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CONTENTS

Page

INTRODUCTION

The present paper is the result of an analysis of the chronological changes as well as the current situation of landings and CPUE of invertebrate resources in Thailand. Economically the most important groups of invertebrates are shrimps, squids and cuttlefishes, which are caught not only for local consumption, but also for export. We have, therefore, given special attention to these three groups of marine catches.

The first part of this paper contains a description of the general situation of landings of marine invertebrates in the Gulf of Thailand, based on the catch data collected by the Statistics Section of the Department of Fisheries, Thailand.

The second part is a close study of annual and monthly changes in stock density (CPUE) of economically important species and groups of species of invertebrates. The main purpose of this paper is to compare the landings data and the CPUE data, so as to clarify the current status of invertebrate fisheries in the Gulf of Thailand.

The present paper is descriptive rather than analytical; however, the information given here is, we believe, indispensable for any future close study of the population dynamics of invertebrate fisheries.

We should like to thank Mr. Kian Sinanuwong and Mrs. Mala Supongpan who made useful suggestions concerning this study.

MATERIALS AND METHODS

1. Landings data

The landings data were collected and processed by the Fisheries Statistics Unit of the Department of Fisheries, Thailand. The catch data were classified according to seven major invertebrate groups, namely large-sized shrimps, small-sized shrimps, squids, cuttlefishes, octopus, swimming crabs and Spanish lobster. The annual changes in catch have been tabulated and presented graphically. The biennial increments have also been calculated. The catches of the four commercially most important groups, namely large-sized shrimps, small-sized shrimps, squids and cuttlefishes, were examined with reference to different types of fishing gear also on a biennial basis.

The effort data of the fishing fleet engaged in commercial and subsistence fisheries in the Gulf of Thailand specify the annual number of vessels, classified by type of management.

The fishing grounds for shrimps by otter-board trawlers and for squids and cuttlefishes by otter-board and pair trawlers were investigated on the basis of relative abundance of catch. And finally, stock evaluation was attempted by using MSY estimates.

2. CPUE data

The CPUE (Catch per Unit of Effort) data were collected and processed by the Invertebrate Fisheries Unit, Marine Fisheries Division, Department of Fisheries, Thailand. The survey was conducted on board the research vessels PRAMONG 4 and PRAMONG 5, from 1976 to 1981. The two research vessels have a similar general design and equipment. Both are wooden stern trawlers with an overall length of 23 metres, a displacement of 93 gross tons, and diesel engines of 360 HP. The vessels were operated at 2.5 - 3.0 knots while trawling. An otter trawl of German design was used, with 1 × 2 metre otter-boards, and a polyethylene net, with 20-25 mm mesh cod end. Its head rope and ground rope were 34.80 and 43.90 metres long, respectively.

The identification of species and measuring of body weight of fish were conducted on board ship. The catch was divided into three categories, namely invertebrates, good fish (fish for direct human consumption) and trash fish (fish below the size acceptable at landing fish market). The invertebrates were further divided into crustaceans and cephalopods.

1) Crustaceans

Shrimps were divided into large-sized and small-sized shrimps. Both of them belonged to family PENAEIDAE. Five major genera were identified: *Penaeus*, *Metapenaeus*, *Trachypenaeus*, *Metapenaeopsis* and *Parapenaeopsis*.

One species of Spanish lobster was identified: *Thenus orientalis*.

Two species of swimming crabs were identified, namely *Portunus pelagicus* and *Charybdis feriatus*.

Squillas were identified as *Harpiosquilla harpax*, *Oratosquilla nepa* and *Oratosquilla woodmasoni*.

Horseshoe crabs belonged to the order XIPHOSURA.

2) Cephalopods

Squids were identified as three species of *Loligo* and one species of *Sepioteuthis*.

Cuttlefishes belonged to five species of *Sepia* and one species of *Sepiella*.

Octopuses could not be identified.

The names of identified species of large-sized shrimps, squids and cuttlefishes are listed in Table 1.

Table 1. Scientific, English and Thai names of economically important invertebrates in the Gulf of Thailand

Scientific	English	Thai
Penaeus spp.		
Penaeus merguiensis	Banana prawn	กุ้งแชบ๊วย
Penaeus semisulcatus	Green tiger prawn	กุ้งกุลาลาย
Penaeus latisulcatus	Western king prawn	กุ้งเหลือง
Other *Penaeus* spp.		
Penaeus monodon	Giant tiger prawn	กุ้งกุลาดำ
Penaeus japonicus	Kuruma prawn	กุ้งลายเสือ
Penaeus longistylus	Red-spot king prawn	กุ้งเหลืองจุด
Metapenaeus spp.		
Metapenaeus affinis	Jinga shrimp	กุ้งตะกาด
Metapenaeus ensis	Greasyback shrimp	กุ้งตะกาดกรีฑุด
Metapenaeus intermedius	Middle shrimp	กุ้งตะกาดหางม่วง
Squids		
Loligo duvauceli	Indian squid	หมึกกล้วย, หมึกหลอด
Loligo chinensis	Mitre squid	หมึกกล้วย, หมึกศอก
Loligo uyii	Little squid	หมึกกล้วย, หมึกตะเภา
Sepioteuthis lessoniana	Bigfin reef squid	หมึกหอม
Cuttlefishes		
Sepia pharaonis	Pharaoh cuttlefish	หมึกกระดอง
Sepia recurvirostra	Curvespine cuttlefish	หมึกกระดอง
Sepia aculeata	Needle cuttlefish	หมึกกระดอง
Other cuttlefishes		
Sepia lycidas	Kisslip cuttlefish	หมึกกระดอง
Sepia brevimana	Shortclub cuttlefish	หมึกกระดอง
Sepiella inermis	Spineless cuttlefish	หมึกกระดอง, หมึกกระดองก้นไหม้

Among the shrimps and cephalopods listed in Table 1, six species of shrimps, and six species of squids and cuttlefishes were recognized as economically important species in the Gulf of Thailand.

The coastal waters of the Gulf were divided into nine survey areas and a grid system was adopted, whereby one trawl operation was conducted in each grid of 225 square miles (771.75 Km^2). From 1976 to 1979, random monthly survey operations were carried out at night, between 1800 and 0600 hours, with about eight hauls per area. In 1980 and 1981, however, only four to six operations per area were carried out once every two months. Before data processing, the nine areas were rearranged into five areas in connection with commercial trawl activities.

The unit of fishing effort is one towing hour, and the CPUE (Catch per Unit of Effort) denotes catch in kilograms per hour.

All CPUE data were calculated using the following methods:

1) All demersal catches were categorized into good fish, trash fish, crustaceans and cephalopods, for investigating the share of invertebrates in the overall catch.

