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REPORT OF THE THAI-SEAFDEC JOINT FISHERY OCEANOGRAPHIC SURVEY IN THE CENTRAL GULF OF THAILAND

(16 May - 9 June 1984)

Volume I

Training Department

Southeast Asian Fisheries Development Center

Foreword

The work on fishery oceanography is only at the initial stage in the Southeast Asia, despite a number of studies on fisheries resources and the oceanic properties which have greatly expanded since the 1960s. On the other hand, there is a pressing requirement to know more on the effects of various parameters of oceanic environment which play an important role in determining the productivity of resources available to fisheries in all regions.

The coastal areas of the Gulf of Thailand up to the 40-meter depth were studied extensively by the Thai Department of Fisheries during the past two decades. The central part of the Gulf, however, was studied less. The SEAFDEC Training Department therefore initiated a joint survey of the central part of the Gulf in 1984, in cooperation with the Thai Department of Fisheries and other research institutes in Thailand, with a view to collect and compile information on fishery oceanography of this area for further study in the future.

The present volume contains the reports on the investigations on stock density of demersal fishes, marine bivalves, and results of bottom vertical longline experiments in the central part of the Gulf of Thailand. The fisheries oceanographic conditions, distribution of nutrients and dissolved organic carbon as well as the distribution of phytoplankton in this area are also presented. In addition, a study on food composition found in the stomach of squids is included.

The second volume of this Report is under preparation. It is our sincere hope that this Report would serve as a stepping stone in fulfilling the information gap for better understanding of the Gulf of Thailand.

Veravat Hongskul

Veravat Hongskul
Secretary-General of SEAFDEC

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COMPOSITION DISTRIBUTION AND STOCK EVALUATION OF DEMERSAL FISHES IN THE CENTRAL GULF OF THAILAND

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INTRODUCTION

Since the introduction of otter trawl in 1961, there has been a rapid development of fishery production in Thailand. The excessive use of otter trawl has, however, resulted in over-fishing and depletion of demersal resources especially in coastal areas of the Gulf of Thailand[1]. On the other hand, the demersal fish stocks in the central part of the Gulf have so far been spared, simply because the topographic conditions made this area unsuitable for trawling. In the present situation it has become necessary to investigate the possibility of exploitation of those unknown demersal fish resources.

Two resource surveys for evaluation of fishing ground and topography of the central part of the Gulf of Thailand were jointly organized by the Department of Fisheries, Thailand, and the Training Department, SEAFDEC. The surveys were conducted on board M.V. PAKNAM from 16 May to 9 June, and from 20 to 26 September, 1984.

The present paper deals with the analysis of the catch data which were collected by bottom trawl. Four subjects are discussed here; (i) fish composition of trawl catch, (ii) habitat and distribution of major demersal fishes, (iii) abundance of major demersal fishes in the survey areas, and (iv) general remarks on stock evaluation of demersal fishes in the central part of the Gulf. However, as this was the first attempt to carry out such a survey and because of the limitations of both space and time, the data given in the present report may not always be sufficient to draw conclusions with a high degree of accuracy.

It is therefore felt that further studies are necessary to evaluate the demersal resources in the central part of the Gulf.

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1) According to a report published in the Far Eastern Economic Review on 2 August 1984, the average catch of demersal fish in the inner Gulf of Thailand fell from 231.6 kg /hr in 1963 to 38.9 kg /hr in 1980

MATERIALS AND METHODS

1. Vessel and equipment

The M.V. PAKNAM is a 41.8 m stern trawler with a main engine of 1,000 horsepowers. The vessel is equipped for bottom trawling, tuna longline, drift net fishing, hydrography and plankton observation etc.

Two sizes of bottom trawl nets were used for the surveys. The design of the bottom trawl nets and the schematic representation of the gear is given in Figure 1.

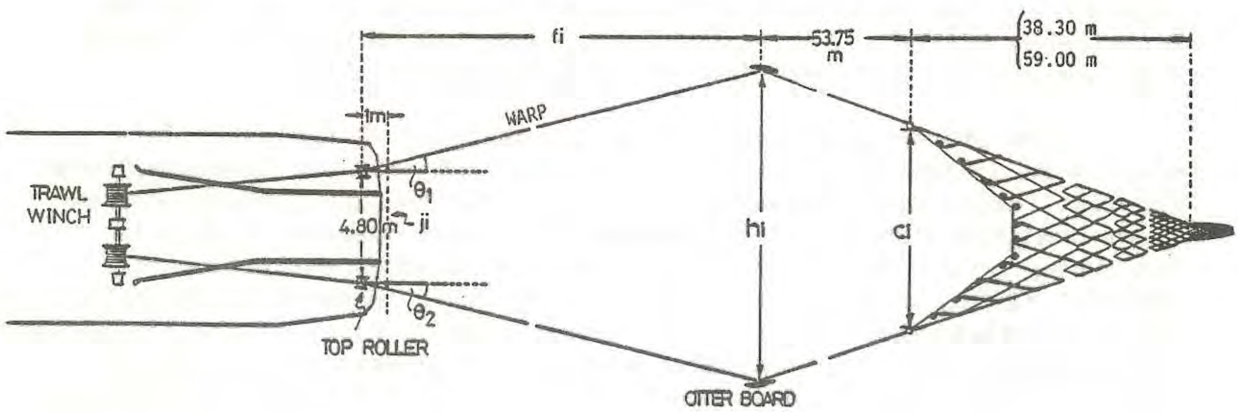


Fig. 1 Trawl net used in the survey(two net sizes).

2. Sampling and data processing

Nearly forty bottom hauls were made during the surveys. Of these, eleven hauls in the first survey and three hauls in the second survey were unsuccessful because of some mishaps with the net towing. Also, four hauls in the first survey were conducted in the zone of shallow waters in less than 40 m depth. As a result, the catch data collected from eleven trawling stations in the first survey and those from nine trawling stations in the second survey were used in the analysis. The locations of trawling stations are shown Figure 2. The hauls of the first survey were done after 1.5 to 2.5 hours' towing and six hauls of the second survey were operated after about an hours' towing. The towing speed was 3.0 to 3.2 knots.

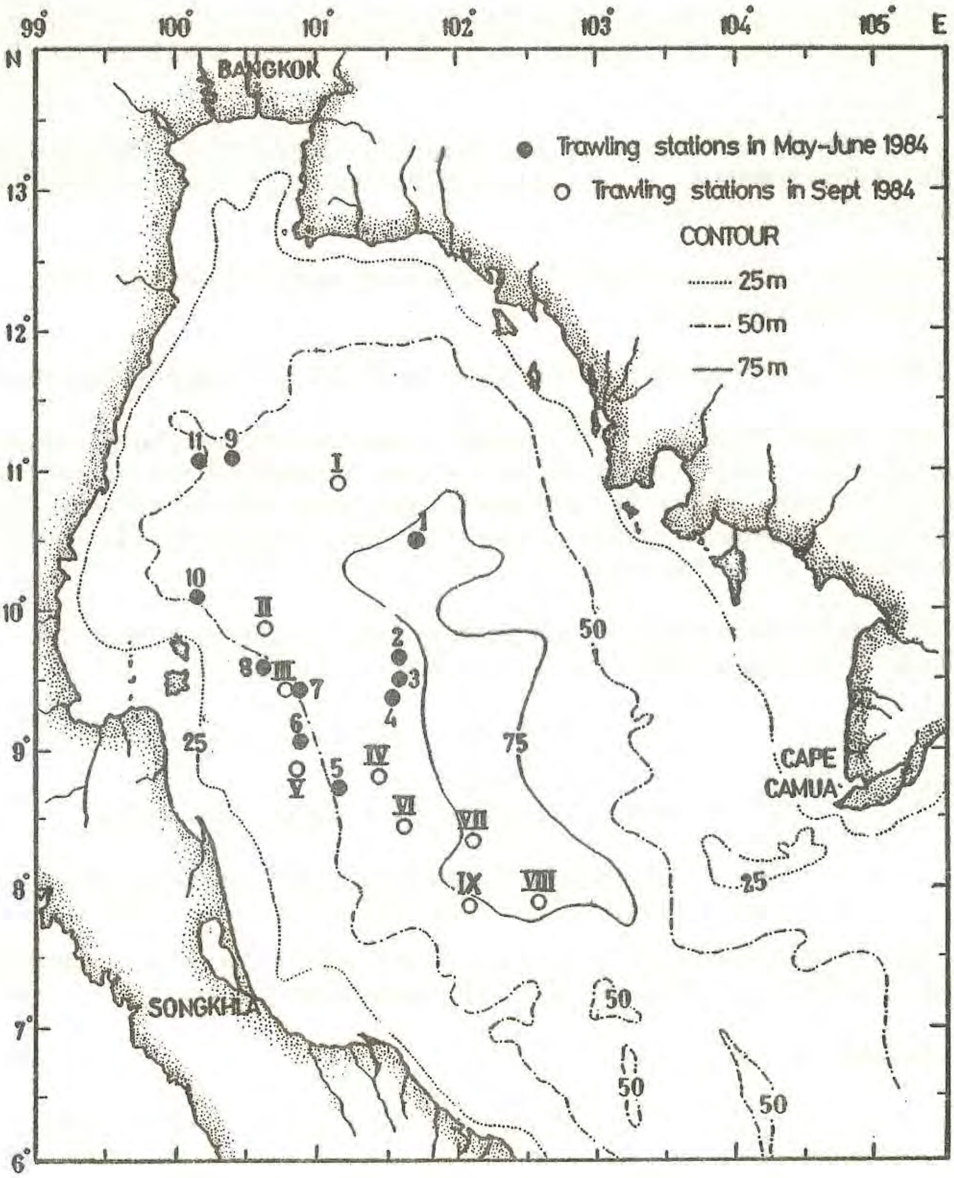


Fig. 2 Map showing trawling stations in the two surveys.

All the specimens caugth were weighed on board and the number in each species was recorded.

The species determination was mostly based on the *FAO Species Identification Sheets for Fishery Purpose* (FISCHER & WHITEHEAD (eds.) 1974).

The fishes belonging to the families CARANGIDAE, ENGRAULIDAE, GERRIDAE, and SCOMBRIDAE were classified as pelagic species when they occurred in the bottom trawl.

Habitat and distribution of selected major demersal fish species were investigated.

3. Estimation of abundance of demersal fish by the swept area method

The swept area method is widely used in estimation of abundance of demersal fish. The method rests on some assumptions because the area covered a single tow is different each time and is affected by such factors as distance between wings of net, towing speed, towing time, catchability coefficient etc.

The effective area (a_i:km^2) covered by a single towing is calculated by the equation:

$$a_i = b_i \cdot c_i \quad .... (1)$$

b_i : Towing distance in i trawl operation

c_i : Distance between wings of net in i trawl operation

The towing distance (b_i) in a trawl operation can be obtained by either of the following two methods described below:

Method I:

$$b_i = d_i \cdot e_i \quad .... (2)$$

d_i : Towing speed in i trawl operation

e_i : Towing time during i trawl operation

Method II was applied to the actual difference in locations of the net at the start and at the end of operation.

In the analysis, the authors adopted the mean value of b_i obtained by both methods.

For the calculation of the distance between wings (c_i), such parameters as the length of wire (f_i) the releasing angles of warps $(\theta_{1i})(\theta_{2i})$, and the distance between the otter boards (h_i) are required.

The distance between the otter boards (h_i: m) can be computed as follows;

$$h_{1i} = 2 \cdot f_i \cdot \sin \frac{\theta_{1i} + \theta_{2i}}{2} + 4.8 \quad \text{..........} \quad (3)$$

or

$$h_{2i} = f_i\ (j_i - 4.8) + 4.8 \quad \text{...................} \quad (3')$$

j_i : Distance between two warps at one meter out from top rollers

In the analysis, we used the mean value of h_i obtained from equations (3) and (3').

Then the value of c_i can be formulated as;

$$c_i = 59 \times h_i\ /112.75 \quad \text{........................} \quad (4)$$

$$c_i = 38.3 \times h_i\ /92.05 \quad \text{.......................} \quad (4')$$

The notation and values used in equations (1) to (4') are shown in Figure 1.

Density (D), and standing stock (B) for selected fish species in each trawling station were calculated and the equations are given below;

$$D_{ji} = C_{ji}\ /\ (a_i \times q_i) \quad \text{.......................} \quad (5)$$

$$B_{ji} = A_i \times D_{ji} \quad \text{..............................} \quad (6)$$

C_{ji} : Catch (kg) of j fish species in i trawl operation

A_i : Effective area of block representing i trawl operation

q_i : Catchability coefficient or Efficiency coefficient of trawl gear

Although the size of block (A) representing an operation was nearly the same for all operations, there was quite a difference among them in species composition and catch. Therefore, it is necessary to classify the trawling stations according to the observed similarity in distribution pattern for demersal fishes and local environmental conditions, especially the type of bottom. The authors calculated the actual size of block (A_i) under the above-mentioned consideration.

RESULTS AND DISCUSSION

Part I. Composition of trawl catch

1. Families level

The catches during the survey comprised demersal fishes from 23 families.

Trash fish predominated in the catch of the May-June survey. NEMIPTERIDAE and PRIACANTHIDAE followed with smaller proportion, ranging from 3.3 to 4.3 percent in weight. On the other hand, two families, NEMIPTERIDAE and PRIACANTHIDAE predominated in the September catches: 97 kg in weight and 2,254 individuals of NEMIPTERIDAE, 66 kg in weight and 778 individuals of PRIACANTHIDAE were caught. SYNODONTIDAE were rather more abundant in numbers than in weight in both surveys (Fig. 3).

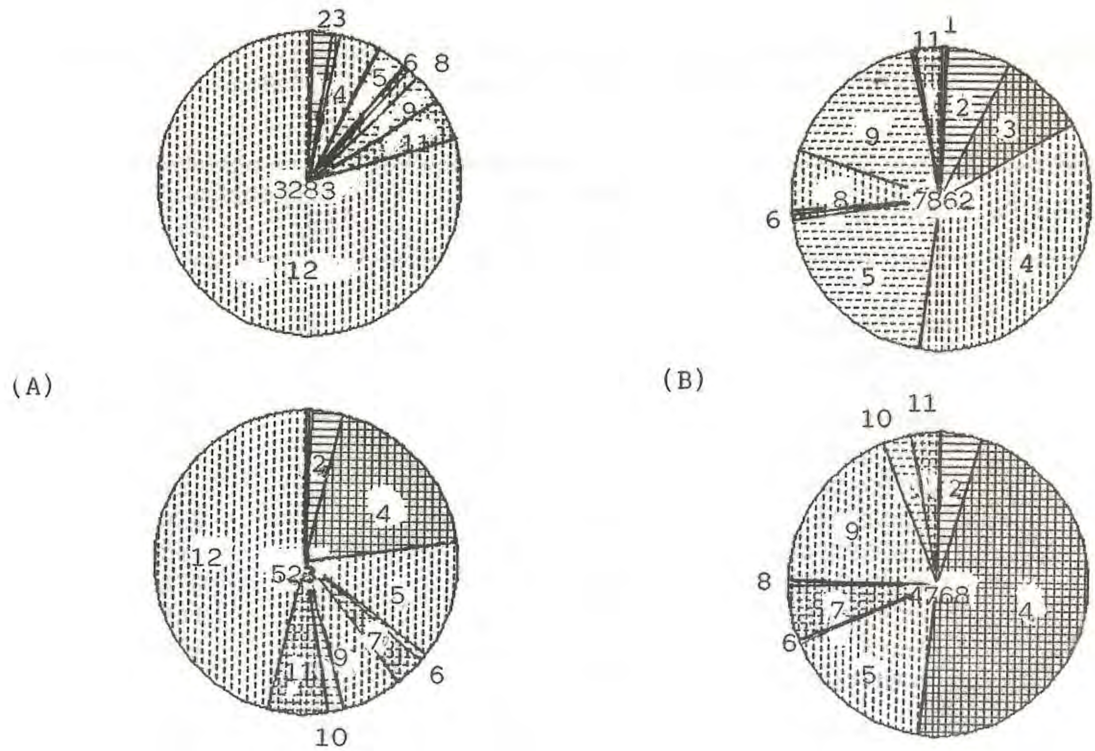


Fig. 3 Fish composition at family level collected in bottom trawl catches in all areas. A) Proportional composition by weight (total weight is given in the center of the circle). B) Proportional composition by number of fish (total number of fish is given in the center). Upper: May-June cruise, Lower: September cruise. The numbers from 1 to 12 show the names of family groups; 1: BALISTIDAE, 2: LUTJANIDAE, 3: MULLIDAE, 4: NEMIPTERIDAE, 5: PRIACANTHIDAE, 6: SERRANIDAE, 7: SIGANIDAE, 8: SPHYRAENIDAE, 9: SYNODONTIDAE, 10: TRICHIURIDAE, 11: Others, 12: Trash fishes.

More detailed information is given in Table 1.

Table 1. Fish composition by weight and by number at family level collected in bottom trawl catches in all areas.

Code No.	Family name	May-June kg	May-June No.	September kg	September No.
1	BALISTIDAE	14	53	4	12
2	LUTJANIDAE	69	531	16	210
3	MULLIDAE	23	733	1	25
4	NEMIPTERIDAE	142	2791	97	2254
5	PRIACANTHIDAE	107	1599	66	778
6	SERRANIDAE	17	73	4	21
7	SIGANIDAE	4	50	17	318
8	SPHYRAENIDAE	37	513	3	48
9	SYNODONTIDAE	106	1326	33	871
10	TRICHIURIDAE	3	31	9	146
11	Others	146	243	34	158
12	Trash fishes	2615	-	239	-
	TOTAL	3283	7862	523	4768

The diversity and similarity of demersal fish communities in all trawling areas were tested (Table 2).

The diversity indices ($1/\lambda$, $1/\Sigma II^2$) and the similarity indices ($C\lambda$, C_{II^2}) were computed as follows;

i) SIMPSON (1949) and MORISHITA (1959 b)

$$\lambda_1 = \sum_{i=1}^{k_1} n_{1i}(n_{1i}-1) \Big/ N_1(N_1-1),$$

$$\lambda_2 = \sum_{i=1}^{k_2} n_{2i}(n_{2i}-1) \Big/ N_2(N_2-1)$$

$$C_\lambda = 2 \sum_{i=1}^{\min(k_1,k_2)} n_{1i}n_{2i} \Big/ (\lambda_1+\lambda_2)N_1N_2$$

$$0 \leqq C\lambda \lneqq 1$$

ii) SIMPSON (1949) and KIMOTO (1967)

$$C_{II} = \frac{2 \sum n_{1i} n_{2i}}{(\sum \Pi_1^2 + \sum \Pi_2^2) N_1 N_2} \quad 0 \leq C_{II} \leq 1$$

$$\sum \Pi_1^2 = \frac{\sum n_{1i}^2}{N_1^2} \quad \sum \Pi_2^2 = \frac{\sum n_{2i}^2}{N_2^2}$$

Where n_i is the number of individuals of family i, k is the number of family groups and $N = \Sigma n_i$. Subscripts 1 and 2 indicate samples I and II respectively.

Table 2. Values of the index of community for fish samples collected in all trawling stations.

		May-June	September
No. of family groups	k	18	20
No. of individuals	$N = \Sigma n_i$	7862	4768
Indices of concentration	λ	0.21	0.29
	ΣII^2	0.21	0.29
Indices of diversity	$\beta(=1/\lambda)$	4.76	3.45
	$1/\Sigma \text{II}^2$	4.76	3.45
Similarity indices as degree of overlap	$C\lambda$	0.95	
	C_{II}	0.95	

As shown in this Table, the indices of diversity of fish population at family level was nearly the same, and the result of similarity indices between two surveys showed fairly high values. In other words, this suggests that the degree of overlap of the same fish group between two surveys is very high, especially for two dominant families, NEMIPTERIDAE and PRIACANTHIDAE.

The close similarity of composition of catches by trawl in the two surveys may be due to the fact that both May-June, and September, are in the rainy season in the Gulf of Thailand.

Trash fishes comprised verious kinds of small-sized uncommercial fishes. Among them, LEIOGNATHIDAE, NEMIPTERIDAE, SYNODONTIDAE predominated. They comprised a majority of all catches in weight.

Cephaloponds were not abundant in the catches and they were mostly small-sized individuals. In the first survey 182 kg and in the second survey 37 kg of cephalopods were caught, and the average weight of individual was 33.7 g and 46.5 g respectively (Fig. 4).

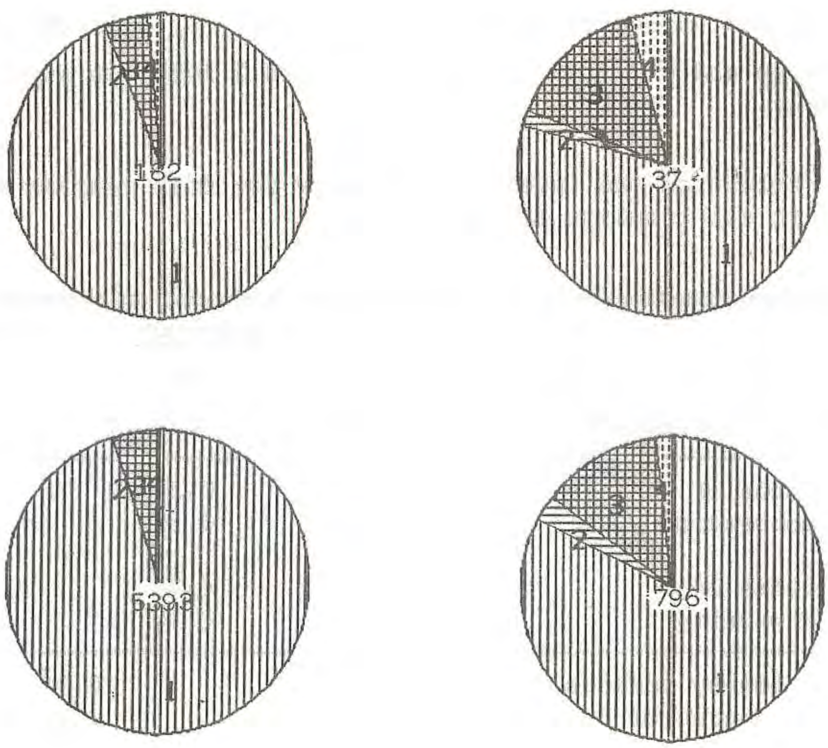


Fig. 4. Cephalopoda composition in all survey areas from bottom trawl catches. Left: May-June, Right: Sept. Upper part: in weight (kg), Lower part: in numbers.

1: *Loligo* sp., 2: *Octopus* sp., 3: *Sepia* sp., 4: *Sepioteuthis* sp.

According to the biological aspects of cephalopods, *Loligo* and *Sepioteuthis* belong to the neritic squids. The squid cast net,pair- and otter trawl are the major gear for catching squids. *Sepia* and *Sepiella* are predominantly shollow-water cuttlefishes living between the shore and the edge of the continental shelf and upper slope, and they are caught mostly by otter trawl. As already mentioned, however, the proportion of cephalopods in trawl catches from two surveys were not very important. Therefore, cephalopods were omitted from further analyses.

The bottom trawl catches included fishes from five pelagic families. CARANGIDAE were predominant both in weight and in numbers, followed by GERRIDAE and SCOMBRIDAE (Fig. 5).

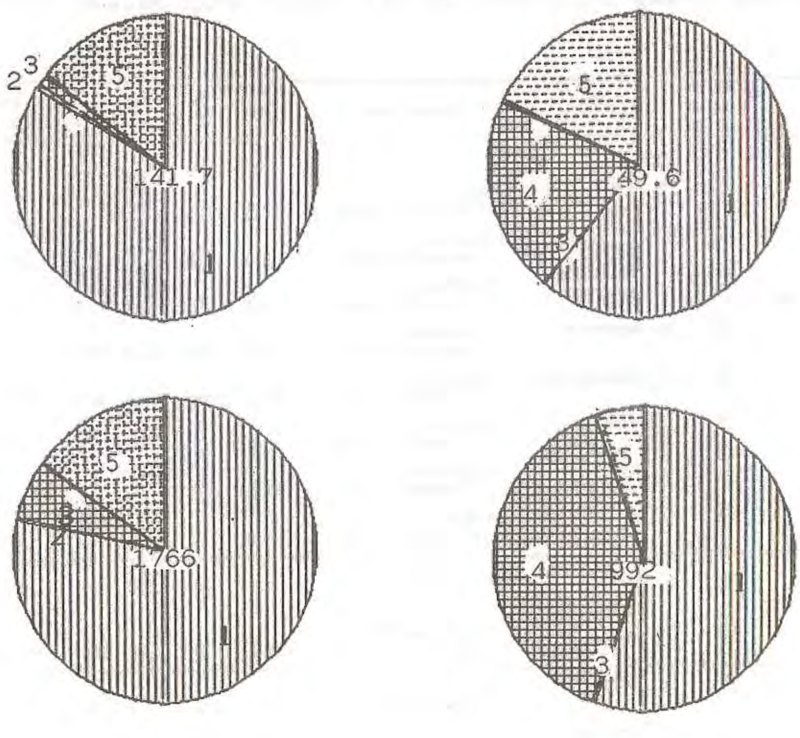


Fig. 5 Composition of pelagic fish in all survey areas from bottom trawl catches. Left: May-June, Right: September Upper part: in weight(kg), Lower part: in numbers.

1: CARANGIDAE, 2: CHIROCENTRIDAE, 3: ENGRAULIDAE, 4: GERRIDAE, 5: SCOMBRIDAE.

The proportion of pelagic fishes in the bottom trawl catches, however, does not seem very significant, with only 3.9-8.2 percent of the whole catch. Normally, pelagic fishes are collected as a by-catch from the bottom trawl catches. Therefore, we omitted pelagic fishes from further analyses.

2. Genera and species level

2.1 Seasonal occurrence in all survey areas

Among all demersal fishes (about 30 genera and 60 species) collected from bottom trawl catches in both surveys, three species of genus *Nemipterus*, one species of genus *Priacanthus*, and three species of genus *Saurida* were predominant both in weight and in numbers (Fig. 6).

The species were coded for convenience. Detailed information is given in Table 3.

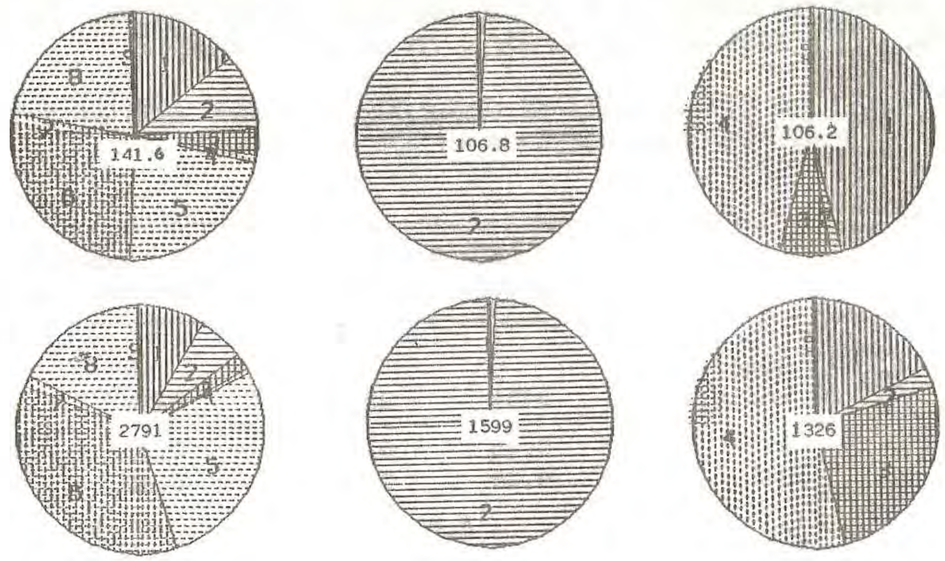
Table 3. Fish composition by weight and by number, at genera and species level collected in all areas from bottom trawl catches.

Genera	Species Code No.	Species	Common name	May-June kg.	May-June No.	September kg.	September No.	Pooled kg.	Pooled No.
Nemipterus Threadfin bream	1	*N. bleekeri*		20.3	246	6.2	94	26.5	340
	2	*N. hexodon*	Ornate threadfin bream	13.8	162	6.7	88	20.5	250
	3	*N. japonicus*	Japanese threadfin bream	5.1	59	9.4	129	14.5	188
	4	*N. marginatus*	Palefinned threadfin bream	1.3	15	0.9	23	2.2	38
	⑤	*N. mesoprion*	Redfilament threadfin bream	31.4	777	26.9	796	58.3	1573
	⑥	*N. nematophorus*	Doublewhip threadfin bream	35.9	999	38.1	937	74.0	1936
	7	*N. nemurus*	Redspine threadfin bream	2.5	40	0.4	5	2.9	45
	⑧	*N. tambuloides*	Fivelined threadfin bream	30.3	485	7.9	182	38.2	667
	9	*N. tolu*	Notched threadfin bream	1.0	8	0.0	0	1.0	8
Priacanthus Bigeye	1	*P. macracanthus*	Red bigeye	1.3	19	4.4	54	5.7	73
	②	*P. tayenus*	Purple-spotted bigeye	105.5	1580	61.5	724	167.0	2304
Saurida Lizardfish	①	*S. elongata*	Slender lizard fish	48.8	236	7.1	30	55.9	266
	2	*S. hoshinonis*		1.5	34	0.1	3	1.6	37
	③	*S. isarankurai*		7.4	346	9.0	595	16.4	941
	④	*S. undosquamis*	Brush-toothed lizard fish	48.5	710	15.2	199	63.7	909
Synodus	5	*S. variegatus*	Lizard fish	0.0	0	1.6	44	1.6	44

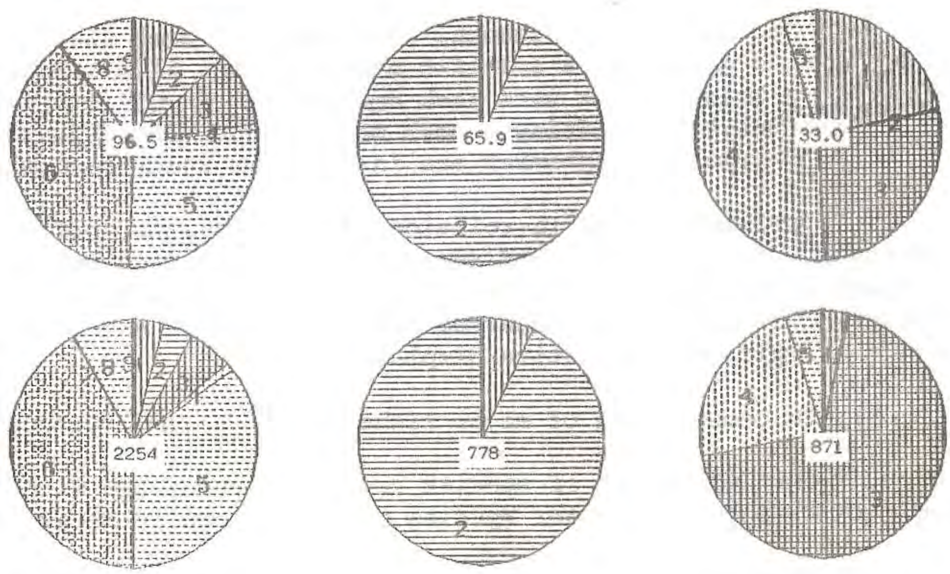
O : Dominant species

Three genera, *Nemipterus*, *Priacanthus* and *Saurida* were also found to predominate in annual catches from commercial trawlers (SEAFDEC, 1984).

a) May-June survey



b) September survey



Genus I II III

Fig. 6. Fish composition of genera and species level.
Upper half: in weight (kg). Lower half: in numbers.
The numbers from I to III and from 1 to 9 indicate the name of genus and species in each genus group, respectively;

I: *Nemipterus* – 1: *N. bleekeri*, 2: *N. hexodon*,
3: *N. japonicus*, 4: *N. marginatus*,
5: *N. mesoprion*, 6: *N. nematophorus*,
7: *N. nemurus*, 8: *N. tambuloides*,
9: *N. tolu*

II: *Priacanthus* – 1: *P. macracanthus*, 2: *P. tayenus*

III: *Saurida* – 1: *S. elongata*, 2: *S. hoshinonis*,
3: *S. isarankurai*, 4: *S. undosquamis*, and
5: *Synodus* variegatus

The value of the similarity index of species composition in genus *Nemipterus* was quite high for May-June and September. For genus *Saurida*, this index was not so high, as shown in Table 4.

Table 4. Values of the index of similarity for fish species collected in all trawling stations in two surveys.

	Nemipterus		*Saurida*	
	May-June	September	May-June	September
No. of species	9	8	4	5
No. of indiv.	2791	2254	1326	871
λ	0.25	0.31	0.39	0.52
ΣII^2	0.25	0.31	0.39	0.52
$C\lambda$	0.96		0.67	
C_{II}	0.96		0.67	

Thus the pattern of seasonal occurrence of each fish species in the same genus group has a specific peculiarity. This suggests that there is a tendency for such fish species as lizardfish to have a segregated habitat by shifting a peak of its occurence slightly, even though May-June and September are in the same rainy season.

The most serious intra-relation within the same species is the competition for the same food resources. If the food resources are insufficient in an inhabiting area, displacement occurs so as to reduce competition. The phenomenon observed for lizardfishes may be a remarkable example of competitive displacement.

2.2 Length composition of major fishes at each sampling station

From the viewpoint of species level analysis, the distribution of length composition for major species revealed some interesting figures.

The threadfin breams, *Nemipterus nematophorus* and *N. mesoprion* of May-June samples, both of which were dominant in catches, were found to consist of two different size groups. There was a significant difference in average size between them.

The small-sized groups concentrated in northward direction from approximately 9°30'N and the large-sized ones to the south of that latitude (Table 5-a). There was also a tendency that the mean length of each group became smaller as the sampling went in the southward direction (Fig. 7-a).

The differential-sized groups of threadfin breams were also found in the samples of September. However, in that month more large-sized groups were abundant, especially of *N. mesoprion* (Table 5-b).

According to the pooled data arranged by samples in different depth zone (because the sampling stations in September were mostly concentrated in the southern Gulf) the mean length of *N. nematophorus* becomes smaller from the shallower zones to the deeper zones (Fig. 7-b).

The most abundant species of bigeye, *Priacanthus tayenus*, showed a similar tendency. In this case, however, a various-sized groups of bigeye co-occurred in the regions above $9^{o}30'$N, or in the waters of 50-60 m depth (Table 5, Fig. 7).

Brush-tooth lizardfish, *Saurida undosquiamis*, showed a different pattern. Two size groups also co-occurred in the May-June survey, however, they distributed widely in all sampling areas and the geographic monocline of length composition of both size groups was not clear (Table 5, Fig. 7)

Table 5. Mean length, standard deviation and coefficient of variance of fish group of major species collected by trawl survey.

(a) May-June survey

Direction	North						South					
Station number	74	75	125	140	182	Average	204	207(1)	207(2)	223	271	Average
○ *Nemipterus nematophorus*												
No. of specimens	68	105	212	25	54	464	58	66	67	-	-	191
Mean length (M.L.: mm)	127.9	139.3	125.5	120.1	123.5	128.4	158.8	146.1	155.7	-	-	153.3
Standard deviation (S.D.)	19.58	18.87	21.11	19.20	35.62	6.11	27.45	15.94	16.26	-	-	5.41
Coefficient of variation (C.V.)	0.15	0.13	0.16	0.15	0.28	0.05	0.17	0.11	0.10	-	-	0.04
△ *N. mesoprion* (No. of sp.)	75	65	94	63	128	425	155	-	-	125	47	327
M.L.	123.8	133.3	121.2	128.7	133.2	128.2	149.9	-	-	152.4	143.3	149.9
S.D.	21.58	26.55	17.97	21.13	25.48	5.08	12.55	-	-	14.45	16.19	2.94
C.V.	0.17	0.19	0.14	0.16	0.19	0.04	0.08	-	-	0.09	0.11	0.02
○ *N. tambuloides* (No. of sp.)	-	21	162	-	-		-	136	84	-	-	
M.L.	-	180.5	151.7	-	-		-	174.6	191.7	-	-	
S.D.	-	27.29	36.70	-	-		-	30.98	27.63	-	-	
C.V.	-	0.15	0.24	-	-		-	0.18	0.14	-	-	
○ *N. hexodon*, No. (M.L.) / * *N. bleekeri* No. (M.L.)	32(185.9)	32(194.4)	- / 85(172.5)	-	19(188.2)		14(207.9)	- / 80(185.3)	- / 59(210.0)	27(190.6)	15(188.7)	
○ *Priacanthus tayenus* (No.)	*368	*188 / 79 / ○82	*33 / ○37	*57	*44 / ○6	*690 / ○125	6 / ×20	×198	×214	-	×43	×475
M.L.	125.2	124.3 / 173.7 / 219.6	109.8 / 218.2	127.6	126.1 / 206.7	124.5 / 218.6	138.3 / 217.5	201.7	212.0	-	201.3	207.0
S.D.	14.17	12.75 / 9.50 / 14.94	11.48 / 17.95	11.57	18.32 / 25.62	3.40 / 2.75	9.83 / 12.51	21.86	18.88	-	22.89	5.53
C.V.	0.11	0.10 / 0.05 / 0.07	0.10 / 0.08	0.09	0.14 / 0.12	0.03 / 0.01	0.07 / 0.05	0.11	0.09	-	0.11	0.03
○ *Saurida undosquamis* (No.)	#84	99	#57	#53	#52	252	#56	#111	-	#64	-	#225
M.L.	214.6	245.5	214.5	235.2	232.5	212.7	228.6	210.3	-	226.4	-	230.4
S.D.	29.71	23.35	27.35	32.31	22.91	2.12	23.77	22.19	-	25.81	-	3.44
C.V.	0.14	0.09	0.13	0.14	0.10	0.01	0.10	0.10	-	0.11	-	0.01
△ *S. elongata* (No.)	-	25	23	-	-		-	55	81	-	-	
M.L.	-	301.6	316.7	-	-		-	321.3	305.06	-	-	
S.D.	-	34.12	37.13	-	-		-	38.44	29.59	-	-	
C.V.	-	0.11	0.12	-	-		-	0.12	0.10	-	-	

Table 5. continued

(b) September survey

Depth (m)	60-70	50-60			40>	70<		
Station Number	93	160	204	Average	246	300	353	Average
° *Nemipterus nematophorus*								
No. of specimens	58	229 *58	*306	287 *364	–	×191	×20 13	×211 13
Mean length (M.L.: mm)	136.4	137.0 184.1	190.3	136.9 189.3	–	126.0	127.0 181.9	126.1 181.9
Standard deviation: (S.D.)	21.39	15.22 19.40	24.08	0.24 2.27	–	22.6	15.08 17.97	0.29 17.97
Coefficient of variation (C.V.)	0.16	0.11 0.11	0.13	0.00 0.01	–	0.18	0.12 0.10	0.00 0.10
° *N. mesoprion* (No.)	–	195	226	421	397	–	–	
M.L.	–	204.6	205.8	205.2	127.2	–	–	
S.D.	–	20.34	18.70	0.60	17.07	–	–	
C.V.	–	0.10	0.09	0.00	0.13	–	–	
* *N. tambuloides* (No.)	36	40 2	–	76 2	76 2	–	–	76 2
M.L.	156.4	154.7 255.0	–	155.5 255.0	161.8 300.0	–	–	161.8 300.0
S.D.	27.48	17.61 14.14	–	0.85 14.14	24.01 21.21	–	–	24.01 21.21
C.V.	0.17	0.11 0.06	–	0.01 0.06	0.15 0.07	–	–	0.15 0.07
* *N. japonicus* (No.)	–	49 2	68 3	117 5	–	–	–	–
M.L.	–	174.4 240.00	157.8 241.7	164.8 241.0	–	–	–	–
S.D.	–	16.88 7.07	20.28 11.55	8.23 0.93	–	–	–	–
C.V.	–	0.10 0.03	0.13 0.05	0.05 0.00	–	–	–	
° *Priacanthus tayenus* (No.)	–	232 65	124		46	–	–	
M.L.	–	180.0 243.5	154.3		167.0	–	–	
S.D.	–	18.23 15.83	19.37		27.05	–	–	
C.V.	–	0.10 0.06	0.12		0.16	–	–	
° *Saurida undosquamis* (No.)	*17	*64	*30	*124	*13	24		
M.L.	218.5	228.1	230.0	226.7	222.7	195.0	–	
C.D.	19.98	23.02	24.74	3.83	12.35	21.67	–	
C.V.	0.09	0.10	0.11	0.02	0.06	0.11	–	

*: Calculated by 20 mm interval

o: Calculated by 10 mm interval

Other marks were used for average values

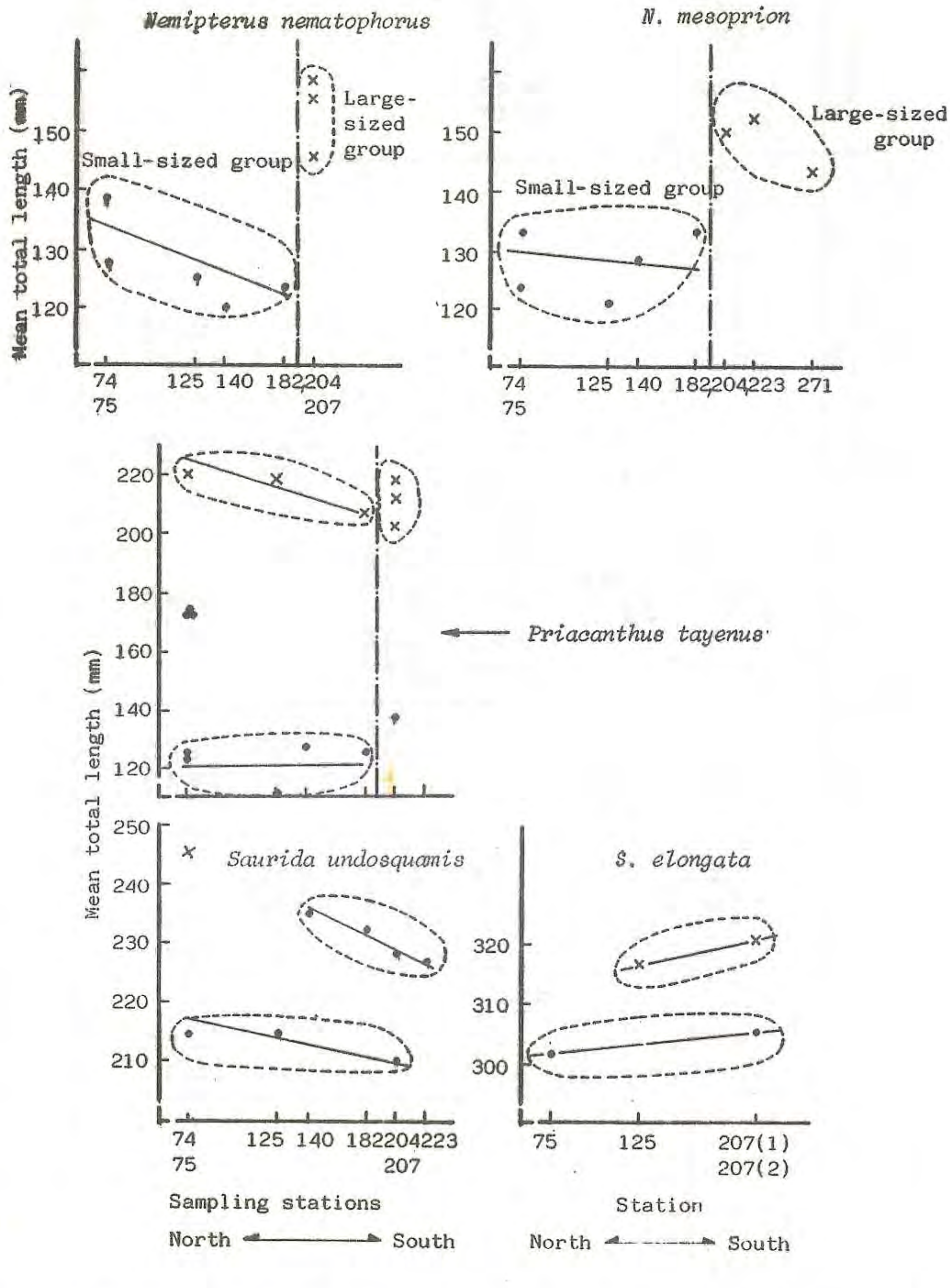


Fig. 7-a Distribution of mean length for fish samples of major species collected in each sampling station (May-June).

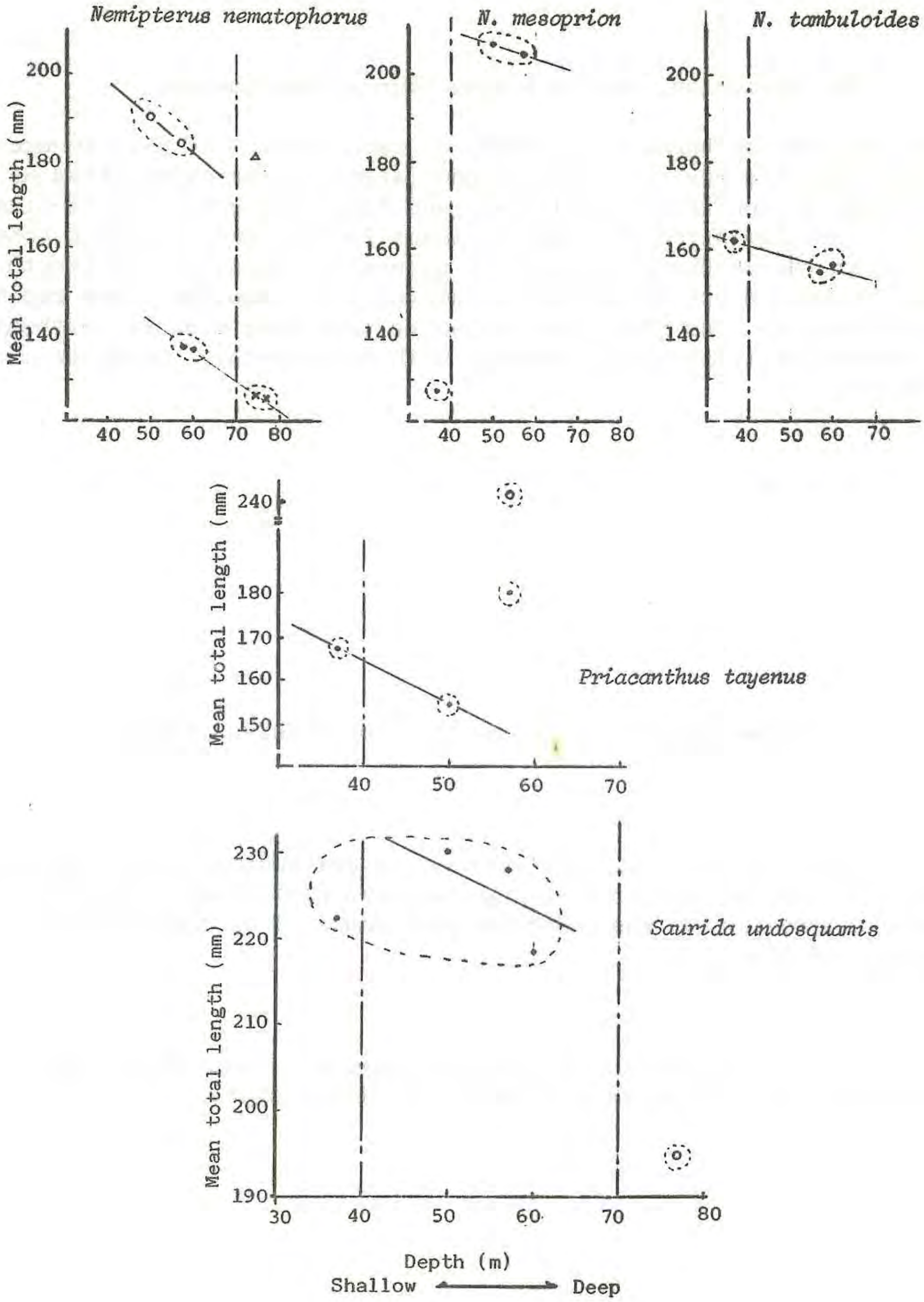


Fig. 7-b Distribution of mean length for fish samples of major species from bottom trawl catches in different depth zones (September).

In conclusion, the following four points emerge:

1) at least two or three size groups of each species of fish co-occurred in each sampling period; 2) fish population can be categorized as early-born group (large-sized fish) and late-born group (small-sized fish); 3) large-sized fish are dominant in intermediate depth zone of 50-60 m in the southern region; 4) geographic monocline of length composition(fish are larger in the northern and shallow water region) within the same size fish group suggests that they migrate northward (or shoreward) in the rainy season, with some monthly variation of migration.

Part II. Habitat and distribution of major demersal fishes

Although there are differences in the environmental conditions among the trawling stations in two surveys, some local similarity of community composition was observed when compared by the similarity indices (Table 6).

In the calculation of Table 6, however, crustaceans and cephalopods were included with demersal fish groups.

Table 6. Values of the index of community, C_λ and C_{II}, for family level in each trawling station.

a) May-June survey

Grid No. Depth(m)	125 70-72	186 70	207 70-71	271 59-60	223 40-43	204 48-52	182 48-50	75 60	140 53-60	74 49-54
No.of fish group(k)	11	9	13	8	14	11	12	11	12	12
No.of indiv.(n)	2711	289	810	244	1448	1280	1303	962	604	2438
λ	0.20	0.37	0.24	0.24	0.38	0.52	0.41	0.25	0.27	0.45
$\Sigma\ II^2$	0.20	0.38	0.24	0.24	0.38	0.52	0.41	0.25	0.27	0.45

$C\lambda$ (C_{II}) values	186	207	271	223	183	182	75	140	74
125	0.75 (0.74)	0.79 (0.79)	0.66 (0.66)	0.32 (0.32)	0.40 (0.40)	0.44 0.44	0.66 (0.66)	0.62 (0.62)	0.34 (0.34)
186		0.81 (0.79)	0.86 (0.85)	0.65 (0.64)	0.77 (0.76)	0.78 (0.77)	0.64 (0.63)	0.85 (0.84)	0.64 (0.63)
207			0.88 (0.88)	0.43 (0.43)	0.50 (0.50)	0.54 (0.54)	0.94 (0.94)	0.76 (0.76)	0.52 (0.52)
271				0.66 (0.66)	0.74 (0.74)	0.80 (0.80)	0.85 (0.85)	0.89 (0.89)	0.75 (0.75)
223					0.90 (0.90)	0.91 (0.91)	0.44 (0.44)	0.84 (0.84)	0.90 (0.90)
204						0.99 (0.99)	0.50 (0.50)	0.89 (0.89)	0.95 (0.95)
182							0.54 (0.54)	0.93 (0.93)	0.96 (0.96)
75								0.74 (0.74)	0.62 (0.62)
140									0.89 (0.89)

b) September survey

Grid No. Depth(m)	93 60-62	160 56-57	204 50-52	248 60-62	246 37-40	298 60-61	300 77	353 75	351 70
No.of fish group (k)	8	13	15	8	18	7	9	9	6
No.of indiv.(n)	660	1939	1194	290	1001	89	1058	302	63
λ	0.28	0.25	0.36	0.31	0.28	0.20	0.38	0.47	0.25
$\Sigma_{II}{}^2$	0.28	0.25	0.36	0.31	0.28	0.21	0.38	0.47	0.26

C_λ (C_{II}) values	160	204	248	246	298	300	353	351
93	0.71 (0.71)	0.79 (0.79)	0.94 (0.94)	0.72 (0.72)	0.72 (0.71)	0.78 (0.78)	0.38 (0.38)	0.51 (0.50)
160		0.81 (0.81)	0.77 (0.77)	0.60 (0.60)	0.95 (0.93)	0.72 (0.72)	0.37 (0.37)	0.80 (0.78)
204			0.93 (0.93)	0.80 (0.80)	0.81 (0.80)	0.94 (0.94)	0.48 (0.48)	0.43 (0.42)
248				0.83 (0.83)	0.79 (0.77)	0.90 (0.90)	0.41 (0.41)	0.48 (0.47)
246					0.59 (0.58)	0.72 (0.72)	0.26 (0.26)	0.26 (0.26)
298						0.80 (0.79)	0.56 (0.56)	0.78 (0.74)
300							0.70 (0.70)	0.46 (0.46)
353								0.36 (0.35)

Generally there is a tendency that the high values of C_λ and C_{II} were observed for fish groups at the family level collected from nearly the same depth zone, especially in the shallower waters less than 50 m deep. These were classified for convenience in follows;

May-June			September		
Grid No.	Depth (m)	Mean value of C_λ	Grid No.	Depth (m)	Mean value of C_λ
223, 182	40-50	0.91	246	40≥	-
271, 204, 140, 74	50-60	0.85	160, 204,	50-60	0.81
75, 186,	60-70	0.64	93, 248, 298, 351	60-70	0.70
125, 207	70≤	0.79	300, 353,	70≤	0.70

Thus the sea depth seems to be one of the factors to decide the habitat of demersal fish groups at the family level.

Table 7 gives the catch rate (kg/h) of major demersal fish species in different depth zones.

Table 7. Average catch rate (kg/h) of major fishes from bottom trawl catches in different depth zones. Values are shown for May-June and, in parentheses, for September.

