ARTIFICIAL REEFS IN THAILAND

BY
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INTRODUCTION

The coast line of Thailand is separated by the Malay Peninsula into two parts, one is the Gulf of Thailand that connects to the Pacific Ocean and the other connects to the Andaman Sea. The total coastline is about 2,625 km. Along the coastline, especially in the Gulf of Thailand, is a large continental shelf that is suitable for fishing. The marine fishery of Thailand has been developed since the Second World War. The fishing gears at the beginning were purse seine and bamboo stake trap, the major marine production was chub mackerel. There was no major fishing gear to capture demersal fish until 1961, when the beam trawl was introduced into Thailand. Even though it was an efficient gear it was not very successful due to the low demand. Two to three years latter the demand was increasing however, and the beam trawls were changed into otter board trawls that were more effecient. Consequently, the marine fisheries developed rapidly, the production increased from 1.5 thousand metric tons in 1960 to 2 million metric tons in 1977. Most of the production is consumed by the people of the country while a portion is exported to many countries in the world.

Meanwhile, the fishing boats also increased rapidly by number and size together with the increase in efficiency of the fishing gears. In 1984, a total of 16,006 fishing boats was registered by the Department of Fisheries. According to the type of fishing gears used fishing boats were divided into 9,131 trawlers, 961 purse seiners, 4,012 gill netters, 960 push netters and 942 boats using miscellaneous fishing gears. About 19 percent of these boats were over 18 metres in length and were classified as large-size fishing boats, whilst 20 percent of them were middle-size fishing boats of 14–18 metres in length and the rest (61 percent) were classified as small-size fishing boats.

At present, there are many problems in regard to marine fishery activity in Thailand, such as the over-exploitation of marine resources in the Gulf of Thailand by the middle and small-size trawlers and the return of large-size trawlers from international waters to the Thai fishing grounds as a result of the enforcement of EEZ's claimed by neighbouring countries. The main problem is that the nearshore areas especially those within the 3 km boundary from the shore are the most seriously overfished. Although there is a regulation for the conservation of marine resources, especially in the area within 3 km from shore, issued by the Department of Fisheries prohibiting trawlers and push netters from intruding the coastal area, it is often ignored by the fishermen, and it is not possible to effectively enforce the regulation.

The Department of Fisheries has recently decided to launch the coastal artificial reef project as a tool for marine fisheries conservation because the reefs can effectively protect the coastal area for marine living resources. The reefs also have potentials to increase fish and shellfish production. Moreover, the artificial reef might effectively obstruct the operation of trawlers and push netters and increase the fishing opportuntities for the small-scale fishermen who comprise 80 percent of the total fishermen in the country and rely upon inexpensive fishing gears and small boats with a limited range of operation.

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REVIEW OF ARTIFICIAL REEFS (ARs) IN THAILAND

Since 1978, 40 ARs have been installed in Thailand (Table 1). Rayong was the first province selected for the installation with two assigned objectives. The first was to study the species composition of fish in the ground around the ARs and the second was to study what would be the appropriate material to be used in construction of the ARs in the future. Three types of materials, scrap tyres, concrete and rock were used in the experiment at Rayong. The result of the study was to show that there were some changes in species composition of fish after the installation. Before the installation, trammel nets were used four times to collect the data and 26 species of fishes were caught, but 6 months after the installation, 49 species of fishes were caught by using the same fishing gear (Table 2).

In addition, it was also found that all three types of materials used in the construction of ARs made no difference in enticing the fish to live in the grounds and that it would be more conveninent to use scrap tyres and concrete rather than rock because ARs made of rock scattered and fewer species of fishes were enticed by the scattered rocks (Somphon and Suraphon, 1979).

After the first AR installation at Rayong, many experiments were made in the provinces along the coast such as Chantaburi, Songkhla, Phang-nga, and Phuket with results similar to the experiment in Rayong. However, ARs for the specific purpose of directly benefitting the fisheries were not built yet.

In 1985, the Department of Fisheries included the Artificial Reefs Installation Project in the Fifth National Economic and Social Development Plan (1982–1986) with the objective of installing ARs off six poverty stricken villages each year and a budget of 500,000 Baht for each village was provided for construction. The six villages selected were three villages along the Gulf of Thailand and three villages along the coast of the Andaman Sea. This project had as its major objective the conservation of the coastal living resources.

Therefore, it could be concluded that the two main objectives of AR installation were:

1. The productive fishing ground for small-scale fishermen.
2. The conservation of the coastal living resources.

In accordance with the different objectives of the project, all the procedures of the project such as site selection, installation, pattern and follow-up had to be carried out differently in response to the different objectives. This report is therefore divided into two parts to match the above objectives.

In 1987, ARs made of scrap tyres and concrete were installed in Rayong province with the following specific objectives.

1. To study what would be the appropriate material and appropriate pattern of construction for the installation of ARs.
2. To study the species and quantity of living resources in the ground.
3. To promote and increase the capability of the small-scale fisheries.

SITE SELECTION

The selected site should not be too far from the fishing village in order to be benificial to the small-scale fishermen. In general 3,000 m from the village was an average distance which was considered to be not so dangerous for the fisheries.

Because most of the living resources enticed into the sites were predators which prefer to live in clear water, the selected sites should be translucent to a high degree. For this project the average clearness of water is upto a depth of 4.5 m.

DEPTH OF WATER

The appropriate depth which could entice living resources should not be less than 15 m. In the Gulf of Thailand however, the depth of water is related to distance from the coast, and the depth of 15 m is not less than 5 km from the coast which was too far for the small-scale fisheries. Therefore, it was necessary for the ARs to be installed at a depth of 8 m.

SUBSTANCE OF THE BOTTOM-TYPE

The selected site must have a bottom-type hard enough to prevent the sinking of the materials in the ground. This project was installed on a smooth sandy bottom covered with silt.

Baseline information

The major objective of this experiment was mainly to study about the composition and quantity of the living resources enticed by the ARs and the appropriate installations to be used. Evaluation of this project was sought from the catch composition which varied from one gear to another gear, as well as the diving survey which indicated the degree of change in the installation patterns and the sinking of the materials.

The evaluation of this project could be concluded as follows:

The choice of material and design for the reefs

At present, scrap tyres and concrete are the only two types of material used in AR installation because of two significant reasons. The first reason is that they are not expensive and the second is that they are easily available.

Rock and wood were used but the result was not quite satisfactory because it was difficult to form the rock into the required patterns and wood had a very short durability. Therefore, these two kinds of materials have not been used again.

So far, no significant conclusion about the appropriate module design suitable for the bottom-type has been drawn. However, it was reported that the appropriate module should be 1−2 m high (Somphon, Suraphon, 1979). Thus, scrap tyres and concrete in different module patterns were used in this experiment (Fig.1).

Construction of reefs

There were four groups in this installation, each group was 200 m apart from each other, and were made up of the following quantities of materials (Fig. 2).

Site A composed of scrap tyres tied up into different module patterns with many kinds of materials such as polypropylene 10mm, wire No. 10, and 3/4 inch iron wire, each scrap tyre was perforated on the upper side to let the air come out easily and concrete or bags of sand were put in the lower side to weigh the scrap tyres.

