PN-ABX-173

Artificial Reefs in the Philippines

Edited by

J.L. Munro and M.C. Balgos

1995

ICLARM
International Center for Living Aquatic
Resources Management

ded
German Development Service

Artificial Reefs in the Philippines

Proceedings of a Workshop held at the
International Center for Living Aquatic Resources Management
Manila, Philippines
30-31 August 1994

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1995

Printed in Manila, Philippines

Published by the International Center for Living Aquatic Resources Management (ICLARM), MCPO Box 2631, 0718 Makati City, Philippines and the German Development Service (DED), Philippine Office, 65 Juan Luna Street, San Lorenzo Village, Makati City, Philippines.

Munro, J.L. and M.C. Balgos, Editors. 1995. Artificial reefs in the Philippines. ICLARM Conf. Proc. 49, 56 p.

ISSN 0115-4435
ISBN 971-8709-63-0

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Preface

This workshop and the resulting proceedings came into being as a result of cumulative concerns by aid agencies, nongovernmental organizations and by government authorities and researchers about the mass installation of artificial reefs in the Philippines .

Artificial reefs are usually constructed from materials such as scrap tires, metals, concrete blocks, bamboo and nondegradable synthetics such as polypropylene rope. What are their environmental impacts? Do they increase fish harvests in a sustainable way by providing additional nursery habitat for reef fishes, additional productive surface area or additional substrata for filter-feeding benthic communities or an additional site at which planktivorous fishes can aggregate? Or do they simply aggregate surviving adult fishes, generate increased fishing mortality rates and, thus, deliver a transient increase in catches in fish communities many of which are already overexploited?

The answers to some of these questions are found in the following pages. The consensus of the deliberations was that increased attention to the conservation and rehabilitation of the extensive coral reef systems of the Philippines would pay far greater dividends than interventions based on the installation of artificial structures on the seabed.

An important viewpoint on artificial reefs in the Philippines was provided to the workshop by Dr. Angel C. Alcala, Secretary of the Department of Environment and Natural Resources of the Government of the Philippines, who set up the first artificial reef in the Philippines in Dumaguete in 1977. Artificial reefs are one of the management interventions of the Coastal Environment Program (CEP) of his Department. However, the primary management tool of the program is community-based protected areas, at least one to be established in each of the regions of the country. These are seascapes where a variety of uses are permitted; 25% of the area is designated as sanctuary and 75% is a buffer area for nondestructive uses. The expectation is that some of the larval fishes from the sanctuary will be retained in the buffer areas where they can settle and be fished, while other larvae will be dispersed throughout the Philippine reef systems. Dr. Alcala suggested that artificial reefs should only be deployed away from natural reefs and that appropriate materials should be used for construction.

J.L. Munro
Manila
November 1994

Part I
REPORTS OF THE WORKING GROUPS AND RECOMMENDATIONS

The Workshop's main purpose was to consider and comment upon three major topics:

- To consider and evaluate the negative and positive features of artificial reefs;
- To make an inventory of deployed and existing artificial reefs in the Philippines;
- To comment on and suggest alternatives or supplements to the installation of artificial reefs.

These were accomplished through papers and plenary discussions on the three themes, followed by detailed discussion and formulations of recommendations by Working Groups on each theme.

The recommendations arising from these deliberations are as follows:

1. Policy

- Better environmental management programs using a holistic approach should be implemented.
- A decision support system should be developed to facilitate proper implementation of management programs for artificial reefs.
- The human population density in coastal zones at specific sites should always be taken into account in more rational long-term planning.
- Marine protected areas should receive priority as potentially important, relatively short-term and low-cost alternatives to artificial reefs.
- Fisheries enhancement should be explored as a viable option.
- No artificial reefs should be placed in overfished areas, especially if they will be used as fishing grounds, because they function as benthic fish aggregating devices and therefore contribute to overfishing.
- Artificial reefs may be deployed if they are intended to function as fish sanctuaries. However, the economic costs and benefits must be properly weighed.
- All ongoing artificial reef development programs in the Philippines should be concluded within five years and no new artificial reef programs initiated.
- Agencies involved in artificial reef development should coordinate and network their efforts and, to guide their development, should develop a memorandum of agreement with the Department of Agriculture (DA), Department of Science and Technology (DOST), and the Department of Environment and Natural Rresources (DENR).
- The need for artificial reef development should be reevaluated at a workshop after two years of monitoring and evaluation of existing artificial reefs.

2. Management

- All alternative or supplementary actions should not be viewed in isolation but as part of an overall "Integrated Coastal Zone Management" package.

- Efforts should be concentrated on the management and monitoring of existing artificial reefs in order to provide scientific information for future decisionmaking.
- Installed artificial reefs should be monitored in terms of number, location and status. Catch statistics for artificial reefs should be monitored, in coordination with the National Fisheries Information System, and research should be done on the turnover of fish, initial recruitment, socioeconomic impacts and other impact factors.
- No artificial reefs should be deployed without monitoring programs and management plans.

3. *Social aspects*

- All suggested alternatives to artificial reefs will be best achieved by implementation at the community level, where possible.
- Better fisheries management programs should be implemented, with greater fishing village involvement in implementation and monitoring.
- Mariculture should be approached at the community level.

4. *Education*

- Education programs on environmental/renewable resource issues should be encouraged.
- Education of people and communities on possible negative impacts of artificial reefs and the importance of managing natural reefs should be intensified.
- Information campaigns and enforcement of fishing laws and regulations in support of initiatives taken for cooperative coastal ecosystem management should be implemented.
- Provincial and regional personnel should be trained in monitoring artificial reefs in their respective areas.

Working Group I initially discussed definitions of the types of artificial reefs being addressed in the workshop. Artificial reefs were defined as assemblages of any hard structure or material placed on the seabed to provide habitats for fish and other marine organisms. Artificial reefs may have some or all of the following ecological and socioeconomic features:

- habitat or shelter for fish and other marine organisms
- substrate for regeneration of corals and other marine organisms
- feeding, breeding or nursery area
- reference point
- deterrent to trawling
- eco-tourism and other recreational purposes
- waste disposal
- mariculture
- fishing ground
- sanctuary
- substitute for destroyed coral reefs
- entry point for coastal management initiatives
- focus for propaganda purposes of vested interest groups
- replenishment area
- provide a known and easily located fishing area.

It was concluded that all of the ecological functions of artificial reefs mentioned above are generally beneficial. The impact may be positive through increase of survival of marine organisms if habitat is limiting and if no fishing is done on the artificial reef. If there is no fishing on an artificial reef and it is used as a sanctuary it can make a small, but perhaps irrelevant, contribution to production. It can also provide substrate for settlement of fish and growth of algae and other marine organisms that will provide food resources to higher trophic levels. However, artificial reefs are generally too small in comparison to natural reefs to have any significant impact on total fish production.

It was agreed that the aggregating capacity of artificial reefs increases the catchability of fish. If the catches on artificial reefs and natural reefs exceed the new maximum potential production, then the result would be negative and artificial reefs would function mainly as benthic fish aggregating devices and contribute to overfishing. Other negative features are that they can be unsightly and leave a residue of garbage on the seabed if they decay, and they can also be a source of chemical contaminants (e.g., from vehicle tires).

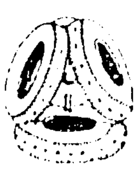
Working Group 2 concluded that about 70,000 modules (see box for definition) had been deployed since 1977, and that not more than 20% (about 14,000 modules) are believed to still exist. The following are very rough estimates of module deployments by agency:

Agency	Deployed	Existing
Department of Agriculture	21,325	11,492
Central Visayas Regional Project	26,000	0
Calancan Bay Rehabilitation Program	2,000	1,600
National Power Corporation	816	653
State Colleges/Universities & other research agencies	150	120
NGOs, civic/private groups	200	160
LGUs	50	40
Total number of modules	70,541	14,065

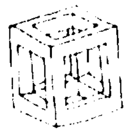
Artificial Reefs and Modules: Definitions

The words *unit* and *module* are frequently encountered in the literature on artificial reefs, but are not used consistently. Throughout these proceedings the word *module* is used to refer to a single standardized structure that is a constituent of an artificial reef. Modules are then combined in various configurations as shown in the following illustrations to form an artificial reef. The term *unit* is not used in this context.

- an artificial reef consists of eight tire modules arranged in a conical structure. Each module consists of four tires (BFAR-ARDP).



- an artificial reef is a pyramidal pile of cubical or cylindrical concrete modules (FSP).



- some artificial reefs are merely *clusters* of modules arranged on the seabed in regular or irregular configurations.
- groups of artificial reefs are referred to as *arrays*.

Additional artificial reefs which are currently planned or under construction include:

Agency	Artificial reef structures for deployment
DA-FSP	1,000 modules (concrete, cubes)
DA Region 3	38 modules (concrete, cylindrical) 100 modules (bamboo)
Southeast Asian Fisheries Development Center-(SEAFDEC-AQD)	1,600 modules (concrete)
Visayas State College of Agriculture	9 modules (concrete, trapezoidal)
NGOs	3,200 modules (tire modules)
Total number of modules	5,947 modules

Thus, a total of around 20,000 modules will be operational in the relatively near future.

Working Group 3 felt that alternative or supplementary actions should not be viewed in isolation but as part of an overall "Integrated Coastal Zone Management" package. This encompasses environmental management of all those areas in which environmental effects may impinge on the coastal zone (e.g., upland areas, surrounding oceans).

The group concluded that all suggested alternatives will best be achieved by implementation at the community level, where possible. However, it was acknowledged that the legal framework for any alternative actions will likely be above the 'barangay' level (i.e., municipal or sometimes higher). Furthermore, recognizing the often large spatial scales of fish stocks, some alternative actions may involve political and scientific action co-ordinated at a much higher level than that of individual communities. One example of dealing with such a need is the 'Bay Management Councils' within the Fisheries Sector Program in the Philippines.

Specific alternatives suggested were:

a. *Better environmental management programs, with greater regard for alleviation of environmental problems which impinge on the sustainability of coastal zones*

Fig. 1 of Munro (this vol.) makes the point that a large variety of environmental problems in the terrestrial environment affect the coastal zone dramatically (e.g., deforestation, mining, road construction and poor land use leading to erosion and siltation; sewerage and garbage disposal). These environmental problems should be addressed in a holistic approach (along with the more obvious environmental problems on coastlines such as destruction of coral reefs, mangroves, seagrass beds, and problems of overfishing).

b. *Better fisheries management programs*

The bases for such programs could include greater involvement of village fishing communities in fisheries management (e.g., development of local fishing cooperatives as a means for effort control, taking greater account of local knowledge of the stocks such as locations of nursery and spawning grounds) and improved fisheries monitoring systems; specifically the encouragement of village level data acquisition systems (e.g., requesting selected fishers to monitor their CPUE and catch composition).

Care will have to be taken to address fisheries access rights at the village level in areas which have previously been considered open access.

c. Marine protected areas (MPAs)

Some evidence now exists that MPAs may enhance local adjacent fisheries by acting as a source for movement of fish from unfished to fished areas (e.g., Sumilon and Apo Islands, Philippines). If such effects are real and sustainable they are potentially important and bring relatively short term (3-5 years?) benefit to the local community. Even more immediate benefits to the community may accrue in terms of tourism. A potentially far more important role for MPAs is protection of spawning stock biomass. In the long term they may be the only viable solution to the problem of declining size of spawning stocks, and thus act as an insurance policy against fishery collapse.

d. Fisheries enhancement programs

It was pointed out that the Japanese now rear and release juveniles of 86 marine species back into the sea. The Chinese have recently established a viable shrimp fishery where one previously did not exist. It has been shown that there are no practical or economic reasons why the fishery for dolphin fish could not be enhanced by hatchery releases in Hawaii. Fishery enhancement now appears to be a viable option.

e. Mariculture ventures

Mariculture of organisms such as algae, giant clams, grouper and shrimp was discussed. Such ventures would be best approached at the community level.

Development of these alternatives to artificial reefs requires a Decision Support System to facilitate their proper implementation. Such a system or "checklist" should include a clear statement of aims, and detailed evaluation mechanisms for the alternatives using clear methodologies for experimental assessment and monitoring, including economic, social and environmental evaluations. The "checklist" for the Decision Support System developed for the management of San Miguel Bay (Fisheries Sector Program, Philippines) provides a useful example.

Assessment of the human carrying capacity of coastal zones at specific sites is also needed to permit more rational long term planning. Detailed demographic predictions should be encouraged and have been made for the 12 bays under the FSP. Population programs such as family planning should be encouraged.

Educational programs on environmental and renewable resource issues should be encouraged, particularly at the primary and secondary levels. Changing the attitudes of people to unsustainable environmental practices is a long-term task but ultimately will be a major factor in the future success of any Integrated Coastal Zone Management program.

Part II
DISCUSSION PAPERS

Evaluation of Artificial Reef Development in the Philippines*

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BALGOS, M.C. 1995. Evaluation of artificial reef development in the Philippines, p. 6-22. *In* J.L. Munro and M.C. Balgos (eds.) Artificial reefs in the Philippines. ICLARM Conf. Proc. 49, 56 p.

Abstract

In 1977-1984, scrap tire and bamboo artificial reefs were deployed for experimental purposes by the Silliman University, University of the Philippines Marine Sciences Center and the Bureau of Fisheries and Aquatic Resources, with the assistance of the US Peace Corps and the Japan Overseas Cooperation Volunteers. Encouraged by the abundance of fish attracted by the experimental reefs and their value as rallying tools for fisheries protection in coastal communities, BFAR, in collaboration with the Ministry of Human Settlements, launched the Artificial Reef Development Program through which around 3,690 tire and 11 bamboo modules were deployed with the assistance of various government and nongovernment organizations in 1985-1988. During this period of widespread technology transfer, problems on purpose, technical manpower, funding and management policies became evident. These problems were not adequately addressed in succeeding programs of deployment (1989-present), even with the Department of Agriculture's Fisheries Sector Program which deployed 7,972 tire, concrete and bamboo modules in twelve bays in the country. Donor conditionalities aggravated the problems. Monitoring and research on recent deployments by the UP Marine Science Institute and the Southeast Asian Fisheries Development Center-Aquaculture Department are supplementing the meager scientific data generated during the experimental period. Ecological and management considerations continue to challenge the viability of artificial reefs as a fisheries management tool in the country.

Introduction

This is a review of the historical development of artificial reefs in the Philippines, including the major reef installation programs and the issues and lessons learned as a consequence of these programs. Research and management experience should be able to show what modifications are needed for the artificial reefs to be viable fisheries enhancement tools. The review is drawn from published literature, unpublished field notes, consultancy, annual and technical reports, and interviews of people who have been involved in artificial reef deployment in the country.

Artificial "reefs" made of materials such as bamboo, trees or twigs, stone or rock piles, wrecked cars and sunken ships have often been used as fish aggregating devices (FADs) in both marine and freshwater, where they are often marked by vari-

*ICLARM Contribution No. 1139.

ous types of buoys or other methods of identification. In the last two decades, two types of artificial habitats have become popular in Philippine marine waters: *payaos*, bamboo rafts used as a deepwater fish aggregating device for catching tunas and other pelagic species, and benthic artificial reefs made of bamboo, rubber tires, concrete and other materials. This paper is confined to the latter type, which has become popular as a fisheries management tool with the rise in coastal management efforts in the country and elsewhere.

Reef Installations: History and Program Descriptions

The following description of artificial reef installations in the Philippines has been divided into four periods based on purpose (from experimental to technology application) and on implementation of major programs (Table 1 and Figs. 1 and 2).

