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

by

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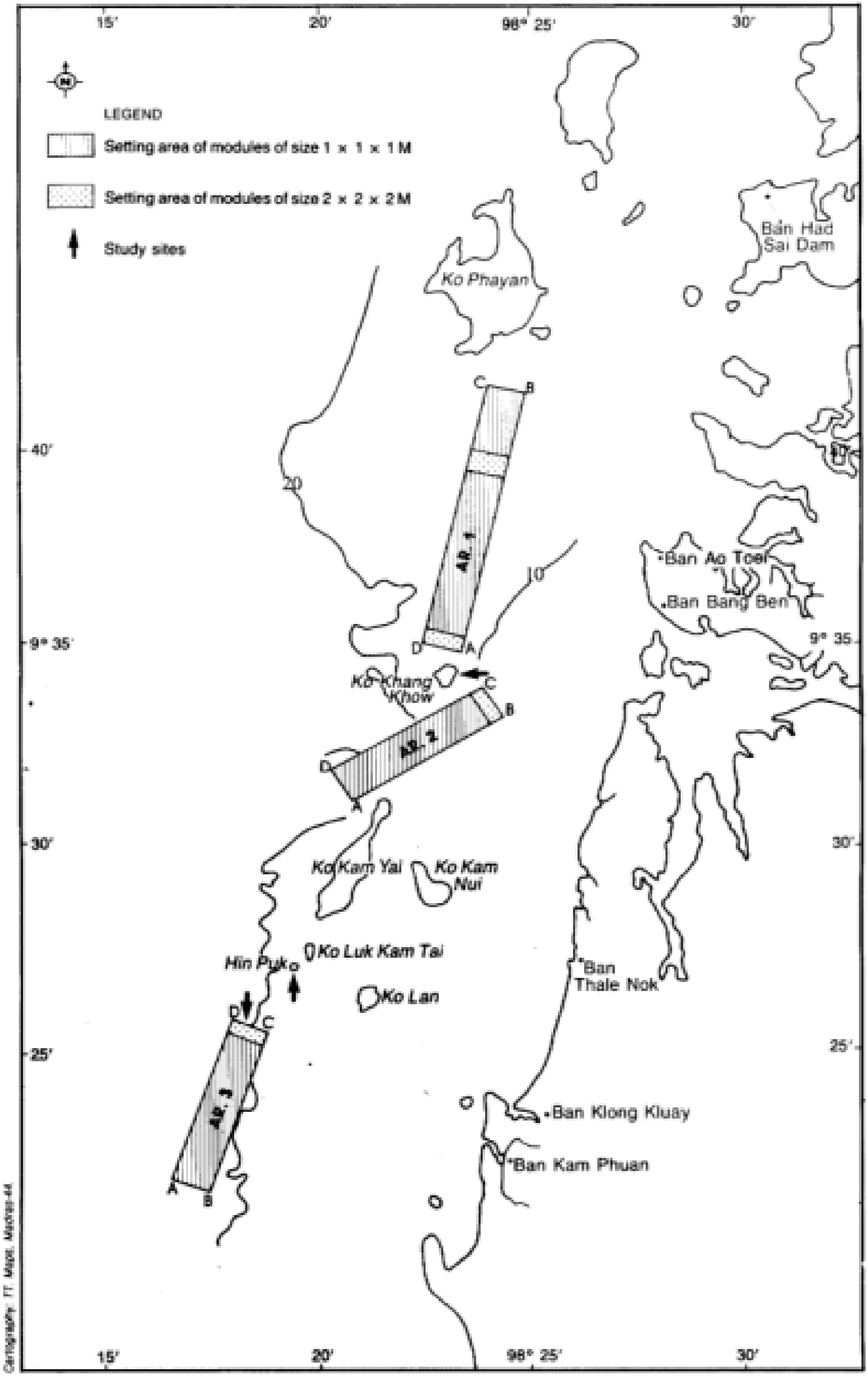
Fig 22. Study sites of AR3, Hin Puk and Ko Khang Khow in Ranong Province, Thailand



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).

