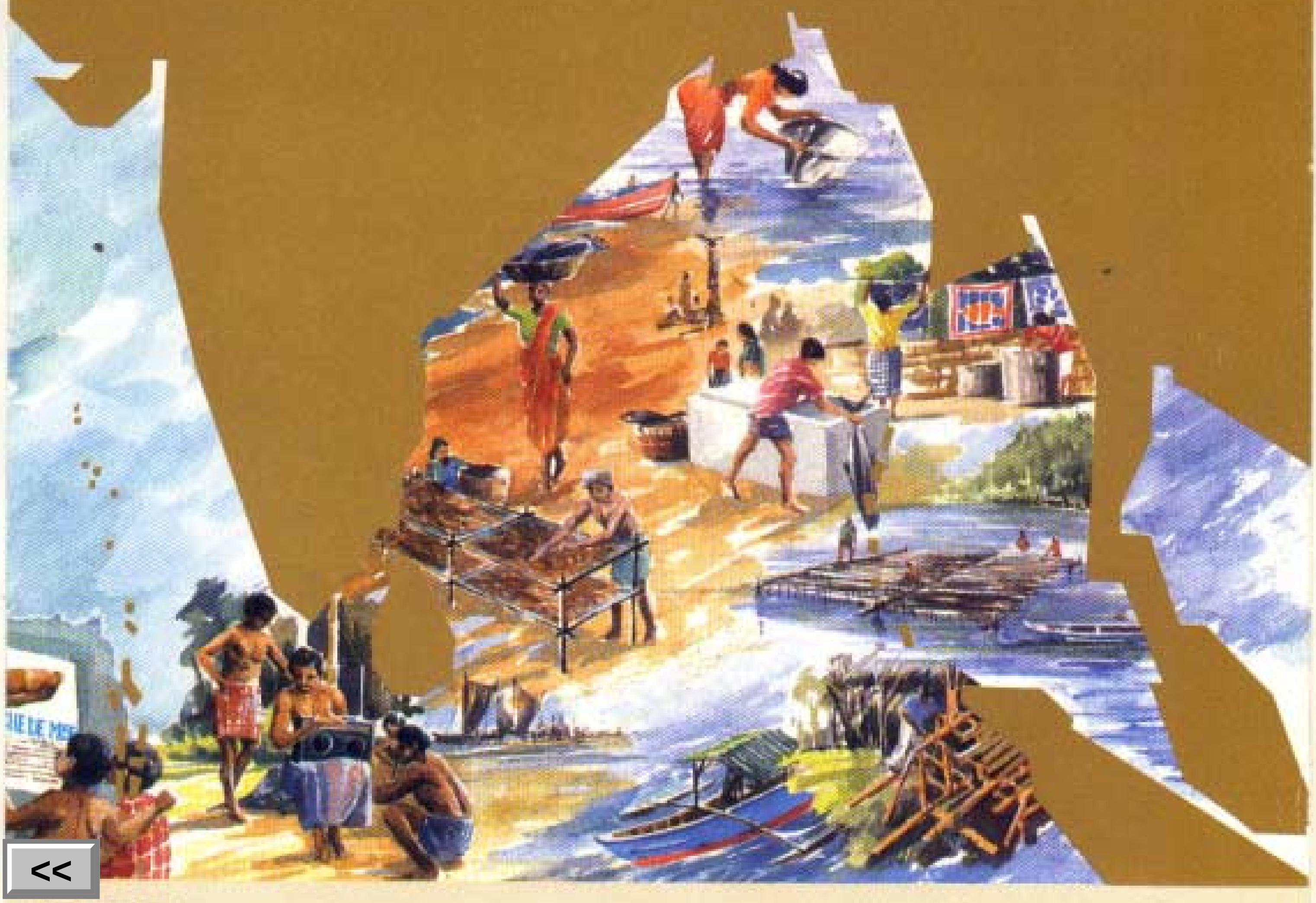
BOBP/WP/97

The effect of artificial reef installation on the biosocioeconomics of small-scale fisheries in Ranong Province, Thailand



BOBP For Fisheries Development
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Small-scale Fisherfolk Communities GCP/RAS/188/MUL
Bioeconomics of Small-scale Fisheries RAS/91/006

The effect of artificial reef installation on the biosocioeconomics of small-scale fisheries in Ranong Province, Thailand

BAY OF BENGAL PROGRAMME
Madras, India
1994

The Government of Thailand felt that installation of suitable Artificial Reefs (ARs) in the coastal waters around the country would contribute towards management of coastal fisheries resources, restrict operation of such efficient methods as trawling in the coastal waters, reduce conflicts among fishermen, and increase opportunities for small-scale fisherfolk to improve their income from fishing.

In 1989, ARs were installed in three locations in Ranong Province. The three ARs covered an area of 50.8 km^2, about 9-11 km from the shoreline and at depths ranging from 12 to 17 m.

The Bay of Bengal Programme (BOBP), within the framework of its project RAS/9J/006, Biosocioeconomics of Small-scale Fisheries, agreed to support the implementation of a subproject that would take up as a case study and assess the impact of the ARs by applying biosocioeconomic analytic methods. The investigations between 1991 and 1993 were done under BOBP's 'Small-scale Fisherfolk Communities' project funded by DANIDA and SIDA and the reporting under 'Bioeconomics of Small-scale Fisheries' funded by UNDP.

This document is a compilation of working documents describing the separate but simultaneously carried out investigations into the suitability of the locations, the environmental conditions around the ARs, colonization of the ARs, enhancement of the resources, the influence of the ARs on the fisheries, and the impact of income changes, if any, on the socioeconomic conditions of the small-scale fisherfolk fishing at the ARs.

The Bay of Bengal Programme (BOBP) is a multiagency regional fisheries programme which covers seven countries around the Bay of Bengal — Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka and Thailand. The Programme plays a catalytic and consultative role: it develops, demonstrates and promotes new technologies, methodologies and ideas to help improve the conditions of small-scale fisherfolk communities in member countries. The BOBP is sponsored by the governments of Denmark, Sweden and the United Kingdom, and also by UNDP (United Nations Development Programme). The main executing agency is the FAO (Food and Agriculture Organization of the United Nations).

This document is a working paper and has not been cleared by the Government concerned or the FAO.

July 1994

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CONTENTS

PREFACE

The marine coastal fisheries in Thailand have developed rapidly and reached a stage where the need for management has become extremely urgent. Development of the small-scale fisheries has proceeded parallel to large-scale fisheries such as the bottom trawl fisheries for shrimp and demersal finfish and purse seine fisheries for small and large pelagics. Competitive and interactive fisheries between the large-scale and small-scale fisheries not only tend to affect the resources, hut also affect the small-scale fisherfolk whose fishing methods are relatively less efficient than those of the large-scale fisheries.

The Government of Thailand considered that installation of suitable Artificial Reefs (ARs) in the coastal waters around the country would contribute towards management of coastal fisheries resources, restrict operation of very efficient fishing methods — such as trawling — in the coastal waters, reduce conflicts among fishermen, and also increase opportunities for small-scale fisherfolk to improve their income from fishing.

In 1989, ARs were installed in three locations in Ranong Province — AR1, AR2 and AR3. The three ARs cover a total area of 50.8 km^2, about 9 - 11 km from the shoreline and at depths ranging from 12 to 17 m.

An FAO/DANIDA workshop on Fisheries Research Planning was held in 1991 at Phuket to discuss management aspects and methods to assess the impact of ARs on the marine resources in and around the areas where they were installed. The BOBP, within the framework of its project RAS/91/006, ‘Biosocioeconomics of Small-scale Fisheries’, agreed to support the implementation of a subproject that would take up as a case study and assess the impact of ARs by applying biosocioeconomic analytic methods.

The objective of this case study was to investigate:

- The suitability of the locations and environmental conditions for ARs;
- The influence of the ARs on the environmental conditions;
- Colonization of the ARs by various organisms and animals of commercial value; and
- Enhancement of the resources through increase in biomass of commercially valuable species;

The case study was also to assess:

- The influence of these ARs on the fisheries;
- Changes in income from fisheries; and

- The impact of income changes on the socioeconomic conditions of the fisherfolk fishing at the ARs.

Well-designed pre-deployment surveys had not been carried out prior to this case study and the ARs were nearly two years old. The analysis, therefore, had to resort to indirect assessments of the environmental conditions, fisheries and income levels to attempt quantification of the pre-deployment scenario and to compare them with quantified parameters assessed by the post-deployment surveys carried out under this case study from mid-1991 to mid-1993.

This document is a compilation of working documents describing the separate but simultaneously carried out investigations concerning:

- Specifications, installation and locations of the ARs.

- Water conditions and nutrient content at AR sites.

- Colonization of the artificial reef structure, association of other fauna and productivity of the ARs.

- Fish aggregation at ARs.

- Fishing gear and methods used in AR areas, before and after deployment of ARs.

- Fisheries resources and bioeconomics of fishing with the different fishing gear, at the ARs.

- Socioeconomic changes in fisherfolk communities whose fishing is influenced by the presence of ARs.

Installation of artificial reefs in Ranong Province, Thailand

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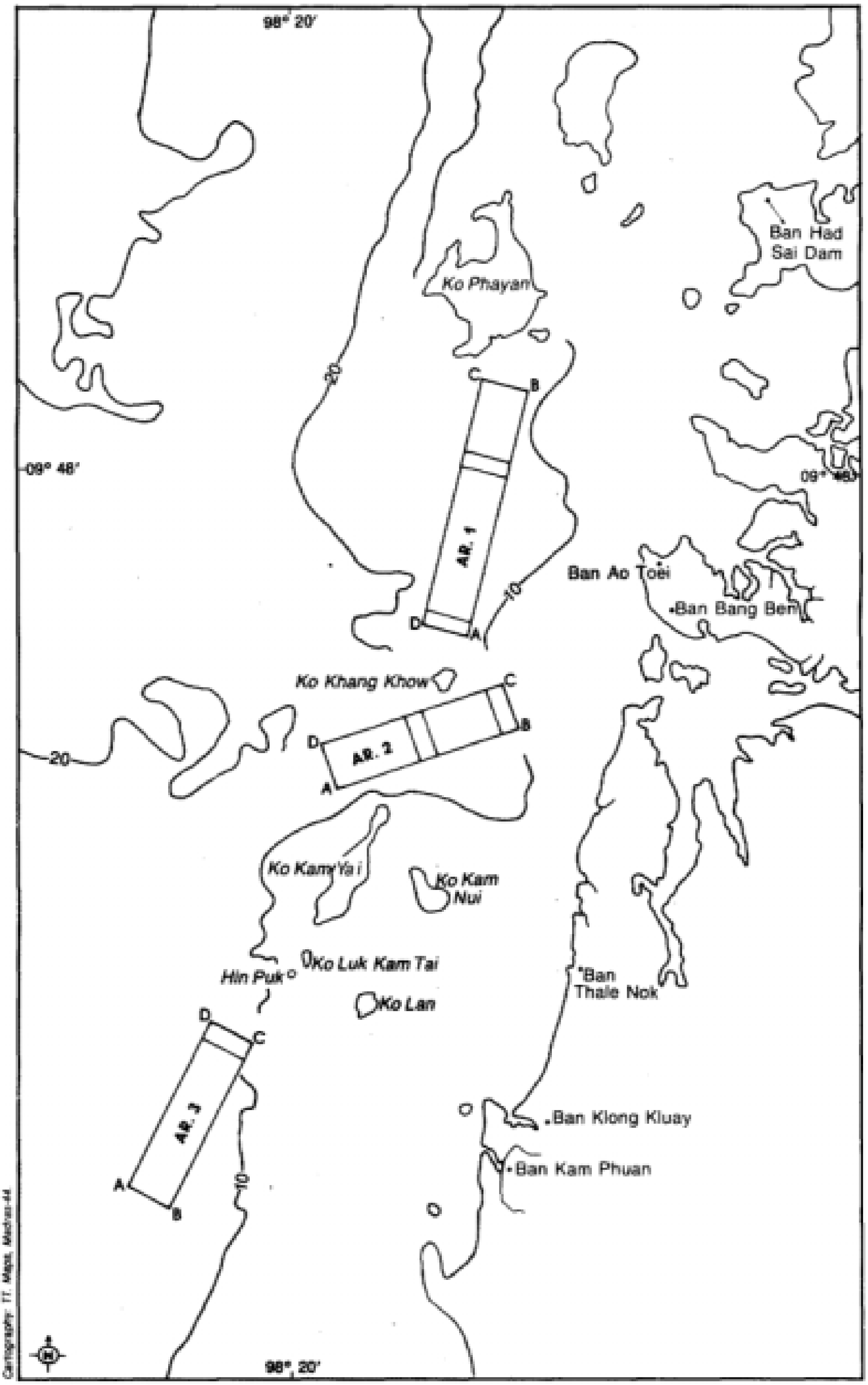
Fig 1. Location of artificial reefs (ARs) in Ranong Province, Thailand



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The artificial reefs — reinforced concrete cubical modules — were installed at three locations (identified as ARI, AR2, and AR3) in a 51 sq.km area, 9-11 km *off* the Ranong Province coast at 12-17 metre depths (Figure 1).

The concrete modules were laid out in such a fashion as to create a rectangular patch at each of the sites. Within this patch, more modules were laid close to each other. This was done with the idea of deterring trawling in these areas.

The physical characteristics of the three ARs and their cost are given in Table 1.

Table 1: Main physical and financial characteristics of AR area in Ranong Province, Thailand - 1989

	Modules in reinforced concrete			Volume (m^3)		Investment (Bah*)			Total AR Area
AR area	*Size (m)*	*Volume (m^3)*	*Number*	*Per size of module*	*Total*	*Per module*	*Per size of module*	*Total*	*sq. k,n.*
1	1x1x1	0.145	3240	469.80	1869.80	495	1,602,763	6,378,947	22.05
	2x2x2	1.250	1120	1400.00		4264	4,776,184		
2	1x1x1	0.145	2440	353.80	1753.80	495	1,207,019	5,983,203	14.40
	2x2x2	1.250	1120	1400.00		4264	4,776,184		
3	lxlxl	0.145	1920	278.40	978.40	495	949,786	3,337878	14.40
	2x2x2	1.250	560	700.00		4264	2,388,092		
	Grand Total	7600	1102.00	4602.00	4602.00		3,759,568	15,700,028	50.85
			2800	3500.00			11,940,460		

ARI is in a 22.65 sq.km area, between Ko Phayan and Ko Khang Khow in Muang District. The four corners of the rectangular patch (12,250 x 1200 m) have the following coordinates (latitude, longitude):

A - 9°34 48"N; 98°23 36"E

B - 9°41′ 18″N; 98°25′ 12″E

C - 9°41’ 30″N; 98°24 12″E

D - 9°35’ 00”N; 98°22’ 36”E

Figure 2 (overleaf) shows details of the layout of the modules for AR1, outlining the patch and the two inner spots with a heavier concentration of modules of 1 x l x lm and 2 x 2 x 2m.

AR2 covers an area of 14.40 sq.km. between Ko Khang Khow and Ko Kam Yai in Kaper District. The layout is given in Figure 3 overleaf and the coordinates of the four corners are:

A - 9°31’ 00”N; 98°,20’ 54” E

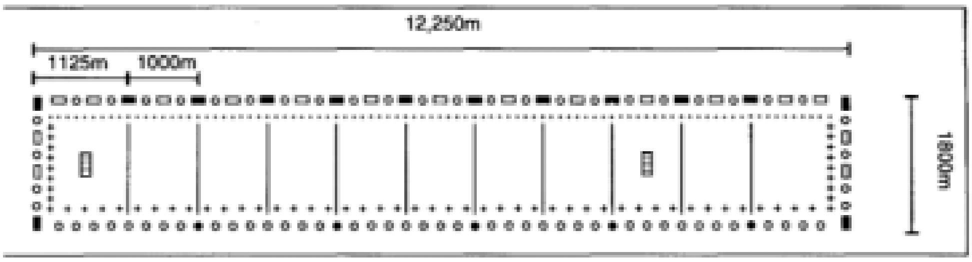
B - 9°33’ 12”N; 98°,24 38” E

C - 9°34’ 03”N; 98°,24’ 03” E

D - 9°31 SIN; 98°20’ 24” E

US $ 1 = *25* Baht (appx.)

Fig 2. AR1 — Ko Phayan - Ko Khang Khow, Muang District, Ranong Province



AR layout and module assembly, module ixixim

▬	Group of 5 modules with buoy	Total group: 14: total modules: 70
▭	Group of 5 modules	Total group: 18: total modules: 90
○	Group of 3 modules	Total group: 80; total modules: 240
●	Group of 3 modules with buoy	
+	Group of 2 modules	Total group: 168; total modules: 336
—	Row of 126-127 modules	Total row: 11; total modules: 1,464

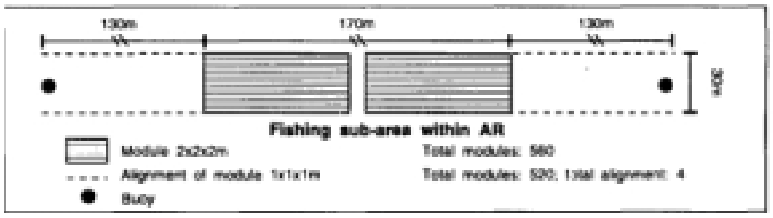
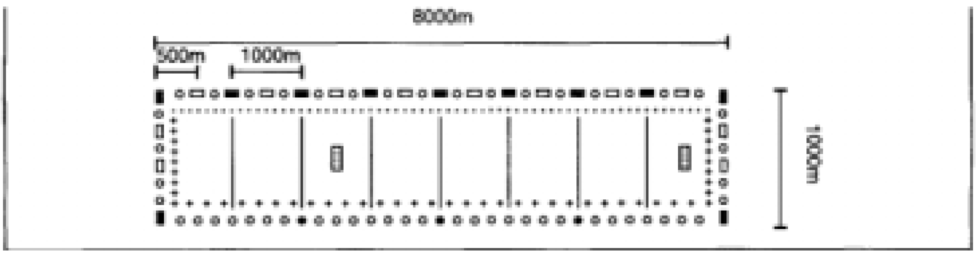


Fig 3. AR2 — Ko Khang Khow - Ko Kam Yai, Kaper District, Ranong Province



AR layout and module assembly, module ixixim

▬	Group of 5 modules with buoy	Tofal group: 11; total modules: 55
▭	Group of 5 modules	Total group: 12; total modules: 60
○	Group of 3 modules	Total group: 55; total modules: 165
●	Group of 3 modules with buoy	
+	Group of 2 modules	Total group: 117: total modules: 234
—	Row of 126-127 modules	Total row: 7; total modules: 886

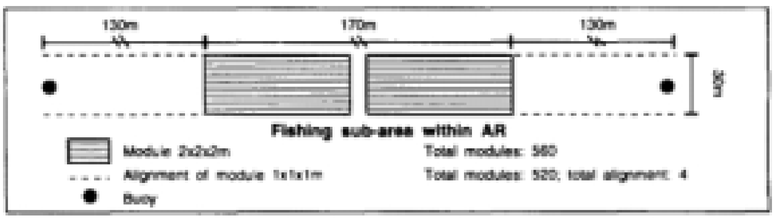


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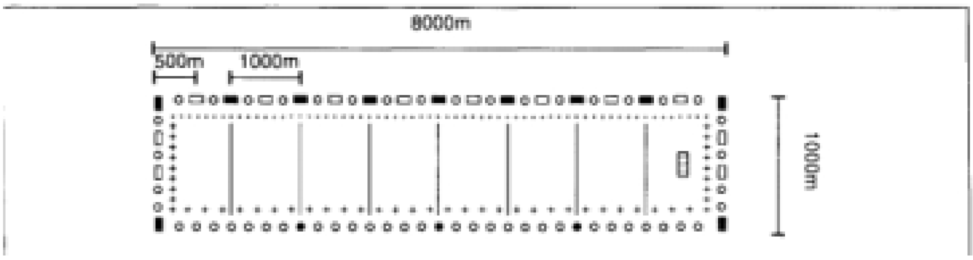
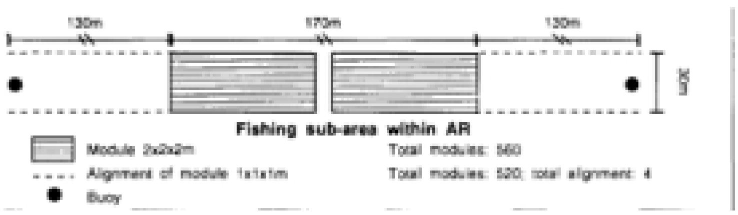
Fig 4. AR3 — Ko Lan - Ko Khai, Kaper District, Ranong Province



AR layout and module assembly, module 1x1x1m

▬ Group of 5 modules with buoy	Total group: 11: total modules. 55
▭ Group of 5 modules	Total group: 12: total modules: 60
○ Group of 3 modules	Total group: 55: total modules: 165
● Group of 3 modules with buoy	
+ Group of 2 modules	Total group: 117: total modules: 234
— Row of 126-127 modules	Total row: 7: total modules: 886

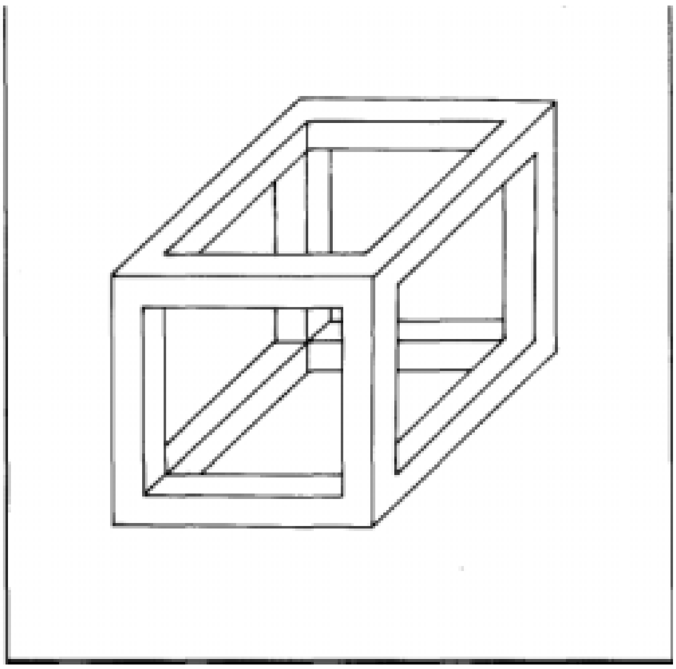


AR3 is similar to AR2 and lies between Ko Lan and Ko Khai, also in Kaper District (Figure 4).

Figure 5 is a diagram of a simple concrete module.

The total cost of installing the ARs was 15.7 million Baht, with ARI costing 6.4 million, AR2 6.0 million and AR3 3.3 million Baht respectively.

Fig 5. Diagram showing a concrete module



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Water conditions and nutrient content at the artificial reef sites in Ranong Province, Thailand

by

Prawin Limpsaichol
Somkiat Khokiattiwong
Nipavan Bussarawit

Phuket Marine Biological Centre
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1. *INTRODUCTION*

The primary reason for installing artificial reefs (ARs) in Ranong Province was to prevent trawling and, thereby, improve catches with passive artisanal fishing gear. But artificial reefs also serve an important function of habitat rehabilitation. Some of the factors that influence this are

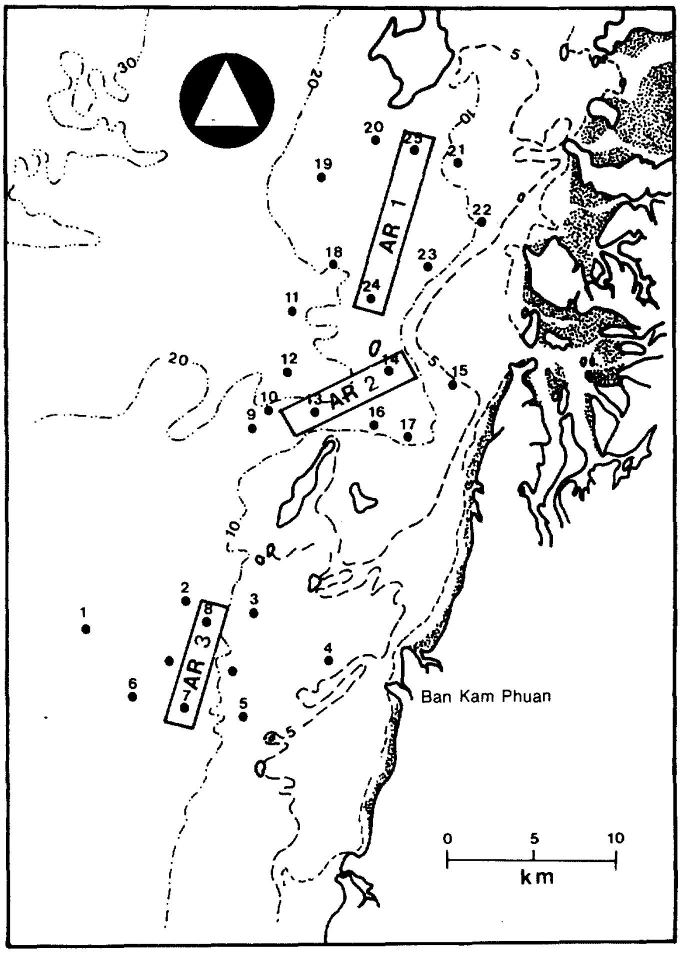
- water quality,
- nature of bottom sediment, and
- nutrient content.

As part of the biosocio—economic case study to assess the effect of installing artificial reefs, on small-scale fisheries, studies were conducted to quantify and assess environmental parameters at the AR sites.

Data was collected in December 1990, February 1992 and December 1992, during three separate cruises to the AR areas using fishery survey vessels belonging to the Andaman Sea Marine Fishery Department.

Samples were taken at 25 locations (Figure 6) to estimate total suspended solids, salinity, dissolved oxygen and other chemical parameters. Temperature and current strength! direction were also measured. In **the later cruises,** additional parameters were studied to determine the presence of inorganic nu**trients (PO4, NO3 and** NO2) and chlorophyll-a in the water column. Sediment cores were also analyzed.

Fig 6. Map showing location and 25 environmental sampling sites at AR1, AR2 and AR3, Ranong Province, Thailand



2. *FINDINGS*

AR1 and AR2 areas showed relatively high turbidity due to dense suspended matter in the water column, particularly at ARI in December 1990 (Figure 7A-9B). It is possible that this suspended matter was a result of the run-off from the estuarine area with its mangrove vegetation.

Fig 7 A-D. Showing areas of persistently or temporarily high content in total suspended solids. A: Distribution of depth average total suspended solids in December 1990. B: Distribution of rms values in December 1990. C: Distribution of depth average total suspended solids in February 1992. D: Distribution of rms values in February 1992

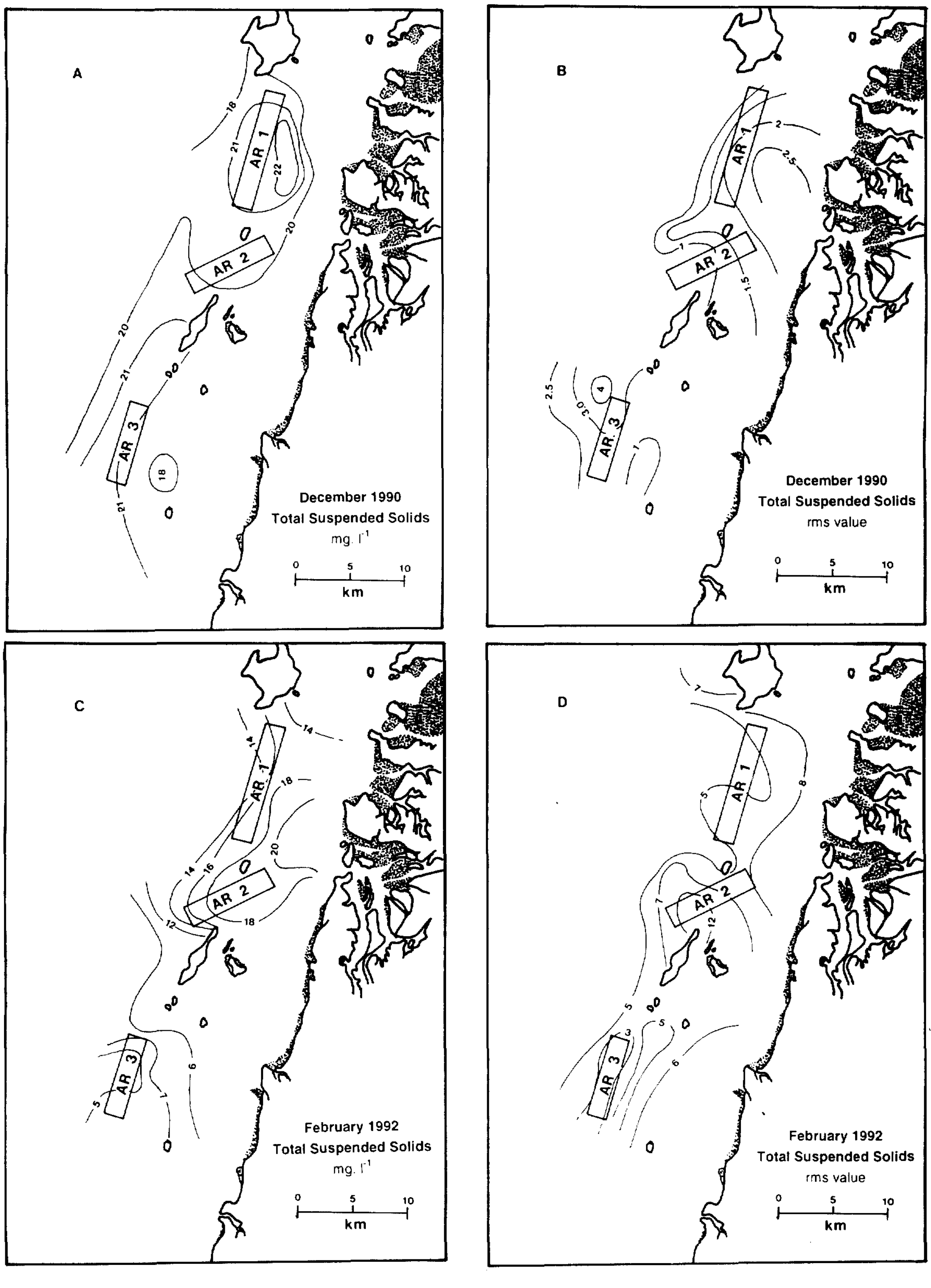


Fig 8A-B. Distribution of depth average total suspended solids in December 1992 (A) indicates zones of high content. (B) rms values indicate zones of persistent and temporary high contents

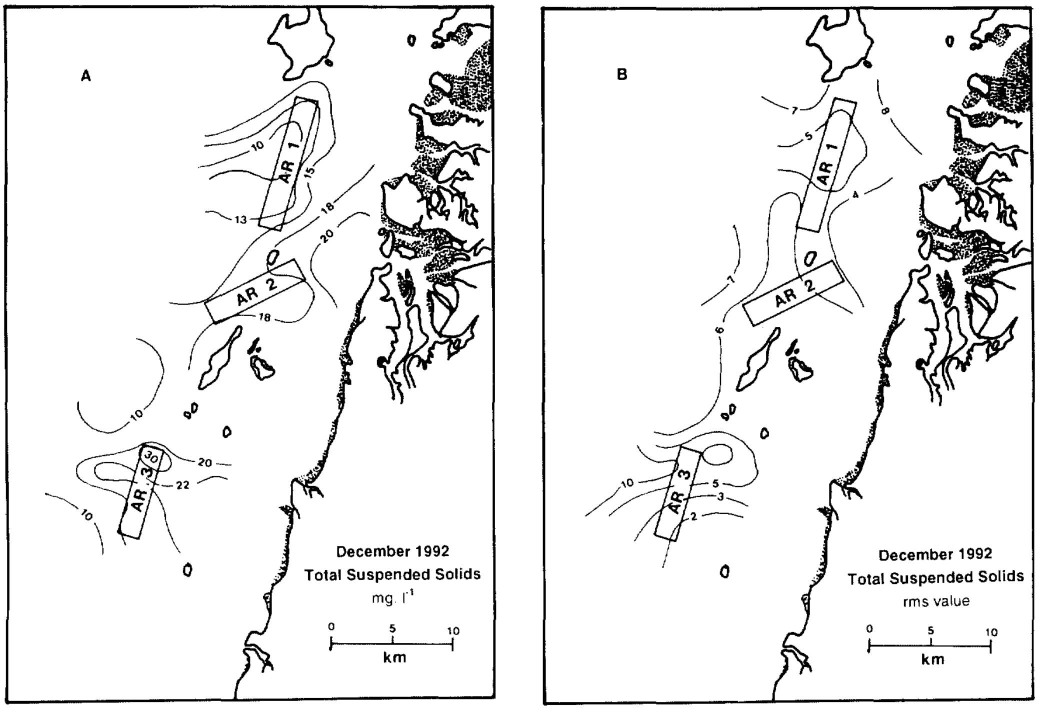
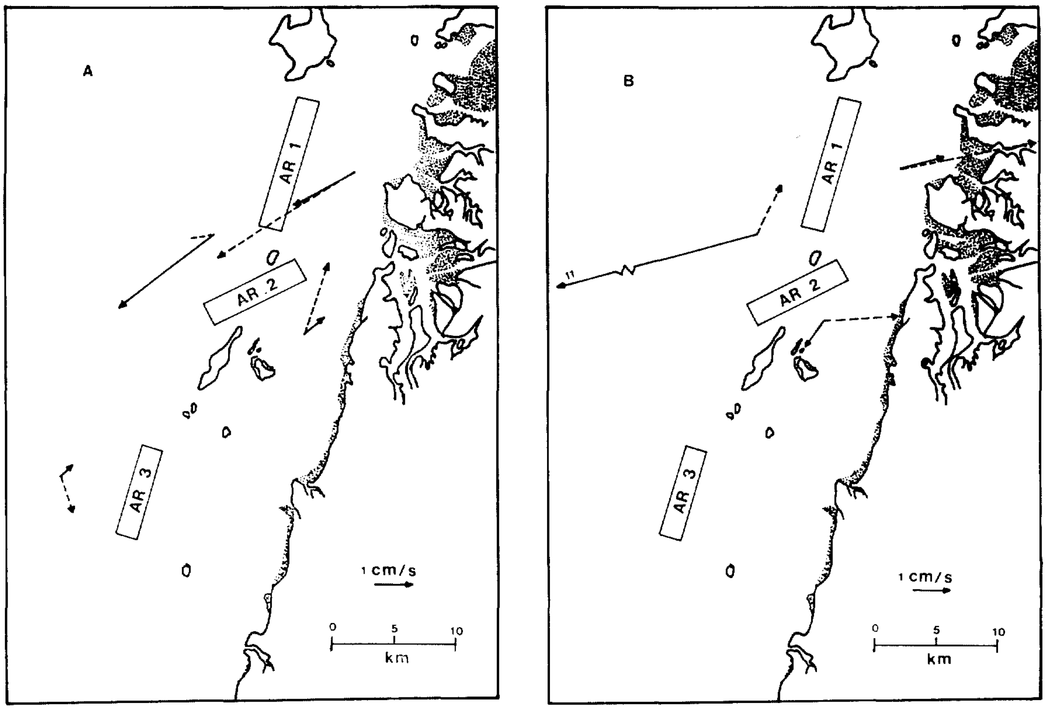


Fig 9A-B. Residual tidal current of surface flow (—>) and subsurface flow (- - - ->) are shown (A) in February 1992, and (B) in December 1992



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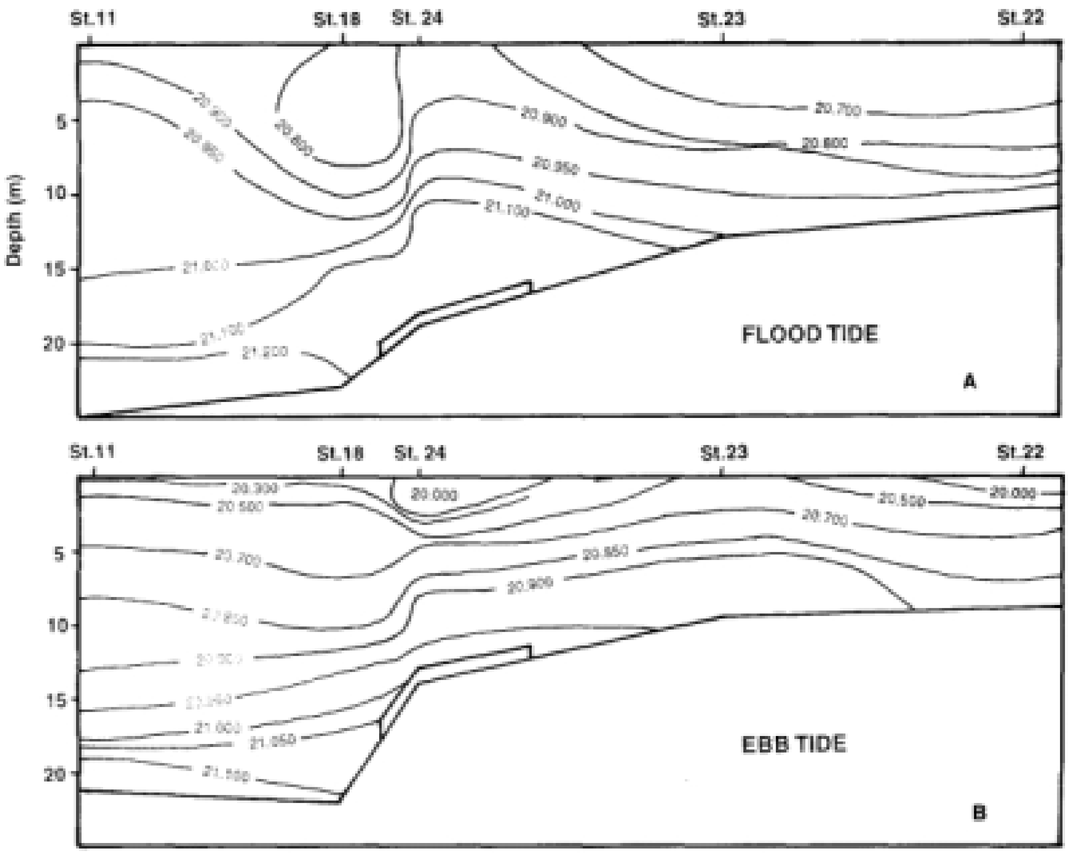
After continuous rainfall in December 1990 and December 1992, the total suspended solids increased at all three sites, but reduced in concentration during dry months (February 1992).