1977-1984

The artificial reefs in this initial period were installed for experimental purposes by Silliman University (SU) in 1977 and 1978 in Dumaguete, by the University of the Philippines Marine Sciences Center (UPMSC) at Bolinao, Pangasinan in 1978, and by the Bureau of Fisheries and Aquatic Resources (BFAR) at sites in Ilocos Sur, La Union, Pangasinan, Manila, Batangas, Albay, Masbate, Cebu, and Bohol between 1979 and 1984 (Miclat 1988). All of these reefs were constructed of scrap tires and bamboo, and were low profile reefs in varied arrays, some in combination with *payaos*. The installations were done in collaboration with US Peace Corps and Japanese volunteers, and local organizations including fishers' associations, civic organizations, diving groups, the Ministry of Human Settlements (MHS) and the Natural Resources Management Center (Alcala 1979; Murdy 1979; Kitamado 1984; Suzuki 1984).

The SU and UPMSC reefs were monitored for some time and data on physical and chemical parameters and on the succession of fish, corals, molluscs and other marine organisms were recorded (Alcala 1979; Murdy 1979; Alcala et al. 1981; Gomez et al. 1982).

US Peace Corps volunteers have played a significant role in the initial development of artificial reefs in the Philippines. Volunteers assisted in fish identification in the monitoring of the first artificial reef installed by Silliman University and initiated the artificial reef project at the UPMSC. Preliminary site survey, module construction and monitoring of the tire reef in Bolinao, Pangasinan were undertaken by the volunteers (Murdy 1979).

The BFAR projects had the following objectives: a) improvement of design and construction; b) establishment of criteria for site selection; c) monitoring the recruitment and succession of fish and benthic organisms; and d) study of the feasibility of artificial reefs as a supplementary resource for fishing using traditional gears (Miclat 1988).

The Japan Overseas Cooperation Volunteers worked with the BFAR Regional Office I in deploying artificial reefs in Lingayen Gulf. They assisted in the initial survey of reef sites, test installations of small-scale tire reefs and *payaos* and in expanding the artificial reef off Port Sual based on careful analysis of the test installations results (Kitamado 1984).

1985-1988

Encouraged with the preliminary results of the experimental artificial reefs, BFAR, in collaboratio.. with MHS, launched an Artificial Reef Development Program between May 1985 and March 1987 which covered all the regions of the country. Some 3,690 tire modules

Table 1. Artificial reef installations in the Philippines.

	Program implementing agency	Collaborating agencies	Location	Date of deployment	Purpose	No. and kind of modules deployed	Status
1	Silliman University	BFAR, US Peace Corps	Dumaguete City	June 1977- Oct 1978	Experimental	70 modules (2 low profile tire reefs)	Existing
2	UP Marine Sciences Center	US Peace Corps	Bolinao, Pangasinan	Feb-May 1978	Experimental	80+ modules (1 low profile tire reef)	Existing
3.	DA-BFAR	MHS, NRMC, JOCV, FAs, Civic orgs., dive grps.	Ilocos Sur La Union Pangasinan Manila Batangas Albay Masbate Cebu	Oct. 1979- Oct 1984	Improvement of design and construction Establishment of site selection criteria Recruitment and succession monitoring Feasibility study of AR as supplementary fishery resource	1,498 tire and tire-bamboo modules 55 bamboo modules	Not monitored
4.	Artificial Reef Devt Program/BFAR-MHS	GOs, NGOs, POs, FAs	Regs. 1-12	May 1985- March 1987	Fishing and rehabilitation	3,690+ tire modules 11 bamboo modules	Not monitored
5	Samar Sea Ticao Pass Project/Philippine Fisheries Devt. Authority			1984-1985	Fishing and rehabilitation	8,099 bamboo and ipil-ipil modules	Not monitored
6	Central Visayas Regional Project	Communities	Bohol, Siquijor, Cebu, Negros Oriental	July 1984- June 1988	Fishing and rehabilitation	26,000 bamboo pyramidal modules	Not monitored
7	Philippine Council for Aquatic and Marine Research and Devt	San Jose LGU, DA Fishermen's Cooperative PNAC RIFT, SIDF, Ateneo de Davao youth grp. COs, Sagay LGU Jaycees, SUML	San Jose, Camarines Sur Ulugan Bay, Palawan Samal Island, Davao Sagay, Negros Occidental	1990-1992	Fishing and rehabilitation	Concrete cube and pyramidal modules Scrap tire modules	No monitoring except for Sagay
8	Calancan Bay Rehabilitation Program	DENR, Marcopper Mining BFAR, PCAMRD, SUML, UPMSI	Calancan Bay Marinduque	1989-1994	Rehabilitation and resource enhancement	848 tire modules 1,134 concrete modules 18 bamboo modules	Ongoing monitoring

continued...

Table 1 continued

Program implementing agency	Collaborating agencies	Location	Date of deployment	Purpose	No. and kind of modules deployed	Status
9 National Power Corporation	BFAR, DA, LGUs Brgys , FAs	Calaca, Batangas Tiwi, Albay Naga Cebu Limay Bataan	July 1990-Dec. 1990	Fishing	816 tire modules	No monitoring
10 Fisheries Sector Program/DA	BFAR, DENR, DILG LGUs, FAs, NGOs	Manila Bay Calauag Bay Tayabas Bay Ragay Gulf Lagonoy Gulf San Miguel Bay Carigara Bay Ormoc Bay San Pedro Bay Sogod Bay Panguil Bay	1990-1993	Fishing and rehabilitation	45 bamboo modules 7,472 tire modules 455 concrete modules	No quantitative monitoring
11 Small Islands Integrated Development Project/US Peace Corps	DA, NGO, FA	Sta. Cruz, Marinduque		Fishing	Concrete modules	Awaiting deployment
12 DA Regional offices		Regs. 1-12	1990-1994	Fishing		No monitoring
13 ASEAN Australia Living Coastal Resources Project/UPMSI		Bolinao, Pangasinan	March 1991	Experimental	32 concrete tent-like modules	
14 Community Fishery Resources Management/SEAFDEC AQD	FAMI	Malalison Island, Culasi, Antique	May 1994	Experimental Rehabilitation of fish and benthic communities	31 concrete modules (beams and cylinders piled into reefs)	Continuing monitoring

Abbreviations/acronyms

BFAR	Bureau of Fisheries
Bgys	Barangays
COs	Community organizations
DA	Department of Agriculture
DENR	Department of Environment and Natural Resources
DILG	Department of Interior and Local Government
FAMI	Fishermen's Association of Malalison Island
FAs	Fisher's associations
GOs	Government organizations
JOCV	Japan Overseas Cooperation Volunteers
LGU	Local Government Unit
MHS	Ministry of Human Settlements
NGOs	Nongovernment organizations
NRMC	Natural Resources Management Council
PNAC-RIFT	Palawan National Agricultural College - Regional Institute of Fisheries Technology
POs	People's organizations
SIDF	Small Island Development Foundation
SUML	Silliman University Marine Laboratory
UP	University of the Philippines

(1) **Cagayan**
San Vicente

(2) **Ilocos Norte**
Calayab, Laoag City
Puyupuyan, Pasuquin

(3) **Ilocos Sur**
Salomague, Cabugao
Bacques, Tagudin
Pilar, Sta. Cruz
Calongbuyan, Candon
Katipunan, Sinait
P ing-os, Cabugao
Namruangan, Cabugao
San Pedro, Vigan
Pantoc, Narvacan

(4) **La Union**
Baluarte, Agoo
Casantaan, Damortis
Bani, Rosario
Dulao, Aringay
Mindoro, Bangar

(5) **Pangasinan**
Tobuan, Labrador
Baquioen, Sual
Centro Toma, Bani
Sunip, Bani
Boboy, Agno
Canal Bay, Alaminos
Pandan, Alaminos
Cabungan, Anda
Carot, Anda
Cato Infanta
Victoria, Alaminos

(6) **Zambales**
Uacon, Candelaria

(7) **Palawan**
Tagburos, Pto. Princesa

(8) **Manila**
San Nicolas Shoal, Manila Bay
Manila Bay Fish Sanctuary

(9) **Batangas**
Calubcub II, San Juan

(10) **Quezon**
Hondagua, Lopez
Caridad, Atimonan
Lumutan, Atimonan
Sabang, Calauag
Camuhaguin, Gumaca
Concepcion, Plaridel

(11) **Romblon**
Canduyong, Odiongan

(12) **Albay**
Alimsog, Sto. Domingo

(13) **Masbate**
Washington, San Jacinto

(14) **Sorsogon**
Caricaran, Bacon
Bato, Bacon
Gatbo, Bacon
Bon-ot, Bacon
Santa Lucia, Bacon
Sawanga, Bacon
Cawit, Casiguran

(15) **Iloilo**
Bungol, Guimbal

(16) **Negros Occidental**
Sangwa, Bangsua
Banago, Bacolod City

(17) **Cebu**
Caubian Is., Lapu-lapu City
Mactan Is., Lapu-lapu City
Tabunok, Tabuelan
Cantuba-on, Tabuelan
Calajo-an, Minglanilla

(18) **Negros Oriental**
Poblacion, Zamboanguita
San Jose, Siaton

(19) **Samar**
Lalawigan, Borongan

(20) **Leyte**
East & West Visoria, Carigara

(21) **Bohol**
Manga, Tagbilaran City
Cogtong, Candijay

(22) **Misamis Oriental**
Initao

(23) **Zamboanga del Norte**
San Pedro, Dapitan
Polo, Dapitan
Talisay, Dapitan

(24) **Lanao del Norte**
Kawit Or., Kauswagan
Dalicanan, Kauswagan
Segod Bay, Matanog

(25) **Davao City**

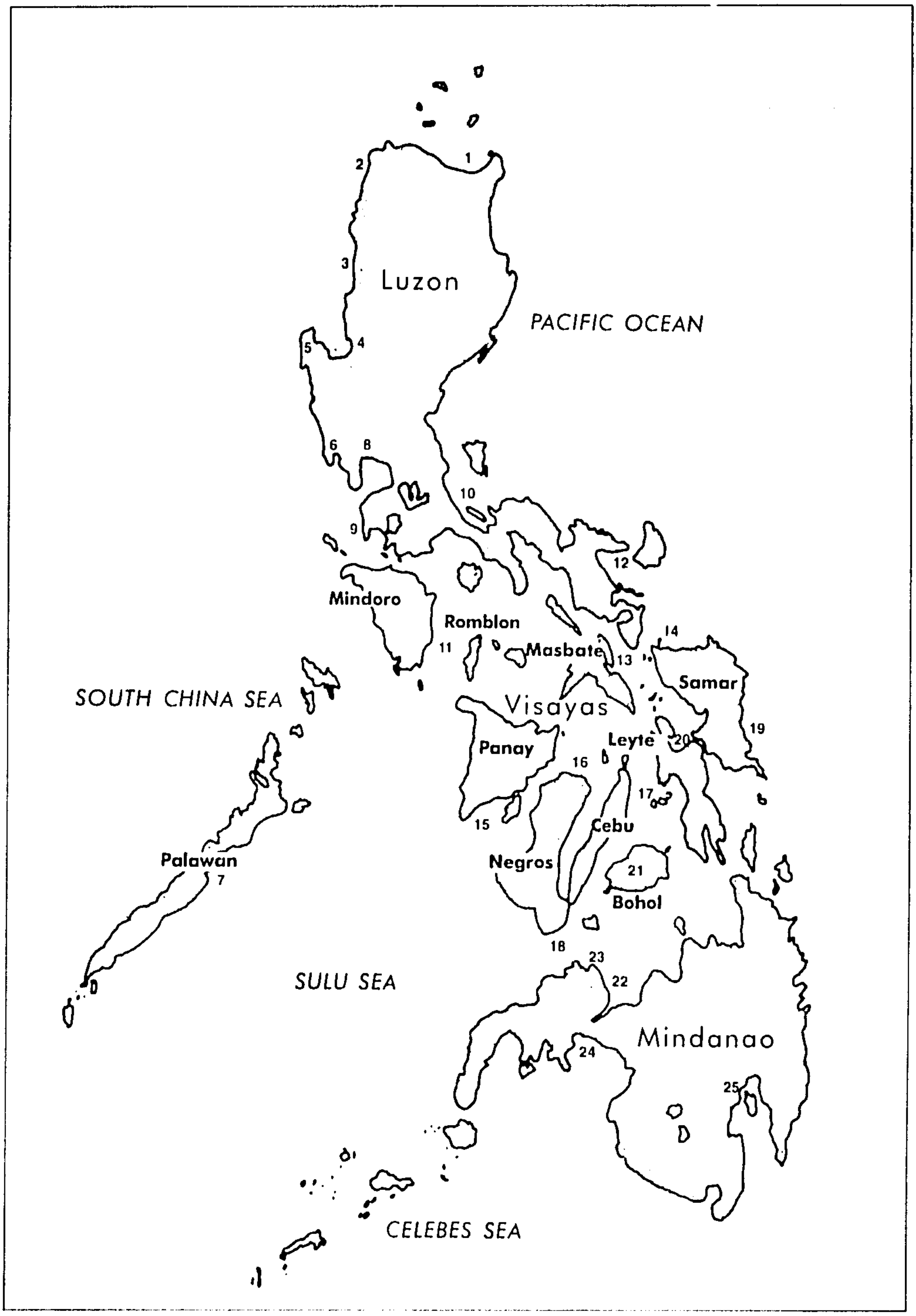

Fig. 1. Department of Agriculture Artificial Reef Development Program. Numbered sites are described opposite.

