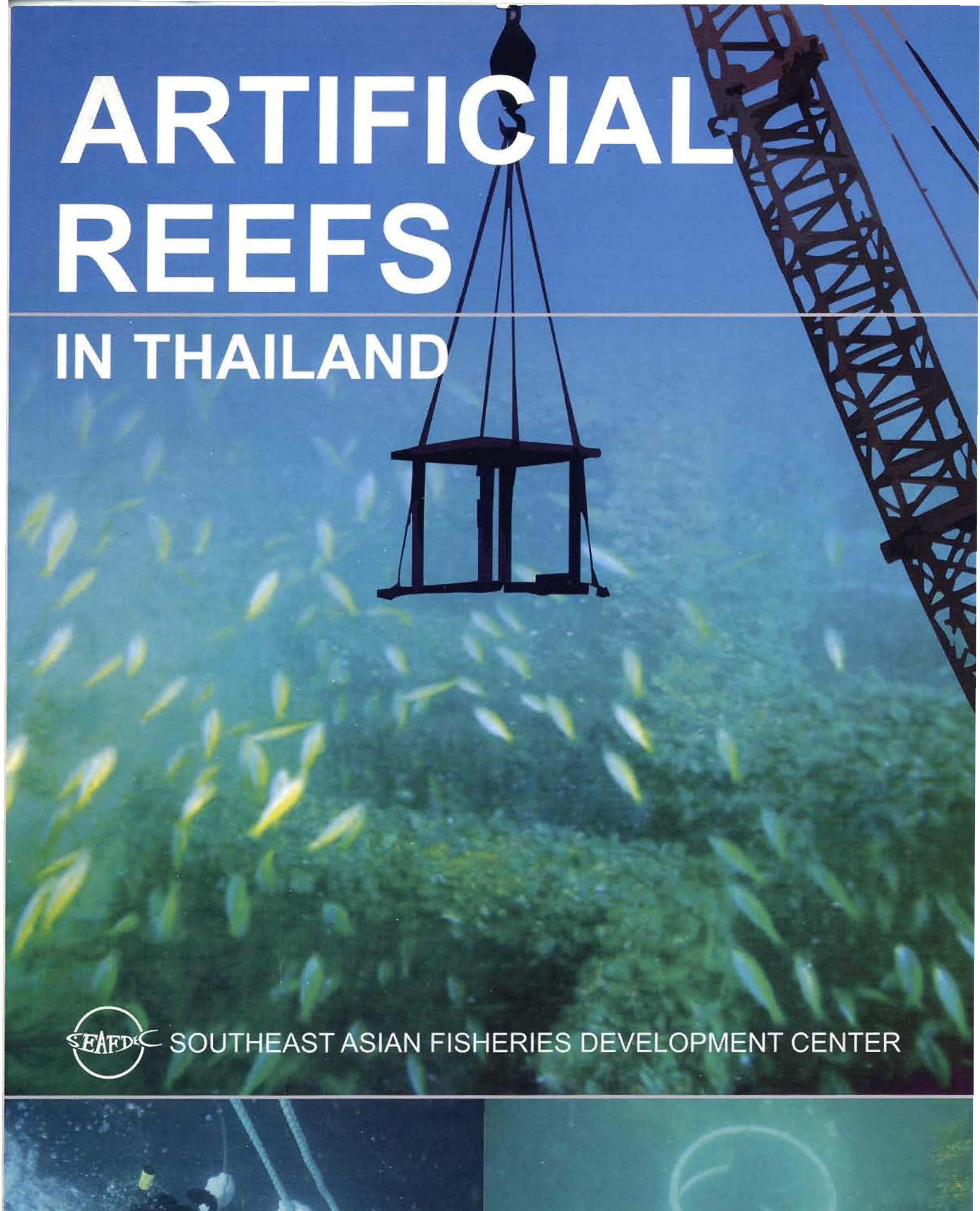
ARTIFICIAL REEFS

IN THAILAND



SEAFDEC SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER

ARTIFICIAL REEFS IN THAILAND

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SOUTHEAST ASIAN FISHERIES DEVELOPMENT CENTER
TRAINING DEPARTMENT

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PREFACE

In accordance with the "Resolution and Plan of Action" adopted at the ASEAN-SEAFDEC millennium Conference 'Fish for the People" in 2001. SEAFDEC as the competent regional fisheries technical organization has perceived the potential on sustainable development of fisheries in this sub-region. With the view to work towards the conservation and rehabilitation of aquatic habitats essential to enhancing fisheries resources. SEAFDEC/TD had conducted an ASEAN-SEAFDEC Special 5 Years Program 1006-2010 on Rehabilitation of Fisheries Resources and Habitats/Fishing Ground through Resources Enhancement Project. Since, artificial reefs are not only effective methods for resource enhancement, but are also useful management tools. The integrated and optimized usage of artificial reefs facilities in inshore waters needs to be developed. This should be a component of any co-management system for determine their placement.

As a contribution to this resources enhancement, there-fore, SEAFDEC is issuing a technical manual which is concerned with artificial reefs, in particular. The paper reviews the objectives to install artificial reefs, the artificial reef concept, importance of the ecosystem in the natural and artificial reef areas, and evaluation on economic and social issues for fishers living around artificial reefs as case study in Thailand.

Hopefully, the publication will provide useful information and contribute to the management and development of fishery sector in the region.

Dr. Siri Ekmaharaj
Secretary-General and
The Chief of Training Department of SEAFDEC

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Sakul SUPONGPAN

Abstract

This paper describes briefly the development of artificial reef installations in Thailand, and the objectives, concept and background of artificial reef installations in South Asia. It also reviews the ecosystem of the natural and artificial reefs, appropriated structure, material used, design, places to install ARs, Fish Aggregating Devices (FADs), sizes of ARs. Special reference is made on the artificial reefs using train wagons and truck carrying household garbage under the King's Project on the coastal resource rehabilitation in Pattani and Naratiwas provinces. Evaluation on the economic and social issues for fishers living around ARs and the project implementation was described. Recommendations for further development of ARs were made.

A case study of ARs installation in Petchaburi Province was raised as an example for learning by practice. The methods for collecting data, data analysis for catch and effort of the production around ARs areas, cost and benefit estimation as well as the altitude of the fishers living around ARs areas were reported.

I. Introduction

The production of marine capture fishery in Thailand has been ranked as one of the top ten countries in the world since 1975. In the year 2002, the total marine production accounted for 3,797,000 metric tons. The fishery production is utilized for local consumption and for exporting to foreign countries. The latter amounted to 1,449,959 metric tons with a value at 169,186.4 million Baht (US$ 4,229 million) in 2002 (Fisheries Statistic, 2004).

Thailand has advantageous geographic conditions as the Gulf of Thailand, located between 6º N to 13º 30' N and 99º E to 104º E with a seabed area of 304, 000 km^2, is rich in nutrients to support high productivity of marine lives in the food web. Similarly, the Andaman sea coast also provides rich fishing ground.

To strengthen the habitats for coastal fisheries the Thai Department of Fisheries launched a Small Scale Fisheries Development Project under the National Social and Economic Development Plan VI (1988-1992) from 1988 until 2003. The project comprised three aspects for development: 1. Coastal Small Scale Fisheries Development, 2. Artificial Reef Installation and 3. Fishery Resource Rehabilitation. The project aimed to conserve areas for marine and environmental resources in both the Gulf of Thailand and Andaman Sea; in each province at least 50 km^2 would be designated as fishing ground for small scale fishers and in at least 25,000 m^2 in order to reduce conflicts and poverty.

During 1978–1986 the installation of artificial reefs was experimented on material, structure, installation technique and duration of ARs for further development in order to achieve the maximum benefit. The results of the ARs installation were accepted by fishers and the resources were recovered. The biodiversity of the marine lives inhabited in the ARs areas consisted of more than fifty species which were recognized as the same species to those inhibited in the natural coral reefs. The best structure for ARs was square concrete tube that lasted longer than other types. However, the fish species and fish production around different ARs structures were almost the same. Another important objective of installing the ARs was to obstruct the trawlers and push netters to fish near shore and around ARs.

The Department of Fisheries has allocated a considerable amount of its annual budget to develop the artificial reef installation, and the DOF will continuously provide ARs for fishers upon their requests. However, more indicators are needed to evaluate ARs' benefit for conservation purpose in co-management for resource sustainability, fisher awareness, and socio-economic benefit for local fishers.

