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# PATTERNS IN COMMUNITY STRUCTURE OF TRAWL CATCHES ALONG COASTAL AREA OF THE SOUTH CHINA SEA

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***ABSTRACT.*** **–** Community structure of trawl catches including fishes and macro-invertebrates was assessed in relation to depth zone, time of year, and the influence of selected environmental factors. A total of 151,799 fishes, representing 59 families and 157 species were collected by bottom trawls during daylight hours between November 2005 and July 2007 from 16 sites along coastal waters off Pattani and Narathiwat provinces, Thailand. Of these, the ten most dominant species accounted for 90.7% of the catch. A great dominance of Leiognathidae, principally *Leiognathus splendens* (51.5%) and *Leiognathus brevirostris* (16.5%) was recorded. Families with the greatest number of species were Leiognathidae (10 species) and Carangidae (8 species). A highly significant difference ($P<0.001$) between fish density collected at different zones indicates that depth is a major factor structuring the community. Highly significant differences ($P<0.001$) between months on fish species richness and biomass were found ($P< 0.05$). Cluster analysis indicated further that the difference was based mainly on seasonal and annual effects. Temperature had an impact on fish species richness and density, whilst dissolved oxygen influenced only on fish biomass. For macro-invertebrates, 5,574 individuals belonging to three main groups including Decapoda, Mollusca, Echinodermata and other phyla were recorded. Analysis of variance indicated site differences for macro-invertebrate density ($P<0.05$) and biomass ($P<0.005$) and monthly difference for species number ($P<0.0005$). Molluscs and crabs were the largest group together with shrimps and other organisms and could be divided by cluster into two different depth communities.

***KEY WORDS.*** **–** Gulf of Thailand; fish ecology, demersal species; fish and environment.

## INTRODUCTION

The importance of tropical coastal habitats as productive areas used by larvae, juveniles and adults of many estuarine-dependent fish species for reproductive activities, foraging and shelter are well-recognized (Blaber, et al., 1995; Peterson & Whitfield, 2000; Harris et al., 2001). Fishes living in these near to shore are subject to a complex matrix of interacting physical and biological factors that determine their occurrence, distribution and movement pattern (Blaber, 2000). Among the main parameters to affect the spatial and temporal organization of fish communities in these habitats are salinity, temperature, turbidity, substrate type, benthic composition and depth. Seasonal recruitment and migration of young fishes from shallow estuaries and coastal areas to deeper waters and adults moving to spawning areas produce a great change in local near-shore fish community structure (Cladridge et al., 1986). Analysis of community structure of demersal species is important for an understanding of ecological processes and functions of a particular ecosystem and providing a basis for management of fisheries resources. Several approaches have been used in the description of fish assemblages and their explanatory factors. Some studies focus on environmental influences (Howell & Simpson, 1994; Gelwick et al., 2001; Griffiths, 2001; Jaureguizar et al., 2004), some investigate seasonal and spatial patterns of community structure (Maes et al., 1998; Rhodes, 1998) and some examine both factors simultaneously (de Azevedo et al., 2007).

The huge estuarine coastal areas of the South China Sea support the largest and most productive of the world's tropical estuarine fisheries. These areas, however, and especially the Gulf of Thailand, are subjected to heavily fishing pressure from various types of gears used (Blaber, 2000). Some studies have investigated assemblages and ecological aspects of fishes in shallow sheltered-estuarine habitats of the region (Pinto, 1988; Chong et al., 1990; Sasekumar et al., 1992; Ikejima, 2003; Hajisamae & Chou, 2003), but information on the fish communities of deeper near-shore waters (up to 30 m depth, which is considered one of the busiest fishing ground exploited by most fishermen) is poorly investigated in Asia generally with no literature available for Southeast Asia.

The objectives of this study are to examine diversity, distribution, density and biomass of fishes and benthic macro-invertebrates and to clarify how important is depth zone, time of year and selected environmental parameters in shaping their community.

## MATERIALS AND METHODS

### Study area, sampling strategy and hydrological measurements

Sampling sites were located along the coasts of Pattani and Narathiwat provinces, southern Thailand. This area is part of the western and southern South China Sea, considered to be heavily over-fished (Blaber, 2000). The coastline is characterized by long sandy beaches, semi-diurnal tides with approximately 0.3–0.9m tidal ranges, and two tropical monsoons; the North-East monsoon from November to February and South-West monsoon from May to August. Freshwater inputs are from four main rivers: the Takbai, Bangnara, Saiburi and Pattani. Pattani bay, a 74 $km^2$ semi-enclosed estuarine bay with several ecosystem types, provides shelter for juveniles of many taxa before migrating to deeper areas (Hajisamae et al., 2006). Four sites (A, B, C and D) were selected and at each site, four different depth contours were marked as zones 1, 2, 3 and 4 (Fig. 1). The average depths at these zones were 12.3±1.0m, 15.8±1.0m, 19.8±1.0m and 23.3±1.5m, respectively. These areas are unobstructed by formations except for a small island between stations D3 and D4.

Between November 2005 and July 2007, fish and macro-invertebrate samplings were conducted every two months by a bottom trawl towing during daylight hours at approximately 2.3 knot for 60 minutes. A total of 144 hauls (4 sites × 4 depths × 9 months) were conducted. Each trawl followed a depth contour to minimize the impact of depth changes (de Azevedo, et al., 2007). The trawl was constructed with a 14 m headline, 15 m ground rope, and 2.20 cm mesh cod-end liner. The catches were immediately iced and transported to the laboratory for sorting, identifying and determining of total length. All material are deposited in Fishery Technology collection, Faculty of Science and Technology, Prince of Songkla University, Thailand for future reference.

Dissolved oxygen, pH, salinity and temperature were measured in situ by a YSI 556 MPS meter at the depth of 1.0 m below sea surface. Salinity was measured using the Practical Salinity Scale.

### Statistical Analysis

Fish catch data was analyzed for: (1) community parameters; Shannon Weiner's diversity index (H') and mean species richness (SR) per sampling occasion, (2) relative abundance and (3) ecotypes, indicating either the fish is pelagic, semi-pelagic or demersal species based on adult inhabitancy. Analysis of variance (ANOVA) was used to compare density of fish, numbers of species and biomass between all sites and months. Catch data were non-normalized distributed and so both number of individuals and species were log (X+1) transformed. To test for the difference in community assemblages between sites and months, a cluster analysis was carried out using PRIMER statistical package version 5.0 (Clarke and Gorley 2001), with a Bray-Curtis similarity and a complete linkage cluster mode. Analysis of similarity (ANOSIM) was used to determine whether the community separated by the dendogram differed significantly. Once the significant difference was detected, a Similarity Percentage (SIMPER) was used to examine which species contributed most to the classification. To test for preference over sites and months of 30 dominant fish species, a cluster analysis constructed the dendogram and ANOSIM tested a difference of the groupings. SIMPER examined which sampling sites or months the identified species are likely to inhabit or distribute. Regression analysis was performed on log-transformed data to examine relationship between fish community structure and environmental parameters.