2) Four major groups of invertebrates, namely large-sized shrimps, small-sized shrimps, squids and cuttlefishes, were selected from the overall catch for comparison with the commercial catch data.

3) Habitat and distribution of some economically important species of large-sized shrimps were investigated.

4) The major species of squids and cuttlefishes were selected for investigating their habitat and distribution.

The calculated CPUE was arranged for each statistical area on a biennial basis (1976-1981).

Furthermore, as regards the selected species of large-sized shrimps, squids and cuttlefishes, monthly changes in the CPUE in all survey areas were discussed.

The landings and the CPUE data were treated as comparative studies, and the reliability of those data was examined from various aspects of otter-board trawl operation. On the basis of the results derived from the landings and CPUE data analyses, some recommendations were made regarding the current status of invertebrate fisheries by otter-board trawling.

RESULTS AND DISCUSSION

Part I. Landings data

1. General situation of landings of marine invertebrates

In the early days, invertebrate fisheries in the Gulf of Thailand were generally carried out on a small scale, in the coastal waters, mostly by non-powered boats and using traditional gears and methods. After 1961, otter-board trawling began spreading rapidly in the Gulf of Thailand. The annual invertebrate catch by otter-board trawls increased gradually and reached the peak of about 141,000 metric tons or 16.6 per cent of the total marine catch by otter-board trawls in 1978. Since then the production has been decreasing (Table 2).

Table 2. Total marine catch, invertebrate catch, crustacean catch and cephalopod catch (metric tons) by otter-board trawls, 1972-1981

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Average
Total marine catch	788,315	941,120	833,011	744,162	608,059	798,601	850,935	730,706	759,560	724,068	777,854
Invertebrates (%)	90,317 (11.4)	115,681 (12.3)	101,981 (12.2)	99,945 (13.4)	91,966 (15.1)	131,345 (16.4)	140,965 (16.6)	114,922 (15.7)	109,491 (14.4)	110,222 (15.2)	110,683 (14.2)
Crustaceans (%)	55,547 (7.0)	83,026 (8.8)	69,354 (8.3)	66,140 (8.9)	63,132 (10.4)	91,182 (11.4)	91,829 (10.8)	76,990 (10.5)	71,569 (9.4)	74,024 (10.2)	74,279 (9.5)
Cephalopods (%)	34,770 (4.4)	32,655 (3.5)	32,627 (3.9)	33,805 (4.5)	28,834 (4.7)	40,163 (5.0)	49,136 (5.8)	37,932 (5.2)	37,922 (5.0)	36,198 (5.0)	36,404 (4.7)

Invertebrates: Crustaceans and cephalopods only

Cephalopods: Squids and cuttlefishes

During the ten-year period up to 1981, crustacean and cephalopod catches averaged about 74,300 metric tons for crustaceans and 36,400 metric tons for cephalopods, and accounted for about 9.5 per cent and 4.7 per cent respectively of the total annual marine landings by otter-board trawl.

2. Annual changes in landings of invertebrates

Table 3 and Figure 1 show the annual changes in landings of invertebrates in the Gulf of Thailand. Data for seven major groups of invertebrates were analysed, namely large-sized shrimps, small-sized shrimps, squids, cuttlefishes, octopus, Spanish lobster and swimming crabs.

Table 3. Annual changes in catch (metric tons) for seven major groups of invertebrates in the Gulf of Thailand, 1972-1981

	1972		1973		1974		1975		1976		Average		
Code*	Catch	R.I.**	Catch	R.I.	Catch	R.I.	Catch	R.I.	Catch	R.I.	Catch	R.I.	S.D.*** of R.I.
1	15,880	-	26,419	1.66	22,992	0.87	23,343	1.01	19,273	0.82	21,581.4	1.09	0.39
2	38,661	-	55,395	1.43	46,582	0.84	49,216	1.06	54,470	1.11	48,864.8	1.11	0.24
3	42,521	-	30,749	0.72	39,264	1.28	35,198	0.90	33,980	0.96	36,338.4	0.97	0.23
4	22,119	-	18,187	0.82	18,719	1.03	22,975	1.23	21,514	0.94	20,698.8	1.01	0.17
5	4,097	-	1,310	0.32	1,563	1.19	3,021	1.93	3,988	1.32	2,795.8	1.19	0.66
6	1,326	-	927	0.70	1,570	1.69	1,489	0.95	1,055	0.71	1,273.4	1.01	0.47
7	15,255	-	14,540	0.95	23,156	1.59	17,640	0.76	16,406	0.93	17,400.0	1.06	0.37
Total	139,858	-	147,507	1.05	153,846	1.04	152,882	0.99	150,686	0.98	148,952.6	1.02	0.04

	1977		1978		Average			1979		1980		Average		
Code	Catch	R.I.	Catch	R.I.	Catch	R.I.	S.D. of R.I.	Catch	R.I.	Catch	R.I.	Catch	R.I.	S.D. of R.I.
1	24,523	1.27	22,867	0.93	23,695.0	1.10	0.24	21,609	0.94	21,475	0.99	21,542.0	0.97	0.04
2	78,164	1.43	72,703	0.93	75,433.5	1.18	0.35	61,102	0.84	73,484	1.20	67,293.0	1.02	0.25
3	47,210	1.39	47,235	1.00	47,222.5	1.20	0.28	37,347	0.79	36,158	0.97	36,752.5	0.88	0.13
4	30,098	1.40	30,756	1.02	30,427.0	1.21	0.27	25,293	0.85	23,444	0.89	24,368.5	0.87	0.03
5	7,400	1.85	6,923	0.93	7,161.5	1.39	0.65	7,414	1.07	6,436	0.87	6,925.5	0.97	0.14
6	2,065	1.96	2,189	1.06	2,127.0	1.51	0.64	905	0.41	890	0.98	897.5	0.70	0.40
7	21,316	1.38	20,629	0.97	20,972.5	1.14	0.23	23,597	1.14	24,302	1.03	23,949.5	1.08	0.08
Total	210,776	1.40	203,302	0.96	207,039.0	1.18	0.31	176,267	0.88	188,192	1.04	182,229.5	0.96	0.11

	1981	
Code	Catch	R.I.
1	26,556	1.24
2	94,533	1.29
3	43,778	1.21
4	23,582	1.00
5	5,347	0.83
6	1,234	1.39
7	23,230	0.95
Total	218,260	1.17

* Code 1 : Large-sized shrimps
2 : Small-sized shrimps
3 : Squids
4 : Cuttlefishes
5 : Octopus
6 : Spanish lobster
7 : Swimming crabs