The objectives of this finding are as follow:

1. To analyze the fishery situation around ARs
2. To assess the socio-economic benefit of fishers living around ARs site
3. To evaluate the small scale fisher's attitude for ARs installation
4. To learn the practices in Petchaburi province as a case study for ARs installation.

II. ARs Concept

Nakamura (1981) defined the artificial reef as the facilities to improve fishery resources with the following objectives:

1. To increase catch rate in fisheries
2. To rehabilitate fishery resources and increase nursing ground
3. To protect fishing areas where the fishery was already overexploited

In Thailand, the objectives to install the artificial reefs were different from other countries. The objectives were:

1. To rehabilitate the coastal fishing ground
2. To develop and extend job opportunity and to increase small scale fisher income
3. To promote conservation measures and manage the coastal fisheries
4. To reduce conflicts among fishers and resources users

However, any type of artificial reefs that lead to the rehabilitation of the resources may be useful. There is no limit in AR structure, material used, size; other structures achieve any of those objectives is recognized as ARs.

III. ARs Background

The use of ARs was recorded since 1775 by the fishers in Banziai and Awaji villages, in Japan. It was constructed using wooden frame and placed at 40 m depth in the sea for fish to gather around. It was firstly known that wooden frame could be used as ARs. The capture fisheries production was high after installation of ARs especially the yellow spotted grunt. As a result, fishers were happy with these results. In 1954, fishers further developed ARs with unused wood, wrecked boat, sand bag and rock. As a starting point, concrete tubes were further used to construct ARs (Nakamura, 1989).

In the 18th century, the Japanese fishers found that they could catch a lot of fish in the area around ship wrecks. This experience gave them the idea to build big wooden frame consisted of bamboo, wood and small tree branches, which were weighed down to 30-40 m in the sea using sand bags. The fish catch was even greater than the area around the ship wrecks. This method was widely used thereafter (Ino, 1974).

It was reported that almost all fishes like the new material placed at the sea; they often swim around and use new material as shelter to save their energy during swimming against strong currents (Ogden, *et al*. 1981). Since 1970, the Asian countries have alerted ARs installation as a means for sustainable management of coastal resources. For example, Taiwan installed ARs in 1973 to conserve coastal resources resulting from the declaration of EEZs by neighboring countries and reduced Taiwanese fishing areas causing decline in fishery production (Chang *et al*., 1984). Riggio *et al.* (1985) conducted research on the biology of small organisms that attached on the ARs surface in 1982-1983 and found that these organisms comprised 175 invertebrate taxa. The dominant groups were polychaetes, gastropod, polyzao. It also showed that each species had different way to attach onto the surface of concrete tubes. As the feeding habit was up to each species behavior, these small organisms were important to lure fish to feed on. In general, big fish feed on small fish.

In Israel in the Mediterranean Sea, Diamant (1986) found that there were 54 fish species of 23 families living around ARs one year after installation and those were the same species found around natural rocks; several years after installation, the fish production increased number and biomass, but the species diversify did not change. Consequently, ARs installation was supposed to build new environment that attract new species of fish and small organisms.

Miclat *et al*. (1989) reviewed the history of the AR installations in South and Southeast Asian countries and summarized their findings in each country as follow:

1. *Malaysia*

   In early 1970, the national research center in Penang, Malaysia installed ARs in Kalantan, Kuala Trenganu of the eastern part of the country. The materials used were 60,000 used tires. Further installation was done at 77 sites along coastal areas of Malay water, with 90% used tires and the rest concrete tubes and wrecked boats. Malaysia installed tires reefs for ARs until 1987 and later changed to use prefabricated concrete and PVC for specific purpose of squid and spiny lobster fisheries; in 2000 Reef Ball was promoted (SEAFDEC, 2005).

2. *Philippines*

   The Philippinoes started ARs installation in 1981 with 70 small-sized ARs along its coast. The core center to install the ARs was the government agricultural sector incorporated with local authorities, civil services, municipal, fishery societies and private sectors. After placed the ARs, they monitored biological aspects by diving observations and evaluated the socio-economic changes of the local fishers. Furthermore, Philippines will place 50,000 used tires as ARs in the important bays. The Philippines have installed 50 sites of ARs in the marine reserve/sanctuary areas. Red marker buoys demarcating the ten-hectare areas and 49 ARs modules were deployed in 2003 (SEAFDEC, 2005).

3. *Singapore*

   The earliest artificial reef project was initiated in the late 1980s under the USAID/ASEAN Coastal Resources Management Program. Several sites were identified for placing ARs. In 1989 the National University of Singapore started conducting research on ARs under the USAID/ASEAN project. The objective of the project was to monitor the effect of ARs using used tires and concrete tubes in the sea. The cost and benefit analysis for long term ARs use was also done. The study on the nature of sedimentation at ARs installation sites was also conducted. The long-term use of tires may cause toxicity and also become solid-waste pollutants of the sea if they get loose from the main module (SEAFDEC, 2005).

4. *Brunei*

   In 1984, Brunei started using ARs as artificial habitats to lure fish; there was also some studies on the material used, e.g. used tires, oil pipes. At present the ARs project is concentrated on using prefabricated concrete pyramidal structures. The small reef unit measuring 2.5 x 2.5 m^2 was used for shallow areas; the larger triangular pyramid measuring 6 x 4 m^2 for deeper areas (SEAFDEC, 2005).

5. *Taiwan*

   Taiwan had ARs project to support fishery industries.

6. *Indonesia*

   Indonesia placed used tires to the Jakarta bay to lure fish gathering at ARs.

7. Cambodia

Cambodia had initiated artificial reef program in 1991, 1997 and 2002 using concrete modules and base/log of trees. A total 300 units of ARs were deployed in 1991 and 700 ARs in 1997 and 100 units in 2002. ARs were placed at the bottom at water depth less than 100 m within the fish sanctuaries in the Great Lake (Tongle Sap- freshwater; SEAFDEC, 2005).

8. Myanmar

The ARs have not been established yet in Myanmar because of lacking technical and financial support (SEAFDEC, 2005).

9. Vietnam

ARs have played a very important role in resource enhancement but the progress is very slow because the resource protection and fishery policy are major tasks for the sustainable development of marine fisheries rather than ARs (SEAFDEC, 2005).

In some foreign countries, artificial reef were developed for more than ten decades (Grove, 1985) with the objectives to increase production in capture fishery and fishery resource conservation (Grove and Sonu, 1991). It is also evident that at least fifty three countries in the world have installed artificial reef for the purpose of increasing fishing grounds and conservation areas.

Many countries were interested in ARs installation and more applied research concerned with ARs was conducted as fishery extension. The interest was evident at the International Conference on ARs that presented 57 research works from seven countries at the Third Conference in 1983; at the Forth Conference, 19 countries with 131 research works were presented. The total number of the participants was 350 with representatives from Australia, Japan, Southeast Asian Countries, Caribbean countries, Pacific island countries and North American countries, etc. (Polovina, *et al*., 1991). In 2004, SEAFDEC (2005) held a Regional Workshop on Enhancing Coastal Resources: Artificial Reefs in Southeast Asia, at which the member countries presented their ARs installation situation. Among the SEAFDEC countries the ARs are more or less developed as means for resources enhancement.

Even though the ARs installation has a long history, the budgetary preparation for big projects has just started by the individual government. Due to the high cost of installation, each country tries to use the used materials to reduce the budget, e.g. used tires, cars, boats for ARs. In Japan, the use of various kinds of materials and models for the ARs installations have been developed with high costs and they are not yet affordable for most ASEAN countries in term of budget provision.

IV. Importance of Ecosystem in the Areas of Natural and Artificial Reefs

Artificial reefs mean man-made materials being used as shelter, refugee, nursing ground, spawning and resource enhancing for fish species in the sea and freshwater basin. Artificial reefs in marine ecosystem are recognized more widely used than in freshwater ecosystem. Artificial reefs can support marine ecosystem by increasing greater substrate surface areas as habitats for marine animals and plants. Based on various objectives the ARs usage can be classified as follow:

1. to gather fish for increasing marine resource production (enhancing tool)
2. to function as a protected nursery area for juvenile and young fish from trawl and push net activities
3. to enhance attachment of small organisms, hence to induce food web that effectively enhance the marine resource.
4. to induce natural coral attachment that will increase new fishing ground

5. to serve as a spawning ground

Woodhead *et al*. (1985) reported results of a study comparing marine species attached on the coal waste bricks with concrete blocks as ARs. The species attached on both materials were not different, e.g. various mollusk, *Polydona socialis*, *Zirfaea crispata*, Epitaunal community, and several invertebrate species. However, the animal colonies attached on the concrete surface, e.g., mollusk, *Batanus crenatus* had greater growth rate than on the brick surface; meanwhile, *Polydona socialis* and *Zirfaea crispate* and members of Epitaunal community faired better on the brick than the concrete.

