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ภาคผนวกที่ 1

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Community structure of coral reef fishes at a sink reef in the inner Gulf of Thailand

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Abstract

Reef fish assemblages in the inner Gulf of Thailand exist in a low salinity, high sediment environment with limited connection to other reefs. Monitoring of reef fish assemblages at Khangkao Island from October 1997 to November 1998 revealed 83 species from 28 families. Pomacentridae was dominant in terms of both numbers of species and abundance. Small water column feeders (13 species, 40% abundance) and small herbivores (4 species, 39% abundance) dominated the assemblages. Invertebrate feeders and piscivores were less prominent, with a moderate number of species in low abundance. Canonical Discriminant Analysis (CDA) indicated that differences in species composition between sites arose because habitat is a major source of variation while the time of year of sampling and reef orientation with reference to seasonal winds were less important. Variation among stations was detected only in fish assemblages of the reef slope. Temporal variation was also detected but mainly on dominant fish taxa in each study site. Community parameters indicated pattern similar to the CDA where habitat is a major source of variation in species composition. The results suggested that fish assemblages on reef slopes had higher species and abundance than other habitats. The present structure of the fish assemblage of Khangkao Island illustrated a dramatic shift from the structure 10 years ago. Benthic invertebrate feeders declined severely while small plankton feeders and herbivores increased. This may reflect a pattern of increasing disturbance affecting reef fish assemblages in the inner Gulf of Thailand.

Keywords: reef fishes, community structure, connectivity, Gulf of Thailand

Introduction

Many marine organisms including reef fishes are assumed to have an open population (Johannes 1978). For coral reefs, this assumption leads to the concept of connectivity where source reefs facilitate seeding of sink reefs (Veron 1995). This concept also leads to the question of how different reefs maintain their populations and community of reef organisms. This question may also relate to disturbances influencing different reefs. The study of ecosystems at their environmental limits is ideal for examining ecological processes regulating population and community of reef organisms (Harriott and Simpson 1997).

Differences in reef fish assemblage structure have been recognized over different areas with different underlying causes. Different zoogeographic regions demonstrate very large-scale spatial variation due to evolutionary history and larval dispersal (Gladfelter et al. 1980; Findley and Findley 1985). The influence from land relating to reef development such as run-off water has been demonstrated for the Great Barrier Reef (Williams 1982; Williams and Hatcher 1983; Russ 1984) and Red Sea (Roberts et al. 1992). At smaller spatial scales, reef habitat variation due to geomorphological differences (Russ 1984; Galzin 1987) and also human disturbance (Parrish et al. 1988) are known. There has been little work, however, documenting the community structure of assemblages of individual reefs with limited connectivity in a low salinity and nutrient rich environment.

The inner part of the Gulf of Thailand (inner Gulf) is the northwest apex of the Gulf of Thailand. It has a squarish shape covering an area of 10,360 km^2 fringed by 300 km of coastline (3.2% of the total area and 4.3% of the coastline of the entire Gulf of Thailand). Coral formations are found only on the East Coast of the inner Gulf where a chain of islands known as Sichang Islands are located inner most. One of these, Khangkao Island, located in the southern most part of the Sichang Islands has the best-developed and largest area of coral formations. These coral formations are classified as coral assemblages and are characterized by poorly developed or no reef framework (Sakai et al. 1989). Primary factors limiting reef development here are low salinity and high nutrient concentrations maintained by runoff from four majors rivers (Siripong 1990). Water circulation is also limited where tidal currents cause north-south movements of water mass in the area (Hydrographic Department 1995). The connection to other reefs is limited as the nearest coral reefs are found only in the south. These coral formations at Khangkao Island can be considered as sink reefs from their position at downstream end. This raises the question of how these reefs maintain their populations and community structure. Furthermore, their sensitivity to any sources of disturbance is also in doubt.

In this study we investigated reef fish assemblages on such a reef system in a low salinity environment with limited larval supply from other reefs. A description of reef fish assemblages at Khangkao Island was first provided by Menasveta et al. (1986). To date, there is little new information on fish assemblages from this area. During this time, anthropogenic disturbances to this area had increased especially from port construction, rock mining and tapioca dust. The intention is to provide an updated description of the community structure of reef fishes and to determine their spatial and temporal variations.

Materials and methods

Study sites

Khangkao Island (13006χ30χN, 100048χE) is located in the southern most part of the Sichang Islands in the inner Gulf of Thailand (Fig. 1). It is 7 km off the East

Coast of Sriracha District, Chonburi Province and 30 km south of Bangpakong River. It is a small island (1.5 km x 0.8 km) with narrow strips of coral assemblages, generally 30-100 m in width and 3-5 m in depth. Reef development is generally limited. Structures of coral assemblages here were described by Sakai et al. (1986). Four localities around the island were selected for study, North reef (N), Northeast reef (NE), Southeast reef (SE), and Southwest reef (SW). The coral assemblages on each locality are subjected to different wind and wave action. The SW reef is exposed to the SW-monsoon and experiences the strongest wave action, while N and NE reefs are exposed to the NE-monsoon and receive only moderate wind and wave action. The SE reef is sheltered and relatively free from monsoonal influence.

Sampling procedures

This study was conducted from October 1997 to November 1998. Fishes were censured on 11 occasions spanning 14 months at 4 localities. These localities had 2 habitats, reef flat and reef slope, which differed in substrate types, depth and influence from wave action. The term "site" will be used to represent sampling of each habitat at each locality. At each site fishes were counted along 5 random transects each 30m long and 5m width. Transects were positioned with their long axis parallel to the shoreline and were separated by approximately 10-15m. Instantaneous visual census (Fowler 1987) was employed by a SCUBA diver who identified and counted fishes during the deployment of the measuring tape simultaneously. However, small and cryptic species, e.g. gobies and blennies were excluded from the census, as they were difficult to see and count accurately. Menasveta et al. (1986) showed the proportion of these groups at Khangkao Island was small, and we considered them to be only a minor component.

Fish community structure was categorized according to feeding niche of each species. These categories were defined on the basis of both visual observation and from a number of references (Williams and Hatcher 1983; Sano et al. 1987; Lewis 1997). The following categories are used:

A) Herbivores: Species feeding on algae or other plant materials and there were 3 recognized groups:

1. Site attached. Small species which feed within a small area, e.g. *Pomacentrus cuneatus, P. chrysurus*.
2. Gardener. Species which defend territories and feed on algae within their territories, e.g. *Hemiglyphidodon plagiomatopon, Stegates obreptrus*
3. Home range. Usually moderate to large species which feed over a large area, e.g. Siganids, Mugillids, Kyphosids

B) Omnivores: Species feeding on both plant and animal materials. They are organized into 2 groups:

4. Plankton feeders. The fishes of this group were usually small and had short home ranges. They hover over the substratum and feed on plankton or suspended materials in water column, e.g. *Abudefuf* spp., *Amblyglyphidodon* spp., *Neopomacentrus* spp.
5. Pelagic. Species of moderate size feeding on suspended materials and always swimming over large areas, e.g. Caesionids, Carangids

C) Carnivores: Species that feed exclusively on benthic invertebrates. Two groups were categorized based on their daily activities:

6. Diurnal feeders. Species feeding only during daytime e.g. Labrids, Chaetodontids, *Pomacanthus* spp., *Scolopsis* spp.

7. Nocturnal feeders. Species feeding only at night, e.g. Holocentrids, Apogonids and Pempherids

D) Piscivores: Species feeding primarily on other fishes.

8. Site attached. Small piscivores which have a limited home range, e.g. Serranids

9. Home range. Moderate to large piscivores which are restricted to a particular area or moving over a large area , e.g. Lutjanids, Haemulids

Data analyses

Canonical Discriminant Analysis (CDA) was employed to test the hypothesis that key dependent variables (fishes) were influenced by the factors in question. *A priori* tests were performed on the data matrix to verify that data satisfy the assumptions of parametric statistical methods (Clarke and Green 1988). Log (x+1) transformation, therefore, was applied to stabilize the variance of the data set. This transformation was also used to reduce the chance that a few extremely dominant species would skew the results of CDA. The CDA analysis was performed on the centered data matrix using SPSS 7.5 for Windows (SPSS Inc. 1997). The canonical structure of each species was used as the "responsive" factor for the discrimination of sites (i.e. the interpretation indicates species would be most different for two centroids). Angular interpretation was thus used to interpret the ordination plot produced by CDA.