The distribution of seawater density measured over an offshore transect across AR! (Figures l0a-b) showed a definite interaction with the tides.

Fig 10A-B. Cross section σ_t(density of seawater) distribution on an offshore transect (Stations 22, 23, 24, 18 and 11) at ARI in December 1992. (A) Zones of seawater intrusion and interaction are shown during flood tide. (B) Zones of less saline nearshore water extrusion and interaction are shown during ebb tide.



Outflow of detritus from the mangroves, as part of the suspended matter, resulted in large amounts of dissolved inorganic nutrients (PO4, NO3 and NO2) in the waters around the ARs, though the concentration varied with rainfall (Table 2).

Table 2: Multiple range analysis (ANOVA) of each parameter of three cruises which show significant difference if the asterisk (*) locates in a different column and nonsignificant difference if the asterisk (*) is in the same column (P=0.05)

Cruise no.	*P04 ug.atm PO4/l*		*NO3 ug-atm NO3/l*		*NO2 ug-atm NO2/l*		*TSS m*		*Trans*		*pH*	
1	0.656	*	0.130	*	0.063	*	20.08	*	—		—	
2	0.115	*	0.489	*	0.031	*	12.41	*	7.06	*	8.05	*
3	0.163	*	0.239	*	0.073	*	16.64	*	8.55	*	8.32	*

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Chlorophyll-a measurements (Tables 3 and 4) showed that, at ARI, the concentration was influenced by both seawater flushing and the run-off from the estuary, at AR2 by the run-off from the mangroves and at AR3 by seawater **intrusion alone. AR3 waters were comparatively** clear, with lower suspended solids. Relatively higher chlorophyll-a content and phaeo-pigment content occurred at AR1 and AR2. Also, the content was **more at the bottom than at the** surface (Table 4), probably due to primary benthic production. Since no significant changes in nutrients were observed at the different depths, it can be concluded that phytoplankton **were not the reason for high chlorophyll-a 1evels at the bottom.**

The tidal surface and subsurface flows (Figures 9a-b) influenced the state of the sea-bed. The mean grain size of sediment at AR1 and AR2 was 2-3 O (0.18mm), whereas at AR3 the grains were bigger. Taking the flood and ebb tides into account, a speed of 4-6 cm/sec, with relatively low residual speeds, was **common for the three AR** sites. The sandy mud **sediment of smaller grain size at AR**1 **and AR2** was comparatively easy to move and be re-suspended, thus increasing turbidity. Studies of the seabed sediments conducted in 1988 by the Marine Fishery Division also showed the same findings, leading to the conclusion that there is no significant change in the bottom sediment before and after installing ARs.

Table 3: Multiple range analysis (ANOVA) of chlorophyll-a and phaeo-pigment contents. Results show depth average of each reef indicating significant difference if asterisk (*) locates in a different column and no difference if asterisk (*) is in the same column (P = 0.05)

***AR*s No.**	*Chlorophyll-a* mg/m^3		*Phaeo-pigment* mg/m^3	
1	0.76	**	2.37	**
2	1.08	*	2.94	*
3	0.47	*	1.39	*

Table 4: Multiple range analysis of chlorophyll-a and phaeo-pigment contents in the surface, mid-depth and bottom water. Results show elevated values of both parameters in the bottom waters *(P<0.05;* **ANOVA, multiple range analysis) while no** significant difference in the upper layer (P>0.05; ANOVA, multiple range analysis).

Water layer	*Chlorophyll-a* *mg/m3*		*Phaeo-pigment* *mg/rn3*	
Sur.	0.33	*	1.48	*
Mid.	0.46	*	1.72	*
Bottom	1.36	*	3.31	*

3. *CONCLUSIONS*

Environmentally, ARs 1 and 2 are located very close to mangrove and estuarine areas and, hence, prone to high turbidity. This could, perhaps, play a negative role on the sealife dwelling near them. **AR3 showed less suspended solids, particularly during the dry winter months.**

The Southwest Monsoon in the summer months brings heavy rain and heavy run-off from the mangroves and estuaries, causing considerable mixing of water. These conditions also contribute to inorganic nutrients being discharged into the sea. While AR2 has pronounced mangrove run-off, AR3 is dominated by seawater intrusion and, hence, has more marine conditions, relatively clear water and less suspended solids. Higher nutrient levels at AR1 and AR2 contribute to high chlorophyll-a content also.

The sediments around ARs 1 and 2 were fine and, generally, undisturbed by the dynamics of the water around them, but the sand and mud around AR3 were of larger sized grains and less easily unsettled. Weak turbulence in the water observed may have been due to bottom obstruction contributed by the scattered modules of the ARs, but is of little consequence.

These results indicate that the locations of ARI and AR2 did not favour colonization and aggregation of various organisms of commercial value, though nutritional enrichment of the water was evident. AR3 appeared to have environmental conditions which were more favourable for the objectives of the AR.

The presence of ARs does not seem to affect the natural environmental conditions in any significant way.

Colonization of fouling communities and associated fauna at artificial reefs in Ranong Province, Thailand

by

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4. *INTRODUCTION*

An artificial reef (AR) is a device installed to provide a habitat for marine life, resulting in new fishing grounds for small-scale fisheries and sport fishing. The sessile benthic organisms colonizing reef structures can be a major source of food supply. High densities of benthic organisms have formed on artificial reefs and have been reported (Woodhead and Jacobson, 1985; Carter *et al.*, 1985). Bohnsack and Sutherland (1985) concluded that artificial reefs either aggregate existing scattered fish or allow secondary biomass production through increased survival and growth of new individuals as a result of the shelter and food resources provided by the AR.

From the time artificial reefs were established in 1978 in Thai waters, most of the studies concerned abundance of fish population relating to fishing effort. Information on benthic organisms on reef modules was presented mainly as general descriptions. The purpose of this paper is to describe the community composition and abundance of benthic organisms on reef modules after their installation three years ago in Ranong Province and to demonstrate the importance of the reef as a source of food for fish and other economic marine fauna.

5. *METHODOLOGY*

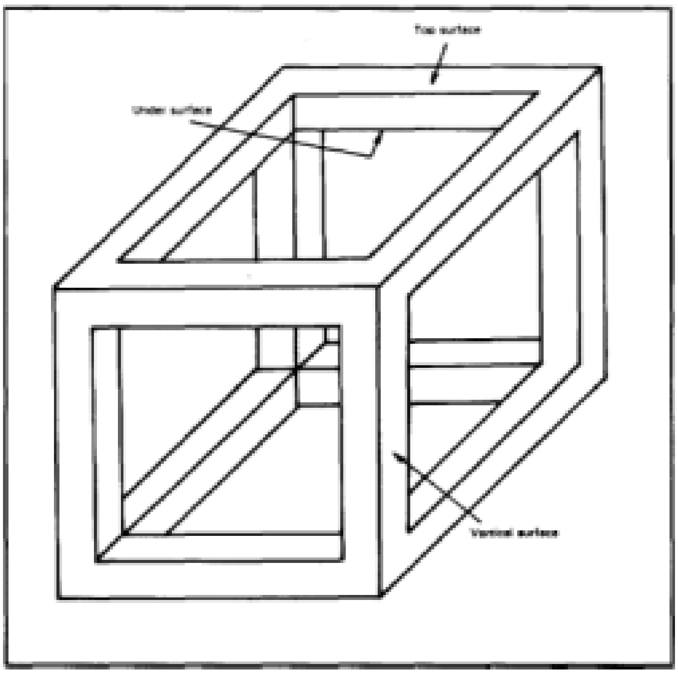
5.1 *Study site and reef structure*

AR3 was chosen for study, as the other two ARs did not permit underwater investigations because of high turbidity.

5.2 *Sampling methods*

Sessile organisms on the concrete surfaces were collected by scraping the sampling plots (20 cm x 60 cm) with axes or knives. Positions of the sampling plots were categorized as **(1) top surface, (2) under** surface, and (3) vertical surface (Figure 11). Sampling was done in February 1992, December 1992 and April 1993 (hereafter referred to as the first, second and third surveys respectively).

Fig 11. Diagram showing a concrete module with the positions of sampling plots designed into three categories: top surface, under surface and vertical surface



In the first survey, six samples from each were collected from the top and under surfaces and ten samples from the vertical surface; in the second survey, 11 samples each, from the under and vertical surfaces, and ten from the top surface were collected; and in the third survey, ten samples each, from the top and under surfaces, and 11 samples from the vertical surface were collected. Samples were preserved in ten per cent formalin before sorting in the laboratory. Biomass (dry weight) of each taxa was examined. With the exception of tiny organisms, *i.e.* tube polychaete and bryozoa, it was not possible to separate those cemented on substrates, such as on mollusc shells. Thus, their weight was not calculated, but were included as the weight of such faunal substrate instead. The small cryptic fauna, which contributed low weight but were defined

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here as important food sources of reef fishes, *i.e.* crabs, shrimps, brittle stars and polychaetes, could not be weighed either. However, a number of individuals were analyzed from the samples obtained during the second and third surveys.

In order to observe the initial stage of fouling organism formation, in December 1992, ***155*** plexiglass plates, each of 10 x 10 cm, were tied securely on the concrete surfaces in two sets, *i.e.* horizontal (top) and vertical surface. The plates were collected in April 1993.

Six hundred and eight (608) plexiglass plates had also been placed in February 1992 to study the seasonal differences in settlement rate of sessile organisms. However, it was not possible to retrieve the first batch during the second and third trips. Thus, only the dry season settings (December-April period) were available for evaluation.

In the laboratory, organisms encrusting on the inner side of the plates were removed before examining biomass of organisms on the exposed side. Area cover of the organisms on the plates was also estimated by measurement..

6. FINDINGS

6.1 *Physical description of the artificial reef*

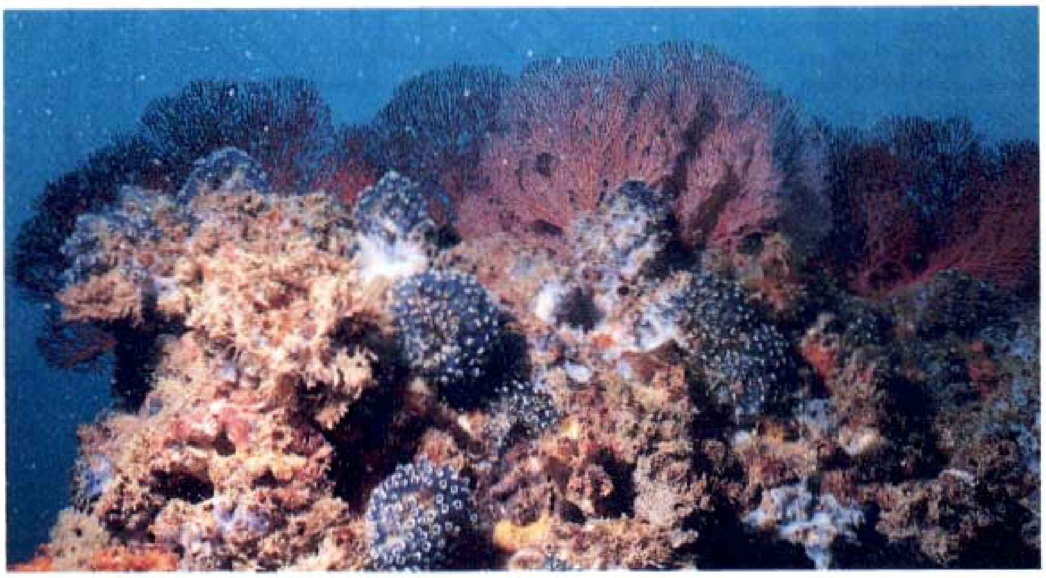
Although the reef was designed to form a belt of 2 x 2 x 2 m cubes spaced im apart, the modules settled on the bottom haphazardly. There were no clearly defined boundaries. At the sample collecting site, the concrete modules of 2 x 2 x 2m size were scattered and distributed in clusters. Generally, they lay ***2-5*** m apart from each other. In certain areas, modules were piled one upon the other. The base of the structure was sometimes buried in the sandy bottom.

Observations in a wider area showed that the concrete modules of 1 x 1 x 1 m size were further apart from each other than planned. The organisms on such modules were generally the same as on the larger modules. The modules of both sizes were generally stable. Only one of them had collapsed.

6.2 *Fouling organisms and associated fauna*

Figure 12 shows the general scenery at the modules with encrusting organisms.

Fig 12. General scenery at a concrete module with fouling organisms (at AR3)



The sessile organisms on the concrete structures included invertebrates of seven phyla, namely Porifera, Coelenterata, Annelida, Mollusca, Echinodermata, Arthopoda and Chordata. Their bio-mass varied in different positions and in different years (see Figures 13, 14 and 15 on facing page).

Fig 13. Average dry weight (g/m^2) of the organisms found on different surfaces of the concrete modules in February 1992

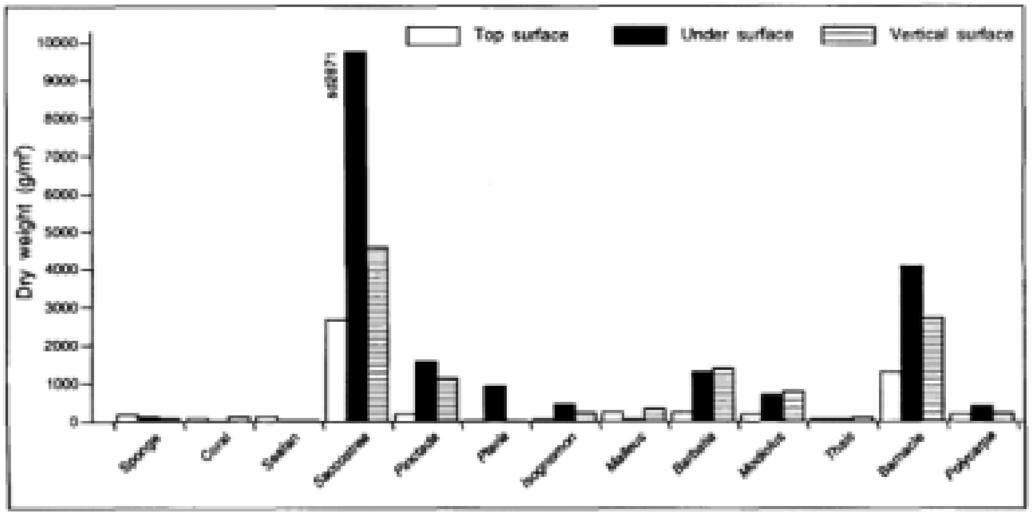


Fig 14. Average dry weight (g/m^2) of the or9anisms found on different surfaces of the concrete modules in December 1992

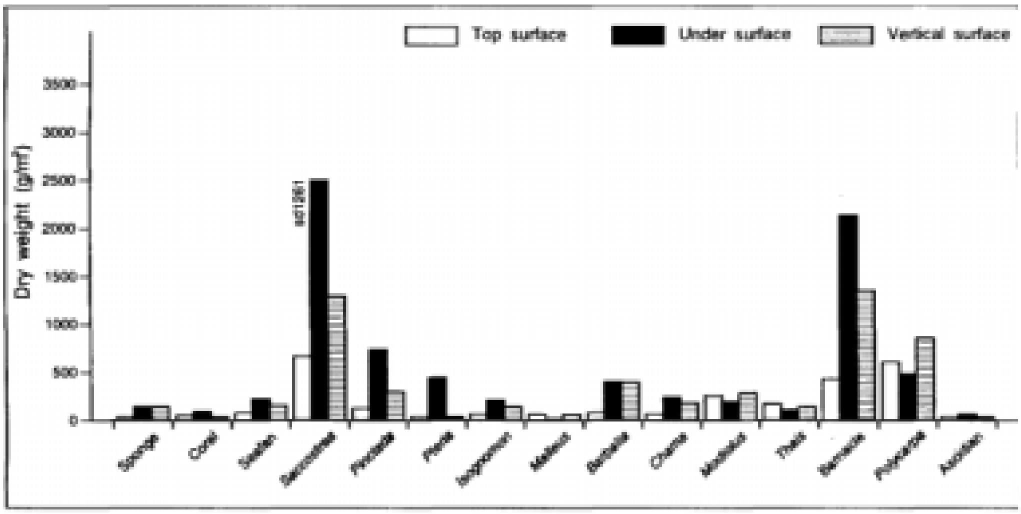
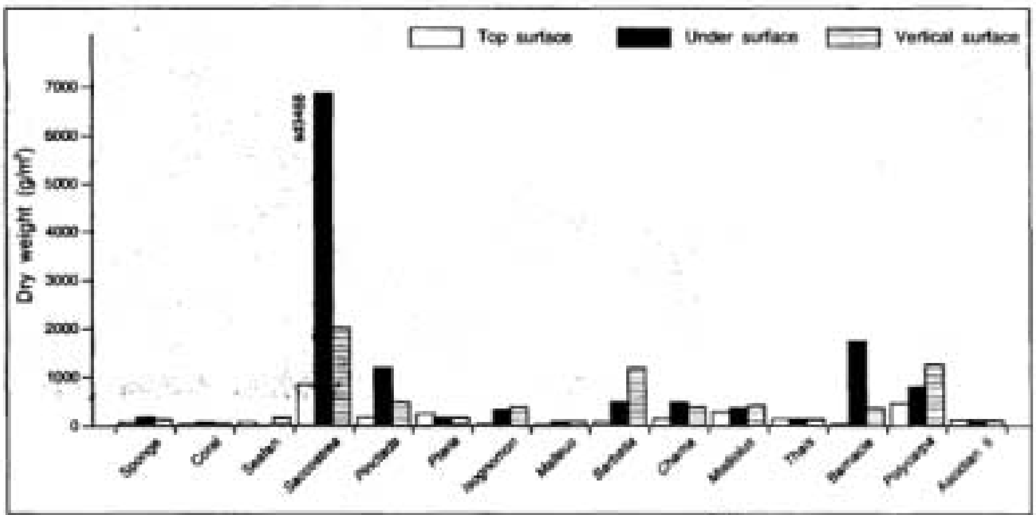


Fig 15. Average dry weight (g/m^2) of the organisms found on different surfaces of the concrete modules in April 1993



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This reflects the fluctuation of the average biomass of total organisms (Figure 16). The molluscs of the family Ostreidae, *Saccostrea,* were the most abundant group. They were the major contributors to the reef structure and were mainly responsible for influencing a change of total biomass. The next most abundant groups after *Saccostrea* were barnacle *(Balanus* sp.), molluscs of genera *Pinctada, Barbatia, Modiolus* and *Pteria,* and ascidian *(Polycarpa* sp.). Sponges were sometimes found in abundance. However, their dry weight was negligible.

Among the small cryptic fauna, the most abundant groups included polychaetes *(e.g.,* families Eunicidae, Phyllodocidae, Lumbrineridae, Polyodonidae, Nereididae, Flabelligeridae and Syllidae), crab *(e.g.,* families Portunidae, Xanthidae, Majidae, Porcellanidae and Calappidae), shrimp (Infraorder Caridea), brittle stars (family Ophiotrichidae: *Ophiothrix martensi;* family Ophiactidae: *Ophiactis savignyi)* and isopod (family Cirolanidae: *Cirolana* sp.). Figures 17 and 18 show the number of individuals of the abundant groups found at different positions on the reef modules and in different years. The rare groups recorded were holothurian, sea urchin, limpet, nudibranch, gastropod *(Thais* sp., *Cryprae* spp., *Tridacna,* cerithid), scallop, squid and young fish.

Fig 16. Average dry weight (g/m²) of the organisms found on different surfaces of the concrete modules during the three surveys

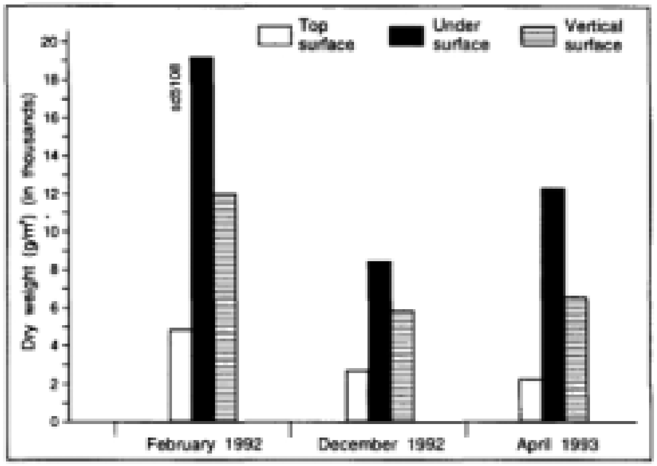


Fig 17. Number of individuals of the cryptic fauna (excluding Brittle star) associated on different surfaces of the concrete modules in December 1992

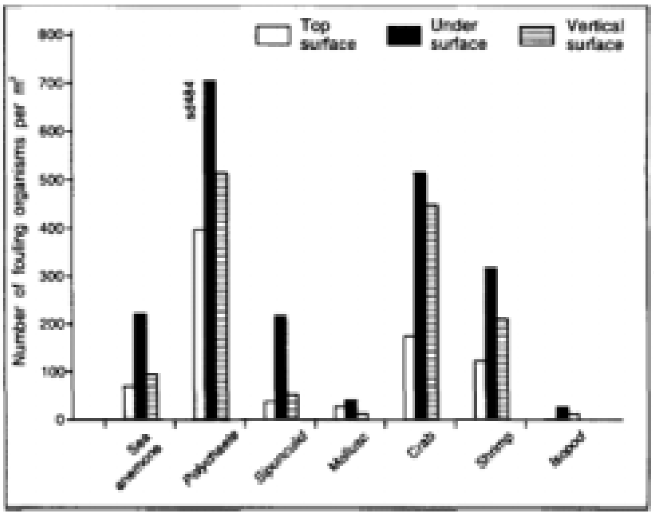
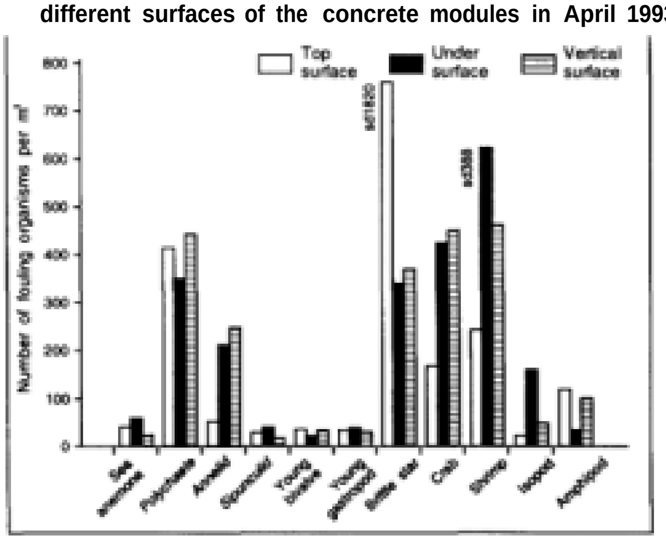


Fig 18. Number of individuals of the cryptic fauna associated on different surfaces of the concrete modules in April 1993



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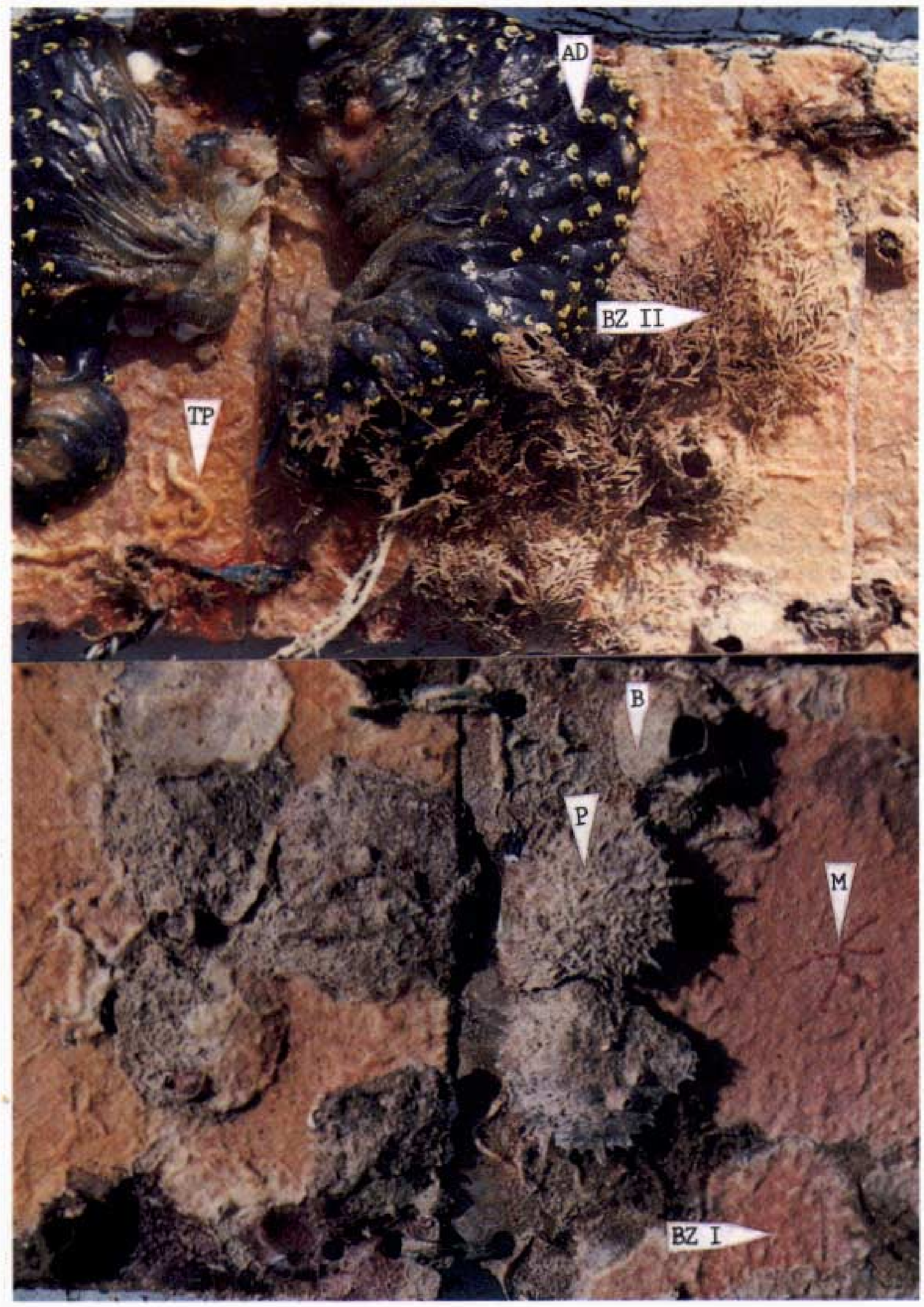
The experiment on the plexiglass plates revealed the early stages of organism-development on the new substrate. Figure 19 shows the general appearance of fouling organisms on the plate.

Fig 19. General appearance of fouling organisms growing on plexiglass plates which had been on the concrete modules for four months. (AD = ascidian type II; B = *Balanus* sp.; BZ I = bryozoa type I; BZ II = bryozoa type II; TP = tube polychaete; M = juvenile *Melithea* sp.; P = *Pinctada sp.)*



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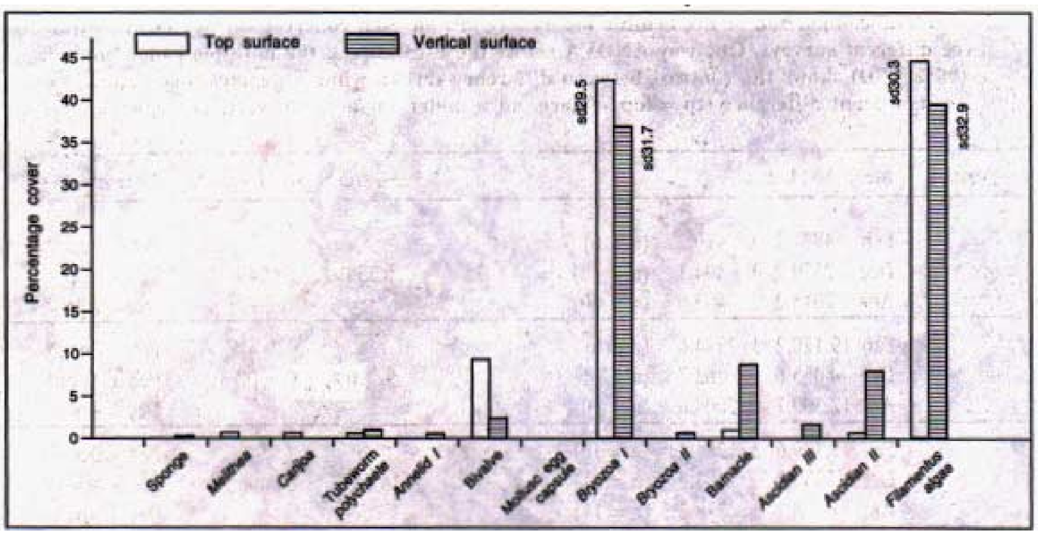
The total biomass of the organisms on the horizontal plates was 661 ±sd601 g/m2. There was no significant difference between biomass on horizontal and vertical plates. A thin cover of filamentous algae and encrusting bryozoa (type 1) accounted for the highest average of total cover, *i.e.* 42.1 ±sd31.8% and 40.0 ±sd30.8% respectively (Figure 20).

Fig 20. Percentage cover of the fouling organisms found on the settling plates which were attached on the top and vertical surfaces of the concrete modules for a four-month period



The densities of epifauna on the sandy bottom inside the concrete frames varied among the modules. As shown in Figure 21, they tended to form along the frames. Under modules piling together, the density was greater than in the case of single-layer modules. They were the same groups as found on the concrete surfaces, but with the addition of *Pinna. bicolor,* such predators as gastropods *(Conus* sp., *Murex djariaensis poppei*, *Trachycardium mode* and *Chichoreus ramosa),* sea star *(Pentaceraster* sp.) and crab *(Charybdis* sp.)

Fig 21. Formation of benthic organisms on sandy bottom inside the module frame

7. CONCLUSIONS

A comparison of the biomass at each collecting position, in different years, with the statistic test (one-way ANOVA) shows a significant difference between the biomass of the organisms of the first and second surveys, but no significant difference between those in the second and third surveys (Table 5).

Table 5: The comparison of the benthic biomass (g/m^2) on each concrete surface position' during three different surveys. One-way ANOVA shows the F-ratio, and the multiple range analysis (95% LSD) shows the contrast between different surveys, while * denotes a statistically significant difference (tp = top surface, ud = under surface, v = vertical surface).

Position	Mean ± std. error	d.f	F-ratio	Sig. level	Contrast
	Feb 4771.2 ±970.2 (n = 6)				Feb - Dec *
tp	Dec 2539.2 ±304.1 (n = 10)	25	6.759	0.0049	Feb - Apr *
	Apr 2015.2 ±403.0 (n = 10)				Dec - Apr
	Feb 19,120.2 ±2284.6 (n = 6)				Feb - Dec *
ud	Dec 8065.6 ±763.7 (n = 11)	26	9.790	0.0008	Feb - Apr *
	Apr 12,300.7 ±2004.6 (n = 10)				Dec - Apr
	Feb 11,739.6 ±1284.3 (n = 10)				Feb - Dec *
v	Dec 5336.0 ±483.0 (n = 11)	31	14.587	0.0000	Feb - Apr *
	Apr 6438.2 ±778.2 (n = 11)				Dec - Apr

There is no satisfactory explanation, as the site of the first survey could not be subsequently located, even though it was in the same vicinity. The sessile organisms could have reached an equilibrium after three years. The fluctuation, especially on the under and vertical surfaces, may be due to overweight of the aggregated mass, causing it to collapse and drop to the sea floor; a lot of organisms (especially oysters) were observed lying on the bottom, inside the reef modules. Nevertheless, it does not mean that the communities have reached mature stages.

From general visual observation, the population of octocoral (*Carijoa* sp. and *Melithea* sp.) and blue ascidian (Type II: unidentified bouquet-like species) appeared to be much denser in the second and third surveys than in the first survey. Lasker (1988) reported that octocorals exhibit a particularly great range of mechanisms of vegetative propagation. Ascidians also increase their population rapidly, as they have short-lived larvae that often settle immediately after release from the parent (Hurlbut, 1988).

These special biological characteristics caused the explosive growth of octocorals and ascidians. It can be concluded that the octocoral and ascidian population might grow denser in future, as a lot of young individuals were observed on the plexiglass plates and on natural substrates such as mollusc shell fragments at the site.

When comparing biomass on concrete surfaces at different positions in each survey, there were statistical differences (one-way ANOVA) between the positions (Table 6, see page 26). It was obvious that the biomass on the under surface was greater than on the vertical and top surfaces. This indicated a lower chance of survival of the juveniles of the fouling organisms on the top surface, where sedimentation and grazing pressure are higher than on the under or vertical surface.

The experiment on plexiglass plates revealed the initial stage in the formation of this complex system. The common groups found, *i.e.* oysters, barnacles, tube worms and bryozoa, are those that Bailey-Brock (1989) and Ardizzone *et al.* (1989) reported in temperate and subtropical waters. In general, thin-layered filamentous algae was the first organism occupying the space (Chansang *et al.* 1987). Carlisle *et al.* (1964) and Turner *et al.* (1969) (cited in Carter *et al.*, 1985) described the first-year succession of benthic organisms as being the same group (*i.e.* barnacle, mollusc and ascidian) as in this study. Osman (1982) and Buckley *et al.* (1985) stated that barnacle tests on

Table 6: The comparison of the benthic biomass (g/m²) found on different positions of the concrete surfaces in each of the three surveys. One-way ANOVA shows the F-ratio, and the multiple range analysis (95% LSD) shows the contrast between biomass at the different times of the survey, while * denotes a statistically significant difference (tp = top surface, ud = under surface, v = vertical surface).

Survey date	*Position*	*Mean ±std. error*	*d.f*	*F-ratio*	*Sig. level*	*Contrast*
	tp	*4771.7 ± 970.1 (n = 6)*				*ud - tp* *
Feb	*ud*	*19,196.6 ±2284.2 (n = 6)*	*21*	*17.586*	*0.0000*	*ud - v* *
	v	11,741.5 ±1283.9 (n = 10)				tp - v *
	tp	2539.2 ± 763.7 (n = 10)				ud - tp *
Dec	ud	8065.6 ± 763.7 (n = 11)	31	23.645	0.0000	ud - v *
	v	5336.0 ± 483.0 (n = 11)				tp - v *
	tp	2015.0 ± 403.0 (n = 10)				ud - tp *
Apr	ud	12,300.0 ±2004.6 (n = 10)	30	16.837	0.0000	ud - v *
	v	6438.2 ± 778.2 (n = 11)				tp - v *

substrate provided microhabitat, then increased the colonization rate of other organisms, such as algae, leading to increased colonization of shrimp and crab.

When considering the biomass at the initial stage and at three years of age, it may be inferred that the biomass increases more or less at a stable rate. If this is true, the biomass in the first six months should be 991 ±sd901/m² on the upper horizontal plates or 1167 ±sd870 g/m² on the vertical plates. This biomass is much greater than that found in the same season in coral reefs at Phuket Island (Chansang *et al.*, 1987), when biomass ranged between 57 and 165 g/m². Nevertheless, the standard deviation of the average biomass in this study was very high due to the occasional settlement of the heavy organisms, such as bivalves and ascidian type II, so the minimum biomass was close to the range reported for the Phuket reefs. In addition, it could be due to variation in water velocity and sedimentation; Baynes and Szmant (1989) observed that, in the same location, the area of high velocity flow and low sedimentation supports high cover and species diversity. The site of AR3 is more exposed, has stronger water circulation and lower sedimentation than other reefs along the west coast of Phuket.