Site B composed of 233 pieces of concrete module in pattern of water pipe with 0.3 m diameter, 1 m length and 2.5 inches thickness.

Site C consisted of 232 concrete rings of 0.3 m diameter, 0.3 m height and 0.03 m thickness.

Site D composed of 253 pieces of concrete cube in the size of 0.5+0.5+0.5 m and 6 inches thickness.

An amount of 96,000 Baht was spent as the cost of material in this experiment.

Monitoring system

After the installation of ARs, data was collected by using 2 kinds of fishing gear i.e. traps and hand line. Two traps were used for a period of 4–7 days three times a month.

Three hand lines were used for fishing, one hour for each group of material, data were collected once a month for three months.

Collecting data by means of diving survey was conducted once a month for each group of material for a period of 4 months.

Results of the study

Before the installation of the ARs in the said ground, the information and data were collected through fishing with three kinds of fishing gear i.e. hand lines, fish trap and trawl. Besides, diving survey was conducted once (Table 3). 19 species of living resources were found, 4 species by hand line, 4 species by fish trap, 14 species by trawl, and 3 species by diving survey.

After the installation of the ARs, a total of 18 species of living resources were found, of which 9 species by hand line and 17 species by fish trap (Table 4).

When the species of living resources compared before and after installation (Table 5), it was found that 5 species of living resources were found before installation and 20 species of living resources after installation. Therefore, the species composition increased by 15 and all the 15 species like to live along with gravel. However, for one species of fish *(Sillago sp.)* it was not certain whether or not it moved away from the area as it was not encountered after AR installation.

The catch per unit effort before and after installation (Table 5) was from 0.13 kg/line/hr to 0.33 kg/line/hr or 0.03 kg/trap/day to 0.54 kg/trap/day. In the case of the latter, it indicates roughly that the fish abundance increased 20 times. Therefore, installation of artificial reefs increased the enrichment of that ground..

Concerning the patterns and material used in the four groups, the following analysis shows (Table 6):

Site A in which 15 species of living resources were found composed of scrap tyres, while concrete block (Site D), water pipe (Site B) and concrete ring (Site C) enticed 12, 9 and 8 species of fish respectively. Comparing the total catch it was found that Site A caught a total of 822 gm/trap/day and Site D, Site B and Site C had a respective total catch of 548,521 and 275 gm/trap/day.

Site A occupied 600 sq. m., Site B 150 sq.m. Site C 225 sq. m. and Site D 200 sq. m. Sessile and associated mobile organisms were found in every site, for example barnacles which sprang out on the fifth day of the installation and covered all the surface of the material by the fortieth day of the installation.

Besides, gastropods, sea whips, bryozoa, polycheates were found perching on the materials in every site. It appears therefore that scrap tyres and concrete showed no difference as regards the living resources perching on them.

In regard to model design, no conclusion could be made as to which module was the best, for no difference could be seen between the many module patterns and they all sank 4–8 cm. in the sand. And

keep in mind that these ARs were installed for only a short period of time. Continued monitoring must be carried out periodically to get the correct conclusion.

The second objective

Reservation of the coastal living resources. Although there is a regulation covering the conservation of marine resources in the Gulf of Thailand, especially the area within 3 km from shore, issued by the Department of Fisheries in order to prevent trawlers and push netters from intruding into the coastal area, it is often ignored by the fishermen. Thus, it is not possible to enforce the regulation effectively. Therefore, the Department of Fisheries tried to find another measure to prevent trawlers and push netters and finally the Artificial Installation Project was considered because the materials used in the installation were very heavy and structurally strong so that they would serve as an obstruction to the trawlers and push netters.

Consequently, in 1985, the Department of Fisheries started this project in Nakhonsrithammarat province and a budget of 1,500,000 Baht was allocated for the benefit of small-scale fishermen.

General information on fishing villages

Ban Pak Poon, Ban Laemtalumpuk No. 2, 3 were the small villages which were selected as the target for the project. The major objective was to support the villagers engaged in coastal fishering without coming into conflict with the trawlers and push netters.

1 Ban Pak Poon

This village comprised 331 families of which 55% earned their living from fisheries, 40% from agriculture, and 5% from trade. 60% of the population was Muslim. most of them fishermen and 40% was Buddhist who earned their living from agriculture.

The fishermen in this village used many fishing gears, for example, thread fin gillnet, mugil gillnet, crabtrap, trawl. White shrimp and threadfin fish were the main source of income. The total catch was sold to the village middleman because 90% of the fishermen in the village were in debt to him. The villagers earned an average annual income of 23,900 Baht from fisheries and 10,500 Baht from other sources, or a total annual income of 34,400 Baht whereby approximately 30,000 Baht was spent on family expenses, and 22,000 Baht on fisheries expenses. In general each family had a debt burden of 6,000–25,000 Baht.

2 Ban Leamtalum Puk No. 2, 3

The two villages, situated close to each other, consisted of 89 families 85 of which were fisherfolk and the rest merchants.

Similar to the first village, the fishing gears used were trammel net, crab gillnet, threadfin gillnet. Major source of income were from expensive catch e.g. white shrimp, blue swimming crab and threadfin fish. The total catch would be sold to the middleman.

The average annual income was approximately 29,100 Baht of which 24,600 Baht came from the fisheries and 4,500 Baht from other sources. 35,000 Baht a year would be spent for family expenses and 20,000 Baht for fisheries expenses while in general the debt of each family to the middleman was around 8,000 to 30,000 Baht.

The objective of the reef programme

Beside the objective of reservation of the coastal living resources, the other objectives were as follows:

1. To set the fishing ground for the small-scale fisheries in this area.

2. To reduce the conflict between commercial fisheries and small-scale fisheries.

Site selection

When the Department of Fisheries was planning to push the Artificial Reefs Installation Project for the benefit of the small-scale fisheries it was obvious that the people in the three villages were facing a conflict with the commercial fisheries especially the trawlers. The small-scale fishermen complained that the trawlers had violated the law by intruding within the limit of 3 km from the coast thereby causing serious damage to their fishing gears and overexploit the living resources along the coastline.

Consequently, the Department of Fisheries decided to carry out the Artificial Reefs Installation Project to test whether or not the result would be beneficial to the small-scale fisheries. Therefore, in this case, general principles of site selection were not considered rigidly in choosing the most appropriate villages to install the project. The only significant considerations were the following:

1. The site should be within 3,000 m from the coast in order to stay free of complaints by the trawlers.

2. The materials used in the installation must not obstruct navigation.

Baseline information

As this project had the major objective of reserving the living resources along the coastline, the data collected for project evaluation was mostly biological and fisheries data of specific gears. Data collection was made before and after the installation for a period of 2 years to analyze the advantages of the project and its benefit to the small-scale fisheries.

Few socio-economic data of the fisheries in the three villages described above, may be used for further economic analysis in the future.

CONSTRUCTION OF THE REEFS

As mentioned earlier, a major objective of the project was to reserve the living resources along the coastline, so the installation should cover a large area (Fig. 3) and divided into 3 sites.