Four parameters were considered as community characteristics; total abundance, species richness, diversity and evenness indexes. The abundance of all fishes at each site was calculated as the mean abundance from five replicates. Therefore, mean abundance of all fishes was expressed as individuals per 150 m^2. Species richness was a count of total species found in each site. A Shannon-Wiener diversity index (H' = -6

$p_i\log_e p_i$) and evenness index ($E = H'/\log_e S$) were calculated using natural logarithms throughout (Pielou 1974; Magurran 1988). Computation of these community parameters (except total abundance) was executed on mean abundance of each site rather than abundance of each transect. These parameters were considered as semi-quantitative variables rather than quantitative. For example, mean number of species of each site calculated from replicate transects tends to underestimate the actual number of species found at each site. The actual number of species of each site, therefore, should be the accumulative total from each replicate rather than averaged. This is also the problem when calculating the species diversity and evenness indices.

ANOVA was used to test the hypothesis that there are influences on community parameters by occasion (A), locality (B) and habitat (C). Full factorial three-way ANOVA was applied to the total abundance, while three-way ANOVA without replicates was applied to species richness, species diversity and evenness indexes. This is because these community parameters are calculated from mean of each site, and therefore lack replication. In this case, error mean square was assumed to be zero and then second order interaction MS is used as F-denominator (Sokal and Rohlf 1995). For statistical hypothesis testing, a significance level of 0.05 was used throughout the study, but the lowest level was also reported where appropriate.

Results

Assemblage structure

A total of 139,764 fishes were counted during study period. Species and mean abundance associated with each habitat at four localities around Khangkao Island are presented in Table 1. Eighty-three species belonging to 29 families were found.

Pomacentridae dominated this assemblage with 20 species and represented 76.87% of total abundance (Table 2). Five families were represented as minor components; Labridae, Apogonidae, Nemipteridae, Carangidae and Chaetodontidae, each family contributed 2-6 species and represented 2-6% of total abundance. The families Serranidae, Siganidae and Lutjanidae were each represented by 5-6 species. Only 1 or 2 species from each of several families were recorded. The relative abundance of these poorly represented families was less than 1%.

According to ecological categories (Table 3), omnivores and herbivores dominated the assemblage accounting for 82% of total abundance and represented by 32 species. Within these categories, small site-attached herbivores (39%) and water column feeders (40%) were the most dominant groups. Remarkably, small site-attached fish was represented by only 4 species dominated solely by *Pomacentrus cuneatus*. In comparison, water column feeders were represented by 13 species, dominated by *Neopomacentrus filamentosus, N. anabantoides* and *N. cyanomos*. Invertebrate feeders had the highest species number, 35 species but representing only about 18% of total abundance. Among this group, *Scolopsis* spp. and *Halichoeres* spp. were the most abundant. For the piscivores, 16 species were sighted but their abundance was low, representing less than 1%. Most of the piscivores found were small, certainly under 15 cm. in total length e.g. *Cephalopholis boenack*

Species composition

The results from CDA illustrated spatio-temporal variability in community structure of fish in the study area (Fig. 2). The first two discriminant functions explained 63.9% of total variance in the data set. It was clear that community structure of fish on the reef flat and the reef slope is distinct. Community structure of fish on the reef flat at all localities showed less variation and species characterizing this habitat were *Pomacentrus chrysurus* (POMCHR), *Abudefduf bengalensis* (ABUBEN) and *Gerres filamentosus* (GERFIL).

On the reef slope, by contrast, there were variations between localities where N and NE had similar structure while SW and SE had different structures. Fishes characterizing reef slopes of N and NE reefs were *Halichoeres purpurescens* (HALPUR), *Neopomacentrus filamentosus* (NPOFIL), *N. cyanomos* (NPOCYA), *N. bankerii* (NPOBAN), *N. anabantoides* (NPOANA), *Cheilodipterus quinquelineatus* (CDIQUI) and *Diploprion bifasciatus* (DIPBIF). The SE reef slope is characterized by *Neoglyphidodon nigroris* (NEONIG), *Hemiglyphidodon plagiometopon* (HEMPLA) and *Pomacentrus moluccensis* (POMMOL). *Apogon doederleini* (APODAF), A. cyanosoma (APOCYA) and *Halichoeres nigrescens* (HALNIG) dominate the reef slope of SW reef.

CDA of species composition over the entire sampling period showed a consistent pattern of the same site aggregated in the same group on different occasions. This result suggests that community structure of each site vary temporally in the major fish components.

Community parameters

Total abundance varies over test factors as there was significant Time x Locality x Habitat interaction (Table 4). Habitat, however, was a major source of variation accounting for 61.6% while Locality and Time explained less variation. As variation between localities was not prominent, total abundance was averaged across localities (Fig. 3a). Fishes on reef slopes (300-600 indiviuals/150m^2) were more abundant than those on reef flats (200 indiviuals/150m^2). However, fish abundance on reef slopes exhibited fluctuations over sampling occasions while fish abundance on reef flat remained relatively stable. Total abundance of fish on reef slopes was highest in December-January and in July-September, both maxima followed the influx of recruits the previous month (Manthachitra unpublished data).

Results from ANOVA suggested some variation on species richness over test factors, significantly Time x Locality and Locality x Habitat interactions. The variance components, however, indicated that Habitat (24.9%) and Time (22.2%) were the major contributing source of variation while other sources contributed less than 10%. Locality, therefore, was dropped and mean was illustrated for Time and Habitat (Fig. 3b). It is clear that species richness on reef slopes (22-32 species) was higher than that on reef flats (15-20 species). The number of species at both habitats over time had a similar pattern (non-significant interaction among Time x Habitat). There was some fluctuation over sampling occasion with species richness being highest in December, kept stable until dropping sharply in May, before increasing again with little fluctuation.

Habitat was also a major source of variation in species diversity and evenness indices, with their variance components representing 80.6% and 69.8% of total variance respectively (Table 3). There was significant effect from Locality x Habitat interaction on species diversity and evenness indices (Table 1). Fig. 3b and 3c illustrated that reef slope had higher fish diversity and more evenness than the reef flat. Species diversity at both habitats showed the same pattern of fluctuation over time. Species diversity index increased from October to a peak in January before decreasing slightly to July and then increasing again. For evenness index, the fluctuation over time was less prominent (no significant effects relevant to Time were detected).

Discussion

The prominent features of Khangkao's reef fish assemblages, in general, are low species diversity and absence of many reef fish taxa e.g. Acanthuridae. Considering the previous records of fishes at Khnagkao Island, Monkolprasit (unpublished report) recorded 40 species from – families. Menasveta et al. (1986) reported 70 species from 31 families including some cryptic species. Thus, species pool at Khangkao Island is estimated at 100 species. The reason for this low diversity is its geographic location in the innermost of the Gulf of Thailand. The location of this reef is comparable to near-shore reefs where the structure of reef fish assemblages is less complicated when compared with offshore reef (Williams and Hatcher 1983; Russ 1984). Furthermore, this reef also has limited connection to nearby reefs. The area of reef is also important, estimated at only 0.5 km^2 while the total reef area of the Sichang Islands is less than 1 km^2. Species and area relationship has been pointed out as one of the important ecological factors (Connor and McCoy 1979; Cornell and Karlson 2000).

Most significant in the reef fish assemblages at Khangkao Island is the domination of individuals from the family Pomacentridae. Which is consistent with the earlier investigation of Menasveta et al. (1986). However, the representation of other families differed in the two studies. Individuals from Pomacentridae and Labridae were more abundant in the present study while those from Apogonidae, Chaetodontidae, Pempheridae, Atherinidae and Serranidae were less abundant (Table 3). This result also suggested a shift in trophic structure from benthic invertebrate feeders to small herbivorous and plankton feeders.

Several studies reported spatial variability of fish assemblage structure. Williams and Hatcher (1983) illustrated cross-shelf variability of fish assemblage structure across the central Great Barrier Reef. They reported that for fish assemblages of inshore reefs planktivores and benthivores form the major component while algal feeders represent less than 10%. In contrast, Parrish et al. (1985) studying fish assemblages from pristine reefs of Hawaii found that benthic invertebrate feeders were the major component (57%) while algal and plankton feeders represented 22% and 10% respectively. They also reported that the three most species-rich families were Labridae, Acanthuridae and Chaetodontidae, and the three most abundant families were Gobiidae, Apogonidae and Pomacentridae. Parrish et al. (1985) illustrated that food availability is a factor structuring fish assemblage in each reef system. The assemblage structure of fish at Khangkao Island is quite different from the above studies. The geographical position and influence from land may contribute to this difference.

Spatial variation

Zonation patterns of fish assemblages on coral reefs are common (Russ 1984; Meekan et al. 1995). This study indicated that reef habitat is the main contributing factor to zonation patterns. Although the reef framework is less developed and distance and depth among habitats are relatively short, the assemblages of fish on the reef flat are distinct from those on the slope when considering both species composition and community parameters. Results from CDA illustrated that patterns of species composition of fish on the reef flat were similar over four localities. Locality variation was detected only for total abundance and species richness, but this factor contributes less variation than habitat and time.

