Preliminary Analysis of Demersal Fish Assemblages in Coastal Waters of the Gulf of Thailand

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Abstract

The 1995 trawl data of the research vessels Pramong 2 and 9 in the Gulf of Thailand were analyzed using TWINSPAN and DCA. Four main station clusters were identified related to geographic location and depth. Two clusters are associated with shallow water areas and the other two clusters are found in deeper areas with water depths > 30 m. Temporal analysis indicates clustering of monthly data into wet and dry seasons. Examination of species abundance data indicates that the seasonality may not be very pronounced. However, this may be due to the degree of disaggregation used in sorting the trawl survey samples.

Introduction

There is much evidence indicating over-exploitation of marine resources in the Gulf of Thailand. The evidence includes the results of trawl monitoring surveys using RV Pramong #2 and #9. A declining trend in catch-per-unit effort (CPUE, kg•hr^{-1}) has been observed: from 172 kg•hr^{-1} in 1966 to about 40kg•hr^{-1} in 1989 (Eiamsa-ard and Amornchairojkul 1997). The decline continues up to the present time. The same trend has been observed in the commercial trawl fisheries operating in the Gulf. The species and sizes captured reflect the very small cod-end mesh size used by trawlers, resulting in a high percentage of trash fish (about 40 - 50%) in the catch. In addition, approximately 40 - 60% of the trash fish consists of young, economically-important food fish (Isara 1996; Supongpan and Kongmuag 1981). The young economically important food fish caught averaged total length from 3.5 to 4.5 cm (Isara 1996).

The fishing mortality index also showed a slight increase from 1961 to 1986, and increased tremendously from 1987 onwards (FAO 1996a). The number of registered trawlers in Thailand increased from 2 601 in 1970 to 12 639 in 1989 (Department of Fisheries 1995a). The excess fishing effort is estimated to be about 60% of the number of registered trawlers (FAO 1996b). Since 1990, registered trawlers have not exceed 10 000 units due to a policy of allowing no new entry and termination of registration of old units. However frequent requests to re-open registration for illegal trawlers have resulted in poor compliance with the policy. In addition, trash fish requirements of fishmeal plants are about 1.75 million t annually. The Gulf supplies about 52% of this demand, with sardine catches and imported dried trash fish making up the rest (Department of Fisheries, 1995b). Trash fish demand is one of the main reasons for continuing over-exploitation of the Gulf.

This paper presents results of analyses of data from trawl surveys conducted in the Gulf of Thailand in 1995 using methods commonly used for community structure analysis. The study aims to determine the (1) composition of species assemblages; and (2) environmental parameters which help explain the assemblage patterns observed.

Materials and Methods

The Gulf of Thailand (Fig. 1) is situated from 6º N to 13º30' N latitude and 99ºE to 104º E longitudes. It has a seabed area of 304 000 km^2 and is relatively shallow, with a mean depth of 58 m and maximum depth of 85 m. Fishing activities occur throughout the area (Supongpan 1996). The Gulf is delineated into 9 statistical areas. Each area is divided into grids measuring 30 nm^2. Sampling was set to 80 trawl hauls (each lasting 1 hr) in each area, or a total of 720 hauls for the 9 areas in one year. Routine surveys using this sampling scheme was started in 1963 and continued up to 1976. The abundance of commercially important demersal species in the Gulf of Thailand has been found to be very low beyond 50 m depth while depths of less than 10 m yield very high quantities of trash fish (Isarankura 1971). The surveys therefore were carried out mainly within the 10 to 50 m depth range. Sampling was stratified by depth: 10 - 19 m, 20 - 30 m, 31 - 44 m and more than 44 m.

The R.V. Pramong 9 and R.V. Pramong 2 were used for monthly sampling from 1977. In a sampling month, the R.V. Pramong 2 was used in Areas I to IV while R.V. Pramong 9 was used in Areas V to IX. This deployment was reversed in the next sampling month. In 1977, depth stratification was discarded although the grid area was reduced to 15 x 15 nm^2. Information on the catch, species caught, biological data and size distribution of important species were collected routinely. The number of hauls in each area has varied; currently the number of hauls is about 60 hauls per area, with a total of about 540 hauls per year for the 9 statistical areas.

R.V. Pramong 2 is a 320 HP wooden stern trawler of 79.13 gross tons (GT) and 24.5 m length overall. On the other hand, R.V. Pramong 9 is a 415 HP wooden stern trawler of 84.89 GT and 25.25 m length. Both research vessels use the same German trawl net with otter boards. The trawl net is made of nylon and has a total length of 47.7 m, wing width of 17 m, and a height of 3.5 m. The mesh sizes decrease from 16 cm stretched mesh at the wing to 4 cm at the cod-end. The ground rope and head rope is 48 and 39 m, respectively. The otter boards are made of hard wood covered with steel at their edges (Eiamsa-ard and Amornchairojkul 1997; Eiamsa-ard et al. 1977). Due to differences in size and power of the research vessels, the fishing efficiency of the two vessels was experimentally standardized in 1977 (Eiamsa-ard et al. 1977).

