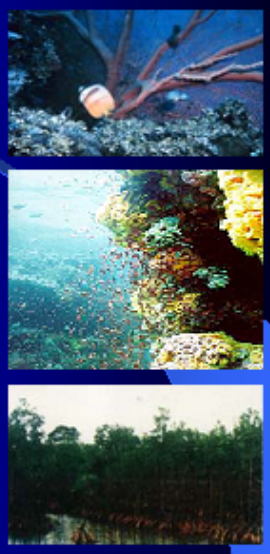
Pierre Easter L. Velasco


Coral Garden and Reef Rehabilitation Project of the Bureau of Fisheries and Aquatic Resources
Republic of the Philippines
Department of Agriculture
BUREAU OF FISHERIES AND AQUATIC RESOURCES
860 Arcadia Building, Quezon Ave., Quezon City


Factors Attributing to the Destruction and depletion of the coral reefs in the Philippines
Destructive/illegal fishing (Dynamite and cyanide fishing)
Pollution (urbanization, coastal construction, sewage, solid wastes)
Sedimentation (Forest and Mangrove denudation)
Anthropogenic activities (Reckless recreations, Aquarium fish traders)
Coral Bleaching (El Niño Southern Oscillation)
Coral Reef Diseases (SED, PEY, BBD caused by deteriorating water quality)

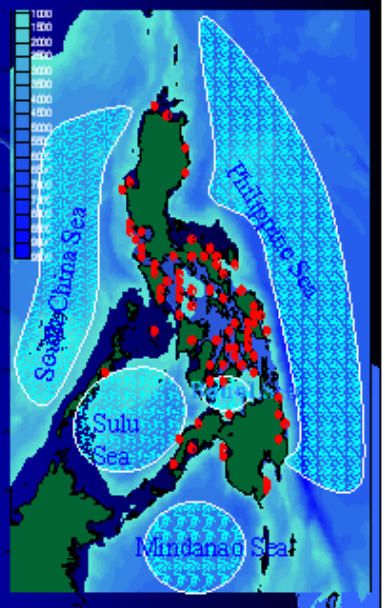
The Nationwide implementation of the establishment of Marine reserves and sanctuaries will protect the coral reefs from further degradation and destruction due to illegal and destructive fishing activities, pollution, sedimentation and human activities. Coastal and Municipal Fisheries has declined its production, from a peak of 1,070,195 (million) m.t. in 1988 to only 924,466 (33.4%) m.t. in 1997.

To address this dilemma, the Bureau of Fisheries and Aquatic Resources (BFAR) launched an innovative coral reef management and regeneration program: The Coral Gardening and Reef Rehabilitation Project, the initial implementing strategy for sustainable fisheries management.



The Program seeks to promote alternative livelihood to reduce community pressure on the reefs through "green" coral aquaculture. The BFAR with the LGU will identify and delineate the 10 ha. site/area for the said coral rehabilitation and marine resource conservation and protection project.

In addition to the 13 identified sites of the NFARMC (National Fisheries and Aquatic Resource Management Council), the BFAR-CO has identified 26 sites from ARMM (Autonomous Region of Muslim Mindanao) and 21 from BFAR-RFO 2. Overall, 60 sites/areas has been identified which needs prioritization and assessment as basis for introducing management interventions. To date, over 400 marine reserves and fish sanctuaries have been established all over the country with a total area of 8,313.90 has.



Location of ARs

General:

- To conserve and initiate the rehabilitation of damaged reefs in the fish sanctuary in the Philippines initially in Puntod Reef, Tangalan, Aklan
- To uplift the standard of living conditions of the fisherfolk in the local fishing communities

Specific:

- To concentrate marine organisms to allow for more efficient but selective and regulated fishing activities
- To protect small/juvenile organisms and nursery areas from destructive fishing activities
- Increase the natural productivity eventually by supplying new habitats for sessile or permanently attached organisms and by allowing the establishment of an associated food chain
- To create habitats and stimulate natural reefs for desired target species
- Restore dead or degraded coral reefs
- Generate income through tourism
- To educate the primary stakeholders in the local fishing communities about coral reef conservation and rehabilitation and build their capabilities to monitor and manage their coral reef resources

DESCRIPTION OF THE PROJECT

The Bureau of Fisheries and Aquatic Resources (BFAR) has formed and organized the BFAR SCUBA Divers Task Force with a primary purpose to monitor, manage, safeguard the Coral Reef Resources of the Philippines.

COMPONENTS OF THE PROJECT

Survey/Assessment

A survey of the proposed site will be conducted using the Line Intercept Transect Method (LIT). This will determine the condition/status of the marine benthos communities (English et. al. 1997). Furthermore, the results of the survey will help stakeholders determine the appropriate actions and formulate ordinances, guidelines, etc. in the protection, management, and conservation of the marine resources with the recommendation of the BFAR and other concerned agencies.

Site Selection

The selection of the proposed coral garden site/area and the establishment of ARs were based on the following criteria:

- At least 500m away from natural reefs
- Near an alternative food source (i.e. sea grass beds)
- Constructed on a barren and stable substrate area of flat or gently sloping bottom of relatively good visibility.
- At depths of 15m to 25m, protected form wave action but still accessible to local fishermen.
- If coastal management project is already on going, or if site is a successful marine protected area
- Absence of sources of chronic damage to reefs. Otherwise, reef rehabilitation will not succeed.
- Relatively protected from wave action
- Deployment of Artificial reefs (AR's) may be considered in areas where there is no stable substrate available
- Accessible and manageable to the fisherfolk/stakeholders

Artificial Reef

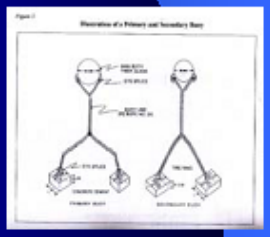
Fifty (50) modules of concrete building block (1 module=16 units, 2m x 0.20m x 0.15m) served as artificial reefs (ARs). The artificial reefs were installed/sited within the marine reserve/sanctuaries.

Establishment of Marine Reserve/Sanctuaries

The BFAR and the Local Government units have deemed it important to establish marine reserves and fish sanctuaries to rehabilitate, regenerate, manage and protect the remaining fishery and marine resources.

An area (10 ha.) with heavily depleted demersal/benthic fish stocks, coral, and coral reef species will be delineated using a Global Positioning System (GPS). Local Government Units (LGUs) will be encouraged to formulate Municipal Ordinances with the BFAR recommendation and technical assistance to enact and strengthen the protection, conservation and management of the Marine Sanctuary.

Marker buoys will be installed to delineate the identified sites for the proposed marine reserves and sanctuaries. Fifty (50) units of marker buoys (30 cm diameter, orange sphere, 8 mm thick) will be used.



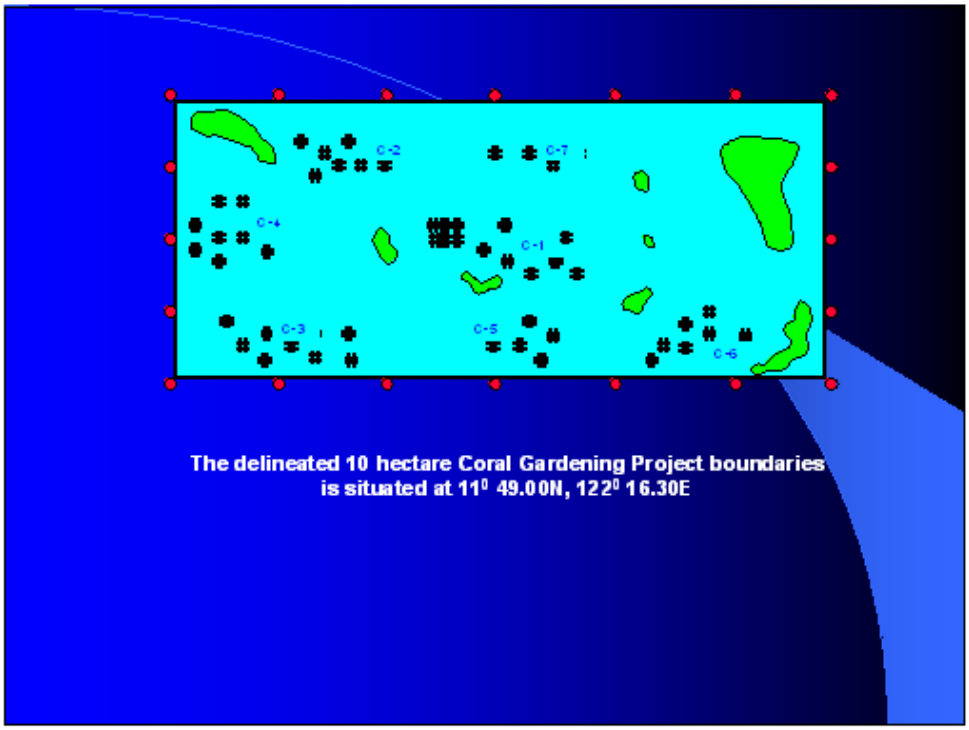
Monitoring and Assessment of the Coral Garden and Reef Rehabilitation Project in Tangalan, Aklan

The ten (10) hectare Coral Gardening and Reef Rehabilitation Project is a collaborative project of the Marine Fisheries Development Center - Bureau of Fisheries and Aquatic Resources (MFDC – BFAR) and the Local Government of Tangalan, Aklan. It is situated inside the 60-hectares Marine Fish Sanctuary at Pungtod Reef, Barangay Jawili, Tangalan, Aklan. The sanctuary was declared through a municipal ordinance passed in 1993.The Fish Sanctuary is located at 11^0 49.21 N and 122^0 16.29 E

The members of the BFAR SCUBA Divers Task Force initially assessed the reef last August 4, 2002. The percent of live coral cover at Pungtod Reef registered only 12.09%, a poor coral cover as described by Mantachitra (1998).

As component of the Reef Rehabilitation project, artificial reefs were deployed within the site of the Coral Gardening and Reef Rehabilitation Project. Artificial reefs are means of increasing coastal productivity in the long term by providing substrates for growth of sessile organisms and establishing new food chains. In addition, artificial reefs serve as protection of shelter for fish juveniles, preventing their early harvest.

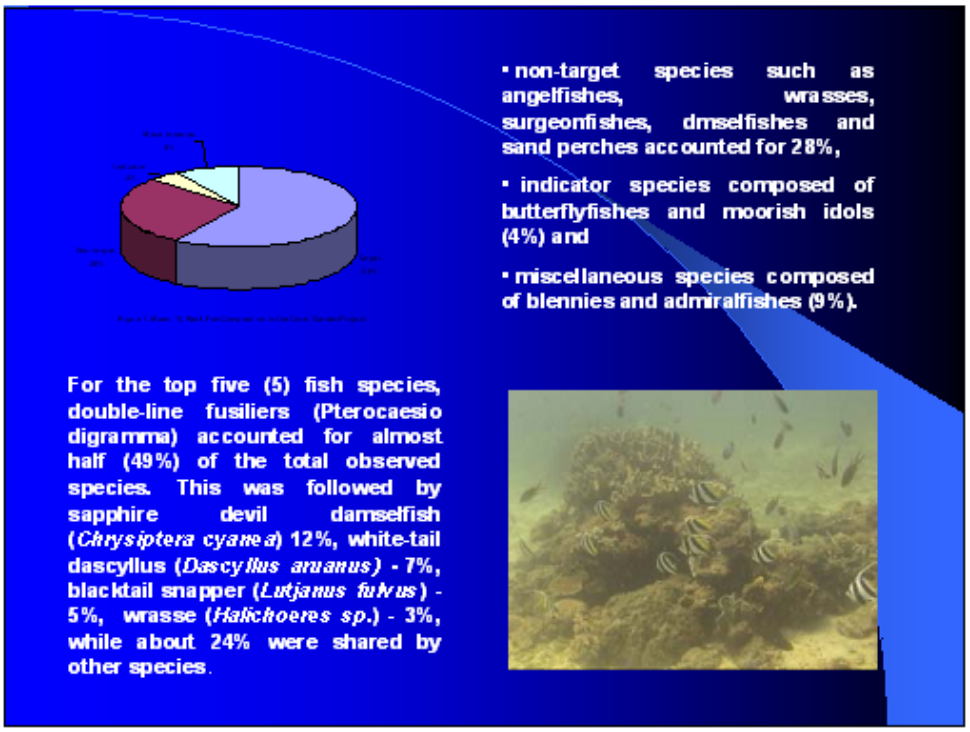
Preliminarily, red marker buoys demarcating the ten (10) hectare area and 49 artificial reef modules were deployed last July 11 - 22, 2003 composed of forty-eight (48) artificial reef modules of 16 slabs each and one (1) mother artificial reef composed of forty-eight (48) concrete slabs. These concrete slabs with a dimension of 10 inches by 8 inches by 2 meters were piled on top of each other, with the upper slabs inserted about 5 inches inward forming a pyramid type of module creating a larger surface area for benthic settlers and to capture wider range for sunlight. These artificial reefs were left in the area for a period of nine (9) months to allow growth and shelter for benthic and other marine organisms, with the local SCUBA Divers and Bantay Dagat members periodically monitoring and occularly inspecting the status of the project.

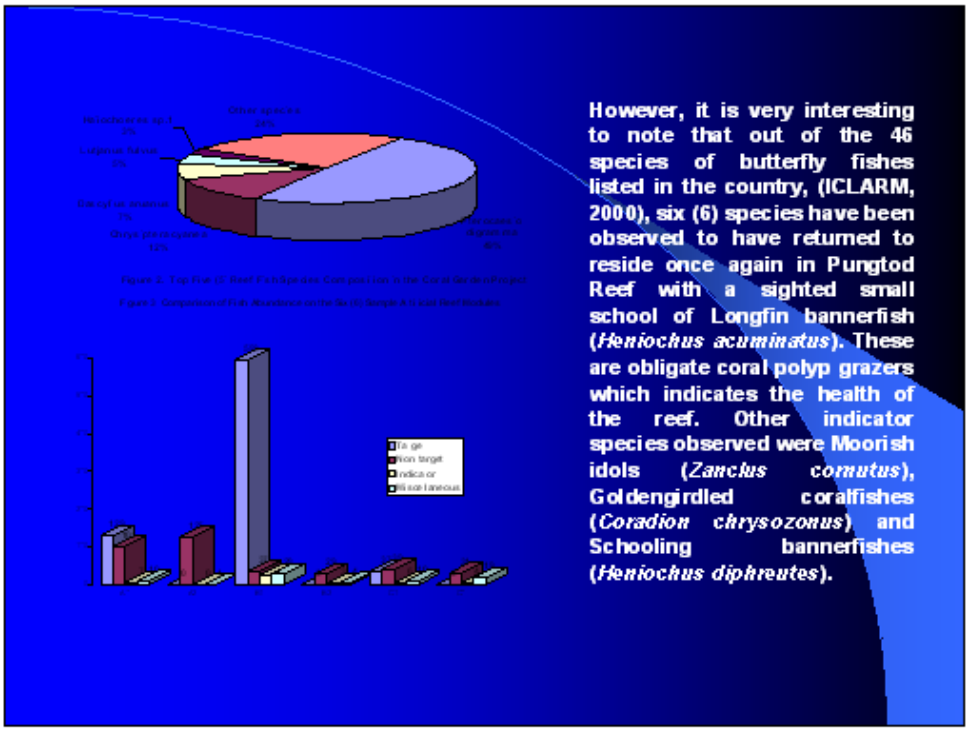


A total of 40 fish species and 22 genera belonging to 14 families were identified and recorded from the three (3) representative artificial reef clusters at the center of the Coral Garden Project posted the highest species count of 27.

In terms of reef fish composition, dominant target species were composed of

- snappers, fusiliers, nemipterids, goat fishes and parrotfishes composed more than half of the observed species present in the area with 59%,


• non-target species such as angelfishes, wrasses, surgeonfishes, damselfishes and sand perches accounted for 28%,
• indicator species composed of butterflyfishes and moorish idols (4%) and
• miscellaneous species composed of blennies and admiralfishes (9%).
For the top five (5) fish species, double-line fusiliers (Pterocaesio digramma) accounted for almost half (49%) of the total observed species. This was followed by sapphire devil damselfish (Chrysiptera cyanea) 12%, white-tail dascyllus (Dascyllus aruanus) - 7%, blacktail snapper (Lutjanus fulvus) - 5%, wrasse (Halichoeres sp.) - 3%, while about 24% were shared by other species.


However, it is very interesting to note that out of the 46 species of butterfly fishes listed in the country, (ICLARM, 2000), six (6) species have been observed to have returned to reside once again in Pungtod Reef with a sighted small school of Longfin bannerfish (Heniochus acuminatus). These are obligate coral polyp grazers which indicates the health of the reef. Other indicator species observed were Moorish idols (Zanclus cornutus), Goldengirdled coralfishes (Coradion chrysozonus) and Schooling bannerfishes (Heniochus diphreutes).

Basing from the 6 sampled modules out of 49 artificial reefs deployed. There was a total of 1,281 fishes observed. The volume of water space per reef was 38.48 m^3. For the 6 artificial reefs sampled, there were a total of 230. 9 m^3 available water space. From the above calculation, it can be deduced that there were approximately 6 fishes observed per cubic meter.

Other living creatures attached to or present on the artificial reef modules were soft corals, encrusting corals, turf algae, barnacles, mollusks, zoanthids, ascidians, sponges, starfishes and other invertebrates.

After only a period of nine (9) months, these were the marine organisms recruited on the artificial reef structures. Recruitment refers to the number of organisms that initially settle minus the number that die before a count is made (Gomez & Yap, undated).

The artificial reef modules, although devoid of any marine creatures at first, was eventually covered by benthic fauna and being utilized as breeding and feeding grounds for free-swimming marine fish species. As agreed by Chua and Chou (1994), a concrete artificial reef module was effective in terms of fish abundance per unit volume.

ARTIFICIAL REEF PROGRAMMES IN SINGAPORE

Chou Loke Ming, Ph.D.

ARTIFICIAL REEF PROGRAMMES IN SINGAPORE

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ABSTRACT

Artificial reef projects were initiated in Singapore in 1989 using tyre pyramids and hollow concrete modules. These were deployed at depths of 15m and were aimed at improving fish stocks. Larger-sized fish preferred the concrete modules while juveniles favoured the tyre reefs. Fish abundance and diversity increased over 7 years before reaching equilibrium. In recent years, fibreglass modules referred to as "Reef Enhancement Units" were established in shallow reef areas to investigate their effectiveness in reef restoration. Early results showed that they provided suitable substrata for the settlement and development of coral recruits and other reef-associated species, as well as for coral transplants.

■ INTRODUCTION

The Republic of Singapore has over 60 small offshore islands located mostly south of the main island. Fringing and patch reefs are associated with these offshore islands. It has a combined land area of approximately 660 km^2, and its marine territory covers 630 km^2. With a human population of 3.9 million, it supports a high density of 5,900 persons per km^2 (Anon, 2000). Its marine environment continues to be an important resource, playing an important role in economic growth and prosperity, but it has undergone tremendous change over the years. It supports one of the world's busiest ports and one of the largest oil refining centres. Close to 60% of the total coral reef areas have been lost through foreshore reclamation (Chou, 1995; Chou & Goh, 1998).

With its highly urbanised setting, fishing pressure on the reefs, either from aquarium trade or for subsistence, declined steadily since the 1980s. Records are not available of coral reef fish harvested from reefs, as reef fisheries are practically non-existent. Trawling is prohibited in territorial waters due to limited space and risk to navigational safety. Local fish catch comes mainly from the diminishign numbers of licensed commercial palisade trap operations and local production from marine aquaculture (Chou, 2002). The country does not have any extensive monitoring programmes for fish re-stocking and stationary fishing gear.

Illegal collection of corals and other reef invertebrates stopped with stronger enforcement by the Police Coast Guard in the 1990s. Effective regulatory measures prevent marine pollution. The greatest impact however is the high sediment load generated by land reclamation, the regular dredging of rivers and shipping lanes, and the dumping of these material out at sea. In the past three decades, the high sedimentation levels generated by these activities have reduced the abundance but not the diversity of the coral reef life-forms (Hsu & Chou, 1991). Coral growth zone is reduced to shallower depths where high diversity still exists. Efforts aimed at enhancing the marine resources in the past two decades through artificial reef programmes have been implemented. These include concrete blocks and tyre modules as artificial reef sturctures in the 1980s (Chua & Chou, 1994; Chou, 1991) and the present project using fibreglass strutures (Loh & Chou, 2002).

■ MARINE RESOURCE ENHANCEMENT AND PROTECTION

Coastal fisheries production of 40,000 tonnes annually declined since the late 1940s, due to increased shipping activities, loss of original coastal habitats and fishing grounds to land reclamation, and better alternative employment opportunities. Palisade traps ("kelongs"), which were located at the nearshore, were phased out particularly along the southern coast as they posed a threat to navigational safety (Chou & Chan, 2001). The use of simple fish traps such as the "bubu" has decreased over the years. Coastal aquaculture practices have shifted from traditional to intensive system while mariculture, using floating net cages, has been actively promoted.

In 1977, the Singapore Government initiated a 10-year River Clean-up programme to improve the water quality of the Singapore River to transform the riverbanks into beautiful parks and walkways with clean river water. The fauna returned to the river after the water quality improved. The Primary Production Department (the now Agri-Food & Veterinary Authority) launched a 10-year stocking programme in 1986 aimed at enhancing the fish population. The stocked fish would establish as resident fish and promote game fishing (Lee & Low, 1991). Over 80,000 seabass *(Lates calcarifer)*, 8,500 cherry snappers *(Oreochromis niloticus)* and 630,000 banana shrimp *(Penaeus merguiensis)* were released into the river as stock.

Khin & Chou (1991) studied the effects of stocking in the river during the period April 1986-October 1988. It was thought that introduced seabass and banana shrimps may have established themselves. Further in vestigations revealed that only seabass had established well in the river but not the snappers and banana shrimps (Lee & Low, 1991). Seabass had also been found to have a preference for the artificial seagrass, which Lee & Low (1991) speculated made a good ecological niche for the stocked seabass. However, due to multi-sectoral conflicts in the use of the site, follow-up monitoring had to be abandoned. Besides these studies, no other re-stocking efforts are know, except for giant clam re-stocking research currently conducted by the Tropical Marine Science Institute of the National University of Singapore.

There are some coastal protected areas in Singapore (Sungei Buloh Wetlands Reserve and Labrador Nature Reserve) but none that covers reef systems. There are no national policies on coral reefs and neither is there a government agency with the distinct responsibility of managing reef resources. The protection and conservation of fisheries are regulated by the Fisheries Act (Chapter 111). The Act has strict prohibitions on the use of poisons or explosives, as well as trawl net fishing.

■ ARTIFICIAL REEFS

Intensive development of coastal areas since the 1960s resulted in the degradation of the coral reef ecosystem. The earliest artificial reef project was initiated in the late 1980s under the ASEAN-USAID Coastal Resources Management Programme. Several sites were identified for artificial reef establishment. Reef resources (Hsu & Chou, 1991), fish fauna (Lim & Chou, 1991) and physical parameters (Hsu & Chou, 1987) of these sites were assessed to determine the potential of establishing artificial reefs. In mid-1989, the first artificial reef was launched (Chua & Chou, 1994), using hollow concrete cubes and tyre-pyramid modules. These structures were established at 15m depth of the sea floor adjacent to a natural patch reef (Terumbu Pempang Tengah) west of Pulau Hantu. The purpose was to test the effectiveness at restoring and enhancing fish communities.

Observations indicated growth of a layer of filamentous algae over the surface of materials within the first few weeks. This was followed by a diversity of encrusting organisms such as hydroids, tunicates, barnacles, developing on the concrete modules but not on the tyre modules (Han *et al*, 1994).

Initial fish community surveys showed a total of 37 and 32 fish species recorded over a period of 1.5 years at the concrete and tyre reefs respectively (Chua & Chou, 1994). Fish community surveys conducted between September 1989 to January 1996 at the concrete and tyre reefs indicated significant increase in fish abundance and species richness

(Low & Chou, 1999). A total of 68 species from 26 families were recorded at both types of artificial reefs – 55 species from 22 families at the concrete and 48 species from 24 families at the tyre reef.

Generally, both concrete and tyre artificial reefs contributed to an increased fish population. However, the fish communities of both artificial reefs appeared to reach a state of equilibrium by the seventh year after establishment, based on increasing species evenness and the absence of additional new species (Low & Chou, 1999).

Low & Chou (1999) also found that fish abundance, density and size were greater at the concrete than the tyre reef. This is because fishes prefer to inhabit crevices similar to their body sizes (Hixon & Beets, 1989; Randall, 1963; Shulman, 1984). Adult batfish (*Platax)* and snappers were observed residing at the concrete modules while the juvenile stages of various fish species preferred the tyre reef, which offered tighter crevices.

Concrete and tyre reefs could only be placed at deep areas (15m depth) and served only for fish enhancement. Coral and other reef invertebrates do not extend to these depths due to high sedimentation levels and low light penetration. For reef restoration, artificial reef structures had to be designed for deployment in shallow reef locations.

The National University of Singapore (NUS) and Singapore Tourism Board (STB) initiated a research project in 2001 on the use of artificial reefs to promote coastal tourism. As Singapore reefs are shallow, fringing and not extending deeper than 10m (Lim *et al*, 1990), the earlier concrete and tyre reefs were unsuitable and cannot be placed in shallow waters as they required a large vessel for deployment. A specially fabricated module, termed as "Reef Enhancement Unit" (REU) was then designed (Loh & Chou, 2002). The REUs are made of fibreglass coated with sand and calcium carbonate to roughen the exterior surface and a suitable settlement substrate to coral recruits. Each module is light enough for divers to handle in the water and relatively easy to manoeuvre. They can then be carried on smaller boats to shallow parts of the reef and moved by divers to precise locations for deployment.

These REUs were deployed at 3m depth of various reefs. Algal assemblages exceeded 90% of surface area in the first month followed by settlement and growth of other organisms such as ascidians, coralline algae, hydroids and bryozoans. Coral recruits were detected on the REUs in the 9th month. These results showed that fibreglass is a suitable structure for artificial reefs. In addition, artificial substrates can provide the stable surfaces for coral recruitment (Chou & Lim, 1986). The project is now in the second phase focusing on maximising the effectiveness of REUs for reef rehabilitation. On-going investigations include attachment of coral transplants, the use of sea urchins to remove algae and the development of the fish community at REUs.

The earlier experience with tyre and concrete structures in deeper waters demonstrated their suitability for fish community enhancement. The REUs are better suited for reef rehabilitation, particularly in shallow reefs areas. Artificial reefs must be part of programmes to manage fishing effort and resources, to obtain an overall positive effect. If properly planned, executed and managed, artificial reef programmes can enhance the marine environment in the long term (Chou, 1997).

Artificial reefs have a role in enhancing fish and reef resources in Singapore. Reef rehabilitation is needed to restore many of the reefs, which have been affected by sedimentation impacts and to compensate for reefs lost through land reclamation. The ultimate goalis to have a coordinated effort at connecting marine resource enhancement programmes to coral reef rehabilitation. The effectiveness of the REUs can be maximised with a better understanding of the most appropriate time for deployment, e.g. to coincide with local mass coral spawning events. Guest *et al* (2002) confirmed that coral spawning events occurred in March or April with a smaller event in October. Efforts were made to tie in REU deployment with the mass spawning event.

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EVALUATION OF ARTIFICIAL REEFS IN PHANGNGA BAY

Suchat Sangchan

EVALUATION OF ARTIFICIAL REEFS IN PHANG NGA BAY

BY

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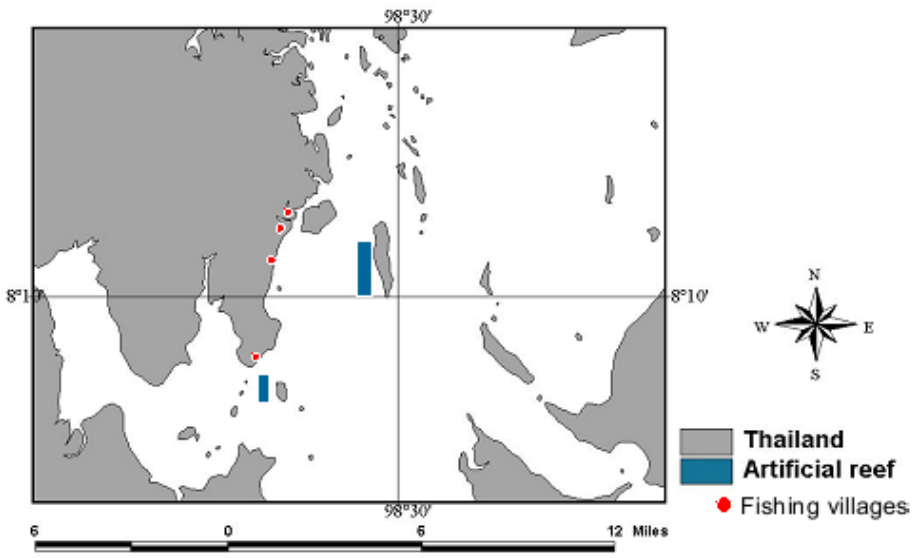
Objectives

- To Study on species diversity in Artificial Reefs area, of the Phang nga Bay
- To study on fisheries status in Artificial Reefs area.

Methodology

- Species diversity
  - Collected by 20 trips of Trammel net
- Fisheries status
  - Collected from 3 main small scale fishing gears, Bamboo stake trap, Trammel net, Modified mackerel gill net.
  - Interview on fisheries situation
- Duration of Data collecting
  - January 1999-December 2002



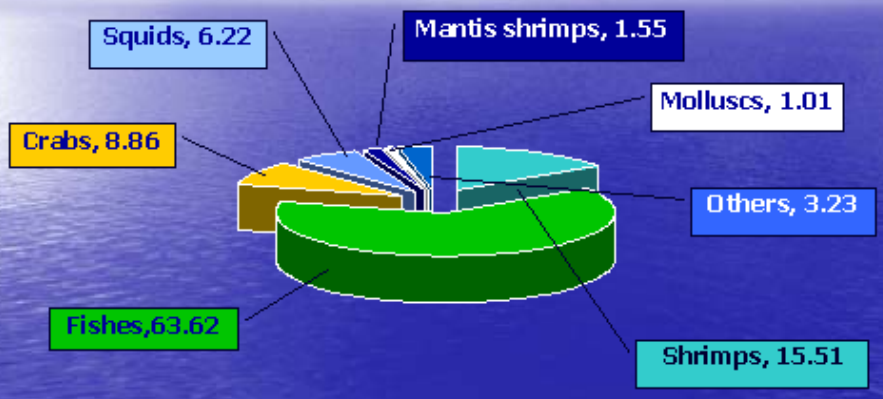
Phang Nga Bay

Species diversity

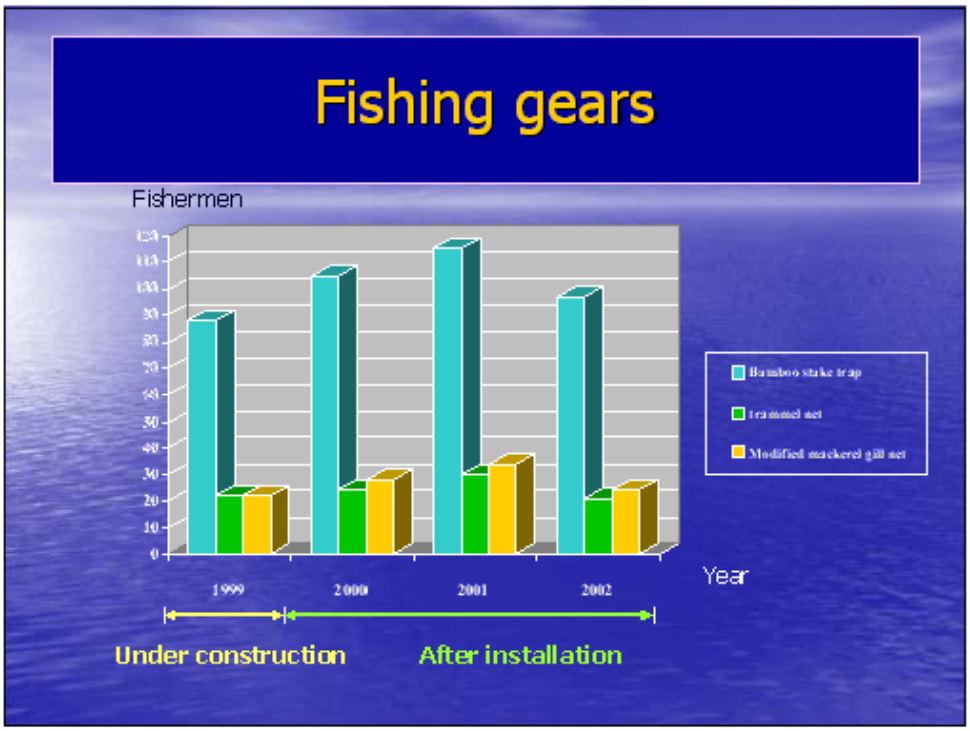
- Groups of marine fauna

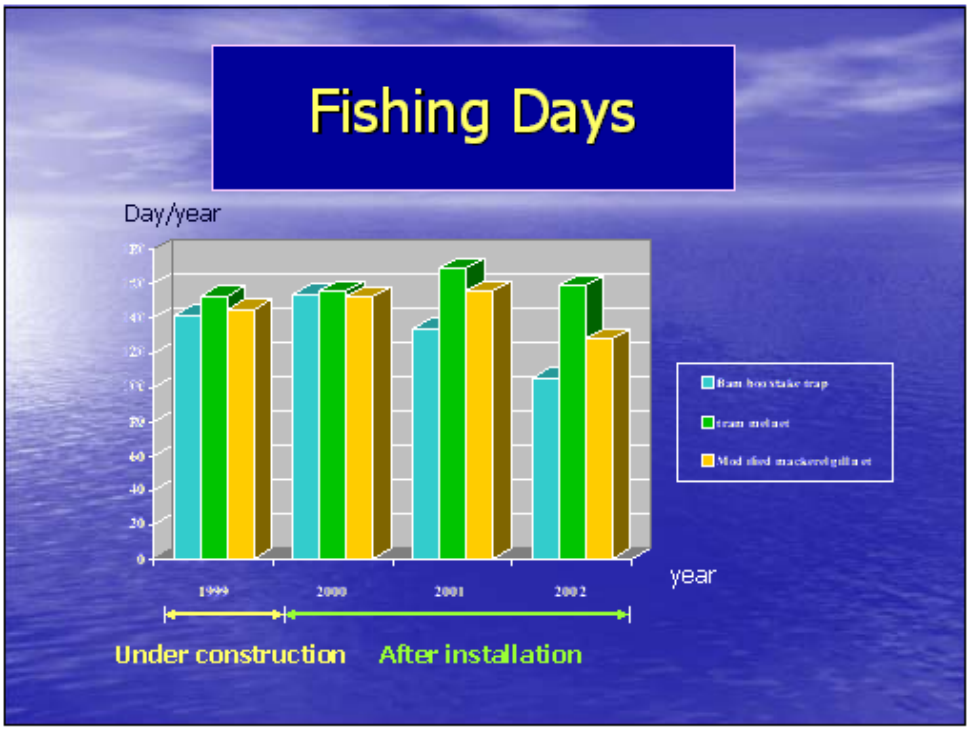
Shrimps	11
Fishes	64
Crabs	4
Squids	5
Mantis shrimps	3
Molluscs	4
Others	2

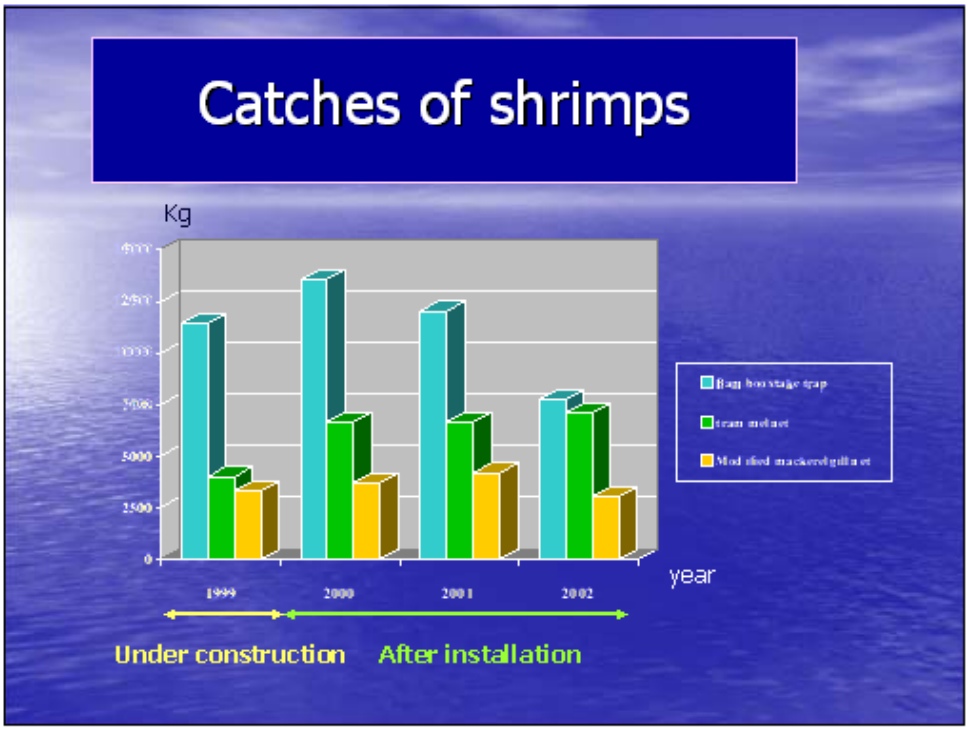
Species diversity

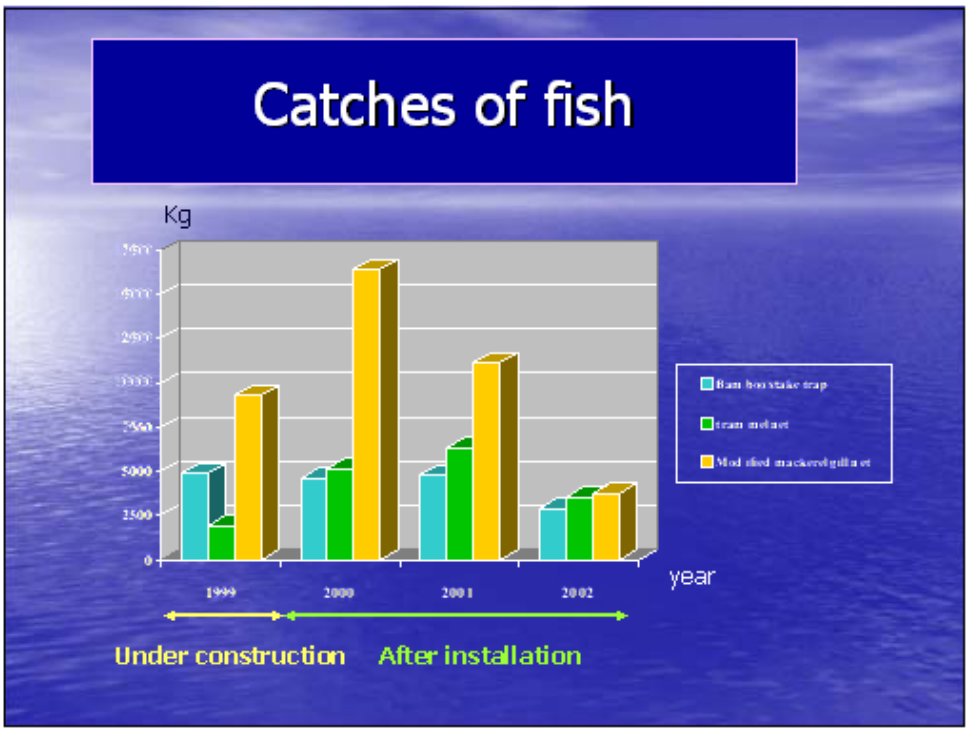


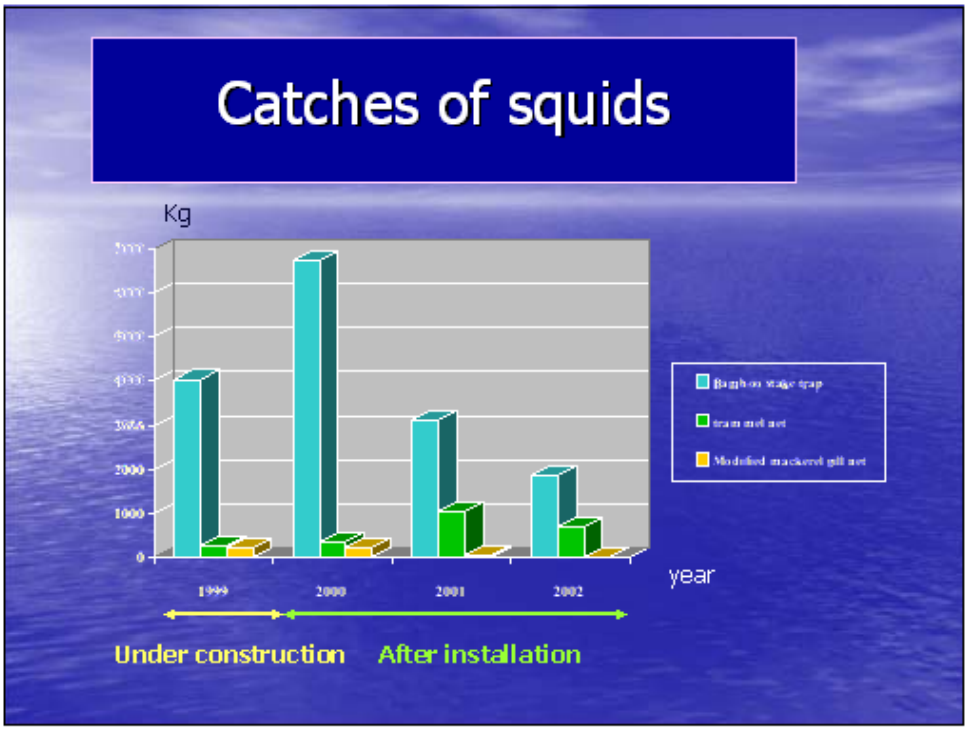
Weight Percentage of aquatic animals

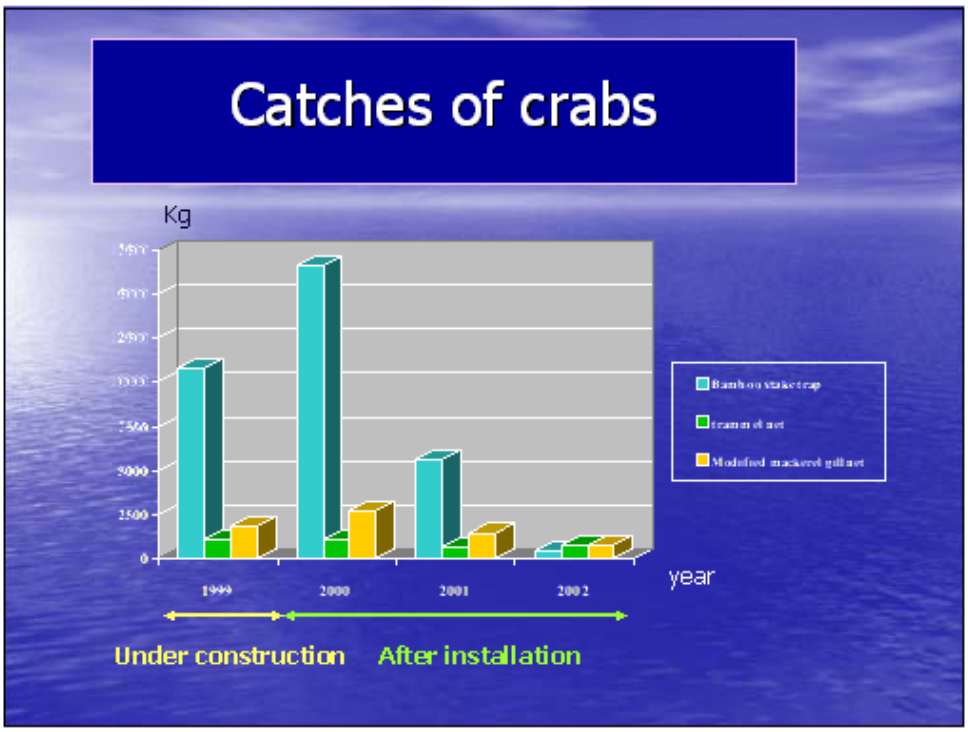

Fishing gears
Fishermen
Year
1999
2000
2001
2002
Under construction
After installation