In general, the assemblages of fish on the reef flat have relatively low individuals and number of species which agree with several studies (Russ 1984; Meekan et al. 1995). Low species diversity and evenness indices suggested that fish assemblages on the reef flat are dominated by a few species. This is shown by data on species composition where only *P. cuneatus* was the most abundant fish on the reef flat (80-150 individual/150m^2), but is not detected by CDA because of its wide distribution over both habitats. Fishes characterizing the reef flat were *Pomacentrus chrysurus* and *P. tripunctatus*, but their abundances were relatively low (<10 individual/150m^2). However *P. chrysurus* was also found on both habitats of SW reef which has the narrowest reef area. Meekan et al. (1995) found that *Pomacentrus bankanensis/chrysurus* characterized reef flat and crest zones of damselfishes at Lizard Island, GBR. *Abudefduf bengalensis* and *Gerres filamentosus* (*punctatus*) also characterized reef flats by their higher abundance.

The consistent pattern of fish assemblages on the reef flat over four localities can be explained by habitat structure as all localities have a sand stone platform with boulders except North reef with some sandy bottom (Sakai et al. 1986). Coral cover is relatively low and dominated by massive or submassive forms especially *Porites lutea* and *Pavona* spp.. This also suggests that wind and wave action from moonsoons have less influence on variability of fish assemblage on reef flats.

For reef slopes, in contrast, fish assemblages have relatively higher community parameter values than on reef flats. Overall, locality difference influenced species richness and abundance but was not significant. Species composition, however, was a more obvious indication of locality difference. Species composition on reef slope at North and Northeast reefs were similar where *Halichoeres purpurescens* and *Neopomacentrus* spp. had the greatest abundance. Both reefs have the highest wave influence during the NE monsoon in winter. Southeast reef receives waves from the south wind during summer. Fishes characterizing reef slope assemblages were *Neoglyphidodon melas* and *Hemiglyphidodon plagiometopon*. Southwest reef receives wave from the influence of SW monsoon during summer and its reef slope had more *Apogon doederleini*, *A. cyanosoma* and *Scolopsis ciliatus* than other reefs.

Temporal variation

There were no dramatic changes on the fish assemblages during 14 months of this study. It should be noted that widespread coral reef bleaching occurred in the Gulf of Thailand during the study (April – June 1998). At Khangkao Island, bleaching resulted in the decline of living coral especially *Acropora* spp. and *Porites lutea*. About 40% of living coral died after 6 months of the bleaching event (unpublished data). The impact on coral feeders was not prominent, as their diversity and abundance in the study area were already low. There was also no prominent change on other groups of fish. This can be explained as the effect was relatively short and physical structure of habitat did not change during the study period. Sano et al. (1987) illustrated that two years after the destruction of corals by *Acanthaster planci*, coral feeders disappeared completely from the impact area due to shortage of food supply, while other fishes decreased in both numbers of species and abundance due to destruction of habitat structure. The effect from coral reef bleaching is likely to be comparable to the effect from *A. planci* infestation. However, long term monitoring is needed to clarify the effect of habitat structure on fish assemblage at Khangkao Island.

The most prominent fluctuation, however, was in total abundance of reef slope fishes. Less fluctuations of species richness, species diversity and evenness suggested that seasonal variability were relatively similar. Less variation of species diversity and evenness also indicated that the abundance of most species varied through time but with different magnitude. In general, seasonal variability has two peaks, first during early summer (high temperature) and then during rainy season (high nutrients). Higher abundance of fishes resulted from the increased sub-adult population, following recruitment. This may indicate the role of recruitment on the structure of fish assemblage in the study area. However, the relative importance of recruitment on populations and assemblages of coral reef fishes at Khangkao is not known.

Most studies revealed that the extent of population change through time in reef fishes is species specific (Jones 1988) and some found less significance than spatial variability (Fowler 1990). In this study, members of two genera of the family Pomacentridae, *Pomacentrus* and *Neopomacentrus* mostly contributed a change in total abundance at the reef slope. This result agrees with the conclusion made from CDA that the variation of total abundance over time is the result of fish dominating in each site.

In conclusion, small site attached herbivores and small water column feeders dominate the assemblage structure of fish on coral reef at Khangkao Island. Pomacentrids characterized these fish assemblages with the highest number of species and abundance. This indicates the influence from terrestrial runoff, which supply nutrients and suspended food materials to the reef area. Habitat or reef zonation is the main contributing factor to variability of fish assemblage structure. Spatial and seasonal variations are less prominent. The absence or rare presence of piscivores may indicate intense fishing pressure and also limited recruitment. Community parameters suggested the fish assemblages to be relatively stable, although the present structure is different from that of earlier reports. This indicates a shift in the status of present fish assemblages over the past 10 -15 years as the pressure of disturbances increased. Processes determining this shift include habitat structure, food supply, predation and recruitment. There is little information on the recruitment of reef fishes in this area. Determination of the role of the recruitment process in structuring fish community in this area is necessary to show whether or not the larvae supply is limited by it geographical position. This study is the first to describe the spatio-temporal variability in the structure of reef fish assemblages at Khangkao Island. The present reef fish assemblage illustrated a simple structure under limited reef development and environmental constraints.

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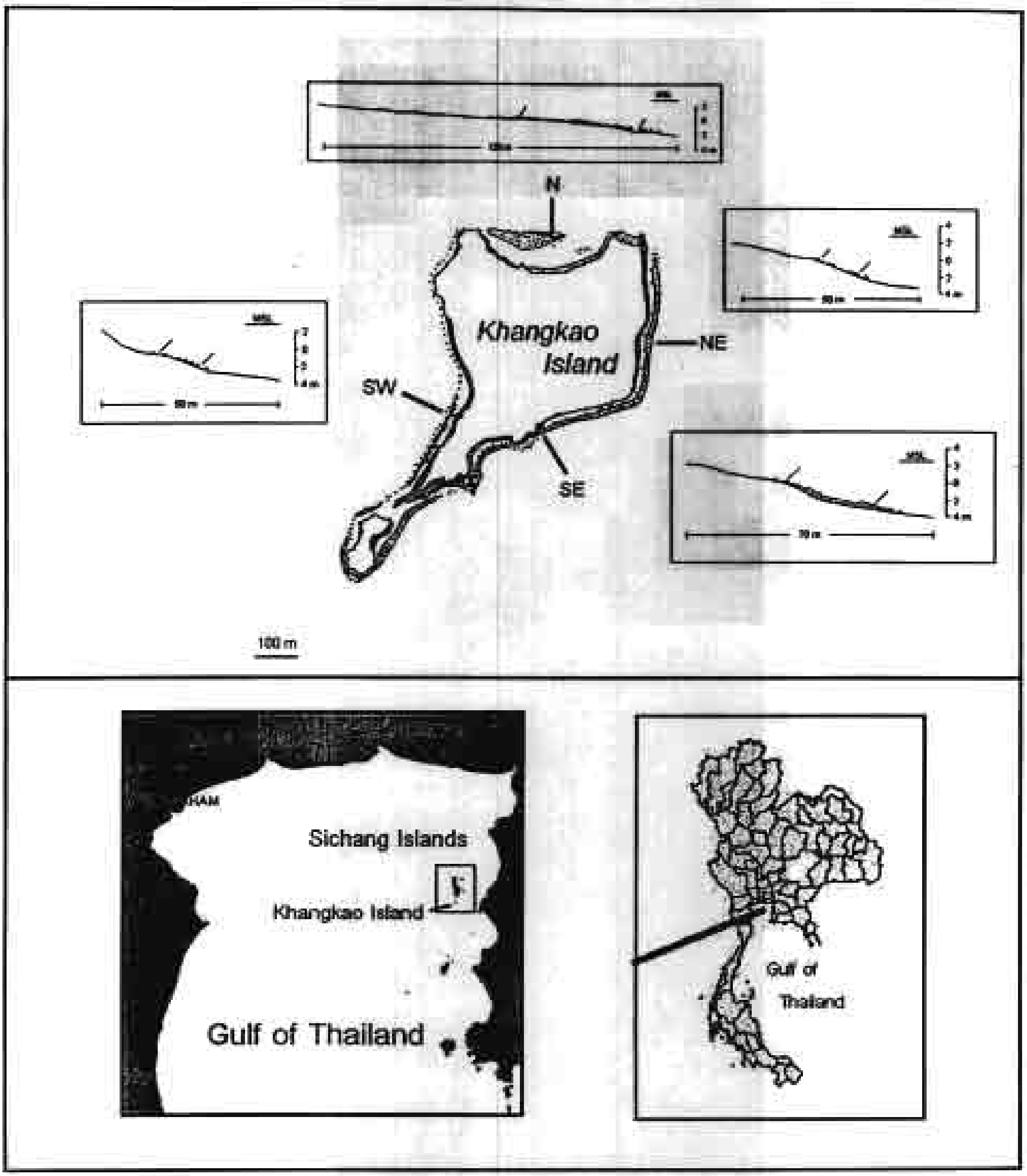

Figure 1. Map of Khangkao Island showing 4 study localities with profiles indicated 2 sampling habitats.