Genus	Species	Depth zone (m) / No. of hauls	≤40 / 0 (1)	40-50 / 2 (0)	50-60 / 4 (2)	60-70 / 2 (4)	70≤ / 3 (2)
Nemipterus			- (18.0)	4.4 (-)	4.3 (27.5)	4.3 (4.3)	12.0 (11.1)
	N. bleekeri		- (0.0)	0.0 (-)	0.0 (0.0)	0.3 (0.7)	3.2 (3.2)
	N. hexodon		- (4.4)	1.0 (-)	0.9 (1.2)	0.8 (0.0)	0.0 (0.0)
	N. japonicus		- (0.0)	0.4 (-)	0.4 (4.4)	0.0 (0.1)	0.0 (0.3)
	N. mesoprion		- (13.4)	2.6 (-)	1.9 (6.6)	0.6 (0.1)	0.5 (0.1)
	N. nematophorus		- (0.1)	0.4 (-)	0.9 (13.7)	1.4 (1.5)	3.6 (4.9)
	N. tambuloides		- (0.0)	0.0 (-)	0.1 (1.2)	1.0 (1.8)	4.4 (2.7)
	Other *Nemipterus*		- (0.1)	0.0 (-)	0.1 (0.4)	0.2 (0.1)	0.3 (0.0)
Priacanthus			- (3.0)	0.8 (-)	2.9 (29.4)	5.0 (1.4)	10.2 (1.1)
	P. macracanthus		- (0.0)	0.1 (-)	0.0 (1.2)	0.0 (0.3)	0.1 (1.0)
	P. tayenus		- (3.0)	0.7 (-)	2.9 (28.2)	5.0 (1.1)	10.1 (0.1)
Saurida			- (2.6)	2.6 (-)	2.6 (8.8)	3.1 (3.2)	10.5 (4.4)
	S. elongata		- (0.6)	0.3 (-)	0.2 (0.6)	2.4 (1.2)	6.2 (2.0)
	S. isarankurai		- (0.1)	0.0 (-)	0.0 (3.3)	0.1 (0.3)	1.2 (1.0)
	S. undosquamis		- (1.4)	2.3 (-)	2.3 (4.3)	0.5 (1.6)	3.1 (1.4)
	Other SYNODONTIDAE		- (0.5)	0.0 (-)	0.1 (0.6)	0.1 (0.1)	0.0 (0.0)
Lutjanus			- (3.6)	1.8 (-)	2.1 (0.6)	1.2 (2.3)	6.8 (4.5)
	L. artiforntalis		- (0.0)	0.0 (-)	0.3 (0.0)	0.0 (0.0)	1.1 (0.0)
	L. malabaricus		- (0.1)	0.1 (-)	1.4 (0.0)	0.0 (0.0)	0.0 (1.7)
	L. lineolatus		- (2.9)	0.0 (-)	0.0 (0.1)	0.3 (1.6)	0.2 (0.0)
	L. sanguineus		- (0.3)	0.0 (-)	0.0 (0.1)	0.0 (0.6)	0.9 (0.0)
	Pristipomoides spp.		- (0.0)	0.0 (-)	0.0 (0.1)	0.8 (0.0)	2.5 (2.7)
	Other LUTJANIDAE		- (0.3)	1.7 (-)	0.4 (0.3)	0.1 (0.1)	2.1 (0.1)
Sphyraena			- (0.4)	7.0 (-)	0.5 (0.8)	0.0 (0.0)	0.3 (0.4)
	S. forsteri		- (0.2)	2.4 (-)	0.5 (0.6)	0.0 (0.0)	0.2 (0.4)
	S. jello		- (0.2)	0.0 (-)	0.0 (0.2)	0.0 (0.0)	0.1 (0.0)
	S. obtusata		- (0.0)	4.6 (-)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)

Among the dominant genera, *Nemipterus* has a wide range of distribution, while *Priacanthus* and *Saurida* live in rather deeper waters (more than 50 m depth).

Of the six threadfin breams, *Nemipterus mesoprion* and *N. nematophorus* have special distribution patterns, namely, in September one inhabits a shallow zone (less than 40 m depth) and the other lives in a intermediate zone (50-60 m depth) and both form large school, with small-sized individuals.

Bigeye, *Priacanthus tayenus*, shows significant abundance at the 50-60 m depth in September, and in a deeper waters (more than 70 m depth) in May-June.

Lizardifishes, *Saurida elongata* and *S. undosquamis* are distributed in the deepest waters (more than 70 m depth) in both seasons.

The maximum average catch rate of all demersal fish population excluding trash fishes occurred at 50-60 m depth in September, reaching a value of about 70 kg/hr. At the depths of less than 50 m and more than 60 m, the catch rates were 20-40 kg/hr in both seasons.

Part III. Abundance

1. The area swept by the trawl

The calculated towing distance (length of the tow :b_i) for each operation is given in Table 8.

Table 8 Towing distance in each trawl operation (unit: km)

Trawling station	b_i value		Mean value of b_i	Trawling station	b_i value		Mean value of b_i
	Method I	Method II			Method I	Method II	
May-June				September			
1	11.46	18.03	14.75	i	2.77	3.75	3.26
2	12.15	14.59	13.37	ii	5.56	4.30	4.93
3	11.11	9.45	10.28	iii	5.56	-	5.56
4	11.11	11.41	11.26	iv	0.93	2.03	1.48
5	11.11	11.35	11.23	v	5.56	5.97	5.77
6	14.82	18.09	16.46	vi	5.56	7.00	6.28
7	10.87	14.71	12.79	vii	3.24	3.44	3.34
8	11.11	10.37	10.74	viii	5.56	5.69	5.63
9	11.85	12.18	12.02	ix	1.02	1.04	1.03
10	9.68	12.29	10.99				
11	11.85	13.25	12.55				

The value of b_i was quite different in two surveys: it ranged from 10.3 to 16.5 km in May-June, and 1.0 to 6.3 km in September.

The distance between wings (c_i) was estimated by using various parameters and the result is given in Table 9.

Table 9. Estimation of the distance between wings (c_i) in each trawl operation (notation shown in Figure 1).

	Trawling station	θ_{1i}/θ_{2i}	$f_i(m)$	$h_{1i}(m)$	$h_{2i}(m)$	Mean h_i	$c_i(km) \times 10^{-3}$	
May-June	1	-	-	-	-	-	*26.29	
	2	$6^\circ/5^\circ$	150	33.6	34.9	34.3	17.9	
	3	$6^\circ/4^\circ$	200	39.7	40.9	40.3	21.1	
	4	$6^\circ/7^\circ$	250	61.4	54.9	58.2	30.5	
	5	$-2^\circ/17^\circ$	200	57.0	48.9	53.0	27.7	m=26.29
	6	$7^\circ/9^\circ$	200	60.5	50.9	55.7	29.1	s.d. = 4.08
	7	$5^\circ/10^\circ$	200	57.0	48.9	53.0	27.7	
	8	$5^\circ/5^\circ$	250	48.4	46.9	47.7	25.0	
	9	$5^\circ/8^\circ$	200	50.1	46.8	48.5	25.4	
	10	$8^\circ/4^\circ$	250	57.1	49.9	53.5	28.0	
	11	$7^\circ/6^\circ$	250	61.4	54.9	58.2	30.5	
September	i	$9^\circ/2^\circ$	250	52.7	49.9	51.3	26.8	
	ii	$4^\circ/8^\circ$	200	46.6	46.8	46.7	24.4	
	iii	$0^\circ/10^\circ$	200	39.7	40.9	40.3	16.8	
	iv	-	250	-	49.9	49.9	20.8	m=24.76
	v	$3^\circ/10^\circ$	200	50.1	48.9	49.5	25.9	s.d.=3.78
	vi	$3^\circ/7^\circ$	250	48.4	46.9	47.7	25.0	
	vii	$7^\circ/2^\circ$	300	51.9	50.9	51.4	26.9	
	viii	$-2^\circ/11^\circ$	300	51.9	50.9	51.4	26.9	
	ix	$4^\circ/6^\circ$	300	57.1	54.9	56.0	29.3	

*: estimated value, m: mean c_i, s.d.: standard deviation

The value of c_i ranged from 0.018 to 0.031 km with an average of 0.026 km in May-June, and from 0.017 to 0.029 km with an average of 0.025 km in September.

The effective area (a_i) swept by each trawl operation was calculated according to the formula (1) and the result is given in Table 10.

Table 10 The estimated value of the effective area (a_i) swept by each trawl operation.

May-June Trawling station	b_i (km)	c_i (km)	a_i (km^2)	q_i	September Trawling station	b_i (km)	c_i (km)	a_i (km^2)	q_i
1	14.75	*0.026	*0.38	0.5	i	3.26	0.027	0.09	0.5
2	13.37	0.018	0.24	0.4	ii	4.93	0.024	0.12	0.5
3	10.28	0.021	0.22	0.4	iii	5.56	0.017	0.09	0.5
4	11.26	0.031	0.35	0.5	iv	1.48	0.021	0.03	0.4
5	11.23	0.028	0.31	0.5	v	5.77	0.026	0.15	0.6
6	16.46	0.029	0.48	0.6	vi	6.28	0.025	0.16	0.6
7	12.79	0.028	0.36	0.5	vii	3.34	0.027	0.09	0.5
8	10.74	0.025	0.27	0.4	viii	5.63	0.027	0.15	0.6
9	12.02	0.025	0.30	0.5	ix	1.03	0.029	0.03	0.4
10	10.99	0.028	0.31	0.5					
11	12.55	0.031	0.39	0.6					
95% confidence intervals of average a_i ($\mu_L - \mu_U$) : 0.28-0.38					0.06-0.14				

* : estimated value

The effective area swept by each trawling in May-June was about two or three times as large as those in September.

2. Density of major demersal fish species

When the density is estimated, the reliability of value of q poses a serious problem. The gear efficiency of trawl net or the catchability coefficient q are generally regarded as factors which can have significant effect on estimates of abundance calculated on the basis of catch per haul data. Although several values of q have been used by various authors working in the tropical areas, those estimates are not directly applicable to the present study, because both physical conditions (gear, fishing ground etc.) and the fish population are different. Therefore, as a first approximation, it was assumed that each q value (q_i) is correlative to a_i value in this study and was estimated as follows;

It was assumed that if each calculated value of a_i is within 95% confidence intervals of average value a_i ($\mu_L \leq a_i \leq \mu_U$), which is representative of the normal trawl operation, each value of a_i can coincide with the normal value of q_i (q_i = 0.5 at confidence intervals of average a_i), i.e. the approximate value within the confidence intervals of average a_i ($\mu_L \leq a_i \leq \mu_U$) is an equivalent to 0.5 of q_i, under-value of a_i ($a_i < \mu_L$) is equivalent to 0.4 of q_i, and over-value of a_i ($a_i > \mu_U$) is equivalent to 0.6 of q_i

For example, in September survey a_i value in station viii is 0.15. This is above the confidence interval of average a_i for that month which was 0.06 - 0.14. And therefore, q_i is equivalent to 0.6. While station ix, a_i value is 0.03, where corresponding q_i value is 0.4 (see Table 10).

Thus the value of q_i corresponding to each trawl operation was estimated and indicated in the last colum of Table 10.

Then the density of fish population in each trawling area covered by the trawl was calculated by using the formula (5), and the result is given in Table 11 and Figure 8.

Table 11. The density (kg/km^2) of major demersal fish species from trawl catches in different depth zones.

a) May - June

Depth zone (m)	40-50		Average value	50-60		Average value	50-60		Average value	60-70	60-70	70<	70<		Average value
No. of hauls	2			2			2			1	1	1	2		
Grid No.	223	182		271	204		140	74		75	186	125	207	207	
All useful demersal fishes	264.3	249.1	256.7	220.6	175.6	198.1	105.8	138.0	121.9	315.4	182.3	474.2	1879.6	707.4	1293.5
Nemipterus	35.4	91.6	63.5	28.4	90.5	59.5	25.8	32.8	29.3	76.7	61.4	165.2	228.5	115.4	172.0
N. bleekeri	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.5	34.2	73.9	34.3	54.1
N. hexodon	8.7	16.7	12.7	8.4	8.9	8.7	3.2	12.8	8.0	20.7	0.0	0.0	0.0	0.0	0.0
N. mesoprion	24.3	44.4	34.4	11.6	44.4	28.0	13.5	9.4	11.5	16.0	1.0	12.6	3.4	1.7	2.6
N. nematophorus	0.7	15.7	8.2	1.3	23.3	12.3	3.9	8.1	6.0	28.7	13.5	73.7	34.1	25.7	29.9
N. tambuloides	0.0	0.0	0.0	0.6	0.0	0.3	0.0	0.4	0.2	10.0	27.1	44.7	102.3	48.6	75.5
Other *Nemipterus*	1.7	14.8	8.3	6.5	13.9	10.2	5.2	2.1	3.7	1.3	6.3	0.0	14.8	5.1	10.0
Priacanthus	5.6	18.5	12.1	38.7	13.4	26.1	12.2	50.0	31.1	134.7	0.0	31.5	284.1	171.4	227.8
P. macracanthus	0.7	0.0	0.4	0.0	1.7	0.9	0.6	0.9	0.8	0.0	0.0	2.6	0.0	0.0	0.0
P. tayenus	4.9	18.5	11.7	38.7	11.7	25.2	11.6	49.1	30.4	134.7	0.0	28.9	284.1	171.4	227.8
Saurida	25.7	41.7	33.7	4.5	27.8	16.2	41.3	30.4	35.9	48.0	57.3	105.2	259.1	112.0	185.6
S. elongata	4.9	0.0	2.5	1.3	0.6	1.0	3.9	1.7	2.8	34.0	46.9	31.6	159.1	94.3	126.7
S. isarankurai	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	36.8	3.4	0.0	1.7
S. undosquamis	20.8	41.7	31.3	3.2	27.2	15.2	35.5	27.8	31.7	7.3	9.4	36.8	96.6	17.7	57.2
Other SYNODONTIDAE	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.9	1.4	6.7	0.0	0.0	0.0	0.0	0.0
Lutjanus	16.0	33.3	24.7	87.0	7.3	47.1	4.5	0.0	2.3	8.7	36.5	45.3	52.3	154.9	103.6
L. artiforntalis	0.0	0.0	0.0	16.1	0.0	8.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.1	18.6
L. malabaricus	1.4	0.0	0.7	67.7	0.6	34.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L. sanguineus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8	25.0	0.0	12.5
L. sebae	0.0	0.0	0.0	3.2	0.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	5.7	28.6	17.2
Pristipomoides spp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.3	1.1	15.9	74.3	45.1
Other LUTJANIDAE	14.6	33.3	24.0	0.0	6.7	3.4	4.5	0.0	2.3	8.7	5.2	28.4	5.7	14.9	10.3
Sphyraena	107.7	4.6	56.2	0.0	0.6	0.3	4.5	12.4	8.5	0.0	0.0	2.6	5.7	5.7	5.7
S. forsteri	36.5	4.6	20.6	0.0	0.6	0.3	4.5	12.4	8.5	0.0	0.0	0.5	0.0	5.7	2.9
S. jello	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	5.7	0.0	2.9
S. obtusata	71.2	0.0	35.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other demersal fishes	74.0	59.3	66.7	61.9	36.1	49.0	17.4	12.4	14.9	47.3	27.1	124.2	1050.0	148.0	599.0
Trash fishes	3645.8	1614.8	2630.3	645.2	1083.3	864.3	843.9	559.0	701.5	1889.3	427.1	1052.6	1704.5	914.3	1309.4

b) September

Depth zone(m) / No. of hauls / Grid No.	40> 1 246	50-60 2 160	204	Average value	60-70 2 93	248	Average value	60-70 2 298	351	Average value	70< 2 300	353	Average value
All useful demersal fishes	574.5	1593.3	1140.0	1366.7	277.8	483.3	380.6	62.5	116.7	89.6	571.1	348.9	460.0
Nemipterus	200.0	430.1	648.9	539.5	91.1	183.3	137.2	15.6	8.3	12.0	306.7	42.1	174.4
N. bleekeri	0.0	0.0	0.0	0.0	6.7	75.0	40.9	0.0	0.0	0.0	86.7	12.2	49.4
N. hexodon	48.9	15.0	31.1	23.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N. japonicus	1.1	66.7	106.7	86.7	0.0	8.3	4.2	0.0	0.0	0.0	0.0	4.4	2.2
N. mesoprion	148.9	100.0	160.0	130.0	4.4	0.0	2.2	0.0	0.0	0.0	0.0	1.1	0.6
N. nematophorus	1.1	200.0	342.2	271.1	40.0	16.7	28.4	7.3	8.3	7.8	133.3	20.0	76.7
N. tambuloides	0.0	36.7	2.2	19.5	35.6	83.3	59.5	7.3	0.0	3.7	86.7	4.4	45.6
Other *Nemipterus*	0.0	11.7	6.7	9.2	4.4	0.0	2.2	1.0	0.0	0.5	0.0	0.0	0.0
Priacanthus	33.3	778.3	266.6	522.5	11.1	8.3	9.7	14.5	41.6	28.1	31.1	3.3	17.2
P. macracanthus	0.0	5.0	44.4	24.7	0.0	0.0	0.0	1.0	33.3	17.2	31.1	2.2	16.7
P. tayenus	33.3	773.3	222.2	497.8	11.1	8.3	9.7	13.5	8.3	10.9	0.0	1.1	0.6
Saurida	29.0	221.6	93.4	157.5	55.5	50.0	52.8	22.9	49.9	36.4	100.0	27.8	63.9
S. elongata	6.7	8.3	15.6	12.0	13.3	16.7	15.0	9.4	33.3	21.4	48.9	11.1	30.0
S. isarankurai	1.1	100.0	13.3	56.7	11.1	8.3	9.7	0.0	8.3	4.2	20.0	7.8	13.9
S. undosquamis	15.6	100.0	57.8	78.9	28.9	25.0	27.0	13.5	8.3	10.9	31.1	8.9	20.0
Other SYNODONTIDAE	5.6	13.3	6.7	10.0	2.2	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Lutjanus	39.9	1.7	22.1	11.9	55.5	141.7	98.6	0.0	0.0	0.0	93.3	32.2	62.8
L. lineolatus	32.2	0.0	2.2	1.1	51.1	50.0	50.6	0.0	0.0	0.0	0.0	0.0	0.0
L. malabaricus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.1	15.6
L. sanguineus	3.3	0.0	4.4	2.2	0.0	91.7	45.9	0.0	0.0	0.0	0.0	0.0	0.0
L. sebae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pristipomoides spp.	0.0	1.7	2.2	2.0	0.0	0.0	0.0	0.0	0.0	0.0	93.3	1.1	47.2
Other LUTJANIDAE	4.4	0.0	13.3	6.7	4.4	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0
Sphyraena	4.4	20.0	6.7	13.4	0.0	0.0	0.0	0.0	0.0	0.0	13.3	0.0	6.7
S. forsteri	2.2	13.3	6.7	10.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	0.0	6.7
S. jello	2.2	6.7	0.0	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S. obtusata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other demersal fishes	267.8	141.7	102.2	122.0	64.4	100.0	82.2	9.4	16.7	13.1	26.7	243.3	135.0
Trash fishes	911.1	1050.0	1400.0	1225.0	173.3	0.0	86.7	125.0	0.0	62.5	200.0	27.8	23.9

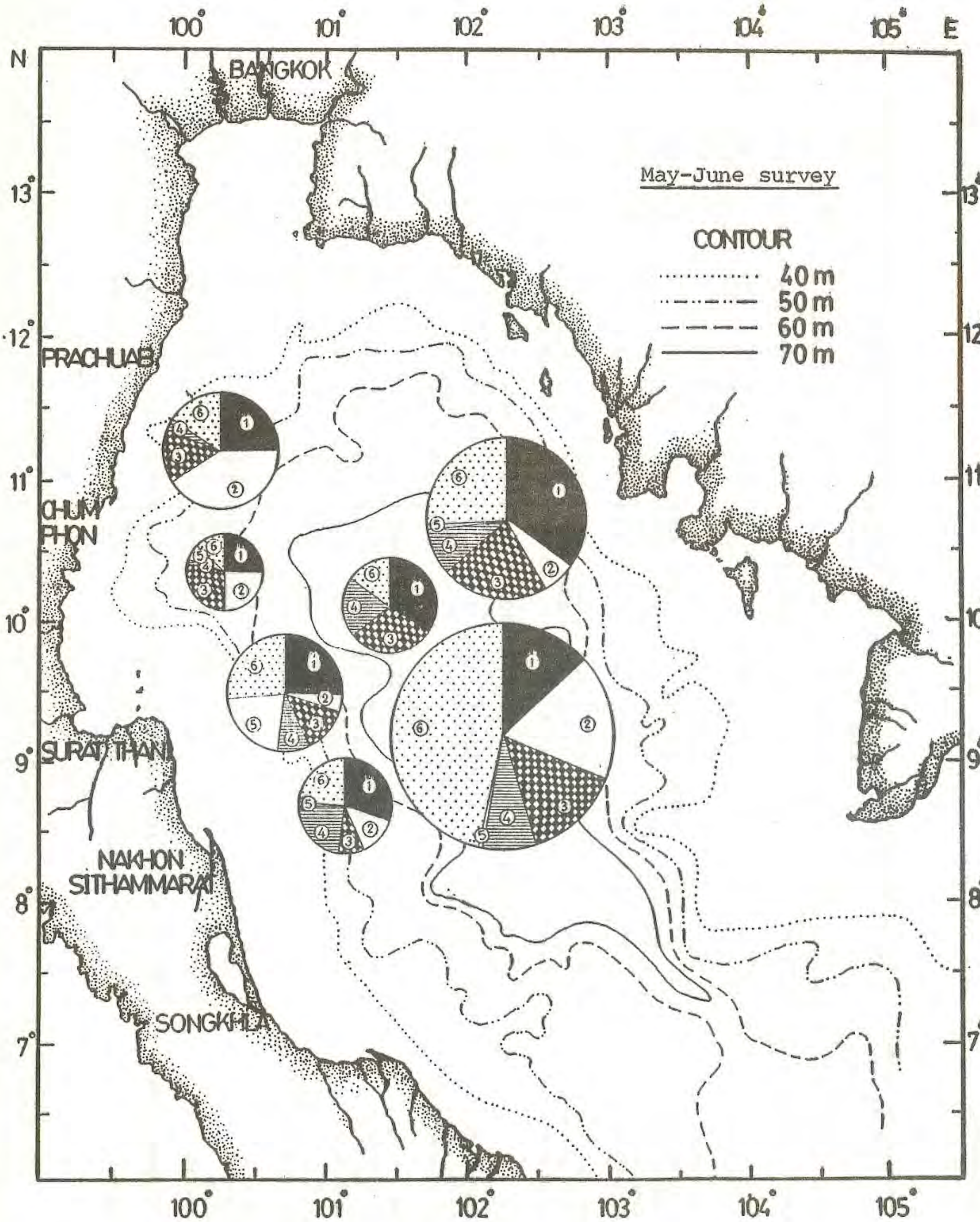


Fig. 8 Density composition (kg/km^2) of major demersal fishes from bottom trawl catches in different sampling areas. The radius of each circle is proportional to the square root of the grand total of each family group. 1: NEMIPTERIDAE, 2: PRIACANTHIDAE, 3: SYNODONTIDAE, 4: LUTJANIDAE, 5: SPHYRAENIDAE, 6: Others.

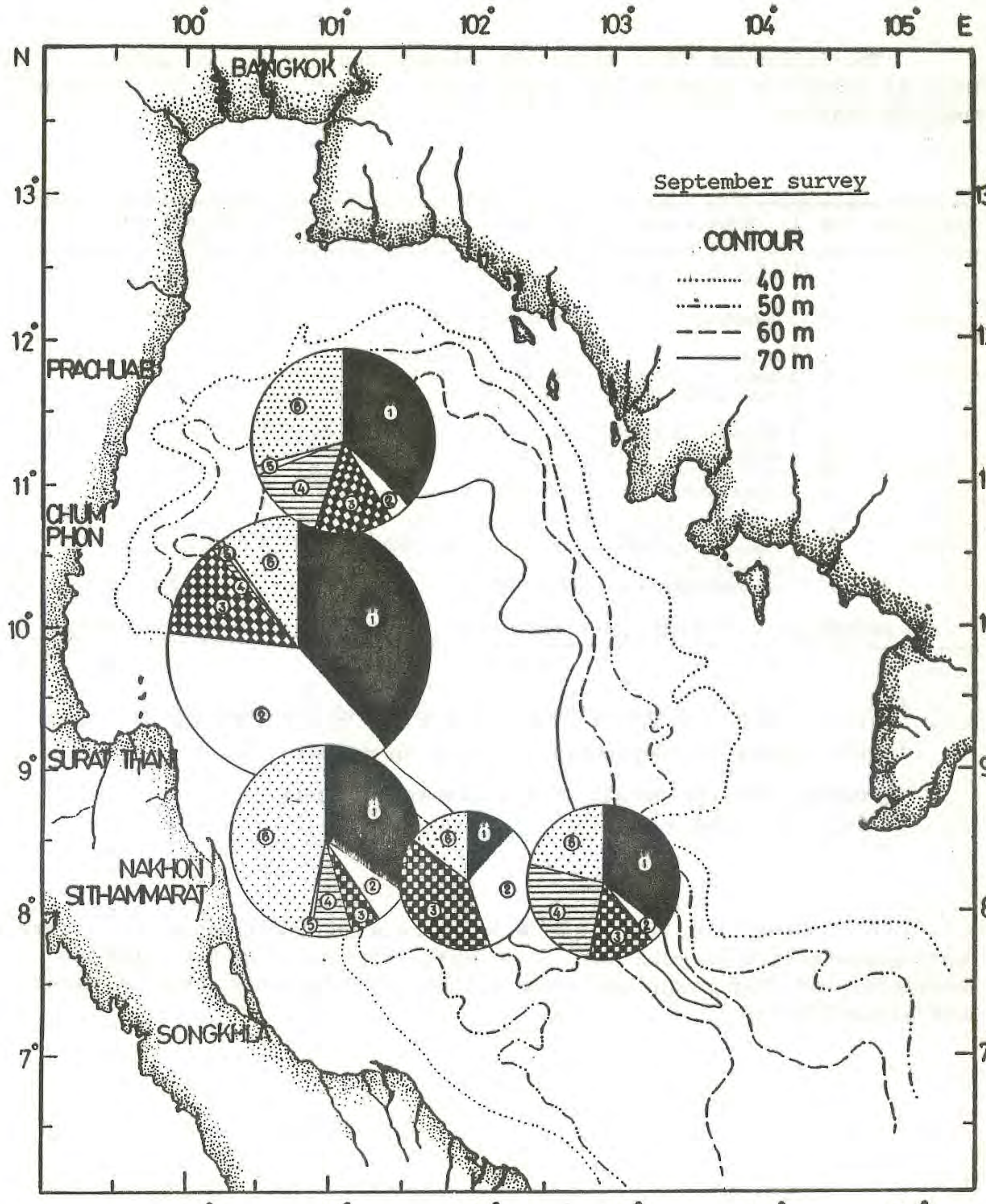


Fig. 8 Continued

The following table shows the average density of all useful demersal fishes in differential depth zones of each area in two different sampling seasons:

Depth zone (m)	Type[1]	Offshore areas	Grid No.[2]	Density (kg/km²)[3] May-June	Density (kg/km²)[3] September	*Dominant fish groups
40>	A	Nakhon Sithammarat	(246)		570	6 > 1 ≫ 4
40-50	B	Surattani	182, 223	250-260		6 ≥ 1 > 5
50-60	C_1	Chumphon	140, 74	110-140		3 ≥ 2 ≥ 1
	C_2	Nakhon Sithammarat	204, 271	180-220		1 > 6 ≥ 4
	C_3	Chumphon-Surattani	(204, 160)		1100-1600	1 ≥ 2 ≫ 3
60-70	D_1	Prachuap-Chumphon	75, (93)	320	280	2 ≫ 1 1 > 6 > 3,4
	D_2	Central Gulf (Surat.)	186	180		1 > 3 ≫ 4
	D_3	Surattani-Nakhon	(248)		480	1 ≫ 4 > 6
	D_4	Nakhon-Songkhla	(298, 351)		60-120	3 ≫ 2 ≫ 1, 6
70<	E_1	Central Gulf (Chum.)	125	470		1 ≫ 6 > 3
	E_2	Central Gulf (Surat.)	207, 207	700-1900		6 ≫ 2 > 3, 1
	E_3	Central Gulf (Nakhon-Songkhla)	(353, 300)		350-570	1 ≫ 6 ≫ 3,4

* 1: NEMIPTERIDAE, 2: PRIACANTHIDAE, 3: SYNODONTIDAE, 4: LUTJANIDAE, 5: SPHYRAENIDAE, 6: Others

[1] Type of fishing area divided by depth and fish density

[2] Grid number for September is shown in parentheses

[3] Average density of all useful demersal fishes (Code No. from 1 to 6)

Generally, the high density areas of useful demersal fishes were concentrated in more than 50 m depth, southward in the Chumphon Province, and they comprised three genera, NEMIPTERIDAE, PRIACANTHIDAE and SYNODONTIDAE.

3. Standing stock

Estimation of standing stock by using the formula (6) is very simple; it consists of expanding the density to each survey area.

Although the size of block (A) representing each trawling operation is always nearly the same and is assumed to be a square grid of 15' × 15' (771.75 km^2), the effective area of block (A_i) for bottom trawling varies because the bottom (observed by echosounder) shows great topographic variations.

The type of bottom is the main factor which decides suitability for bottom trawling and therefore k was used as a coefficient of effective area, as follows:

1. Even, flat bottom, suitable for all kinds of bottom trawl; value of k is assumed to be 0.9-1.0.
2. Generally smooth, but more uneven bottom where the use of bobbins is recommended; value of k ranges from 0.6 to 0.8.
3. Rough bottom, unsuitable for trawling; value of k ranges from 0.3 to 0.5.

The survey areas were classified according to the type of bottom, and the standing stock of major demersal fish groups in each calculated effective fishing area was estimated (Table 12).

Table 12 Estimation on standing stock of demersal fishes in each calculated effective fishing area.

a) May - June

Type (Depth in m)	Grid No.	A (km^2)	k	A_i (km^2)	Standing stock (× 10^2 tons) 1	2	3	4	5	6	7
B (40-50)	223	771.75	0.7	540.2	21.12	19.69	1.43	0.19	0.03	0.14	1.07
	182	771.75	0.9	694.6	12.95	11.22	1.73	0.64	0.13	0.29	0.67
	Subtotal			1234.8	34.07	30.91	3.16	0.83	0.16	0.43	1.74
C (50-60)	271	771.75	0.8	617.4	5.35	3.98	1.37	0.18	0.24	0.03	0.92
	204	771.75	0.8	617.4	7.77	6.69	1.08	0.56	0.08	0.17	0.27
	140	771.75	0.6	463.1	4.40	3.91	0.49	0.12	0.06	0.19	0.12
	74	771.75	0.9	694.6	4.84	3.88	0.96	0.23	0.35	0.21	0.17
	Subtotal			2392.5	22.36	18.46	3.90	1.09	0.73	0.60	1.48
D (60-70)	186	771.75	1.0	771.75	4.70	3.29	1.41	0.48	0.00	0.44	0.49
	75	771.75	1.0	771.75	17.01	14.58	2.43	0.59	1.04	0.37	0.43
	Subtotal			1543.50	21.71	17.87	3.84	1.07	1.04	0.81	0.92
E (70<)	125	771.75	0.9	694.60	10.61	7.31	3.30	1.15	0.22	0.73	1.20
	207	771.75	1.0	771.75	27.66	13.15	14.51	1.77	2.19	2.00	8.55
	207	771.75	1.0	771.75	12.51	7.06	5.45	0.89	1.32	0.86	2.38
	Subtotal			2238.10	50.78	27.52	23.26	3.81	3.73	3.59	12.13
TOTAL				7408.90	128.92	94.76	34.16	6.80	5.66	5.43	16.27

(b) September

A (40>)	246	771.75	1.0	771.75	11.46	7.03	4.43	1.54	0.26	0.22	2.41
C (50-60)	160	771.75	1.0	771.75	20.40	8.10	12.30	3.32	6.01	1.71	1.26
	204	771.75	1.0	771.75	19.60	10.80	8.88	5.01	2.06	0.72	1.01
	Subtotal			1543.50	40.00	18.90	21.10	8.33	8.07	2.43	2.27
D (60-70)	93	771.75	0.5	385.90	1.74	0.67	1.07	0.36	0.04	0.21	0.46
	248	771.75	0.3	231.50	1.12	0.00	1.12	0.42	0.02	0.12	0.56
	298	771.75	1.0	771.75	1.45	0.97	0.48	0.12	0.11	0.18	0.07
	351	771.75	0.3	231.50	0.27	0.00	0.27	0.02	0.10	0.11	0.04
	Subtotal			1620.70	4.58	1.64	2.94	0.92	0.27	0.62	1.13
E (70<)	300	771.75	0.6	463.10	3.57	0.93	2.64	1.42	0.14	0.46	0.62
	353	771.75	1.0	771.75	2.91	0.22	2.69	0.32	0.03	0.21	2.13
	Subtotal			1234.90	6.48	1.15	5.33	1.74	0.17	0.67	2.75
TOTAL				5170.90	62.52	28.72	33.80	12.53	8.77	3.94	8.56

1: All demersal fishes, 2: Trash fishes, 3: All useful demersal fishes
4: NEMIPTERIDAE, 5: PRIACANTHIDAE, 6: SYNODONTIDAE, 7: Others

As regards all useful demersal fishes, the estimated standing stock was nearly the same, about 3,400 tons in both survey seasons even though the calculated effective fishing area in September was only 70 percent of that in May-June.

Higher values of standing stock were shown in particular areas, i.e. grid No.207 (more than 70 m depth) in May-June and No.160 (50-60 m depth) in September. This suggests that the major demersal fishes tend to be concentrated in a particular area in each season, in accordance with their seasonal migration from offshore to inshore.

On the contrary, trash fishes which are mainly composed of a number of small-sized uncommercial fishes are distributed at random or in the form of the Poisson distribution in all areas in May-June, but are concentrated in particular areas near islands (grid Nos.160 and 204) in September. They constitute a large proportion of standing stock of all demersal fishes.

The three most abundant fish groups and their estimated standing stock (in May-June and in September) were: NEMIPTERIDAE (680 and 1,250 tons), PRIACANTHIDAE (570 and 880 tons) and SYNODONTIDAE (540 and 390 tons). These three fish groups contributed about 52 percent in May-June and about 75 percent in September of the total standing stock of all useful demersal fishes.

Part IV General remarks on stock evaluation of major demersal fishes in the central Gulf.

The Demersal Fish Unit of the Marine Fisheries Division, Department of Fisheries, Thailand, conducted a long-term experimental trawl survey between 1966 and 1981 (Shindo and Charnprasertporn, 1984). Although their two research vessels were only 23 and 25 m long and therefore smaller than M.V.PAKNAM which was used in the present study, the length of the trawl nets (47.7 m) used in those surveys was not very different from our survey nets. Therefore, the gear efficiency of nets used in the two surveys can be regarded as nearly the same.

Table 13 gives a summary of the average catch rate (kg/hr) in trawling areas shown in Fig. 9. Only two trawling stations, Nos. 74 and 75 in the May-June survey were located within Area V, and other stations in the present study were located in the central Gulf, outside the statistical areas surveyed by the Department of Fisheries.

Table 13 Average catch rate (kg/hr) of demersal fishes collected in each trawling area.

Year	70/71*	74/75*	80/81*	Present (84) (2)+ May-June	(1)+ September
		Area V			
NEMIPTERIDAE	14.8	8.5	6.9	4.8	8.8
PRIACANTHIDAE	8.4	3.9	11.2	8.0	1.1
SYNODONTIDAE	10.6	1.0	5.7	3.6	5.3
LUTJANIDAE	1.3	0.6	0.3	0.3	5.3
Subtotal	35.1	14.0	24.1	16.7	20.5
Others	0.4	0.1	0.1	1.3	3.2
TOTAL	35.5	14.1	24.2	18.0	23.7
		Area VI		(4)	(1)
NEMIPTERIDAE	10.2	8.1	5.1	6.7	25.8
PRIACANTHIDAE	3.2	5.1	3.3	1.3	46.7
SYNODONTIDAE	4.1	3.1	2.5	4.8	13.3
LUTJANIDAE	0.8	0.4	0.3	2.1	0.1
Subtotal	18.3	16.7	11.2	14.9	85.9
Others	2.0	0.5	1.1	2.4	0.8
TOTAL	20.3	17.2	12.3	17.3	86.7
		Area VII		(5)	(3)
NEMIPTERIDAE	6.9	2.0	5.6	6.9	22.8
PRIACANTHIDAE	7.5	3.5	3.4	6.3	7.0
SYNODONTIDAE	3.6	3.2	3.6	5.4	3.4
LUTJANIDAE	1.5	0.4	0.1	4.9	2.9
Subtotal	19.5	9.1	12.7	23.5	36.1
Others	3.8	1.3	0.9	1.1	1.1
TOTAL	23.3	10.4	13.6	24.6	37.2
		Area VIII			(4)
NEMIPTERIDAE	10.0	4.9	4.8		6.9
PRIACANTHIDAE	8.2	2.8	2.7		1.3
SYNODONTIDAE	4.2	1.9	2.6		3.5
LUTJANIDAE	1.8	0.4	0.7		2.6
Subtotal	24.2	10.0	10.8		14.3
Others	6.0	1.2	0.6		0.0
TOTAL	30.2	11.2	11.4		14.3

* Data adapted from Shindo and Charnparasertporn (1984) and used an average value for two years

+ Numbers in parenthesis indicate the number of trawling operations.

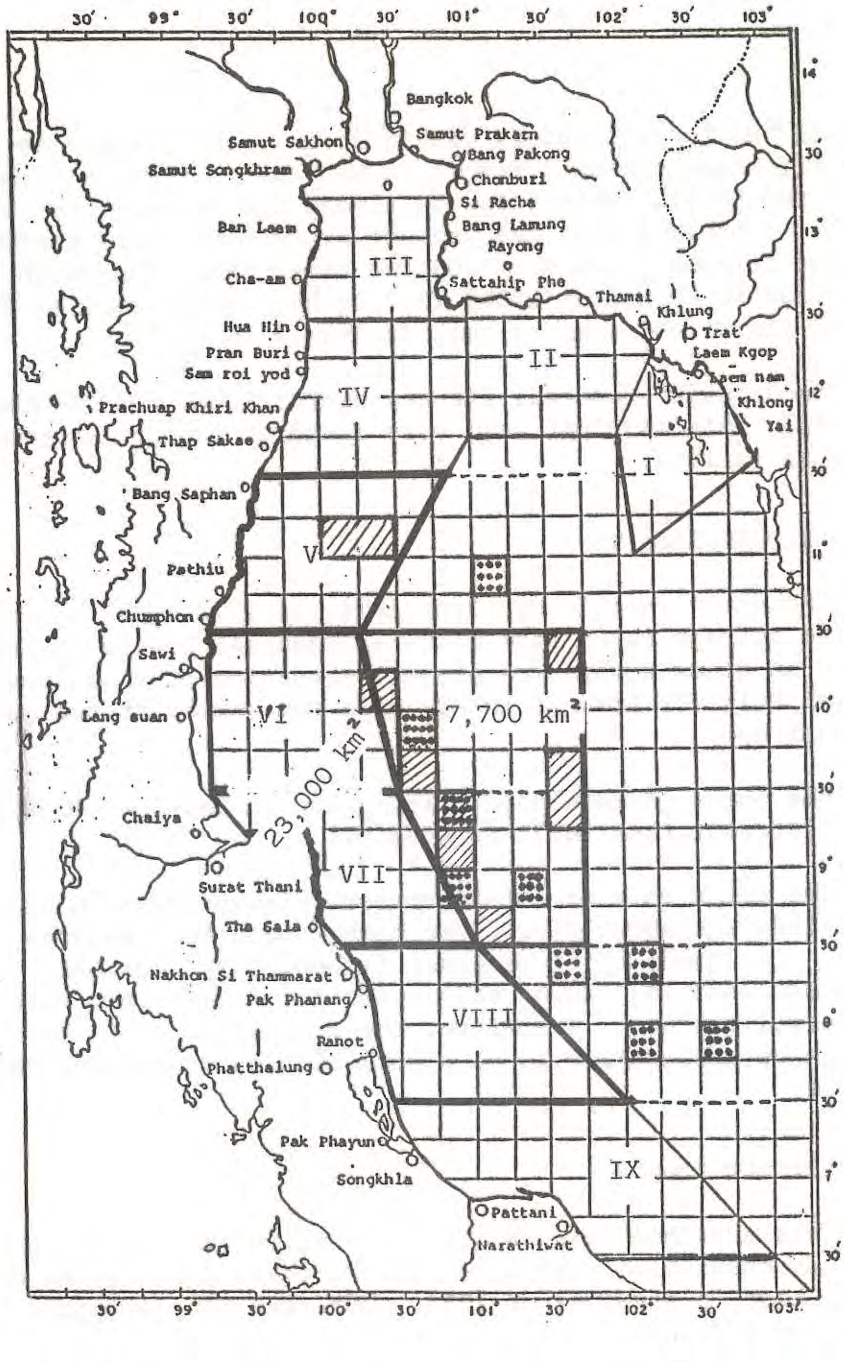


Fig. 9 Map showing sampling areas in the Gulf of Thailand. The statistical areas in the Department of Fisheries survey are marked I - IX and the shaded squares show sampling areas in the present survey;

▨ : May-June survey ▦ : September survey

The potential sizes of effective fishing areas (ΣA_i) within and off Area VI and VII are 23,000 km^2 and 7,700 km^2, respectively.

Area V

In the coastal waters within Area V, the catch rate of 16.7 kg/hr obtained for major demersal fishes in May-June survey is in between those for 74/75 and 80/81. This value is almost one half of the catch rate in 70/71. In other words, the present stock density is nearly half of what it was fifteen years ago. On the other hand, the catch rate of demersal fish in September 1984, 23.7 kg/hr, in the central Gulf off Area V was almost the same as that in Area V in 80/81.

Among major demersal fishes, NEMIPTERIDAE and PRIACANTHIDAE predominated; PRIACANTHIDAE were very abundant in Area V both in 80/81 and May-June in 1984.

Central Gulf off Area VI

The catch rate in May-June 1984, of 17.3 kg/hr was nearly the same as the average catch rate of total demersal fishes in Area VI in 74/75. In other words, the present situation of stock density in the central Gulf off Area VI in May-June was nearly at the same level as ten years ago.

The share of each major fish group in May-June 1984 was also not very different from 74/75 in Area VI.

The catch rate of total demersal fishes (86.7 kg/hr) in September 1984 was about five times higher than that in Area VI in 74/75. Among major demersal fishes, PRIACANTHIDAE predominated; with 46.7 kg/hr they constituted more than half of the total demersal catches. Therefore, the central part of the Gulf off Area VI can be recoganized to be a good fishing ground for PRIACANTHIDAE in September.

Central Gulf off Area VII

This area has also a high possibility as good fishing grounds for major demersal fish resources because their catch rates were constantly high in May-June of 1984. NEMIPTERIDAE dominated in September (22.8 kg/hr).

Central Gulf off Area VIII

The catch rate for all demersal fishes in this area was lower than in other areas. The total demersal catch (14.3 kg/hr) was almost one half of that in Area VIII in 70/71. Thus, in this area, a higher value of catch rate cannot be expected.

CONCLUSION

We can conclude that the central Gulf, in general, contains fairly abundant demersal stocks so far as the catch rate is considered. High density areas of useful demersal fishes were concentrated in more than 50 m depths, in the central parts of the Gulf, off Area VI and Area VII.

The potential size of statistical areas within the central part of the Gulf, off Areas VI and VII is estimated to be about 29,300 km^2. However, the effective fishing area(7,700 km^2), which is only 26% of the total, is smaller than the coastal water(23,000 km^2)within Areas VI and VII (see Fig. 9). Futhermore in those areas, there were difficulties with the trawl net towing caused by rough bottom conditions.

Therefore, in conclusion, it is advisable to use other gears and not trawl for catching demersal fishes in the central Gulf. If gears such as longline and trap-net are improved, the proportion of large-sized fish in the catch would increase. An improvement in such alternative fishing gears would contribute both to utilization and control of useful demersal fish stocks in the central parts of the Gulf.

SUMMARY

This paper discusses the stock evaluation of demersal fishes in the central Gulf of Thailand. The data were collected in the Thai-SEAFDEC joint surveys on board M.V.PAKNAM, from 16 May to 9 June and from 20 to 26 September, 1984. The results can be summarized as follows:

(1) Demersal fishes caught by otter trawl were classified into major genera and species groups in accordance with their dominant occurrence in the catch as regards both weight and number.

(2) Where habitat and distribution are concerned, the major demersal fishes live separately from each other in that they inhabit different depth zones with a geographic monocline of length composition.

(3) The effective area swept by each trawling was calculated, and then the density of major demersal fish species was estimated by using a modified simple equation based on the swept area method.

(4) The standing stock of both useful and trash fishes in each effective fishing area of the Gulf were estimated and it was concluded that higher values of standing stock of useful demersal fishes were concentrated in deep waters (more than 70 m depth).

(5) General remarks for stock evaluation of major demersal fishes in the central Gulf were discussed and it was concluded that the central Gulf probably contains fairly abundant demersal fish stocks so far as the catch rate is concerned, however, the effective area for trawling is limitted to only a small part of the Gulf.

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ANNEX

Appendix I: TRAWL EFFORT DATA

2) May–June survey

Date	Grid No.	Operation No.	Set net Time	Set net Location	Haul net Time	Haul net Location	Trawling time (min)	Speed (knot)	Depth (m)	Warp length (m)	Wire angle L/R	Type of bottom	Total catch (kg)	Remarks Haul No.
17/5/84	81	1	1603	11°02′5″N 101°51′0″E	1620	11°03′2″N 101°56′5″E	17	3.0	64-67	200(4)	-	Rough	-	Net broken
18/5/84	125	2	1552	10°22′4″N 101°36′3″E	1748	10°32′1″N 101°35′5″E	116	3.2	70-72	200(4)	-	Flat	309.7	1
19/5/84	146	3	1439	10°00′0″N 101°43′3″E	1449	--	10	3.0	72-73	--	-	Rather smooth	-	Net stacked Catch failed
19/5/84	164	4	1628	09°56′7″N 101°41′0″E	1658	09°56′4″N 101°41′1″E	30	3.0	73	250(40)	-	Rough	-	Net stacked Catch failed
21/5/84	186	5	1057	09°38′2″N 101°34′4″E	1300	09°30′4″N 101°33′3″E	123	3.2	70	150(20)	6°/5°	Even	66.9	2
21/5/84	207	6	1350	09°28′9″N 101°33′3″E	1550	09°23′8″N 101°33′5″E	120	3.0	70-71	200(20)	6°/4°	Flat	330.5	3
21/5/84	207	7	1635	09°23′8″N 101°33′5″E	1835	09°17′8″N 101°32′1″E	120	3.0	71	250(20)	6°/7°	Even	301.5	4
22/5/84	276	8	0525	08°41′8″N 101°15′5″E	0725	08°34′6″N 101°15′9″E	120	3.0	75-77	250(20)	7°/2°	Rough Very soft	-	Net broken Catch failed
23/5/84	329	9	0815	08°07′4″N 102°54′7″E	1007	08°09′0″N 102°51′7″E	112	3.0	71-72	238(20)	1°/10°	Rough	-	Reset net
23/5/84	329	10	1230	08°07′9″N 102°41′1″E	1417	08°08′5″N 102°48′9″E	107	3.0	74-75	200(20)	4°/9°	Rather smooth	~30.0	Full of mud Net stacked
23/5/84	329	11	1518	08°08′1″N 102°49′4″E	1547	--	209	3.0	73-74	150(20)	7°/11°	Rather smooth Sticky mud	-	Net didn't touch the bottom Catch failed

a) continued

Date	Grid No.	Operation No.	Set net Time	Set net Location	Haul net Time	Haul net Location	Trawling time (min)	Speed (knot)	Depth (m)	Warp length (m)	Wire angle L/R	Type of bottom	Total catch (kg)	Remarks Haul No.
23/5/84	329	12	1647	08°10'5"N 102°46'8"E	1847	08°08'5"N 102°42'0"E	120	3.0	74-75	160(20)	2°/8°	Rather smooth very soft	-	Net didn't touch the bottom Catch failed
24/5/84	321	13	1019	08°07'8"N 100°51'6"E	1223	08°01'2"N 100°54'5"E	124	3.0	30-31	150(20)	9°/4°	smooth	~35.0	Out of zone
24/5/84	346	14	1310	07°59'5"N 100°52'7"E	1530	07°54'2"N 100°58'8"E	140	—	30-36	250(40)	10°/4°	Not even	~38.0	Out of zone
24/5/84	372	15	1922	—	1925	—	5	-	36-38	250(40)	10°/2°	Rough	—	Out of zone
24/5/84	372	16	2025	07°41'5"N 101°05'9"E	2035	—	10	-	36-38	160(20)	0°/15°	Rough	—	Out of zone
25/5/84	378	17	0820	07°35'7"N 102°38'6"E	0830	—	10	—	67	190(20)	-2°/19°	Even Sticky mud	—	Otter board stacked Catch failed
25/5/84	378	18	0938	07°34'0"N 102°40'0"E	1044	07°31'8"N 102°41'7"E	106	—	66-67	200(20)	—	Rather smooth soft	~20.0	Catch failed Net borken
25/5/84	379	19	1154	07°39'7"N 102°45'4"E	1332	07°46'7"N 102°42'9"E	98	3.0	69-70	—	—	Rough soft	—	Net broken Catch failed
25/5/84	379	20	1415	07°47'3"N 102°43'4"E	1423	—	8	3.0	70	300(20)	—	Rough soft	—	Otter board stacked Catch failed
2/6/84	271	21	0930	08°39'8"N 101°01'8"E	1130	08°42'5"N 101°07'3"E	120	3.0	59-60	200(20)	-2°/17°	Rather smooth Silt & Mud	139.9	5
2/6/84	223	22	1507	09°06'0"N 100°48'6"E	1737	09°15'0"N 100°52'4"E	150	3.2	40-43	200(20)	7°/9°	Rather smooth	1205.1	6

a) continued

Date	Grid No.	Operation No.	Set net Time	Set net Location	Haul net Time	Haul net Location	Trawling time (min)	Speed (knot)	Depth (m)	Warp length (m)	Wire angle L/R	Type of bottom	Total catch (kg)	Remarks Haul No.
3/6/84	204	23	0936	09°24´7"N 100°47´7"E	1126	09°31´5"N 100°51´8"E	110	3.2	48-52	200(20)	5°/10°	Flat Mud	264.2	7
4/6/84	181	24	0604	09°31´2"N 100°12´6"E	0904	09°40´6"N 100°12´8"E	180	3.0	21-24	150(20)	5°/12°	Flat Sand & Mud	57.0	Out of zone
4/6/84	180	25	2037	09°37´1"N 100°11´4"E	0037	09°26´5"N 100°17´9"E	240	3.0	21-25	150(20)	14°/9°	Smooth Sand & Mud	62.0	Out of zone
5/6/84	182	26	1155	09°34´4"N 100°37´8"E	1355	09°40´0"N 100°37´7"E	120	3.0	48-50	250(20)	5°/5°	Smooth	239.6	8
6/6/84	75	27	1727	11°08´4"N 100°24´0"E	1927	11°11´5"N 100°29´8"E	120	3.2	60	200(20)	5°/8°	Even	349.5	9
7/6/84	140	28	1424	10°05´6"N 100°17´2"E	1602	10°11´5"N 100°18´8"E	98	3.2	53-60	250(20)	8°/4°	Uneven Net broken	177.9	10
8/6/84	74	29	0525	11°05´2"N 100°08´7"E	0725	11°09´1"N 100°14´7"E	120	3.2	49-54	250(20)	7°/6°	Flat	215.6	11

b) September-survey

Date	Grid No.	Operation No.	Set net Time	Set net Location	Haul net Time	Haul net Location	Trawling time (min)	Speed (knot)	Depth (m)	Warp length (m)	Wire angle L/R	Type of bottom	Total catch (kg)	Remarks Haul No.
21/9/84	93	1	0908	11°00´81"N 101°07´14"E	1008	10°57´4" 101°07´2"	60	3.2	60-63	200	9°/2°	Rough Mud	-	Catch failed
21/9/84	93	2	1057	10°56´4"N 101°06´9"E	1125	10°55´3"N 101°08´6"E	28	3.2	60-62	250	9°/2°	Rough Mud	22.9	I
22/9/84	160	3	0804	09°49´5"N 100°36´6"E	0904	09°49´5"N 100°38´9"E	60	3.0	56-57	200	4°/8°	Flat Mud	167.2	II
22/9/84	206	4	1735	09°21´5"N 101°15´8"E	1742	09°18´5"N 101°13´5"E	7	2.5	67-69	250	0°/10°	Rough	-	Net broken
23/9/84	204	5	0745	09°25´96"N 100°47´7"E	0845	09°24´3"N 100°53´9"E	60	3.0	50-52	200	0°/10°	Flat Mud	134.9	III
23/9/84	248	6	1422	08°51´4"N 101°19´8"E	1522	08°48´3"N 101°22´5"E	60	3.0	57-60	200	8°/4	Rough	~10	Catch failed
23/9/84	248	7	1610	08°47´0"N 101°23´2"E	1620	08°46´28"N 101°24´03"E	10	3.0	60-62	250	-	Very rough	7.8	IV
24/9/84	246	8	0700	08°48´88"N 100°50´77"E	0800	08°51´9"N 100°51´9"E	60	3.0	37-40	200	3°/10°	Flat	161.5	V
24/9/84	298	9	1430	08°23´71"N 101°37´33"E	1530	08°26´84"N 101°39´45"E	60	3.0	60-61	250	3°/7°	Flat Mud	30.6	VI
25/9/84	300	10	0740	08°20´6"N 102°08´1"E	0815	08°21´7"N 102°09´6"E	35	3.0	77	300	7°/2°	Generally Smooth	41.0	VII
25/9/84	353	11	1318	07°52´22"N 102°34´23"E	1418	07°55´1"N 102°35´3"E	60	3.0	75	300	-2°/11°	Even	43.4	VIII
25/9/84	351	12	1752	07°52´6"N 102°06´6"E	1803	07°52´58"N 102°06´04"E	11	3.0	70	300	4°/6°	Rough uneven	1.8	IX