Sites: Site 1 covered 4 sq. mile for expansion of the spawning ground of blood cookles. Site 2 covered 1 sq. mile and Site 3 covered 6 sq. miles. All were installed to obstruct the trawlers and push netters.

Concrete was chosen to be used in the installation because it was very heavy and strong. Because of the limited budget allocated for the project, which had to cover a large area, the module patterns were designed in order to be easy, convenient and economical to build. Finally 3 concrete rings with 1 meter diameter, 50 cm long, 5 cm thick, were tied up together with 0.6 mm steel wire (Fig. 4) weighing 300 kg and then installed in the ground.

INSTALLATION PATTERN

There were 1,308 sets of module patterns which had to be installed to cover the area of 11 sq. miles. They were installed in the following ways (Fig. 5).

Site 1

Because the fishermen used push netters with small boats in this ground, only 5 sets of modules were installed in one spot and a total of 205 sets of modules were deployed in Site 1.

Sites 2 and 3

The fishermen used trawlers in this ground. 10 sets of module patterns were installed in each spot and a total of 140 sets were allocated to Site 3. The remaining 383 sets were installed tightly in Site 3 to form a fishing ground for the small-scale fishermen who use hand lines and traps.

MANAGEMENT MEASURES AND CONTROLS

In Thailand the fisheries are open access. For example, under the Fisheries Law, fishermen can fish wherever they like, the trawlers can operate anywhere except within 3,000 m from the coastline. At present, there is no law to prohibit anyone from other villages to fish in the ARs. Therefore, these ARs would be fishing grounds for all small-scale fishermen. Since everyone had the right to fish there, the small-scale fishermen in the three villages did not feel that the ARs belonged to them and showed lack of awareness that the government had built it for their benefit and that they ought to make use of it. They had no feeling of possession and did not feel that it was their responsibility to look after them.

On the government side, very little could be done in such a case because there were not enough officials to look after the ARs. The only thing the government could do was to inform the people of the three villages that they should report promptly whenever they saw anyone violating the law.

Monitoring System

These ARs were installed near the coastline at 4–6 m depth and the water transparency inhibit observation through diving. The evaluation was thus merely based on catch data in the grounds.

In this case, the monthly total catch of threadfin fish and shrimp sold to the village middleman was recorded and used as an indicator.

EVALUATION AND ESTIMATE OF BENEFITS

The Artificial Reefs Installation Project constructed ARs in the ground which could be divided into 3 sites. Site 1 was the natural ground of blood cockles where cockle fishermen have faced problems because the push netters invaded the ground resulted in the decrease of blood cockles catch. The small-scale fishermen requested the Department of Fisheries to install the artificial reefs to prevent the push netters from intruding into the ground. Unfortunately, the installation did not give the expected result because the substratum of the ground was muddy and consequently the modules sank in the mud gradually until in 6-month period all the modules had sunk completely in the mud.

Sites 2 and 3 were fishing grounds for the threadfin gillnet small-scale fishermen whose fishing season was from September to November.

These small-scale fishermen have always had problems with trawlers. During the fishing season they had only 5–10 days of fishing because trawlers would rush in the ground and catch most of the fish. On top of that, the small-scale fishermen had another problem to face as their nets were damaged by the trawlers.

After the installation of Artificial Reefs it was found that in Sites 2 and 3 the total catch of the small-scale fishermen increased (Table 7). In 1985, before the installations, 1,921.8 kg of fish was caught by 408 trips of 21 floating gill nets throughout the year. In 1986, after the installation, it was reported

that 6,962.7 kg of fish was caught by 895 trips of 21 floating gill nets. The earning was estimated to be about 16,761 Baht/boat/year, in other words the fishermen earned 11,650 Baht more for each boat.

The survey in 1986 showed that there were 120 fishing boats. It was estimated that the ARs has increased the annual income of the three fishing villages by 1,398,000 Baht.

The total catch of trammel nets fishermen also increased in 1986 as described below (Table 8).

In 1985, the data collected from 85 boats indicated that 11,414.5 kg of shrimp was caught in 3,188 trips while in 1986 there were 3,290 trips which produced 14,839.5 kg or 3,425 kg more than in 1985. This could be explained by the fact that after the AR installation, the number of trawlers in the ground decreased and the trammel nets therefore caught much more shrimp. In addition, in 1985 trammel nets produced a total catch of 24,770 Baht/boat/year while in 1986 was 32,934 Baht/boat/year, so that a trammel net boat earned an increment of 8,164 Baht in a year. As the survey showed that there were 200 boats, therefore, the trammel net fishery increased the total value of 1,632.800 Baht a year. Furthermore, an increased value of 1,398,000 Baht a year was obtained from the threadfin gillnet. Thus, the AR installation enabled the small-scale fishermen to increase their income by 3,030,800 Baht a year.

Unfortunately, these ARs disappeared in 1987 due to the damage by trawlers, particularly pair trawlers and the modules sank gradually in the muddy sand and finally disappeared completely.

SUMMARY

The AR installation had a specific target to increase the annual income of the small-scale fishermen by allowing them to do their fishing in the ARs.

The conclusion drawn from the experiment shows that the AR installation is beneficial for the small-scale fisheries. There were however, some problems concerning the durability of the materials used. The ARs at Nakhonsrithamarat lasted for a year and a few months and then sank in the sand and disappeared. The fishermen who benefitted from the ARs requested the Department of Fisheries to install a new AR for them and the Department of Fisheries agreed to do so. But it is still unknown what would be the appropriate module patterns to be installed to suit the soft and muddy substrates. If scrap tyres are used they cannot prevent the trawlers from intruding into the ground. Besides appropriate module design which stands from sinking should also be found. Furthermore, the design has to be simple and easy to match the small budget provided for the project. If the module design is complicated enough the budget may not be sufficient to complete the installation of the new ARs.

An appropriate module design is therefore required to make the project feasible.

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REFERENCES

BOONGERD.S. and S. VADHANAKUL, Experiment On Artificial Reef Construction No. 1, No. 2, 1979 and No. 3, in Rayong Province. Rayong Marine Fisheries Station, Marine Fisherics Division, Department of Fisheries. 53 pp.

BANASOPIT, T. and T. WONGRATANA, A Check List of Fishes in The Reference Collection 1967 Maintained at The Marine Fisheries Laboratory, Division of Research and Investigations, Department of Fisheries. Contribution No. 7, 73 pp.

SINANUWONG, K. Artificial Reefs Construction in Nakornsrihammarat and Pattani Provinces Publication No. 1/1987, Small scale Fisheries Develoment Section, Marine Fisheries Division. 10 pp.

SUNGTHONG, S. Experiment on Fish Apartment at Ao Ban-Phae Rayong, Province Publication No. 1/1987, Eastern Marine Fisheries Development Centre, Marine Fisheries Division. 25 pp.