Bohnsacle *et al*. (1985) reported that the biomass around natural reefs was less abundant when compared to the artificial reefs, especially in the temperate zone. It was concluded that the ARs installation was to increase areas for marine life. Usually, the natural coral reef is an area for abundant marine animals and is recognized as one of most productive marine ecosystems. An important aspect is that the natural coral reef creates more surface areas and great species diversify. Hence, the installation of ARs is to imitate the natural coral reefs inducing more surface areas and species diversification.

V. Structure, Material, Design and Installation Site for ARs

The materials used for making ARs comprise several types, e.g. used tires, scrapped car, boat, bamboo wood, concrete block, fiberglass, steel pipe. In case of old car usage, it might release some dangerous chemical substances, e.g. paints, plastic material, etc. when cars deteriorate over time. In some countries, they were still using used tires and at the same time began to use concrete block with greater costs. In general, the chosen material used depended on the budget and the ease of transportation and installation. In Japan, one fifth of the coastline at depth 2-3 m up to 100 m, and far from shoreline 100 m to 3,000 m had been placed with ARs. The height and length of ARs ranges from 1 to 10 m with the weight about 10 metric tons and more than 100 models were used. The oceanographic factors should be considered at the ARs sites (Mathiews, H., 1983).

Fish often swim close to new and strange materials at sea bottom as their instinct behavior. Hence, ARs will attract fish to gather around in large numbers. Fish often swim to hide at ARs away from strong water currents to save their energy. Moreover, herbivorous species usually come to feed on several species of algae and small organisms attached on the surface of ARs. New fish recruits are preyed by bigger fish in the food chain of that ecosystem. Some fish may come close to ARs sometimes as a temporary shelter.

Mathiews, H. (1983) conducted an experiment on the ARs models for demersal coral fish, mid water fish and pelagic fish. He used simple available concrete block and placed at the chosen sites with known water depth, models and oceanographic conditions. Those sites with good results were set as a prototype for further development of ARs.

The selection for suitable AR model and structure needs to consider the behavior of fish that result in achieving the required objectives. The fish behavior can be classified into the following 3 groups:

1. Highly migratory fish comprise pelagic and mid-water fish, e.g. carangid, tuna, king mackerel, sardine, porpoise, dolphin, swordfish. These fish will be lured by bamboo, wood, FADs (fish aggregating device) and payao. Some times those fish migrate between FADs.
2. Migratory fish comprises demersal fish, e.g. snapper, *Nemipterus* spp.
3. Non-migratory fish that stay permanently at the reef, e.g. grouper, eel, big size grouper. These fish will occupy ARs as their homes and will attack intrusive foreign species.

VI. Fish Aggregating Devices (FADs)

FADs are used to lure fish to gather in a large quantity and it is recognized as one type of ARs. FADs are usually placed at the surface or mid-depth of sea water. Thai fishers called "*Sung*", the Filipino called "*Payao"*. These FADs are placed to lure fish for efficient capture purpose. FADs originated from small scale fishers in the Oceanic Pacific countries and they also called "*Payao*". Payao is composed of floating bamboo raft and anchored by weight under the raft. Tree branches and coconut palm leaves are used as fish shelter especially for small fish. The big fish are lured to feed on these small fish. At present, Payao is commonly used in the Philippines, Indonesia and Thailand. The model for FADs varies in each country based usually on local and cheap materials to make FADs such as bamboo and tree branches, coconut palm leaves. The most expensive parts of FADs are anchors and chains. Payao used to lure tuna in the Philippines is placed at site depth more than 2,000 m. The nylon rope size 16 mm for anchoring should have 4,000 m in length that this part is much more expensive. These FADs can be used to lure yellow fin tuna and the fishers capture tuna by purse seine. At times, it can effectively captured tuna up to 36 metric tons in one haul. The small scale fishers used small size Payao and caught small size fish. Therefore, it should limit the number of Payao used in each area and target different species to prevent deterioration and conserve fish stocks (cited after Jarusombat, 1992).

The major objectives to install ARs are to extend and provide more fish habitats for fish and invertebrate to imitate the natural coral reefs; therefore, the place chosen for ARs installation is important. It also needs further researches, e.g. in the Philippines where the concepts and terms for choosing suitable places for installing ARs are as follow:

1. Away from natural coral reef more than 1 km
2. Near natural food sources, e.g. sea grass beds
3. On gentle slope of sea bed
4. At depth of 15-25 m in sheltered area, away from strong wind and fishers can come in and out conveniently.

In the Southeast Asian countries, the popular materials used for ARs are used tires, concrete blocks, old boats, bamboo, and used cars. Among these materials, used tires are more preferable as they are cheap and sometimes free of charge, and they can tolerate sea water better than other material and easy to transport. About 36 used tires can be fastened together to make 9 sets of ARs with each set contains 4 tires. Monofilament ropes are used to fasten each set of ARs. ARs are sunk by 4 concrete blocks which are placed in rows and sometime placed near FADs to lure pelagic and mid-water fish. However, using concrete blocks as ARs is rather expensive and it can be found in Japan and Thailand. Old boat is a good material to make ARs, it is only to drag and sink the old boat to the chosen areas. The ARs using old boat is the place where several fish species inhabited and popular for diver and game fishing. However, over a long time period materials from old boats e.g. paints, rubber, lubricant, metals can release some toxic substances. The sunken boats can also obstruct transportation in water ways. Bamboo is popularly used in the Philippines because bamboo is a low cost material and can be relocated easily. But, its duration time is short, normally only 3 years.

VII. Big Size ARs

A base for crude oil drill at sea contains several pipes at various sizes of which the diameter ranges from 0.5 to 1.0 m, and the length is from the water surface to the sea floor. This kind of construction is recognized as a big size ARs. These ARs act as fish shelter and feeding areas where organisms attach at its surface attracting other invertebrates and fish to feed on each other as food web of an ecosystem. Bigger size fish, e.g. king mackerel and shark come from a long distance away from the big ARs. The abundance of living animals around the big ARs was observed by the construction staff. For example, in Brunei, small organisms and animals live abundantly at big ARs where the layer of attached organisms is about 10 cm thick and consists of soft coral, spiny mollusk, oyster, sea weed and a lot of fish species. Big ARs can be recognized as a type of FADs and fish habitats. At present, several oil drill bases in Indonesia and Brunei are abandoned. If governments have their own wills then these oil drill bases can be moved to some suitable places. Though it will require certain amount of cost it may be cheaper than to install the new ARs. Brunei conducted an experiment in 1988 on using two oil drill bases as ARs by placing about 1,500 m^3 of rocks horizontally to the sea bottom. The fishery production around big AR was recorded. In USA wastes of big size materials, e.g. cars, boats were disposed in deep sea for increasing fish habitats - a value added waste materials to benefit the environment. Warship wrecked during the Second World War in the ocean become interesting sites for tourists and fishers to fish.

Any construction at sea shores and protruding into deep sea, e.g. pier, telephone poles, electrical pipes are popular for fishing with hooks by both professional and armature fishers. These structures act liked FADs for fish habitats, especially those extruding through the deep sea and against strong current are effectively to attract fish and invertebrates. The construction of dry dock in the southern Florida, USA was an example of placing ARs coincidently by using big size rocks. This planning case and technique were more beneficial not only to fishery production but also to the environment, society and economics. (cited after Jarusombat, 1992).

VIII. Evaluation on the Economic and Social Issues for ARs

There are few research works on the evaluation of socio-economic benefits of ARs. No standard format or questionnaire has been used to interview and evaluate the effect of ARs to fishers or local community living around the ARs. It should have evaluations for reducing cost and benefiting from ARs. Preference, acceptance and cooperation from local community will create awareness for resource conservation and take care of ARs as their own belongings.