Appendix II: TRAWL CATCH DATA

Demersal fish (weight in kg.)
1st cruise

Date Station number	11/05/84 125	21/05/84 186	21/05/84 207	21/05/84 207	02/06/84 271	02/06/84 223	03/06/84 204	05/06/84 182	06/06/84 75	07/06/84 140	08/06/84 74	Frequency of occur.(%)
BALISTIDAE	1.7	0.6	0.2	4.3	0.0	6.5	0.0	0.0	0.0	0.0	0.7	54.5
- *Abalistes stellaris*	1.7	0.0	0.2	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.3	36.4
- *Alutera monoceros*	0.0	0.6	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.4	27.3
- *A. venosus*	0.0	0.0	0.0	0.0	0.0	6.5	0.0	0.0	0.0	0.0	0.0	9.1
CYNOGLOSSIDAE	0.0	0.0	0.0	0.0	0.0	4.0	0.8	1.2	0.0	0.7	0.0	36.4
- *Cynoglossus* sp.	0.0	0.0	0.0	0.0	0.0	4.0	0.8	1.2	0.0	0.7	0.0	36.4
LEIOGNATHIDAE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	9.1
- *Leiognatus equulum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	9.1
- *Gassa minuta*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LETHRINIDAE	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.4	0.0	0.0	18.2
- *Lethrinus leutjanus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	9.1
- *L. nebulosus*	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
LUTJANIDAE	8.6	3.5	4.6	27.1	13.5	4.6	1.3	3.6	1.3	0.7	0.0	90.9
- *Caesio* sp.	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
- *Lutjanus argentimaculatus*	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0	0.0	9.1
- *L. artiforntalis*	0.0	0.0	0.0	6.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	18.2
- *L. lineolatus*	0.4	0.0	0.0	1.0	0.0	0.4	0.0	0.0	1.3	0.7	0.0	45.5
- *L. lutjanus*	0.0	0.0	0.2	1.6	0.0	0.1	0.0	3.6	0.0	0.0	0.0	36.4
- *L. malabaricus*	0.0	0.0	0.0	0.0	10.5	0.4	0.1	0.0	0.0	0.0	0.0	27.5
- *L. russelli*	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	9.1
- *L. sanguineus*	3.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2
- *L. sebae*	0.0	0.0	0.5	5.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	27.3
- *L. vitta*	0.0	0.5	0.3	0.0	0.0	0.1	0.6	0.0	0.0	0.0	0.0	36.4
- *Pristipomoides multidens*	0.0	3.0	1.4	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3
- *P. typus*	0.2	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2
MULLIDAE	16.5	0.3	0.8	0.3	0.0	0.1	1.3	1.2	1.1	0.4	0.9	90.9
- *Parupeneus heptacanthus*	0.0	0.0	0.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2
- *Upeneus bensasi*	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2	0.0	0.1	27.3
- *U. sulphureus*	16.5	0.2	0.0	0.0	0.0	0.0	0.5	1.0	0.0	0.3	0.8	54.5
- *U. tragula*	0.0	0.1	0.0	0.0	0.0	0.1	0.6	0.2	0.9	0.1	0.0	54.5
MURAENESOCIDAE	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	9.1
- *Muraenesox talabonoides*	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	0.0	0.0	0.0	9.1
NEMIPTERIDAE	31.4	5.9	20.1	20.2	4.4	10.2	16.3	9.9	11.5	4.0	7.7	100.0
- *Nemipterus bleekeri*	6.5	1.3	6.5	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.4
- *N. hexodon*	0.0	0.0	0.0	0.0	1.3	2.5	1.6	1.8	3.1	0.5	3.0	63.6
- *N. japonicus*	0.0	0.0	0.0	0.0	0.0	0.2	2.5	1.6	0.0	0.8	0.0	36.4
- *N. marginatus*	0.0	0.0	0.2	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3
- *N. mesoprion*	2.4	0.1	0.3	0.3	1.8	7.0	8.0	4.8	2.4	2.1	2.2	100.0
- *N. nematophorus*	14.0	1.3	3.0	4.5	0.2	0.2	4.2	1.7	4.3	0.6	1.9	100.0
- *N. nemurus*	0.0	0.6	1.1	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3
- *N. tambuloides*	8.5	2.6	9.0	8.5	0.1	0.0	0.0	0.0	1.5	0.0	0.1	63.6
- *N. tolu*	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.2	0.0	0.5	27.3
POMADASYIDAE	0.0	0.3	0.1	8.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	36.4
- *Plectorhynchus pictus*	0.0	0.3	0.1	8.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	36.4
PRIACANTHIDAE	6.0	0.0	25.0	30.0	6.0	1.6	2.4	2.0	20.2	1.9	11.7	90.9
- *Priacanthus macracanthus*	0.5	0.0	0.0	0.0	0.0	0.2	0.3	0.0	0.0	0.1	0.2	45.5
- *P. tayenus*	5.5	0.0	25.0	30.0	6.0	1.4	2.1	2.0	20.2	1.8	11.5	90.9
PSETTODIDAE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	9.1
- *Psettodes erumei*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	9.1
RACHYCENTRIDAE	0.1	0.0	7.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	36.4
- *Rachycentron canadus*	0.1	0.0	7.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	36.4
SCOLOPSIDAE	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.1	0.2	27.3
- *Scolopsis taeniopterus*	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.1	0.2	27.3
SERRANIDAE	2.1	0.2	2.5	1.6	1.8	0.2	2.9	1.9	3.2	0.8	0.0	90.9
- *Epinephelus areolatus*	0.6	0.2	1.5	1.0	0.5	0.2	0.2	0.1	0.2	0.0	0.0	81.8
- *E. bleekeri*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	0.0	9.1
- *E. heniochus* sp.	0.5	0.0	0.9	0.0	1.2	0.0	2.0	1.1	0.0	0.8	0.0	54.5
- *E. sexfasciatus*	1.0	0.0	0.1	0.6	0.1	0.0	0.7	0.7	0.2	0.0	0.0	63.6
SIGANIDAE	0.0	0.1	0.0	0.8	0.0	0.7	0.2	0.3	0.7	0.7	0.3	72.7
- *Siganus oramin*	0.0	0.1	0.0	0.8	0.0	0.7	0.2	0.3	0.7	0.7	0.3	72.7
SPHYRAENIDAE	0.5	0.0	0.5	1.0	0.0	31.0	0.1	0.5	0.0	0.7	2.9	72.7
- *Sphyraena forsteri*	0.1	0.0	0.0	1.0	0.0	10.5	0.1	0.5	0.0	0.7	2.9	63.6
- *S. jello*	0.4	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.2
- *S. obtusata*	0.0	0.0	0.0	0.0	0.0	20.5	0.0	0.0	0.0	0.0	0.0	9.1
SYNODONTIDAE	20.0	5.5	22.8	19.6	0.7	7.4	5.0	4.5	7.2	6.4	7.1	100.0
- *Saurida elongata*	6.0	4.5	14.0	16.5	0.2	1.4	0.1	0.0	5.1	0.6	0.4	90.9
- *S. hoshinonis*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.3	0.2	27.3
- *S. isarankurai*	7.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.3
- *S. undosquamis*	7.0	0.9	8.5	3.1	0.5	6.0	4.9	4.5	1.1	5.5	6.5	100.0
- *Synodus variegatus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TRICHIURIDAE	1.8	0.0	0.0	0.0	0.0	0.8	0.0	0.2	0.0	0.0	0.5	36.4
- *Trichiurus haumela*	1.5	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	18.2
- *T. mutiqus*	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.5	27.3
Others	1.4	1.1	1.8	0.0	2.6	8.0	0.2	1,6	0.0	0.0	0.0	63.6
Rays	0.0	0.0	80.0	10.0	0.0	0.0	0.0	0.0	1.3	0.0	0.3	36.4
CEPHALOPODA	9.4	3.4	10.5	7.1	4.6	32.7	21.6	29.0	11.8	11.8	39.9	100.0
- *Loligo* sp.	8.0	2.8	9.0	6.2	4.6	32.0	21.0	28.0	9.6	10.5	39.0	100.0
- *Sepia* sp.	1.4	0.6	0.9	0.9	0.0	0.7	0.6	1.0	1.2	0.8	0.2	90.9
- *Sepioteuthis* sp.	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	1.0	0.5	0.7	36.4
Trash	200.0	41.0	150.0	160.0	100.0	1050.0	195.0	174.4	283.4	130.8	130.8	100.0
TOTAL	299.5	61.9	325.9	290.9	138.8	1158.8	248.2	230.3	342.5	159.0	203.2	100.0
OPER. TIME (MINS)	116	123	120	120	120	150	110	120	120	98	120	
CATCH RATE hour	154.9	30.2	162.9	145.4	69.4	463.5	135.4	115.1	171.3	97.3	101.6	
DEPTH/m.	70-72	70	70-71	71	59-60	40-43	48-52	48-50	60	53-60	49-54	

Demersal fish (in number)
1st cruise

Date Station number	18/05/84 125	21/05/84 186	21/05/84 207	21/05/84 307	02/06/84 271	02/06/84 223	03/06/84 204	05/06/84 182	06/06/84 75	07/06/84 140	08/06/84 74	Frequency of occur. (%)
BALISTIDAE	7	2	1	12	0	29	0	0	0	0	2	54.5
- *Abalistes stellaris*	7	0	1	7	0	0	0	0	0	0	1	36.4
- *Alutera monoceros*	0	2	0	5	0	0	0	0	0	0	1	27.3
- *A. venosus*	0	0	0	0	0	29	0	0	0	0	0	9.1
CYNOGLOSSIDAE	0	0	0	0	0	55	13	22	0	15	0	36.4
- *Cynoglossus* sp.	0	0	0	0	0	55	13	22	0	15	0	36.4
LEIOGNATHIDAE	0	0	0	0	0	0	0	0	0	0	4	9.1
- *Leiognatus equulus*	0	0	0	0	0	0	0	0	0	0	4	9.1
- *Gazza minuta*	0	0	0	0	0	0	0	0	0	0	0	0.0
LETHRINIDAE	0	0	0	4	0	0	0	0	2	0	0	18.2
- *Lethrinus lentjan*	0	0	0	0	0	0	0	0	2	0	0	9.1
- *L. nebulosus*	0	0	0	4	0	0	0	0	0	0	0	9.1
LUTJANIDAE	326	3	13	40	29	8	5	88	5	14	0	90.9
- *Caesio* sp.	314	0	0	0	0	0	0	0	0	0	0	9.1
- *Lutjanus argentimaculatus*	0	0	0	0	0	1	0	0	0	0	0	9.1
- *L. artiferntalis*	0	0	0	7	6	0	0	0	0	0	0	18.2
- *L. lineolatus*	9	0	0	10	0	4	0	0	5	14	0	45.5
- *L. lutjanus*	0	0	2	10	0	1	0	88	0	0	0	36.4
- *L. malabaricus*	0	0	0	0	22	1	2	0	0	0	0	27.3
- *L. russelli*	0	0	0	0	0	0	1	0	0	0	0	9.1
- *L. sanguineus*	1	0	4	0	0	0	0	0	0	0	0	18.2
- *L. sebae*	0	0	1	2	1	0	0	0	0	0	0	27.3
- *L. vitta*	0	2	2	0	0	1	2	0	0	0	0	36.4
- *Pristipomoides multidens*	0	1	4	4	0	0	0	0	0	0	0	27.3
- *P. typus*	2	0	0	7	0	0	0	0	0	0	0	18.2
MULLIDAE	550	5	4	1	0	4	22	48	17	16	66	90.9
- *Parupeneus heptacanthus*	0	0	4	1	0	0	0	0	0	0	0	18.2
- *Upeneus bensasi*	0	0	0	0	0	0	4	0	5	0	5	27.3
- *U. sulphureus*	550	3	0	0	0	0	10	46	0	14	61	54.5
- *U. tragula*	0	2	0	0	0	4	8	2	12	2	0	54.5
MURAENESOCIDAE	0	0	0	0	1	0	0	0	0	0	0	9.1
- *Muraenesox talabonoides*	0	0	0	0	1	0	0	0	0	0	0	9.1
NEMIPTERIDAE	858	141	308	232	75	160	256	226	227	128	180	100.0
- *Nemipterus bleekeri*	86	23	77	60	0	0	0	0	0	0	0	36.4
- *N. hexodon*	0	0	0	0	14	28	25	22	34	7	32	63.6
- *N. japonicus*	0	0	0	0	0	2	20	16	0	21	0	36.4
- *N. marginatus*	0	0	3	1	11	0	0	0	0	0	0	27.3
- *N. mesoprion*	88	3	8	7	46	125	155	134	64	72	75	100.0
- *N. nematophorus*	518	30	67	66	3	3	56	54	106	28	68	100.0
- *N. nemurus*	0	13	16	11	0	0	0	0	0	0	0	27.3
- *N. tambuloides*	166	72	137	87	1	0	0	0	21	0	1	63.6
- *N. tolu*	0	0	0	0	0	2	0	0	2	0	4	27.3
POMADASYIDAE	0	2	1	10	0	0	3	0	0	0	0	36.4
- *Plectorhynchus pictus*	0	2	1	10	0	0	3	0	0	0	0	36.4
PRIACANTHIDAE	172	0	178	214	46	19	23	48	360	65	474	90.9
- *Priacanthus macracanthus*	9	0	0	0	0	3	2	0	0	1	4	45.5
- *P. tayenus*	163	0	178	214	46	16	21	48	360	64	470	90.9
PSETTODIDAE	0	0	0	0	0	0	0	0	1	0	0	9.1
- *Psettodes erumei*	0	0	0	0	0	0	0	0	1	0	0	9.1
RACHYCENTRIDAE	1	0	6	0	0	0	1	0	1	0	0	36.4
- *Rachycentron canadus*	1	0	6	0	0	0	1	0	1	0	0	36.4
SCOLOPSIDAE	0	0	0	0	0	6	0	0	0	1	1	27.3
- *Scolopsis taeniopterus*	0	0	0	0	0	6	0	0	0	1	1	27.3
SERRANIDAE	14	1	10	10	9	2	13	6	7	1	0	90.9
- *Epinephelus areolatus*	6	1	6	6	5	2	2	1	2	0	0	81.8
- *E. bleekeri*	0	0	0	0	0	0	0	0	3	0	0	9.1
- *E. heniochus* sp.	3	0	3	0	3	0	6	3	0	1	0	54.5
- *E. sexafasciatus*	5	0	1	4	1	0	5	2	2	0	0	63.6
SIGANIDAE	0	1	0	6	0	12	4	4	9	10	4	72.7
- *Siganus oramin*	0	1	0	6	0	12	4	4	9	10	4	72.7
SPHYRAENIDAE	7	0	4	9	0	421	1	5	0	9	57	72.7
- *Sphyraena forsteri*	4	0	0	9	0	123	1	5	0	9	57	63.6
- *S. jello*	3	0	4	0	0	0	0	0	0	0	0	18.2
- *S. obtusata*	0	0	0	0	0	298	0	0	0	0	0	9.1
SYNODONTIDAE	491	34	170	118	7	79	57	57	144	79	90	100.0
- *Saurida elongata*	24	20	55	80	1	14	1	0	23	15	3	90.9
- *S. hoshinonis*	0	0	0	0	0	0	0	0	23	7	4	27.3
- *S. isarankurai*	342	2	2	0	0	0	0	0	0	0	0	27.3
- *S. undosquamis*	125	12	113	38	6	65	56	57	98	57	83	100.0
- *Synodus variegatus*	0	0	0	0	0	0	0	0	0	0	0	0.0
TRICHIURIDAE	18	0	0	0	0	1	0	3	0	0	9	36.4
- *Trichiurus haumela*	16	0	0	0	0	1	0	0	0	0	0	18.2
- *T. muticus*	2	0	0	0	0	0	0	3	0	0	9	27.3
Others	1	1	1	0	0	0	1	1	0	0	0	45.5
Rays	0	0	1	1	0	0	0	0	8	0	1	36.4
CEPHALOPODA	268	100	138	119	76	1011	883	795	182	264	1557	100.0
- *Loligo* sp.	207	78	114	101	76	996	844	761	149	242	1540	100.0
- *Sepia* sp.	61	22	22	18	0	15	39	34	27	20	9	90.9
- *Sepioteuthis* sp.	0	0	2	0	0	0	0	0	6	2	8	36.4
Trash	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	2713	290	835	776	243	1807	1202	1303	963	602	2445	100.0
OPER. TIME (MINS)	116	123	120	120	120	150	110	120	120	98	120	
CATCH RATE/HOUR	1403.3	141.5	417.5	388.0	121.5	722.8	699.3	651.5	481.5	368.6	1222.5	
DEPTH/m.	70-72	70	70-71	71	59-60	40-41	48-52	48-50	60	53-60	49-54	

Demersal fish (weight in kg.)
2nd cruise

Date	21/09/84	22/09/84	23/09/84	23/09/84	24/09/84	24/09/84	25/09/84	25/09/84	25/09/84	Frequency of
Station number	93	160	204	248	246	298	300	353	351	occur. (%)
BALISTIDAE	0.0	1.5	0.1	0.0	0.3	0.0	0.9	1.0	0.2	66.7
- *Abalistes stellaris*	0.0	1.2	0.1	0.0	0.0	0.0	0.9	1.0	0.2	55.6
- *Alutera monoceron*	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0	22.2
BOTHIDAE	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	11.1
- *Pseudorhombus elevatus*	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	11.1
CHIROCENTRIDAE	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	11.1
- *Chirocentrus dorab*	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	11.1
CYNOGLOSSIDAE	0.0	0.2	0.3	0.0	0.2	0.0	0.0	0.0	0.0	33.3
- *Cynoglossus* sp.	0.0	0.2	0.3	0.0	0.2	0.0	0.0	0.0	0.0	33.3
FORMIONIDAE	0.0	0.0	0.4	0.0	0.7	0.0	0.0	0.0	0.0	22.2
- *Formio niger*	0.0	0.0	0.4	0.0	0.7	0.0	0.0	0.0	0.0	22.2
LETHRINIDAE	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	11.1
- *Lethrinus nebulosus*	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	11.1
LUTJANIDAE	2.5	0.1	1.0	1.7	3.6	0.0	4.2	2.9	0.0	77.8
- *Caesio* sp.	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1
- *Lutjanus lineolatus*	2.3	0.0	0.1	0.6	2.9	0.0	0.0	0.0	0.0	44.4
- *L. lutjanus*	0.0	0.0	0.6	0.0	0.1	0.0	0.0	0.0	0.0	22.2
- *L. malabaricus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8	0.0	11.1
- *L. sanguineus*	0.0	0.0	0.2	1.1	0.3	0:0	0.0	0.0	0.0	33.3
- *L. vitta*	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	11.1
- *Pristipomoides multidens*	0.0	0.1	0.0	0.0	0.0	0.0	2.7	0.1	0.0	33.3
- *P. typus*	0.0	0.0	0.1	0.0	0.0	0.0	1.5	0.0	0.0	22.2
MULLIDAE	0.0	0.3	0.5	0.0	0.3	0.1	0.0	0.0	0.04	55.6
- *Upeneus bensasi*	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	22.2
- *U. sulphureus*	0.0	0.0	0.2	0.0	0.1	0.1	0.0	0.0	0.0	33.3
- *U. tragula*	0.0	0.3	0.2	0.0	0.1	0.0	0.0	0.0	0.04	44.4
NEMIPTERIDAE	4.1	23.8	29.2	2.2	16.0	1.5	13.8	3.8	0.1	100.0
- *Nemipterus bleekeri*	0.3	0.0	0.0	0.9	0.0	0.0	3.9	1.1	0.0	44.4
- *N. hexodon*	0.0	0.9	1.4	0.0	4.4	0.0	0.0	0.0	0.0	33.3
- *N. japonicus*	0.0	4.0	4.8	0.1	0.1	0.0	0.0	0.4	0.0	55.6
- *N. marginatus*	0.0	0.5	0.3	0.0	0.0	0.1	0.0	0.0	0.0	55.6
- *N. mesoprion*	0.2	6.0	7.2	0.0	13.4	0.0	0.0	0.1	0.0	55.6
- *N. nematophorus*	1.8	12.0	15.4	0.2	0.1	0.7	6.0	1.8	0.1	100.0
- *N. nemurus*	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.2
- *N. tambuloides*	1.6	0.2	0.1	1.0	0.0	0.7	3.9	0.4	0.0	77.8
POMADASYIDAE	0.0	0.0	0.3	0.0	1.5	0.0	0.0	0.0	0.0	22.2
- *Plectorhynchus pictus*	0.0	0.0	0.3	0.0	1.5	0.0	0.0	0.0	0.0	22.2
PRIACANTHIDAE	0.5	46.7	12.0	0.1	3.0	1.4	1.4	0.3	0.5	100.0
- *Priacanthus macracanthus*	0.0	0.3	2.0	0.0	0.0	0.1	1.4	0.2	0.4	66.7
- *P. tayenus*	0.5	46.4	10.0	0.1	3.0	1.3	0.0	0.1	0.1	88.9
SCOLOPSIDAE	0.0	0.1	0.2	0.3	1.0	0.0	0.0	0.0	0.0	44.4
- *Scolopsis taeniopterus*	0.0	0.1	0.2	0.3	1.0	0.0	0.0	0.0	0.0	44.4
SERRANIDAE	1.5	0.5	1.22	0.0	0.34	0.0	0.0	0.0	0.0	44.4
- *Epinephelus areolatus*	0.0	0.1	0.02	0.0	0.04	0.0	0.0	0.0	0.0	33.3
- *E. bleekeri*	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1
- *E. heniochus* sp.	0.0	0.4	0.8	0.0	0.0	0.0	0.0	0.0	0.0	22.2
- *E. sexfasciatus*	0.0	0.0	0.4	0.0	0.3	0.0	0.0	0.0	0.0	22.2
SIGANIDAE	0.0	0.4	0.7	0.1	16.0	0.0	0.1	0.0	0.0	55.6
- *Siganus oramin*	0.0	0.4	0.7	0.1	16.0	0.0	0.1	0.0	0.0	55.6
SPHYRAENIDAE	0.0	1.2	0.3	0.0	0.4	0.0	0.6	0.0	0.0	44.4
- *Sphyraena forsteri*	0.0	0.8	0.3	0.0	0.2	0.0	0.6	0.0	0.0	44.4
- *S. jello*	0.0	0.4	0.0	0.0	0.2	0.0	0.0	0.0	0.0	22.2
STROMATEIDAE	0 0	0 0	0 0	0.0	0.0	0.0	0.0	0.1	0.0	11.1
- *Psenopsis anomala*	0 0	0 0	0 0	0.0	0.0.	0.0	0.0	0.1	0.0	11.1
SYNODONTIDAE	2.5	13.3	4.2	0.6	2.6	2.2	4.5	2.5	0.6	100.0
- *Saurida elongata*	0.6	0.5	0.7	0.2	0.6	0.9	2.2	1.0	0.4	100.0
- *S. hoshinonis*	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1
- *S. isarankurai*	0.5	6.0	0.6	0.1	0.1	0.0	0.9	0.7	0.1	88.9
- *S. undosquamis*	1.3	6.0	2.6	0.3	1.4	1.3	1.4	0.8	0.1	100.0
- *Synodus variegatus*	0.0	0.8	0.3	0.0	0.5	0.0	0.0	0.0	0.0	33.3
TRICHIURIDAE	0.12	5.5	0.7	0.5	0.4	0.3	0.2	0.8	0.0	88.9
- *Trichiurus armatus*	0.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1
- *Trichiurus* sp.	0.08	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	22.2
- *T. haumela*	0.0	5.5	0.7	0.5	0.4	0.3	0.0	0.8	0.0	66.7
Others	0.3	0.2	0.2	0.3	0.0	0.0	0.0	0.0	0.0	44.4
Sharks	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	11.1
Rays	1.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	22.2
CEPHALOPODA	1.3	5.6	9.7	1.0	11.4	1.0	4.0	3.0	0.1	100.0
- *Loligo* sp.	1.1	4.0	8.4	0.1	9.9	1.0	2.1	2.8	0.1	100.0
- *Octopus* sp.	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	11.1
- *Sepia* sp.	0.2	1.6	0.6	0.8	0.7	0.0	1.4	0.2	0.0	77.8
- *Sepioteuthis* sp.	0.0	0.0	0.7	0.1	0.3	0.0	0.5	0.0	0.0	44.4
Shrimps	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1
Trash	7.8	63.0	63.0	0.0	82.0	12.0	9.0	2.5	0.0	77.8
TOTAL	21.62	162.2	124.02	6.8	145.14	19.0	38.7	36.9	1.54	100.0
OPER. TIME (MINS)	28	60	60	10	60	60	35	60	11	
CATCH RATE/hour	46.3	162.2	124.02	40.8	145.14	19.0	66.3	36.9	8.4	
DEPTH/m.	60-62	56-57	50-52	60-62	37-40	60-61	77	75	70	

Demersal fish (in number)
2nd cruise

Date Station	21/09/84 93	22/09/84 160	23/09/84 204	23/09/84 248	24/09/84 246	24/09/84 298	25/09/84 300	25/09/84 353	25/09/84 351	Frequency of occur. (%)
BALISTIDAE	0	4	1	0	1	0	3	2	1	66.7
- *Abalistes stellaris*	0	2	1	0	0	0	3	2	1	55.6
- *Alutera monoceros*	0	2	0	0	1	0	0	0	0	22.2
BOTHIDAE	0	0	0	0	12	0	0	0	0	11.1
- *Pseudorhombus elevatus*	0	0	0	0	12	0	0	0	0	11.1
CHIROCENTRIDAE	0	0	0	0	0	1	0	0	0	11.1
- *Chirocentrus dorab*	0	0	0	0	0	1	0	0	0	11.1
CYNOGLOSSIDAE	0	4	5	0	1	0	0	0	0	33.3
- *Cynoglossus* sp.	0	4	5	0	1	0	0	0	0	33.3
FORMIONIDAE	0	0	4	0	13	0	0	0	0	22.2
- *Formio niger*	0	0	4	0	13	0	0	0	0	22.2
LETHRINIDAE	0	0	0	0	3	0	0	0	0	11.1
- *Lethrinus nebulosus*	0	0	0	0	3	0	0	0	0	11.1
LUTJANIDAE	95	1	16	8	86	0	2	2	0	77.8
- *Caesio* sp.	16	0	0	0	0	0	0	0	0	11.1
- *Lutjanus lineolatus*	79	0	2	7	82	0	0	0	0	44.4
- *L. lutjanus*	0	0	11	0	2	0	0	0	0	22.2
- *L. malabaricus*	0	0	0	0	0	0	0	1	0	11.1
- *L. sanguineus*	0	0	1	1	1	0	0	0	0	33.3
- *L. vitta*	0	0	0	0	1	0	0	0	0	11.1
- *Pristipomoides multidens*	0	1	0	0	0	0	1	1	0	33.3
- *P. typus*	0	0	2	0	0	0	1	0	0	22.2
MULLIDAE	0	2	13	0	6	1	0	0	3	55.6
- *Upeneus bensasi*	0	0	2	0	1	0	0	0	0	22.2
- *U. sulphureus*	0	0	7	0	3	1	0	0	0	33.3
- *U. tragula*	0	2	4	0	2	0	0	0	3	44.4
NEMIPTERIDAE	129	611	665	29	424	25	321	48	2	100.0
- *Nemipterus bleekeri*	27	0	0	7	0	0	54	6	0	44.4
- *N. hexodon*	0	10	12	0	66	0	0	0	0	33.3
- *N. japonicus*	0	52	71	1	3	0	0	2	0	55.6
- *N. marginatus*	1	10	8	0	2	2	0	0	0	55.6
- *N. mesoprion*	5	206	231	0	352	0	0	2	0	55.6
- *N. nematophorus*	58	288	341	6	1	15	193	33	2	100.0
- *N. nemurus*	2	3	0	0	0	0	0	0	0	22.2
- *N. tambuloides*	36	42	2	15	0	8	74	5	0	77.8
POMADASYIDAE	0	0	1	0	1	0	0	0	0	22.2
- *Plectorhynchus pictus*	0	0	1	0	1	0	0	0	0	22.2
PRIACANTHIDAE	8	520	176	1	45	16	5	3	4	100.0
- *Priacanthus macracanthus*	0	3	42	0	0	1	5	2	1	66.7
- *P. tayenus*	8	517	134	1	45	15	0	1	3	80.9
SCOLOPSIDAE	0	2	3	1	16	0	0	0	0	44.4
- *Scolopsis taeniopterus*	0	2	3	1	16	0	0	0	0	44.4
SERRANIDAE	1	11	7	0	2	0	0	0	0	44.4
- *Epinephelus areolatus*	0	2	1	0	1	0	0	0	0	33.3
- *E. bleekeri*	1	0	0	0	0	0	0	0	0	11.1
- *E. heniochus* sp.	0	9	1	0	0	0	0	0	0	22.2
- *E. sexfasciatus*	0	0	5	0	1	0	0	0	0	22.2
SIGANIDAE	0	8	12	2	294	0	2	0	0	55.6
- *Siganus oramin*	0	8	12	2	294	0	2	0	0	55.6
SPHYRAENIDAE	0	32	3	0	9	0	4	0	0	44.4
- *Sphyraena forsteri*	0	29	3	0	8	0	4	0	0	44.4
- *S. jello*	0	3	0	0	1	0	0	0	0	22.2
STROMATEIDAE	0	0	0	0	0	0	0	1	0	11.1
- *Psenopsis anomala*	0	0	0	0	0	0	0	1	0	11.1
SYNODONTIDAE	65	502	95	10	38	20	97	35	9	100.0
- *Saurida elongata*	3	2	3	1	5	3	8	4	1	100.0
- *S. hoshinonis*	3	0	0	0	0	0	0	0	0	11.1
- *S. isarankurai*	42	407	48	6	6	0	63	20	3	88.9
- *S. undosquamis*	17	67	37	3	16	17	26	11	5	100.0
- *Synodus variegatus*	0	26	7	0	11	0	0	0	0	33.3
TRICHIURIDAE	3	100	9	2	7	11	1	13	0	88.9
- *Trichiurus armatus*	2	0	0	0	0	0	0	0	0	11.1
- *Trichiurus* sp.	1	0	0	0	0	0	1	0	0	22.2
- *T. haumela*	0	100	9	2	7	11	0	13	0	66.7
Others	3	4	3	1	0	0	0	0	0	44.4
Sharks	0	0	0	0	0	0	0	1	0	11.1
Rays	1	0	0	0	7	0	0	0	0	22.2
CEPHALOPODA	28	142	184	5	243	15	187	197	2	100.0
- *Loligo* sp.	18	104	156	2	207	15	174	185	2	100.0
- *Octopus* sp.	0	0	0	0	21	0	0	0	0	11.1
- *Sepia* sp.	10	38	21	2	8	0	12	12	0	77.8
- *Sepioteuthis* sp.	0	0	7	1	7	0	1	0	0	44.4
Trash	-	-	-	-	-	-	-	-	-	-
TOTAL	333	1940	1197	59	1208	89	622	302	21	100.0
OPER. TIME (MINS)	28	60	60	10	60	60	35	60	11	
CATCH RATE/hour	713.6	1940.0	1197.0	354.0	1208	89.0	1066.3	302.0	114.5	
DEPTH/m.	60-62	56-57	50-52	60-62	37-40	60-61	77	75	70	

Pelagic fish (weight in kg.)
1st cruise

Date Station number	18/05/84 125	21/05/84 186	21/05/84 207	21/06/84 207	02/06/84 271	02/06/84 223	03/06/84 204	05/06/84 182	06/06/84 75	07/06/84 140	08/06/84 74	Frequency of occur. (%)
CARANGIDAE	5.1	4.9	4.3	10.5	0.8	38.9	13.4	8.8	5.7	18.4	7.6	100.0
- *Alepes melanoptera*	0.0	0.0	0.1	0.7	0.0	0.6	0.6	0.9	0.2	0.0	0.1	63.6
- *Atule mate*	0.0	0.0	0.0	0.9	0.3	8.0	5.0	1.3	1.8	6.2	3.0	72.7
- *Carangoides malabaricus*	0.0	0.9	0.0	0.0	0.0	0.0	2.8	0.0	0.3	0.1	0.6	45.5
- *Decapterus dayi*	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	18.2
- *D. maruadsi*	1.3	0.1	0.0	0.0	0.0	0.9	0.1	0.0	0.0	0.0	0.0	36.4
- *Megalaspis cordyla*	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.3	18.2
- *Scomberoides commersonianus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.3	18.2
- *S. tol*	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	9.1
- *Selar crumenophthalmus*	1.0	3.0	0.2	2.2	0.0	14.5	1.3	4.5	0.8	10.2	1.1	90.9
- *Selaroides leptolepis*	0.0	0.0	0.0	0.0	0.0	1.2	0.6	0.1	0.1	0.1	0.3	54.5
- *Seriolina nigrofasciata*	2.8	0.5	4.0	3.7	0.5	13.0	2.1	1.4	2.5	1.6	1.9	100.0
- *Uraspis helvorus*	0.0	0.0	0.0	3.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	18.2
CHIROCENTRIDAE	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.1	0.0	0.3	0.0	36.4
- *Chirocentrus dorab*	0.0	0.0	0.0	0.0	0.1	0.4	0.0	0.1	0.0	0.3	0.0	36.4
ENGRAULIDAE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	9.1
- *Stolephorus indicus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	9.1
SCOMBRIDAE	5.0	0.2	0.3	0.1	0.1	7.0	2.6	0.4	1.4	0.3	3.1	100.0
- *Rastrellinger* spp.	5.0	0.2	0.3	0.1	0.1	7.0	2.6	0.4	1.4	0.3	2.8	100.0
- *Scomberomorus guttatus*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	9.1
TOTAL	10.1	5.1	4.6	10.6	1.0	46.3	16.0	9.3	7.1	19.0	12.4	100.0
OPER. TIME (MINS)	116	123	120	120	120	150	110	120	120	98	120	
CATCH RATE/hour	5.2	2.5	2.3	5.3	0.5	18.5	8.7	4.7	3.6	11.6	6.2	
DEPTH/m.	70-72	70	70-71	71	59-60	40-43	48-52	48-50	60	53-60	49-54	

Pelagic fish (in number)
1st cruise

Date Station number	18/05/84 125	21/05/84 186	21/05/84 207	21/05/84 207	02/06/84 271	02/06/84 223	03/06/84 204	05/06/84 182	06/06/84 75	07/06/84 140	08/06/84 74	Frequency of occur.(%)
CARANGIDES	86	86	24	50	3	502	125	70	41	331	67	100.0
- *Alepes melanoptera*	0	0	1	4	0	5	4	6	2	0	1	63.6
- *Atule mate*	0	0	0	5	2	76	43	12	17	122	28	72.7
- *Carangoides malabaricus*	0	6	0	0	0	0	31	0	3	2	12	45.5
- *Decapterus dayi*	0	3	0	0	0	0	0	0	0	6	0	18.2
- *D. maruadsi*	48	3	0	0	0	22	2	0	0	0	0	36.4
- *Megalaspis cordyla*	0	0	0	0	0	0	10	0	0	0	1	18.2
- *Scomberoides commersonianus*	0	0	0	0	0	0	0	2	0	0	1	18.2
- *S. tol*	0	0	0	0	0	5	0	0	0	0	0	9.1
- *Selar crumenophthalmus*	23	72	5	11	0	313	12	44	8	193	10	90.9
- *Selaroides leptolepis*	0	0	0	0	0	38	17	2	4	2	9	54.5
- *Seriolina nigrofasciata*	15	2	18	16	1	42	6	4	7	6	5	100.0
- *Uraspis helvorus*	0	0	0	14	0	1	9	0	0	0	0	18.2
CHIROCENTRIDAE	0	0	0	0	1	2	0	1	0	2	0	36.4
- *Chirocentrus dorab*	0	0	0	0	1	2	0	1	0	2	0	36.4
ENGRAULIDAE	0	0	0	0	0	0	0	0	0	0	109	9.1
- *Stolephorus indicus*	0	0	0	0	0	0	0	0	0	0	109	9.1
SCOMBRIDAE	67	6	4	1	1	100	33	6	14	3	27	100.0
- *Rastrellinger* spp.	67	6	4	1	1	100	33	6	14	3	26	100.0
- *Scomberomorus guttatus*	0	0	0	0	0	0	0	0	0	0	1	9.1
TOTAL	153	92	28	51	5	604	158	77	55	336	203	100.0
OPER. TIME (MINS)	116	123	120	120	120	150	110	120	120	98	120	
CATCH RATE/hour	79.1	44.9	14.0	25.5	2.5	241.6	86.2	38.5	27.5	205.7	101.5	
DEPTH/m.	70-72	70	70-71	71	59-60	40-43	48-52	48-50	60	53-60	49-50	

Pelagic fish (in number)
2nd cruise

Date Station number	21/09/84 93	22/09/84 160	23/09/84 204	23/09/84 248	24/09/84 246	24/09/84 298	25/09/84 300	25/09/84 353	25/09/84 351	Frequency of occur.(%)
CARANGIDAE	19	16	173	2	256	80	1	2	0	88.9
- *Atule mate*	0	0	11	1	92	14	0	0	0	44.4
- *Carangoides malabaricus*	7	1	0	0	0	0	0	0	0	22.2
- *Decapterus maruadsi*	0	0	0	0	0	21	0	0	0	11.1
- *Scomberoides commersonianus*	0	0	0	0	4	1	0	0	0	22.2
- *Selar crumenophthalmus*	6	0	0	0	113	44	0	2	0	44.4
- *Selaroides leptolepis*	~~6~~	~~12~~	~~158~~	~~0~~	~~46~~	~~0~~	0	0	0	44.4
- *Seriolina nigrofasciata*	0	3	1	0	1	0	1	0	0	44.4
- *Uraspis helvorus*	0	0	3	1	0	0	0	0	0	22.2
ENGRAULIDAE	0	2	0	0	0	0	0	0	0	11.1
- *Stolephorus indicus*	0	2	0	0	0	0	0	0	0	11.1
GERRIDAE	10	16	117	3	0	0	80	152	9	77.8
- *Pentaprion longimanus*	10	16	117	3	0	0	80	152	9	77.8
LEIOGNATHIDAE	0	0	0	0	7	0	0	0	0	11.1
- *Gazza minuta*	0	0	0	0	7	0	0	0	0	11.1
SCOMBRIDAE	0	17	10	0	14	2	0	3	1	66.7
- *Rastrelliger kanagurta*	0	17	10	0	11	2	0	0	1	55.6
- *Scomberomorus guttatus*	0	0	0	0	3	0	0	3	0	22.2
TOTAL	29	51	300	5	277	82	81	157	10	100
OPER. TIME (MINS)	28	60	60	10	60	60	35	60	11	
CATCH RATE/hour	62.1	51.0	300.0	30.0	277.0	82.0	138.9	157.0	54.5	
DEPTH/m.	60-62	56-57	50-52	60-62	37-40	60-61	77	75	70	

Pelagic fish (weight in kg.)
2nd cruise

Date Station number	21/09/84 93	22/09/84 160	23/09/84 204	23/09/84 248	24/09/84 246	24/09/84 298	25/09/85 300	25/09/84 353	25/09/84 351	Frequency of occur.(%)
CARANGIDAE	1.1	0.8	6.2	0.5	9.4	11.6	0.4	0.3	0.0	88.9
- *Atule mate*	0.0	0.0	1.3	0.2	2.8	2.1	0.0	0.0	0.0	44.4
- *Carangoides malabaricus*	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.2
- *Decapterus maruadsi*	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	11.1
- *Scomberoides commersonianus*	0.0	0.0	0.0	0.0	1.6	1.2	0.0	0.0	0.0	22.2
- *Selar crumenophthalmus*	0.6	0.0	0.0	0.0	2.9	7,4	0.0	0.3	0.0	44.4
- *Selaroides leptolepis*	0.1	0.4	4.4	0.0	1.7	0.0	0.0	0.0	0.0	44.4
- *Seriolina nigrofasciata*	0.0	0.3	0.1	0.0	0.4	0.0	0.4	0.0	0.0	44.4
- *Uraspis helvorus*	0.0	0.0	0.4	0.3	0.0	0.0	0.0	0.0	0.0	22.2
ENGRAULIDAE	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1
- *Stolephorus indicus*	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1
GERRIDAE	0.2	0.3	3.7	0.9	0.0	0.0	2.0	3.1	0.2	77.8
- *Pentaprion longimanus*	0.2	0.3	3.7	0.9	0.0	0.0	2.0	3.1	0.2	77.8
LEIOGNATHIDAE	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	11.1
- *Gazza minuta*	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	11.1
SCOMBRIDAE	0.0	2.0	1.0	0.0	2.2	0.2	0.0	3.3	0.1	66.7
- *Rastrelliger kanagurta*	0.0	2.0	1.0	0.0	0.7	0.2	0.0	0.0	0.1	55.6
- *Scomberomorus guttatus*	0.0	0.0	0.0	0.0	1.5	0.0	0.0	3.3	0.0	22.2
TOTAL	1.3	3.2	10.9	1.4	11.8	11.8	2.4	6.7	0.3	100
OPER. TIME (MINS)	28	60	60	10	60	60	35	60	11	
CATCH RATE/hour	2.8	3.2	10.9	8.4	11.8	11.8	4.1	6.7	1.6	
DEPTH/m.	60-62	56-57	50-52	60-62	37-40	60-61	77	75	70	

DISTRIBUTION OF NUTRIENTS AND DISSOLVED ORGANIC CARBON IN THE GULF OF THAILAND

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ABSTRACT

This work is a preliminary study to find out the amounts of nutrients and dissolved organic carbon in the Gulf of Thailand from Chumphon to Songkhla during southwest monsoon. The data from 35 oceanographic stations reveal that the amounts of nutrients in seawater, especially phosphate and nitrate, were relatively large in the upper Gulf compared with the lower Gulf. The highest level of silicate and nitrite were found in the central Gulf. The dissolved organic carbon was very low in the central Gulf but higher in the nearshore waters.

The results show decomposition of organic carbon in the bottom water to produce higher nutrients. The findings concerning DOC were similar to those of other studies, but differ as to nutrients concentrations.

INTRODUCTION

Changes in the composition of seawater are associated with the growth and decomposition of organisms. Organic matter in seawater consists of an autochthonous contribution resulting from primary production with seawater, and an allochthonous contributions from adjacent ecosystems. Plants utilize sunlight and inorganic nutrients to produce organic molecules via photosynthesis.

For convenience, organic substances in seawater or natural waters may be classified into their dissolved and particulate fractions. These fractions are made by the adoption of an arbitrary filter pore size, e.g. 0.45 µm. Organic matter unable to pass through the filter is termed "particulate organic carbon" (POC). That which passes through the filter is termed "dissolved organic carbon" (DOC).

The purpose of the present study was to determine the distribution of nutrients and DOC during the southwest monsoon. Because the Gulf of Thailand is a closed gulf, the hypothesis was that there should be very little influence from outside factors.

MATERIALS AND METHODS

Collection of samples

For nutrient examination of seawater, samples were collected by Nansen bottle at three levels: surface, 30 m, and bottom. For DOC, samples were collected at every 10 m depth, also by Nansen bottle. The nutrient samples were transferred to polyethylene bottles, treated with a few drops of chloroform and then frozen until they could be analyzed at Paknam laboratory. The DOC samples were filtered using 0.45 µm membrane filters, then transferred to 10 ml ampoules, sealed with flame from Bunsen burner and stored in a dark place prior to analysis.

The locations of sampling stations are shown in Fig.1.[1]

Experimental method

a) Analysis of nutrients: nitrite, nitrate, phosphate and silicate were determined by the method of Strickland and Parsons (1972).

B) Analysis of DOC: ampoules were opened and one drop of 85% H_3PO_4 pH-2 was added, together with N_2 gas to eliminate inorganic carbon. DOC was analyzed by direct injection into TOC-10B Analyzer with salt traps to eliminate salt (Mackinnon, 1978). Glucose was used for standard DOC calibration.

The environmental oceanographic data such as salinity, temperature, dissolved oxygen were received from Takahashi et al. (1984).

RESULTS

The nitrate values were found to be higher than in other areas, especially above the bottom, where there were over 4 µM. The mean value at the bottom was high, except in the middle Gulf where it is lower than 1 µM, as shown diagrammatically in Fig. 2.

The values of nitrite at the bottom were higher than at other levels, especially in the middle Gulf. The mean value was 0.32 µM and the lowest values were found at the bottom near Songkhla; less than 0.10 µM, as shown diagrammatically in Fig. 3.

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[1] Figure and tables appear at the end ot the text.

The values of phosphate (Fig.4) in the surface layer were higher than at other levels, especially in the upper Gulf, where they ranged from 0.6 to 1.5 μM. However, the values in the middle Gulf were lower than 0.3 μM.

The silicate values (Fig. 5) were highest in the middle and lower Gulf. The mean value was 12.85 μM. In the upper Gulf, the mean value was 8 μM.

The values of DOC were in the range of 0.52-2.21 mg/L. This was lower than 2.50 mg/L given by Head (1976) for the open sea. The DOC values (Fig. 6) in the middle Gulf were below 1 mg/L. But in the near-shore water and in the lower Gulf, the values were higher at surface, mid-depth and bottom layers.

DISCUSSIONS

The nutrients and DOC distributions (Figs. 2, 3, 4, 5, 6) show that there is upwelling in nearshore water, probably explained by the more southwesterly direction of the wind in May and June.

Average vertical nutrients and DOC profiles (Fig. 7) show that nitrate and nitrite increase with increasing depth, while silicate decreases slightly with increasing depth. Phosphate contribution is highest at surface and decreases at 30 m depth, then increases again at the bottom. This may be the influence of phosphate consumption by large amount of phytoplankton at 30 m depth. Average DOC increases slightly with increasing depth, but drops to 0.78 mg/L at 70 m depth. This implies that photochemical reactions may effectively remove or decompose DOC from the surface seawater (Carlson, 1983). Average dissolved oxygen (Takahashi and Ruangsivakul, 1984) decreases down to the bottom. We may conclude that in deeper layers of the Gulf of Thailand there are *in situ* processes consuming oxygen to decompose organic carbon and producing nitrite, nitrate, phosphate and silicate.

The average nutrients are listed in Table 1. They differ from the data of Takahashi et al. (1984), in that our results show higher nitrite and phosphate.

These differences, which may be due to filtration, are minor when compared with results obtained in the upper Gulf of Thailand (Silpipat et al., 1984). The high values might be due to supply of rivers; the value of nitrate 2.7-13.4 μM was inferred from data by Garside (1981).

The values for DOC in the Gulf of Thailand were found to be similar to the values found by other studies. Careson (1983) found that DOC in the surface microlayer ranged from 0.78-2.15 mg/L in oceanic samples and in bulkwater 1.3 mg/L in the North Atlantic, and 2.0 mg/L in the open Gulf of Maine.

Average distribution of nutrients (Fig. 8) shows that silicate decreases in the middle Gulf and increases in the lower Gulf. This may be due to the fact that there are rivers supplying silicate to the lower Gulf, but these do not influence the middle Gulf. In Fig. 9, silicate is higher offshore than in nearshore waters. In the western nearshore waters, silicate is probably consumed by diatoms to produce their structures and then deposited at the bottom. In the eastern offshore waters there is less diatom and therefore the consumption of silicate is lower.

Phosphate and nitrate (Fig. 8) decrease from the middle to the upper Gulf, which may be the result of flowing of river plumes from the middle Gulf areas. In Fig. 9, phosphate and nitrate decrease from the western nearshore to the eastern offshore water. In this case it may be due to the southwest monsoon which usually takes nutrients to the western nearshore in this season.

Nitrite (Fig. 8, 9) showed a constant distribution; the mean value was 0.2 μM. According to Grasshoff (1976) the average value for nitrite in all oceans was 0.1 μM. This may indicate that the amount of nitrogen compound is not too high for over-distribution of phytoplankton.

Differences of DOC concentrations as shown in Fig. 8 and Fig. 9, were small in absolute terms.

Table 1. Nutrients and DOC concentrations in the Gulf of Thailand (16 May - 9 June 1984).

Station No.		75	77	79	81	106	108	110	112	140	142	144	146
Phosphate-P	1m	0.69	-	-	0.64	2.96	0.75	4.41	0.21	0.97	0.25	0.22	0.47
(μM)	30m	0.54	3.12	0.28	-	3.76	-	0.25	0.21	0.83	0.28	0.10	0.01
	Bottom	0.34	-	0.33	1.17	3.95	0.93	-	0.92	0.50	2.18	0.65	0.32
Silicate-Si	1m	4.35	6.66	-	21.85	3.75	22.53	16.19	12.72	6.40	8.11	21.34	15.87
(μM)	30m	9.39	9.56	13.14	-	7.68	8.45	11.44	7.60	13.66	10.58	7.08	7.00
	Bottom	6.32	7.25	17.16	36.96	11.35	20.48	-	22.19	8.79	-	5.96	15.62
Nitrate-N	1m	0.97	4.16	-	0.68	3.16	2.74	0.45	2.55	1.71	2.58	-	0.35
(μM)	30m	4.35	1.19	3.77	4.81	-	5.23	3.39	7.39	-	4.74	-	1.29
	Bottom	4.19	-	-	6.45	3.23	-	5.10	-	-	0.87	3.90	2.68
Nitrite-N	1m	ND	0.24	-	0.05	ND	0.19	0.38	ND	0.13	0.11	ND	0.03
(μM)	30m	0.03	0.35	0.91	0.16	-	ND	ND	0.11	0.27	0.00	0.19	0.08
	Bottom	0.03	-	-	0.40	0.35	0.40	0.30	0.22	-	0.89	0.30	0.30
DOC	0m	0.88	1.18	-	-	0.52	1.03	-	-	0.81	0.96	2.21	-
(mg/L)	10m	1.03	1.18	1.40	-	0.59	0.96	0.81	-	1.03	0.81	2.14	1.18
	20m	1.03	1.11	-	-	0.66	1.03	0.81	-	0.44	0.96	2.07	-
	30m	1.18	1.11	1.70	-	0.66	1.48	1.55	-	0.96	0.96	2.07	-
	40m	1.11	1.11	1.25	-	0.81	1.18	0.96	-	0.96	0.96	2.21	1.11
	50m		1.11	1.48	-	0.81	1.11	1.03	-	1.18	1.11	1.92	1.18
	60m			1.70	-	-	1.33	1.18	-		0.81		0.96
	70m												

Table 1. (cont.)

Station No.		180	182	184	186	221	223	226	228	271	272	273	274
Phosphate-P	1m	0.71	0.25	0.22	0.40	-	0.34	-	0.80	-	0.15	0.24	-
(μM)	30m	-	0.39	-	0.22	-	0.34	0.37	0.53	0.53	0.28	0.34	0.24
	Bottom	-	1.24	3.01	0.44	-	1.17	0.54	0.56	0.40	0.79	1.61	0.53
Silicate-Si	1m	9.22	7.00	18.26	13.23	8.71	16.05	-	12.80	-	9.90	13.40	-
(μM)	30m	-	9.81	12.12	8.19	-	19.72	21.31	14.59	11.86	9.47	11.95	5.04
	Bottom	-	11.10	6.40	8.71	8.19	6.32	9.64	10.75	8.02	13.31	21.59	9.73
Nitrate-N	1m	-	1.68	0.84	3.29	-	0.94	3.45	4.74	0.84	-	4.23	-
(μM)	30m	-	-	1.06	5.45	-	0.29	1.61	2.58	3.00	2.61	1.19	3.61
	Bottom	-	2.55	2.39	-	1.90	2.87	1.94	2.39	1.55	3.48	3.94	1.68
Nitrite-N	1m	0.08	0.24	0.05	0.32	ND	ND	0.05	0.11	0.13	0.03	0.05	0.13
(μM)	30m	-	0.03	0.05	0.05	-	0.13	0.05	0.13	0.03	0.40	0.19	0.11
	Bottom	0.32	0.16	0.35	-	0.19	0.03	0.30	0.30	0.40	0.40	0.38	0.59
DOC	0m	1.40	1.18	0.88	1.77	0.81	1.25	1.40	1.11	0.96	1.03	1.48	1.33
(mg/L)	10m	1.62	1.11	0.81	1.55	1.11	0.88	1.25	-	0.96	1.11	1.70	1.18
	20m		0.81	0.96	1.03	1.11	0.81	1.48	0.96	0.88	1.11	1.48	1.11
	30m		1.03	0.88	1.25	0.74	0.86	1.40	1.03	0.81	1.25	-	1.33
	40m		1.11	0.81	-			1.55	-	1.11	1.11	1.33	1.62
	50m		0.89	0.74	1.11			1.18	0.88	1.11	0.96	1.77	1.25
	60m				1.18			1.33	-			1.92	1.18
	70m								0.81				

Table 1. (cont.)