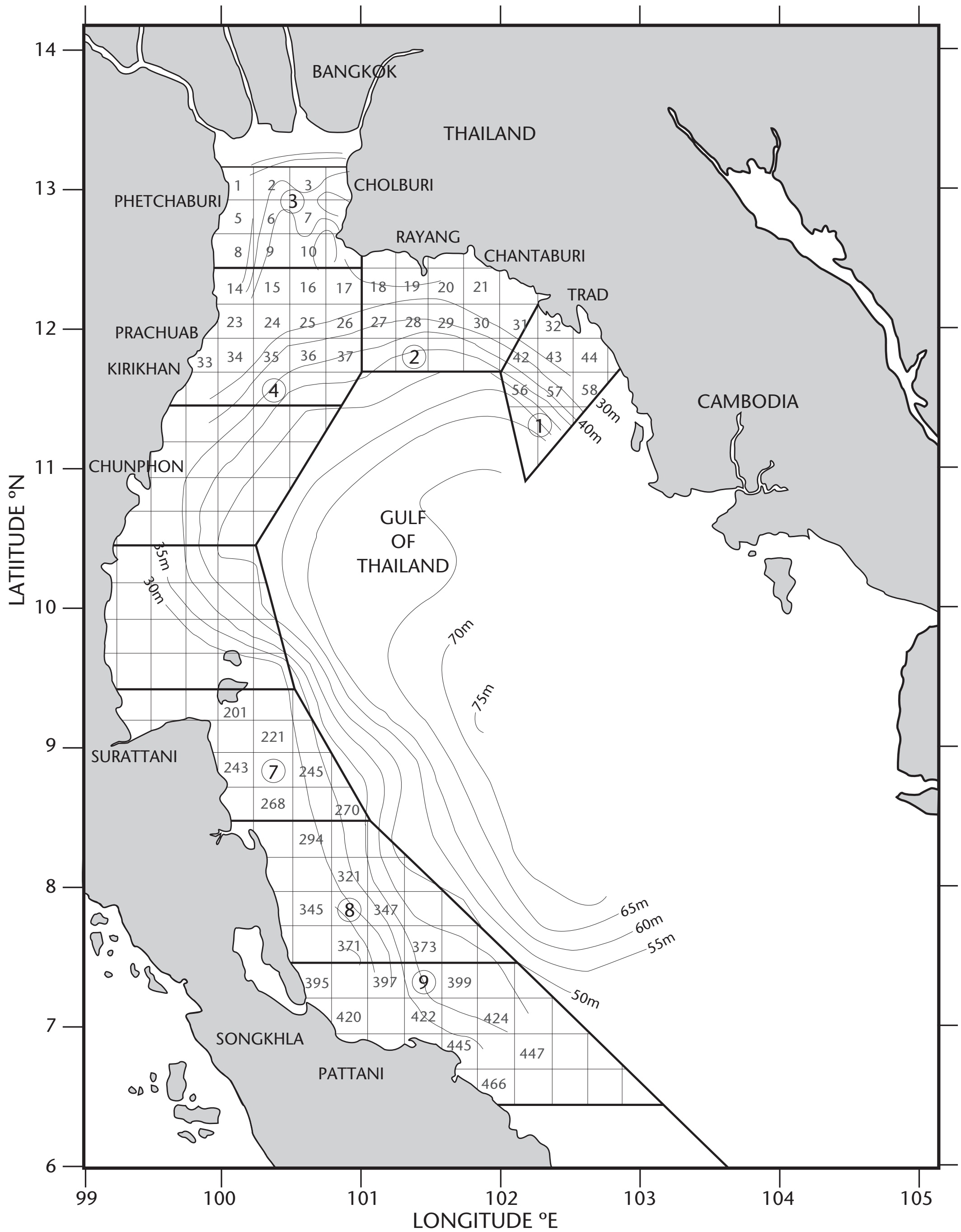


Fig. 1. Grid stations and depth contours in the Gulf of Thailand used in the study. Circled numbers indicate statistical areas.

Data collected by RV Pramong 2 and 9 in 1995 were used in this study. Data from a total of 59 fixed stations or grids numbered in Fig. 1 each measuring 225 nm^2 (15 x15 nm) were used. Data for areas 5 and 6 were not available. CPUE data for 8 months (January, March, June, July, August, September, October and December) were available to estimate mean biomass for each month using the swept area method. The analysis steps undertaken during the course of this study are illustrated in Fig. 2. CPUE values by statistical grid were utilized to estimate biomass. Biomass was estimated using the swept area method (Sparre and Venema 1992) as follows:

$$B= \frac{CPUE}{a \cdot X_1} \cdot A$$

where A is the station or grid area (= $(15 \cdot 1.853\,2)^2$ km^2),
a is swept area (= 0.090 29 km^2), and
X_1 is the proportion of fish in the path of the gear retained in the net (= 0.5).

The swept area was estimated from the equation:

$$a = t \cdot v \cdot h \cdot X_2$$

where t is the time spent trawling (= 1 hr),
v is velocity of trawling (= 2.5 knot),

h is the length of head-rope (= 39 m), and
X_2 is the ratio representing the effective head-rope length (= 0.5).

The resulting swept area (a) is 0.090 29 km^2.

CPUE ($kg \cdot hr^{-1}$) was recorded to species level whenever possible. A total number of 175 species or groups were recorded across the grids covered by the study. After deleting species of less than 0.1% relative abundance, a total of 90 species or groups and 59 stations were used in the analyses. Mean biomass by grid or station was used in **T**wo-**W**ay **IN**dicator **SP**ecies **AN**alysis (TWINSPAN) (Hill, 1979) and Detrended Correspondence Analysis (DCA) using the CANOCO program (Ter Braak, 1988). Classification diagrams were drawn to show the species and sites assemblages. Outliers were deleted in the process of analyses.