(1) Manila Bay
Mariveles, Bataan
Maragondon, Cavite

(2) Calauag Bay
Manhulugin, Calauag
Dominlog, Calauag
Balibago, Calauag
Pinagbayanan, Calauag
Pinagsakayan, Calauag
Atulayan, Calauag
Villa Mercedez, Quezon
Pinagtubigan Weste, Perez
Pinagtubigan Este, Perez
Mainit Sur, Perez
Gordon, Perez
Quezon, Quezon

(3) Tayabas Bay
Pitogo, Quezon
Agdangan, Quezon
Macalelon, Quezon
Mayao, Castillo
San Juan, Batangas
Barra, Lucena City
Unisan, Quezon
General Luna, Quezon

(4) Ragay Gulf
Caranan, Pasacao
Tagkawayan, Quezon

(5) Lagonoy Gulf
Mayong Tiwi, Albay
Cabcab, San Andres
Sibaguan, Sangay

(6) San Miguel Bay
Sapinitan Bay, Siruma
Quinapaguian, Mercedes

(7) Carigara Bay
Balud, Capoocan
Naugisan, Carigara
Guindapunan East, Carigara
Poblacion, Babatngon
Bacong, Babatngon
Maanda, Leyte

(8) San Pedro Bay
Baras, Palo
San Jose, Tacloban

(9) Ormoc Bay
Ipil, Ormoc City
Albuera, Leyte

(10) Sogod Bay
San Jose, Southern Leyte

(11) Panguil Bay
Clarin
Maigo
Segapod
San Antonio, Ozamis City

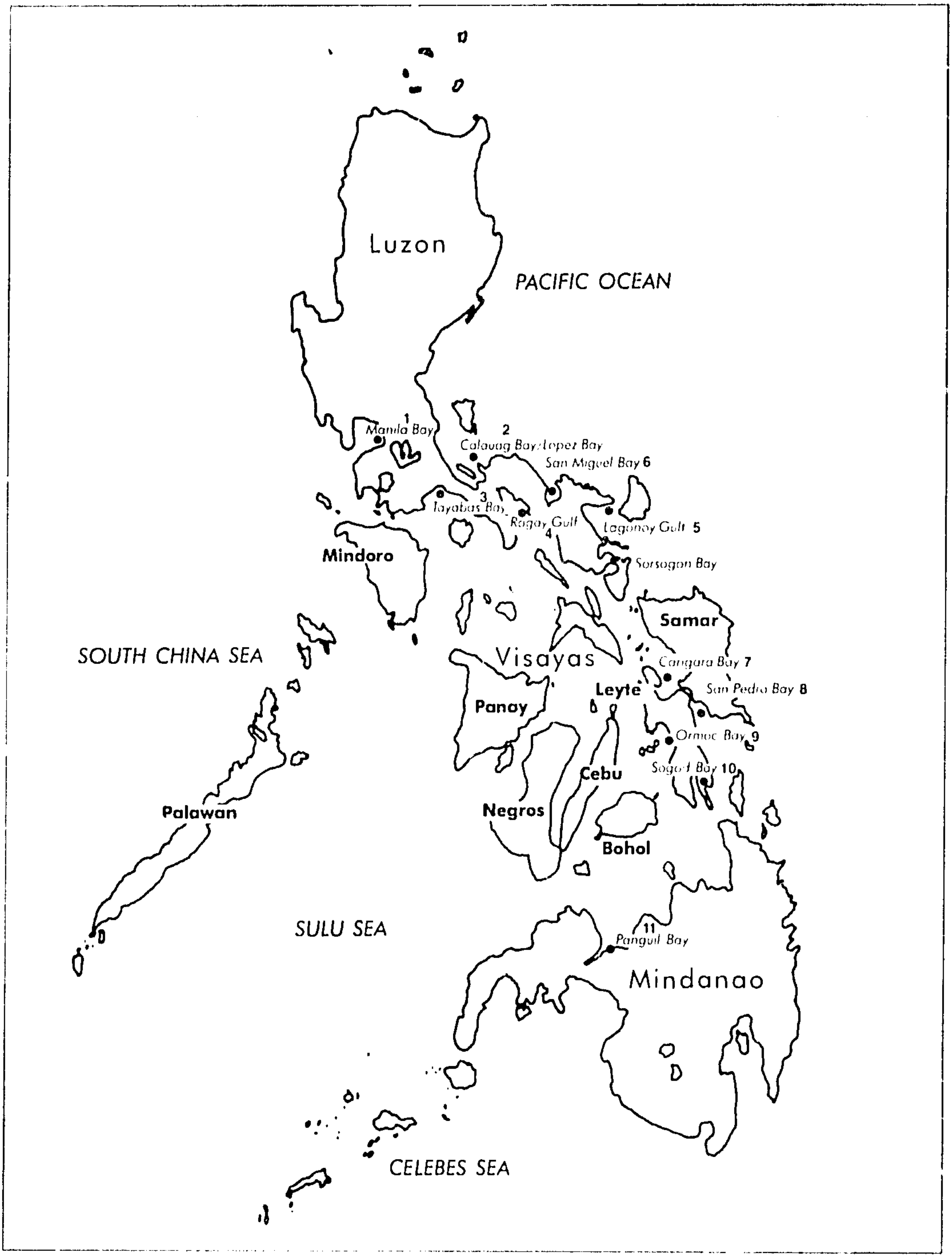

Fig. 2. Artificial reef installations in the Philippines - Fisheries Sector Program sites. Numbered sites are described opposite.

(triangular or conical) and high relief pyramidal structures constructed by tying together eight modules were deployed with the assistance of various government and nongovernment organizations, including fishers' groups, with the objective of enhancing the fisheries (Miclat 1988).

During this period of widespread technology transfer, problems relating to the use of artificial reefs became evident. There was a general lack of understanding of the concept of artificial reefs, and their purpose, whether for fishing or for, in some undefined way, the rehabilitation of coral reefs and of their ownership and management. Problems arose from a lack of technical abilities of the personnel involved and resulted in faulty siting of artificial reefs and lack of monitoring. Trained manpower was practically nonexistent outside of the Coral Reef Research Unit of BFAR. Inadequate funding and absence of policies on the use of artificial reefs as a fisheries management strategy resulted in the poor quality of some of the artificial reefs deployed.

Additionally, the Samar Sea-Ticao Pass Project of the Philippine Fisheries Development Authority deployed 8,099 bamboo and ipil modules between 1984 and 1985 (Montemayor 1991) and the Central Visayas Regional Project installed 26,000 pyramidal bamboo modules between 1985 and 1988 (Bojos and Vande Vusse 1988). Because of the short life of these modules, any impacts which they had were not sustained. The Project later designed concrete modules which were supposed not to need replacement and to be able to support reef fish populations in time.

A technology manual based on the SU, UPMSC, ARDP and CVRP experiences, estimated costs and returns of bamboo and tire artificial reefs (PCARRD 1986). In addition to the income derived from fishing activities outside the artificial reef, a net income of P10,500 and P11,300 (P25 US$1 in 1986) could be gained in the fourth and fifth years of operating 10 tire reefs which then cost a total of about P2,500. Ten bamboo modules costing about P1,800 could yield a net profit of P8,600 and P10,300 in the second and third years of operation.

1989-1990

The Philippine Council for Aquatic and Marine Research and Development (PCAMRD) launched a National Coral Reef Management Conservation Program in 1990 which addressed the management of natural stocks in coral reefs, with emphasis on community based management techniques (Balgos and Salacup 1994). Members of its network of national and regional centers, cooperating stations and collaborating specialized agencies implemented projects under this program, four of which deployed artificial reefs. Between 1990 and 1992, tire and concrete reefs were installed by the San Jose local government unit (LGU) in Camarines Sur, by the Palawan National Agricultural College-Regional Institute of Fisheries Technology in Ulugan Bay, by Samal Island Development Foundation in Samal Island, Davao, and by the Sagay LGU in Negros Occidental.

The Sagay artificial reef was installed near a marine sanctuary where fishing is prohibited and fishing was also not allowed on the reef during the year after deployment. Standing stock, species diversity, total length and number of fishes were monitored through fish visual census for a year by SU as a collaborating institution but only preliminary analyses were done (Luchavez, unpubl. data).

The materials used to construct and deploy concrete cubical modules in Camarines Sur cost about P30,800 per two hundred 0.6-m^3 modules or P154 each (unpublished handout). This did not include cost of labor which was provided by the fishers' cooperative.

The PCAMRD projects were beset by the same problems related to technical manpower shortage and the lack of an adequate management plan for the artificial reefs as had been observed in previous projects.

Between 1989 and 1994, the Calancan Bay Rehabilitation Program (CBRP) established artificial reefs which were intended to reduce the impact of mine tailings which are dumped directly into Calancan Bay in Marinduque by a copper mining corporation. The program was implemented by an inter-agency group led by the Department of Environment and Natural Resources (DENR) for the "sustained conservation and development of Calancan Bay and vicinities through the restoration of natural communities and processes and the improvement of overall environmental quality" (CBRP unpubl. data). A causeway formed from the dumping of mine tailings bisects the bay. A total of 2,000 tire, concrete and bamboo modules were deployed on both sides of the causeway and in sites unaffected by the tailings. Monitoring of fish diversity and abundance through monthly fish visual census, qualitative listing of other fauna, and underwater photo and video documentation were undertaken. Yields from fishing in the areas were also monitored. The CBRP was funded through an ecology trust fund accumulated by contributions paid by the mining company as a cost for dumping mine tailings into the bay.

Constraints identified in the CBRP project included problems in siting of the modules, the quality of sand used and the design of concrete modules, uncontrolled dynamite fishing in the study areas and lack of personnel able to interpret fish recruitment data (Albaladejo, unpubl. data).

The National Power Corporation (NPC 1991) installed artificial reefs in four areas (Batangas, Albay, Cebu and Bataan) in response to the allegation that pollution from power plants was the cause of diminishing catches in areas near the power plants. It also enabled the disposal of a huge number of scrap tires and a total of 816 tire modules arranged in high profile pyramidal design were deployed in 14 sites in 1990. However, no adequate system for monitoring and managing these artificial reefs was implemented.

Between 1982 and 1990, the Peace Corps organized an artificial reef program. No details of this program are available but reports from individual volunteers within this period describe activities, including deployment of modules in Agno, Pangasinan and at 12 other (unidentified) sites, and training on artificial reef construction. The main objectives of the Peace Corps efforts were to increase the income and improve nutrition in fishing communities. The project claimed that there was a clearly perceived need, by fishing communities, for development projects in fisheries conservation. They claimed that community participation highlighted their resourcefulness and that appropriate technology was easily transferable to fishers and co-workers. They identified a need for stronger emphasis on community organization techniques and ecosystem conservation.

1991-Present

Constructing artificial reefs is one of the resource enhancement measures of the current Fisheries Sector Program (FSP) of the Department of Agriculture (DA). The reefs are intended for fishing as well as habitat enhancement in coastal waters. The Provincial Fisheries Management Units created by FSP in the provinces have responsibility for the implementation, monitoring and evaluation of FSP activities including the construction and impact monitoring of artificial reefs (DA 1993). The associations were to be involved in the construction and management of the reefs along with the BFAR, DENR, and various national, provincial and municipal government agencies and NGOs. Between 1990 and 1994, FSP planned to install artificial reefs in various places along about 500 km of coastline in twelve bays in the country. The intention was to install artificial reefs along one kilometer of coastline in each coastal barangay. As of December 1993, 7,472 tire modules, 455 concrete modules and 45 bamboo modules had been constructed and deployed in 48 locations. There were concrete cubical as well as cylindrical modules. An array of 20 reefs each consisting of 10 cubical modules cost about P42,000 while an array of 20 high relief tire reefs each constructed from eight tire modules was estimated to cost about P 41,000. Both estimates included materials and deployment costs (PRIMEX 1992).

Fishers and other concerned members of the barangay were trained on the construction and deployment of the artificial reefs and given data forms for use in collecting data on catches from the reefs. Two technical staff from each DA regional office involved in FSP were trained in SCUBA for artificial reef and fish sanctuary monitoring. In Region V (Southern Luzon, Bicol region), 32 divers were also trained by the BFAR. However, neither type of monitoring was adequately undertaken and there are no quantitative catch data nor underwater visual censuses of fish or estimates of recruitment of benthic organisms.

Based on field evaluation reports (April-August 1993), other issues that were identified in the implementation of the FSP program included faulty siting or arrangement of the reefs, inappropriate design, poor construction and the absence of management plans.

In March 1991, experimental, tent-like concrete modules were installed in Bolinao, Pangasinan, under the ASEAN-Australia Economic Cooperation Program (AAECP) Living Coastal Resources project. Invertebrate and fish community development in these modules, deployed in silty and clear environments was studied and data gathered within seven months after deployment indicated higher initial recruits to the artificial reefs in the silty area (Pamintuan et al. 1992).

The Southeast Asian Fisheries Development Center-Aquaculture Department (SEAFDEC-AQD) initiated work on artificial reefs in 1991 at Malalison Island, Culasi, Antique, where it has been implementing a community-based fishery resource management project since 1991. The deployment of artificial reefs was one of the measures which were aimed at developing the local fishers into a strong and independent association which can effectively manage the island's resources. Two concrete reefs of different prototypes were deployed in May 1994, each costing about P 5,000 including labor for construction and deployment. They are managed by the Fishermen's Association of Malalison Island. The goal is stated to be the rehabilitation of the island's fish and marine benthic communities. Data on the marine ecosystems around the island have been gathered since 1991 and the artificial reefs are being monitored to collect information on the abundance of algae, corals and fish.

Under the Small Island Integrated Development project, the Peace Corps initiated an artificial reef project in Bgy. Alobo, Santa Cruz, Marinduque with the assistance of an NGO, Plan International. Some 50 fishers in that community hope to increase their catch through the artificial reef which was awaiting deployment as of April 1994.

The DA continued with artificial reef installations when BFAR terminated the Artificial Reef Development Program. Under the Artificial Reef Development component of the Fisheries Resources Conservation Program, artificial reefs were reported installed and maintained by its regional offices. Annual reports provide numbers of training courses and trainees, modules deployed, sites established and maintained, the area covered by the artificial reefs, and the numbers of fishers and other beneficiaries served by the program (DA 1990-1994). However, the significance of these figures could not be ascertained.

Artificial reefs are also among the proposed management interventions under the Coastal Environmental Program (CEP) of the DENR launched in 1993. To date, no artificial reefs have been reported to be deployed.

There are reports of other artificial reef installations in Zambales, Batangas, Misamis Occidental including some facilitated by LGUs and NGOs (e.g., Haribon Foundation, Save Our Seas Foundation) but they appear to be undocumented.

Research Considerations

Very few of the artificial reefs deployed have been studied as to ecological and socioeconomic impacts. Research areas considered but not adequately addressed, include fish recruitment (Table 2), standing stock (Alcala 1979), growth of corals and molluscs (Alcala et al. 1981; Gomez et al. 1982), materials for construction (Hillmer 1991), and monitoring (Aliño et al. 1994).

Artificial reefs appear to be a useful tool in demonstrating recruitment processes, both in clear and in silty environments (Pamintuan et al. 1992). Some 143 species belonging to 34 families were observed in tent-like concrete structures deployed in Bolinao, Pangasinan, indicating some degree of enhancing areas which used to be barren and silty. It has not been established, though, if the attraction to these reefs has an impact on fishes dwelling in nearby habitats as had been shown in artificial reefs elsewhere (Alevizon and Gorham 1989).

Growth of corals, molluscs and fish was also studied in the tire reefs of Dumaguete and Bolinao. Growth data on certain species of molluscs (*Mancinella, Pteria, Pinctada, Ostrea, Malleus* and *Spondylus*) and fish (*Plectorhynchus* and *Acanthurus*) were derived from length and weight measurements. Growth rates of eight scleractinian genera (*Acropora, Dendrophyllia, Favia, Pocillopora, Seriatopora, Stylophora* and *Millepora*) were obtained, together with possible effects of depth, siltation and attachment varying with taxon and age of organism (Alcala et al. 1981). In the Dumaguete modules, the fastest growing genera were *Millepora, Pocillopora, Stylophora, Seriatopora, Cyphastrea, Acropora, Porites, Favia* and *Psammocora* (Gomez et al. 1982).

Bamboo was found to be inappropriate as artificial reef material because of its short module life (Bojos and Vande Vusse 1988). Scrap tires are not very stable and may be washed away and lost to deeper waters. Scrap tires have been reported to release toxic chemicals in freshwater, but not at toxic concentrations (Nelson et al. 1994). However, some species of corals have been known to grow on them as fast as on natural rocky substrates (Gomez et al. 1982). Concrete and metal structures which disintegrate slowly are recommended over tires because of durability, flexibility and because community development on such materials was likened to that on corals (Fitzhardinge and Bailey-Brock 1989). A concrete module was also more effective than a tire reef in terms of fish abundance per unit volume within a period of 1-½ years of deployment (Chua and Chou 1994). Another material, carcar limestone, has been recommended for use in the Central Visayas region because of its availability in the area and high potential for encrustation (Hillmer 1991).

Experiments by the SEAFDEC AQD on prototypes and module arrangements, depth and substrate types with considerations including ease of deployment, cost and ease of fabrication are continuing.

Table 2. Summary of some fish recruitment studies in artificial reefs in the Philippines.