Abundance and distribution at each depth zones of macro-invertebrates were analyzed. Analysis of variance (ANOVA) was used to compare; (1) density, numbers of species and biomass between all sites and months. Cluster analysis was applied to test for community structure at different depth before SIMPER was used to identify which taxa contributing to the formation of cluster group on the dendogram.

## RESULTS

### Hydrological parameters

Mean surface water temperature, pH, DO and salinity were 31.4 ± 1.0°C, 7.7 ± 1.2, 6.3 ± 0.7ppm and 34.5 ± 2.8, respectively. Detail of average hydrological parameters is presented in Table 1.

### General catch data

A total of 151,799 fishes representing 59 families and 157 species were collected in this study. The ten most numerically

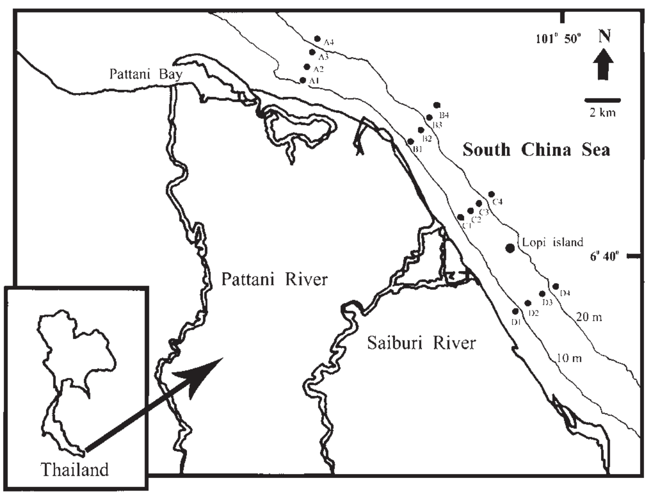



Fig. 1. Map of the study area.

Table 1. Water parameters collected off Pattani and Narathiwat provinces between Nov.2005 and Jul.2007.

| Site | Water parameter | | | |
|---|---|---|---|---|
| | Temperature | pH | DO | Salinity |
| A1 | 31.3 ± 1.1 | 7.8 ± 1.3 | 6.2 ± 0.7 | 34.7 ± 3.3 |
| A2 | 31.3 ± 1.0 | 7.8 ± 1.3 | 6.1 ± 0.7 | 34.6 ± 3.3 |
| A3 | 31.0 ± 0.9 | 7.8 ± 1.3 | 6.3 ± 0.6 | 35.0 ± 35.0 |
| A4 | 30.9 ± 0.8 | 7.6 ± 1.4 | 6.2 ± 0.6 | 35.0 ± 2.6 |
| B1 | 31.8 ± 0.5 | 7.8 ± 1.3 | 6.2 ± 0.6 | 34.1 ± 3.1 |
| B2 | 31.5 ± 0.7 | 7.8 ± 1.3 | 7.0 ± 1.4 | 34.3 ± 3.0 |
| B3 | 31.1 ± 0.8 | 7.7 ± 1.5 | 6.2 ± 0.7 | 34.2 ± 3.0 |
| B4 | 30.8 ± 1.0 | 7.6 ± 1.2 | 6.3 ± 0.6 | 34.6 ± 2.7 |
| C1 | 32.0 ± 0.9 | 7.8 ± 1.1 | 6.3 ± 0.7 | 34.4 ± 2.8 |
| C2 | 31.7 ± 0.9 | 7.7 ± 1.2 | 6.4 ± 0.8 | 34.3 ± 2.8 |
| C3 | 31.5 ± 1.1 | 7.6 ± 1.4 | 6.1 ± 0.7 | 34.3 ± 2.9 |
| C4 | 30.9 ± 1.1 | 7.1 ± 1.1 | 6.1 ± 0.6 | 34.6 ± 3.0 |
| D1 | 31.8 ± 0.9 | 7.8 ± 1.1 | 6.2 ± 0.6 | 34.7 ± 2.9 |
| D2 | 31.6 ± 1.0 | 7.8 ± 1.2 | 6.2 ± 0.6 | 34.6 ± 2.8 |
| D3 | 31.4 ± 1.0 | 7.8 ± 1.0 | 6.2 ± 0.6 | 34.5 ± 2.6 |
| D4 | 31.0 ± 1.0 | 7.4 ± 1.3 | 6.3 ± 0.5 | 33.7 ± 3.0 |
| **Average ± SE** | **31.4 ± 1.0** | **7.7 ± 1.2** | **6.3 ± 0.7** | **34.5 ± 2.8** |

abundant species accounted for 90.7% of the total catch (Tables 2, 3 and 4). Leiognathidae, principally, *Leiognathus splendens* and *Leiognathus brevirostris* dominated the catch with 51.5% and 16.5%, respectively. It was followed by *Priacanthis macracanthus* (5.4%), *Secutor ruconius* (5.0%), *Upeneus tragula* (3.7%), *Leiognathus stercorarius* (2.3%) and *Scolopsis taeniopterus* (2.1%). Families with the greatest number of species were Leiognathidae (10 species), followed by Carangidae (8 species) and Monacanthidae, Apogonidae, Lutjanidae and Tetraodontidae (6 species each). Twenty-five families were represented by only a single species.

Mean species richness (SR), number of individuals per trawl, and biomass per trawl were 16.0±0.9 species, 1054.2±406.4 individual/haul and 11.8±3.7 kg/haul, respectively. H' value for overall catch was 1.98. Details for ecological attributes for each depth zones and months are presented in Table 5.

Based on eco-type analysis, fishes could be categorized into three different ecological groups; demersal, pelagic and semi-pelagic (Fig. 2). Of these, semi-pelagic species was the largest group both as total number of species (93.9%) and overall catch (51.3%).

## Effect of depth zones

Analysis of variance indicated a highly significant difference between fish density collected from four different zones (df = 3, F = 6.87, P=0.0002). The largest density was in zone 1, followed by zones 2, 3 and 4, respectively. There was no difference for species richness (df = 3, F = 0.495, P = 0.686) and fish biomass (df = 3, F = 2.51, F = 0.061).