Successful recruitment of scleractinian corals did not occur, although there was evidence that coral larvae were available in the reef area, *i.e.* there appeared to be some colonies of ahermatypic coral *(Astrangia* sp.), whose larvae were possibly from the fringing reefs on nearby islands (for instance, Khang Khow Island) where a record from the 100 m transect line shows a 72 per cent cover of living corals (data from author's unpublished observation). It is likely that the coral reef could not develop in the AR3 area as it is directly exposed to the Southwest Monsoon waves. In contrast, the suspension feeders, especially oysters, could form an oyster reef.

In conclusion, it can be said that AR3 is a productive system that has a high complexity of benthic communities, in contrast to the bare sandy bottom just outside the reef modules. The evidence shows the increasing secondary production of important benthic organisms such as crabs, shrimps, polychaetes etc., which are the major components of a coral reef ecosystem *(e.g.,* Hutchings and Howitt, 1988). These organisms are the food source for the mobile fauna, especially commercial fish. Consequently, it would seem that fish do not aggregate at the AR just to hide or for shade but also to forage.

AR3 is located in a suitable position where the benthic communities can develop considerably, unlike AR2 which, when checked by the authors, had a very poor development of fouling organisms. AR3 is still in the process of undergoing change, with the substrates on the sea bottom having increased by a large number of oyster shells. Consequently, future studies on the development of the benthos communities on the bottom in this area would be of interest.

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Fish aggregation at the artificial reefs,
in **Ranong Province, Thailand**

by

Ukkrit Satapoomin

Phuket Marine Biological Centre
Phuket, Thailand

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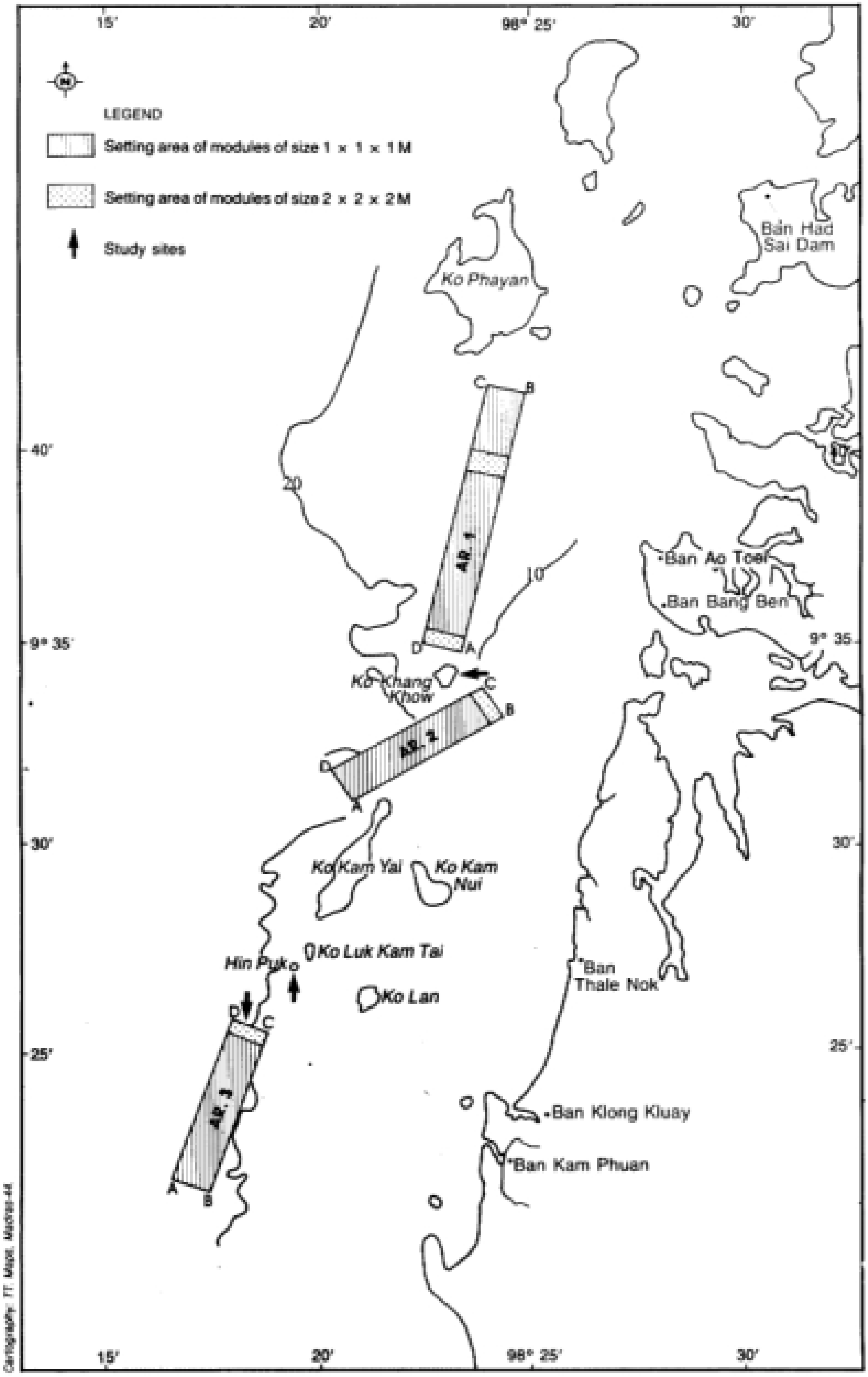
Fig 22. Study sites of AR3, Hin Puk and Ko Khang Khow in Ranong Province, Thailand



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9. *INTRODUCTION*

Artificial reefs (AR) have been used in fishery management to

- provide new habitats that increase number and biomass of depleted fishery resources,
- restore habitats,
- prevent trawlers from using certain areas,
- reduce fishing pressure, and
- possibly, mitigate deterioration of habitats (Bohnsack and Sutherland, 1985; Chang, 1985; Polovina, 1991; Seaman and Sprague, 1991).

In Thailand, artificial reefs have been in use from 1978, as part of a marine conservation programme and to enhance coastal fishing while reducing conflict between artisanal and commercial fishermen (Boonkird, 1984; Boonprakob, 1986; Supongpan and Singtothong, 1991). Under Thailand's national fishery plans, artificial reefs have been deployed in several places (Sinanuwong *etal.,* 1986; Awaiwanont, 1991) in the Gulf of Thailand (Rayong, Chantaburi, Petchaburi, Nakorn Srithammarat, Songkhla and Pattani) and in the Andaman Sea (Phang Nga, Phuket, Satun, Trung, Krabi and Ranong). In most cases, investigations suggest that artifical reefs are effective in natural resources conservation and habitat reconstruction. They are also beneficial to small-scale fisheries (Phanichsuk *etal.,* 1985; SEAFDEC and MDF, 1989; Awaiwanont *etal.,* 1991; Fujisawa *etal.,* 1991; Supongpan and Singtothong, 1992).

The present study deals in part with a monitoring and evaluation programme for an artificial reef project in Ranong Province (Lohakarn *et al., 1985).*

The specific aims of the study were to describe the aggregation of fish on the artificial reef and compare these assemblies with those in natural reef and rocky reef habitats in the vicinity.

10. *STUDY AREA*

The present study was conducted at AR3 (see Figure 22 on facing page). Highly turbid water prevented monitoring of AR1 and AR2.

Observations were made at the northern end of the plot, where 2 m3 concrete modules were installed in clumps. The water depth in this area is approximately 15 m.

The reef at Hin Puk, near Ko Luk Kam Tai (see Figure 22), was selected as a representative natural rocky reef (RKR). This reef consists of irregular rocky boulders up to 5 m in diameter and rockshelves extending to the rubble substrate at a depth of approximately 12 m. The coverage of abiotic components (rocks and rubble) and benthic fauna is 83.2 per cent and 15.4 per cent, respectively. The predominant fauna found in this area includes gorgonians *(Junceela* sp., *Ctenocella* sp., *Subergorgia* sp., *Nicella* sp.), soft corals *(Sinularia dura, Sinularia* sp.) and scleractinian corals *(Porites* sp., *Acropora* spp).

The representative natural coral reef (NR) was at Ko Khang Khow, further north and in the vicinity of AR2 (see Figure 22). Even though there are some coral reefs present near AR3, by the Kam Islands group, the reefs are not well developed. The selected reef is dominated by several species of scleractinian corals, with *Porites lutea* and *Montipora* spp. predominant. The total living coral cover at a depth of 3 m is *65.5* per cent.

11. *METHODOLOGY*

Fish aggregations associated with the natural and artificial reef habitats were assessed during three successive surveys (February 1992, December 1992 and April 1993), using the fish visual census techniques as described in Dartnall and Jones (1986). Although this technique has been criticized for underestimating the abundance of cryptic and/or nocturnal fish species (Brock, 1982; De Martini and Roberts, 1982), it has the advantage of being relatively accurate, rapid, inexpensive and nondestructive (Dartnall and Jones, 1986).

Two 50-rn lengths of tape were laid over the substratum at each site. Observations were made within a range of 5 m on either side of, and above, the transect line. All fish species present within the census area were recorded in terms of their relative sizes and abundance. Due to difficulties in counting and estimating the length of large numbers of different species of fish underwater, estimates were made of four life history stages and their abundance (Table 7).

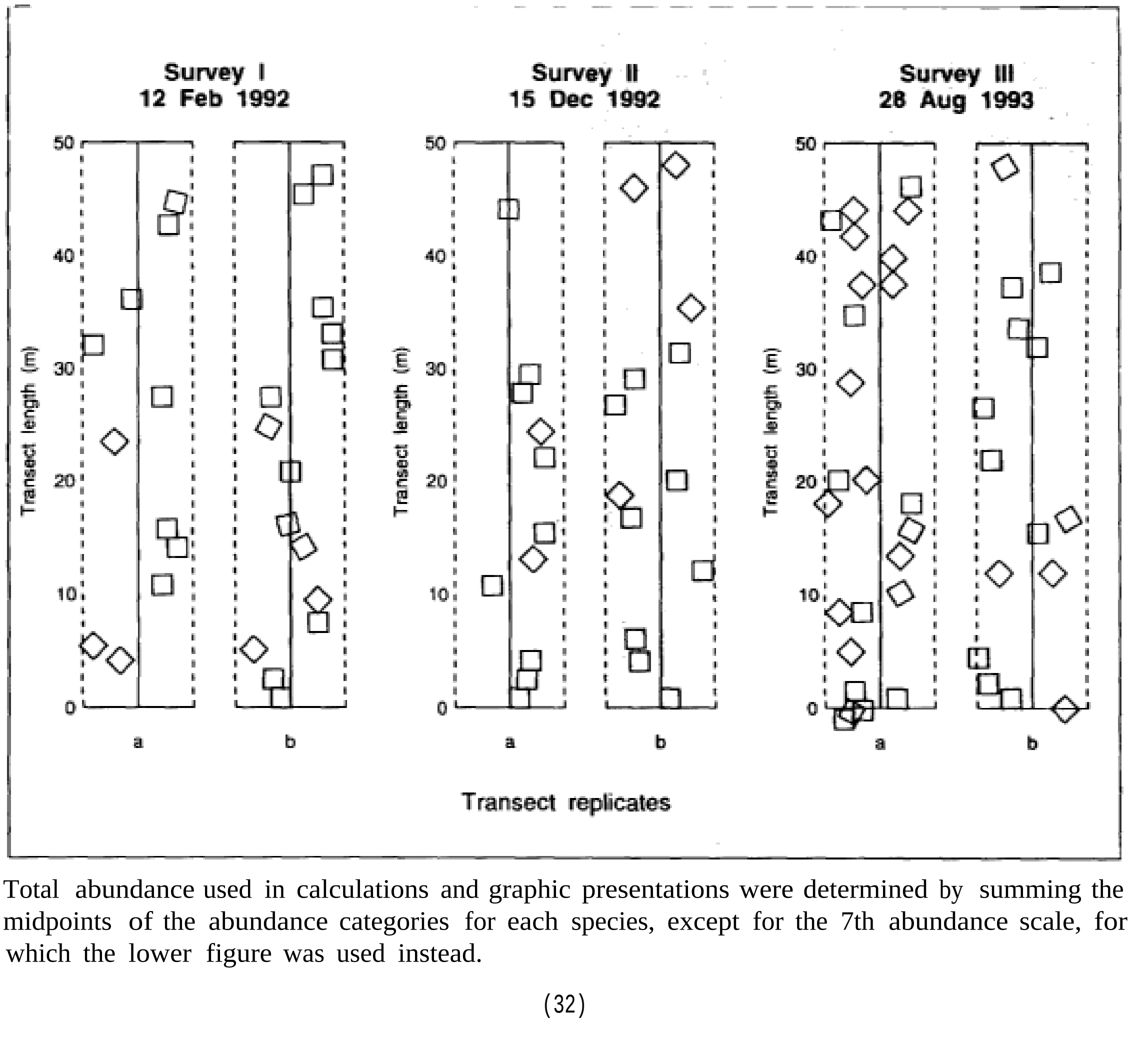
Table 7: Fish size and abundance categories applied for the study

Size (life history stage)	*Abundance (log 4-scale)*
J = juvenile	1 = rare (1)*
SA = subadult	2 = occasional (2-4)*
A = adult	3 = uncommon (5-16)*
LA = large adult	4 = common (17-64)*
	5 = very common (65-256)*
	6 = abundant (257-1024)*
	7 = very abundant (1024-4096)*

* The number in parentheses indicates number of individuals

The number of concrete modules distributed along the fish census transects at AR3 were counted and mapped as shown in (see Figure 23). The number of modules within the census area (1,000 m^2) varied from 24 to 39 modules.

Fig 23. Distribution of concrete modules (2x2x2m) along the census transects of three successive surveys at AR3



Total abundance used in calculations and graphic presentations were determined by summing the midpoints of the abundance categories for each species, except for the 7th abundance scale, for which the lower figure was used instead.

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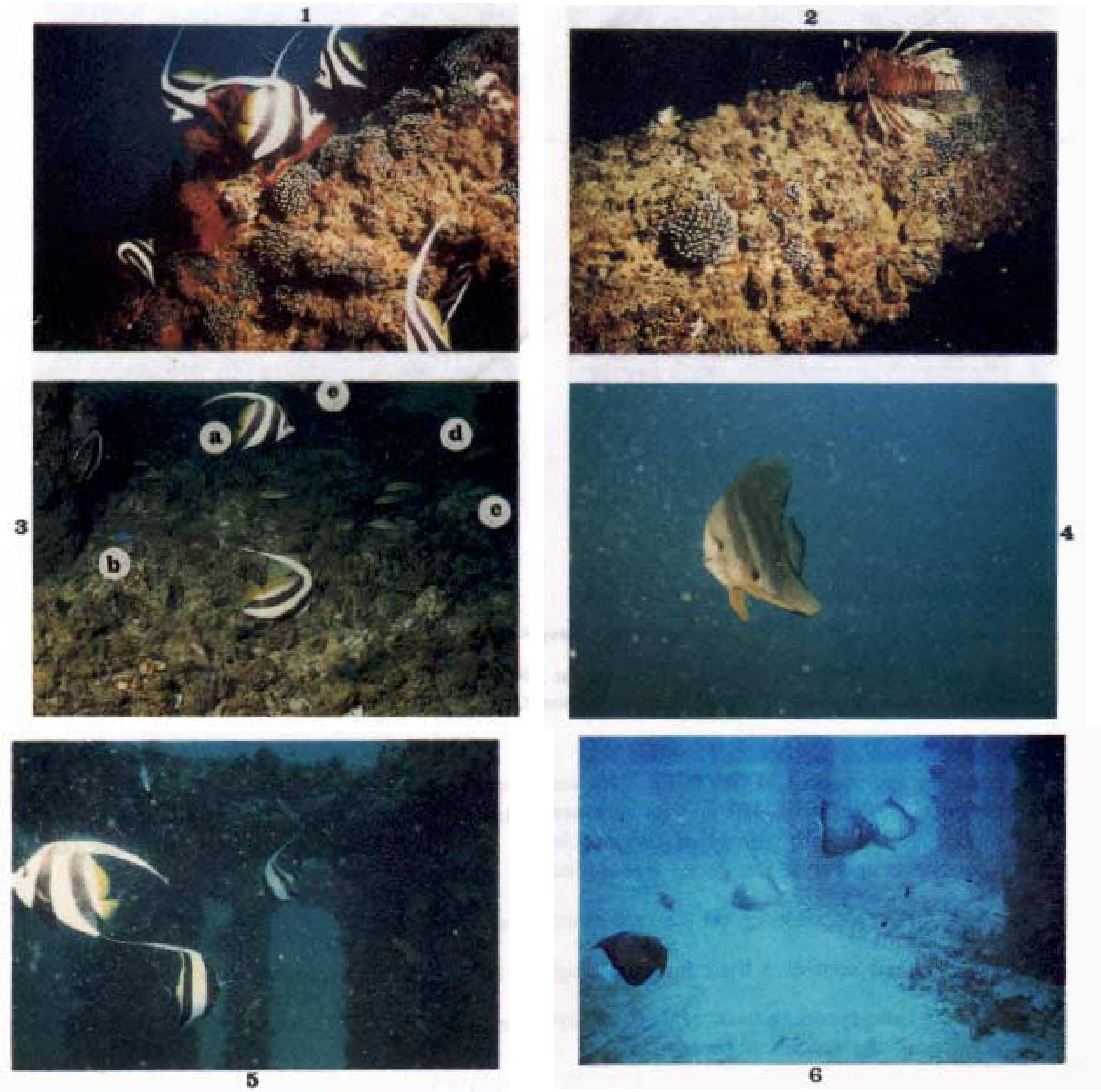
In order to get a complete list of fish fauna inhabiting the artificial reef, diving observations were made during each survey considerable distances apart and well outside the line-census area. During the second and third surveys, an underwater scooter was used to facilitate operations. In addition, supplementary information was obtained by underwater photography and handling operations in the area.

12. *RESULTS*

12.1 *Description offish aggregations at the artificial reef*

Initial fish colonization and utilization of the AR structures were known, because monitoring had begun in February 1992, about three years after construction. Monitoring revealed that artificial reefs were effective in attracting and holding fish (see photographs below and overleaf). Aggregations of several fish species were always confined to the reef structures rather than the open sand substrate within or outside the reef.



Photographs: Courtesy Niphon Phongsuwan (1-4) and Dr. Hansa Chansang (5 and 6)

Common fish found at AR3: 1. *Heniochus acuminatus,* 2. *Pterois miles,* 3. a. ***H.*** *acuminatus,* b. *Pomacentrus similis,* and c-*e. Thalassoma lunare* (juvenile, subadult and adult, respectively). *4. Platax teira, 5. Zanlus cornutus, 6. Pomacanthus annularis.*

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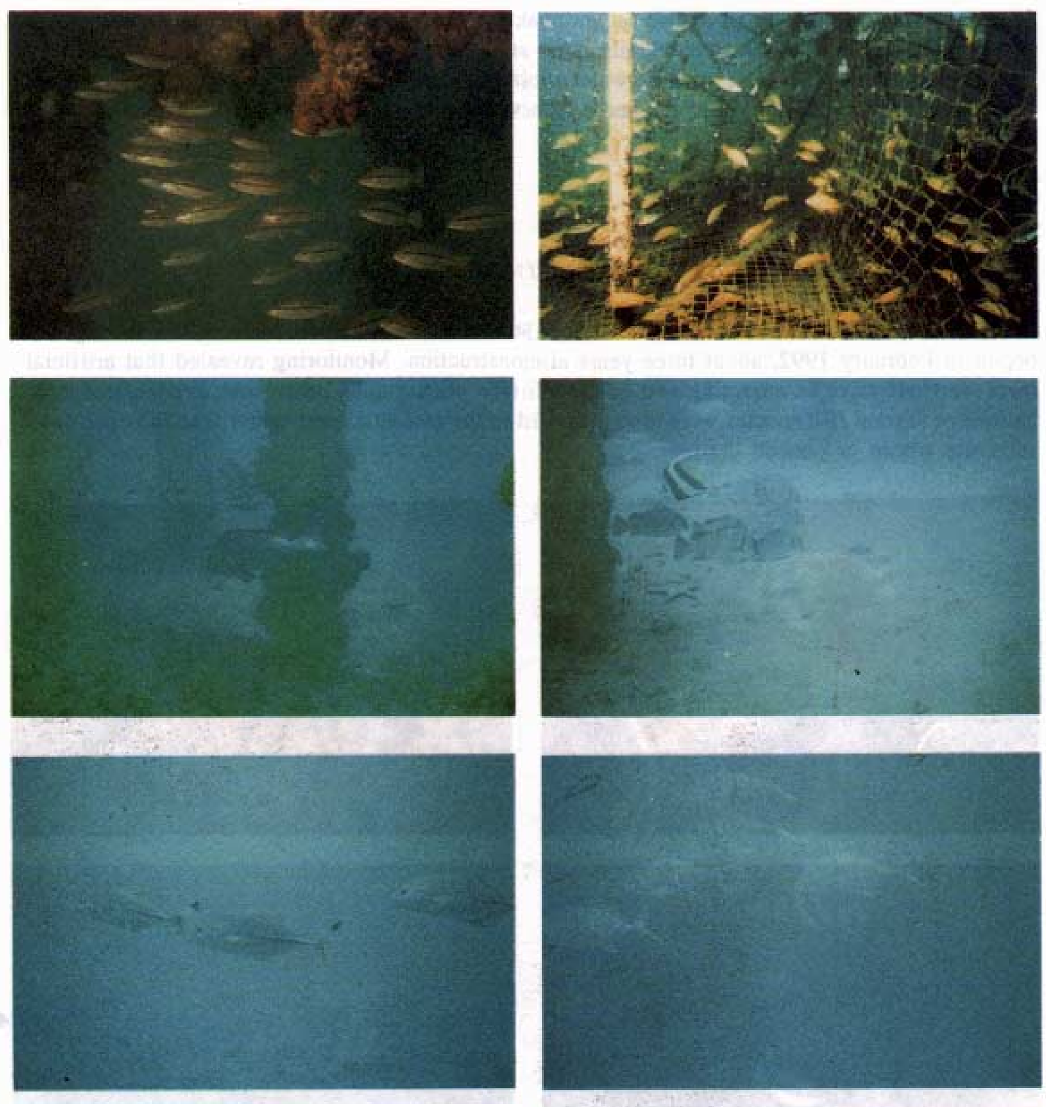

Photographs: Courtesy Niphon Phongsuwan (1 and 2) and Dr. Hansa Chansang (3-6)

Some economically important species found at AR3: 1. *Lutjanus vitta,* 2. ***L. quinquelineatus,*** 3. *Diagramma pictum,* 4. *Plectorhinchus gibbosus,* 5. *Caranx sem,* 6. *Gnathanodon speciosus.*

The presence and absence of fish in the three surveys during February 1992-April 1993 are shown in Appendix I. Altogether, 101 species representing 42 families of fish were encountered in the study area. The majority (82%) of fish species accounted were found to be residents (either permanent or temporary). Residence was defined on the basis of

- their dependence on the reef structures as shelter,
- their confining their foraging range to reef structures, and/or,
- their spending most of their life cycle in the habitat ***(i.e.*** nearly the whole size range of the species is present).

The rest (18%) of the species were transitory, being generally found over a much wider range of habitats. They were usually mobile schooling species *(e.g.* members of the Casionidae, Carangidae, Engrauridae etc.)

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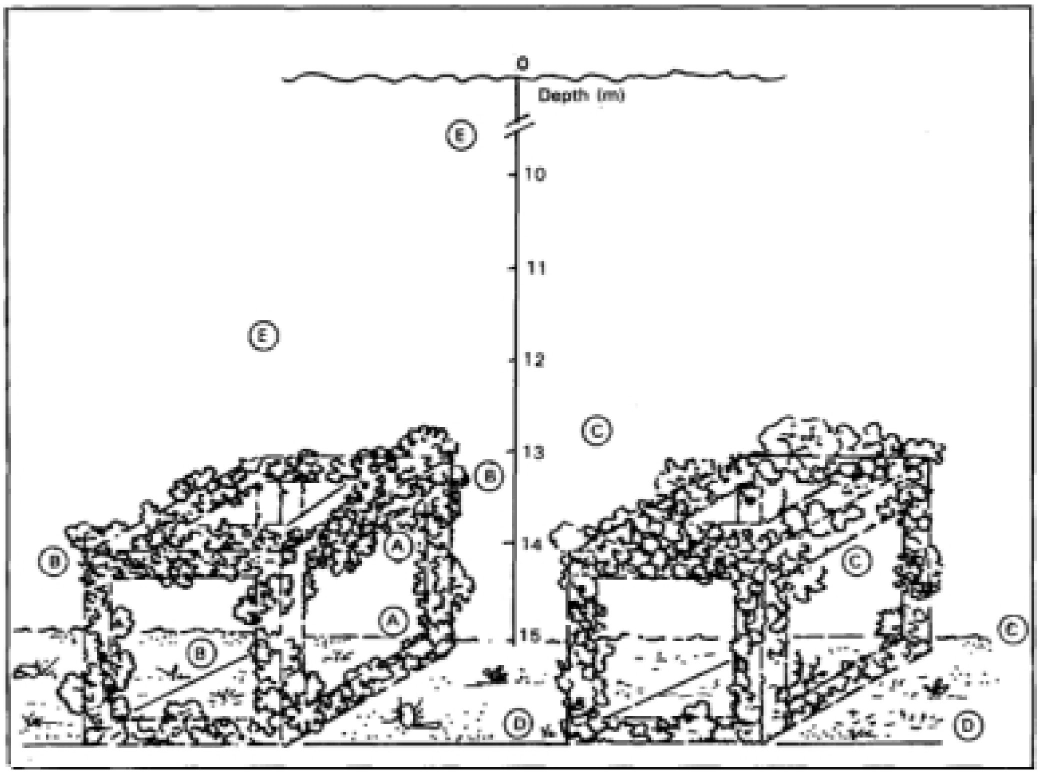
With regard to the behavioral aspects and space partitioning among artificial reef fish, there were five major groups of fish recognized in accordance with their relationship to the reef structures (see Figure 24).

Fig 24. Typical assemblage (groups A-E) of fish at AR3



- **Type A** fish preferred physical contact with the reef, and occupied holes, crevices and complex surfaces (which are provided and established by the fouling organisms). They were dominantly benthic dwellers, such as Groupers *(Cephalopholis* spp. and *Epinephelus* spp.), Dottybacks *(Pseudochromis* sp.), some Blennies *(Escenius bicolor, Petroscirtes variabilis)* and Lionfish *(Pteroismiles, Dendrochirus zebra* and *Scorpaenopsis* sp.). These fish constituted 15 per cent of the total species recorded.

- Type B fish usually swam close to the modules and also occupied the complex surfaces as shelter, especially when disturbed. They included members of such families as Pomacentridae, Apoqonidae, Diodontidae, Monacanthidae, Ostraciidae, Tetraodontidae and also some Blennies *(Plagiotremus rhinorhynchos).* These fish constituted 20 per cent of the total species recorded.

- Type C fish preferred to swim through and around the modules while remaining near the bottom and up to one metre above the modules. They did, however, sometimes leave the immediate area of the modules. They included Snappers (Lutjanidae), Sweetlips (Haemulidae), Wrasses (Labridae), Parrotfish (Scaridae), Rabbitfish (Siganidae), Ponyfish (Leiognathidae), Butterflyfish (Chaetodontidae), Angelfish (Pomacanthidae), Triggerfish (Balistidae), Surgeonfish (Acanthuridae), and Moorish idol (Zanclus cornutus). This was the most diverse group of fish and consituted 28 per cent of the total.

- Type D fish preferred to orientate themselves close to the bottom, sometimes moving around the base of modules but extending their range over the open sand substrate within the reef. They included Goatfish (Mullidae), Monocle breams *(Scolopsis* spp.), Emperors *(Lethrinus* spp.), Sandperch *(Parapercis* sp.), Lizardfish *(Synodus* sp.), Cobia *(Rachycentron canadum),* Spotted sicklefish *(Deprane punctatus),* Pipefish *(Trachyhamphus bicoarctatus),* Flutemouth *(Fistularia* *petimba)*, Whiting *(Sillago sihama)*, Dragonets *(Callionymus* sp.) and Sting ray *(Dasyatis khulii)*. There were also some cryptic and burrowing species *(i.e.,* gobids and Moray eels). This group consituted 22 per cent of the total species recorded.

- Type E fish tended to hover above the reef while remaining in the middle and upper part the water column. They were dominantly pelagic species, which usually form schools. These included Fusiliers (Caesionidae), Jacks and Trevallies (Carangidae), Batfish *(Plataxteira)*, Barracuda *(Sphyraera* spp.), Anchovy *(Stolephorus* sp.), Halfbeaks *(Hemirhamphus* sp.), Suckerfish *(Echenius naucrates)* and Eagle rays *(Aetobatus narinari)*. These fish constituted 15 per cent of the total species recorded.

It is important to note that these groups are more or less distinctive. But there are some exceptional cases, depending on the life cycle stages of the fish, their specific behaviour and/or their particular environment. The juvenile form of some Wrasses *(Tha!asoma lunare, Halichoeres* spp.) and Snapper *(Lutjanus lutjanus* and *L. vitta)* were recorded as Type B, while the adults were recorded as Type C. The transition from Type B to Type D is usually found in juveniles and adults of the Monocle breams *(Scolopsis mograrnma* and *S. vosmeri)*. Barracuda *(Sphyraera jello)* and Trevally *(Carangoides ferdua)* were usually found as Type E when forming schools, but in certain circumstances scattered individuals tended to occupy space within the modules or remained near the sea-bed (Type C).

12.2 *Habitat comparison*

In all, 184 species representing 45 families of fish were recorded from the artificial reef (AR3), natural coral reef (NR) and rocky reef (RKR). The results of the visual censuses are presented in Appendices II, III and IV. The total population density and species richness of fish among habitats were consistently ranked through time, *i.e.* **NR>RKR>AR3 (Table** 8). On an average, AR3 contained a lower density of fish, densities being just 40 per cent and 60 per cent of those at the NR and RKR, respectively. The AR3 had a species richness of about 65 per cent of that found at the other reefs.

Table 8: Summary of parameters from the census data obtained during three surveys between February 1992 and April 1993

Parameter	*Site/Survey*											
	AR				*NR*				*RKR*			
	I	*II*	*III*	*Avg.*	*I*	*11*	*III*	*Avg.*	*I*	*II*	*III*	*Avg.*
Total number of census species *(No. spp./1,000 m²)*	38.0 *(46.0)**	34.0 *(60.0)*	51.0 *(86,0)*	41.0 *(64.3)*	63.0 *(68.0)*	70,0 *(80.0)*	63.0 *(89.0)*	65.3 *(79.0)*	- -	**62.0** *(67.0)*	53.0 *(60.0)*	57.5 *(63.5)*
Total number of census fish (No. ind./1 000 m²)	*1805.0*	*1849.0*	*3158.0*	*2270.7*	*5172.0*	*6584.0*	*4454.0*	*5403.3*	-	*3787.0*	*2870.0*	*3328.5*
Total number of target species (No. spp./1,000 m²)	*14.0 (19.0)*	*12.0 (28.0)*	*11.0 (29.0)*	*12.3 (25.3)*	*16.0 (16.0)*	*15.0 (18.0)*	*17.0 (24.0)*	*16.0 (19.3)*	. -	*20.0 (20.0)*	*15.0 (17,0)*	*17.5 (18.5)*
Total number of target fish (No. ind./1 000 m²)	*1282.0*	*928.0*	*1008.0*	*1072.6*	*359.0*	*1904.0*	*1017.0*	*1093.3*	-	*2194.0*	*1615.0*	*1904.5*

* Values in parentheses are the total number of records.

The population of economically important (target) fish, in terms of both species richness and density, found at the NR and RKR were comparatively higher than those at AR3. However, in terms of relative density, the target fish contributed 57 per cent and 47 per cent of the total fish at the RKR and AR3, respectively. Only 20 per cent of the total fish were target species at the NR.

The life stages of the fish population in the various habitats indicated locational differences during the three surveys. The majority of the population were, however, adults. This pattern was more consistent where life stages were considered by species. A markedly high proportion of juvenile fish noticed at the RKR during the second survey may be explained as a deviation on account of the abundance of the new recruits of Fusiliers, namely *Caesio caerulaurea, C. cuning* and *Pterocaesio chrysozona.*

Regardless of temporal aspects, the composition of species recorded at AR3 and at the NR and RKR are compared in Table 9. The NR was richest in species composition (119 species). Using the underwater scooter, extensive observation of AR3 was done and several additional species noted. At a higher taxonomic level, AR3 had the highest family composition (see Table 9 and 10).

Table 9: Diversity of fish observed at artificial reef (AR), natural coral reef (NR), and rocky reef (RKR).

Family	*Total species recorded*	*Number of species* AR	NR	RKR
Acanthuridae	3	2	2	1
Apogonidae	6	2	5	3
Balistidae	2	2	1	1
Blenniidae	6	3	4	2
Caesionidae	3	2	3	3
Calliomynidae	1	1	0	0
Carangidae	8	6	1	1
Chaetodontidae	9	5	8	7
Dasyatidae	2	1	2	1
Diodontidae	2	2	1	1
Depranidae	1	1	0	0
Echeneidae	1	1	0	0
Engrauridae	1	1	0	0
Ephippidae	1	1	0	0
Fistulariidae	1	1	0	0
Gerridae	2	0	2	0
Gobiidae	13	2	12	4
Grammistidae	1	0	1	1
Haemulidae	2	2	1	1
Hemiramphidae	1	1	0	0
Labridae	24	8	21	12
Leiognathidae	1	1	1	0
Lethrinidae	3	2	0	1
Lutjanidae	10	6	7	4
Monacanthidae	2	2	0	0
Mullidae	4	2	2	3
Muraenidae	3	2	2	1
Myliobatidae	1	1	0	0
Nemipteridae	4	3	3	3
Ostraciidae	2	2	1	1
Pempheridae	1	0	1	1
Pinguipedidae	1	1	0	0
Pomacanthidae	1	1	0	1
Pomacentridae	23	5	21	10
Pseudochromidae	1	1	0	1
Rachycentridae	1	1	0	0
Scaridae	2	1	2	1
Scorpaenidae	3	3	1	0
Serranidae	14	9	8	4
Siganidae	3	2	2	2
Sillaginidae	1	1	0	0
Sphyraenidae	3	2	1	1
Syngnathidae	1	1	0	0
Synodontidae	2	1	1	1
Tetraodontidae	6	6	1	2
Zanclidae	1	1	1	1
No. of families	43	42	30	30
No. of species	184	101	119	76

Table 10: Comparison of fish fauna shared among habitats

Family	*NR&RKR*	*NR&AR*	*RKR&AR*
Acanthuridae	1	1	1
Apogonidae	3	1	1
Balistidae	1	1	1
Blenniidae	2	1	1
Caesionidae	3	2	2
Callionymidae	-	-	-
Carangidae	0	0	0
Chaetodontidae	6	4	5
Dasyatidae	1	1	1
Diodontidae	0	1	1
Depranidae	-	-	-
Echeneidae	-	-	-
Engrauridae	-	-	-
Epippidae	-	-	-
Fistulariidae	-	-	-
Gerridae	-	-	-
Gobiidae	4	1	0
Grammistidae	1	0	-
Haemulidae	1	1	1
Hemiramphidae	-	-	-
Labridae	9	6	7
Leiognathidae	0	1	0
Lethrinidae	0	0	0
Lutjanidae	2	3	3
Monacanthidae	-	--	
Mullidae	1	1	2
Muraenidae	1	1	1
Myliobatidae	-	-	-
Nemipteridae	3	2	2
Ostraciidae	1	1	1
Pempheridae	1	0	0
Pinguipidae	-	-	-
Pomacanthidae	0	0	1
Pomacentridae	9	4	4
Pseudochromidae	0	0	1
Rachycentridae	-	-	-
Scaridae	1	1	1
Scorpaenidae	0	1	0
Serranidae	4	3	3
Siganidae	1	1	2
Sillaginidae	-	-	-
Sphyraenidae	0	0	1
Syngnathidae	-	-	-
Synodontidae	1	0	0
Tetraodontidae	1	1	2
Zanclidae	1	1	1
No. of families	27	27	28
No. of species	59	41	46

<<

The results in Table 10 indicate that the similarity of fish communities at the three habitats varied in different degrees. But the ranking of similarity was the same when dealing with either number of families or species shared, *i.e.* AR and NR < NR and **RKR.** Ranking the ten most common families also showed a similar pattern at the NR and RKR, while they were quite different at AR3 (see Table 11).