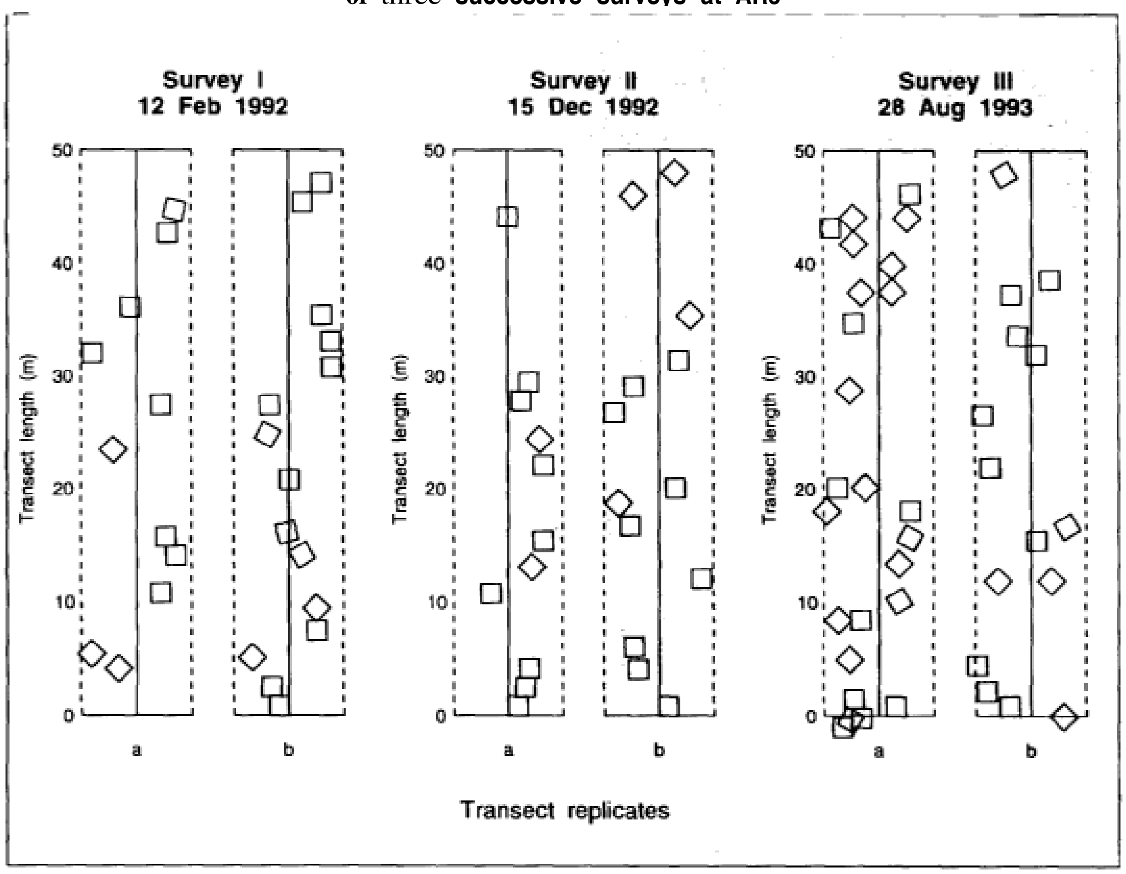
Table 7: Fish size and abundance categories applied for the study