Table 1. Mean abundance ±SE (no./150m^2) by species of reef fishes observed on 2 habitats of 4 localities at Khangkao Island, inner Gulf of Thailand, during 1997-1998.

Species	Abbreviation	Trophic category	Residency	N Flat	N Slope	NE Flat	NE Slope	SE Flat	SE Slope	SW Flat	SW Slope
Pomacentridae											
Abudefduf bengalensis	ABUBEN	4	P	3.6 ± 0.5	3.8 ± 0.4	10.6 ± 1.3	7.0 ± 0.9	24.4 ± 2.7	7.2 ± 1.4	30.4 ± 3.1	26.4 ± 2.5
Abudefduf sexfasciatus	ABUSEX	4	P	0.9 ± 0.3	0.51 ± 0.2	-	0.4 ± 0.2	< 0.1	0.2 ± 0.1	3.5 ± 0.9	4.0 ± 1.0
Abudefduf vaigiensis	ABUVAI	4	P	-	-	-	-	< 0.1	-	0.1 ± 0.1	0.3 ± 0.1
Amblyglyphidodon curacao	AMBCUR	4	P	0.2 ± 0.1	0.2 ± 0.1	< 0.1	0.3 ± 0.1	0.2 ± 0.1	0.4 ± 0.1	< 0.1	-
Amphiprion perideraion	AMPPER	6	P	0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	0.3 ± 0.2	0.4 ± 0.1	0.3 ± 0.2	0.5 ± 0.1	0.3 ± 0.1
Chromis cinerascens	CHRCIN	4	P	0.9 ± 0.9	9.8 ± 4.8	-	0.8 ± 0.5	-	0.9 ± 0.8	-	-
Hemiglyphidodon plagiometopon	HEMPLA	2	P	0.2 ± 0.1	0.4 ± 0.1	0.1 ± 0.03	0.7 ± 0.1	0.5 ± 0.1	1.4 ± 0.2	-	-
Neoglyphidodon melas	NEOMEL	6	P	0.1 ± 0.1	< 0.1	-	-	0.2 ± 0.1	< 0.1	< 0.1	0.2 ± 0.1
Neoglyphidodon nigroris	NEONIG	6	P	0.1 ± 0.1	0.4 ± 0.1	< 0.1	0.4 ± 0.1	0.5 ± 0.1	3.3 ± 0.3	< 0.1	0.1 ± 0.1
Neopomacentrus anabatoides	NPOANA	4	P	12.0 ± 4.4	72.4 ± 12.7	2.0 ± 0.9	61.2 ± 14.2	0.2 ± 0.2	94.6 ± 16.5	1.8 ± 1.3	46.1 ± 9.5
Neopomacentrus cyanomos	NPOCYA	4	P	0.6 ± 0.6	34.0 ± 6.3	0.6 ± 0.6	44.1 ± 6.7	-	27.9 ± 5.9	-	15.1 ± 4.6
Neopomacentrus bankieri	NPOBAN	4	P	0.4 ± 0.4	23.2 ± 3.5	-	18.0 ± 3.3	-	32.6 ± 4.3	-	2.5 ± 0.6
Neopomacentrus filamentosus	NPOFIL	4	P	22.3 ± 4.7	156.2±19.7	2.4 ± 1.3	90.6 ± 10.4	-	70.0 ± 13.2	< 0.1	16.2 ± 3.8
Pomacentrus cuneatus	POMCUN	1	P	115.6 ± 7.2	139.2 ± 8.7	120.0 ± 3.8	83.4 ± 5.7	99.1 ± 5.1	129.5 ± 6.8	135.5 ± 6.3	155.6±10.0
Pomacentrus chrysurus	POMCHR	1	P	1.8 ± 0.2	0.1 ± 0.1	0.1 ± 0.1	12.2 ± 5.3	3.8 ± 0.4	< 0.1	0.5 ± 0.2	0.5 ± 0.3
Pomacentrus moluccensis	POMMOL	1	P	-	0.1 ± 0.1	-	0.7 ± 0.2	-	0.9 ± 0.2	-	-
Pomacentrus tripunctatus	POMTRI	1	P	0.2 ± 0.2	-	0.1 ± 0.1	-	0.1 ± 0.1	-	< 0.1	-
Plectroglyphidodon lacrymatus	PTOLAC	6	P	-	< 0.1	-	-	-	-	-	-
Cheiloprion labiatus	CHILAB	6	P	-	-	-	< 0.1	-	-	< 0.1	-
Stegastes obreptus	STEOBR	2	P	< 0.1	0.4 ± 0.1	0.2 ± 0.1	< 0.1	0.4 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	-
Labridae											
Halichoeres chloropterus	HALCHL	6	P	10.8 ± 0.8	8.6 ± 0.8	9.6 ± 0.9	9.7 ± 0.7	8.5 ± 0.8	9.9 ± 0.7	9.4 ± 0.7	11.2 ± 0.8
Halichoeres purpurascens	HALPUR	6	P	1.3 ± 0.2	5.4 ± 0.5	0.2 ± 0.1	3.2 ± 0.4	0.3 ± 0.1	5.0 ± 0.5	0.2 ± 0.1	3.4 ± 0.4

Table 1. Continued.

Species	Abbreviation	Trophic category	Residency	N Flat	N Slope	NE Flat	NE Slope	SE Flat	SE Slope	SW Flat	SW Slope
Halichoeres nigrescens	HALNIG	6	P	3.6 ± 0.4	5.1 ± 0.5	6.3 ± 0.5	4.9 ± 0.3	4.1 ± 0.3	4.3 ± 0.4	6.7 ± 0.5	9.7 ± 0.7
Halichoeres vrolikii	HALVRO	6	P	0.3 ± 0.2	0.6 ± 0.2	-	-	0.1 ± 0.1	0.9 ± 0.3	-	0.3 ± 0.1
Halichoeres poecilopterus	HALPOE	6	P	0.3 ± 0.1	0.1 ± 0.1	-	< 0.1	-	0.1 ± 0.1	-	0.3 ± 0.1
Hemigymnus melapterus	HEMMEL	6	P	-	-	-	< 0.1	< 0.1	< 0.1	-	-
Cheilinus fasciatus	CHIFAS	6	P	-	-	-	-	-	< 0.1	-	-
Choerodon schoenleinii	CHESCH	6	P	-	-	-	-	-	-	-	< 0.1
Apogonidae											
Apogon doederleini	APODOE	7	P	0.6 ± 0.4	1.6 ± 0.9	-	5.6 ± 2.2	-	2.2 ± 1.1	0.6 ± 0.6	35.5 ± 6.3
Apogon cyanosoma	APOCYA	7	P	-	5.3 ± 2.2	-	2.6 ± 1.0	-	0.6 ± 0.6	0.1 ± 0.1	11.8 ± 3.0
Archamia fucata	ARCFUC	7	P	-	-	-	0.3 ± 0.2	-	0.1 ± 0.1	-	-
Cheilodipterus quinquelineatus	CDIQUI	7	P	0.1 ± 0.1	10.7 ± 1.8	-	4.0 ± 0.9	-	6.8 ± 1.6	-	11.2 ± 4.6
Cheilodipterus macrodon	CDIMAC	7	P	-	3.3 ± 1.0	-	0.3 ± 0.2	-	1.8 ± 0.9	-	-
Cheilodipterus artus	CDIART	7	P	-	3.4 ± 1.7	-	0.4 ± 0.4	-	-	-	-
Serranidae											
Cephalopholis boenak	CEPBOE	8	P	0.9 ± 0.2	1.3 ± 0.2	1.8 ± 0.3	0.3 ± 0.1	0.6 ± 0.1	1.5 ± 0.2	2.1 ± 0.3	2.8 ± 0.3
Cephalopholis formosa	CEPFOR	8	P	< 0.1	0.4 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	< 0.1	0.4 ± 0.1	< 0.1	0.4 ± 0.1
Cephalopholis cyanostigma	CEPCYA	8	P	-	-	-	-	< 0.1	-	-	-
Epinephelus merra	EPIMER	8	P	< 0.1	-	-	-	< 0.1	-	< 0.1	< 0.1
Epinephelus fasciatus	EPIFAS	8	P	-	-	-	-	-	-	-	< 0.1
Epinephelus malabricus	EPIMAL	8	P	-	< 0.1	-	< 0.1	-	-	-	-
Siganidae											
Siganus guttatus	SIGGUT	3	V	0.6 ± 0.2	2.2 ± 0.5	0.3 ± 0.1	5.3 ± 1.0	2.5 ± 0.9	3.1 ± 0.5	0.5 ± 0.2	1.2 ± 0.6
Siganus javus	SIGJAV	3	V	< 0.1	1.0 ± 0.7	< 0.1	0.7 ± 0.3	1.2 ± 0.9	0.1 ± 0.1	0.2 ± 0.1	2.3 ± 1.0
Siganus virgatus	SIGVIR	3	V	-	-	-	< 0.1	< 0.1	-	-	-

Table 1. Continued.