An attempt to use the biomass data and environmental parameters in the southern part of the Gulf (areas 7, 8 and 9) in external analysis was made (by plotting the first DCA axis scores vs. environmental parameters). Chemical and physical parameters were collected specific to the same time and grid. Environmental parameters assembled were depth, bottom type, temperature, salinity, pH, dissolved oxygen, total suspended solids, nitrates, nitrites, ammonia and phosphate during the months of July, September and October 1995. A summary of the bottom type data is illustrated in Fig. 3. Due to the limited spatial and temporal coverage of the environmental data, the external analysis was discontinued.

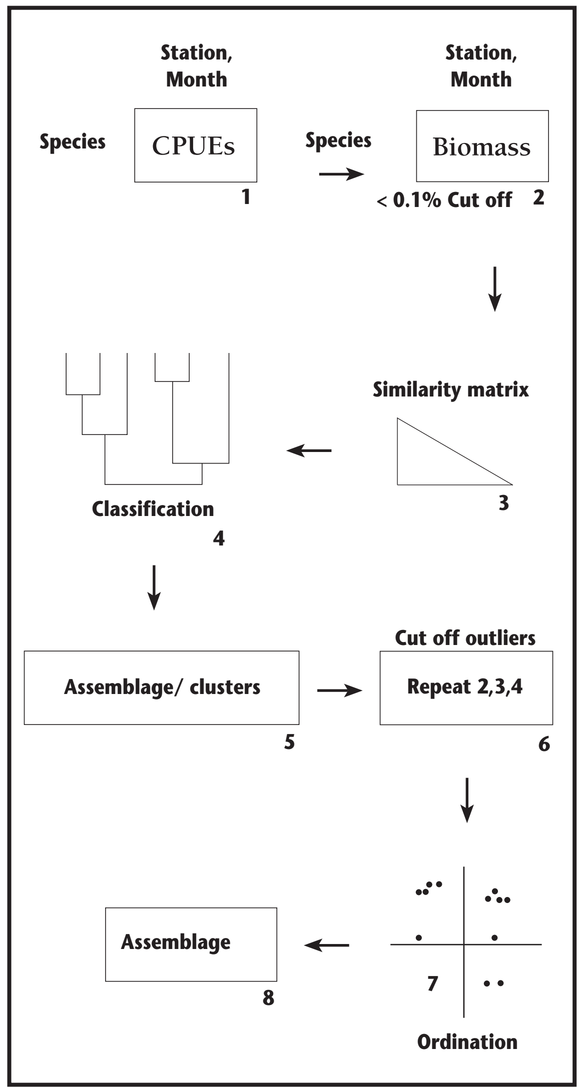


Fig. 2. Graphical representation of the stages of analysis made in this study.