Cluster analysis separated the fish community into two main groups (Fig. 3a). The first group consisted almost entirely of sites from zones 1 and 2. The second group comprised entirely of sites from zones 3 and 4. Analysis of similarity (ANOSIM) demonstrated a significant difference between compositions of fish samples from these two groups (Global R = 0.899, P <0.01). A similarity percentage analysis (SIMPER) showed, in the case of group 1, that the fish species made up >70% of the definitive group including *Leiognathus splendens*, *Leiognathus brevirostris*, *Scolopsis taeniopterus*, *Leiognathus stercorarius*, *Apogon quadrifasciatus* and *Secutor ruconius.* For the second group, SIMPER indicated that fishes that made up >70% of this

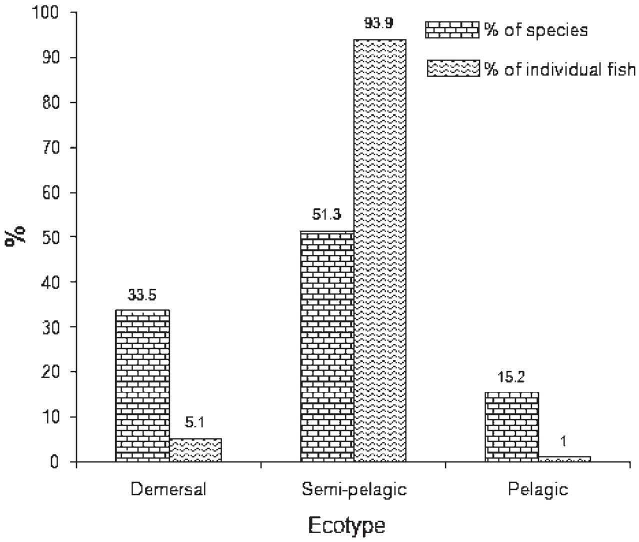


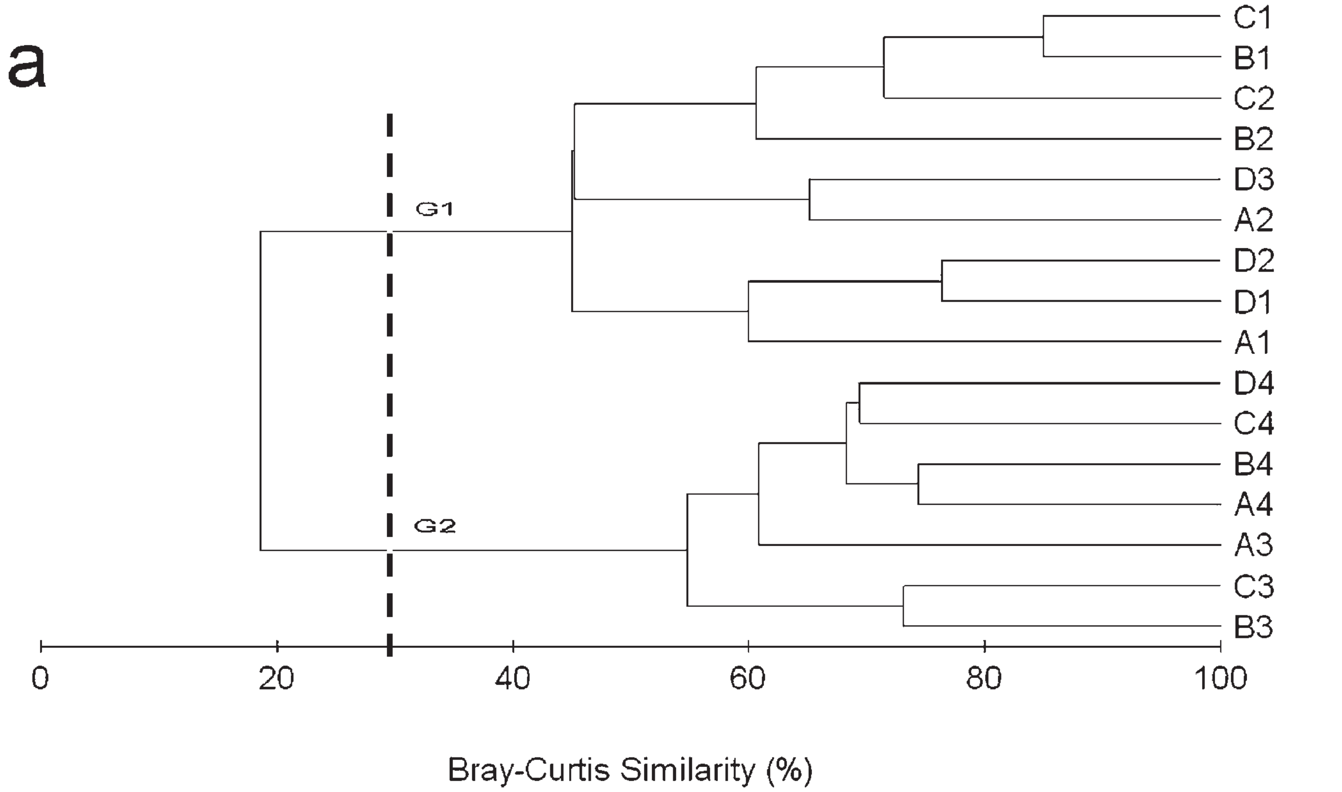

Fig. 2. Relative number of fish species and total number of individuals of different eco-types collected bimonthly off Pattani and Narathiwat provinces between Nov.2005 and Jul.2007.

Table 2. Fish families with total number of individual and number of fish species collected off Pattani and Narathiwat provinces between November 2005 and July 2007.