Station No.		276	321	323	325	327	329	372	374	376	378	380
Phosphate-P	1m	0.56	-	0.93	0.90	0.07	0.24	0.45	1.98	3.57	0.68	0.47
(μM)	30m	0.34	-	-	-	0.39	0.29	0.11	-	0.28	0.28	0.42
	Bottom	0.42	0.32	-	-	0.29	0.34	0.28	0.17	0.34	0.19	0.61
Silicate-Si	1m	13.83	-	11.78	19.03	13.06	13.66	22.87	9.47	14.68	7.51	11.18
(μM)	30m	14.42	-	-	-	21.25	11.26	10.41	-	24.15	18.78	33.11
	Bottom	11.10	10.16	-	-	17.41	4.10	15.02	7.00	7.34	12.80	21.76
Nitrate-N	1m	1.45	-	3.77	3.32	2.00	2.13	-	-	1.16	-	5.68
(μM)	30m	4.39	-	1.39	1.35	0.81	1.87	1.58	0.84	0.42	1.35	0.87
	Bottom	2.06	2.45	4.84	-	-	1.55	3.00	0.58	3.35	1.58	1.13
Nitrite-N	1m	0.05	-	0.43	0.19	0.13	0.11	-	-	ND	-	0.19
(μM)	30m	0.11	-	0.46	0.30	0.38	0.05	0.40	0.91	0.08	0.08	0.51
	Bottom	0.24	ND	0.56	-	-	0.16	0.03	0.16	1.21	0.16	0.13
DOC	0m	-	1.11	0.52	0.52	1.48	1.33	1.48	0.96	1.11	2.07	1.92
(mg/L)	10m	-	1.18	0.66	0.96	1.48	1.48	1.77	-	0.96	1.92	2.07
	20m	-	1.25	0.59	0.96	-	1.33	1.62	1.18	1.33	1.99	-
	30m	-	-	-	0.66	1.55	1.25	1.62	0.96	0.81	1.92	-
	40m	-		0.81	1.40	1.25	1.33	1.33	0.96	0.74	2.07	-
	50m	-			0.81	1.25	1.84			0.81	1.77	1.99
	60m	-			0.66	1.33	1.77			0.59	2.07	
	70m									0.74		

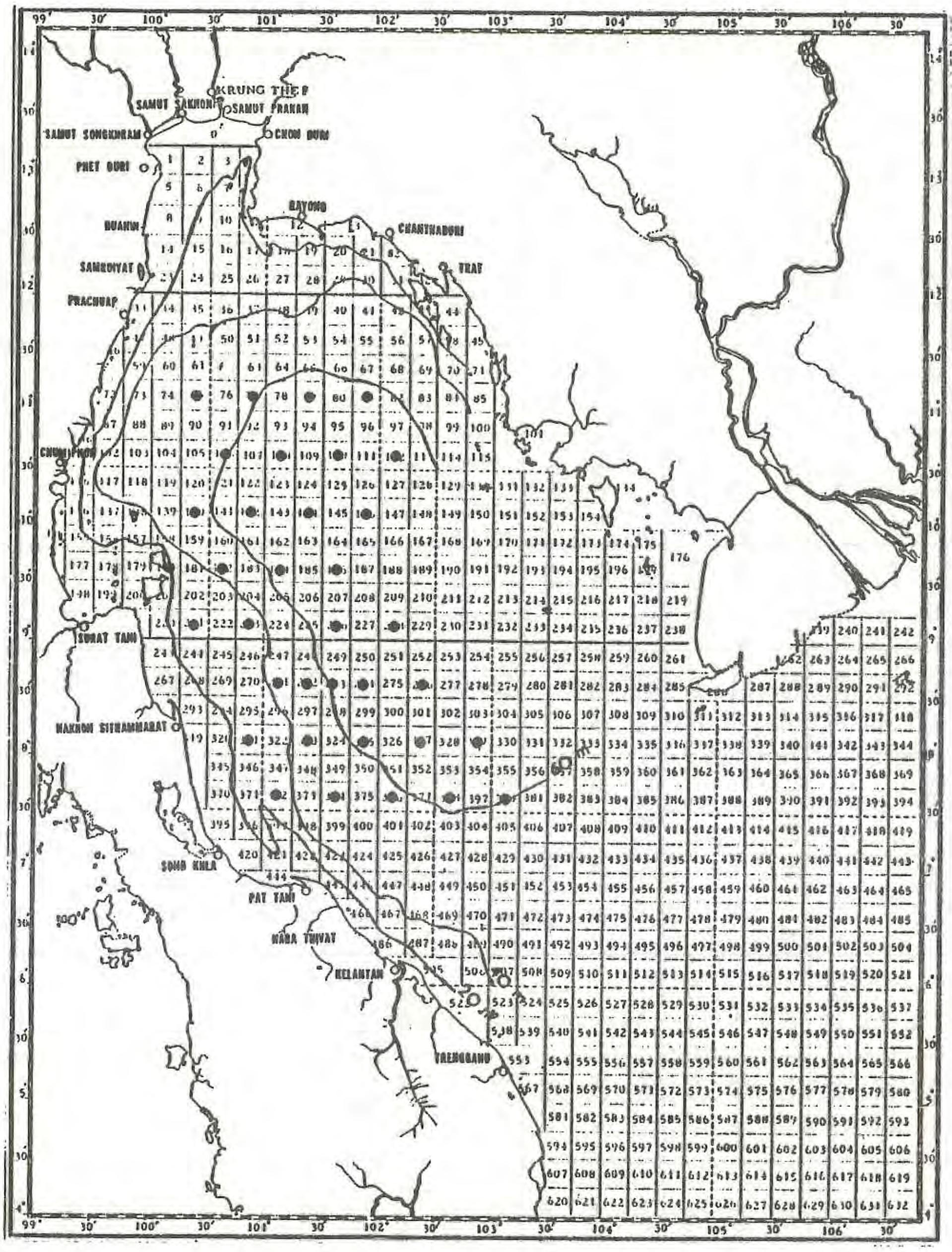

Fig. 1 Location of sampling stations in the Gulf of Thailand, marked by black dots.

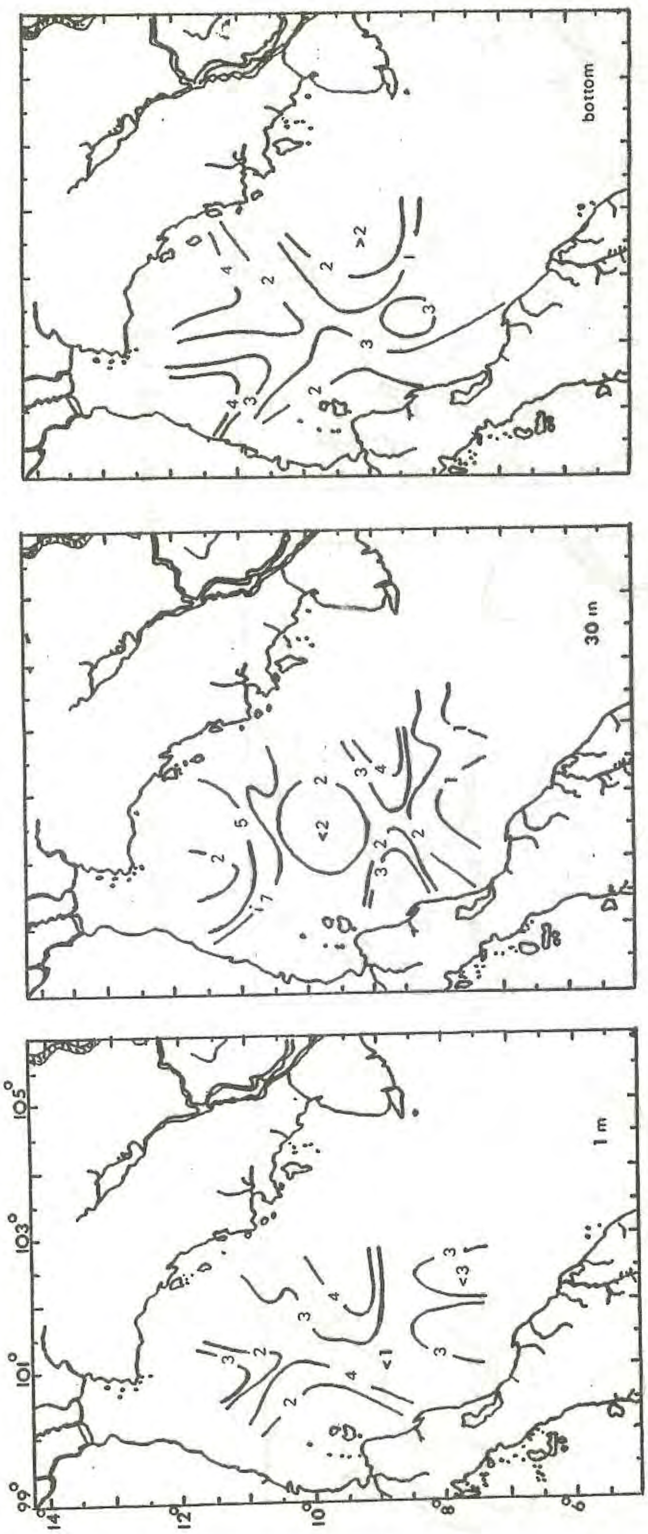

Fig. 2 Nitrate distribution (μM) at 1 m, 30 m, and bottom.

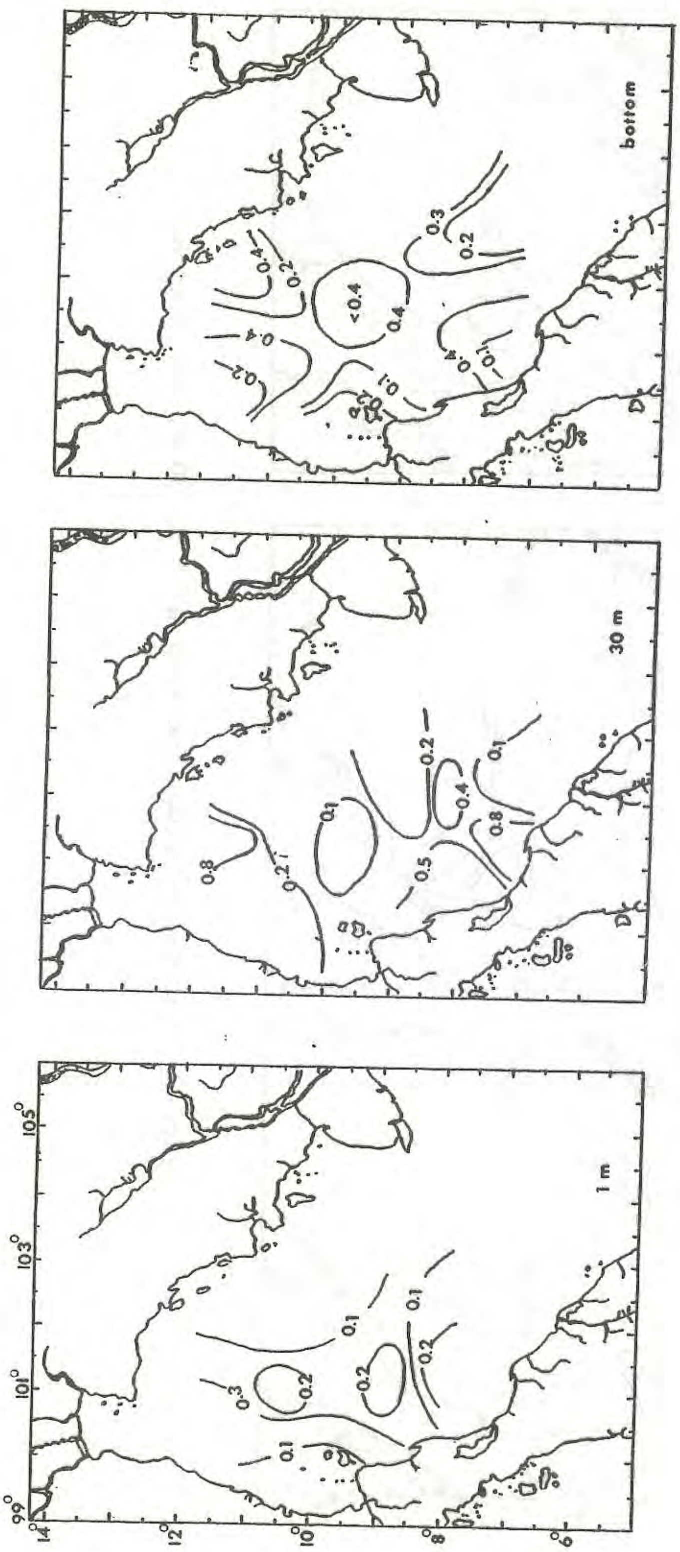

Fig. 3 Nitrite distribution (μM) at 1 m, 30 m, and bottom.

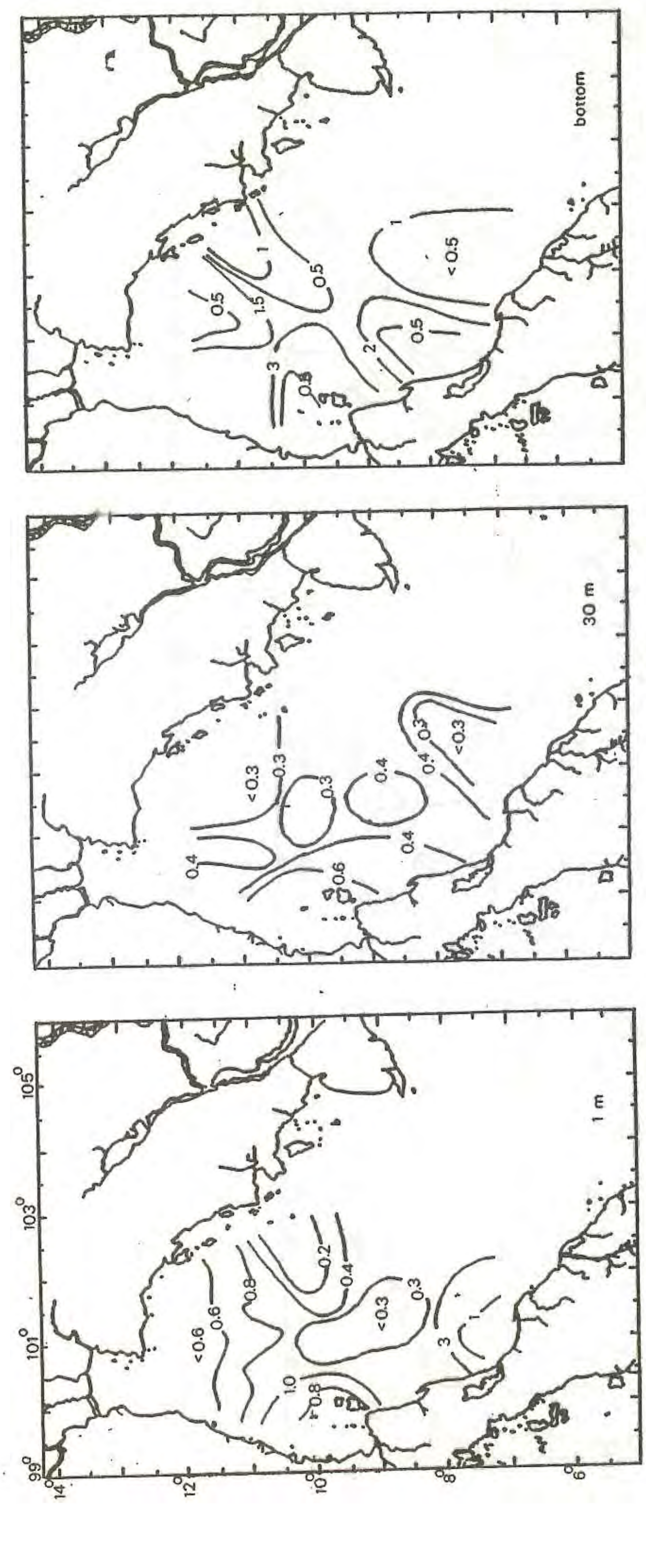

Fig. 4 Phosphate distribution (μM) at 1 m, 30 m, and bottom.

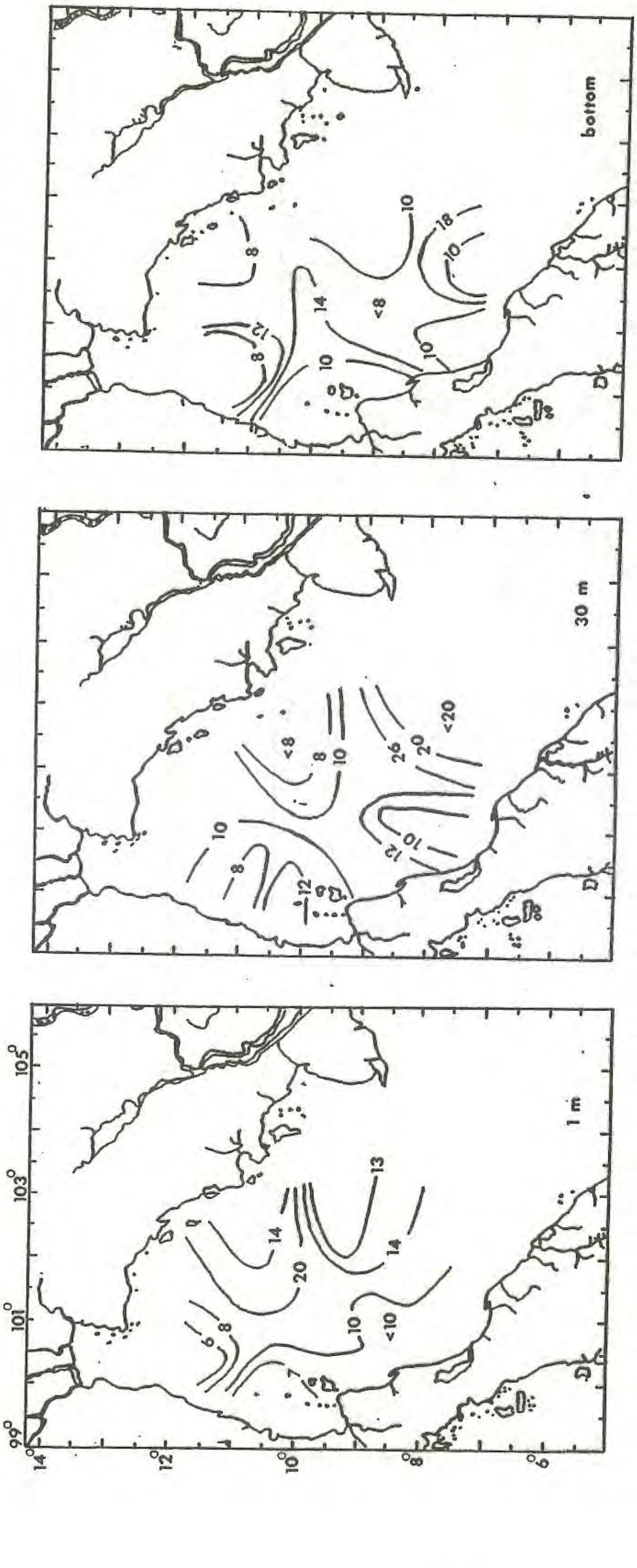

Fig. 5 Silicate distribution (μM) at 1 m, 30 m, and bottom.

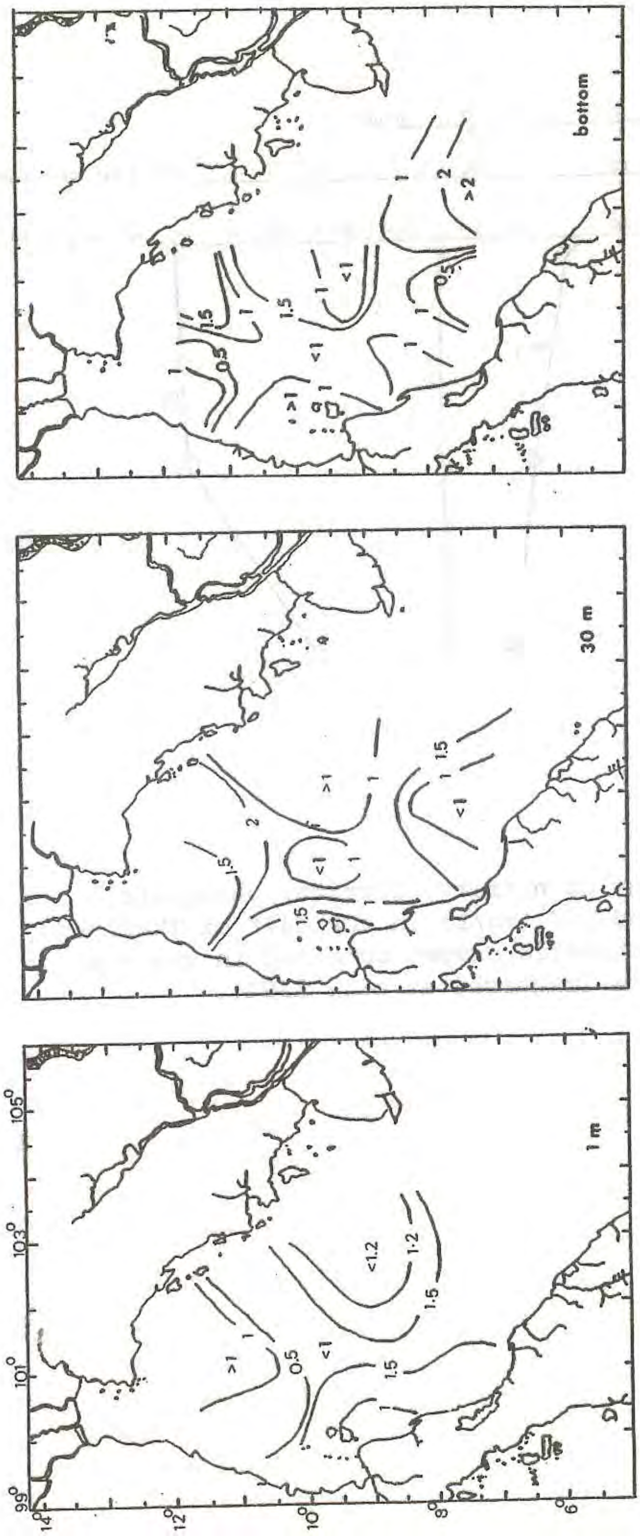

Fig. 6 DOC distribution (mg/L) at 1 m, 30 m, and bottom.

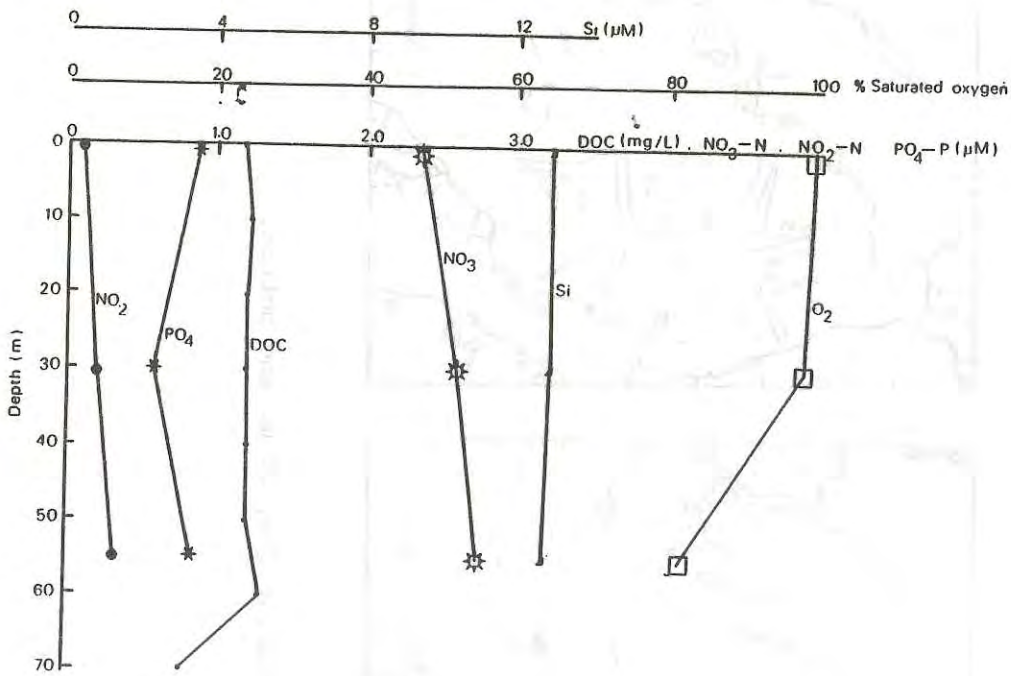

Fig. 7 Vertical profiles of nitrate, nitrite, phosphate, silicate (μM) and DOC (mg/L) in the Gulf of Thailand. Percentage of saturated oxygen obtained in the same cruise (data from Takahashi et al., 1984).

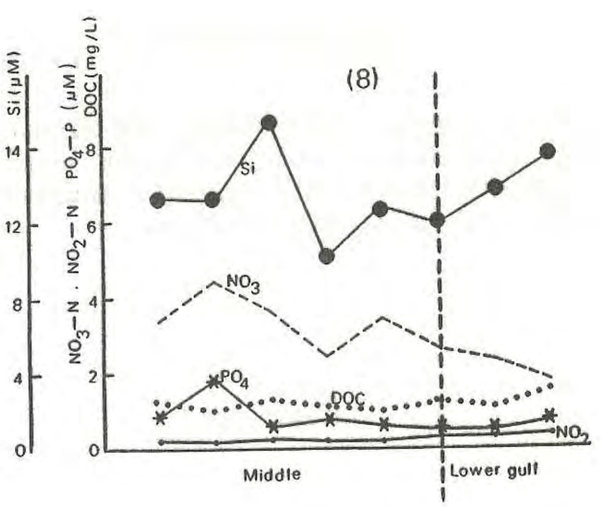

Fig. 8 Distribution of nitrate, nitrite, phosphate, silicate (µM) and DOC (mg/L) from middle to lower Gulf of Thailand.

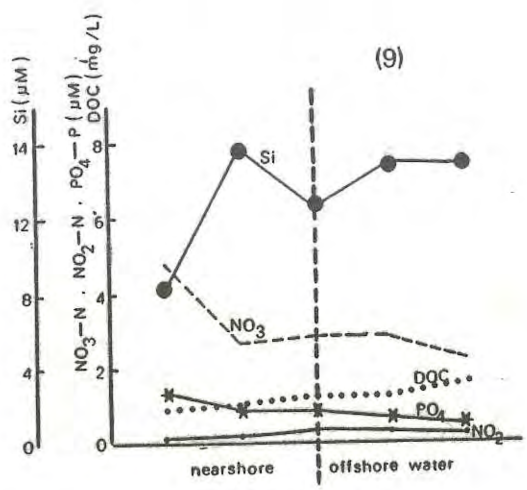

Fig. 9 Distribution of nitrate, nitrite, phosphate, silicate (µM) and DOC (mg/L) from western nearshore to eastern offshore waters in the Gulf of Thailand.

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MARINE BIVALVES IN THE CENTRAL GULF OF THAILAND

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ABSTRACT

Live marine bivalve molluscs were collected during a preliminary study on the living natural resources in the central Gulf of Thailand, on board M.V. Paknam of the Southeast Asian Fisheries Development Center. A total of 25 species were identified and confirmed by comparing with the specimens of the reference collection of Phuket Marine Biological Center and Marine Fisheries Division.

INTRODUCTION

The first report on marine bivalves in Thai waters dates back to 1860, when Professor E.D.V. Martens published his paper "On the Mollusca of Siam" in the *Proceedings of the Zoological Society of London*. He mentioned in it only seven species. In 1891, Paul Fischer recorded 72 species of marine bivalves from the Gulf of Siam in "Catalogue et distribution geographique des Mollusques terrestres, fluviatiles et marins d'une partie de l'Indo-Chine". The number increased to 85 species with Pavie's collection, which Crosse and Fischer (1892) decribed in *Journal de Conchyliologie* (Lynge, 1909). Lynge (1909) decribed Dr. T.H. Mortensen's collection in "The Danish Expedition to Siam 1899-1900. IV: Marine Lamellibranchiata". At that time 379 species were described , but specimens from this expedition were collected only in the northern and eastern parts of the Gulf and down to a depth of 35 fathoms. The mallusc fauna in the western part and also in the deeper parts in the middle of the Gulf were still not investigated. There were some publications after Lynge (Suvatti, 1950 and 1966; Amatayakul, 1958; Chaitiamwong et al., 1971; Neilsen, 1976), but these mosty dealt with organisms in the littorol zones. Only Tantanasiriwong (1979) collected the specimens by dredge or trowl at depths ranging from 8 to 80 metres around Phuket Island.

The purpose of this preliminary study in the central Gulf of Thailand has been to complete the list of marine bivalves in Thai waters and thus provide information for further studies on those organisms.

MATERIALS AND METHODS

Specimens mere collected from 33 stations in the central Gulf of Thailand (75°N to 11.5°N and 100°E to 103.5°E. See Fig. 1). The research cruise took place on board M.V. Paknam from May 16 to June 9, 1984). The specimens were collected mosty by dredge and grab, and at some stations by trawl.

Specimens were divided into two groups:

1. Living specimens, preserved in 10% formalin,
2. Complete shells, which were cleaned and kept in a plastic box.

In this paper only living specimens were identified. The main characters used in identification were shell morphology and distinct soft parts, as established in the publications given in the bibliography. Some specimens were compared with the specimens of the Reference Collection of Phuket Marine Biological Center and the Reference Collection of Marine Fisheries Division. The systematics arrangment of this paper follows that of Moore (1969).

RESULTS

Identification was made and the description of 25 species of bivalves found in the area studied were done with records on distribution which were based upon specific citations in the available literature.

The identified species are listed below, together with their occurrences and distribution. Some of the species are illustrated in Plate I (1-19).

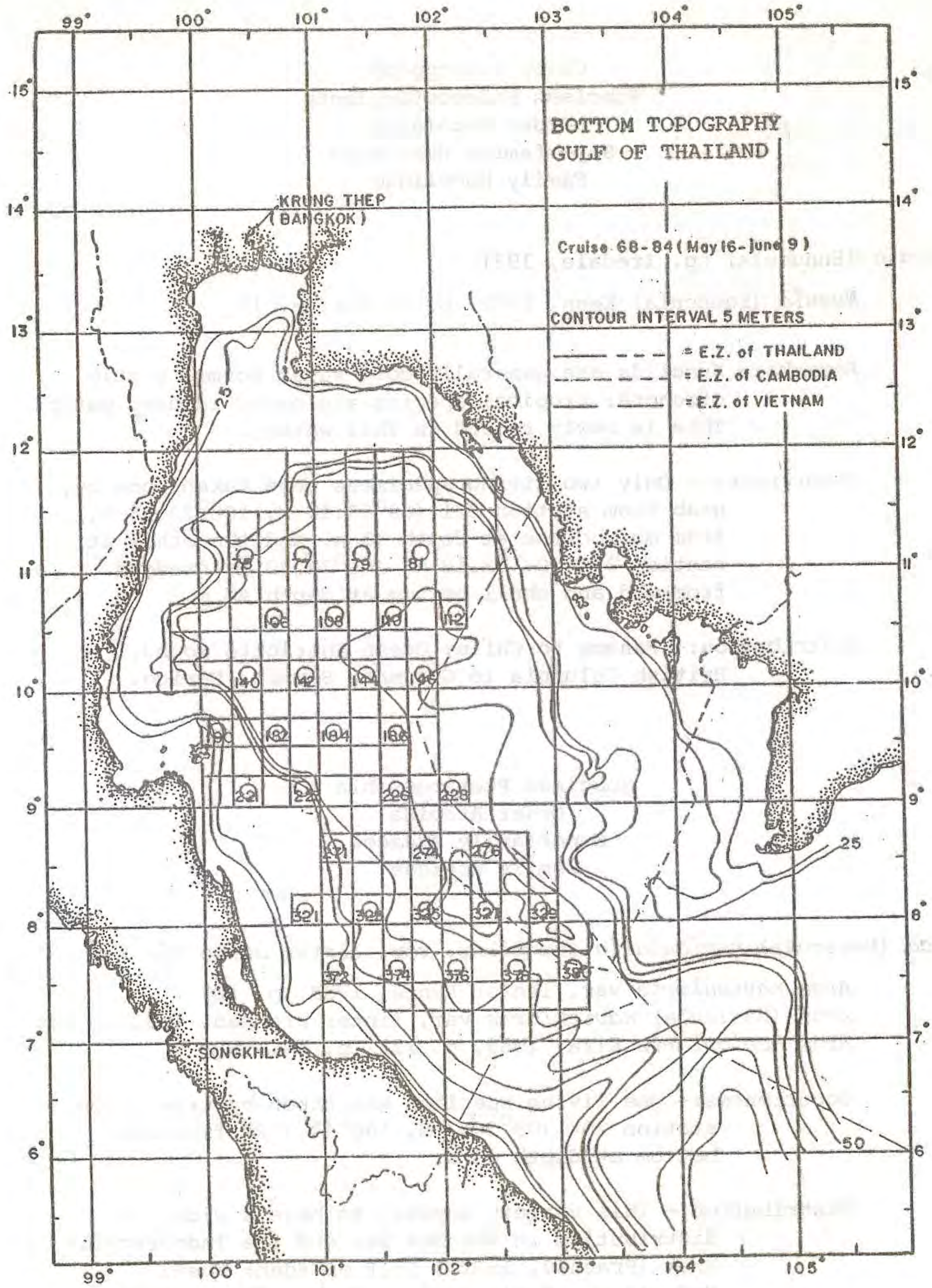

Fig. 1 Sampling stations in the Gulf of Thailand.

Class Pelecypond
Subclass Palaecotaxodonta
Order Nucoloida
Superfamily Nuculacea
Family Nuculidae

Nucula (Ennucula) sp. Iredale, 1931

Nucula (Ennucula) Keen, 1971; p. 27 fig. a, 10

Remarks:- Nuculids are generally cold water forms, mostly offshore; tropical species are occur in deep water. This is newly record in Thai waters.

Occurrences:- Only two living specimens were taken: one by grab from station 221 (09°07'.19 N, 100°22'.95 E.) from mud bottom at depth 33 m, and the other at station 374 (07°38'.18 N, 101°36'.79 E) dredged from mud and shell bottom at depth 48 m.

Distribution:- Panama to Chile; Queen Charlotte Sound, British Columbia to Guaymar, Sonora, Marico.

Subclass Pteriomorphia
Order Arcoida
Superfamily Arcacea
Family Arcidae

Arca (Navicula) *novicularis* Bruguicre, var. linter Jonas *Pl. I-2*

Arca navicularis var. linter Lynge, 1909, p. 109
Arca (Navicula) *navicularis* var. linter Prashad, 1932; p. 34
Arca navicularis Kira, 1965, p. 123; p. 44, fig. 1

Occurrences:- One living specimen was taken by trawl from station 204 (09°24'.7 N, 100°47'.7 E) from mud bottom at depth 40 m.

Distribution:- This variety appears to have a wide distribution in the Red Sea and the Indo-Pacific area (Prashad, 1932); Gulf of Aden; Suez; Madagascar; Poulo Condor; Cochin China; China; Japan; Amboina; Blitong (Post-tertiary); Torres Strait; North, East and South Australia, Tahiti, Salomon Isls; New Caledonia and the Gulf of Siam (Lynge, 1909).

Barbatia descussata (Sowerby, 1833) *Pl. I-3*

Arca (Barbatia) *complanata* Lynge, 1909; p. 111
Arca descussata Plelseneer, 1911; p. 11, pl. II fig.8-11, 13; pl. III fig. 3, 14.

Arca (Barbatia) *descussata* Prashad 1932; p. 42-43
Barbatia descussata Heath, 1941; p. 294; pl. IV fig. 10; pl. V fig. 1, 8; pl. VI fig. 2, 3, 20

Remarks:- After careful examination of specimens and comparison with some specimens from the reference collection of Phuket Marine Biological Center, it is my conclusion that *Barbatia yamamotoi*, identified by Nielsen (1971) is the same species as *Barbatia descussata*.

Occurrences:- Very common, attached to other molluscs or rocks. Many specimens were collected from:

station	lat	long	gear	bottom	depth (m)
223	09°05.0' N	100°48.6' E	trawl	mud	40
271	08°42.5' N	101°07.3' E	trawl	mud	51
272	08°38.23' N	101°22.42' E	dredge	mud/shell	57
321	08°07.8' N	100°51.6' E	trawl	mud	29

Distribution:- *Barbatia descussata* is widely distributed in the Pacific and the Indian Ocean (Prashad, 1932); Lynge (1909) reported the presence of this species in the Gulf of Siam.

Anadara cf. *ferruginea* (Reeve, 1844) *Pl. I-4*
Anadara ferrigomea Tantanasiriwong, 1979; p. 4

Remarks:- I have been able to make comparison only with Tantanasiriwong's specimen from the reference collection of Phuket Marine Biological Center.

Occurrences:- Two live specimens were collected:

station	lat	long	gear	bottom	depth (m)
323	08°07.5' N	101°22.3' E	dredge	mud	49
378	07°36.7' N	102°39.3' E	trawl	mud	69

Family Cucullaeidae

Cucullaea granulosa Jonas, 1846. *Pl. I-5*

Arca (Cucullaea) *concamerata* Lynge, 1909; p. 128
Cucullaea granulosa Pelsencer, 1911; p. 10-12; pl. 11, fig. 6; pl. 111, fig. 7, 8.
Cucullaea granulosa Prashad, 1932; p. 57
Cucullaea granulosa Heath, 1941; p. 306; pl. XV, fig. 10; pl. XVI, fig. 4; pl. XVII, fig. 10; pl. XIX, fig. 4-6; pl. XX, fig. 9, 12 pl. XXI, fig. 8
Cucullaea granulosa Kira, 1965; p. 123; pl. 44, fig. 9.

Occurrences:- Very common, many specimens were taken from the following stations:

station	lat	long	gear	bottom	depth(m)
140	10°05'.6 N	100°17'.2 E	trawl	mud	54
182	09°34'.45 N	100°37'.88 E	trawl	mud	50
186	09°38'.2 N	100°47'.7 E	trawl	mud	70
204	09°24'.7 N	100°47'.7 E	trawl	mud	40
207	09°23'.8 N	101°33'.5 E	trawl	mud	71
223	09°05'.0 N	100°48'.6 E	trawl	mud	40
271	08°42'.5 N	101°7'.3 E	trawl	mud	51

Order Myiloida
Superfamily Pinncea
Family Pinnidae

Atrina pectinata (Linné, 1767) *Pl. I-6*

Atrina pectinata Prashad, 1932; p. 137-138
Atrina pectinata Rosewater, 1961; p. 180, 211
Atrina pectinata Kira, 1965; p. 132; pl. 47, fig. 10

Remarks:- This species exhibited maximum variation, which ranges from the pale, translucent, subinflated olivaceous form (of South India) to the large, tumid, dark "japonica" of South Japan. (Rosewater, 1961)

Occurrences:

station	lat	long	gear	bottom	depth(m)
180	09°31'.2 N	100°12'.6 E	trawl	mud	23
321	08°07'.5 N	100°51'.6 E	trawl	mud	29
372	07°41'.5 N	101°05'.9 E	trawl	mud	43

Distribution: This species has a limited distribution to Southern, East, and Southeast Asia, the East Indies, Northern Australia and Melanesia.

Order Pterioida
Superfamily Pteriacea
Family Pteriidae

Pinctada maxima (Jameson, 1901) *Pl. I-7, 8*

Pinctada maxima Joyce, 1962; p. 266, text fig. 64, 1
Pinctada mazima Tantanasiriwong, 1979; p.6

Remarks: This species was found in depths ranging from shallow water to 35 and even 40 fathoms (78 m). It is most abundant from 15 to 20 fathoms (Joyce, 1962).

Occurrences: Only one specimen was collected by trawl from station 207, lat. 09°23.8 N, long. 101°33.5 E., from mud bottom.

Distribution: Japan, Australia, Southern Pacific (Joyce, 1962).

Family Isognomonidae

Malleus albus Lamarck, 1819 *Pl. I-9*

Malleus albus Lynge, 1909; p. 145
Malleus albus Prashad, 1932; p. 104
Malleus albus Habe, 1970; p. 169; pl. 51, fig. 7
Malleus albus Yonge, 1968; p. 391
Malleus albus Tantanasiriwong, 1979; p. 6

Occurrences:

station	lat	long	gear	bottom	depth(m)
204	09°24'.7 N	100°47'.7 E	trawl	mud	40
378	07°36'.7 N	102°39'.3 E	trawl	mud	69

Distribution: *Melleus albus* has a wide distribution in the Indo-Pacific. Lynge (1909) reported its distribution in Singapore, Ceylon, Gulf of Aden, Philippines, China, Japan; north, east and south coast of Australia; and the Gulf of Siam.

Superfamily Pectinacea
Family Pectinidae

Chlamys (Mimachlamys) *nobilis* Reeve. *Pl. I-10*

Chlamys (mimachlamys) *nobilis* Kira 1965 p. 140; pl. 50, fig. 12

Occurrences:

station	lat	long	gear	bottom	depth(m)
186	09°38'.2 N	101°34'.4 E	trawl	mud	70
321	08°07'.8 N	100°51'.6 E	trawl	mud	29
372	07°41'.5 N	101°05'.9 E	trawl	mud	43
378	07°36'.7 N	102°39'.3 E	trawl	mud	69

Distribution: recorded in Japan and China.

Pecten (Serratovola) *tricarinatus* Anton *Pl. I-11*

Pecten (Serratovola) *tricarinatus* Kira, 1965; p. 136, pl. 49, fig. 5

Occurrence:

station	lat	long	gear	bottom	depth(m)
184	09°32′.8 N	101°07′.4 E	dredge	mud and shell	64
272	08°38′.23 N	101°22′.42 E	trawl	mud and shell	57

Distribution: Japan, China

Amusium pleuronectes (Linné, 1758) *Pl. I-12*

Amusium pleuroncetes Lynge, 1909; p. 158
Amusium pleuronectes Pelseneer, 1911; p. 28.31; pl. XI fig. 9-10
Amusium pleuronectes Kira, 1968; p. 138; pl. 49, fig 16
Amusium pleuronectes Hertlein, 1969; p. N 348-N 351, fig. C 73; 1a, 1b
Amusium pleuronectes Abbott, 1978; p. 137

Occurrence: Very common

station	lat	long	gear	bottom	depth(m)
140	10°5′.6 N	100°17′.2 E	trawl	mud	54
223	09°05′.0 N	100°48′.6 E	trawl	mud	40
271	08°42′.5 N	101°07′.3 E	trawl	mud	51
321	08°07′.8 N	100°51′.6 E	trawl	mud	29
372	07°41′.5 N	101°05′.9 E	trawl	mud	43

Distribution: Very common, abundant in southeast Asia at depth of 50 to 120 feet and wide distribution in Indo-Pacific area.

Family Placunidae

Placuna (Placuna) *placenta* (Linne, 1758)

Placuna placenta Lynge, 1909; p. 107
Placuna (Placuna) *placenta* Kira, 1965; p. 133; pl. 47 fig. 13
Placuna placenta Keen, 1969; p. N 385, fig. C 103, 5

Occurrences: Two live specimens found at station 223 (lat 09°05'.0 N, long 100°48'.6 E), trawled from mud bottom at 40 m depth.

At station 372, I found a lot of shells of this species but no live specimen.

Distribution: This species is widely distributed in the Indo-Pacific region.

Family Placunidae

Plicatula mericata Sowerby, 1873 *Pl. I-13*

Plicatula muricata Pelseneer, 1911; p. 32; pl. XII fig. 12
Plicatula muricata Prashad, 1932; p. 117
Plicatula muricata Kira, 1965; p. 136; pl. 49, fig. 3
Plicatula muricata Tantanasiriwong, 1979; p. b.

Occurrences:

station	lat.	long.	gear	bottom	depth (m)
204	09°24'.7 N	100°47'.7 E	trawl	mud	40
223	09°05'.0 N	100°48'.6 E	trawl	mud	40
271	08°42'.5 N	101°07'.3 E	trawl	mud	51

Distribution: Prashad (1932) recorded its distribution in Japan, Western entrance to Samau Strait, between the islands of Wowoni and Buton, northern entrance of Buton Strait and near Kei Island.

Superfamily Limacea
family Limidae

Lima (Limaria) *orientalis* Adoms & Reeve 1850

Lima (Mantellum) *angulata* Lynge, 1909; p. 159
Lima (Limaria) *orientalis* Prashad, 1932; p. 125; pl. III, figs. 32, 33
Mantellum orientalis Kira, 1965; p. 145, pl. 52, fig. 2
Lima orientalis Tantanasiriwong, p. 7

Occurrences: Only one living specimen collected from station 223, lat. 09°05.0 N, long 100°48.6 E, trawled from mud bottom at 40 m depth.

Distribution: Southern Pacific area, the Philippines, Australia, New Zealand, and its range probably extends through the South China Sea into the Gulf of Siam (Prashad, 1932).

Superfamily Ostreacea
family Gryphaeidae
Subfamily Pycnodontinae

Pycnodonte hyotis (Linné, 1758) *Pl. I-14*

Ostrea hyotis Lynge, 1909; p. 161
Ostrea (Lopha) *hyotis* Prashad, 1932; p. 129
Pycnodonte hyotis Thomson, 1953

Occurrences:

station	lat.	long.	gear	bottom	depth (m)
186	09°38'.2 N	101°34'.4 E	trawl	mud/shell	70
207	09°23'.8 N	101°33'.5 E	trawl	mud	71
223	09°05'.0 N	100°48'.6 E	trawl	mud	40
321	08°07'.8 N	100°51'.6 E	trawl	mud	29
378	07°36'.7 N	102°39'.3 E	trawl	mud	69

Distribution: This species has a wide distribution in the Red Sea, the Indian Ocean and the Western Pacific.

Subclass Heterodonta
Order Veneroida
Superfamily Chamacea
Family Chamidae

Chama cf. *reflexa* Reeve 1846

Chama reflexa Kira, 1965; p. 151, pl. 54, figs, 10, 11
Chama reflexa Tantanasiriwong, 1979; p. 8

Occurrences:

station	lat.	long.	gear	bottom	depth(m)
271	08°42'.5 N	101°07'.3 E	dredge	mud/shell	51
272	08°38'.23 N	101°22'.42 E	dredge	mud/shell	57

Distribution: Indo-Pacific.

Superfamily Cardiacea
Family Cardiidae

Vepricardium multispinosum (Sowerby, 1838)

Cardium (Bucardium) *multispinosum* Lynge, 1909; p. 256
Cardium (Ringicardium) *multispeinosum* Prashad, 1932; p. 271
Vepricardium multispinasum Habe, 1970; p. 186, pl. 57, fig. 23

Vepricardium multispinosum Tantanosiriwong, 1979; p. 9

Remarks: The number of ribs on the shells of this species is variable and the small spines on the ribs also are not equally developed on shells.

Occurrences:

station	lat.	long.	gear	bottom	depth(m)
140	10°05'.6 N	100°17'.2 E	trawl	mud	54
180	09°31'.2 N	100°12'.6 E	trawl	mud	23
240	09°24'.7 N	100°47'.7 E	trawl	mud	40

station	lat.	long.	gear	bottom	depth(m)
207	09°23'.8 N	101°33'.5 E	trawl	mud	71
223	09°05'.0 N	100°48'.6 E	trawl	mud	40
321	08°07'.8 N	100°51'.6 E	trawl	mud	29
327	07°41'.5 N	101°05'.9 E	trawl	mud	43

Distribution: This species was decribed in the Philippines but has been recorded in China, North and East coast of Australia, Gulf of Siam, Madagascar and Mozambique (Lynge, 1909 and Prashad, 1932).

Superfamily Solenacea
Family Cultellidae

Cultelleus sp. Schumacher 1817 *Pl. I-15*

Cultelleus Ghosh, 1920; p. 61-62
Cultelleus Keen, 1969; p. N 611-612, fig. E 103, 2

Remarks: Shell oblong, ends rounded, gaping; beak not terminal; hinge with one cardinal and one posterior lateral tooth in RV.; two cardinal teeth in LV., which posterior rigid; pallial sinus small; with rib above rounded, anterior adductor scar.

Siphons separate, very short, fringed with tentacles which extend to the adjacent fused mantle margin.

In my opinion this species may be *Cultelleus* (Cultelleus) *Lacteus* (Spengler, 1793).

Occurrences:

station	lat.	long.	gear	bottom	depth(m)
329	08°07'.9 N	102°41'.1 E	trawl	mud	71
380	07°37'.6 N	103°07'.07 E	dredge	mud/shell	61

Distribution: Indo-Pacific

Phaxas (Ensiculus) cf. *cultellus* (Linne, 1758) *Pl. I-16*

Phaxas (Ensiculus) *cultellus* Keen, 1969); p. N 612, fig. E103, 3

Phaxas cultellus Tantanasiriwong, 1979; p. 11.

Occurrences: Station 140 (10°07′.41 N, 100°22′.52 E), dredged from mud bottom at 56 m depth

Distribution: East Indies.

Superfamily Tellinocea
Family Tellinidae
Subfamily Tellininae

Tellina (Angulus) cf. *rhondon* (Hanley, 1844)

Tellina (Angulus) *rhondon* Prashad, 1932; p. 194, pl. V fig. 37-38

Occurrences:

station	lat.	long.	gear	bottom	depth (m)
106	10°37′.18 N	101°36′.72 E	dredge	mud	60
323	08°07′.21 N	101°22′.03 E	grab	mud/shell	51

Distribution: The Philippines, Java Sea, Ruma-Kuda Bay, Roma Island (Siboga Exped.)

Tellina sp.

Occurrences:

station	lat.	long.	gear	bottom	depth (m)
221	09°07′.19 N	100°22′.95 E	grab	mud	33
321	08°08′.08 N	100°50′.09 E	dredge	mud/shell	29

Subfamily Macominae

Macoma (Psammacoma) cf. *candida* (Lamarck, 1818)

Tellina (Macoma) *fallax* Lynge, 1909; p. 207
Macoma (Psammacoma) *fallax* Prashad, 1932; p. 197
Macoma (Psammacoma) *candida* Keen, 1969; p. N 623, fig. E110, 12 a, b.

Occurrences: Station 378 (07°36.7' N 102°39.3' E) trawled from mud at 69 m depth

Distribution: East Indies, China Sea and Gulf of Siam (Lynge, 1909 and Keen 1969).

Superfamily Veneracea
Family Veneridae
Subfamily Dosiniinae

Dosinia (Austrodosinia) cf. *conglobata* Romer, 1862 *Pl. I-17*

Dosinia (Austrodosinia) *conglobata* Prashad, 1932; p. 245; pl. VI, fig. 17-20

Remarks: It is beleived to be *Dosinia* (Austrodosinia) *conglobata*, according to Prashad's figure.

Occurrences:

station	lat.	long.	gear	bottom	depth(m)
323	08°07.5' N	101°22.3' E	dredge	mud	49
374	08°38.18' N	101°36.79' E	dredge	mud/shell	48

Subfamily Tapetinae

Paphia (Paratapes) *undulata* (Born, 1778) *Pl. I-18*

Tapes (Paratapes) *undulatus* Lynage, 1909; p. 237
Tapes undulatus Pelseneer, 1911; p. 52, pl. XIX, fig. 9
Paphia (Paratapes) *undulata* Prashad 1932; p. 241
Paphia (Paratapes) *undulata* Kira, 1965; p. 161; pl.57 fig. 24

Occurrence:

station	lat.	long.	gear	bottom	depth(m)
182	09°40'.81 N	101°37'.26 E	grab	mus/shell	53
184	09°32'.8 N	101°07'.4 E	dredge	mud/shell	64

Distribution: Indo-Pacific

Order Myoida
Super family Myacea
Family Corbulidae

Corbula (Solidicorbula) *erythrodon* Lamark, 1818 *Pl. I-19*

Corbula (Solidicorbula) *erythrodon* Kira, 1965; p. 179; pl. 62, fig. 19

Corbula (Solidicorbula) *erythrodon* Keen, 1969; p. N 694; fig. E 157, 1

Occurrences:

station	lat.	long.	gear	bottom	depth(m)
81	11°07'.5 N	101°52'.4 E	grab	mud/shell	25
180	09°31'.2 N	100°12'.6 E	trawl	mud	23
182	09°34'.45 N	100°37'.88 E	trawl	mud	50

Distribution: Western Pacific

Plate I

1: *Nucula* (Ennucula) sp. Iredale 1931

2: *Arca* (Navicula) *novicularis* Bruguicre, var. linter Jonas

3: *Barbatia descussata* (Sowerby, 1833)

4: *Anadara* cf. *ferruginea* (Reeve, 1844)

5: *Cucullaea granulosa* Jonas, 1846

6: *Atrina pectinata* (Linné, 1767)

7,8: *Pinctada maxima* (Jameson, 1901)

9: *Malleus albus* Lamarck, 1819

10: *Chlamys nobilis* Reeve

11: *Pecten* (Serratovola) *tricarinatus* Anton

12: *Amusium pleuronectes* (Linné, 1758)

13: *Plicatula mericata* Sowerby, 1873

14: *Pycnodonte hyotis* (Linné, 1758)

15: *Cultelleus* sp. Schumacher 1817

16: *Phaxas* (Ensiculus) cf. *cuttellus* (Linné., 1758)

17: *Dosinia* (Austrodosinia) cf. *conglobata* Romer 1862

18: *Paphia* (Paratapes) *undulata* (Born, 1778)

19: *Corbula* (Solidicorbula) *erithrodon* Lamark, 1818

Plate I


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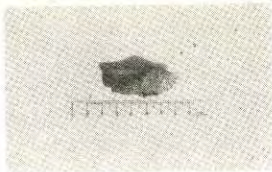
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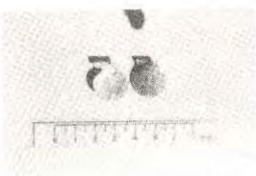
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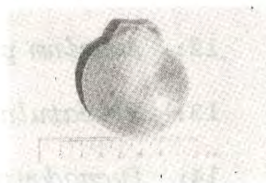
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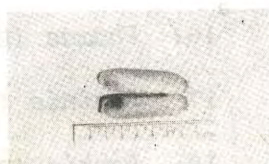
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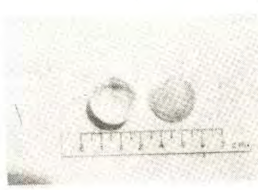
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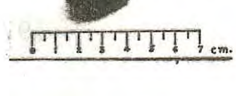
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DISTRIBUTION OF PHYTOPLANKTON
IN THE CENTRAL GULF OF THAILAND

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ABSTRACT

Species composition of phytoplankton in the central Gulf of Thailand was studied from samples collected at 33 stations, at three levels of depth; surface, mid-depth and bottom. Density of phytoplankton was reported in cell number per cubic meter. Both vertical and horizontal distribution of phytoplankton species was considered. The species that were confined to the bottom were *Planktonella sol*, *Gosslerriella tropica* and *Biddulphia sinensis*. Density of some species was found to vary significantly with depth of water. Those were: *Thalassiothrix frauenfeldii*, *Coscinodiscus* spp., *Rhizosolenia calcaravis*, *Ceratium dens*, *C. trichoceros* and *Thalassiosira subtilis*.

It was also found that *Cerataulina compacta*, *C. bergonii* and *Guinardia flaccida* were coastal species, while *Asterolampra marylandica*, *Asteromphalus* sp., *Dactyliosolen antarcticus* and *Planktonella sol* were offshore species. The dominant species in all stations was *Trichodesmium thiebauti*.

INTRODUCTION

Most of the past studies on phytoplankton in the Gulf of Thailand were confined to the coastal areas and the estuarine waters (Schmidt 1915, Suvapepun 1978, Boonyapiwat 1978, 1979, 1981, 1982, 1983, Suvapepun et al. 1982, Wongratana 1982, Phovichit and Ajara 1981, 1984, Piromnim 1981). Little has been done on taxonomy of phytoplankton from the deep waters of the Gulf (Rose 1926, Silathornvisut 1961).

The purpose of the present survey was to study the species composition of phytoplankton in the central Gulf, and to find out vertical and horizontal distribution of phytoplankton density.

MATERIALS AND METHODS

A sample survey of phytoplankton was carried out between 17 May and 7 June 1984, at 33 stations in the central Gulf of Thailand (See Fig. 1)[1]. Samples were collected with a closing net of 45 cm month diameter and 20 microns mesh size, by vertical haul at three levels: surface, mid-depth and bottom. Hauling distances were 10 meters. At stations where the water depth was less than 50 m, samples were taken only of two levels, surface and bottom. In one station, where the water depth was only 17 m, one sample was taken at the surface level.

