FISHING OPERATION AND FISHERIES SURROUNDING THE ARTIFICIAL REEFS

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Abstract

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

■ INTRODUCTION

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

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

■ BACKGROUND OF ARTIFICIAL REEF INSTALLATION

1. The Development of ARs Installation

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

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

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

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

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

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

2. Considering for the Areas Installation

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

• The bottom should not be a muddy type.

• The areas should not have mud corrosive suspension.

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

• The areas should not be water ways.

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

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

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

3. Materials Used for ARs

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

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

3.2 Compatibility and suitable to the natural habitats.

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

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

The followings are some examples of material used for ARs:

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

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

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

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

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

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

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

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

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

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

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

4. The Implementation of the ARs

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

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

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

4.3 Marking the latitude and longitude of the target area.

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

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

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

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

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

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

4.10 Report the results of the installation.

4.11 Steel floating signs for navigation activities notices.

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

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

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

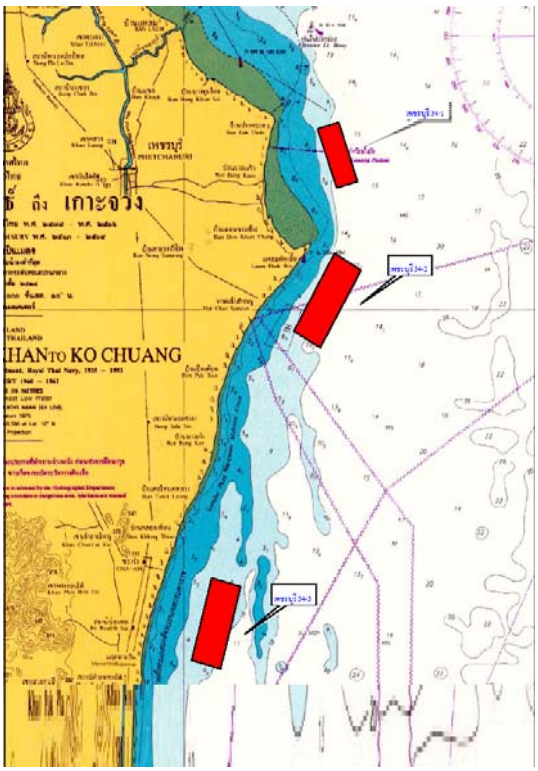


Figure 6. ARs locations in Petchaburi Province installed in 1991(Supongpan and Chenkitkosol (2003).

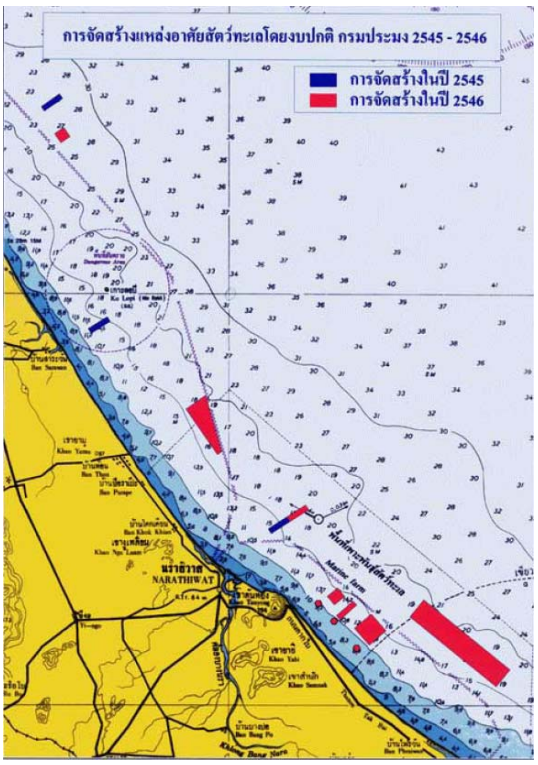


Figure 7. ARs locations in Pattani and Naratiwas Provinces installed in 2002 and 2003 (http:www.fisheries.go.th/marine/artificial reef).

5. Thailand ARs Installation of the Years 2004 and 2005

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

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

■ FISHING OPERATIONS AND FISHERIES SURROUNDING ARS

1. Catches, CPUE and Fish Species Caught Around ARs

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

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

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

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

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

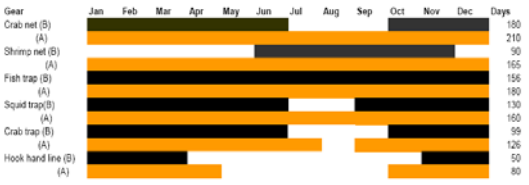
Furthermore, it was intended to determine the changes in fisher incomes from fishery activities due to the impact from the project. The comparison of the total effort, catch and catch per trip before and after installation of the ARs were carried out. The data used in this study were collected from three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

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

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

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

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



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

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

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

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

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

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

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

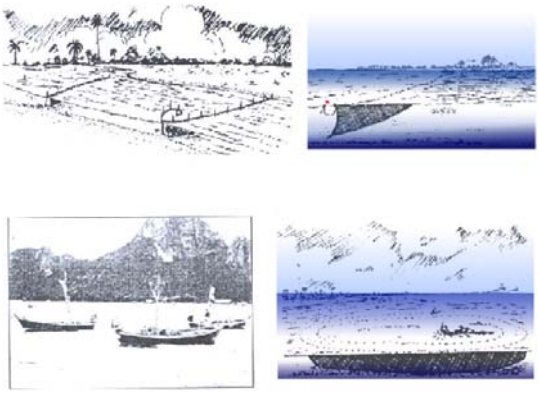


Figure 8. Mullet encircling gill net (Supongpan and Chenkitkosol, 2003).

