The local people were actively involved in fisheries conservation activities in the project area such as re-plantation of mangroves, installation of artificial reefs and selling fish-based food products. The institutional arrangement for the project implementation was done with the strong role of SEAFDEC and DoFM, while a fisheries resources management committee was formed under the supervision of the DoFM and Fisheries Development Board. The organized fishers group was able to prepare their own fisheries resource management plan (FRMP). However, there was a problem in the implementation of the planned activities due to inadequate number of DoFM staff in the project site (SEAFDEC, 2009).

A traditional community-based approach had been implemented in Sabah, East Malaysia over the past 20 years. Locally called tagal, the system prohibits fishing by concerned communities in a river for a certain period. Since 2001, the Department of Fisheries Sabah (DoFS) has extended support to promote this approach in order to conserve and protect freshwater riverine fisheries. As a result, more than 240 tagal fisheries groups have been established in various locations in Sabah. The DoFS and local community had worked jointly in this co-management project. Only local people with traditional use rights are included in the tagal fisheries groups, which have established fish sanctuaries and introduced restrictions on using fishing gears such as gill net in particular fishing area in the river. Eco-tourism activities have also been promoted very successfully in many tagal projects. Although in general, the tagal co-management approach is promising, but in some areas this system has not been successful due to weak institutional arrangements and lack of enforcement.

In Cambodia, riverine fisheries are open access especially in the upstream provinces near the Mekong River Basin. In 2000, the Royal Government of Cambodia, through the Fisheries Administration (FiA) reformed the fisheries policy of the whole country by empowering the local communities to manage the resources by themselves, known as the "community fisheries" or CF. However, the process of CF establishment and implementation varies and relies on the supporting organizations and government agencies. A co-management pilot project implemented in 2005-2009 by the FiA with funding support from the Japanese Grassroots Level Aid, focused on community organization, capacity building and empowerment of local fishers in order to ensure their participation in the management of the resources and improve livelihoods through alternative income earning opportunities. In the process, the organized local community groups were able to prepare their own Community Fisheries Area Management Plan (CFAMP) which together with other related documents such as Internal Law, By-Laws, and the community fisheries zoning map were endorsed by the local administration to the Governor with the Community Fishing Area Agreement for approval. Under the co-management project, the Community Fishers (CF) and Local Enforcement Unit (LEU) were established in 2002. Although community management is a very new concept in Cambodia compared with that the other countries in the Southeast Asian region, the country has an excellent opportunity to practice sound community management because the Cambodian Government encourages the fishers to be actively involved in community resource management.

In Vietnam, communities are not yet regulated by the rule of law, which is very important for sustainable resource use. The legal framework is not yet clear on how much the local government can be creative and proactive in the decision-making and planning of the local community. Based on traditional methods and practices along with the lessons learned and experience gaines, Vietnam could have the real chance to implement successful community-based management if the government would only remain highly supportive and would continue to encourage the stakeholders to implement such scheme.

4.3.2 Future Direction

Thus in the Southeast Asian region, community-based management and co-management arrangements in fisheries are considered as feasible options for bringing together the relevant levels of the government and users in pursuing a common set of goals to improve the resource and socio-economic conditions of the communities. More than two decades of research have provided sufficient conclusive support for co-management and community-based management as approaches for effective enforcement and equitable access for the poor and often voiceless fishers (Dey and Kanagaratnam, 2008). Nevertheless, in the context of small-scale fisheries in Southeast Asia which is complex, one single community-based fisheries approach may not be applicable everywhere, considering that community-based co-management approach involves continuous consultation, negotiations, information sharing, and conflict management among stakeholders for the improvement of the existing management systems.