| Family | No. of individuals | % | No. of species | % |
|---|---|---|---|---|
| Leiognathidae | 118,516 | 78.07 | 10 | 6.3 |
| Carangidae | 201 | 0.13 | 8 | 5.1 |
| Monacanthidae | 151 | 0.10 | 6 | 4.4 |
| Apogonidae | 2,404 | 1.58 | 6 | 3.8 |
| Lutjanidae | 481 | 0.32 | 6 | 3.8 |
| Tetraodontidae | 236 | 0.16 | 6 | 3.8 |
| Mullidae | 6,857 | 4.52 | 5 | 3.2 |
| Nemipteridae | 3,419 | 2.25 | 5 | 3.2 |
| Labridae | 633 | 0.42 | 5 | 3.2 |
| Sciaenidae | 67 | 0.04 | 5 | 3.2 |
| Clupeidae | 6 | 0.00 | 5 | 3.2 |
| Soleidae | 752 | 0.50 | 4 | 2.5 |
| Platycephalidae | 505 | 0.33 | 4 | 2.5 |
| Gobiidae | 213 | 0.14 | 4 | 2.5 |
| Serranidae | 135 | 0.09 | 4 | 2.5 |
| Cynoglossidae | 93 | 0.06 | 4 | 2.5 |
| Haemulidae | 187 | 0.12 | 4 | 2.5 |
| Callionymidae | 2,488 | 1.64 | 3 | 1.9 |
| Synodontidae | 1,049 | 0.69 | 3 | 1.9 |
| Synanceiidae | 214 | 0.14 | 3 | 1.9 |
| Gerreidae | 65 | 0.04 | 3 | 1.9 |
| Engraulididae | 13 | 0.01 | 3 | 1.9 |
| Terapontidae | 8 | 0.01 | 3 | 1.9 |
| Priacanthidae | 8,198 | 5.40 | 2 | 1.3 |
| Ariidae | 633 | 0.42 | 2 | 1.3 |
| Siganidae | 565 | 0.37 | 2 | 1.3 |
| Plotosidae | 548 | 0.36 | 2 | 1.3 |
| Scorpaenidae | 100 | 0.07 | 2 | 1.3 |
| Pegasidae | 64 | 0.04 | 2 | 1.3 |
| Batrachoididae | 27 | 0.02 | 2 | 1.3 |
| Ostraciidae | 16 | 0.01 | 2 | 1.3 |
| Scombridae | 15 | 0.01 | 2 | 1.3 |
| Hemiscylliidae | 9 | 0.01 | 2 | 1.3 |
| Blenniidae | 3 | 0.00 | 2 | 1.3 |
| Stromateidae | 2 | 0.00 | 2 | 1.3 |
| Caesionidae | 1,262 | 0.83 | 1 | 0.6 |
| Centriscidae | 828 | 0.55 | 1 | 0.6 |
| Bothidae | 446 | 0.29 | 1 | 0.6 |
| Parolichthyidae | 121 | 0.08 | 1 | 0.6 |
| Sillaginidae | 107 | 0.07 | 1 | 0.6 |
| Pinguipedidae | 31 | 0.02 | 1 | 0.6 |
| Trichiuridae | 25 | 0.02 | 1 | 0.6 |
| Ephipidae | 16 | 0.01 | 1 | 0.6 |
| Dasyatidae | 13 | 0.01 | 1 | 0.6 |
| Cepolidae | 10 | 0.01 | 1 | 0.6 |
| Lethrinidae | 10 | 0.01 | 1 | 0.6 |
| Polynemidae | 10 | 0.01 | 1 | 0.6 |
| Samaridae | 9 | 0.01 | 1 | 0.6 |
| Glaucosomatidae | 6 | 0.00 | 1 | 0.6 |
| Narcinidae | 5 | 0.00 | 1 | 0.6 |
| Sphyraenidae | 5 | 0.00 | 1 | 0.6 |
| Fistularidae | 4 | 0.00 | 1 | 0.6 |
| Menidae | 4 | 0.00 | 1 | 0.6 |
| Syngnathidae | 4 | 0.00 | 1 | 0.6 |
| Dactylopteridae | 3 | 0.00 | 1 | 0.6 |
| Antennariidae | 2 | 0.00 | 1 | 0.6 |
| Chirocentridae | 2 | 0.00 | 1 | 0.6 |
| Diodontidae | 2 | 0.00 | 1 | 0.6 |
| Exocoetidae | 1 | 0.00 | 1 | 0.6 |
| **Total** | **151,799** | | **157** | **100.0** |

Table 3. Ten most dominant fishes at each zone collected off Pattani and Narathiwat provinces between November 2005 and July 2007.

| Species | Zone 1 | Species | Zone 2 | Species | Zone 3 | Species | Zone 4 |
|---|---|---|---|---|---|---|---|
| *Leiognathus splendens* | 51,612 | *Leiognathus splendens* | 20,224 | *Priacanthus macracanthus* | 6,945 | *Upeneus tragula* | 2,900 |
| *Leiognathus brevirostris* | 9,035 | *Leiognathus brevirostris* | 15,282 | *Leiognathus splenden* | 6,350 | *Caesio cuning* | 969 |
| *Secutor ruconius* | 6,422 | *Scolopsis taeniopterus* | 1,313 | *Upeneus tragula* | 1,809 | *Scolopsis taeniopterus* | 863 |
| *Gazza minuta* | 1,754 | *Leiognathus stercorarius* | 1,249 | *Scolopsis taeniopterus* | 804 | *Apogon quadrifasciatus* | 582 |
| *Callionymus planus* | 1,631 | *Secutor ruconius* | 1,171 | *Leiognathus brevirostris* | 500 | *Leiognathus stercorarius* | 418 |
| *Leiognathus stercorarius* | 1,503 | *Priacanthus macracanthus* | 1,039 | *Siaganus canaliculatus* | 470 | *Upeneus sulphureus* | 392 |
| *Arius venosus* | 631 | *Gazza minuta* | 684 | *Xyrichtys trivittatus* | 470 | *Liachirus melanospiles* | 229 |
| *Plotosus anguillaris* | 520 | *Aeroliscus strigatus* | 589 | *Apogon quadrifasciatus* | 398 | *Leiognathus brevirostris* | 163 |
| *Upeneus tragula* | 453 | *Lieognathus decorus* | 558 | *Saurida micropectoralis* | 350 | *Upeneus sundaicus* | 158 |
| *Lieognathus decorus* | 368 | *Upeneus tragula* | 498 | *Liachirus melanospiles* | 338 | *Apogon niger* | 149 |