Table 11: The ten most common families of fish fauna observed at AR3, NR, **RKR,** compared with the species found in the Andaman coral reefs in general

		Site		*Andaman reefs*
Rank	*AR3*	*NR*	*RKR*	*'in general'*
	Serranidae (9)	Labridae (21)	Labridae (12)	Labridae (52)
2	Labridae (8)	Pomacentridae (21)	Pomacentride (10)	Pomacentridae (52)
3	Lutjanidae (6)	Gobiidae (12)	Chaetodontidae (7)	Gobiidae (27)
4	Carangidae (6)	Chaetodontidae (8)	Gobiidae (4)	Chaetodontidae (25)
5	Tetraodontidae (6)	Serranidae (8)	Serranidae (4)	Serranidae (25)
6	Chaetodontidae *(5)*	Lutjanidae (7)	Lutjanidae (4)	Acanthuridae (19)
7	Pomacentridae (5)	Apogonidae (5)	Apogonidae (3)	Apogonidae (18)
8	Blenniidae (3)	Blenniidae (4)	Caesionidae (3)	Scaridae (16)
9	Nemipteridae (3)	Caesionidae (3)	Mullidae (3)	Blenniidae (15)
10	Scorpaenidae (3)	Nemipteridae (3)	Nemipteridae (3)	Lutjanidae (15)
% of total species concerned	53.5%	77.3%	69.7%	75.2%

13. *DISCUSSION*

Even though there was no data on the colonization of fish at AR3 **before this study, the results** indicate attainment of species equilibrium in the three years since the deployment of the reef. This is corroborated by the findings that there is a diverse species composition of fish at AR3, comparable to that at the natural coral reef, and that the majority (80%) are residents. Several previous studies have suggested that equilibrium of fish communities at artifical reefs is attained *1-5* years after deployment, although there could be seasonal variability of equilibrium (Bohnsack and Talbot, 1980; Bohnsack and Sutherland, 1985; McIntosh, 1981; Walsh, 1985).

The impact of artificial reefs on the aggregation of fish is diverse. Some evidence from both natural (Sale, 1980; Shulman, 1984) and artifical reefs (Hixon and Beets, 1989) suggests that shelter from predation may be more important than food in determining the abundance of fish. In truth, the bare surfaces of concrete modules are not directly beneficial to fish until communities of fouling organisms develop and provide complex surfaces! The AR in Ranong was a typical heterotrophic community with a variety of invertebrate taxa flourishing on its surfaces. The results of this study reveal a close relationship between modules with a flourishing invertebrate fauna and aggregation of fish. However, aggregation seems to depend, in part, on the fish sizes and the stages of their life cycle as well. Anderson *et al.* (1989) found that fish have been shown to stay near artifical reef structures for protection when small, but when larger and less vulnerable to predators, they spend more time away from the habitat. Fish Types A-C, which constituted over 60 per cent of the total recognized species, seemed to be more directly dependent on the reef structures than the others.

The complexity of reef structures *(i.e* size and density of installed modules) appears to have a direct influence on fish aggregation. Larger size modules seemed to attract more species and show a greater abundance of fish than smaller ones. Furthermore, fish tended to congregate more in patches where the modules were set in clusters than where they were sparse. Several studies have revealed that increasing habitat complexity results in an increased average number of individuals and number of species (Shulman, 1984; Phanichsuk *et al.,* 1985; Gorham and Alevizan, 1989). The results from census data here also support this general finding, the measured parameters (species richness and population density) of the third census being markedly higher than the first and second censuses (refer Table 8) and showing a correlation with the density of modules within the census area. The density of modules was 39 units/1,000 m^2 for the third census area and 27 and 24 units/l,000 m^2 for the first and second censuses, respectively. Whether or not a higher density of AR modules increases the effectiveness in attracting and holding fish remains to be evaluated. If a clear positive relationship is indicated, then, ARs set up in future should have a higher density of modules.

The finding that the community structure of fish at the AR was different from that found at the nearby natural rock/coral reef habitats was consistent with the original expectation. The natural reef habitats (NR and RKR) had more species and individuals (as was found by Burchmore *et al.*, 1985 in a similar study in Australia), suggesting that they possessed certain features that were not present or as well developed as the AR. This could be simply explained as differences in the nature of benthic structures. Several studies had revealed positive relationships between various aspects of substratum heterogeneity and the occurrence, distribution and abundance of fish on coral reefs *(e.g.* Luckhurst and Luckhurst, 1978; Carpenter *et al.,* 1981; Sutton, 1983).

The NR was dominated by hard coral cover *(65.5%),* while the RKR had a lower living cover (15.4%) of hard corals and other reef cnidarians. In contrast, the AR had a cover of benthic invertebrate taxa *(e.g.,* bryozoans, sponges, barnacles and ascidians) limited in number and confined to the concrete modules. In a census area with thirty $2m^3$ modules per 1,000 m^2, plane coverage by the benthic invertebrates on the AR was estimated to be not more than around 12 per cent. Both quantitative and qualitative differences in the nature of the benthic structures in the different habitats could account for differences in composition of fish species. A lack of critical resources has been suggested as the reason for the absence of many species (Bohnsack *et al.,* 1991). Reese (1981) showed that obligative coral-feeding chaetodontids *(i.e., Chaetodon trifascialis* and *C. trifasciatus)* were notably absent from artificial reefs where corals were not present or did not grow well.

Evidence from natural coral reef studies suggest that settlement and recruitment from the pelagic larval phase are highly variable in both time and space. It has also been suggested that they play a major role in the structuring of the adult fish community (Sale, 1983; Sutton, 1983; Williams, 1983; Doherty, 1991). The three study sites in Ranong were in the same vicinity and, thus, may have shared the same larval pool. The chance of a particular fish species existing in any habitat seems to directly depend upon its basic requirements of habitat and food (as well as what external forces of predation and competition are present). Any fish, if properly adapted to the available resources, can survive. It is not surprising that there is some similarity in the representative fish fauna between the AR and those of the natural reef habitat. Even though the number of species shared by AR3 and the NR at Ko Khang Khow was as low as 41 (ca*. 40%), it could be as high as 78 species (ca. 77%) judging from records of fish for the Andaman reefs in general (Satapoomin, unpublished data; Appendix I). The remaining 23 per cent were confined to the AR and included economically important demersal and pelagic fish such as Spotted sicklefish *(Dreprane punctata),* Longface emperor *(Lethrinus olivaceus),* John's snapper *(Lutjanus johni),* Groupers *(Epinephelus b!eekeri* and *E. undulosus),* Cobia *(Rachycentron canadum),* Whiting *(Sillago sihama),* Trevallies *(Caranxignobilis* and *C. sem),* Black-banded kingfish *(Seriolina nigrofasciata)* and Anchovy *(Stolephorus* sp.). Quantitative results based on census assessment also revealed a higher proportion of target fish at the AR site when compared to those at the natural reef habitat. The effectiveness of artifical reefs attracting target species has also been reported elsewhere *(e.g.* Alevizon *et al.,* 1985; Burchmore, *et al.* 1985; Chang, 1985; Campos and Gamboa, 1989). It should, therefore, be recognized that artificial reefs may help to sustain local fisheries.

With regard to the visual census techniques employed in this study, a transect length of 100 m/census was generally adopted as giving reliable and representative data for a coral reef habitat, but this would appear inadequate for artificial reefs. Since major colonization of fish at AR3 was confined to the modules and the modules were scattered, the census area of $1000m^2$

* Census area/asessmcnt

seemed insufficient for all the fish species in the vicinity; in fact, a considerable number of additional species (17-43% of the total recorded for each census) were encountered outside the census transects. In the case of natural rocky/coral reefs, additional species outside the transects were fewer (7-10% for the RKR and *7-25%* for the NR). There appeared to be a patchy distribution of fish at all these habitats, but this patchiness seemed to be more pronounced at the AR site than at the others. Greater replication of transects is recommended for future research involving visual census at artificial reefs.

Several damaged trawinets were seen on the modules of both sizes. Even an otter board was found in a large clump of modules. This would indicate that ARs could have an important role to play in the regulation of some prohibited fishing activities in coastal areas where conservation is necessary. Since intensive trawling has overexploited fishery resources, which are destructive to habitats as well as conflicting with small-scale fisheries, artificial reefs could serve as an effective tool in regulating such fishing gear.

It could be concluded that artificial reefs would appear to be important in conserving fishery resources and re-creating habitats, and might even prevent conflicts among the various fisheries in a particular area.

14. *CONCLUSIONS*

The results of this study indicate that:

- The AR is effective in aggregating a variety of fish species and in holding them by providing suitable habitats.
- Aggregation of fish at an AR depends upon the complexity of reef structures (size of modules, density of installed modules etc.). ARs to be set up in future should be of complex types.
- ARs could play an important role in conservation of fishery resources, habitat re-creation and reduction of fishery conflict, as they help to eliminate destructive fishing gear from the area.
- The abundance of target fish at ARs would increase incomes of local fishermen.

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APPENDIX I

List of fish species at AR3

Taxa	Survey I	Survey II	Survey III	Residency class	Means of record
ACANTHURIDAE (Surgeonfish)					
* *Acanthurus xanthopterus*	*	*	*	RE	S, H
* Naso lituratus	*			RE	St
APOGONIDAE (Cardinalfish)					
* Apogon sp.			*	RE	S, P
* *Archamia fucata*			*	RE	S
BALISTIDAE (Triggerfish)					
* Balistoides *viridescens*		*	*	RE	S
* *Sufflamen frenatus*	*	*	*	RE	S
BLENNIIDAE (Blennies)					
* *Exsenius bicolor*		*	*	RE	S
* *Pttroscirtts* variabilis			*	RE	S
* *Plagiotremus rhinorhynchos*			*	RE	S
CAESIONIDAE (Fusiliers)					
* *Caesio cutting*	*	*		RE	S
* *Pterocaesio chrysozona*	*	*	*	RE	S
CALLIONYMIDAE (Dragonets)					
Callionymus sp.			*	RE	S
CARANGIDAE (Trevallies)					
* Carangoides *ferdua*		*	*	TR	S
Caranx ignobilis			*	TR	H
Caranx sem			*	TR	S,P
* Caranx sexfasciatus	*		*	TR	S, St
* *Gnathanodon speciosus*			*	TR	S, P
Seriolina nigro *fasciata*		*		TR	S
CHAETODONTIDAE (Butterflyfish)					
* *Chaetodon collare*		*	*	RE	S, P
* *Chaetodon* decussatus	*	*	*	RE	S
* *Coradion chrysozonus*			*	RE	S
• *Heniochus acuminatus*	*	*	*	RE	S, P
• *Heniochus* singularius			*	RE	S, P
DASYATIDAE (Sting rays)					
• Dasyatis kuhlii			*	TR	S, H
DIODONTIDAE (Porcupinefish)					
* *Diodon histrix*			*	RE	S
* *Diodon liturosus*	*	*	*	RE	S, P
DREPANIDAE (Sicklefish)					
Drepane punctata		*	*	TR	S
ECHENEIDAE (Suckerfish)					
* *Echeneius naucrates*		*	*	TR	S
ENGRAULIDAE (Anchovies)					
Stolephorus sp.			*	TR	S
EPHIPIDAE (Batfish)					
* *Platax ttira*	*	*	*	TR	S, H, P
FISTULARIIDAE (Flutemouths)					
Fistularia petimba			*	TR	S
GOBIIDAE (Gobies)					
* Valenciennea mularis			*	RE	S
* *Valenciennea pleullaris*	*		*	RE	S
HAEMULIDAE (Sweetlips)					
* *Diagramma pictum*		*	*	RE	S, P
* *Plectorhinchus gibbosus*			*	RE	S, P
HEMIRAMPHIDAE (Halfbeaks)					
Hemiramphus sp.			*	TR	S
LABRIDAE (Wrasses)					
* *Bodianus diana*			*	RE	S, P
* *Cheilinus chlorourus*			*	RE	S
* *Helichoeres dussumieri*	*	*	*	RE	S
* *Halichoeres marginatus*	*		*	RE	S
* Labroides dimidiatus	*	*	*	RE	S, P
* *Leptojulis cyanopleura*		*	*	RE	S
* *Stethojulis inerrupta*	*		*	RE	S
* *Thalassoma lunare*	*	*	*	RE	S, P
LEIOGNATHIDAE (Ponyfish)					
* Secutor sp.			*	RE	S
LETHRINIDAE (Emperors)					
* *Lethrinus* nebulosus	*	*	*	RE	S, St, H
Lethrinus olivaceus			*	RE	H
LUTJANIDAE (Snappers)					
* *Lutjanus fulvus*	*	*	*	RE	S, H, P
Lutjanus johni		*		RE	S
* *Lutjanus lutjanus*		*	*	RE	S, P
* Lutjanus *quinquelineatus*	*			RE	S
* *Lutjanus russelli*		*		RE	S
* *Lutjanus* vitta	*	*	*	RE	S, P, H

Taxa	Survey I	Survey II	Survey III	Residency class	Means of record
MONACANTHIDAE (Leatherjackets)					
Aluterus monoceros	*	*		TR	SI
Monacanthus chinensis	*		*	RE	S
MULLIDAE (Goatfish)					
* *Mulloides* flavolineatus		*	*	RE	S
* *Upeneus tragule*	*		*	RE	S
MURAENIDAE (Morays)					
* Gymnothorax favageneus	*			RE	S
* Gymnothorax *flavimarginatu*	*			RE	S
MYLIOBATIDAE (Eagle rays)					
* *Aetobatus narinari*		*		TR	S
NEMIPTERIDAE (*Monocle* breams)					
* *Scolopsis* bilineatus	*	*		RE	S
* *Scolopsisi monogramma*	*	*	*	RE	S, H
* *Scolopsis* vosmeri	*		*	RE	S, P, H
OSTRACIIDAE (Boxfish)					
* Ostacion cubicus	*	*	*	RE	S
Tetrosoma gibbosa	*			RE	S
PINGUIPEDIDAE (Sandperches)					
Parapercis cylindrica	*	*	*	RE	S
POMACANTHIDAE (Angelfish)					
* *Pomacanthus annularis*	*	*	*	RE	S, P
POMACENTRIDAE (Damselfish)					
* *Dascyllus trimaculatus*		*	*	RE	S
* *Neopomacentrus azysron*	*	*	*	RE	S, P
* *Neopomacentrus cyanomos*	*	*	*	RE	S, P
* *Pomacentrus similis*	*		*	RE	S, P
Pristotis *jerdoni*			*	RE	S
PSEUDOCHROMIDAE (Dottybacks)					
Pseudochromis sp.	*	*	*	RE	S, P
RACHYCENTRIDAE (Cobias)					
Rachycentron canadum		*	*	TR	S
SCARIDAE (Parrotfish)					
* *Scarus ghobban*		*	*	RE	S
SCORPAENIDAE (Scorpionfish)					
* *Dendrochirus zebra*			*	RE	S
* *Pttrois mills*	*	*	*	RE	S, P
* *Scorpaenopsis* sp	*	*	*	RE	S, H
SERRANIDAE (Groupers)					
* *Cephalopholis boenak*	*	*	*	RE	S
* *Cephalophilos formosa*	*		*	RE	S
* *Cromileptes* altivelis			*	RE	P
* *Epinephelus areolatus*			*	RE	S
Epinephelus bleekeri	*		*	RE	S
* *Epinephelus erythrurus*	*		*	RE	S
* *Epinephelus lanceolatus*			*	RE	S
* *Epinephelus* tauvina	*		*	RE	S, St, P
Epinephelus undulosus		*		RE	S, H
SIGANIDAE (Rabbitfish)					
* *Siganus* canaliculatus	*		*	RE	S, P
* *Siganus javus*	*		*	RE	S, P
SILLAGINIDAE (Whitings)					
Sillago sihama		*		TR	H
SPHYRAENIDAE (Barracudas)					
* *Sphyraena jello*	*		*	TR	S, P
• *Sphyraena putnamiae*			*	TR	S, P
SYNGNATHIDAE (Pipefish)					
Trachyrhamphus bicoarctatus	*		*	RE	S
SYNODONTIDAE (Lizardfish)					
Synodus sp.			*	TR	S
TETRAODONTIDAE (Puffers)					
* *Arothron hispidus*			*	RE	S, H
Arothron immaculatus		*	*	RE	S
* *Arothron mappa*	*		*	RE	S
* *Arothron nigropunctatus*			*	RE	S
* *Arothron stellatus*			*	RE	S
* *Canthigaster solandri*		*	*	RE	S
ZANCLIDAE (Moorish Idol)					
* Zanclus cornutus		*	*	RE	S, P

Note: List of fish species at AR3 (Ranong 3) Fish were simply classified as resident (RE) and transient (TR) species Species marked with asterisks were in general accounted as Andaman reef fish. Records were made by means of sighting within or outside the census transect (S), sighting of trapped fish in situ (St), handling (H) and photographing (P)

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APPENDIX II

Summary of fish census data from AR3 during surveys in
February 1992 (I), December 1992 (II), and April 1993 (III)

TAXA	Survey I Log4 Abundance scale	Survey I Pre-dominant life history stage	Survey II Log4 Abundance scale	Survey II Pre-dominant life history slage	Survey III Log4 Abundance scale	Survey III Pre-dominant life history stage
ACANTHURJDAE (Surgeonfish)						
Acanthurus xanthopterus	3	A	1	A	3	A
Naso lituratus	x	A				
APOGONIDAE (Cardinalfish)						
Apogon sp.	-		-		5	SA
Archamia fucata	-			-	6	SA
BALISTIDAE (Triggertish)						
Balistoides viridescens			x	A	2	SA
Sufflamen frenatus	1	A	x	A	2	A
BLENNIIDAE (Blennies)						
Ecsenius bicolor			3	A	3	A
Petroscirtes variabilis			-		1	A
Plagiotremus rhinorhynchos			-		1	A
CAESIONIDAE (Fusiliers)	3	SA	x	SA	-	
* *Caesio cuning*						
* *Pterocaesio chrysozona*	5	SA	x	SA	x	SA
CALLIONYMIDAE (DragonetS)						
Callionymus sp.					x	A
CARANGIDAE (Trevallies)						
* *Carangoides ferdua*			x	LA	x	A
* *Caranx ignobilis*					x	A
* *Caranx sexfasciatus*	x	A	-		x	A
* *Caranx sem*			-		x	A
* *Gnathanodon speciosus*					x	A
* *Seriolina nigrofasciata*			x	SA	-	
CHAETODONTIDAE (Butterfiyfish)						
Chaetodon collare			x	A	2	A
Chaetodon decussai'us	2	A	1	A	2	A
Coradion chrysozonus			-		1	A
Heniochus acuminatus	2	A	4	A	5	A
Heniochus singularius			-		1	A
DASYATIDAE (Sting rays)						
Dasyatis kuhlii			-		x	A
DIODONTIDAE (Porcupinefish)						
Diodon histrix			-		x	A
Diodon liturosus		A	1	A	2	A
DREPANIDAE (Sicklefish)						
* *Drepane punctata*			x	LA	x	LA
ECHENEIDAE (Sucklefish)						
Echeneius naucrates				SA	2	SA
ENGRAULIDAE (Anchovies)						
Stolephorus sp.			-		x	A
EPHIPIDAE (Batfish)						
Platax reira			3	A	3	A
FISTULARIIDAE (Flutemouth)						
Fistularia petimba					3	SA
GOBIIDAE (Gobies)						
Valenciennea mularis			-		3	A
Valenciennea pleullaris	3	A	-		x	A

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Appendix II - *contd.*

TAXA	Survey I Log4 Abundance scale	Survey I Pre-dominant life history stage	Survey II Log4 Abundance scale	Survey II Pre-dominant life history stage	Survey III Log4 Abundance scale	Survey III Pre-dominant life history stage
HAEMULIDAE (Sweetlips)						
* *Diagramma pictum*	-		x	A	x	A
* *Plectorhinchus gibbosus*	-		-		x	A
HEMIRAMPHIDAE (Halfbeaks)						
Hemiramphus sp.	-		-		x	A
LABRIDAE (Wrasses)						
Bodianus diana	-		-		1	SA
Cheilinus chiorourus	-		-		2	A
Helichoeres dussumieri	4	SA	4	SA	3	A
Halichoeres marginatus	2	A	-		x	A
Labroides dimidiatus	3	A	2	A	4	A
Leptojulis cyanopleura	-		2	A	3	A
Stethojulis interrupta	x	A	-		x	A
Thalassoma lunare	4	SA	4	SA	4	SA
LEIOGNATHIDAE (Ponyfish)						
Secutor sp.				4	J	
LETHRINIDAE (Emperors)						
* *Lethrinus nebulosus*	x	A	x	A	x	A
* *Lethrinus olivaceus*			-		x	LA
LUTJANIDAE (Snappers)						
* *Lutjanus fulvus*	2	SA	4	A	x	A
* *Lutjanus johni*			x	LA	-	
* *Lutjanus lutjanus*			x	J	6	J
* *Lutjanus quinquelinealus*	5	A	-			
* *Lutjanus russelli*			x	A	-	
* *Lutjanus vitta*	6	A	6	A	4	J
MONACANTHIDAE (Leatherjackets)						
Aluterus monoceros	x	A	-			
Monacanthus chinensis	2	A	1	A	x	A'
MULLIDAE (Goatfish)						
* *Mulloides flavolineatus*	-		3	J	4	J
* *Upeneus tragula*	3	A	x	J	4	J
MURAENIDAE (Morays)						
Gymnothorax flavageneus	1	A				
Gymnothorax flavimarginatus	1	A				
MYLIOBATIDAB (Eagle rays)						
Aetobatus narinari	-		x	A		
NEMLPTERIDAE (Monocle breams)						
* *Scolopsis bilineatus*	4	A		A	4	A
* *Scolopsis monogramma*	2	A				
* *Scolopsis vosmeri*	5	SA	5	SA	5	SA
OSTRACIIDAE (Boxfish)						
Ostacion cubicus	1	A	x	A	1	A
Tetrosoma gibbosa	1	A				
PINGUTPEDIDAE (Sandperches)						
Parapercis cylindrica	3	A	I	A	4	A
POMACANTHIDAE (Angelfish)						
Pomacanthus annularis	3	J	2	A	3	A
POMACENTRIDAE (Damselfish)						
Dascyllus trimaculatus	-		x	SA	x	SA
Neopomacentrus azysron	5	A	6	A	6	A

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Appendix II - *contd.*

TAXA	*Survey I* Log4 Abundance scale	*Survey I* Pre-dominant life history stage	*Survey II* Log4 Abundance scale	*Survey II* Pre-dominant life history stage	*Survey III* Log4 Abundance scale	*Survey III* Pre-dominant life history stage
Neopomacentrus cyanomos	4	A	4	A	4	A
Pomacentrus similis	5	SA	4	A	4	A
Pristotis jerdoni					3	A
PSEUDOCHROMIDAE (Dottybacks)						
Pseudochromis sp.	3	A	4	A	5	A
RACHYCENTRIDAE (Cobias)						
* *Rachycentron canadum*	-		x	LA	x	LA
SCARIDAE (Parrotfish)						
Scarus ghobban			x	A	x	SA
SCORPAENIDAE (Scorpionfish)						
Dendrochirus zebra					x	A
Pterois miles	2	A	2	A	1	A
Scorpaenopsis sp. 1	1	A	x	A	x	A
SERRANIDAE (Groupers)						
* *Cephalopholis boenak*	2	J	3	J	4	J
* *Cephalopholos formosa*	3	SA	x	SA	1	A
* *Cromileptes altivelis*					x	SA
* *Epinephelus areolatus*	-		x	J	x	A
* *Epinephelus bleekeri*	2	J	4	J	x	SA
* *Epinephelus erythrurus*	x	A	-		1	A
* *Epinephelus lanceolatus*		-	2	J		-
* *Epinephelus tauvina*	x	A	1	A		
* *Epinephelus undulosus*	-		x	A	x	A
SIGANIDAE (Rabbitfish)						
* *Siganus canaliculatus*	4	A	2	A	2	SA
* *Siganus javus*	4	A	3	SA	2	A
SILLAGINIDAE (Whitings)						
* *Sillago sihama*	-		x	A	-	
SPHYRAENIDAE (Barracudas)						
* *Sphyraena jello*	x	LA	3	LA	x	LA
* *Sphyraena putnamiae*	-		-		x	LA
SYNGNATHIDAE (Pipetish)						
Trachyrhamphus bicoarctatus	x	A	x	A	x	A
SYNODONTIDAE (Lizardfish)						
Synodus sp.	-		-		x	SA
TETRAODONTIDAE (Puffers)						
Arothron hispidus	•		1	A	2	A
Arothron irnmaculatus			1	A	2	A
Arothron mappa		A	-		2	A
Arothron nigropunclatus						A
Arothron stellatus	-		.		x	A
Canthigaster solandri	-		1	A	3	A
ZANCLIDAE (Moorish idol)						
Zanclus cornutus	-		x	A	2	A

Note: x = records outside the transect without quantification, *i.e.* records from sighting, trapped fishes and handlining
* = economically important species
J = juvenile
SA = subadult
A = adult
LA = large adult

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APPENDIX III

Summary of fish census data from the natural coral reef (Ko Khang Khow) during surveys in February 1992 (I), December 1992 (II) and April 1993 (III)

TAXA	*Survey I* Log4 Abundance scale	*Survey I* Pre-dominant life history stage	*Survey II* Log4 Abundance scale	*Survey II* Pre-dominant life history stage	*Survey III* Log4 Abundance scale	*Survey III* Pre-dominant life history stage
ACANTHURIDAE (Surgeonfish)						
Acanthurus mata	1	A	-			
Acanthurus xanthopterus	-		3	A	1	A
APOGONIDAE (Cardinalfish)						
Apogon cyanosoma	2	A	2	A	1	A
Apogon pseudotaeniatus	*x*	A	-		-	
Apogon taeniophorus	*4*	A	-		1	A
Archamia fucata	*6*	A	7	SA	5	A
Cheilodipterus quinquelineatus	2	A	3	A	3	A
BALISTIDAE (Triggerfish)						
Balistoides viridescens	-		x	A	-	
BLENNIIDAE (Blennies)						
Astrosalarias fuscus	-		3	A	2	A
Ecsenius bicolor	3	A	3	A	-	
Meiacanthus smithi	3	A	3	A	2	A
Plagiotremus phenax	-		1	A	-	
CAESIONIDAE (Fusiliers)						
* *Caesio caenulaurea*	4	A	6	J	6	A
* *Caesio cuning*	3	A	*5*	J	3	A
* *Pterocaesio chrysozona*	5	A	7	J	5	A
CARANGIDAE (Trevallies)						
* *Caranx melampygus*	-		-		3	A
CHAETODONTIDAE (Butterflyfish)						
Chaetodon collare	3	A	3	A	4	A
Chaetodon decussatus	-		-		*x*	A
Chaetodon octofasciatus	*4*	A	5	SA	5	SA
Chaetodon plebeius	-		-		1	A
C. trifascialis	-		-		1	A
Heniochus acuminatus	1	A	-		3	A
Heniochus pleurotaenia	1	A	-		*x*	A
Heniochus singularius	2	A	3	A	3	A
DASYATIDAE (Sting rays)						
Dasyatis kuhlii	-		-		1	A
Dasyatis sp.					x	A
DIODONTIDAE (Porcupinefish)						
Diodon histrix	1	A	-		-	
GERREIDAE						
Gerres acinaces	-		-		x	A
Gerres lucidus	-		x	A	-	
GOBIIDAE (Gobies)						
Amblyeleotris sp.	2	A	-		x	A
Amblygobius hectori	3	A	1	A	-	
Amblygobius nocturnuus	2	A	-		x	A
Cryptocentrus strigilliceps	3	A	2	A	x	A
Cryptocentrus sp.	-		-		x	A
Ctenogobiops aurocingulus	*x*		*4*	A	x	A
Fusigobius sp.	x		-		-	
Istigobius ornatus	2	A	3	A	X	A
Ptereleotris evedes		*4*	A	4	J	-

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Appendix III - *contd.*

TAXA	*Survey I* Log4 Abundance scale	*Survey I* Pre-dominant life history stage	*Survey II* Log4 Abundance scale	*Survey II* Pre-dominant life history stage	*Survey Ill* Log4 Abundance scale	*Survey Ill* Pre-dominant life history stage
Ptereleotris microlepsis	-		4	A	2	A
Valenciennea mularis	2	A	4	A	I	A
Valenciennea sexguttatus		2	A	3	A	-
GRAMMISTIDAE						
Diploprion bifasciatum	-		I	SA	-	
HAEMULIDAE (Sweetlips)						
* *Diagramma pictum*	I	A	-		3	A
LABRIDAE (Wrasses)						
Bodianus axillaris	I	A	-			
Bodianus diana	-		-		I	A
Bodianus mesothorax	-		-		x	A
Bodianus sp.	-		I	A	I	A
Diproctacanthus xanthurus	2	A	I	A	x	A
Cheilinus chlorourus	-		I	A	3	A
Cheilinus faciatus	*x*		2	A	I	A
Cheilinus trilobatus	2	A	-		-	
Cons variegata	-		x	A	x	A
Epibulus unsidiator		I	A	-		
Halichoeres argus	2	A	-			
Helichoeres chloropterus	3	SA	2	A	x	A
Helichoeres dussumieri	*4*	SA	4	A	-	
Helichoeres kallochroma		-		I	A	-
Halichoeres marginatus	3	A	-		3	A
Halichoeres timorensis	4	A	2	A	3	A
Halichoeres vrolikii	4	A	4	A	4	A
Hemigymnus melapterus	*x*		*x*	A	x	A
Labrichys unilineatus	-		-		2	A
Labroides dirnidiatus	3	A	2	A	3	A
Thalassoma lunare	*4*	SA	4	SA	4	A
LEIOGNATHIDAE (Ponyfish)						
Secutor s.p	-		4	J	-	
LUTJANIDAE (Snappers)						
* *Lutjanus biguttatus*	2	SA	2	A	x	A
* *Lutjanus decussatus*	3	SA	3	A	2	A
* *Lutjanus fulvijiamma*	-		-		X	A
* *Lutjanusfulvus*	3	A	3	A	3	A
* *Lutjanus gibbus*	-		x	A	-	
* *Lutjanus lutjanus*	-		-		-	
* *Lutjanus russelli*	-		I	A	4	A
MULLIDAE (Goatfish)						
* *Perupeneus barberinus*			*x*	A	x	A
* *Upeneus tragula*	1	A	-		3	A
MURAENIDAE (Morays)						
Gymnothoraxfavageneus	-		I	A	I	A
Gymnothorax permistus	-		I	SA	-	
NEMIPTERIDAE (Monocle breams)						
* *Scolopsis ciliatus*	*4*	A	3	A	4	A
* *Scolopsis monogramma*	-		2	A		
* *Scolopsis vosmeri*	3	A	3	A	x	A
OSTRACIIDAE (Boxfish)						
Ostacion cubicus	-		-		I	A
PEMPHERIDAE						
Pempheris vanicolensis	3	A	4	A	4	A

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Appendix III - *contd.*

TAXA	Survey I Log4 Abundance scale	Survey I Pre-dominant life history stage	Survey II Log4 Abundance scale	Survey II Pre-dominant life history stage	Survey III Log4 Abundance scale	Survey III Pre-dominant life history stage
POMACENTRIDAE (Damselfish)						
Abudefduf bengalensis	-		1	A	-	
Abudefduf vaigiensis	5	A	4	A	4	A
Amblyglyphidodon leucogaster	-		2	A	I	A
Amphiprion akallopisos	4	A	4	A	4	A
Amphiprion ocellaris	4	A	5	A	4	A
Cheloprion labiatus	-		2	A	-	
Chromis cinerascens	6	A	4	A	5	A
Chromis ternatensis	-		4	A	-	
Dascyllus trimaculatus	-		2	SA	1	SA
Dischistodus perspicillatus	I	A	-		x	A
Hemiglyphidodon plagiometopon	-		2	A	-	
Neoglyphidodon nigroris	-		-		2	A
Neopomacentrus anabatoides	6	A	6	A	2	A
Neopomacentrus azysron	7	SA	7	SA	6	A
Neopomacentrus cyanomos	7	SA	6	A	6	A
Plectroglyphidodon lacrymatus	-		3	A	3	A
Pomacentrus adelus	3	A	5	A	5	A
Pomacentrus amboinesis	-		-		x	A
Pomacentrus moluccensis	5	A	5	A	4	A
Pomacentrus similis	3	A	4	A	4	A
Stegastes obreptus	3	A	-		2	A
SCARIDAE (Parrotfish)						
Scarus ghobban	-		x	A	3	A
Scarus quoyi	-		x	A	1	A
SCORPAENIDAE (Scorpionfish)						
Pterois miles	I	A	-		-	
SERRANIDAE (Groupers)						
* *Anyperodon leucogrammicus*	-		-		1	A
* *Cephalopholis argus*	3	SA	1	SA	2	SA
* *Cephalopholis boenak*	1	SA	3	A	3	A
* *Cephalopholis formosa*	3	SA	3	A	3	A
* *Epinephelus erythrurus*	2	A	x	A	-	
* *Epinephelus polyphekadion*	-		-		x	J
* *Plectropomus areolatus*	-		-		x	A
* *Plectropomus maculatus*	-		1	A	-	
SIGANIDAE (Rabbitfish)						
* *Siganus guttatus*	-		-		3	A
* *Siganus javus*	3	A	3	A	3	A
SPHYRAENIDAE (Barracudas)						
* *Sphyraena obtusata*	4	A	-		4	A
SYNODONTIDAE (Lizardfish)						
Synodus variegatus	-		1	A	x	A
TETRAODONTIDAE (Puffers)						
Arothron nigro punctalus	-		x	A	-	
ZANCLIDAE (Moorish idol)						
Zanclus cornutus	2	A	3	A	3	A

Note: x = sighting records outside the census transect
* = economically important species
= juvenile
SA = subadult
A = adult
LA = large adult

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APPENDIX IV

Summary of fish census data from the natural rocky reef (Hin Puk) during surveys in December 1992 (II) and April (1993) (III)

TAXA	Survey II Log 4 Abund-ance scale	Survey II Pie-dominant life history stage	Survey III Log4 4 Abund-ance scale	Survey III Pre-dominant life history stage
ACANTHURIDAE (Surgeonfish)				
Acanthurus xanthopterus	3	A	1	SA
APOGONIDAE (Cardinalfish)				
Apogon taeniophorus	3	A	2	A
Archamia fucata	4	A	x	A
Cheilodipterus quinquelineatus	x	SA	3	J
BALISTIDAE (Triggerfish)				
Balistoides viridescens	1	A	1	A
BLENNIIDAE (Blennies)				
Ecsenius bicolor	3	A	-	
Meiacanthus smithi	2	A	x	A
CAESIONIDAE (Fusiliers)				
Caesio caenulaurea	6	J	5	A
* *Caesio cuning*	5	J	3	SA
* *Pierocaesio chrysozona*	7	J	7	SA
CARANGIDAE (Trevallies)				
* *Mule mate*	-		5	A
CHAETODONTIDAE (Butterflyfish)				
Chaetodon collare	3	A	3	A
Chaetodon decussatus			2	A
Chaetodon octo fasciatus	3	A	3	A
Chaetodon plebeius	2	A	-	A
coradion chrysozonus	-		1	A
Heniochus acuminatus	-		2	A
Heniochus singularius	2	A	2	A
DASYATIDAE (Sting rays)				
Dasyatis kuhlii	-		2	A
DIODONTIDAE (Porcupinefish)				
Diodon liturosus	1	A		
GOBIIDAE (Gables)				
Cryptocentrus strigilliceps	2	A	2	A
Istigobius ornatus	X	A	x	A
Ptereleotris evedes	4	J	-	
Valenchiennea sexguttatus	x	A	-	
GRAMMISTIDAE				
Diploprion bifasciatum	x	A	1	A
HAEMULIDAE (Sweetlips(				
* *Diagramma pictum*	1	A	-	
LABRIDAE (Wrasses)				
Bodianus axillaris			2	SA
Bonianus up.	1	A	2	A
Cheilinus chlorsurus	3	A	1	A
Helichoeres dussumieri	5	SA	4	A
Halichoeres marginatus	2	A		
Halichoeres timorensis	2	A	2	A
Halichoeres vrolikii	3	A	x	A
Labroides dimidants	2	A	2	A
Loptojulis cyanopleura	2	SA	4	SA
Stethojulis bandanensis	2	A	-	
Stethojulis interrupta	-		3	A
Thalassoma lunare	4	SA	4	SA
LETHRINIDAE (Emperors)				
* *Lethrinus ornatus*			1	SA
LUTJANIDAE (Snappers)				
* *Lutjanus biguttatus*	-		3	A

TAXA	Survey II Log 4 Aband-ance scale	Survey II Pie-dominant life history stage	Survey III Log 4 Abund-ance scale	Survey III Pie-dominant life history stage
Lutjanus fulvus	3	A	3	A
Lutjanus quinquelineatus	3	A	-	
* *Luijanus vitta*	4	A	4	A
MULLIDAE (Goatfish)				
* *Mulloides flavolineatus*	3	SA	-	
* *Parupeneus indicus*	3	A	x	A
* *Upeneus tragula*	3	A	x	A
MURAENIDAE (Moryas)				
Gymnothoraxfavageneus		1	A	-
NEMIPTERIDAE (Monocle breams)				
* *Scolopsis ciliatus*	2	A	x	A
* *Scolopsis monogramma*	3	A	2	A
* *Scolopsis vosmeri*	S	SA	5	SA
OSTRACIIDAE (Boxfish)				
Ostracion cubicus	1	A	2	A
PEMPHERIDAE				
Pempheris vanicolensis	3	A	x	A
POMACANTHIDAE (Angelfish)				
Pomacanthus annularis	2	A	1	A
POMACENTRIDAE (Damselfish)				
Abudefduf bengalensis	2	A	2	A
Amphiprion akallopisos	5	A	3	A
Amphiprion ocellaris	3	A	3	A
Chromis cinerascer.s	5	A	4	A
Dascyllus carneas	3	A	2	A
Dascyllus trimaculatus	3	SA	3	SA
Neopomacentrus azysron	6	A	6	A
Neopomacentrus cyanomos	5	A	5	A
Pomacentrus moluccensis	3	A	3	A
Pomacentrus similis	3	A	5	A
PSEUDOCHROMIDAE (Dottybacks)				
Pseudochromis sp.	3	A	2	A
SCARIDAE (Parrotftsh)				
Scarus ghobban		x	A	-
SERRANIDAE (Groupers)				
* *Cephalopholis boenak*	1	SA	2	A
* *Cephalopholos formosa*	3	A	3	A
* *Epinephelus eryihrurus*	3	A	2	A
* *Plectropomus maculatus*		1	A	-
SIGANIDAE (Rabbitfish)				
* *Siganus cwialiculatus*	3	A	3	A
* *Siganus javus*	4	A	3	A
SPHYRAENIDAE (Barracudas)				
* *Sphyraena jello*	4	L A		
SYNODONTIDAE (Lizardflsh)				
Synodus variegatus	1	A	x	A
TETRAODONTIDAE				
Arothron nigropunclatus	1	A	1	A
Canthigaster solandri	2	A	2	A
ZANCLIDAE (Moorish idol)				
Zanclus cotnutus	3	A	2	A

Note: x = sighting record outside the census transect
* = economically important species; SA = subadult
A = adult; LA = large adult

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Small-scale fishing gear used in the artificial reef areas, Ranong Province, Thailand

by

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16. *INTRODUCTION*

Artificial reefs (AR) were installed in Ranong Province for a variety of reasons:

- They would effectively prevent trawlers from operating within the 3 km coastal belt and would reduce operational costs of patrolling the regulated coastal fishery areas.