** R.I. : Rate of increment

*** S.D. : Standard deviation

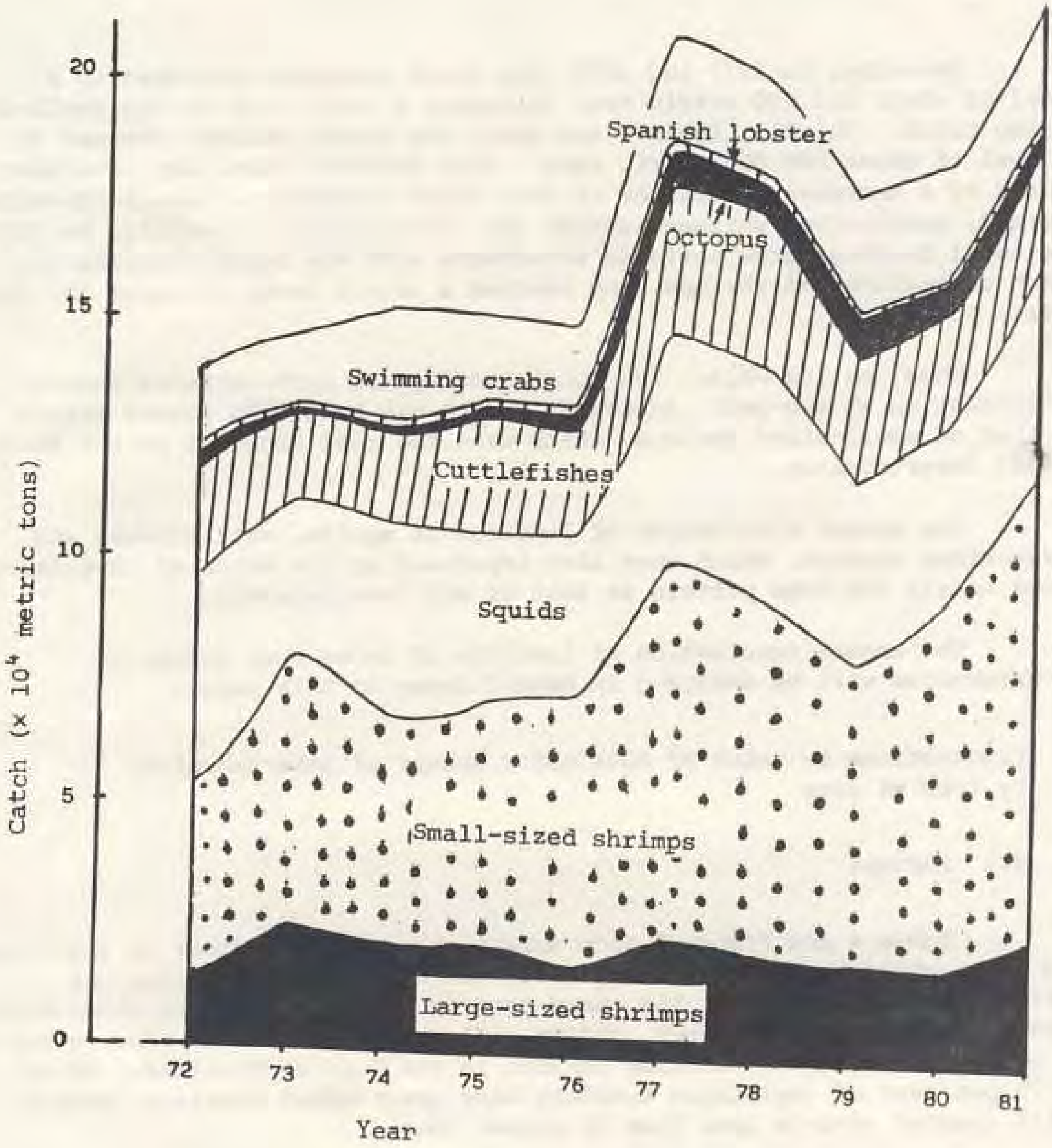

Figure 1. Annual fluctuation in landings of seven major groups of invertebrates in the Gulf of Thailand, 1972-1981

From Table 3 and Figure 1, we can infer the following four patterns of fluctuation. First, during the period between 1972-1976, the annual fluctuations of total landings showed a small variation with an increment rate of 0.98 to 1.05 (average 1.02). In other words, the catch of all invertebrates sustained a stable level of about 150,000 metric tons, and this small fluctuation of total landings almost coincided with that of small-sized shrimps.

Secondly, in 1977 and 1978, the total landings increased to a level of about 210,000 metric tons following a rapid rise in the small-sized shrimp catch. Thirdly, in 1979 and 1980, the total landings dropped to a level of about 180,000 metric tons. This downward trend may have been caused by a decrease in catches of four major components, i.e. large-sized shrimps, small-sized shrimps, squids and cuttlefishes. Fourthly, in 1981 the total landings grew again in accordance with the rapid increase in catch of small-sized shrimps, and reached a record level of about 220,000 metric tons.

Thus, on the whole, the total landings of invertebrates showed a fluctuation at two-year intervals, which may have been caused mainly by that of small-sized shrimps, which were the most abundant in the catch of all invertebrates.

The annual fluctuation of landings of squids, cuttlefishes and large-sized shrimps, which were also important in the catch of invertebrates, shows nearly the same pattern as that of all invertebrates.

The annual fluctuation of landings of those four groups of invertebrates will be analysed in detail later in this paper.

3. Fluctuations in catch of four major groups of invertebrates, by type of gear

3.1 Shrimps

Table 4 and Figure 2 show annual changes in landings of small-sized and large-sized shrimps caught by different types of gear during the period from 1972 to 1981. The gears used in this analysis are otter-board trawl, pair trawl, beam trawl, shrimp gill net, push-net and other gears most commonly employed for catching shrimps in the Gulf of Thailand. About 77-79 per cent of registered trawlers were otter-board trawlers, mainly small coastal vessels less than 18 metres long.