Species	Abbreviation	Trophic category	Residency	N Flat	N Slope	NE Flat	NE Slope	SE Flat	SE Slope	SW Flat	SW Slope
Siganus canaliculatus	SIGCUN	3	V	-	-	-	0.6 ± 0.3	0.3 ± 0.3	0.6 ± 0.4	< 0.1	0.1 ± 0.1
Siganus corallinus	SIGCOR	3	V	-	-	< 0.1	-	-	< 0.1	-	-
Lutjanidae											
Lutjanus argentimaculatus	LUTARG	9	P	-	-	-	-	-	< 0.1	-	-
Lutjanus russelli	LUTRUS	9	P	-	0.4 ± 0.2	-	0.5 ± 0.3	-	2.9 ± 1.9	< 0.1	< 0.1
Lutjanus vitta	LUTVIT	9	P	-	0.1 ± 0.1	-	1.8 ± 0.7	-	1.3 ± 0.7	-	0.5 ± 0.2
Lutjanus carponotatus	LUTCAR	9	P	-	0.1 ± 0.1	-	-	-	0.5 ± 0.2	-	-
Lutjanus fulviflamma	LUTFUL	9	P	< 0.1	< 0.1	-	-	-	< 0.1	-	-
Nemipteridae											
Scolopsis dubiosus	SCODUB	6	V	1.0 ± 0.2	0.6 ± 0.2	0.1 ± 0.1	1.1 ± 0.3	0.4 ± 0.1	0.3 ± 0.1	0.4 ± 0.1	0.9 ± 0.2
Scolopsis margaritifer	SCOMAR	6	V	2.2 ± 0.4	1.2 ± 0.2	2.3 ± 0.4	1.7 ± 0.3	1.4 ± 0.3	1.5 ± 0.3	0.2 ± 0.1	1.1 ± 0.3
Scolopsis ciliatus	SCOCIL	6	V	5.7 ± 1.0	5.7 ± 1.0	4.0 ± 0.5	20.0 ± 2.9	1.2 ± 0.3	8.6 ± 1.4	5.5 ± 0.8	17.1 ± 1.9
Scolopsis vosmeri	SCOVOS	6	V	-	-	-	0.02 ± 0.02	-	0.04 ± 0.03	-	-
Carangidae											
Atule mate	ATUMAT	5	V	1.8 ± 0.8	4.5 ± 1.4	0.5 ± 0.3	4.5 ± 1.3	1.6 ± 1.0	6.7 ± 2.3	1.5 ± 0.7	17.4 ± 4.5
Selaroides leptolepis	SELLEP	5	V	0.3 ± 0.2	1.2 ± 1.0	< 0.1	0.1 ± 0.1	-	0.3 ± 0.2	0.3 ± 0.2	2.0 ± 1.0
Gnathanodon speciosus	GNASPE	5	V	< 0.1	-	-	-	-	-	< 0.1	< 0.1
Haemulidae											
Plectorhynchus chaetodonoides	PLECHE	9	P	-	-	-	< 0.1	-	< 0.1	-	-
Plectorhynchus gibbosus	PLEGIB	9	P	-	0.1 ± 0.1	-	< 0.1	-	< 0.1	-	-
Diagramma pictum	DIAPIC	9	P	-	0.2 ± 0.1	-	< 0.1	-	< 0.1	-	< 0.1
Chaetodontidae											
Chaetodon octofasciatus	CHEOCT	6	P	8.0 ± 1.6	7.6 ± 0.9	6.0 ± 0.7	6.5 ± 0.7	6.6 ± 0.6	6.0 ± 0.6	5.2 ± 0.5	6.5 ± 0.7
Chelmon rostratus	CELROS	6	P	0.2 ± 0.1	0.3 ± 0.1	-	0.1 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.1 ± 0.1	0.3 ± 0.1

Table 1. Continued.

Species	Abbreviation	Trophic category	Residency	N Flat	N Slope	NE Flat	NE Slope	SE Flat	SE Slope	SW Flat	SW Slope
Mugilidae											
Ellochelon vaigiensis	ELLVAI	3	V	-	-	-	0.1 ± 0.1	0.2 ± 0.2	-	0.1 ± 0.1	-
Moolgarda seheli	MOLSEH	3	V	-	-	-	1.4 ± 0.7	0.4 ± 0.2	0.7 ± 0.6	< 0.1	0.5 ± 0.4
Pomacanthidae											
Pomacanthus annularis	POCANN	6	P	-	< 0.1	-	-	-	< 0.1	-	-
Pomacanthus sexstriatus	POCSTR	6	P	< 0.1	0.2 ± 0.1	< 0.1	< 0.1	0.2 ± 0.1	0.4 ± 0.1	-	0.3 ± 0.1
Dasyatidae											
Taeniura lymma	TAELYM	6	P	< 0.1	< 0.1	-	-	-	-	-	-
Gobiesocidae											
Diademaichthys lineatus	DIALIN	4	P	< 0.1	0.6 ± 0.1	< 0.1	0.1 ± 0.1	-	0.3 ± 0.1	< 0.1	0.6 ± 0.1
Holocentridae											
Sargocentron rubrum	SARRUB	7	P	< 0.1	4.6 ± 1.0	< 0.1	2.7 ± 0.8	< 0.1	0.2 ± 0.1	0.2 ± 0.1	1.1 ± 0.3
Centropomidae											
Psammoperca waigiensis	PSAWAI	8	P	< 0.1	< 0.1	< 0.1	< 0.1	-	< 0.1	-	-
Grammistidae											
Diploprion bifasciatus	DIPBIF	6	P	0.4 ± 0.1	1.7 ± 0.2	0.5 ± 0.2	1.7 ± 0.2	0.2 ± 0.1	1.6 ± 0.3	0.1 ± 0.1	1.8 ± 0.3
Leiognathidae											
Leiognathus equulus	LOGEQU	6	V	-	-	-	-	-	-	< 0.1	-
Caesionidae											
Caesio cuning	CAECUN	5	V	0.1 ± 0.1	0.8 ± 0.4	-	1.8 ± 0.8	-	3.7 ± 1.2	-	7.1 ± 1.9
Gerreidae											
Gerres filamentosus	GERFIL	6	V	< 0.1	-	0.2 ± 0.2	0.1 ± 0.1	1.8 ± 0.8	0.3 ± 0.2	11.8 ± 3.4	0.9 ± 0.4
Mullidae											
Upeneus tragula	UPETRA	6	V	0.2 ± 0.1	< 0.1	0.2 ± 0.1	4.3 ± 2.0	0.2 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	0.5 ± 0.1

Table 1. Continued.

Species	Abbreviation	Trophic category	Residency	N Flat	N Slope	NE Flat	NE Slope	SE Flat	SE Slope	SW Flat	SW Slope
Pempheridae											
Pempheris oualensis	PEMOUL	7	P	-	4.2 ± 1.4	-	2.3 ± 0.7	-	5.3 ± 1.3	-	9.6 ± 2.6
Kyphosidae											
Kyphosus vaigiensis	KYPVAI	3	V	-	-	-	< 0.1	0.3 ± 0.1	0.2 ± 0.1	< 0.1	-
Sphyraenidae											
Sphyraena obtusata	SPYOBT	9	V	1.5 ± 1.1	0.2 ± 0.2	-	-	-	-	-	-
Scaridae											
Scarus ghobban	SCAGHO	3	V	-	-	-	-	< 0.1	< 0.1	-	-
Microdesmidae											
Ptereleotris sp.	PTE	4	P	0.9 ± 0.9	9.5 ± 4.0	1.6 ± 1.6	28.0 ± 6.5	-	-	0.1 ± 0.1	-
Monacanthidae											
Monacanthus chinensis	MONCHI	6	V	< 0.1	< 0.1	-	-	-	-	< 0.1	< 0.1
Ostraciidae											
Ostracion cubicus	OSTCUB	6	P	< 0.1	< 0.1	< 0.1	0.14 ± 0.06	-	< 0.1	0.11 ± 0.05	0.18 ± 0.05
Diodontidae											
Diodon liturosus	DIOLIT	6	P	< 0.1	-	< 0.1	< 0.1	-	-	-	< 0.1

Table 2. Major coral reef fish families found at Khangkao Island during 1997-1998 compare with 1984 (Menasveta et al., 1986).