Sato (1985) reported that Japan spent an average of 21.36 US$ per m^3 of ARs after one year of installation, the fish production accounted for 16-20 kg per m^3 per year or amounted to 30 US$ per m^3 per year. It was concluded that the cost for ARs returned only one year after the installation from the fisheries profit. Supongpan (1995) reported that a similar result was also observed in Petchaburi province, Thailand, where only in one year the profit from fish production amounted to 58,982,740 Baht compared to 14,360,000 Baht for installing the ARs. However, this was a gross profit which includes wages, fuel cost, fishing gear repairing, boat repairing, engine repair, ice, meal, interest, etc.

IX. ARs Installation in Thailand

In Thailand, the Department of Fisheries set an AR installation project called Improvement of Fish Habitats, along the coastal provinces both in the Gulf of Thailand and Andaman Sea from 1978 to 1986. A total of 34 sites covering 300 km^2 were placed. The private sectors, e.g. Fishery Association of Songkhla, Cholburi and Petchaburi were invited to donate some funds. The materials used were used tires, concrete tubes, steel pipes and several kinds of wood.

During the first phase of AR development, Thailand used all kinds of material e.g. stones, bamboo sticks, rubber trees, used tires, concrete tubes to make ARs. Experiments on suitability of AR structure and evaluation on fish catch were conducted (Sinanuwong, *et al*., 1986). Studies on the social and economic aspects of the fishers using ARs for fishery activities (Insrisawang, 1999), physical changes in environment, suitable structural models as well as material used (Awaiwanon *et al*., 1991) were also carried out. Results of these studies showed that ARs could be used to increase the fishery resources, in some cases as spawning areas to certain species, e.g. big fin reef squid (*Sepioteuthis lessoniana*).

The artificial reef installation in Thailand was developed in two phases (Ingsrisawang 1999); the first was exploration and experimental phase during 1978 - 1986 (Pramokchutima, *et al*., cited after Ingsrisawang, 1999), and the second phase was installation and resource enhancing which was started in 1986 until the present.

From the results of these experiments, Thailand has succeeded in resource enhancement as indicated by the fact that the areas around ARs are fruitfully inhabited by about 50 fish species similar to natural reefs. Manasveta, *et al*., (1987) found 70 species living around ARs in Amphoe Sriracha, Chonburi province; Mantachita (1990) reported 64 species were found in Amphoe Sattahip, Chonburi province; Monkolprasit and Sotirat (1980) found 230 species around ARs areas in Satun Province in the Andaman Sea Coast. In general, the number of species found in the Andaman Sea was more than that in the Gulf of Thailand due to the strong current in the Andaman Sea, and ARs provide shelters to small sized fish, e.g. coral fish. As a result, there is greater species diversification at AR sites in the Andaman Sea coast.

In Thailand, studies showed that red snapper, yellow-striped fish and big fin reef squid came to feed on small organisms on the ARs after 1-2 months of installation, Further succession involves invertebrate species attached at the ARs surface, e.g. mollusk offspring, barnacle and bryozoa. Finally, the big economic fish came to feed on small fish at the ARs area, e.g. grouper, snapper, parrot fish, etc. Some fish that disappeared previously returned, e.g. white pomfret in Petchaburi province (Supongpan, 1995).

From the results of monitoring and evaluation, the Department of Fisheries has merged the Artificial Reef Project into the National Economic and Social Development Plan V and which provides the artificial reef project with greater budget during the Plan V and further extension to the Plan IX. The project is called “Artificial Reefs” which initial objectives for artificial reef installation were to:

1. Install as areas for natural resource and environmental conservation using square concrete tubes with size 2 x 2 x 2 m or 1.5 x 1.5 x1.5 m (Figs. 1, 2, 3) to cover 50 km^2 at each designated area. This size of ARs was categorized as big ARs.

Figure 1. The square concrete tubes with size 2*2*2 m or 1.5*1.5*1.5 m.
(Under construction)

Figure 2. The square concrete tubes with size 2*2*2 m or 1.5*1.5*1.5 m.
(Ready to be placed onto the sea bottom)

Figure 3. Transporting the ARs to designated location

2. Install as areas for fishing ground improvement, the square concrete tubes with size 1*1*1 m or 1.5*1.5*1.5 m to cover 1-3 km^2 at each designated area. This size of ARs was categorized as small ARs.

During 1988-2002, the Department of Fisheries has placed the ARs at 232 sites (or number of fishing villages) including 207 small ARs and 25 big ARs along the coastal areas in the Gulf of Thailand and Andaman Sea. The total areas with ARs installation covered 1,578.11 km^2 with budget amounted to Baht 807,360,000 (Annex 1). From 2003 - 2006 the Department of Fisheries provides 15 small ARs and one big ARs with annual budgetary provision of 65 million Baht. At present, the local authorities/CEO governor have more budgetary provision, fishers can request the ARs project directly from local authorities (Ao Bo To (or TAO; Tambol Administrative Organization) through the governor, and the project is subject to the approval of the National Committee. The members of the National Committee comprise representatives from Department of Fisheries, Navy, Port authority, Natural Resource Department, Leaders of local fisher groups. The sites for placing ARs are to be chosen and agreed through participatory approach.

The Department of Fisheries provided an annual budget of about 65 million Baht for the year 2004 to install artificial reefs along the coasts of both the Gulf of Thailand and Andaman Sea at 16 locations with small ARs at 15 locations and 1 large AR.

Apart from this, in 2004 the DOF also installed 300 train wagons as ARs in Pattani and Naratiwas Provinces (Fig. 4) under the King's Project (The Royal Development Project: Coastal Resources Rehabilitation in Pattani and Songkhla Provinces-one of the Royal Development Project). Plans have been made to install at 12 more locations on the southern coast of Thailand including Pattani and Naratiwas Provinces in 2005. The local fishers in Pattani Province asked to enhance and rehabilitate the coastal resources that were badly depleted. The project is targeted for Pattani and Naratiwas Provinces using train wagons, disused water pipe drains, concrete tube frames and wrecked boats to make ARs in the target areas. The project will rehabilitate and enhance the fishery resources, and provide obstacles to trawling activities, and to provide protected areas for juveniles and young fishes and to promote ecotourism and diving exercises. In 2005, the Department of Fisheries approved to provide a budget for ARs (one large ARs and fifteen small ARs) along the Gulf of Thailand and Andaman Sea coasts (Supongpan, 2004).

In conclusion, the Department of Fisheries has installed ARs altogether 280 sites for small ARs and 30 sites for large ARs with budgetary provision amounted to 1,126.360 million Baht since 1988 to 2006 (as detailed appearing in Annex 1 and Annex 2a and 2b).

Figure 4. Train wagons used to install artificial reefs

Pattani and Naratiwas provinces were located in the southern part of the Gulf of Thailand where the coastal resource rehabilitation project was established under the Royal Development Project. In the year 2006 the Department of Fisheries has deployed the artificial reefs using household garbage trucks and water transport trucks in Patani and Naratiwas coastal waters. The Bangkok Metropolitan provided hundreds of cleaned-unused trucks for making ARs and DOF had designated the locations (Fig. 5).

Nowadays, the fishers can request directly to the local authorities (TAO or provincial governor) to provide budget for ARs, and the work plan to install ARs have to be approved by the Committee and selected location be approved by local participation approach. Not only the Department of Fisheries, Ministry of Agriculture and Cooperatives that has installed ARs but also the Department of Natural Resource, Ministry of Natural Resource and Environment or even the Department of Navy have also implemented ARs.

Figure 5. Old household garbage trucks and water transport trucks used for ARs

X. Recommendation

The following recommendations are made to resolve the problems that frequently encountered:

10.1. Problem Occurred in the ARs Areas

At present, there are several ARs that have been installed both in the Gulf of Thailand and Andaman Sea in the photic zones where sun light can be penetrated through. The ARs can compensate the natural coral or natural habitats, where about 80% of the fishing areas were destroyed by trawl and push net activities. Coral zone is an area comprising complex and diverse natural resources in the marine ecosystem. From the bottom up to the surface of the sea the water forms an ecosystem with small organisms including both flora and fauna that feed small pelagic and demersal fish as a lower rank of prey and predation. Furthermore; these fish are fed by the higher rank and top predators as part of the marine food web. The ecosystem and biodiversity of the natural resources are changed by trawling activities. In 1963 about 298 benthic species were found and only 89 species left in 1993. The reduction of these benthic fauna caused dwindling demersal fish that fed on these benthic species. Furthermore, living organisms inhibited the coral zone were also lost.