Table 4. (Continued)

(B) Small-sized shrimps

	1972		1973			1974			Average				1975			1976			Average			
Code*	Catch	%	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.
1	29,316	75.83	49,209	88.83	1.68	37,565	80.64	0.76	43,387	85.09	1.22	0.65	40,836	82.97	1.09	44,579	81.84	1.09	42,707.5	82.38	1.09	0.0
2	182	0.47	90	0.16	0.49	94	0.20	1.04	92	0.18	0.77	0.39	126	0.26	1.34	80	0.15	0.63	103	0.20	0.99	0.50
3	1,495	3.87	2,339	4.22	1.56	1,306	2.80	0.56	1,822.5	3.57	1.06	0.71	1,025	2.08	0.78	1,568	2.88	1.53	1,296.5	2.50	1.16	0.53
4	-	-	-	-	-	1,101	2.36	-	550.5	1.08	-	-	1,101	2.24	1.00	704	1.29	0.64	902.5	1.74	0.82	0.25
5	-	-	-	-	-	3,909	8.39	-	1,954.5	3.83	-	-	3,456	7.02	0.88	3,700	6.79	1.07	3,578	6.90	0.98	0.13
6	7,668	19.83	3,757	6.78	0.49	2,607	5.60	0.69	3,182	6.24	0.59	0.14	2,672	5.43	1.02	3,839	7.05	1.44	3,255.5	6.28	1.23	0.30
Total	38,661	100.00	55,395	100.00	1.43	46,582	100.00	0.84	50,988.5	100.00	1.14	0.42	49,216	100.00	1.06	54,470	100.00	1.11	51,843	100.00	1.09	0.04

1977			1978			Average				1979			1980			Average				1981		
Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.	Catch	%	R.I.
64,496	82.50	1.45	64,052	88.10	0.99	64,269.0	85.30	1.22	0.33	53,570	87.57	0.83	51,543	70.14	0.96	52,526.5	78.86	0.89	0.09	57,958	61.31	1.12
119	0.15	1.49	170	0.23	1.43	144.5	0.19	1.46	0.04	224	0.37	1.32	139	0.19	0.62	181.5	0.28	0.97	0.49	180	0.19	1.29
3,531	4.52	2.25	2,497	3.43	0.71	3,014.0	3.98	1.48	1.09	1,347	2.20	0.54	5,265	7.16	3.91	3,306.0	4.68	2.23	2.38	7,786	8.24	1.48
1,639	2.09	2.33	1,118	1.54	0.68	1,378.5	1.82	1.51	1.17	751	1.23	0.67	927	1.26	1.23	839.0	1.25	0.95	0.39	2,087	2.21	2.25
2,865	3.67	0.77	3,235	4.45	1.13	3,050.0	4.06	0.95	0.25	3,490	5.71	1.08	8,434	11.48	2.42	5,962.0	8.59	1.75	0.95	12,216	12.92	1.45
5,524	7.07	1.44	1,631	2.24	0.79	3,577.5	4.66	0.87	0.81	1,780	2.91	1.09	7,176	9.77	4.03	4,478.0	6.34	2.56	3.08	14,306	15.13	1.99
78,164	100.00	1.43	72,703	100.00	0.93	75,433.5	100.00	1.18	0.35	61,102	100.00	0.84	73,484	100.00	1.20	67,293.0	100.00	1.02	0.25	94,533	100.00	1.29

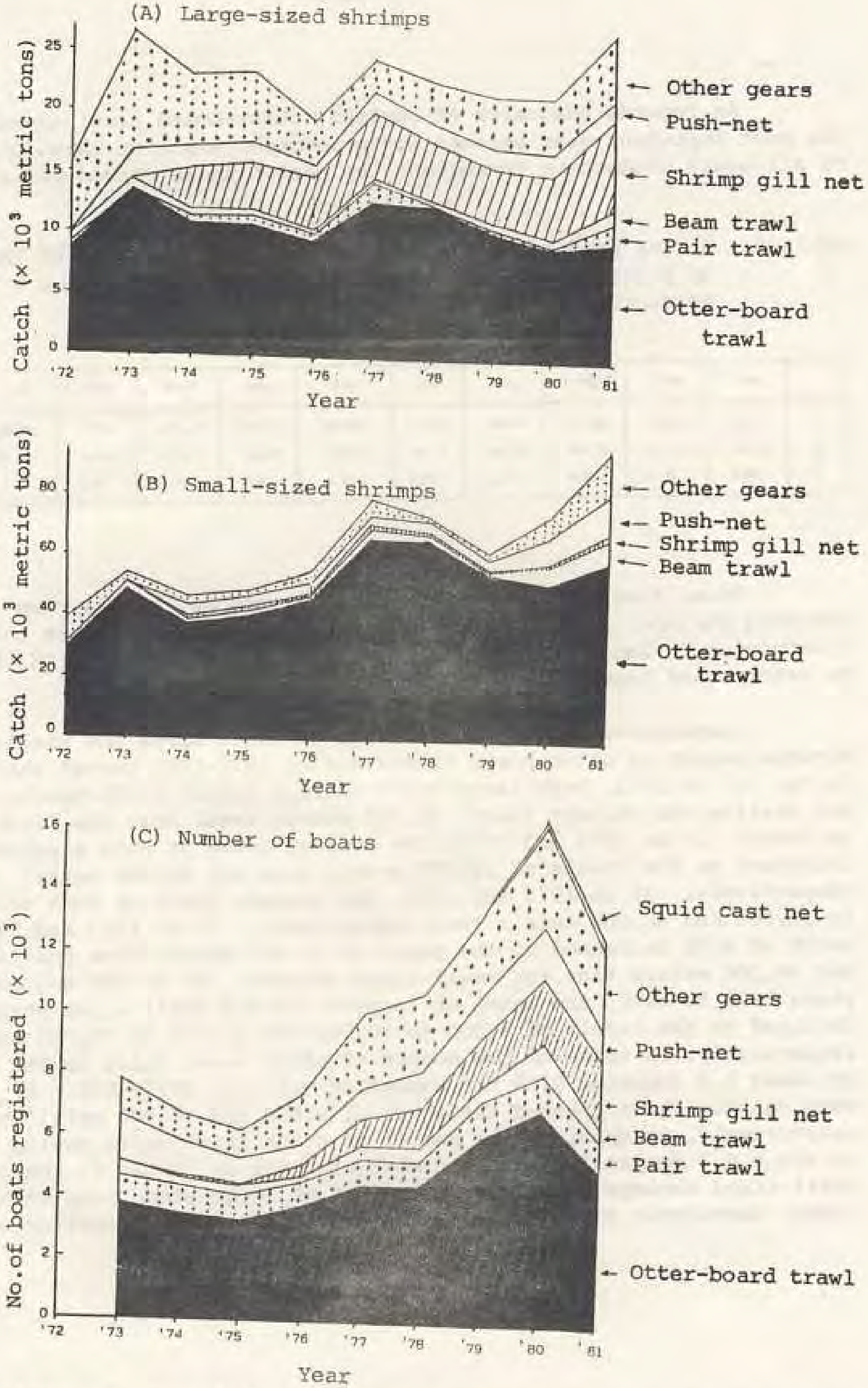

Figure 2. Annual fluctuation in landings of large-sized shrimps (A) and small-sized shrimps (B) caught by different types of gear, and the number of boats (C) operating those gears in the Gulf of Thailand, 1972-1981

As regards the catch of shrimps, otter-board trawl seems to be the most important gear because its production was more than 70 per cent of all-gears production throughout the period under consideration (Table 5).