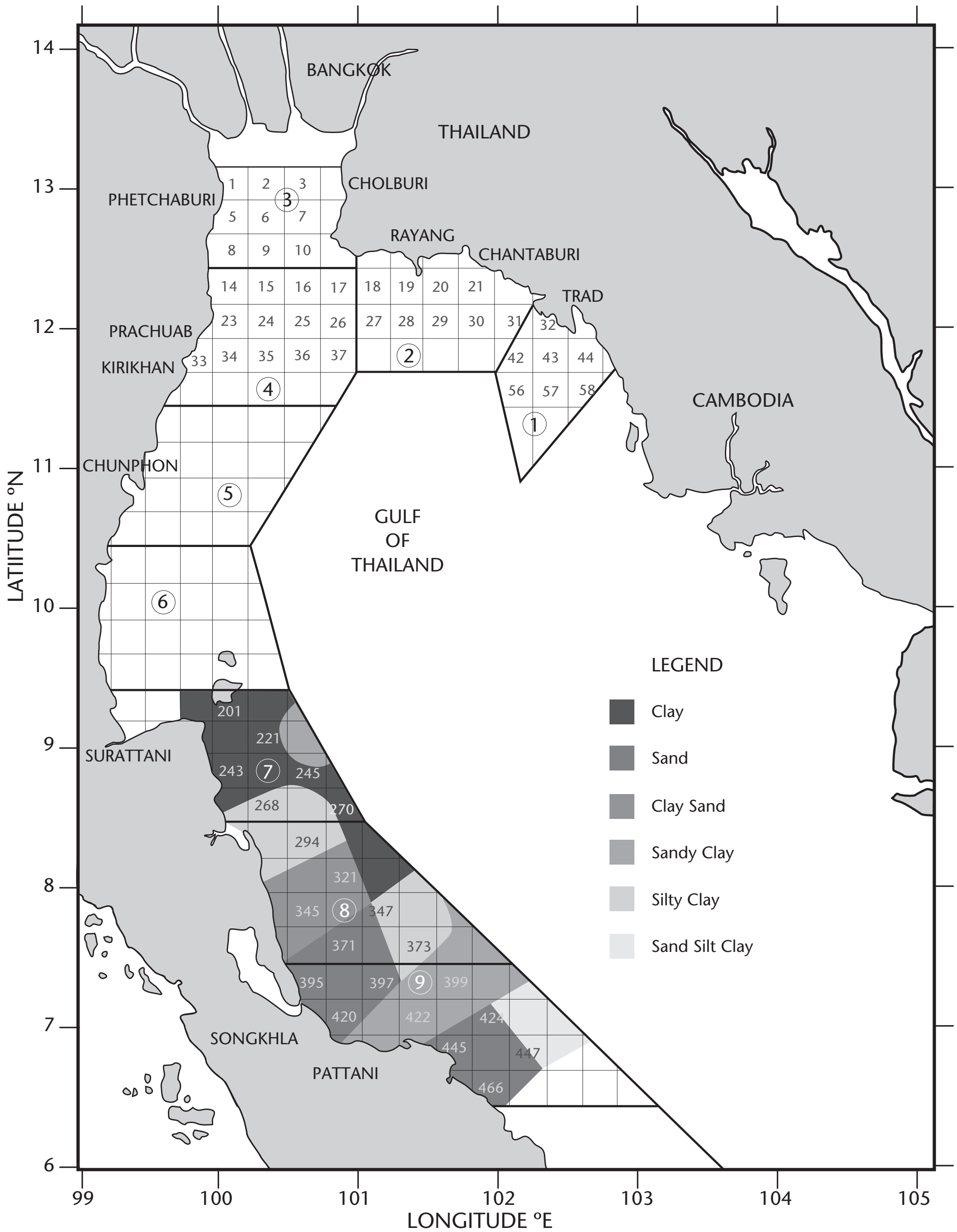


Fig. 3. Bottom types in the southern Gulf of Thailand, 1995.

Results and Discussion

Species Composition

A total of 175 species/groups from the 59 trawl grids/stations were caught by RV Pramong 2 and 9 in 1995. Data for species/groups which formed less than 0.1% of the total biomass were deleted, resulting into 90 species/groups retained for the analysis (Table 1). The most abundant groups were Leiognathidae (slipmouths), squids, Synodontidae, Sphyraenidae, miscellaneous trash fish, all Nemipteridae, *Priacanthus* spp., Mullidae, Carangidae and *Siganus* spp.. Leiognathids were dominant comprising over 20% of catches, and this included *Leiognathus elongatus, Leiognathus splendens, Leiognathus bindus* and *Leiognathus leniolatus.* In 1995, Leiognathidae was classified as food fish compared to previous work which grouped them as trash fish. Trash fish comprised about 40 - 50% of the total catch (Marine Fisheries Division 1997).

Two stations (016 and 033) were deleted because these were identified as outliers. Station 016 and 033 catches comprised 38 and 47 species/groups, respectively. The most abundant species/group in station 016 was Sphyraenidae (including *Sphyraena obtusata*), which accounted for about 84% of the biomass. At station 033, the most abundant group was miscellaneous trash fish which made up 82% of the biomass. One group heavily dominated these two outlier stations. The use of large categories (such as miscellaneous trash fish) gives the opportunity to dump species that are difficult to identify into this category. This issue has been noted in other studies (Bianchi et al. 1996). This can lead to inconsistencies between different stations of a given survey.

Table 1. CPUE (kg·hr^{-1}) and biomass (t) of 90 species/groups in the Gulf of Thailand, 1995.

Taxa	CPUE (kg·hr^{-1})	Biomass (t)	Taxa	CPUE (kg·hr^{-1})	Biomass (t)
Leiognathidae	277.1	3 496	Bothidae	7.0	134
Squids	154. 6	2 550	*Atule mate*	8.0	131
Leiognathus elongatus	103.6	1 702	Serranidae	7.5	125
Leiognathus splendens	126.6	1 491	*Alepes melanoptera*	7.0	118
Miscellaneous trash	124.0	1 478	*Charybdis ferriatus*	6.5	108
Synodontidae	84.4	1 405	*Scomberomorus commerson*	6.0	101
Sphyraenidae	70.4	1 194	*Leiognathus* spp.	12.1	101
Sphyraena obtusata	62.9	1 075	*Lutjanus vitta*	5.1	93
Scolopsis spp.	59.8	1 013	Miscellaneous crabs	5.9	92
Scolopsis taeniopterus	59.7	1 013	Fistulariidae	6.2	91
Saurida undosquamis	45.9	770	*Encrasicholina* spp.	6.2	90
Mullidae	41.4	659	Sciaenidae	6.3	87
Carangidae	36.9	564	*Sepia recurvirostris*	5.1	84
Loligo duvauceli	33.4	556	Trichiuridae	4.3	71
Leiognathus bindus	31.9	538	*Caranx malabaricus* *(Carangoides malabaricus*)*	4.3	71
Siganidae	34.0	527	*Rastrelliger kanagurta*	4.0	65
Nemipteridae	30.1	505	*Sepia lycidas*	3.9	64

Table 1. CPUE (kg·hr^{-1}) and biomass (t) of 90 species/groups in the Gulf of Thailand, 1995. (continued)