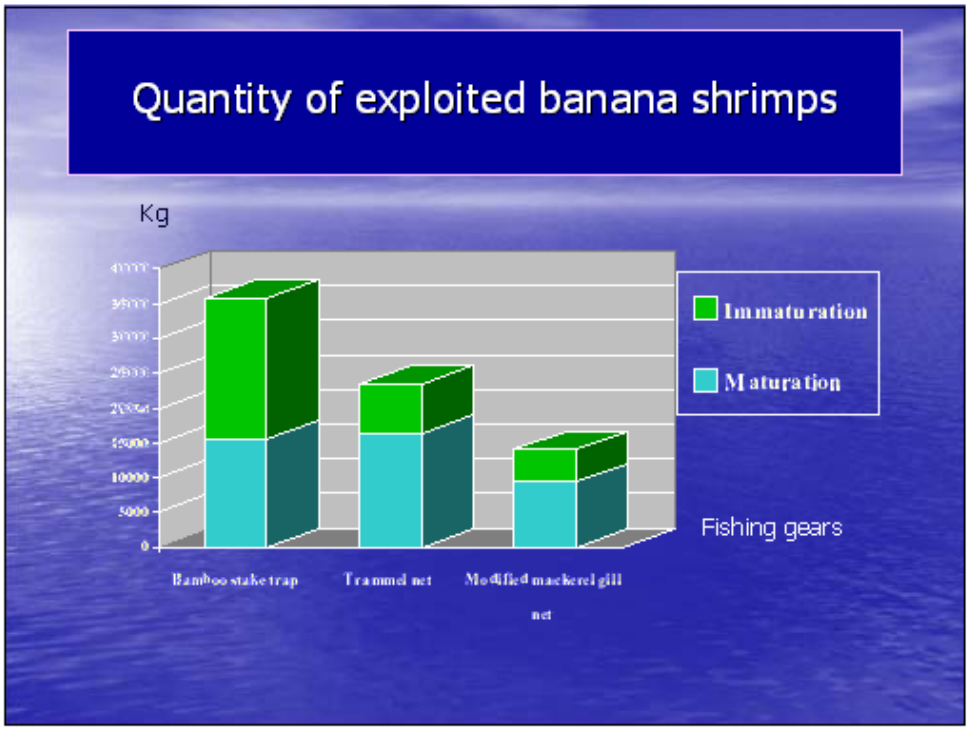

Fishing Days
Day/year
year
1999
2000
2001
2002
Under construction
After installation

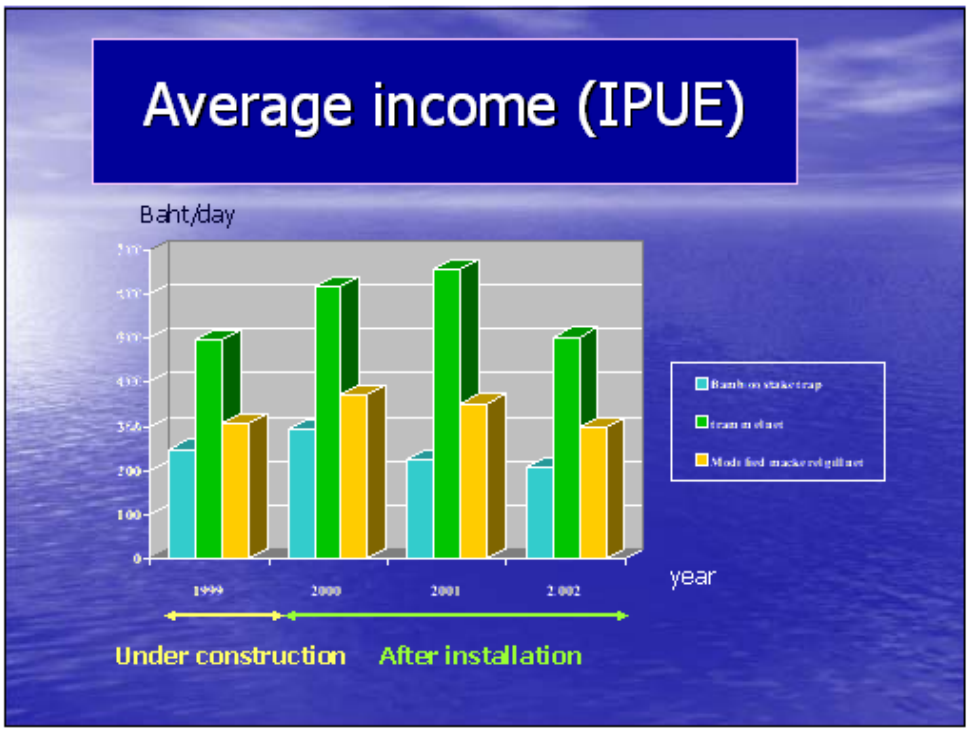

Catches of shrimps
Kg
5000
2500
0
1999
2000
2001
2002
year
Under construction
After installation


Catches of fish
Kg
5000
2500
0
1999
2000
2001
2002
year
Under construction
After installation


Catches of squids
Kg
1000
0
1999
2000
2001
2002
year
Under construction
After installation


Catches of crabs
Kg
2500
0
1999
2000
2001
2002
year
Under construction
After installation


Quantity of exploited banana shrimps
Kg
Immaturation
Maturation
Fishing gears
Bamboo stake trap
Trammel net
Modified mackerel gill net


Average income (IPUE)
Baht/day
year
1999
2000
2001
2002
Under construction
After installation

Aquatic animal value and return on investment

	Under construction	After installation		
	1999	2000	2001	2002
Cost	4,973,700			
Lost of investment	3.75%	3.75%		
Total cost	5,160,214	5,353,722		
Value of exploited	3,901,317	7,266,755	6,284,402	4,082,653
Additional value compare with installation year		3,365,438	2,383,085	181,336
Accumulation to fishing community		3,365,438	5,748,523	5,929,859
Benificial		-1,608,262	774,823	956,159
Return on investment period			22	

Conclusion

- Found 93 species of marine animals in ARs area of Phang Nga Bay.
- After installation about 2 year, fishing effort increase (fishing gears and fishing days). After that decrease trend.
- After installation about 2 year, Catches of aquatic animals and income increase. After that trend decrease but higher than under construction.

ARTIFICIAL REEF INSTALATION IN THE SOUTHERN GULF OF THAILAND

Amnaj Siripeah

ARTIFICIAL REEF INSTALLATION IN THE SOUTHERN GULF OF THAILAND

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Southern marine fisheries research and development center
Department of fisheries

■ INTRODUCTION

Thailand is situated in the Southeast Asian Peninsula. It is bounded by Myanmar in the north and west, Laos in the north and northeast, Cambodia in the east and Malaysia in the south with area of 513,155 km.^{2} The coastline of Thailand is separated by the Malay Peninsula into two parts, one is the Gulf of Thailand that connects to the Pacific Ocean and the other connects to the Andaman Sea. The total coastline is about 2,625 km.

The Gulf of Thailand extends northwest from the southern part of the South China Sea. It is bordered by the coasts of Vietnam, Cambodia and Thailand on the east, by the coast of Thailand on the north and west, and by a line drawn from the Thai-Malaysia border to the tip of Cape Camau of Vietnam on the south. It is approximately 835 km long on the northwest axis. The maximum width is approximately 555 km. The mouth of the Gulf, as indicated by the above mentioned line, is about 370 km wide. The Gulf of Thailand covers an area of approximately 350,000 km.^{2}Being a part of the Sunda Shelf, the Gulf is relatively shallow, with a mean depth of approximately 45 m and a maximum depth of approximately 80 m.

The Southern Gulf of Thailand are in 4 provinces areas as followed : Nakhon si thammarat, Songkhla, Pattani and Narathiwat. In these areas, there are some problems concerning about illegal fishing, and also regulations that are imposed but weak enforced. There is conflict among different groups of fishermen in using the same fishing ground. as well. Department of fisheries has considered many measurement strategies for more effective management. The artificial reefs to protect illegal trawlers and motorized push net fishing near shore and enrich fishery resources in coastal area have been initiated for many years and achieved very well outcome. Furthermore, their objectives are also for fisheries enhancement and coastal zone rehabilitation. The 2 projects regarding the artificial reefs in these areas are: the artificial reef installation project and coastal resources rehabilitation project under the Royal Initiation of Her Majesty the Queen in Pattani and Narathiwat province.

■ ARTIFICIAL REEF INSTALLATION PROJECT

In the Southern Gulf of Thailand, since 1983, the national institute of coastal aquaculture in Songkhla province had installed artificial reefs for the experiment in front of the institute. After that, thousands of artificial reefs have been constructed along the coast of the Southern Gulf of Thailand, 555 kilometers in coastline. The artificial reefs installation in 4 provinces, Nakhon si thammarat, Songkhla, Pattani and Narathiwat during 1983 – 2004 had been done for 64 sites in total and the budget of 206 million Baht has been used. (Table 1). The materials used for constructing artificial reefs were tire, concrete pipe, and dice block.

Table 1 Number of sites and budget of artificial reefs installation project during 1983 – 2004 in the Southern Gulf of Thailand.

Province	Year	Number of sites	Budget (million Baht)
Nakhon si thammarat	1986 - 2004	19	70.0
Songkhla	1983 - 2004	18	72.5
Pattani	1985 – 2004	21	37.5
Narathiwat	1989 - 2004	6	27.0
Total		**64**	**206.0**

■ COASTAL RESOURCES REHABILITATION PROJECT UNDER THE ROYAL INITIATION OF HER MAJESTY THE QUEEN IN PATTANI AND NARATHIWAT PROVINCE

The Coastal Resources Project in Pattani and Narathiwat Provinces was conceived as a result of Her Majesty's attention being drawn to the plight of local fishermen who informed her the dangerous decline in marine resources. When people's hardships were brought to the attention of His Majesty, of consultation, it was agreed that the key of a sustainable solution was to bring fertility back to the sea through the rehabilitation of marine resources.

To increase marine life, it was decided to create a habitat for nurturing tiny creatures by providing artificial reefs. Department of Fisheries, the organization in charging of this royal project, addressed this through a joint strategy that saw a revamp of the management of coastal fisheries, and implementation of a coastal resources rehabilitation program. Since October 2002, the artificial reefs installed along the coasts of Pattani and Narathiwat province was composed 208 covered goods wagon and 707 concrete pipes donated, respectively, by The state railway of Thailand and department of highway. This was the first project in Thailand that the covered goods wagons were used to make artificial reefs.

Before being submerged, all of the rolling stocks were completely cleaned to remove oil and grease and other elements that might harm to environmentally. The wheel bogies were removed and the doors were fixed in an open position. At the depth of 26 to 30 meters of sea water, these sanitized goods wagons were arranged in five groups, each group consisting of 41-42 vans and was 11-12 kilometers far from the coastline of Pattani province.There were placed in the areas that was agree by the local fishermen. The concrete pipes, meanwhile, were installed in the area which was 9.5 kilometers far from the coastline of Narathiwat province.

In year 2003 and 2004, the 100 and 300 covered goods wagons were installed along the coastline of Pattani and Narathiwat province respectively, as well as the 11,545 disc blocks. (Figure 1). And also, were installed too. Three types of materials are showed as Figure 2. During 2002 – 2004, the artificial reef construction in 2 provinces was done in 32 sites and used 41.0 million Baht at. budget. (Table 2)

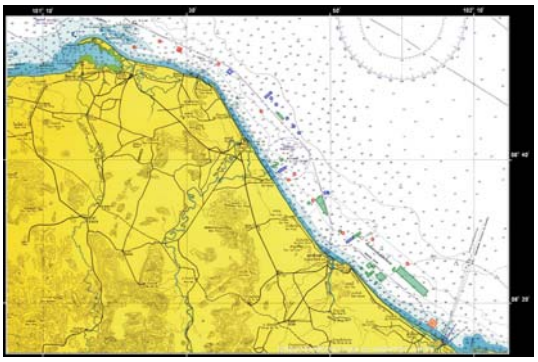


Figure 1 Map of the area of coastal resources rehabilitation project under the Royal Initiation of Her Majesty the Queen in Pattani and Narathiwat province

Figure 2a. Materials used for the installation of artificial reef, covered goods wagon

Figure 2b. Materials used for the installation of artificial reef, disc block

Figure 2c. Materials used for the installation of artificial reef, concrete pipe

Table 2 Number of sites and budget of coastal resources rehabilitation project during 2002 – 2004 in Pattani and Narathiwat province.

Province	Year	Number of sites	Budget (Million Baht)
Pattani	2002 – 2004	20	15.0
Narathiwat	2002 - 2004	12	26.0
Total	**3**	**32**	**41.0**

■ THE RESULTS OF ARTIFICIAL REEF INSTALLATION

After the artificial reefs installation, in the first two years, the surveys have been conducted to follow up the results of the installation. It was found that the objects were not much covered by sand and also there were a lot of fish coming in the areas which all were 64 species in the second year. (Table 3). It was observed that some of the fish were big and never found in those areas before. The appearances of artificial reefs are shown in figure 3-5.

Table 3 Water quality, appearances of artificial reefs and number of fish species in artificial reef installation area.

Title	After installation	
	1st year	2nd year
Water quality	normal	normal
Appearance of artificial reefs		
Disc block	5-10 cm was covered by sand	
Concrete pipe	10-20 cm was covered by sand	
Covered goods wagon	no sand covered	
Fish species		
Disc block	24	50
Concrete pipe	23	33
Covered goods wagon	15	43
Total fish species	38	64

Figure 3a Underwater communities on covered goods wagons.

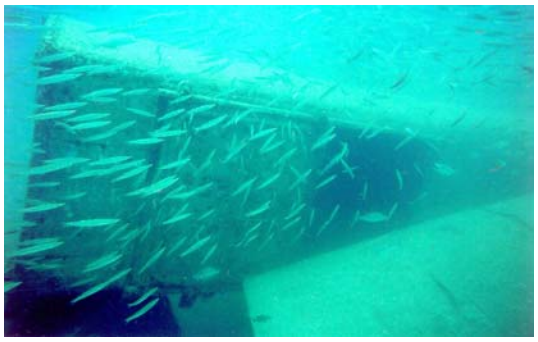


Figure 3b Underwater communities on covered goods wagons.

Figure 3c Underwater communities on covered goods wagons.

Figure 3d Underwater communities on covered goods wagons.

Figure 4a Underwater communities on disc blocks.

Figure 4b Underwater communities on disc blocks.

Figure 4c Underwater communities on disc blocks.

Figure 4d Underwater communities on disc

Figure 5a Underwater communities on concrete pipes.

Figure 5b Underwater communities on concrete pipes.

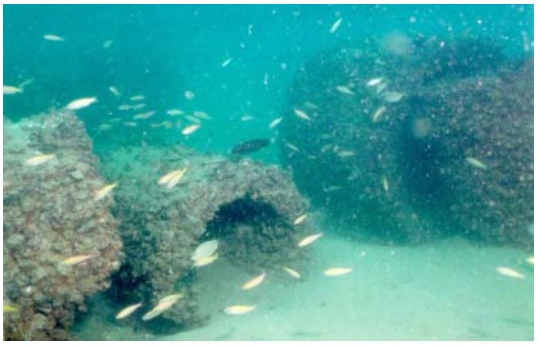


Figure 5c Underwater communities on concrete pipes.

Figure 5d Underwater communities on

The research had been conducted to determine the catch rate (CPUE) and average income. The results showed that the CPUE and average income from 6 main fishing gears commonly used in the project area i.e. trammel net, crab gill net, whiting gill net, squid trap, hook and line and mackerel gill net were increasing. (Table 4) Most of the small scale fishermen who live in the project area have good attitude to artificial reef installation.

Table 4 catch rate (kg/trip) and average income from fisheries activities operated in the artificial reef installation area.

Title	After installation	
	1st year	2nd year
CPUE (kg/trip)		
Trammel net	5.7	7.1
Crab gill net	13.5	17.9
Whiting gill net	20.8	26.0
Squid trap	18.5	20.0
Hook and line	7.9	14.5
Mackerel gill net	17.0	23.0
Average income (Baht)		
Per day	613	772
Per month	12272	15440
Per year	73629	92640

■ CONCLUSION

The artificial reef installation in the Southern Gulf of Thailand used three types of materials which are: covered goods wagon, disc block and concrete pipe. After the installation, water quality in this area was still normal. The total number of fish species in the second year was 64 species. The catch rate (CPUE) of all small scale fishing gears from operated in the artificial reef installation area were increasing. It made high income for fisheries households.

The artificial reef installation project would be a long term engagement, which is expected to play a key role in future fisheries development of the Southern Gulf of Thailand.

COUNTRY REPORT OF VIETNAM

Nguyen Quang Hung

COUNTRY REPORT OF VIETNAM

Nguyen Quang Hung
Research Institute for Marine

■ INTRODUCTION

Seawater and continental shelf belonging to the Exclusive Economic Zone of Vietnam are estimated to be over 1 million Km2, about 3 times bigger than the mainland area. Seawaters and continental shelf increasingly play an important role in fisheries in particular and in national marine economics in general. The coastline of Vietnam is 3260 km long and stretches through 15 degrees of latitude in the North-South direction. The continental shelf is wide in the North and South with a quite complex terrain.The maximum depth is about 5000m in the Centre region.

The Vietnamese Government pays much attention to the marine fisheries and has applier proper measures in resource management and fishing, in order to meet the domestic demand for protein and export.

In some recent years, coastal resources have been over-exploited while offshore ones have not been well exploited yet. The development of offshore fisheries therefore has a great significance in Vietnam's fisheries. Resources preservation is a necessary task of Vietnamese fisheries. Ordinance on preservation and development of fisheries resources and regulations in fisheries management play an important role in Vietnamese seawaters.

The world's fisheries are encountering two great pressure such as depletetion of fisheries resource and increasing demand for fisheries products. In Vietnam, especially in the coastal areas, the exploitation of marine resources has reached to the limit of renewal capacity of resources. Many species of hight economic values have been overexploited. Though the catches have gone down significantly. Therefore, sustainable management of marine resources play a very important role.

In order to find solutions to the above issues, the Government of Vietnam has paid great attentions to marine fisheries, taken appropriate measures to protect and exploit resources properly to meet people's need for animal protein. However, Vietnam has many obstacles such as lack of information, research equipment and facilities, technical know-how, and especially financial capital.

■ CURRENT SITUATION OF STOCK ENHANCEMENT AND ARTIFICIAL REEFS ISSUE IN VIETNAM

As many Country in the region, In Vietnam, the introduction of man-made structures, including artificial reefs, aquaculture facilities, breakwater, stationary fishing gears and Marine Protected Areas MPAs are considered as resources management strategies and to enhance local populations of aquatic organisms, provided that there are sufficient numbers of structures to have a significant and positive impact on ecosystem productivity and that they are intergrated into coastal zone management regimes.

In some recent rears, in order to enhance local population of marine organisms we express initial concern on two main man-made structures as following:

MPA system

Marine conservation starts late in Vietnam compared to other country in the region. At the moment there is only one MPA (***Hon Mun***, south of Vietnam) available. Another one (***Cu Lao Cham***, DaNang, Vietnam) is being setup and expected to start zoning in next year 2005. However, the plan

for establishment of a system of MPAs have been setup and put into effect. In early of this year (2004), the Ministry of Fisheries (MoFi) have submitted a proposal "*Network of 15 MPAs along coastal areas in Vietnam* " to Government and waiting for permitions.

The idea to establish am MPA system started in 1999 when scientists collected bio-diversity data to select sites for conservation. In the first proposal, about 30 sites were proposed. After many revisions, some 15 sites were finally accepted and ranked by level of priority. They cover most of the high diversity areas in vietnamese sea. Therefore, Vietnam become one of a few countries in the region establishing MPAs in a special system.

Following this plan, in 2000, the first MPA in Vietnam was established in the Centre of Vietnam, referred as the pilot MAP Hon Mun, funded by the World Bank, IUCN and ADB. After two years running it has shown some signals of stock enhancement and recovery of reef fish population, coral reefs and other marine animals in the MPA. The project operators claim that the establishment of such MPA is somewhat late in terms of ability for the recover of resources as they are exhaust. If it were established earlier, it would be less difficult and needs shorter time to recover the resources. This is a valuable lesson for the conservation process in Vietnam. The process must be pushed forwards, before it is too late.

The second MPA is now being setup in CuLaoCham (also in the Central of Vietnam). This is a part of the project called:"supporting the MPA system in Vietnam" supported by DANIDA which aims to motivate the establishment of the MPA system in Vietnam. There are also two other small local marine protected sites created by local governments in cooperation with NGOs in Ran Trao (60 km to the north of HonMun MPA) and Phu Long (in the north of Vietnam) set up bylocalgovernments. In addition, three other national terrestrial parks ConDao (in the south), Bai Tu Long and Cat Ba (both in Ha Long Bay) also take care of marine areas within or surrounding them. However, they do not focus much on marine resources due to the limit in human resources and budgets. Under the planning of Vietnam, many other MPAs are expected to be established in near future.

Artificial Reefs

As the MPA system is being setup, artificial reef is also expected to play an important roles in the conservation process, particularly in areas where reefs are unable to self-recover or they are suffer from mud siltation. However, the establishment of artificial reefs strongly depends on the conservation process. As this process is moving slowly, the application of artificial reef is also slowly in Vietnam. In some years ago, there has not been a real artificial reef in Vietnam. The only functioning MPA (Hon Mun), It does not use artificial reefs because they have other choices cheaper than artificial reefs: Protect and let the reef self-recovering.

Early of last year, a testing artificial reef was setup at the local protected site Ran Chao (in the central of Vietnam). Numbers of concrete tanks with holes were laid on seabed. But up to now, no data on the development of the reef available yet and the success of these work is still uncertain.

In 2003-2004, artificial reef is strongly motivated by Research Institute for Marine Fisheries (RIMF). It is now creating an artificial reef in HaLong Bay in an attemp to check the possibility of recovery of the reef and proper methods in building artificial reefs in this high turbidity area.

Figure 1. Design and construction of concrete tanks being used for artificial reefs in Ha Long Bay (2003-2004).

Figure 2. Concrete tanks as artificial reefs are being laid on seabed in Ha Long Bay, North of Vietnam.

■ SUMMARY AND RECOMMENDATION FOR FUTHER PROMOTION OF ARTIFICIAL REEFS IN THE REGION.

It is necessary to work out appropriates measures for resources management such as limitations on fishing efforts, setting a limit to the protected areas according to spawning seasons and nutriention periods, limitation of the number and size of fish to be caught. Appropriates measures should be applied to manage and exploit fisheries resources in a reasonable way in order to meet the people's demand for animal proteins.

Vietnam shold strive to overcome difficulties to manage coastal resources in terms of fishing operation, environment awareness, improvement of rules and regulations, limitation of the private sector and scientific infrastructure, and institution potential. In order to do so, it is necessary to give priority to environment issues and to develop an appropriate master plan with a view to meeting the requirements for resources exploitation and environmental protection in coastal seawaters.

In order to get comprehensive development, it is
necessary to focus on the following main measures:

- It is necessary to establish marine protected areas; to develop programs on proper utilization of coastal wetlands in the Red and Mekong rivers.
- All the management and strategic issues have shown that inforamtion exchange and experience sharing is an important issues in the intergrated management of nearshore waters, the best way is to achieve it through regional initiatives.
- Resource protection and fisheries policies are major tasks for the sustainable development of marine fisheries in Vietnam. In order to protect resources, it is necessary to have technical and administrative measures on coastal fishing. Fishing activities should be limited in spawning seasons; it is banned the exploitation of endangered species and the use of destructive fishing gears.

Experience Papers

REPORT OF ENVIRONMENTAL SURVEY STUDIES ON ARTIFICIAL REEFS AT CHUMPORN PROVINCE, THAILAND

Yuttana Theparoonrat, Ph.D.

REPORT OF ENVIRONMENTAL SURVEY STUDIES ON ARTIFICIAL REEFS AT CHUMPORN PROVINCE, THAILAND.

Dr. Yuttana Theparoonrat
SEAFDEC/TD

TD in collaboration with ASEAN and SEAFDEC member countries conducted Resources Enhancement project in Chumporn province, Thailand as a case study. This project is designed to integrated installation of artificial habitats in inshore waters with careful pre-assessment of environmental and socio-economic impact.

Department of Fisheries, Thailand conducted an installation of artificial reefs at Chumporn province on March – April 2004. Two group of cubic shape concrete type, 1.5x1.5x1.5m, total 1750 pieces, are set on the project area number 46-16-07 and 46-16-08 (Fig.1). The artificial reefs settle at 12m depth with area cover is 2 km2.

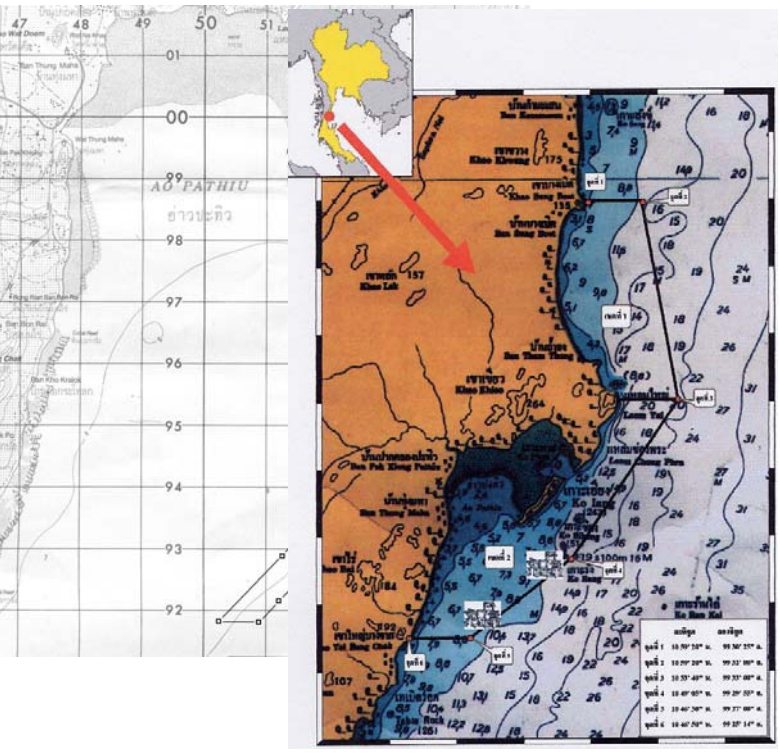
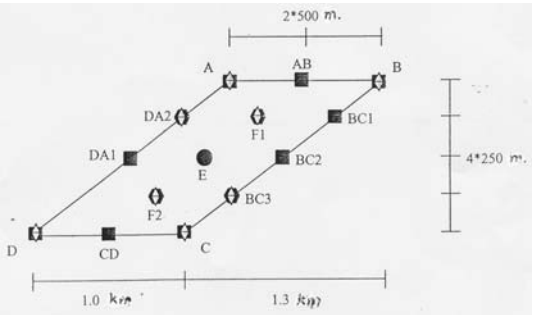


Figure 1. Location of Artificial Reefs project site at Chumporn Province, Thailand

Figure 2. Layout of two group of Artificial Reefs set at project site at Chumporn Province, Thailand

Position:	A. Lat. 10 – 49.00 N,	Long. 99 – 28.85 E	Buoy No. 1	(Height 3 m)
	B. Lat. 10 – 49.00 N,	Long. 99 – 29.35 E	Buoy No. 2	
	C. Lat. 10 – 48.50 N,	Long. 99 – 28.70 E	Buoy No. 4	
	D. Lat. 10 – 48.50 N,	Long. 99 – 28.20 E	Buoy No. 5	
	BC3. Lat. 10 – 48.64 N,	Long. 99 – 28.85 E	Buoy No. 3	
	DA2. Lat. 10 – 48.85 N,	Long. 99 – 28.68 E	Buoy No. 6	(Height 2 m)
	F1.Lat.	Long.	Buoy No. 7	(Height 7 m)
	F2.Lat. 10 – 48.64 N,	Long. 99 – 28.63	Buoy No. 8	
	E. Lat.10 – 48.75 N,	Long. 99 – 28.81 N		

Budget: 3,000,000.- Baht



■ Group of 40 pieces, Total 360 pieces
⬢ Group of 100 pieces, Total 400 pieces
● Group of 115 pieces, Total 115 pieces
◆ Mark Buoy, Total 8 pieces

Figure 3. Layout of artificial reefs setting at area number 46-16-07.

Project Number: 46-16-08
Location: Moo 6, Bonrai, Pakklong Village, Pratew District, Chumporn Province,
Area: 0.5 x 2.0 kilometer
Water Depth: 9.5 – 11.0 meter
Bottom: Muddy sand
Dist. From Shore: 3.0 – 4.5 kilometer
Material: Concrete 1.5 x 1.5 x 1.5 meter, 875 pieces

Position:	A. Lat. 10 – 48.20 N,	Long. 99 – 28.05 E	Buoy No. 1	(Height 3 m)
	B. Lat. 10 – 48.20 N,	Long. 99 – 28.30 E	Buoy No. 2	
	C. Lat. 10 – 47.20 N,	Long. 99 – 27.00 E	Buoy No. 5	
	D. Lat. 10 – 47.20 N,	Long. 99 – 26.75 E	Buoy No. 6	
	BC3. Lat.	Long.	Buoy No. 3	(Height 2 m)
	DA1. Lat.10 – 47.57 N,	Long. 99 – 27.25 E	Buoy No. 7	
	DA2. Lat. 10 – 47.82 N,	Long. 99 – 27.58 E	Buoy No. 8	(Height 5 m)
	E. Lat 10 – 47.72 N,	Long. 99 – 47.54 E		(Height 4 m)

Budget: 3,000,000.- Baht

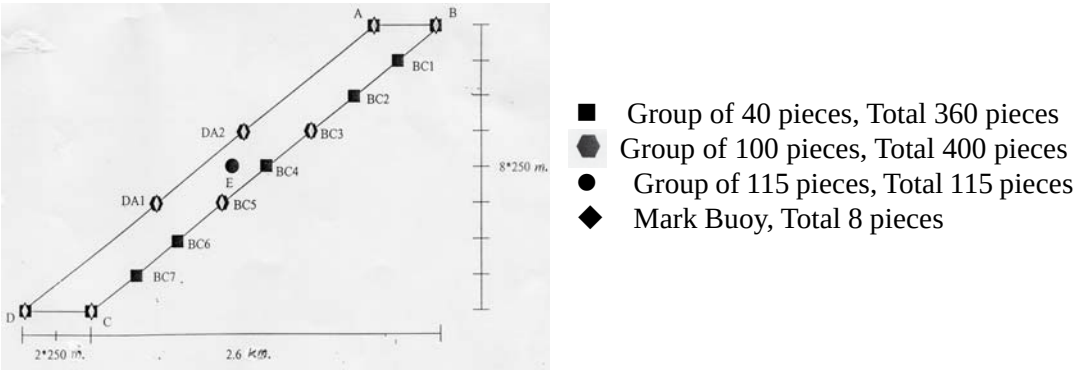


Figure 4. Layout of artificial reefs setting at area number 46-16-07.

Figure 5. M.V. . Khaow Khang, carry ,cubical shape concrete, artificial reefs to install at Pratew dis-

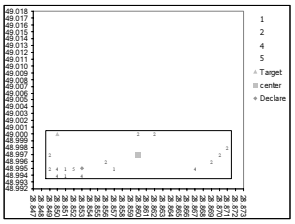
(a). (b).

Figure 6. Fork lift using for convey the cubical shape concrete dumping on the project site (a), the dumping position are marked by anchor flag buoy (b).

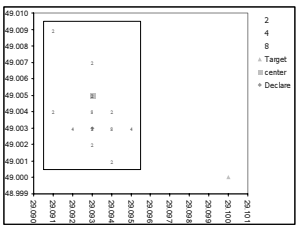
<u>Result of setting position of cubical shape concrete block at artificial reef group</u>.

<u>Project Number: 461607</u>

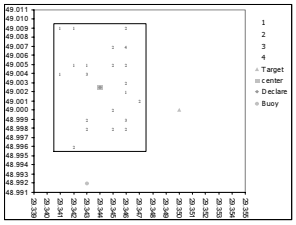
Group A (40 pieces)



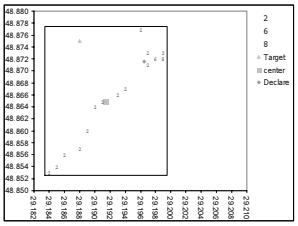
Group AB (40 pieces)



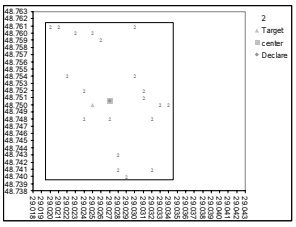
Group B (40 pieces)



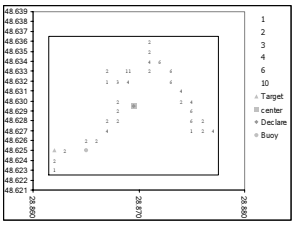
Group BC1 (40 pieces)



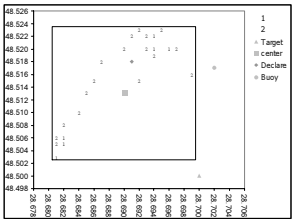
Group BC2 (40 pieces)



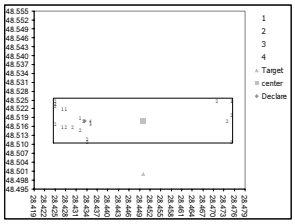
Group BC3 (100 pieces)



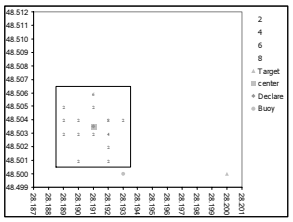
Group C (40 pieces)



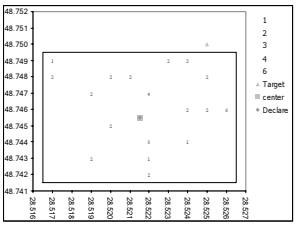
Group CD (40 pieces)



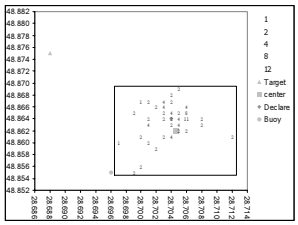
Group D (40 pieces)



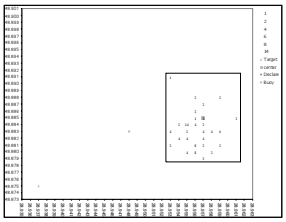
Group DA1 (40 pieces)



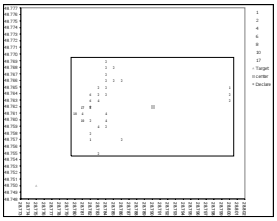
Group DA2 (100 pieces)



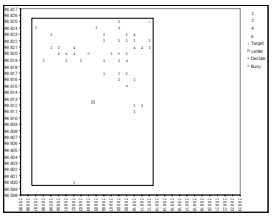
Group F1 (100 pieces)



Group E (115 pieces)

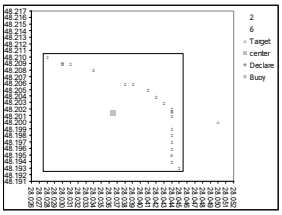


Group F2 (100 pieces)

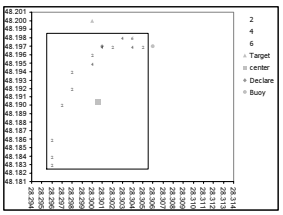


Project Number 46-16-08

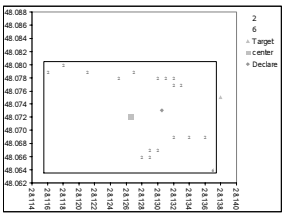
Group A (40 pieces)



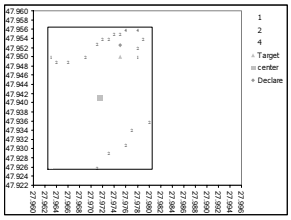
Group B(40 pieces)



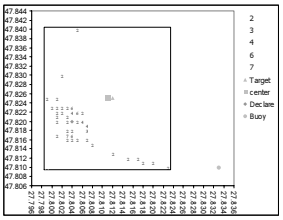
Group BC1 (40 pieces)



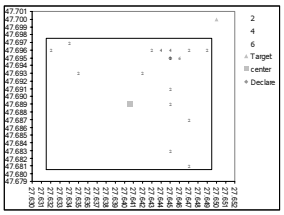
Group BC2 (40 pieces)



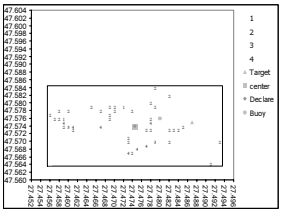
Group BC3 (100 pieces)



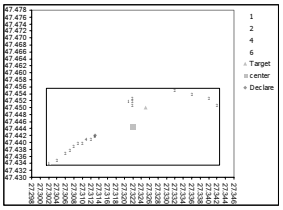
Group BC4 (40 pieces)



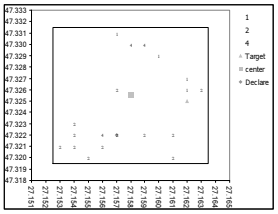
Group BC5 (100 pieces)

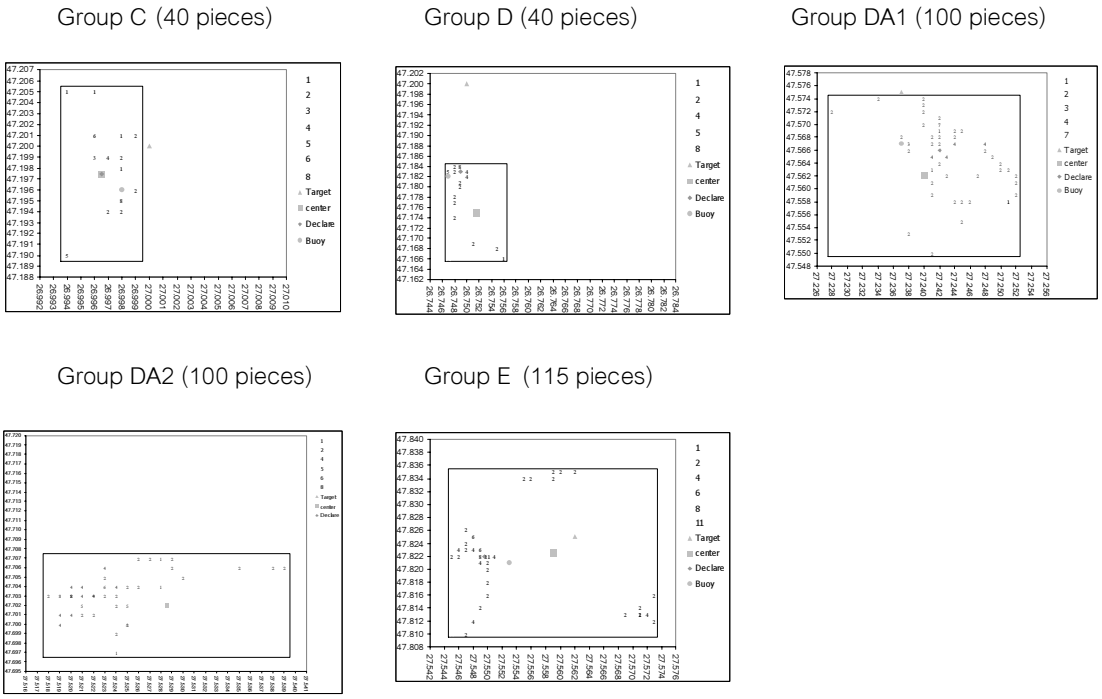


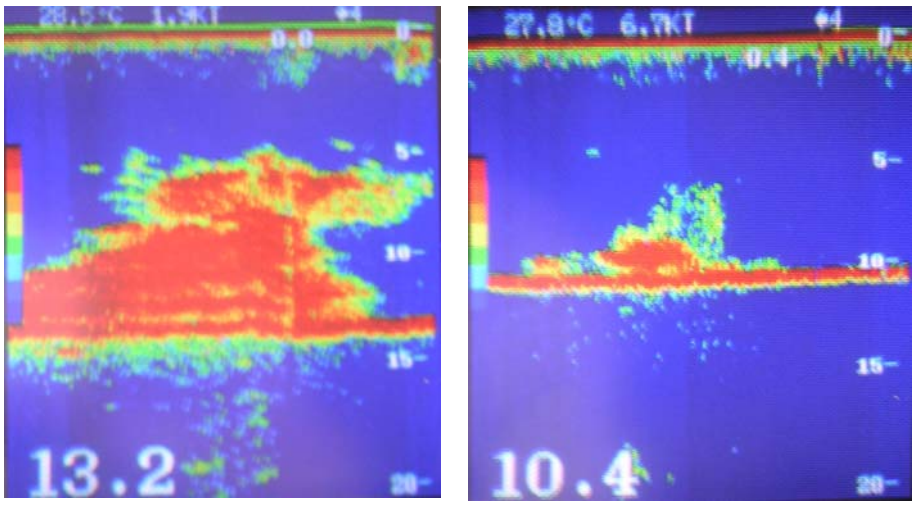
Group BC6 (40 pieces)



Group BC7 (40 pieces)







(a). (b).