4.4 Habitats Protection and Coastal Fishery Resources Enhancement

4.4.1 Issues and Concerns

The coastal waters of Southeast Asia comprise a rich ecosystem characterized by the existence of areas with extensive coral reefs and seasonal up-welling, as well as the presence of dense mangrove forests enriched with nutrients from land. These areas are critical to a broad range of aquatic organisms during their life

cycle from breeding, spawning, nursing and growing, hosting the feeding zones of aquatic species that are economically important, and serving as important source of recruitment of a wide diversity of fish species. In view of the economic benefits that these areas could provide, human settlements have mushroomed in coastal areas leading to the significant deterioration of the quality of the ecosystem as a result of continued and increasing human activities. More specifically, the commercially important fishery resources in the region have declined due to many factors that include overfishing, illegal fishing, use of destructive fishing practices, and environmental degradation. Massive clearance of mangrove forests for aquaculture, urbanization, industrialization, wood fuel, timber and the like, could bring about large temporary economic benefits to certain groups of people or the governments but in the end, the breeding, nursery and feeding areas of many aquatic species such as fishes, crustaceans, and mollusks have been destroyed and lost. For example, sand mining destroys the natural habitats of many commercial fish species while the use of dynamites in fishing could seriously destroy the coral reefs which serve as the natural habitats for the highly economic and commercially important demersal fishes such as groupers, humphead wrasse, snappers and others.

In addressing such concerns, most countries in this region have deployed artificial reefs (ARs) to restore the depleting coastal fisheries resources, prevent encroachment of trawlers, reduce conflict between commercial and traditional fishers, and increase the opportunities for small-scale fishers to improve and sustain their incomes from fishing. Other measures have also been promoted such as the installation of fish enhancing devices, promotion of stock enhancement through re-stocking, development of fish *refugias*, seasonal closure of breeding grounds, and establishment of marine protected areas or marine parks. Fish *refugia* is the spatially and geographically defined inland, marine or coastal areas in which specific management measures are applied to sustain important species (fisheries resources) during the critical stages of their life cycle. The establishment of fish *refugia* had been intensified in Thailand, Vietnam and Cambodia. Other man-made structures including aquaculture facilities, breakwaters, oil platforms, oil and gas pipe lines, stationary fishing gears, and jetties have also enhanced the biodiversity of aquatic organisms including fish. Thus, strengthening the linkages between resource enhancement activities and integrated coastal fisheries management with particular emphasis on decentralized rights-based fisheries has been promoted in the Southeast Asian region for the sustainable development of coastal fisheries for food security.

Fish *refugia* and ARs can be complementary tools for conservation, management and enhancement of fisheries resources. However, note should be taken that the use of ARs can result in positive social and economic benefits if fishing effort is regulated, but it could result in further overfishing if uncontrolled. A combination of integrated programs using ARs, closed season, limited entry, habitat protection and restoration, fish sanctuaries, mangrove reforestation; and increased community awareness of the need to conserve the resources is therefore necessary. AR programs also need proper planning and management at the national and regional levels while the implementation of any AR-related activity must be based on scientific knowledge and multi-discipline expertise. In the process, it is necessary to strike a balance between the objectives and benefits of the AR projects in terms of the environmental, economic and social aspects in fish production for food security.

4.4.2 Use of Big-size Artificial Reefs: Malaysian Experience

Focusing on the efforts of Malaysia, its ARs program which was started in 1975, aimed to promote fish sanctuaries, recover seriously depleted coastal fishery resources and prevent the encroachment of trawlers into the prohibited inshore areas. The country's ARs program started with the use of discarded car tires and later, under the Ninth Malaysian Plan in 2006, the Department of Fisheries Malaysia focused on the design and construction of big-sized reinforced concrete ARs suitable for installation in hard and soft bottom sea beds. The structures considered various factors such as the fish behavior, marine engineering aspects, physical oceanography, and the target species. The structures were constructed according to the British Standard 8110, and until the end of 2010, fifteen new designs of concrete ARs weighing about 6-42 MT/module and measuring 1.6 to 3.8 m (length, width and height) were produced. The various ARs had their specific functions, for example the cuboid bio-active ARs, anti-trawling ARs, juvenile ARs, soft bottom ARs (2 designs), tetrapod ARs (2 designs), recreational ARs (2 designs), cube ARs (2 designs), cuboids ARs (2 designs), and lobster ARs (2 designs).