Type of artificial reef	Location	Date of deployment	No. of species	No. of families	Duration of observation	Site characteristics	References
1 Tire, low profile	Bolinao, Pangasinan	Feb-May 1978	48	24	Nov 1978-Apr 1979	Sandy, surrounded by seagrass beds, reef areas 20 m away, 3-4 m deep	Murdy (1979)
2 Tire, low profile	Dumaguete, Negros Oriental	May-Jun 1977	81	29	Jul 1977-Aug 1979	Sandy, 15-18 m deep	Alcala (1979)
3 Bamboo pyramidal	San Jose, Batangas	Sep 1984	88	36	Oct 1984-Nov 1985	1.5 km away from natural reef, patch reefs within 1 km radius of the artificial reef, 12 m deep	Barretto (1986)
4 Concrete tent-like	Bolinao, Pangasinan	Mar 1991	143	34	Apr-Oct 1991	Sandy/sandy-muddy; silty/clear, occasionally patched with corals and seagrass, 4-6 m deep	Pamintuan et al. (1992)
5 Concrete cube	Pasacao, Camarines Sur	Oct 1989	88	33	Feb 1993-Jan 1994	Flat, sandy bottom, 11-12 m deep	Diaz (1994)

Gaps were identified in important areas of research including ecology (recruitment and survival of juveniles), engineering (materials design, placement and physical performance), fishery management (function, management plan), mitigation (biological indicators for site selection, assessment of reefs as mitigation techniques), environmental assessment and monitoring (refinement and standardization of field procedures), socioeconomics and policy (ownership and use, economic assessment of performance), and petroleum platform conversion (impacts and alternatives of redeployment of platforms) (Bohnsack and Sutherland 1985; Seaman et al. 1989). Interdisciplinary approaches such as economic and life history considerations in designing structures are encouraged. Additional research is also needed on the factors affecting colonization of artificial reefs such as natural reef availability, mechanisms of natural population limitation, exploitation pressure, life history dependency on reefs, and species-specific and age-specific behavioral characteristics in order to provide greater understanding of attraction and production in artificial reefs (Bohnsack 1989).

The socioeconomics of the use of artificial reefs pose another array of issues that include ownership, encouragement of the use of destructive fishing practices, and multiple use conflicts (Galvez 1991). The problems may be related to previously identified economic research issues, namely: a) the absence of well-defined biological and economic objectives; b) lack of understanding of the user groups' perceptions and demand for artificial reef deployment; c) lack of socioeconomic baseline data for economic performance appraisal; and d) the lack of understanding of the artificial reef's role in fisheries management (Milon 1989). A socioeconomic study of artificial reefs in Panguil Bay, Mindanao, is being conducted by the DA under the FSP National Fisheries Research Program but it is not certain if the above considerations are sufficiently addressed.

Issues and Lessons Learned (Management and Policy Considerations)

Artificial reefs have been deployed in the Philippines with the main objective of enhancing catch rates of small-scale fishers, in a situation of decreasing catch and increasing cost of fuel. Where fishing effort is regulated, the use of this tool can result in positive social and economic benefits but could result in further overfishing if uncontrolled (Polovina 1991).

The Philippine marine fisheries have been characterized as overfished in recent years and massive reduction of fishing effort had been recommended (Pauly 1989). Interestingly, artificial reefs which have the potential to cause overfishing were and are being installed all over the country. This potentially disastrous development, usually near fishing villages, is tempered by these artificial habitats becoming instrumental in drawing coastal communities together into a constituency of fisheries resources protection and rehabilitation. The artificial reefs help to show that coral reefs and other marine ecosystems are invaluable and must be protected from destruction.

Experiences in artificial reef installations also include the following observations. That:

a. Lack of good data constrains ongoing and planned reef construction.

b. There is insufficient education and technology transfer on artificial reefs for nontechnical people are insufficient.

c. Lack of technical abilities of personnel involved has resulted in faulty siting of reefs, and a lack of monitoring, in-depth analyses and interpretation of field data.

d. The absence of policies governing the construction, deployment and use of artificial reefs gave rise to related issues including the choice of appropriate materials, design, and siting criteria; ownership and management; and research, monitoring and evaluation systems.

Interdisciplinary research involving economists, biologists and social scientists should be able to direct establishment of suitable policies (Seaman et al. 1989) that would take care of the above considerations for best results at the least cost and negative impacts (Fig. 3.). A well-designed public education agenda keeping in mind the specific information and training needs of various groups involved in artificial reef deployment (policymakers, planners, coastal fishing communities, other resource managers, technical personnel) would be very useful in successfully using artificial reefs as tools for fisheries management.

In line with coastal management strategies emphasizing the use of combinations of management techniques, artificial reefs can be integrated in a fisheries management program involving other tools such as minimum sizes, closed seasons, limited entry, habitat protection and restoration (Meier et al. 1989) along with nonregulatory techniques (e.g., alternative livelihoods, incentives, habitat enhancement, etc.). The impacts of artificial reefs on other elements of the resource base can also be determined in the context of broader coastal management programs, particularly in case of resource use conflicts.

The FSP approximates an integrated program with fish sanctuaries and mangrove reforestation used as "resource enhancement measures" along with artificial reefs (DA 1993). Income diversification, research and extension, law enforcement, credit and infrastructure are supposed to help relieve some of the fishing pressure off the stocks. However, in a hurry to meet donor conditionalities, its artificial reef program failed in establishing matching technical manpower required for proper construction, deployment, monitoring and management of the artificial reefs.

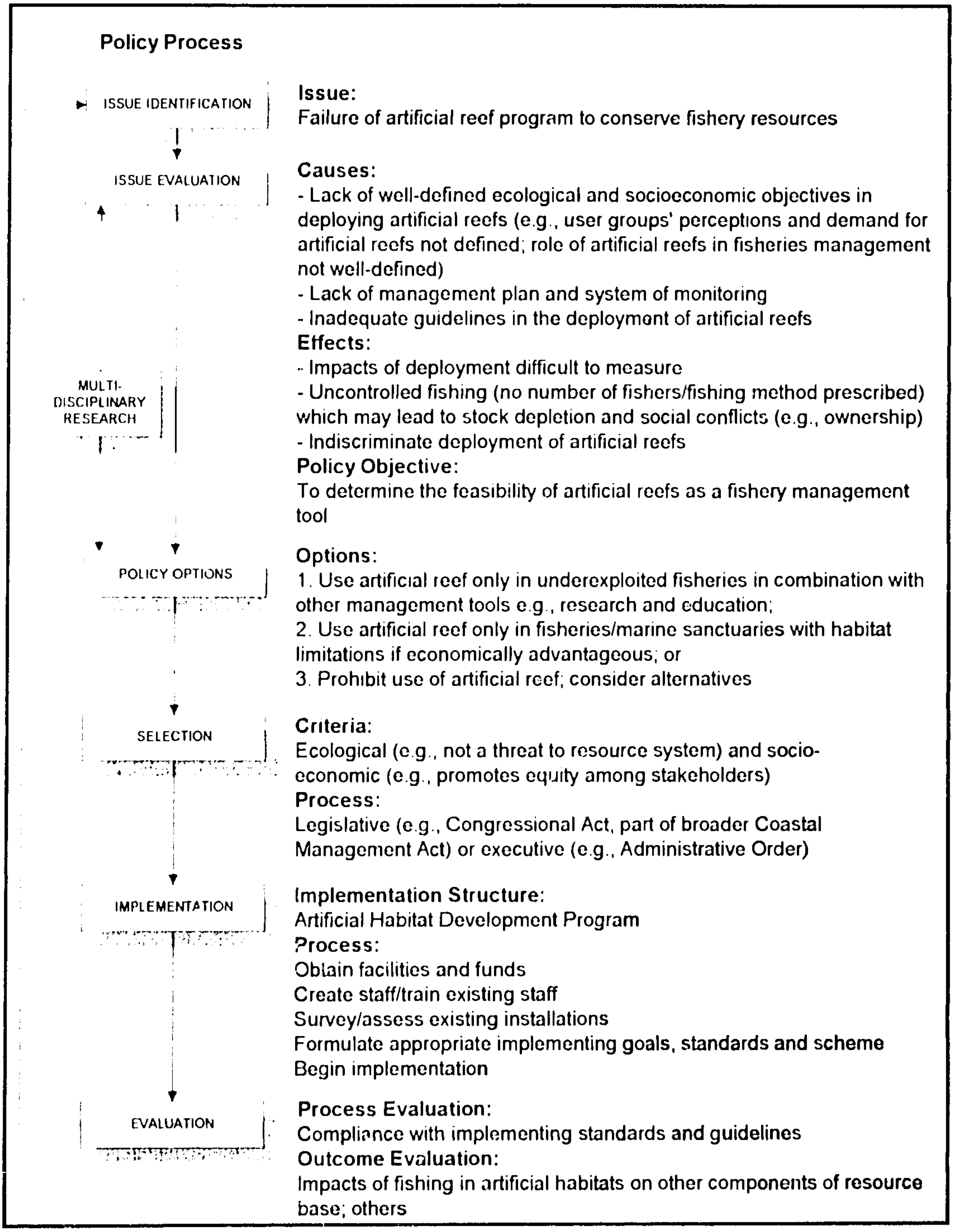

Fig. 3. A policy process on the use of artificial reefs for fisheries management.

Acknowledgements

I would like to thank staff from DA (BFAR, FSP, and the Policy and Planning Group), PCAMRD, the Provincial Government of Camarines Norte, SEAFDEC-AQD, PRIMEX, UPMSI, and US Peace Corps Philippines who provided information on programs and experiences on artificial reefs.

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Discussion

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Discussion ranged over many issues, not all related to the topic. First, discussion was confined to bottom structures. *Payaos* were excluded. Then the following broad areas were covered:

Objectives of Artificial Reefs

- BFAR's artificial reef program was a response to coastal problems; a rallying point to make communities aware of the need to conserve marine ecosystems.
- One view was that the wrong questions are being asked concerning objectives of artificial reefs. A decisionmaking tree was described in which artificial reefs were described as not useful for commercial fishing; useful for artisanal fishing if catches are falling, but not if effort was also falling; and if the proportion of juvenile fish is decreasing, the case for an artificial reef increases. Finally to have an impact at the stock level (as opposed to local aggregation or recruitment), a large investment would be needed.
- It was pointed out that the above argument might only apply if the objective was to increase catch, i.e., a management function; not if the purpose is rehabilitation.
- Further, studies have shown that the proportion of juveniles in catches is increasing; they are being targeted; there seems to be recruitment overfishing, meaning that at least half the stock has been removed; thus, there is plenty of substrate available. Artificial reefs become just

another fishing gear, which will add to the long-term problem, even if catches increase in the short term.

- In some cases the objective has been the physical exclusion of commercial fishing gear.
- Unless the objectives of artificial reef installation are defined clearly, discussion of benefits is useless. In the view of several participants, the social benefits were the key element.

Evaluation of Artificial Reefs

- Few catch statistics, measures of coral growth or survival of artificial reefs seem to have been gathered in the 17-year history of artificial reefs in the Philippines.
- Data have been published for the Silliman artificial reef.
- In some cases, benefits have been "obvious" to villagers and researchers with small-scale artificial reefs; further analysis seemed superfluous.
- Artificial reefs are cheap, involve communities and show some impact; thus are favored by politicians, who may not take into account negative aspects; the number of artificial reefs they can provide is felt to be a measure of success in itself.
- With regard to the Central Visayas Regional Project artificial reefs, a survey showed that all the bamboo ones disintegrated, 35% of the others were lost (mostly in typhoons); few had many fish, and one had to be removed from a healthy reef. The Philippine Institute for Development Studies has done impact studies, including cost-benefits.
- An Antique study of 38 artificial reefs showed that only five were intact; others had sunk in silt or were lost in strong currents. The remaining five, which fishers had not located, had clearly attracted many fish.
- The absence of evidence of increases in fish numbers at the stock level was stressed.

Siting of Artificial Reefs

- Site selection criteria have usually been employed in placing artificial reefs.
- Recruitment of fish was found better on coral reefs than on nearby artificial reefs, according to Silliman University experience. However, at Bolinao, experiments suggest better recruitment away from natural reefs.

Monitoring of Artificial Reefs

- Monitoring an artificial reef alone may not be useful; there is a need to investigate where the recruits are coming from and to study trophic relationships in refuges or in feeding and breeding areas.
- Monitoring is required before as well as after installing artificial reefs to determine benefits.
- When there were few artificial reefs in the early period, they could be easily monitored by existing researchers. However, while the artificial reefs have increased greatly, the number of researchers has not; thus, most artificial reefs cannot now be monitored.
- BFAR asked DA to stop building artificial reefs in 1989 and begin an evaluation exercise. However, DA could not stop their construction due to political pressure.
- In Malaysia, the general consensus about the big artificial reef program there was that real benefits result from excluding trawlers but there is no net increase in fish production; rather a transfer of some of the resources towards the poorest sectors.

Guidelines for Artificial Reefs

- There is a lack of clear guidelines due to controversies about artificial reefs, due to poor cooperation between researchers and other government agencies and NGOs.
- In the FSP, Bay Management Councils were formed of all the stakeholders in each bay. Ordinances were encouraged which would permit groups of fishers to make and control artificial reefs; the artificial reefs would be two - thirds sanctuary (rehabilitation) and one - third for exploitation. However, it was pointed that such "privatization" would be a negative feature.

Documentation of Artificial Reefs

- The past and existing artificial reef projects and their findings need to be better documented. Participants were urged to bring forward references which could be made into a bibliography of Philippine artificial reefs for the workshop report; and data on artificial reef performance.

Effects and Management of Artificial Reefs, Including Experiences Outside the Philippines

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Abstract

Artificial reefs are widely used for various purposes. In the Philippines, they are mainly used for fishing and fisheries management. Since 1991, 174 artificial reefs have been deployed in 75 sites in Negros Oriental, Central Visayas, Philippines. It was estimated that the annual harvest from these artificial reefs is 3.0 $kg{\cdot}m^{-2}$ which can be about 150 times higher than the yield from natural coral reefs. In this area, and elsewhere in the Philippines, artificial reefs are popular because they attract a great abundance of fish and enable fishers to reduce fishing effort in terms of time and fuel. However, it appears that they can contribute severely to overfishing if the catches exceed the maximum potential new production. This may be the case in the Philippines because the artificial reefs are not monitored and managed properly. Ownership and management policies are nonexistent except for a few organizations which protect their artificial reefs as marine sanctuaries.

Introduction

A wide variety of materials and structures are used for the construction of artificial reefs. The materials include scrap tires, mangrove branches, concrete structures, pedicabs, shipwrecks, coal waste products, scrap metals and used oil drilling platforms. These underwater structures are placed all over the globe. Table 1 gives examples of the main applications of artificial reefs in different countries.

Artificial reefs provide shelter for adult and juvenile fish (Bohnsack 1989), reference points for orientation (e.g., for the formation of schools), feeding areas (Bohnsack 1989) and breeding areas (White et al. 1990). However, an important question, mostly neglected, is whether or not artificial reefs lead to an increase of fish

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Table 1. Materials and purposes of artificial reefs in various countries.

Area	Material	Purpose	References
Mediterranean: Italy, France and Spain	Concrete structures	Attraction of fish; shellfish farming; trawl deterrent	Bombace (1989, 1990)
UK, North Sea	Coal waste products	Waste disposal; habitat for lobster	Collins et al. (1990)
USA	Ships, tires	Recreational fishing and diving	McGurrin et al. (1989)
Gulf of Mexico	Oil drilling platforms	Aggregation for recreational fishing; waste disposal	Stark (1990); Stanley and Wilson (1991)
Costa Rica	Tires	Increase exploitable biomass	Campos and Gamboa (1989)
Cuba	Mangrove branches	Lobster attraction	Polovina (1990)
Australia	Tires	Recreational fishing and diving	Young (1988)
Japan	Concrete	Habitat enhancement, increase exploitable biomass	Yamane (1989), Polovina (1990)
Thailand	Concrete and tires	Increase exploitable biomass; close areas for trawlers	Sinanuwong (1988)
Indonesia	Old pedicabs	Waste disposal; attraction of fish	White et al. (1990)
Malaysia	Concrete pipes, shipwrecks	Enhance biological productivity; fishing prohibited at AR sites	Hung (1988)
Philippines	Tires, concrete and bamboo	Increase exploitable biomass; habitat replacement for destroyed corals	Vande Vusse (1991)

populations. Could the fish have used another area or is habitat a limiting factor? Is fish production a function of available habitat?