- They would be an effective tool to conserve living resources.

- They would effectively extend suitable breeding and living grounds for demersal species.

- They would be a submerged fish aggregating structure, enabling small-scale fishertolk living near the artificial reef areas to increase their income by catching more fish with reduced effort.

The objectives of the study were:

- To identify changes in the composition of fishing gear, methods of operation and gear population, as a result of the installation of artificial reefs in Ranong.

- To determine the effect of artificial reefs on the traditionally used gear in the area.

- To examine the options for introducing suitable gear for small-scale fisherfolk to operate near the artificial reef.

- To carry out experimental/test fishing with selected fishing gear to determine technical viability.

17. *METHODOLOGY*

17.1 *Fishing gear survey*

Information on types, numbers, cost, material etc. of fishing gear was collected by interviewing fisherfolk. Data obtained from this survey was compared with data obtained from a survey conducted by the Department of Fisheries in 1987 (DOF, 1987), prior to installation of artificial reefs.

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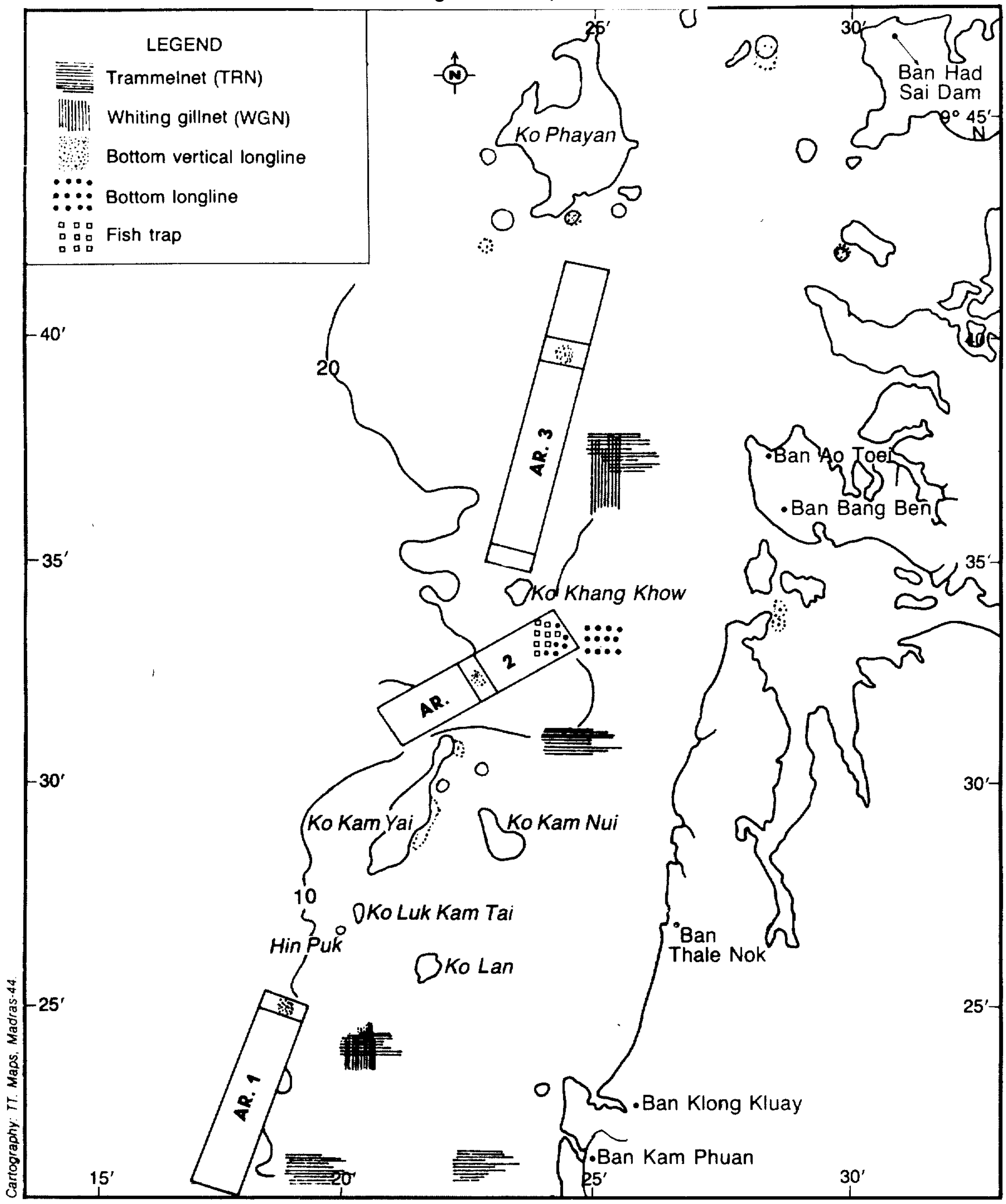
17.2 *Fishing gear trials*

Five fishing gear, including the trammclnet, whiting gillnet, bottom vertical longline, bottom longline and fish trap were selected for trials to determine their efficiency in the artificial reef areas. The bottom vertical longline, bottom longline and fish trap were selected as they were expected to be more suitable in artificial reef areas than the bottom drift gillnet. The trammelnet was selected to confirm its efficiency at catching shrimp and for further development of the net. The whiting gillnet was selected to study its efficiency when its depth was reduced as a measure of reducing cost. The trials were carried out at the sites shown in Figure 25.

Fig 25. Fishing grounds for experimental gear at artificial reefs (ARs) in Ranong Province, Thailand



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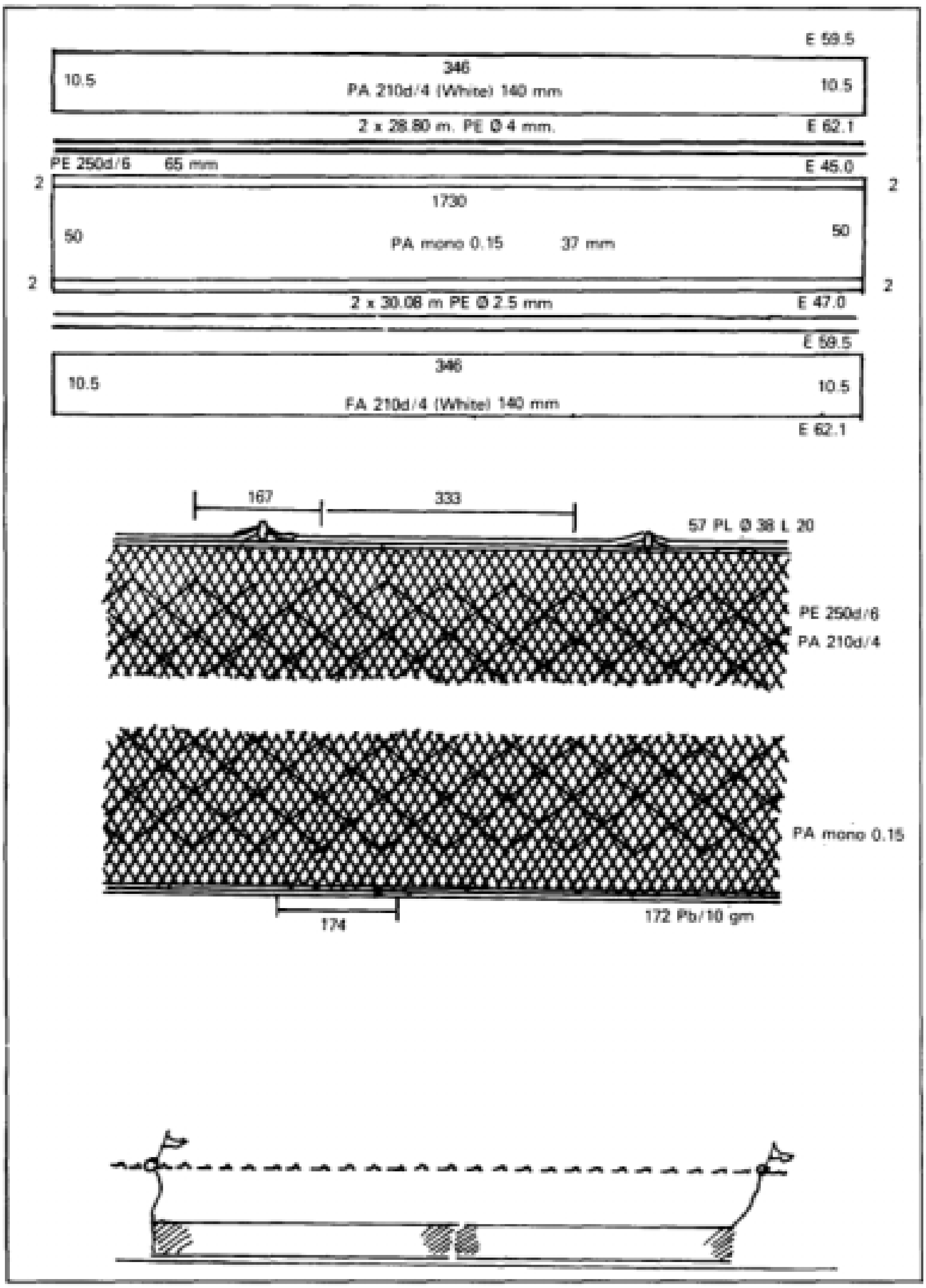
Trammelnet (Figure 26). This gear is commonly used in shrimp fishing. The inner net, 3.7 cm. mesh size, is of monofilament nylon of diameter 0.15 cm, whereas the outer net, 14 cm. mesh size, is of multifilament 210d/4 nylon. The hanging ratio of the inner net is 0.45 on the float line, while the hanging ratio of the outer net is 0.59. Fishing operations were carried out during the day by placing the net across the tide and allowing it to drift with the tide for 30 minutes to one hour before hauling.

Fig 26. Trammelnet specifications



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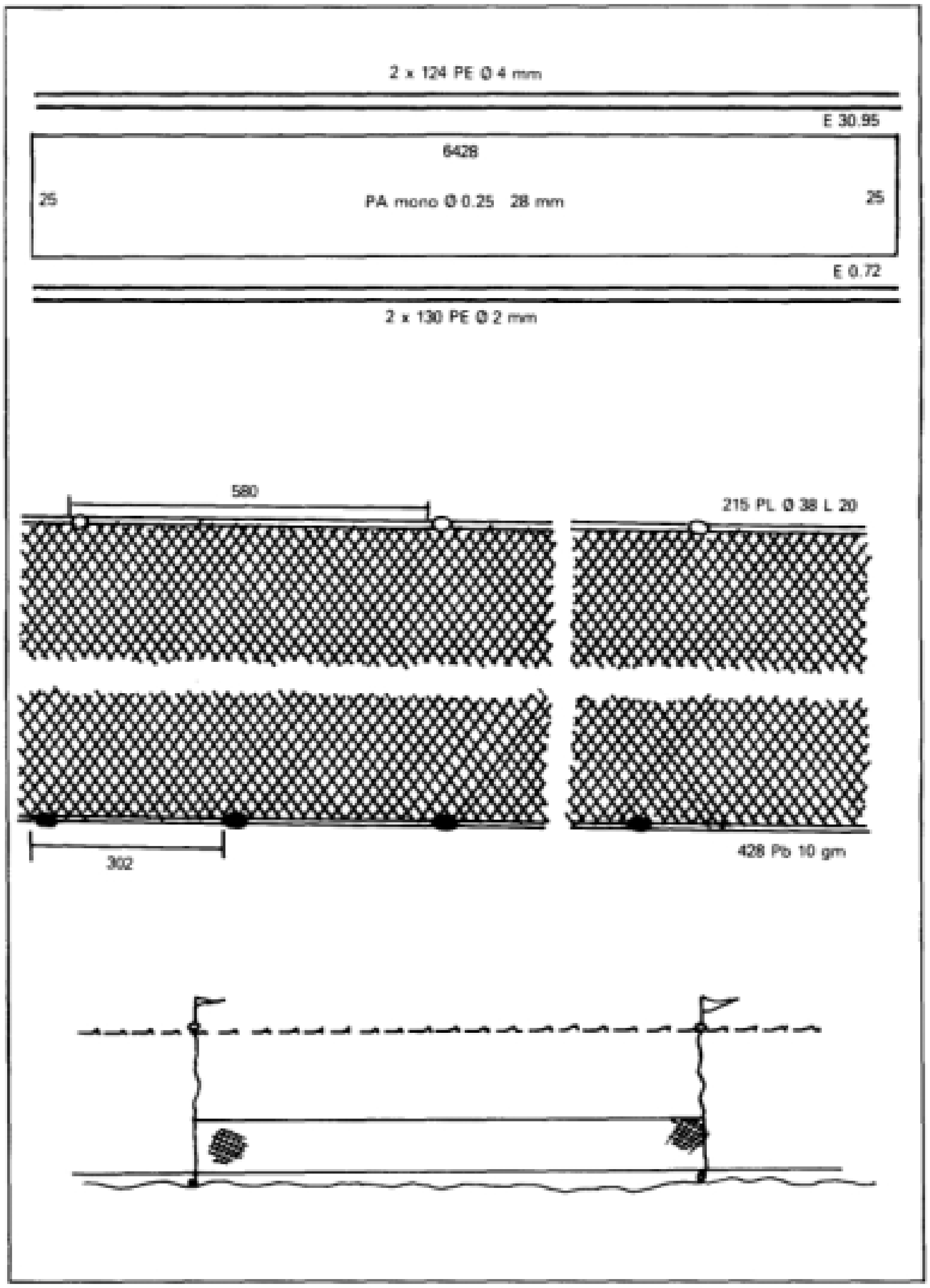
Whiting gilinet (Figure 27). The netting, 2.8 cm mesh size, is of 0.25 mm diameter monofilament nylon. The hanging ratio is 0.31 on the float line and 0.28 on the sinker line. Fishing operations were carried out during the day. The net was shot across the tide and allowed to drift with tt for one hour, before hauling.

Fig 27. Whiting gillnet specifications



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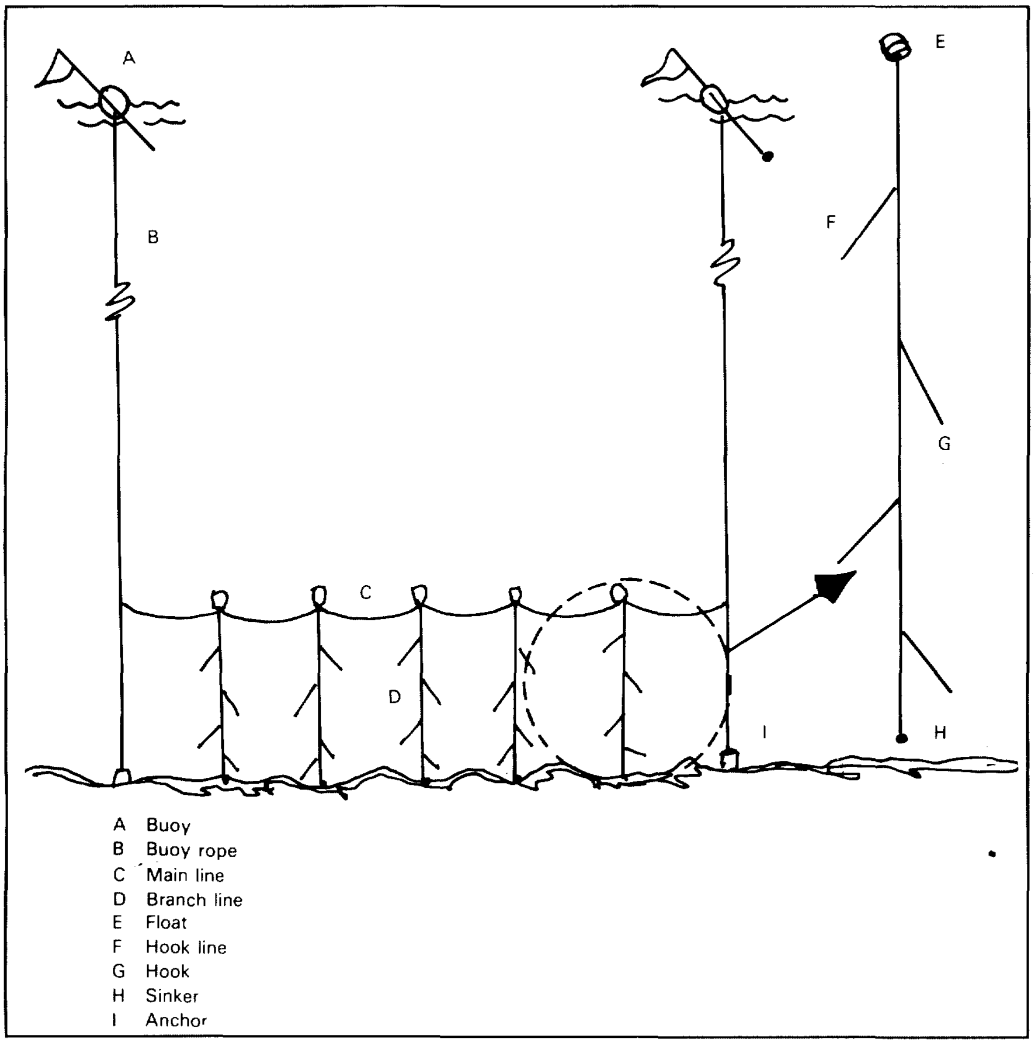
Bottom vertical longline (Figure 28). The main line of this gear is of 5.5 mm. vinylon and the branch line is of 210d/60 nylon. The interval between each branch line is 15 m. Each branch line is 5 m long and to it are connected four 60 cm-long hook lines at 1 m intervals. Nylon monofilament No. 60 (0.74 mm) is used for the hook line which is connected to a No. 8 hook. The branch lines are stored in specially designed boxes made of wood and plastic plates with a rubberized rim around the top. Three branch lines are stored per box, each separated by a thin sheet of canvas.

Fig 28. Bottom vertical longline arrangement



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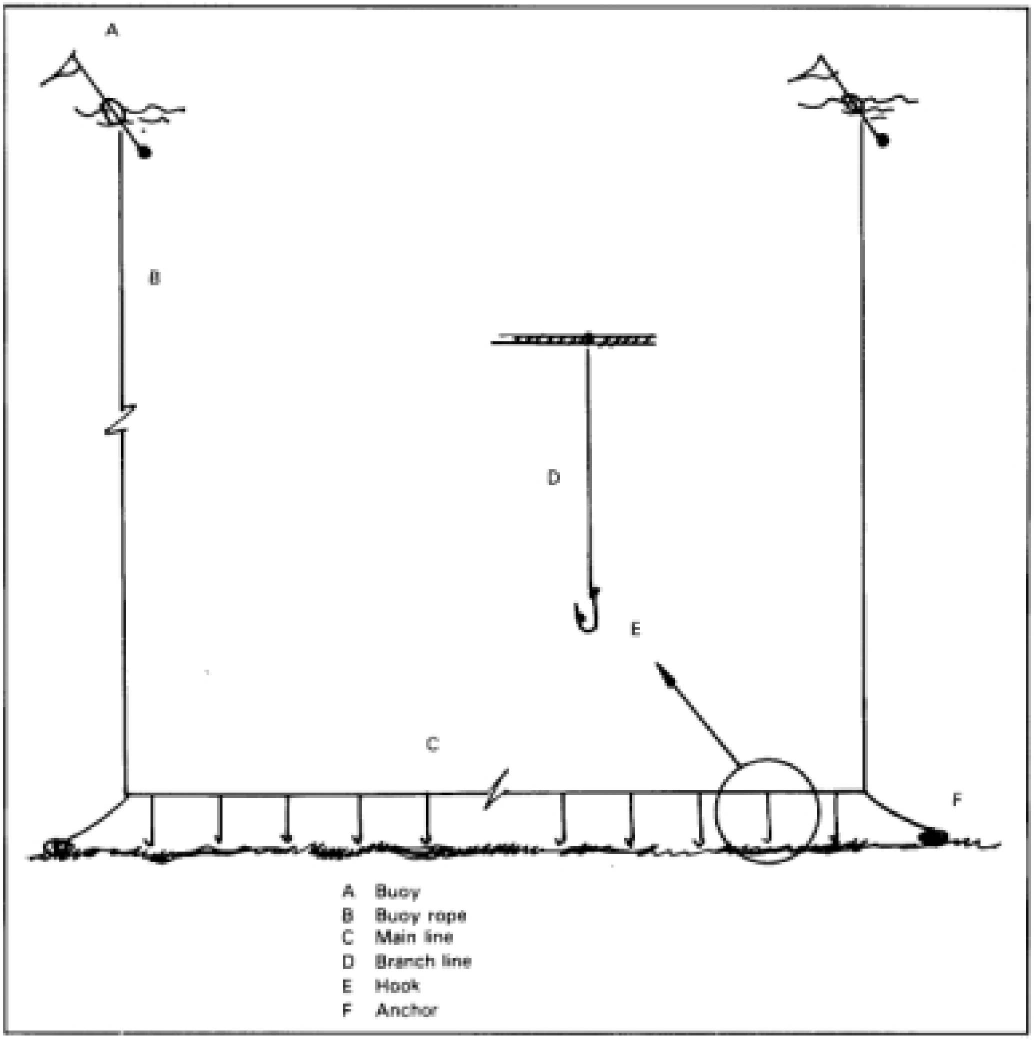
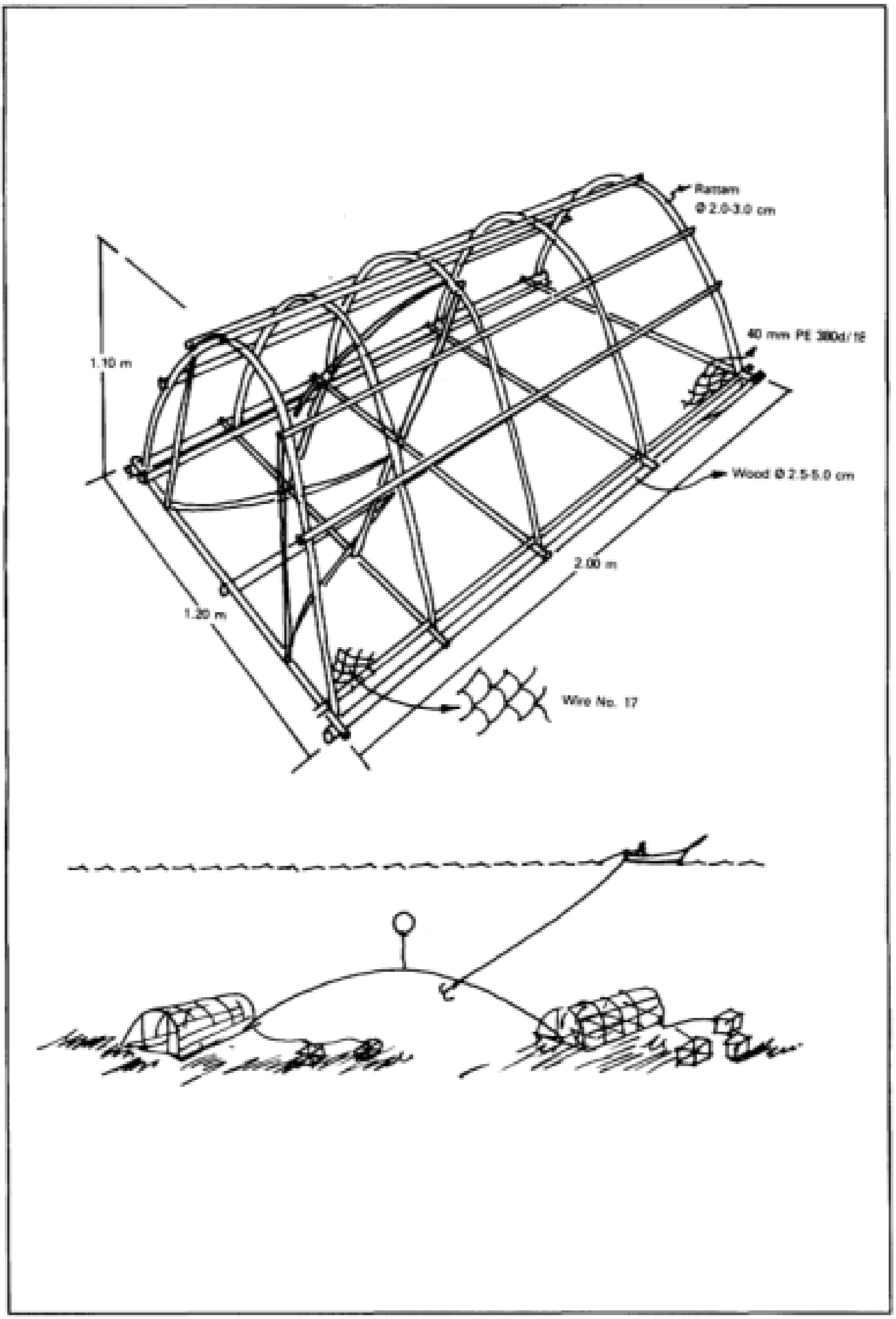
Bottom longline (Figure 29). The main line of this gear is 4 mm vinylon, while the branch line is 380/36 polyethylene. The interval between branch lines is 2.5 m. Hook No. 5 is used on the branch line.

Fig 29. Bottom longline arrangement



Fish trap (Figure 30). This is a semi-cylindrical trap. The frame is made of wood and rattan **covered** with wire netting (wire No. **17). The entrance** is **wedge-shaped. The size of the trap** is **2 m long, 1.2 m wide and 1.1 m high. No bait is required for the fishing operation..**

Fig 30. Fish trap specifications



17.3 *Fishing gear demonstration*

Based on the successful results of trials, suitable gear were demonstrated to the fisherfolk in the fishing villages adjacent to the artificial reef areas. Training was provided on making and operating the gear.

18. *RESULTS*

18.1 *Fishing gear survey*

The survey on fishing gear was carried out in six villages around the artificial reefs in Muang and Kapur Districts of Ranong Province in February 1992. Twentyfour (24) types of fishing gear (see Table 11 below and Table 12 on facing page) were found in the area and the major gear were trammelnet, crab gillnet, whiting gillnet, squid trap, grouper trap and scoopnet. Comparison with data from a survey conducted in 1987, by DOF (DOF, 1987), showed an increase in the number of gear types (7) after the installation of artificial reefs. The new gear recorded are gillnet (for threadfin, mackerel and sardine), stick-held castnet (for squid), crab trap, trollingline, bottom

Table 11: Type and number of fishing gear in six fishing villages around the three artificial reefs in Ranong Province in 1987 and 1992

	Ban Thale Nork		*Ban Kam Phuan*		*Ban Kiong Kluay*		*Ban Bang Ben*		*Ban Ao Toei*		*Ban Sai Dam*		*Total*	
Type of fishing gear	1987	1992	1987	1992	1987	1992	1987	1992	1987	1992	1987	1992	1987	1992
Trammelnet	4	-	22	80	40	60	3	15	5	40	28	90	102	285
Crab gillnet	-	-	-	10	-	-	-	20	-	40	3	100	3	170
Whiting gillnet	-	-	5	65	15	-	2	15	-	40	-	50	22	170
Threadfin gillnet	-	-	-	4	-	2	-	2	-	-	-	-	0	8
Mackerel gillnet	-	-	-	10	-	5	-	-	-	-	-	-	0	15
Sardine gillnet	-	-	-	5	-	-	-	-	-	-	-	3	0	8
Mullet gillnet	-	1	-	-	-	-	1	-	-	10	35	-	36	11
King mackerel gillnet	-	-					-	-	-	-	15	-	15	0
Pomfret gillnet	-	-			-	-	-	-	-	-	12	-	12	0
Pushnet	-	-	-	2	-	-	-	2	9	10	3	-	12	14
Small otter trawl with boom	-	-	7	10	-	-	-	-	-	-	10	-	17	10
Stick-held castnet	-	-	-	10	-	-	-	-	-	-	-	-	0	10
Grouper trap	-	-	-	10	-	20	1	3	-	10	37	40	38	83
Squid trap	-	-	4	70	-	40	-	3	-	-	3	15	7	128
Crab trap	-	7	-	-	-	-	-	20	-	20	-	3	0	50
Crab liftnet	-	-	-	20	15	2	22	-	15	-	75	20	127	42
Handline	-	3	-	10	-	-	10	15	3	10	50	-	63	38
Trollingline	-	-	-	20	-	-	-	-	-	-	-	-	0	20
Bottom longline	-	-	-	-	-	-	-	-	-	1	-	-	0	1
Setnet	13	-	-	-	-	1	-	-	-	-	8	-	21	1
Small set bagnet	-	-	-	5	30	30	-	-	-	-	-	-	30	35
Set bagnet	-	-	-	-	30	-	-	2	-	-	-	3	0	5
Scoopnet	19	25	9	20	-	-	25	30	8	40	2	10	63	125
Shrimp castnet	-	-	-	20	-	-	-	15	-	-	-	-	0	35
Total	36	36	47	371	100	160	64	142	40	221	281	334	568	1264

<<

longline, set bagnet and shrimp castnet. Trammelnet, crab gillnet, whiting gillnet, pushnet, grouper trap, squid trap, small set bagnet and scoopnet appeared to have increased in numbers considerably. Mullet gillnet, king mackerel gillnet, pomfret gilinet, small otter trawl with boom, crab liftnet, handline and setnet had, on the other hand, decreased in number.

Gear used in the six villages had increased from 568 units in 1987 to 1264 units in 1992. Significant changes were evident in the Ban Kam Phuan, Ban Bang Ben and Ban Ao Toei.

It should be noted, however, that changes in types and numbers of the fishing gear were not due only to the presence of the artificial reef. There were other factors, such as the increasing number of fisherfolk, increasing prices and demand and the adoption of new technologies.

Table 12: Specifications of fishing gear, their average life and approximate cost in six villages near the ARs in Ranong Province

Type of fishing gear	*No. offishing gear in six villages*		*No. of hooks/ No. of traps/ No. panels/set*	*Hook size/ Trap size/ Mesh size (cm)*	*Avg. lift (year)*	*Appx. cost (bht) per panel or piece*
	1987	*1992*				
Trammelnet	102	285	8-10/2-3	14 x 3.7 x 14	3-4*	300
Crab gillnet	3	170	20-40	10	1-3*	120
Whiting gillnet	22	170	6-10/1-3	2.8-3	2-3	450
Threadfin gillnet	-	8	8-10	5	3	1400
Mackerel gillnet	-	15	8-10	4.7	2-3	1000
Sardine gillnet	-	8	10	2.5-3	1-2	950
Mullet gillnet	36	11	10	3.5	1-2	800
King mackerel gillnet	15	-	15-30	8.7	3	800
Pomfret gillnet	12	-	10	11.2	2-3	400
Pushnet	12	14	1-2	2-4	1	1200-3000
Small otter trawl with boom	17	10	1-2	2-6	1	1800-4000
Stick-held castnet	-	10	1	2.5-3.2	1-2	10000-15000
Grouper trap	38	83	20-40	27 x 55 x 23	6*	60
Squid trap	7	128	20-100	75 x 100 x 70	2-4*	50-70
Crab trap	-	50	20-50	30 x 50 x 27	1	50
Crab liftnet	127	42	20-40	10	2-4	20
Handline	63	38	1-5	No.14 - No.2	1	30-100
Trollingline	-	20	1-5	No.8/U	1	50
Bottom longline	-	1	100-200/5-10	No.5	I	500-750
Setnet	21	1	1	2.5-4	1	2500-3000
Small set bagnet	30	35	1	0.2-3	1	1000
Set bagnet	-	5	1	1.5-5	1-2	3000
Scoopnet	63	125	1	0.2	3-5*	300
Shrimp castnet	-	35	1	2.5-3	2-3	700

* month

18.2 *Fishing gear trials*

Fishing gear trials were performed during May 1992 - May 1993 (refer Figure 25) and the following results were recorded

Trammelnet: Fifteen fishing operations were conducted at ARs 1,2 and 3 in May and August 1992; one atAR1, another at AR2 and 13 at AR3. Due to poor performance at ARI and AR2, trials were concentrated close to AR3. The results showed relatively better performance at AR3 (Table 13) with a total catch rate of 257 g/panel, of which 95.6 g (37.22%) were shrimp (most of it *Penaeus merguiensis).* The average total length of the shrimp was 14.04 cm (11.00 - 16.40 cm). The trials showed that the area close to AR3 has encouraging possibilities, but further trials for longer periods are necessary to establish economic feasibility.

Table 13: Species composition of marine animals caught by trammelnet at AR1, AR2 and AR3

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Date	8/5/92	9/5/92	22/8/92	22/8/92	23/8/92	22/8/92	23/8/92	24/8/92	24/8/92	23/9/92	23/8/92	23/8/92	244/8/92	24/8/92	24/8/92
Place	AR 2	AR 1	AR 3	AR 3	AR 3	AR 3	AR 3	AR 3	AR 3	AR 3	AR 3	AR 3	AR 3	AR 3	AR 3
Depth	13	8	10	10	11	11	11	10	10	5	5	5	6	6	6
No of paneLc	10	10	JO	10	JO	10	10	10	10	10	JO	10	10	10	tO
Penaeus merguiensis	-	-	75	140	2170	1280	2635	1150	910	1300	700	630	35	100	250
P.monodon	-	-	-	-	-	-	40	-	-	-	-	-	-	-	-
Other shrimp	-	-	-	10	175	70	310	200	160	15	70	-	10	-	-
Blue swimming crab	130	-	-	-	-	-	-	-	-	-	-	-	-		
Threespot swimming crab	-	-	-	-	-	150	-	-	-	45	-	-	-	65	-
Mantis shrimp	20	40	-	-	20	-	-	10	-	-	-	-	-	-	40
Mule male	130	50	85	-	-	-	-	-	-	20	80	30	-	-	-
Selaroides (eptolepis	50	-	-	35	-	-	-	-	-	-	-	-	-	-	-
Anodontostoma chacunda	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephippus orbis	-	-	-	-	-	-	-	-	-	-	-	40	-	-	-
Scomberomorus sp.	-	-	-	-	-	-	-	-	-	-	-	130	-	-	-
Scoraberoides sp.	-	-	-	-	-	-	-	-	-	-	40	-	-	-	-
Rastrelliger sp.	200	-	55	-	155	-	180	-	60	1050	530	40	480	-	395
Sillago sp.	40	-	-	40	20	-	-	-	-	-	-	-	-	-	-
Polynenus sp.	-	-	-	-	35	-	-	-	-	-	30			-	-
Pomadasys *kaakan*	-	-	-	-	-	-	-	-	-	-	50	-	-	-	-
Ariss sp.	-	-	-	80	20	-	-	-	-	15	-	-	-	-	-
Nemipterus sp.	330	-	-	-	-	-	-	-	-	-	-	-		-	
Ilisha sp.	-	-	-	-	-	-	-	-	-	-	-	-	100	-	-
Trichiurus sp.	-	-	-	75	1135	70	2030	550	700	-	150	-	-	-	-
Terapon sp.	-	-	100	380	2200	40	-	-	-	-	-	-	-	-	-
Siganus sp.	30	10	-	-	20	-	-	-	-	-	-	-	-	-	-
Thryssa sp.	-	-	40	105	830	10	50	10	460	555	70	10	350	-	tOO
Gerres sp.	80	100	-	-	-	-	-	-	-	-	-	-	-	-	-
Dasyatis sp	700			-	-	-	-	-	-	-	-	-	-	-	-
Apogon sp.	30	-	-	-	-	-	-	-		-	-	-	-	-	-
Sardine	400	-	-	-	-	-	30	100	-	-	-	-	-	10	-
Croaker	-	-	55	190	2860	470	120	100	1150	100	50	-	30	50	80
Slipmouth	780	30	720	195	140	20	110	150	15	10	15	-	15	-	-
Flathead	110	10	-	-	-	-	-	-	-					-	-
Sole	-	-	-	-	-	-	15	10	10						
Total	3080	240	1130	1250	9780	2110	5520	2280	3465	3110	1785	880	1020	225	865

Note: Average total length of *P.* ***merguiensis*** is 14.04 cm. (11.0 - 16.4 cm). Price of *P. merguiensis* is 95-105 baht/kg.