Figure 7. Echo gram of artificial reefs installed in the project site (a) 7 m height, (b) 3 m height

■ FISHING OPERATION SURVEY

1. Fish Trap Fishing Operation

Fish traps with dimension of 90Wx190Lx60H cm, PE net webbing mesh size 6.5 cm, wooden frame diameter 3.5 cm, entrance wire mesh #3.5 cm, were individual setting around the artificial reefs project site where water depth is 12 m. The 8 pieces of fish trap were setting fixed at bottom near by artificial reefs Project No. 46-16-07 A, DA2, E and F1, and for Project No. 46-16-08 BC3, BC5, DA2 and E. The fish caught were collected for species identification after 6 days of fishing operation.

2. Squid Trap Fishing Operation

Squid traps with dimension of 85Wx110Lx70H cm, PE net webbing mesh size 5.5 cm, wooden frame diameter 2.5 cm, were individual setting around the artificial reefs project site where water depth is 12 m. The 12 pieces of squid trap were hang on the buoy line at 3 meter below water surface. The squid caught were collected daily in the morning time for 4 days for species identification and size composition study.

(a)

(b)

Figure 9. Squid trap fishing operation (a),(b)

3. Bottom Gill net (Trammel net) Fishing Operation

Bottom trammel net with inner webbing mesh size 4.5 cm, and 26 cm for outer net, were setting around the artificial reefs project site where water depth is 12 m. The height of net is 2.4m and 35 m long. Total 15 pieces of joining continuous net (total length 525 m) were set fixing at bottom by anchor at both end. The fishing operation are conducted for 3 days with net soaking period of 15 hours from the evening to next day morning time. The fish caught were collected, species identification, size and weight measurement were performed.

4. Collapsible Crap Trap Fishing Operation

Collapsible crap trap with dimension of 38Wx54Lx18H cm, PE net webbing mesh size 3 cm, iron frame diameter 4mm, were joining continuous setting around the artificial reefs project site where water depth is 12 m. The 80 pieces of crab trap were setting by long-line fishing operation pattern fixed at bottom for 3 days of opreation. The traps soaking period is 15 hours cover on the nigh time operation. The crab caught were collected, species identification, size and weight measurement were performed.

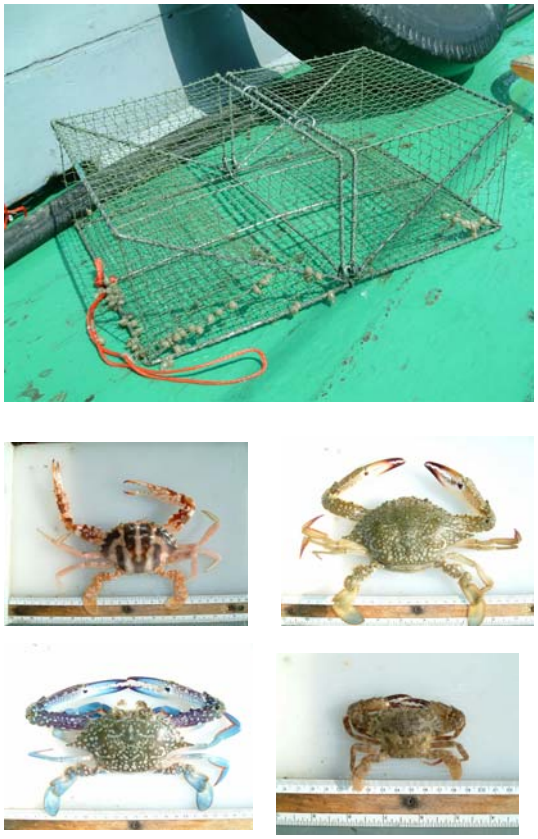


Figure 11. Collapsible crab trap fishing operation an its catch.

2. Benthos Survey

The survey stations for benthose were set at 0m, 250m, 500m, and 750m, in the direction of N,S,E, and W, away from the center position of each group of Artificial Reefs setting position. Total benthose sampling are 22 stations. At each station a random samplings of bottom sediment was collected using a Smith-McIntyre grab (area coverage 0.05 m^2). The sediment was washed through a set of sieves, the smallest one with a mesh size of 0.5 mm. Benthic animal were collected and fixed in 10% formaldehyde solution in sea water on board. The preserved macrobenthic fauna were brought to laboratory for further identify.

Figure 12. Random sampling of benthos by Smith-McIntyre grab and washed through a set of sieves.

3. Fish Larvae Survey

Sampling for fish larvae was carried out using M.V.PLALUNG on 19 November 2003. The bongo net, 60 cm. in diameter with mesh size 500 micron at the mouth part and 330 micron at the cod end, was employed for the horizontal haul. The net was towing at 1 meter below the surface with speed of 2 knots for 30 min. A flow meter was attached to the mouth of the net. Specimens were preserved in 10% formalin/sea water mixture immediately after a haul completed. Sorting and identification was done at the laboratory.

Figure13. Fish larvae collection by using bongo net.

4. Phyto-Plankton Survey

The phyto-plankton samples was collected from water sampler at 1 m below the sea surface. Fifty liters of water samples were filtered through a phyto-plankton net (20 ì m mesh size) and preserved in a 10% formalin/sea water mixture. The samples were concentrated by sedimentation. Cell count and identification were conducted in laboratory.

5. Zoo Plankton survey

Sampling for zoo-plankton was carried out using bongo net, 60 cm. in diameter with mesh size 300 micron with employed in the horizontal haul. The net was towing at 1 meter below the surface with speed of 2 knots for 30 min. A flow meter was attached to the mouth of the net. Specimens were preserved in 10% formalin/sea water mix immediately after a haul completed. Sorting and identification was done at the laboratory.

6. Water Current Measurement

The water current observation was conducted by using Acoustic Doppler Current Profilers (ADCP). The ADCP unit was face-up setting at the sea bottom. The measurement was carried out at the center position of artificial reefs No. 46-16-08 (Group B) setting position. The water depth is 12 m. The current speed and direction were continuous recorded at 10 minutes interval for 24 hours. The recorded data will be analyze for water circulation pattern in the area.

Figure 14. The water current observation was conducted by using Acoustic Doppler Current Profilers (ADCP)

7. Fisheries Resources Survey by Hydro-Acoustic Equipment

The fisheries resources survey in the project site by using scientific echo sounder (FQ-80) on board M.V.SEAFDEC 2 are performed on 3 August 2004. The transect of parallel cruise tract of 0.5 nautical mile were conducted to cover area of 3x4 square nautical miles of artificial reefs setting area. The scientific echo sounder was equipped with dual frequencies by using two split beam transducer with frequencies of 38 and 120 kHz. The data collected from the echo sounder were recorded into hard disk for further analysis.

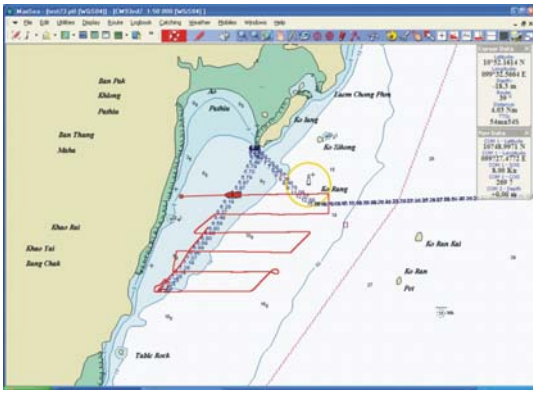


Figure 15. The transect of parallel cruise tract of 0.5 nautical mile were conducted to cover area of

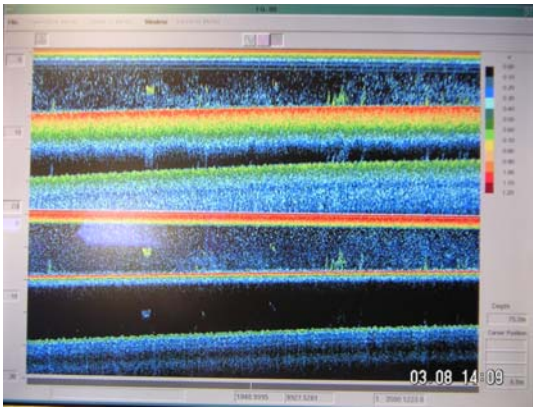


Figure 16. The echo gram of fish detected during the survey.

Results

1) Fishing Operation

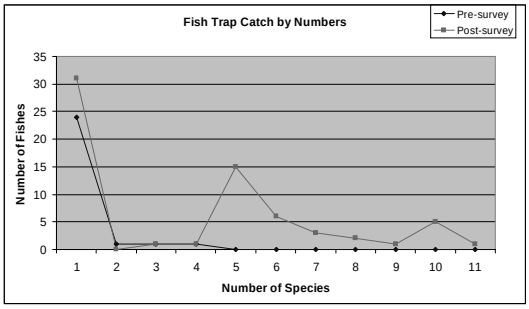
1.1) Fish trap

There are 4 species with total number of 27 fish composed of *Scatophagus argus, Plotosus canius, Lutjanus sp., and Synanceja horrida* collected during the 1 st (Pre.) survey cruise. The number of species collected increasing to 10 species with total number of 66 fish during 2nd (Post.) survey cruise. Spotted butter fish *(Scatophagus argus)*, Lactice monocle beam (*Scolosis taeniopterus)*, Onespot snapper (*Lutjanus monostigma)* and Blue swimming crab (*Portunus pelagicus)* are the major species collected from fish trap.

Table 1. Number of species of fish catch by fish trap during the 1st and 2nd survey (November 2003 and August 2004).

			Fish Trap 1st Survey		Fish Trap 2nd Survey	
No	**Common name**	**Species**	**Number**	**Weight (g.)**	**Number**	**Weight (g.)**
1	Spotted butter fish	*Scatophagus argus*	24	1336	31	2525
2	Canine catfish eel	*Plotosus canius*	1	280	0	0
3	Snapper	*Lutjanus sp.*	1	175	1	321
4	Stonefish	*Synanceja horrida*	1	55	1	300
5	Lactice monocle beam	*Scolosis taeniopterus*	0	0	15	2470
6	Onespot snapper	*Lutjanus monostigma*	0	0	6	1380
7	Whitespotted spinefoot	*Siganus canaliculatus*	0	0	3	180
8	Grouper	*Epinephelus sp.*	0	0	2	390
9	Two-banded soapfish	*Diploprion bifasciatum*	0	0	1	160
10	Blue swimming crab	*Portunus pelagicus*	0	0	5	560
11	Ridged swimming crab	*Charybdis natator*	0	0	1	130
		TOTAL	**27**	**1846**	**66**	**8416**

During 2nd (Post.) survey cruise Lactice monocle beam (*Scolosis taeniopterus)*, and Onespot snapper (*Lutjanus monostigma)* are showing high capture rate both in term of number and weight (Figure 17).



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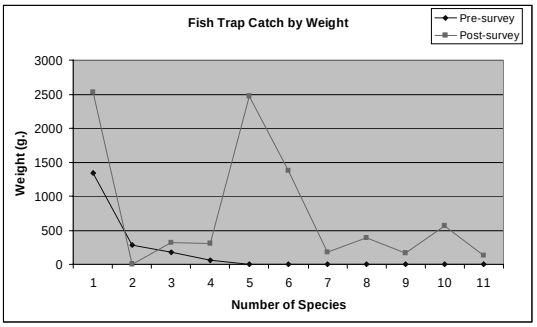

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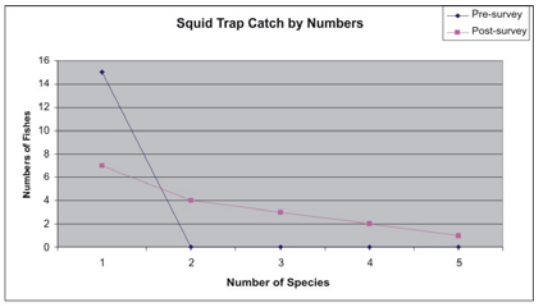
Figure 17. Amount of fish catch by fish trap in Pre. and Post-survey cruise in term of (a) number and (b) weight.

1.2) Squid trap

During the pre-survey cruise, only Bigfin reef squid (*Sepioteuthis lessoniana)* was recorded in the amount of 15 individual. The number of species catch increased to 5 species with the total number of 17 individual. However, Bigfin reef squid still the major catch species for post-survey cruise but the size of squid dramatically decrease. The average weight of Bigfin reef squid catch for pre-survey cruise was 339.0 g. and 142.6 g. for post-survey cruise. It was found that the number of squid trap operated by local fisherman in the project area increasing from few number up to more than 200 trap after the artificial reefs were installed.

Table 2. Number of species of fish catch by squid trap during the 1st and 2nd survey (November 2003 and August 2004).

			Squid Trap 1st Survey		Squid Trap 2 nd Survey	
No.	**Common name**	**Species**	**Numbers (cm.)**	**Weight (g.)**	**Number**	**Weight (g.)**
1	Bigfin reef squid	*Sepioteuthis lessoniana*	15	5085	7	998
2	Whitespotted spinefoot	*Siganus canaliculatus*	0	0	4	215
3	Matted leatherjacket	*Acreichthys tomentosus*	0	0	3	162
4	Spotted butter fish	*Scatophagus argus*	0	0	2	140
5	Two-banded soapfish	*Diploprion bifasciatum*	0	0	1	150
		TOTAL	**15**	**5085**	**17**	**1665**



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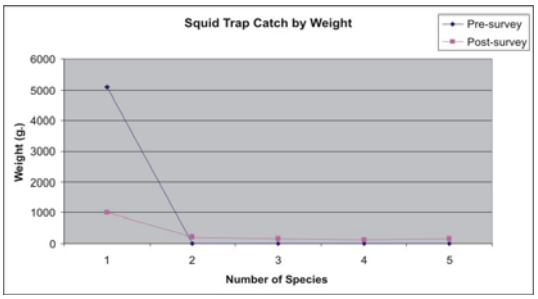


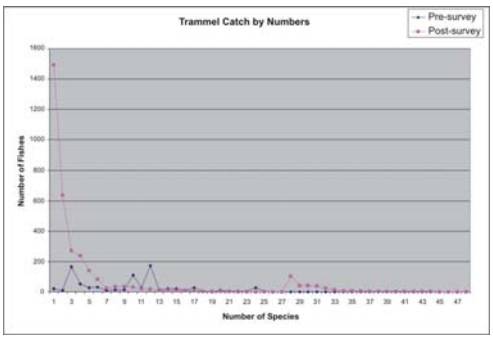
(b)

Figure 18. Amount of fish catch by squid trap in Pre. and Post-survey cruise in term of (a) number and (b) weight.

1.3) Bottom gill net

Number of fish species catch during pre-survey by using trammel net was 27 species. The total catch was 809 individual with total weight of 46,264 g. Three major species catch were Croaker (*Johnius sp)* 165 individual, weight 10,242 g. , Pufferfish (*Arothron nigropunctatus)* 171 individual, weight 10,524 g., and Indo-pacific mackerel (*Rastrelliger brachysoma)* 111 individual, weight 6,296 g.

During post-survey, number of species catch were increasing up to 44 species with consist of 3,403 individual and total weight of 156,542 g. The major species catch were compose of Long tongue sole (*Cynoglossus lingua)*, 1,492 individual, weight 57,852 g., Flathead (Sarsogona tuberculata) 638 individual, weight 37,531 g., Croaker (*Johnius sp.)* 271 individual, weight 20,918 g., Smooth-tailed trevally (*Selaroides leptolepis*) 141 individual, weight 4,600 g., and False stonefish (*Scorpaenopsis neglecta)* 102 individual, weight 2,205 g. There are 4 species catch during pre-survey but disappear in post-survey catch record. That 4 species were consist of Golden scad (*Caranx kalla),* Canine catfish eel (*Plotosus canius)*, Mangrove blue crab (*Scylla serrata)* and Crucifix crab (*Charybdis affinis)*.



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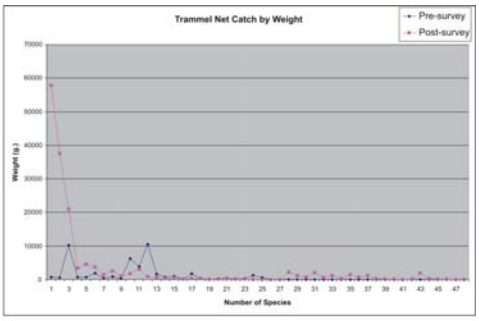


(b)

Figure 19. Amount of fish catch by bottom gillnet (Trammel Net) in Pre. and Post-survey cruise in term of (a) number and (b) weight.

Table 3. Number of species of fish catch by bottom gill net during the 1st and 2nd survey (November 2003 and August 2004).

			Trammel Net 1st Survey		Trammel Net 2nd Survey	
No.	**Common name**	**Species**	**Numbers**	**Weight (g.)**	**Number**	**Weight (g.)**
1	Long tongue sole	*Cynoglossus lingua*	19	712	1492	57852
2	Flathead	*Sarsogona tuberculata*	11	586	638	37531
3	Croaker	*Johnius sp.*	165	10242	271	20918
4	Ponyfish	*Leiognathus sp.*	52	680	239	3362
5	Smooth-tailed trevally	*Selaroides leptolepis*	28	749	141	4600
6	Threadfin bream	*Nemipterus sp.*	30	1876	84	3678
7	Terapon	*Terapon sp.*	12	469	25	1540
8	Blue swimming crab	*Portunus pelagicus*	13	960	36	2530
9	Mantis shrimp	*Hepiosquilla harpax*	15	236	33	1040
10	Indo-pacific mackerel	*Rastrelliger brachysoma*	111	6296	32	1805
11	Cattlefish	*Sepia pharaonis*	26	3914	20	3115
12	Pufferfish	*Arothron nigropunctatus*	171	10524	16	835
13	Stingray	*Dasyatis sp.*	13	1670	12	640
14	Fringescale sardinella	*Sadinella fimbriata*	22	683	9	265
15	Mullet	*Moolgarda sp.*	22	1010	8	655
16	Greasyback shrimp	*Metapenaeus ensis*	11	170	8	175
17	Hairfin anchovy	*Setipina sp.*	29	1853	6	230
18	Brushtooth lizardfish	*Saurida undosquamis*	3	299	5	315
19	Western king prawn	*Penaeus latisulcatus*	1	20	4	100
20	Banana prawn	*Penaeus merguiensis*	10	280	3	105
21	Bigfin reef squid	*Sepioteuthis lessoniana*	5	490	3	170
22	Indian squid	*Photololigo duvoucelli*	4	175	1	105
23	Cobia	*Rachycentron canadus*	2	320	1	100
24	Golden scad	*Caranx kalla*	28	1390	0	0
25	Canine catfish eel	*Plotosus canius*	4	584	0	0
26	Mangrove blue crab	*Scylla serrata*	1	50	0	0
27	Crucifix crab	*Charybdis affinis*	1	26	0	0

Table 3. (Cont.)

			Trammel Net 1st Survey		Trammel Net 2nd Survey	
No.	**Common name**	**Species**	**Numbers**	**Weight (g.)**	**Number**	**Weight (g.)**
28	False stonefish	*Scorpaenopsis neglecta*	0	0	102	2205
29	Apogon	*Apogon sp.*	0	0	43	1130
30	Unicorn leatherjacket	*Aluterus monoceros*	0	0	42	706
31	Torpido scad	*Megalaspis cordyla*	0	0	38	2145
32	Mantis shrimp	*Hepiosquilla harpax*	0	0	24	665
33	Flounder	*Pseudorhombus sp.*	0	0	14	1235
34	Whitefin silver-biddy	*Gerres filamentosus*	0	0	8	325
35	Striped sea catfish	*Plotosus lineatus*	0	0	6	1510
36	Malabar snapper	*Lutianus malabaricus*	0	0	6	725
37	eil	*lycodontis tile*	0	0	5	1140
38	Lactice monocle bream	*Scolosis taeniopterus*	0	0	5	250
39	Whitespotted spinefoot	*Siganus canaliculatus*	0	0	4	140
40	Sentinel crab	*Podophthalmus vigil*	0	0	4	120
41	Smooth shelled swimming crab	*Charybdis affinis*	0	0	4	25
42	Green tiger prawn	*Penaeus semisulcatus*	0	0	3	100
43	Giant johnfish	Sciaena albida	0	0	2	1900
44	Baracuda	*Sphyraena sp.*	0	0	2	320
45	Snapper	*Lujanus sp.*	0	0	1	100
46	Matted leatherjacket	*Acreichthys tomentosus*	0	0	1	75
47	Longheaded Goby	*Parapercis sexfaciata*	0	0	1	40
48	Sillago	*Sillago sp.*	0	0	1	20
		TOTAL	**809**	**46264**	**3403**	**156542**

1.4) Collapsible trap

There are 10 species with 94 individual and total weight 7,013 g. recorded during the pre-survey cruise. The major species were Smoothshelled swimming crab (*Charybdis affinis*) 35 individual, weight 473 g, Blue swimming crab (*Portunus pelagicus*), 32 individual, weight 3,335 g., Mud crab (*Pilumnus sp.*) 8 Individual , weight 550 g. and Crucifix crab (*Charybdis affinis*), 6 individual, weight 595 g.

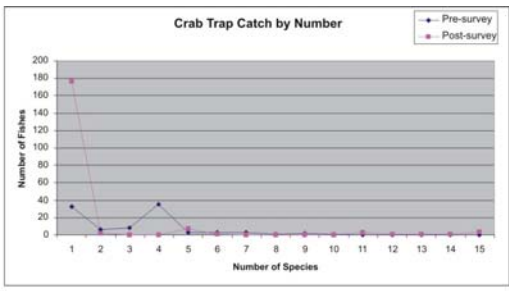
During the post-survey cruise, there are 9 species with 197 individual and total weight of 17,130 g.

Blue swimming crab (*Portunus pelagicus*) was the major species with 177 individual and weight 15,480 g.

However, the average weight of Blue swimming crab (*Portunus pelagicus*) catch decreasing from 104.2 g. for pre-survey cruise to 87.5 g. for post-survey cruise. There are 6 species recorded in pre-survey cruise not found in post-survey cruise but new 5 species recorded in post-survey cruise. .

Table 4. Number of species of fish catch by collapsible trap during the 1st and 2nd survey (November 2003 and August 2004).

			Crab Trap 1st Survey		Crab Trap 2nd Survey	
No.	**Common name**	**Species**	**Numbers**	**Weight (g.)**	**Number**	**Weight (g.)**
1	Blue swimming crab	*Portunus pelagicus*	32	3335	177	15480
2	Crucifix crab	*Charybdis affinis*	6	595	2	280
3	Mud crab	*Pilumnus sp.*	8	550	0	0
4	Smooth shelled swimming crab	*Charybdis affinis*	35	473	0	0
5	Spider crab	*Dorippe dorsipes*	3	260	7	720
6	Mantis shrimp	*Hepiosquilla harpax*	3	100	1	40
7	ell	*lycodontis tile*	3	1320	0	0
8	Cattlefish	*Sepia pharaonis*	1	210	0	0
9	Spottedtail grouper	*Epinephelus sp.*	2	120	0	0
10	Flathead	*Sarsogona tuberculata*	1	50	0	0
11	Grouper	*Epinephelus sp.*	0	0	3	220
12	Smooth-tailed trevally	*Selaroides leptolepis*	0	0	1	20
13	Striped sea catfish	*Plotosus lineatus*	0	0	1	200
14	Whitespotted spinefoot	Siganus canaliculatus	0	0	1	20
15	Threadfin bream	*Nemipterus sp.*	0	0	4	150
		TOTAL	**94**	**7013**	**197**	**17130**



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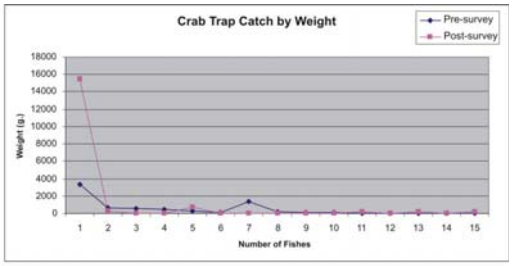
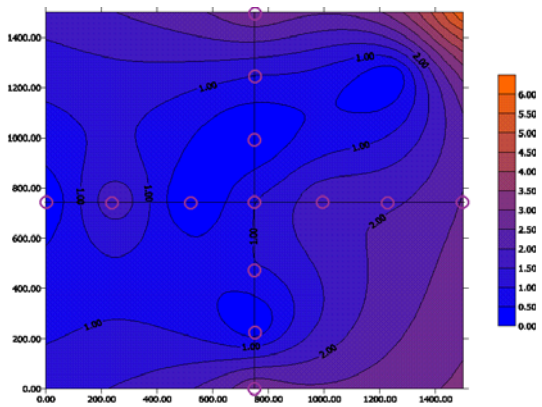


(b)

Figure 20. Amount of fish catch by collapsible trap in Pre. and Post-survey cruise in term of (a) number

2) Benthos survey

There are 42 species of macro benthos found at the site before artificial reefs installation during November 2003 survey. Among this, 23 species are identify and 19 species could not identify yet. There are 76 individual found at location of artificial reefs group A and 81 individual found at artificial reefs group B. The major species are Family Orbiniidae (36), *Nephtys sp.*(31), Family Maldanidae (13) and *Notomastus sp.*(9). Distribution of Family Orbiniidae in AR Group A does not show any different but its show high concentration at 250 m Southward from center of AR group B. The most concentration of *Nephtys sp.* found at 500 m. Southward from center of AR Group A and at the center of AR Group B.



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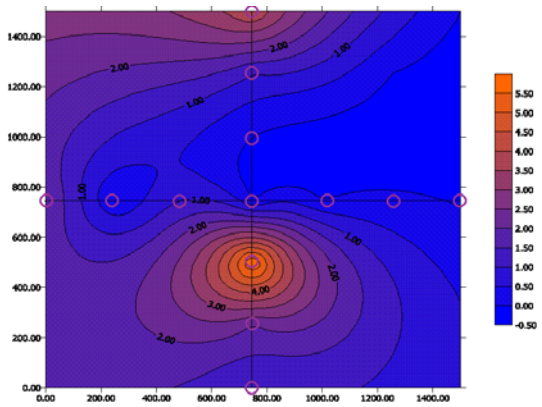

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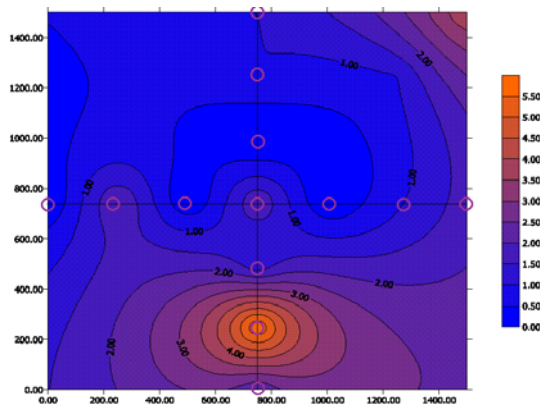
Figure 21. Distribution of benthos Family Orbiniidae around the center group of artificial reefs during November 2003, (a) artificial reefs group A, (b) artificial reefs group B



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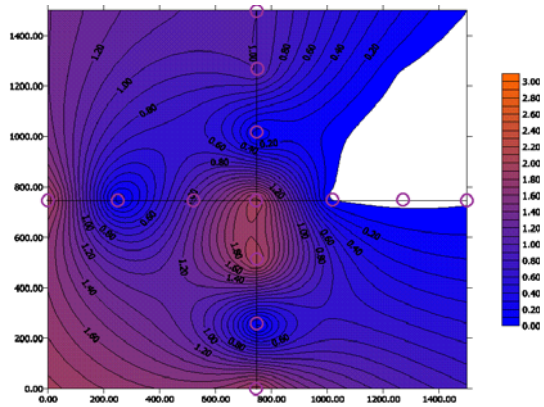
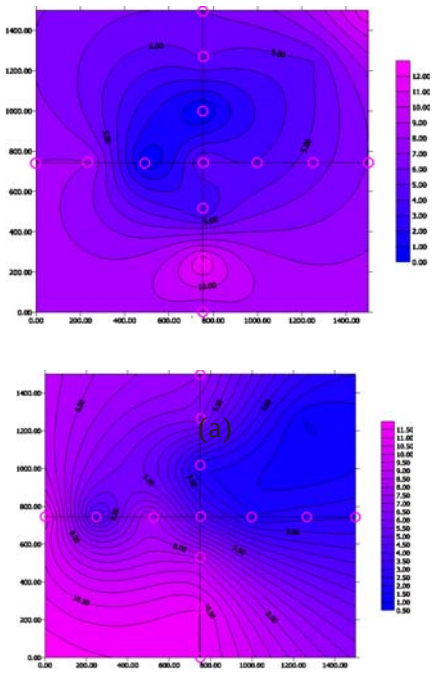


(b)

Figure 22. Distribution of benthos *Nephtys sp*. around the center group of artificial reefs during November 2003, (a) artificial reefs group A, (b) artificial reefs group B

Table 5. List of macro benthos found in the site of artificial reefs during the survey on November 2003.

No.	Scientific Name	20 µm	300 µm
		(unit/lit)	(unit/ml)
	MARINE PHYTOPLANKTON		
	DIVISION CYANOPHYTA (Blue green algae)		
	CLASS CYANOPHYCEAE		
1	*Lyngbya* sp.	-	5
2	*Oscillatoria erythraea* (Ehrenberg) Gomont	374	61
3	*Richelia intracellularis* Schmidt	34	5
4	Unknown Blue-green algae	-	20



(b)

Figure 23. Distribution of benthos all Family around the center group of artificial reefs during November 2003, (a) artificial reefs group A, (b) artificial reefs group B

3) Fish larvae survey

During the pre-survey cruise, it found that fish larvae 5genus composted of *Engraulidae*, *Gobiidae*, *Callinymidae*, *Cynoglossidae* and *Nemipteridae* as well as fish eggs were recorded as shows in Table 6.

Table 6. List of fish larvae found in the site of artificial reefs during the survey on November 2003.

Phylum CHORDATA	**Number**
Fish eggs	27
Fish larvae	
Engraulidae	5
Gobiidae	7
Callinymidae	2
Cynoglossidae	1
Nemipteridae	1

4) Phyto-plankton survey

Phyto-Plankton found during pre-survey cruise were composed of 2 Division, 4 Classes, 38 species as followings:

DIVISION CYANOPHYTA (Blue green algae)
CLASS CYANOPHYCEAE
Lyngbya sp.
Oscillatoria erythraea (Egrenberg) Geitler
Richelia intracellularis Schmidt
Unknow Blue-green algae

DIVISION CHROMOPHYTA
CLASS BACILLARIOPHYCEAE
Order Biddulphiales (Centric Diatom)
Order Bacillariales (Plannet Diatom)
CLASS DICTYOCHOPHYCEAE
CLASS DINOPHYCEAE (Dinoflaglet)

Table 7. List of phyto-plankton found in the site of artificial reefs during the survey on November 2003.

No.	Scientific Name	20 µm (unit/lit)	300 µm (unit/ml)
	MARINE PHYTO-PLANKTON		
	DIVISION CYANOPHYTA (Blue green algae)		
	CLASS CYANOPHYCEAE		
1	*Lyngbya* sp.	-	5
2	*Oscillatoria erythraea* (Egrenberg) Geitler	374	61
3	*Richelia intracellularis* Schmidt	34	5
4	Unknow Blue-green algae	-	20
	DIVISION CHROMOPHYTA		
	CLASS BACILLARIOPHYCEAE		
	Order Biddulphiales (Centric Diatom)		
5	*Asteromphalus* sp.	136	2
6	*Bacteriastrum delicatulum* Cleve	34	-
7	*Chaetoceros coarctatus* Lauder	306	-
8	*C. diversus* Cleve	476	2
9	*Climacodium biconcavum* Cleve	374	-
10	*C. frauenfeldianum* Grunow	-	8
16	*Odontella sinensis (Greville) Grunow*	-	5
17	*Palmeria hardmaniana Greville*	34	2
18	*Proboscia alata (Brightwell) Sundström*	-	-
19	*Pseudosolenia calcar avis (Schultze) Sundström*	68	2
20	*Rhizosolenia clevei Ostenfeld*	34	-3

Table 7. (Cont.)

No.	Scientific Name	20 µm (unit/lit)	300 µm (unit/ml)
21	*R. robusta* Normann	-	5
22	*R. styliformis* Brightwell	34	1
23	*Thalassiosira* sp.	272	52
24	*Triceratium favus* Ehrenberg fo. *quadrata* Grunow	34	
	Order Bacillariales (Plannet Diatom)		
25	*Pseudo-nitzschia* sp.	-	25
26	*Thalassionema frauenfeldii* (Grunow) Hallegraef	272	2,264
27	*T. nitzschioides* (Grunow) Mereschkowsky	2550	9,823
28	*Dictyocha fibula* Ehrenberg	68	-
	CLASS DINOPHYCEAE (Dinoflaglet)		
29	*Ceratium furca* (Ehrenberg) Claparéde & Lachmann	68	11
30	*C. fusus* (Ehrenberg) Dujardin	-	5
31	*C. trichoceros* (Ehrenberg) Kofoid	-	1
32	*Dinophysis caudata* Saville-Kent	-	2
33	*Prorocentrum micans* Ehrenberg	-	2
34	*P. sigmoides* Böhm	34	1
35	*Protoperidinium oceanicum* (Vanhöffen) Balech	68	-
36	*Protoperidinium* sp.1	34	-
37	*Protoperidinium* sp.2	34	-
38	*Protoperidinium* sp.3	-	15

Remark: Sample 1.20 µm : Number of sample Unit/Lit
Sample 2.300 µm : Number of sample Unit/ml (1 bottle 2,400 ml) (3 Bottles)

5) Zoo-plankton survey

Zoo-plankton found during pre-survey cruise were composed of 7 Phylums, 8 Classes, 19 species
as followings:

PHYLUM PROTOZOA
CLASS CILIATA
PHYLUM CHAETOGNATHA (ARROW WORM)
CLASS SAGITTOIDAE
PHYLUM NEMATODA
PHYLUM ARTHROPODA
CLASS CRUSTACEA
PHYLUM MOLLUSCA
CLASS GASTROPODA
CLASS PELECYPODA
PHYLUM ECHINODERMATA
CLASS ECHINOIDEA
CLASS OPHIUROIDEA
PHYLUM CHORDATA
CLASS LARVACEA

Table 8. List of zoo-plankton found in the site of artificial reefs during the survey on November 2003.

No.	Scientific Name	20 µm (unit/lit)	300 µm unit/ml
	MARINE ZOOPLANKTON		
	PHYLUM PROTOZOA		
	CLASS CILIATA		
1	*Tintinnopsis gracilis* Kofoid and Campbell	-	1
	PHYLUM CHAETOGNATHA (ARROW WORM)		
	CLASS SAGITTOIDAE		
2	*Sagitta* sp.	-	1
	PHYLUM NEMATODA		
3	Free living Nematode	-	5
	PHYLUM ARTHROPODA		
	CLASS CRUSTACEA		
4	*Corycaeus* sp.	17	1
5	*Oithona* sp.	-	5
6	*Lucifer* sp.	-	49
7	Brachyuran larvae	-	5
8	Nauplius copepod	323	13
9	Unidentified calanoid copepods	17	20
	Class Ostracoda		
10	Ostracod		
	Family OCYPODIDAE		
11	*Macropthalmus (Mareotis) definitus* (Adam and White, 1848)	15	
	Family SQUILLIDAE		
12	*Oratosquillina soliticans* (Manning, 1978)	2	
13	Caridea	7	
	PHYLUM MOLLUSCA		
	CLASS GASTROPODA		
14	*Creseis* sp.	-	6
15	Gastropod larvae	-	1

Table 8 (Cont.)

No.	Scientific Name	20 µm (unit/lit)	300 µm unit/ml
	CLASS PELECYPODA		
16	Pelecypod larvae	-	6
	PHYLUM ECHINODERMATA		
	CLASS ECHINOIDEA		
17	Echinopluteus larvae	-	1
	CLASS OPHIUROIDEA		
18	Ophiopluteus larvae	-	5
	PHYLUM CHORDATA		
	CLASS LARVACEA		
19	*Oikopleura* sp.	-	7

■ CONCLUSION

There are 35 fish species were recorded during the pre-survey collected by all type of fishing gear. During post-survey 52 species were collected, while 30 species found both pre and post-survey. The average fish size recorded during post-survey show decreasing for some species such as, Threadfin bream (from 62.5 to 43.8 g.), Stingray (from 128.5 to 53.3 g.), Hairfin anchovy (from 63.9 to 38.3 g.), Brushtooth lizardfish (from 99.7 to 36.7 g.) and Bigfin reef squid (from 98.0 to 56.7 g.). The species shows size increasing were Croaker (from 62.1 to 77.2 g.), Terapon (from 39.1 to 61.6 g.), Mantis shrimp (from 15.7 to 31.5 g. and , Mullet (from 45.9 to 81.9 g.). Total species collected from both pre and post-survey were 57 species. It shows clearly that artificial reefs could be induced many fish species both pelagic and demersal fish to feeding around the site. Hopefully, the new artificial fish habitat could be generating the spooning area for some species.

Since, data from post-survey of fish larvae, phyto-plankton, zoo-plankton and benthos could not make a comparison between pre and post-survey yet because of the samples are under analysis. However, the duration of 3 months after artificial installation may not sufficient to observed any effect artificial reefs to fisheries resources yet. Then, it need for more longer period to evaluate the enhancement ability of artificial reefs to fisheries resources.

ANNEX I

ICTD Data

Ship M.V.SEAFDEC 2 Cruise No. 3-3/2004

Station No. 1 (AR Group A)

Position Lat .10_48.85 N Long. 99_28.66 E

Bottom Depth 12 m

Pressure	Temp.	Salinity	Oxygen	pH	PAR/Irradia .	Fluores.		Density	Conduct.	
1	27.7879	33.2082	3.47489	8.101	2.01E+02	2.58 E+00	2.584	21.1166	5.344781	0.00E+00
2	27.8026	33.4487	4.32143	8.11	1.58 E+02	2.35 E+00	2.353	21.2927	5.380766	0.00E+00
3	27.8051	33.45	4.31551	8.11	1.08 E+02	2.56 E+00	2.556	21.2929	5.381253	0.00E+00
4	27.8038	33.4495	4.30755	8.11	7.40 E+01	2.67 E+00	2.667	21.2931	5.381076	0.00E+00
5	27.8006	33.4473	4.29871	8.11	5.25 E+01	2.38 E+00	2.379	21.2926	5.380485	0.00E+00
6	27.8013	33.4542	4.31031	8.11	3.77 E+01	2.41 E+00	2.413	21.2976	5.381585	0.00E+00
7	27.8014	33.4586	4.26406	8.106	2.71 E+01	2.57 E+00	2.567	21.3009	5.382255	0.00E+00
8	27.8001	33.4623	4.23377	8.104	1.95 E+01	2.40 E+00	2.400	21.3042	5.382706	0.00E+00
9	27.7974	33.4677	4.2196	8.102	1.44 E+01	2.51 E+00	2.505	21.3092	5.383248	0.00E+00
10	27.7954	33.4691	4.19644	8.1	1.05 E+01	2.58 E+00	2.583	21.311	5.383275	0.00E+00
11	27.7948	33.4708	4.18447	8.097	7.54 E+00	2.63 E+00	2.626	21.3125	5.383506	0.00E+00
12	27.7934	33.4618	4.18357	8.097	5.24 E+00	3.05 E+00	3.054	21.3063	5.38213	0.00E+00

Ship M.V.SEAFDEC 2 Cruise No. 3-3/2004

Station No. 2 (AR Group B)

Position Lat .10_48.52 N Long. 99_28.26 E

Bottom Depth 12 m

Pressure	Temp.	Salinity	Oxygen	pH	PAR/Irradia .	Fluores.		Density	Conduct.	
1	27.7586	33.2533	3.92102	8.092	4.48E+02	2.66 E+00	2.664	21.16	5.348286	0.00E+00
2	27.7836	33.4437	4.41138	8.102	2.66 E+02	2.69 E+00	2.694	21.2951	5.378127	0.00E+00
3	27.7814	33.4469	4.40268	8.105	1.78 E+02	2.78 E+00	2.783	21.2983	5.37839	0.00E+00
4	27.7866	3.4563	4.37864	8.103	1.20 E+02	2.88 E+00	2.884	21.3038	5.380305	0.00E+00
5	27.7873	33.4575	4.33798	8.1	8.26 E+01	3.01 E+00	3.006	21.3045	5.380587	0.00E+00
6	27.7834	33.4637	4.29968	8.097	5.59 E+01	3.06 E+00	3.056	21.3105	5.381128	0.00E+00
7	27.7818	33.4664	4.25827	8.097	3.94 E+01	3.09 E+00	3.086	21.3131	5.381385	0.00E+00
8	27.7793	33.4659	4.22552	8.095	2.71 E+01	3.16 E+00	3.159	21.3136	5.381097	0.00E+00
9	27.7769	33.4664	4.19841	8.093	1.73 E+01	3.28 E+00	3.276	21.3148	5.380964	0.00E+00
10	27.7767	33.4666	4.1875	8.093	1.19 E+01	2.72 E+00	2.715	21.3152	5.381027	0.00E+00

POTENTIAL OF ARTIFICIAL REEFS FOR ENHANCEMENT OF FISHERIES RESOURCES - CASE STUDY FROM JAPAN

Yasushi ITO & Hiroaki TERASHIMA, Ph.D.