The experience and knowledge gained since 1975 was used to improve the planning and management of the ARs program during the Ninth Malaysia Plan (2006-2010). New objectives were set-up which included the development of new AR sites and deployment of additional AR modules at the existing/present sites for resource enhancement; conduct of research and compilation of information on suitable AR designs, durability of materials, and suitable sites of local fishery resources; development of new AR designs which can deter the encroachment of unfriendly fishing operations especially trawlers into traditional fishing grounds and specific zones; and providing substrates for corals to grow.

During the Ninth Malaysia Plan (2006-2010), ARs program was implemented in all states of Malaysia for the first time since 1975 using funding from the federal and state governments. The research and development program focused on design and construction of big size reinforced concrete ARs for installation in hard and soft bottom seabeds taking into consideration fish behavior, marine engineering, physical oceanography and target species (Zaidil Abdilla *et al*., 2010).

Construction using reinforced concrete grade 30-50 was started in 2006. The structures constructed included soft bottom ARs measuring 3 m x 3 m x 3.6 m (18-22 MT/module); cube and cube juvenile ARs 2.5 m x 2.5 m x 2.5 m (14-14.5 MT/module); cuboid and cuboid juvenile ARs, 2 m x 2 m x 3 m (10-10.5 MT/module); tetrapod ARs, 2.655 m x 2.655 m x 2.385 m (8 MT/module); lobster ARs, 1.65 m x 1.65 m x 1.65 m (5-6 MT/module); recreational and recreational juvenile ARs, 1.85 m x 1.85 m x 1.85 m (6-6.5 MT/module); and juvenile soft bottom ARs and anti-trawler ARs, 3.4 m x 3.4 m x 3.75 m (35-42 MT/module). The construction work followed the British Standard 8110, where concrete covers at least 50 mm, column and beam rebar make use of 4 rod of Y12, link uses R8 @ 200mm c/c and slab reinforcement uses BRC A10. Ready-mix concrete from batching plant grade 40 was used for all designs except for the soft bottom ARs, anti-trawler ARs and juvenile soft bottom ARs. Since these designs were quite big and heavy, ready-mix concrete grade 50 was used. Cube test was conducted 7 and 28 days after construction at the government and private laboratory. Curing was implemented for at least 28 days before deployment. Any module which did not follow the specification as stated in the quotation or tender documents was rejected (Zaidil Abdilla *et al*., 2010).

The newly designed ARs for soft and hard bottom sea bed were deployed in 2006, where a total of 33 modules of soft bottom ARs were deployed in Pulau Payar Marine Park, Kedah for research purposes and another 16 modules in Kuala Langat, Selangor for resource enhancement. Forty tetrapod AR modules were also deployed on sandy bottom in Terengganu and Pahang. A series of visual observations by SCUBA diving was conducted to study the fish behavior especially their interaction to the ARs structures, while information on the bio-fouling on the ARs surface was also recorded. Minor modifications were made from year to year until the most suitable design was materialized in 2010 (Fauzi, 2010).

In 2007, the project was expanded to another 10 new sites, especially making use of the tetrapod ARs to deter the encroachment of illegal trawlers into traditional fishing grounds in Kelantan and Johor, while soft bottom ARs were also deployed in Kedah and Selangor, and ARs for recreational anglers deployed in Terengganu and Pahang. In 2008, the ARs project was implemented in all states except in Sabah and Sarawak. Another 19 new sites were identified and a new design for lobster ARs was deployed in the Federal Territory of Labuan. The success of big size ARs in enhancing coastal fisheries resources as well as hindering illegal trawlers had encouraged the Federal Government to allocate additional budget for the project in 2009.