The major factors determining the distribution and abundance of fishes on coral reefs are controversial (Hixon and Beets 1989). The hypothesis that structural shelter is a primary limiting resource for reef fishes was proposed by Smith and Tyler (1972). In contrast, Doherty and Williams (1988) stated that there is little evidence for resource limitation for reef fishes and that populations are strongly influenced by fluctuations in recruitment. The corollary of this is that availability of habitat would not usually be a limiting factor.

When fish stocks of the natural reefs are below carrying capacity because of exploitation, habitat is not limiting. However, even if habitat was a limiting factor, the positive impact of artificial reefs would probably be very small because the areas covered with artificial reefs in most countries are very small compared to the size of remaining natural coral reef areas.

The high abundance of fish around the artificial reefs as observed by diving, the attractiveness of artificial reefs as fishing grounds for fishers with catch rates of up to 16-20 $kg.m^{-2}$ (Polovina and Sakai 1989) and rapid fish colonization (Bohnsack 1989), all indicate that artificial reefs aggregate fish.

According to Polovina (1991) artificial reefs may result in one or more of the following impacts on marine resources:

- Biomass which is currently exploited is redistributed from natural habitat to artificial reefs.
- Biomass which is currently not being exploited is attracted to artificial reefs to increase the total available exploitable biomass without increasing stock size.
- Stocks which are limited by high relief habitat can increase.

The aggregating capacity of artificial reefs increases the catchability of fish. If the catches exceed the maximum potential new production, then artificial reefs are functioning primarily as a benthic fish aggregating device and can contribute to the depletion of fish stocks if resources are already overexploited (Bohnsack 1989; Polovina 1991).

The impacts of artificial reefs on fisheries production in Shimamaki, Japan were investigated by Polovina and Sakai (1989). The result showed that only octopus catches were increased (by 4% per 1,000 m^2 of artificial reef or by an average of 1.8 $kg.m^{-2}$). Flatfishes were aggregated by artificial reefs but production for the region did not increase.

Fig. 1. The tire module deployed in Negros Oriental, Central Visayas, Philippines.

Artificial Reefs in Negros Oriental, Philippines

In the Philippines, as in many other countries, artificial reef programs have been promoted in response to declining fish populations and catch rates (Polovina 1991; authors' observations). Proponents expect that through the additional habitat offered by artificial reefs, fish production will be increased. Some proponents of artificial reefs in the Philippines argue that since natural reefs are destroyed by destructive fishing methods and siltation, artificial reefs are needed as a substitute. Additionally, in the Philippines, most natural reefs are considered highly exploited or overexploited due to the large number of fishers (Vande Vusse 1991; Pauly and Saeger 1992).

The great abundance of fish on many artificial reefs, as observed by divers and documented by underwater videos, as well as high catch rates from artificial reefs have helped to convince people of the positive effect of artificial reefs and made artificial reef programs popular, especially among nonscientists.

Since 1991, 174 artificial reef clusters have been established in 75 sites off Negros Oriental covering about 12,200 m^2. Surveys by Alcala (unpubl. data) covered 4,122 km² of the coral reef area in Negros Oriental. If fish production is a linear function of habitat, the artificial reefs could increase fish production by <0.3% only.

In Negros Oriental, such artificial reef cluster consists of 32 modules. A module consists of a cement cross as a base and two old tires (one small, one big) which are split almost into two halves (Fig. 1). Each module covers roughly one square meter. Mostly, the modules are not placed very near together and a cluster of 32 modules usually cover about 70 m², with some variations between different reefs, depending on arrangement of the modules and the degree to which the modules are scattered.

The 174 tire clusters cost P1,812,210 (P10,415 per cluster) excluding installation and labor costs. The establishment of marine reserves may be less expensive.

Preliminary eval ations of monitoring data gathered by the Resource Management Division of the Provincial Planning and Development Office in Negros Oriental indicate the strong aggregating capacity of artificial reefs. The following calculation demonstrates that even if the artificial reefs cover only a small percentage of the existing natural coral reef area they can severely contribute to overfishing.

About 25% of the artificial reefs area in Negros Oriental was monitored. The site in San Miguel, Bacong, serves as an example for the method applied to eight other sites. Members of a fishers' association in San Miguel, Bacong, took 1,510 kg fish from three artificial reef clusters during a period of one year (May 1993 - April 1994). These tire clusters cover an area of about 210 m² and are located at a depth of 15 m. All catches within 50 m distance from the artificial reefs were recorded daily by the fishers. Since the surrounding area consists of barren sand, production there was assumed to be neg-

Table 2. Location, area covered and estimated annual yield per square meter of Negros Oriental artificial reefs.

Site	Artificial reef area (first period) (m²)	Catch (first period) (kg)	Artificial reef area (second period) (m²)	Catch (second period) (kg)	Annual harvest harvest (kg.m⁻²)
Bangcolotan (Zamboanguita)	600 (12)	378			0.6
Masaplod Norte* (Dauin)	315 (10)	293	455 (2)	135	1.2 (0.9+0.3)
Dayoyo* (Jimalalud)	70 (9)	117	140 (3)	38	1.9 (1.67+0.27)
Jilocon* (San Jose)	280 (6)	432	420 (6)	203	2.0 (1.5+0.5)
Jugno* (Amlan)	210 (3)	347	280 (9)	276	2.6 (1.6+1)
Inalad* (Siaton)	420 (6)	635	630 (6)	1,787	4.3 (1.5+4.3)
Lutoban (Zamboanguita)	140 (12)	790			5.6
Dalakit (Zamboanguita)	105 (12)	815			7.7
San Miguel (Bacong)	210 (12)	1,510			7.2

*The artificial reef area was increased during monitoring. The figure in brackets represents the number of months the monitored artificial reef had the given size. The catch in kg.m⁻² was calculated separately for the two periods with different sizes of artificial reef area. The two calculated values were totaled for the annual harvest.

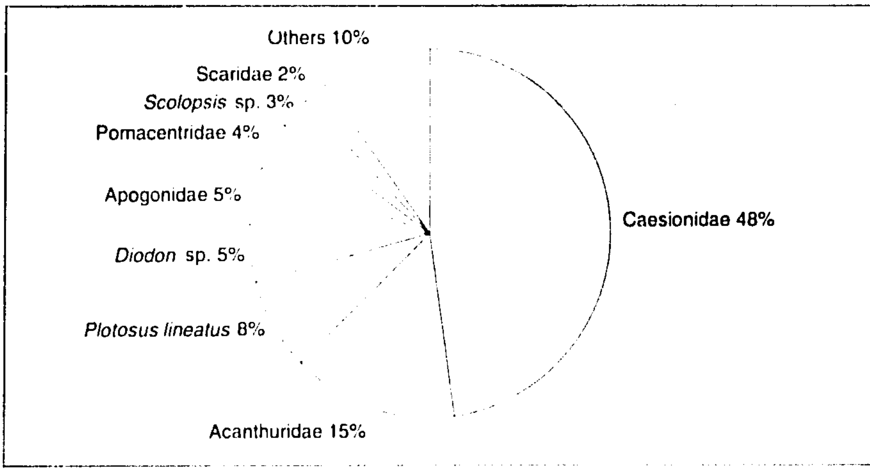

Fig. 2. Composition of catch from an artificial reef in San Miguel, Bacong, Negros Oriental, Philippines in May 1993 (total of 168 kg).

ligible and the following calculations are based on the 210 m^2 covered by the artificial reef cluster. Data for the nine sites are shown in Table 2.

The average annual harvest based on the nine monitored artificial reefs representing 25% of the total artificial reefs area in Negros Oriental, is 3.0 $kg.m^{-2}$. For natural coral reef areas Alcala (1981) reported high values around 20 $t.km^{-2}$ or 0.02 $kg.m^{-2}$. It seems that the yield from artificial reef sites can be about 150 times higher than the yield from natural coral reefs.

An analysis of the total catch in May 1993 from the San Miguel artificial reef show that schooling planktivores provide the greatest biomass (Fig. 2). According to Vande Vusse (1991) these species provide the greatest volume of reef fishes in heavily fished coastal waters.

Can Artificial Reefs Be Successfully Managed?

There is no doubt that artificial reefs enable fishers to save time and fuel, reduce fishing effort and locate fish more predictably (Bohnsack 1989). But according to our observations, management of artificial reefs in the Philippines is poor or management policies are nonexistent (see Vande Vusse 1991).

Government agencies have to fulfill their physical targets (numbers of clusters installed), which sometimes results in wrong placement of artificial reefs. Monitoring is poor or nonexistent. The locations of artificial reefs installed under some programs are not properly recorded.

Artificial reefs are mostly used as fishing grounds without any fishing regulations and are heavily exploited in some sites. Potential negative impacts of artificial reefs are generally unknown to fishers, who strongly believe that fish populations are enhanced by the artificial reefs. There are a few fishers' associations which protect their artificial reefs as marine sanctuaries.

Even if new laws would be formulated to regulate fishing activities in artificial reefs, implementation of laws has always been a big problem in the Philippines. Absence of policies on ownership and fishing rights aggravate the problem and lead to social conflicts.

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Discussion

Convenor: G. Silvestre
Rapporteur: A. Cabanban

The topic paper presented evidence that artificial reefs have little impact on overall fish production, but have strong aggregating capacities, leading to ultimate depletion of stocks. They have high biomasses of planktivores. Artificial reefs may be expensive and difficult to manage.

The ensuing open forum brought forth many questions and discussions. These are summarized below:

Utility of Artificial Reefs

Different views were held regarding the utility of artificial reefs.

- It was argued that they are beneficial if settlement, recruitment, and colonization are allowed to occur. They are thus useful for rehabilitation of degraded areas by providing alternative substrates and shelter for settlers and may also increase the biomass of the fish populations.

- The alternative view was that they are aggregating devices. Adult fishes seen at the early stage of reef deployment are not from recruitment. Rather, these individuals have strayed from natural reefs and found shelter in the artificial reefs. If these individuals are fished, the artificial reefs are actually serving to aggregate individuals from already overfished stocks.
- It was agreed that the uses of artificial reefs can range from rehabilitation devices to aggregating devices. Artificial reefs may also be used for development of new habitats. This requires time for colonization by marine organisms but it has a long-term benefit as such artificial reefs can become part of the underwater landscape. However, managers would need to provide assistance to fishers who are displaced.

Yields and Productivity

Direct comparative studies on the yields of artificial and natural reefs are lacking.

- Artificial reefs need to be monitored to document increases in production and for comparative studies to be made between artificial and natural reefs.
- Caution should be exercised in comparing yields from artificial and natural reefs without looking at the scale, depth, and zone of the reefs being compared.
- Furthermore, comparisons of biomasses should consider the kinds of fishes and the comparative physical three-dimensionality of artificial and natural reefs.
- Observed harvests near artificial reefs are not necessarily due to productivity within the reef but also derive from the productivity of nearby reefs, adjacent level bottom and pelagic habitats and the ecosystem as a whole.
- Planktivorous fishes, such as caesionids, and other filter feeding organisms feed on plankton from passing currents and thus aggregate this source of energy within the artificial reef. This forms the basis of new or enhanced food chains.

Management

The preliminary result of the study, which suggested that artificial reefs attract fishes from natural habitats and therefore increase the catch-per-unit effort was stressed.

- Artificial reefs are effective fishing gears, concentrating both fish and fishing effort in a specific area.
- This requires management of the fishing on the installation. The management options presented by various participants included no fishing, the regulation of fishing gear, regulation of number of fishers (in a cooperative system) and regulation of fishing with regard to distance from the installation.
- It was suggested that the management of artificial reefs should not be separated from management of the local fishery. In addition, the manager should also distinguish nominal fishing versus effective fishing.

There are many cases in the Philippines where the management of artificial reefs failed or was ineffective. Failures were attributed to the use of unregulated gears and to poaching by fishers who had not participated in the construction of the artificial reefs.

- It was suggested that fishers should be educated as to the proper regulation of fishing and that this should be demonstrated in small artificial reefs.

- Furthermore, artificial reef management may be used to promote the management of natural reefs.
- The seasonality of fishing should also be considered in the management of artificial reefs. Spatial and temporal effects of artificial reefs are not well understood. For example, caesionids are not always present on artificial reefs.
- The regulation of the number of fishers (in a cooperative system) is a form of privatization of common property. Local government units have instituted legal ownership of artificial reefs, giving preference for local fishers.

Socioeconomics

- Cost-benefit analysis, in terms of harvests, shows that returns from artificial reefs are very low. However, if artificial reefs are used as a means to introduce other management schemes (limited entry, mesh regulations) or alternative uses (marine parks, mariculture) then relatively greater benefits might accrue.
- Evaluation of artificial reefs must be comprehensive, including socioeconomic and political issues.
- Overexploitation of coastal fisheries in the Philippines must be addressed by the reduction of effort and in conjunction with changing the open-access exploitation of the fisheries.

Future Prospects for Artificial Reefs in the Philippines*

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McMANUS, J.W. 1995. Future prospects for artificial reefs in the Philippines, p. 33-39. *In* J.L. Munro and M.C. Balgos (eds.) Artificial reefs in the Philippines. ICLARM Conf. Proc. 49, 56 p.

Abstract

The coastal waters of the Philippines are generally overfished to the point of having more than twice as much fishing pressure as necessary for optimal harvests. Artificial reefs are commonly justified either as structures to attract fish for easy exploitation, or as a method to improve fish production by increasing the amount of habitat area suitable for breeding or rearing harvestable fish. As fish attracting devices, artificial reefs exacerbate the already serious problem of overfishing. However, at an estimated construction cost of US$3 to $6 per m² ($3 million to $6 million per km², not including diver costs), it would be far more cost effective to concentrate efforts on more certain ways of improving fishery production such as the establishment of marine reserves and the alleviation of fishing pressure through the implementation of alternative livelihood programs.

Introduction

Is an artificial reef program a rational approach to conservation and fisheries management in the Philippines? This question has many facets. Several of the key issues have been discussed elsewhere in this volume. This paper focuses on selected issues from a national planning standpoint, including the aspects of practicality and the optimal use of public funds.

The Philippine Fisheries Situation

The Philippines is in a state of overfishing at a national scale. Studies have clearly demonstrated that trawl (Silvestre and Pauly 1986), pelagic (Dalzell et al. 1987; Trinidad et al. 1994) and artisanal (Fox and FRMT 1986) fisheries are overfished. Where bioeconomic analyses have been conducted, the result has been to recommend a reduction in the fishing effort of at least 60% of that now in place. In general, it appears that most of the country is now or will soon be overfished by more than twice the labor force it should have in order to optimally harvest the available fish stocks (McManus et al. 1992). Programs in the last two decades to improve the lot of fishers through loans to improve boats and gear have succeeded only in exacerbating the situation (Smith 1981). The rapid population growth rate, inequitable use of resources and relatively open-access fisheries have led to a state of Malthusian overfishing, in which fishing methods harmful to the environment, and to the fishers

*ICLARM Contribution No. 1140

themselves, tend to proliferate (Pauly et al. 1989). Thus, coral reefs throughout the country are being doused with poisons, blasted with bombs and scoured with suicidal "hookah" diving gear in efforts to hunt down the remaining adult fish (McManus et al. 1992). Stocks of fish seem to be replenished, in spite of this overfishing, by influxes from offshore, mainly subsurface reefs. However, many potential sources of juvenile fish, such as the Spratly Islands, face growing threats (McManus 1994).