During the evaluation of the ARs project, it was found that in every AR area, the trawl, push net, light fishing and fishing with acetylene gas were fishing within the area destroying ARs including the marine ecosystem.

The Department of Fisheries should consider using the Fisheries Act B.E 2490 (being revised for update version), Section 32 under the Ministry of Agriculture and Cooperatives to strongly enforce for illegal fishing as mentioned above. Otherwise the Department of Fisheries should propose to the provincial governor using the Section 16 and 32 that empower the provincial governor to limit certain types of fishing gear and fishing operation in the designated areas (ARs areas) as stipulated in the Fisheries Act.

10.2 The Policy of the Department of Fisheries

a. The Department should have clear policy to establish the community-based fishery management or co-management mechanism for local fishers and authorities in harmony with the central decentralized policy of the National Constitution B.E 2540 (1997). The fishers and local authorities can manage their own fisheries and ARs belong to them, to limit access for fishers (no more open accessed to any fisher); the local authorities and fishers should collaborate to manage the fisheries and ARs as well. These policies will protect ARs to last its life span and the government can reduce its budget on the costly ARs.

b. The study on the size of fish stocks should be also done together with the above mentioned approaches. The information on stock size can be used to properly allocate fishing effort for each type of fishing gear to contribute to fishers. This will lead to the right users in the communities and the fishery resources will be managed by the communities in collaboration with the local authority and consulted by the central research agencies for sustainable utilization.

c. The Department of Fisheries has installed artificial reefs all over the coastal areas in the Gulf of Thailand and Andaman Sea since the 6th National Social and Economic Development Plan until the present day. No study on the usage age of concrete ARs has been conducted. The study or research on this issue will be beneficial for the government in providing budget to the demand of ARs installation from fishers. The government will also be able to determine and plan the location and number of ARs to be installed. Even though the installation of ARs is costly it is a rather small budget compared to that for other developmental items.

d. The Department of Fisheries should set a master plan for ARs installation in 22 coastal provinces. Consideration will be made for the suitable sites and annual budgetary provision to gain maximal benefit for fishers and local people. The master plan should be developed through the participation of the stakeholders in both local and central levels. The participatory aspects for ARs installation should include:

1). Sites for ARs installation:

1.1 The sites that the local fishers do their fishing and it can apply Fisheries Act B.E. 2490, Section 32 or Section 16 to limit the fishing capacity within that demarcated areas.

1.2 The sites should be developed to promote eco-touring, diving, athletic games and recreational fishing activities, etc.

2). Model and size of ARs

2.1 In case of ARs installation at the fishing ground of small scale fisheries, the model that the Department of Fisheries has been used and studied are the concrete type. That would be suitable to install in the fishing ground for small scale fisheries. The steel concrete size is 1.5*1.5*1.5 m would be suitable for thin mud layers; if the mud layer is thick then the model should be 2.0*2.0*2.0 m.

2.2 The structure of ARs to support the tourism should have diverse model and structure that imitated the natural coral reefs and placing at places where natural corals were destroyed. Further models should provide places where the eel and spiny lobsters inhibit and prevent from predators.

3). Surveys and monitoring should be conducted on existing ARs installed earlier before developing the master plan. The surveys should include why, where and how many areas are still needed for ARs. The results of survey will prevent replication in ARs installation at the same sites.

10.3 Suitable model of ARs that matching to fish behavior

The suitable ARs models should match the fish behaviors, e.g. pelagic fish, mid water fish, demersal fish and invertebrate, etc. For example, the pelagic fish need more oxygen due to their strong and fast swimming and the AR models should have wider openings to let greater water circulation around the ARs allowing more oxygen for the fish. Another important aspect is that the ARs should be placed in the sea bottom at the depth where the sun light can reach. That will stimulate photosynthesis and oxygen generation for living organisms inhibiting the ARs. For demersal fish, e.g. demersal fish, shrimp, and mollusk, they like to live at the sea bottom with dim light or dark shelters, in water with little current, or calm environment. The research works that support these concepts were carried out (Avaiwanon 1991; Supongpan 1995; Ingsrisawang, 1999; and Siripet, 2004).

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CASE STUDY:

PROJECT: ARs Installation in Petchaburi Province, Case Study for Learning by Practices.

1. Objectives

The objectives of these studies are as follow:

.1 To estimate catch and effort of fishery production from fishing around ARs in Petchaburi province

.2 To evaluate the socio-economic of fishers fishing around ARs in Petchaburi province

.3 To know the altitude of fishers to ARs installation

Fig. 1 Gulf of Thailand showing Petchaburi province

2. Materials

2.1 Sail slips from fish agents

2.2 GPS (Global Positioning System)

2.3 Record of fish price by species or group of species from Fish Marketing Organization

2.4 Shrimp price from middle men

3. Methods

Data collection

Data were collected from ARs namely, Petch 1, Petch 2 and Petch 3 in the Petchaburi Province (Annex 2, 3 and 4). Catch and effort of fishery production were collected from small scale fishers coming to fish around ARs areas. Sail slips were collected from agents at local fishing piers in Baan Panern, Lam Pakbia, Amphoe Baan Lam (Petch 1); Baan Haad Chao Samran, Baan Bang gurao, Baan Tanode Noi, Amphoe Maeng (Petch 2) and fishing piers in Moo Baan Bang Kao, Pak Klong, Amphoe Cha-am (Petch 3). The catch and effort data were compiled from 23 boats in the year 1990 before ARs installation. After ARs installation, 1992 to 1998 (No data in 1991 and 1995), number of boats that were collected data were 23, 23, 22, 33, 31 and 29 of the years 1992, 1993, 1994, 1996, 1997 and 1998 respectively. From data compilation, data were categorized by type of fishing gear, by day and by month bases. The types of fishing gear that used in the ARS areas were *Sillago* gillnet, Mugil gillnet (Fig. 2), Indo-Pacific mackerel gillnet (Fig. 3), swordfish gillnet (Fig. 4), pomfret gillnet (Fig. 5), threadfin gillnet (Fig. 5), shrimp trammel net, swimming crab gillnet, squid light luring cast net (Fig. 6) and hook (Fig. 7).

Catch and effort data were collected daily from each trip of every fishing boat landed at the local fishing piers.

Data on cost and benefit were collected by using questionnaires and 100 fishers were interviewed. The questionnaires for the fisher’s altitude in ARs installation were also done by 100 fishers.