Table 1. List of Artifical Reefs in Thailand

Zone	Province	Reef No.	year	Material (No.)	Module	No. of Unit	Area (m^2)	Depth (m)	Distance from shore	Type of Bottom	Funding level(Baht)	Source	Objective
A.Eastern Gulf of Thailand	Rayong	1	1978	Tires(400) Concrete(70)	1 unit=13 tires Block	140	1,200	18	10 km.	Sand, Mud Shell	34,078	DOF	Fishing ground
		2	1978	Tires(410) Concrete(73)	1 unit=13 tires Block	145	2,000	4	40 m.	Sand, Mud Shell			
		3	1978	Tires(390)	1unit=7-8tires	50	900	5	50 m.	Sand, Mud Shell			
		4	1981	Tires(528) Concrete(252)	1 unit=8 tires Cylinder	129	1,350	11	2.5 km.	Sand, Mud	88,676	DOF	
		5	1981	Tires(450) Concrete(274)	1 unit=4 tires Cylinder	203	1,500	12	3.9 km.	Sand, Mud			
		6	1982-1983	Tires(420) Concrete(210)	1unit=4-8tires Cylinder	175	4,900	9	3 km.	Sand, Mud	88,000	DOF	
		7	1984	Tires(5,553) Concrete(2,000)	1unit=4-8tires Cylinder	1,900	45,000	18	2 km.	Sand, Mud Shell	167,480	DOF	
		8	1987	Tires(766) Concrete(718)	1 unit=4 tires Block,Cylinder	599	40,000	7	2.1 km.	Sand, Mud Shell	89,000	DOF	
	Chantaburi	9	1982	Tires(1,000)	1 unit=4 tires	250	1,300	10	500 m.	Sand, Mud	18,000	DOF	
	Trad.	10	1987	Tires(4,800)	1 unit=8 tires	600	9,540	8	2 km.	Sand, Mud	209,400	Province Governor	
B.Inner Gulf	Cholburi	11	1986	Concrete(2,000)	Cylinder	667	810,000	6	1.5 km.	Sand, Mud Shell	150,000	Province	Gonservation of the natural Resources
	Petchburi	12	1985	Tires(3,176)	1 unit=4 tires	794	13 km^2	6	1.5 km	Sand, Mud Shell	400,000	Private Sector	
		13	1986	Tires(3,000)	1 unit=4 tires	750	7.5 km^2	7	2 km.	Sand, Hud Shell	200,000	Private Sector	

Table 1. List of Artifical Reefs in Thailand (Cont.)

Zone	Province	Reef No.	year	Material (No.)	Module	No. of Unit	Area (m^2)	Depth (m)	Distance from shore	Type of Bottom	Funding level(Baht)	Source	Objective
C. Southern Gulf	Nakornsri-Thamma-rat	14	1985	Concrete(3,300)	Cylinder	1,100	12 km^2	5–6	1.5 km.	Sand, Mud	1,490,000	DOF	
		15	1985	Concrete(645)	Cylinder	215	5 km^2	5	1 km.	Mud			
		16	1986	Tires(4,800)	1 unit–4 tires	1,200	13 km^2	4–6	1.5 km	Sand, Mud Shell	500,000	DOF	
		17	1986	concrete(420)	Cylinder	140	1.5 km^2	5–6	1.5 km	Sand, Mud Shell	500,000	DOF	Fishing ground
		18	1987	Concrete(850)	Block	850	8 km^2	4.6	1.5 km	Sand, Mud Shell	500,000	DOF	Conservation of the natural Resource
	Songkhla	19	1982	Tires(800)	1 unit=4 tires	320		5		Sand, Shell	60,000	DOF	Fishing groud
				Concrete(120)	Block								
		20	1987	Concrete(850)	Block	850	8 km^2	4–6	1.5 km	Sand, Mud Shell	500,000	DOF	Conservation of the natural Resources
	Pattani	21	1986	Tires(4,800)	1 unit=4 tires	1,290	13 km^2	4–6	1.5 km	Sand Mud Shell	500,000	DOF	Conservation of the natural Resource
		22	1987	Concrete(850)	Block	850	8 km^2	4–6	1.5 km	Sand, Mud Shell	500,000	DOF	
D. Andaman Sea.	Phang-nga	23	1982	Tires(550)	–	–	2,000	7	–	Sand, Mud Shell	–	Province Governor	
		24	1983	Concrete(200)	Block	200	1,800	8	–	Sand, Shell	1,657,280	Province Governor	Fishing ground
		25	1983	Concrete(200)	Cylinder	100	1,800	9	–	Sand, Shell			
		26	1983	Concrete(350)	Cylinder	175	2,200	7	–	Sand, Mud Shell			
		27	1983	Concrete(320)	Cylinder	160	2,200	7.9	–	Sand, Mud Shell			

Table 1. List of Artifical Reefs in Thailand (Cont.)

Zone	Province	Reef No.	year	Material (No.)	Module	No. of Unit	Area (m^2)	Depth (m)	Distance from shore	Type of Bottom	Funding level(Baht)	Source	Objective
		28	1983	Concrete(340)	Cylinder	170	2,200	9.5	–	Sand, Mud Shell			
		29	1983	Concrete(250)	Cylinder	125	2,000	10.5	–	Sand, Mud Shell			
		30	1983	Concrete(250)	Cylinder	125	2,000	5	–	Sand, Mud Shell			
		31	1983	concrete(320)	Cylinder	160	2,200	14	–	Sand, Mud Shell			
		32	1983	Concrete(330)	Cylinder	165	1,800	11	–	Sand, Mud Shell			
	Phuket	33	1984	Tires(750)	1 unit=5 tires	150	3,750	7–13	–	Sand, Mud Shell		DOF	Fishing ground
		34	1985	Tires(750)	1 unit=5 tires	150	3,750	7–13	–	Sand, Mud Shell		DOF	
	Satul	35	1986	Concrete(750)	Cylinder	250	50,000	4	1.5 km	Sand, Mud	350,000	DOF	
		36	1986	Concrete(750)	Cylinder	250	50,000	4	1.5 km	Sand, Mud	350,000	DOF	
		37	1986	Concrete (1,500)	Cylinder	500	2.5 km^2	8	1.5 km	Sand, Mud	500,000	DOF	Conservation of the
		38	1987	Concrete(1,230)	Cylinder	410	4 km^2	5	2.5 km	Sand, Mud Shell	500,000	DOF	natural resource
		39	1987	Concrete(1,230)	Cylinder	410	2 km^2	8	0.5 km	Sand, Mud	500,000	DOF	
	Krabi	40	1987	Tires(2,800)	1 unit=5 tires	700	1.5 km^2	10	1 km	Sand, Shell	Private Sector	Private	Conservation of natural resources

Table 2. Comparison of catch composition by trammel net between pre-reef and post-reef.