Whiting Gilinet: One fishing operation was performed at AR1 and four at AR3 in May 1992. The results (Table 14) indicate that performance at AR1 was relatively poor compared to that at AR3, where there was a total catch rate of 589.4 g/panel, of which 305 g (51.75%) were whiting *(Sillago* sp.). The trials should, however, be extended over a longer period at ARI before conclusions are drawn on the viability of establishing this fishery at AR1.

Table 14: Species composition of marine animals caught by whiting gillnet at AR! and AR3

No.	*1*	*2*	*3*	*4*	*5*	
Date	*10/5/92*	*10/5/92*	*11/5/92*	*12/5/92*	*13/5/92*	
Place	*AR1*	*AR3*	*AR3*	*AR3*	*AR3*	
Depth	*8*	*11*	*11*	*11*	*11*	
No. of panels	*8*	*4*	*4*	*4*	*4*	*Total*
Sillago sp.	30	850	3630	170	230	4910
Atule mate	60	-	-	-	-	60
Selaroides leptolepis	110	-	-	-	20	130
Sphyraena sp	-	-	-	190	240	430
Carangoides sp.	-	-	10	-	-	tO
Scolopsis sp.	-	-	50	-	-	50
Terapon sp.	-	-	30	-	-	30
Gerres sp.	-	40	70	-	10	120
Saurida sp.	-	40	190	20	-	250
Nemipterus sp.	70	10	-	-	-	80
Thryssa sp.	-	-	-	200	100	300
Apogon sp.	20	-	-	-	-	20
Croaker	-	-	60	-	-	60
Flathead	-	30	40	50	-	120
Goatfish	-	80	790	50	50	970
Sole	20	-	30	80	-	130
Sardine	20	-	150	-	-	170
Slipmouth	360	260	30	-	20	570
Goby	50	80	-	20	-	150
Leatherjacket	10	-	220	1250	40	1520
	750	1390	5300	2030	710	10180

Note: Average total length of whiting is 14.86 cm. (12.1 - 20.4 m.)

Price (baht/kg.) of whiting is 35 baht.

Bottom **vertical** longline: Nine fishing operations were conducted at ARs 1, 2 and 3. The average catch rate per box of hooks (12 hooks) was 81.6 g (Table 15). Most of the catch was commercially valuable and included species such as snapper, grouper, emperor and silver grunt. But economic viability of the new fishery at all three ARs is still not conclusive.

Table 15: Species composition of marine animals caught by bottom vertical longline at AR1, AR2 and AR3

No.	*1*		*2*		*3*		*4*		*5*		*6*		*7*		*8*		*9*			
Date	*7/5/92*		*8/5/92*		*9/5/92*		*10/5/92*		*11/5/92*		*12/5/92*		*27/2/93*		*2712/93*		*21/4/93*			
Place	*AR3*		*AR2*		*AR1*		*AR1*		*AR1*		*AI*		*AR2*		*AR2*		*AR2*		Total	
Depth	*12*		*20*		*13*		*13*		*1*		*13*		*21*		14		13			
No. of hooks (box)	*15*		*5*		*5*		*10*		*10*		*8*		*10*		*10*		*10*			
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Luijanus vitius	1	400	-																	400
Ephinephelus lauvina	-	-	-	-	1	130	-	-	-	-	2	750	-	-	-	-	-	-	3	880
E. bleekeri	-	-	-	-	1	70	-	-	I	300	-	-	-	-	I	350	1	330	4	1050
E. fasciatus	-	-	-	-	-	-	1	290	-									-	1	290
E. erythrurus	-	-	-	-	-	-	1	350	1	180	-	-	1	240	-	-	-	-	3	770
Lethrinus sp.	-	-	-	-	-	-	1	550	-									-	1	550
Pomadesys kaakan	-									-	1	550	1	700	1	550	1	500	4	2300
Arius sp.	-									-	2	380	-	-	-	-	-	-	2	380
Conger eel	-	-	-	-	-	-	-	-	1	150	-	-	-	-	-	-	-	-	1	150
Total	1	400	-	**0**	**2**	**200**	**3**	**1190**	3	630	5	**1680**	2	940	2	900	2	830	20	6770

Note: Price — ***E. tauvina*** 40 baht/kg; ***E. bleekeri*** 30 baht/kg.

Bottom longline: Eight fishing operations were conducted at AR2 in November and December 1992 and in January, February and April 1993. Six species of fish were caught and the major catch was of shark and skate (Table 16). The results were encouraging, but additional trials are required for a full fishing season to establish economic viability.

Table 16: Species composition **of marine animals caught by bottom longline at AR2**

No.	1		2		3		4		5		6		7		8			
Dale	*18/11/92*		*19/11/92*		*19/11/92*		*4/12/92*		*5/12/92*		*18/1/93*		*28/2/93*		*22/4/93*			
Place	*AR2*		*AR2*		*AR2*		*AR2*		*AR2*		*AR2*		*AR2*		*AR2*		*Total*	
Depth	21		21		21		11		11		21		20		21			
No. of *hooks* (box)	600		*600*		*600*		*600*		600		*600*		500		*500*			
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wi.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Pomadesys *kaakan*	13	19680	3	3560	10	11050	-	-	-	-	4	5000	10	14400	7	9750	47	63440
Luijanus *johni*	1	900	-	-	-	-	-	-	-	-	-	-	1	700	-	-	2	1600
L malabaricus	2	1780	I	950	1	800	-	-	-	-	-	-	1	800	1	750	6	5080
Ephinephelus tauvina	-	-	-	-	-	-	-	-	-	-	2	3000	-	-	-	-	2	3000
Carcharhinus albimaginalus	2	4900	3	8400	2	5600	1	2600	2	4600	-	-	3	7900	2	5200	15	39200
Skates	1	14000	-	-	1	8000	15	132000	12	117000	3	30000	3	25000	1	11000	36	337000
Total	19	41260	7	12910	14	*25450*	**16**	**134600**	**14**	**121600**	**9**	38000	18	48800	11	26700	108	449320

Note: Price (baht/kg.)

P. kaakan	25
L. johni	30
L. ***malabaricus***	25
E. tauvina	40
C. albimaginatus	4
Skates	6

Fish trap: Five fishing operations were conducted at AR2 in November 1992 and during April/May 1993. The results showed a high catch rate (Table 17). Average catch per trap was 6955.7 g. Most of the catch were commercially valuable fish, such as grouper, snapper etc.

Table 17: Species composition of marine animals caught by fish **trap at AR2**

No.	*1*		2		3		4		5			
Date	19/11/92		8/4/93		18/4/93		23/4/93		1/5/93			
Date of hauling	28/11/92		18/4/93		23/4/93		1/5/93		18/5/93			
Place	*AR2*		*AR2*		*AR2*		*AR2*		*AR2*			
Depth	*20*		*21*		*21*		*21*		*21*			
No. of panels	*1*		*2*		*2*		*2*		*2*		*Total*	
	No.	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*	*No.*	*Wt.*
Pomadesys kaakan	-	-	3	4000	1	1300	3	4700	4	6200	11	16200
Luifanus johni	-	-	2	1800	3	2800	5	4900	2	1700	12	11200
L. malabaricus	3	3300	2	2700	-	-	1	1400	-	-	6	7400
Ephinephelus tauvina	2	2300	-	-	1	700	1	1100	-	-	4	4100
E. bleekeni	1	900	1	800	-	-	-	-	1	700	3	2400
Carangoides sp.	3	9000	-	-	-	-	-	-	1	3300	4	12300
Skates	-	-	1	9000	-	-	-	-	-		1	9000
Total	9	15500	9	18300	5	4800	10	12100	8	11900	41	62600

Note: Price

P. kaakan	**25** baht/kg
L johni	30 baht/kg
L. *malabaricus*	25 bahtfkg
E. tauvina	40 baht/kg (Live 200 baht each)
E. bleekeri	30 baht/kg
Carangoides sp.	20 baht/kg
Skates	6 baht/kg

18.3 *Fishing gear demonstration*

The catch made by the experimental fishing gear at all three ARs is tabulated below. Some of the catch figures are encouraging.

Table 18: Catch made by experimental fishing gear at ARI, AR2 and AR3

Fishing gear	*Area*	*No. of experiments*	*No/set*	Total *catch (g)*	Total catch *of target species (g)*	Avg. catch *per piece, trap box or* 100 hooks	Avg. catch *of target species per piece, trap box* or 100 hooks	Percentage *catch of target species*
Trammelnet	ARI	1	10	240	0	24	0	0
	AR2	1	10	3080	0	308	0	0
	AR3	13	10	33,420	12,435	257.08	95.65	37.21
Whiting gillnet	AR1	1	8	750	30	93.75	3.75	4
	AR3	4	4	9430	4880	589.38	305	51.75
Bottom vertical longline	AR!	4	8.25	3700	3170	112.12	96.06	85.68
	AR2	4	8.75	2670	2670	76.28	76.28	100
	AR3	1	15	400	400	26.67	26.67	100
Bottom longline	AR2	8	5.75	449,320	449,320	9767.82	9767.82	100
Fish trap	AR2	5	1.8	62,600	62600	6955.56	6955.56	100

Due to the short duration of the project, however, the establishment of economic viability, to convince the fisherfolk, could not be achieved. Demonstration of some of the methods could also not be completed. However, fish trap construction was demonstrated and net-making materials were provided to three fisherfolk in one fishing village.

19. *CONCLUSIONS*

- Increase in the number of fishing gear units in the villages adjacent to the artificial reef areas may not be entirely due to the installation of the artificial reefs.
- Installation of the artificial reef has deterred the operation of trawls and gilinets, though not completely.
- Environmental conditions around the artificial reef have not changed enough to cause any significant difference between the operations of each type of fishing gear.
- Trammelnet and whiting gillnet were found to be suitable for operating on the shore side of the artificial reef, especially in the AR3 area, but some changes to the depth of the nets are needed.
- Bottom longline and fish traps are suitable gear to be introduced in artificial reef areas.
- Bottom vertical longline, on the other hand, did not show encouraging results near the artificial reef.
- More extensive trials are required to establish economic viability of these methods and to encourage participation by the fisherfolk.

20. *REFERENCES*

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Bioeconomics of small-scale fisheries in the artificial reef areas in Ranong Province, Thailand

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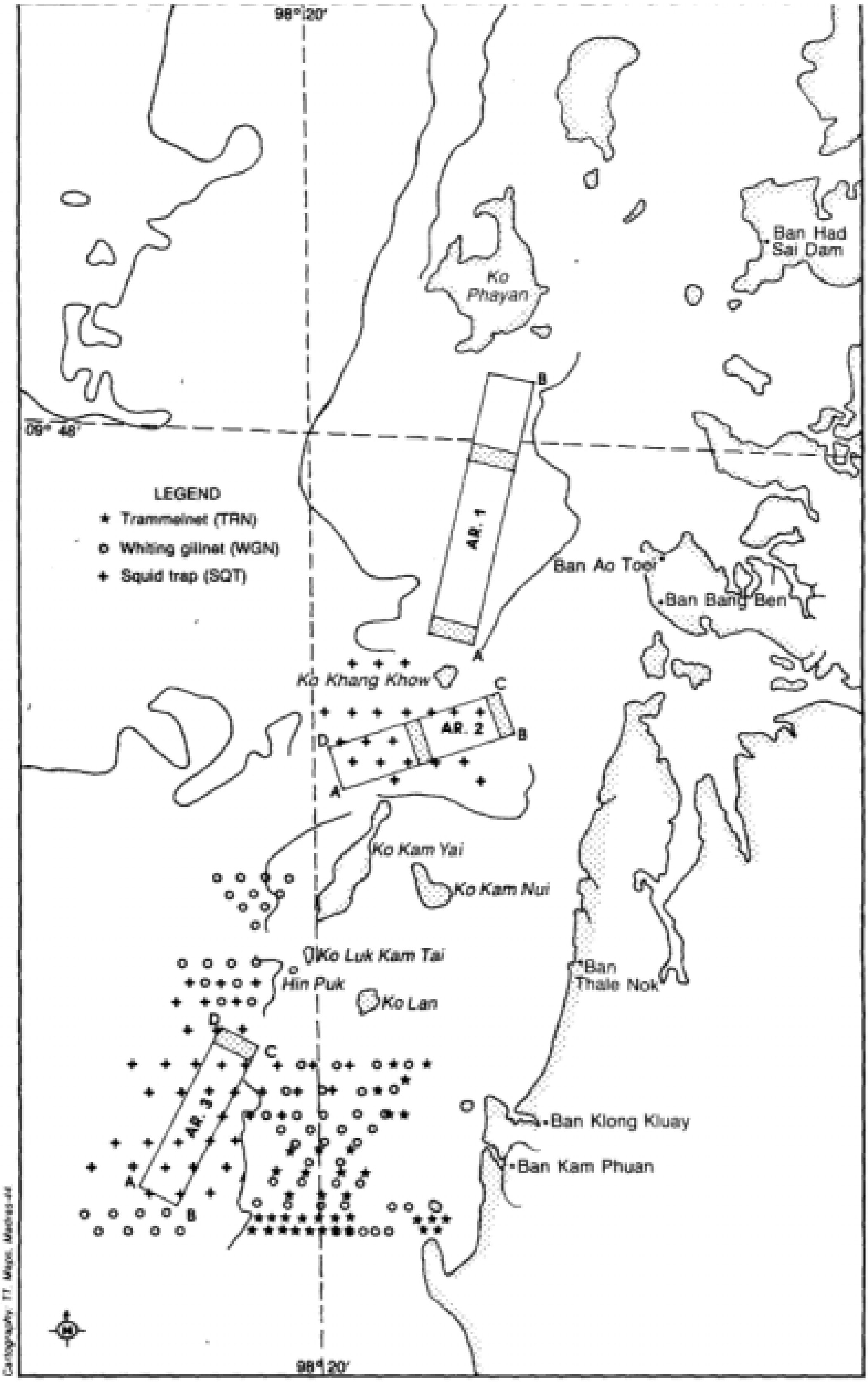
Fig 31. Fishing gear used at the artificial reefs (ARs) in Ranong Province. Thailand



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21. *INTRODUCTION*

A study to look into the operations and economics of existing small-scale fishing methods was considered an important component of the case study to assess the biosocioeconomics of small-scale fisheries in Ranong Province, particularly in the region likely to have been influenced by the installation of artificial reefs (ARs) in 1988.

This document describes the findings on the marine resources exploited, catch per unit effort (CPUE), income from fishing, operational costs and profitability when using the three most important fishing gear at or near the artificial reefs.

22. *FISHING GEAR AND OPERATION*

The choice of fishing gear and type of operation is sometimes dictated by considerations other than fishing efficiency or the level of investment. For instance, in the villages close to ARI (see Figure 31 on facing page), the fisherfolk — mostly Muslim — prefer fishing very close to the shore using small boats, despite a reported biomass much greater than at AR2 or AR3. It appears that religious obligations and social traditions outweigh such reasons as increased fishing income. As a result, most of the investigations have been limited to the fishing villages in the vicinity of AR3, where there are definite signs that small-scale fisheries have been influenced by the presence of artificial reefs.

The different fishing gear observed are given in Table 19.

Table 19: Types and number of fishing gear in two fishing villages around AR3, Ranong Province, in 1987 and 1992

	Ban Kam Phuan		*Ban Klong Kluay*		*Total*	
Type of fishing gear	*1987*	*1992*	*1987*	*1992*	*1987*	*1992*
Trammelnet	22	80	40	60	62	140
Whiting gillnet	5	65	15	-	20	65
Squid trap	4	70	-	40	4	110
Crab gillnet	-	10	-	-	-	10
Threadfin gillnet	-	4	-	2	-	6
Mackerel gillnet	-	10	-	5	-	15
Sardine gillnet	-	5	-	-	-	5
Pushnet	-	2	-	-	-	2
Small otter trawl with boom	7	10	-	-	7	10
Stick-held castnet	-	10	-	-	-	10
Grouper trap	-	10	-	20	-	30
Crab liftnet	-	20	15	2	15	22
Hand liftnet	-	10	-	-	-	10
Trollingline	-	20	-	-	-	20
Setnet	-	-	-	1	-	
Small set bagnet	-	5	30	30	30	35
Scoopnet	9	20	-	-	9	20
Shrimp castnet	-	20	-	-	-	20
Total	**47**	**371**	**100**	**160**	**147**	**531**

The three main types of fishing gear used in the AR3 area are:

- Trammelnet (TRN)
- Whiting gillnet (WGN)
- Squid trap (SQT)

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Though the boats using these gear varied in size and engine power, the fishing gear was similar. Of course, the larger boats carried more traps.

The two villages investigated are Ban Kam Phuan and Ban Klong Kluay. The former is close to the Myanmar border and several immigrant fisherfolk are available as crew to operate WGN. The latter village has a predominantly Muslim population and fisherfolk use smaller boats, mainly operating TRN and SQT.

22.1 *Trammelnet (TRN)*

The length of the net ranged from 960 - 1280 m and the depth from 1.4 to 1.5m. This net is operated during the day at depths of 4-12m to the east of AR3. Soaking time is usually 1-1 1/2 hours. Fishermen alternate this gear with others, depending on catches. The target species for this net is shrimp, particularly Banana shrimp *(Penaeus merguiensis)*. Besides shrimp, other species caught are Swimming crab, Mackerel and Croaker. These are mostly for home consumption. CPUE for all species ranged from 9.5 to 22 kg/trip, with the shrimp accounting for 5-10 kg/trip (see Appendix I, A and B). Two to four crew are required to operate this net.

22.2 *Whiting gilinet (WGN)*

The length of the net varies from 3,120 to 3,260 m and the depth from 1.5 to I.6m. This net is also used during the day at depths of 8-16m in the north, east and south of AR3. Average soaking time is 1-1½ hours. The target species for this net is Sand whiting *(Sillago sihama)*. Other species caught are similar to TRN. CPUE for whiting was 11-67 kg/trip and 12.5-103 kg/trip for the total catch. Peak catches occurred during July and August, the Southwest Monsoon period (see Appendix I, C and D).

22.3 *Squid trap (SQT)*

The size of the trap is 0.80 x 0.12 x 0.60m and the number of traps carried depends on the size of the boat. About 30 traps are carried by boats 8-10m long, while the bigger boats carry upto 50 traps. Traps are set during the day and left for 6-7 hours. They are then lifted and stored on board at night to avoid damage from trawlers and prevent theft, Fishing trips could last upto three days with the smaller boats and upto six days with the bigger boats. About three fishermen are needed for the smaller boats and four for the bigger boats.

Traps are set to the west of AR3 at depths of 10-25 m — much deeper than TRN or WGN. The target species is Cuttlefish *(Sepioteuthis lessoniana)*. CPUE for the smaller boats is 17-50 kg/trip and 60-150 kg/trip for the bigger boats. About 70 per cent of the catch is squid (see Appendix I, E and F).

23. *FISHING EFFORT, COSTS AND EARNINGS*

The total number of boats in operation varied from 46-80 boats a month. There were more operations during the Northeast Monsoon than during the stronger Southwest Monsoon. TRN were used more commonly during the Southwest Monsoon, while more SQT were set at the start of the Northeast Monsoon (see Figure 31).

Gross income from TRN was 500-1000 Baht*/trip, of which more than 90 per cent was got from sales of *P. merguiensis* (see Table 20 on facing page).

Prices obtained for different sizes and species are given in Table 20.

* US $1 = 25 Baht (appx.)

Fig 31. Fishing effort (operating days) per gear and boat (Ban Kam Phuan, AR3, Ranong Province, Thailand)

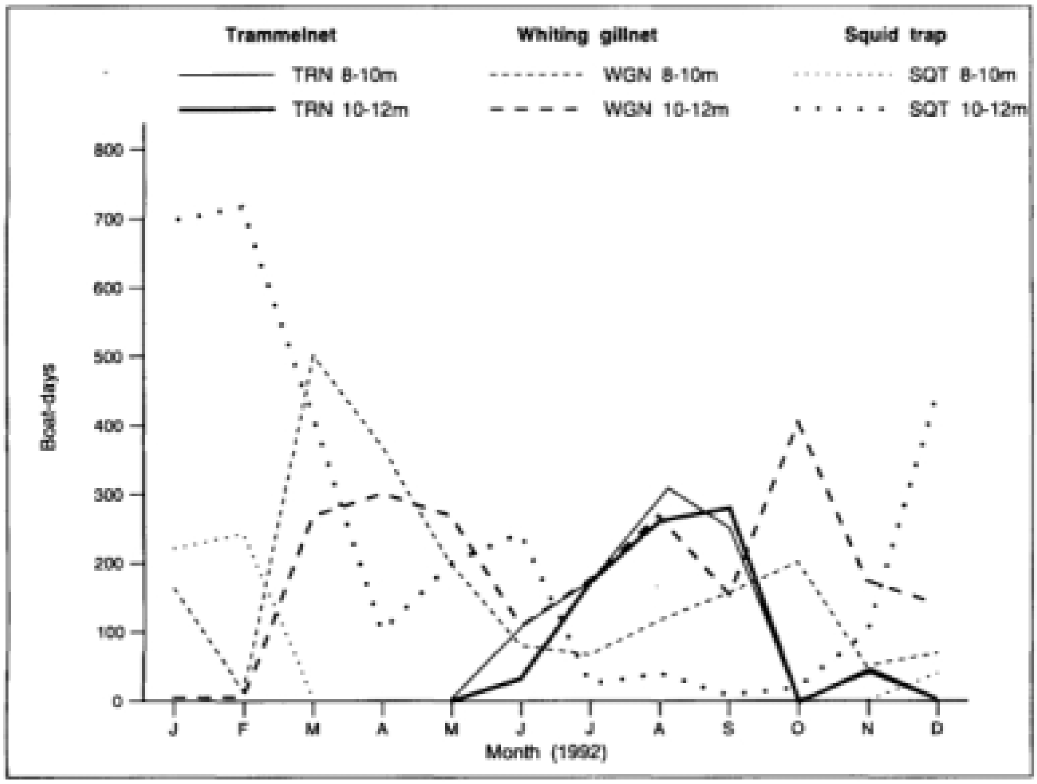

Table 20: Comparison of catch prices at Ban Klong Kluay and Ban Kam Phuan of species caught at AR3 (1988-89 and 1992)

Gear	*Type of catch*	*Size*			*Price / kg (Baht)*	
		Length *(mm)*	Weight (g)	PCS/kg	1988/89	1992
		(CL)				
	Big shrimps	23-46	12-72	<70	90-110	110-120
	Penaeus merguiensis					
	P. monodon					
TRN	*P. semisulcatus*					
	Small shrimps					
	Metapenaeus spp.				25	35
		(TL)				
	Sillago sihama	130-240	18-106	<40	35	35
WGN	*S. ciliata*				20	20
	Sillago spp. (incomplete body)					5
		(TL)				
	Sepiotuethis lessniana					
	big	175-280	294-800		40	63-67
	medium	142-176	185-320		40	33-37
	small	102-175	99-214		40	23-27
SQT						
	Sepia pharaonis					
	big	173-225	490-1,010		20	47-52
	small	132-168	210-350		20	18-22

CL - Carapace length; TL - total length

<<

Gross income from WGN was 325-2200 Baht/trip, with the higher incomes occurring during June to October (see Table 21 and Figures 32 and 33 on facing page).

Gross income with SQT ranged from 850 to 2785 Baht/day for the smaller boats with 30 traps and from 3745-8350 Baht/day for the larger boats. The smaller boats made 1-3 trips a day, while the bigger ones did 3-6. Over 70 per cent of the income is from the sale of Cuttlefish (*S. lessomiana*).

Table 21: Income per trip and gear from fishing at AR3, in 1992

	TRN		WGN		SQT			
Month	*Boat size 8-12*	*Day/trip*	*Boat size 8-12*	*Day/trip*	*Boat size 8-10*	*Day/trip*	*Boat size 10-12*	*Day/trip*
Jan	***		470.50	1	840.80	1	4,701.40	4
Feb	***		736.60	1	1,579.40	3	5,556.20	4
Mar	***		944.30	1	***		4,535.00	4
Apr	***		619.60	1	***		3,774.40	4
May	***		455.60	1	***		6,085.80	4
Jun	814.60	1	971.70	1	***		6,482.50	3
Jul	1,014.60	1	2,153.70	1	***		3,745.00	6
Aug	941.50	1	1,365.90	1	***		5,010.50	3
Sep	771.40	1	910.00	1	***		4,410.10	4
Oct	***		1,133.20	1	***		8,348.00	4
Nov	***		330.80	1	***		5,627.50	5
Dec	497.30	1	318.30	1	2,785.20	3	5,055.20	4

Note: TRN Big shrimp 110 Baht/kg; Small shrimp 35 Baht/kg
WGN *Sillago sihama* 35 Baht/kg; *Sillago ciliata* 20 Baht/kg; *Sillago* spp. (incomplete body) 5 Baht/kg
SQT

	Sepiotuethis lessoniana			*Sepia pharaonis*	
Size	Big	Medium	Small	Big	Small
Bodyweight (g)	>300	200/300	100/200	>400	150-400
Price (Baht/kg)	63-67	33-37	23-27	47-52	18-22

Table 22: Record of fishing operations AR3, Ranong Province, Thailand (1992)

Ban Kam Phuan

WGN = Whiting gillnet, SQT = Squid trap, TRN = Trammelnet

Boat size	*Gear*	*Fishing operations recorded*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
		No. of trips	***	***	***	***	***	105	163	334	252	***	62	***	916
		CPUE		***	***	***	***	7.48	9.66	8.92	7.49	***	4.80	***	
	TRN	Total catch	***	***	***	***	***	785.40	1,574.58	2,979.28	1,887.48	***	297.60	***	7,524.34
		Income/trip	***	***	***	***	***	814.60	1,014.60	941.50	771.40	***	497.30	***	
		Total income	***	***	***	***	***	85,533.00	165,379.80	314,461.00	194,392.80	***	30,832.60	***	790,599.20
		No. of trips	161	35	510	364	182	77	68	132	161	224	81	90	2085
		CPUE	13.68	21.36	27.47	18.55	13.36	27.78	66.90	41.46	27.85	36.881	11.25	11.13	
8-10m	WGN	Total catch	2,202.48	747.60	14,009.70	6,752.20	2,431.52	2,139.60	4,549.20	5,472.72	4,483.85	8,245.44	911.25	1,001.70	52,946.72
		Income/trip	470.50	736.60	944.30	619.60	455.70	971.70	2,153.70	1,365.90	910.00	1,133.20	330.80	318.30	
		Total income	75,750.50	25,781.00	481,593.00	225.534.40	82,937.40	74,820.90	146,451.60	180,298.80	146,510.00	253,836.80	26,794.80	28,647.00	1,748,956.20
		No. of trips	238	84	***	***	***	***	***	***	***	***	***	20	342
		CPUE	17.00	28.29	***	***	***	***	***	***	***	***	***	50.80	
	SQT	Total catch	4,046.00	2,376.36	***	***	***	***	***	***	***	***	***	1,016.00	7,438.36
		Income/trip	840.80	1,579.40	***	***	***	***	***	***	***	***	***	2,785.20	
		Total income	200.110.40	132,669.60	***	***	***	***	***	***	***	***	***	55,704.00	388,484.00
		No. of trips	***	***	***	***	***	32	175	281	296	***	48	***	832
		CPUE	***	***	***	***	***	7.48	9.66	8.92	7.49	***	4.80	***	
	TRN	Total catch	***	***	***	***	***	239.36	1,690.50	2,506.52	2,217.04	***	230.40	***	6,883.82
		Income/trip	***	***	***	***	***	814.60	1,014.60	941.50	771.40	***	497.30	***	
		Total income	***	***	***	***	***	26,067.20	177,555.00	264,561.50	228,334.40	***	23,870.40	***	720,388.50
		No. of trips	8	12	288	297	274	108	178	287	160	396	152	137	2297
		CPUE	13.68	21.36	27.47	18.55	13.36	27.78	66.90	41.46	27.85	36.81	11.25	11.13	
	WGN	Total catch	109.44	256.32	7,911.36	5,509.35	3,660.64	3,000.24	11,908.20	11.899.20	4,456.00	14.576.76	1,710.00	1,524.81	66.522.14
		Income/trip	470.50	736.60	944.30	619.60	455.70	971.70	2.153.70	1,356.90	910.00	1,133.20	330.80	318.30	
		Total income	3,764.00	8,839.20	271,958.40	184,021.20	124,861.80	104,943.60	383,358.60	392,013.30	145,600.00	448,747.20	50,281.60	43,607.10	2,161,996.00
		No. of trips	175	179	98	21	50	76	4	14	4	9	24	120	774
		CPUE	82.17	92.11	74.46	68.56	100.61	102.00	59.00	78.55	73.49	150.73	90.58	83.19	
	SQT	Total catch	14,379.75	16,487.69	7.297.08	1,439.75	5,030.50	7,752.00	236.00	1,099.70	293.96	1,356.57	2,173.92	9,982.80	67,529.73
		Income/trip	4.701.40	5,556.20	4,535.00	3,774.40	6,085.80	6,482.50	3,745.00	5,010.50	4,410.10	8,348.00	5,627.50	5,055.20	
		Total income	822,745.00	994,559.80	444,430.00	79,262.40	304,290.00	492,670.00	14,980.00	70,147.00	17,640.40	75,132.00	135,06.00	606,624.00	4,057,540.60
	Total Income		**1,102,370.00**	**1,161,850.00**	**1,197,981.00**	**488,817.00**	**512,089.00**	**784,035.00**	**887,726.00**	**1,221,482.00**	**732,477.00**	**777,716.00**	**266,839.00**	**734,582.00**	**9,867,964.00**

Ban Klong Kluay

Boat size	*Gear*	*Fishing operations recorded*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
		No. of trips	***	***	***	***	***	240	273	675	615	***	132	***	1935
		CPUE	***	***	***	***	***	7.48	9.66	8.92	7.49	***	4.80	***	
	SQT	Total catch	***	***	***	***	***	1,795.20	2,637.18	6,021.00	4,606.35	***	633.60	***	15,693.33
		Income/trip	***	***	***	***	***	814.60	1,014.60	941.50	771.40	***	497.30	***	
		Total income	***	***	***	***	***	195,504.00	276,985.80	635,512.50	474,411.00	***	65,643.60	***	1,648,056.90
8-10m															
		No. of trips	312	96	***	***	***	***	***	***	***	***	***	22	430
		CPUE	17.00	28.29	***	***	***	***	***	***	***	***	***	50.80	
	SQT	Total catch	5,304.00	2,715.84	***	***	***	***	***	***	***	***	***	1,117.60	9,137.44
		Income/trip	840.80	1,579.40	***	***	***	***	***	***	***	***	***	2,785.20	
		Total income	262,329.60	151,622.40	***	***	***	***	***	***	***	***	***	61,274.40	475,226.40
	Total income		**262,329.60**	**151,622.40**	***	***	***	**195,504.00**	**276,985.80**	**635,512.50**	**474,411.00**	***	**65,643.60**	**61,274.40**	**2,123,283.30**

<<

Total gross income with all three fishing gear in 1992, at Ban Kam Phuan (Table 22), was 9.87 million Baht, with SQT accounting for close to half the income (45%). In Ban Klong Kluay, total income was 2.12 million Baht, with TRN accounting for over 70 per cent. For the two villages combined — the AR3 area — the total catch amounted to 234.5 t, valued at nearly 12 million Baht.

Fig 32. Income per day per trip, by gear and size of boat (Ban Kam Phuan, AR3, Ranong Province, Thailand)

Fig 33. Total income per month, by gear and size of boat (Ban Kam Phuan, AR3, Ranong Province, Thailand)

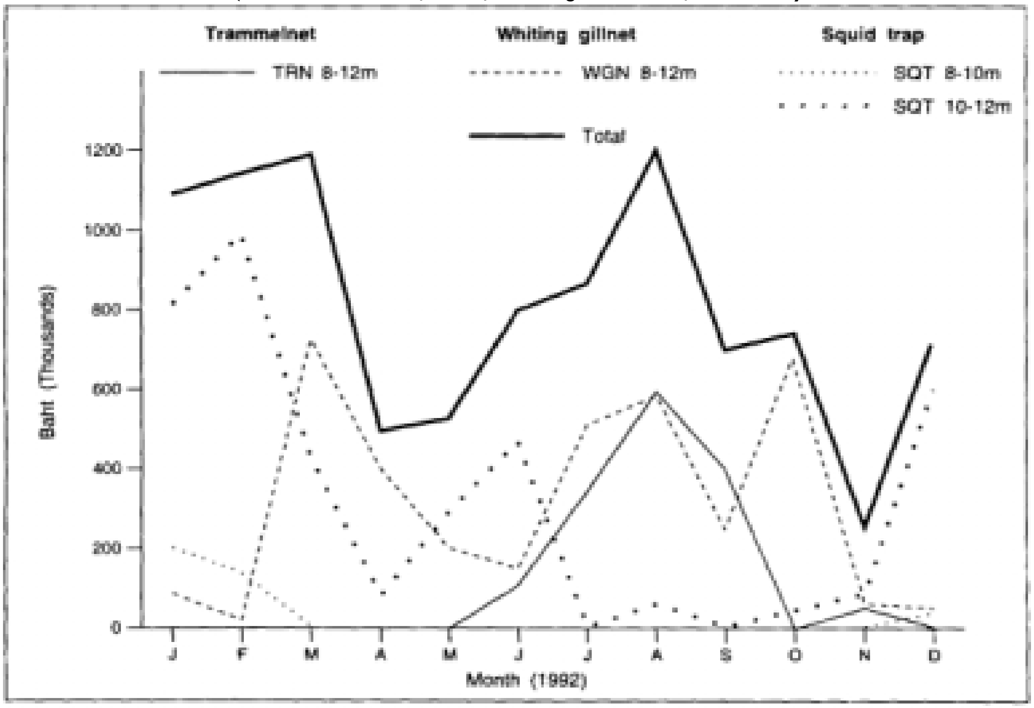

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Figure 34 gives details of fixed costs for both boat types using TRN, WGN or SQT. The engines for the smaller boats are more expensive than those for the larger boats, because the latter generally use reconditioned automotive diesel engines. Among the three fishing gear, investment costs for WGN are the highest. Variable costs for each craft/gear combination are given in Figure 35. Also see Appendix II.

Fig 34. Fixed costs per day, by gear and size of boat (Ban Kam Phuan, AR3, Ranong Province, Thailand)

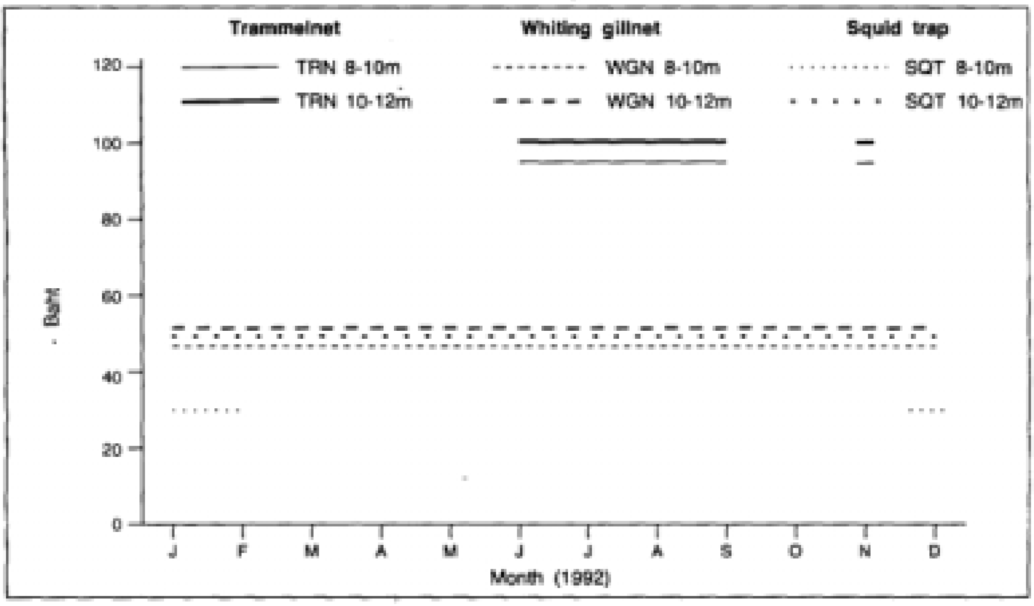
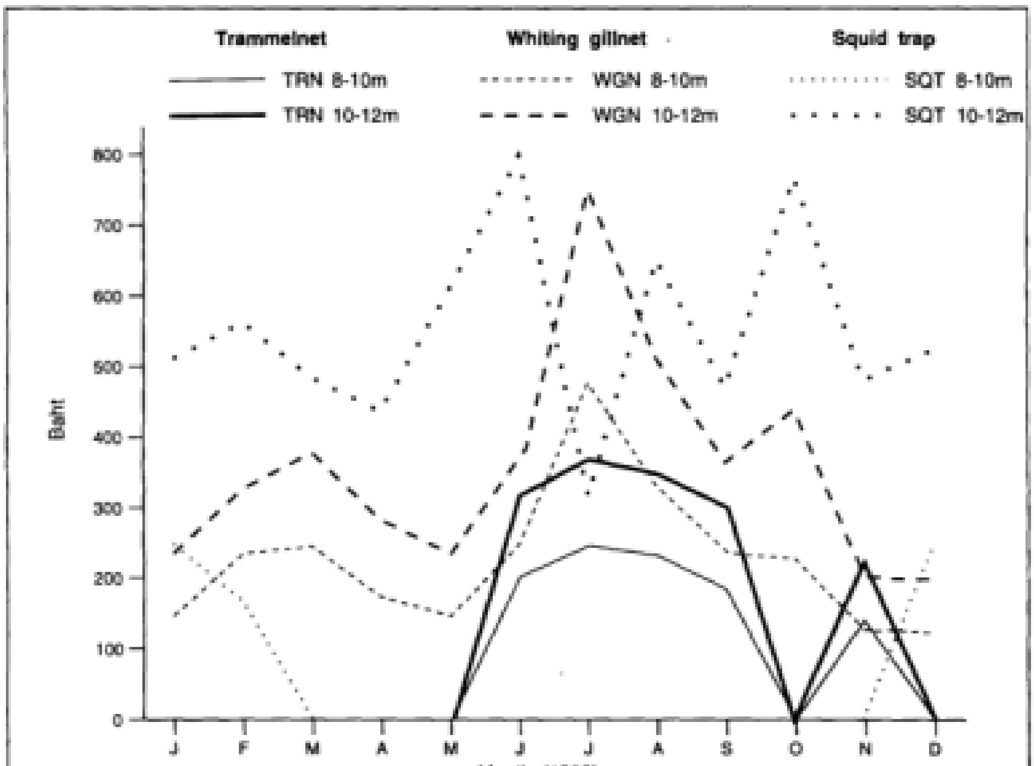


Fig 35. Variable costs per day, by gear and size of boat (Ban Kam Phuan, AR3, Ranong Province, Thailand)



Crew share is arrived at after deducting variable costs from gross income and can vary between 20 and 30 per cent of the balance.