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



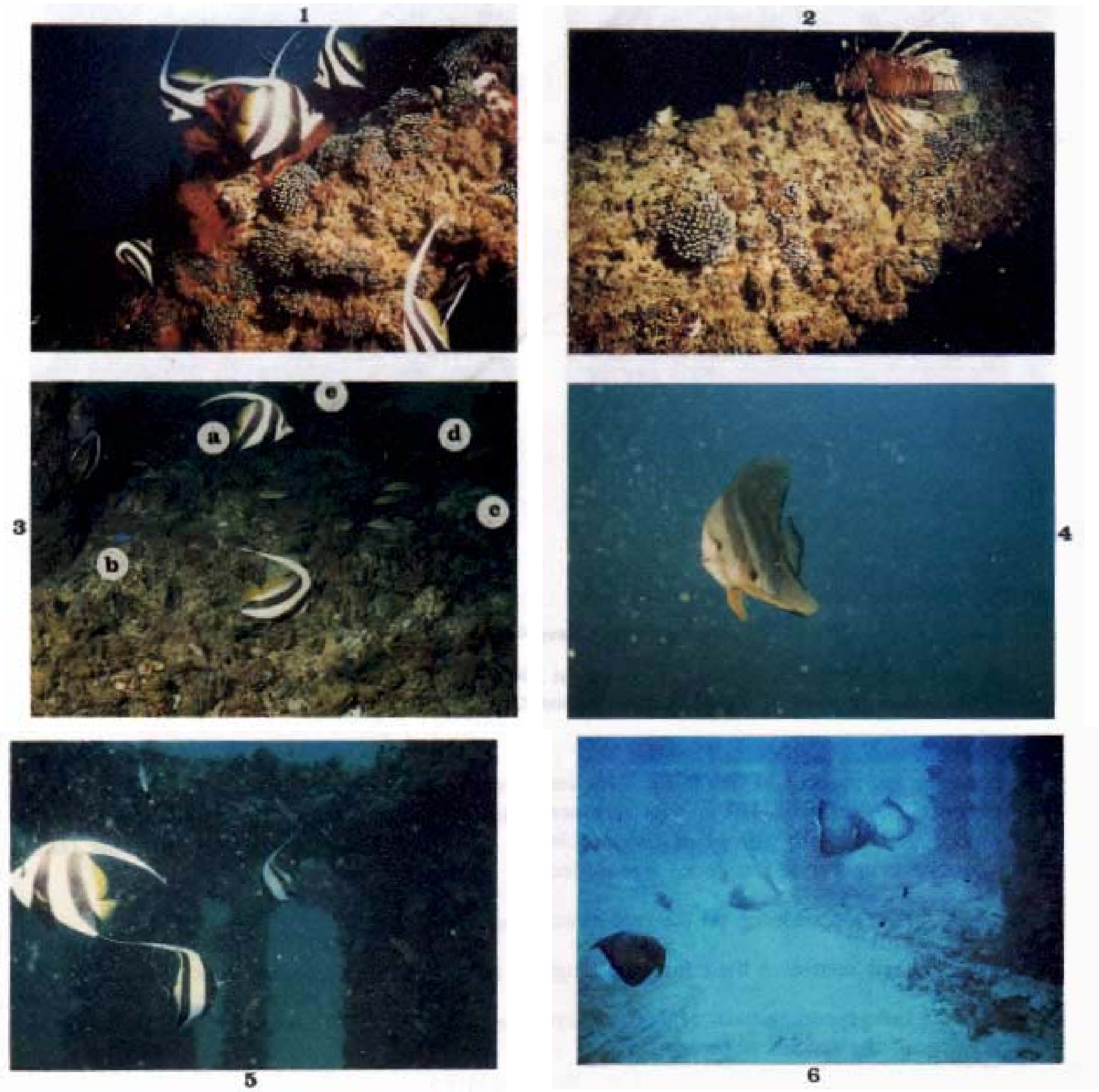
Total abundance used in calculations and graphic presentations were determined by summing the midpoints of the abundance categories for each species, except for the 7th abundance scale, for which the lower figure was used instead.