Species	Pre-reef No.	Post-reef No.	Species	Pre-reef No.	Post-reef No.
1. Dasyatis zuigei	2	12	27. Siganus oramin	1	5
2. Taeniura lymma	1	11	28. Pomadasys maculatus	–	2
3. Epinephelus tauvina	1	2	29. Therapon puta.	–	1
4. E. areolatus	2	6	30. Monacanthus chinensis	6	25
5. E. moara	–	2	31. Leiognathus elongatus	4	10
6. Epinephelus sp	–	5	32. Pempheris vanicolensis	–	4
7. Chiloscyllium griseum	–	2	33. Secutor reconius	5	–
8. Lutianus vitta	1	13	34. Apogon sp.	–	1
9. L. johnii	–	13	35. Setipinna melanochir	–	1
10. L. lineolatus	2	9	36. Cynoglossus sp.	4	19
11. Plectorhyncus pictus	–	1	37. Platycephalus sp.	1	1
12. Lethrinus lentjan	11	67	38. Pterois ruselli	–	3
13. Scolopsis temporalis	4	13	39. Gymnothorax boschi	–	2
14. Nemipterus hexodon	5	4	40. Batrachus grunniens	–	5
15. Caranx leptolepis	–	1	41. Scorpaenodes guamensis	–	1
16. Caranx williamsi	–	1	42. Amphiprion polymnus	1	1
17. Rastrelliger neclectus	–	1	43. Arothron stellatus	–	1
18. Gerres filamentosus	3	51	44. Cyclichthys orbicularis	1	2
19. Mugil sp.	–	1	45. Penaeus latisulcatus	3	11
20 Plotesus anguillalis	–	3	46. Squilla sp.	7	12
21. Sphyraena obtusata	–	6	47. Portunus pelagicus	28	82
22. Sillago maculata	1	7	48. Charybdis natator	6	22
23. Saurida undosquarmis	–	2	49. Sepioteuthis lessoniana	1	22
24. Pentapodus setosus	7	6	50. Loligo sp.	–	11
25. Parupeneus sp.	–	1	51. Sepia sp.	2	–
26. Siganus guttatus	–	9	52. Octopus	1	–

Table 3. Catch Composition from various types of fishing gear in the area of artificial reef construction (Pre-reef).

Species	Handline (No.)	Fish trap (No.)	Trawler (No.)	Diving (No.)
1. Pentapodus setosus	3	4	–	–
2. Nemipterus delagoae	4	1	–	–
3. Scolopsis cancellatus	1	2	–	1
4. Sillago maculata	1	–	13	–
5. Lethrinus ornatus	–	1	–	–
6. Leiognsthus sp.	–	–	67	–
7. Saurida tumbil	–	–	2	–
8. Apogon sp.	–	–	13	–
9. Secutor insidiator	–	–	1	–
10. Pseudupeneus luteus	–	–	14	2
11. Dussumieria hasseltii	–	–	1	–
12. Caranx malabaricus	–	–	1	–
13. C. Leptolepis	–	–	5	–
14. Oxyurichthys sp.	–	–	–	5
15. Sepia pharaonis	–	–	1	–
16. S. recurvirostra	–	–	1	–
17. Loligo sp.	–	–	11	–
18. Starfish	–	–	13	–
19. Sea cucumber	–	–	2	–

Table 4. Catch composition by handline and fish trap in the area of artificial reef construction (Post-reef).

Species	Handline (kg.)	Fish Trap (kg.)
1. Pentapodus setosus	2.450	3.020
2. Scolopsis cancellatus	0.530	4.730
3. Nemipterus delagoae	0.430	–
4. Lutianus lineolatus	4.405	2.685
5. L. johni	0.665	0.555
6. L. sp.	–	1.630
7. Epinephelus tauvina	1.060	8.060
8. E. areolatus	3.665	1.865
9. Lethrinus ornatus ornatus	1.435	1.560
10. Alutera monoceros	1.620	–
11. Monacanthus chinensis	–	1.540
12. Chromis cinerascens	–	5.255
13. Plectorhynchus sp.	–	1.100
14. Therapon sp.	–	0.408
15. Rhynchostracion nasus	–	0.410
16. Cyclichthys orbicularis	–	2.220
17. Psammoperca waigiensis	–	0.480
18. Taeniura lymma	–	0.560
19. Gymnothorax boschi	–	1.400
Total	16.26	37.45
Average/gram/line/Hr.	0.332	–
Average/gram/trap/day	–	0.542

Table 5. Comparative quantity of the total catch before and after installation.

Species	Handline (kg.)		Trap (kg.)	
	Before	After	Before	After
1. Pentapodus setosus	0.065	2.450	0.15	3.020
2. Scolopsis cancellatus	0.08	0.53	0.04	4.730
3. Nemipterus delagoae	0.17	0.43	0.04	–
4. Luthanus lineolatus	–	4.405	–	2.685
5. L. johni	–	0.665	–	0.555
6. L. sp.	–	–	–	1.630
7. Epinephelus tauvina	–	1.060	–	8.060
8. E. areolatus	–	3.665	–	1.865
9. Lethrinus ornatus	–	1.435	0.12	1.560
10. Alutera monoceros	–	1.620	–	–
11. Monacanthus chinensis	–	–	–	1.540
12. Chromis cinerascens	–	–	–	5.255
13. Plectorhynchus sp.	–	–	–	1.100
14. Therapon sp.	–	–	–	0.480
15. Cyclichthys orbicularis	–	–	–	2.120
16. Psammoperca waigiensis	–	–	–	0.480
17. Taeniura lymma	–	–	–	0.560
18. Rhynchostracion nasus	–	–	–	0.410
19. Silago sp.	0.025	–	–	–
20. Gymnothorax boachi	–	–	–	1.400
Total	0.34	16.260	0.35	37.45
Average Gram/line/Hr.	0.13	0.332	–	–
Gram/trap/day	–	–	0.03	0.542

Table 6. Comparative quantity of catch among site a, b, c and site d by fish trap and handline.

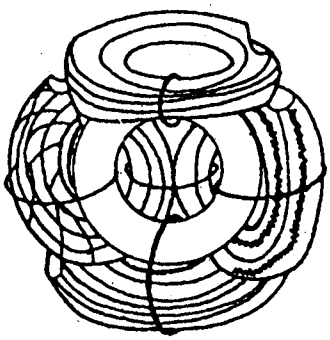
Species	Fish trap (gm.)				Handline (gm.)			
	Site A	Site B	Site C	Site D	Site A	Site B	Site C	Site D
1. Epinephelus tauvina	2150	2310	1260	2340	240	480	150	190
2. E. areolatus	710	990	–	160	1640	270	120	1635
3. Chromis cinerascens	1850	1155	890	1360	–	–	–	–
4. Plectorhynchus sp.	640	320	–	140	–	–	–	–
5. Bethrinus ornatus	650	670	120	120	–	170	260	1005
6. Pentapodus setoslis	430	410	960	1220	780	520	520	625
7. Scolopsis cancellatus	1940	2020	440	330	210	–	150	170
8. Lutianus lineolatus	1250	925	45	465	1400	900	480	1625
9. L. johni	410	145	–	–	205	130	80	250
10. L. sp.	1550	–	–	80	–	–	–	–
11. Cyclichthys orbicularis	2120	–	–	–	–	–	–	–
12. Therapon sp.	340	–	70	70	–	–	–	–
13. Gymnothorax boschi	1400	–	–	–	–	–	–	–
14. Monacanthus chinensis	–	–	550	990	–	620	–	1000
15. Alutera monoceros	–	–	–	–	–	–	–	–
16. Rhynchostraction nasus	410	–	–	–	–	–	–	–
17. Psmmoperca waigiensis	480	–	–	–	–	–	–	–
18. Taemipterus delagone	–	–	–	560	–	–	–	–
19. Nemipterus delagoae	–	–	–	–	100	80	150	100
Total	16330	8950	4335	7835	4575	3170	1915	6600
Gram/trap/day	822.55	521.42	274.94	547.91	416.81	282.5	150.78	479.50

Table 7. Comparison of catch and value (threadfin gillnet) between pre-reef and post-reef.