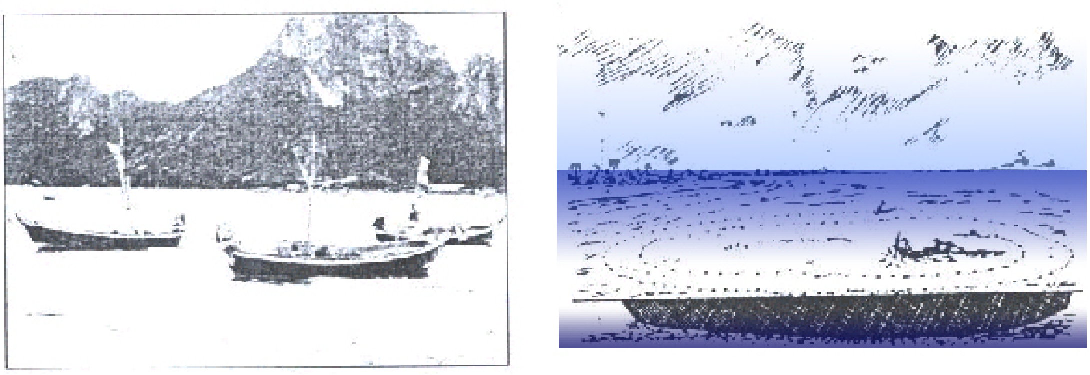

Fig. 2 Mullet encircling gill net

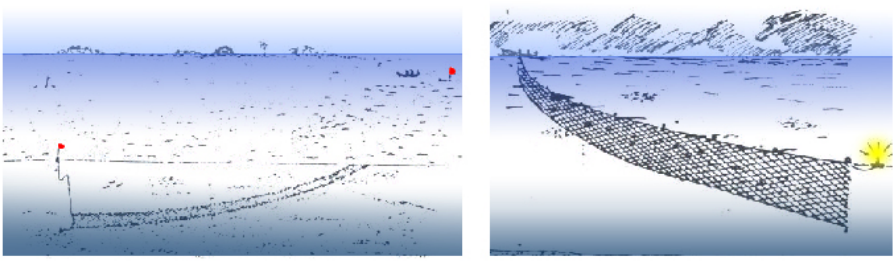

Fig. 3 Indo-Pacific mackerel gillnet

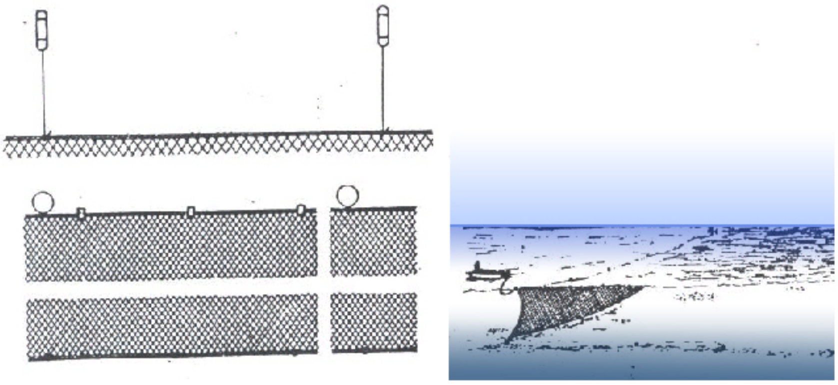

Fig. 4 Dorab gill net (swordfish)

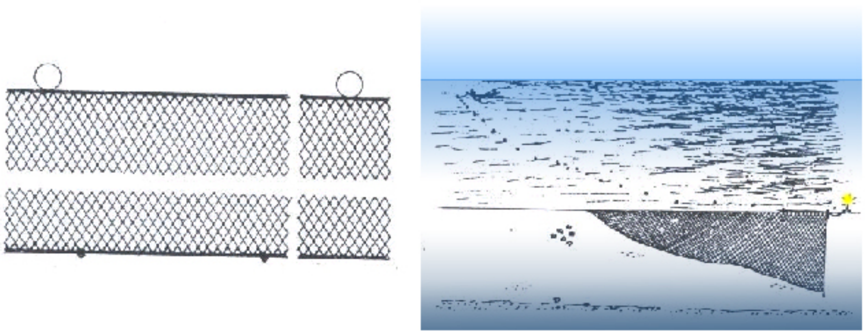

Fig. 5 Threadfin gillnet and promfet gillnet

Fig. 6 Squid cast net with light luring   Fig. 7 Hook hand line

Method of Analysis

Catch and Effort Estimation

Analytical steps of catch and effort data are as the following:

a. Separate the catch and effort from each gear on daily basis, and for each month during 1990-1998 (except 1991 and 1995).
b. Combine catch by species from all types of gear in daily basis, and for each month during 1990-1998 (except 1991 and 1995).

c. Calculate the fish price by species from record of the Fish Marketing Organization (FMO); using the average minimum price of each year
d. Estimate the total catch by using number of fishery household with outboard engine boats from National Statistic Record of the year 1995 in Amphoe Baan Lam, Maeng and Cha-am coming to fish in the areas. The total number of household was 2,215 from Petch 1, 2 and 3.

Economic Analysis

a. Data from 100 questionnaires were analyzed by comparing the cost-benefit of fishers before and after installation ARs and standardize each year data using index of consumer from Economical Commercial Department of each year (Ministry of Commerce, 1998). The estimation was done following Narongsak *et al*., (1993):

Fisher Benefit = Studied Benefit/ Consumer index

b. Data obtained from questionnaires for altitude of small scale fishers in Petchaburi province to ARs installation were analyzed using percentage and descriptive analysis.

4. Results

4.1 Catch and effort of small scale fishery production from fishing around ARs in Petchaburi Province

The catch effort collected from sail slips of the agents for the small scale fishers at landing sites, 1990 and 1992-1998 was estimated as follow:

a. The total effort of 22-33 fishing boats from 16,492 trips was averaged 78.79 trip per boat per year, both before and after installation of ARs, compared to 1,518 trips for eight types of fishing gear among 23 boats before installation of ARs in 1990.
b. When categorize by gear, it appeared that the *Silago* (sand whiting) gillnet operated more than other gear with the fishing effort of 41.48 trip per boat per year. The effort for swimming crab gillnet and dorab gillnet was 11.91 and 4.73 trip per boat per year, respectively.
c. After installation of ARs from year 1 to year 7, the total effort was 14,974 trips from 12 types of fishing gear, and the number of fishing boats for year 1, 2 and 3 was 23, 23 and 22 whereas in year 5, 6, and 7 was 33, 31 and 29, respectively. The average effort of year 1992, 1993, 1994, 1996, 1997 and 1998 was 114.96, 95.87, 87.23, 91.64, 77.52, and 95.83 trip per boat per year, respectively. The average total effort for seven years after installation of ARs was 93.84 trip per boat per year. When categorize by gear, it appeared that the *Silago* gillnet had operated more than other gear with the fishing effort of 42.57 trip per boat per year. The effort for the Indo-Pacific mackerel gill net and trammel net was 15.80 and 9.99 trip per boat per year, respectively (Table 1).
d. Comparison was made for data sampled before and after installation of ARs during six years of this study. The types of fishing gear used were mackerel GN, sand whiting GN, trammel net, mullet GN, and dorab GN, hook and line and miscellaneous GN. The results indicate that the average effort after installation increased to 27.53 trip per boat per year. The mackerel encircling GN had the highest effort of 15.41 trip per boat per year, followed by trammel net, mullet GN, sand whiting, hook and line of 9.29, 3.78, 1.09 and 0.39 trip per boat per year, respectively. The decreasing effort was observed for dorab GN and miscellaneous GN. The swimming crab GN disappeared

in year 2 after installation due to the ARs damaged nets and little catch near ARs (Table 2).

4.2. The catch and value

The catch and value of fish by species collected from sail slips of fish agents both before and after installation of ARs were compared year by year (Table 3).

Before installation of ARs

In 1990, the total catch recorded for all household resided around ARs area was 18,832.1 kg with an average of 804.0 kg per boat per year. The total economic important fish caught belonged to 18 species that were landed at fishing piers of fishing villages in Tambol Lam Pakbia, Amphoe Baan Lam in Petchaburi Province.

The most abundant species was sand whiting amounted to 7,261.6 kg, valued at Baht 217,848, followed by dorab and trash fish amounted to 2,724.6 and 2,362.3 kg valued at Baht 38,144.4 and 8,197.2.

The most valuable species was sand whiting, followed by swimming crab and king mackerel which was accounted for Baht 217,848; 77,154 and 47,186.7, respectively.

After Installation of ARs

The largest catch in 1992 was trash fish at 20,544 kg followed by sand whiting 18,345.4 kg and Indo-Pacific mackerel 9.68.2 kg. When considered the value of fish, the most valuable fish was sand whiting followed by Indo-Pacific mackerel, and trash fish which accounted for Baht 642,089; 108,818.4; and 74,780.20 respectively.

The largest catch in the year 1993 was also trash fish at 12,965 kg, followed by Indo-Pacific mackerel 10,890.4 and sand whiting 7,480.7 kg. When considered the value of fish, the most valuable fish was sand whiting, followed by Indo-Pacific mackerel, and trash fish accounted for Baht 299,288; 130,684.8; and 51,989.8 respectively.

The largest catch in 1994 was Indo-Pacific mackerel at 36,653.3 kg, followed by trash fish 13,142.4 kg, and sand whiting 7,296.8 kg. When considered the value of fish, the most valuable fish was Indo-Pacific mackerel, followed by sand whiting and trash fish which accounted for Baht 659,759.40; 350,244.00 and 52,569.60 respectively

The high catch in the year 1996 was also Indo-Pacific mackerel at 32,359.0 followed by trash fish 28,844.1 kg, and Setipinna 19,243.3 kg. When considered the value of fish, the most valuable fish was Indo-Pacific mackerel followed by trash fish and Setipinna which accounted for Baht 388,308; 115,376.40, and 96,216.50 respectively

The largest catch in the year 1997 was trash at fish 33,209.1 kg followed by Setipinna 30,510 kg and Indo-Pacific mackerel 12,847.9. When considered the value of fish, the most valuable fish was Indo-Pacific mackerel followed by Setipinna and trash fish which accounted for Baht 256,958; 152,550 and 132,836.4 respectively

The largest catch in the year 1998 was Setipinna at 80,960.9 kg followed by trash fish 34,887 kg and sand whiting 15,849.2. When considered the value of fish, the most valuable fish was sand whiting followed by Setipinna and trash fish which accounted for Baht 817,706; 404,804 and 139,548 respectively.