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*

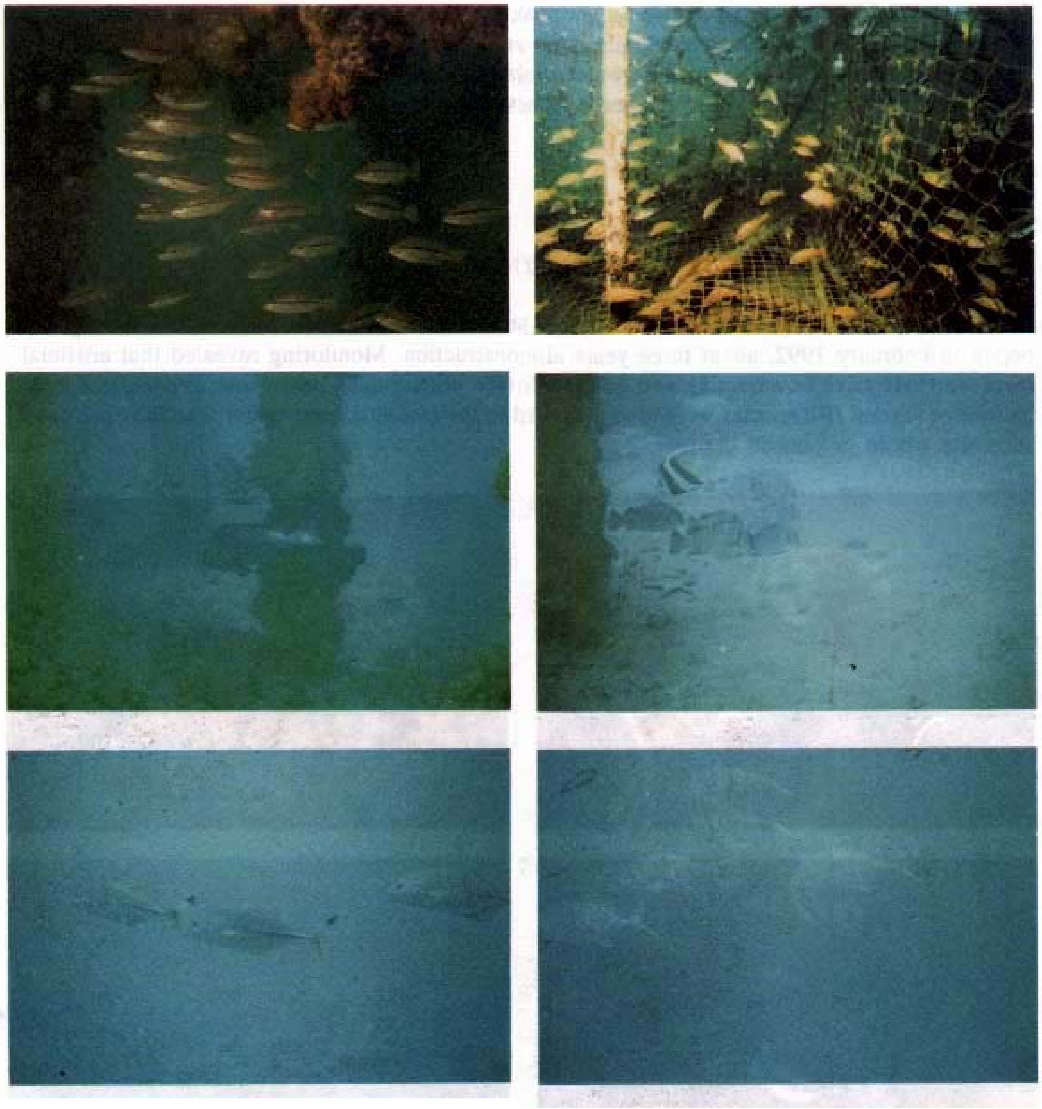
12.1 *Description offish aggregations at the artificial reef*