POTENTIAL OF ARTIFICIAL REEFS FOR ENHANCEMENT OF FISHERIES RESOURCES - CASE STUDY FROM JAPAN

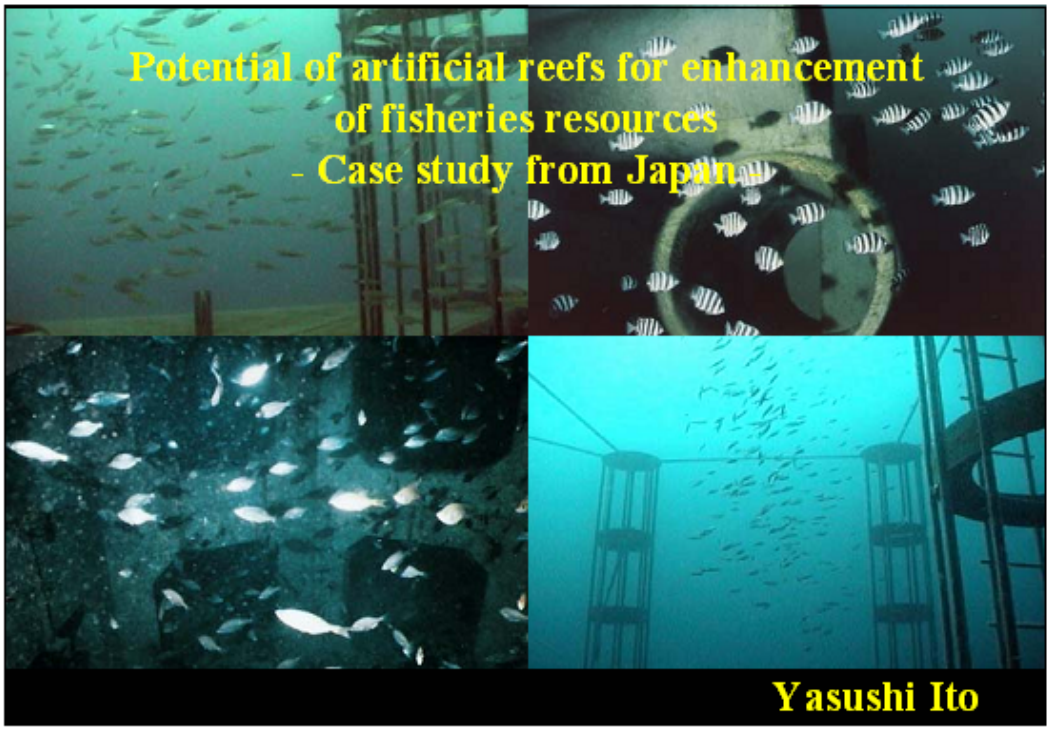
Yasushi ITO
Hiroaki TERASHIMA
The Japanese Institute of Technology on
Fishing ports, Grounds and Communities
(JIFIC)

Artificial reefs provide habitats to a multitude of marine organisms, which form a food web that supports a variety of fish species. Artificial reefs not only provide food ,shelter and resting areas to fish but also serve as spawning grounds, hence enhancing fishery resources.

In recent years, many artificial reef projects implemented in shallow waters in Japan have focussed on nurturing bait organisms for enhancing fish growth, although artificial reef projects have implemented in deeper waters have aimed at enhancing fish stocks, mainly of sedentary fish species.

This study detail the functions of nurtured bait creatures around shell covered stock enhancement structures in shallow waters of Seto inland sea.

In addition it shows the correlation between bait creatures and aggregation of fish. We also present results of a stock assessment study conducted on an artificial reef set in relatively deeper waters of Yamagata prefecture.



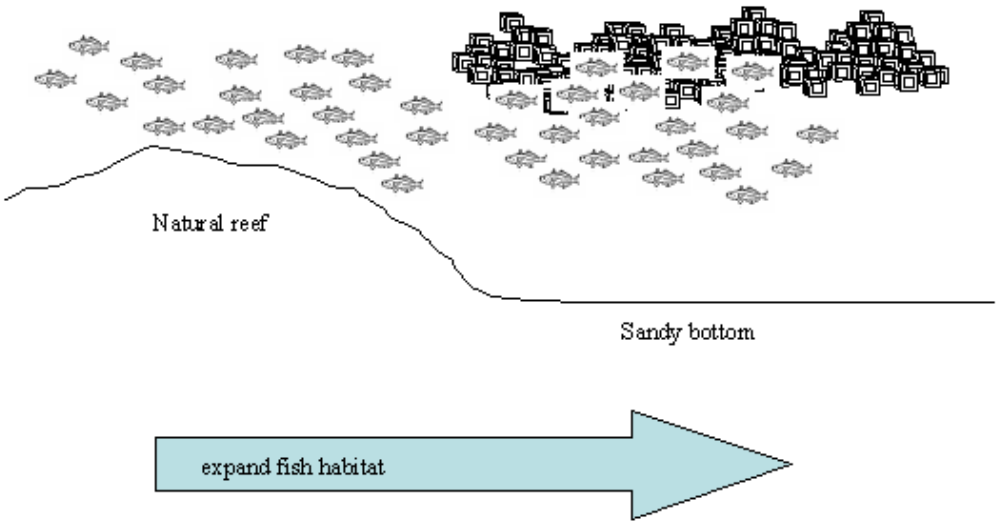
Structure of presentation

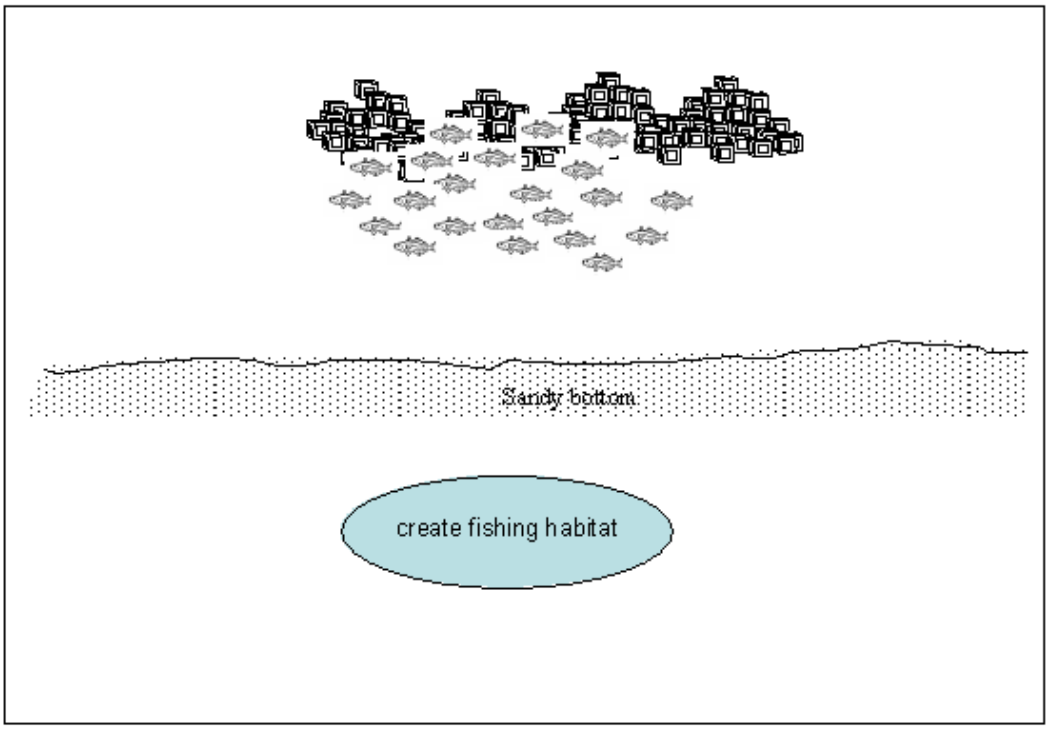
- General concept of artificial reef
- Case study in shallow waters
- Case study in deeper waters

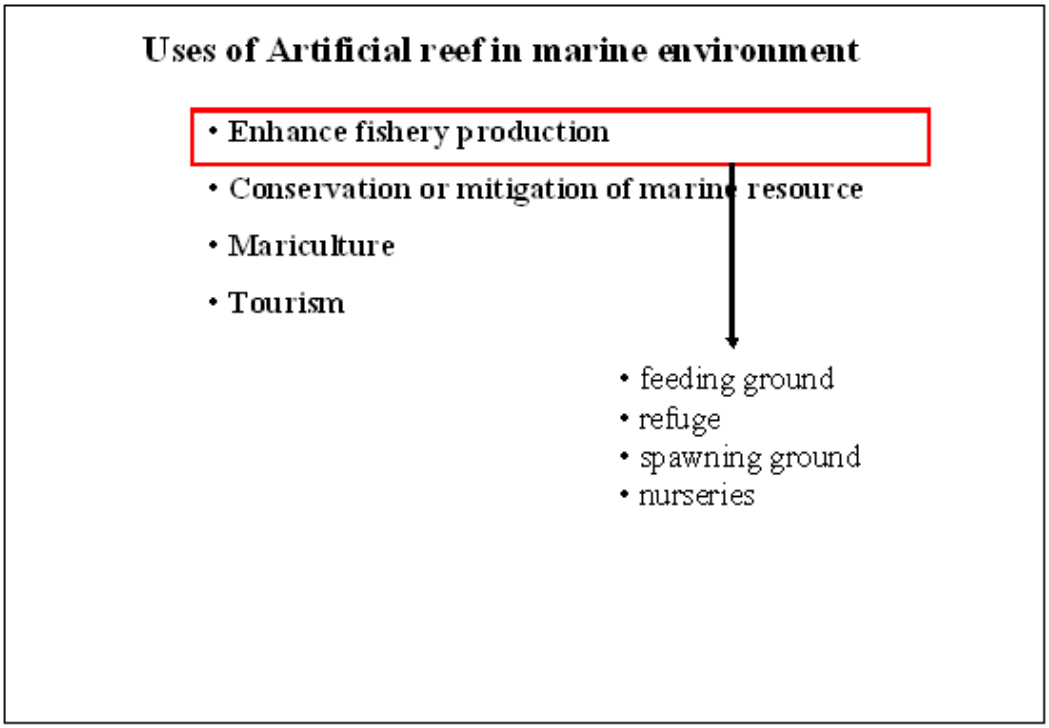
Uses of Artificial reef in marine environment

- Enhance fishery production
- Conservation or mitigation of marine resource
- Mariculture
- Tourism

Expansion or creation of fish habitat



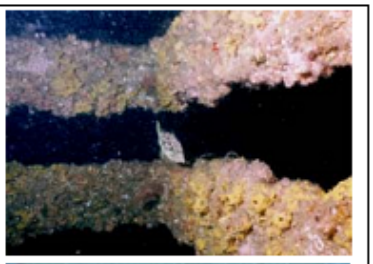

Sandy bottom
create fishing habitat


Uses of Artificial reef in marine environment
• Enhance fishery production
• Conservation or mitigation of marine resource
• Mariculture
• Tourism
• feeding ground
• refuge
• spawning ground
• nurseries

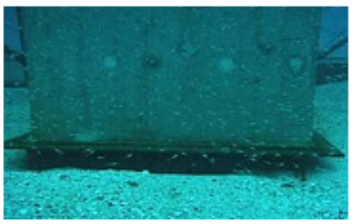
Function as feeding ground

aggregation of prey organisms

- increase of periphyton on the surface of artificial reef



- increase of plankton & benthic organisms due to turbulence & topographic transitions around artificial reef

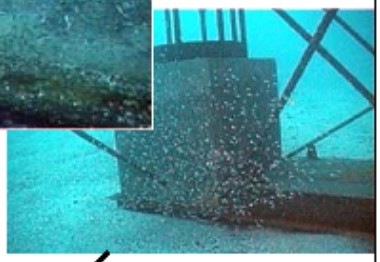


- increase of organisms associated with attached macroalgae

- Attract organisms from higher trophic levels
- Promote growth and hence enhance fish stocks

Newly installed artificial reef

Colonisation of substrate by polychaetes



Accumulation of plankton

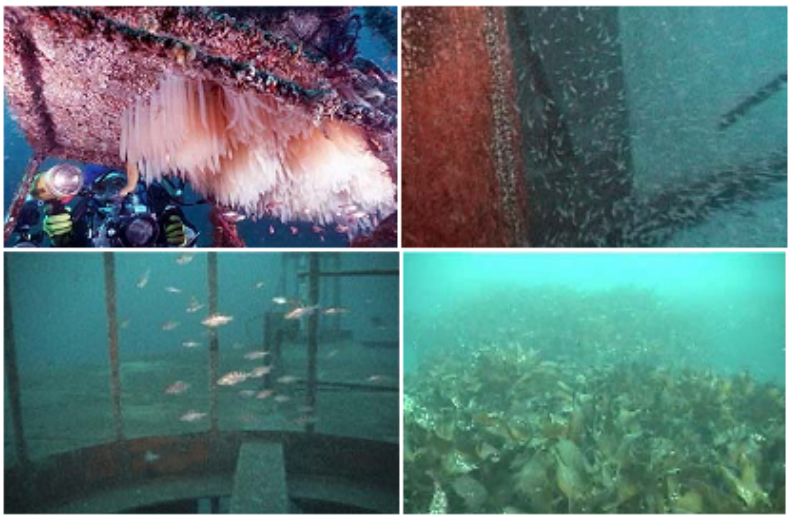
Aggregation of small fish

predation of small fish by larger carnivorous fish

Function as Refuge

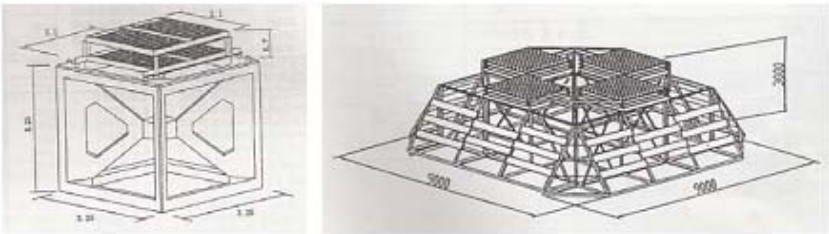
- Multidimensionality provides hiding places for demersal organisms

- Function as spawning ground & nurseries
  - Creation of spawning grounds
  - Creation of nursery grounds



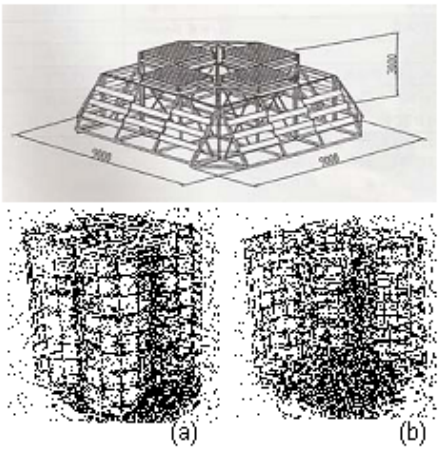
Case study 1 - Artificial reef in inland shallow waters (10-15m) of Japan

Nurturing of bait organisms for enhancing fish growth.



Artificial reefs with shell plates

Procedure used for installing test pieces of oyster shells on artificial reef

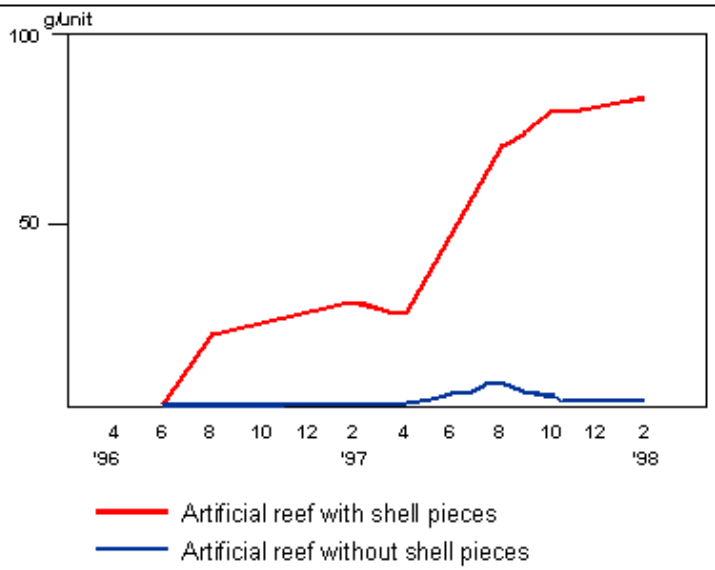


Experimental structures

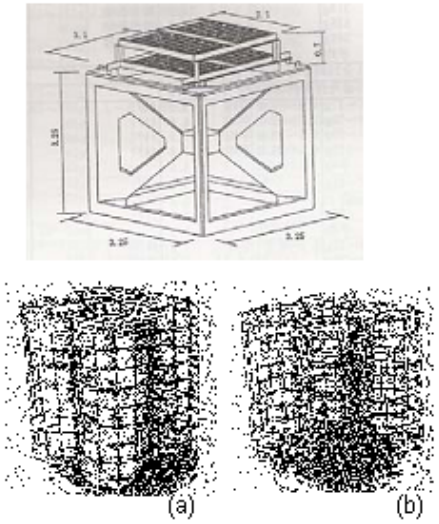
(a) artificial reef with shells

(b) artificial reef without shells

Map of study area (Seto inland sea)



Weight of food organisms (crustaceans) collected on artificial reef with & without shell pieces over 20 months

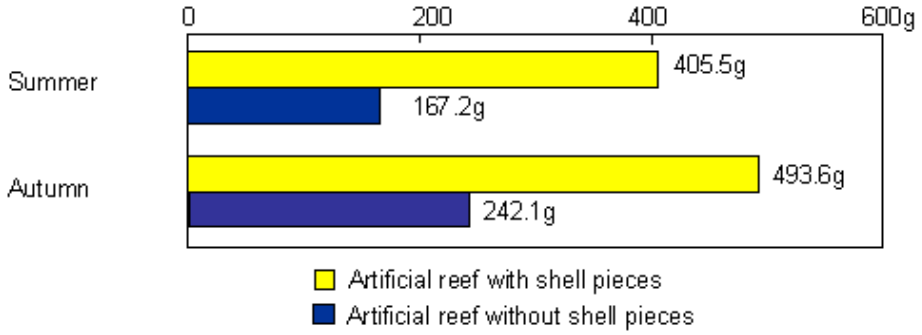


Experimental structures

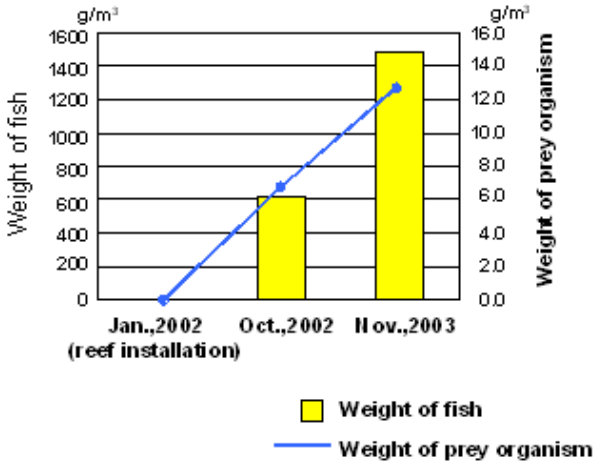
(a) artificial reef with shells

(b) artificial reef without shells

Map of study area (Himejima, Ohita)



Weight of fish collected in unit (g/m^3) on artificial reefs with & without shell pieces at two seasons (2002)



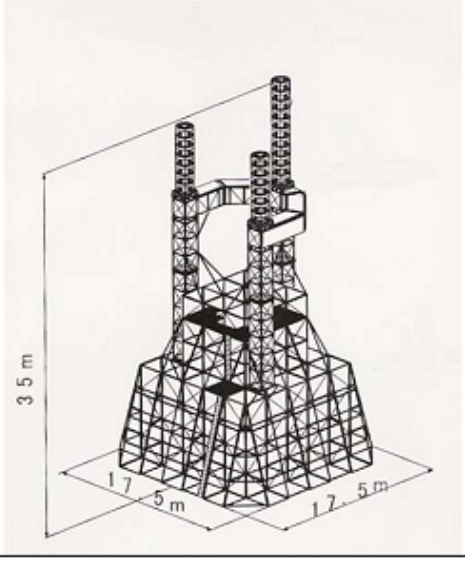
Weight of fish (g/m^3) and prey organisms over 22months on artificial reef with shell pieces

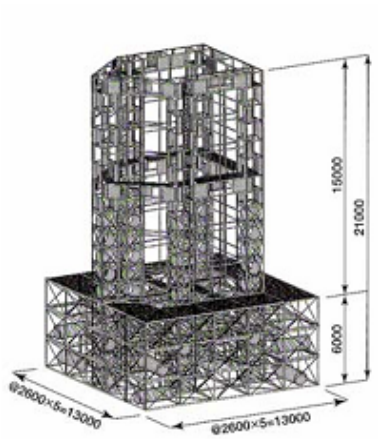
Conclusion

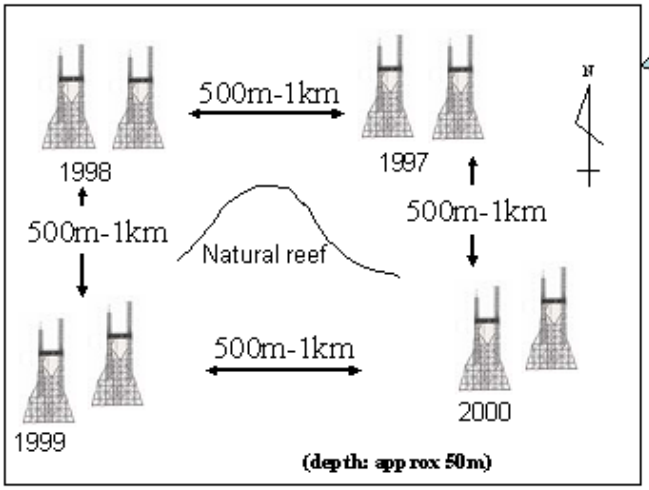
- Small organisms (e.g amphipods, decapods) colonise more abundantly structures offering much topographic (habitat) complexity.
- These become preys for larger organisms in the food web e.g commercially important fish.
- May be used as nursery and refuge by juvenile fish.
- Oyster shell can be utilised at minimal cost in Japan for enhancing fish production in shallow waters.

Case study 2 - Artificial reef in deeper waters (~50m)

High-rise artificial reef projects have also implemented at several locations in Japan (e.g. Yamagata pref., Ishikawa pref.)

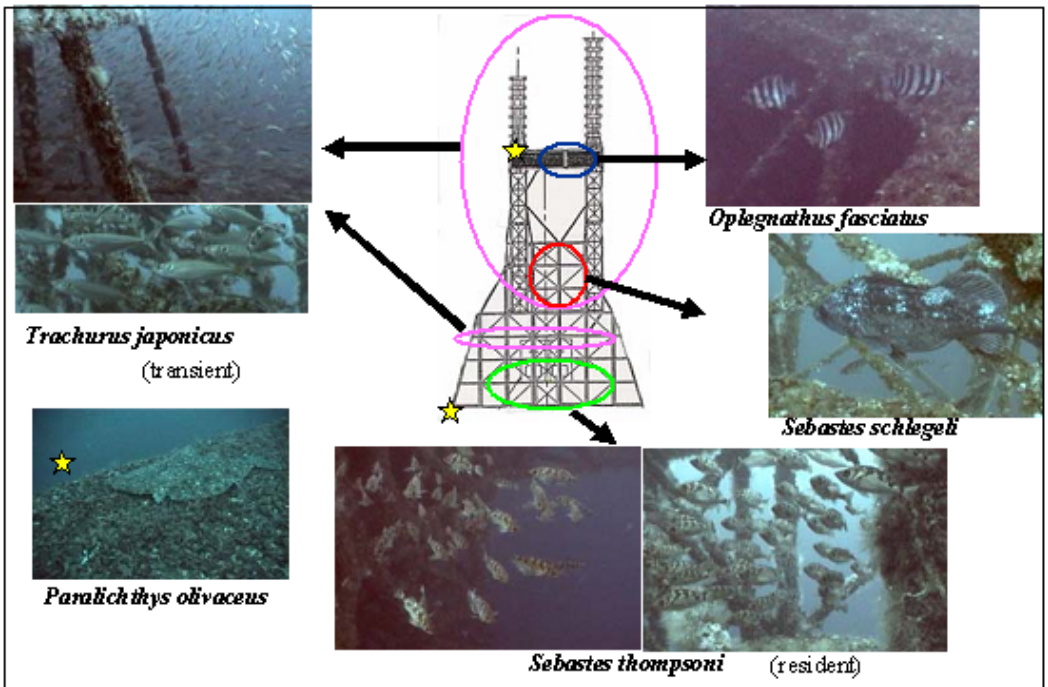






Map of study site (Sea of Japan)

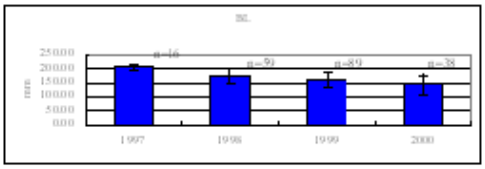
Schematic illustration of deployed artificial reefs around Tayusho reef

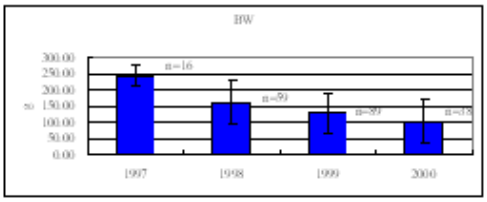


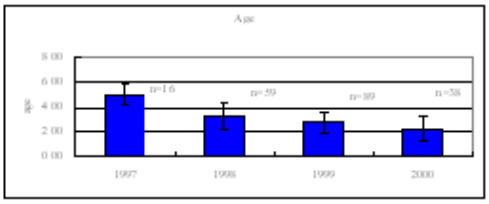
Zonation pattern of fish on the artificial reef

Sebastes thompsoni

- This species found on the artificial reef structure, although not observed in the adjacent natural reef
- Seems to settle in artificial reef over the years and increase in body size over time (U/W observations)

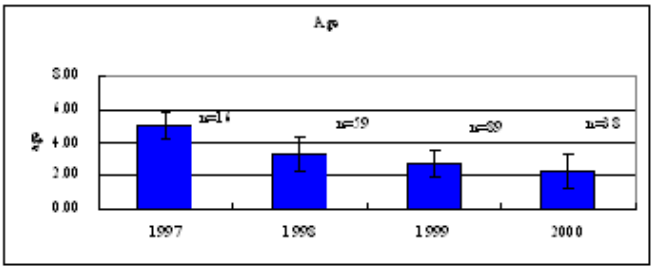






Sampling date: 23-24 May 2003

extracting otolith for age determination



Sampling date: 23-24 May 2003

It seems cohort born in the year following installation of an artificial reef becomes a dominant group within that reef.

↓

Each cohort has grown on the same reef where it settled in its larval stages.

Conclusion

- High-rise artificial reefs offer topographic complexities that accommodate pelagic and demersal fish assemblages.
- Fish assemblages on the artificial reefs consist of both resident and migrant species.
- Sebastes thompsoni seems to grow from larval to adults stages on the artificial reefs and reside permanently on the same reefs.
- Artificial reefs are effective in creating productive hard bottom habitat where there are none (highseas 50 to 100m depth), hence enhancing fish production.
- Further studies using Tag and recapture method needed to confirm our data.

Overall Conclusion

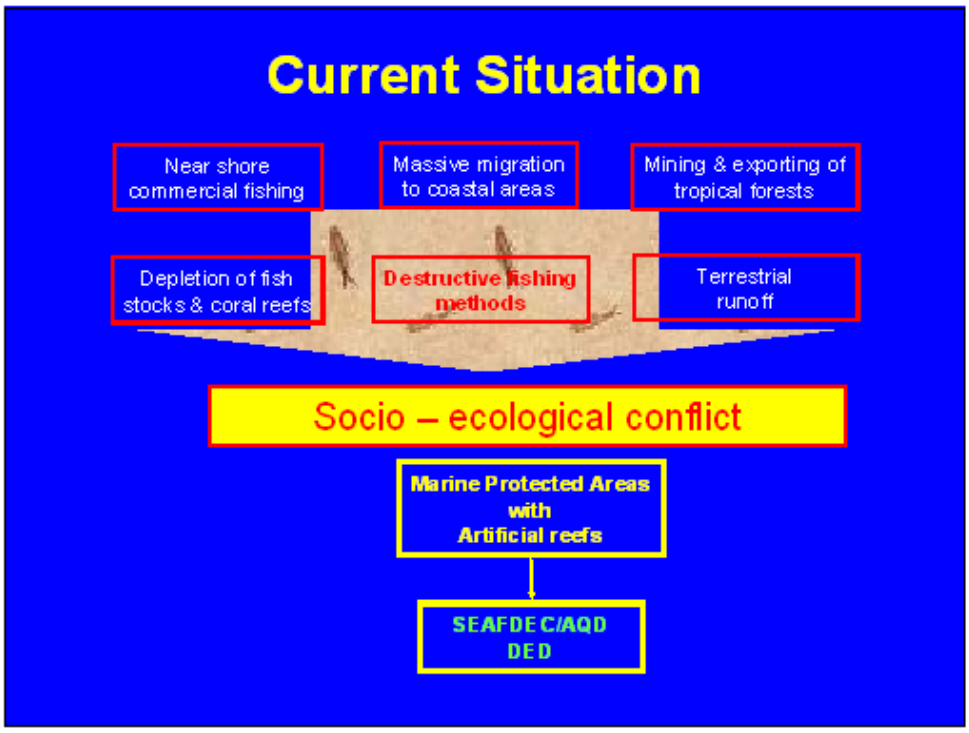
The role of artificial reefs is to serve as tool for proper management of marine fisheries.

There is a need to collect more biological as well as ecological data to understand the proper functioning of artificial reefs so that we can manage them in more sustainable manner.

ARTIFICIAL REEFS - A REWARDING ATTEMPT

J.H. Primavera, Ph.D. & K. - J. Kuhimann


Artificial reefs – a rewarding attempt?
J. H. Primavera & K. - J. Kühlmann
Aquaculture Department
Southeast Asian Fisheries Development Center
Tigbauan, Iloilo, Philippines
German Development Service (DED)
Provincial Planning & Development Office (PPDO)
Kalibo, Aklan, Philippines
SEAFDEC
ded
Deutscher
Entwicklungsdienst


Current Situation
Near shore commercial fishing
Massive migration to coastal areas
Mining & exporting of tropical forests
Depletion of fish stocks & coral reefs
Destructive fishing methods
Terrestrial runoff
Socio – ecological conflict
Marine Protected Areas with Artificial reefs
SEAFDEC/AQD
DED

What is an artificial reef?

•**Definition:**

Artificial reefs (ARs) are effective tools to enhance marine environment and to increase fish biomass and abundance.

•**Pros:**

- deployed within MPAs, ARs will contribute to fish stock increase
- also, corals or other marine organisms may settle on AR structures

•**Cons:**

- ARs deployed outside MPAs or municipal waters could damage trawl nets of commercial fishers
- will serve as fish aggregating device (FAD) and contribute to "empty" **marketable fish from** coastal waters ...

Artificial reefs are used for ...

Japan
Commercial fishing

U.S.A.
Habitat restoration

Southwest Pacific
Artisanal fishing

Caribbean
Recreational diving

Southern Pacific
Submarine tour operators

Australia
Sports fishing

Spain
Prevent entry of trawlers

[Reference: Seaman (edit) 2000, p. 206)]

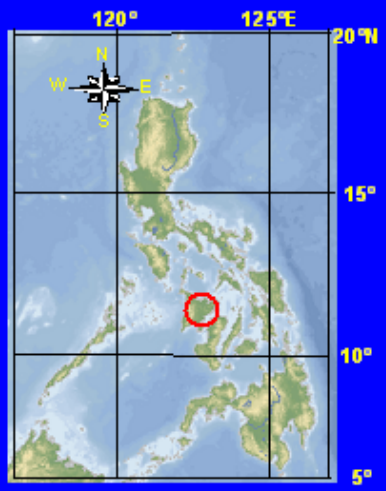
1989: IDRC grant to AQD for CRM Project

SITE SELECTION

Socioeconomic – dependence on fishing, use of fishing credit, potential alternative livelihood membership in association, awareness of NGOs

Biophysical – extent of live coral/seagrass, hard substrates, water depth (10-30 m) & transparency, absence of runoff, monsoon protection

Philippines



MALALISON FISHERIES

- 1980s: destructive fishing (dynamite, cyanide, muro ami), open access fishery
- Fishing gears: hookah (compressor diving), set gill net, spear gun, hook and line
- Fishing sites – Nablag reef, Balabago reef


INSTITUTION BUILDING
- FAMI organized & registered (1990)
- community organizing by NGO PROCESS
- cross visits


4 STAGES OF PROJECT
I – community/institution-building
II – livelihood: interest-free loans for seaweed farming, hog raising (1992), cooperative store started in 1994
III – territorial use rights in fisheries (TURFs), AR deployment
IV – searanching
1993 start of yearly SEAFDEC AQD-FAMI Forum

TURFS & Artificial Reefs

1990 - Mun. Ord. 5-90 designating 100 ha exclusive TURF for FAMI
1991 - Mun. Ord. 2-91 prohibits transient & commercial fishers
ARs allowed in TURF area
1995 - Village Ord. establishing Guiob reef sanctuary, creation of FARMC
1995 - ARs (blocks, culverts) deployed: 8.5% expenses from village
1996 - Guiob Sanctuary ordinance approved by Culasi Municipality
1997 - LIPASECU established: 4 municipalities with 14 fish sanctuaries
1999 - Village Ord. 11-99 bans compressor (hookah) fishing

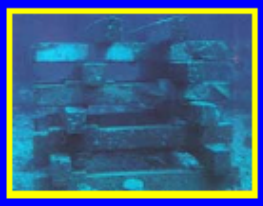
ARTIFICIAL REEFS

Design: survey of Japanese prototypes, availability, cost of materials, ease of transport, installation/deployment

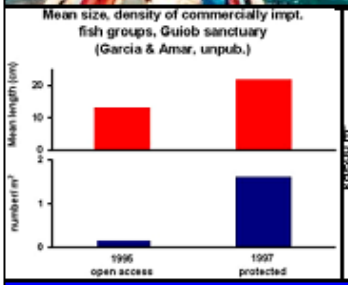
Siting: based on data from fishers, AQD survey
- water velocity
- hard substrate, topography
- declared fish sanctuary

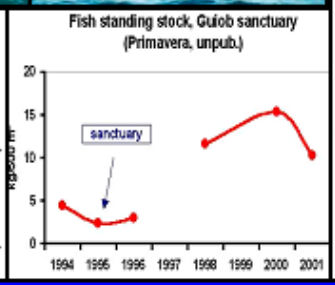
Transport & deployment:
- motorized boat (10 min) vs raft towed by 4 boats (45 min)
- good weather, clear water
- teams of 6-8 persons
- each block tied with ropes, lowered by divers with air compressors then assembled

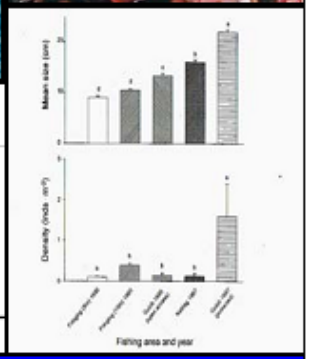
MALALISON AR TYPES

	Building Blocks	Culvert	Modified Culvert
			
Unit size	1.5 cmx20cmx2m	30cm dia x 1.2m	40cm dia x 50cm
Module no: size	16: 2x2x1.6m	15: 1.2x2.5x2.1m	30: 1.5x2.5x1.5m
Construction cost	US$178	US$156	US$138
Deployment cost	US$38	US$38	US$38
Handling	difficult because of corners	easy to roll	easy to roll, lightest
Time to deploy	4 hr	3 hr	3 hr
No. of fish species	9-16	21-22	20-24

EFFECT OF ARS ON FISHERIES







MALALISON – WHAT NEXT??

- 1998 - Project turn-over from SEAFDEC/AQD to FAMI; 6 Antique towns federated into LIPASECU
- stock monitoring/assessment
  - corals, fish
  - natural reefs vs ARs
  - sanctuary vs open area
- stock enhancement
  - abalone, top shell, sea horse, fish species??
  - sanctuary vs open area
- documentation/info. dissemination
  - SEAFDEC courses on CRM

2003 - AQD ACTIVITIES STOPPED!!!

MALALISON PAPERS

- Siar, SV, RF Agbayani, JB Valera. 1992. Acceptability of territorial use rights in fisheries: towards community-based management of small-scale fisheries in the Philippines. Fisheries Research 14: 295-304 (socioeconomics)
- Siar, SV. 1994. Conflict in small-scale fisheries: a case study of Malalison Island, Philippines. In: Chou et al. (eds), The Third Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines (socioeconomics)
- Agbayani, RF, DB Baticados, SV Siar. 2000. Community fishery resources management on Malalison Island, Philippines: R & D framework, interventions and policy implications. Coastal Management 28: 19-27 (socioeconomics)
- Baticados, DB and RF Agbayani. 2000. Co-management in marine fisheries in Malalison Island, central Philippines. Int. J. Sustain. Dev.World Ecol. 7: 343-355 (socioeconomics)
- Tenedero, RA. 1995. Engineering and deployment of artificial reefs for a community-based fishery resources management project at Mararison Island, Antique, Philippines. Proceedings ECOSET '95 International Conference on Ecological System Enhancement Technology for Aquatic Environment, November 1995, Japan. pp. 640-645 (engineering)
- Amar, EC, RMT Cheong, MVT Cheong. 1996. Small-scale fisheries of coral reefs and the need for community-based resource management in Malalison Island, Philippines. Fisheries Research 25: 265-277 (fisheries)
- Primavera, YH. 2002. Aspects of hookah fishing in Malalison Island, west central Philippines. Presented at the Asia-Pacific Conference on Marine Science and Technology, May 12-16, 2002, Kuala Lumpur, Malaysia (fisheries)
- Primavera, YH. 2002. The coral reef fisheries of Malalison Island, west central Philippines two years after fish sanctuary protection. UPV J. Nat. Sci. 7 (1 & 2): 120-132 (fisheries)
- Garcia, LMB. Coral reef Almanac of the Philippines (corals)

Conclusions (1)

- Artificial reefs can contribute to enhance fish biomass/ abundance once deployed within marine protected areas
- Artificial reefs should be placed on hard soil of coral free areas, e.g. rubble stones
- Artificial reefs should be made of concrete for easy settlement of marine organisms (corals, sponges, feather stars)
- Artificial reefs to be placed in vicinity of healthy coral reefs so coral larvae can easily settle

STOCK ENHANCEMENT IN ARS - SOME POINTS TO CONSIDER

a) Interventions to restore depleted stocks:
1st: regulate fishing effort = habitat protection/ rehabilitation
2nd: stock enhancement

b) Candidate species/sites for stock enhancement:
Mortality not density-dependent
Release sites with natural food, shelters
Need behavioral conditioning

c) Species (mis)match:
Enhancement of cultured stock in artificial reefs (=natural habitats)

STOCK (CULTURED) ENHANCEMENT IN ARTIFICIAL REEFS (CAPTURE)??