Taxa	CPUE (kg·hr^{-1})	Biomass (t)	Taxa	CPUE (kg·hr^{-1})	Biomass (t)
Priacanthidae	28.6	482	*Chirocentrus dorab*	3.9	62
Secutor spp.	51.3	455	*Megalaspis cordyla*	3.9	62
Cuttlefishes	23.9	412	*Sepia pharaonis*	3.7	60
Lutjanus lutjanus	24.4	402	Muraenesocidae	3.5	59
Amusium pleuronectes	23.3	390	Lutjanidae	3.5	59
Crabs	23.2	380	*Loligo chinensis*	4.2	52
Saurida elongata	22.3	365	*Pentaprion longimanus*	3.1	52
Lutjanidae	18.4	318	Clupeidae	3.8	52
Priacanthus tayenus	18.8	315	*Secutor ruconius*	2.6	51
Crabs (trash)	19.8	296	*Anodontostoma chacunda*	3.1	50
Loligo sumatrensis	17.6	291	Dorosomatinae	3.1	50
Saurida isarankurai	15.3	254	*Trichiurus lepturus*	3.0	49
Nemipterus mesoprion	14.9	246	*Selaroides leptolepis*	3.4	48
Sepioteuthis lessoniana	12.7	209	*Sphyraena jello*	2.7	47
Nemipterus hexodon	12.3	208	*Alepes kalla (A. djedaba*)*	5.1	47
Apogonidae	11.3	184	*Plectorhinchus pictus*	2.8	46
Lutjanus johni (L. johnii)*	11.1	176	Pleuronectidae	2.9	46
Leiognathus lineolatus	10.3	173	*Scomberomorus* spp.	3.4	43
Tetraodontidae	11.0	171	*Selar crumenopthalmus*	2.5	42
Portunus pelagicus	10.2	168	*Nemipterus peronii*	2.3	38
Priacanthus macracanthus	9.9	166	Cynoglossidae	1.8	38
Platycephalidae	9.8	163	Pentapodidae	2.3	38
Scombridae	10.18	157	*Sepia brevimana*	2.3	37
Balistidae	12.0	157	*Gazza minuta*	2.1	34
Octopus spp.	9.6	150	*Parastromateus niger*	2.	34
Rastrelliger spp.	9.0	149	*Rastrelliger brachysoma*	1.8	33
Sepia aculeata	7.9	147	*Secutor insidiator*	1.9	32
Mantis shrimps	9.2	147	Rays	2.2	32

Note: * valid name in Fishbase.

Spatial Analysis

The resulting station groupings using TWINSPAN are illustrated in Figs. 4 and 5. The DCA results are summarized in Fig. 6. Trawl stations are clustered into 4 groups, viz. Group A, B, C and D.

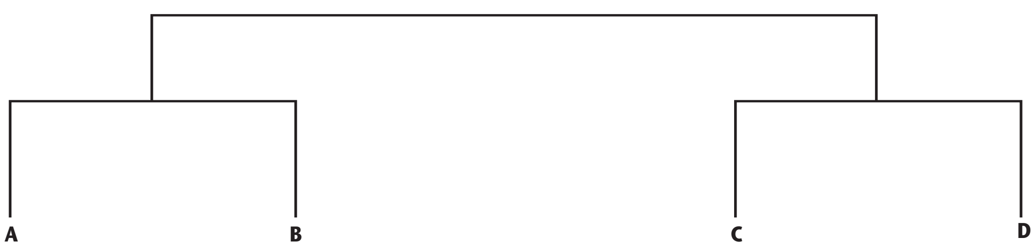
Group A includes 3 stations (stations 032, 044 and 058) located in the near-shore area at Ao Trad, Trad Province in the eastern part of the Gulf (Fig. 6). This group is in shallow areas with water depths less than 30 m (Fig. 1). The abundant species/groups in these stations are Leiognathidae (five groups/species), crabs, Synodontidae, miscellaneous crabs, carrangids and squid (Table 2). Pelagic crabs and mud crabs are also abundant in this group.

Group B includes 16 stations located near-shore in the inner and southern parts of the Gulf. This group is in water depths less than 30 m. The abundant species/groups in this cluster are miscellaneous trash fish, Leiognathidae, squid, two species of *Leiognathus*, two species of *Scolopsis*, cuttlefishes, Siganidae and crab (Table 2).

Group C includes 23 stations located in deeper areas in the inner and eastern part of the Gulf. This group is found in depths of about 30 m. The most abundant species/groups in this cluster are Sphyraenidae, squid, Synodontidae, Leiognathidae, *Scolopsis* spp. and Mullidae (Table 2).

Group D includes 15 stations located in deeper areas in the southern Gulf and two stations in the inner Gulf. This group is found in depths of more than 30 m. The most abundant species/groups are Leiognathidae, squid, Siganidae, Synodontidae, *Lutjanus* spp., *Priacanthus* spp., carrangid and *Nemipterus* spp. (Table 2).

It was observed that squid was distributed widely, but more abundant in deeper water. Crabs were found abundant only in Group A and B, in shallow areas. *Scolopsis* spp. was found only in the shallow water of upper and southern parts of the Gulf. Synodontidae was abundant in Groups A, C and D. In general, differences in abundance were related to geographic location. Considering the depth contour in Fig. 1 and the station groupings in Fig. 6, the four station groups indicate clustering by geographic zone and depth.



Group	Trawl grids/stations
A	032,044,058
B	001,002,003,005,006,008,014,023 201,221,243,268,294,345,395,420
C	018,021,007,009,010,015,017,024,025,026,035,036 042,043,056,057,019,020,027,028,029,030,031
D	034,037,245,270,321,347,371,373,397,399,422,424,445,447,466

Fig. 4. Classification diagram of station clusters in the Gulf of Thailand based on trawl survey data collected in 1995.