Thus, another 38 new sites for ARs were identified in 2009. The project was continued in 2010 with another 35 new sites identified and by the end of 2010 a total of 105 new sites were deployed with the appropriate ARs, where each site had 12-134 modules depending on the available budget. Thus, Sabah had 17 new sites for reinforced concrete ARs while Terengganu had 15, Kedah (12), Federal Territory Labuan (9), Kelantan and Perak (8), Pahang and Selangor (7), Negeri Sembilan and Johor (4), Malacca and Penang (3), and Perlis two sites. From 2009 until the end of 2010, a total of 237 recreational concrete ARs and anti-trawling ARs were deployed at 12 sites in Sabah. Management and monitoring of all AR sites are under a co-management approach between the DoFM and local fishers. Meanwhile, the Department of Fisheries Sabah (DoFS) put up a condition that ARs would be deployed near the fishers' fishing villages only if local fishers are willing to take part in the Local Artificial Reef Committee which functions and commits to protect, monitor and harvest fish in a sustainable manner from the AR sites. The approach introduced by the DoFS has succeeded in protecting the resources in the AR sites from dynamite and cyanide fishing by illegal fishers. In addition, the DoFS also prescribed that only angling is allowed while other gears are prohibited to operate near the AR sites. The Marine Police and the Malaysian Maritime Enforcement Agency also participate in the activities that aim to protect the AR sites from illegal fishing. The local fishers in Sabah that have ARs projects near their villages are now very happy to have such big concrete artificial reefs deployed because the structures function not only as resource enhancement but also prevented trawlers from encroaching into their inshore areas.

Site selection is an important component in the deployment of ARs. Thus, a series of surveys were carried out in the waters of Malaysia using echo-sounder for seabed topography, grab or divers for collecting sediments, and current meters for information on direction and speed of current. Divers also used to explore and film the seabed areas to obtain baseline information especially on the topography, substrate stability, proximity to natural coral reefs, and the biological resources within the immediate vicinity of the site. Bamboo traps, and hooks and lines were also used to gather preliminary indication of the fishery resources of the selected sites.

Considering the heavy weights of the ARs, pontoon or barge was used to transport and deploy the concrete ARs to the selected sites. During the installation processes, free fall deployment method was applied using 44-100 MT crane. Special mechanical device was constructed which worked very successfully during the deployment process. Each module was placed on the sea bed at 2-3 meters apart from each other. After the completing the deployment, several divers inspected the position of each module and all information was recorded by video camera for future reference (Zaidil Abdilla *et al*., 2010).

Monitoring activities are conducted regularly every 3-6 months after deployment to record the changes in fishery resources as well as the physical stability of the reef modules by the Penang-based DoFM staff of the Fisheries Research Institute, staff of SEAFDEC/MFRDMD in Terengganu, and from the Fisheries Research Institute Sarawak Branch. Several survey methodologies were used and this included intersected transect method for sessile, fouling and encrusting organisms, and visual observation via transect, fixed stationary points as well as search pattern for fishes. Information on the encrusting, sessile and fouling organisms, fish assemblages, fish composition, as well as physical, chemical and biological parameters were recorded and analyzed. Several research activities were conducted in collaboration with local universities involving the undergraduate as well as post-graduate students. Mapping of the AR locations were also conducted using side-scan sonar.

Results of the monitoring by SCUBA diving showed fast development of the resources that had been enhanced and various organisms had immediately encrusted the structures while all surface areas have been covered with bio-fouling, sessile and encrusting organisms within six months after deployment especially for ARs deployed on sandy sediments. Generally, the surfaces of most ARs have been covered with mollusks, barnacles and multi-species corals. In Kuala Terengganu, an average of 364 tails of fish was estimated at each module for cuboid ARs after six months of deployment. These included 45 juveniles of high quality grouper (*Epinephelus coioides* and *E. areolatus*). After 11 months, the mean count/module was increased to 1839 tails and mostly dominated by the bigeye snapper, *Lutjanus lutjanus* and yellowtail scad, Atule mate (Mohammed Pauzi *et al*., 2010). Fauzi (2010) reported that big size ARs deployed in the coastal waters of Peninsular Malaysia in 2006 has become a nursery and breeding ground for lobsters and crabs, especially the fully gravid animals which were found within the AR structures during the series of visual observations conducted by DoFM researchers. The structures also function as substrate for many marine fauna and flora to grow, and also proved successful in hindering illegal trawlers especially because the cod-end of a trawler could be entangled with the AR structures.