Malalison fish biomass, 1995-97 (Primavera, 2002)	AQD Cultured Species	Habitat
33% Caesionidae	X	coral reef
28% Acanthuridae	X	coral reef
6% Holocentridae	X	coral reef
4.4% Scaridae	X	coral reef
2% Serranidae (groupers)	*Epinephelus coioides*	estuary- coral reef
1% Lutjanidae (snappers)	*Lutjanus argentimaculatus*	estuary- coral reef
??	seahorse	seagrass
??	ornamental fish	seagrass, coral reef
X	Siganidae (rabbitfish)	seagrass
X	*Chanos chanos* (milkfish)	estuary-pelagic
??	mudcrab, tiger shrimp	estuarine, sed. comm.
??	oyster, mussel	estuarine, sed. comm.
	topshell, abalone	seagrass, coral reef

Note: Species differences in fisheries (*Penaeus indicus/ P. merguiensis*) vs aquaculture (*P. monodon*)

Conclusions (2)

Fish stock enhancement in artificial reefs:

- most reef-dwelling fish species are not cultured
- cultured reef fish species (grouper, snapper) are not abundant in nature

Invertebrates are more promising for stock enhancement

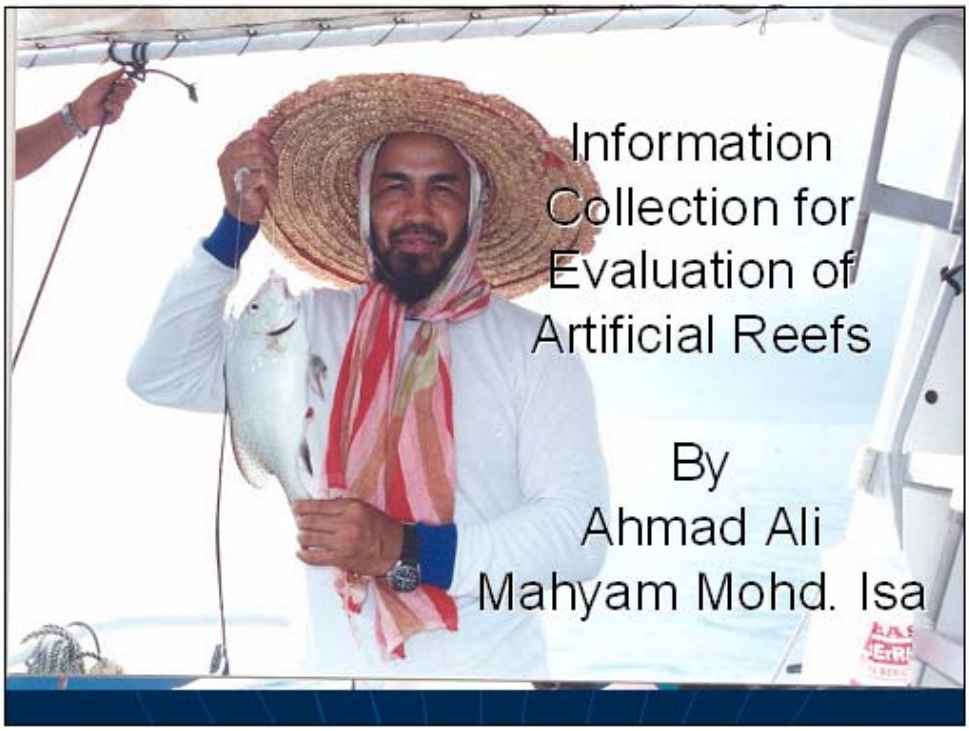
seagrass/coral reefs – abalone, top shell, sea urchin, giant clam
sediment communities – mudcrab, shrimp, windowpane shell
mangroves – mudcrab

Juveniles for stock enhancement need behavioral conditioning for

- foraging (for natural food)
- avoidance of predators

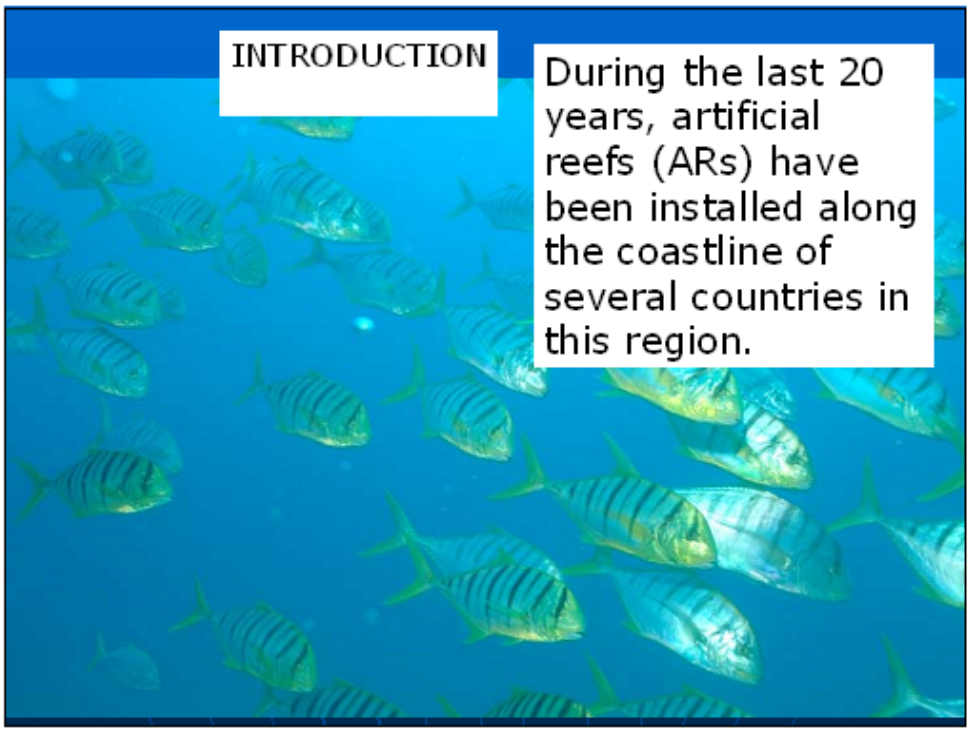
INFORMATION COLLECTION FOR EVALUATION OF ARTIFICIAL REEFS

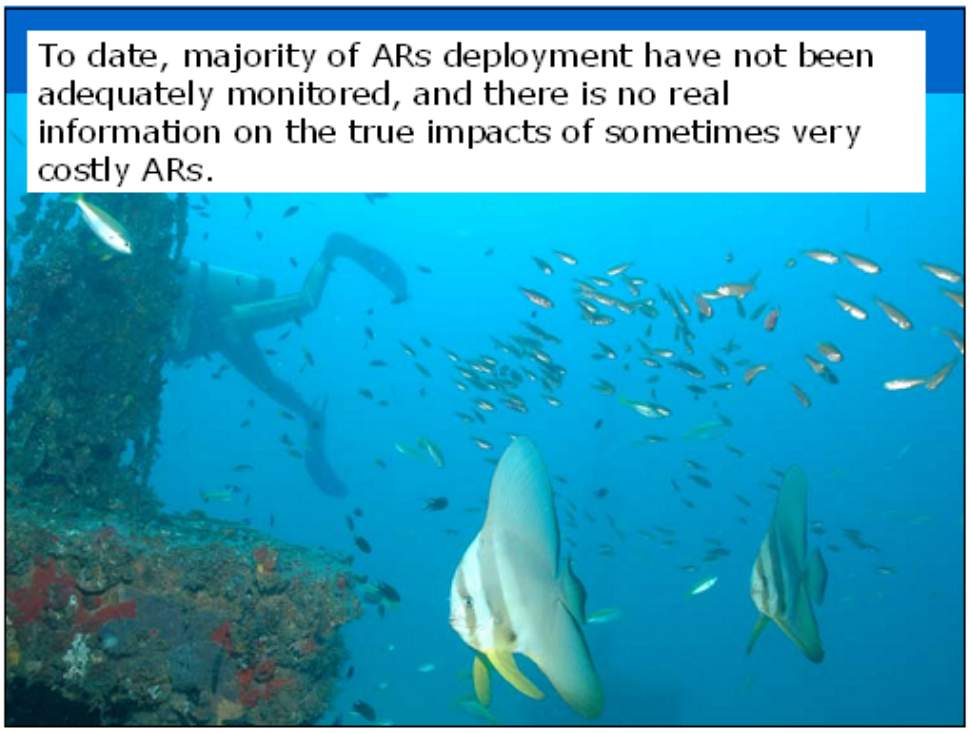
Ahmad Ali & Mahyam Mohd. Isa

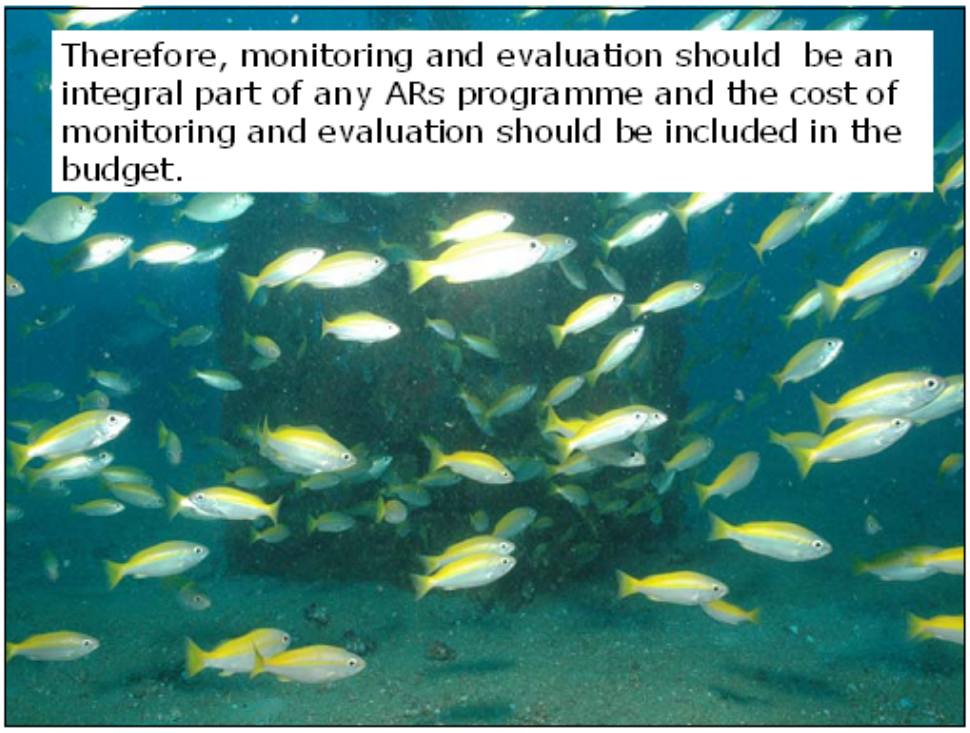

Information
Collection for
Evaluation of
Artificial Reefs
By
Ahmad Ali
Mahyam Mohd. Isa

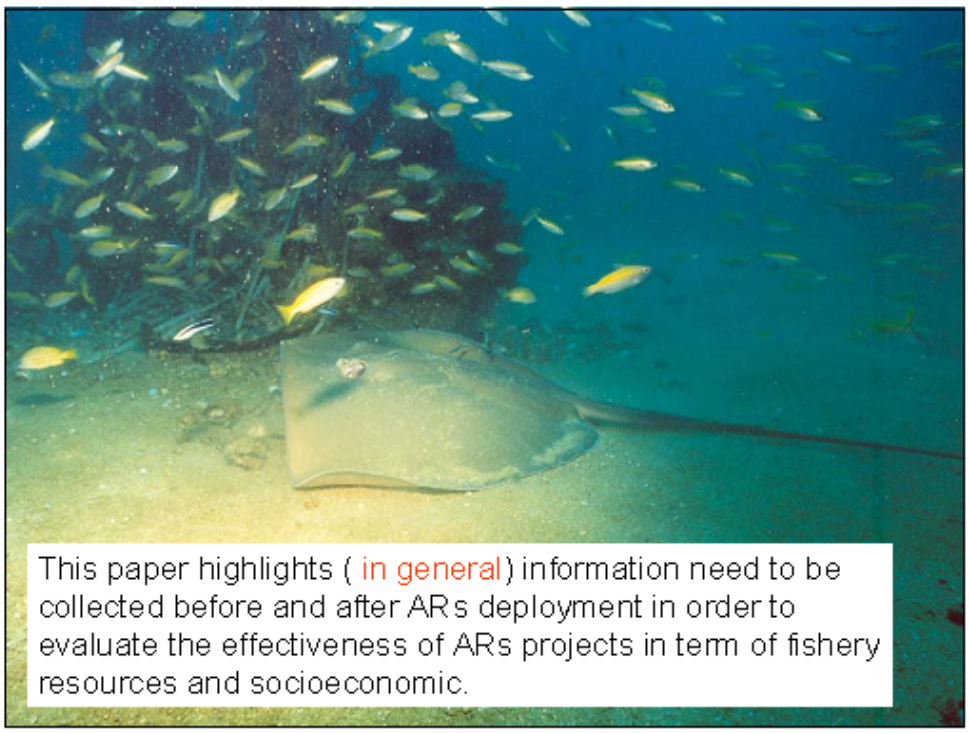

WHERE ARE THEY FISHING?
A
B

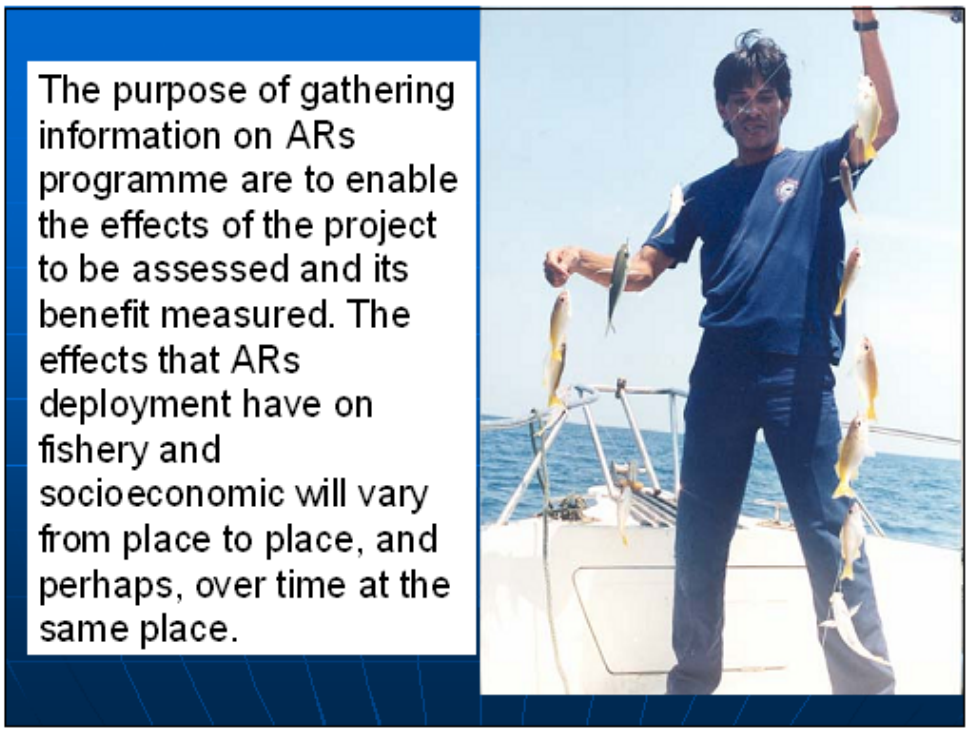

ANSWER
Coral reef area/Natural reef
(> 80 nm from coastline)
in the South China Sea
Artificial reef area
(3 nm from coast line)
in the South China Sea


INTRODUCTION
During the last 20 years, artificial reefs (ARs) have been installed along the coastline of several countries in this region.


To date, majority of ARs deployment have not been adequately monitored, and there is no real information on the true impacts of sometimes very costly ARs.


Therefore, monitoring and evaluation should be an integral part of any ARs programme and the cost of monitoring and evaluation should be included in the budget.


This paper highlights (in general) information need to be collected before and after ARs deployment in order to evaluate the effectiveness of ARs projects in term of fishery resources and socioeconomic.


The purpose of gathering information on ARs programme are to enable the effects of the project to be assessed and its benefit measured. The effects that ARs deployment have on fishery and socioeconomic will vary from place to place, and perhaps, over time at the same place.

Some surprises can result, including unpleasant ones. The potential for ARs to provide expected benefits may be reduced unless a careful assessments of their impact are made.

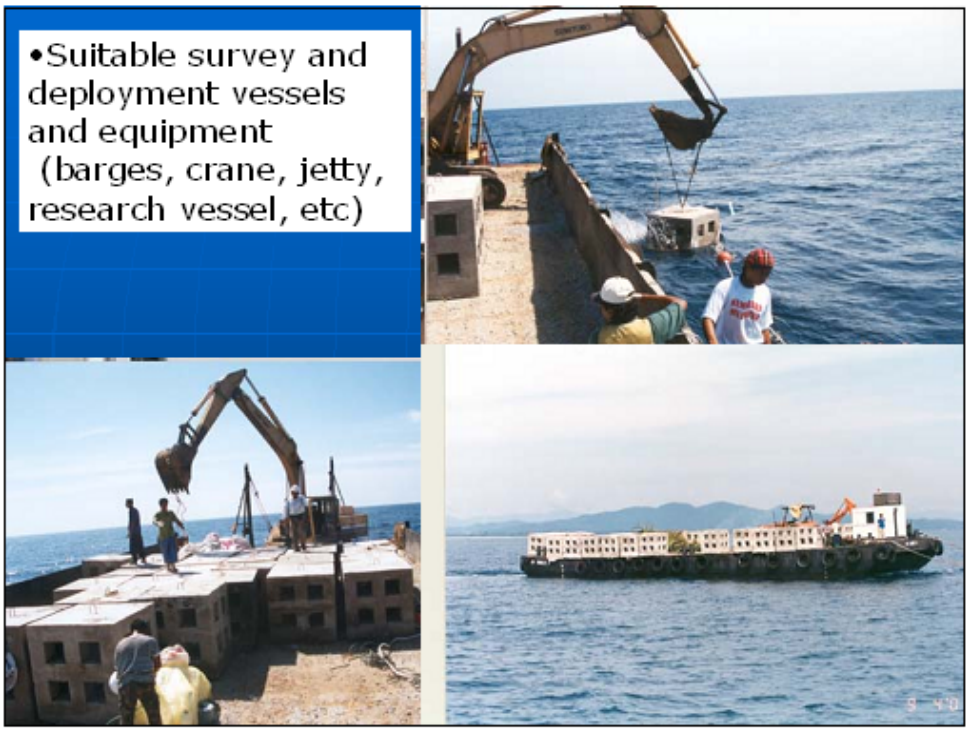
RESOURCE NEEDS IN THE IMPLEMENTATION OF ARs PROGRAMME

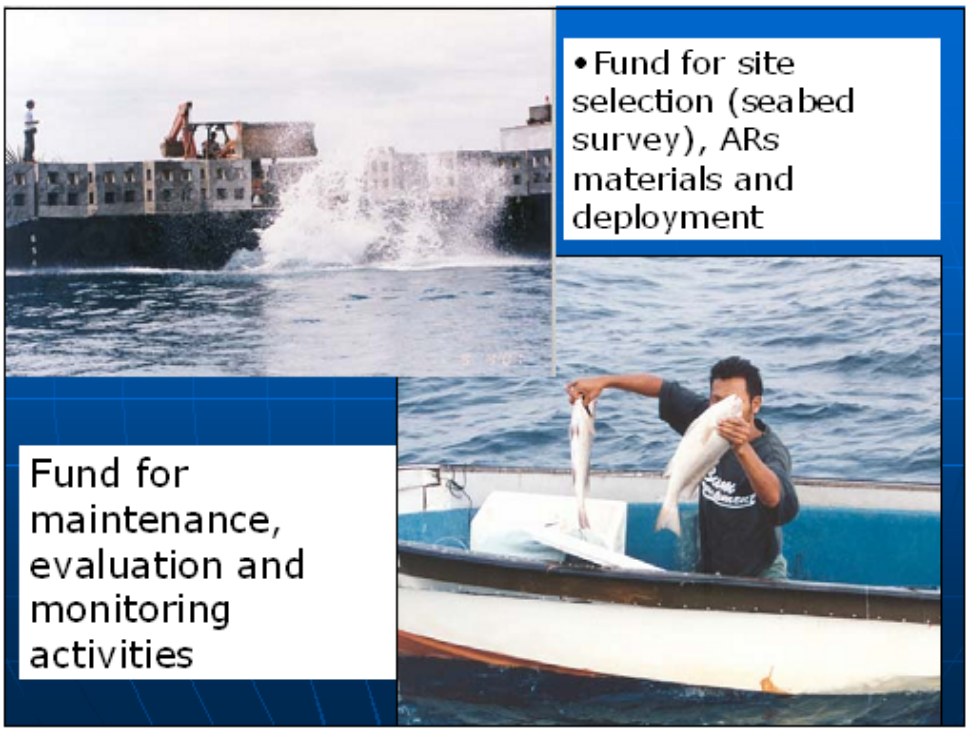
Certain basic resources are needed to implement a successful ARs programme. These include;

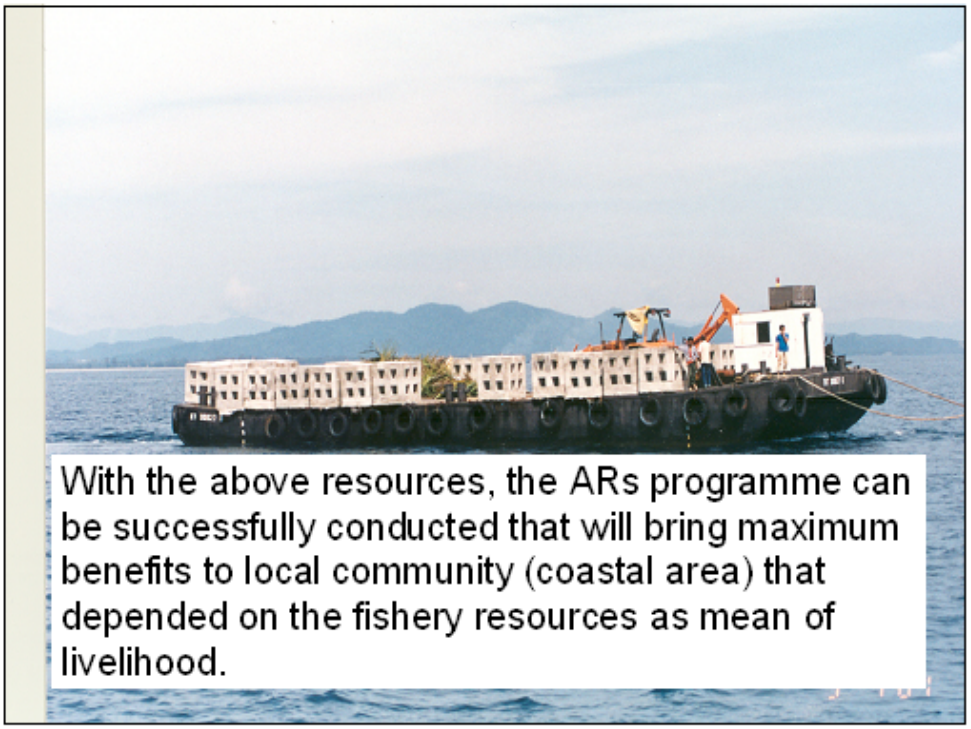
- Sufficient skilled manpower (fish taxonomist, marine biologist, oceanographers, socioeconomics, marine engineer, etc)


Biologist


Certificate Divers


•Suitable survey and deployment vessels and equipment (barges, crane, jetty, research vessel, etc)

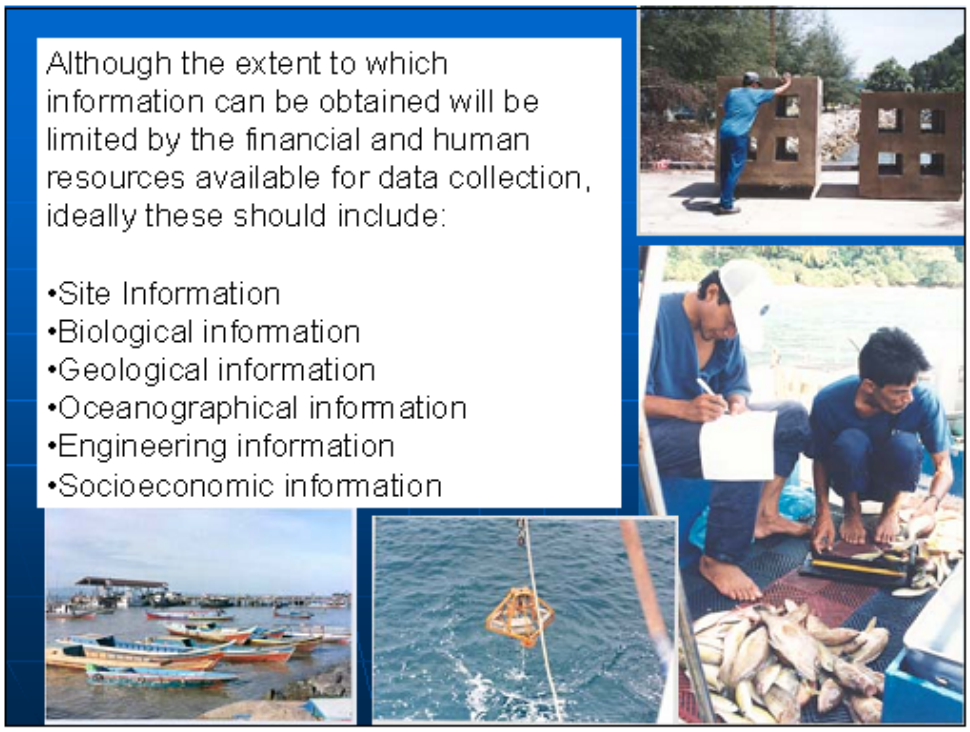

•Fund for site selection (seabed survey), ARs materials and deployment
Fund for maintenance, evaluation and monitoring activities

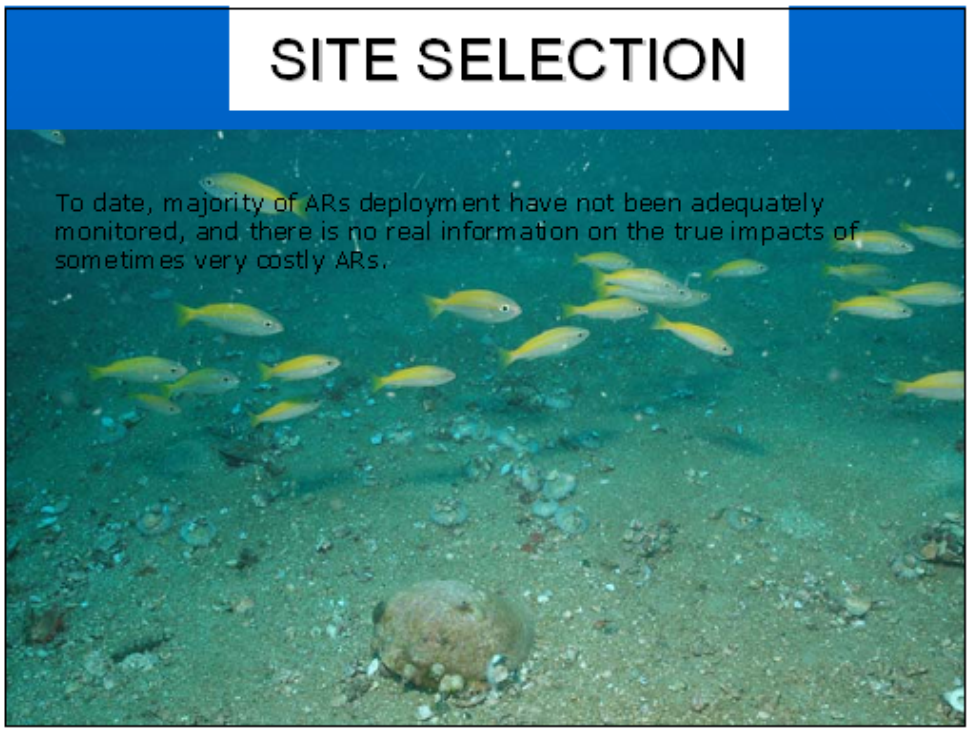


Methods of Information Collection

- There are two main methods collection of information, which are referred to as active and passive.
- The active collection involves visiting to the areas and carry out research activity, interview and gathered anecdotal information from fishers and others. It is thus a labour-intensive operation requiring a significant commitment of manpower and funds.
- Passive information collection, on the other hand, relies on fisher themselves providing the requested data in a standard format, usually through filling in log-books or pre-printed data forms. This method of obtaining information is cheaper and less labour-intensive.

Note: Collection information should be a regular activity.

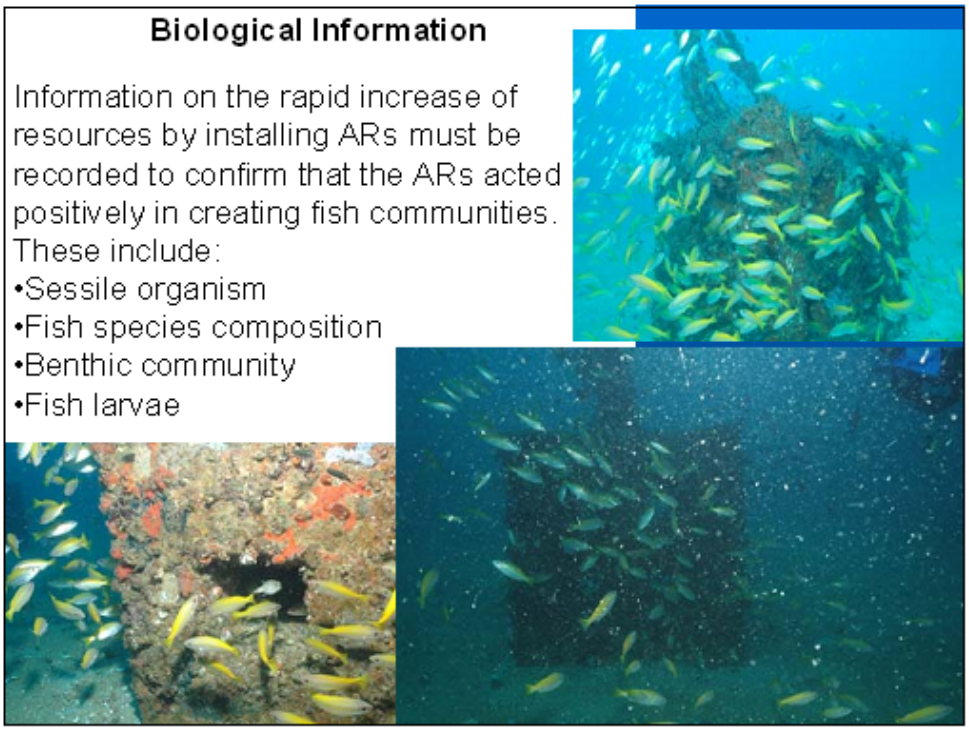

Although the extent to which information can be obtained will be limited by the financial and human resources available for data collection, ideally these should include:
•Site Information
•Biological information
•Geological information
•Oceanographical information
•Engineering information
•Socioeconomic information

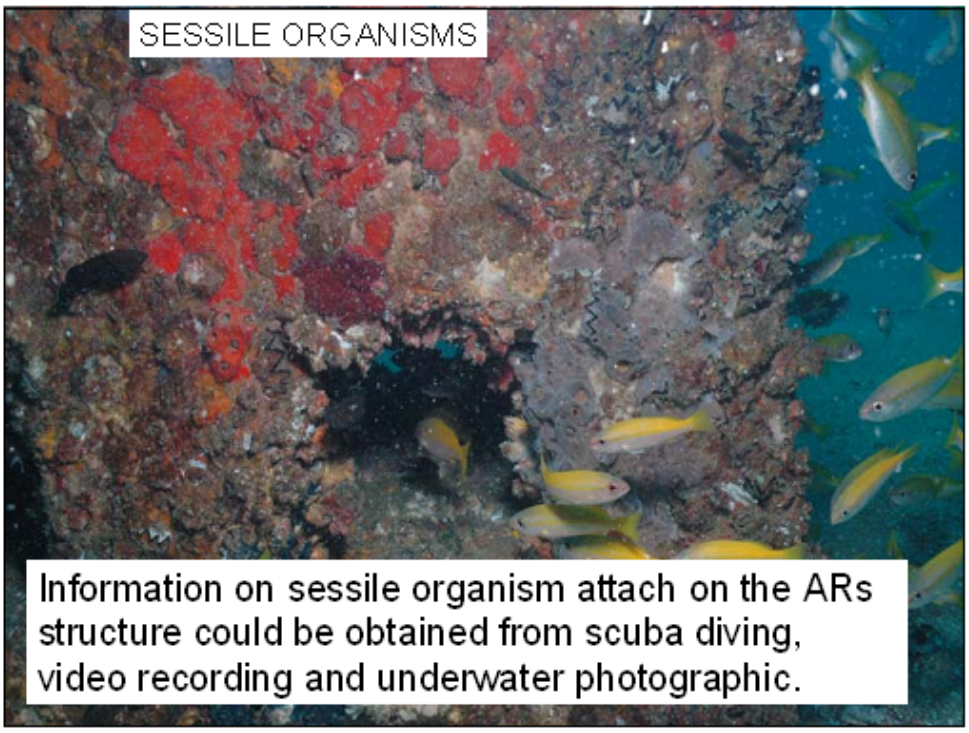

SITE SELECTION
To date, majority of ARs deployment have not been adequately monitored, and there is no real information on the true impacts of sometimes very costly ARs.

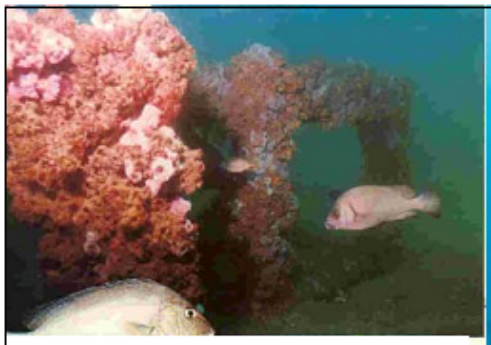
Using a checklist enable those sites that are least suitable for ARs deployment to be detected. Prioritization of the various criteria listed here will largely depend upon local circumstance and the objectives of the ARs programme.

The check-list below shows most of the important characteristics to be considered, and can be used to refine the site selection process:

- Type of sea floor
- Current speed
- Wind and storm
- Market
- Distance from fisher village
- Gears used by local fishers
- Number of fishermen
- Risk of conflict between different communities
- Limitation of fishing area
- Capability of local fishers to maintain and look after ARs

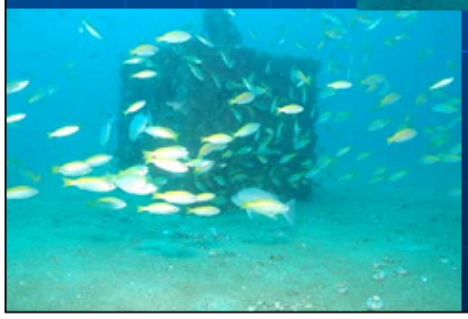

Biological Information
Information on the rapid increase of resources by installing ARs must be recorded to confirm that the ARs acted positively in creating fish communities. These include:
•Sessile organism
•Fish species composition
•Benthic community
•Fish larvae

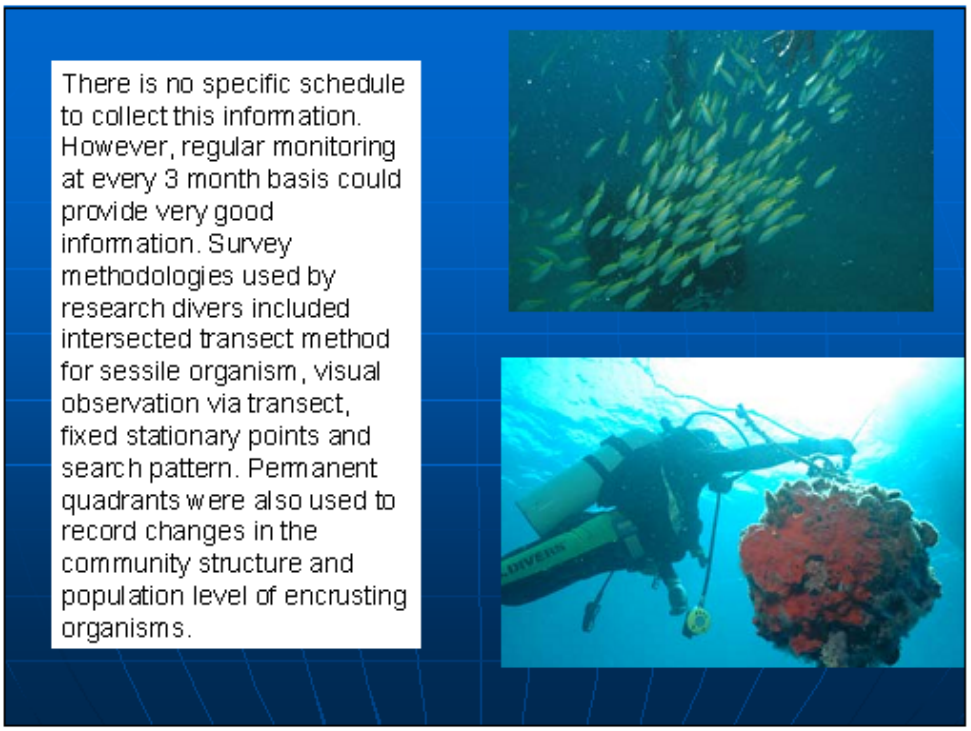

SESSILE ORGANISMS
Information on sessile organism attach on the ARs structure could be obtained from scuba diving, video recording and underwater photographic.



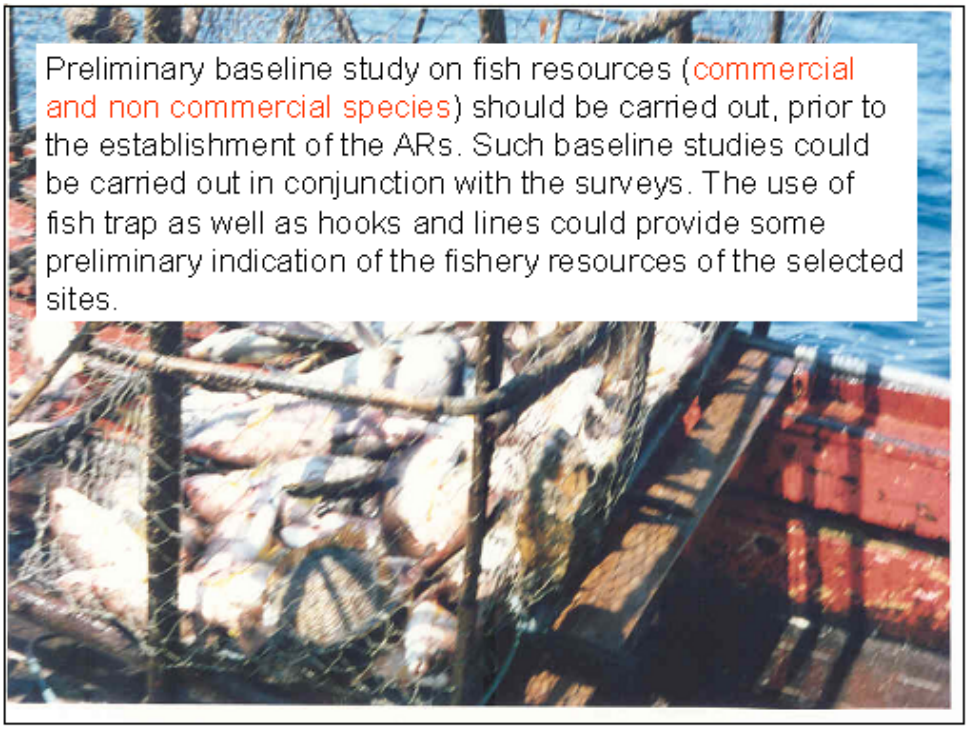
During scuba diving, divers can record the marine organisms such as sponges, corals, sea fans, mollusks,, and other sessile organisms that attach on the structure of the ARs. Qualitative study on encrusting organisms should also be done in order to compile information on the abundance of encrusting organism on the ARs structures.

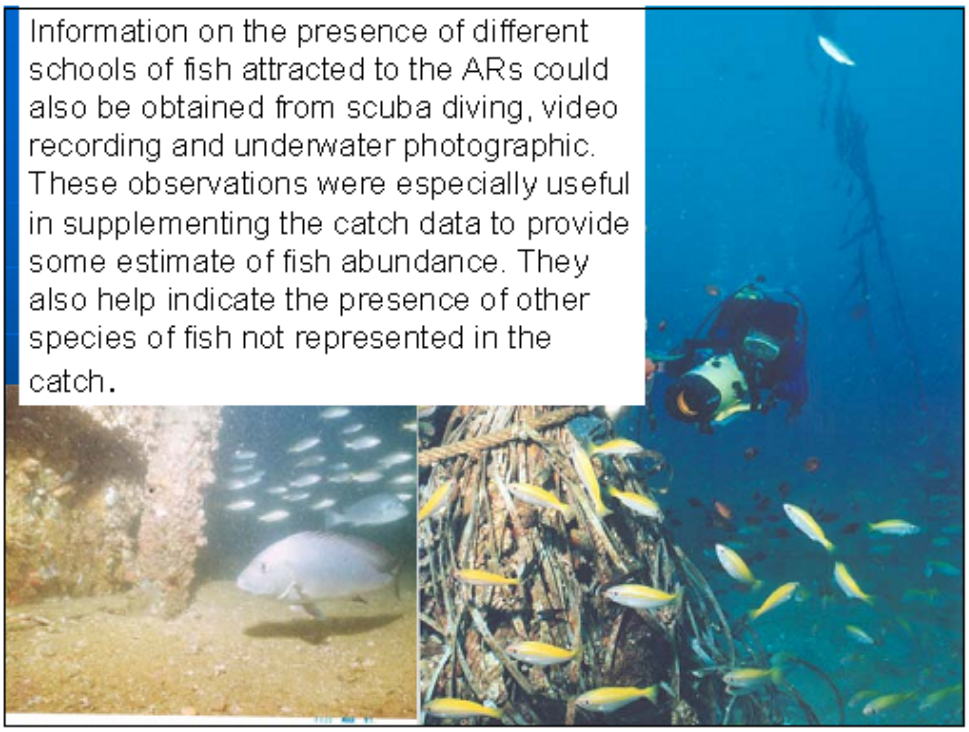
This is important because these organism themselves also indirectly create a complex habitat for associated animals. The habitat complexity is an important factor in reducing predation for small associated fauna. These fauna will exist well and increase in abundance providing an important source of food for many fish species, with reference to omnivores and generally carnivores.




There is no specific schedule to collect this information. However, regular monitoring at every 3 month basis could provide very good information. Survey methodologies used by research divers included intersected transect method for sessile organism, visual observation via transect, fixed stationary points and search pattern. Permanent quadrants were also used to record changes in the community structure and population level of encrusting organisms.