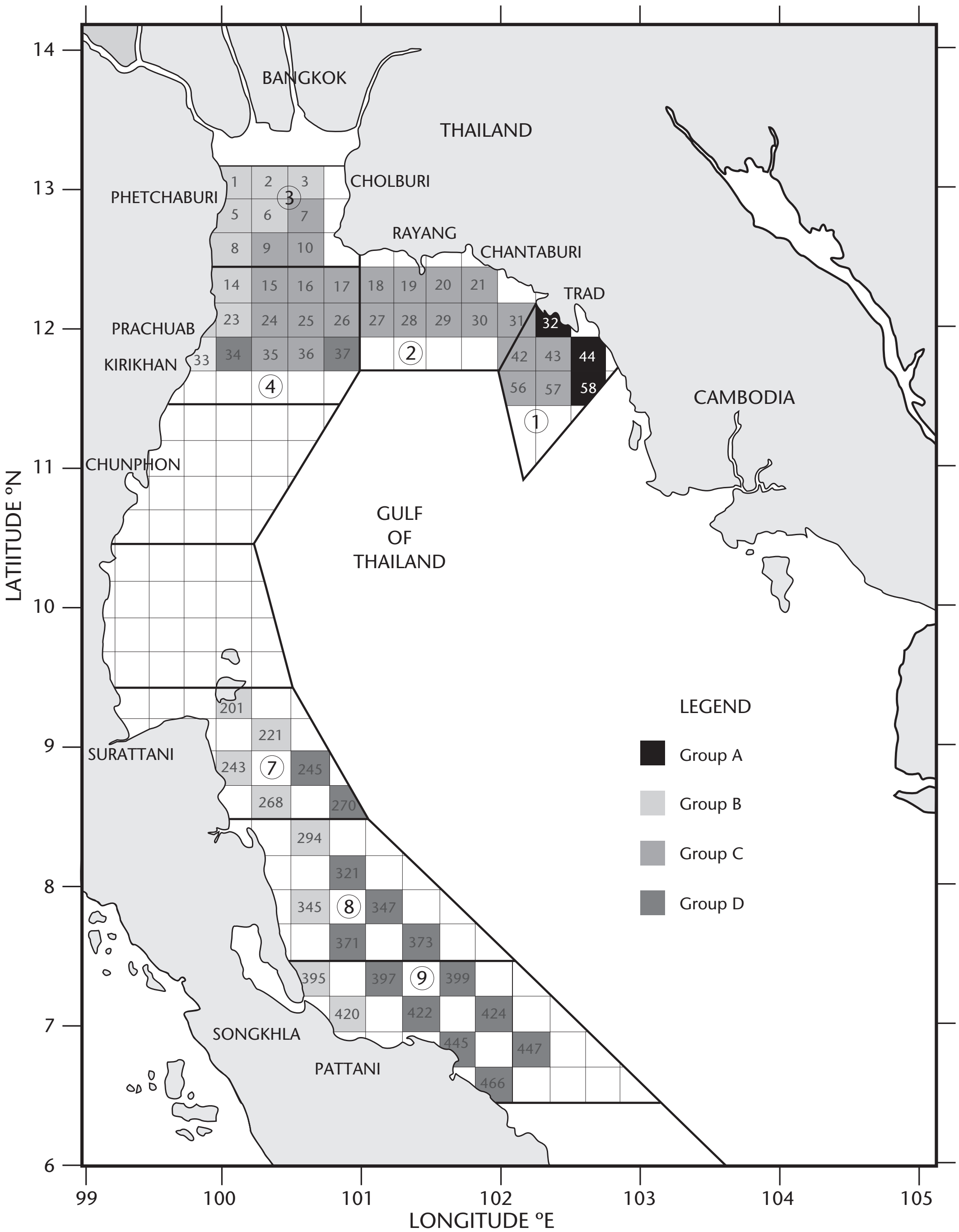


Fig. 5. Trawl grid/station groupings in the Gulf of Thailand based on 1995 research survey data.