The Comparison of fish caught before and after ARs installation

Results showed that the catch per unit effort (CPUE; kg/boat/year) of fish caught from the 1st to the 7th year after ARs installation increased substantially year by year (except for the 2nd year). The sequence of the increasing CPUEs of the year 1, 3, 5, 6, and 7 was 2,537.5, 3,148.1, 3,281.3, 3,380.4 and 5,287.6 kg/boat/year whereas the 2nd year was 1,904.8 kg/boat/year. The CPUE of the year before installation was 804 kg/boat/year (Table 3).

4.3 Fishery Economic of Small Scale Fishers

Cost and Benefit Analysis

Fish consumption in household was considered as non in cash. From the study on the non in cash of fish consumed and other 6 items from the fishery both before and after ARs installation for cost and benefit analysis. The results showed the following:

Before installation

In 1990, non in cash was estimated to be Baht 3,578.10 and in cash was 15,253.98. Then the total revenue was estimated at Baht 18,832.08 (Table 4). The operation costs included 7 items in Table 4 was estimated at Baht 11,300. The operation costs were labor wage, fuel, fishing gear, ice, repairing boat, repairing engine and debt interest. Then, the benefit was estimated at Baht 7,532.08 per family per year.

After installation

The cost and benefit analysis was done the same way as the above estimation. The benefits from the 1st to the 7th year fluctuated and accounted for Baht 32,088.76, 23,254.04, 46,875.56, 19,962.60, 25,018.56 and 51,123.12 per family per year, respectively.

Comparison of Cost and Benefit

Data were standardized using consumer index from the Ministry of Commerce (1998). Outputs of the estimation of cost and benefit for the year before and after installation were tested by statistics for the differences. Results could be concluded as follow:

The annual revenue in cash after installation was higher than before, and was significantly different (95% level) before and after AR installation. The operating cost increased every year and was tested the same way as the above, showing no significant difference (at 95% level) before and after installation, except for the first and seventh year. The results of the test on other items, e.g. labor wage, fuel, boat repairing, engine repairing and fishing gear repairing were the same as the operating cost with no significant difference, except for the engine repairing of the second and seventh year (Table 5).

4.4 Altitude of fishers to ARs installation

A total number of 100 questionnaires was used to interview fishers on their altitude of artificial reef installation. The following results were concluded (Table 6):

The results showed that every fisher knew and heard about the artificial reef. But for the difference between ARs and natural habitats, 90% of fishers recognized ARs as natural habitats but 2.0% did not and 8% was unsure. The 100% of fishers believed that ARs could lure fish abundantly gathering around. For conservation purposes, 70% of fishers agreed, 17% did not and 13% was unsure; 90.5% of fishers believed that ARs could be new fishing grounds, 8.5% didn't believe and 1.0% was unsure. On effect of ARs installation on fishing gears, especially trawlers by destroying the net and accessory: 94% fishers agreed, 1% didn't and 5% was unsure. On ARs reduction in fishing areas: 1% of fishers agreed and 99% didn't agree. One half of the fishers knew the installation before and the rest did not. For those fishers entered around ARs to fish, 70% of fishers recognized the ARs location by the natural coastal marks and 30% recognized by floating marks of the project. All fishers needed the Department of Fisheries to install more ARs. The module types of ARs from DOF were preferred by 90% of fishers and 10% were not.

In case of ARs installation in Petchaburi province, 70% fishers recognized the sited installation were not suitable due to the sea water levels being too shallow, 30% preferable for the sites; 40.5% of fishers considered the distance from shoreline was too near and the rest 59.5% considered suitable. For the floating mark position (buoys), 30% fishers recognized as suitable and the rest 70% not suitable. (Table 7)

5. Conclusion and Discussion

5.1 The fishery status in the ARs areas

It was found that eight types of fishing gear were used before installation of ARs and one year after installation, namely, mackerel encircling GN, sand whiting GN, trammel net, mullet EGN, dorab GN, fish GN, hook and line and crab BGN. At the second year of installation the four finger threadfin DGN was newly operated in the area and the crab BGN was ceased to use. This may be due to the changing food web in favor of the four finger threadfin fish. The quitting of using the crab BGN might be because the destruction of the net by currents that wiped the long net to the concrete ARs. After the 3rd year of installation of ARs, there were two new types of fishing gear operating around ARs namely, the light luring squid CN and white pomfret DGN targeting the squid and white pomfret. It was evident that the ARs were also used as rehabilitation tool for fishery resources. Some fish species have been recovered as they inhabited around ARs.

Over all, the catching rate of fishery resources showed a substantial increasing trend, comparing before and after ARs installation. At the 7th year there was another fish species occurred in the ARs area with obviously large number, especially for Setipinna fish. This fish has high market demand and high price which resulted in high capture production.

The fishing effort of the fishing gear before and after installation of ARs was compared. Orderly increasing fishing effort was observed in mackerel encircling GN (+18.13 trip/boat/year), highly fluctuated trammel net (+11.0), sand whiting GN (+7.22), mullet EGN (+4.84) and hook and line (+0.76).

The mackerel encircling GN has two types of fishing operation. The first one is to place the net at the sea bottom that enable the fishing operation the whole day. The second is to catch only at the surface of sea water by placing the net upon the ARs areas during the night time. This fishing gear is more adaptive gear to catch Indo-Pacific and Indian mackerels, which resulted in increasing fishing effort of mackerel encircling GN. The mullet EGN has also two types of fishing operation. The first is an ordinary operation but the second is to frighten the fish to swim faster to be gill netted.

Orderly decreasing fishing effort was seen in crab BGN (-11.71 trip/boat/year), other fish GN (-1.47) and dorab GN (-1.07). For crab BGN, the nets were damaged by strong currents. Usually they used at least 2 km length of nets to catch swimming crab and the nets have to be placed against the current for two days before hauling. Within two days the nets were wiped against the concrete ARs and destroyed. The fishers found that no profit due to nets damage and they have to buy or repair net frequently. Some of them decided to move out of the ARs areas to fish in the deeper grounds.

It was concluded that the suitable types of fishing gear that should be allowed to fish around ARs were the fishing effort depending on the gear type that had high fishing effort before installation of ARs such as mackerel encircling GN, mullet EGN, sand whiting GN, trammel net; and others that had high fishing efforts after installation were four finger threadfin DGN, white promfret DGN, Setipinna DGN and light luring squid CN. Those types of fishing gear should be promoted and extended to small scale fisheries around ARs areas. On the other hand, the crab BGN, dorab GN and other GN were not suitable to fish around ARs and should not be promoted or extended.

Small scale fishers may use any type of fishing gear around ARs depending on the fishing season and the market price and demand for whatever species that were abundant. Setipinna, for example, at first there was no fishing for this species due to lack of recruit in the fishing ground. When the environment and food production cycle were suitable for them, they occurred abundantly and the market demand increased as well as market price. Consequently, the production increased to supply the demand as tuna live fish bait. Setipinna having strong muscle could also be kept alive for a longer time than other species. Hence, the fluctuation in fish production was subject to types of fishing gear used and the abundance of target fish species as well.

5.2 The Production and Value

The results showed that the capture of economic fish around ARs before installation was comprised of high value economic fish and shrimp which amounted to 803.96 kg and valued at 18,832.09 Baht/boat/year. After AR installation the production and value increased yearly and amounted to 2,535.68, 1,904.75, 3,148.36, 3,281.34, 3,380.39 and 5,287.58 kg/boat/year and valued at 48,188.79, 46,109.08, 72,580.39, 53,112.64, 57,979.50 and 82,773.15 Baht/boat/year, respectively. The highest production was sand whiting, seconded by Indo-Pacific mackerel, followed by shrimp. The yearly series for fish production increased but the values were not increased linearly with the production due to the fishers targeting the fish demanded by the market but not the valuable species. Fish were used for several purposes asides for consumption as before, but also for cage culture, processed products, fish bait, etc.