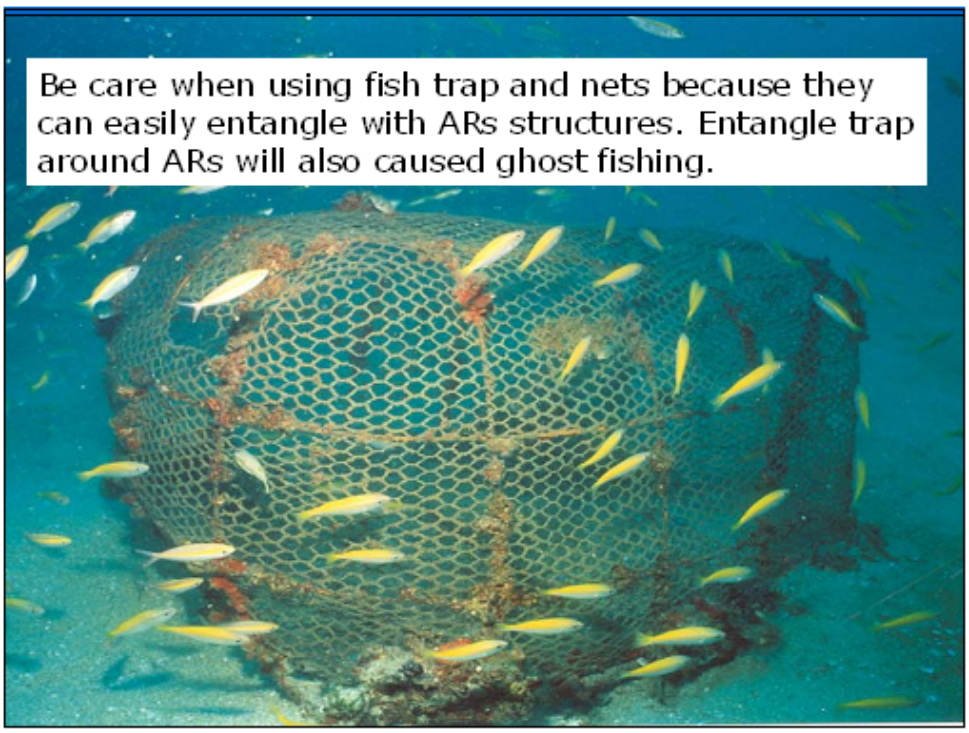

FISH SPECIES COMPOSITION

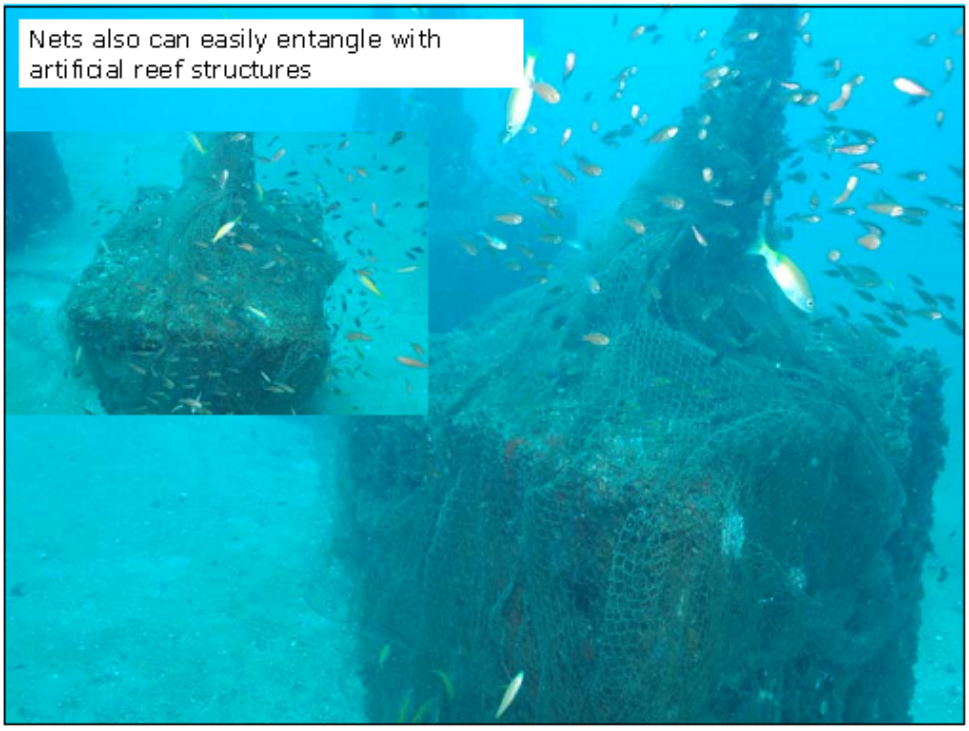

Preliminary baseline study on fish resources (commercial and non commercial species) should be carried out, prior to the establishment of the ARs. Such baseline studies could be carried out in conjunction with the surveys. The use of fish trap as well as hooks and lines could provide some preliminary indication of the fishery resources of the selected sites.

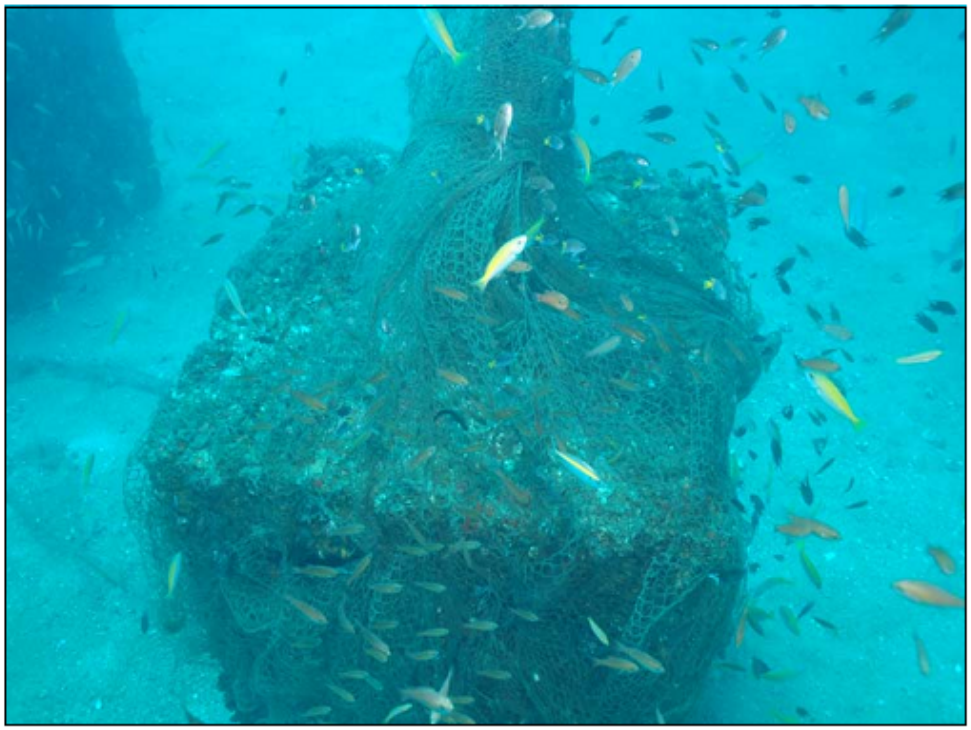

Information on the presence of different schools of fish attracted to the ARs could also be obtained from scuba diving, video recording and underwater photographic. These observations were especially useful in supplementing the catch data to provide some estimate of fish abundance. They also help indicate the presence of other species of fish not represented in the catch.

Observation by fishfinder or echo-sounder also provides information of the fish around the ARs but not to the species level. Fish species observed by underwater visual observation should be listed during each diving activities. Nights diving also recommended in order to getting more diversify information on fish species.

The best methods to collect information on species composition on commercial species around ARS are hand lines, squid jigging and trolling.


Be care when using fish trap and nets because they can easily entangle with ARs structures. Entangle trap around ARs will also caused ghost fishing.


Nets also can easily entangle with artificial reef structures



- Sampling activities could be applied during day and night time. Sampling should be conducted monthly in order to get better information. Data on the catches, strikes, and efforts should be collected. Fish caught must be recorded according to the species, weight and number. The length, weight also must be recorded.

Benthic Community

Benthic community especially macrofauna is considered to be affected by the installation of the ARs, and it is considered to play an important role in the ecosystem. Normally the density of benthic macrofauna is higher inside the ARs area than outside.

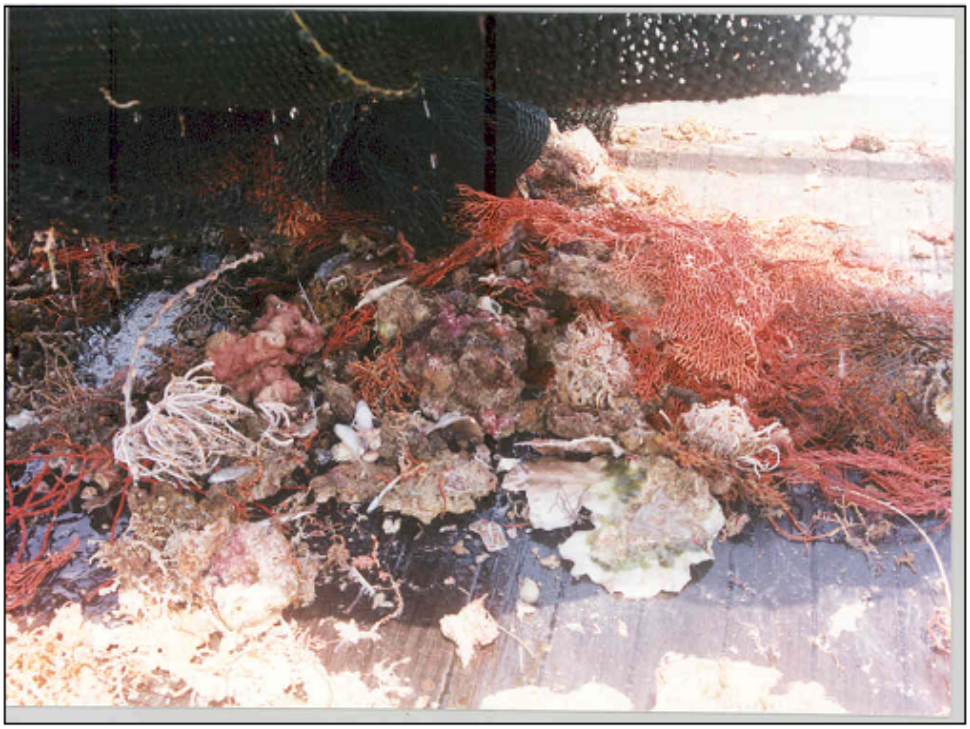
Sediment sample for benthic macrofauna can be collected by using grab sampler. Specimen than identify into taxonomic group at least at family level to obtain information on species composition, density and community characteristic. The Species Evenness Index (J) and Diversity Index (H) could be used to measure species diversity and richness. This information could be conducted prior to the deployment of ARs and every 6 month to one year basis after the depyoyment.

Fish Larvae

The present of multispecies fish as well as their larvae around the ARs proved that this structure has turned into new habitats that resemble natural habitat for several demersal fish species as well as sanctuaries and nursery for fish and other marine life. Information on the presence of different fish larvae species attracted to the ARs could be obtained by using bongo net. This information could be conducted prior and after the deployment of ARs.

Geological Information

It is very important to take sediment sample before any deployment of ARs. The particle size composition of the bottom under an ARs can play a vital role in the effectiveness of the artificial reef structures. Sediment particles are divided into several different size ranges based on their average diameter. In general a bottom composed largely of all sand size particles would be suitable for artificial reef site while bottom composed of unconsolidated clay size particles would not support even low density reef materials.



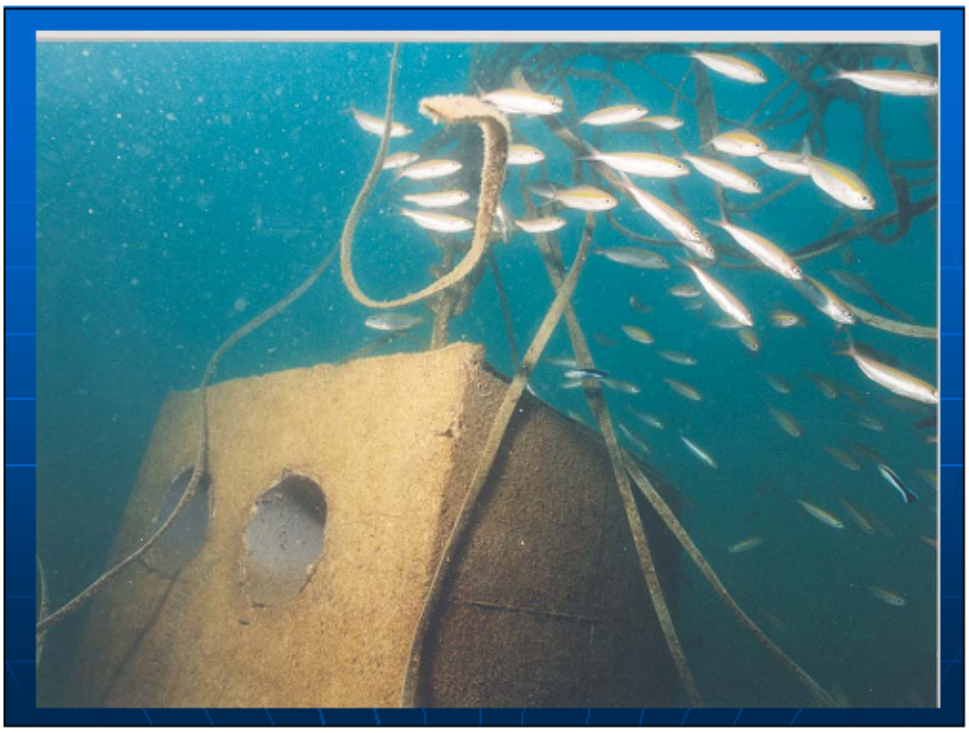
Oceanographical Information

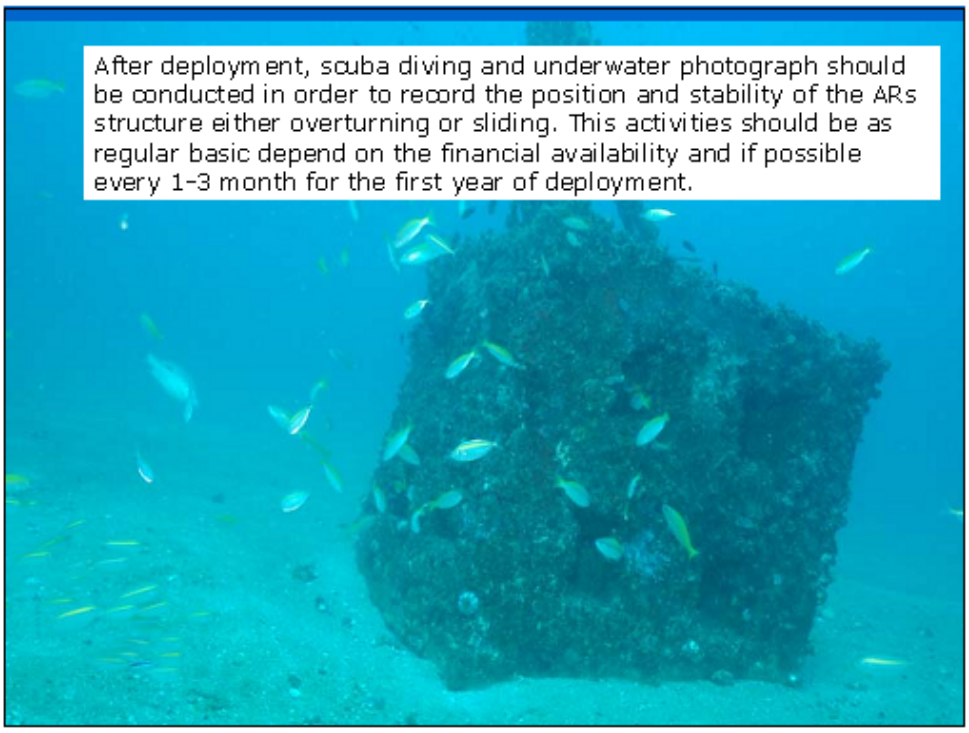
The most important oceanographical data are current. These data should be collected over a long period in order to understand the changing of wave and current speed as well as their direction. Other information those should be collected included, plankton diversity, salinity, suspended solids and temperature. While sediment traps could be used to determine the level of sedimentation at the artificial reef sites.

Engineering Information

Stability of ARs Structures

When considering the design of ARs, the simpler shape is better. Another factors are the stability of the modules again the wave action and current.




After deployment, scuba diving and underwater photograph should be conducted in order to record the position and stability of the ARs structure either overturning or sliding. This activities should be as regular basic depend on the financial availability and if possible every 1-3 month for the first year of deployment.

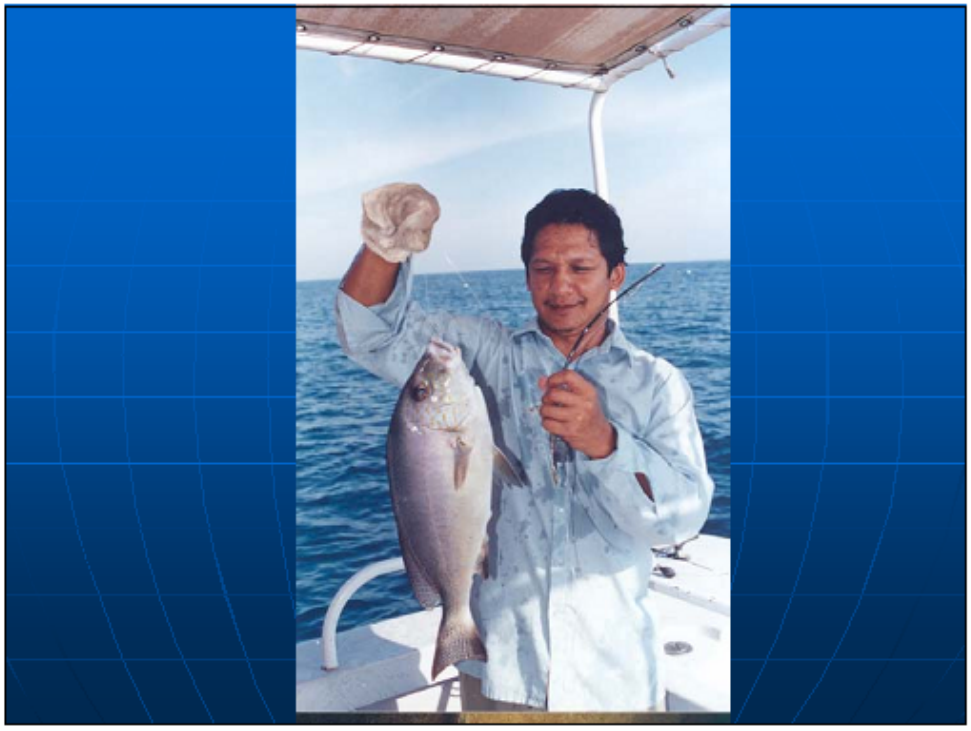

Socio-Economic Information
•Catch and Effort Data
•Economic Data
•Market
•Social
•ARs Usage

CATCH AND EFFORT DATA

It will be impossible to collect data on every fish caught by every boat, but the information collection programme should be design to obtain representative samples so that information for the multiplying up the data gathered. A representative number of fishing vessel should be sampled from time to time and following data recorded for each fishing trip:

- Fishing area or ARs location
- Fishing method used
- Time spend using each method
- Total number and weight of each species caught by each fishing method

It is valuable to measure the individual lengths and weights of representative samples of fish caught. This will allow investigation of changes in the nature of the fish resource itself over time, and will be especially valuable in the distant future when questions of resource over-exploitation may arise.



In addition to the catch and effort data, sampling of fishing vessel should also include gathering of the following set of economic data:

- Length of fishing trip
- Cost of fuel, bait, ice and other expendable items used during the trip
- Price for each different species

Comparison of these data with information obtained before the ARs were deployed makes it possible to assess of the real economic impact of the ARs.

MARKET

As well as gathering economic data from fishermen, it is important to obtain similar information from as wide a variety of retail and wholesale market outlets as possible. These include the level of demand for fresh fish in local, urban and rural area. There are usually local preferences for certain species of fish. In some area, certain species are not familiar with locals and they fetch lower prices, while in the other areas the opposite is the case.

Social

Social information is not as amenable to quantitative sampling than catch-and- effort and market data. However it should be possible to obtain qualitative information on the social impacts of an ARs programme through communication with ARs users.

ARs may change the way fishermen organize their time. Fisher can target particular fishing areas and organize their day fishing trip to the ARs, rather than searching open water for fish and having less chance of making good catches. This may allow them to spend more time on other economic or subsistence activities or to have more leisure or family time.

One important potential impact is the creation of new activity such as recreational fishing. In particular, fishers are likely to use their facilities to organize fishing trip to family member, friend or anglers as part-time job.

ARs Usage

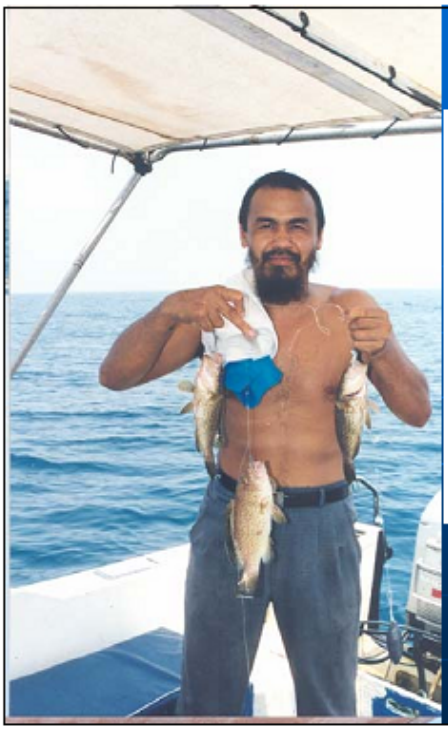
If the ARs were deployed To create a new demersal fishery or enhance an existing one, an estimate of the numbers of traditional fishers using ARs should be made.

If the intention of deploying ARs was to reduce pressure on the coastal fishery, it is important to find out whether inshore fishers have switched to use ARs and also the number of recreational fishing are making use of them. Information on the numbers and types of fishers using an ARs, and the reasons why they enter and leave the fishery, will allow planning for new ARs deployment, and the avoidance of conflicts between users if overcrowding appears to be a problem.

Alternatively, if the fishers are not fishing at ARs as much expected, it is important to discover why. The ARs may be not aggregating good quantities of commercial species, in which case the only real solution is to look for more productive sites.

CONCLUSION

- Investment in ARs programme, like any investment, contains an element of risk.
- When ARs deployment have considered as an *ad hoc* fisheries development tool, with little considering being given to the wider context (socio-economic, biology, geology, oceanographic etc), conflict, useless, unproductive, and wasted funding have often been the final outcome.
- The benefit of the ARs programme can be maximized, the cost minimized and the risks of failure reduce by proper planning, good management, consistent and adequate in monitoring and evaluating



GRACIAS

AND

HAPPY FISHING

FISH VISUAL CENSUS TECHIQUE - AN ALTERNATIVE METHOD FOR THE ASSENMENT OF FISH ASSEMBLAGES ON ARTIFICIAL REEFS

Ukkrit Satapoomin

Fish visual census technique – an alternative method for the assessment of fish assemblages on artificial reefs

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■ BACKGROUND

Artificial reefs (ARs) have been used as part of coastal zone management or in fishery management to provide new habitats (that increase number and biomass of fishery resources), to restore habitats, to protect sensitive area (such as spawning and nursery grounds), to protect biodiversity, to reduce fishing pressure in certain areas, to reduce fishery conflicts, e.g., by limiting trawling in nearshore areas where commercial trawling completes with artisanal fishermen, and also to support recreational uses, e.g., recreational fishing, diving, and tourism (Bohnsack and Sutherland, 1985; White et al., 1990; Seaman and Jensen, 2000). Particularly in Southeast Asian countries where coastal marine resources have been heavily exploited (Pauly and Chua, 1988), ARs have become a popular resource enhancement technique (White et al., 1990). In most countries, AR construction is supported and sponsored largely by government.

In Thailand, ARs have been in use since 1978 as part of a marine conservation program of the Department of Fisheries (Boonkird, 1984; Boonprakob, 1986). ARs have been installed in many places both in the Gulf of Thailand and the Andaman Sea (Sinanuwong et al., 1986; Awaiwanont, 1991). The plan for construction and installation of ARs is still kept going on. Although without sufficient scientific evaluation for the effectiveness of ARs installed so far since the past 25 years, local communities, especially fisher-folk, still appreciate the AR construction plan. They have positive attitude to the effect of AR against the degradation of coastal resources, in particular by preventing destructive fishing gears like push nets and trawlers - on one extreme in their opinion, AR is the ultimate tool. More ARs are continuously proposed by local fishermen through local governmental organizations. Their requests always attract political concerns. This (political influence) is why AR installation plan is easily adopted as a national policy.

From scientific stand point, there have been serious criticisms over failure or success of AR construction program worldwide. Bohnsack and Sutherland (1985), for example, warned that: “Perhaps too much effort has been expended in building ARs and not enough in research….not all ARs have increased fish harvest or productivity. In many areas, managers have the mistaken belief that they can proceed with large-scale programs without research.” There are also several other serious critics, but very useful for further consideration:

- The present state of knowledge can not as yet give a clear understanding of AR biological and ecological functions (White et al., 1990).
- Lack of knowledge concerning ecology of ARs is a central problem in the debate on their proper use in fishery management (Bohnsack et al., 1991).
- Inadequate long-term monitoring of ARs precluded explanation of their functions and inevitably results in an inability to evaluate the degree to which the habitat meets its original objectives (Seaman and Sprague, 1991).

Evaluation schemes for AR, spanning from biological to socioeconomic aspects, had been set up along with nearly all construction and installation programs in Thailand (Sinanuwong et al, 1986; Artificial Reefs Study Team, 1989; Boonchuwong, 1994) but most of the results are less substantive. Although limitations of budget and scientific personnel

were always claimed to be major problems, in my opinion inadequate sampling protocol as well as its associated methods for each evaluation scheme was the real problems. The limitations of sampling methodology remain a major obstacle to our understanding of AR ecology (Bohnsack and Sutherland, 1985). Fishes and fisheries within and around ARs are among the most important components for AR evaluation. However, there is still limited number of studies regarding biological and ecological impacts of ARs on associated fish populations. As pointed out by Polovina (1991), such limitation is certainly not due to a lack of interest but rather to the difficulty in collecting the appropriate data. Rather than criticizing the AR evaluation program (a tough job to touch), this article aim to recommend a useful methodology, visual census technique (VCT), which is applicable for studying fish populations or fish assemblages at artificial reefs. Some results of my previous studies applying VCTs at selected AR sites in Thailand are exemplified.

■ VISUAL CENSUS TECHNIQUES

AR assemblages are dynamic and respond to the same ecological factors (i.e., physical disturbances, recruitment, competition, and predation) that operate on natural reefs. Interestingly, much of what we know about natural reef ecology, particularly on the ecology of fishes, is based on experimental studies using artificial or manipulated habitats (e.g., Sale and Dybdahl, 1975, Ogden and Ebersole, 1981, Bohnsack, 1983, Walsh, 1985, Caley, 1995, and Kawasaki et al., 2003). To date, fish visual census technique is widely used for studying fish assemblages on natural coral reefs (e.g., Williams, 1982, Alevizon et al., 1985, and Letourneur, 1996) as well as other subtidal habitats such as rocky reefs (e.g., Berry et al., 1982 and Tuya et al., 2004) and macrophytic communities (e.g., Nakamura and Sano, 2004). The techniques can also be applicable in ecological study of fishes at ARs. There is a variety of sampling performances for the so called VCT which have been described in details elsewhere (e.g., Bortone and Kimmel, 1991, Halford and Thompson, 1994, Cappo and Brown, 1996, English et al., 1997, and Hill and Wilkinson, 2004). In this regard, only brief description is provided here.

***VCT – with predetermined area or belt transect*:**

For the case of predetermined area, sampling area will be defined in the first place, usually as experimental plots, grids, or permanent quadrats. Fishes in each sampling area will be censused (i.e., each individual species is identified and counted) within a fixed period of time. For the case of belt transect, transect line has usually been used as a leading line or a reference for the exact length of the censused area. Transect lines will be laid down first then one or a pair of observers census fishes within a restricted length either side of (as belt or strip) and above transect. Number of transects (as sampling replicates), length of each transect, and width can be adjustable according to situations and purposes. Narrower width (e.g., 5m [2.5 m either side]) is applied in low visibility condition. The width (1 m either side) is recommended for studying juvenile-fish recruitment. The number of replicate transects must be determined on the basis of statistical approach, i.e., as to represent fish populations in the area. Duration of observation for each belt-transect must be standardized in order to minimize observer's bias. For working in an area with heterogeneous bottom topography, such as coral reefs, observer has to swim in a zigzag fashion in order to increase ability to detect fishes within the observed area.

***VCT – timed swim (species-time random count)*:**

For this technique, observer swims haphazardly and records fishes in a field of vision (sighting range) within a set time. Usually, this technique increases a chance to recount the same individuals, hence increasing observation error. Particularly in coral reef area where physiographic zones (each with unique assemblage of associated fishes) are pronounced, haphazard swimming path must be avoided, unless zonation of assemblages is

not a matter for consideration. If mixing up of species assemblages from different zones is preferably avoided, observer should restrict the sighting range to certain depth contour or just keep the swimming path in a specific zone. Although swimming time is fixed, swimming performance (i.e., speed) must also be standardized as to ensure comparable observed distance or area among sampling sites.

***VCT – point count*:** Observer will count the fishes within a confined area, either as circular shape or square. From the first sampling point, observer goes to the next randomly. Taking a fixed number of fin-kicks from one point to another is a good practice. For this technique, a reference line (measure tape or rope) can be used to determine the radius (in case of circular area) or the length (in case of square area) of observed field at each sampling point.

***Data achievable*:**
Basic information to be achieved from VCT includes:

- Species composition and richness.
- Species diversity index (by applying appropriate formulae).
- Quantitative abundance data (by counting actual number of individuals present).
- Semi-quantitative abundance data (by using rank or scale for enumeration).
- Size and/or biomass (size is first estimated as length and later converted into weight (biomass) using the data from studies on length-weight relationships.

Note that for enumeration, if possible, counting actual number of individuals present is recommended. The data can then be used for parametric statistic, which is the most powerful testing. However, the way to overcome errors or biases while counting supra-abundant or schooling species is just to use abundance scale – no other good choice. An example of log 4 abundance categories is shown in Table 1. If the most dominant species in the observed area in certain habitat is not more than the magnitude of thousand, log 3 scale can be applicable. The mid-point value of each category is used to represent the best estimate for number of individuals. Except for the two highest categories, the lower quartile of each category is used as to avoid overestimation. Log abundance scale is actually developed by statistic thinking – normally before any statistical analysis, raw data is usually normalized by applying logarithmic transformation.

Table 1. Logarithmic abundance categories used in estimates of abundance of fish species.

Log 4 abundance category	Number of fishes	Estimate value for enumeration
1	1	1
2	2-4	3
3	4-16	10
4	17-64	40
5	65-256	160
6	257-1,024	640
7	1,025-4,096	1,025
8	4,097-16,384	4,097

***Advantages of the VCT*:**

- It is rapid.
- It is flexible and can be adapted to a variety of different situations, purposes, and habitats.
- It is less selective when compared to most other sampling methods.
- It is nondestructive (for both habitats and associated fauna) and can be used to resurvey the same area through time, i.e., monitoring purpose.
- It is inexpensive, requiring no sophisticated equipment.
- It utilizes a minimum of personnel.
- It has the potential to produce large databases rapidly.

***Disadvantages of VCT*:**

- Observers must be well-trained and experienced.
- Observers' errors and biases occur in estimating numbers and sizes.
- There is low statistical power to detect change in rare species.

- The use of abundance categories reduces the power to detect small changes.
- It is not applicable for censusing small and cryptic or secretive species.
- Fish may be attracted towards or dispersed away from observer.
- Inadequate visibility limits the use of this technique.
- Strong surges, waves, and current can prevent diver surveys.
- The technique is restricted to shallow depths due to decompression constraints.

Case study 1: Ranong Artificial Reefs

Investigation of fish assemblages at AR in Ranong Province, Anadaman Sea, was carried out in early 1992, about 3 years after installation (Satapoomin, 1994). This AR is one among many AR sites of the past extensive AR installation program conducted by the Department of Fisheries. The Ranong AR was a typical heterotrophic community (Fig. 1) with a variety of invertebrate taxa flourishing on the surfaces of AR structures (Phongsuwan et al., 1994). The objectives were to provide general description of fish assemblages at the AR and also to compare the pattern of fish assemblages at the AR to nearby natural subtidal habitats including coral reef and rocky reef. VCT incorporating belt transect (10 x 50 m) is used. Two replicates of belt transect were used at each habitat type in each sampling occasion. Three successive surveys were conducted in February 1992, December 1992, and April 1993, respectively. Log4 abundance category was applied for abundance estimate of fishes in the censused area. In addition, underwater observation outside the censused area was also made in order to detect as much species as possible.

Figure 1. Fouling community on the structures (made of 2x2x2 m open concrete cubes) of AR in Ranong Province about 3 years after installation.

General description of fish assemblages:

The Ranong AR was effective in attracting and holding fishes; 101 species in 42 families being encountered. Typical assemblages of fishes at the AR were classified into 5 groups with respect to the patterns of habitat utilization and/or association of fishes in the area (Fig. 2).

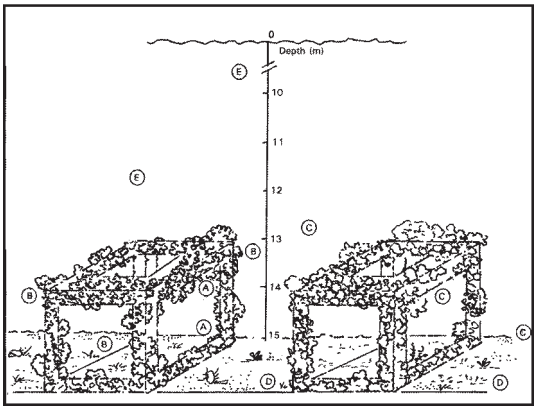

Figure 2. Typical assemblage (groups A-E) of fishes at Ranong AR.

- Type A fish (15% of total species recorded) preferred physical contact with reef, and occupied hole, crevices and complex surfaces. They were several benthic dwellers, such as groupers (*Cephalopholis* spp. and *Epinephelus* spp.), dottybacks (*Pseudochromis* sp.), blennies (*Ecsenius bicolor*), and lionfishes (*Pterois miles*, *Dendrochirus zebra* and *Scorpaenopsis* sp.)

- Type B fish (20%) usually swam close to the modules and also occupied complex surfaces as shelter. They included members of such families as Pomacentridae, Apogonidae, Diodontidae, Monacanthidae, Ostraciidae, Tetraodontidae and also certain blennid (*Plagiotremus rhinorhynchos*).
- Type C fish (28%) preferred to swim through and around the modules while remaining near the bottom or up to a meter above the modules. They included snappers (Lutjanidae), sweetlips (Haemulidae), wrasses (Labridae), parrotfishes (Scaridae), rabbitfishes (Siganidae), butterflyfishes (Chaetodontidae), angelfishes (Pomacanthidae), triggerfishes (Balistidae), surgeonfishes (Acanthuridae), and moorish idol (*Zanclus cornutus*).
- Type D fish (22%) preferred to orientate themselves close to the bottom, sometimes moving around the base of modules or extending their range over the open sand substrate within the reef. They included goatfishes (Mullidae), monocle breams (*Scolopsis* spp.), emperors (*Lethrinus* spp.), sandperch (*Parapercis punctata*), lizardfish (*Synodus* sp.), cobia (*Rachy centron canadum*), spotted sicklefish (*Deprane punctatus*), pipefish (*Trachy rhamphus bicoarctatus*), flutmouth (*Fistularia petimba*), whiting (*Sillago sihama*), dragonets (*Callionymus* sp.) and blue-spotted stingray (*Dasyatis kuhlii*). There were also some cryptic and burrowing species (e.g., gobies and moray eels).
- Type E fish (15%) tended to hover above the reef while remaining in the middle and upper part of water column. They were mainly pelagic species which usually form schools. These included fusiliers (Caesionidae), jacks and trevallies (Carangidae), batfish (*Platax teira*), baracudas (*Sphyraena* spp.), anchoby (*Stolephorus* sp.), halfbeaks (*Hemiramphus* sp.), suckerfish (*Echenius naucrates*), and eagle ray (*Aetobatus narinari*).

***Habitats comparison*:**

The survey results applying VCT at artificial reef (AR), natural coral reef (CR) and rocky reefs (RK) in Ranong are presented in Table 2. The total population density and species richness of fishes were highest at CR, whereas AR had the lowest values. The population of economically important (target) fish, in terms of both species richness and density, found at the CR and RK were also comparatively higher than those at AR. However, in terms of relative density, the target fishes contributed 57% and 47% of the total fish at the RK and AR, respectively. Only 20% of the total fish were target species at the CR.

Ranking the ten most common fish families showed a general pattern of similarity in the composition of fishes at CR and RK, as compared to the AR (Table 3). The multivariate statistical procedures (cluster analysis and MDS) also showed a clear separation of fish assemblages among habitat types (Fig. 3). CR and RK had much more similarity of fish assemblages, as compared to AR. Several most common species shared among the three habitats included some damselfishes (*Neopomacentrus azysron*, *N. cyanomos*, and *Pomacentrus similis*) and a wrasse species (*Thalassoma lunare*). Fishes dominantly found on CR and RK but were either less represented or absent from the AR including certain fusiliers (*Pterocaesio chrysozona* and *Caesio caerulaurea*), butterflyfish (*Chaetodon octofasciatus*), and several damselfishes (*Chromis cinerascens*, *Pomacentrus moluccensis*, *Amphiprion ocellaris* and *A. akallopisos*). Fishes those were common and exclusively found (so called as characteristic or conspicuous species) on CR were certain damselfishes (*Neopomacentrus anabatoides*, *Abudefduf vaigeinsis*, and *Pomacentrus adelus*). The characteristic or conspicuous fish species at the AR included certain dottyback (*Pseudochromis* sp.), bannerfish (*Heniochus acuminatus*), angelfish (*Pomacanthus annularis*), and sandperch (*Parapercis punctata*). Some fishes are commonly found at both AR and RK but less represented on CR. These included certain monocle bream (*Scolopsis vosmeri*), snapper (*Lutjanus vitta*), wrasse (*Halichoeres nigrescens*), and rabbitfishes (*Siganus javus* and *S. canaliculatus*).

Table 2. Summary of parameters from the census data obtained during the three surveys (I: February 1992; II: December 1992; III: April 2003) at each habitat type (AR: artificial reef; CR: coral reef; RK: rocky reef). Values in parentheses are the total number of records.

Parameter	AR				CR				RK			
	I	II	III	Avg.	I	II	III	Avg.	I	II	III	Avg.
Total number of species/1,000 m^2	38	34	51	41	63	70	63	65	-	62	53	57
	(46)	(60)	(86)	(64)	(68)	(80)	(89)	(79)	-	(67)	(60)	(63)
Total number of fish/1,000 m^2	1805	1849	3158	2271	5172	6584	4454	5403	-	3787	2870	3328
Number of target species/1,000 m^2	14	12	11	12	16	15	17	16	-	20	15	17
	(19)	(28)	(29)	(25)	(16)	(18)	(24)	(19)	-	(20)	(17)	(18)
Number of target fish/1,000 m^2	1282	928	1008	1073	359	1904	1017	1093	-	2194	1615	1904

Table 3. The 10 most speciose families of fish fauna observed at artificial reef (AR), natural coral reef (CR), and rocky reef (RK) in Ranong Province.

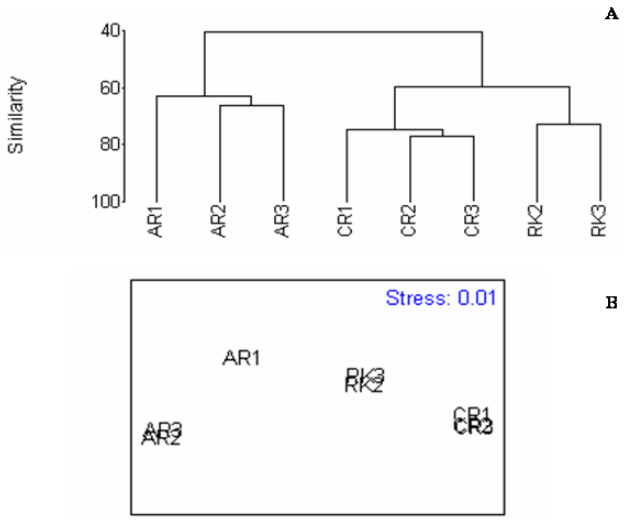

Figure 3. Dendrogram (A) and MDS ordination (B) from Bray-Curtis similarity matrix of species abundance data obtained from three successive surveys at artificial reef (AR1-AR3), natural coral reef (CR1-CR3), and rocky reef (RK1-RK3) in Ranong Province.

Case study 2: Small AR structures deployed in natural coral reef

This case study was part of the coral reef rehabilitation project initiated in 1994 by the Phuket Marine Biological Center (Satapoomin, 2002). Coral reef on the northeast coast of Maithon Island was selected to test the success of coral reef rehabilitation by a provision of artificial substrate specifically in the area where natural substrates were not suitable for settlement and colonization of coral larvae. This reef was damaged by storm in 1986 and unconsolidated substrate remains (mainly *Acropora* fragments) prevented recovery of the reef through natural recruitment of coral larvae. Three different complexities of concrete modules (Fig. 4) were used to test their relative effectiveness in enhancing natural recruitment of corals (Thogtham and Chansang, 1999). For each type of the modules, three 5x5 m plots were manipulated on open sand/coral fragment sea floor within the reef. In each plot, 25 modules of the same type were installed. Another 3 (5x5 m each) plots assigned in the area with 10-20% live coral cover were treated as control. Fish abundances in all experiment plots were periodically monitored applying VCT (adopting an actual count for the number of individuals with a fixed 5-minute census) in 4 sampling occasions, including the first sampling in August 1994 (as T0), about one month before placement of the concrete modules, and the other three subsequent samplings at the fourth (T4), nineteenth (T19), and eighty-fifth (T85) months after placement of the modules.

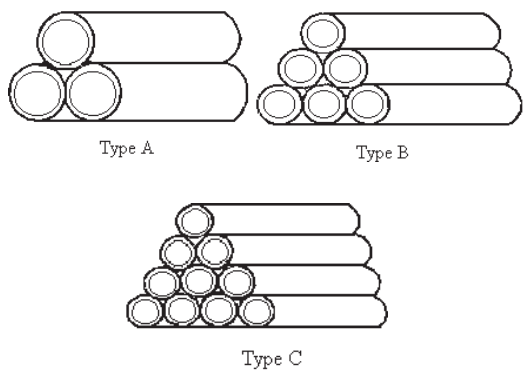

Figure 4. Tree types of concrete modules used for coral reef rehabilitation project at Maithon Island. The dimension at base and the height of each module is 0.5x0.x0.5 m.

Early colonization of fishes, in terms of both numbers of species and individuals, in all manipulated plots was rapid being contributed largely by immigration of fishes from nearby coral patches in the reef. Most parameters measured at T4 of all types of the modules were significantly greater compared to T0, but not with the following samplings, T19 and T85 (Figs. 5-7). Fish assemblages did not differ among the plot types of different concrete modules, but they were distinguishable over time (Fig. 8). At T0, before placement of the modules into the assigned plots, the unique assemblage of fishes on the open sea floor with coral fragments and sand included certain damselfish (*Pomacentus chrysurus*) and some wrasses (*Coris batuensis*, *Halichoeres hortulanus* and *Thalssoma lunare*). First colonization (T4) and early establishment of the assemblages (T19) of fishes on those manipulated plots lacked uniqueness because of variation in the composition of assembled species. Although their occurrence and abundance were uneven among plots, fishes those became much more obvious at T4 and T19 assessments including some damselfishes (*Pomacentrus adelus*, *P. similis* and *Chromis weberi*), wrasses (*Halichoeres timorensis*, *H. vrolikii* and *Stethojulis interrupta*), monocle bream (*Scolopsis bilineatus*), goatfish (*Parupeneus macronema*), and sandperch (*Parapercis clathrata*). At T85, there was a similarity in the composition of fishes among all experiment plots, including the controls. This also suggested that fish assemblages in the manipulated plots become much more similar to that of natural coral reef in the area. Conspicuous fish populations in the plots included certain damselfishes (*Pomacentrus adelus*, *P. chrysurus*, and *P. moluccensis*), wrasses (*Halichoeres hortulanus*, *H. vrolikii* and *Thalassoma lunare*), parrotfishes (*Scarus quoyi* and *Chlorurus sordidus*), butterflyfish (*Chaetodon trifasciatus*), morrish idol (*Zanclus cornutus*), and grouper (*Cephalopholis polyspila*). The development of fish assemblages seems to relate to habitat-use patterns of fishes which also coincides with he establishment and development of fouling

community, particularly corals, on the concrete structure (Fig. 9). Along with such development, the manipulated area has either increased in or diversified both food resources and microhabitats (for fishes) and both of which can play a key function in regulating fish assemblages in the area. Figures 10 and 11 exemplified the establishments of two populations of damselfishes (*P. adelus* and *P. moluccensis*) in the manipulated plots. Marked increasing in their population densities notably at the time of 103 months (about 8.5 years) after installation seems to relate to a well development of coral community in the plots. Particularly for *P. moluccensis*, the fish has a strong habitat preference for corymbose or digitate *Acropora* colonies.