Table 5. Shrimp production (in metric tons) from the Gulf of Thailand by all gears (A), by otter-board trawls (B), and as a percentage (C) of total production, 1972-1981.

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Average
A	54,341	81,814	69,574	72,559	73,743	102,687	95,570	82,711	94,939	121,089	84,925
B	38,089	62,778	48,283	51,582	54,223	77,268	76,480	63,739	66,641	67,585	60,678
C	69.8	76.7	69.5	71.1	73.5	75.2	80.0	77.1	70.2	55.8	70.9

Otter trawl fisheries have been carried out with a view to catching shrimps as well as other demersal species; therefore the annual fluctuation in landings of shrimps has a close connection with the catch by otter-board trawlers.

Comparative studies on landings of large-sized and small-sized shrimps caught by otter-board trawls during 1972-1981 reveal the following facts: 1) in 1972, both large-sized shrimps (about 8,800 metric tons) and small-sized shrimps (about 29,000 metric tons) held the first place in catch; 2) in 1973 and 1974, the average catch of both sizes of shrimps increased to the levels of 12,000 metric tons and 43,000 metric tons respectively; 3) in 1975 and 1976, the average catch of both decreased to 10,000 and 42,000 metric tons respectively; 4) in 1977 and 1978, the catch of both increased to the peaks of 13,000 metric tons for large-sized and 64,000 metric tons for small-sized shrimps; 5) in the following two years 1979 to 1980, the catch of large-sized and small sized shrimps declined to the levels of 9,000 to 10,000 and 51,000 to 53,000 metric tons respectively, in spite of the number of otter trawl units having increased by about 1.5 compared with the number of units in 1977-1978; 6) in 1981, both catches again reached the level of 9,600 and 58,000 metric tons respectively, in spite of the number of otter trawl units having decreased by about 0.7 compared with the number of units in 1980; 7) the catch of small-sized shrimps was larger than that of large-sized ones (3.3 to 6.0 times) throughout the 10-year period and this trend is continuing.

The shrimp gill net for large-sized shrimps and the push-net for small-sized shrimps rank second in importance, but the catch of small-sized shrimps by push-net has grown remarkably, showing a steep slope since 1980 (R.I. 1980 was 2.4).

Thus, in general the landings of shrimps fluctuated about every two years, and this fluctuation was mainly determined by otter-board trawl catches.

The trend of decreasing shrimp catches despite increased effort in 1979-1980 suggests that there was overfishing during that period. Furthermore, a rapid increase in small-sized shrimp catches in 1981 may have resulted in a decreased age at first capture in the years that followed.

3.2 Squids and cuttlefishes

Table 6 and Figure 3 show the annual changes in landings of squids and cuttlefishes caught by different types of gear. The gears used in this analysis are otter-board trawl, pair trawl, beam trawl, squid cast net, push-net and others. The squid cast net fishing with luring lamps has been developing only recently; therefore the data concerning the number of boats engaged in this fishery are limited. Bamboo stake traps have been operated commonly in the Gulf of Thailand as the simplest traditional fishing method. In the present analysis, however, the catch by bamboo stake traps has been included in the item "others" because they cannot be counted in the number of boat units.

As regards the catch of cephalopods, both otter-board trawl and pair trawl seem to be important. Their share of catches was quite large, averaging about 90 per cent for squids and about 97 per cent for cuttlefishes over a ten-year period. Those two types of trawls operate at different times: otter-board trawls operate during both the night and daytime, but the pair trawls operate only in the daytime. These practices resulted in a different catch composition, as shown in Table 7.

Table 6 Annual changes of catch (in metric tons) of cephalopods by different types of gear in the Gulf of Thailand, 1972-1981

(A) Squids

	1972		1973			1974			Average				1975			1976			Average			
Code*	Catch	%	Catch	%	R.I.**	Catch	%	Catch	Catch	%	R.I.	S.D.of R.I.	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.*** of R.I.
1	15,007	35.29	13,306	40.32	0.89	15,025	38.27	1.13	14,165.5	39.20	1.02	0.17	13,799	39.30	0.92	14,779	43.52	1.07	14,289	41.32	1.00	0.11
2	24,049	56.56	19,416	58.83	0.81	21,606	55.03	1.11	20,511	56.76	0.96	0.21	18,336	52.09	0.85	17,385	51.19	0.95	17,860.5	51.65	0.90	0.07
3	18	0.04	13	0.04	0.72	9	0.02	0.69	11	0.03	0.71	0.02	17	0.05	1.89	11	0.03	0.65	14	0.04	1.27	0.88
4	0	0	77	0.23	0.33	207	0.53	2.69	142	0.39	-	-	241	0.68	1.16	195	0.57	0.81	218	0.63	0.99	0.25
5	366	0.86	191	0.58	0.52	575	1.46	3.01	383	1.06	1.77	1.76	248	0.70	0.43	232	0.74	0.92	240	0.72	0.73	0.42
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	796	2.34	0	398	0.15	-	-
7	3,081	7.24	0	0	0	1,842	4.69	0	921	2.55	-	-	2,557	7.26	1.39	542	1.60	0.21	1,549.5	4.48	0.80	0.83
Total	42,521	100.00	33,003	100.00	0.78	39,264	100.00	1.19	361,33.5	100.00	1.38	1.12	35,198	100.00	0.90	33,960	100.00	0.96	34,579	100.00	0.93	0.04

1977			1978			Average				1979			1980			Average				1981		
Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.	Catch	%	R.I.
21,194	44.89	1.43	26,454	56.01	1.25	23,824.0	50.45	1.34	0.13	19,015	50.91	0.72	20,773	57.45	1.09	19,894.0	54.18	0.91	0.36	18,962	43.31	0.91
23,757	50.32	1.37	17,561	37.18	0.74	20,659.0	43.75	1.06	0.45	13,815	36.99	0.79	10,962	30.33	0.79	12,388.5	33.65	0.79	0.00	11,248	25.69	1.03
0	0.00	0.00	0	0.00	0.00	0.0	0.00	0.00	0.00	9	0.02	0.00	10	0.03	1.11	9.5	0.03	0.56	0.78	29	0.07	2.90
520	1.10	2.07	341	0.72	0.65	430.5	0.91	1.66	1.43	262	0.70	0.77	285	0.79	1.09	273.5	0.75	0.93	0.23	277	0.63	0.97
364	0.77	1.44	320	0.68	0.88	342.0	0.73	1.16	0.39	0	0.00	0.00	75	0.21	0.00	37.5	0.11	0.00	0.00	216	0.49	2.88
932	1.97	2.17	1,692	3.58	0.81	1,312.0	2.78	1.49	0.45	2,826	7.57	1.67	2,880	7.97	1.02	2,853.0	7.77	1.35	0.46	11,032	25.20	3.83
443	0.94	0.82	867	1.84	1.96	655.0	1.39	1.39	0.81	1,420	3.80	1.64	1,173	3.24	0.83	1,296.5	3.52	1.24	0.57	2,014	4.60	1.72
47,210	100.00	1.39	47,235	100.00	1.00	47,222.5	0.00	1.19	0.28	37,347	100.00	0.79	36,158	100.00	0.97	36,752.5	100.00	0.88	0.13	43,778	100.00	1.21