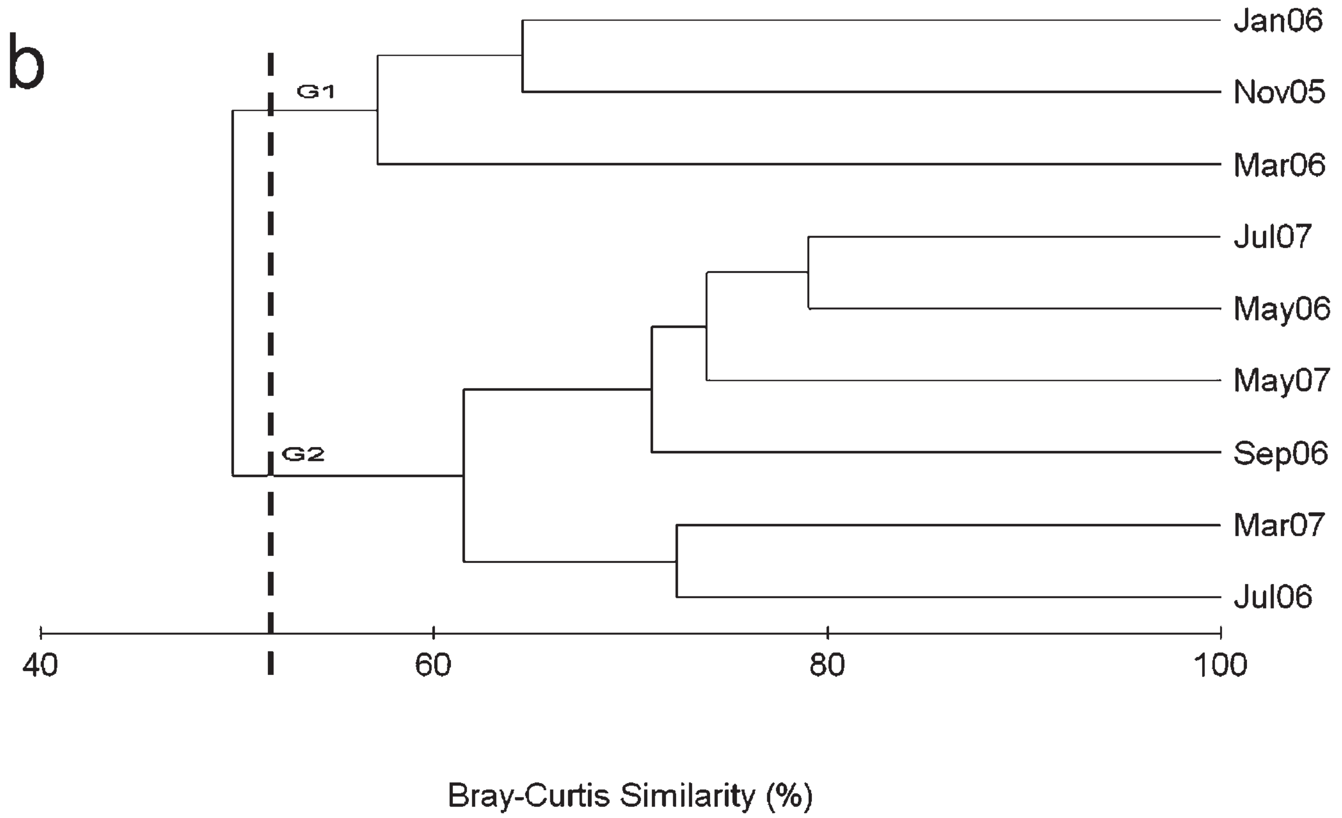




Fig. 3. Cluster dendogram of abundance data for each fish samples collected bimonthly (a) at four different zones and (b) in different months off Pattani and Narathiwat coasts between Nov.2005 and Jul.2000

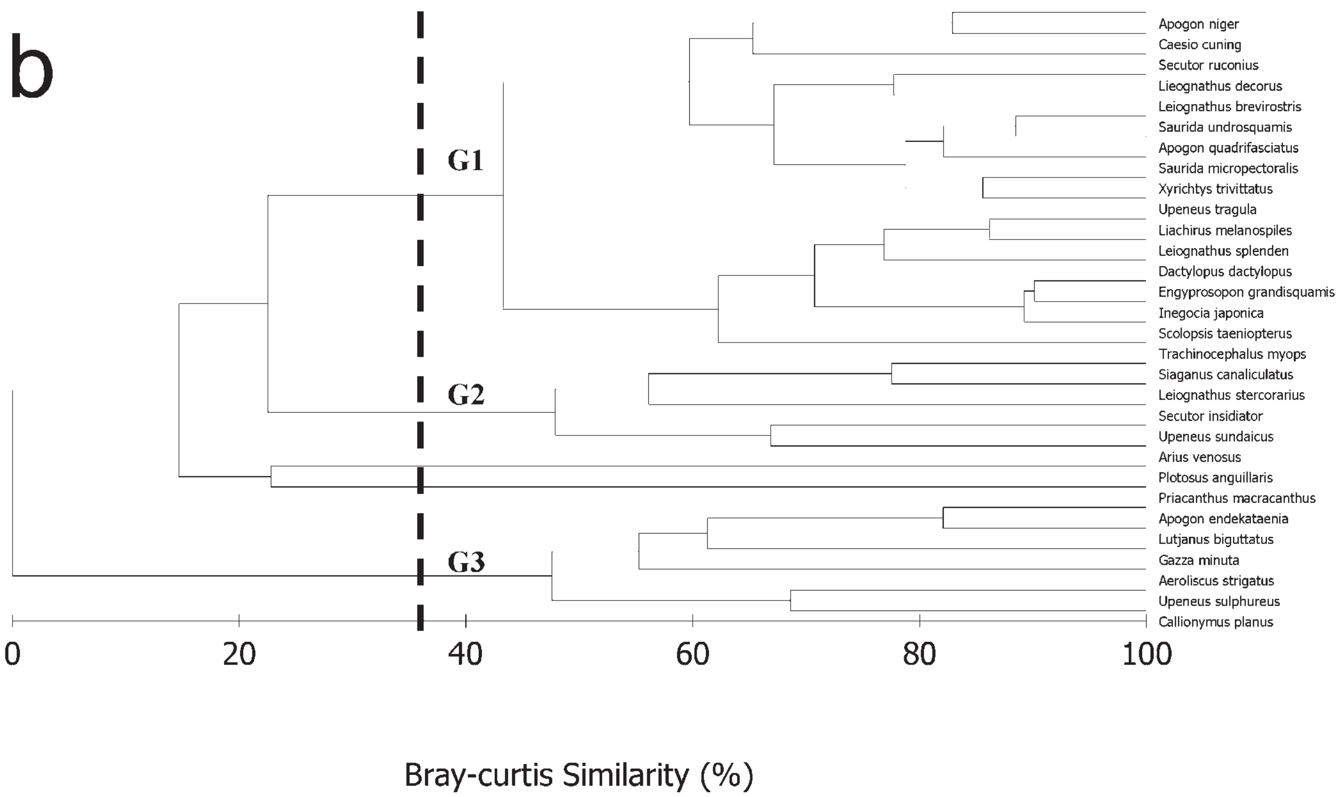




Fig. 4. Cluster dendogram of abundance data for preference of 30 dominant fishes collected bimonthly (a) at different study sites and (b) in different months off Pattani and Narathiwat coasts between Nov.2005 and Jul.2007.

Table 4. Fishes collected off coastal waters of Pattani and Narathiwat provinces between November 2005 and July 2007.