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.*



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.*

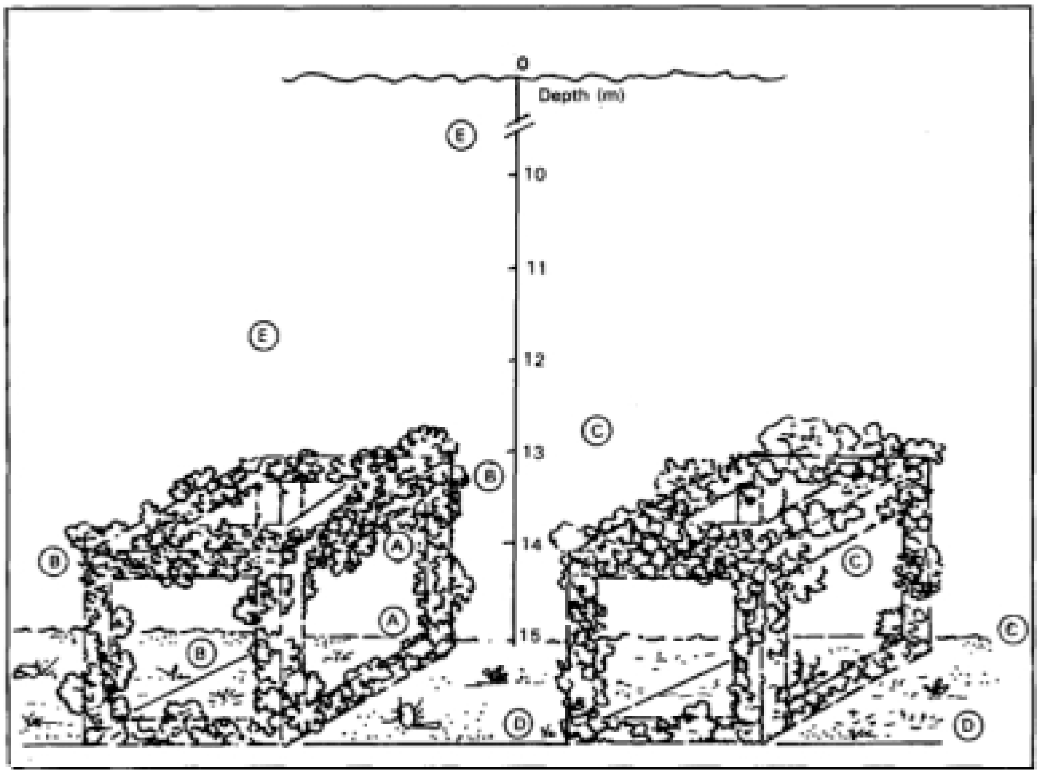
The presence and absence of fish in the three surveys during February 1992-April 1993 are shown in Appendix I. Altogether, 101 species representing 42 families of fish were encountered in the study area. The majority (82%) of fish species accounted were found to be residents (either permanent or temporary).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

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*	*II*	*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 nigrofasciata		•		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 pleuilaris*	•		•	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
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 milts*	•	•	•	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)

APPENDIX II

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

TAXA	Survey / Log4 Abundance scale	Survey / 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

Appendix II - *contd.*

TAXA	*Survey I* Log4 Abundance scale	Pre-dominant life history stage	*Survey II* Log4 Abundance scale	Pre-dominant life history stage	*Survey III* Log4 Abundance scale	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	I	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

Appendix II - *contd.*

TAXA	Survey / Log4 Abundance scale	Survey / 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	•		I	A	**2**	A
Arothron irnmaculatus			**I**	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

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*		*Survey II*		*Survey III*	
	Log4 Abundance scale	*Pre-dominant life history stage*	*Log4 Abundance scale*	*Pre-dominant life history stage*	*Log4 Abundance scale*	*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	-

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
Ptereleotris microlepsis	-		4	A	2	A
Valenciennea mularis	2	A	4	A	1	A
Valenciennea sexguttatus		2	A	3	A	-
GRAMMISTIDAE						
Diploprion bifasciatum	-		1	SA	-	
HAEMULIDAE (Sweetlips)						
* *Diagramma pictum*	1	A	-		3	A
LABRIDAE (Wrasses)						
Bodianus axillaris	1	A	-			
Bodianus diana	-		-		1	A
Bodianus mesothorax	-		-		x	A
Bodianus sp.	-		1	A	1	A
Diproctacanthus xanthurus	2	A	1	A	x	A
Cheilinus chlorourus	-		1	A	3	A
Cheilinus faciatus	*x*		2	A	1	A
Cheilinus trilobatus	2	A	-		-	
Cons variegata	-		x	A	x	A
Epibulus unsidiator		1	A	-		
Halichoeres argus	2	A	-			
Helichoeres chloropterus	3	SA	2	A	x	A
Helichoeres dussumieri	*4*	SA	4	A	-	
Helichoeres kallochroma		-		1	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*	-		1	A	4	A
MULLIDAE (Goatfish)						
* *Perupeneus barberinus*			*x*	A	x	A
* *Upeneus tragula*	1	A	-		3	A
MURAENIDAE (Morays)						
Gymnothoraxfavageneus	-		1	A	1	A
Gymnothorax permistus	-		1	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	-		-		1	A
PEMPHERIDAE						
Pempheris vanicolensis	3	A	4	A	4	A

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
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

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	LA		
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