Samples were fixed and preserved in 4% formalin solution. The phytoplankton cells were examined and counted by using a Sedgewick Rafter Counting cell under a microscope at 200x magnification. Where possible, identification was made to the species level, and some species of the same genus were combined to the genus level. The species and densities are shown in Table 1. Species which could not be identified with complete certainly are listed in parentheses.

As the cell density values were very high, they have for convenience been presented as ten levels, as follows:

1	represents the density of		1-100	cells/m
2	"	"	101-300	"
3	"	"	301-600	"
4	"	"	601-1,000	"
5	"	"	1,001-3,000	"
6	"	"	3,001-6,000	"
7	"	"	6,001-10,000	"
8	"	"	10,001-15,000	"
9	"	"	15,001-80,000	"
*	"	"	over 80,000	"

1 Figures and tables appear at the end of the text.

The survey area covered a wide range of depths, so that the stations were grouped according to depth into three groups: with the depth range of 17-48, 50-61 and 65-77 m (Fig. 2). Analysis of varience by one-way classification was used to analyse the difference of cell density in different levels.

RESULT AND DISCUSSION

The phytoplankton samples comprised 28 genera of diatoms, seven genera of dinoflagellates and one genus of green algae. Average density of phytoplankton in stations of groups I, II and III were 96,674, 17,689 and 8,729 cells/m^3, respectively.

Trichodesmium thiebauti was dominant at almost every station and at all levels. In some stations, however *Thalassiothrix frauenfeldii* and *Thalassiosira subtilis* were predominant at the bottom level.

Group I comprised six stations with the depth between 17 and 48 meters. Station 180 was the shallowest one, with 17 m depth. Only one sample was taken at the surface level, and the density of phytoplankton at this station was the highest. The remarkably high density phytoplankton species at this station were *Bacteriastrum* spp., *Thalassionema nitzschoides* and *Thalassiothrix frauenfeldii* with more than 80,000 cells/m^3. Samples at other stations in this group were collected at two levels, surface and bottom. At stations in this group, cell density at the bottom level was higher than at surface level, except at the station 374. However, the total phytoplankton density between surface and bottom were significantly different at 90% confidence only. The density distribution of some species such as *Biddulphia sinensis*, *Thalassiothrix frauenfeldii*, *Coscinodiscus* spp., *Mastogloia rostrata* etc. were not significantly different between levels of depth.

Group II comprised 11 stations with depths between 50 and 61 m. The highest cell density was found at the bottom level of stations 323 and 140, because of the abundance of the bottom-dwelling *Thalassiosira subtilis*. The cell density was generally higher at the bottom layer than at mid or surface layers, the only exceptions being stations 106 and 184 where the highest densities were at mid-depth and surface layer, respectively. Statistical tests showed that cell densities between three levels in this group of stations were significantly different ($\alpha = 0.0119$). The vertical distribution of *T. frauenfeldii* and

Coscinodiscus spp. was also significantly different between levels (α = 0.0038 and 0.0588). *Planktonella sol, Gossleriella tropica* and *B. sinensis* were not found at surface levels.

Group III comprised 16 stations, with the depth range between 65 and 77 m. The highest cell density of this group was at the bottom layer of station 79. The cell density at mid-depth of station 146 appeared very low, probably due to an error in sampling operation. The statistical analysis showed that the total cell density between levels in this group was not significantly different. However, significant differences between layers were found in distribution of *B. sinensis* (α = 0.0006), *Ceratium dens* (α = 0.014), *C. trichoceros* (α = 0.008), *Rhizosolenia calcaravis* (α = 0.013), *T. subtilis* (α = 0.057), and *Coscinodiscus* spp. (α = 0.001). *Planktonella sol* and *Gossleriella tropica* were found only at the bottom level.

Data from stations of Group I and Group II showed that phytoplankton density was high at the bottom level and gradually decreased at upper levels. It can be assumed that the water transparency and light intensity at the depth around 60 m were sufficient for photosynthesis of phytoplankton to take place. The phytoplankton samples collected from stations of Group III were not from bottom level exactly, they were collected at about 60 m depth only. However, the phytoplankton density at bottom level of stations with depth about 70 m tends to be lower than the density at mid-depth. The light intensity is a factor that effects the growth of phytoplankton at the bottom level.

The vertical distribution patterns of some phytoplankton species that showed significant differences between levels are shown in Fig. 3. Most of them were more abundant at the bottom level, except *C. dens* whose number was higher at surface than at bottom.

Among dinoflagellates, genus *Ceratium* was dominant, especially *C. trichoceros*, followed by *C. dens*.

The horizontal distribution of dinoflagellates was similar to that of diatoms, that were high in coastal areas. The average cell density of dinoflagellates in station Group I, II and III was 1,321, 654 and 580 cells/m^3 respectively. However, the proportion of dinoflagellates in the total phytoplankton in coastal areas was lower than offshore. The percentage of dinoflagellates was 1.36, 3.70 and 6.64 in station groups I, II and III respectively.

On the basis of this survey it can be concluded that Asterolampra marylandica, Asteromphalus sp., Dactyliosolen antarcticus and Planktonella sol are oceanic species, because they were not found in coastal areas (Group I stations). On the other hand, Cerataunline compacta, C. bergoniiand Guinardia flaccida were found only in Group I stations, and are therefore assumed to be coastal species. Wongratana (1982) reported on the species of Ceratium found in the coastal areas; his findings were similar to the conclusions of the present study, except that the abundance of some species was different. For example, in Wongratana(1982) C. breve and C. inflatum were recorded as commonly found species, whereas they were rare in this survey. This may be due to the difference in survey areas and in season. Further study should be made in the same area but in different seasons.

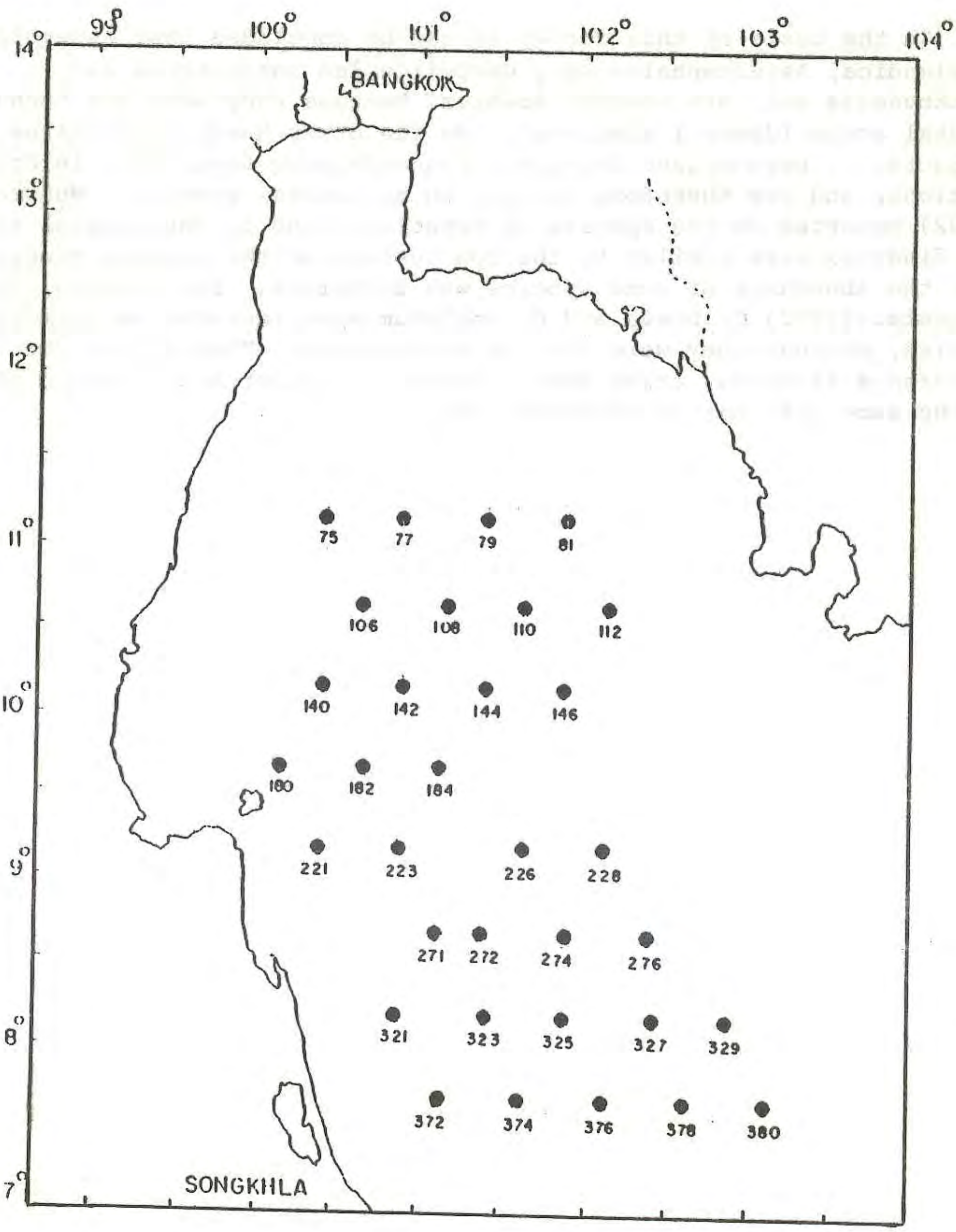

Fig. 1. Location chart of survey stations in the Gulf of Thailand.

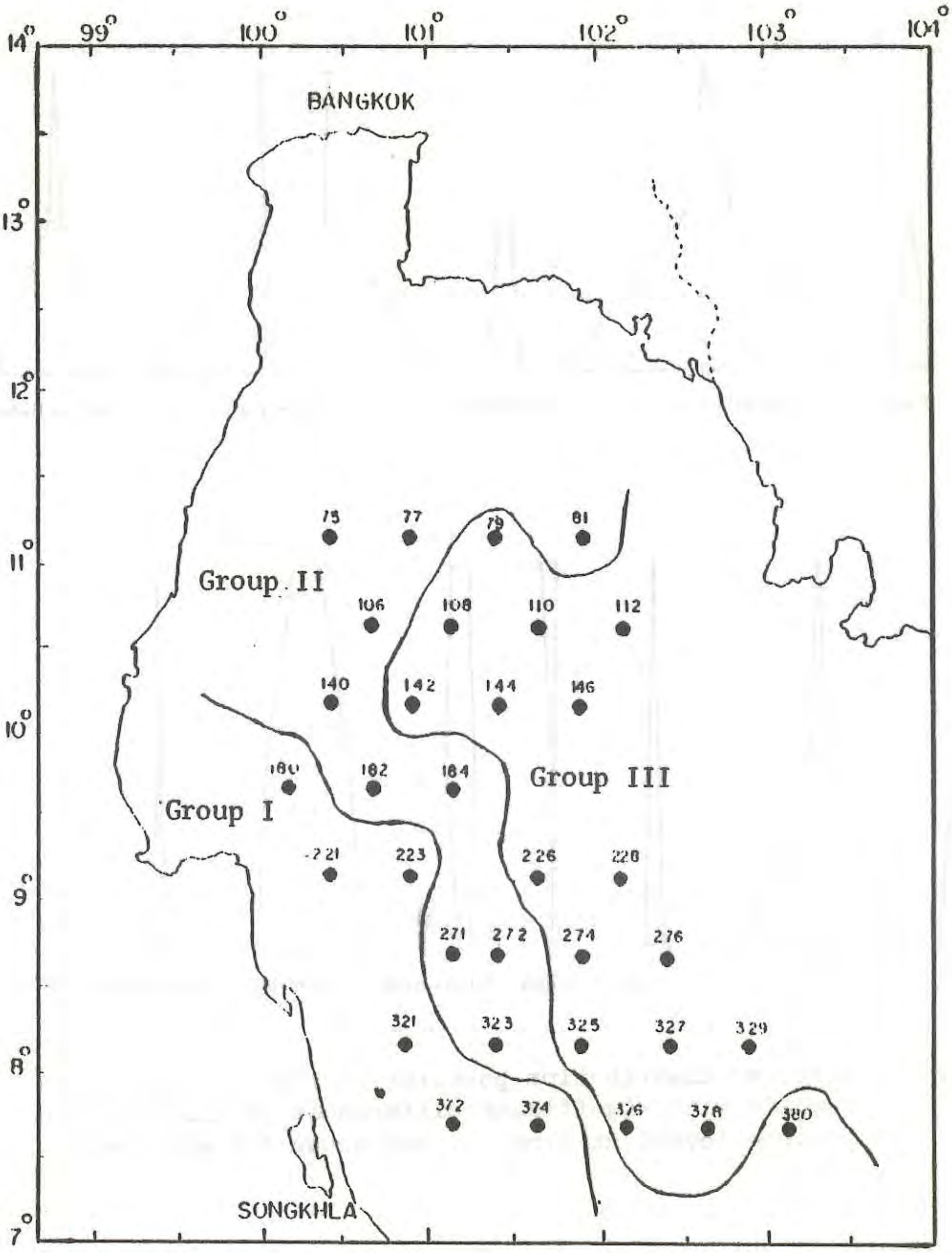

Fig. 2. Stations ranked according to depth: Group I, 17 to 48 meters; Group II, 50 to 61 meters; Group III, 65 to 77 meters.

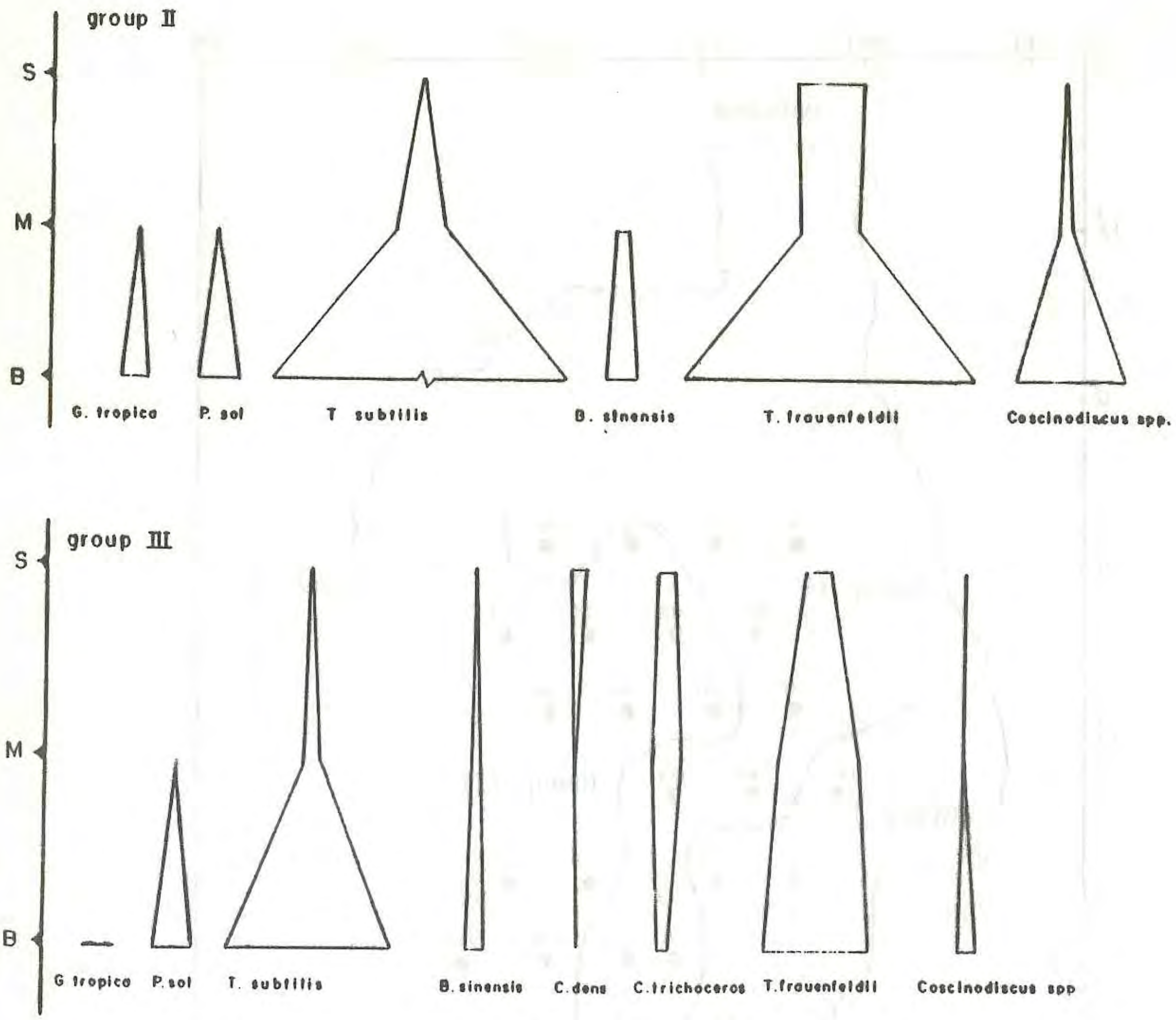

Fig. 3. Vertical distribution patterns of some phytoplankton species with significant differences in distribution between levels at Group II and Group III stations.

Table 1. Density of phytoplankton species surface (S), mid-depth, (M) and bottom, (B) layer, at 33 stations Number 1 to 9 and * express density (No./m), as follows:

1 :	1 - 99		6 :	3,000 - 5,999
2 :	100 - 299		7 :	6,000 - 9,999
3 :	300 - 599		8 :	10,000 - 14,999
4 :	600 - 999		9 :	15,000 - 79,999
5 :	1,000 - 2,999		* :	80,000

Station No.	180	221		223		321		372		374		75			77		
Depth (m)	17	33		41		29		42		48		50			60		
Species / Level		S	B	S	B	S	B	S	B	S	B	S	M	B	S	M	B
Asterolampra marylandica												1	1		1		
Asteromphalus sp.												1	1				
Bacteriastrum spp.	*	4	7	3		8	9	3	3	2	1	3	5	4	5	5	5
Biddulphia sinensis	9		1	2	3	3	5									1	
Cerataulina compacta	7					2											
C. bergonii	8		1		5		4		1								
Chaetoceros spp.	9	2	4	3	4	5	7		2		1	3	3	3	4	3	3
C. affinis	5			1		3	5										
C. atlanticus																	
C. brevis	5						5										
C. coarctatum		3	2	2		1	4		3	1	1	2	2	3		3	4
C. constrictus			2			3	7										
C. (convolutus)																	
C. (danicum)														2		3	
C. denticulatum		1	1	1		5	5					2	3	4	2	2	3
C. densum																	
C. (dichaeta)																	
C. didymum	5	3	3				4			1	1	4	4	3	5	5	3
C. distan	8		2	2		2						3	3		2	3	3
C. diversus	7					5	5										

Station No.	81			106			140			182			184			271			272			323			380		
Depth (m)	60			60			56			53			60			55			56			51			61		
Species / Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Asterolampra marylandica								1						2		1	1						1	1			
Asteromphalus sp.		1			1																		1				
Bacteriastrum spp.		1	2	6	5	4	2	3	1	1	1	3	1			1	3	5	1		3	3	3	5	3	5	3
Biddulphia sinensis		1	2		2	1		1	3		2	2		1	2		1	5		3	2			2		1	3
Cerataulina compacta																											
C. bergonii																											
Chaetoceros spp.		1	3	2		3	2	2	2	1	2	3	2		1		1	2		1	2	1	2	2		2	1
C. affinis					3				2						1							2	1			11	
C. atlanticus			1					1																			
C. brevis			1	5	2	2																					
C. coarctatum	1			2		3	2	2	2		2	2	3	1	2				1	1		2	3	2	2		1
C. constrictus			1														1						2	1			
C. (convolutus)			1																								
C. (danicum)																											
C. denticulatum	1		1				1	1	1			2											1	1			2
C. densum																					2						2
C. (dichaeta)																					2						
C. didymum				3	5	5	1	1	2	1		1	1	1	1	1	3				1	3	2		1	2	
C. distan			1			2		1	1			2					1		2	1	2		2				
C. diversus																											

Station No.	79			106			110			112			142			144		
Depth (m)	65			66			69			67			66			71		
Species / Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Asterolampra marylandica						1						1	1	2				
Asteromphalus sp.					2								1					1
Bacteriastrum spp.	1	3	3	5	5	5	4	4		2	1	2	3	5	3	1	2	1
Biddulphia sinensis	1	3	3	2	1			2	2	1	2	2		1	2	1	1	2
Cerataulina compacta																		
C. bergonii																		
Chaetoceros spp.	1	2	2	5		5	2	3		1	2	2	3	3	1	2		2
C. affinis																		
C. atlanticus																		
C. brevis																1		
C. coarctatum		1	1		1	1			1				1	1	2		1	1
C. constrictus		1	1				1	1								1		
C. (convolutus)																		
C. (danicum)																		
C. denticulatum			2										3	4	2			
C. densum		1						2								1	1	1
C. (dichaeta)																		
C. didymum				2	5	5	1	1					3	4	2	1	1	
C. distan							1	1	1		1	1		2	1			
C. diversus																		

Station No.	146			226			228			274			276			325			327			329			376			378		
Depth (m)	74			66			67			74			77			72			75			71			72			69		
Species / Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Asterolampra marylandica			1							1	1			1				1			1		1			1			1	
Asteromphalus sp.																														
Bacteriastrum spp.			2	1	2		1			1	1	1	1	1	1	1	5	5	2	2		2	1	1	4	5	5	4	5	3
Biddulphia sinensis	1				1	1	1	1	2	1	2	2	1	2	2			1	1	2	4					2	3		2	3
Cerataulina compacta																											1			
C. bergonii																														
Chaetoceros spp.	1		1	1	2	2	1		1	1	1	1	1		1		3	2	2	1	1	2		2	2	3	2	1	2	1
C. affinis																	2	1								2	1			
C. atlanticus																											1			
C. brevis																														
C. coarctatum	1		2		1	1	1	1	2		2	2		1		1	2	2	1	2	2	1	2	1	1	3	1	1	1	1
C. constrictus																1	4	1							2	1	1		2	
C. (convolutus)												1																		
C. (danicum)																	1													
C. denticulatum															1			1						1						
C. densum	1		1	1	1					1			1	1	2								1		1	1	1	1		
C. (dichaeta)																														
C. didymum							1					1				1	1	2		1			1			2	2			
C. distan			1									1				1										1	1			
C. diversus																														

Table 1. (Continued)

Station No. / Species (Level)	180	221 (S B)	223 (S B)	321 (S B)	372 (S B)	374 (S B)	75 (S M B)	77 (S M B)	81 (S M B)	106 (S M B)	140 (S M B)	182 (S M B)	184 (S M B)	271 (S M B)	272 (S M B)	323 (S M B)	380 (S M B)
C. levis	5																
C. lorenzianus	9	2 2		5 7	1		1	1 1		3	2	2	1	1 2	1 1	1 2	
C. (messanense)		1		3			1	1 2		1 1	1	1				1	1
C. paradoxum	5	2 2					1 2 1	3 3 1		3 3 2	1 1		1	1 1 3		1	
C. peruvianum	7	2		3 5	1	1	2 3 4	3 1 2	2	3 2 2	1	1			1 1	2 2	2
C. pseudocurvisetum	9	4	1 5	4 6			1 3 5	1 2		2 2	1	4	1		2		
C. (vanheurckii)				5													
Climacodium frauenfeldianum																	
Coscinodiscus spp.	4	1 3	1 5	4 3	1		1 2 2	2 2 3	1		2 1 5	4	1	1 6		1	1
C. (asteromphalus)		1	4	1				1		1	1 3			4	1	3	
C. (centralis)	5		1	2			1 2	1				1			1		
C. (excentricus)											2						
C. gigas		1 1		2	1					1			1			1	
C. (jonesianus)		1	6	1	1		1 2	2	1		1 4				1 3	4	
C. (perforatus)					1.2		1	1	2		1	2					
Dactyliosolen antarcticus													1 1			3 5	
Ditylum sol	5			3			1 5				2		4	2		1	2
Eucampia cornuta															1		1
Gossleriella tropica			1 3				1		1	1	2 5	4	1	2		2	
Guinardia flaccida	5			4													

Station No. / Species (Level)	79 (S M B)	108 (S M B)	110 (S M B)	112 (S M B)	142 (S M B)	144 (S M B)	146 (S M B)	226 (S M B)	228 (S M B)	274 (S M B)	276 (S M B)	325 (S M B)	327 (S M B)	329 (S M B)	376 (S M B)	378 (S M B)
C. levis																
C. lorenzianus			1		1	1		1 1		1	1 1	2 5 3	1	1	1 1 4	1
C. (messanense)		2 2					1									
C. paradoxum		1 2			1 1		1 1					3 3			1	
C. peruvianum		2 2	2 2		1 1 2	1			1	1	3	1 2 2	1	1	1 1	1
C. pseudocurvisetum	2							1	1			1 1			5	2
C. (vanheurckii)																
Climacodium frauenfeldianum	4															
Coscinodiscus spp.	1	1	1 1		2			1		1 1	5·2				1 1 1	2
C. (asteromphalus)																
C. (centralis)													1			
C. (excentricus)																1
C. gigas												1 2 1				
C. (jonesianus)	3		1					2		1 2		1			2	3
C. (perforatus)	2			1	1	2		2	1 2							
Dactyliosolen antarcticus							4	2			2	5 5			3	3
Ditylum sol	1							1							1 5	1 2
Eucampia cornuta					2	1					1					
Gossleriella tropica	5			2				2							1	
Guinardia flaccida																2

Table 1. (Continued)

Station No.	180	221		223		321		372		374	
Species / Level		S	B	S	B	S	B	S	B	S	B
R. setigera											
R. stolterfothii							3				
R. styliformis	4	3	3	2		3	5	2	2	2	1
Schrodella delicatula											
Stephanopyxis palmeriana	4										
S. turris					3						
Thalassionema nitzschioides *				2					3		
Thalassiothrix frauenfeldii *		4	7	2	4	7	9	3	7	5	2
T. longissima	6	1	3	1	3	8	5	2	2	1	1
Thalassiosira spp.	7			1	5	3		2	3	1	
T. (bigensis)						1					
T. lineata											
T. (subtilis)			1	5	*		5				
Triceratium favus									1		
Trichodesmium thiebauti	7	4	2	5	6	6	7	5	5	5	4
T. (hildebrantii)				2	3		3	1	1		1
Amphisolenia bidentata		1			3						1
Ceratium sp.											
C. breve											
C. carriense											

Station No.	75			77			81			106			140		
Species / Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
R. setigera															
R. stolterfothii															
R. styliformis	5	5	5	5	5	6	1			5	5	3	2	3	2
Schrodella delicatula			1												
Stephanopyxis palmeriana															
S. turris															
Thalassionema nitzschioides *									2						
Thalassiothrix frauenfeldii *	6	5	5	3	3	4			3	5	6	5		3	7
T. longissima	4	3	3	2	2	3		1	1	3	3	2			2
Thalassiosira spp.					2				1			1			
T. (bigensis)															
T. lineata															
T. (subtilis)		5	6	4		2			6			4		2	8
Triceratium favus															
Trichodesmium thiebauti	6	6	6	5	5	5	3	5	9	6	5	5	7	6	5
T. (hildebrantii)							2	1	1						
Amphisolenia bidentata	1	1				1				2	1	1		1	
Ceratium sp.															
C. breve															
C. carriense															

Station No.	182			184			271			272			323		
Species / Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
R. setigera			1												
R. stolterfothii															
R. styliformis		1		3	1	1	3	2	2				3	1	2
Schrodella delicatula															
Stephanopyxis palmeriana			1												1
S. turris															
Thalassionema nitzschioides *		1	5					2		2	5	4		3	5
Thalassiothrix frauenfeldii *		2	6	1	1	3	3	5	6	2	1	6	2	4	6
T. longissima	1	1	1	1		1		3	3	1	1	1	1	1	
Thalassiosira spp.	3	1	3					2	3		5	2		2	
T. (bigensis)						1		1							5
T. lineata								1	5		2			1	7
T. (subtilis)		6	8			5			*		5	5		1	8
Triceratium favus															
Trichodesmium thiebauti	6	7	4	7	7	5	5	6	6	5	4	4	5	5	5
T. (hildebrantii)		1		1	1	1	2	1		2	1	1		2	
Amphisolenia bidentata	1	2	1		2			1		1				1	
Ceratium sp.							1				1				
C. breve															
C. carriense															

Station No.	380			79			108			110			112		
Species / Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
R. setigera			1												
R. stolterfothii															
R. styliformis	2	3	1				3	5	4		1		2		
Schrodella delicatula															
Stephanopyxis palmeriana															
S. turris															
Thalassionema nitzschioides *			3			1									
Thalassiothrix frauenfeldii *		1	8			6	5	5	6		2	1	1	1	4
T. longissima			3				2	1	1	1	2	1	1	1	1
Thalassiosira spp.	1	1	1					1	1	1	1	1			2
T. (bigensis)				1		1									
T. lineata															
T. (subtilis)					5	7									
Triceratium favus						1									
Trichodesmium thiebauti	4	5	3				3	5	5	5	6	6	5	6	7
T. (hildebrantii)	2	2	1	6	8	7				2	2	2	1	2	
Amphisolenia bidentata					1		1				1				
Ceratium sp.								1	1						
C. breve															
C. carriense											1				

Station No.	142			144			146			226			228			274		
Species / Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
R. setigera																		
R. stolterfothii																		
R. styliformis	4	3	1	1		1	1				1					2	1	1
Schrodella delicatula																		
Stephanopyxis palmeriana																		
S. turris																		
Thalassionema nitzschioides *										2		3						5
Thalassiothrix frauenfeldii *	3	3	5	1		3	1	2	5	3	2	4	3	1	4	3	3	5
T. longissima	2	2	1	1	1				3	1	2	1		1	3	2		1
Thalassiosira spp.		1	1	1		2				1		3						
T. (bigensis)													1		1			
T. lineata						1						1						
T. (subtilis)		2	2							1		5		2	3			3
Triceratium favus																		
Trichodesmium thiebauti	3	4	5	5	5	5	5	1	7	5	6	2	6	4	5	5	8	5
T. (hildebrantii)				2	2	1	2		1	1	4	1	3	1		2	2	1
Amphisolenia bidentata	1	1		1				1									1	1
Ceratium sp.											1	1						
C. breve																		
C. carriense		1																

Station No.	276			325			327			329			376			378		
Species / Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
R. setigera																		
R. stolterfothii				1														
R. styliformis	1			2	3	2	2	1		3	1		3	3		3	3	1
Schrodella delicatula																		
Stephanopyxis palmeriana					1													
S. turris																		
Thalassionema nitzschioides *																3	2	5
Thalassiothrix frauenfeldii *	2	3	2	5	5	6	1	2	5	3	3	2	3	2	5	1		3
T. longissima	1	2	1	2	4	3	2	2		1	1	2	1		5		1	1
Thalassiosira spp.	1						1		1	1					1	1	1	2
T. (bigensis)				2	3	2												
T. lineata						1												
T. (subtilis)															3			
Triceratium favus																		
Trichodesmium thiebauti	5	8	4	6	7	5	5	5	2	7	5	4	8	6	3	5	4	2
T. (hildebrantii)	1	4	1				3	2	1	3	1		3	3	2	2	2	
Amphisolenia bidentata	1		1		1								1					1
Ceratium sp.			1			1					1							1
C. breve																	2	
C. carriense		1																

Table 1. (Continued)

Station No.	180	221		223		321		372		374		75			77			81			106			140		
Species \ Level		S	B	S	B	S	B	S	B	S	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gyrosigma sp.					3							2	1	2	2	1	2	1				3	1	1	3	
Bemiaulus indicus						1										1					5			2		
B. sinensis	8								1						1											
B. hauckii																										
Bemidiscus hardmanianus		1							2								1									
Mastogloia rostrata				1				2		1	1	3	2	2	5	5	5				3	5	3	4	2	
Navicula spp.	1		4	2	3	3	5	1	1		3	3	4	2	5	4	4	1	1		4	5	5	3	4	
Nitzschia spp.	9		3	3		1	5					3	3	5	4	5		2	1	1	3	5	5	4	5	4
N. closterium	4		1				4													2						
N. longissima	5					1	4																			
N. paradoxa			5			6	7		3																	5
Planktoniella sol.																				5						1
Pleurosigma sp.	6		1			2	4	2																		
Rhizosolenia alata	8		1	1		4	5	1	3	1		2		2		2	2	1		1	3	1		2	2	1
R. acuminata	1						4		1																	
R. bergonii	5		1	5			3	2	5					1												1
R. calcar avis	7	1	3	3	4	4	5			4	3	5	5	5	5	5	5	1	1		5	6	5	4	5	2
R. cylindrus																										
R. imbricata	9		2	6		3	5		2					2												
R. robusta																										

Station No.	182			184			271			272			323			380			79			108			110			112		
Species \ Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gyrosigma sp.				1		1								1			2	1	2						1	1	1			
Bemiaulus indicus																									1					
B. sinensis																														
B. hauckii							2																							
Bemidiscus hardmanianus												1																		
Mastogloia rostrata				3	3	2	2	1	2	1			1	1	2	3	3	3	2	1				1	2	4	1	1		
Navicula spp.	5	2	1				4	3	2				2	5	2	5	3	1	2	2	1	6	5	1	2	3	1	3	2	
Nitzschia spp.	3	1		3	1	2				2		2	3	1	3	3	2	2	3	3			2	2	4	5	3	1	1	2
N. closterium		1	1		3												1					1								
N. longissima						1																								
N. paradoxa		3	5			3									3															
Planktoniella sol.			2			2			2		1	2			4															4
Pleurosigma sp.												3																		
Rhizosolenia alata	1	1		1	1		1	1		1		1		1	2			1	1			1		1	1	1		1		1
R. acuminata			1									1																		
R. bergonii																														
R. calcar avis	2	1	1	4	3	2	4	2	2	1	2	1	5	5	3	3	3	2	3	2	1	5	5	3	2	2	2	1	2	1
R. cylindrus												1			3							1								
R. imbricata				2					2															1						
R. robusta																		2												

Station No.	142			144			146			226			228			274			276			325			327			329			376			378		
Species \ Level	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Gyrosigma sp.	1	2	1		1	1					1		1			1			2		1													2	1	
Bemiaulus indicus																							2								1		1			
B. sinensis			1		1		2		1																			1					1			
B. hauckii		1		1	1																															
Bemidiscus hardmanianus											1																									
Mastogloia rostrata	2	4	2	2	2	2	1				1		1	1		2		1	1		1			1	1						2	2			4	3
Navicula spp.	3	5	5	2	2	1	1	1	2	1	1				1	1	1	1	2	2	1		1		3	2	1			2	3	3			5	4
Nitzschia spp.	2	4	5	2	3	2	1		4			2	1	1		2		3	2	1				1	2	2	1	1	1		2	3		2	4	1
N. closterium																											1						1			
N. longissima											3	2				1																				
N. paradoxa																		2			1															
Planktoniella sol.			1									3														1	3						2			1
Pleurosigma sp.															1			1		1																
Rhizosolenia alata	1	1		2	1	1	1			1	1		1	1		1		1	1	1		1	3		1		1	5	3	2	2		1	1		
R. acuminata																							1										1			
R. bergonii																		1				1	2	1												
R. calcar avis	4	5	2	5	2	2	1			2	4	1	3	1	1	3	3	2	3	3	2				2	2	1				4	3	2	4	4	1
R. cylindrus														1																						
R. imbricata												1						1			1		1				1		2	1					1	2
R. robusta																		1																		

Table 1. (Continued)

Station No. / Species (Level)	180	221 S	221 B	223 S	223 B	321 S	321 B	372 S	372 B	374 S	374 B	75 S	75 M	75 B	77 S	77 M	77 B	81 S	81 M	81 B
C. contortum													1	1						
C. dens		2				2		1	1		2		1	2			2	1		
C. extensum			1	1				1			1		1	1	1	1	2	1		
C. furca		1																		
C. fusus	5	1		1		1														
C. inflatum								1							1		2			
C. gibberum																2				
C. karsteni																			1	
C. (macroceros)								1							1					
C. (massiliense)	4	1	1					1	2	2	1		1					1	1	1
C. ranipes																				1
C. trichoceros	5	2	4	1		4	4	3	3	2	2	2	2	3	2	3	5	1	2	3
C. tripos	5													2			1		1	3
C. vulture																				
Dinophysis miles																				
Gymnodinium sp.																				
Peridinium depressum	4	1				1							1	1			1	1	1	1
Pyrocystis fusiformis																	1			
P. pseudonoctiluca									1			1	1						1	2
Pyrophacus horologicum	4			1								1								
TOTAL	582,397	5,416	26,021	6,397	213,774	47,664	153,995	4,709	15,680	4,796	2,571	21,597	17,864	27,821	15,058	18,565	25,327	1,193	2,653	31,192

Station No. / Species (Level)	106 S	106 M	106 B	140 S	140 M	140 B	182 S	182 M	182 B	184 S	184 M	184 B	271 S	271 M	271 B	272 S	272 M	272 B	323 S	323 M	323 B	380 S	380 M	380 B
C. contortum							1	1																
C. dens	2	3	2	1	2	3		1	1	2				1	3	2	1	1	1	1			2	1
C. extensum		2	1	1							1					1								
C. furca																						1		
C. fusus																								
C. inflatum				1																				
C. gibberum						1		1											1			1	1	
C. karsteni																								
C. (macroceros)		2	2																					1
C. (massiliense)	2			2	1		1	1		1									2	1	2			
C. ranipes																								
C. trichoceros	4	3	3	2	3	1	1	2	1	1	2		2	3	2		1		2	4	2	2	2	1
C. tripos			1																				1	1
C. vulture					3																			
Dinophysis miles														1										
Gymnodinium sp.										1														
Peridinium depressum				1	1			1	1			1			4									
Pyrocystis fusiformis		1																						1
P. pseudonoctiluca		1	1			1	1	1	2						2									1
Pyrophacus horologicum				1	1									1										
TOTAL	25,674	28,970	14,945	11,282	14,482	33,421	8,795	15,908	29,193	11,776	10,040	5,017	5,686	10,348	95,670	3,531	5,325	11,861	6,218	11,815	34,561	4,662	7,326	15,150

Station No. / Species (Level)	79 S	79 M	79 B	108 S	108 M	108 B	110 S	110 M	110 B	112 S	112 M	112 B	142 S	142 M	142 B	144 S	144 M	144 B	146 S	146 M	146 B
C. contortum													1								
C. dens	3	2	1	1			2	2	1	2		1		1		3	2	1	2		1
C. extensum	1					1	1			1			2	2		1	1				
C. furca																1					
C. fusus	1						1												1		1
C. inflatum																					
C. gibberum						1								1		1					1
C. karsteni						1	1	1	1	1									1		
C. (macroceros)	1										1			1	2						
C. (massiliense)	1	3		1	1	1		2	1		1		1			1	1				1
C. ranipes									1												
C. trichoceros	2	4	2	3	2	1	1	4	2	1	2	2	4	4	3	2	2	2	1		4
C. tripos		1	2					1	2			2	1			1			1		2
C. vulture										1											
Dinophysis miles															1						
Gymnodinium sp.								1													
Peridinium depressum		1	2		1		1	1	1		1	1			1		1	1	1		
Pyrocystis fusiformis					1			1													1
P. pseudonoctiluca	1	2	1					2	1		2	1				1	1	2	1		2
Pyrophacus horologicum							1	1						1							1
TOTAL	9,768	17,236	26,529	11,767	17,020	12,615	5,042	11,322	6,457	2,730	5,240	11,191	5,728	11,369	8,792	7,050	3,106	5,323	3,640	155	12,707

Station No. / Species (Level)	226 S	226 M	226 B	228 S	228 M	228 B	274 S	274 M	274 B	276 S	276 M	276 B	325 S	325 M	325 B	327 S	327 M	327 B	329 S	329 M	329 B	376 S	376 M	376 B	378 S	378 M	378 B
C. contortum																						1					
C. dens	2	1		2	1	1	2		1	1		1	1	2	1		1	1	2			2	1			1	1
C. extensum		1		1		1	1			1				1											1		
C. furca									1																		
C. fusus							1								1							1		1			
C. inflatum																											
C. gibberum																1						1			1		
C. karsteni								1			1																
C. (macroceros)			1			1										1		1									
C. (massiliense)		1		1			1		1		21			2	1				1				2				1
C. ranipes							1																				
C. trichoceros	3	1	1	1	1	1	1	3	1	1	2	1	2	4	3	2	4		1	2	1	2	3		2	3	2
C. tripos	1	1		1	1				1		1	1			2			1							1		
C. vulture																											
Dinophysis miles			1																								
Gymnodinium sp.																1											
Peridinium depressum			1					1	2						1	1		1		1		1				1	1
Pyrocystis fusiformis																										1	2
P. pseudonoctiluca			1					1	2		1	1	1	1	1			1						1	1	1	2
Pyrophacus horologicum			1				1	1	1				1	1		1						1					
TOTAL	4,218	7,775	6,706	7,771	868	4,930	5,195	13,706	7,972	3,128	19,095	2,566	7,951	31,855	12,969	4,883	3,731	479	11,329	4,066	2,173	16,830	11,329	10,838	7,103	8,170	6,569

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EXPERIMENTS WITH BOTTOM VERTICAL LONGLINE IN THE CENTRAL GULF OF THAILAND

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INTRODUCTION

The Gulf of Thailand is located approximately between the latitude 6°N and 13°N and the longitude 99°E and 104°E. It is the largest fishing ground in Thailand, and can be divided into two parts; and coastal waters less than 50 meters deep, and the central Gulf where the depth ranges from 50 to 85 meters. The coastal waters have been well exploited, particularly by trawl fishery. The central Gulf, on the other hand, has remained relatively untouched. One reason for this is that the uneven bottom with its rolling mounds of mud (Phasuk, 1978) makes it unsuitable for trawling. Secondly, very little is known about the resources available in waters of more than 50 meters depth.

The Department of Fisheries of Thailand and the Training Department of SEAFDEC have been conducting a joint research project, with the view of gathering oceanographic data and developing the hitherto unutilized fishing grounds in the central Gulf of Thailand. The present report concerns a reasources survey and an experiment with the bottom vertical longline carried out on board the research vessel M.V. Paknam. The location of the experimental fishing grounds is shown in Figure 1.

Six experimental operations were carried out, from 26 to 29 May 1984. In the first five operations squid was used as bait. The sixth operation was an experiment with artificial bait, and the number of hooks was doubled.

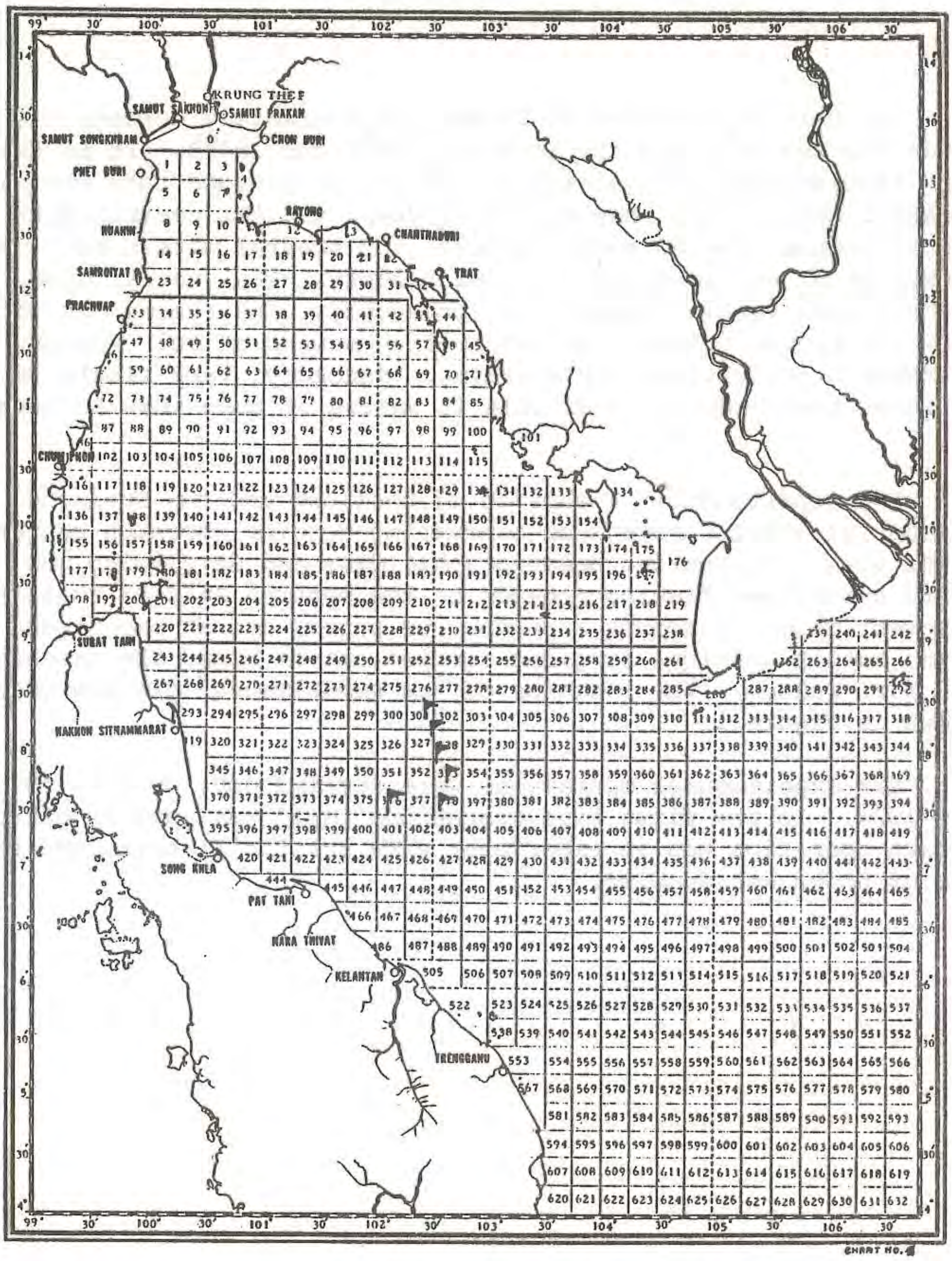


Fig. 1 Fishing grounds where experimental operations were carried out (mark ▶): The system of numbered squares has been used by the Department of Fisheries.

MATERIALS AND METHODS

The gear

The bottom vertical longline, which was used in our experiments, has a considerably more complex structure than other kinds of bottom longline. The main line of this gear does not touch the bottom but is suspended at some distance above it, depending on the length of the branch lines. The hooks are thus between the main line and the bottom so that the fish dwelling near or at the bottom are caught.

A schematic diagram of the bottom vertical longline is shown in Fig. 2, and its specifications are given in Table 1.

The main line of the gear was made of vinylon because this material has a high specific gravity that allows the gear to sink rapidly. In this way, the effect of current on the gear is reduced. One unit, or basket of the main line comprised six lengths of 50 meters each, with loop joints. Branch lines and floots were connected to the loops of the main line.

Branch lines were also made of vinylon but two-strand twine was used because it is soft and easy to coil for storage in boxes.

Eight hook lines, each one 80 cm in length, were connected with one branch line at intervals of 1.5m. Nylon monofilament No.26 (Ø 0.84 mm) or No.30 (Ø 0.90 mm) was used for the hook lines.

Since the gear used in the present experiment was constructed at the Training Department and there were not enough hooks of the same shape and size at that time,three different kinds of hooks were used: *Mutsu-bari* No.20 and No.26 and *Tainawa-bari* No.20.

The branch lines were stored in specially designed boxes, made of wood and porous plastic plate with rubberized edge on the top (see Fig. 3). Three branch lines were stored in one box, separated by sheets of paper. Hooks were fixed on the foam inside the box. Before the fishing experiment, the hooks were baited and hung out of the box through the slits in the rubberized edge.

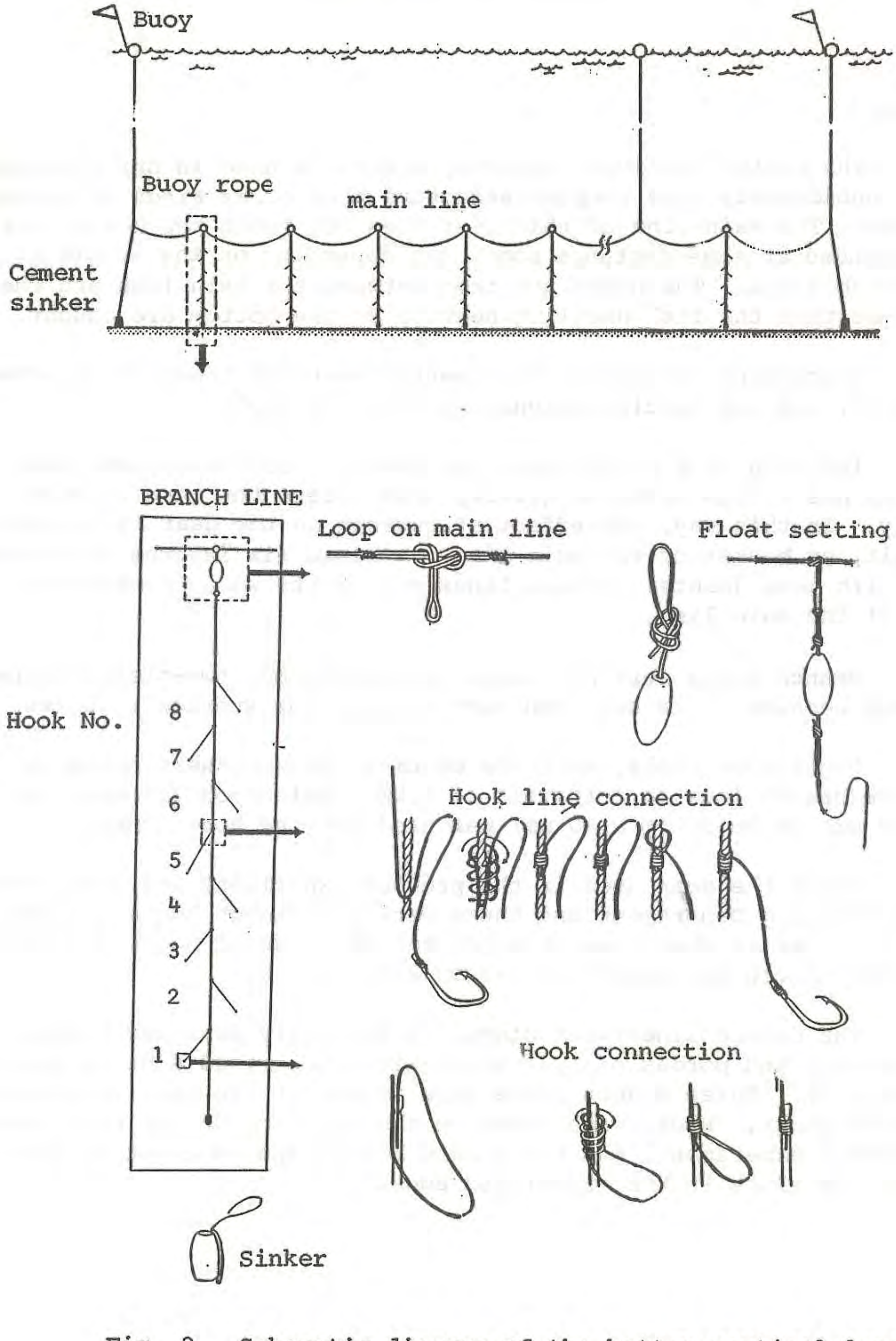


Fig. 2. Schematic diagram of the bottom vertical longline

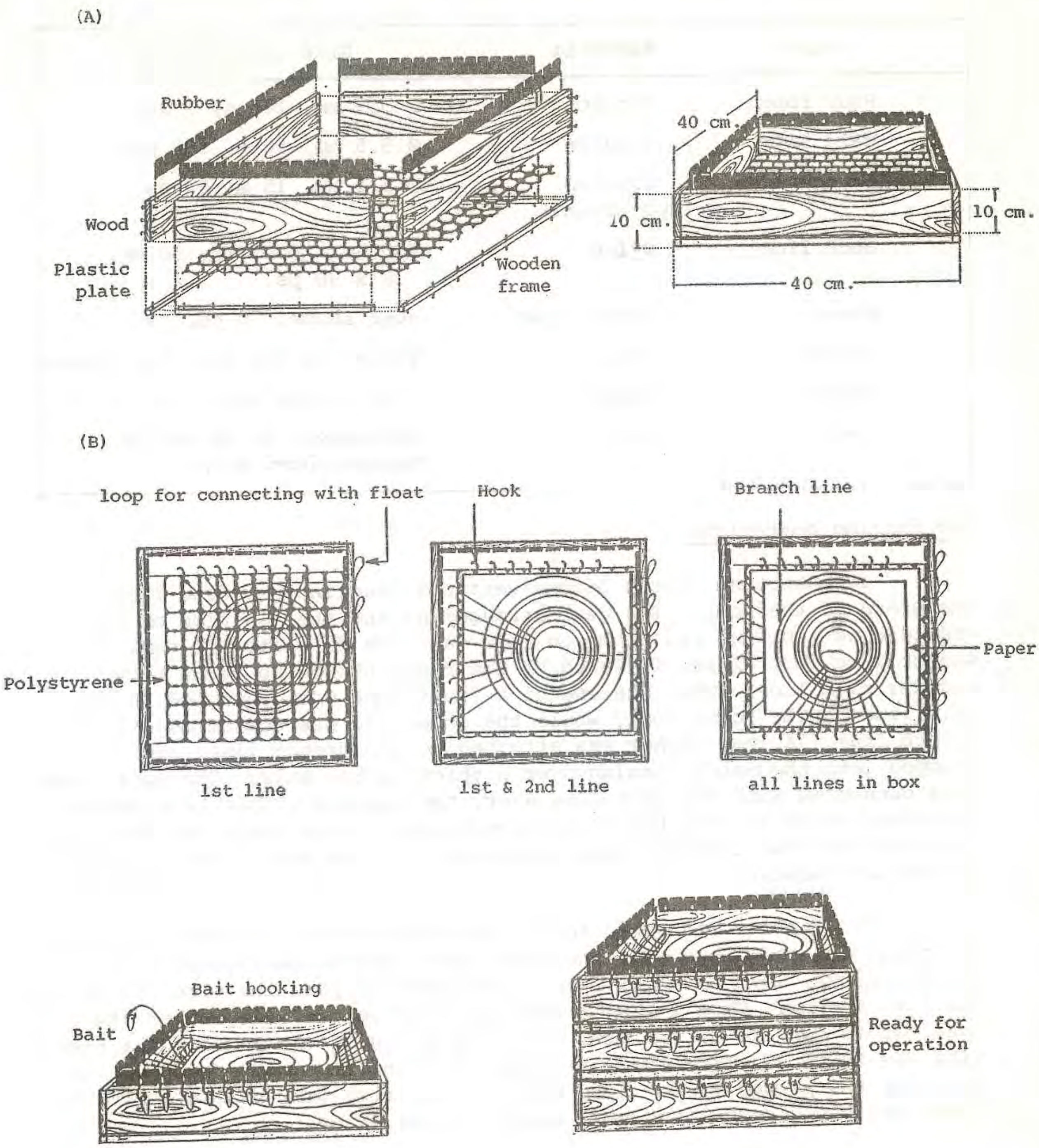


Fig. 3 (A) Box for storing of branch lines

(B) Arrangement of lines in the box

Table 1. Specifications of the bottom vertical longline

Name	Material	Size and quantity
Buoy rope	Vinylon	Ø 5.5 mm, 100 m, 9 ps.
Main line	Vinylon	Ø 5.5 mm, 50 m, 108 ps.
Branch line	Vinylon (two-strand)	Ø 3.0 mm, 15 m, 90 ps.
Hook line	Nylon	Ø 0.84 - 0.90 mm, 80 cm, 8 x 90 ps.
Float	Foam rubber	oval shape, 90 ps.
Sinker	Lead	700 g in the air, 8 x 90 ps.
Sinker	Cement	3 kg in the air, 4 ps.
Hook	Iron	*Mutsu-bari* No.20 and 26 *Tainawa-bari* No.20

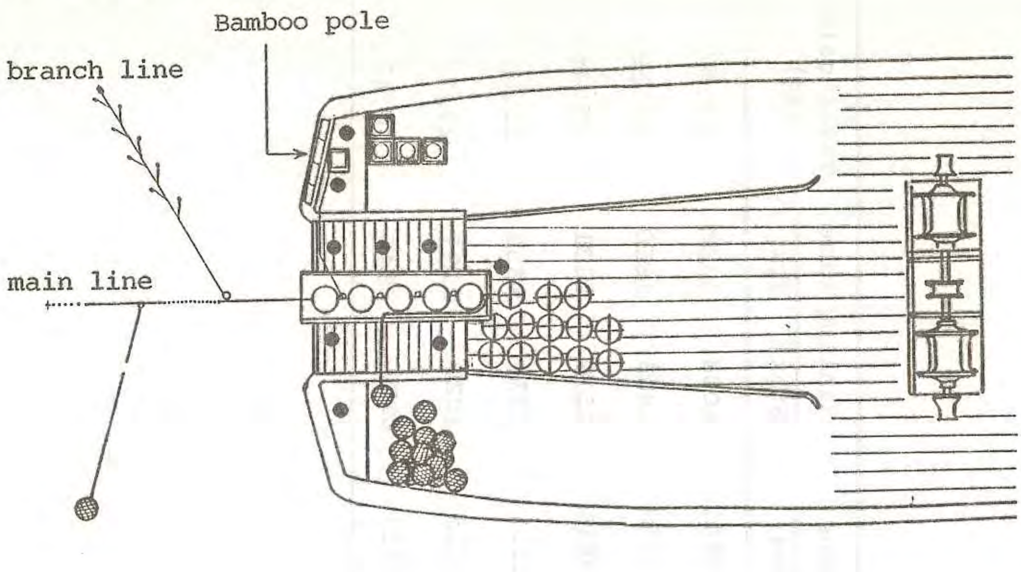
The fishing operations

1) Shooting of the bottom vertical longline was done from the stern of the boat. The gear arrangement and the position of the crew during shooting are shown in Fig. 4a. The flag and the cement sinker were shot first, followed by the radio buoy, the light buoy and the main line. Then one end of a float rope was connected to the main line at the joint loop, while the other end was connected with a branch line. A lead sinker was attached to the branch line, and dropped into the water passing over a thick bamboo pole. The buoy ropes were connected with the main line every two baskets. This process was continued until all the branch lines were used, then the light buoy, the flag and the cement sinker were connected with the main line at the end of the last basket.