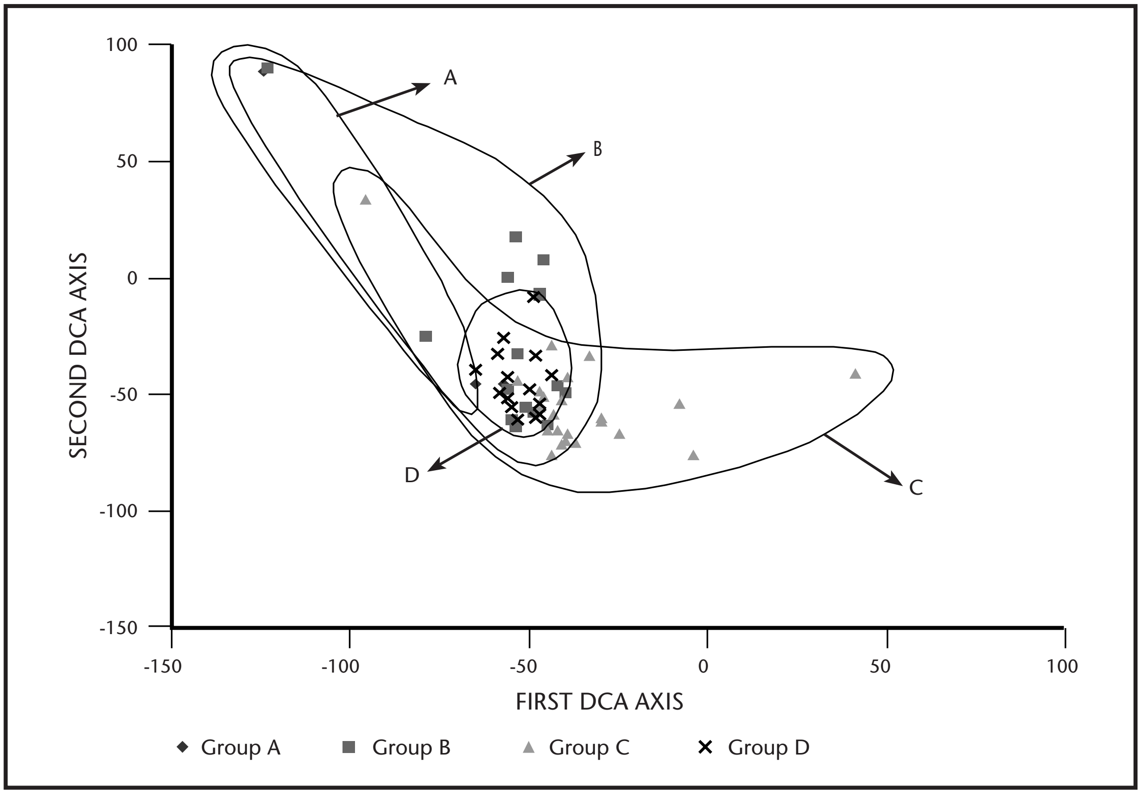


Figure 6. DCA plots showing the station assemblages.

Table 2. Biomass (t) and relative abundance (%) of the top ten species/group in each station-cluster resulting from spatial analysis.

Group A			Group B		
Species/Group	**Biomass (t)**	**%**	**Taxa**	**Biomass (t)**	**%**
Leiognathidae	1 051.0	31.51	Miscellaneous trashfish	1 212.5	16.85
Leiognathus splendens	501.7	15.04	Leiognathidae	937.7	13.03
Secutor spp.	402.7	12.07	Squids	799.9	11.12
Balistidae	108.7	3.26	*Leiognathus splendens*	774.4	10.76
Leiognathus spp.	100.1	3.00	*Leiognathus elongatus*	620.2	8.62
Crabs	94.6	2.84	*Scolopsis* spp.	169.5	2.36
Synodontidae	88.8	2.66	*Scolopsis taeniopterus*	168.8	2.35
Miscellaneous crabs	87.3	2.62	Cuttlefishes	160.1	2.23
Carangidae	84.0	2.52	Siganidae	111.6	1.55
Squids	79.1	2.37	Crabs (trash)	103.9	1.44

Table 2. Biomass (t) and relative abundance (%) of the top ten species/group in each station-cluster resulting from spatial analysis. (continued)

Group C			Group D		
Species/Group	**Biomass (t)**	**%**	**Taxa**	**Biomass (t)**	**%**
Sphyraenidae	1 137.9	8.95	Leiognathidae	761.6	10.31
Sphyraena obtusata	1 074.4	8.45	Squids	643.6	8.71
Squids	1 027.4	8.08	*Leiognathus elongatus*	389.2	5.27
Synodontidae	882.7	6.95	Siganidae	371.9	5.03
Leiognathidae	746.0	5.87	Synodontidae	347.9	4.71
Scolopsis spp.	658.2	5.18	*Lutjanus lutjanus*	335.5	4.54
Scolopsis taeniopterus	658.2	5.18	Priacanthidae	313.0	4.24
Leiognathus elongatus	652.1	5.13	*Leiognathus bindus*	289.9	3.92
Saurida undosquamis	583.1	4.59	Carangidae	264.7	3.58
Mullidae	489.7	3.85	Nemipteridae	250.1	3.39

Temporal Analysis

The average biomass by month was computed and used in the temporal analysis. Two temporal groups were identified: Group A comprising September and October; and Group B comprising January, March, June, July, August and December. In September and October, rainfall in the Gulf of Thailand is high compared to other months. In 1995, very heavy rainfall (about 500 - 2 600 mm) occurred during October (Department of Meteorology, 1995). It appears that Group A is associated with the wet season, and Group B with the dry season. The species appearing in both groups were almost the same but with different relative abundances (Table 3). The observed relative abundances are not very different however, suggesting that seasonal variability may not be pronounced. This may be due to the level of disaggregation used in sorting the survey catch into species/groups. Demersal fish and trashfish were the major components accounting for 18.4% and 17.8% of the biomasses of group A and B respectively. Squid appeared in both groups (5 - 6% of the total biomass). Sphyraenidae and *Sphyraena obtusata* were the only ones, which showed large differences in biomass between wet and dry seasons. In Group A (September and October), Sphyraenidae and *Sphyraena obtusata* amounted to about 12% of biomass whereas they were very low in abundance in Group B. Trashfish and *Leiognathus spendens* were abundant in the dry season. Species occurring in Group B were common throughout the year (Table 3). The DCA output is given in Fig. 7. It is suggested that further analysis should be completed with environmental data including biological information to explain these temporal differences in biomass estimates.