| Family | Species | Number | % |
|---|---|---|---|
| Antennariidae | *Antennarius hispidus* | 2 | 0.00 |
| Apogonidae | *Apogon endekataenia* | 269 | 0.18 |
| | *Apogon niger* | 268 | 0.18 |
| | *Apogon quadrifasciatus* | 1,564 | 1.03 |
| | *Apogon striatus* | 107 | 0.07 |
| | *Archamia lineolata* | 191 | 0.13 |
| | *Vincentia chrysura* | 5 | 0.00 |
| Ariidae | *Arius venosus* | 632 | 0.42 |
| | *Arius maculatus* | 1 | 0.00 |
| Batrachoididae | *Bastrichthys grunniens* | 25 | 0.02 |
| | *Batrachomoeus trispinosus* | 2 | 0.00 |
| Blenniidae | *Plagiotremus phenax* | 1 | 0.00 |
| | *Xiphasia setifer* | 2 | 0.00 |
| Bothidae | *Engyprosopon grandisquamis* | 446 | 0.29 |
| Caesionidae | *Caesio cuning* | 1,262 | 0.83 |
| Callionymidae | *Callionymus planus* | 2,153 | 1.42 |
| | *Callionymus schaapii* | 6 | 0.00 |
| | *Dactylopus dactylopus* | 329 | 0.22 |
| Carangidae | *Alectis indicus* | 31 | 0.02 |
| | *Alepes kleinii* | 14 | 0.01 |
| | *Alepes vari* | 49 | 0.03 |
| | *Apolectus niger* | 23 | 0.02 |
| | *Megalaspis cordyla* | 1 | 0.00 |
| | *Selaroides leptolepis* | 6 | 0.00 |
| | *Carangoides hedlandensis* | 76 | 0.05 |
| | *Carangoides armartus* | 1 | 0.00 |
| Centriscidae | *Aeroliscus strigatus* | 828 | 0.55 |
| Cepolidae | *Acanthocepola abbreviata* | 10 | 0.01 |
| Chirocentridae | *Chirocentrus dorab* | 2 | 0.00 |
| Clupeidae | *Anodontostoma chacunda* | 1 | 0.00 |
| | *Escualosa thoracata* | 1 | 0.00 |
| | *Herklotsichthys dispilonotus* | 1 | 0.00 |
| | *Sardinella albella* | 2 | 0.00 |
| | *Sardinella gibbosa* | 1 | 0.00 |
| Cynoglossidae | *Cynoglossus macrolepidotus* | 12 | 0.01 |
| | *Cynoglossus bilineatus* | 6 | 0.00 |
| Cynoglossidae | *Cynoglossus semifasciatus* | 4 | 0.00 |
| | *Cynoglossus puncticeps* | 71 | 0.05 |
| Dactylopteridae | *Dactyloptena orientalis.* | 3 | 0.00 |
| Dasyatidae | *Himantura bleekeri* | 13 | 0.01 |
| Diodontidae | *Diodon holocanthus* | 2 | 0.00 |
| Engraulididae | *Stolephorusi indicus* | 6 | 0.00 |
| | *Stolephorus* sp. | 1 | 0.00 |
| | *Thryssa hamiltonii* | 6 | 0.00 |
| Ephipidae | *Drepane punctata* | 16 | 0.01 |
| Exocoetidae | *Cypselurus* sp. | 1 | 0.00 |
| Fistularidae | *Fisturaria villosa* | 4 | 0.00 |
| Gerreidae | *Gerres abbreviatus* | 8 | 0.01 |
| | *Gerres filamentosus* | 56 | 0.04 |
| | *Gerres oyena* | 1 | 0.00 |

Table 4. Cont'd.

| Family | Species | Number | % |
|---|---|---|---|
| Glaucosomatidae | *Gnatophis nystromi* | 6 | 0.00 |
| Gobiidae | *Acentrogobius caninus* | 5 | 0.00 |
| | *Yongeichthys nebulosus* | 5 | 0.00 |
| | *Oxyurichthys saru* | 163 | 0.11 |
| | *Valenciennea wardi* | 40 | 0.03 |
| Haemulidae | *Diagramma pictum* | 63 | 0.04 |
| | *Plectorhinchus vittatus* | 9 | 0.01 |
| | *Pomadosys maculatus* | 106 | 0.07 |
| | *Pomadasys kaakan* | 9 | 0.01 |
| Hemiscylliidae | *Chiloscyllium griseum* | 2 | 0.00 |
| | *Chiloscyllium punctatum* | 7 | 0.00 |
| Labridae | *Halichoeres bicolar* | 17 | 0.01 |
| | *Halichoeres nigrescens* | 5 | 0.00 |
| | *Leptojulis cyauopleura* | 1 | 0.00 |
| | *Xyrichtys evides* | 21 | 0.01 |
| | *Xyrichtys trivittatus* | 589 | 0.39 |
| Leiognathidae | *Gazza minuta* | 2,622 | 1.73 |
| | *Lieognathus decorus* | 1,070 | 0.70 |
| | *Leiognathus brevirostris* | 24,980 | 16.46 |
| | *Leiognathus equulus* | 39 | 0.03 |
| | *Leiognathus leuciscus* | 3 | 0.00 |
| | *Leiognathus splendens* | 78,230 | 51.54 |
| | *Leiognathus stercorarius* | 3,484 | 2.30 |
| | *Lieognathus moretoniensis* | 15 | 0.01 |
| | *Secutor insidiator* | 457 | 0.30 |
| | *Secutor ruconius* | 7,616 | 5.02 |
| Lethrinidae | *Lethrinus lentjan* | 10 | 0.01 |
| Lutjanidae | *Lutjanus biguttatus* | 305 | 0.20 |
| | *Lutjanus erythropterus* | 35 | 0.02 |
| | *Lutjanus johnii* | 3 | 0.00 |
| | *Lutjanus lutjanus* | 94 | 0.06 |
| | *Lutjanus madras* | 39 | 0.03 |
| | *Lutjanus russelli* | 5 | 0.00 |
| Menidae | *Mene maculata* | 4 | 0.00 |
| Monacanthidae | *Anacanthus barbatus* | 19 | 0.01 |
| | *Chaetodermis penicilligerus* | 4 | 0.00 |
| | *Monacanthus tomentosum* | 5 | 0.00 |
| | *Monacanthus chinensis* | 77 | 0.05 |
| | *Paramonacanthus choirocephalus* | 28 | 0.02 |
| | *Paramonacanthus curtorhynchus* | 18 | 0.01 |
| Mullidae | *Upeneus bensasi* | 110 | 0.07 |
| | *Upeneus sulphureus* | 847 | 0.56 |
| | *Upeneus sundaicus* | 222 | 0.15 |
| | *Upeneus tragula* | 5,675 | 3.74 |
| | *Parupeneus heptacanthus* | 3 | 0.00 |
| Narcinidae | *Temera hardi* | 5 | 0.00 |
| Nemipteridae | *Nemipterus hexodon* | 199 | 0.13 |
| | *Pentapodus setosus* | 67 | 0.04 |
| | *Scolopsis taeniopterus* | 3,117 | 2.05 |
| | *Scolopsis vosmeri* | 3 | 0.00 |
| | *Nemipterus virgatus* | 33 | 0.02 |
| Ostraciidae | *Lactoria cornuta* | 8 | 0.01 |
| | *Ostraction orbiculatus* | 8 | 0.01 |

Table 4. Cont'd.