5.3 Fishery Economic

Overall, the cash profit of fishers increases significantly after the installation of ARs and has an increasing trend yearly. But, the non in cash is not different from year to year before and after installation. This means fish consumption in house hold is stable. The fisher’s annual expenditure in all items is the same. No offshore fishing is necessary as before, and no expenditure is needed for gear repairing, net damages. Fuel is saved except for those fishers who might have more fishing efforts to catch fish.

5.4 The Fisher Altitude to ARs Project

For the altitude of small scale fishers the ARs project was positively regarded. Almost all of them would like to have more ARs in the coastal areas. They had some comments on net damage due to the strong current wiping the net obstruct to the concrete ARs e.g. gill net, anchovy purse seine and trawl. The issue concerning reduction of the fishing ground was raised because that former fishing ground has been placed by ARs and thus they could not fish there anymore. It was suggested that the study on design and type of fishing gear should be conducted before allowing to fish around ARs in the future.

The fishers proposed to do more research and solve the problems on the net damage and the buoy positions; the positions to be movable, not permanent. More study on the catching gear was more interested due to vast areas of ARs in the coastal areas were different from one to another. The plan for research on catch and effort by gear types should be carefully settled to cover all issues concerned.

Annex 1. Budget provision, numbers of sites and areas for Ars during 1985 - 2006, Thailand.

Fiscal Year	Small Ars			Large Ars			Total		Remarks
	Budget (million Baht)	Sites	Areas (km^2)	Budget (million Baht)	Sites	Areas (km^2)	Budget (million Baht)	Areas (km^2)	National Social and Economic Development Plan
1985	3.00	5	40.81				3.00	40.81	5th Plan1982-1986
1986	2.50	5	47.80				2.50	47.80	
1987	2.50	5	30.00				2.50	30.00	6th Plan1987-1991
1988	2.00	4	16.00	30	2	100	32.00	116.00	
1989	2.50	5	22.00	30	2	100	32.50	122.00	
1990	5.60	8	24.00	30	2	100	35.60	124.00	
1991	5.88	8	24.00	30	2	100	35.88	124.00	
1992	5.88	8	24.00				5.88	24.00	7th Plan1988-1992
1993	7.50	10	2.50	30	2	100	37.50	102.50	
1994	15.00	10	5.00	30	2	100	45.00	105.00	
1995	15.00	10	5.00	30	2	100	45.00	105.00	
1996	45.00	29	14.50	15	1	50	60.00	64.50	
1997	10.00	5	2.50	30	2	100	40.00	102.50	8th Plan1992-2001
1998	50.00	20	15.00	35	2	100	85.00	115.00	
1999	60.00	20	20.00	40	2	100	100.00	120.00	
2000	87.00	29	29.00	40	2	100	127.00	129.00	
2001	45.00	15	15.00	20	1	50	65.00	65.00	
2002	33.00	11	11.00	20	1	30	53.00	41.00	9th Plan 2002-2006
2003	48.00	16	16.00	40	2	60	88.00	76.00	
2004	81.00	27	27.00	20	1	30	101.00	57.00	
2005	45.00	15	15.00	20	1	30	65.00	45.00	
2006	45.00	15	15.00	20	1	31	65.00	46.00	
Total	**616.36**	**280**	**421.11**	**510**	**30**	**1,381**	**1,126.36**	**1,802.11**	

Annex 2a. Results of Small Ars by province and by year, Thailand.

Year/Province	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	***Total***
Trad										1		2			2	3			1	1		1	***11***
Chantaburi												4			2		1	1	1		1	1	***11***
Rayong							1	1	2	2		1	1	2		2		2		1	1	1	***17***
Cholburi																	4						***4***
Petchaburi												1				2			2	2		2	***9***
Prachuab Kiri Khan						2	2	2	2	1	2	4	1	4	3	7	2		2	2	2		***38***
Chumphon						2	2	2	2	2	2	2		2	2	2	2	2	2	2	2	3	***33***
Surat Thani																				1	2		***3***
Nakorn Sri Thammarat	2	2	1				1							1	3	2	1		2		1		***16***
Songkhla			1								2	3	1	3		3	1			1	1	1	***17***
Pattani		1	1	1	2	2	1	2				3		1	1	1		3	1	7	1	1	***29***
Naratiwas												2			1	1	1	1	2	7	1	1	***17***
Satun	3	2	2	3	1				1		2	3	1		1				1	1	1		***22***
Trang					1			1	2	2	1		1		2	3	2					2	***17***
Krabi					1									1	1	2	1	1	2			2	***11***
Phang-Nga						1	1		1	2		1		4		1		1		2	2		***16***
Phuket						1					1			1									***3***
Ranong												3		1	2								***6***
Total				***4***	***5***	***8***	***8***	***8***	***10***	***10***	***10***	***29***	***5***	***20***	***20***	***29***	***15***	***11***	***16***	***27***	***15***	***15***	***280***

Annex 2b. Results of Large Ars by province and by year, Thailand.

Year/Province	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	***Total***
Trad		1											1							***2***
Chantaburi						1					1									***2***
Rayong								1												***1***
Cholburi										1										***1***
Samuth Sakorn													1							***1***
Petchaburi				1										1						***2***
Prachuab Kiri Khan							1				1				1					***3***
Chumphon									1											***1***
Surat Thani			1																	***1***
Nakorn Sri Thammarat								1									1			***2***
Songkhla	1											1								***2***
Pattani						1														***1***
Naratiwas		1														1				***2***
Satun										1										***1***
Trang				1																***1***
Krabi			1																	***1***
Phang-Nga							1									1				***2***
Phuket												1						1		***2***
Ranong	1																		1	***2***
Total	***2***	***2***	***2***	***2***	***0***	***2***	***2***	***2***	***1***	***2***	***2***	***2***	***2***	***1***	***1***	***2***	***1***	***1***	***1***	***30***

Annex 3. Area, number of fishing village and budgetary support for Ars installation in Thailand.

Fiscal year	Small ARs			Large ARs			Total	Total
	Budget (mil. Baht)	No. Fish. village	Area (km^2)	Budget (mil. Baht)	No. Fish. village	Area (km^2)	Budget (mil. Baht)	Area (km^2)
1985	3.00	5	40.81				3.00	40.81
1986	2.50	5	47.80				2.50	47.80
1987	2.50	5	30.00				2.50	30.00
1988	2.00	4	16.00	30.00	2	100.00	32.00	116.00
1989	2.50	5	22.00	30.00	2	100.00	32.50	122.00
1990	5.60	8	24.00	30.00	2	100.00	35.60	124.00
1991	5.88	8	24.00	30.00	2	100.00	35.88	124.00
1992	5.88	8	24.00				5.88	24.00
1993	7.50	10	2.50	30.00	2	100.00	37.50	102.50
1994	15.00	10	5.00	30.00	2	100.00	45.00	105.00
1995	15.00	10	5.00	30.00	2	100.00	45.00	105.00
1996	45.00	29	14.50	15.00	1	50.00	60.00	64.50
1997	10.00	5	2.50	30.00	2	100.00	40.00	102.50
1998	20.00	10	5.00	15.00	1	50.00	35.00	55.00
1988 (additon)	30.00	10	10.00	20.00	1	50.00	50.00	60.00
1999	60.00	20	20.00	40.00	2	100.00	100.00	120.00
2000	75.00	25	25.00	40.00	2	100.00	115.00	125.00
2000 (additon)	12.00	4	4.00				12.00	4.00
2001	45.00	15	15.00	20.00	1	50.00	65.00	65.00
2002	33.00	11	11.00	20.00	1	30.00	53.00	41.00
2003	48.00	16	16.00	40.00	2	60.00	88.00	76.00
2004	45.00	15	15.00	20.00	1	30.00	65.00	45.00
2004 (addition)	36.00	12	12.00				36.00	12.00
2005	45.00	15	15.00	20.00	1	30.00	65.00	45.00
2006	45.00	15	15.00	20.00	1	31.00	65.00	46.00
Grand total	**616.36**	**280.00**	**421.11**	**510.00**	**30.00**	**1,381.00**	**1,126.36**	**1,802.11**