	1997/98		1984	
Family	No. species	% abundance	No. species*	% abundance
Pomacentridae	20	76.9	10	54.1
Labridae	8	5.6	4	1.6
Apogonidae	6	4.2	5	15.5
Serranidae	6	0.5	2	2.9
Siganidae	5	0.9	-	-
Lutjanidae	5	0.3	4	<1
Nemipteridae	4	3.2	-	-
Carangidae	3	1.7	1	<1
Haemulidae	3	0.02	-	-
Chaetodontidae	2	2.1	2	6.9
Mugilidae	2	0.1	-	-
Pomacanthidae	2	0.05	-	-
Others	17	4.5	42	ca. 19
Total	83	100	70	100

* including cryptic species

Table 3. Composition of fish assemblage on coral reef of Khangkao Island classified based on ecological guild.

Ecological guilds	No. species	% abundance
A) Herbivores	**15**	**39.7**
1. Site attach	4	38.5
2. Gardener	2	0.2
3. Homerange	9	1.0
B) Omnivores	**17**	**41.8**
4. Water column	13	39.6
5. Pelagic	4	2.2
C) Invertebrate feeders	**35**	**17.5**
6. Substrate feeders	27	12.1
7. Nocturnal feeders	8	5.4
D) Predators	**16**	**0.9**
8. Site attach	7	0.6
9. Homerange	9	0.4
Total	83	100

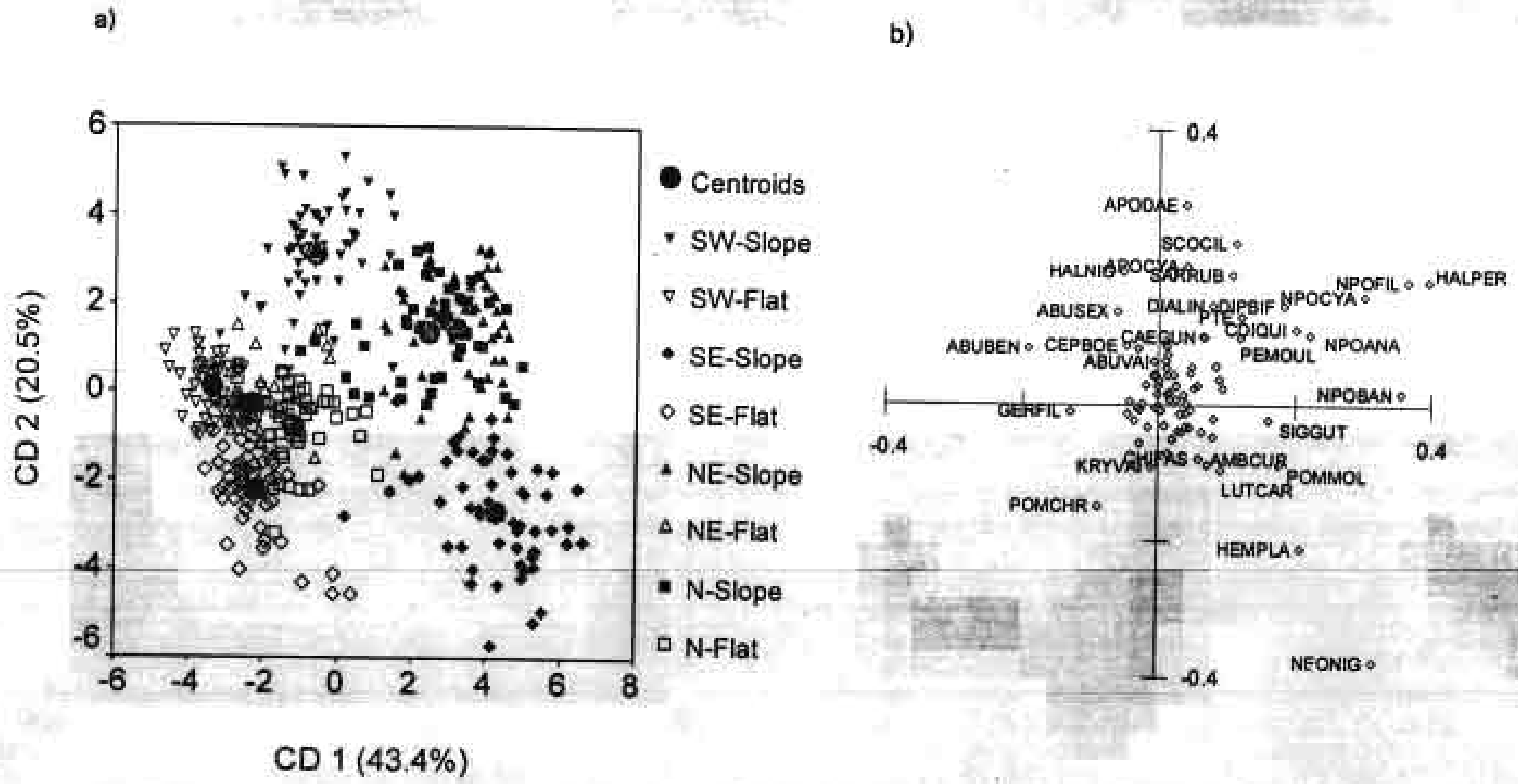

Figure 2. Ordination plots from Canonical Discriminant Analysis illustrated spatio-temporal variability of fish assemblages on coral reef at Khangkao Island; a) Site scores and b) Canonical structures of species (some species are presented due to overcrowd problem).

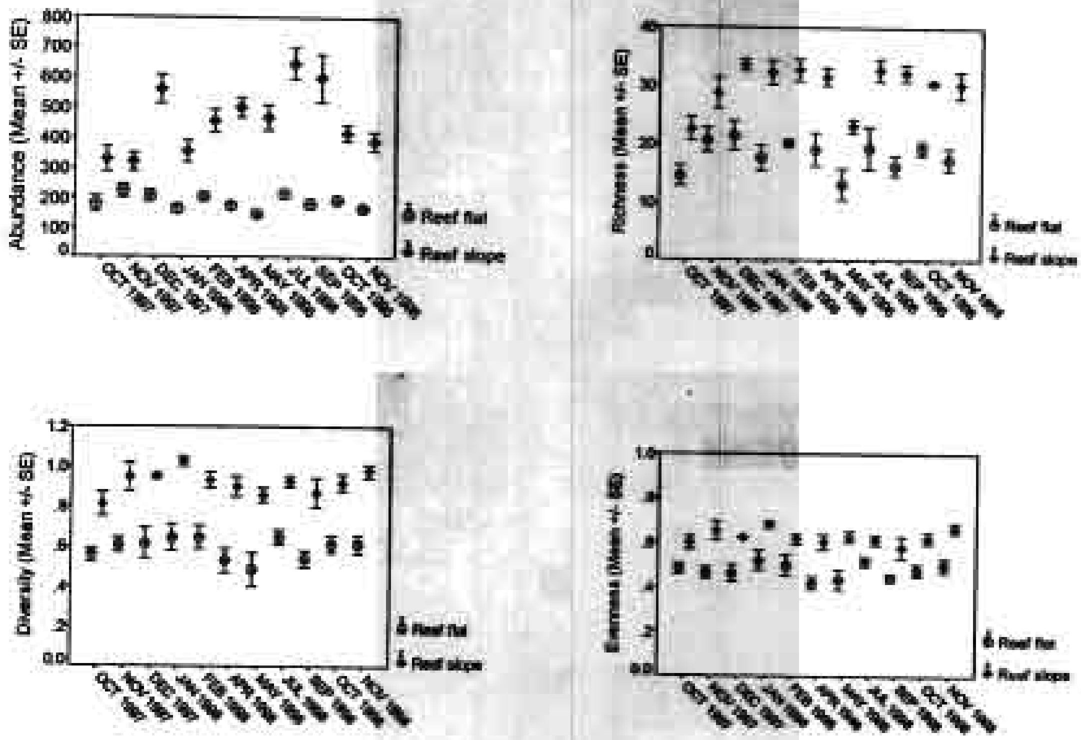

Figure 3. Community parameters of fish on coral reef at Khangkao Island indicated variation through time and between habitats.

Table 4. ANOVA table showing testing factors effect on four community parameters. ABC interaction is used as F denominator for species richness, Diversity and Evenness Index. * significant at P <0.05 and ns – non-significant.