The abuses to coral reefs from overfishing and destructive fishing compound the similarly growing problem of reef demise due to siltation from deforestation, pollution from densely-packed coastal towns and cities, and a variety of other problems. Fisheries and coastal zone management in the country are now largely exercises in desperately seeking ways to diminish fishing pressure and to protect the remaining natural coastal ecosystems through the development of appropriate alternative livelihood programs. The latter have consistently proven to be difficult to design and initiate, given the limited resources of each municipality, their dominance by wealthy families, difficulties in societal transitions, rampant illiteracy and its effects on trainability, the need for active market development, the lack of government funds, and the bureaucratic hindrances to the effective application of existing funds to the problems at hand. The rate of implementation of such projects is unlikely to keep up with the rapid rise in the target populations, and the latter is maintained in part by strong resistance to government family planning programs from influential private sectors. It is within this context that artificial reefs have been turned to increasingly as an option for coastal zone management.

Scale and Economic Considerations

A review of four studies of artificial reefs in the Philippines for which species or family lists have been published reveals that all sites were dominated by coral reef fish (Murdy 1979; Barreto 1986; Diaz 1994; Waltemath and Schirm, this vol.). These include primarily grazers (e.g., many pomacentrids), planktivores (e.g., caesionids) and piscivores (e.g., lutjanids). The few exceptions include principally a few transient groups of nonreef planktivores such as atherinids and leiognathids (e.g., Barreto 1986). This pattern persists even when the reef is apparently several kilometers from the nearest natural coral assemblage. Artificial reefs in Japan and elsewhere are sometimes dominated by pelagic species, but this has not been the case in the published Philippine studies (caesionids are sometimes considered to be pelagic, but they rarely occur outside waters over coral assemblages and artificial reefs). A study of charts and topographic maps of the country reveals that there are very few areas of the Philippines which are not within 10 km of some kind of coral assemblage. Exceptions to this include relatively straight coastal areas of shifting subsurface sand dunes, such as the inside of the Lingayen Gulf, and these would often be unsuitable substrates for the establishment of artificial reefs. Thus, it is clear that the debate over artificial reef deployment in the Philippines is one concerning coral reefs and associated fisheries, rather than nonreef demersal or pelagic fisheries.

The coral reef area of the country was estimated to be approximately 27,000 km^2 by Carpenter (1977), using charted reefs and adjacent bathymetry estimates.

McManus and Arida (in press) estimated areas of uncharted pinnacle reefs in two areas of the country to a total of 5,000-10,000 km². Thus, the total reef area of the country is probably between 30,000 and 40,000 km².

Most of the artificial reefs of the country have been installed under a few large-scale programs — the Artificial Reef Development Program of BFAR which installed around 5,188 tire modules and 66 bamboo modules, the Philippine Fisheries Development Authority's program which installed 8,099 bamboo and ipil modules, the Central Visayas Regional Project which installed 26,000 bamboo modules, the Calancan Bay Rehabilitation Program which installed 848 tire modules, 1,134 concrete modules and 18 bamboo modules, the National Power Corporation's program which installed 816 tire modules, and the Fisheries Sector Program, accounting for 7,472 tire modules, 455 concrete modules and 45 bamboo modules (Balgos, this vol.). This totals to 50,141 modules which have been installed since 1979. Assuming that the modules constructed from natural materials have decayed by now, and that perhaps another 2,000 tire or concrete modules have been installed in smaller programs, we can estimate that approximately 18,000 modules are currently present in Philippine waters.

Waltemath and Schirm (this vol.) report that 174 clusters of modules covering 12,200 m² (with 50% bottom cover) cost P1,812,210 (US$70,000). This comes to approximately $6 per m² ($6 x 10⁶ per km²). However, their estimated cost of P10,415 per unit is approximately twice as high as some other estimates, such as that of the SEAFDEC project reported in Balgos (this vol.). Thus, a lower estimate of bottom coverage would be $3 per m². Thus, assuming that one could, in fact, replace true reefs with artificial reefs, then replacing all the coral reefs of the Philippines would cost, pairing low values with low areas and high values with high areas, between $90 billion and $240 billion. In order to even show a significant impact on national coral reef fisheries, one would probably have to install at least 10% of the natural reef area, at a cost of at least $9 billion to $24 billion. Note that the two studies mentioned did not include adequate estimates for diver costs, and so the actual deployment cost may be far greater.

However, a large-scale project of this type would entail rising costs as materials became scarce. It has been estimated that there are 2.1 million vehicles in the Philippines. At roughly five tires per vehicle, this means that there are about 10 million tires in current use. The figure of 11,136 tires in an artificial reef covering 12,200 m² (Waltemath and Schirm, this vol. - each module was constructed from two tires) gives us approximately 1 m² per tire. Ten million tires could be deployed to cover 10 million m², or 10 km² or 0.025-0.033% of the area of coral reefs. Of course, tires are used for a variety of products in the Philippines, such as trash cans, barrels and planters. As excess tire accumulations are depleted, additional costs would accrue from competition for other uses and increasing transportation distances. The program would have to turn increasingly to alternative materials, such as concrete. The volume of cement to be used would be substantial in a country where cement shortages and ensuing "panic buying" is common. This would lead to rising prices for the program.

Rubber tires gradually lose strength over time in the ocean, and little would remain after 40 years (Sato and Yoshioka 1982). The materials used to bind the tires together may last far shorter times, particularly when stressed by tangled fishing lines or subjected to blast fishing. Concrete structures can last much longer. However, this depends greatly upon the design of the module, type of cement and the care taken to construct the module. Various marine salts interact with the concrete, most prominently magnesium sulfate which forms complexes with the concrete which expand and heat up, cracking surrounding areas. Assuming that moderate care has been taken in the construction of the modules, many would have to be replaced every few decades. The use of metal waste such as used vehicles would also be severely limited by supplies and competitive use, and metal deteriorates much faster than well-made concrete, particularly at welding points (Sato and Yoshioka 1982).

The need for replacement would not be as much of a problem if the structures were designed to serve as substrates for replacement by natural reef material. However, coral reef accretion rates are often reported to be in terms of one or a few centimeters per year. A structure designed to initiate a substantial accretion within a few decades, prior to its own demise, would generally be low and very solid, a design which conflicts with the high profile, open structural orientation of most modern modules designed to attract fish (Brock and Norris 1989).

Habitat Limitation

Polovina (1989) pointed out that there would generally be no lack of fish habitat in an overfished ecosystem. Recruitment overfishing generally implies that stocks have been reduced below 50% of their virgin biomasses. Thus, there should generally be an excess of habitat area for the remaining fish. In the Philippines, the problem is not quite so simple because of Malthusian overfishing, which fosters habitat destruction in addition to recruitment, growth and ecosystem (i.e., shifts to unfavorable species composition) overfishing. Even where habitats have not been destroyed the proliferation of conventional fishing methods is such that available reef habitats near shore are generally fished to scarcities which are uncharacteristically extreme for existing habitats (e.g., 70 adult fish per hectare on a Bolinao reef slope - McManus et al. 1992). Thus, Polovina's point is valid even in the Philippine context.

Competing With Natural Reefs For Fish

The average coral reef fish species is believed to remain in a pelagic state for 3 - 4 weeks before settling on a coralline habitat. Many apparently wait 1-2 months before settling (McManus 1994). There is considerable debate as to which, if any, settle on their natal reefs and which settle on downstream reefs, and in what proportions under various circumstances (Leis 1991). There has been concern that artificial reefs might deplete schools of settling postlarvae before they encounter natural habitats. Given that it is virtually impossible for workers in the Philippines to construct artificial reefs which would amount to any more than a small fraction of a per cent, of the area of existing reefs, this would certainly not be a general problem in the foreseeable future.

However, concerns about the effect of artificial reefs in depleting existing adult fish stocks are quite reasonable. It is clear that most artificial reefs in the Philippines become inhabited very rapidly, in terms of weeks or months, far too quickly for the fish to have settled and grown to observed sizes. Polovina (1989) has pointed out that reported harvest rates greatly exceed those expected from juvenile recruitment. One can expect that an artificial reef placed near or on a coral reef would tend to attract adult fish from places where they had managed to escape fishers, to one in which they can escape no longer. Artificial reefs would be potentially useful if placed in fisheries reserves and used to augment the capacity to enhance fish populations in adjacent areas. This would be reasonable if there were strong guarantees that the structures would never be fished. However, it is doubtful that even in this context, it would be more effective in the long run to put time and money toward such construction rather than toward programs to ensure the success of the reserves.

Other Uses for the Money

Alternative approaches to coastal fisheries enhancement have been discussed by Munro (this vol.). As noted above, financial constraints significantly hinder the implementation of alternative livelihood programs. A second constraint is the lack of trained professional environmental scientists and community organizers. It would be reasonable to concentrate both limited money and human resources on more certain approaches to fisheries management than artificial reefs.

Nonreef Areas

Some uncertainty remains with regard to the potential benefits of installing artificial reefs in areas far from coral reefs (i.e., several tens of kilometers). One factor would be related to the reasons why such an area is not suitable for coral reef growth. Coral reefs cannot grow in areas of excessive nutrient or sediment loading. In the former, an artificial reef which served as a platform for algal growth might be reasonably desirable. Such growth might absorb excess nutrients and support fish populations. However, if the high nutrient levels were a result of pollution from human wastes, then contamination of the fish would be a concern.

Many areas of nonreef coastline, such as the coast of La Union Province, are characterized by sandy bottoms and shifting sand bars. Burial by sand bars would be a constant concern. Even in the absence of sand bars, there is often a strong tendency for structures to accumulate sand and silt, and to sink into the substrate due to constant vibration and shifting of the particles.

A major consideration in programs to introduce artificial reefs to nonreef areas is the human dimension. Imagine a village with a history of the use of drifting gill nets and long (0.25 to 1 km) beach seines suddenly being presented with a small, potentially profitable coral reef type fishery. Who will have the right to fish there? How will outside entrants be limited? Who will be responsible for and pay for regulation enforcement? Who will maintain the structure? There are many complex issues to be settled in such an enterprise. The lack of agreed access arrangements prior to artificial reef deployment can lead to problems such as dominance of the resource by a powerful few and the blasting of the reef as a competitive strategy. Other difficulties have been discussed by Ferrer (1991). Given the mobile, excess labor force in the country, any such structure which is not well defended at great cost in time, effort and money will eventually be overfished to the point of minimal net profit. Any benefits which would accrue to the average villager would be temporary and would generally diminish because of new entrants, or through efforts to prevent such resource sharing.

It is widely acknowledged that a supplemental or even primary objective in the placement of some artificial reefs is the prevention of encroachment of trawlers into artisanal fishing grounds. This purpose is quite distinct from those of fishery enhancement and habitat restoration. It would seem desirable for structures to be used in such a context to be designed to maximize their trawl-stopping properties, and to minimize their use as a fishing gear by subduing their fish-attracting properties. This would prevent a fisheries protection device from adding to the overfishing problem. Thus, simple concrete structures with minimal shelter characteristics might be optimal, such as the simple concrete bar arrangements used in the Central Visayas program (Balgos, this vol.). The cost effectiveness of such devices versus alternative means of trawler control is beyond the scope of this paper.

Tourism Potentials

The international diving community is often at the forefront of artificial reef promotion. There are many examples of tourist businesses being established on or greatly enhanced by the presence of shipwrecks, whether intentionally placed or not. Sunken airplanes appear to be great tourist draws, and some notable success has been reported from the use of sunken luxury automobiles.

Such uses are distinct from the use of artificial reefs to enhance fishing yield. Tourism potential would generally be highest if such structures were not fished at all. There is some chance that such protected structures would be a source of postlarvae for nearby fished zones, but only substantial developments would contribute significantly in this manner.

Conclusions

Given the current limitations of public funds in the Philippines, it is doubtful whether any funds should be used to construct artificial reefs. This money would be best directed to the major problem of alternative livelihood generation, and the prevention of further environmental deterioration. Tourist enhancement is a commercial enterprise, and thus one which should be feasible within the investment-profit strategy of a coastal establishment or diving organization. Efforts to prevent trawlers may or may not utilize deterrent structures in the future, but the confusion in purpose of the structures could be minimized through the use of terms such as "trawl deterrent" rather than the already misleading term "artificial reef".

Acknowledgements

I would like to thank John Munro, Garry Russ, Daniel Pauly, Miriam Balgos, Maike Waltemath, Porfirio Aliño, Liana McManus and others for helpful discussions on topics which have been addressed in this paper.

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Discussion

Convenor: J. Muñoz
Rapporteur: G. Russ

The questions and discussion that followed the presentation fell into the following broad categories:

Alternative Livelihoods

Much of the initial discussion centered upon this topic, as this was the area targeted by the speaker as the prime alternative to funding for artificial reefs.

- A comment was made to the effect that in suggesting that the solution was creation of alternative livelihoods, the biologists were simply passing the problem to another sector, the economists.
- Some discussion of alternative livelihoods ensued. Examples were cited for village level efforts in Mindanao, Carigara Bay, Visayas (loans provided to fishers for backyard gardening, raising terrestrial animal stocks, purchase of pedicabs) and Bolinao, Luzon (e.g., using *Sargassum* cooked with ash from coconut fronds to produce fertilizer for sale).
- A point was made that great problems exist with such programs, particularly where collateral, such as land is required by fishers to receive the loans. It was emphasized that such programs must be low capital/high employment ventures.
- The "Participatory Resource Evaluation" system at Bolinao was cited, in which the community itself examines its potential resources and sets up lists of potential alternative livelihood projects.
- The users of artificial reefs are usually poor fishers. Their response to alternative livelihoods will be: how long will it take? what will I do while waiting? Without artificial reefs or marine reserves what can we offer as alternatives if the fishers want to retain strong links to the sea?
- Alternative livelihoods such as mariculture may affect the marine ecosystems almost as much as overfishing if the scale of the mariculture exercise was excessive.

The Bioeconomic Resource Model

- Regarding the bioeconomic resource model, it was asked if in many cases fishers are actually running at a loss consistently rather than breaking even, with financial subsidies from family members keeping fishers viable. It was stated that many fishers can operate at a loss for long periods but continue fishing because of the chance of an occasional good catch. In small-scale fisheries where capture costs are low and opportunity costs are low, the chance of the occasional good catch is a strong incentive to continue fishing.
- Most of the fisheries in the Philippines have twice the number of fishers for Maximum Economic Yield (MEY).

The Future of Artificial Reef Programs in the Philippines

- If there is no prospect for artificial reef programs in the Philippines and elsewhere, why are they in the Fisheries Sector Program (FSP)? What should be recommended for the other artificial reef programs in the Philippines?
- It was noted that it took many years to convince funding agencies not to fund programs which increased fishing efficiency (which may be counterproductive).
- Several people expressed the view that since artificial reef programs do exist, this workshop must explain some of the problems of artificial reefs as a fishery management tool and the statement of the workshop should be some form of compromise, rather than a flat 'no' to artificial reefs.

The Dilemma of Funding Agencies over Artificial Reef Programs

- Faced with goals of poverty alleviation and development of resource management projects, some compromise view on artificial reef projects was needed, not total abandonment.
- It will be difficult to say no to funding agencies wishing to fund artificial reef programs and to convince them of the negative case with graphs and models. Funding agencies view alleviation of poverty and restoration of resources as more pressing.
- What is needed is advice from experts on how to proceed, given such circumstances and views of funding bodies.