2) Hauling was conducted at the fore-deck of the boat (Fig. 4b). The flag, the radio buoy and the light buoy were hauled through the gangway first, then the main line was brought to pass the side roller and the line hauler. When a branch line appeared on the side roller the crew had to stop it at the side roller by pressing the break. The branch line was taken off from the main line, then the float was removed, and the line was passed to the line keeper. The fish were removed from the hooks and the branch lines were stored in the boxes.

The data concerning the times and locations of all six fishing operations, as well as the amounts of catch, are given in Table 2. The catch of each hook was also recorded. Individual fish were weighed and measured for total length, and samples were brought back to the SEAFDEC Training Department for identification.

(a) Shooting



(b) Hauling

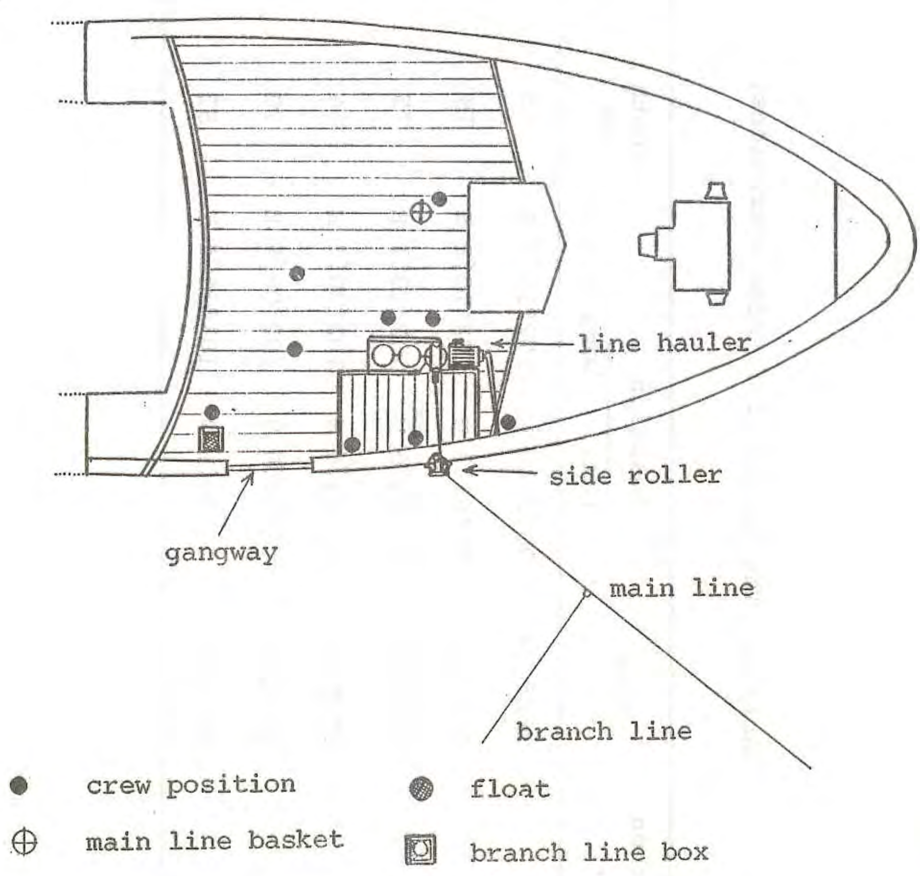


Fig. 4. Shooting and hauling of the bottom vertical longline.

Table 2. The record of fishing operations.

Operation No.	Date	Position		Depth (m)	Shooting time		Hauling time		Total catch (kg)
		Lat.	Long		Start	End	Start	End	
1	26/5/84	08°25.'0 N	102°19.'5 E	76	0557	0641	1004	1106	43.67
2	26/5/84	08°24.'2 N	102°19.'3 E	79	1622	1655	1803	1850	17.58
3	27/5/84	08°00.'6 N	102°29.'1 E	75	0452	0535	1138	1231	25.45
4	27/5/84	07°42.'6 N	102°30.'3 E	74	1439	1531	1734	1852	33.03
5	28/5/84	07°39.'0 N	102°08.'8 E	70	0721	0815	1027	1137	27.22
6	29/5/84	07°38.'1 N	101°36.'5 E	52	0438	0513	0803	0946	16.47

RESULTS

Species composition

The fish caught by bottom vertical longline belonged to eleven families: Balistidae, Carangidae, Carcharhinidae, Echeneidae, Lutjanidae, Muraenidae, Nemipteridae, Orectolobidae, Rachycentridae, Serranidae and Synodontidae. The following 18 species were identified:

1. *Abalistes stellaris* (Balistidae)
2. *Carangoides talampara* (Carangidae)
3. *Seriolina nigrofasciata* (Carangidae)
4. *Carcharhinus spallazani* (Carcharhinidae)
5. *Echeneis naucrates* (Echeneidae)
6. *Lutjanus malabarbicus* (Lutjanidae)
7. *L. sebae* (Lutjanidae)
8. *L. vitta* (Lutjanidae)
9. *Pristipomoides multidens* (Lutjanidae)
10. *P. typus* (Lutjanidae)
11. *Gymnothorax* sp. (Muraenidae)
12. *Nemipterus nematophorus* (Nemipteridae)
13. *N. tambuloides* (Nemipteridae)
14. *Chiloscyllium griseum* (Orectolobidae)
15. *Rachycentron canadus* (Rachycentridae)
16. *Epinephelus areolatus* (Serranidae)
17. *E. heniochus* (Serranidae)
18. *Saurida elongata* (Synodontidae)

The Lutjanidae were dominant both in weight, 101.6 kg, and in number, 42 individuals of the economical fish caught. Three major species of Lutjanidae, *Lutjanus malabarbicus, Pristipomoides multidens* and *Lutjanus sebae* constituted the greatest part of the catch. (Fig. 5)

The species composition of the catch by hook number appears in Table 3 (hooks were numbered in ascending order on a branch line, No.1 being the nearest to the bottom of the sea).

For the first five operations, Table 4 and Fig. 6 show the weight and the percentage of the catch composition of all families. According to the results of the bottom longlining survey of demersal fish resources in the Gulf of Thailand carried out by the R/V Fishery Research No.1 & 2 in 1968, snappers (Lutjanidae) constituted an important part of the longline catches in the Gulf of Thailand, both in weight and commercial value, usually accounting for 70 to 80 per cent in weight of the total catch. One of the reasons for snappers being considered of high commercial value may be their large size and weight. Figure 7 shows the size composition of *L. malabarbicus* which was in the range from 30 to 70 cm and the mean length ($\bar{X}$) = 55.825 cm.

Table 3. Species composition of the catch of vertical bottom longline

	Species	No. of hook								TOTAL
		1	2	3	4	5	6	7	8	
1.	Starry triggerfish *Abalistes stellaris*	0 (0)	1 (50)	0 (0)	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	2
2.	Trevally *Carangoides tarampara*	0 (0)	1 (33.33)	1 (33.33)	0 (0)	1 (33.33)	0 (0)	0 (0)	0 (0)	3
3.	Black-banded travally *Seriolina nigrofasciata*	8 (32)	1 (4)	3 (12)	5 (20)	3 (12)	0 (0)	1 (4)	4 (16)	25
4.	Black-tip shark *Carcharhinus spallazani*	1 (50)	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	0 (0)	0 (0)	2
5.	Slender suckerfish *Echeneis naucrates*	0 (0)	3 (6.25)	2 (4.17)	9 (18.75)	11 (22.91)	9 (18.75)	6 (12.50)	7 (16.67)	47
6.	Malabar red snapper *Lutjanus malabarbicus*	2 (8.33)	1 (4.17)	3 (12.50)	0 (0)	2 (8.33)	3 (12.50)	2 (8.33)	11 (45.83)	24
7.	Emperor-red snapper *Lutjanus sebae*	1 (50)	0 (0)	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	0 (0)	2
8.	Olive-striped snapper *Lutjanus vitta*	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)	1
9.	Sharp toothed snapper *Pristipomoides multidens*	0 (0)	6 (42.86)	4 (28.57)	1 (7.14)	0 (0)	0 (0)	2 (14.28)	1 (7.14)	14
10.	Sharp toothed snapper *Pristipomoides typus*	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
11.	Moray *Gymnothorax* sp.	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
12.	Doublewhip threadfin bream *Nemipterus nematophorus*	0 0	2 (66.67)	0 (0)	0 (0)	0 (0)	1 (33.33)	0 (0)	0 (0)	3
13.	Five line threadfin bream *Nemipterus tambuloides*	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)	1
14.	Catshark *Chiloscyllium griseum*	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1
15.	Black Kingfish *Rachycentron canadus*	0 (0)	0 (0)	0 (0)	0 (0)	1 (50)	0 (0)	0 (0)	1 (15)	2
16.	Areolated-grouper *Epinephelus areolatus*	3 (33.33)	2 (22.22)	0 (0)	1 (11.11)	0 (0)	1 (11.11)	1 (11.11)	1 (11.11)	9
17.	Banded-cheek grouper *Epinephelus heniochus*	0 (0)	0 (0)	1 (33.33)	0 (0)	1 (33.33)	0 (0)	1 (33.33)	0 (0)	3
18.	Lizard fish *Saurida elongata*	1 (7.69)	6 (46.15)	0 (0)	1 (7.69)	1 (7.69)	4 (30.77)	0 (0)	0 (0)	13
	TOTAL	17 (11.04)	23 (14.94)	16 (10.39)	18 (11.69)	23 (14.94)	19 (12.34)	13 (8.44)	25 (16.23)	154

Table 4. The weight composition by families in catches by bottom vertical longline in operations 1-5.

	FAMILY	Weight (kg)	%
1.	Balistidae	1.24	0.84
2.	Carangidae	10.00	6.80
3.	Carcharhinidae	2.49	1.69
4.	Echeneidae	20.32	13.82
5.	Lutjanidae	101.56	69.09
6.	Muraenidae	0.64	0.44
7.	Nemipteridae	0.60	0.41
8.	Orectolobidae	1.65	1.12
9.	Rachycentridae	2.17	1.48
10.	Serranidae	4.54	3.09
11.	Synodontidae	1.77	1.20
	Total	146.98	100

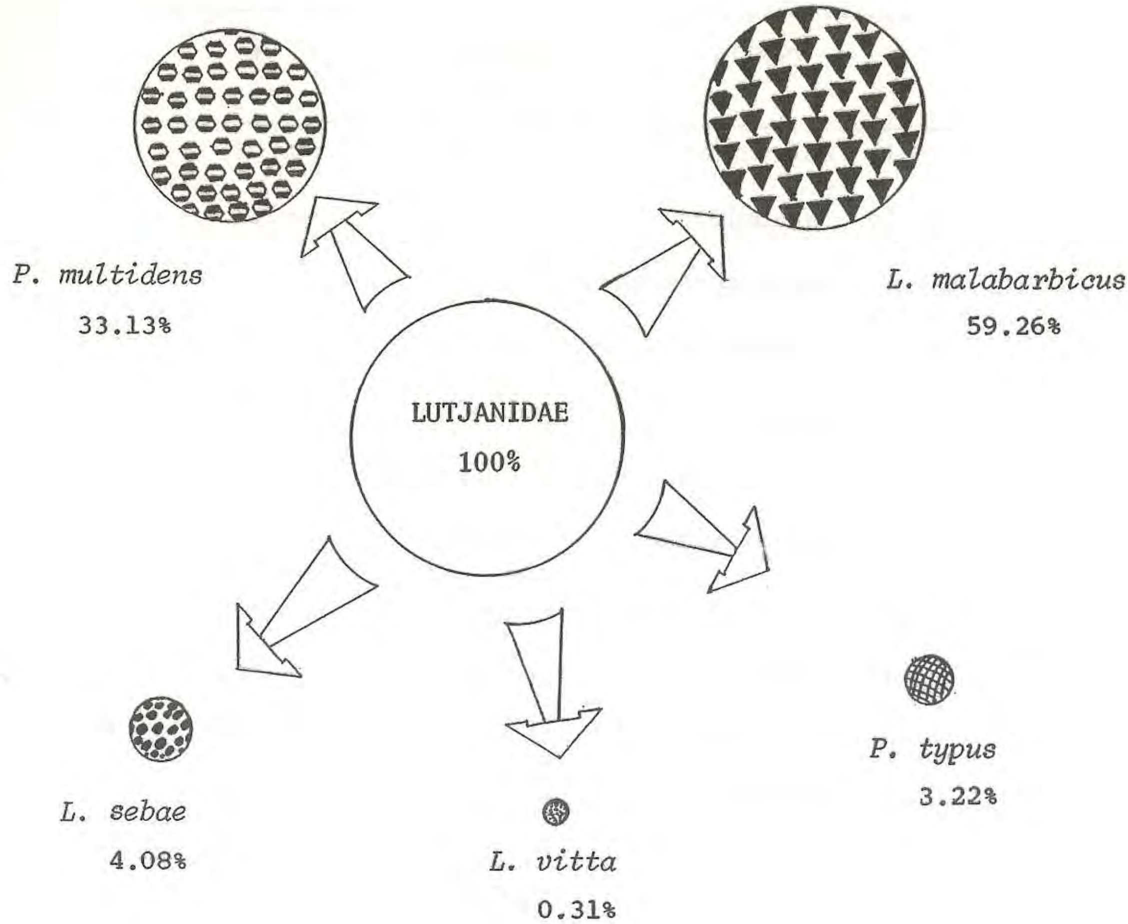


Fig. 5. Weight composition of the fish of family Lutjanidae caught in operations 1-5.

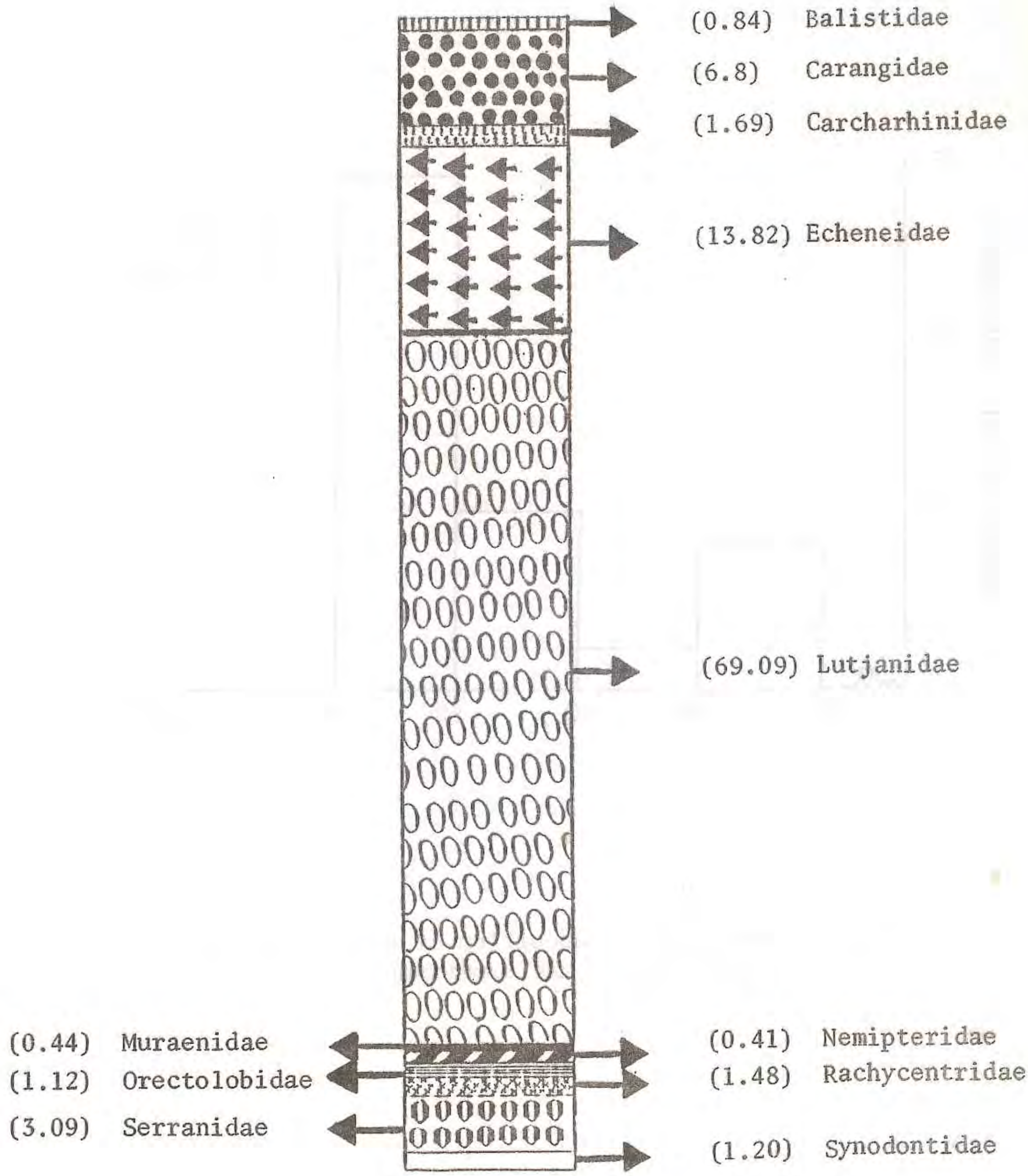


Fig. 6. The catch in operations 1-5, as a percentage of total weight.

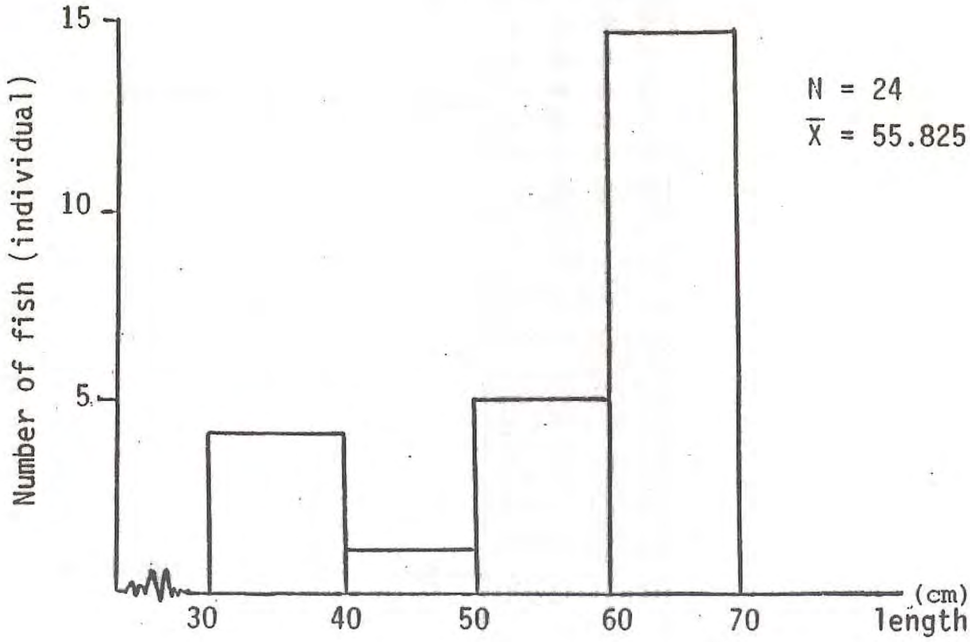


Fig. 7 The length composition of *L. malabarbicus* caught during the experiment.

The first five operations were carried out in the depth zone of 70-79 m, and using squid as bait. The last operation was an experiment with artificial bait in the waters of about 52 meters depth.

Experiment with artificial bait

The sixth experimental fishing operation was conducted on 29 May 1984, in waters with 52 m depth. Instead of the usual squid bait, we used tufts of plastic fibres of various colors, previously soaked in fish sauce. For this operation 180 branch lines were used. After every 33 branch lines with artificial bait there were 3 branch lines with squid bait. The artificial bait attracted only *Echeneis naucrates* whereas the natural bait (squid) resulted in the catch of several other species as shown in Table 5.

Table 5. The catch record of the experiment with artificial bait.

Species composition	Weight (kg)	Number of fish
Natural bait		
- *Echeneis naucrates* (Echeneidae)	10.97	16
- *Rachycentron cănadus* (Rachycentridae)	3.90	1
- *Epinephelus areolatus* (Serranidae)	0.10	1
- *Saurida elongata* (Synodontidae)	?	1 (damaged fish)
Artificial bait (90% of hooks)		
- *Echeneis naucrates* (Echeneidae)	2.06	4

The poor results obtained with the artificial bait may be due to olfactory responses of fish. It is necessary to improve artificial bait, especially for the demersal fish.

The hook rate

The hook rate* obtained from these operations ranged from 2.08-5.41 for the first five operations where natural bait was used, and 1.59 for the last operation where plastic fibres were used as bait. These very low hook rates may be due to the wrong size of the hooks used for the experiment. According to Koike and Takeuchi (1970), the selective catching efficiency of a hook depends on its size and on the maximum breadth of the fish's mouth, which will be the selection factor for catching the fish of a certain size.

The fish caught during the experimental operations were rather big, for example for *L. malabarbicus* and *S. nigrofasciata* the body length ranged from 34.0 to 65.0 cm and from 21.0 to 34.0 cm, respectively. That seems to suggest that the hooks used here can catch only large fish. However, even though the hook rates were rather low, most of the baits were lost. This probably happened because small fish dwelling near the bottom could not swallow the hook, but could nibble at the bait. The interrelationship of all hooks in all operations are shown in Fig. 8 and Table 6. The vertical of the fish caught by each hook in all six experimental operations is shown in Fig. 9.

The best catch was obtained by hook No.8, particularly of *L. malabarbicus* and *E. naucrates*.

In order to find out the interrelationships between catches of different hooks, correlation coefficients were calculated. On the basis of the results, it was shown that similarities exist between catches of hooks 5, 6 and 7 and also between hooks 1, 2 and 3.

The first group (hook No. 5, 6, 7): the fish mostly caught by these hooks belonged to Lutjanidae and Echeneidae, especially *L. malabarbicus* and *Echeneis naucrates*.

The second group (hook No.1, 2, 3): the fish mostly caught by these hooks belonged to Carangidae, Lutjanidae and Serranidae, especially *S. nigrofasciata*, *P. multidens*, *E. areolatus* and *E. heniochus*.

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*Number of fish per 100 hooks.

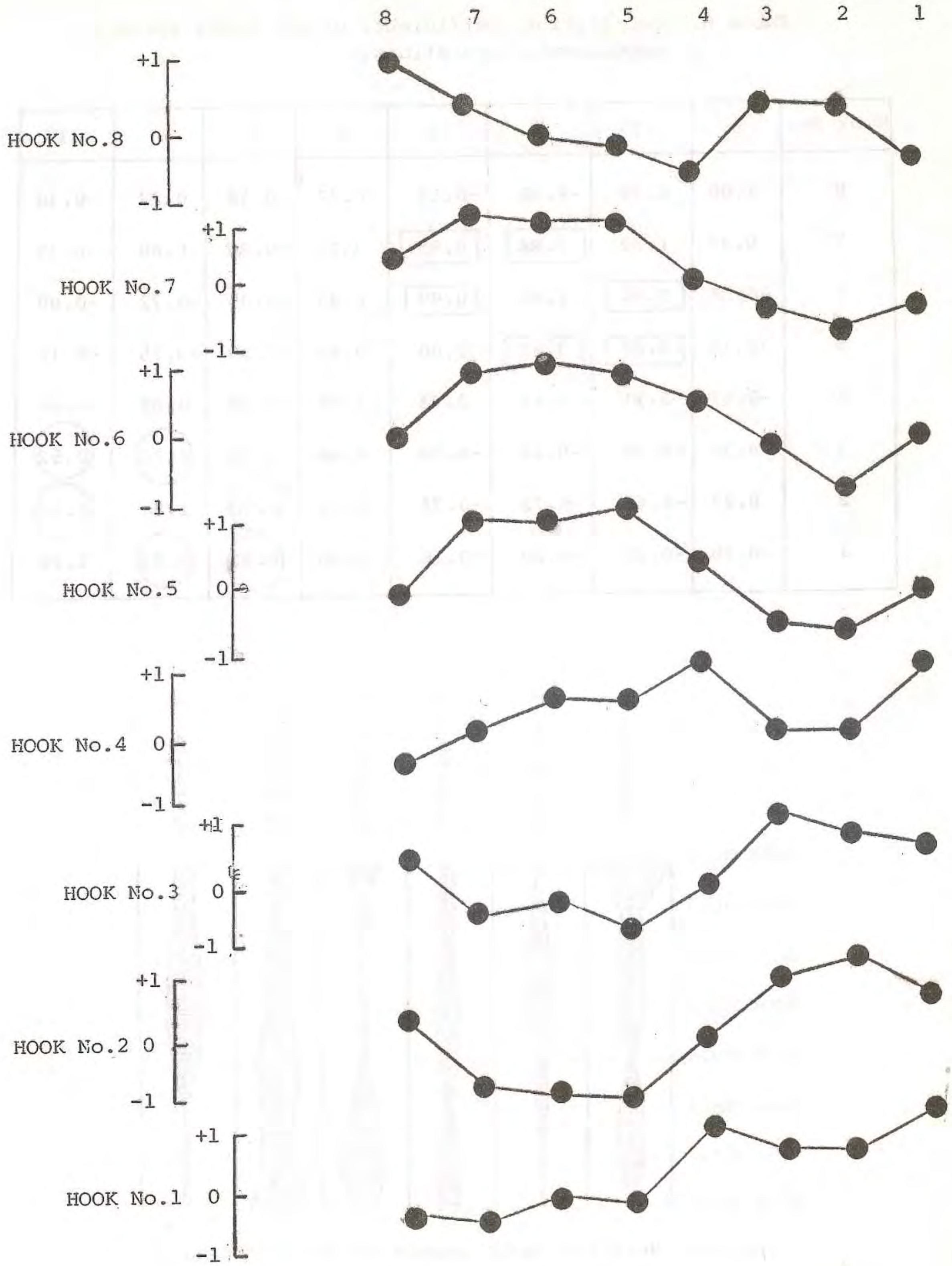

Fig. 8. The correlation coefficients graph shows the interrelationship of all hooks, for all experimental operations.

Table 6. Correlation coefficients of all hooks for all experimental operations.

Hook No.	8	7	6	5	4	3	2	1
8	1.00	0.39	-0.00	-0.13	-0.47	0.38	0.27	-0.38
7	0.39	1.00	0.84	0.85	0.11	-0.36	-0.60	-0.39
6	-0.00	0.84	1.00	0.89	0.43	-0.25	-0.72	-0.09
5	-0.13	0.85	0.89	1.00	0.43	-0.59	-0.75	-0.16
4	-0.47	0.11	0.43	0.43	1.00	0.08	0.02	0.80
3	0.38	-0.36	-0.25	-0.59	0.08	1.00	0.70	0.52
2	0.27	-0.60	-0.72	-0.75	0.02	0.70	1.00	0.53
1	-0.38	-0.39	-0.09	-0.16	0.80	0.52	0.53	1.00

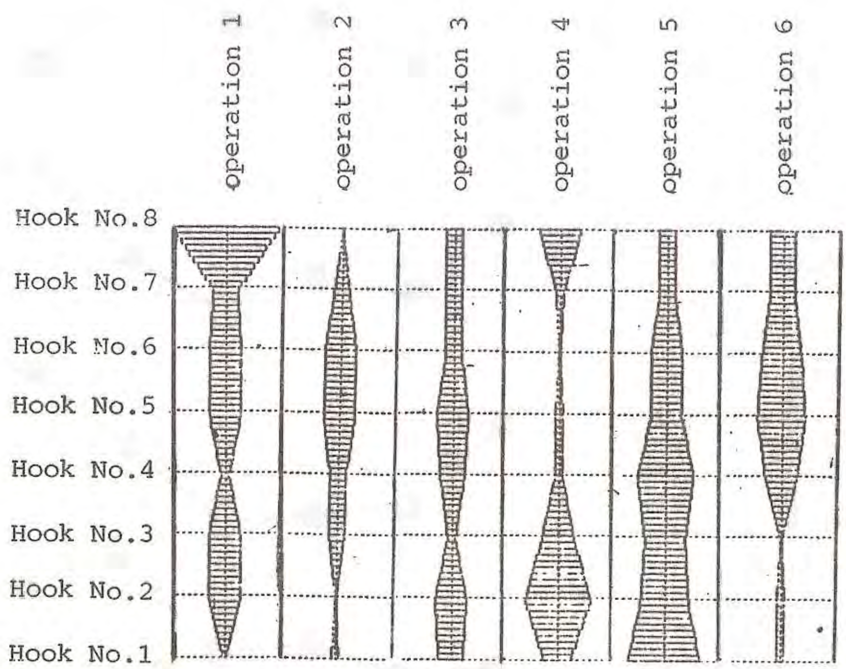

Fig. 9. Vertical catch record of the fish caught for each hook in all six experimental operations.

The vertical distribution of fish

Kanda and Yoshihara (1972) stated that the vertical distribution of fish caught by bottom vertical longline can be summarized by the formula of the normal distribution:

$$P_{(Z)} = \frac{1}{\sigma\sqrt{2\pi}} \cdot e^{-(Z-m)^2/2\sigma^2}$$

$P_{(Z)}$ = Catch ratio at the distance Z

Z = Distance from the sea bottom represented by hook No.

m = Centre of the vertical distribution

The catch rate of each hook was adjusted to the normal distribution of *E. naucrates*. It showed that the vertical centre of distribution of this species was at the distance between hook No.5 and No.6 (Fig. 10). The transformed values of catch into logarithm for each hook showed the regression line and correlation coefficient r = 0.74 (Fig. 11).

It was assumed from the result of adjustment and its correlation coefficient that the centre of distribution might be at the distance between hook No.5 and No.6.

Regarding all those results, it was very difficult to explain the vertical distribution of each species by adjusting the catch rate to the normal distribution. The difficulty was due to insufficient number of fish caught by each hook and the position of each hook affected by uneven topography. Hence, the fish caught during the experiment could give only a rough estimate of the distribution of fishes.

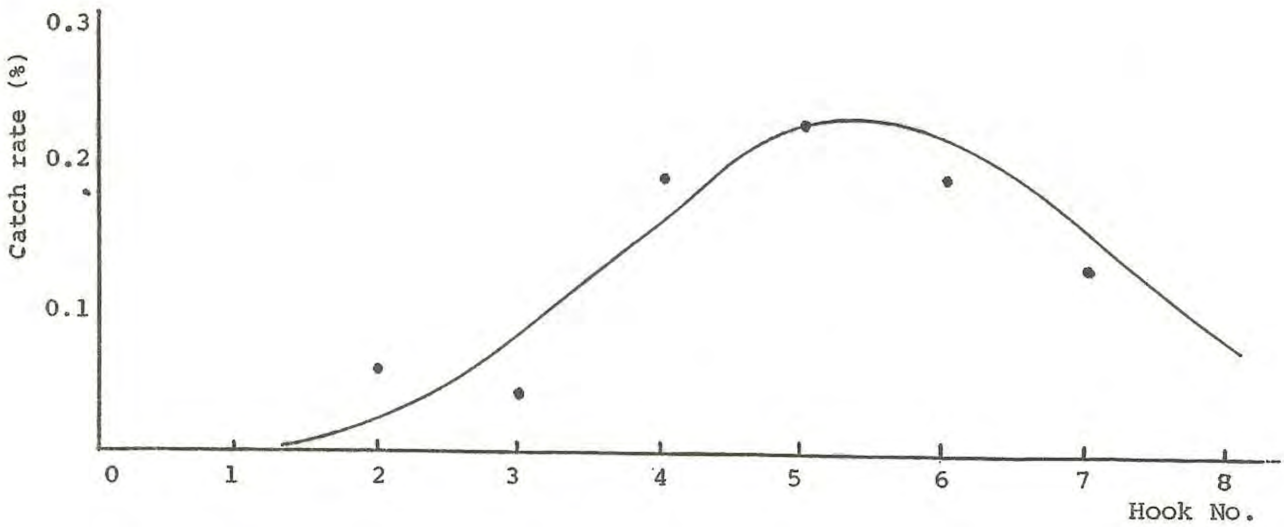

Fig. 10. Ratio of catch for each hook comparing with adapted normal distribution pattern, for *E. naucrates*.

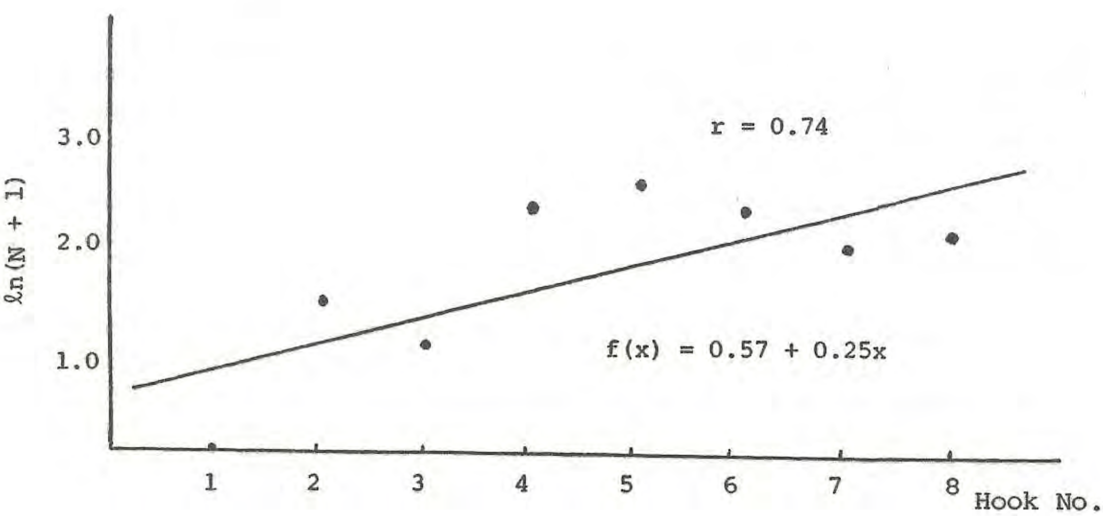

Fig. 11. Transformed values of catch into logarithms ℓn (N + 1) for each hook and its regression line

Distribution of some economical fish in the central Gulf of Thailand

Several bottom vertical longline operations were carried out as a part of training activities by M. OKAWARA in the central part of the Gulf of Thailand during February 1982 and January 1983. The major fish caught on those occasions belonged to three species: *L. malabarbicus*, *Pristipomoides multidens* and *Seriolina nigrofasciata* (1983 data Table 7). Vadhanakul (1974 & 1975), Poreeyanond (1978), and Pokapunt et al. (1983), stated that catch rate of Lutjanidae was decreasing until it reached the minimum level of zero in 1976-1977. Most of the fish caught (Lutjanidae) by trawlers in the coastal areas were juvenile fish (especially *L. malabarbicus*, *L. sebae* and *P. multidens)*. All the juvenile fishes were treated as trash fish.

The observations and the records of catches obtained by the training vessel M.V. PAKNAM during 1982-84 (unpublished data), showed that most of the *S. nigrofasciata* caught in the coastal areas were small in size.

The adult fish of the economical species distribute widely in the central part of the Gulf of Thailand, while the juvenile fish are easily found in the coastal areas.

It is supposed that the central part of the Gulf of Thailand is a suitable area for adult fish to live and it is safe from the exploitation especially by trawlers because of the rough topographic condition of the bottom. Further study about the whole stock is needed to clarify the above supposition.

Table 7. Catch record of the bottom vertical longline in the Gulf of Thailand (after Okawara, 1983).

Date	Position Lat.	Position Long.	Species	Weight (kg)
25/1/83	10°-53′.5N	100°-59′.8E	*P. multidens* Others	2.2 3.0
25/1/83	10°-23′.2N	100°-59′.8E	*L. malabarbicus* Others	3.2 4.0
26/1/83	09°-52′.9N	100°-47′.0E	*L. malabarbicus* *P. multidens* Others	8.0 1.8 3.0
26/1/83	09°-15′.9N	100°-57′.5E	Others	3.0
27/1/83	08°-57′.8N	101°-17′.5E	*P. multidens* *L. malabarbicus* Others	1.3 7.0 5.0
30/1/83	08°-38′.0N	101°-20′.6E	*L. malabarbicus* *S. migrofasciata* Others	7.2 8.0 10.0

SUMMARY

1. The fish caught by the bottom vertical longline in the central Gulf of Thailand belonged to 18 species of the following eleven families: Balistidae, Carangidae, Carcharhinidae, Echeneidae, Lutjanidae, Muraenidae, Nemipteridae, Orectolobidae, Rachycentridae, Serranidae and Synodontidae.

2. Lutjanidae were a dominant part of the catch both in weight (101.6 kg) and in number, (42 individuals) of the economical fish caught here. As regards species, three major species of Lutjanidae, that is, *Lutjanus malabarbicus*, *Pristipomoides multidens* and *Lutjanus sebae* had a majority in weight.

3. An experiment with artificial bait was carried out, using multicoloured tufts of plastic fibre soaked in fish sauce. Only *E. naucrates* could be caught with artificial bait.

4. The hook rates obtained from the experiment ranged from 2.08 - 5.41 for the first five operations, and 1.59 for the last operation. The catching efficiency was very low, possibly of the size of hooks used.

5. The catch graph correlation of each hook showed the interrelationship of the fish caught during the experiment. The hooks No.5, 6, 7 mostly caught fish of families Lutjanidae and Echeneidae. The hooks No.1, 2, 3 mostly caught the fish of families Carangidae, Lutjanidae and Serranidae.

6. The best catch was obtained by hook No.8, which is placed in the highest position. The main species caught were *L. malabarbicus* and *E. naucrates*.

7. The vertical distribution of *E. naucrates* was obtained by the adjustment of the catch rate of each hook to the normal distribution pattern. The center of the vertical distribution of this species is assumed to be between the hook No.5 and No.6.

8. The adult fish of *L. malabarbicus*, *P. multidens* and *S. nigrofasciata* distributed widely in the central part of the Gulf of Thailand.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the captain and all the crew of the M.V. PAKNAM, SEAFDEC, for their kind cooperation during the survey. Special thanks to Mr. Yuttana Theparoonrat who assisted us in preparation and execution of the present experiment.

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FOOD COMPOSITION IN STOMACHS OF SQUID, *Loligo duvaucelii* (d'Orbigny)

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ABSTRACT

An examination of the stomach contents of *Loligo duvaucelii* revealed that the main food was fish, shrimps and squid. In terms of frequency of occurrence, fish were found as 48.00%, shrimps 28.14% and squid 19.95%. In terms of the biomass, fish had 79.77%, squid 18.63% and shrimps 1.60%. There were no significant differences in diet among different sizes and between sexes of *L. duvaucelii*.

INTRODUCTION

Many species of cephalopods are commercially important animals which contribute a very large biomass in the marine ecosystem. Many countries in the world have developed cephalopod fisheries interests. Cephalopods are an important fishery in Thailand, although in recent years there has been a decrease in landings (see statistics published by the Fisheries Economics and Planning Sub-Division, 1981-83.)

Vibhasiri and Khongmuak (1978 and 1979) studied the invertebrate catches by trawl and found that four species of squid were widely distributed in the Gulf of Thailand. *Loligo duvaucelii* is the most widely represented species of squid and also commercially the most important invertebrate species in Thailand. *L. duvaucelii*, like other squids, feeds at night and remains on the bottom by day (Amaratunga, 1980). Squid catches by trawl reveal that in the daytime most squid stomaches are empty while at night they are mostly full of food.

The purpose of this study was to examine the composition of food in stomcahs of *Loligo duvaucelii*. This basic information on the biology of *L. duvaucelii* will be useful for fishery and for conservation purposes.

MATERIALS AND METHOD

Sampling method

Samples of *Loligo duvaucelii* were collected from station 180, east of Ko Samui (Fig.1)[1], between 0240 and 0445 hours on 5 July 1984. The squid were caught by squid net with the help of luring lights. The samples were frozen and stored at the temperature of -40°C for further study in the laboratory.

Laboratory examination

Squid samples were thawed as quickly as possible, each squid was numbered and the dorsal mantle length was measured to the nearest millimetre. The excess water was drained from each squid for approximately 30 seconds, and it was weighed with electronic scales to the nearest gram. Sexes were separated and maturation was determined by examining Needham's sac in the male and nidamental gland in the female (O'Sullivan and Cullen, 1983). The length of nidamental gland was measured, the stomach of squid was cut, put in 70% alcohol and numbered corresponding to the number of each squid.

Stomachs were dissected, food contents were sorted and identified under dissecting microscope. Each type of food was separated and spread in a thin layer, and its area of coverage measured to the nearest square millimetre. Food was kept for further identification.

RESULTS

Dorsal mantle length and body weight

The dorsal mantle length of the squid ranged from 40 to 223 mm. The maximum mantle length was 223 mm for the male and 126 mm for the female (Fig. 2 and Table 1). There was no significant difference in distribution between sexes and among sizes of *L. duvaucelii* in the sample (Tables 2 and 3).

The relation between the mantle length and body weight was determined by $\log W = a + k \log L$. The values of $k♀$ and $k♂$ were 2.26 and 2.12 respectively (Fig. 3). As there is no significant difference between these values, we can also say that there is no significant difference between the relation of mantle length and body weight of the sexes.

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1 Figures and tables appear at the end of the text.

Maturation

The relation between the mantle length and maturation of squid in the sample is shown in Table 4. The smallest size on maturation was approximately 60 mm for males and 60-70 mm for females. The nidamental gland size in female corresponded to the size of squid (Fig. 4). In the spawning season, the nidamental gland was inflated.

Feeding

Most of the food in stomach of *L. duvaucelii* consisted of fish, shrimps and squid (Fig. 5, Table 5). The percentage of food occurrence in stomachs of *L. duvaucelii* was: fish 48.00%, shrimps 28.14% and squid 19.95%. In terms of biomass, which was determined by the percentage of area coverage, there was fish 79.77%, shrimps 1.60% and squid 18.63%. Copepods, gastropods and bivalves were found in small numbers.

Among the fish prey we found many types of otolith (Fig. 5) and scale. The scales were ctenoid and cycloid (Fig. 6). The size of fish and the size of otolith in stomachs of *L. duvaucelii* indicate that the fish prey were smaller than the mouth of *L. duvaucelii*. Crustaceans in stomach of *L. davaucelii* were from the shrimp group and there were more than one species, but these could not be identified because they were incomplete. Shrimps in stomachs of *L. duvaucelii* were not much smaller than fish. The third main food of *L. duvaucelii* were cephalopods; the type of beak showed that they were squid. The comparison of beak size of predators and prey reveal that the body size of squid prey was less than half of body size of predator.

There were no significant differences between sexes and among sizes of *L. duvaucelii* regarding the percentage of occurrence of fish, shrimp and squid in the stomach.

DISCUSSION

Ommastrephid and loliginid squid are predators to many kinds of animals, mostly fish, crustaceans and cephalopods (Saito et al., 1974; Amaratunga, 1980; O'Sullivan and Cullen, 1983). *Loligo duvaucelii* of the present study fed on fish, shrimp and squid (Table 4, Fig. 4). Copepods, gastropods and bivalves were found in small amounts; thier presence may be due to accidental feeding. By the percentage of occurrence method we found that food categories were: fish, shrimp and squid in ratio 12:17:5 respectively. In terms of biomass by the percentage of area coverage, fish, shrimp and squid were in ratio 40:2:20 respectively. The difference of ratios may be due to different sizes of prey. Ratanaanun (1978, 1979) made a study of squid caught by trawl and found that food of *L. duvaucelii* were squid, fish and crustacean, but that the percentage of squid and fish was the same.

We found many types of fish otolith in stomachs of *L. duvaucelii* (Fig. 6). The size of fish and otilith reveal that the fish prey were smaller than *L. duvaucelii* predators. The fish may be the common small pelagic fishes or small immature pelagic fishes in that area which feed at night and come to feed under the luring light which is used for squid fishing. In a study on feeding of squid, *Nototodarus gouldi* in Bass Strait area, O'Sullivan and Cullen (1983) showed that *N. gouldi* feed on common pelagic fish which feed at night in surface waters illuminated by fishing lights. Crustaceans found in stomachs, of *L. duvaucelii* were shrimps which however were too fragmented to be identified. Squid were one important kind of food in *L. duvaucelii* but with a percentage of occurrence smaller than for shrimp. However, cannibalism may not be common among squid, but may be due to a high concentration of squid under the luring light and the tendency of squid to attack anything they come in contact with (Amaratunga, 1980, Ennis and Collins, 1979. The beak size of the prey squid revealed that they were less than half the size of the predator squid.

The statistical analysis of feeding among sizes and between sexes of *L. duvaucelii* showed that there were no significant differences among them in feeding. In this respect our observation are different from those in a study by O'Sullivan and Cullen (1983), who found that the squid *Nototodarus gouldi* in Bass Strait area differred significantly in feeding on crustacean and squid, because of the relation between sizes of predator and prey.

We should like to point out that it is necessary to carry out further study of the feeding habits of *L. duvaucelii*. The sampling should be extensive, all the year round and at different times of day and night. Also, it would be useful to identify the small fish that are lured together with the squid under the fishing lights, and that constitute prey for *L. duvaucelii*. Thirdly, cannibalism of the squid should be examined.

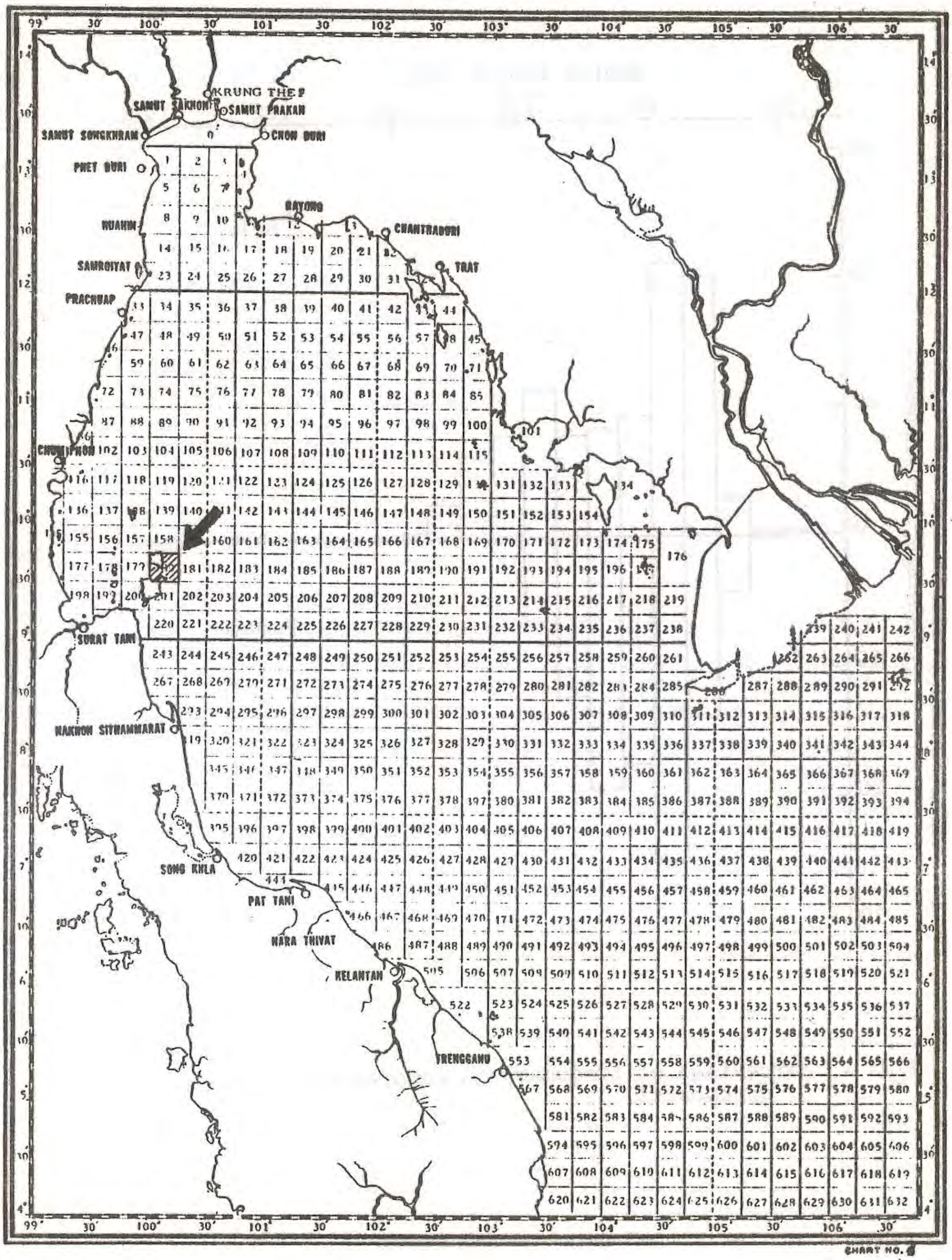

Fig. 1 Location of the sampling station (arrow) in the Gulf of Thailand

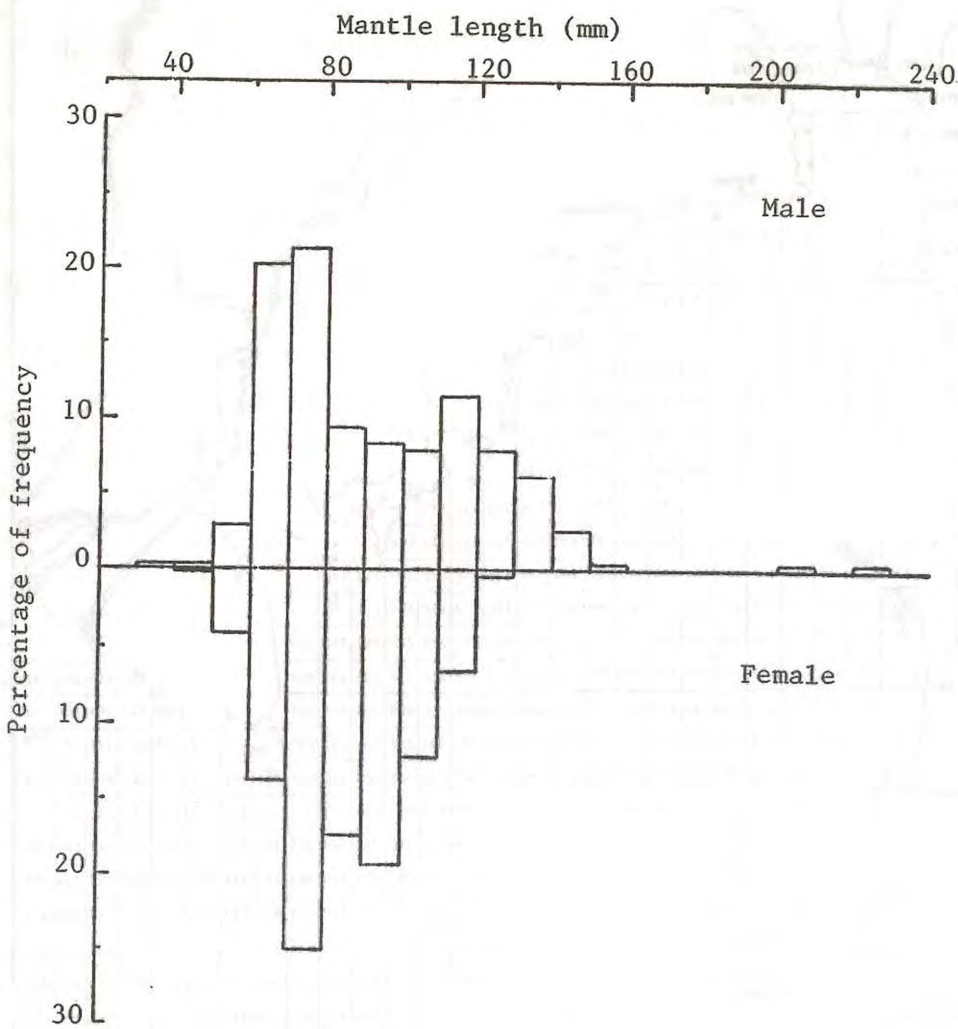

Fig. 2 Percentage of frequency in each size of *L. duvaucelii*.