SOV		Total abundance			Species richness			Diversity			Evenness		
	Df	MS	F	%VC	MS	F	%VC	MS	F	%VC	MS	F	%VC
Time (A)	10	0.18	10.43*	3.7	69.88	8.95*	22.2	11.80	3.38*	0.34	6.10	2.12^{ns}	2.48
Locality (B)	3	0.12	7.12*	0.1	80.76	10.34*	9.5	2.20	0.63^{ns}	-	1.38	0.48^{ns}	-
Habitat (C)	1	15.03	871.44*	61.6	3052.57	390.95*	24.9	1253.60	358.99*	80.57	504.00	175.61*	69.84
AB	29	0.14	7.93*	10.8	15.43	1.98*	10.9	5.41	1.56^{ns}	2.85	4.03	1.41^{ns}	3.57
AC	10	0.09	5.43*	3.5	9.74	1.25^{ns}	1.4	1.40	0.40^{ns}	-	1.81	0.63^{ns}	-
BC	3	0.11	6.27*	1.5	42.02	5.38*	8.9	28.10	8.05*	6.34	14.20	4.95*	7.76
ABC	29	0.04	2.08*	3.4	7.81		22.3	3.49		9.90	2.88		17.75
Error	344	0.02		15.6	-	-	-	-	-	-	-	-	-

ภาคผนวกที่ 2

การประชุมเพื่อเสนอผลงานวิจัย

โครงการทุนวิจัยหลังปริญญาเอก

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ผศ.ดร. สุรพล สุดารา

Community structure, spatio-temporal variation and recruitment of fishes on coral reefs at the inner Gulf of Thailand

Vipoosit Manthachitra and Suraphol Sudara

Fish assemblages on coral reefs at the inner Gulf of Thailand are subjected to low salinity but high sediment environment and also limited connection to other reefs. Results from the monitoring of reef fish assemblages at Khangkao Island during October 1997 to November 1998 found 83 species from 28 families. Small water column feeders (15 species, 39.63% abundance) and small herbivores (4 species, 38.54% abundance) dominated in the assemblages while predatory fish had moderate number of species but very low abundance (16 species, 0.91% abundance). Canonical discriminant analysis indicated the variation of fish assemblage over spatial and temporal scales which habitat is the major source of variation. Variation among stations was detected only on fish at reef slope and temporal variation was also detected but occurred mainly on fishes dominated in each study area. Community parameters indicated a similar pattern where habitat was a major source of variation. There were 33 species recruit during study periods, indicated different recruitment strategies among species of fishes in the study area. This is a significant factor that structure and maintains fish assemblage in this limited environment.

โครงสร้างสังคม, ความผันแปรจากพื้นที่และเวลา และการทดแทนประชากรของปลาในแนวปะการังบริเวณตอนในสุดของอ่าวไทย

วิภูษิต มัณฑะจิตร และ สุรพล สุดารา

กลุ่มปลาที่อาศัยอยู่ในแนวปะการังบริเวณหมู่เกาะสีชัง ซึ่งอยู่ตอนในสุดของอ่าวไทย อยู่ในสิ่งแวดล้อมที่มีความเค็มต่ำแต่ตะกอนมาก และติดต่อกับแนวปะการังอื่นเฉพาะจากทางทิศใต้ ผลจากการติดตามโครงสร้างสังคมของกลุ่มปลาแนวปะการังที่เกาะค้างคาว ระหว่างเดือนตุลาคม 2540 ถึง พฤศจิกายน 2541 พบปลา 83 ชนิดจาก 28 วงศ์ กลุ่มปลาที่พบเป็นองค์ประกอบหลักเป็นปลาขนาดเล็กกินอาหารจากมวลน้ำ (15ชนิด และ 39.63 %ของความชุกชุม) และปลาขนาดเล็กที่กินพืชเป็นอาหาร (4 ชนิด, 38.54%ของความชุกชุม) ปลากินเนื้อพบจำนวนชนิดปานกลางแต่ความชุกชุมต่ำมาก ผลจาก Canonical Discriminant Analysis แสดงให้เห็นความผันแปรจากปัจจัยพื้นที่และเวลาของโครงสร้างสังคมว่ามาจากแหล่งที่อยู่มากกว่าจากสถานี สำหรับความผันแปรจากเวลาเกิดเฉพาะกับองค์ประกอบหลักในแต่ละสถานีที่ทำการศึกษา เมื่อพิจารณาพารามิเตอร์ทางสังคม พบว่ากลุ่มปลาในเขต reef slope มีความสมบูรณ์กว่าในเขต reef flat ส่วนความแตกต่างระหว่างสถานีและระหว่างเวลามีน้อย การทดแทนประชากรของปลาพบรวม 33 ชนิด แสดงให้เห็นว่าปลาแต่ละชนิดมีลักษณะการทดแทนประชากรที่แตกต่างกัน และเป็นปัจจัยสำคัญที่มีผลต่อโครงสร้างสังคมและการดำรงอยู่ของสังคมปลาในบริเวณนี้

reef fishes, community structure, spatio-temporal variation, recruitment, Gulf of Thailand

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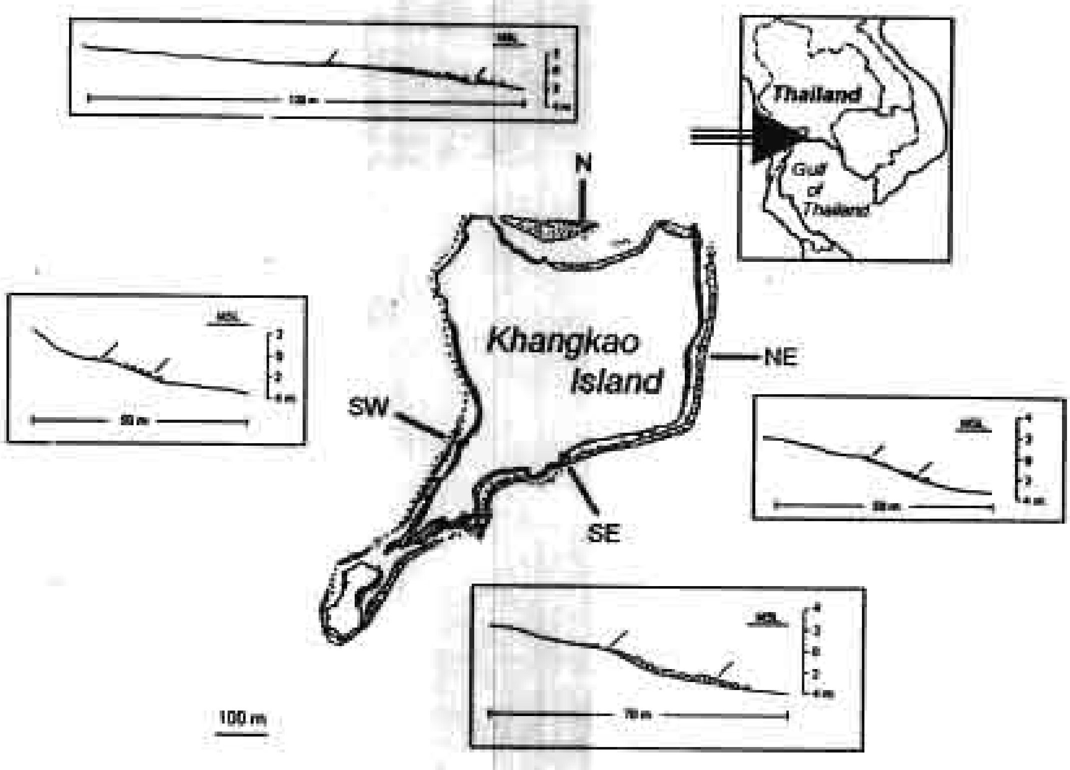
วิภูษิต (2544) การผันแปรตามเวลาและการทดแทนประชากรของปลาแนวปะการังบริเวณหมู่เกาะสีชัง (ส่วนในสุดของอ่าวไทย)

ชื่อเรื่อง (ภาษาอังกฤษ) **Community structure, spatio-temporal variation and recruitment of fishes on coral reefs at the inner Gulf of Thailand**

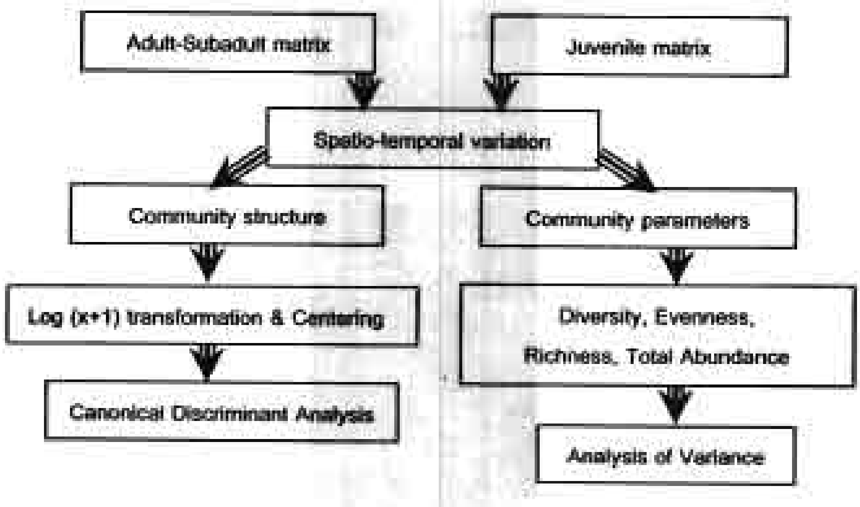
Study sites



Sampling

1. Factorial design: Time (11), Location (4), Habitat (2), 5 replicates
2. SCUBA Diving
3. Visual census: Identified & Count along 30x5 m^2 transect
4. Adult-Subadult assemblages & Juvenile assemblages

Data analysis



ชื่อเรื่อง (ภาษาอังกฤษ) **Community structure, spatio-temporal variation and recruitment of fishes on coral reefs at the inner Gulf of Thailand**

Table 1. Major coral reef fish families found at Khangkao Island during 1998.