The Dilemma of Community Organizers if Such a Workshop Rejects the Idea of Artificial Reef Programs

- The point was made that community workers and advisers such as Peace Corps volunteers and NGOs may lose considerable credibility within their communities if they must reject the artificial reef concept after having spent considerable time and effort convincing the community of their benefits. This would be doubly difficult if the community perception of artificial reefs was good, as a result of improved catch rates.

The Role of Artificial Reefs as "Rallying Tools" for Village Fishing Communities

- A community organizer from Bolinao pointed out that artificial reefs serve as an important community organizing or "rallying tool". Would it be possible to continue artificial reef programs in order to maintain their value in this context?

Marine Reserves as "Alternative Rallying Tools"

- Some suggested the creation of marine reserves as an alternative to artificial reefs to act as community "rallying" tools. They have already been very successful in this regard in the Philippines.
- McManus had previously stressed the need for alternatives to artificial reefs in this regard to get villagers thinking about other things (e.g., marine reserves, the community planning options developed by Dr C. Lightfoot (ICLARM) and colleagues in farming communities.

Funding for Monitoring and Stock Assessment in Artificial Reef Programs

- The importance of rehabilitating fish stocks was noted. An artificial reef context is one potential part of this.
- If artificial reef programs proceed, clear objectives must be stated and adequate funding made available for objective monitoring and stock assessment to try to build up data on whether or not artificial reef programs affect yields.

A Small Paper/Pamphlet Summarizing the Views and Recommendations of the Workshop

- It was proposed that in addition to the workshop proceedings, a paper or glossy brochure summarizing views and recommendations of the workshop would serve to make the outcome of the workshop more accessible to policymakers and funding bodies.

Alternative Strategies for Coastal Fisheries Rehabilitation*

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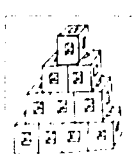
MUNRO, J.L. 1995. Alternative strategies for coastal fisheries rehabilitation, p. 42-51. *In* J.L. Munro and M.C. Balgos (eds.) Artificial reefs in the Philippines. ICLARM Conf. Proc. 49, 56 p.

Abstract

Alternative uses are proposed for financial resources devoted to the construction and installation of coral reefs. These include environmental management and rehabilitation, the development of community-based resource management or co-management systems, the creation of marine protected areas, active management of fish stocks and fisheries enhancement for selected species.

The benefits and constraints of these alternatives are evaluated and it is concluded that many of these options should be given priority over the installation of artificial reefs.

Introduction



This review is presented in the context of a workshop on the use of artificial reefs and their positive and negative features. Their popularity in many quarters is partly attributable to the publicity which often surrounds their installation. This makes them politically popular and also readily fundable from public or private sources. Installation is often a community-based effort, or at least has public involvement, leading to a sense of community achievement and pride in the accomplishment.

Undoubtedly, artificial reefs are often good fishing spots, particularly for recreational anglers, but the issue of whether or not they are merely serving as fish aggregation devices and thus concentrating the remaining resources remains unresolved. Artificial reefs can also serve as obstructions to trawlers and have been advocated for use as devices to exclude trawlers from inshore waters and reserve such areas for small-scale fishers (Munro and Polovina 1984). Such interventions require careful economic evaluation to weigh possible production losses against putative social benefits. Different fishing strategies would also need to be defined under such circumstances.

Negative features include the destruction of insubstantial artificial reefs by storms, or the decomposition of elements in the construction, leading to low profile benthic garbage dumps embedded in the soft sediments. This applies particularly to artificial reefs constructed from bamboo, used vehicle tires and scrap metals.

Where access to artificial reefs is restricted to the "owners" or selected groups of users, the social or economic aspects of the

*ICLARM Contribution No. 1141

privatization of part of the resource system need to be examined.

However, the foregoing begs the question of why artificial reefs should be needed in the first place. If the objective is the diversification of habitats by, for example, the creation of a foundation for a natural coral reef in an otherwise uniform soft-bottom habitat, then there is no question that this will benefit the biodiversity of the area and, provided that shipping and other fishing interests (trawling, purse seining) are considered, could be of overall public benefit. If a "new" coral reef is established, local fish productivity will undoubtedly increase.

However, if the artificial reefs are proposed merely as substitutes for degraded natural reefs, in an area where sufficient rocky substrate already exists, then the installation of artificial reefs becomes pointless. Instead, attention should be given to alternative strategies for protecting or enhancing the marine environment and managing the resource system.

Alternative Management Strategies

Environmental Management and Rehabilitation

It can be assumed that the objective in managing a marine resource system is to ensure sustainable economic and social benefits for the community as a whole. The first step is therefore to ensure the protection of the marine environment by a systematic appraisal of the causes of degradation and sources of environmental contamination by pollutants and toxins (Fig. 1). This is, as is very well known, very difficult in the face of extremes of population density, poverty and ineffectual legislation.

Urban infrastructures have been overwhelmed by rapid urbanization and urban migration throughout the poorer countries of the world, leading to inadequate treatment of domestic wastes and the accumulation of organic and inorganic garbage. Low purchasing power in the population means that industrial enterprises take short cuts in production processes or use outmoded technology, increasing the loads of contaminants and pollutants which, almost inevitably, find their way into the water courses and into the sea. Deforestation, poor land use, mining and road construction all lead to erosion and siltation, one of the primary causes of degradation of coral reefs.

The only solution to these problems is properly enforced environmental legislation, starting at the watershed and moving downstream until all sources of pollution are eliminated or at least controlled. The twin specters of poverty and corruption most often combine to render such efforts ineffectual. Infusions of money are only effective if the funding finds its way to the community level. Control of pollution can best be effected at the community level, but only if the community has sufficient knowledge and motivation to implement or demand effective controls. In short, this is difficult to achieve, but without this all else fails. Clearly, it is more achievable in the rural areas.

Where the prime causes of degradation are eliminated or curtailed, work on rehabilitation of degraded areas can be undertaken, such as restoration of mangroves, seagrasses and coral reefs. In many cases this will proceed naturally if the problems are removed; but in most cases the process can be accelerated by a systematic replanting or rehabilitation process. Control of replanted areas is a problem and conflicts can arise over the use of replanted areas.

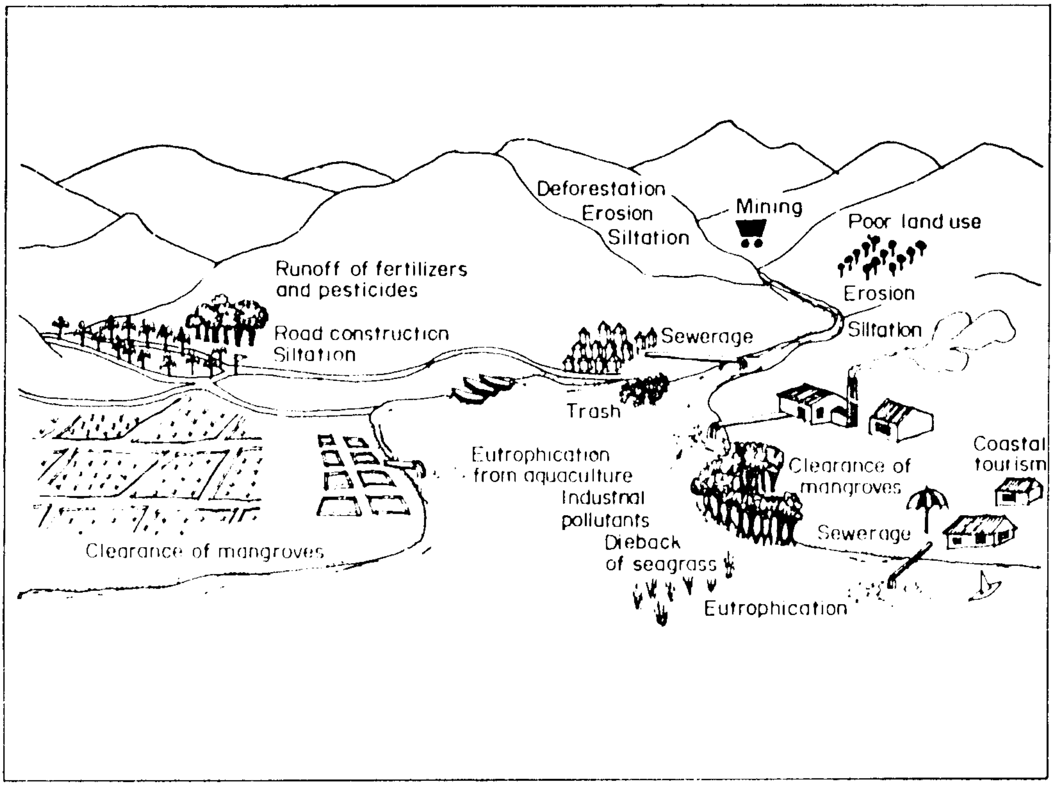


Fig. 1. The environmental scenario in developing countries in which the coastal ecosystem is adversely affected by a wide variety of land-based activities.

Community-based Management Systems

One of the most obvious factors which has emerged from many years of attempts to manage fisheries is that few systems work if they do not have the support of the fishing community. The same applies to management of other natural resource systems such as forests. Irrigation schemes have also been successfully managed on a communal basis.

Community-based systems in which the community acts independently or, more realistically, co-management systems, in which the community acts on the basis of authority conferred by government and with the active support and collaboration of government, are currently perceived as the only-way-to-go (if only because all alternatives have failed).

Co-management or community-based management implies that the community will be able to perceive and effectively implement a management strategy. Such strategies could encompass the creation of marine protected areas, fish stock management, fish stock enhancement or habitat enhancement. The corollary to all these is that the community exerts political pressure to ensure that the environment is maintained in the best possible condition.

Marine Protected Areas

The establishment of marine protected areas (MPAs) in various forms is becoming a popular management option (Davis 1989; Bohnsack 1993; Russ 1994). Well-established MPAs are considered to be beneficial to fisheries for a variety of reasons. In the first place, harvestable resources

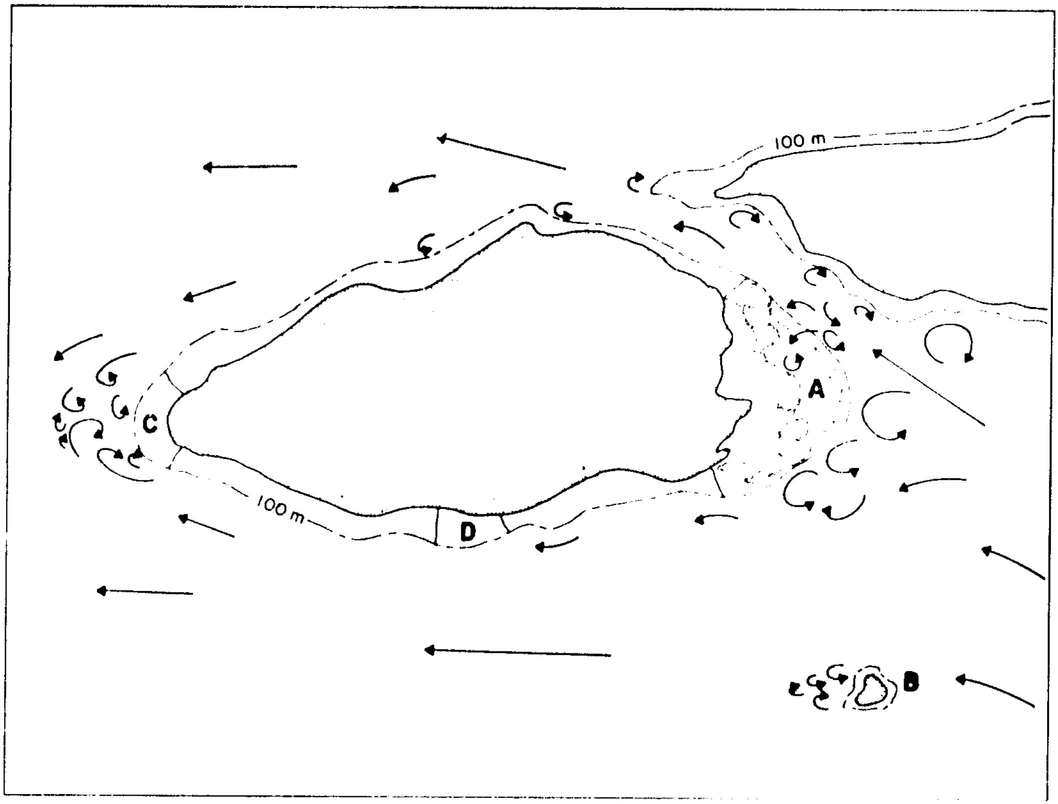


Fig. 2. The effectiveness of a marine protected area in enhancing harvests and as a management tool is strongly influenced by its size and siting relative to exploited parts of the continental or island shelf. In this hypothetical example, larvae spawned in a topographically complex area (A) would be expected to be retained in the spawning area by eddies or distributed along the coasts of the island. In contrast, larvae spawned at an isolated oceanic reef (B) or along a relatively straight stretch of shelf (D) are likely to be entrained by currents and swept into deep waters. Eddies and gyres at the downcurrent end of an island (C) may return some larvae but most would also be swept into deep oceanic waters.

will grow to a relatively large size and progressively move out of the reserve and be harvested. In effect, the age and size at recruitment to the fishery is delayed, with the average size of recruitment being a function of the relative mobility of the species. Species which are small or strongly site attached might never move out of the MPA in which they initially settle and therefore never become exploitable. Highly mobile species may range in and out of an MPA at will and thus benefit only from a slight reduction in mortality rates. These effects are also dependent upon the size of an MPA. Most of the harvestable resources in extremely large MPAs will never encounter the border and never become fishable. Very small MPAs will be ineffective in that almost all of the important fisheries resources will frequently cross the boundaries (DeMartini 1993). However, there are currently no criteria for establishing an optimum size for an MPA (Salm and Clark 1984; Carr and Reed 1993) (Fig. 2).

A second benefit from MPAs lies in the accumulation of resident broodstock of large average size which will spawn and serve as major sources of recruits. The essence of this strategy is that fecundity increases dramatically with increasing size and that very large females produce very large numbers of eggs. For this strategy to be effective, the MPA must be of sufficient size to ensure that outmigration and consequent harvest of the broodstock is an exceptional occurrence. A corollary of this strategy is that the sites of spawning aggregations must be within the MPA. An additional corollary is that the oceanographic regime should not consistently disperse most eggs and larvae into the deep ocean. Topographically-complex areas, which generate lots of gyres and eddies are probably more effective as reservoirs of broodstock than MPAs situated on small oceanic islands or on narrow linear shelves. MPAs situated on the upcurrent side of a shelf are probably more effective than those situated downstream of the prevailing current during the spawning season (Fig. 2).

MPAs come in many forms. Token MPAs in which "traditional" exploitation is permitted are notoriously ineffective, as all forms of exploitation are progressively deemed to be traditional or customary. Total protection is the ideal strategy and compromises should be avoided. Temporary areal closure is a standard fishing management strategy and should not be confused with the creation of MPAs.

Fish Stock Management

Management of a fishery resource requires a fairly detailed assessment of the state of exploitation of the component fish stocks and an effective system for enforcement of management decisions. In a co-management system the implication is that technical and scientific advice would be provided by a government agency and the management decisions would be effected by the appropriate local authority. The need for appropriate advice appears to not always be perceived by advocates of co-management. It is possible for decisions to be made which are inappropriate on biological, economic or ecological grounds, with adverse consequences either for the fishers or for the fish stock. The difficulty of making sound fish stock assessments is a major factor and the precautionary principle should apply - that management decisions should be on a very conservative basis until such time as it is shown that negative effects will not occur.