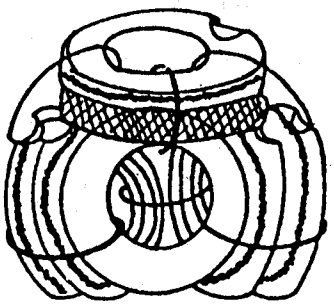
Month	No. of Trip From 21 boats		Total catch		Threadfin		Silk fish		Spanish Mackerel		Caranx sp		Black Pomfret		Chub Mackerel	
	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
January	0.0	83	0.0	875.1	0.0	593.0	0.0	22.0	0.0	39.8	0.0	215.7	0.0	4.6	0.0	0.0
February	16	149	412.3	1494.4	332.6	1161.2	26.5	65.6	0.0	79.7	52.0	186.6	1.2	1.3	0.0	0.0
March	0.0	152	0.0	1161.5	0.0	694.8	0.0	59.4	0.0	44.3	0.0	124.1	0.0	0.3	0.0	238.0
April	0.0	182	0.0	1002.8	0.0	930.4	0.0	17.8	0.0	6.4	0.0	47.2	0.0	1.0	0.0	0.0
May	0.0	18	0.0	67.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
June	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
July	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
August	0.0	33	0.0	233.7	0.0	164.5	0.0	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.4
September	242	120	465.0	1171.6	465.0	1027.1	0.0	66.9	0.0	12.0	0.0	21.9	0.0	3.2	0.0	40.5
October	139	91	958.0	897.6	926.4	865.3	4.0	0.0	36.2	3.7	29.0	19.2	2.4	1.0	0.0	8.4
November	11	3	46.5	41.6	22.7	41.6	0.0	0.0	0.0	0.0	21.0	0.0	0.8	0.0	2.0	0.0
December	0.0	4	0.0	16.6	0.0	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total (kg)	408	835	1921.8	6962.7	1746.7	5562.3	30.5	244.5	36.2	185.9	102.0	614.7	4.4	11.4	2.0	343.5
Value (Bht)	–	–	107,336.5	351,981	104,802	333,733	457.5	3667.5	905	4647.5	1,020	6,147	132	342	20	3,439
Value/Boat/year	–	–	5,111.26	16,761	–	–	–	–	–	–	–	–	–	–	–	–

Table 8. Comparison of catch and value (Trammel net) between pre-reef and post-reef.

Month	No. of Trip		Total catch		White Shrimp		Yellow shrimp		Pink shrimp	
	1985	1986	1985	1986	1985	1986	1985	1986	1985	1986
January	126	123	845.5	237.8	453.6	147.6	236.2	83.4	155.4	6.8
February	248	297	975.7	1,553.9	660.6	1,364.4	169.7	17.6	145.4	171.9
March	585	266	2,318.5	1,159.7	1,884.6	998.1	39.2	0.0	394.7	161.6
April	427	155	1,360.8	397.3	1,214.6	325.5	1.4	0.0	144.8	71.8
May	486	527	1,362.8	2,306.3	1,330.5	2,098.0	0.0	5.9	32.2	202.1
June	126	159	283.4	469.7	283.4	462.0	0.0	0.0	0.0	7.7
July	315	232	666.0	867.9	666.0	840.0	0.0	4.6	0.0	23.3
August	136	356	406.2	997.3	406.2	878.0	0.0	0.0	0.0	119.3
September	0.0	414	0.0	1,315.4	0.0	1,278.8	0.0	0.0	0.0	44.6
October	401	95	1,160.6	189.7	1,045.8	188.3	0.0	0.0	114.8	1.4
November	338	423	2,035.0	3,270.7	1,880.2	2,977.7	15.4	80.1	139.4	212.9
December	0.0	243	0.0	2,074.1	0.0	1,701.5	0.0	52.2	0.0	320.4
Total (kg.)	3,188	3,290	11,414.5	14,839.5	9,825.5	13,251.9	461.9	243.8	1,127.1	1,343.8
Value (Bht)	–	–	2,105,524	2,799,388	1,965,100	2,650,380	27,714	14,628	112,710	34,380
Value/boat/ year	–	–	24,770	32,934						



FIVE SCRAP TIRES



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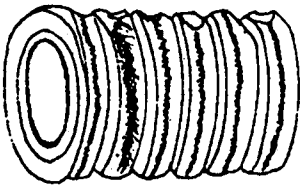

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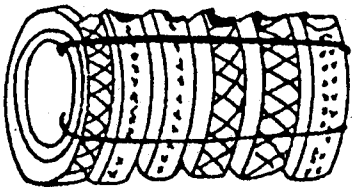

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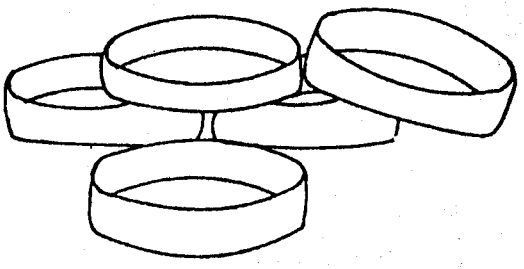
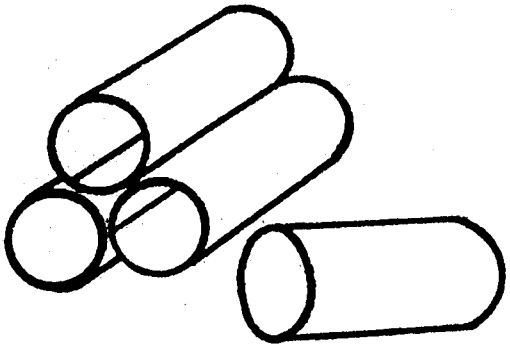
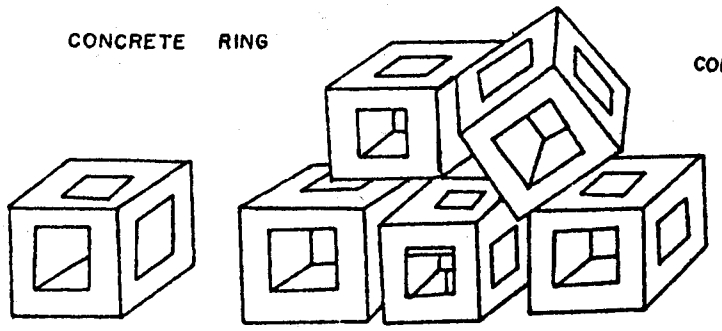


CONCRETE RING



CONCRETE WATER PIPE



CONCRETE BLOCK.