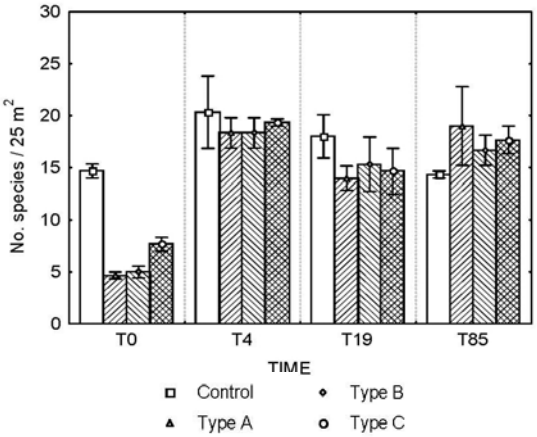

Figure 5. Total number of fish species (mean ± SD) in each experiment plot at four sampling times (T0-T85).

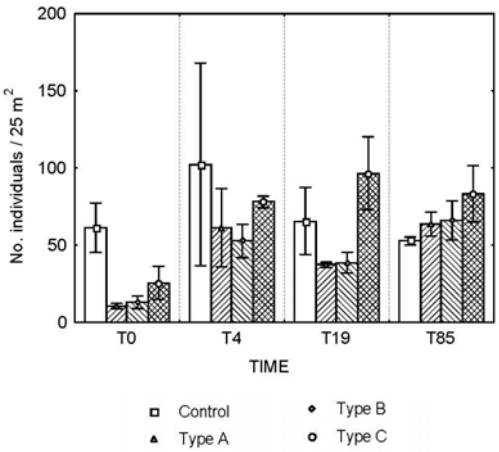

Figure 6. Abundance of fishes (mean ± SD) in each experiment plot at four sampling times (T0-T85).

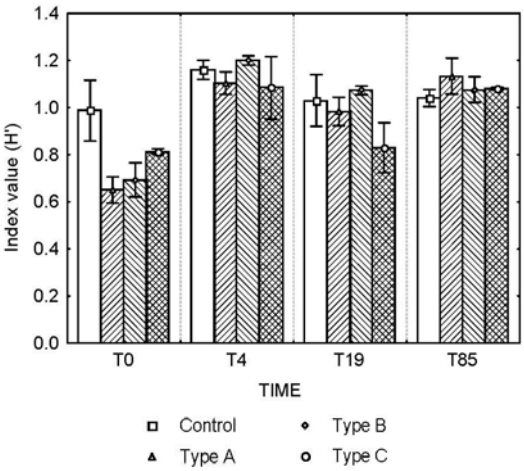

Figure 7. Species diversity, Shannon-Weaver index (mean ± SD) in each experiment plot at four sampling times (T0-T85).

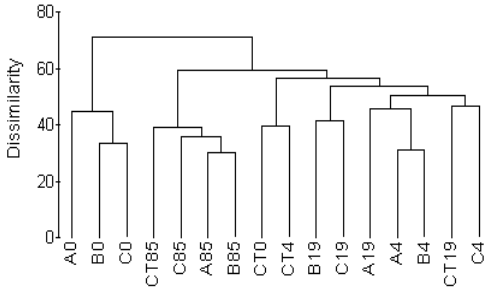

Figure 8. Dendrogram from Bray-Curtis dissimilarity matrix of logarithmic (log (n + 1)) transformed species abundance data obtained from four types of experiment plots (CT, A, B, and C) at four successive samplings (0, 4, 19, and 85).

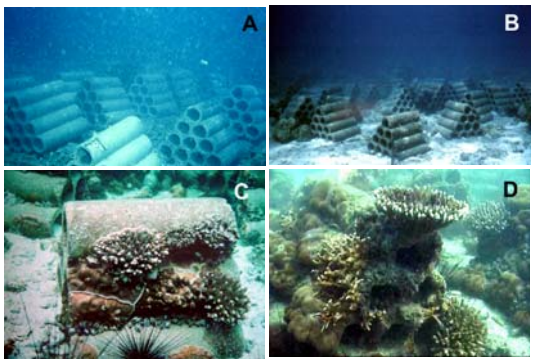

Figure 9. Subsequent changes and development of coral communities in selected manipulated plots from the project site at Maithon Island: (A) one month; (B) 19 months; (C) 85 months; and (D) 96 months after installation of the modules.

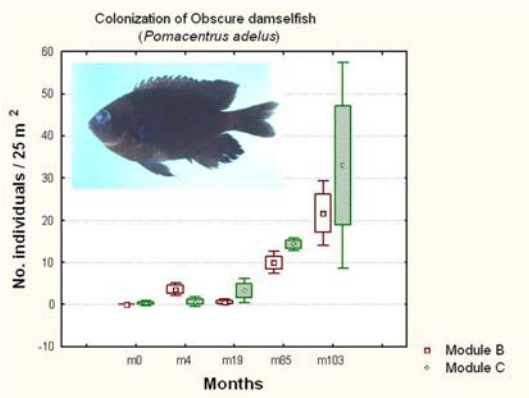

Figure 10. Changes in population densities of Obscure damselfish (*Pomacentrus adelus*) in the manipulated plot types B and C from the month 0 to 103.

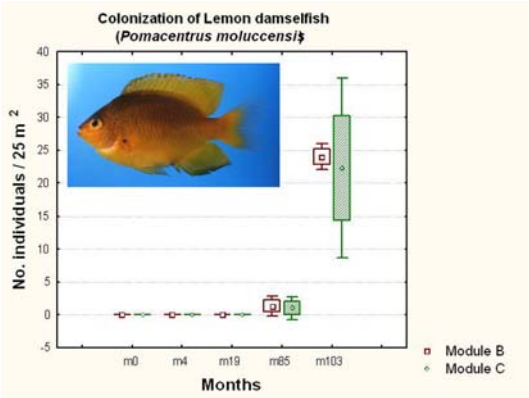

Figure 11. Changes in population densities of Lemon damselfish (*Pomacentrus moluccensis*) in the manipulated plot types B and C from the month 0 to 103.

Case study 3: Railroad goods-van AR in Pattani Province

AR construction program in Pattani and Narathiwat Provinces, southern part of the Gulf of Thailand, was established as part of the Coastal Resource Rehabilitation Project. The project was actually conceived as a result of Her Majesty's attention over the plight and hardships of local fishermen due to the decline in coastal marine resources in the areas. Various governmental agencies have cooperated in this royal project. As for the first phase of AR construction program, the Department of Highway and the State Railway of Thailand donated 707 concrete drainage pipes and 208 ex-railroad goods-vans, respectively, to be used as AR structures. The Department of Fisheries is the agency in charge of installation program. Installation of the goods-van AR took place in April 2002. All goods-vans were installed along the coast off Saiburi District, Pattani Province, 11-12 km offshore, at the depth of 26-30 m, arranged in five groups of about 2-4 km apart, and each group consisting of 41-42 goods-vans. A quick assessment of the AR condition was done in May 2003, one year after installation. VCT incorporating belt transect (10 x 30 m) is used and log 4 abundance scale was applied for abundance estimate of fishes. With a restriction to the period of 2-day survey trip, only 2 out of 5 AR sites (= groups) were assessed and only one belt-transect is possible at each site due to a decompression constraint at the depth of 105 feet where the goods-vans had been found. In order to avoid a dive-decompression practice, only 15 minutes were spent for underwater observation at each site.

Flourishing sessile organisms on the AR structures within one year after installation (Fig. 12) suggests that colonization as well as succession processes were very fast. In all, 27 species representing 17 families of fishes were found. Species richness and abundance of fishes in the area were 19-22 species/300 m^2 and 1,207-1,739 individuals/300 m^2, respectively. Orientation of fishes in relation to the goods-van structures were simply classified and depicted in Figure 13. The criteria of this classification were the same as those used for Ranong AR (case study 1), except for type A which is an inclusion of types A and B of the case study 1.

- Type A fish used the AR structures as refuges or microhabitats. They accounted for 33% and 23% in terms of relative numbers of species and individuals, respectively. These included certain damselfishes (*Neopomacentrus cyanomos* and *N. bankieri*), groupers (*Cephalopholis boenak*, *Epinephelus*

bleekeri and *E. coioides*), squirrelfish (*Sargocentron rubrum*), lionfish (*Pterois russelli*), and bamboo shark (*Chiloscyllium punctatum*), puffers (*Arothron stellatus*) and boxfish (*Ostracion cubicus*). Among these *N. cyanomos* was the most abundant species.

- Type B fish had lesser dependent, as compared to A, on the AR structures as refuges or habitat. However, they were mainly invertebrate feeders which tend to dependent on AR structures as the source of foods. This group had the most diverse number of species (41%), but relatively low in number of individuals (4%). These included several common fishes, such as sweetlips (*Diagramma pictum*), wrasses (*Labroides dimidiatus* and *Leptojulis cyanopleura*), snappers (*Lutjanus russelli* and *L. vitta*), rabbitfishes (*Siganus canaliculatus* and *S. javus*), soapfish (*Diploprion bifasciatus*), and angelfish (*Pomacanthus annularis*).
- Type C fish preferred open sand area as for either habitat or foraging ground. This group had lowest contribution in terms of both numbers of species (11%) and individuals (1%). These included certain species of shrimp-goby (*Myersina crocatus*), sand perch (*Parapercis xanthozona*), and monocle bream (*Scolopsis vosmeri*).
- Type D fish was typical pelagic species. The group contributed the greatest in terms of number of individuals (72%), but only 15% for species composition. They were mainly schooling species, such as a snapper (*Lutjanus lutjanus*), fusiliers (*Caesio cuning* and *Pterocaesio chrysozona*), and trevally (*Selaroides leptolepis*). *Lutjanus lutjanus* was the most abundant species although the individuals were mainly found as juveniles or sub-adults.

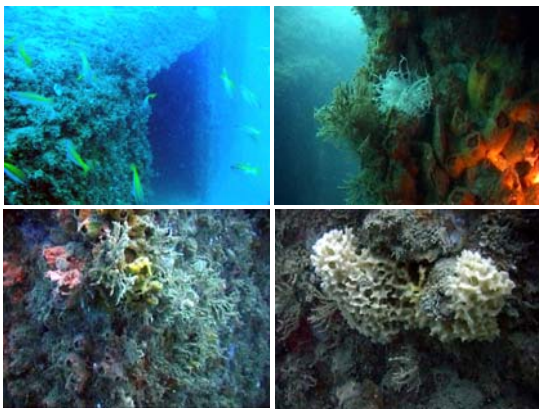

Figure 12. The condition of goods-van AR in one year after installation.

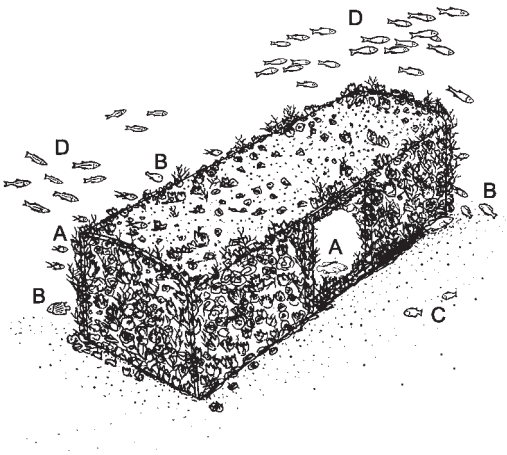

Figure 13. Typical assemblage of fishes (groups A-D) at the goods-van AR.

■ CONCLUDING REMARKS

Fisheris and stock assessment data are usually considered as useful parameters for evaluating the effectiveness of AR construction program. For earlier case studies in Thailand, the data regarding fish species composition, catch, and fishing efforts were either directly collected by researchers using various types of fishing gears (e.g., Yanagawa, 1989 and Aosomboon, 194) or indirectly obtained from fisheries-based operations conducted by local fishermen (e.g., Yonesaka,

1989 and Yodee, 1994). The latter is useful for socioeconomic evaluation (Yonesaka, 1989; Boonchuwong, 1994; Yodee, 1994) but seems to have limited use for evaluating biological or ecological impacts of the ARs. Most of the commonly used fishing gears for fish assessment in ARs (e.g., fish trap, hand line, bottom gillnet, trammel net, bottom longline, and bottom vertical longline) are highly selective for fish species and provide only qualitative species composition. Underwater observations applying sighting, taking picture, and recording VDO were also incorporated in certain AR evaluation programs (e.g., Sinanuwong et al., 1986 and Munprasit, 1989). Although these methods are less selective compared to those commonly used fishing gears, the data achieved and presented in those studies were non-quantitative.

As have been shown in the present case studies, VCT can give either semi-quantitative (case studies 1 and 3) or absolute values (case study 2) of fish abundances, depending on the choice of enumeration approach. VCT are easily modified to the special circumstances of the situation and also to the specific purpose of the study. However, care must be taken to assure that the sampling protocol is well-defined. For the case studies 1 and 3, none (single transect at each site) and inadequate (two transects at each site) replicates, respectively, can not permit reliable comparisons for the variables of interest using univariate statistic. Case study 3 shows the depth constraint for VCT. To get adequate transect replicates at such depth, much longer length of sampling period must be taken at each site. Case study 2 shows an importance of long-term study for an AR construction program. Changes in community organization of fish populations including influencing factors and processes involved over time are essential for AR evaluation as well as for an understanding of AR ecology. For monitoring purpose, sampling frequency is also needed special attention. Time frame and sampling frequency must be seriously designed on a systematic basis (i.e., with specific purposes or questions to be answered) rather than on a chance basis. Temporal basis for studies can be day to night, to account for diurnal-nocturnal changes of fish populations; one or a few months, for evaluation of tidal and lunar effects; several months in a year, to evaluate seasonal influences; or many years, to account for long-term changes. Although logistic constrains (i.e., availability of time, equipment, budget or man-power) are always the problems for any study program, these, on the other hand, are useful for researcher to postulate very specific objective(s) of study and also can be used as a factor to determine minimal but adequate number and frequency of samplings. It is highly recommended that VCT with well defined sampling protocol and strategy should be incorporated into any ongoing or future AR construction programs.

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INVESTIGATION ON BIOLOGICAL ASPECT

Hansa Chansang

Objectives for Artificial Reefs Construction

To promote economic development

- To enhance seafood production
- To enhance recreational activities

To enhance or manage living marine resources

- To protect marine resources
- To restore marine habitats

Evaluation of the Performance of Artificial Reefs for Various Purposes

- Commercial fishing
- Artisanal fishing
- Sport fishing
- Habitat restoration
- Recreational diving
- Submarine tour operator
- Prevention of illegal fishing

Biological Evaluation of Artifical Reefs (AR)

- **Objective:** To assess the productivity and biological process of AR

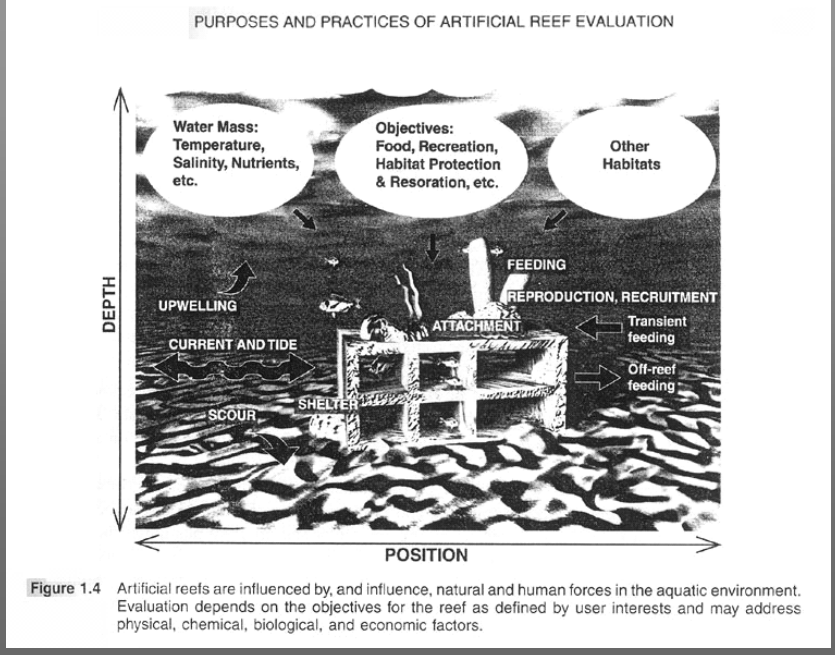


Figure 1.4 Artificial reefs are influenced by, and influence, natural and human forces in the aquatic environment. Evaluation depends on the objectives for the reef as defined by user interests and may address physical, chemical, biological, and economic factors.

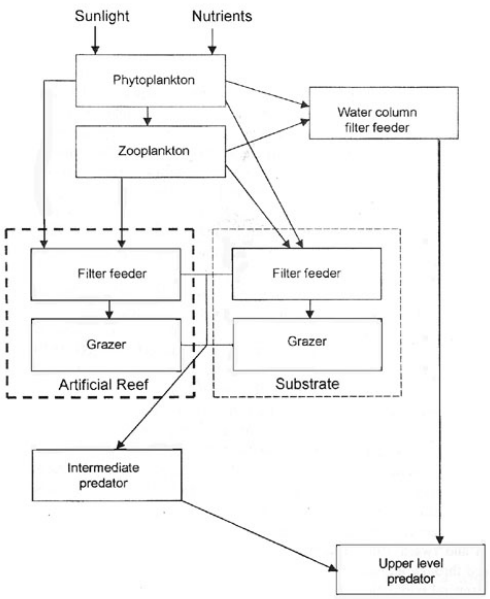
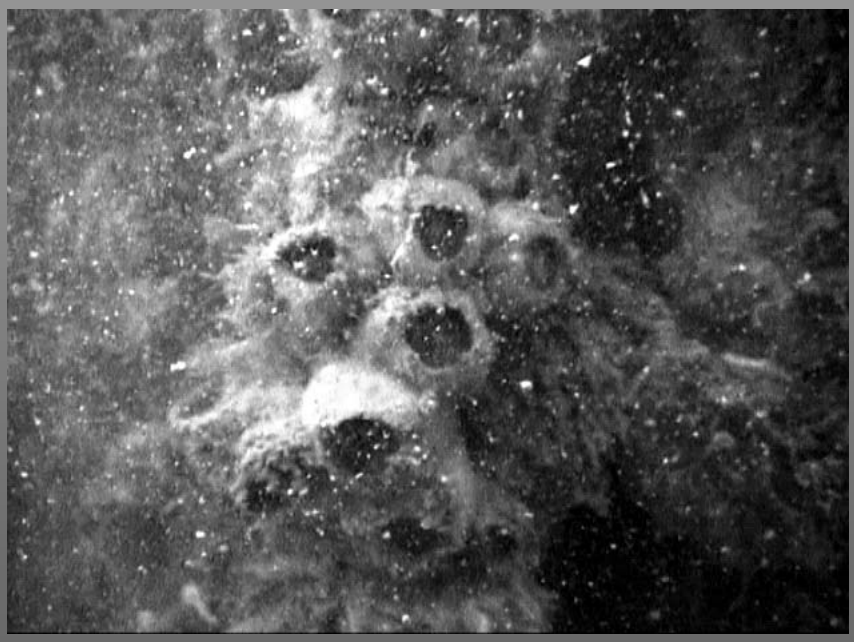
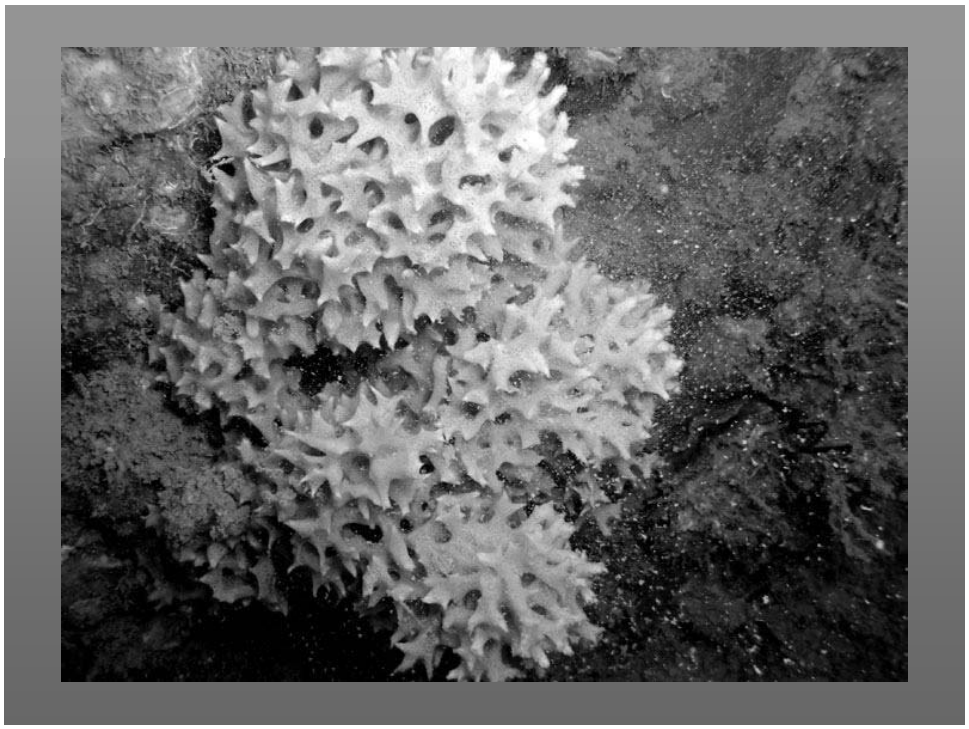


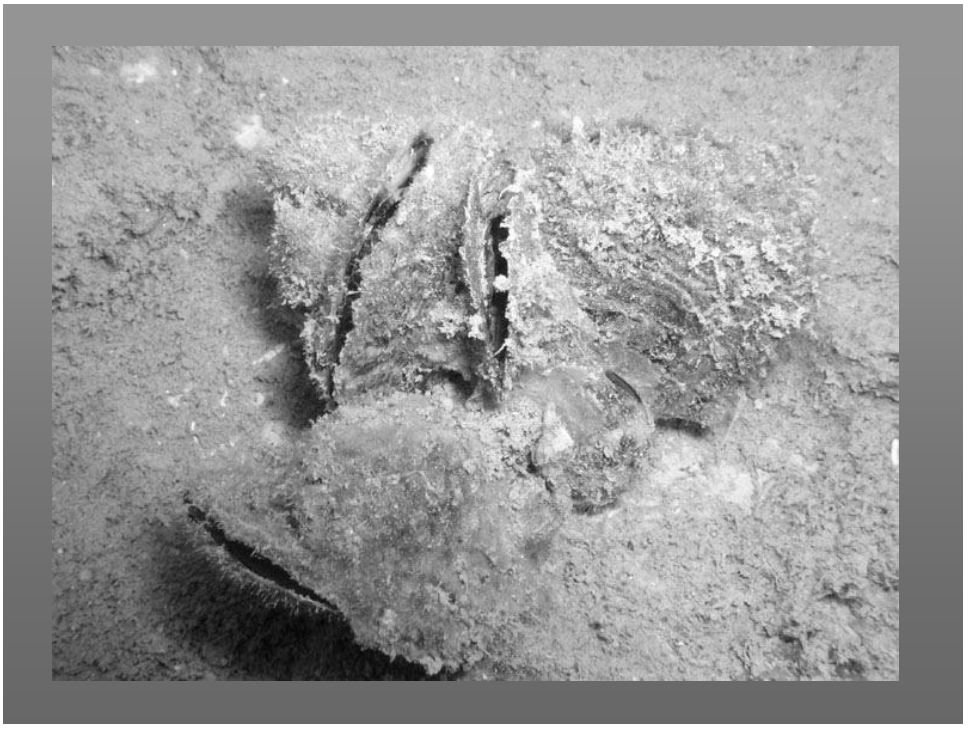
Figure 5.1 Relationships among the major trophic groups found on artificial reefs.

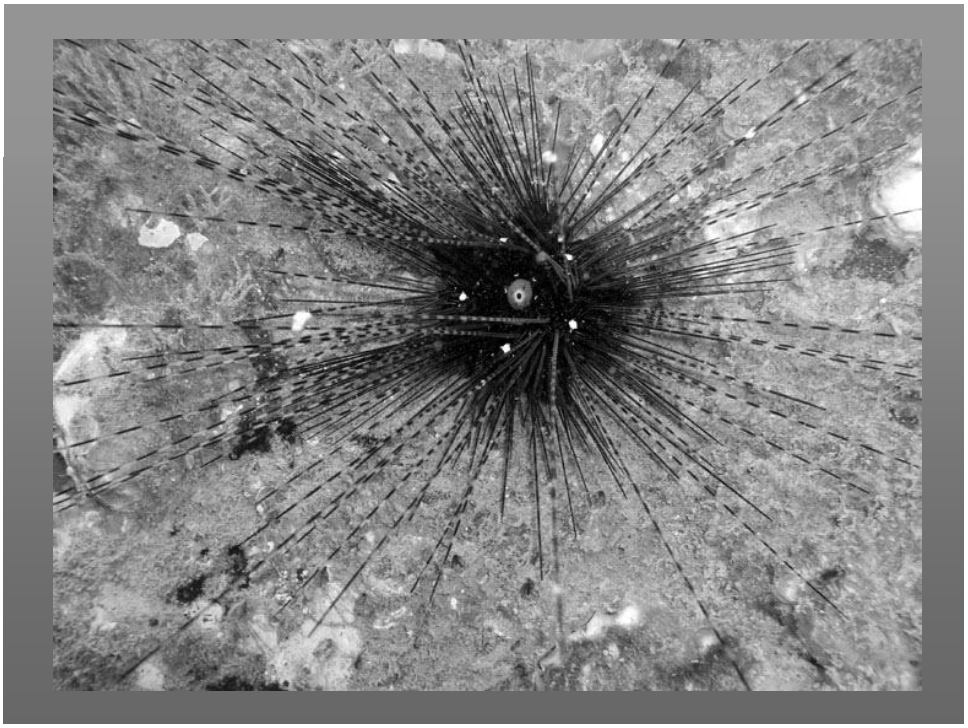
Common Dominant Sessile Organisms

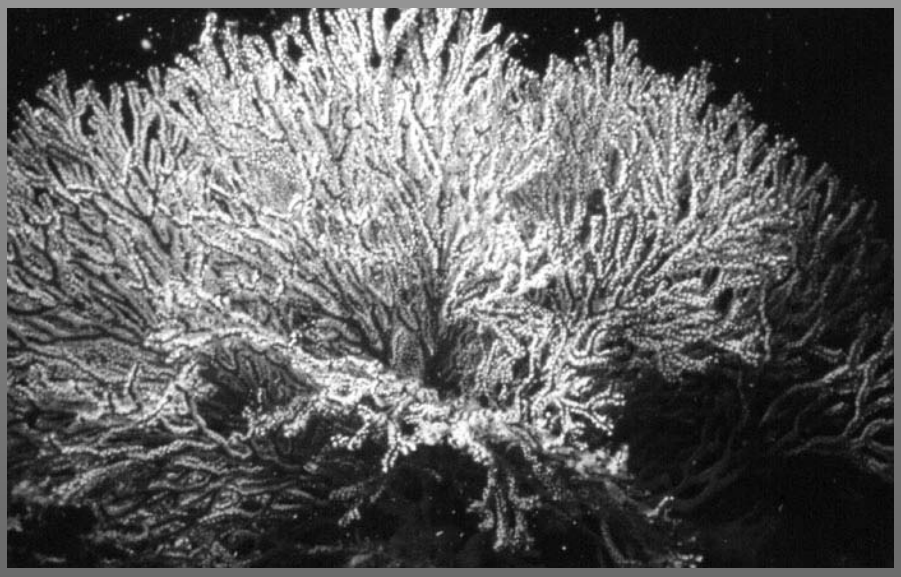
- **Filamentous Algae**
- **Barnacles**
- **Bryozoa**
- **Ascidians**
- **Polychaeta**
- **Mollusca** (Bivalves)
- **Sponges**
- **Other crustaceans** (shrimps, crabs, Amphipods)
- **Coelenterata** (Hydriods, Gorgonians, hard corals)











Common Topics for Monitoring

- Fish fauna
- Benthic communities
- Environmental parameters

Factors to be Considered for Choosing Methods for Assessment

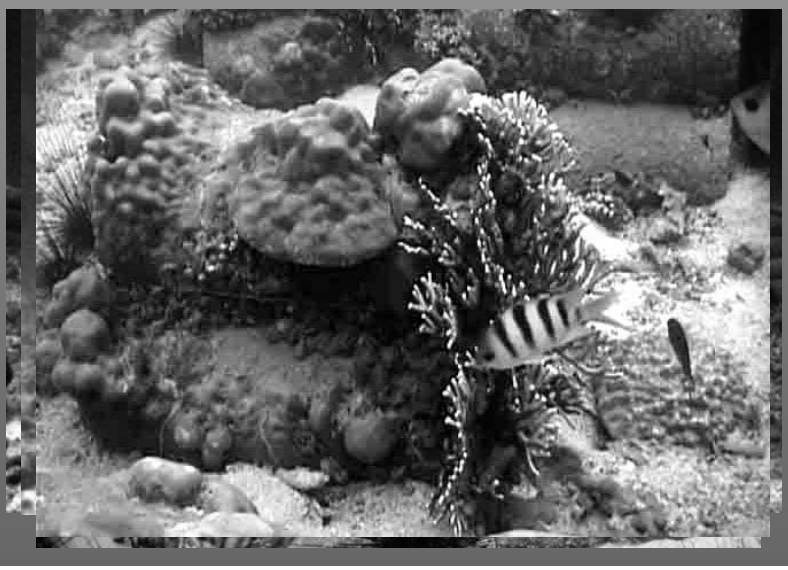
- **Manpower** (number and capability)
- **Budget** (equipment, expenditure of field work, etc.)
- **Time**

Level of Assessment

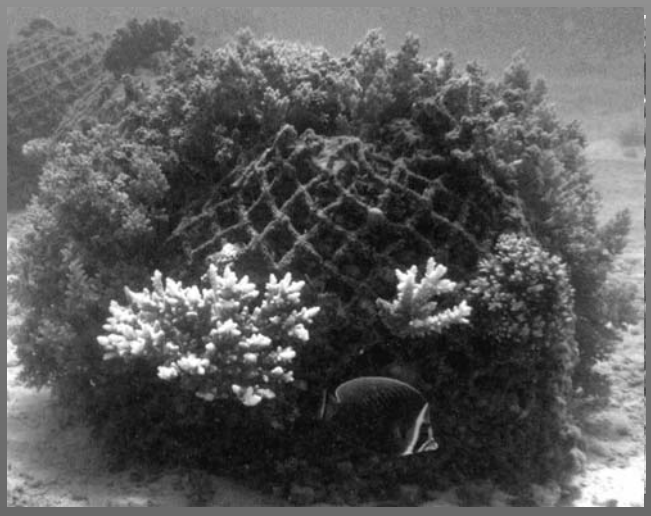
- **Common method used:** Scuba diving
- **Qualitative survey**
  - **General description of AR**
  - **Substrate type and other environmental condition**
  - **Living organisms found** (ranging from taxa to species level)
- **Quantitative survey**
  - **Sampling methods**
    - **Random**
    - **Quadrat/point count**
    - **Line intercept transect**
    - **Visual census**
    - **Setting plates/blocks**
    - **Etc.**

Examples of ARs Under Different Environmental Condition

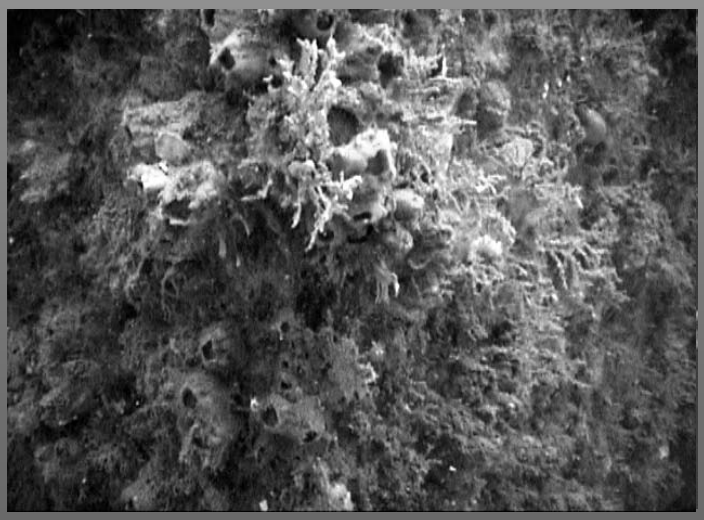
AR for Coral Reef Restoration



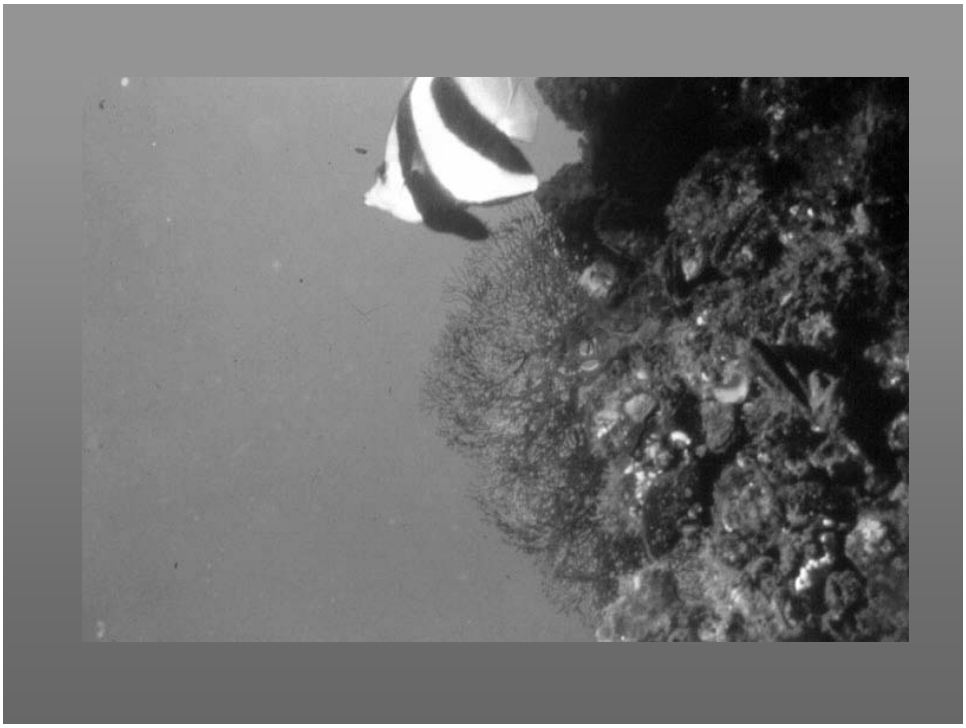
AR for Coral Reef Restoration

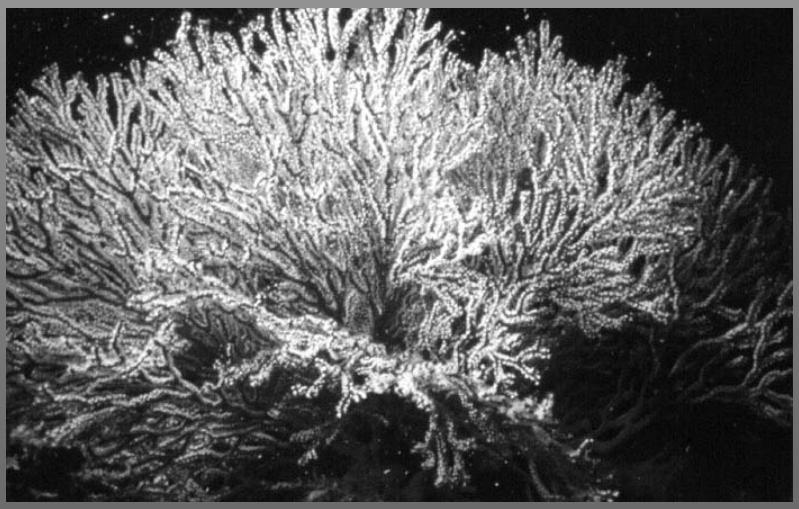


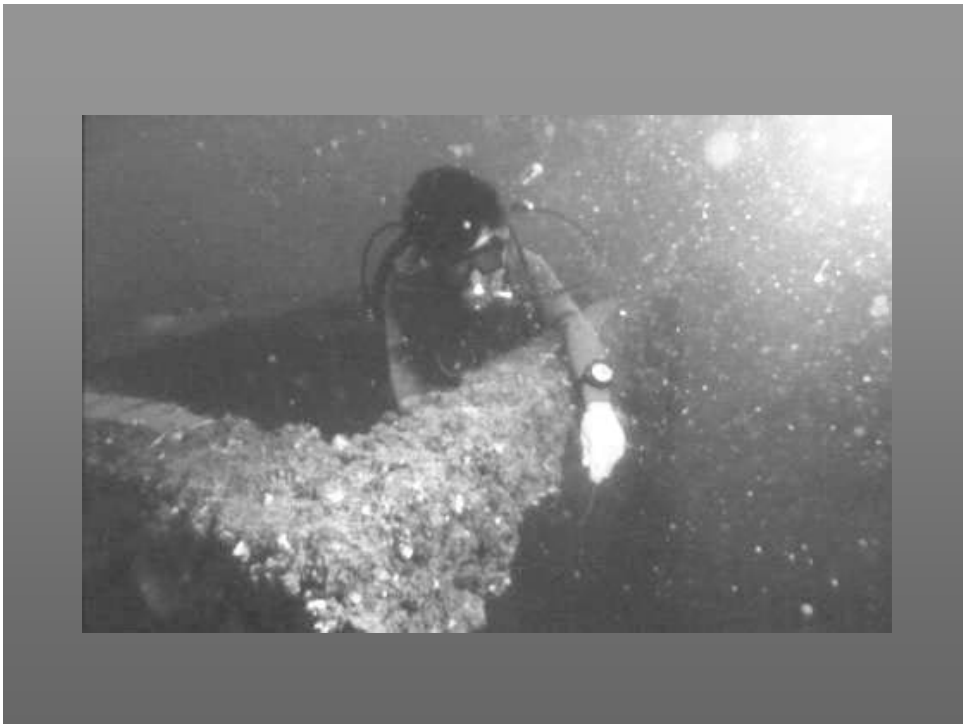
AR in Deep Water

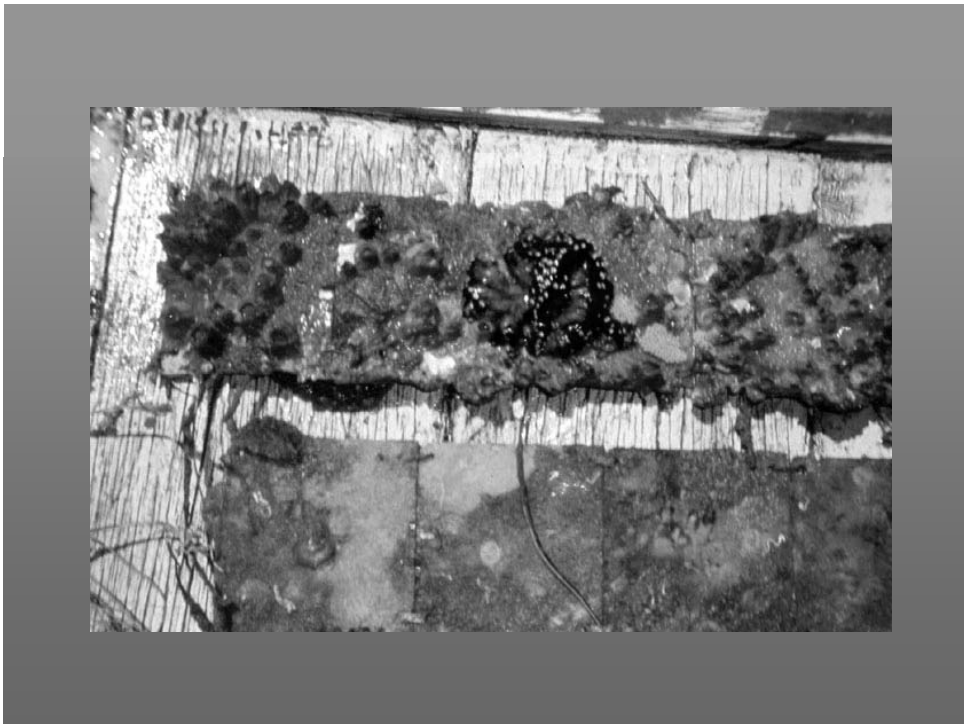



AR in Open Coastal Area









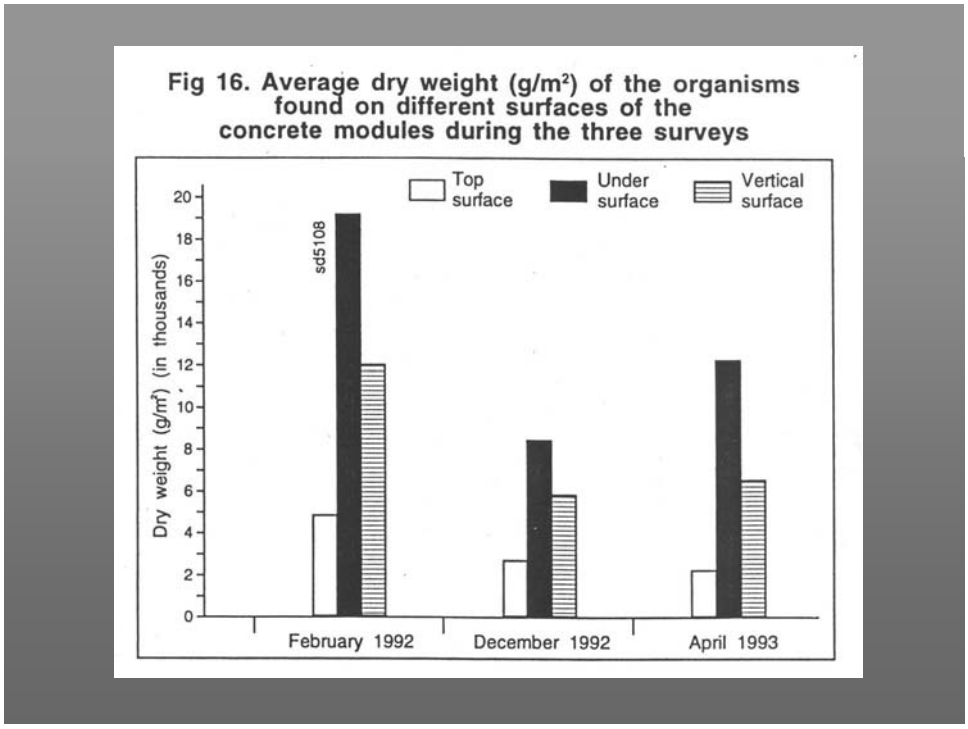


Fig 16. Average dry weight (g/m²) of the organisms found on different surfaces of the concrete modules during the three surveys
Top surface
Under surface
Vertical surface
Dry weight (g/m²) (in thousands)
sd5108
0
2
4
6
8
10
12
14
16
18
20
February 1992
December 1992
April 1993