In the latest findings in 2010, more than 100 species of fish were recorded at the AR sites in Terengganu, Kedah, Sabah, Sarawak and Federal Territory of Labuan. Among the species found were the highly commercial species such as groupers, red snappers, sweetlips, lobsters, and coral fishes such as banner fish, anemone fish, lion fish, bat fish, chromis, among others. Tetrapod ARs deployed near the Mak Daerah turtle nesting beach in 2006 has become a safe resting place for green turtles during their inter-nesting period. Adult green turtle *Chelonia mydas* was observed resting closed to the ARs in July 2010. This place is now a safe temporary habitat for this reptile away from trawling activities. A study in May-June 2010 by the DoFS on ARs deployed in Tempurong and Lok Nunuk in 2009 recorded 22 species and among them are high grade snappers (*Lutjanus* spp.), groupers (*Epinephelus* spp. and *Cephalopholis* spp.), Carangoides (*Caranx* spp.), stingrays, and spiny lobster (*Panulirus* spp.).

The DoFM has imposed prohibitions against fishing in the immediate vicinity of up to a radius of 0.5 nm of the ARs, the locations of which had been suitably indicated by marker buoys (Jothy, 1986; Wong1991; Abdul Razak and Mohamed Pauzi, 1991). However, all marker buoys were lost due to vandalism and from forces of nature. In Sabah, the DoFS enforced a policy or condition that only local fishers who are committed to take active part in the Local Artificial Reef Committee to protect and monitor the AR sites from dynamite and cyanide fishing, overfishing, from net and trap fishing with only angling allowed, will be considered as ARs project beneficiaries and where ARs would be deployed near their fishing villages.

Generally, the ARs program of Malaysia in 2006-2010 has achieved its objectives of deterring illegal trawling activities into the coastal waters. Moreover, the involvement and commitment of local fishers in protecting, monitoring and managing the ARs from illegal fishing and overfishing had been the most effective form of management in the AR sites. The DoFM also gathered valuable experiences that will serve as guide through its future undertakings in habitat enhancement as well as on the suitable materials, appropriate designs, size and strength that will provide the best performance of the ARs.

For example, the large concrete artificial reef modules currently being promoted by DoFM have the strength, design and size which are most suitable in terms of creating new habitat, resisting environmental conditions and also withstanding the onslaught of the illegal trawlers' malpractices. The DoFM is continuing its efforts to find new designs for concrete ARs that will be able to closely imitate the natural reefs, preferably those that could protect young juveniles of marine organisms and at the same time provide niche for a host of marine organisms. Nevertheless, various issues have also arisen during the

implementation of the ARs project in Malaysia in 2006-2010. These include: (a) perceptions of most people and policy makers that ARs are constructed for fishing, and as a consequence AR sites outside Marine Park areas are fished without control; (b) fishers' management responsibility of the ARs is unclear because many government agencies are directly involved in the construction and deployment of ARs; (c) conflict of interest among user groups especially between drift net and anglers in the AR areas, especially that drift nets are always entangled with the AR modules and are left unrecovered; (d) inadequate technical knowledge among officers involved in ARs project especially in marine engineering construction and physical oceanography; (e) insufficient facilities and infrastructures such as jetty, pontoon, crane and concrete batching plan; and (f) limited funding for the scheduled monitoring activities.