Figure 1. Materials used in different modules.

A 730 SCRAP TIRES

B 233 PIECES OF CONCRETE WATER PIPE

C 232 PIECES OF CONCRETE RING

D 263 PIECES OF CONCRETE BLOCK

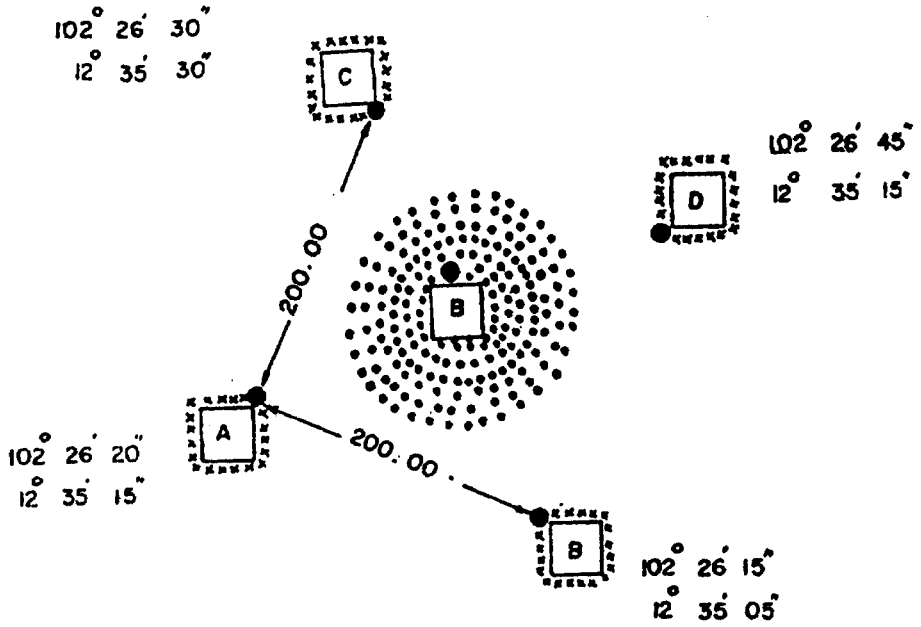


Figure 2. The pattern of artificial reef installation.

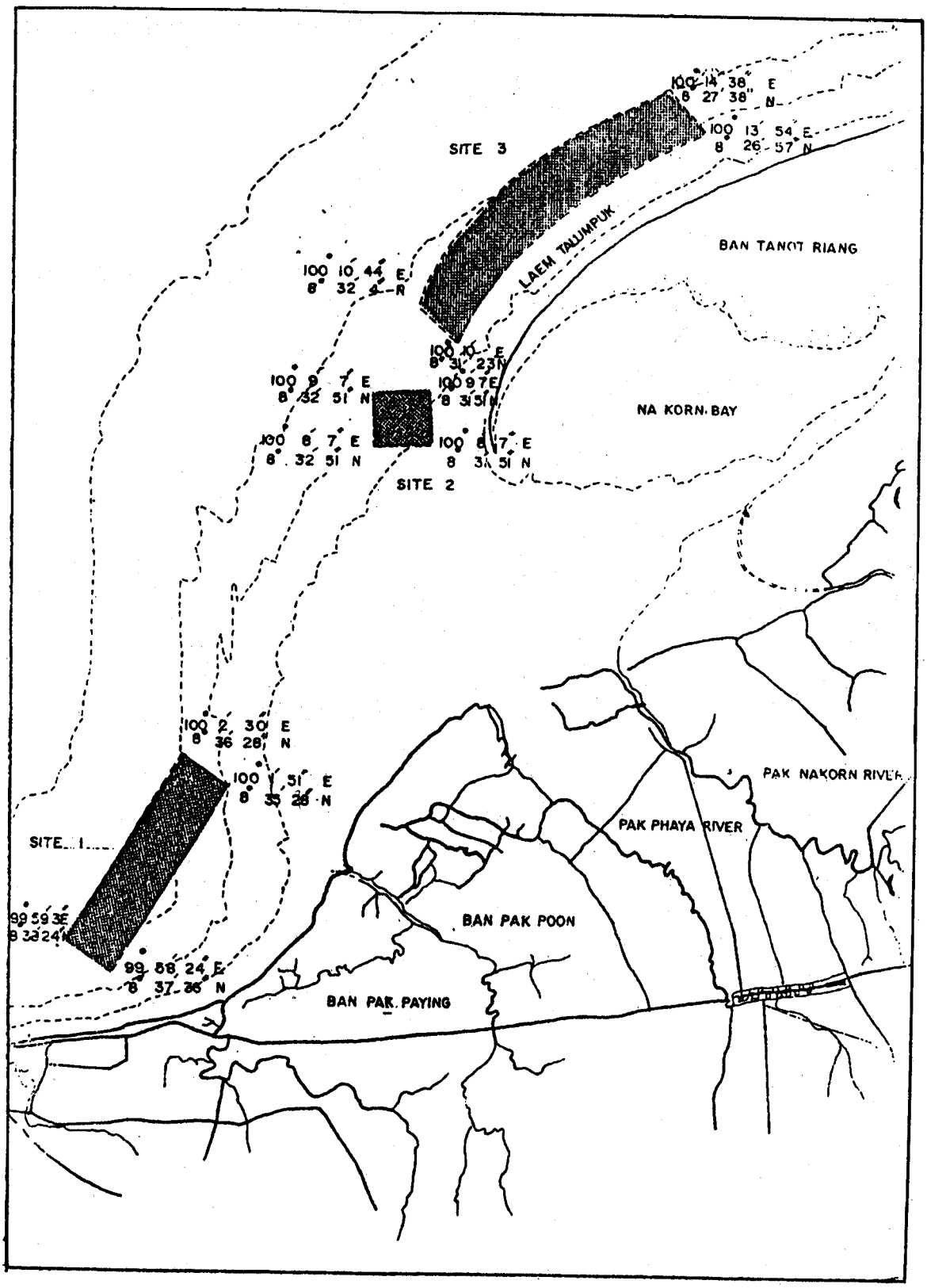


Figure 3. Map showing the site of artificial reefs at Nakorn Sri Thammarat Province.