| Family | Species | Number | % |
|---|---|---|---|
| Parolichthyidae | *Pseudorhombus arsius* | 121 | 0.08 |
| Pegasidae | *Parapegasus natans* | 26 | 0.02 |
| | *Pegasus volitans* | 38 | 0.03 |
| Pinguipedidae | *Parapercis alboguttata* | 31 | 0.02 |
| Platycephalidae | *Elates ransonneti* | 2 | 0.00 |
| | *Inegocia japonica* | 479 | 0.32 |
| | *Platecephalus indicus* | 13 | 0.01 |
| | *Grammoplites scaber* | 11 | 0.01 |
| Plotosidae | *Plotosus anguillaris* | 546 | 0.36 |
| | *Plotosus lineatus* | 2 | 0.00 |
| Polynemidae | *Polynemus tetradactylum* | 10 | 0.01 |
| Priacanthidae | *Priacanthus macracanthus* | 8,172 | 5.38 |
| | *Priacanthus tayenus* | 26 | 0.02 |
| Samaridae | *Samaris cristatus* | 9 | 0.01 |
| Sciaenidae | *Dendrophysa russelli* | 9 | 0.01 |
| | *Otolithes ruber* | 3 | 0.00 |
| | *Pennahia macrocephalus* | 8 | 0.01 |
| | *Nibea soldado* | 26 | 0.02 |
| | *Johnius dussumieri* | 21 | 0.01 |
| Scombridae | *Rastrelliger brachysoma* | 9 | 0.01 |
| | *Scomberomorus commerson* | 6 | 0.00 |
| Scorpaenidae | *Pterois russelii* | 37 | 0.02 |
| | *Scorpaeniopsis cirrhosus.* | 63 | 0.04 |
| Serranidae | *Epinephelus areolatus* | 1 | 0.00 |
| | *Epinephelus bleekeri* | 17 | 0.01 |
| | *Epinephelus coioides* | 30 | 0.02 |
| | *Epinephelus sexfasciatus* | 87 | 0.06 |
| Siganidae | *Siganus canaliculatus* | 559 | 0.37 |
| | *Siaganus javus* | 6 | 0.00 |
| Sillaginidae | *Sillago sihama* | 107 | 0.07 |
| Soleidae | *Asereggodes dubius* | 63 | 0.04 |
| | *Liachirus melanospiles* | 604 | 0.40 |
| | *Solea stanalandi* | 84 | 0.06 |
| | *Synaptura commersoniana* | 1 | 0.00 |
| Sphyraenidae | *Sphyraena jello* | 5 | 0.00 |
| Stromateidae | *Pamphus argenteus* | 1 | 0.00 |
| | *Pampus chinensis* | 1 | 0.00 |
| Synanceiidae | *Minous monodactylus* | 198 | 0.13 |
| | *Inimicus didactylus* | 3 | 0.00 |
| | *Inimicus cuvieri* | 13 | 0.01 |
| Syngnathidae | *Hippichthys penicillus* | 4 | 0.00 |
| Synodontidae | *Saurida micropectoralis* | 526 | 0.35 |
| | *Saurida undrosquamis* | 298 | 0.20 |
| | *Trachinocephalus myops* | 225 | 0.15 |
| Terapontidae | *Terapon jarbua* | 1 | 0.00 |
| | *Terapon theraps* | 6 | 0.00 |
| | *Terapon puta* | 1 | 0.00 |
| Tetraodontidae | *Arothron immaculatus* | 1 | 0.00 |
| | *Arothron meleagris* | 1 | 0.00 |
| | *Arothron stellatus* | 1 | 0.00 |
| | *Lagocephalus lunaris* | 179 | 0.12 |
| | *lagocephalus sceleratus* | 49 | 0.03 |
| | *Takifugu oblongus* | 5 | 0.00 |
| Trichiuridae | *Trichiurus lepturus* | 25 | 0.02 |

group including *Upeneus tragula, Scolopsis taeniopterus, Apogon quadrifasciatus, Caesio cuning, Leiognathus stercorarius, Saurida micropectoralis, Upeneus sulphureus, Liachirus melanospiles* and *Trachinocephalus myops*.

### Site preference of dominant fish species

Fishes formed five different clusters on the dendogram (Fig. 4a). Analysis of similarity (ANOSIM) significantly divided 30 dominant species into five separate groups (Global R = 0.696, *P<0.01*). With the exception of G3 and G5, significant differences were demonstrated for all pair-wise tests.

Seven species formed the first cluster, including *Apogon niger, Caesio cuning, Trachinocephalus myops* and *Upeneus tragula*. A similarity percentage (SIMPER) indicated that they were found mainly at deeper stations such as A3, D4, A4 and B3. The species *Saurida micropectoralis, Liachirus melanospiles, Scolopsis taeniopterus* and *Leiognathus stercorarius* created the largest cluster (Group 2). SIMPER identified that these species were distributed in almost all areas. The third group consisting of *Lutjanus biguttatus, Plotosus anguilaris* and *Aeroliscus strigatus* were found at A1 and C4. The forth cluster, consisting of all leiognathid species such as *Leiognathus decorus, Leiognathus splendens* and *Gazza minuta*, was identified by SIMPER that they were found almost entirely at the shallow stations including D2, D1, A1 and C1. *Arius venosus* and *Callionymus planus* formed the fifth cluster and was indicated by SIMPER that their preferred site was shallowest waters, especially at C1, B1 and A1.

### Effect of months

Analysis of variance (ANOVA) showed a highly significant difference in monthly fish species richness (df = 8, F = 4.146, P = 0.0002) and a significant difference in monthly fish biomass (df = 8, F = 2.516, P = 0.014). The highest diversity was in November 2005 and lowest in March 2007. The greatest average fish biomass was in May 2006 and lowest in January 2006. No monthly significant difference on fish density was examined (df = 8, F = 1.501, P = 0.162).

Cluster dendogram separated fish composition into two main groups (Fig. 3b). Analysis of similarity (ANOSIM) demonstrated a significant difference between each cluster groups (Global R-statistic value = 0.71, *P = 0.012*). The first group consisted of November 2005, January 2006 and March 2006, representing northeast monsoon season. A combination of five species including *Leiognathus splendens, Leiognathus brevirostris, Scolopsis taeniopterus, Callionymus planus* and *Upeneus tragula*, contributed >50% to the formation of the group. The months of May 2006, July 2006, September 2006, March 2007, May 2007 and July 2007 constructed another group on the ordination. A combination, with >50% contribution, of *Leiognathus splendens, Leiognathus brevirostris, Upeneus tragula* and *Secutor ruconius* was responsible for this grouping.

### Preference over months of dominant fish species

Analysis of similarity (ANOSIM) divided 30 dominant fish species into three significantly separated groups and two individual species (Global R = 0.814, P=0.001) (Fig. 4b). Seventeen species formed the largest cluster, including *Apogon niger, Caesio cuning, Secutor ruconius, Leiognathus splendens* and *Scolopsis taeniopterus*. Similarity percentage (SIMPER) indicated that these species were found the whole year round. *Siganus canaliculatus, Leiognathus stercorarius, Secutor insidiator, Upeneus sundaicus* and *Arius venosus* created the second cluster. They occurred mainly in May 2006, September 2006, July 2006 and July 2007, i.e., during the southwest monsoon season. The third group consisted of six species, including *Lutjanus biguttatus, Gazza minuta* and *Upeneus sulphareus*. They were found only in November 2005, March 2006, March 2007 and January 2006, coinciding with the wet season (northeast monsoon).

### Relationship between water parameters and fish attributes

Relationships between water parameters and fish community attributes including biomass, species richness and density are presented in Table 6. Highly significant positive correlations (P<0.001) were found between water temperature vs. species richness and fish density. A significant correlation was found between dissolved oxygen and fish biomass (P<0.05). Apart from these, no significant difference between fish attributes and other water parameters were recorded.