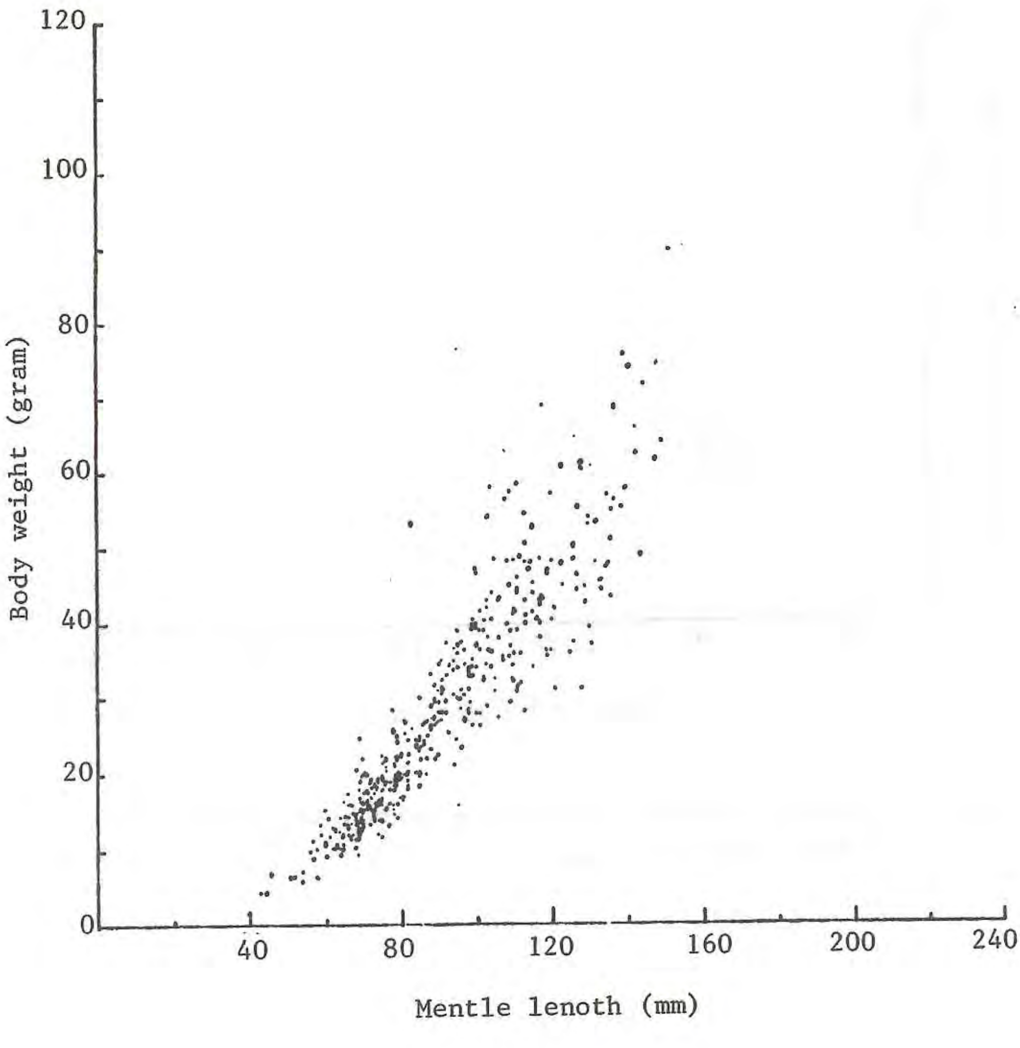

Fig. 3 Relation between mantle length and body weight.

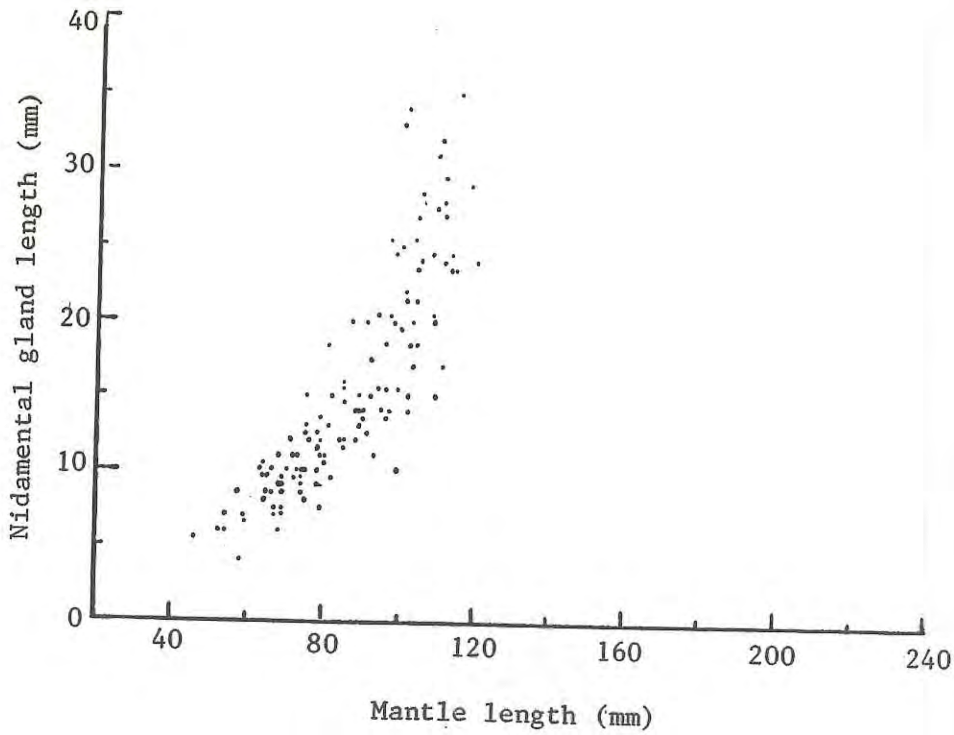

Fig. 4 Relation between the mantle length and nidamental gland length in female.

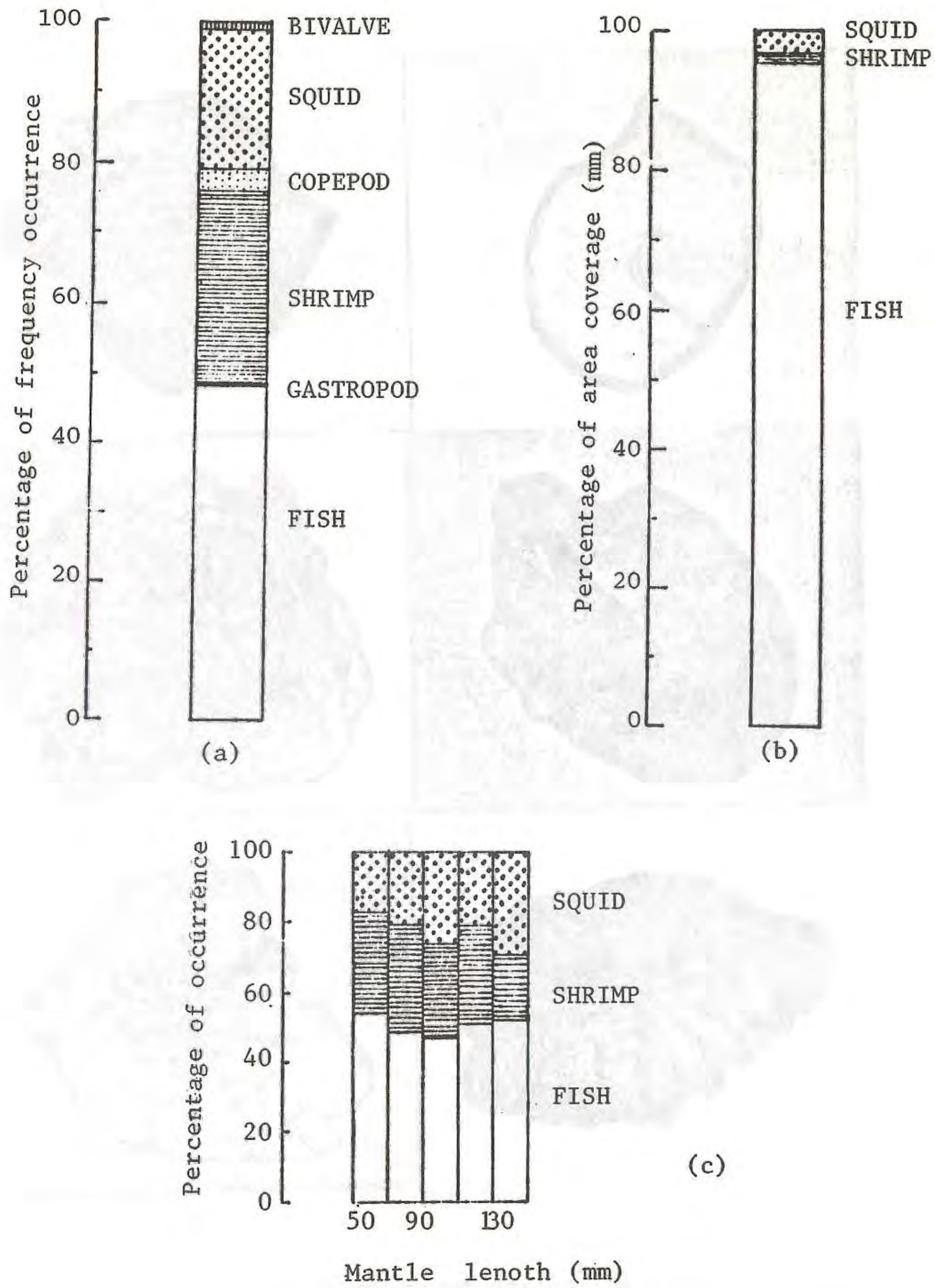

Fig. 5 (a) Percentage of occurrence of each food

(b) Percentage of area coverage

(c) Percentage of occurrence in each size of *L. duvaucelii*

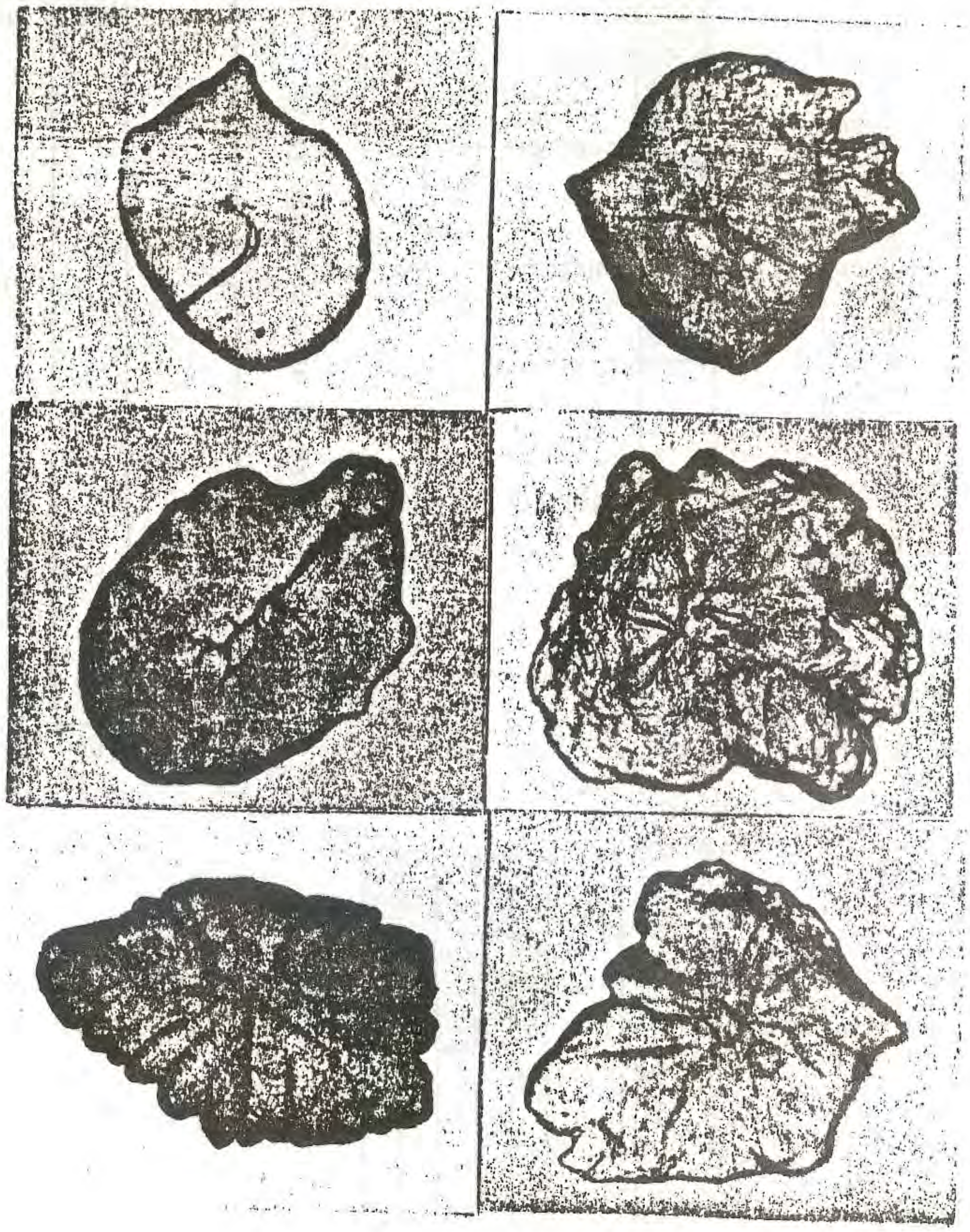

Fig. 6 Types of otolith found in stomachs of *L. duvaucelii*.

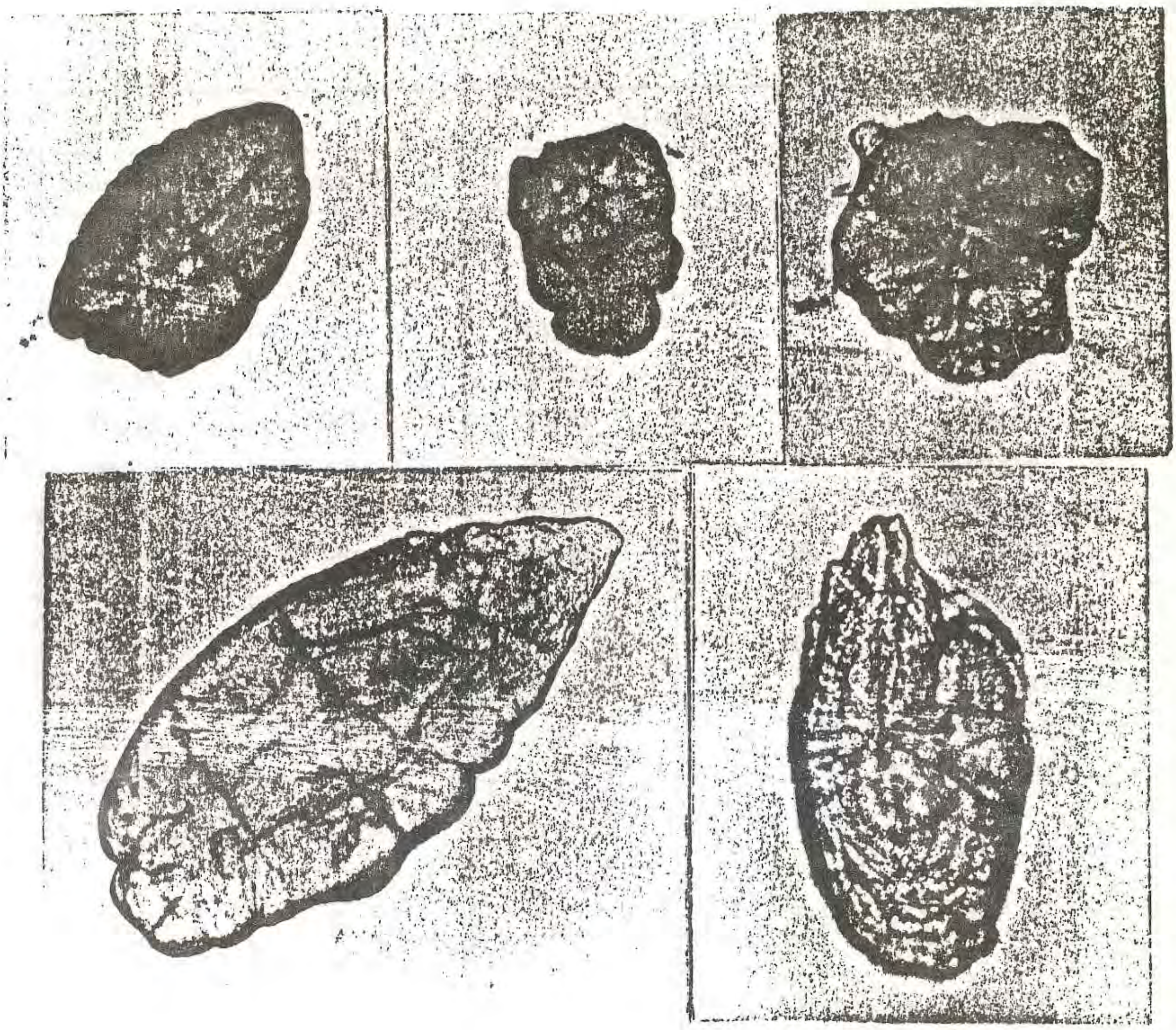

Fig. 6 (Continued)

Table 1 Number of *Loligo duvaucelii* in each size and sex.

mantle length (mm)	female		male	
	frequency	% frequency	frequency	% frequency
31-40	-	-	1	0.29
41-50	2	0.82	1	0.29
51-60	9	3.69	8	2.29
61-70	33	13.52	73	20.92
71-80	63	25.82	84	24.07
81-90	46	18.85	40	11.46
91-100	47	19.26	29	8.31
101-110	29	11.89	28	6.02
111-120	14	5.74	35	10.03
121-130	1	0.41	23	6.59
131-140	-	-	17	4.87
141-150	-	-	7	2.01
151-160	-	-	1	0.29
⋮				
201-210	-	-	1	0.29
⋮				
221-230	-	-	1	0.29
Total	244	100	349	100

Table 2 Mean sex difference of mantle length

difference (mm)	t	df	p
5.87	3.24	591	0.01

Table 3 Distribution of male and female squid in the sample

No. of males	No. of females	$\bar{x}$	df	χ^2	p
349	244	296.5	1	18.59	< 0.01

Table 4 Relation between mantle length and maturation

mantle length (mm)	male maturation 1	2	3	Total	female maturation 1	2	3	4	Total
40 -	2	-	-	2	2	-	-	-	2
50 -	3	1	-	4	7	1	-	-	8
60 -	3	9	42	54	15	7	1	-	23
70 -	3	3	59	65	8	36	5	-	49
80 -	-	3	20	23	-	22	9	2	33
90 -	1	5	17	23	2	14	12	10	36
100 -	-	6	13	19	-	5	5	17	27
110 -	-	10	27	37	-	1	2	11	14
120 -	-	3	17	20	-	-	1	1	2
130 -	-	1	17	18					
140 -	-		17	17					
150 -	-	2	-	2					
Total	12	43	229	334	34	86	34	41	195

Table 5 Number of occurrence, percentage of occurrence area coverage and percentage of area coverage.

food category	No. of occurrence	% of occurrence	% of feeding squid	area coverage	% area coverage
Fish	539	48.00	98.18	532,670	79.77
Shrimp	316	28.14	57.56	10,662	1.60
Squid	224	19.95	40.80	124,428	18.63
Copepod	28	2.49	5.10		
Bivalve	11	0.98	2.00		
Gastropod	6	0.44	0.91		
Total	1124	100.00	204.55	667,770	100.00

Table 6 Number of occurrence and percentage of occurrence in each size.

	Food category	mantle length (mm)					Total
		50 -	70 -	90 -	110 -	130 -	
No. of occurence	Fish	96	218	123	76	25	538
	Shrimp	57	136	70	44	9	316
	Squid	36	88	57	28	14	223
	Total	189	442	250	148	48	1077
% of occurence	Fish	50.79	49.36	49.20	51.35	52.08	49.95
	Shrimp	30.16	30.77	28.00	29.73	18.75	29.34
	Squid	19.05	19.91	22.80	18.92	29.17	20.17

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FISHERIES OCEANOGRAPHIC CONDITIONS IN THE CENTRAL GULF OF THAILAND

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INTRODUCTION

In recent years there have been many scientific investigations in the waters of the Gulf of Thailand. A program of hydrographic surveys was established by the research vessel the *Stranger*, University of California, already in 1959 and 1960. In 1979, 1980 and 1982 fisheries oceanographic investigations were conducted by the Japanese-Thai-SEAFDEC Joint Survey.

The present paper deals, in a comprehensive way, with the fisheries oceanographic conditions of waters in the Gulf, particularly its central part. The paper is mainly based on the records collected during a survey on board M.V. Paknam from 16 May to 9 June 1984, conducted under the Thai-SEAFDEC Joint Research Program.

The location of the survey stations is shown in Fig. 1.

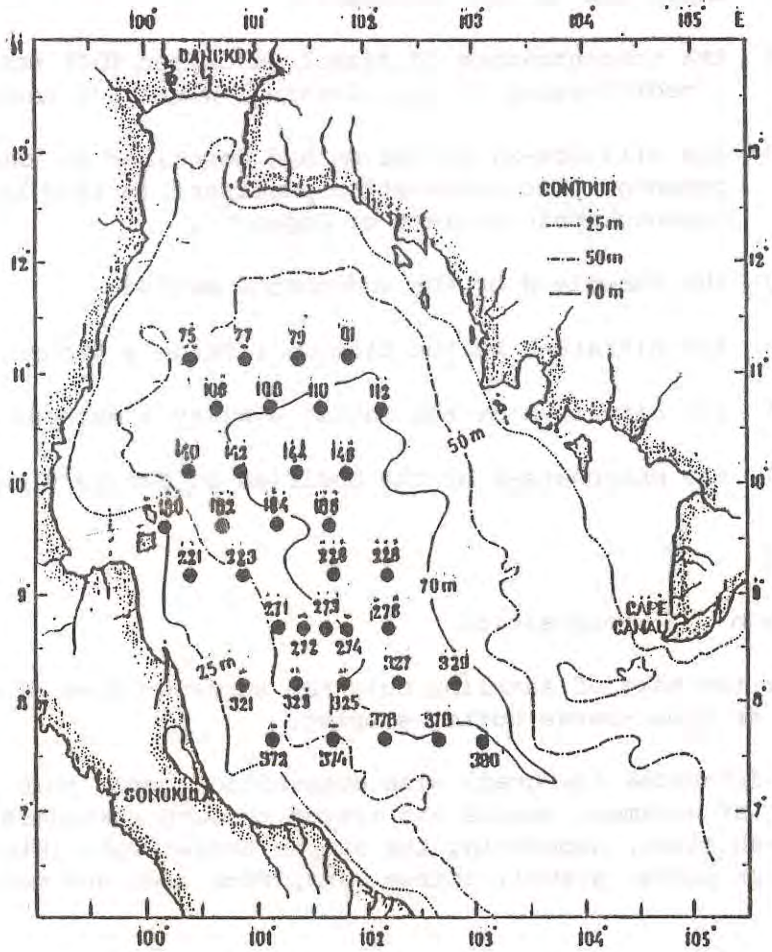

Fig. 1. Location chart of oceanographic survey stations.

MATERIALS AND METHODS

1. Sea Water

Sea water samples were collected by means of a Nansen reversing water bottle and a Van Dorn water sampler. For the chemical analysis, the water samples were filtered through the Whatman Glass microfiber filter (GFIA). Chemical and physical determinations were carried out on the following:

(1) the temperature was measured with a reversing thermometer and a bathythermograph (BT);

(2) the salinity was detèrmined by the inductive salinometer, model 601 MK-111, Australia;

(3) the concentration of dissolved oxygen (DO) was found by a modification of the classical Winkler's method;

(4) the silicate-Si by the method described in the Manual of oceanographic observation published in 1970 by the Oceanographic Society of Japan[2];

(5) the ammonia-N by the indophenol method;

(6) the nitrate-N by the Ilosvay & Dunge's method;

(7) the nitrite-N by the Mullin & Riley's method;

(8) the phosphate-P by the modified G. Denige's method.

2. Sediment

(i) Grain size composition

For the sake of sampling only the surface layer of the bottom, we utilized an Ekman-Berge bottom sampler.

To determine the grain size composition, more than 50 g (dry weight) of sediment sample was sieved through strainers of different mesh sizes, seperating the sample tentatively into the following four parts: gravel, coarse sand, fine sand and mud.

Mesh size (mm)	73.0	0.5-3.0	0.05-0.5	0.05
Name	Gravel	Coarse sand	Fine sand	Mud

(ii) Organic matter and carbonate content

The organic matter and carbonate contents in the sediments were quickly determined by the ignition loss method according to Dean (1974).

(iii) COD and total sulfides

The chemical oxygen demand (COD) was determined by the reduction of permanganate when the organic matter has been completely oxidized. The total sulfides were measured by using the Gastic Hydrotec S Detector Kit.

3. Chlorophyll

The chlorophyll determination was carried out on 5 ℓ water samples collected from the surface layer. The absorbencies at 644, 674 and 630 mμ were determined.

RESULTS AND DISCUSSION

1. Bottom character

(1) Bottom topography

The Gulf of Thailand is a shallow arm of the South China Sea with the same surface features, but separated from the sea by a sill of 50 m depth. This sill extends roughly from the Thai-Malaysian border, in the northeast direction towards the Cape Ca Mau (see Fig.2). The deepest part of the Gulf is about 80 m in the central depression which appears to be narrow, and the 50 m depth contour enters near the Bight of Bangkok[3].

These features of the topography play a significant role in the fisheries. For example, depth is an important factor by which the distribution of demersal fish can be determined. This is shown in Table 2 which was prepared by S. Pornpatimakorn and W. Pokaphunt on the basis of the data collected during the Thai-SEAFDEC Joint Survey in May and June 1984 on board M.V. Paknam (from now on, the survey will be referred to as M.V. Paknam, 1984). Among demersal fishes caught by trawling in the central Gulf, the red snapper, *Lutjanus sanguineus*, and threadfin bream, *Nemipterus bleekeri*, were found in comparatively large numbers in the depth of more than 70 m. On the other hand, threadfin bream, *Nemipterus hexodon*, was caught in the depth of less than 50 m.

The bottom in the central Gulf is very irregular and shows some interesting features, that is to say, there are a large number of particularly rugged structures on the bottom[4]. Echo profiles across those structures are shown in Fig. 3 and their positions are given in Fig. 2. Their height is between 4 and 5 m only, while the width varies greatly from 50 m to more than 4,000 m. The structures are comparatively flat on top. The distance between neighboring ridges ranges from 500 m to 2,000 m[5]. Such bottom configuration often presents serious obstacles to trawl fishing.

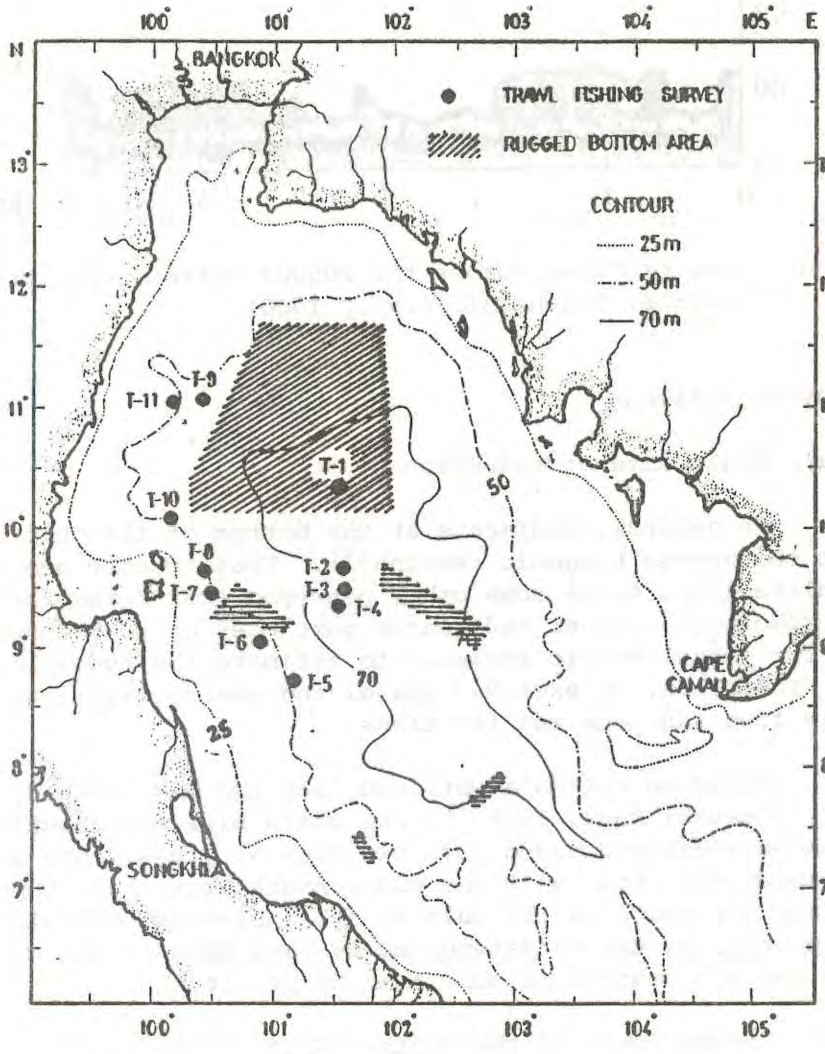

Fig. 2. Bottom topography and trawl operation stations (source for bottom topography: Yada *et al.*, 1982).

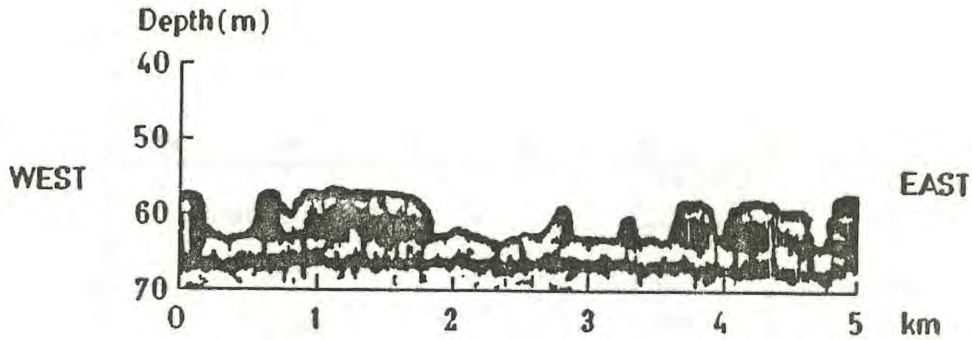

Fig. 3. Echo profiles across the rugged bottom structures (source: Takahashi *et.al.*, 1980).

(2) Bottom sediment

(i) Grain size distribution

In general, sediments at the bottom of the Gulf consist of abundant calcareous biogenic remains(5). Their shapes are varied: rod-like, plate-like, or of some other non-spherical forms reflecting original morphology. Gravel and coarse particles of such shapes are inadequate for granulometric analysis to estimate the hydraulic condition. Therefore, we excluded gravel and coarse fractions and treated only fine sand and mud fractions.

Based on the data obtained from the M.V. Paknam, 1984, and the T.V. Nagasaki Maru, 1980(5), the grain size distribution of the Gulf can be roughly divided into two typical areas. One is the calcareous sandy mud area, with the mud content less than 50 per cent, extending from the mouth of the Gulf to its innermost part along both coasts. The other is the calcareous muddy sand area in the central part, where the mud content is more than 50 per cent.

The sediment in the central Gulf can be further subdivided into three types, according to the grains characterizing the content of samples:

Type	A	B	C
mud content (%)	> 90	90 - 70	< 70

Geographically, the finest particle A-type sediments were concentrated in the waters off Samui Island. They were surrounded by the medium sized B-type particles, which occupied the inner contral part. The coarsest C-type particles were distributed on the outer sides (Fig. 4).

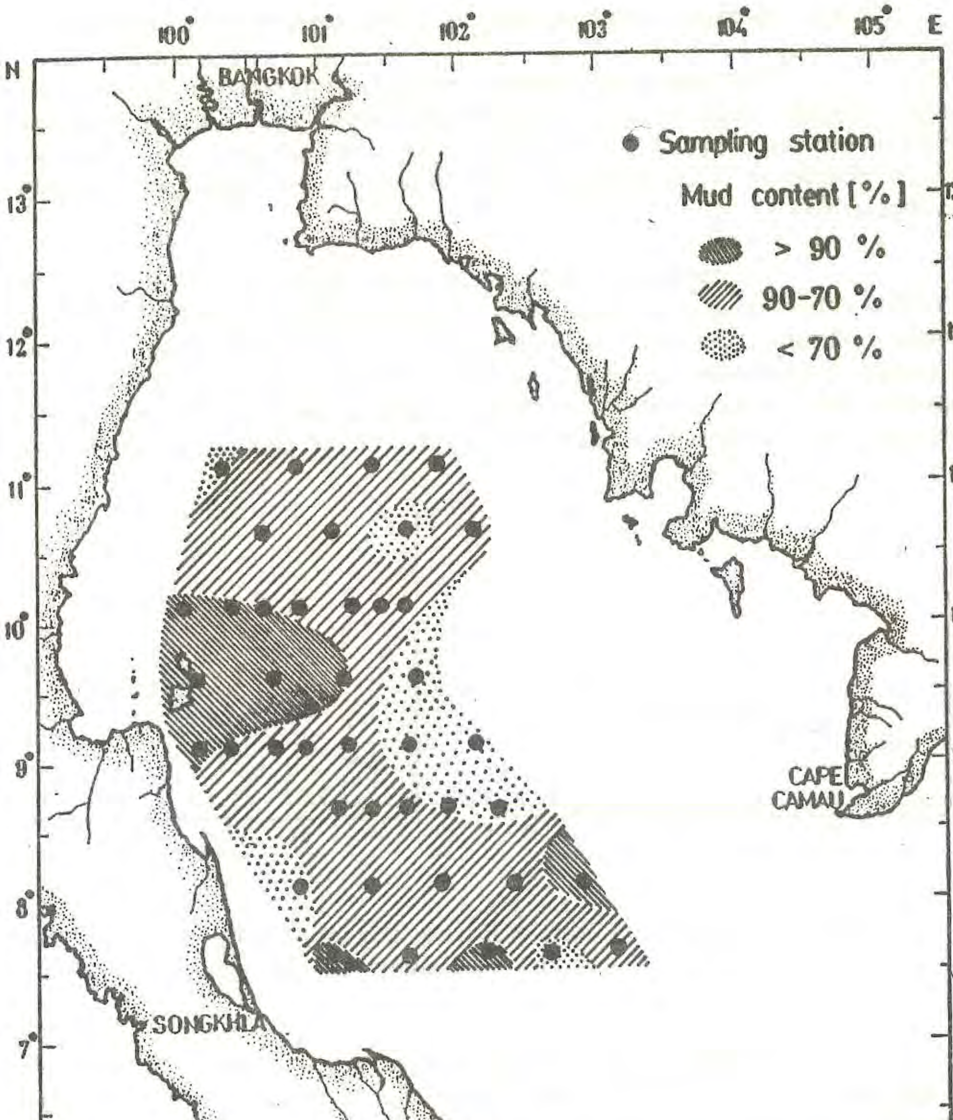

Fig. 4. Geographical distribution of grain size in the central Gulf of Thailand.

Each type of sediment is characterized by its environment of deposition, which is dependent upon the distribution of different velocity of water masses and currents. The sediments which contain the finest particles indicate stagnant waters or eddies.

(ii) Organic matter and calcium carbonate content

The organic content of all sediment samples collected in the central Gulf by M.V. Paknam in 1984, which were combustible at 550°C. averaged 6.73 ± 1.71 weight per cent (Table 3). These levels are low compared with those of Ban Bung Pakong fishing grounds off Chon Buri.(6)

The organic matter content shows no direct correlation with the mud content in the samples as a whole. Among the samples, however, organic content is positively correlated with the mud (Fig. 5), and shows a correlation coefficient of 0.61 against the mud. This suggests that more organic matter coexists with finer sized fractions, which may be a result of similarity in their settling velocities.

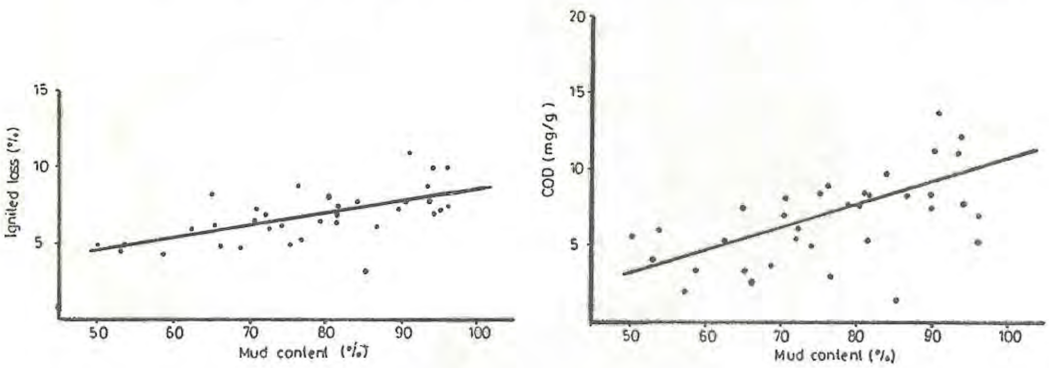

Fig. 5. Relation between the mud content, ignited loss and COD of the sediment in the central Gulf.

The calcium carbonate ($CaCO_3$) content, converted from the ignited loss of carbon dioxide (CO_2) evolved at 950°C, was about 34 weight per cent on the average.

(iii) COD and total sulfides

The content of organic matter is also shown in the level of COD. By use of this method, we have tried to carry out a quantitative analysis of organic compounds in the sediment of the central Gulf. From the results which are shown in Table 3, it can be seen that the levels were less than 20 mg/g at most of the survey stations. However, at the station 180 off Samui Island the level was shown to be a little over 20 mg/g. The COD level is also positively correlated with the mud content, as shown in Fig. 5.

According to the Japanese regulations, the standard level of COD for a good fishing ground is set at less than 20 mg/g.

The total sulfides which indicate the presence of poisonous substances were below the limit of detection at all stations, except station 180 (Table 3).

The survey results have shown that the amount of organic matter in the sediments of the central Gulf are not so large as to cause a shortage of oxygen in the bottom layer of water.

2. Current

Coastal and ocean currents are subject to variations with the times. These variations in turn result in variations in fishing grounds, fishing seasons and amounts of catch.

According to the Naga Report (Wyrtki, 1961[7]), in the South China Sea, the monsoon is well developed, that is, in winter the northeast monsoon from the continent of Asia blows over the sea, and in summer the southwest monsoon blows towards and over the continent. Corresponding to the monsoons, an anti-clockwise monsoon current develops in winter in the South China Sea, and in summer it changes into a clockwise current as shown in Fig. 6.

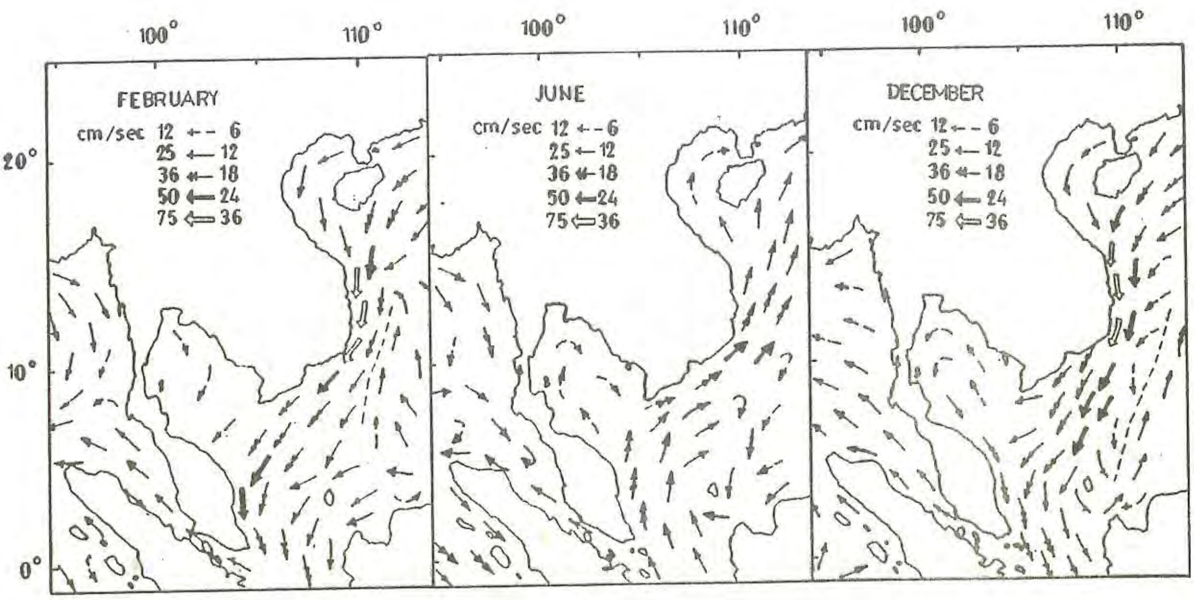

Fig. 6. Surface currents in February, June and December (re-drawn from Wyrtki, Naga Report, 1961).

The Naga Report also described the circulation of water in the Gulf of Thailand, similar to that in the South China Sea. During the southwest monsoon, from May to September, it is clockwise and during the northeast monsoon, from October to January, it is anti-clockwise. However, it is not certain whether this circular movement corresponds to the water circulation in the South China Sea.

Considering the geographical features of the Gulf, the movement of the current seems to be very complicated compared with the main current in the South China Sea. In addition, there are not only wind currents but tidal currents in the Gulf. In oceans, the velocity of a tidal current is extremely low, sometimes even negligible. On the other hand, in an area where the water is shallow, the velocity of tidal current is high.

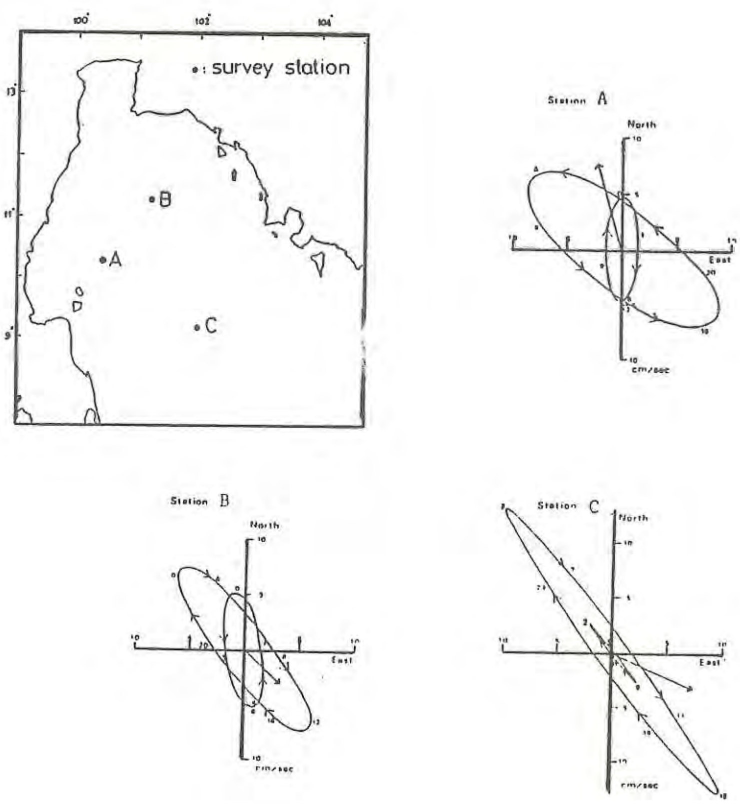

Fig. 7. Current survey stations and current ellipsis at 10 m depth in May 1980 (re-drawn from Yada *et al.* 1982).

⟶	:	constant courrent
large ellipse	:	diurnal tide
small ellipse	:	semi-diurnal tide

In the 1980 survey by the Nagasaki Maru, the current observations at 10 m depth were conducted at only three stations in the central Gulf and the results were published by Yada *et.,at.* (1982).[5]

According to the report, as shown in Fig. 7, at stations A and B the effects of constant current dominate in the current direction due to the fact that the diurnal and semi-diurnal tides tend to offset each other. At station C, as the effects of both tides are always added to each other and the maximum velocity of the diurnal tide is two times greater that the constant current, the diurnal tide has a greater effect than the constant current on the change in the current direction vectors. The movement of water at station C looks like semi-closed circulation. At any rate, it is still too early to draw any conclusions with regard to the circulation of water, as the available data is far from sufficient.

Concentrations of fishes are determined by patterns of water flow. Fishes, particulary demersal species, are attracted to areas of weak movement of water or eddies, and they avoid places where strong currents prevail. In the Nagaseki Maru 1980 survey the velocity of water movement was also recorded, for stations A, B and C as shown in Table 1.

Table 1. Maximum velocity of constant current and of diurnal and semi-diurnal tides at 10 m depth in May 1980 (source Yada *et al.*,(1982).

	Station A	Station B	Station C
Constant current	8.00 cm/sec (0.15)	4.55 cm/sec (0.09)	8.16 cm/sec (0.16)
Diurnal tide	10.44 cm/sec (0.20)	9.23 cm/sec (0.18)	16.26 cm/sec (0.32)
Semi-diurnal tide	4.56 cm/sec (0.06)	5.22 cm/sec (0.10)	3.37 cm/sec (0.06)

( ) : knots

Table 1 shows that the velocity of water movement in the central Gulf seems to be weak even during the southwest monsoon season.

As far as the flow pattern is concerned, the central part of the Gulf seems a good trawl fishing ground. However, the bottom topography is very irregular and many sponges which are found in that area are harmful to the trawl catches (see Takahashi *et al.*, 1984[4]).

Wyrtki (1961)[7] reported that with the movements at the surface out of the Gulf, which seems to prevail from February to April during the northeast monsoon, the movements of branches entering into the Gulf from the South China Sea becomes weaker (Fig. 6). Stocks of fish, such as bonito, little tuna and marlin, migrating from the South China Sea into the Gulf, fluctuate in accordance with the movement of water. Therefore, the stocks increase during the southwest monsoon and decrease in the northeast monsoon season.

3. Oceanic Fronts in the Waters off Samui Island

The term "front" has been borrowed from the meteorological jargon, and is widely used by oceanographers to denote a boundary between two different water masses. An oceanic front is the result the convergence caused by two different currents or water masses flowing towards a line from both sides. Here the planktonic organisms and fishes congregate in a zone of optimum water temperature and salinity.

Dynamically, the collision of two currents represents a front, which shifts to and fro, according to the prevalence of the current on each side, resulting in the formation of dynamic eddies around the zone.[8] Thus, this zone indicates a favourable fishing ground of commercially important fishes.

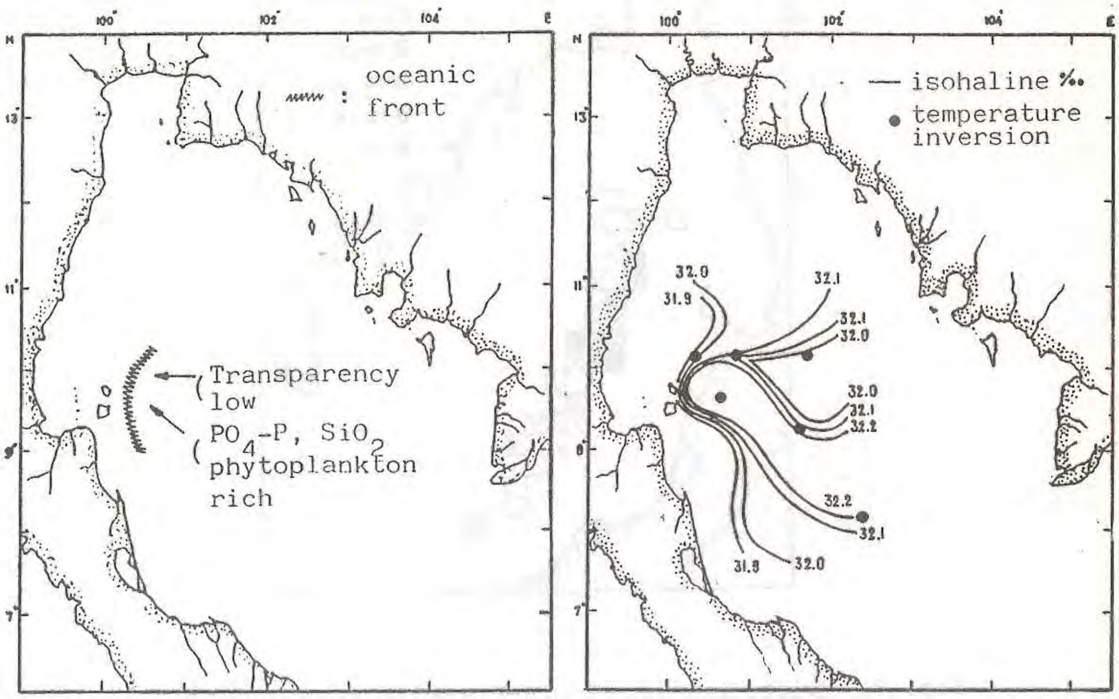

Fig. 8. Schematic oceanographic map of the surface layer, based on data obtained by the Thai-SEAFDEC Joint Survey, May - June 1984.

As shown in Fig. 8 and Table 3, we observed that the regions of relatively steep horizontal gradient of surface water properties, such as salinity, nutrient salts and phytoplankton, were located in the vicinity of Samui Island where the oceanic fronts were formed by the convergence of the coastal water mass and the water mass of the central part originating from the South China Sea. This indicates that the waters off Samui Island are potentially good fishing grounds for marlin, mackerel, little tuna, and other fishes. The pelagic fishes for feeding migration are attached to the zone of densely concentrated marine organisms.

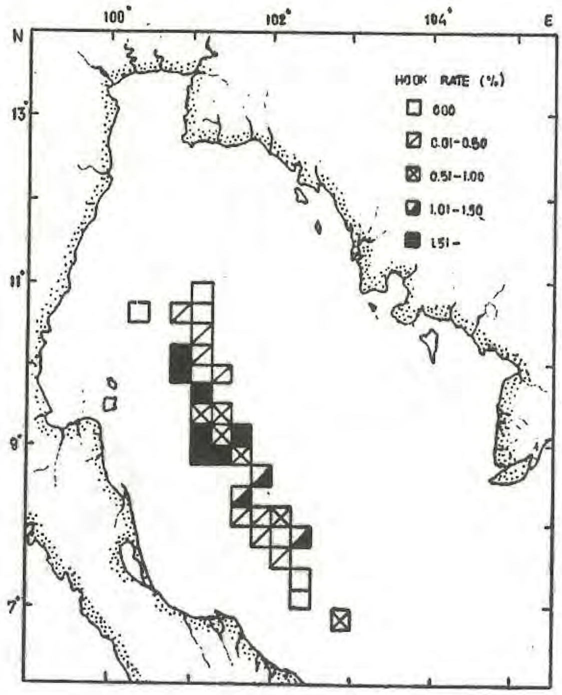

Fig. 9. Distribution of black marlin in the Gulf from 1980 to 1982 (re-drawn from Takahashi *et al.*, 1983).

The fishing grounds for black marlin, *Makaira indica* CUVIER, which are caught by longline, are located at the boundary of a high-salinity water mass extendion from the South China Sea along the Malay Peninsula, with the highest density of distribution in the vicinity of Samui Island (Fig. 9).[9] Purse seine fishery for pelagic fish is also practiced in the same fishing grounds.

According to Morita (1960)[10], the black marlin fishing grounds roughly coincide with those of mackerel, even in the East China Sea. However, each species of fish has its own optimum temperature and salinity zone. The black marlin has a narrower range of the optimum zone than the mackerels. Therefore, distribution of black marlin in the Gulf is limited in the high-salinity water mass which originates in the South China Sea.