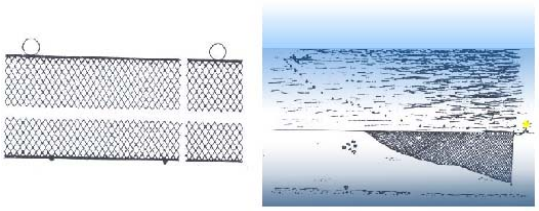


Figure 9. Threadfin gillnet and promfet gillnet (Supongpan and Chenkitkosol, 2003).

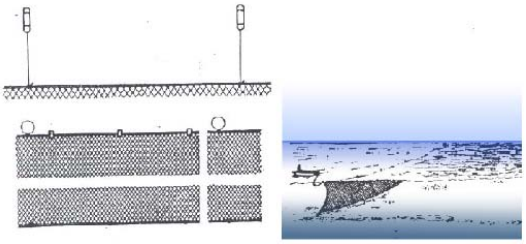


Figure 10. Dorab gill net (Supongpan and Chenkitkosol, 2003).

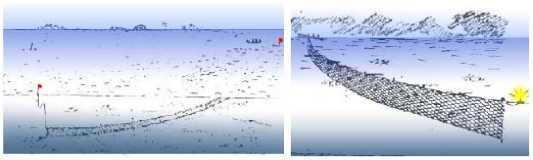


Figure 11. Indo-Pacific mackerel gillnet (Supongpan and Chenkitkosol, 2003).

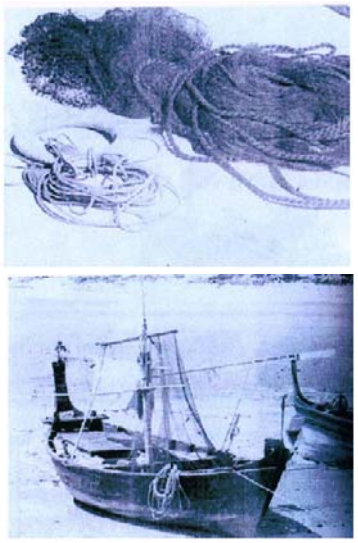
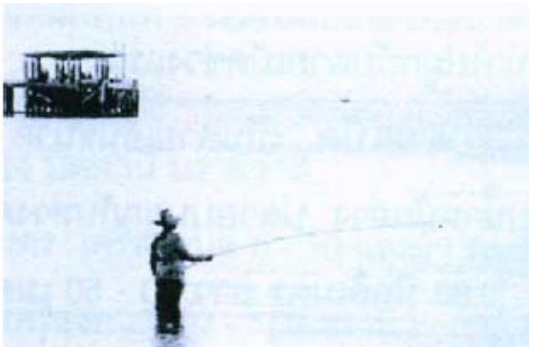


Figure 12. Squid cast net with light luring (Supongpan and Chenkitkosol, 2003).



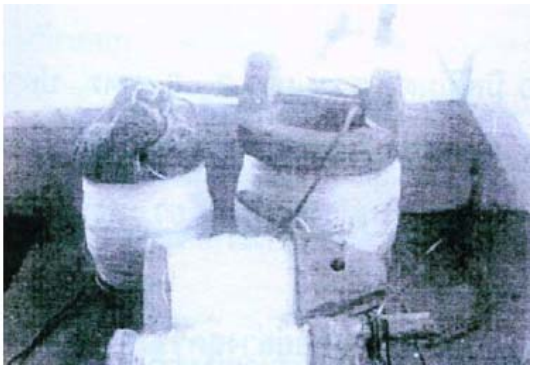


Figure 13. Hook hand line (Supongpan and Chenkitkosol, 2003).

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

Fishing gear	Before (avg 1990)	After (avg 1992-1994; 1995-1998)	Increase/ decrease (+/-)
Mackerel gillnet	0.39	18.52	+18.13
Sand whiting gillnet	41.47	48.7	+7.22
Trammel net	0.69	12.02	+11.33
Mugil gillnet	2.34	7.19	+4.84
Dorab gillnet	4.73	3.66	-1.07
Other fish gillnet	2.95	1.47	-1.47
Hook hand line	1.47	2.24	+0.76
Swimming crab gillnet	11.91	10.2	-1.71

3. Fishing Operation and Methods

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

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

3.1 Shrimp gill net or trammel net

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

3.2 Crab bottom gill net

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

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

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

3.3 Sand whiting gill net

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

3.4 Mackerel gill net

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

3.5 Hook hand line

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

3.6 Squid trap

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

■ DATA COLLECTION SURROUNDING ARS FOR RESEARCH WORKS

Generally data collection is based on the following aspects:

1. Criteria

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

2. Geography and Environment Condition

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

3. Fishing gears, Effort and Methods of Fishing

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

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

4. What types of data to be collected?

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

5. Data collection methods

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

5.1 Complete enumeration

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

5.2 Frame survey or based line surveys

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

5.3 Sampling survey

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

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

5.4 Scuba diving

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

5.4 Opinion polls and questionnaires

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

5.5 Enhancing Activities

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

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

■ COMMUNITY BASED FISHERY MANAGEMENT APPROACH

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

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

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