### Pattern of macro-invertebrates

Altogether, 5,574 individuals accounting for 493.7 kg of macro-invertebrates were collected. Molluscs and crabs were the largest groups together with some contribution of shrimps, echinoderms, sea pens, sponges, sea squirts and jelly-fishes. Details of abundance and distribution at each depth zone of these organisms are presented in Table 7. Analysis of

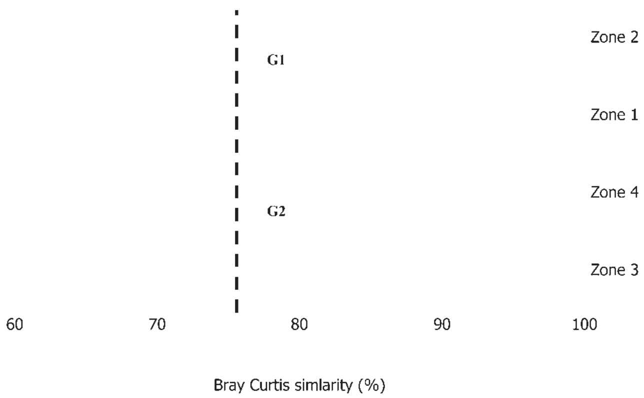



Fig. 5. Cluster dendogram of benthic organisms' abundance data collected off Pattani and Narathiwat coasts between Nov.2005 and Jul.2007.

variance indicated site differences for macro-invertebrate density (df = 7, F = 3.72, P=0.013) and biomass (df = 7, F = 6.03, P=0.001) and no difference for species number (df = 7, F = 1.39, P=0.247). ANOVA also demonstrated monthly difference for species number (df = 7, F = 6.39, P=0.0001) and no differences for density (df = 7, F = 1.04, P=0.41) and biomass (df = 7, F = 1.59, P=0.15).

Macro-invertebrates could be classified according to depth zone into two different clusters. The cluster A consisted of community at zones 1 and 2, whilst the cluster B included zones 3 and 4 (Fig. 5). Similarity analysis (SIMPER) indicated that organisms mainly contributing to the formation of cluster A were *Loligo* spp., *Sepia* spp., *Dromidopsis* sp., *Charybdis* spp., *Oratosquilla* spp. and *Pteroeides* sp. with contribution values of 64.4%, 5.6%, 5.1%, 3.3%, 2.9% and 2.2%, respectively. For cluster B, organisms responsible for the formation of this cluster included *Holotharia* spp., *Minnivola pyxidata, Loligo* spp., *Polycrapa* sp., *Amusium pleuronectes* and *Pinna bicolor* with the contributions of 25.9%, 15.4%, 13.3%, 12.1%, 5.1% and 3.3%, respectively.

## DISCUSSION

Fish within shallow, nearshore waters of the southern Gulf of Thailand forms a species-rich assemblage that is numerically dominated by a few taxa, especially *Leiognathus splendens*, *Leiognathus brevirostris* and *Priacanthus macracanthus*. This reflects a typical pattern of estuaries throughout the world such as those in New Caledonia (Wantiez et al., 1996); Western Yellow Sea, People Republic of China (Rhodes, 1998), Alligator Creek, tropical Australia (Robertson & Duke, 1990), Gulf of Carpentaria, Australia (Blaber et al., 1995), and Johor Strait, Singapore (Hajisamae & Chou, 2003). However, a great dominance by Leiognathidae (pony fish) results in a different community structure to that of sheltered areas of the same region. Hajisamae et al. (2006) found that from 48 families and 108 species of fishes collected in Pattani Bay, Thailand, only 43.3% of Leiognathidae comprised the catch compared to 78.1% in this study. Most species reported in Pattani Bay were also found in this study, with the exception of some pelagic and/or brackish water species. Similarly, the most dominant fish species for both these areas is *Leiognathus splendens*. However, the ten most dominant species in the Pattani Bay habitat was more evenly distributed. The family Centropomidae, especially *Ambassis kopsii*, the third most dominant species in the bay was absent from the present study. Although not directly tested, a strong connection of fish use of these both habitats was observed and, as shown by the results, the more distance from the bay the more difference in fish community structure.

Community structure of fish in the study area was related to both depths and months. This indicates that, in general, there exists seasonality of the spatial assemblage. Even though there were no differences in species richness and fish biomass among depths, the greatest density was at the shallowest zone and reduced substantially towards the deeper zones. This partitioning is due largely to differences in fish community structure between zones. Leiognathids are mostly responsible for this pattern as they are found predominantly in the shallow water areas. Different depth occupancy apparently occurred for some fish species with *Apogon niger, Trachinocephalus myops* and *Caesio cuning* associated with the deeper zones, while *Leiognathus splendens, Leiognathus decorus* and *Gazza minuta* were associated with the shallowest zones. Factors controlling variation of community based on water depth are probably linked to water currents, bottom sediments, and biological processes related to life history such as predation and competition (de Azevedo et al., 2007). Depth is also important for macro-invertebrates as two distinct depth-related communities were identified. Shrimps, squid (*Loligo* spp.), and cuttlefish (*Sepia* spp.) were distributed largely within the shallow zones, whilst echinoderms occupied the deeper zones. Overall the results indicate a change of community structure for both fishes and macro-invertebrates in near-shore habitats of this region between zones 2 and 3 (i.e., at 16–20m). Fishes demonstrated seasonal and annual patterns of community structure in this study. However, only macro-invertebrate species number changed significantly within shorter timescales. In general, most of the dominant fish species were found the whole year round, with some temporal variation in relative abundance. An important observation relevant to change of fish community structure is a strong community difference between years. This pattern of change can be explained with the potential impact of unstable weather condition, especially changes and fluctuation of waves and winds between 2005, 2006 and 2007, when the sea condition and weather, as noted by fishermen, had changed unexpectedly during the sampling periods.

Significant correlations between water temperature and species richness, water temperature and fish density, and dissolved oxygen and fish biomass confirmed the influences of these factors on fish communities. It is believed that, if food is not limiting, temperature is the most important factor controlling recruitment-related processes such as growth and mortality (Gibson, 1994). A strong influence of temperature on both species richness and fish density is rarely reported in the tropics where temperature is fluctuates less compared to temperate counterparts (Blaber, 2000). Variation of fish density and species richness among months is likely a reflection of monthly variation in water temperature. Salinity, the most important factor controlling distribution of fish as well as the attraction of fish larvae, post-larvae and juveniles into many estuaries throughout the world (Costa et al., 2002), has no influence on fish community in the area studied. Generally, in almost all open estuaries, fishes are subject to change in water salinity and such changes are usually diel and depend on tidal reflection (Blaber, 2000). However, almost constant water salinity at all zones during this sampling period suggests no influence of water salinity on fish abundance and distribution. This is contrary to fish communities in Pattani Bay where salinity plays a major role in fish distribution (Hajisamae, 2006). It is possible that salinity plays a greater role in a very shallow coastal waters especially semi-enclosed coastal habitats, whilst less or not at all at deeper sites.

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