4.5 Responsible Fishing and Practices in Southeast Asia

Promotion of the concept of responsible fishing is not new in global fisheries as it can be traced back to the Convention on Fishing and Conservation of the Living Resources of the High Seas in United Nation Law of the Sea (UNCLOS) 1958 which explains the global concern of sustainable utilization of the marine fishery resources. Similar message was reemphasized in the articles of UNCLOS 1982 which concerned more on the conservation and utilization of the living resources, and especially the stocks occurring in the exclusive economic zones of two or more coastal States or transboundary or highly migratory species. However, the fishery resources had gradually declined year by year and in order to address the problems on stock decline, the Committee on Fisheries (COFI) organized the International Conference on Responsible Fishing in 1992 (The Cancun Declaration 1992) to consider the draft of the Code of Conduct for Responsible Fisheries (CCRF). Finally, the global CCRF was adopted in 1995, providing general principles and international standards for responsible fishery practices worldwide. Recognizing that the implementation of the CCRF is very important in ensuring sustainable fisheries in Southeast Asia, SEAFDEC also sustained its campaign for the implementation of the CCRF in the region. In order to encourage the Southeast Asian countries to adopt the CCRF, it was necessary for SEAFDEC to provide clarification on the requirements spelled out in the CCRF taking into consideration the specific situation of the Southeast Asian region.

The different fishing scenarios and issues that exist within the region, especially those related to multi-species, multi-gear and small-scale nature of fisheries are rather dominant and unique, but it is unfortunate that these issues were only superficially covered by the global CCRF. Thus, it was deemed important for SEAFDEC to address the specificity of fisheries in the region through its program on the Regionalization of the Code of Conduct for Responsible Fisheries (RCCRF) starting in 1998. RCCRF aimed to: clarify the requirements of the CCRF; identify and prioritize the required actions; identify the issues that require special consideration from the regional point of view; formulate regional policies that would help the ASEAN Member Countries in implementing the global Code of Conduct for Responsible Fisheries; and facilitate the formulation and implementation by the ASEAN Member Countries of national codes of practices for responsible fishing operations, fisheries management, aquaculture, and post-harvest practices and trade. While the RCCRF focused on the Southeast Asian region's specific context, encompassing its culture, its fisheries structure, and the region's fishery ecosystems, the result was a compilation of regional guidelines accommodating the specific regional concerns that the global CCRF failed to highlight, and where the issues of particular importance to Southeast Asia have been amplified and elaborated on under the framework of the global CCRF.

4.5.1 Key Issues Related to Responsible Fisheries

In order to sustain the marine fishery resources and maintain marine capture fisheries in the Southeast Asian region, the RCCRF attempted to put more emphasis and strengthen Chapter 8 of the CCRF, while the hindrances confronting the development of sustainable fishing were identified. Two main issues were then focused, *i.e.* depleting fishery resources coupled with environmental deterioration, and climate change that impacts on fishing operations and safety of fishers at sea. Since the impacts of fishing operations and practices both legal and illegal had been identified as the main causes of the depletion of fishery resources and deterioration of the environment, these issues were discussed thoroughly during the Regional Workshop on the Reduction of the Impacts of Fishing on Coastal and Marine Environments in the Southeast Asian Waters organized in Thailand in January 2009, and scoped into specific issues that include: over-fishing; destructive gear; on-selective gear and practice, IUU fishing; ghost fishing; and use of fossil fuel. In addition, the 2009 Workshop also identified major fishing practices that could bring negative impacts on the coastal and marine environments hindering all efforts to achieve sustainable fishing especially in the Southeast Asian waters. These included: light fishing; use of stationary gears (*e.g.*, tidal traps, stow-net, fyke net, Japanese set net, Muro-ami, Choko-ami); use of active gears (*e.g.*, trawls, dredge, push net); use of semi-passive gear and small-scale fishing gear (*e.g.*, pot, gill net); longline fisheries; and purse seine operations associated with fish aggregating devices (FADs).