The owner's share in relation to investment cost (boat size) appears to be highest when using WGN with 8-10 m boats and highest with SQT when using larger boats (see Figures 36 and 37).

Fig 36. Profit per day, by gear and size of boat (Ban Kam Phuan, AR3, Ranong Province, Thailand)

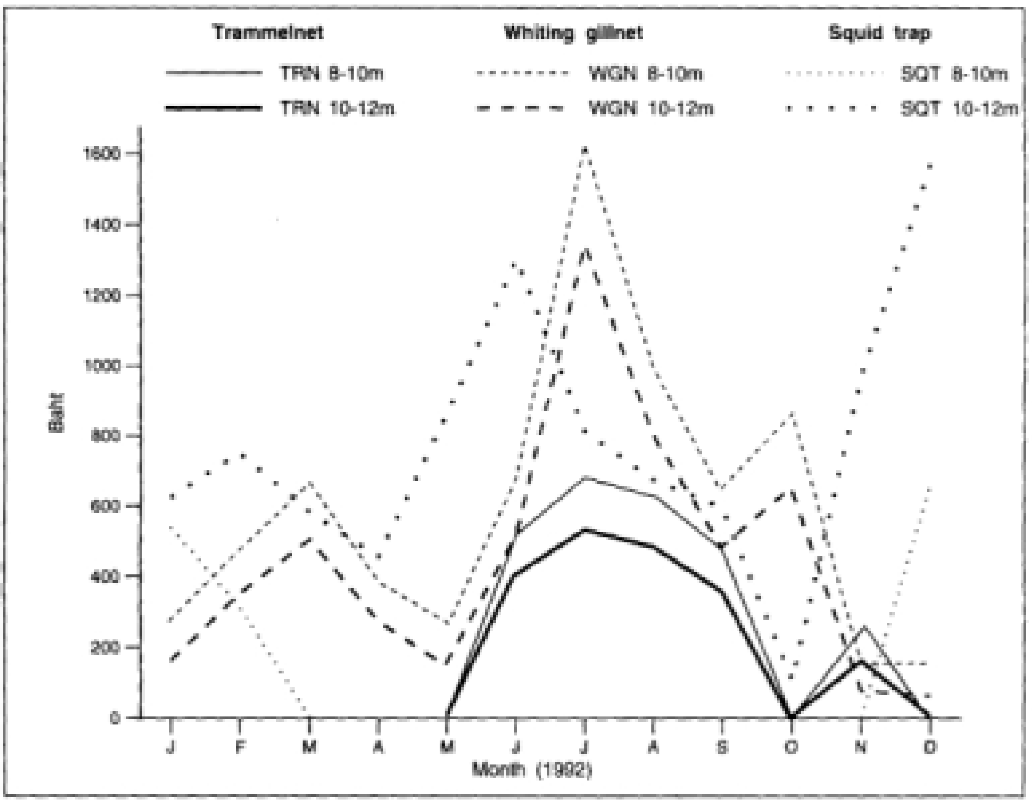
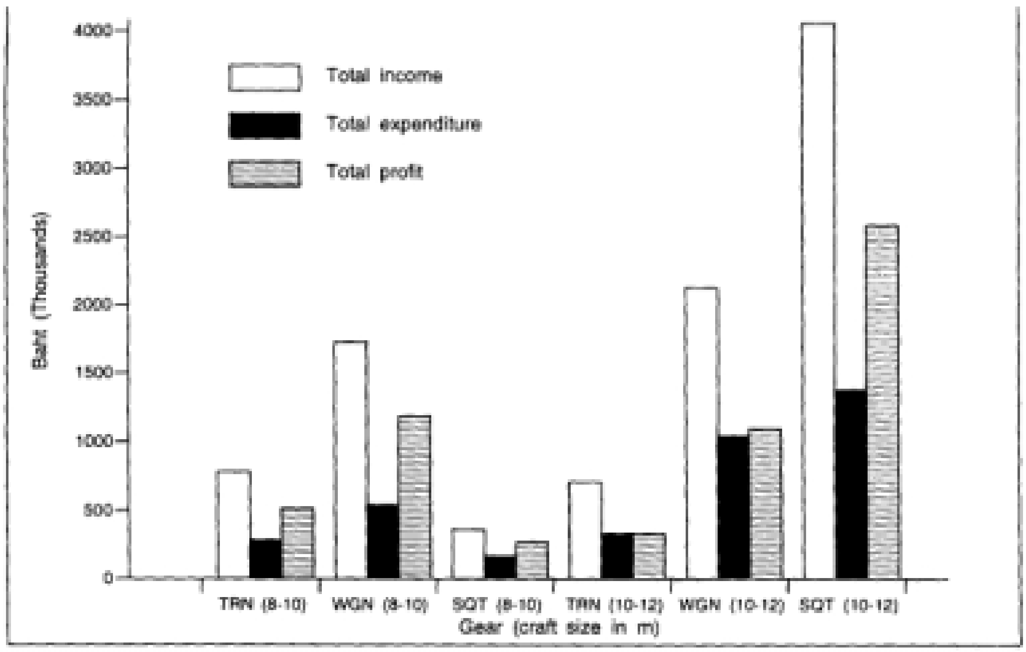


Fig 37. Total income, expenditure and profit, by gear and size of boat



24. CONCLUSIONS

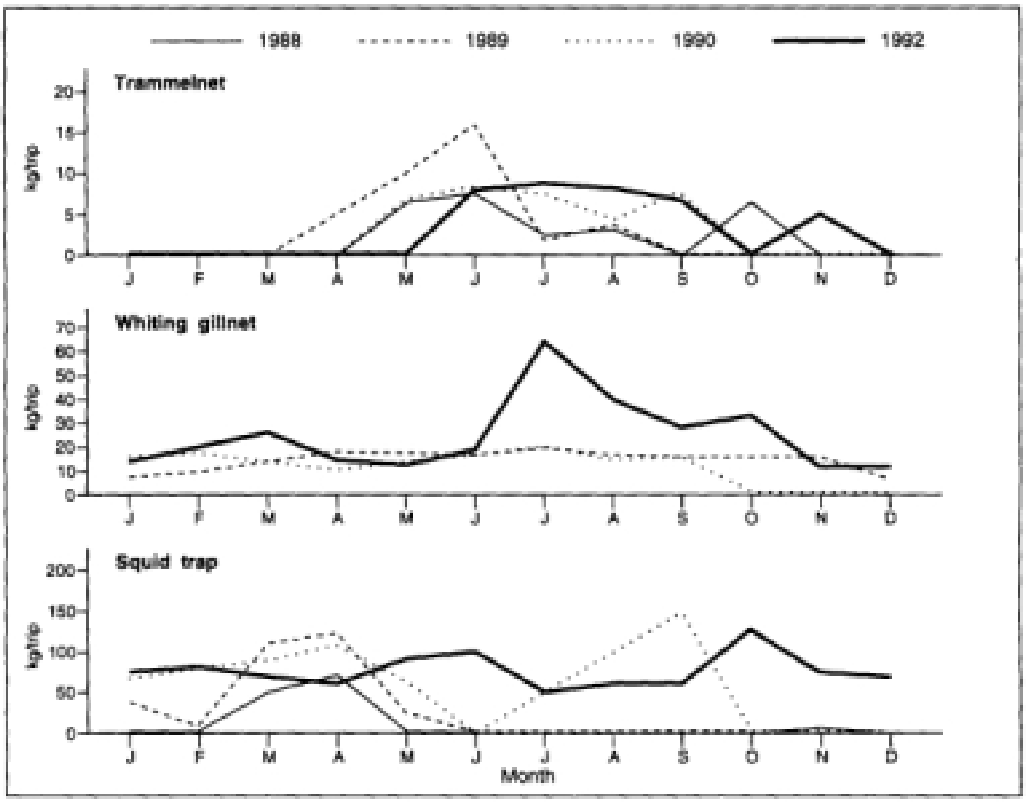
- CPUE values for the three fishing gear have shown an increasing trend since the installation of AR3 (see Figure 38 below).

- Gross income has increased in both villages since 1988, despite the price level remaining nearly constant.

- SQT appears to have benefited most from the presence of AR3. This is evident in its profitability and the progressive increase in number of units over the years.

- TRN and WON are not used in the rectangular area of AR3. This is because it is feared that they may be damaged by the concrete modules, whose positions are no longer defined (all

Fig 38. CPUE (kg/trip) of different gear at AR3, Ranong Province, Thailand, 1988-92



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APPENDIX I

Composition of all economic species captured by different gear at AR3, Ranong Province, Thailand, in 1992, their catch rates, catch rates of shrimp and income from shrimp

A. Composition and catch rates of economic species in the Trammelnet (TRN) fishery

Species composition	*Jun.* %	*Jul.* %	*Aug.* %	*Sep.* %	*Oct.* %	*Nov.* %	*Dec.* %
Penaeus merguiensis	74.90	55.12	51.73	30.94	* * *	38.43	* * *
P. monodon	-	0.18	* * *	0.05	* * *	053	* * *
P. semisulcatus	-	* * *	* * *	* * *	* * *	0.09	* * *
Metapenaeus spp. and small shrimp	1.12	3.93	3.27	3.19	* * *	3.65	* * *
Total shrimp	76.02	59.23	55.00	34.18	* * *	42.70	* * *
Mackerel	2.03	12.02	5.92	*16.52*	* * *	3.03	* * *
Hardtail scad	0.10	0.12	* * *	0.14	* * *	* * *	* * *
Others	1.73	3.68	2.77	4.20	* * *	4.10	* * *
Total pelagic fish	3.86	15.82	8.69	20.86	* * *	7.13	* * *
Catfish	* * *	0.31	0.31	0.05	* * *	* * *	* * *
Tongue sole	1.32	1.59	0.62	1.51	* * *	0.62	* * *
Croaker	5.59	7.85	14.73	29.51	* * *	32.65	* * *
Sand whiting	2.74	1.41	*0.55*	2.65	* * *	* * *	* * *
Others	1.53	3.62	1.12	5.16	* * *	* * *	* * *
Total demersal fish	**11.18**	**14.78**	**17.33**	**38.88**	* * *	33.27	* * *
Portunus pelagicus	4.47	3.37	7.15	1.69	* * *	4.72	* * *
P. sanguinolentus	4.07	6.13	10.05	2.74	* * *	9.16	* * *
Charybdis cruciata	0.10	0.43	* * *	0.14	* * *	0.53	* * *
Othercrab	***	0,18	***	0.87	***		
Mantis shrimp	* * *	* * *	0.49	0.50	* * *	2.22,	* * *
Cuttlefish	0.30	0.06	1.29	0.14	* * *	0.27	* * *
Total invertebrate	**8.94**	**10.17**	**18.98**	**6.08**	* * *	**16.90**	* s *
Total general	**100.00**	**100.00**	**100.00**	**100.00**	* * *	**100.00**	* * *
CPUE (kg/trip)	9.84	16.31	16.22	21.91	* * *	11.24	* * *

Note: Size of boat 8-12 m

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Appendix I (contd.)

B. Catch rate of shrimp in the Trammelnet (TRN) fishery at AR3 and the income from the catch

1992 Month			Penaeus merguiensis	Penaeus monodon	Penaeus semisulcatus	Metapenaeus and small shrimp	Total
June		Kg/trip	7.37		* * *	0.11	7.48
		%	98.50		* * *	1.50	100.00
	Gross	Income (Baht/trip)	810.70		* * *	3.90	814.60
July		Kg/Trip	8.99	0.03	* * *	0.64	9.66
		%	93.10	0.30	* * *	6.60	100.00
	Gross	Income (Baht/trip)	988.90	3.30	* * *	22.40	1,014.60
August		Kg/Trip	8.39		* * *	0.53	8.92
		%	94.10		* * *	5.90	100.00
	Gross	Income (Baht/trip)	922.90		* * *	18.60	941.50
September		Kg/Trip	6.78	0.01	* * *	0.70	7.49
		%	90.50	0.10	* * *	9.40	100.00
	Gross	Income (Baht/trip)	745.80	1.10	* * *	24.50	771.40
October		Kg/Trip					
		%					
	Gross	Income (Baht/trip)					
November		Kg/Trip	4.32	0.06	0.01	0.41	4.80
		%	90.00	1.30	0.20	8.50	100.00
	•Gross	Income (Baht/trip)	475.20	6.60	1.10	14.40	497.30

Note: Size of boat 8-12m

Appendix I (contd.)

C. Composition and catch rate of economic species in the Whiting gilinet (WGN) fishery at AR3

Species composition	1992 Jul.	Aug. %	Sep. %	Oct. %	Nov. %	Dec. %
Sillago sihama	59.09	84.12	72.15	78.32	73.15	54.04
Sillago ciliata	* * *	* * *	* * *	0.23	* * *	7.89
XXX	6.10	6.19	6.06	12.71	16.76	11.77
Total Sandwhiting	65.19	90.31	78.21	91.26	89.91	73.70
Mackerel	0.32	* * *	1.36	2.35	0.82	0.60
Hardtail scad	* * *	0.02	0.35	0.72	0.14	0.06
Yellowstrip trevally	* * *	0.04	0.29	0.03	* * *	0.36
Sardine	0.05	0.39	0.96	0.33	2.06	1.49
Others	0.43	0.19	1.89	1.70	0.41	0.06
Total pelagic fish	0.80	0.64	4.85	5.13	3.43	2.57
Catfish	0.12	* * *	0.38	* * *	* * *	0.36
Tongue sole	1.90	0.35	0.38	0.08	* * *	0.60
Croaker	22.00	0.12	4.27	* * *	1.37	4.24
Threadfinfish	0.06	* * *	0.38	* * *	0.69	* * *
Snapper	0.39	* * *	0.20	* * *	* * *	* * *
Barracuda	1.15	0.31	1.36	0.21	0.96	* * *
Others	0.80	0.27	1.40	1.80	1.23	0.25
Total demersal fish	26.42	1.05	8.37	2.09	4.25	5.45
Squid		***	0.03	***	***	***
Shrimp	0.02	* * *	0.03	* * *	* * *	* * *
Portunus pelagicus	1.66	1.01	3.28	0.67	0.55	1.55
P. sanguinolentus	5.88	0.43	4.27	0.54	1.72	6.69
Other crab	0.03	6.56	0.96	0.31	* * *	10.04
Mantis shrimp	* * *	* * *	* * *	* * *	0.14	* * *
Total invertebrate	7.59	8.00	8.57	1.52	2.41	18.28
Total general	100.00	100.00	100.00	100.00	100.00	100.00
CPUE (kg/trip)	**103.35**	**45.90**	**35.58**	**40.33**	**12.51**	**15.10**

Note: Size of boat 8 - 12 m.

Appendix I (contd.)

D: Catch **Rate of Sillago spp. in the Whiting gillnet (WGN) fishery at AR3 and income from the catch**

1992 Month		Sillago sihama	Sillago cilliata	Sillago spp. *(incomplete body)*	Total
January	Kg/trip	13.13	0.54	0.01	13.68
		96.00	3.90	0.10	100.00
	Income Baht/trip	459.60	10.80	0.10	470.50
February	Kg/trip	20.99		0.37	21.36
	%	98.30		1.70	100.00
	Income Baht/trip	734.70		1.90	736.60
March	Kg/trip	26.79	0.21	0.47	27.47
	%	*97.50*	0.80	1.70	100.00
	Income Baht/trip	937.70	4.20	2.40	944.30
April	Kg/trip	17.13	0.86	0.56	18.55
	%	92.40	4.60	3.00	100.00
	Income Baht/trip	453.30	0.40	2.00	455.70
May	Kg/trip	12.95	0.02	0.39	13.36
	%	96.90	0.20	2.90	100.00
	Income Baht/trip	453.30	0.40	2.00	455.70
June	Kg/trip	27.76		0.02	27.78
	%	99.30		0.70	100.00
	Income Baht/trip	971.60		0.10	971.70
July	Kg/trip	60.64		6.26	66.90
	%	90.60		9.40	100.00
	Income Baht/trip	2,122.40		31.30	2,153.70
August	Kg/trip	38.62		2.84	41.46
	%	93.20		6.80	100.00
	Income Baht/trip	1,351.70		14.20	1,365.90
September	Kg/trip	25.69		2.16	27.85
	%	92.20		7.80	100.00
	Income Baht/trip	899.20		10.80	910.00
October	Kg/trip	31.59	0.09	5.13	36.81
	%	85.80	0.20	14.00	100.00
	Income Baht/trip	1,105.70	1.80	25.70	1,33.20
November	Kg/trip	9.15		2.10	11.25
		81.30		18.70	100.00
	Income Baht/trip	320.30		10.50	330.80
December	Kg/trip	8.16	1.19	1.78	11.13
	%	73.30	10.70	16.00	100.00
	Income Bahtitrip	285.60	23.80	8.90	318.30

Note: **Price of *Sillago* spp. from Whiting gillnet fishery**
- ***Siltago sihama*** **35** Baht/kg
- ***Sillago cilata*** **20 Baht/kg**
- ***Sillago* spp. incomplete body** **5 Baht/kg**

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Appendix I (contd.)

E. Composition and catch rate of squid with squid traps (SQT) at AR3 off Ban Kam Phuan

		Sepiotuethis lessoniana				Sepia pharaonis				
1992 Month	*Boat Size*	*Big %*	*Medium*	*Small %*	*Subtot. %*	*Big*	*Small %*	Subiot	Total	CPUE kg/trip
January	8-10	50.90	31.60	* * *	82.50	6.10	11.40	17.50	100.00	17.00
	10-12	82.10	11.30	0.50	93.90	3.10	3.00	6.10	100.00	82.17
February	8-10	68.70	18.90	* * *	87.60	6.90	5.50	12.40	100.00	28.29
	10-12	83.50	12.80	0.70	97.00	2.70	0.30	3.00	100.00	92.11
March	8-10	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	84.10	10.00	0.40	94.50	5.10	0.40	5.50	100.00	74.46
April	8-10	***	***		***	***	***	***	***	***
	10-12	69.20	22.30	8.00	99.50	0.50	* * *	0.50	100.00	68.56
May	8-10	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	82.80	12.70	* * *	95.50	4.40	0.10	4.50	100.00	100.61
June	8-10	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	93.30	3.00	* * *	96.30	3.70	* * *	3.70	100.00	102.00
July	8-10	***	***	***	***	***	***	***	***	***
	10-12	89.80	* * *	* * *	89.80	10.20	* * *	10.20	100.00	59.00
August	8-10	***	***	***	***	***	***	***	***	***
	10-12	91.90	* * *	* * *	91.90	8.10	* * *	8.10	100.00	78.55
September	8-10	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	66.70	* * *	* * *	66.70	33.30	* * *	33.30	100.00	73.49
October	8-10	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	35.90	* * *	* * *	35.90	64.10	* * *	64.10	100.00	150.73
November	8-10	***	***	***	***	***	***	***	***	
	10-12	80.80	* * *	* * *	80.80	19.20	* * *	19.20	100.00	90.58
December	8-10	53.70	17.40	* * *	71.10	26.80	2.10	28.90	100.00	50.80
	10-12	80.80	7.50	* * *	88.30	11.00	0.70	11.70	100.00	83.I9

Note: Size of boat 8 - 12 m.

Appendix I (contd.)

F. CPUE (kg/trip) and income by species and size of squid caught with squid traps (SQT) at AR3 off Ban Kam Phuan

1992		Sepiotuethis lessoniana					Sepia pharaonis			
Month	*Boat size*	*Big*	*Medium*	*Small*	*Subtotal*	*Big*	*Medium*	*Small*	*Subtotal*	*Total*
		Kg	8.65	5.37	* * *	14.02	1.03	1.95	2.98	17.00
January	8-10	Income	562.30	188.00	* * *	750.30	51.50	39.00	90.50	840.80
	10-12	Kg	67.45	9.26	0.46	77.17	2.55	2.45	5.00	82.17
		Income	4,189.30	324.10	11.50	4,524.90	127.50	49.00	176.50	4,701.40
		Kg	19.43	5.36	* * *	24.79	1.96	1.54	3.50	28.29
February	8-10	Income	1,263.00	187.60	* * *	1,450.60	98.00	30.80	128.80	1,579.40
	10-12	Kg	76.89	11.79	0.63	89.31	2.46	0.34	2.80	92.11
		Income	4,997.90	412.70	15.80	5,426.40	123.00	6.80	129.80	5,556.20
		Kg								
March	8-10	Income	***	***	***	***	***	***	***	***
	10-12	Kg	62.62	7.46	0.28	70.36	3.82	0.28	4.10	74.46
		Income	4,070.30	261.10	7.00	4,338.40	191.00	5.60	196.60	4,535.00
		Kg								
April	8-10	Income	* * *	* * *	* * *	* * *	* * *	***	* * *	* * *
	10-12	Kg	47.47	15.28	5.46	68.21	0.35	***	0.35	68.56
		Income	3,085.60	534.80	136.50	3,756.90	17.50	***	17.50	3,774.40
		Kg								
May	8-10	Income	***	***	* * *	***	***	***	***	***
	10-12	Kg	83.32	12.79	* * *	96.11	4.41	0.09	4.50	100.61
		Income	5,415.80	447.70	* * *	5,863.50	220.50	1.80	222.30	6,085.80
		Kg								
June	8-10	Income	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	Kg	95.21	3.05	* * *	98.26	3.74	* * *	3.74	102.00
		Income	6,188.70	106.80	* * *	6,295.50	187.00	* * *	187.00	6,482.50
		Kg								
July	8-10	Income	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	Kg	53.00	* * *	* * *	53.00	6.00	* * *	6.00	59.00
		Income	3,445.00	* * *	* * *	3,445.00	300.00	* * *	300.00	3,745.00
		Kg								
August	8-10	Income	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	Kg	72.20	* * *	* * *	72.20	6.35	* * *	6.35	78.55
		Income	4,693.00	* * *	* * *	4,693.00	317.50	* * *	317.50	5,010.50
		Kg								
September	8-10	Income	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	Kg	49.04	* * *	* * *	49.04	24.45	* * *	24.45	73.49
		Income	3,187.60	* * *	* * *	3,187.60	1,222.50	* * *	1,222.50	4,410.10
		Kg								
October	8-10	Income	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	Kg	54.10	* * *	* * *	54.10	96.63	* * *	96.63	150.73
		Income	3,516.50	* * *	* * *	3,516.50	4,831.50	* * *	4,831.50	8,348.00
		Kg								
November	8-10	Income	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *
	10-12	Kg	73.23		* * *	73.23	17.35	* * *	17.35	90.58
		Income	4,760.00		* * *	4,760.00	867.50	* * *	867.50	5,627.50
		Kg	27.29	8.81		36.10	13.63	1.07	14.70	50.80
December	8-10	Income	1,773.90	308.40		2,082.30	681.50	21.40	702.90	2,785.20
	10-12	Kg	67.19	6.24		73.43	9.14	0.62	9.76	83.19
		Income	4,367.40	218.40		4,585.80	457.00	12.40	469.40	5,055.20

Note: **Price** of cuttlefish from **squid trap**

	Sepiotuethis lessoniana			*Sepia pharaonis*	
Size	**Big**	**Medium**	**Small**	**Big**	**Small**
Bodyweight (g)	**>300**	**200/300**	**100/200**	**>400**	**150-400**
Price (Baht/kg)	**63-67**	**33-37**	**23-27**	**47-52**	**18-22**

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APPENDIX II

Variable costs, fixed costs, income and profit from fishing at AR3, Ranong Province, Thailand, 1988-92

Operating variable costs per day per gear and size of boat

Boat size (m)	*Gear*	*Variables*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Avg/ day*
			Baht/day												
1988															
	TRN	Fuel	* * *	* * *	* * *	* * *	3700	37.00	3700	3700	* * *	3700	* * *	* * *	37.00
		Ice	* * *	* * *	* * *	* * *	4.0	4.0	4.0	4.0	* * *	40	* * *	* * *	4.0
		Crew	* *	* * *	* * *	* * *	137.00	154.00	61.00	84.00	* * *	148.00	* * *	* * *	116.80
		Total	***	***	***	***	178.00	195.00	102.00	125.00	***	**189.00**	***	***	**157.80**
8-10	WON	Fuel	***	***	***	***	***	***	***	***	***	***	***	***	***
		Ice	* * *	* * *	* * *	* * *	* * *	* * *	***	* * *	* * *	* * *	* * *	* * *	* * *
		Crew			***	***	***	***	***	***	***	***	***	***	***
		Total	***	***	***	***	***	***	***	***	***	***	***	***	***
	SQT	Fuel	* * *	* * *	57.00	57.00	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	5700
		Ice	***	***	31.00	31.00	***	***	***	***	***	***	***	***	31.00
		Crew	* * *	* * *	78.00	129.00	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	103.50
		Total	***	***	**166.00**	217.00	***	***	***	***	***	***	***	***	**19150**
	TRN	Fuel	* * *	* * *	s * *	* * *	91.00	91.00	91.00	91.00	* * *	91.00	* * *	* * *	91.00
		Ice	* * *	* * *	* * *	* * *	4.0	4.0	4.0	4.0	* *	4.0	* * *	* *	4.0
		Crew	* * *	* * *	* * *	* * *	189.00	215.00	75.00	110.00	* * *	206.00	* * *	* * *	159.00
		Total	***	***	***	***	**284.00**	**310.00**	**170.00**	**205.00**		**301.00**	***		254.00
10-12	WGN	Fuel	***	* **	***	***	***	***	***	***	***	***	***	***	***
		Ice	***	***	***	***	***	***	***	***	***	***	***	***	***
		Crew	***	***	***	***	***	***	***	***	***	***	***	***	***
		Total	***	***	***	***	***	***	***	***	***	***	***	***	***
	SQT	Fuel	* * *	***	157.00	157.00	***	***	***	* * *	***	***	***	* * *	157.00
		Ice	***	***	63.00	63.00	***	***	***	***	***	***	***	***	63.00
		Crew	* * *	* * *	77.00	154.00	* *	* * *	* * *	* *	* * *	* *	*	* * *	115.50
		Total			297.00	374.00	***	***	***	***	***	***	***	***	335.50
1989															
	IRN	Fuel	* * *	* *	* * *	37.00	37.00	37.00	37.00	37.00		* * *	* * *	* *	37.00
		Ice	***	***	* * *	4.0	4.0	4.0	4.0	4.0	* * *	* * *	* *	* * *	4.0
		Crew	* *	* * *	* * *	96.00	201.00	356.00	37.00	103.00	* * *	* * *	* *	* * *	158.60
		Total				**137.00**	**242.00**	**397.00**	**78.00**	**144.00**			***		**199.60**
8-10	WON	Fuel	49.00	49.00	49,00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00	49.00
		Ice	9.00	9.00	9,00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00
		Crew	42.00	58.00	108.00	156.00	150.00	157.00	184.00	138.00	119.00	126.00	122.00	45.00	117.08
		Total	**100.00**	**116.00**	**166.00**	214.00	**208.00**	**215.00**	**242.00**	**196.00**	**177.00**	**184.00**	**180.00**	**103.00**	**175.08**
	SQT	Fuel	65.00	65.00	65.00	65.00	65.00	* * *	* * *	* * *	* * *	* * *	* * *	* * *	65.00
		Ice	35.00	35.00	35.00	35.00	35.00	* * *	* * *	* * *	* * *	* * *	* * *	*	35.00
		Crew	46.00	2.00	186.00	211.00	23.00	* *	* * *	* * *	* * *	* * *	* * *	* *	93.60
		Total	**146.00**	102.00	**286.00**	**311.00**	**123.00**	* * *	* * *	* * *	* *	* * *	* *	* * *	**193.60**

TRN — **Trammelnel**
WGN — Whiting gilinet
SQT — Squid trap

Appendix II *(contd.)*

Boat size	*Gear*	*Variables*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Avg/ day*
								Baht/day							
		Fuel				91.00	91.00	91.00	91.00	91.00	***	***	***	***	91.00
	TRN	Ice				4.0	4.0	4.0	4.0	4.0	***	***	***	***	40
		Crew	***	***	**	127.00	285.00	518.00	40.00	139.00	***	***	***	***	221.80
		Total	***	***	***	222.00	380.00	613.00	135.00	234.00	***	***	***		316.80
		Fuel	129.00	129.00	129.00	129.00	129.00	129.00	129.00	129.00	129.00	129.00	129.00	129.00	129.00
10-12	WGN	Ice	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
		Crew	39.00	63.00	137.00	211.00	202.00	211.00	253.00	183.00	155.00	165.00	159.00	43.00	151.75
		Total	177.00	201.00	275.00	349.00	340.00	349.00	391.00	321.00	293.00	303.00	297.00	181.00	289.75
		Fuel	143.00	143.00	143.00	143.00	143.00	***	***	***	***	***	***	***	143.00
	SQT	Ice	70.00	70.00	70.00	70.00	70.00	***	***	***	***	***	***	***	29.17
		Crew	35.00	0.00	245.00	283.00	1.00	***	***	***	***	***	***	***	112.80
		Total	248.00	213.00	458.00	496.00	214.00	***	***	***	***	***	***	***	284.97
1992															
		Fuel	*	***	***	* *	***	45.00	45.00	45.00	45.00	***	45.00	***	45.00
	TRN	Ice			***			5.00	5.00	5.00	5.00	***	500	***	5.00
		Crew	***	***	***	***	***	153.00	193.00	178.00	144.00	***	89.00	***	151.40
		Total	***	***	***	***	**	203.00	243.00	228.00	194.00	**	139.00	***	201.40
		Fuel	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00	60.00
8.10	WON	Ice	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Crew	80.00	133.00	175.00	110.00	77.00	181.00	417.00	259.00	168.00	213.00	52.00	50.00	159.58
		Total	150.00	203.00	245.00	180.00	147.00	251.00	487.00	329.00	238.00	238.00	283.00	122.00	229.58
		Fuel	70.00	50.00		***	***	***	***	***	***			50.00	5667
	SQT	Ice	35.00	35.00		***	***	***	***	***		***	***	35.00	35.00
		Crew	147.00	88.00		***		***	***		***	***	***	169.00	134.67
		Total	252.00	173.00	***	***	***	***	**	***	***	***	***	254.00	226.33
		Fuel	***	***	***	* *	***	95.00	95.00	95.00	95.00	***	95.00	***	95.00
	TRN	Ice	* *	**	***	***	***	5.00	5.00	5.00	5.00	***	5.00	***	5.00
		Crew	***	***	***	***	***	214.00	274.00	252.00	201.00	***	119.00	***	212.00
		Total	***	***	***	***	***	31400	374.00	352.00	301.00	***	219.00	***	312.00
		Fuel	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
10-12	WGN	Ice	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
		Crew	97.00	178.00	240.00	142.00	93.00	248.00	603.00	366.00	229.00	296.00	56.00	52.00	216.67
		Total	242.00	323.00	385.00	287.00	238.00	393.00	748.00	511.00	374.00	441.00	201.00	197.00	361.67
		Fuel	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
	SQT	Ice	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00	70.00
		Crew	287.00	351.00	274.00	217.00	390.00	582.00	121.00	435.00	265.00	560.00	272.00	305.00	338.25
		Total	507.00	571.00	494.00	437.00	610.00	802.00	341.00	655.00	485.00	780.00	492.00	525.00	558.25

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Appendix II *(contd.)*

Income, variable/fixed costs and profit per day per gear and size of boat

Boat size	*Gear*	*income and costs*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Avg/ day*
							Baht/day								
1988															
		Income	***	***	***	***	725.00	810.00	345.00	463.00	***	781.00	***	***	**624.80**
	TRN	Variables	***	***	***	***	178.00	195.00	102.00	125.00	***	189.00	***	***	157.80
		Fixed	***	***	***	***	64.00	64.00	64.00	64.00	***	64.00	***	***	64.00
		Profit	***	***	***	***	483.00	551.00	179.00	274.00	***	528.00	***	**	**403.00**
		Income	***	***	***	***	***	***	***	***	***	***	***	***	***
8-10	WGN	Variables	***	***	***	***	***	***	***	***	***	***	***	***	***
		Fixed	***	***	***	***	***	***	***	***	***	***	***	***	***
		Profit		***	***	***	***	***	***	***	***	***	***	***	***
		Income	***	***	477.00	73200	***	***	***	***	***	***	***		*604.50*
	SQT	Variables	***	***	166.00	21700	***	***	***	***	***	***	***	***	191.50
		Fixed	***	***	20.00	20.00	***	***	***	***	***	***	***		20.00
		Profit	***		291.00	495.00	***	***	***	***	***	***	***	***	**39300**
		Income	***	***	***	***	725.00	810.00	345.00	463.00	***	78100	***	***	624.80
	TRN	Variables	***	***	***	***	284.00	310.00	170.00	205.00	***	301.00	* *	* *	254.00
		Fixed	***	***	***	**	74.00	74.00	74.00	74.00	***	74.00	***	***	74.00
		Profit	***	***	***	***	367.00	426.00	101.00	184.00	* *	406.00	***	***	296.80
		Income		***	***	***	***	***	***	***	***	***	***	***	***
10-12	WGN	Variables	**	***	***	* . *	***	***	***	***	***	***	***	***	***
		Fixed	***	***	***	***	***	***	***	***	***	***	***	***	***
		Profit			***	***	***	***	***	***	***	***	***	***	***
		Income	***	***	477.00	732.00	***	***	***	***	***	***	***	***	604.50
	SQT	Variables	***	***	297.00	374.00	***	***	***	***	***	***	***	***	33550
		Fixed	***	***	38.00	38.00		***	***	***	***	***	***	***	38.00
		Profit	***	***	**142.00**	**320.00**	***	**	***	***	***	* *	***	***	231.00
1989															
		Income	***	***	***	519.00	146.00	1,823.00	228.00	558.00	**	***	***	***	834.80
	TRN	Variables		**	**	137.00	242.00	397.00	78.00	144.00	***	**	**	**	199.60
		Fixed	*	* *	* *	64.00	64.00	64.00	64.00	64.00	*	***	***	* *	64.00
		Profit	***	***	***	318.00	**740.00**	1,362.00	**86.00**	**350.00**	***	***	***	***	**571.20**
		Income	268.00	348.00	596.00	840.00	810.00	842.00	980.00	749.00	654.00	688.00	669.00	281.00	643.75
8-10	WGN	Variables	100.00	116.00	166.00	214.00	208.00	215.00	242.00	196.00	177.00	184.00	180.00	103.00	175.08
		Fixed	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00	29.00
		Profit	139.00	203.00	401.00	597.00	573.00	598.00	709.00	524.00	448.00	475.00	**460.00**	**149.00**	**439.67**
		Income	330.00	110.00	1,028.00	1157.00	217.00	***	***	***	***	***	***	***	568.40
	SQT	Variables	146.00	102.00	286,00	311.00	123.00	*	***	***	* *	* *	* *	* *	193.60
		Fixed	20.00	20.00	20.00	20.00	20,00	***	***	***	***	***	***	***	20.00
		Profit	**164.00**	**-12.00**	**722.00**	**826.00**	**74,00**	***	***	***	***	***	***	***	**354.80**