* Code 1 : Otter-board trawl
2 : Pair trawl
3 : Beam trawl
4 : Push-net
5 : Bamboo stake trap
6 : Squid cast net
7 : Others

** R.I. : Rate of increment

*** S.D. : Standard deviation

Table 6. (Continued)

(B) Cuttlefishes

	1972		1973			1974			Average				1975			1976			Average			
Code	Catch	%	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.
1	12,339	55.90	12,171	63.52	0.98	11,512	61.50	0.94	11,841.5	62.52	0.96	0.03	13,967	60.79	1.31	14,055	65.33	1.01	14,011	62.99	1.12	0.14
2	8,534	38.55	6,697	34.95	0.78	6,796	36.30	1.01	6,746.5	35.62	0.90	0.16	8,546	37.20	1.35	6,955	32.33	0.81	7,750.5	34.84	1.04	0.32
3	166	0.75	124	0.65	0.75	51	0.27	0.41	87.5	0.46	0.58	0.24	84	0.36	1.65	78	0.36	0.93	81	0.36	1.29	0.51
4	0	0	168	0.88	0	161	0.86	0.96	164.5	0.87	-	-	221	0.96	1.37	183	0.85	0.83	202	0.91	1.10	0.38
5	32	0.14	0	0	0	7	0.04	0	3.5	0.02	-	-	2	0.01	0.28	3	0.01	1.50	2.5	0.01	0.89	0.86
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0.10	-	11	0.05	-	-
7	1,038	4.69	0	0	0	192	1.02	0	96	0.51	-	-	155	0.67	0.81	218	1.01	1.41	186.5	0.84	1.11	0.42
Total	22,110	100.00	19,160	100.00	0.87	18,719	100.00	0.98	18,939.5	100.00	0.93	0.08	22,975	100.00	1.33	21,514	100.00	0.94	22,244.5	100.00	1.09	0.21

1977			1978			Average				1979			1980			1981			Average			
Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	Catch	%	R.I.	S.D.of R.I.
18,969	63.02	1.35	22,683	73.75	1.29	20,826.0	68.39	1.27	0.11	18,917	71.95	0.83	17,149	73.15	0.91	17,236	73.09	1.00	17,767.30	72.73	0.91	0.09
10,468	34.78	1.50	7,293	23.71	0.70	8,880.0	29.25	1.10	0.57	6,699	25.48	0.92	5,619	23.97	0.84	5,371	22.78	0.95	5,896.30	24.08	0.90	0.06
112	0.37	1.43	213	0.69	1.56	162.5	0.53	1.67	0.33	74	0.28	0.35	160	0.68	2.16	173	0.78	1.08	135.67	0.56	1.19	0.93
518	1.72	2.83	418	1.36	0.81	468.0	1.54	1.82	1.43	440	1.67	1.05	423	1.80	0.96	372	1.58	0.88	411.67	1.68	0.96	0.09
20	0.07	6.67	15	0.05	0.75	17.5	0.06	3.71	4.19	12	0.05	0.80	4	0.02	0.33	30	0.13	7.50	15.33	0.77	2.88	4.01
11	0.04	0.50	27	0.09	2.45	19.0	0.07	1.48	1.38	151	0.57	5.59	89	0.38	0.59	397	1.68	4.40	212.33	0.88	3.35	7.33
0	0.00	0.00	109	0.35	0.00	54.5	0.17	0.00	0.00	0	0.00	0.00	0	0.00	0.00	3	0.01	0.00	1.00	0.00	0.00	0.00
30,098	100.00	1.40	30,756	100.00	1.02	30,427.0	100.00	1.21	0.37	26,293	100.00	0.85	23,444	100.00	0.89	23,582	100.00	1.00	24,439.67	100.00	0.91	0.08