A number of simple management strategies are within the scope of local communities, based on very elementary concepts. The basic approach should be as follows:

a) Deal with the obvious problems first. For example, if spawning aggregations are being fished this should be proscribed. If certain gears are catching the juvenile stages of species that are of particular value at a larger size, the gear should be banned, at least from certain areas (nursery grounds) or at certain seasons (when the recruits are available). If predatory fishes such as sharks are abundant, they should be selectively exploited in order to enhance survival of more desirable species.

b) The institution of relatively simple data collection systems, including catch length frequencies, on a continuing basis by the local fisheries agencies in collaboration with the community can provide a basis for stock assessments. Monitoring the catch per unit of effort of selected fishers using standardized fishing gears gives a measure of trends in stocks. Such data can give simple assessments of whether stocks are under- or overfished and appropriate decisions can be made.

However, in most of the areas in which the installation of artificial reefs has been advocated, the existence of overfishing is in no doubt - this being the prime reason for the development of artificial reef projects. Usually the prime cause is an excess of fishers, a function of population growth, landlessness and poverty and the open-access nature of most marine fisheries. Control of the numbers of fishers is primarily a social problem. New fishers continue to appear in most fisheries, but recent experience in San Miguel Bay suggests that there might be a lower limit at which no further entry occurs and at which outmigration of young people to urban areas is seen as a more desirable alternative means of survival (G. Silvestre, pers. comm.). Ultimately, it becomes necessary to restrict harvest rate in a fishery, and in small-scale fisheries this usually means restricting the numbers of fishers; first by excluding nonlocal elements and, eventually, placing a limit on the total numbers of fishers by restricting fishing rights to members of the local fishers' cooperative or by some form of licensing scheme (Munro and Smith 1984).

Strategies for management of small-scale fisheries have recently been reviewed by Munro and Fakahau (1993). Customary rights have been frequently discussed (Johannes 1978; Wright 1985; Ruddle and Johannes 1985; Ruddle et al. 1992) and most authors have observed that these tend to be eroded in areas with substantial populations. The trend towards co-management would reinforce customary rights but strong opposition can be expected from those who find themselves excluded from areas to which they have previously had access. This can lead to severe, even violent, conflicts.

Fishery Enhancement

The term "fishery enhancement" includes all aspects of improvement of fisheries, including habitat manipulations such as the improvement or expansion of spawning areas or nursery grounds, the construction of artificial reefs or the release of hatchery-reared fingerlings.

Fish stock enhancement is the process whereby the abundance of a stock is increased by the release of larvae or juveniles in a given habitat. The juvenile stock can be either hatchery-reared or gathered elsewhere and transplanted. Ancillary terms such as "sea-ranching" imply a degree of ownership of the released stock while "culture-based fisheries" are those in which the stock do not reproduce and must be replenished by hatchery-reared stock.

Fish stock enhancement is currently a prime topic for research and many studies have been undertaken in Europe, North America and Japan over the past 100 years, mostly in relation to fisheries for salmon and trout. The economic viability of fish stock enhancement remains unproven in many cases. However, the dramatic improvements in the productivity of hatcheries in recent years (Sorgeloos and Leger 1990) as a result of technological advances and improved understanding of reproduction and nutrition have led to greatly expanded opportunities for stock enhancement.

The literature on fisheries enhancement has numerous references to the question of the "carrying capacity" of the environment and the question of whether or not the habitat is capable of sustaining additional recruits. Two observations are pertinent here. Firstly, in almost all fisheries which have been studied, spectacularly abundant year-classes are a feature of the fishery and such year-classes can be detected for years as they move through successive age groups (Fig. 3). The fact that such year-classes survive suggests that the maximum carrying capacity is seldom attained.

Secondly, the whole question of fishery enhancement usually arises in relation to a heavily exploited stock, in which the biomass has been drastically reduced by exploitation. Therefore, provided that unexploited competitors have not increased in abundance to utilize the unexploited resources, there should be adequate food (Fig. 4). In the context of

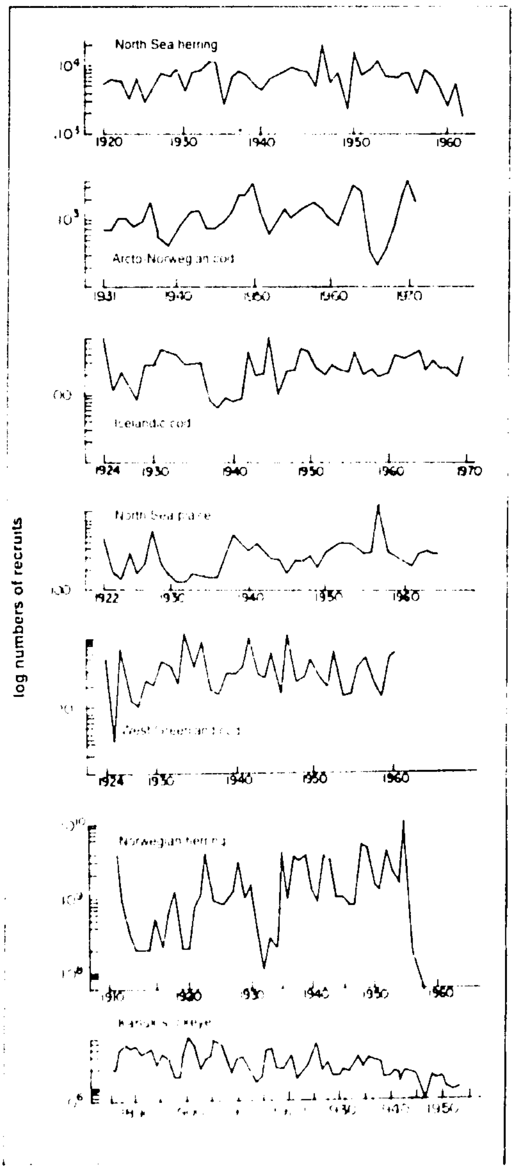


Fig. 3. Examples of variability of recruitment for a selection of northern hemisphere fish stocks (from Cushing 1981).

tropical multispecies fisheries there are seldom any components of the resource system which are not exploited and consequently all stocks are usually well below the carrying capacity of the environment.

The development of ecosystem models, such as ECOPATH II (Christensen and Pauly 1992), provides a means for gaining a good insight into the expected impact of enhancement of a particular component of the aquatic community, particularly expected predation losses of the species stocked and the impact of the increased biomass on lower trophic levels.

Currently, it is claimed that 86 species of marine organisms are reared for many fisheries enhancement in Japan. There is less emphasis on this topic elsewhere but successful enhancement projects have been reported from the USA, Canada, Europe and China. However, examples from the tropics are sparse. For tropical systems some of the obvious choices include sea cucumbers, trochus or green snail, penaeid prawns, mullet, goat fish, siganids, snappers and groupers.

The principal constraints on fish stock enhancement lie in the costs of producing the juvenile stock and the losses of stock due to predation and outmigration (Fig. 5). More cost-effective production systems are rapidly emerging for many species and this is not considered to be major constraint in most instances. Outmigration from the area stocked is a major problem and it is clear that species which are constrained by physical or chemical factors offer the best prospects. Clearly, it is possible to enhance a stock in a small pond which offers no possibility of dispersal. Likewise, stenohaline estuarine species which will not disperse into the open ocean or reef-bound coral reef species offer particular opportunities. Predation control is probably not a major concern in most heavily exploited tropical fisheries as the abundance of top predators is usually drastically reduced (Fig. 5).

There are a variety of negative features which can emerge in fisheries enhancement programs. These include low genetic variability of hatchery-reared fingerlings, the potential loss of biodiversity due to reduction in available niches, inferior survival rates or inferior fitness of hatchery-

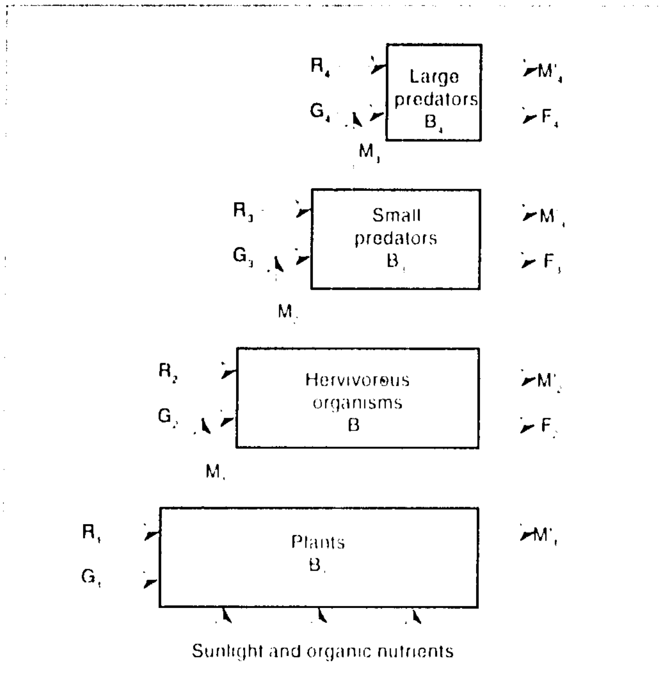


Fig. 4. Schematic and much simplified representation of an exploited aquatic community. Total biomass (B) of different groups is indicated by the size of the boxes (B_1, B_2, B_3, B_4). Recruitment of young organisms (R) and subsequent growth (G) increases the biomass of a group whereas fishing F or death from being eaten (M), or from other causes (M') decreases the biomass. In a heavily exploited community the biomass of the harvestable components is greatly reduced (F_n is large), M_n decreases, this biomass increases at the lower trophic levels. (From Munro et al. 1987).

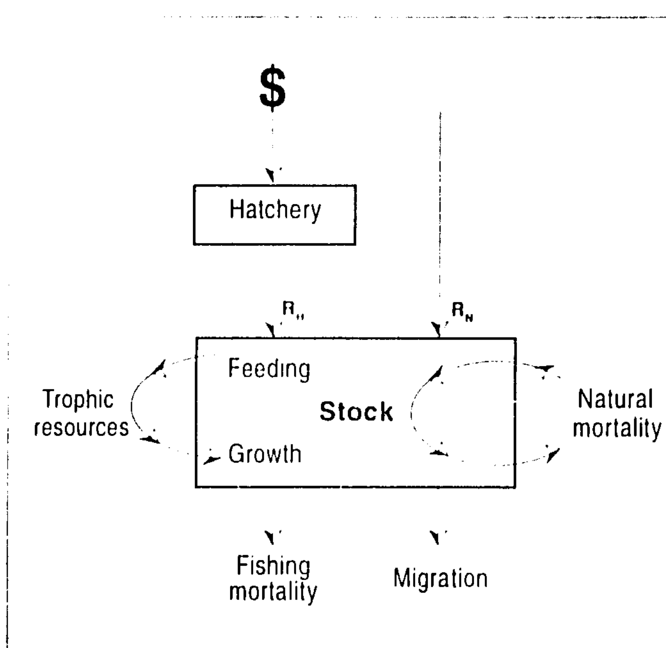


Fig. 5. Schematic representation of the fish stock enhancement process in which hatchery-reared recruits (R_H) supplement natural recruitment (R_N). Provided the trophic resources are adequate, and predation, disease and other sources of natural mortality remain at normal levels, the stock biomass will increase. This leads to increased harvests (fishing mortality). However, substantial outmigration will reduce harvests, and possibly nullify gains.

reared stock and the transmission of hatchery-based diseases and parasites to wild stocks. These are very important problems but it appears that all can be overcome by sensible policies.

The ultimate problem in fish stock enhancement concerns access to and ownership of the enhanced stocks. Systems can run from closed access, sea ranching systems in which private entities pay for the stock and reap the harvests, through community-based, restricted-access systems to open-access, state subsidized systems. Clearly, as is the case in Japan, where access is restricted to a particular community, the community pays the costs of enhancement (often with a state subsidy) and reaps the benefits. Conversely, open-access systems have to be state subsidized in full.

In addition to artificial reefs, the topic of this workshop, interventions in marine habitats can include the enhancement or expansion of spawning and nursery areas by physically modifying the habitat. For example, the installation of spat collectors or settlement surfaces. For the most part, however, habitat modification should be avoided and emphasis placed on environmental conservation instead.

Conclusion

The purpose of this paper has been to show that there are numerous options for aquatic resource management, some of which undoubtedly should take precedence over the installation of artificial reefs. Habitat enhancement is merely a facet of resource management and without a management system any improvements brought about by habitat enhancement will be, at best, transient and, in the worst case might have serious negative consequences.

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Discussion

Convenor: J. Pilz
Rapporteur: V. Palaganas

The major points made in the discussion of the topic paper included the following:

- Artificial reefs are only one of the alternatives for resource management and any construction should be undertaken with other strategies such as protection of existing/natural reefs.
- The viability of stock enhancement is dependent on ownership characteristics of the resources and access arrangements.
- The high level of interest of local communities in artificial reef construction is due to their immediate fish yield although this is only a short-term benefit. In contrast other proposed alternatives such as fisheries management, environmental protection, stock enhancement and recreational marine protected areas are all long-term strategies.
- Integrated approaches to resource management should be undertaken, including education campaigns, protection of the marine environment and population control.
- The social acceptability of alternative strategies depends on villages acting as a unit not as competing groups and the confidence of the local people that such strategies have the full support of local or national governments.

Appendix 1

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Appendix 2

Members of the Working Groups

Working Group 1: Evaluation of Negative and Positive Features of Artificial Reefs

Members:

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Working Group 2: Inventory of Deployed and Existing Artificial Reefs in the Philippines

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Working Group 3: Alternatives and Supplements to the Installation of Artificial Reefs

Members:

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G. Russ (Rapporteur)
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J. Hancock
G. Silvestre
C. Luna
V. Soliman
J. Margraf
L. van Mulekom
P. Milan

Appendix 3

Workshop Program

30 August 1994, Tuesday

8:00 Arrival and Registration

9:00 Opening Ceremony

Welcome Remarks • **Dr. Meryl J. Williams**
Opening Remarks • **Dr. Ullrich Boerner**

9:30 Evaluation of the History of Artificial Reefs in the Philippines • **Ms. Miriam C. Balgos**

10:00 Coffee Break

10:15 Open Forum

Convenor • **Mr. Ramon Miclat**
Rapporteur • **Mr. Jay Maclean**

12:00 Lunch Break

1:15 Effects and Management of Artificial Reefs, Including Experiences Outside the Philippines • **Ms. Maike Waltemath and Mr. Berthold Schirm**

1:45 Open Forum

Convenor • **Mr. Gerry Silvestre**
Rapporteur • **Dr. Annadel Cabanban**

3:15 Coffee Break
3:30 Prospects for Future Artificial Reef Installations • **Dr. John W. McManus**

4:00 Open Forum

Convenor • **Ms. Jessica Muñoz**
Rapporteur • **Dr. Garry Russ**

31 August 1994, Wednesday

8:30 Viewpoint • **Sec. Angel C. Alcala**

9:00 Alternative Strategies for Coastal Fisheries Rehabilitation • **Dr. John L. Munro**

9:30 Open Forum

Convenor • **Dr. Joerg Pilz**
Rapporteur • **Mr. Ver Palaganas**

10:15 Coffee Break

10:30 Open Forum

12:00 Lunch Break

1:15 Review of Workshop Statement and Recommendations

3:00 Closing Remarks • **Dr. John L. Munro**