Appendix II *(contd.)*

Boat size	*Gear*	*Income and costs*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Avg/ day*
								Baht/day							
	TRN	Income	* * *	* * *	* * *	519.00	1,046.00	1,823.00	228.00	55800	* * *		* *	* * *	834.80
		Variables	* * *	* * *	* * *	222.00	380.00	613.00	135.00	234.00	* * *	* * *	* * *	* * *	316.80
		Fixed	* * *	* * *	* * *	7400	74.00	7400	7400	7400	* * *	* * *	* * *	* * *	7400
		Profit	* * *	* * *	* * *	223.00	592.00	1,136.00	**19.00**	250.00	* * *	* * *	* * *	* * *	444.00
10-12	WGN	Income	268.00	348.00	596.00	840.00	810.00	842.00	980.00	749.00	654.00	688.00	669.00	281.00	643.75
		Variables	177.00	205.00	275.00	349.00	340.00	349.00	391.00	321.00	293.00	303.00	297,00	l85.00	290.42
		Fixed	38.00	38.00	38.00	38.00	38.00	38,00	38,00	38.00	38.00	38.00	38.00	38.00	38.00
		Profit	53.00	105.00	283.00	453.00	432.00	455,00	551.00	390.00	323.00	347.00	334.00	58.00	315.33
	SQT	Income	330.00	110.00	1,028.00	1,157.00	217.00	* * *	* * *	* * *	* * *	* * *	* * *	* *	568.40
		Variables	248,00	213.00	458.00	496.00	214.00	* * *	* * *	* * *	* * *	* * *	* * *	* * *	108.60
		Fixed	38.00	38.00	38.00	38,00	38.00	* * *	* * *	* * *	* * *	* * *	* * *	* * *	12.67
		Profit	44.00	-141.00	532.00	623.00	-35.00	* * *	* * *	* * *	* * *	* * *	* * *	* * *	447.13

1992

Boat size	*Gear*	*Income and costs*	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*	*Avg/ day*
	TRN	Income	* *	* * *	* * *	* * *	* * *	814.60	1,014.60	941.50	771.40	* * *	49730	* * *	807.88
		Variables	* * *	* * *	* *	* *	* * *	203.00	243.00	228.00	194.00	* * *	139.00	* * *	201.40
		Fixed	* * *	* * *	* * *	* * *	* * *	93.60	93.60	93.60	93.60	* * *	9360	* * *	93.60
		Profit	***	***	* * *	* * *	* * *	518.00	678.00	619.90	**483.80**	***	264.70	***	**512,88**
8-10	WGN	Income	470.50	736.60	944.30	619.60	455.70	971.70	2,153.70	1,365.90	910.00	1,133.20	330.80	318.30	867.53
		Variables	150.00	230.00	245.00	180.00	147.00	251.00	487.00	329,00	238.00	233.00	122.00	120.00	227.67
		Fixed	43.20	43.20	43.20	43.20	43.20	43.20	43.20	43.20	43.20	43.20	43.20	43.20	43.20
		Profit	277.30	463.40	656.10	396.40	265.50	677.50	1,623.50	993.70	628.80	857.00	165.60	155.10	596.66
	SQT	Income	841.60	526.50	* * *	* * *	* * *	* * *	* * *	* * *	$ * *	* * *	* * *	928.40	765 50
		Variables	252.00	173,00	* *	* *	* * *	* * *	* * *	* * *	* * *	* *	* * *	254.00	226.33
		Fixed	30.00	30.00	***	***	***	***	***	***	***	***	***	3000	30.00
		Profit	**559.60**	**323.50**	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	* * *	644.40	509.17
	TRN	Income	* * *	* *	* * *	* * *	* * *	814.60	1,014.60	941,50	771,40	* * *	497.30	* * *	**807.88**
		Variables	* * *	* * *	* * *	* * *	* * *	314.00	374.00	352.00	301.00	* * *	219.00	* * *	312.00
		Fixed	***	***	* * *	* * *	* * *	102.10	102,10	102.10	102.10	***	102.10	***	102.10
		Profit	* * *	* * *	* * *	* * *	* * *	398.50	538.50	487.40	**368.30**	* * *	**176.20**	* * *	**393.78**
10-12	WGN	Income	470,50	736.60	944.30	619.60	455.70	971.70	2,153.70	1,365.90	910.00	1,133.20	330.80	318.30	867.53
		Variables	242,00	323.00	385.00	287.00	238.00	393.00	748.00	511.00	374.00	441.00	201.00	197.00	361.67
		Fixed	51.70	51,70	51.70	51.70	51.70	51.70	51.70	51.70	51.70	51.70	51.70	51.70	51,70
		Profit	176.80	361.90	507.60	280.90	**166.0**	527.00	1,354.00	803.20	484.30	640.50	78.10	69.60	454.16
	SQT	Income	1,175.40	1,389.10	1,133.00	943.60	1,521.50	2,160.80	1,175.40	1,389.10	1,133.80	943.60	1,521.50	2.160.80	1,387.37
		Variables	507,00	571.00	494.00	437.00	610.00	802.00	314.00	655.00	485.00	780.00	492.00	52500	556.00
		Fixed	49.50	49.50	49.50	49.50	49.50	49.50	49.50	49.50	49.50	49.50	49.50	4950	49.50
		Profit	**618.90**	**768.60**	**590.30**	**457.10**	862.00	1,309.30	811.90	684.60	599.39	114.10	980.00	1,586.30	781.87

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Socioeconomics of small-scale fisheries in the Artificial Reef Areas in Ranong Province, Thailand

by

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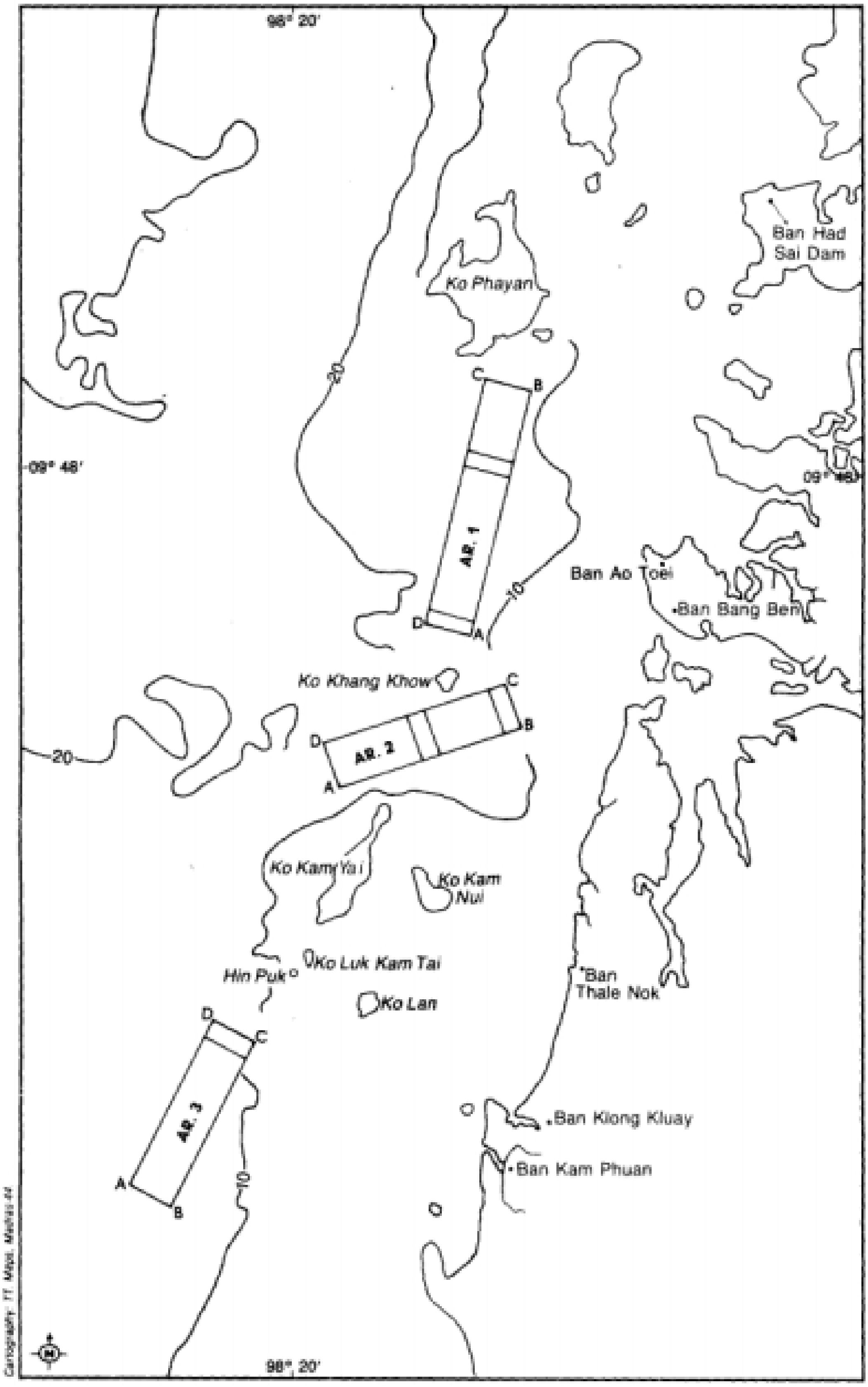
Fig 39. Location of six villages in Ranong Province, Thailand, where a socioeconomic assessment was made of fisherfolk after the introduction of artificial reefs



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25. *INTRODUCTION*

There has been a noticeable increase in fisherfolk population in the districts of Muang and Kapur, which are close to the artificial reef sites AR1, AR2 and AR3. This could be partly due to increase in population and partly due to the influx of immigrant fisherfolk in search of better prospects. Socioeconomic assessment of the fisherfolk community is an important component **to link their** status and well-being to the bioeconomics of their livelihood — fishing.

This document describes the findings of a socioeconomic study undertaken in six villages (see Figure 39) spread along the coastline and representative of villages that may have benefited from the installation of ARs through increased fishing activity and income. Data was collected by direct interviews as well as from past records. The main objectives of the study were to

- Identify changes in fishing households;
- Record the attitude and perceptions of fisherfolk regarding artificial reefs;
- Achieve a better understanding of the socioeconomics of small-scale fisheries; and
- Examine management options likely to benefit the community and optimally utilize the marine resources at the ARs.

A total of 124 households were surveyed in these villages:

ARI - Ban Had Sai Dam
AR2 - Ban Bang Ben, Ban Ao Toei
AR3 - **Ban** Thale Nok, Ban Klong Kluay, Ban Kam **Phuan**

26. *FINDINGS*

26.1 *Changes in number offishing households*

A comparison of the results from the 1985 and 1990 marine fishery censuses showed that while there was a 6.5 per cent reduction in the number of fishing households along the Andaman Sea Coast, there was a I **per cent increase in Ranong Province (Table 23).**

Table 23: Comparison of number of fishing households by provinces in the Andaman coastal zone in 1967, 1985 and 1990

	1967	1985		1990	
Province	*No. offishing households*	*No. offishing households*	*% of change*	*No. offish households*	*% of change*
Ranong	1931	1947	0.8	1959	0.6
Phang Nga	3423	3514	2.7	3072	-12.6
Phuket	1082	1097	1.4	909	-17.1
Krabi	2280	2359	3.5	2276	-3.5
Trang	2446	2528	3.4	2168	-14.2
Satun	3329	3416	2.6	3576	4.7
Total	**14491**	**14861**	**2.6**	**13960**	**-6.1**

Sources: 1. The 1985 Marine Fishery Census of Thailand, National Statistical Office, Thailand.
2. Report of the 1990 Intercensal Survey of Marine Fishery, National Statistical Office, Thailand.

The number of fishing households in the fishing villages close to ARI, AR2 and AR3 increased by 120 per cent, from 210 to 462 between 1987 and 1990 (Table 24). This suggests that installing ARs did spur fishing activity, resulting in an increase of fisherfolk households.

Table 24: Comparison of numbers of households close to ARs in Ranong in 1987 and 1991

AR area	No. of households			No. of fishing households		
	1987 (*Non-ARs*)	1991 (*ARs*)	% change	1987 (*Non-ARs*)	199! (*ARs*)	% *change*
AR1	252	411	63	118	197	67
AR2	101	287	184	60	187	212
AR3	81	80	-l	32	78	144
Total	**434**	**778**	**79**	**210**	**462**	**120**

Source: Small-scale Fisheries Development Project, Ranong Province, Thailand.

26.2 *Changes in fishing methods and fishing gear*

One of the main objectives in installing artificial reefs was to deter trawlers from operating in the area and encourage passive, small-scale fishing methods. The 1987 census figures and present data show (Table 25) that trawlers have definitely reduced in number in the area and have completely disappeared from the coast adjacent to AR1.

Table 25: Type and numbers of fishing **gear used in the area of the ARs, in Ranong, 1987 and 1992**

Types of fishing gear	*AR1* *1987* (no.)	*1992* (no.)	*%* change	*AR2* *1987* (no.)	*1992* (no.)	*%* change	*AR3* *1987* (no.)	*1992* (no.)	*%* change	*Total* *1987* (no.)	*1992* (no.)	*%* change
Whiting gillnet	-	50	-	2	55	2650	20	30	50	22	135	514
Trammelnet	28	90	221	8	55	588	66	140	112	102	285	179
Squid trap	3	15	400	-	3	-	4	110	2650	7	128	1729
Small otter trawl	10	-	-	-	-	-	7	10	43	17	10	-41
Others	240	179	-25	94	250	166	86	242	181	420	671	60
Total	281	334	19	104	363	249	183	532	191	568	1229	116

Source: Small scale Fisheries Development Project, Ranong Province, Thailand.

What is interesting, however, is that the number of trawlers in the entire **Ranong** Province had increased by 113 per cent (Table 26), many fishing in Myanmar waters. The number of fishing craft using whiting gillnet (WGN), trammelnet (TRN) and squid trap (SQT) increased by 6,3 and 18 times, respectively (Table 25)! This clearly vindicates the objective of installing artificial reefs to promote passive fishing gear for the exploitation of marine resources in the coastal areas.

Table 26: Comparison of the numbers of **trawl gear in Ranong Province, in 1985 and 1990**

Types of trawl	*1985* *Amount*	*%*	*1990* *Amount*	*%*	*Percentage of Change*
Otter trawl	73	94.8	156	95.1	114
Pair trawl	4	5.2	8	4.9	100
Total	77	100.0	164	100.0	113

Sources: I. The 1985 Marine Fishery Census of Thailand, National Statistical Office, Thailand.
2. **Report of** the 1990 lntercensal Survey of Marine Fishery, National Statistical Office, Thailand.

26.3 *Profile of fishing households*

In the villages adjoining the three AR sites, 66 per cent of the population is Muslim. Close to 65 per cent of household heads have received primary school education. The number of members per household is 5, on an average. Active fisherfolk between the ages of 15 and 65 are 43 per cent of the fisherfolk population (Table 27).

Table 27: Number of household members by sex and age in 1992

	AR1		*AR2*		*AR3*		*Total*	
Items	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	
Sex:	190	100.0	119	100.0	302	100.0	618	100.0
Male	90	47.4	60	50.4	167	55.3	319	51.6
Female	100	52.6	59	49.6	135	44.7	229	37.1
Age190	100.0	119	100.0	302	100.0	661	100.0	
<15	95	50.0	57	47.9	110	36.4	262	39.6
15-40	68	35.8	55	46.2	139	46.0	262	39.6
41-65	26	13.7	7	5.9	51	16.9	84	12.7
> 65	1	0.5	-	-	2	0.7	3	0.5

Source: By survey.

Some fisherfolk in villages adjoining AR2 have additional income from other sources, such as farming, but villages close to AR1 and AR3 rely on fishing and fishery-related activity for their livelihood (Table 28).

Table 28: Occupation distribution of fishing households by AR areas in 1992

	AR1		*AR2*		*AR3*		*Total*	
Items	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
FO	23	65.7	8	34.8	44	66.7	75	60.5
FO+FP	4	11.4	10	43.5	5	7.6	19	15.3
FO+NF	7	20.0	3	13.0	14	21.2	24	19.4
FO+FP+NF	1	2.9	2	8.7	3	4.5	6	4.8
Total	**35**	**100.0**	**23**	**100.0**	**66**	**100.0**	**124**	**100.0**

Note: FO = **Fishing** operation only
FO+FP = **Fishing operation** + fish-processing
FO+NF = Fishing operation + nonfishing operation
FO+FP+NF = Fishing operation + **fish-processing** + **nonfishing operation**

Most of the fishing households own boats, with over half of them owning boats 8-10 m long and fitted with outboard engines. Most fisherfolk own/operate more than one type of fishing gear. On an average, there were 142 fishing days/household (Table 29).

Table 29: Monthly number of fishing days/household near the ARs in 1992

ARs	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	Total
AR1	20	15	17	14	14	10	7	13	12	7	8	6	139
AR2	23	19	18	20	20	12	9	3	12	18	14	13	138
AR3	26	20	Il	14	11	7	8	4	13	11	14	16	147
Total avg.	23	18	15	16	15	10	8	7	12	12	12	12	142

Source: By **survey**

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26.4 *Income of fishing households and standard of living*

Income from fishing is the main income, though some households derive extra income from fish-processing, *e.g.* drying squid, drying fish and making shrimp paste. Table 30 gives details of household incomes. Income from fishing is highest in villages close to AR3 (5.5,000 Baht/household/year).

Table 30: Monthly net cash income (baht/household) and sources of income in each AR area in 1992

AR *area*	Sources of *income*	*Jan*	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total *(Baht)*	*%*
AR1															
	Fishing	3,138	2,676	2,605	1,383	2,227	1,461	1,968	2,125	3,722	2,149	2,144	2,202	21,868	85.0
	Nonfishing	3,08	1,091	683	509	283	148	277	220	58	55	38	186	3,856	l5.0
	Total	**3,446**	3,767	3,288	1,892	2,510	**1,609**	2,245	2,345	3,780	2,104	2,182	2,388	25,724	100.0
AR2															
	Fishing	3,727	4,677	3,772	2,421	3,666	3,590	2,417	1,186	4,252	1,890	1,693	649	26,558	77.3
	Nonfishing	3,875	30	910	592	133	733			457	183	600	7,783	22.7	
	Total	7,602	4,977	4,682	3,013	3,799	4,323	2,417	1,186	4,252	2,347	1,876	1,249	34,341	100.0
AR3															
	Fishing	6,531	10,248	3,433	2,639	2,864	5,542	4,569	3,114	6,098	4,751	2,139	4,175	46,083	83.5
	Nonfishing	2,656	1,643	1,040	769	750	836313	117	150	246	313	243	9,076	16.5	
	Total	**9,187**	**11,891**	**4,473**	**3,408**	**3,614**	**6,378**	**4,882**	**3,231**	**6,248**	**4,997**	**2,452**	**4,418**	**55,159**	**100.0**
Average															
	Fishing	4,465	5,867	3,270	2,148	2,919	3,531	2,985	2,142	4,691	2,897	1,992	2,342	31,503	84.4
	Nonfishing	2,048	1,087	890	621	392	508	231	148	82	224	156	249	5,8l9	15.6
	Total	**6,513**	**6,954**	**4,160**	**2,769**	**3,311**	**4,039**	**3,216**	**2,290**	**4,773**	**3,121**	**2,148**	**2,591**	**37,322**	100.0

Figures for 1986 and 1992 show that there is an increase of nearly 26 per cent in fishing income and a decrease of household debt by 21 per cent (Table 31)

The standard of living expressed by Engel's Coefficient (% of food expense to total expense) shows that fisherfolk households are better off than the rest of the coastal village population, but they still spend over half their income on food (Table 32 on facing page). At AR3 villages alone, the Engel's Coefficient has reduced from 75 per cent in 1986 to 54 per cent, indicating a definite improvement in the standard of living.

Table 31: Comparison of household income, debt and living expenditure at AR3, before AR deployment (1986) and after AR deployment

Items	*Before deployment of AR* (1986)* Baht/year	%	*After deployment of AR (1992)*** *Baht/year*	*%*	*% of change*
Household income	43,096	100.0	55,159	100.0	28
Fishing operation	36,580	84.9	46,083	83.5	26
Fish processing	1,210	2.8	145	0.3	-88
Farming	4,513	10.5	1,414	2.6	-69
Employee	585	1.4	4,036	7.3	590
Others	208	0.5	3,481	6.3	1574
Living expenditure	28,438	100.0	40 163	100.0	41
Food	21,410	75.3	21,685	54.0	1
Clothes	1,438	5.1	3,735	9.3	160
Utilities	1,152	4.1	5,261	13.1	357
Medical care	1,887	6.6	1,325	3.3	-30
Education	519	1.8	1,526	3.8	194
Others	2,032	7.1	6,631	16.5	226
Debt:	8,523		6,775		-21

Source: * **Boonchuwong,** P., 1987.; **By survey

27. *PERCEPTIONS OF FISHERFOLK*

It is to be expected that with increased fishing incomes, the fisherfolk exploiting AR3 have the most positive reactions to the installation of ARs. The fact that 91 per cent of them feel that ARs are the property of the fisherfolk and should be cared for by them is evidence enough to conclude that the installation of ARs has benefited small-scale fisherfolk. Reactions to other relevant questions are given in Table 33 on facing page.

Table 32: Average annual living expenditure and Engel's Coefficient of fishing households by types of craft-gear combinations operated in different AR areas in 1992

Boat size and types of gear group	AR)		AR2		AR3		Total average	
	Living expenditure (baht/year)	Engel's Cof (%)	Living expenditure (baht/year)	Engel's Cof (%)	Living expenditure (baht/year)	Engel's Cof (%)	Living expenditure (baht/year)	Engel's Cof (%)
Boat size < 8m.	25,611	61	26,258	51	30,728	52	25,943	59
TN-Other	19,918	56	-	-	51,810	34	12,953	34
Others	27,509	62	26,258	51	29,106	54	18,877	53
Boat size 8.10 m.	37,070	55	24,386	54	39,795	58	35,640	56
TN-Other	34,283	62	23,533	60	31,690	58	32,020	60
WGN-TN-Other	38,840	43	37,456	41	-	-	38,247	42
WGN-TN-ST-Other	-	-	-	-	40,180	41	40,180	41
Others	41,927	51	19,805	61	45,493	58	38,174	57
Boat size 11-12 m.	-	-	79,970	42	46,654	52	51,780	50
WGN-Others	-	-	-	-	43,684	49	43,684	49
TN-Others	-	-	37,280	32	-	-	37,280	32
ST-Others	-	-	-	-	49,086	55	49,086	55
WGN-ST	-	-	-	-	56,046	70	56,046	70
WGN-TN-others	-	-	71,920	42	45,140	54	58,530	47
TN-ST-Others	-	-	-	-	70,560	42	70,560	42
WGN-TN-ST-Others	-	-	-	-	30,918	43	30,918	43
Others	-	-	105,340	44	25,770	51	57,598	46
Total	33,141	57	31,652	53	40,158	54	36,600	55

Note: I) WON = Whiting gillnet
TN = Trammelnet
ST = Squid trap
Others = Other fishing gear
2) Engel's Coefficient = Food expenditure/total living expenditure as a percentge

Table 33: Attitude of fishermen to the objectives of the ARs by AR area

Items of attitude	AR1			AR2			AR3			All ARs		
	Ac-cept (%)	Uncer-lain (%)	Dis-agree (%)	Ac-cept (%)	Uncer-lain (%)	Dis-agree (%)	Ac-cept (%)	Uncer-lain (%)	Dis-agree (%)	Ac-cept (%)	Uncer-lain (%)	Dis-agree (%)
Increasing resources in coastal area	42.8	54.3	2.9	60.9	39.1	-	83.3	16.7	-	68.6	30.6	0.8
Trawl gear prevention	48.6	51.4	-	56.5	34.8	8.7	62.1	27.3	10.6	57.2	35.5	7.3
Increasing of catch	31.4	65.7	2.9	56.5	43.5	-	62.1	34.8	1.6	53.2	44.4	2.4
Saving' fishing time	20.0	77.1	2.9	34.8	60.9	4.3	43.9	48.5	7.6	35.5	58.9	5.6
Increasing of fishing season	20.0	77.1	2.9	47.8	52.2	-	47.0	45.4	7.6	39.5	55.7	4.8
Increasing more types of fishing gear	28.6	65.7	5.7	39.1	52.2	8.7	37.9	48.5	13.6	35.5	54.0	10.5
Suitable fishing ground for small-scale fishermen	45.7	51.4	2.9	56.5	43.5	-	74.3	24.2	1.5	62.9	35.5	1.6
Present ARs are useful for small-scale fishing	42.8	54.3	2.9	65.2	34.8	-	78.8	18.2	3.0	67.0	30.6	2.4
The ARs are common property and should be taken care by fishermen	45.7	51.4	2.9	65.2	34.8	-	90.9	7.6	1.5	73.4	25.0	1.6

Results and conclusions of the biosocioeconomic assessment of the impact of the artificial reefs (ARs) on the small-scale fisheries in Ranong Province, Thailand

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28. *RESULTS*

28.1 *Environmental conditions and animal communities*

28.1.1 Environmentally, ARs 1 and 2 are located very close to mangrove and estuarine areas and are, hence, prone to high turbidity. This could, perhaps, play a negative role on the sealife dwelling near these ARs. AR3 showed less suspended solids, particularly during the dry winter months of the northern hemisphere. The Southwest Monsoon in the summer months brings heavy rain and heavy run-off from the mangroves and estuaries, causing considerable mixing of water. These conditions also contribute to inorganic nutrients being discharged into the sea. While AR2 has pronounced mangrove run-off, AR3 is dominated by seawater intrusion and, hence, has better marine conditions, relatively clear water and less suspended solids. Higher nutrient levels at ARs 1 and 2 also contribute to high chlorophyll content.

The sediments around ARs I and 2 are fine and are, therefore, generally unsettled by the dynamics of the water in their areas. But the sand and mud around AR3 comprise of larger-sized grains and are, thus, less easily disturbed. The weak turbulence observed in the water may be due to bottom obstruction contributed by the scattered modules of the ARs, but is of little consequence.

These observations indicate that the locations of AR1 and AR2 did not favour colonization and aggregation of various organisms of commercial value, though nutritional enrichment of the water was evident. AR3 appeared to have environmental conditions more favourable for the objectives of the Government's artificial reef project. The presence of ARs did not seem to affect the natural environmental conditions in any significant way.

28.1.2 Underwater visual census was almost impossible at ARI and AR2 due to poor visibility caused by turbidity. Observations showed that the modules were haphazardly scattered at the bottom and not in the formation expected. The underwater visual census was, therefore, almost entirely at AR3.

Organisms belonging to major groups of animals, such as seafans, sponges, worms, oysters and barnacles, covered almost the entire concrete surfaces. Crawling among these were starfish, tiny shrimp, worms, crab, brittle stars, sea urchins, limpets, sea slugs, sea snails etc.

The oysters *(Saccostrea* spp.) were an edible variety and proliferation of this species in this area was a new development. When the oysters increased in number, the clumps became too heavy, broke off and dropped to the sea bottom, where they formed a hard substratum on which new oyster spat settled. Thus, the surface area of the AR also increased.

From the results of the study, it became evident that positioning of the deployment vessel at the location and the system of lowering the module have to be improved to achieve better positioning of the modules in relation to one another.

28.1.3 During the three field observations, statistically significant differences were recorded in the seasonal variations of the biomass of organisms on the AR. The average of these three values also appeared to differ with the position on the AR — from approximately 2,500 to 3,760 g/m^2 on the upper surface of the horizontal beam of the module to 6,899-8,685/m^2 on the vertical column of the module and 11,447-14,843 g/m^2 on the under side of the horizontal beam of the modules.

28.1.4 Since monitoring commenced about three years after installation of ARs in Ranong, the colonization was expected to have stabilized. During the three underwater visual censuses, 101 species of fish, representing 42 families, were encountered. About 80 per cent of the species were found to be residents, while the rest (Fusilier, Jacks/Trevally, Anchovy etc.) were transitory.

28.1.5 Five types of fish were identified based on the pattern of association with the AR:

- Type A in physical contact with the AR or occupying crevices (Groupers, Dottyback, Lionfish etc);
- Type B swimming close to modules (Damselfish, Cardinalfish, Boxfish, Filefish, Leatherjackets, Puffers etc);
- Type C swimming through and around the modules, but closer to the bottom (Snappers, Sweetlips, Parrotfish, Rabbitfish, Ponyfish, Butterflyfish, Angelfish, Triggerfish, Surgeonfish etc);
- Type D preferring to orientate close to the bottom, near the basal parts of the modules, but extending their range over the open sand area (Goatfish, Monocle bream, Emperors, Lizardfish, Perches, Cobia, Pipefish, Whiting, Stingray etc); and
- Type E, pelagics hovering above the modules (Jacks/Trevallies, Batfish, Barracuda, Halfbeak, Anchovy, Eagle rays etc.).

Comparing the fish aggregation at the ARs with that at a nearby natural reef, 41 species (40%) were found to be common, though at least 78 species (77%) had been expected to be common on the basis of records from the Andaman natural reefs. The remaining 23 per cent are assumed to be confined to the AR only and included economically important species like Spotted sickle *(D. pun ctata)*, Longface emperor *(L. olivaceus)*, Johnius snapper *(L. johni)*, Groupers *(E. bleekari* and *E. undulosus)*, Cobia *(R. canadum)*, Whiting *(S. sihama)* Trevally *(C. ignobilis* and *C. sem)*. Kingfish *(Seriolina nigrofasciata)* and Anchovy *(Stolephorus* sp.). With higher proportions of target species at the ARs, opportunities for better income to fishermen were greater for those fishing there.

28.2 *Impact of ARs on the fishing methods*

28.2.1 Twentytwo types of fishing gear are used by fishermen in the villages adjacent to the three ARs, but the major ones are only the trammelnet, squid trap, whiting gillnet, crab glilnet, grouper trap and scoopnet. A comparison of the results of the gear census in 1987 with those of the gear survey in 1992 showed that there has been a significant increase in the use of the trammelnet, crab gillnet, whiting gillnet, squid trap, scoopnet and grouper trap. At the same time, there was reduced use of the mullet gillnet, kingmackerel gillnet, pomfret gitlnet, otter trawis, crab liftnet, setnet etc. New gear introduced after installation of the ARs are gilinets for Threadfin, Mackerel and Sardine, stick-held castnet for Squid, Crab traps, trollingline, bottom longlines, set bagnet, shrimp castnet etc. Gear in the six villages surveyed has increased from 568 units in the predeployment period to 1264 in 1992.

28.2.2 Fishing trials conducted near the three ARs indicated better performances near AR3 than at the other two. The potential for the development of bottom vertical longline, bottom longline and fish trap were evident, but more trials are necessary to confirm the economic feasibility of those at the three ARs.

Though fish trap construction was demonstrated to the fishermen in one village, demonstration of some of the other experimental gear was not achieved due to the short duration of the project.

It was, however, evident that trawler operation in the AR areas had been reduced significantly, while the number of small-scale fishing operations had increased at the ARs, particularly at AR3.

28.3 *Impact of ARs on the performance of small-scale fisheries*

28.3.1 Lack of information on the performance of the fisheries during the predeployment phase makes quantification of the impact of ARs on the performance after deployment difficult. However, based on available information, it was learned that the catch rate of squid traps had increased by 265 per cent. The whiting gillnet had also shown progressive improvement in the catch rate. But trammelnet showed only slight improvement. It should be recommended that the whiting gillnet and trammelnet values recorded refer to fishing areas in proximity to the AR and not inside it.

28.3.2 Data gathered at the ARs between 1988 and 1993, during the shrimp and fish trawl surveys by the Government research vessel, indicated increase in the catch of shrimp, squid, demersals and pelagic fish. Production also increased considerably, almost doubling, but it was not clear whether this was due to aggregation of the sparsely scattered resources at the AR, enhancement of the biomass of these resources (leading to increase in the density distribution of the stocks) or reduction in the exploitation by trawling (contributing to increased availability of these resources for the small-scale fisheries).

28.3.3 The total investment on the ARs in Ranong province was Baht 15,700,000. AR3 alone cost Bht 3,337,878, but the gross income generated in 1992 by the fisheries in the two villages near it was Baht, 11,991,249. The other two ARs have not been rewarding, so far, for reasons already mentioned.

28.4 *Impact of ARs on fisherfolk and their income*

28.4.1 The results of a socioeconomic survey of the six fishing villages adjacent to the three ARs were compared with the secondary data from the Fisheries Censuses of 1985 and 1990 and the BOBP extension project survey of 1986. The rate of increase in the number of fishing households near the ARs was higher than the increase of fishing households in Ranong Province as a whole. This was probably due to the establishment of the ARs.

28.4.2 The number of trawlers in these fishing villages decreased by 41 per cent with the installation of ARs, while the number of small boats operating whiting gillnet, trammelnet and squid traps increased by about 6, 3 and 18 times, respectively.

28.4.3 All fishing households in the villages are primarily fishing households with their own craft and gear — 61 per cent involved only in fishing, 15 per cent in fishing and fish-processing, 19 per cent in fishing and nonfishery activities and 5 per cent in fishing, fishery-related and nonfishery activities. Those close to AR1 and AR3 depended on fishing more than those adjacent to AR2.

Income from fishing was 84 per cent of the total income and the average net income to a household fishing near an AR in 1992 was about Baht 37,322. The average was higher for those fishing around AR3 (Baht 55,159)) than at AR2 (Baht 34,341) and ARI (Baht 25,724). Engel's Coefficient (EC) (percentage of the food expense in relation to total expenditure) was 55 per cent for the villages near the ARs, whereas it was about 76 per cent in the Ranong Province. The EC average was about the same near all three ARs. Fishermen using larger boats or operating squid traps also had a higher standard of living than those operating other gear.

Comparing the data of the BOBP survey of 1986 (Boonchuwong, p. 1987) in the area of AR3 with that of the survey in 1992, it was observed that there was a 26 per cent increase in fishing income (from Baht 36,580 to Baht 46,083 per year), while the average debt of a fishing household decreased 21 per cent (from Baht 8523 in 1986 to Baht 6775 in 1992). These findings show that the living standard of fishing near AR3 had increased, with Engel's Coefficient decreasing from 75 per cent to 54 per cent.

28.5 *Awareness and perception of small-scale fisherfolk*

Ninetythree per cent of the fishermen in the villages near the ARs were aware of their installation and their positions, 68 per cent knew that ARs aggregated fish and 57 per cent believed that ARs could prevent trawlers from operating in the area. Fiftytwo per cent knew that they could catch more fish at ARs, but only 36 per cent felt that there was a saving of time by fishing at ARs. Forty per cent of the fishermen accepted that ARs enabled a longer fishing-season than before. Most of them accepted that ARs are suitable for small-scale fisheries and that ARs should be common property.

29. *CONCLUSIONS*

- ARs altered the structure of small-scale fisheries in the area by increasing the number of households as well as the number of small-scale fishing craft and gear, while reducing the participation by the trawlers.

- There were more opportunities created to fish with new types of gear.

- Although the income of fishing households was not very high, the standard of living in the areas near the ARs is higher than the average level of small-scale fisherfolk in Ranong Province.

- The selection of locations for ARs should be investigated in greater detail to ensure maximum benefit on the investment made.

- The deployment or installation process needs to be improved to ensure the expected formation of ARs, so as to ensure which will be most effective in meeting all project objectives.

- The present study had many limitations, such as:

  - insufficient pre-installation surveys;

  - incomplete seasonal coverage of environmental investigation;

  - inadequate underwater visual census and sampling of the catches by various gear, particularly of biological parameters such as length-frequencies, maturity stages of animals, spawning, and association of eggs, larvae and juveniles of commercially valuable species at the ARs.

- Data need to be gathered to determine the stocks in the area of the ARs and the changes in their biomass, in order to assess any enhancement of the resources.

- Experimental fishing needs to be continued systematically to establish viability and to determine developmental steps, including demonstration.

- The use of ARs as a management tool for nearshore areas, and regulation and control mechanisms for the fisheries, are yet to be established. A legal framework with jurisdiction over fishing rights needs to be introduced and implemented by Government.

PUBLICATIONS OF THE BAY OF BENGAL PROGRAMME (BOBP)

The BOBP brings out the following types of publications:

Reports (BOBP/REP/...) which describe and analyze completed activities such as seminars, annual meetings of BOBP's Advisory Committee, and subprojects in member-countries for which BOBP inputs have ended.

Working Papers (BOBP/WP/...) which are progress reports that discuss the findings of ongoing work.

Manuals and Guides (BOBP/MAG/...) which are instructional documents for specific audiences.

Information Documents (BOBP/INF/...) which are bibliographies and descriptive documents on the fisheries of member-countries in the region.

Newsletters *(Bay of Bengal News)* which are issued quarterly and which contain illustrated articles and features in nontechnical style on BOBP work and related subjects.

Other publications which include books and other miscellaneous reports.

Those marked with an asterisk (*) are out of stock but photocopies can be supplied.

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38. *Report of the Eleventh Meeting of the Advisory Committee,* Bangkok, Thailand, 26-28 March, 1987. (Madras, 1987.)

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59. *Report on Development of Canoes in Shri Lanka.* G Pajot, O Gulbrandsen. (Madras, 1993.)

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NOTE: Apart from these publications, the BOBP has brought out several folders, leaflets, posters etc.. as part of its extension activities. These include Post-harvest Fisheries folders in English and in some South Indian languages on anchovy drying, insulated fish boxes, fish containers, ice boxes, the use of ice etc. Several unpublished reports connected with BOBP's activities over the years are also available in its Library.

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