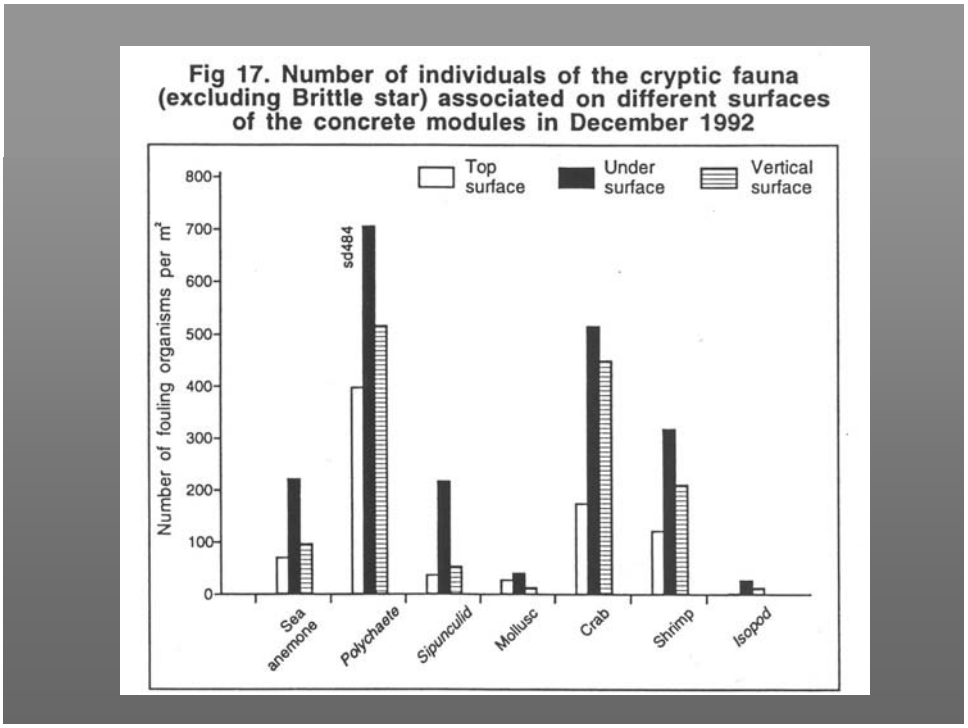


Fig 17. Number of individuals of the cryptic fauna (excluding Brittle star) associated on different surfaces of the concrete modules in December 1992
Top surface
Under surface
Vertical surface
Number of fouling organisms per m²
sd484
0
100
200
300
400
500
600
700
800
Sea anemone
Polychaete
Sipunculid
Mollusc
Crab
Shrimp
Isopod

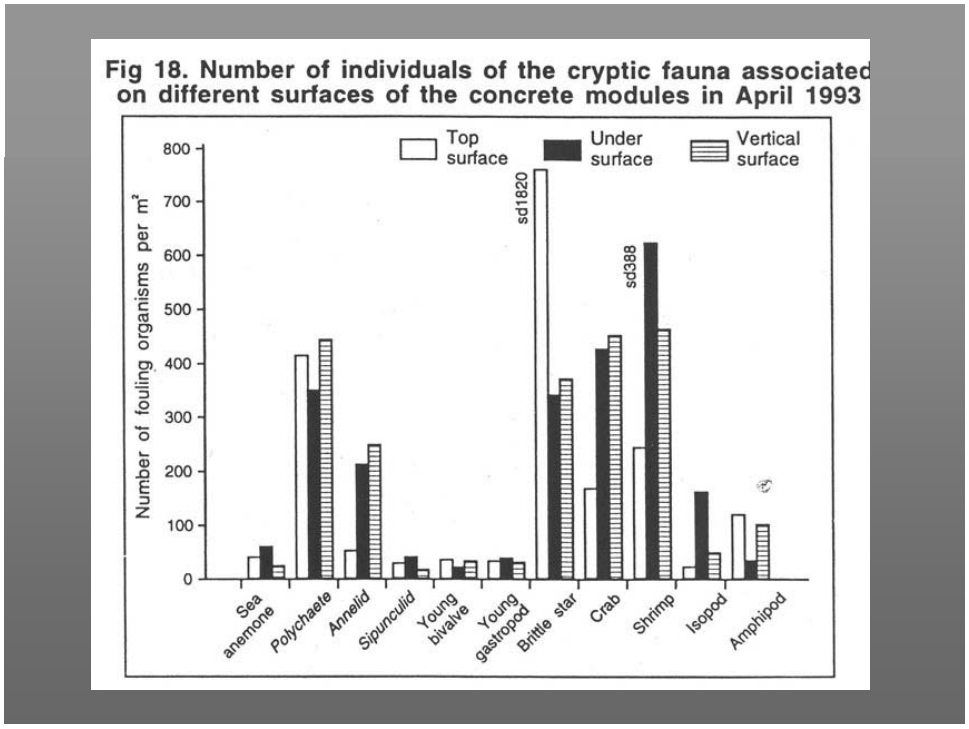


Fig 18. Number of individuals of the cryptic fauna associated
on different surfaces of the concrete modules in April 1993
Top surface
Under surface
Vertical surface
Number of fouling organisms per m²
800
700
600
500
400
300
200
100
0
sd1820
sd388
Sea anemone
Polychaete
Annelid
Sipunculid
Young bivalve
Young gastropod
Brittle star
Crab
Shrimp
Isopod
Amphipod

FISHING OPERATION AND FISHERIES SURROUNDING THE ARTIFICIAL REEFS

Mala Supongpan, Ph.D.

FISHING OPERATION AND FISHERIES SURROUNDING THE ARTIFICIAL REEFS

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Abstract

The paper reveals the background of artificial reefs (ARs) installation in Thailand, materials used to make ARs, types of ARs, the research works before and after installation of ARs, the fishing gears and methods that operated around the ARs areas. The introduction for data collection methods, types of fishing gears and effort that suitable for fishing in ARs areas for fishery sustainable management and friendly to the environment. Consequently, the enhancing activities and community based fishery management approach are also mentioned.

■ INTRODUCTION

Artificial reefs or artificial habitats or fish habitats are man made structures that install for increasing habitats for fish, shelters for young, juvenile fish as well as for spawners to spawn their brood stocks, to obstacle for trawling activities and enhancing the fish to be fruitful. The introduction of artificial reefs (ARs) installation to the habitats should be considered a bit more about the structure of ARs that should be modified to the surrounding environment e.g. strong wave, tidal direction, mud precipitation, water ways and bottom types. The budgetary supports are also necessary due to very high costs for installation of ARs. Since several member countries in the ASEAN/SEAFDEC region have experiences to install several artificial reefs, but few research works have been done on the fishing operation and fisheries surrounding the artificial reefs.

The objectives of the present findings are to observe on the background of the artificial installations for further establish a guideline for research on the fishing operation and fisheries surrounding the artificial reefs areas and such activities should be done in sustainable manners and friendly to the environment.

■ BACKGROUND OF ARTIFICIAL REEF INSTALLATION

1. The Development of ARs Installation

In Thailand, the first introduction on the artificial reef installation was in the year 1978 in Rayong Province, in the Gulf of Thailand using various material structures e.g. unused tires, concrete tubes that tired together with several model units. At that time ARs were called “Fish Habitats” Several experiments had been done to find out the suitable models and material used to attract fish to come in. It was found that there were several fish species living in the artificial reef areas.

In the year 1982, the ARs installations were requested by the local authority in Phang Nga Province, in the Andaman Sea Coast, the Department of Fisheries in collaborated with the local authority had installed the ARs in Phang Nga Bay using unused cars and rectangular shaped concrete tube models tired with steel to make more strong ARs.

In 1983, The National Institute of Coastal Aquaculture in Songkha Province had installed ARs using pyramid shaped concrete models with steel tired together in Songkhla Province, in front of the Institute. In this time, the ARs were called “Artificial Reefs”

Experiences are gained from various experiments using several types of material and models. At present the installation of artificial reefs in Thailand are modified and classified into two types of small and large ARs installations.

1.1 Small ARs. The small ARs will be installed at the area of one square kilometer in the small fishery community. The budget about Baht three millions is provided for each area requested by local community through local authority. Nowadays, the standard and suitable concrete tube is 1.5*1.5*1.5 cubic meters, seven hundreds number of concrete tubes are piled together at sea bottom. The objectives are to enhance the fisheries and to protect the area from large scale fisheries for the small scale fisheries.

1.2 Large ARs. The large ARs will be installed at the area 30 to 50 square kilometers in the large fishery community from several local areas connecting borders. The budget about Baht twenty millions is provided for each area requested by that community through local authority. The standard and suitable concrete tube is 1.5*1.5*1.5 cubic meters, five thousand and four hundreds number of concrete tubes. The objectives are to enhance the fisheries and to protect the area for the small scale fisheries as well as to obstacle fishing activities from trawl gears and purse seines.

2. Considering for the Areas Installation

The areas that will be installed for artificial reefs should have criteria as:

• The bottom should not be a muddy type.

• The areas should not have mud corrosive suspension.

• The areas should not close to the river's mouth that the water salinity changed with a wider range during rainy season.

• The areas should not be water ways.

• The depth of water should be more than 6 meters.

• The areas should be not used for navigation activities, landing port, dry dock, licensing areas for collecting bird nets, natural gas accessing.

• The areas should not be the security areas for navy, naval practices, and neighboring borders.

3. Materials Used for ARs

There are several material sources that use to construct for ARs. Some are natural materials while some are man made or unused accessories of human. These are some concepts to be considered for those materials used for ARs:

3.1 Effective function to attract fish to come in and live there.

3.2 Compatibility and suitable to the natural habitats.

3.3 Duration and stability of the ARs with long live used and sustain effectively.

3.4 Availability for finding the material used with low cost and or unused materials.

The followings are some examples of material used for ARs:

• **Unused tires**. In each year, there are many unused tires that can be used for ARs. These should be tired together in several units with strong wires and weighted by concrete before loading. If wires are not strong enough it will loose and broken then the separated ARs become trash of the sea? It is noticeable that underwater unused tires can discharge petrochemicals or heavy metals into the water. Anyway, this issue still has no responses from supporting research. It was observed that there was a small number of living organisms attached at the surface of unused tires. Further it might say that used tires were not good enough to attract fish to come in. Hence there was no development of food chain in this ecosystem (Figure 1).

Figure1. Unused tired bound together with strong wire. Fish gathering around the unused tires. (http:www.fisheries.go.th/marine/artificial reef)

• **Unused concretes tube**. Round and rectangular shaped unused concrete tubes from water drainage of road reconstruction can be made for ARs. It is recommended not use the broken concrete tubes because it is difficult to compile and tire together. This type of ARs was installed at Pattani and Naratiwas Provinces under the Queen Project in 2002. The evaluation after installation of ARs showed that the concrete tube could attract fish but the concrete tubes could not piled up together due to curvature surface of the tubes (Figure 2).

Figure 2. Unused concretes tubes and fish swimming around. (http:www.fisheries.go.th/marine/artificial reef)

• **Concrete cube frames**. These are the modern models that have been made under experiences to finding for suitable models of ARs. Even it is costly but it is long lasting as well as easy to move and transport to the target area to install. After releasing the tube to the sea, it directly fell down to the bottom. Moreover, these tubes can be piled up together more easy than other types and the fish can come in any side (Figure 3).

Figure 3. Concrete cube frames. (http:www.fisheries.go.th/marine/artificial reef)

• **Wrecked ship**. The wrecked ships in the sea are well known among the fishers that there are abundant of many fish species to live and ground for fish to finding food, food chain for fish and spawning activities. Generally, the wrecked ships are made of several materials e.g. wood, steel, fiberglass and Ferro cement. Among these the steel wrecked ship is considered the best due to her heavy, unmovable and long lasting. Before using as ARs, the ship should be cleaned for spilled oil and other contamination that make surely not transfer into the sea environment. The engine, oil pipe systems and unwanted engine parts should be cleaned and removed. The water ways for navigation activities should also be careful bewared for safety when decided to install the ARs. The position of the sink down ship should be given the head of the ship against the current direction and placed in a position as her normal sail that she can tolerate for her own weight (Figure 4).

Figure 4. Wrecked ship and fish swim surrounding. (http:www.fisheries.go.th/marine/artificial reef)

• **Train cabins**. The frame of train cabins are made of steel that should be taken off as well as other unused parts. The unused cabins should be washed and cleaned before using as ARs. Due to heavy and have a lot of windows, the train cabins are costly for

transportation and installation. Firstly, the Department of Fisheries, Thailand has installed the unused train cabins as ARs under the Queen Project at Pattani and Naratiwas Provinces in 2002. The Train Transportation Authority gave the Department of Fisheries totally 208 unused train cabins for ARs. The evaluation was made after installation, it was shown that there have a lot of fish come in and it was observed that those were some big fishes and some never occurred before (Figure 5).

Figure 5. Train cabins and installation. (http:www.fisheries.go.th/marine/artificial reef)

4. The Implementation of the ARs

The followings are the steps to implement the ARs in Thailand:

4.1 Considering on the requests for ARs from fishers and local authorities.

4.2 Define location together with the local fishers in the requested areas.

4.3 Marking the latitude and longitude of the target area.

4.4 Consult to the Navy and Port Authorities to approve for ARs installation.

4.5 Based line surveys for fisheries, environment and socioeconomic of the fishers in target area (before installation).

4.6 Announcement for ARs installation for companies to be hired by e-Procurement (access through internet).

4.7 Monitoring and control the installation to meet the specification of ARs installation.

4.8 Announcement and distribution the information for public to make them known the location for ARs installation before and after that might be a bit differ from the assigned latitude and longitude due to the movement of the boat by wave during installation.

4.9 Participation approach need for strengthen the community to take care and make use from their ARs.

4.10 Report the results of the installation.

4.11 Steel floating signs for navigation activities notices.

4.12 Based line surveys for fisheries, environment and socioeconomic of the fishers in target area (after installation) and compare to the before surveys.

13. Do routine research on the fishing operation and fisheries in the target areas.

14. Evaluation the project and collecting the fisher attitudes for ARs and further improvement or strengthening.

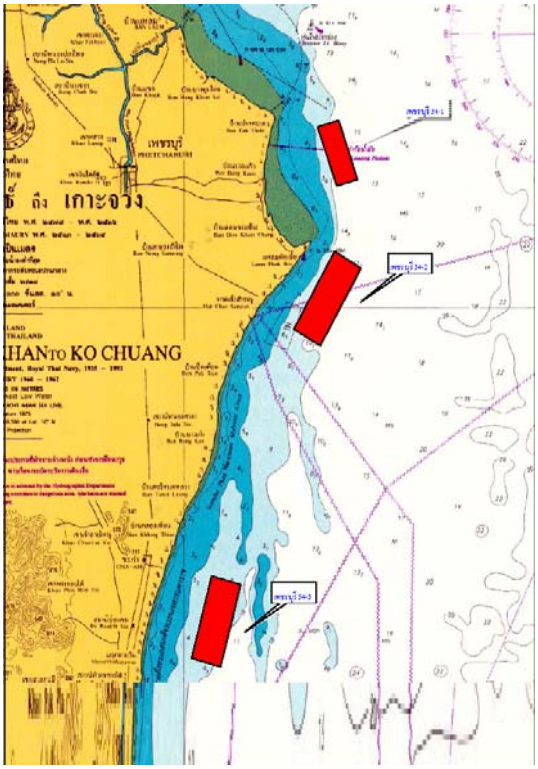


Figure 6. ARs locations in Petchaburi Province installed in 1991(Supongpan and Chenkitkosol (2003).

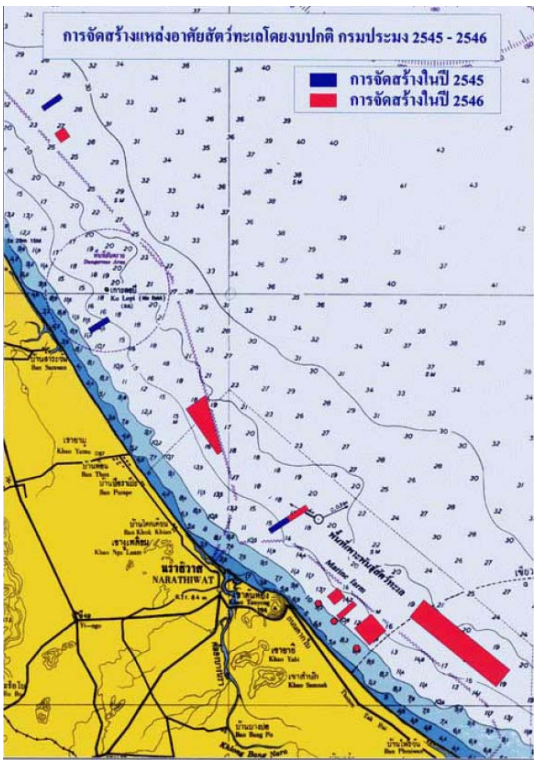


Figure 7. ARs locations in Pattani and Naratiwas Provinces installed in 2002 and 2003 (http:www.fisheries.go.th/marine/artificial reef).

5. Thailand ARs Installation of the Years 2004 and 2005

The Department of Fisheries has provided her annual budget of the year 2004, about millions Baht 65 to install the artificial reefs along the coasts both in the Gulf of Thailand and Andaman Sea. There were 16 locations that classified as 15 locations of small ARs and 1large ARs. Apart from this, the DOF has also installed 300 numbers of train cabins as ARs in Pattani and Naratiwas Provinces under Queen Project in 2004. Plan has been made to install more 12 locations in southern coast of Thailand including Pattani and Naratiwas Provinces in 2005. The Project has been established by the local fishers in Pattani Province requested the Queen to enhance and rehabilitation the coastal resources that has already been depleted. The project is targeting for Pattani and Naratiwas Provinces using train cabins, unused pipe water drainages, concrete tube frames and wrecked boats to make ARs in the target areas. The project will be rehabilitation, enhancing the resources, obstacle for trawling activities, protection for juveniles and young fishes as well as to promote ecotourism for diving exercises.

In 2005, the Department of fisheries has approved to provide her budget for ARs (one large ARs and fifteen small ARs) along the Gulf of Thailand and Andaman Sea coasts.

■ FISHING OPERATIONS AND FISHERIES SURROUNDING ARS

1. Catches, CPUE and Fish Species Caught Around ARs

In the years 1978 to 1987, the Department of Fisheries had installed 8 ARs locations in Rayong Province using tire concrete blocks, concrete rings, water drainage pipe concrete, stones and woods in different models. Few years after installation, the ARs in deeper water and far from shore were destroyed by current, commercial trawlers and dynamite fishing. It was recommended that the future project for ARs, the location and return investment must be considered (Sungthong, 1987).

Since the Department of Fisheries has implemented the ARs project aiming to conserve fishery resources and fishing ground especially for small-scale fishermen along the coastal areas. Phetchaburi Province was one of the area chosen as a project area for the fiscal year 1991, and the DOF had allocated million Baht 15 from her annual budget in order to install ARs covering an area of 50 square kilometers in 3 Districts, namely Muang, Ban Lam and Cha Am. It had been expected that about 2,000 families would have benefit from this project.

The research had been conducted in order to determine the effects of the ARs project on fisheries and fishery resources in Phetchaburi Province. The data used in this research were 4 years time-series; data were collecting from the years 1990, 1992, 1993 and 1994. The study aimed to compare fishery activities and fishery resources between

before and after the installation of ARs. Several authors had reported the results of the studies of ARs in Petchaburi Province.

Supongpan (1985) reported the effects of the ARs installation to the fishery and fishery resources at Phetchaburi province comparing between before and after installation of ARs in 1990 and 1992 to 1994. The results showed that before the ARs had been installed there were 8 main fishing gears commonly used in the project area such as sand whiting gill net, mullet encircling gill net, Dorab gillnet, trammel net, mackerel encircling gill net, crab bottom gill net, hook hand line. From the statistical analysis, the top four effective fishing gears suitably employed were mackerel encircling gill net, mullet encircling gill net, Dorab gill net and trammel net. However, after installation two years, three productive fishing gears were found more namely promfret gill net, fourfinger threadfin gill net and squid light luring cast net. These three fishing gears can be operated in any season around the ARS. On an average the promfret gill net was operated 196 trips yielding 1,872.4 kg or 9.55 kg per trip in 1993; and 107 trips yielding 956.4 kg (8.94 kg per trip) in 1994. The four finger threadfin gill net was operated 73 trips yielding 920.6 kg (12.6 kg per trip) in 1993 while in 1994 it was operated 136 trips yielding 4,833 kg (35.5 kg per trip). The squid light luring cast net was operated 270 trips yielding 3,353.8 kg (12.4 kg per trip) in 1994. From the linear regression analysis using time as an independent variable and fish production as a dependent variable, the pelagic fish, mid water fish, and invertebrate species have high positive correlation coefficients (0.79; 0.79; and 0.99 respectively) that mean the longer live ARs the higher production in the said area especially for the pelagic fish, mid water fish, and invertebrate species. On the other hand the production of demersal fish and trash fish decreased with high negative correlation coefficients (0.78; and 0.72 respectively).

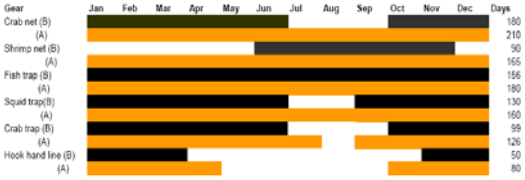
Furthermore, it was intended to determine the changes in fisher incomes from fishery activities due to the impact from the project. The comparison of the total effort, catch and catch per trip before and after installation of the ARs were carried out. The data used in this study were collected from three year surveys in 1992, 1993 and 1994. The results displayed the significant increase in the total effort, catch and catch per trip. Finally the study found that growth rate of fisher incomes were 1.56; 1.56 and 3.01 for the years 1992, 1993 and 1994, respectively.

Sinanuwong and Singtothong (1993) revealed the fish caught by eight fishing gears before and after installation of ARs in Phetchaburi Province in 1991. The fishing gears used were mullet gillnet, shrimp gill net, wolf herring gillnet, Indo-Pacific mackerel gillnet, threadfin gillnet, sand whiting gillnet, promfet gillnet and swimming crab gillnet. The results showed that after installation 3 years there appeared 27 fish species from 16 species. Among these species one species was missing after installation. Catch per boat per year of all gears increased when compare to the catch before installation. Before installation the fish caught from sand whiting gillnet, wolf herring gillnet, mullet gillnet, Indo-Pacific mackerel gillnet, and shrimp gill net accounted for 10,412; 1,291; 716; 161 and 51 Baht per year per family respectively. After installation 3 years the fish caught by Indo-Pacific mackerel gillnet, sand whiting gillnet, mullet gillnet, shrimp gill net and wolf herring gillnet accounted for 36,598; 17,566; 2,181; 1,427 and 1,206 Baht per year per family respectively.

Jankusol (1997) reported the hand line fishing resources around the ARs in Chantaburi Province after one year installation. Hand line was also used to evaluate the effectiveness of ARs. The surveys were carried out in four stations which located around the ARs. Catch from hand line comprised 6 species of pelagic fish, 21 demersal fish species. Each location production was almost the same number of species. The results on the statistical analysis showed that Station 3 was significantly high production than others. Its CPUE was 455.16 g per line per hr. Consequently, the CPUE of the former six months was significantly higher than the latter six months of the year. The abundant species were *Lethrinus* spp., *Nemipterus* spp., *Lutjanus lineolatus*,

Lutjanus vitta, Scolopsis spp., *Pentapodus setosus* which were represented about 80% of individual number in each station. An average weight of each *Lethrinus* spp., *Lutjanus vitta* and *Pentapodus seto* was 50 g with average total length of 15 cm and an average weight of each *Nemipterus* spp., *Scolopsis spp* and *Lutjanus lineolatus* was 100 g with average total length of 20 cm. The socio-economic status of small scale fishers live around the large ARs in Chantaburi Province have been changed after ARs were installed. Results of the study showed that the fishing effort of the year 1997 increased (operation days increased in a year as indicated in Table 1) from the year 1995. Net profit increased from 36,453 to be 56,404 Baht per year. Crab bottom gillnets were replaced by trammel net. The number of small fishing house hold increased 16% and the number of small boats increased 7% as well. Fifty eight percent of the fishers access their fishing grounds near ARs areas. Most of them have good attitudes to ARs projects (Ingsrisawang, 1999).

Table 1. Fishing seasons and fishing days of six major gears fishing around ARs in Chantaburi Province in the year 1995 comparing to 1997. (Ingsrisawang, 1999).



Remarks: B = Before installation of ARs (1995), A = After installation of ARs (1997).

Jenkitkosol (2002) reported the status of squid cast net with light luring in Pranburi and Samroiyod District, Prachuab Khiri Khan Province by collecting the questionnaires from the squid light luring fishermen operating this gear around artificial reef area installed by the Department of Fisheries. The catch data were collected from fish agents in the area during the years 2000 to 2001. It was found that the numbers of boats were gradually increased. Fishermen used green color of fluorescent lights for gathering squids and caught them by cast net with 2.5 - 2.7 cm mesh sizes. Catch per unit effort of squids in the year 2000 and 2001 were 26.54 and 25.16 kg per trip and the average incomes were 1,219 and 1,124 Baht per trip respectively.

Supongpan and Chenkitkosol (2003) evaluated the ARs installation in Petchaburi Province that was expected to minimize conflicts between small scale and commercial fisheries with the fishing ground volume of 50,000 m3 as well as to enhance the fishery resources. Data were collected during January to December 1990 before installation and after installation during January to December, from 1991 to 1998. It was shown that the net profits of fishing household increased from the year 1990 (15,254 Baht/family/year) to be 32,089; 23,254; 46,876; 19,963; 25,019 and 51,123 Baht/family/year of the years 1992, 1993, 1994, 1996, 1997 and 1998 respectively. For the small scale fisher attitudes to the project, it revealed that the fishers have a good attitude to the ARs project. Moreover, the fishers from other areas requested year by year for ARs installation especially for their own areas.

2. Fishing Gears and Fishing Efforts Used in the ARs Areas

Table 2 indicates types of fishing gears that can be used to fish surrounding the ARs areas. Generally the fishing gears are for pelagic fish (Figures 8- 13). The fishing efforts could be considered as day of fishing or trip of fishing which often one day for one trip for small fishing gears (e.g. gillnet for pelagic fish and invertebrates). There should not be allowed for squid cast net and purse seine to fish near the ARs. That light can lure juvenile and small-sized fish and get caught that cause growth over fishing while purse seine can be torn when covered on the ARs during its hauling and lock down the fish then the fish could not swim in and out.

Table 2. Types of fishing gears fishing surrounding the ARs (Supongpan, 1985 and Jenkitkosol, 2002).

Remark: 1. Light can lure juvenile and small-sized fish that cause growth over fishing.
2. Purse seine can be torn and shut down the moving way of fish.

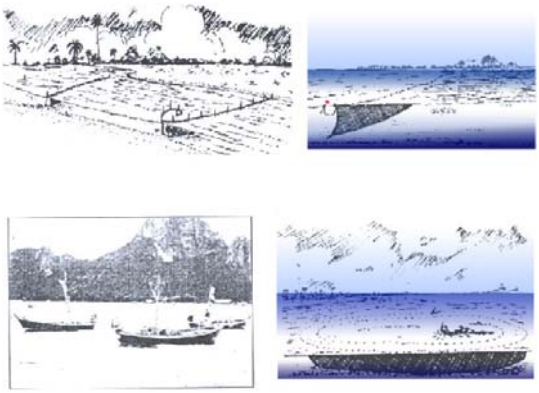


Figure 8. Mullet encircling gill net (Supongpan and Chenkitkosol, 2003).

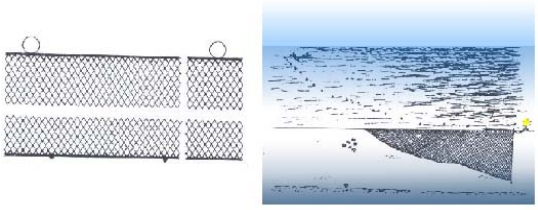


Figure 9. Threadfin gillnet and promfet gillnet (Supongpan and Chenkitkosol, 2003).

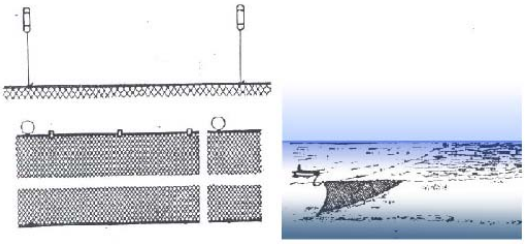


Figure 10. Dorab gill net (Supongpan and Chenkitkosol, 2003).

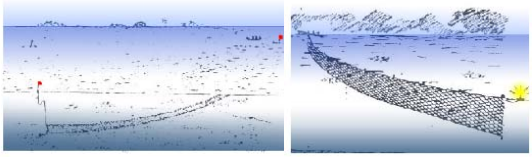


Figure 11. Indo-Pacific mackerel gillnet (Supongpan and Chenkitkosol, 2003).

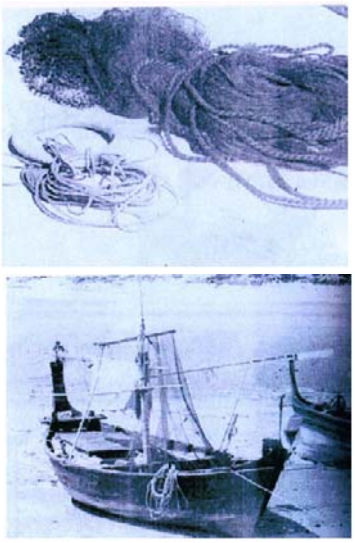
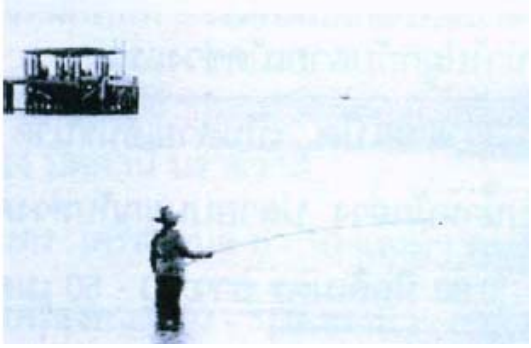


Figure 12. Squid cast net with light luring (Supongpan and Chenkitkosol, 2003).



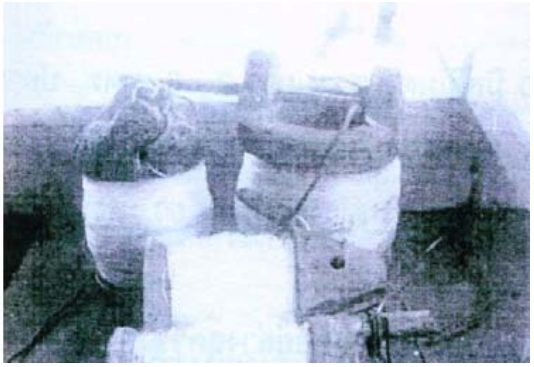


Figure 13. Hook hand line (Supongpan and Chenkitkosol, 2003).

Table 4. Average fishing operation (days) in the year before (1990) and after (1992-1994; 1995-1998) installation in Petchaburi Province (Supongpan and Chenkitkosol, 2003).

Fishing gear	Before (avg 1990)	After (avg 1992-1994; 1995-1998)	Increase/ decrease
Mackerel gillnet	0.39	18.52	+18.13
Sand whiting gillnet	41.47	48.7	+7.22
Trammel net	0.69	12.02	+11.33
Mugil gillnet	2.34	7.19	+4.84
Dorab gillnet	4.73	3.66	-1.07
Other fish gillnet	2.95	1.47	-1.47
Hook hand line	1.47	2.24	+0.76
Swimming crab gillnet	11.91	11.21	-0.70

3. Fishing Operation and Methods

Table 1 shows the fishing days of six major gears fishing around ARs in Chantaburi Province increased in the year 1997 when comparing to the year 1995 (Ingsrisawang, 1999). The result of Ingsrisawang, 1999 was well corresponding to the result of Supongpan and Chenkitkosol (2003). That showed the fishing operation of five fishing gears namely, mackerel gillnet, sand whiting gillnet, trammel net, mugil gillnet and hook hand line, increased after installation of ARs in Petchaburi Province as indicated in Table 4 while there were three gears that the fishing operation decreased (dorab gillnet, other fish gillnet and swimming crab gillnet).

The fishing gears and fishing operations are different among locations and methods. At least the following are some examples that are represented common gear types and methods of fishing in the Gulf of Thailand and Andaman Sea.

3.1 Shrimp gill net or trammel net

The gear is operated at water depth 4-20 m, its usually fish during northeast monsoon, daytime operation between high and low tides. The net is set against the water current and drifted along with the current direction about 20-45 min for each haul. The net comprise three layers of nylon net with mesh sizes ranging 4.2 to 4.5 cm, the depth of the net is 50 meshes. Outer net meshes are 9.0 to 10.0 cm with the depth of 15 meshes. The length of each net is 35 m. One set of the net comprise 10 to 60 nets bound together to make for one set (Siripech *et. al*. 2002).

3.2 Crab bottom gill net

The crab bottom gillnet is operated at water depth 4-10 m from the end of April to October with 2-3 crews on board. The net is set at the fishing ground for 1 to 2 nights in each trip. The nylon net length is 35 m for one net, altogether 10-30 nets bound to be one set.

The mesh sizes vary from 9.0 to 12.0 cm (Siripech *et. al*. 2002).

In Phang Nga Bay, the crab bottom gill net is made from monofilament nylon net with mesh sizes ranging 10.0 to 12.5 cm. The fishing ground is at depth 5–10 m; it can be fished all year round. The length of the net varies in different location e.g. the net has mesh size of 12.5 cm, the length will be 32.2 m for one net; the net has mesh size of 10 cm, the length will be 77.4 m. Number of nets is bound together ranging 24 to 80. The net is set against the water current direction in late afternoon with high tide levels between 3 and 5 m. After that the net is uplifted in early morning of the next day (Sangchan and Sirisak, 2004).

3.3 Sand whiting gill net

The fishing ground is at depth 3 -12 m and fishing season is during June to October. Fishing is operated in daytime with 2-3 crews on board. When the net is set the crews used long wooden stick to make water current frightening the fish and further to be gilled. The nylon net length is 35 m with the depth 50 meshes about 10-15 nets bound together to be one set. The mesh sizes vary from 2.5 to 3.0 cm (Siripech *et. al*. 2002).

3.4 Mackerel gill net

The fishing ground is at depth 15-35 m and fishing season is during March to October. Fishing is operated in early morning with 3-5 crews on board and sailing back in late afternoon of the same day. The nylon net length is 40 m with the depth 50 meshes about 20-30 nets bound together to be one set. The mesh sizes vary from 4.3 to 4.8 cm (Siripech *et. al*.2002).

3.5 Hook hand line

Fishing is operated after making Fish Attracting Device (FAD) using bamboo wood and set to attract fish to gathering around. Most fish caught are pelagic fish and few are demersal fish (Siripech *et. al*. 2002).

3.6 Squid trap

The fishing ground is at depth 12-35 m and fishing season is during February to November. The squid traps are hauling in early morning after placed the traps in the sea for one night with 2-4 crews on board. The trap is a rectangular shaped with a size of 0.6*1.0*0.5 m3 which can be made from various types of woods. There is one opening that fish come in and be trapped inside. One fishing boat can carry about 15-30 traps to place in the sea (Siripech *et. al*. 2002).

■ DATA COLLECTION SURROUNDING ARS FOR RESEARCH WORKS

Generally data collection is based on the following aspects:

1. Criteria

What are the vision and objectives of data collection? Data based may be used for fishery sustainable management and to evaluate the rehabilitation of the ARs areas and or to reduce conflict among different fleet types in these areas. Where are the target areas? What type of data? The frequency of data collection should be set e.g. in every month, twice a month. Who can be that person involved in data collection? Who can effectively collect required data e.g. fishers, aqua-culturist, local government officer, middle person, NGO, company, fishery association, statistician, biologist, enumerators, economist, and institution). Budgetary support and funding from outside should be considered for sustainable collection. International agreements and precautionary approaches should also be integrated in the data collection.

2. Geography and Environment Condition

The geography of the ARs sites and the environment conditions should be collected for more details to improve the structure of ARs and monitor the environmental changes that might affect to the organisms and fish living surrounded ARS.

3. Fishing gears, Effort and Methods of Fishing

The types of fishing gears, effort and mesh sizes including the methods of fishing that not destroy the ARs and fish community

should be recorded and collected. What are the fishing efforts, which indicators that can indicate or represent the fishery situation and fishery trend? The data collection for research works should also scope on the number of each fishing gear that optimum to fish around the ARs. These will include the fishing activities for fishery recreation around the ARs areas.

4. What types of data to be collected?

The fish species and sizes of fish should be recorded for biological study to further promote the enhancement and seed releasing and or for culture the native species for more quality of live of the local people nearby the ARs areas. Survey for fish larvae abundant around ARs using research vessels to find out the suitable species to be enhanced or/ by seed releasing should also be made. The environment indicators, benthic species both flora and fauna should also surveyed to indicate the healthy environment, abundance and biodiversity of that areas.

5. Data collection methods

It should consider on which types of required data e.g. fishery biological data, socioeconomic data, what should be used as indicators to monitor the fishery situation and trend etc. The example of catch data in g or kg or ton; effort in day or trip or piece of net; fleet data in number of boat operated or fish consumption per capita. Data collection should be designed to collect required data. Secondary data should also be analyzed to coincide with the primary data. The followings are the methods to collect data for fishery management proposals.

5.1 Complete enumeration

This method is to collect all data about number of fishers, number of fishing boats, mobility in fishery sector, total catches from capture fisheries, aquaculture, freshwater capture fisheries that will represent the overall data for the country. This is a costly program; it can be collected once with a period for five years.

5.2 Frame survey or based line surveys

The survey will scope in some areas for fishery and socioeconomic data that will survey by every two months or a quarter of the year.

5.3 Sampling survey

In the areas of ARs, sampling survey can be done by using research vessel to collect environment indicators (DO, depth, water transparency, salinity, acidity and alkaline properties of water, etc) and fishery resources (species, size, abundance, biomass etc). Echo sounder can be also used to check the ARs that are still existed or have been destroyed by large fishing gears or others.

Nowadays, fishers (both small and large scale fisheries) and the stakeholders should involve in data collection. Interviewed the skippers and data collected from sale slips of fish agents including processing plants would be very useful sources of data.

5.4 Scuba diving

Scuba diving can be used to monitor and arrange the position of the ARs in the sea bottom after installation as well as sinking rate and destroy rate by nature of ARs. The flora and fauna as well as fishes occurred in successive development in the ARs areas should be observed by using scuba to count the number of individuals. The diving activities should be set for routine observation.

5.4 Opinion polls and questionnaires

The opinion polls and questionnaires are useful to develop the ARs in the future. Stakeholder opinions or attitudes should be carefully collected and considered. Their needs for ARs, types of ARs, for what purposes to have ARs, better benefit or not for their fishing activities, what others are needed for more supporting from government, how they will take care for ARs, etc.

5.5 Enhancing Activities

After installation of ARs, the fishers should have some common benefits or interests, e.g. conservation of the fish for fishery sustainability around ARs areas,

common knowledge in enhancing the fishery resources then they will formulate group of fishers to work together and share benefits; promote and support aquaculture for local fish species, sea farming and crab bank project. Supplying seed releasing and invent fish aggregation devices (FAD) from local material to enhance the fishery resources by government should also be promoted. Establishment for eco-tourism for fishery recreation in diving or game fishing should be promoted by government or private sector both by local and central authorities.

■ COMMUNITY BASED FISHERY MANAGEMENT APPROACH

Since the fishery resources have been overexploited and excess fishing capacity has been occurred dramatically over decades. Several trials have been made to reduce fishing activities to the level of sustainable fisheries. ARs installation is one of those projects to reduce the large scale fishing activities, to protect the grounds for juvenile fish and shelter for fish to spawn and small fish to live as well as for small scale fisheries. After installation of ARs, fishers will gradually gathering into group to make use of ARs as well as to take care ARs for their own areas. Hence it will gradually become to community based fishery management and the right-based fishery management will be also proposed.

Usually the co-management; community based fishery management and locally based fishery management in Thailand are firstly established to meet the objective using ARs to obstacle the fishing activities of the large scale fisheries. The different names of community establishment are basically depended on the degree and level of fisher and stakeholder participation on the management activities that have been delegated to local authorities by central authorities. These will be the new approaches for community based fishery management by local authority coincided with local fishers under the consultation of the government officers in the near future for more effectively management for sustainable fisheries.

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