Table 3. Biomass (t) and relative abundance (%) of the top ten species/group in each station-cluster resulting from spatial analysis.

Group A			Group B		
Species/Group	**Biomass (t)**	**%**	**Taxa**	**Biomass (t)**	**%**
Demersal fishes	273	18.39	Trash groups	345	17.82
Trash groups	128	8.61	Demersal fishes	222	11.45
Cephalopods	110	7.38	Leiognathidae	174	8.97
Sphyraenidae	90	6.04	Cephalopods	124	6.42
Sphyreana obtusata	88	5.93	Misc. trash	115	5.93
Squids	86	5.81	*Leiognathus splendens*	104	5.37
Leiognathidae	80	5.39	Squids	92	4.75
Leiognathus elongatus	60	4.01	*Leiognathus elongatus*	58	2.99
Scolopsis taeniopterus	41	2.75	Synodontidae	57	2.96
Synodontidae	37	2.51	Pelagic fishes	49	2.53
Pelagic fishes	33	2.22	Saurida undosquamis	31	1.62
Secutor spp.	31	2.10	Mullidae	29	1.51
Mullidae	23	1.55	*Scolopsis taeniopterus*	29	1.51
Siganidae	23	1.53	*Leiognathus brevirostris*	25	1.31
Saurida undosquamis	22	1.47	*Loligo duvauceli*	24	1.24
Leiognathus splendens	18	1.24	Carangidae	23	1.17
Loligo duvauceli	16	1.08	*Lutjanus lutjanus*	22	1.13
Shells	15	1.04	Priacanthidae	22	1.12
Amusium pleuronectes	15	1.01	Nemipteridae	20	1.01
Nemipteridae	15	0.98	Crabs	19	0.97
Carangidae	14	0.92	Crabs (trash)	17	0.85
Cuttlefish	13	0.85	Siganidae	16	0.80
Priacanthidae	12	0.79	*Saurida elongata*	16	0.79
Loligo sumatrensis	11	0.71	Cuttlefish	15	0.77
Lutjanidae	10	0.70	*Priacanthus tayenus*	15	0.77

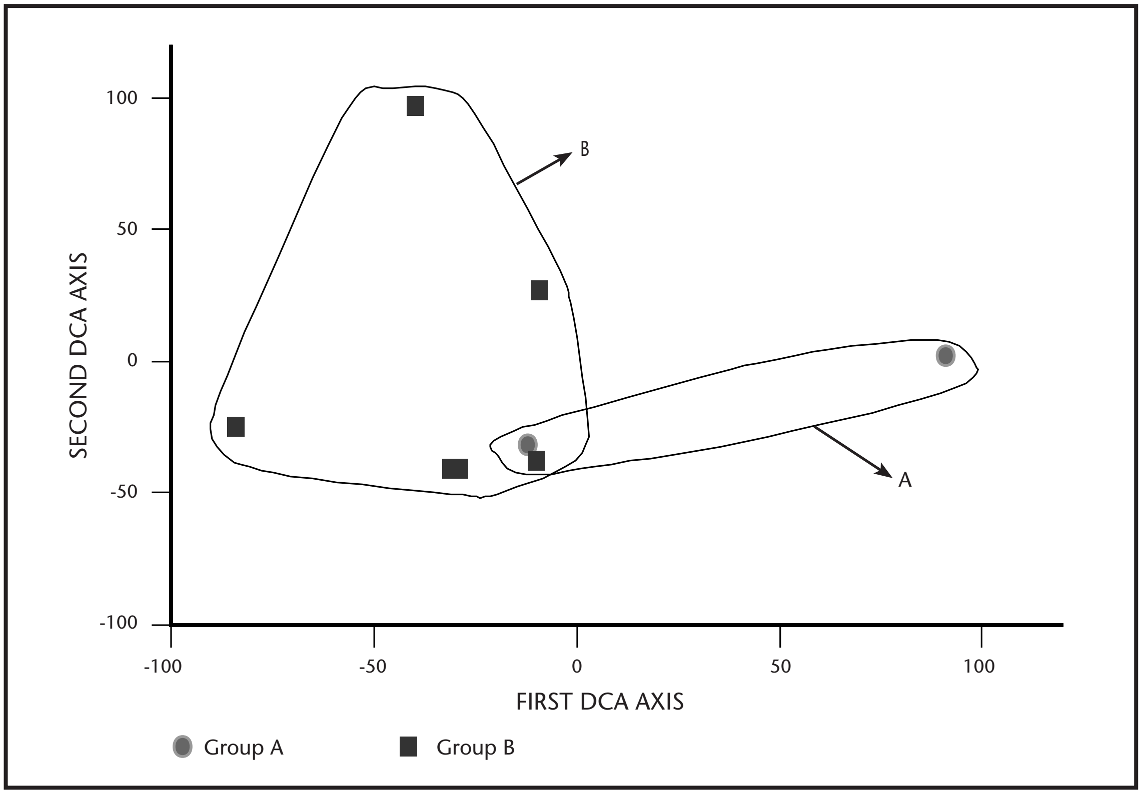


Fig. 7. DCA plots showing temporal groupings of assemblages.

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