Family	Guilds	No. species	% abundance	No. species recruit
Pomacentridae	1,2,4	20	76.87	10
Labridae	6	8	5.57	6
Apogonidae	7	6	4.23	3
Serranidae	7,8	6	0.50	2
Siganidae	3	5	0.88	
Lutjanidae	8	5	0.32	1
Nemipteridae	6	4	3.21	3
Carangidae	5	3	1.67	1
Haemulidae	9	3	0.02	
Chaetodontidae	6	2	2.06	1
Gerreidae	6	2	0.60	
Mugilidae	3	2	0.13	1
Pomacanthidae	6	2	0.05	1
Others	4,5,6,7,8,9	15	3.89	4
Total		83	100	33

Table 2. Composition of coral reef fish assemblages based on ecological guilds.

Ecological guilds	No. species		% abundance	
A) Herbivores	15		39.74	
1. Site attach		4		38.54
2. Gardener		2		0.17
3. Homerange		9		1.03
B) Omnivores	19		41.82	
4. Water column		15		39.63
5. Pelagic		4		2.19
C) Invertebrate feeders	33		17.52	
6. Substrate feeders		25		12.10
7. Nocturnal feeders		8		5.42
D) Predators	16		0.91	
8. Site attach		7		0.57
9. Homerange		9		0.35
Total		83		100

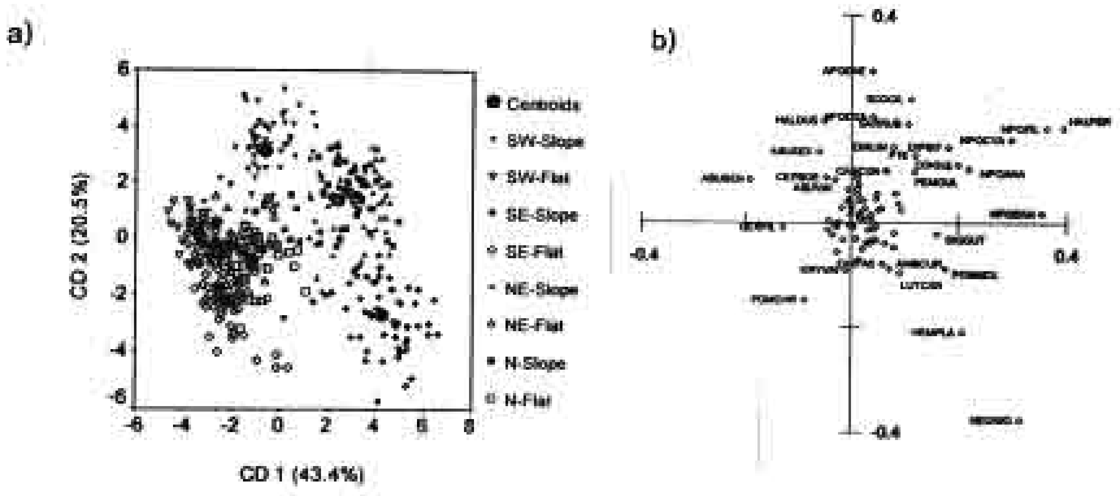


Figure 1. Ordination plots from Canonical Discriminant Analysis illustrated spatio-temporal variation of fish assemblages on coral reef at Khangkao Island: a) Site scores and b) Canonical structures of species.

ชื่อเรื่อง (ภาษาอังกฤษ) **Community structure, spatio-temporal variation and recruitment of fishes on coral reefs at the Inner Gulf of Thailand**

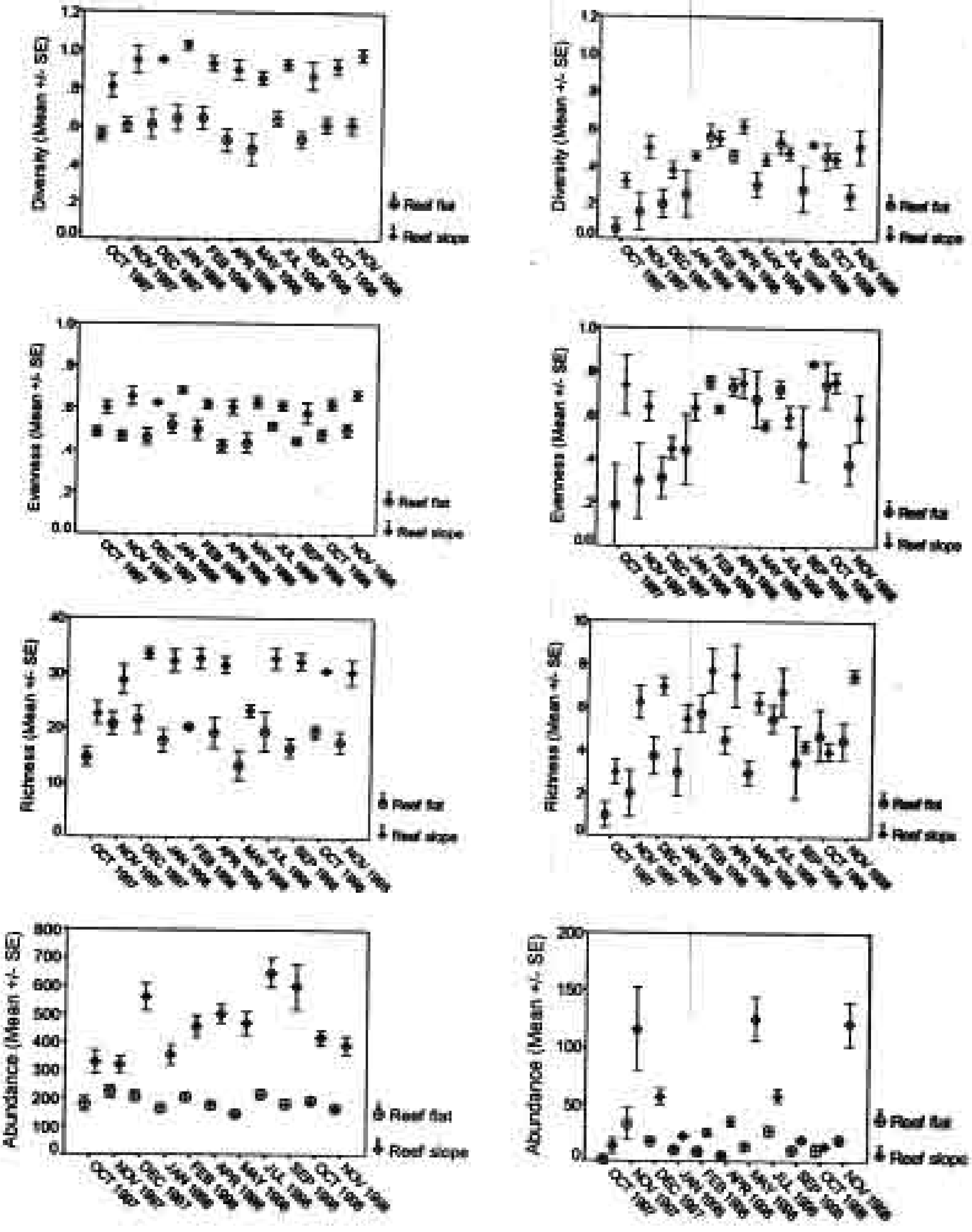


Figure 2. Community parameters of adult-subadult (left) and juvenile (right) fish assemblages on coral reef at Khangkao Island indicated variation through time and between habitats

ภาคผนวกที่ 3

Paper presented at

9^{th} International Coral Reef Symposium

NINTH INTERNATIONAL CORAL REEF SYMPOSIUM

WORLD CORAL REEFS IN THE NEW MILLENNIUM: BRIDGING RESEARCH AND MANAGEMENT FOR SUSTAINABLE DEVELOPMENT

BALI, INDONESIA,
23-27 OCTOBER 2000

ABSTRACTS

STATE MINISTRY FOR THE ENVIRONMENT, INDONESIA
INDONESIAN INSTITUTE OF SCIENCES
THE INTERNATIONAL SOCIETY FOR REEF STUDIES