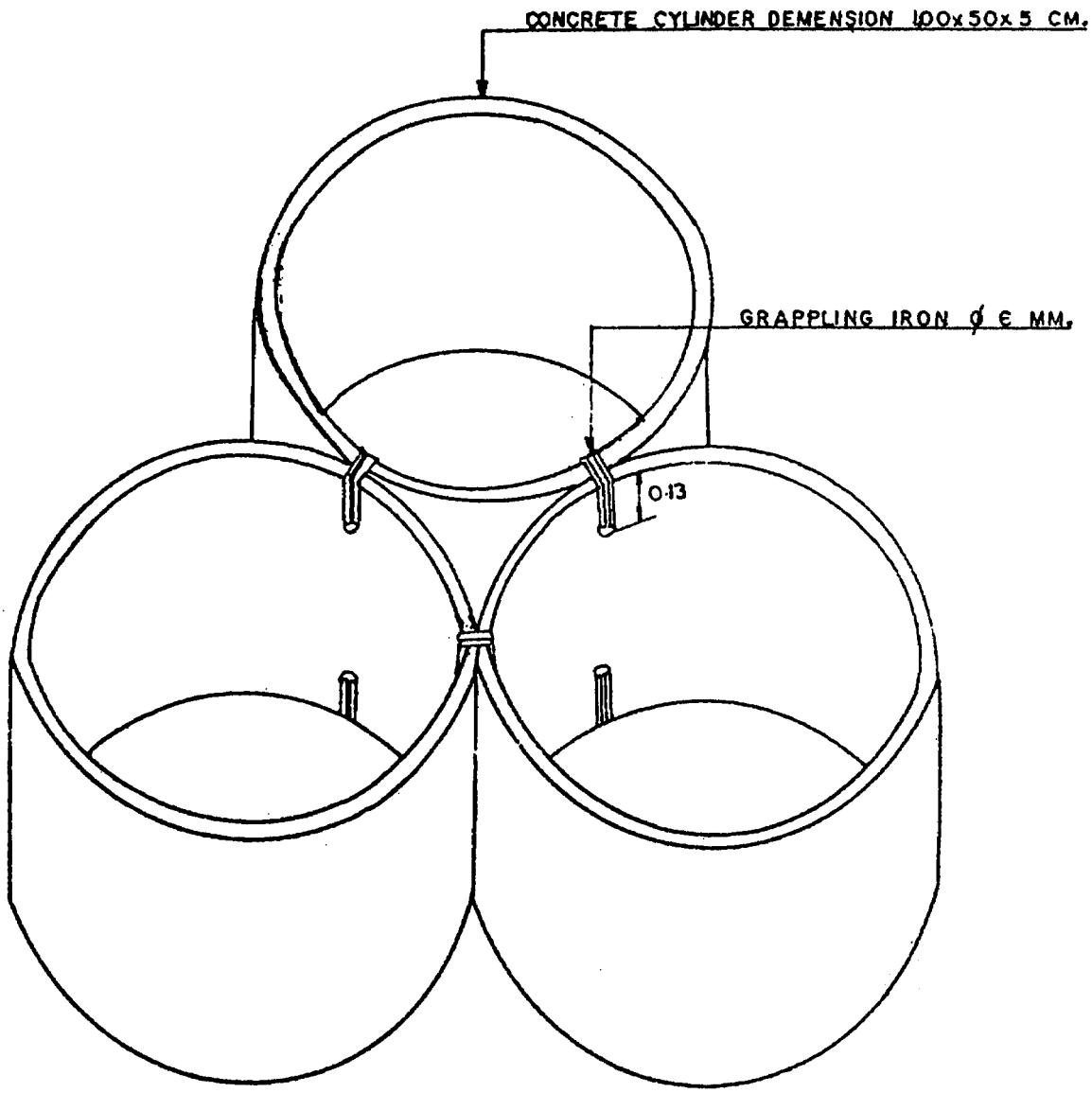


Figure 4. Dimension and set of concrete cylinder.

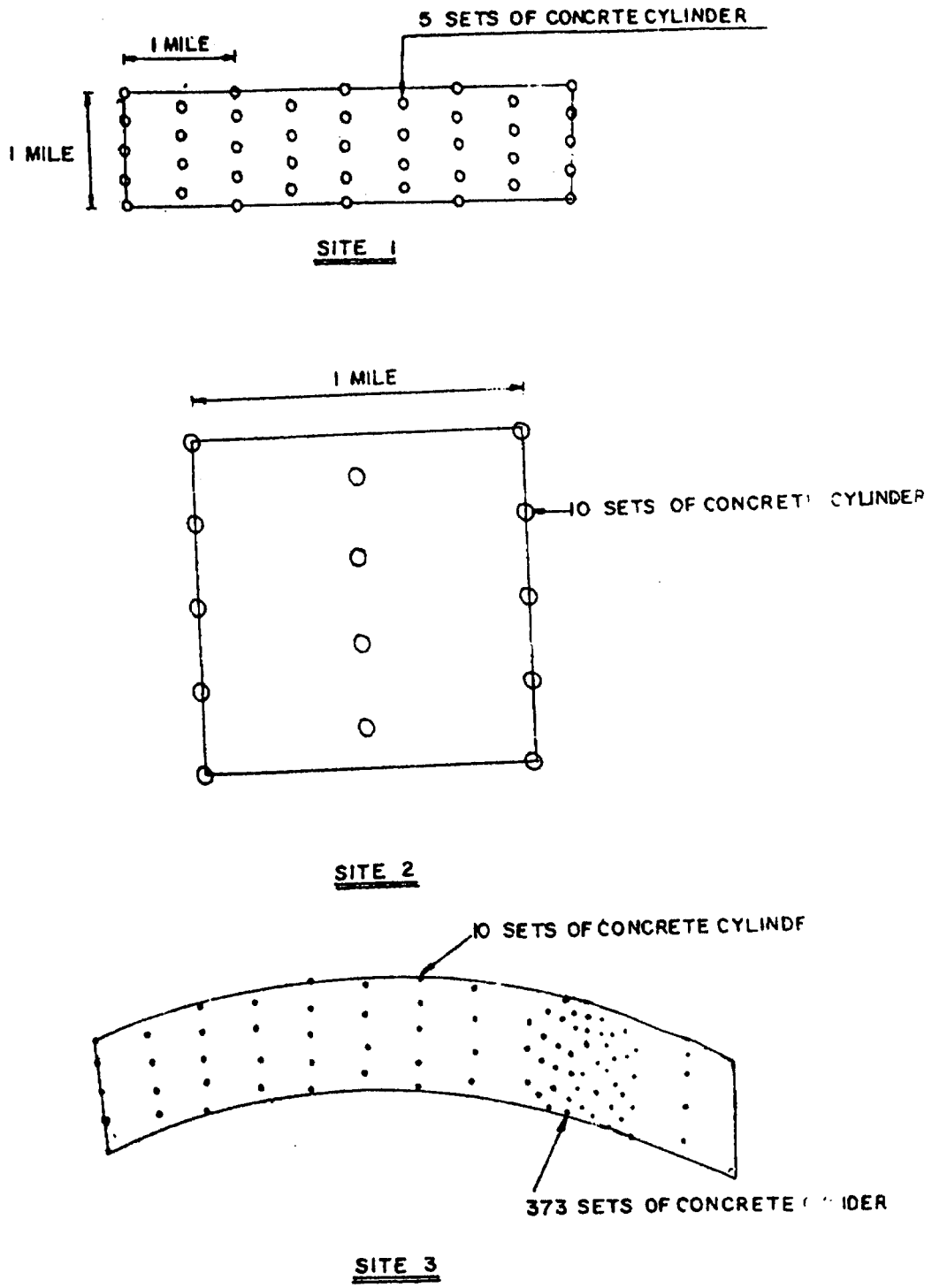


Figure 5. Pattern and arrangement of artificial reef construction