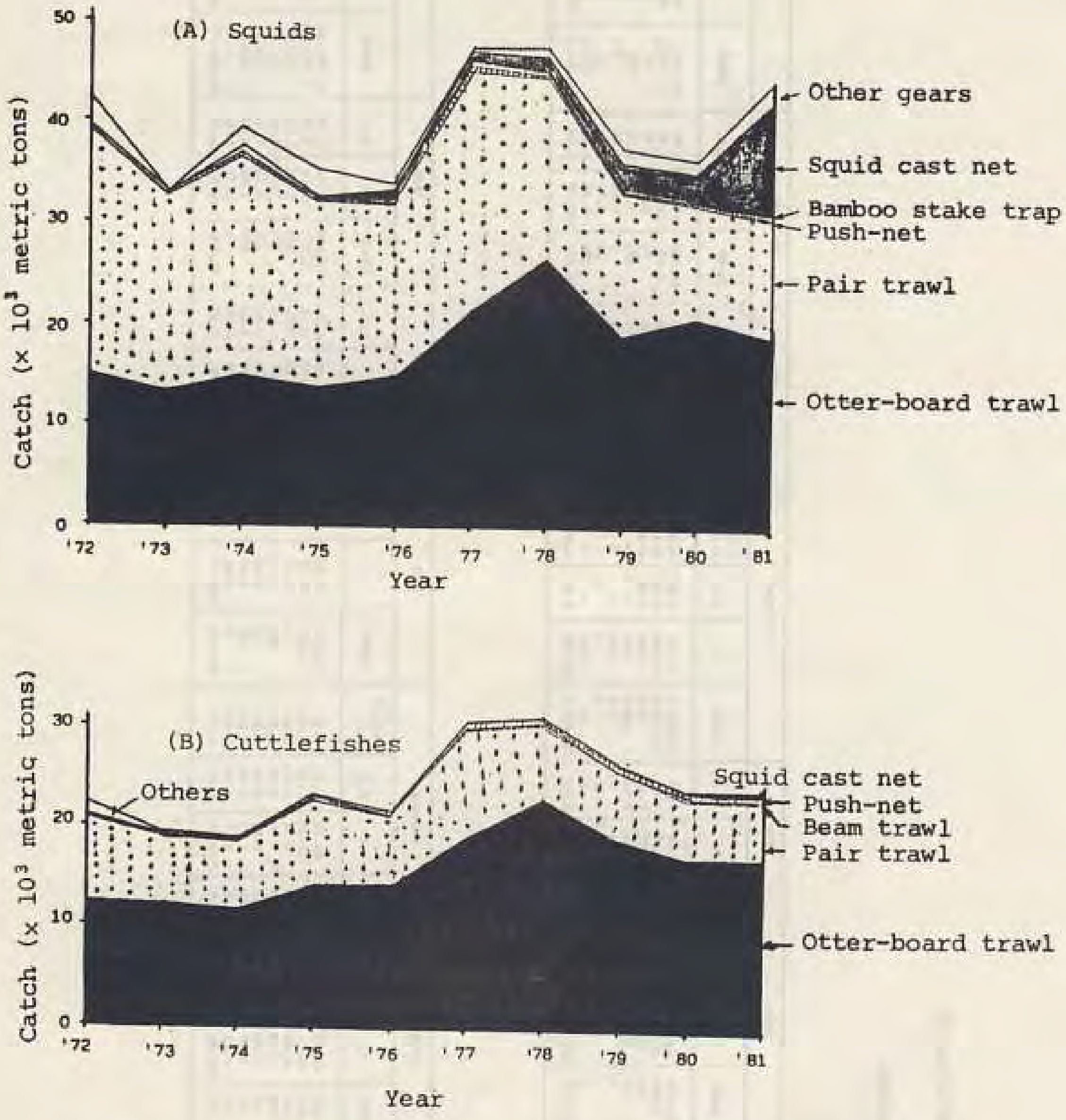

Figure 3. Annual fluctuation in landings of squids (A) and cuttlefishes (B), caught by different types of gear in the Gulf of Thailand, 1972-1981

Table 7. Cephalopod production (in metric tons) from the Gulf of Thailand by all gears (A), by otter-board and pair trawls (B), by otter-board trawls (C), and by pair trawls (D), 1972-1981

		1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	Average
Squids	A	42,521	33,003	39,264	35,198	33,960	47,210	47,235	37,347	36,158	43,778	39,567
	B (%)	39,056 (91.85)	32,722 (99.15)	36,631 (93.29)	32,135 (91.30)	32,164 (94.7)	44,951 (95.2)	44,015 (93.2)	32,830 (87.9)	31,735 (87.8)	30,210 (69.0)	35,645 (90.1)
	C (%)	15,007 (35.29)	13,306 (40.32)	15,025 (38.26)	13,799 (39.20)	14,779 (43.5)	21,194 (44.9)	26,454 (56.0)	19,015 (50.9)	20,773 (57.5)	18,962 (43.3)	17,831 (45.1)
	D (%)	24,049 (56.56)	19,416 (58.83)	21,606 (55.03)	18,336 (52.09)	17,385 (51.2)	23,757 (50.3)	17,561 (37.2)	13,815 (37.0)	10,962 (30.3)	11,248 (25.7)	17,814 (45.0)
Cuttlefishes	A	22,110	19,160	18,719	22,975	21,514	30,098	30,756	26,293	23,444	23,582	23,865
	B (%)	20,883 (94.45)	18,868 (98.47)	18,308 (97.80)	22,513 (97.99)	21,010 (97.7)	29,437 (97.8)	29,974 (97.5)	25,616 (97.4)	22,768 (97.1)	22,607 (95.9)	23,199 (97.2)
	C (%)	12,359 (55.90)	12,171 (63.52)	11,512 (61.50)	13,967 (60.79)	14,055 (65.3)	18,969 (63.0)	22,682 (73.8)	18,917 (72.0)	17,149 (73.1)	17,236 (73.1)	15,902 (66.6)
	D (%)	8,524 (38.55)	6,697 (34.95)	6,796 (36.30)	8,546 (37.20)	6,955 (32.4)	10,468 (34.8)	7,292 (23.7)	6,699 (25.4)	5,619 (24.0)	5,371 (22.8)	7,297 (30.6)

According to Table 7, the catch of otter-board trawls usually consisted both of squids and cuttlefishes in comparable proportions, while the catch of the pair trawls consisted mainly of squids (the cuttlefish catch by pair trawls was only 30 per cent of the average). However, the annual fluctuation in landings of squids and cuttlefishes caught by both gears showed some peculiarities (see Table 6 and Fig. 3). During 1972-1977, the catch of squids by pair trawls was superior to that of otter-board trawls (about 1.2 to 1.6 times), even though there were about five times as many otter-board trawl boats as pair trawl boats. On the contrary, the catch of cuttlefishes by pair trawls in those years was about half as much as by otter-board trawls. The total catch of squids and of cuttlefishes was highest during the period 1977-1978(about 47,000 and 30,000 metric tons), owing mainly to a rapid increase of catch by otter-board trawls, especially in 1978. In the next two years (1979-1980), the catches of squids and cuttlefishes by otter-board trawls were larger (1.4 to 1.9 and 2.8 to 3.1 times) than those by pair trawls, and coincided with a much higher number of otter-board trawl units (5-6 times). However, the total landings of squids and cuttlefishes remained rather low: about 37,000 metric tons for squids and 23-26,000 metric tons for cuttlefishes. In 1981, the total landings of squids and cuttlefishes increased to nearly the same levels (about 44,000 and 24,000 metric tons respectively) as in the previous few years.

The catches by push-net and beam trawls can be disregarded because they were negligible in comparison with otter-board trawl catches.

Thus, in general the landings of squids and cuttlefishes fluctuated biennially, and the pattern of fluctuation was similar to that of shrimp landings.

The distinctive features of cephalopod catches, as compared with those of shrimps, are as follows. The catches by pair trawls as well as by otter-board trawls were important during the early period from 1972 to 1977, indicating that pair trawls are an effective gear for catching cephalopods (particularly squids) in this region. Nevertheless, the superior catch of cuttlefishes by otter-board trawls throughout all years (see Tables 6 and 7) suggests that the otter-board trawl is the most suitable gear for catching cuttlefishes, as well as shrimps.

A decrease in catches of cephalopods, at a time of an increase in the number of both otter-board trawl and pair-trawl boats in 1979-1980, suggests overfishing. Recently, there has been a tendency to use squid cast net because of the rapid development of luring technology. This more widespread use of the squid cast net may be closely connected with overfishing by trawl.

4. Fishing grounds and productive areas for invertebrates

4.1 Small-sized shrimps

Table 8 gives the catch composition in percentage of large and small-sized shrimps by otter-board trawlers in the Gulf, 1979. The data were based on marketing research of landings at main fishing piers*.