4. Oceanographic Structure

(1) Shallow temperature inversion

A small scale vertical gradient of the temperature inversion was found in the vicinity of the region of oceanic boundary in the central Gulf, as shown in Figs. 8 and 10. The layers appeared near the place where the temperature structure was complicated and the isotherm rugged (Fig. 11).

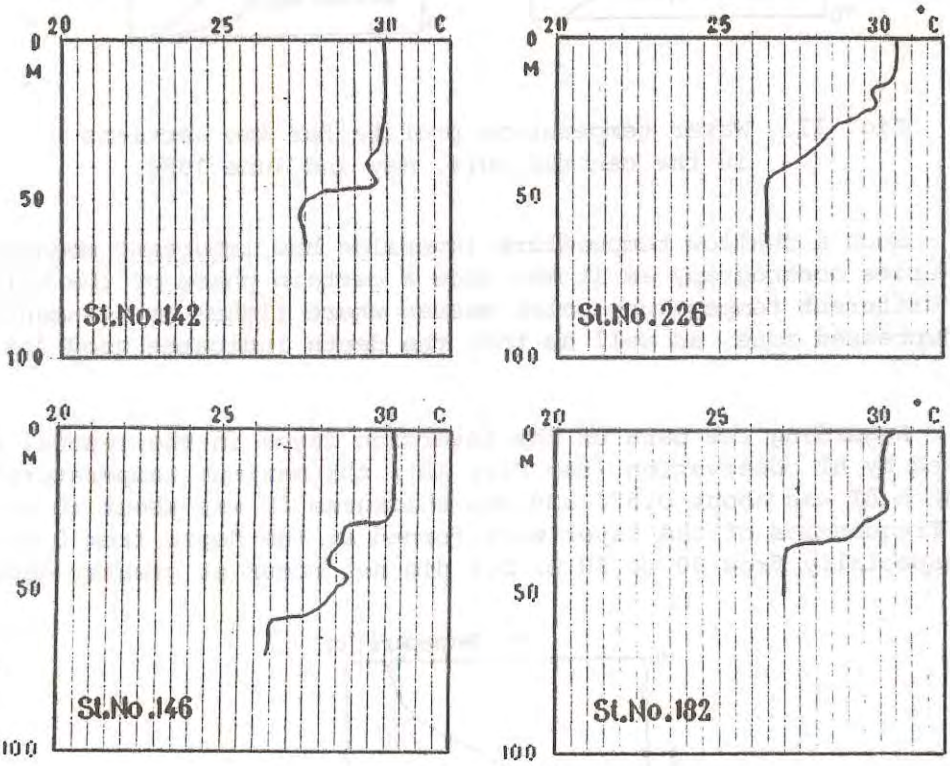

Fig. 10. Temperature inversions at stations 142, 146, 226 and 182, obtained by BT observation.

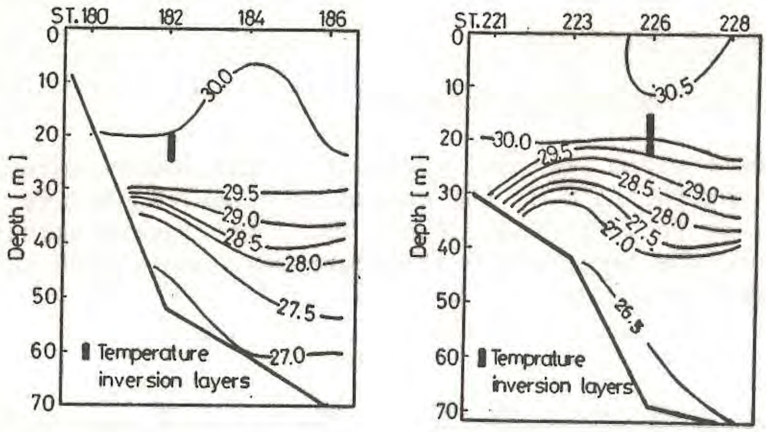

Fig. 11. Water temperature profile for two sections in the central Gulf, May and June 1984.

Such a shallow temperature inversion has important meanings in fisheries oceanograpy as it may show a certain phase of the collision of two different temperature water masses where fishes are concentrated in a compressed zone, as well as that the depth indicates good fishing layer.

Regarding the data on the inversion layer in the central part collected by BT observation (see Fig. 12), the maximum temperature difference ΔT was about 0.5°C and the thickness ΔD was about 10 m. Larger frequencies of the layer were formed at the depth from 0 to 50 m, especially from 30 to 50 m, but did not occur at greater depths.

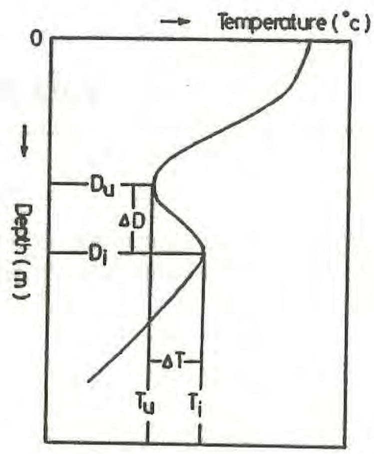

Fig. 12. Schematic representation of the temperature inversion layer.

Since the existence of inversion accompanies oceanic boundaries, these phenomena appear to be formed through the process of the convectional mixing of two different water masses, coastal and oceanic, in the central Gulf. This is also represented by the domain of negative value of the vertical stability of water on the bottom.

A detailed report on the structure of shallow temperature inversion in the Pacific Ocean was published by Nagata (1967)[11].

(2) Vertical distribution of salinity

A high rainfall, a large inflow from many rivers, and the geographical features of the Gulf have a considerable effect on the salinity of the Gulf as a whole. However, a distinct ligulate water area of high salinity at the surface in the central Gulf spreads northwest from the entrance of the Gulf as shown in Fig. 8.

This section discusses the vertical distribution of salinity in the central part of the Gulf.

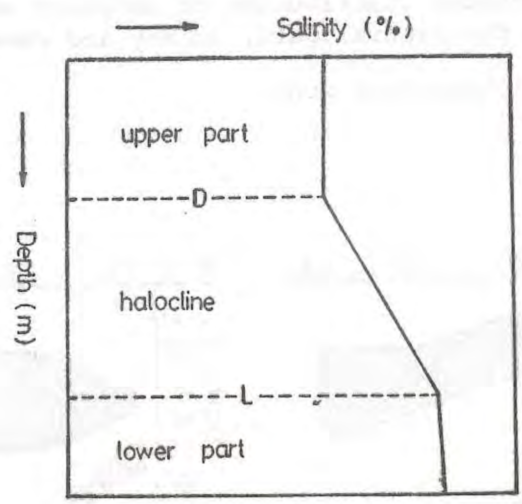

Fig. 13. Schematic representation of the vertical distribution of salinity. D and L denote the upper and the lower zone.

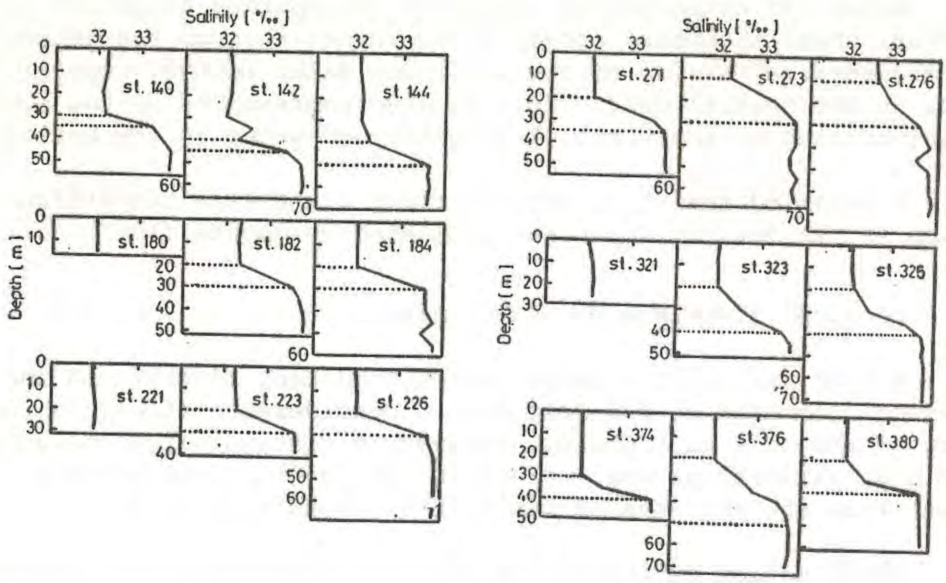

Fig. 14. Vertical distribution of salinity at 18 stations in the central gulf, in May and June 1984.

... halocline zone

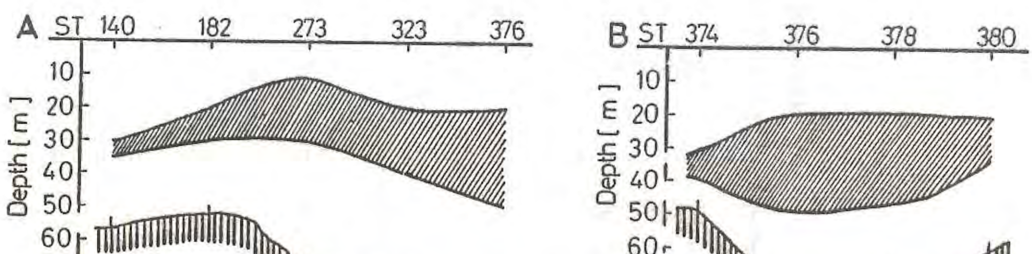

Fig. 15. Vertical profile of halocline layer along the line connecting several stations.

A : from station 140 to station 378

B : from station 374 to station 380

▨ : halochine layer

From Fig. 14 and Table 3, it can be seen that remarkable halocline layers existed at most of the stations. This phenomenon seems to be mainly due to the river discharge in the southwest monsoon season. The upper part above the halocline (Figs. 13 and 14), is mixed nearly to a homogeneous layer by the wind and the movements of water. Below the halocline there is another nearly homogeneous lower zone of more saline water.

The thickness of the halocline layer becomes gradually smaller and the depth (L) tends to become more shallow as we move northward (Fig. 15). These indicate that the flow from the South China Sea into the Gulf in due to the processes of mixing and diffusion.

The most conspicuous region, with the maximum thickness and depth of the halocline layer is located near the entrance of the Gulf (St. 376), and it becomes obscure further north (Fig. 15). The above boundary corresponds to the oceanic front between the coastal water mass and the water mass extended from the South China Sea. On the other hand, there is no conspicuous halocline in waters near the shore, in stations 180, 221 and 321, along the west coast of the Malay Peninsula. This is caused by the intense tidal and turbulent mixing in the shallow waters. It should be noted that the above mentioned data on salinity distribution in the central Gulf were very similar to the data of the survey which was conducted under the Japanese-Thai-SEAFDEC Joint Research Program from 15 to 28 May 1980.

(3) Distribution of dissolved oxygen

(i) Horizontal distribution

As mentioned before, the water mass extended from the South China Sea is shown in the central part and the boundary can be clearly observed by the halocline data.

In addition, a water mass can even be distinctly characterized by measuring the dissolved oxygen content in the water.

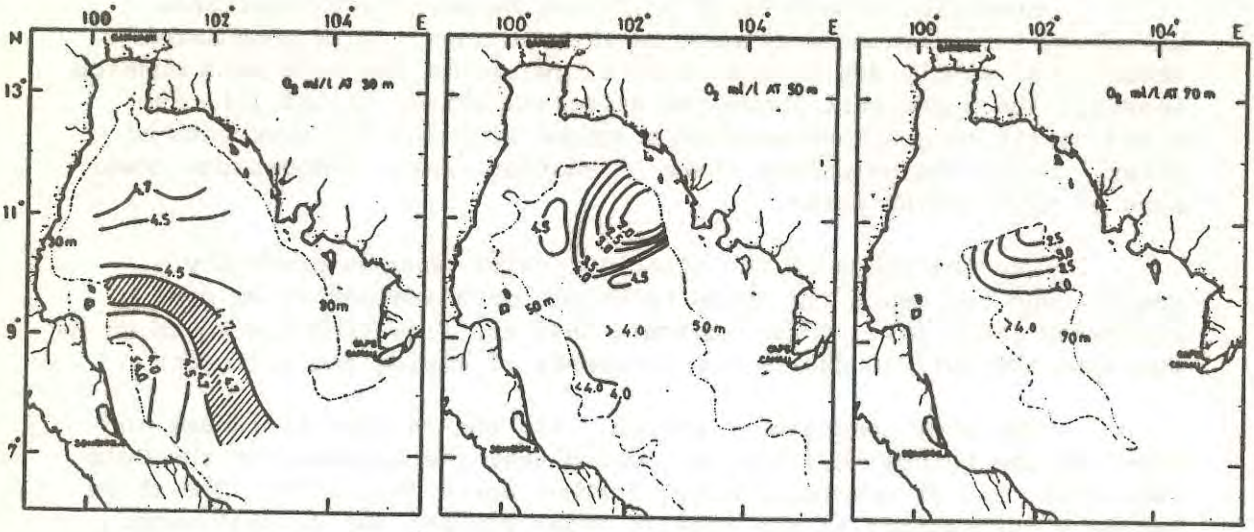

Fig. 16. Horizontal distribution of the dissolved oxygen (ml/L) at 30, 50 and 70 m depth, in May and June 1984.

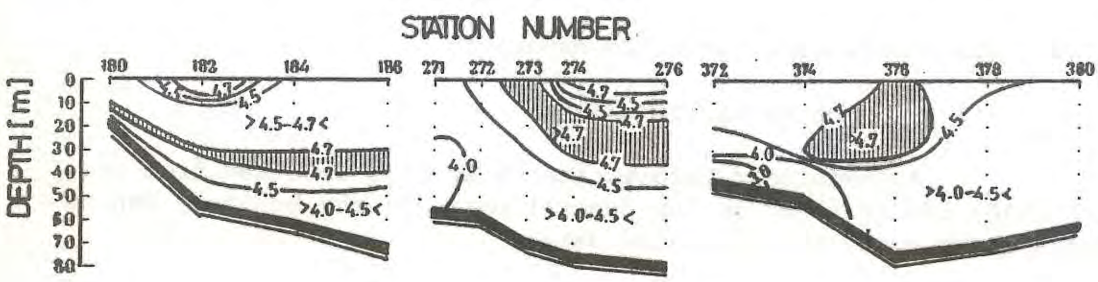

Fig. 17. Vertical profile of dissolved oxygen (ml/L) for three sections in the Gulf, in May and June 1984.

As shown in Figs. 16 and 17, the position of the intruding tongue of high concentration of dissolved oxygen (over 4.7 ml/L) at 30 m depth corresponds to the water mass flowing into the Gulf from the South China Sea. The central axis of the dissolved oxygen extends northwestward approaching the Samui Island, and its thickness tends to decrease.

Taking these facts into consideration, we may conclude that, at the time of the survey conducted by the M.V. Paknam in May and June 1984, the high salinity, high concentration of dissolved oxygen and relatively cool (Table 3) water which came from the South China Sea flowed into the Gulf along the west coast of the Malay Peninsula.

(ii) Vertical distribution

During the survey period, the difference of dissolved oxygen content was not clearly distinguishable between the upper and the lower layers in the central Gulf. Although most of the bottom layer was covered with a high concentration of dissolved oxygen (more than 4.0 ml/L), we observed a low oxygen layer (less than 4.0 ml/L) near the bottom in the corner of the northeast part of the central Gulf. The location is shown in Fig. 16. This occurrence is attributed to the fact that the water exchange between the upper and the lower layers virtually ceases due to stagnant water near the bottom, so that dissolved air does not reach the bottom layer. However, this phenomenon is not confined to the same place all the time. Water movement is subject to variations with the times.

5. Relation between the Production of Shellfish in the Gulf and the Amount of Rainfall in Bangkok

It is well known that fluctuations of the environmental, oceanographic and the meteorological conditions have an influence upon the shellfish fisheries in coastal waters. Owing to a lack of long-range survey records and the complexity of the problems, the research on those inter-relationships has been very scarce in Thailand. We have therefore planned to examine and discuss the fluctuations in shellfish production in the Gulf from 1965 to 1977 in relation to the rainfall in Bangkok, on the basis of the records published in 1977 by the Climatological Division of the Meteorological Department and the Department of Fisheries, Thailand.

The figures pertaining to the yearly production of shellfish and the amount of rainfall are listed in Tables 4 and 5.

From Fig. 18, we can recognize a positive correlation between the shellfish production and the preciptations.

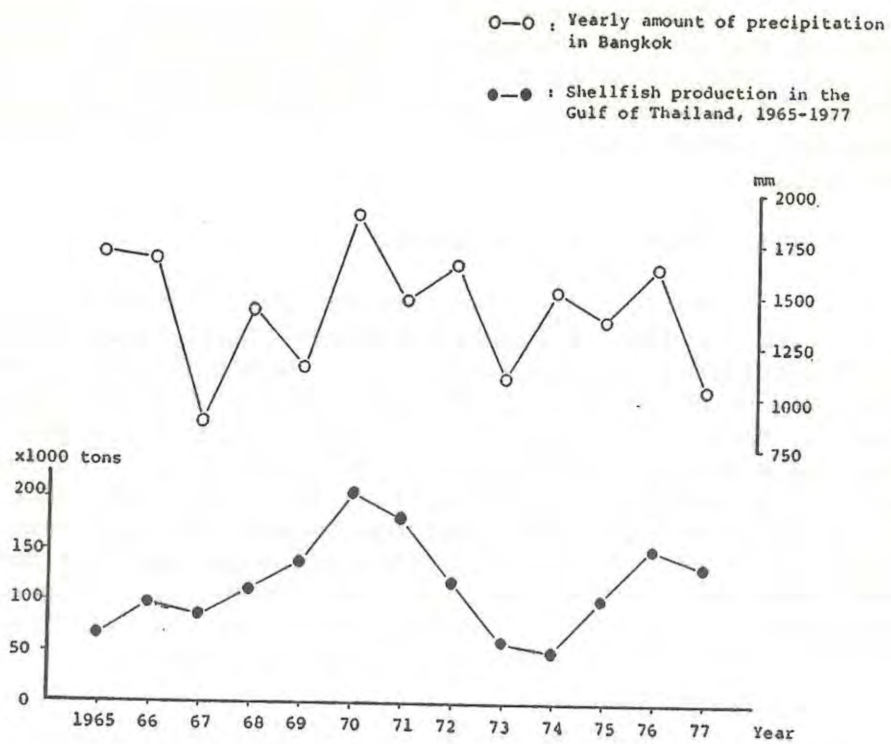

Fig. 18. Relation between the rainfall in Bangkok and the shellfish production in the Gulf, 1965-77 (data) from the Meteorological Dept. and Dept. of Fisheries, Thailand, in 1977).

A marked decline of production in 1967, 1973 and 1977, corresponds to the extremely low rainfall in those years. A poor production in 1974 is probably due to the severe damage suffered by the industry in the previous year, from which it could not recover immediately.

Menasveta (1980)[12] reported that the major contribution to the production of shellfish from the Gulf came from green mussel (*Mytiluss* spp.). This species accounted for 61 per cent of the total production in 1977.

The green mussels are mainly cultivated in the estuary areas of the Bight of Bangkok off Chon Buri and Samut Songkhram. Topographically those areas have the character of being shallow bays. The fresh water flows into the areas from the Bung Pakong and the Mae Klong rivers respectively.

In semi-closed waters, the environmental conditions such as salinity, nutrient salts and phytoplankton, are governed by the amount of inflow from the river.

The fluctuation of phytoplankton biomass and the organic matter which serves as food for the green mussel may be dominant influences on the spawning, survival of larvae, growth and ultimately on the fluctuation of the production.

It can, therefore, be concluded that a reduced discharge from the river into the Gulf will cause, in the same or in the following year, poor feeding conditions for shellfish larvae. This in turn means reduced numbers of market-sized shellfish and ultimately a bad year for the shellfish industry.

SUMMARY

This paper discusses the fisheries oceanographic conditions of waters in the Gulf of Thailand, especially the central part, mainly on the basis of data collected by the Thai-SEAFDEC joint survey from 16 May to 9 June, 1984. The findings can be summarized as follows:

(1) The distribution of demersal fish, red snapper and yellowstrip trevally, varied with the depth;

(2) The grain size distribution of sediment in the central part was divided into three types according to the mud content. The finest particle sediments were found in the vicinity of Samui Island;

(3) The organic matter content of the sediments in the central part was lower than in Ban Bung Pakong fishing ground;

(4) The COD levels of sediments were less than 20 mg/g at most survey stations and the total sulfides were below the limit of detection;

(5) Stocks of fishes migrating from the South China Sea into the Gulf seemed to fluctuate in accordance with the movements of branches entering into the Gulf from the South China Sea;

(6) The oceanic fronts were formed at the surface layer in the vicinity of Samui Island;

(7) A small-scale temperature inversion was found near the region of oceanic boundary in the central Gulf. Large frequencies of the layer were formed at the depth from 30 to 50 m;

(8) Remarkable halocline layers were observed in the central part of the Gulf. Their thickness decreased gradually and the depth tended to become more shallow in northward direction;

(9) A water mass with a high concentration of dissolved oxygen extended northwest-ward from the mouth of the Gulf. Most of the bottom water contained more than 4.0 ml.L;

(10) We found a positive correlation between the production of shellfish in the Gulf and the amount of rainfall in Bangkok from 1965 to 1977.

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We are grateful to Dr. Veravat Hongskul, the Secretary-General, and Mr. Kazuo Inoue, the Deputy Secretary-General of SEAFDEC for their critical reading and useful suggestions.

We also feel a particular debt to all the research secientists who worked with us on board M.V. Paknam.

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TABLES 2 - 5

Table 2. Record of useful fishes in trawl catches collected by the Thai-SEAFDEC Joint Survey, May - June 1984.

Unit Kg.

Bottom Trawl net No.	T1		T2		T3		T4		T5		T6		T7		T8		T9		T10		T11	
Date	18/5/84		21/5/84		21/5/84		21/5/84		2/6/84		2/6/84		3/6/84		5/6/84		6/6/84		7/6/84		8/6/84	
Position Lat. N	10°-21'.96		9°-38'.2		9°-28'.9		9°-23'.8		08°-42'.5		09°-03'.0		09°-24'.7		9°-33'.4		11°-08'.4		10°-04'.6		11°-05'.2	
Position Long. E	10°-36'.38		101°-34'.4		101°-34'.3		101°33'.5		101°-09'.3		100°-48'.6		100°-47'.7		100°-38'.2		100°-24'.0		100°-16'.3		100°-09'.1	
SET DEPTH	70		70-71		70		71		51		40		46		50		51		53		49	
OPERATION TIME (MIN)	118		120		120		120		80		150		120		120		120		107		120	
GRAND TOTAL (Kg.)	309.59		66.562		330.495		311.620		140.122		1204.956		263.958		238.558		350.128		177.760		217.622	
SPECIES COMPOSITION	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.	wt.	No.
1. *Abalistes stellaris*	1.74	7			0.16	1	3.58	7													0.326	
2. *Alepes melanoptera*					0.14	1	0.68	4			0.61	5	0.55	4	0.86	6	0.16	2			0.044	1
3. *Alutera monoceros*			0.56	2			0.72	5													0.41	1
4. *Alutera venosus*											6.5	29										
5. *Atule mate*							0.94	5	0.326	2	8.0	76	5.0	43	1.324	12	1.754	17	6.2	111	2.996	28
6. *Caesio chrysozona*	5.0	314																				

Prepared by : Somnuk Pornpatimakorn
and Weera Pakaphunt

Table 2. (cont'd)

Unit Kg.

SPECIES COMPOSITION	T1 wt.	T1 No.	T2 wt.	T2 No.	T3 wt.	T3 No.	T4 wt.	T4 No.	T5 wt.	T5 No.	T6 wt.	T6 No.	T7 wt.	T7 No.	T8 wt.	T8 No.	T9 wt.	T9 No.	T10 wt.	T10 No.	T11 wt.	T11 No.
20. *L. nebulosus*							0.93	4														
21. *Lutjanus argentimaiaculatus*											3.6	1										
22. *L. artiforntalis*							6.5	7	2.5	6												
23. *L. lineolatus*	0.38	9					1.0	10			0.36	4					1.28	5	0.688	13		
24. *L. lutjanus*					0.19	2	1.57	10			0.12	1			3.6	88						
25. *L. malabarbicus*									10.5	22	0.4	1	0.14	2								
26. *L. russelli*													0.558	1								
27. *L. sebae*					0.5	1	5.0	2	0.506	1												
28. *L. sanguineus*	3.0	1			2.2	4																
29. *L. vitta*			0.45	2	0.3	2					0.12	1	0.56	2								
30. *Nemipterus bleekeri*	6.5	86	1.32	23	6.5	77	6.0	60														
31. *N. hexodon*									1.336	14	2.5	28	1.6	25	1.798	22	3.127	34	0.474	6	2.948	32
32. *N. japonicus*											0.21	2	2.5	20	1.616	16			0.792	19		

Red snapper : *Lutjanus sanguineus*

Threadfin bream : *Nemipterus bleekeri*

Threadfin bream : *Nemipterus hexodon*

Table 3. Data of hydrographic survey in the central Gulf of Thailand, May - June 1984.

Thai-SEAFDEC Joint Survey

St. No.	75	77	79	81	106	108	110	112	140	142	144	146
Lat. N	11°-07.'8	11°-07.'4	11°-04.'8	11°-06.'6	10°-37.'2	10°-35.'0	10°-37.'2	10°-36.'8	10°-07.'5	10°-06.'9	10°-03.'8	10°-01.'4
Long. E	100°-22.'4	100°-52.'6	101°-24.'0	101°-53.'1	100°-36.'8	101°-06.'5	101°-37.'4	102°-07.'5	100°-22.'7	100°-52.'0	101°-24.'2	101°-47.'4
Depth (m)	48.5	55	60	58	58.5	64	65	65	54	64	68	72
Date	6/6	8/6	17/5	17/5	6/6	7/6	18/5	18/5	5/6	6/6	19/5	19/5
Time, Start	1558	1120	0605	1245	1050	0550	1221	0653	1838	0605	0701	1050
Transparency (m)	21	22	22	21	23	20	16	25	-	23	21	21
Temperature (°C) 1 m	29.94	29.92	30.38	30.38	30.02	29.78	30.32	30.16	30.11	29.94	30.24	30.29
10	29.26	29.26	30.26	30.24	30.01	29.85	30.28	30.10	29.96	29.28	30.19	30.30
20	29.91	29.92	30.20	30.06	29.92	29.80	30.13	29.94	29.74	29.92	30.18	29.59
30	29.89	29.71	30.06	29.94	29.88	29.80	30.01	29.93	29.80	29.82	30.03	29.75
35	29.87	29.90	29.50	29.39	29.86	29.80	29.43	28.90	30.31	29.80	30.05	28.85
40	29.89	29.95	28.30	28.46	29.84	29.82	28.78	28.41	29.31	29.31	29.17	28.33
45	29.05	29.96	27.83	28.24	29.89	29.69	28.00	27.85	27.67	29.70	28.63	28.92
50		29.50	27.85	28.23	29.72	28.69	28.05	26.96	27.60	27.57	26.42	28.45
55		28.54	27.90	28.34	28.02	26.89	27.00	26.83		27.32	26.47	28.13
60			27.95			26.81	26.94	26.91		27.54	26.53	26.50
65							26.85	26.65				26.58
70												
Bottom	29.00			28.40	27.96	26.82				27.54	26.45	26.38

Table 3. (cont'd)

St. No.	180	182	184	186	221	223	226	228	271	272	273	274
Lat. N	09°-37'.5	09°-40'.7	09°-32'.8	09°-35'.4	09°06'.9	09°-07'.9	09°-07'.5	09°-07'.3	08°-37'.4	08°-38'.2	08°-38'.2	08°-38'.0
Long. E	100°-04'.7	100°-37'.7	101°-07'.4	101°-38'.2	100°-23'.2	100°-52'.0	101°-37'.1	102°-07'.6	101°-09'.5	101°-22'.4	101°-36'.7	101°-53'.5
Depth (m)	16	50	58	68	30	39	67	70	53	50	65	70
Date	4/6	5/6	3/6	20/5	5/6	2/6	20/5	20/5	2/6	22/5	22/5	22/5
Time, Start	0955	1424	1345	0700	0655	1841	1115	1551	0700	1750	1521	1210
Transparency (m)	2.5	24	25	20	12	26	18	20	21	-	20	18
Temperature (°C) 1 m	30.31	30.60	30.35	30.10	30.26	30.15	30.65	30.50	29.91	Over	31.00	30.70
10	30.10	30.15	29.80	30.10	30.26	30.24	30.58	30.40	29.95	30.46	30.31	30.43
20		30.02	29.71	30.20	30.02	30.13	29.95	30.35	29.95	29.14	29.38	29.20
30		29.44	29.63	28.43	30.02		28.43	29.05	27.20	26.32	26.15	27.78
35		27.66	29.14	29.27			27.90	28.30	26.41	26.21	26.18	26.45
40		27.04	28.63	28.20			27.30	26.88	26.29	26.26	26.14	26.46
45		27.03	27.35	28.14			26.53	26.70	26.29	26.22	26.20	26.41
50		27.00	27.51	27.80			26.48	26.68	26.25	26.25	26.25	26.40
55			27.54	27.40			26.55	26.75			26.19	26.45
60				26.95			26.50	26.70			26.20	26.40
65								26.70			26.19	26.39
70								26.70				26.38
Bottom	30.06		27.50	26.95		27.11	26.48		26.31			

Table 3. (cont'd)

St. No.		276	321	323	325	327	329	372	374	376	378	380
Lat. N		08°-34'.6	08°-08'.0	08°-07'.5	08°-07'.7	08°-08'.1	08°-07'.7	07°-40'.0	07°-38'.2	07°-39'.7	07°-36'.2	07°-37'.6
Long. E		102°-16'.0	100°-22'.3	101°-22'.3	101°-53'.4	102°-23'.1	102°-53'.8	101°-06'.0	101°-36'.8	102°-07'.9	102°-37'.9	105°-07'.0
Depth (m)		75	26	49	71	71	65	40	46	70	66	59
Date		22/5	24/5	1/6	1/6	23/5	23/5	24/5	28/5	28/5	25/5	25/5
Time, Start		0736	0900	1321	1752	2115	0630	1734	1633	1200	0631	1702
Transparency (m)		20	6	22	-	-	17	11	21	21	20	17
Temperature (°C)	1 m	30.17	30.39	30.36	30.31	30.25	30.18	30.46	30.25	30.13	30.43	30.21
	10	30.15	30.38	30.14	30.35	30.30	30.14	30.31	30.28	30.08	30.44	30.25
	20	30.40	30.32	30.03	30.17	30.24	29.70	30.24	30.20	30.02	30.39	30.21
	30	27.10		28.65	28.44	28.56	26.79	28.86	30.16	29.80	28.69	28.87
	35	26.98		28.35	28.30	26.98	26.69	28.73	28.94	28.22	28.46	26.84
	40	26.90		27.46	26.58	26.78	26.93	28.76	26.93	27.44	27.85	26.83
	45	26.73		26.45	26.58	26.70	26.69			26.98	27.14	26.77
	50	26.68			26.52	26.71	26.68			26.87	27.27	26.76
	55	26.68			26.51	26.76	26.75			26.75	27.22	26.81
	60	26.75			26.52	26.71	26.70			26.70	26.15	
	65	26.68			26.52	26.72	26.70			26.70		
	70	26.65								26.69		
	Bottom	26.57	30.12	26.41	26.54	26.72			26.88		27.15	26.78

Table 3. (cont'd)

St. No.		75	77	79	81	106	108	110	112	140	142	144	146
Salinity (‰)	1 m	31.99	32.00	32.07	32.07	31.90	32.08	32.02	32.00	32.19	32.05	32.00	32.02
	10	32.00	31.98	32.08	32.07	32.00	32.07	31.98	31.99	32.20	32.08	32.01	32.04
	20	32.04	32.00	32.01	32.05	31.99	32.07	32.04	32.06	32.10	32.06	32.08	32.14
	30	31.99	31.96	32.01	32.07	32.01	32.09	31.94	32.15	32.18	31.95	32.03	32.04
	35	31.98	31.98	32.00	32.93	32.01	32.08	32.01	33.08	32.23	32.55	32.12	32.13
	40	31.98	31.99	32.00	32.14	32.07	32.05	32.06	32.41	33.42	32.20	32.24	32.74
	45	32.70	31.99	32.43	33.01	32.03	32.09	32.93	32.77	33.64	33.35	32.96	33.71
	50		32.05	32.53	33.12	32.65	32.26	32.81	33.43	33.64	33.66	33.65	33.72
	55		32.26	33.36	33.14	32.79	32.81	33.39	33.48		33.68	33.57	33.72
	60			32.53			33.36	33.39	33.48		33.71	33.61	33.68
	65							33.41	33.52				33.68
	70												
	Bottom	32.15			33.09	32.83	33.37			33.62	33.68	33.58	33.65
DO ml/L (%)	1 m	5.07 (110.11)	4.77 (103.59)	4.67 (102.41)	4.61 (102.15)	5.14 (112.25)	4.42 (96.00)	4.71 (103.33)	4.58 (100.26)	4.46 (97.55)	4.76 (103.57)	4.28 (93.74)	4.39 (96.18)
	10	4.53 (98.63)	3.51 (76.56)	4.69 (102.85)	4.65 (102.06)	4.74 (103.54)	4.48 (97.56)	4.66 (102.12)	4.62 (100.92)	4.74 (103.41)	4.37 (95.46)	4.42 (96.63)	4.36 (95.59)
	20	3.96 (86.07)	4.68 (101.78	4.57 (99.93)	4.73 (103.17)	5.03 (109.43)	4.78 (103.89)	4.75 (103.60)	4.70 (102.35)	4.49 (97.48)	4.42 (96.38)	4.37 (95.92)	4.33 (93.72)
	30	4.78 (103.93)	4.46 (96.83	4.70 (102.66)	4.76 (102.66)	4.66 (103.73)	4.63 (101.74)	4.77 (103.86)	4.46 (93.23)	4.91 (106.67)	4.51 (97.85)	4.51 (98.28)	4.50 (95.68)
	35			4.61 (99.57)	4.74 (102.60)			4.99 (107.69)	4.58 (97.82)			4.49 (98.18)	4.38 (93.53)
	40	4.45 (96.63)	3.43 (74.73)	4.49 (94.88)	4.37 (92.76)	4.63 (100.54)	4.59 (99.54)	4.94 (105.33)	3.38 (81.17)	4.56 (98.92)	3.96 (85.16)	4.23 (90.95)	3.52 (74.62)
	45			3.57 (75.04)	2.49 (52.78)			4.29 (90.42)	3.47 (72.97)			3.37 (72.09)	4.46 (96.29)
	50		4.55 (98.27)	3.39 (71.39)	2.22 (47.20)	4.75 (103.44)	4.49 (95.76)	3.22 (68.10)	2.09 (43.58)	4.38 (92.32)	4.39 (92.57)	3.30 (68.12)	4.69 (100.39)
	55		4.03 (85.61)	3.02 (63.96)	2.90 (61.59)			2.70 (56.25)	2.58 (53.46)			3.31 (68.41)	4.55 (96.72)
	60			3.29 (69.31)			3.43 (71.06)	2.55 (52.97)	2.52 (52.41)		4.20 (88.57)	3.31 (68.41)	3.65 (75.33)
	65							2.76 (57.30)	2.67 (55.20)				3.51 (72.71)
	70												
	Bottom	4.50 (96.45)			1.90 (40.32)	3.80 (80.06)	3.43 (70.06)			4.33 (91.61)	4.62 (97.24)	3.27 (67.48)	3.70 (76.23)

Table 3. (cont'd)

St. No.		180	182	184	186	221	223	226	228	271	272	273	274
Salinity (‰)	1 m	32.02	32.32	32.20	32.04	31.91	32.24	31.99	32.27	31.95	32.04	32.17	32.27
	10	32.02	32.29	32.19	31.98	31.98	32.24	32.02	32.30	32.00	32.09	32.10	32.54
	20		32.29	32.17	32.16	32.02	32.29	32.00	broken	32.01	33.30	33.16	33.70
	30		33.30	33.55	33.63	32.00	33.60	33.65	33.57	33.36	33.74	33.67	33.57
	35		33.67	33.53	33.75		33.62	33.70	33.45	33.62	33.68	33.66	33.83
	40		33.74	33.59	33.78			33.80	33.78	33.68	33.69	33.65	33.82
	45		33.76	33.76	33.77			33.83	33.86	33.66	33.53	33.52	33.76
	50		33.76	33.43	33.80			33.83	33.88	33.66	33.68	33.54	33.86
	55			33.76	33.80			33.80	33.85			33.72	33.83
	60				33.71			33.82	33.89			33.59	33.65
	65								33.84			33.66	33.78
	70								33.59				33.78
	Bottom	32.01		33.76	33.80		33.63	33.77		33.68			
DO ml/L (%)	1 m	4.43 (97.15)	4.89 (103.75)	4.46 (98.02)	4.61 (100.63)	4.79 (105.04)	4.35 (95.44)	4.43 (97.81)	4.51 (99.25)	4.38 (95.26)	4.58 (-)	4.77 (106.07)	4.73 (104.65)
	10	4.71 (102.84)	4.85 (106.45)	4.57 (99.26)	4.67 (102.05)	4.00 (87.76)	4.31 (94.56)	4.52 (99.45)	4.62 (101.49)	4.45 (97.07)	4.63 (102.03)	4.75 (104.33)	4.54 (100.09)
	20		4.48 (97.88)	4.52 (97.98)	4.60 (100.79)	4.55 (99.22)	4.32 (94.49)	4.95 (107.82)	4.56 (-)	4.28 (93.45)	4.40 (94.99)	4.34 (94.23)	5.60 (121.76)
	30		4.83 (104.77)	4.69 (102.67)	4.77 (101.92)	4.64 (101.02	4.06 (84.80)	4.85 (103.68)	5.28 (114.20)	3.45 (72.26)	4.27 (87.80)	4.55 (93.60)	5.19 (109.70)
	35		4.09 (86.36)	4.72 (102.19)	4.76 (103.37)		4.02 (83.34)	4.94 (104.66)	4.82 (102.47)	3.99 (82.35)	4.24 (87.18)	4.40 (90.62)	4.40 (91.01)
	40		4.58 (95.51)	4.61 (98.86)	4.83 (102.88)			4.86 (101.91)	4.67 (97.23)	3.84 (79.03)	4.45 (91.46)	4.22 (86.74)	4.54 (93.98)
	45		4.46 (93.01)	4.32 (90.82)	4.75 (101.15)			4.08 (84.53)	4.24 (87.88)	3.83 (78.70)	4.20 (86.38)	4.31 (88.66)	4.54 (93.51)
	50		4.34 (90.67)	4.20 (88.15)	4.33 (91.46)			4.64 (96.02)	4.34 (90.31)	3.87 (79.71)	4.21 (86.63)	4.42 (90.93)	4.63 (95.55)
	55			4.23 (89.14)	4.41 (92.67)			4.05 (84.02)	4.15 (86.24)			4.32 (88.85)	4.62 (95.41)
	60				4.30 (89.73)			4.10 (84.89)	4.23 (87.88)			4.46 (91.71)	4.86 (100.21)
	65								4.23 (87.76)			4.24 (87.16)	4.62 (95.34)
	70								4.17 (86.41)				4.40 (90.72)
	Bottom	4.36 (95.28)		4.18 (88.16	4.23 (88.25)		3.94 (81.83)	3.98 (82.46)		3.95 (81.26)			

Table 3. (cont'd)

St. No.		276	321	323	325	327	329	372	374	376	378	380
Salinity (‰)	1 m	32.50	31.98	32.00	32.04	32.18	32.09	31.90	31.95	31.98	32.01	32.03
	10	32.56	32.09	31.92	32.06	32.13	32.16	31.89	31.96	31.98	32.01	32.02
	20	32.89	32.11	31.93	32.11	32.21	33.24	31.90	31.94	31.99	32.02	32.01
	30	33.52		32.44	32.49	33.67	33.74	32.24	31.94	32.59	33.01	32.50
	35	33.67		32.84	33.31	33.68	33.68	32.38	32.38	32.87	33.06	33.71
	40	33.80		33.46	33.67	33.73	33.70	32.19	33.55	33.47	33.27	33.73
	45	33.45		33.66	33.72	33.80	33.71			33.66	33.60	33.73
	50	33.72			33.69	33.81	33.97			33.68	33.62	33.74
	55	33.73			33.76	33.83	33.68			33.74	33.59	33.73
	60	33.74			33.74	33.80	33.59			33.74	33.66	
	65	33.82			33.75	33.86	33.73			33.73		
	70	33.78								33.69		
	Bottom	33.82	32.08	33.66	33.72	33.81			33.55		33.68	33.74
DO ml/L (%)	1 m	4.89 (107.36)	4.27 (93.62)	4.30 (94.21)	4.45 (97.54)	4.34 (95.27)	4.53 (99.39)	4.45 (97.82)	4.55 (99.85)	4.72 (103.08)	4.40 (96.40)	4.52 (98.95)
	10	4.53 (99.60)	4.37 (95.83)	4.49 (98.12)	4.40 (96.70)	4.47 (98.29)	4.60 (100.68)	4.49 (98.36)	4.64 (101.78)	4.98 (108.65)	4.43 (97.04)	4.42 (96.93)
	20	5.31 (117.11)	4.43 (97.34)	4.44 (96.67)	4.39 (96.18)	4.45 (97.61)	5.00 (109.10)	4.49 (98.18)	4.61 (100.83)	4.65 (101.22)	4.41 (96.60)	4.50 (98.47)
	30	5.04 (105.24)		4.14 (88.50)	3.86 (82.02)	5.18 (111.05)	4.58 (95.20)	4.28 (91.54)	4.77 (104.42)	4.67 (101.68)	3.54 (75.85)	4.48 (95.89)
	35	5.05 (105.19)		3.50 (74.55)	3.98 (84.72)	4.80 (99.90)	4.52 (93.82)	-	4.43 (94.68)	4.16 (88.18)	4.09 (87.23)	4.36 (90.73)
	40	4.69 (97.79)		3.75 (78.68)	3.92 (81.24)	4.61 (95.88)	4.43 (91.87)	2.93 (62.37)	3.84 (79.73)	4.21 (88.18)	4.07 (85.93)	4.38 (91.04)
	45	4.50 (93.08)		3.81 (78.72)	4.04 (83.71)	4.31 (89.60)	4.39 (91.12)			4.21 (87.60)	4.06 (84.80)	4.39 (91.29)
	50	4.41 (91.51)			4.00 (82.90)	4.44 (92.29)	4.26 (88.57)			4.16 (86.57)	4.08 (85.25)	4.32 (89.71)
	55	4.47 (92.72)			4.01 (83.06)	4.26 (88.48)	4.52 (93.80)			4.16 (86.55)	4.07 (85.13)	4.31 (89.56)
	60	4.51 (93.66)			4.06 (83.95)	4.38 (91.14)	4.48 (92.90)			4.16 (86.53)	4.07 (85.13)	
	65	4.44 (92.14)			4.07 (84.16)	4.47 (92.85)	4.30 (89.27)			4.29 (89.11)		
	70	4.42 (91.74)								4.18 (86.90)		
	Bottom	4.49 (92.98)	4.18 (91.22)	3.75 (77.38)	3.96 (82.03)	4.44 (92.39)			3.93 (81.64)		4.02 (84.06)	4.31 (89.58)

Table 3. (cont'd)

St. No.		75	77	79	81	106	108	110	112	140	142	144	146
Silicate-Si (μg-at/L)	1 m	17.5	10.0	13.5	7.5	6.0	29.0	19.0	10.0	10.0	13.5	12.0	14.0
	30	16.0	10.0	9.5	11.5	10.0	10.0	12.0	13.5	13.5	8.0	8.0	14.0
	Bottom	12.0	12.0	3.5	21.5	14.0	17.5	23.5	25.0	14.0	11.0	18.5	13.5
Phosphate-P (μg-at/L)	1 m	ND	ND	.11	ND	ND	.05	.26	.90	.05	.11	.11	.05
	30	ND	.05	.05	ND	ND	.32	.11	.11	ND	ND	.05	.11
	Bottom	.05	.11	.16	.32	.11	.47	.53	1.00	.11	.16	.53	.32
Nitrite-N (μg-at/L)	1 m	.025	.025	ND	.046	ND	.025	ND	ND	ND	.045	ND	ND
	30	.025	ND	ND	.065	.025	ND	ND	ND	ND	.025	ND	.045
	Bottom	.025	.025	.33	.35	.28	.40	.15	.15	.09	.25	.26	.25
Grain size (mm)	< 0.05	50.16	84.00	90.34	81.60	79.22	74.10	65.20	75.44	91.00	93.52	72.56	70.66
	0.05 - 0.2	44.60	13.60	8.80	※13.30	18.66	24.16	※25.04	※18.00	7.20	5.40	18.30	25.38
	0.20 - 0.5	4.76	2.10	0.34	1.94	1.55	2.74	6.26	4.20	1.12	0.80	8.06	3.29
	0.50 - 1.0	0.30	0.14	0.34	1.36	0.33	0.54	1.46	1.20	0.08	0.20	1.00	0.55
	1.00 - 3.0	0.18	0.16	0.18	1.40	0.24	0.36	1.74	0.84	0.60	0.08	0.08	0.12
	> 3.00	-	-	-	0.40	-	0.10	0.30	0.32	-	-	-	-
Ignited loss	550°C (%)	4.99	7.59	7.89	7.29	6.33	6.20	6.04	4.97	10.79	7.88	5.94	6.55
	950°C (%)	11.28	13.88	15.26	16.47	15.38	14.88	13.74	15.35	16.83	15.22	16.86	16.70
COD (mg/g)		5.56	9.77	11.21	8.37	7.68	4.96	3.30	8.48	13.63	11.00	6.13	7.06
Chlorophyll-a (surface) (μg/L)		0.1020	0.1635	0.1683	0.1020	0.1020	0.2037	0.1374	0.0446	0.1374	0.1326	0.1323	0.1020
Total sulfide (mg/g)		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

Note
< 0.05 : Mud
0.05 - 0.20 : Fine sand
0.20 - 3.00 : Shell fragments
> 3.00 : Shell gravel
※ : mixed with shell fragments

Table 3. (cont'd)

St. No.		180	182	184	186	221	223	226	228	271	272	273	274
Silicate-Si (μg-at/L)	1 m	12.0	13.0	15.5	12.0	13.0	10.5	15.5	0.5	11.0	8.0	10.0	9.5
	30		13.0	10.5	15.5	10.0	10.5	11.0	5.5	18.5	17.0	15.0	12.5
	Bottom	10.0	12.0	9.5	13.5		9.5	16.5	3.5	12.0	16.5	16.0	12.5
Phosphate-P (μg-at/L)	1 m	.05	ND	.11	ND	ND	ND	.11	ND	.05	.05	ND	ND
	30		ND	ND	ND	ND	.11	.05	.05	.42	.16	.05	.05
	Bottom	ND	.05	.16	.38		.38	.11	.11	.16	.42	.32	.26
Nitrite-N (μg-at/L)	1 m	.025	.045	.09	ND	ND	ND	.025	ND	ND	.025	ND	ND
	30		ND	ND	.025	ND	.045	.025	.045	ND	.25	.045	.045
	Bottom	.025	.20	.028	.25		.045	.20	.35	.44	.35	.40	.40
Grain size (mm)	< 0.05	93.25	93.92	86.75	66.16	89.75	70.76	68.74	58.84	96.32	81.56	81.20	62.56
	0.05 - 0.2	4.60	4.60	9.07	※27.16	9.78	20.76	※26.70	※32.96	2.64	※13.44	15.60	※29.56
	0.20 - 0.5	1.90	1.24	4.11	3.44	0.41	6.70	2.60	3.76	0.68	3.56	2.36	6.34
	0.50 - 1.0	0.10	0.16	0.07	1.16	0.06	0.70	0.80	1.48	0.34	0.84	0.60	1.10
	1.00 - 3.0	0.15	0.08	-	0.80	-	0.50	0.96	0.80	0.02	0.56	0.24	0.36
	> 3.00	-	-	-	0.04	-	0.10	0.20	0.16	-	0.04	-	0.08
Ignited loss	550°C (%)	8.67	9.97	6.11	4.78	7.37	7.16	4.75	4.26	7.35	6.36	6.87	5.98
	950°C (%)	15.33	15.76	13.74	14.34	11.80	14.09	12.87	13.57	11.61	13.82	15.56	15.79
COD (mg/g)		21.55	12.43	8.42	2.65	8.32	8.09	3.70	3.28	6.96	5.23	8.49	5.27
Chlorophylla-a (surface) (μg/L)		0.8763	0.1020	0.1374	0.1683	0.1635	0.0666	0.0972	0.1683	0.1374	0.0711	0.0711	0.0972
Total sulfide (mg/g)		1.49	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

<u>Note</u>

< 0.05 : Mud

0.05 - 0.20 : Fine sand

0.20 - 3.00 : Shell fragments

> 3.00 : Shell gravel

※ : mixed with shell fragments

Table 3. (cont'd)

St. No.	276	321	323	325	327	329	372	374	376	378	380
Silicate-Si (µg-at/L) 1 m	16.5	13.5	20.0	14.0	15.5	18.0	10.5	13.0	16.0	14.5	14.0
30	15.5		19.0	14.0	11.0	13.5	21.0	15.5	14.0	16.0	15.5
Bottom	13.5	16.5	12.5	14.0	12.5	12.5	15.0	14.0	8.0	20.0	11.0
Phosphate-P (µg-at/L) 1 m	.05	.05	.32	.05	ND	ND	ND	ND	.11	.11	ND
30	.11		.05	.11	ND	.05	ND	.32	4.07	ND	ND
Bottom	.11	ND	.26	.32	.11	.11	ND	ND	.42	.11	.47
Nitrite-N (µg-at/L) 1 m	ND	ND	.025	ND	ND	ND	ND	.065	.025	ND	ND
30	ND		.065	ND	ND	ND	.045	.25	.09	ND	ND
Bottom	.40	.025	.44	.60	.26	.045	ND	.025	.96	.13	ND
Grain size (mm) < 0.05	72.10	53.18	85.40	53.80	80.50	96.00	94.25	76.60	94.97	64.93	76.25
0.05 - 0.2	22.30	※ 24.56	13.30	※ 39.76	※ 15.40	1.68	4.30	※ 11.26	4.15	23.73	※ 12.93
0.20 - 0.5	5.40	10.60	0.90	4.40	1.50	1.84	0.60	6.60	0.45	10.40	9.45
0.50 - 1.0	0.16	5.30	0.10	1.16	0.86	0.20	0.30	2.74	0.25	0.60	1.05
1.00 - 3.0	0.04	6.10	0.20	0.74	1.74	0.28	0.55	1.74	0.18	0.34	0.32
> 3.00	-	0.26	0.10	0.10	-	-	-	1.08	-	-	-
Ignited loss 550°C (%)	6.88	4.52	2.92	4.81	8.13	9.94	6.94	5.28	7.14	8.12	8.85
950°C (%)	16.93	15.22	7.63	12.88	15.27	15.22	12.08	16.90	14.02	13.17	15.55
COD (mg/g)	5.38	3.90	1.30	5.96	7.84	5.19	7.87	3.10	7.39	7.56	8.85
Chlorophyll-a (surface) (µg/L)	0.1323	0.6114	0.0969	0.1989	0.1326	0.1683	0.1635	0.1323	0.2034	0.1683	0.1635
Total sulfide (mg/g)	ND	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND

<u>Note</u>

< 0.05 : Mud

0.05 - 0.20 : Fine sand

3.00 : Shell fragment

> 3.00 : Shell gravel

※ : mixed with shell fragment

Table 4. Monthly rainfall in Bangkok, 1965-77.

BANGKOK
L 13° 44'.0 N
λ 100° 30'.0 E

Source : The Climatological Division of Meteorological Department, Thailand

(unit : mm)

Month / Year	JAN	FEB	MAR	APR	MAY	JUN	JULY	AUG	SEPT	OCT	NOV	DEC	Year
1965	0.4	125.4	2.6	66.2	264.7	96.0	83.1	188.7	553.4	277.5	26.3	18.3	(1,702.6)
1966	0.0	35.2	1.3	72.0	380.8	214.6	341.1	156.9	257.4	191.3	4.2	39.2	1,667.3
1967	6.3	0.0	4.2	67.6	235.9	28.0	114.7	121.0	165.1	96.5	36.2	0.0	875.5
1968	4.6	51.2	0.4	124.7	124.4	180.1	173.7	269.7	293.7	166.4	31.5	0.0	1,420.4
1969	38.5	0.1	15.2	12.0	68.6	280	78.0	95.6	292.8	159.0	93.6	1.6	1,135.0
1970	1.2	68.2	44.6	157.5	283.0	301.1	189.6	144.3	355.2	187.3	50.4	103.2	1,885.6
1971	0.0	28.1	11.0	31.1	236.3	82.2	178.9	352.1	383.2	177.4	2.8	0.8	1,483.9
1972	0.0	19.9	18.8	146.9	55.1	127.8	69.5	157.0	676.3	237.9	88.4	54.7	1,652.3
1973	0.0	0.0	102.6	5.6	157.5	131.9	68.5	97.3	364.7	113.8	36.8	11.2	1,090.0
1974	0.7	0.0	10.2	130.2	179.2	82.3	129.9	160.9	219.7	471.2	134.8	0.0	1,519.1
1975	38.1	1.0	32.4	3.9	186.2	100.7	174.8	323.7	211.5	261.5	35.0	9.0	1,377.8
1976	0.0	52.2	1.8	55.1	409.6	72.5	283.0	247.6	297.3	198.8	16.8	0.0	1,634.7
1977	27.1	25.7	4.2	28.4	101.3	61.3	113.3	120.7	358.5	135.9	59.8	3.9	1,040.1
Average	8.99	31.31	19.18	69.32	206.35	135.27	151.65	187.35	340.68	205.73	47.43	18.61	

Table 5. Production of shellfish in the Gulf, 1965-77.

(in metric tons)

Year	Production
1965	66,939
1966	98,808
1967	86,063
1968	112,164
1969	139,860
1970	207,987
1971	181,019
1972	118,081
1973	60,242
1974	50,468
1975	102,891
1976	151,443
1977	133,203

Source: Department of Fisheries, Thailand, 1977.