Table 8. Catch composition (in percentage) of large-sized and small-sized shrimps caught by Thai otter-board trawlers in the Gulf, 1979

Area	I	II	III	IV	V	TOTAL
Large	1.65	1.92	2.64	2.00	0.89	9.10
Small	2.88	20.26	44.22	10.86	12.68	90.90
TOTAL	4.53	22.18	46.86	12.86	13.57	100.00

The shrimp catch by otter-board trawlers in 1979 was about 64,000 metric tons, of which more than 70 per cent was caught in the coastal waters of the inner Gulf (Areas I, II and III in Fig. 4). Small-sized shrimps accounted for about 90 per cent of the total shrimp catches. About 44 per cent of all shrimp catches came from Area III, followed by Area II. The southern coastal waters in the Gulf, Areas V and IV, ranked third and fourth respectively. However, the small-sized shrimps from those areas constituted less than 25 per cent of the total shrimp catches.

Thus, in general, the most productive areas for small-sized shrimps were in the coastal waters of the inner Gulf.

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* Fishing piers have been established in ten provinces as follows: Area I: Trat; Area II: Chantaburi and Rayong; Area III: Chon Buri; Samut Sakhon and Phetchaburi; Area IV: Surat Thani and Nakhon Si Thammarat; Area V: Songkhla and Pattani.

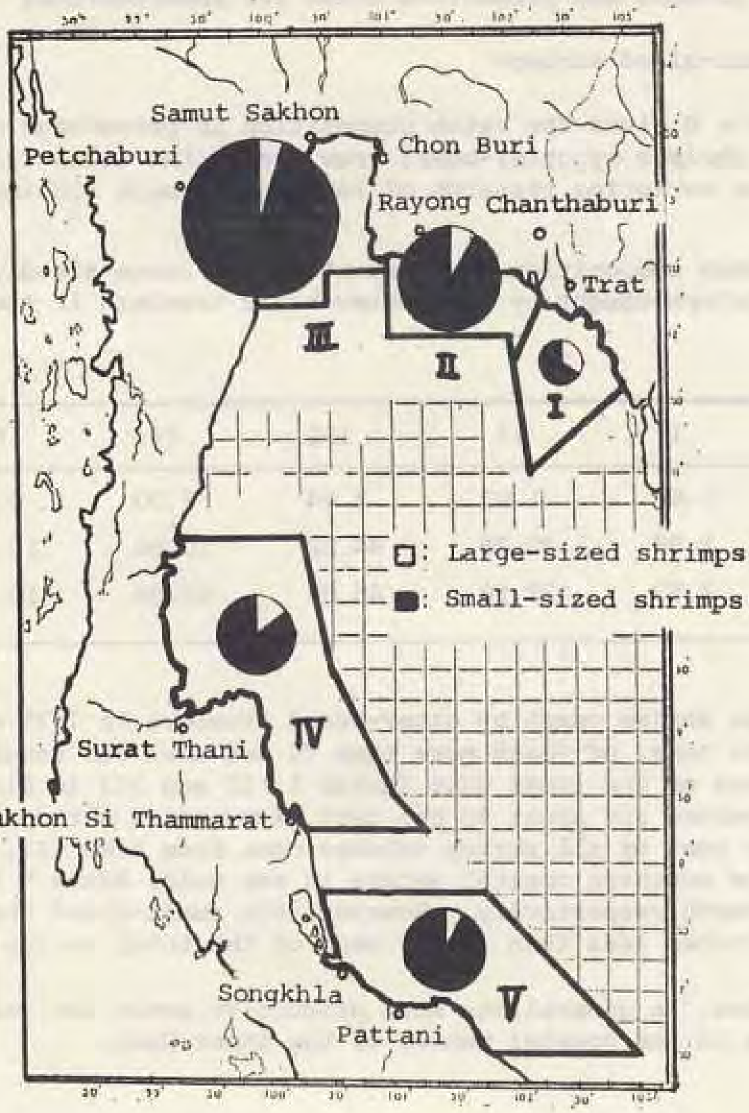

Figure 4. Fishing areas and catch composition of shrimps by otter-board trawlers in the Gulf, 1979. The length of radius in each circle is proportional to the square root of the grand total (in percentage in Table 8) of shrimps (adapted from Atchara, 1984)

4.2 Large-sized shrimps

Table 9 and Figure 5 give the percentage catch composition in 1979 for major species of large-sized shrimps in the Gulf.

Table 9. Catch composition (in percentage) of major species of large-sized shrimps in the Gulf, 1979

Code No.	Species \ Area	I	II	III	IV	V	TOTAL
	PENAEUS	9.91	9.03	8.12	5.28	1.79	34.13
1	P. merguiensis	2.57	0.02	5.38	1.76	0.53	10.26
2	P. semisulcatus	4.89	5.21	1.07	2.44	0.93	14.54
3	P. latisulcatus	0.80	2.43	0.42	0.29	0.04	3.98
4	Others	1.65	1.37	1.25	0.79	0.29	5.35
	METAPENAEUS	8.22	12.07	20.89	16.70	7.99	65.87
5	M. affinis	3.79	0.02	15.59	8.04	0.32	27.76
6	M. ensis	1.78	2.28	3.84	5.03	0.10	13.03
7	M. intermedius	2.65	9.77	1.46	3.63	7.57	25.08
	TOTAL	18.13	21.10	29.01	21.98	9.78	100.00

Others: *Penaeus monodon*, *P. japonicus* and *P. longistylus*

The share of large-sized shrimps in total shrimp catches was very small (less than 10 per cent). They comprised nine species and two genera. Three species of genus *Penaeus*, i.e. *P. merguiensis*, *P. semisulcatus* and *P. latisulcatus*, and three species of genus *Metapenaeus*, i.e. *M. affinis*, *M. ensis* and *M. intermedius* played an important role in the catch of large-sized shrimps, even though the catch of *Metapenaeus* spp. was larger than that of *Penaeus* spp. (1.9 times). Among those three species of *Penaeus* spp., *P. merguiensis* and *P. semisulcatus* are relatively abundant in the inner Gulf regions (Areas I - III). However their proportions are very small (less than 25 per cent). Among *Metapenaeus* spp., *M. affinis* and *M. intermedius* dominate with a higer proportion of occurrence covering a wide area from Area II to Area V.

Most *Penaeus* and *Metapenaeus* spp. (68 per cent) were caught in the **inner Gulf (Areas** I - III), but some *Metapenaeus* spp. were caught in the **southern waters** around small islands of the Gulf (especially in Area IV).

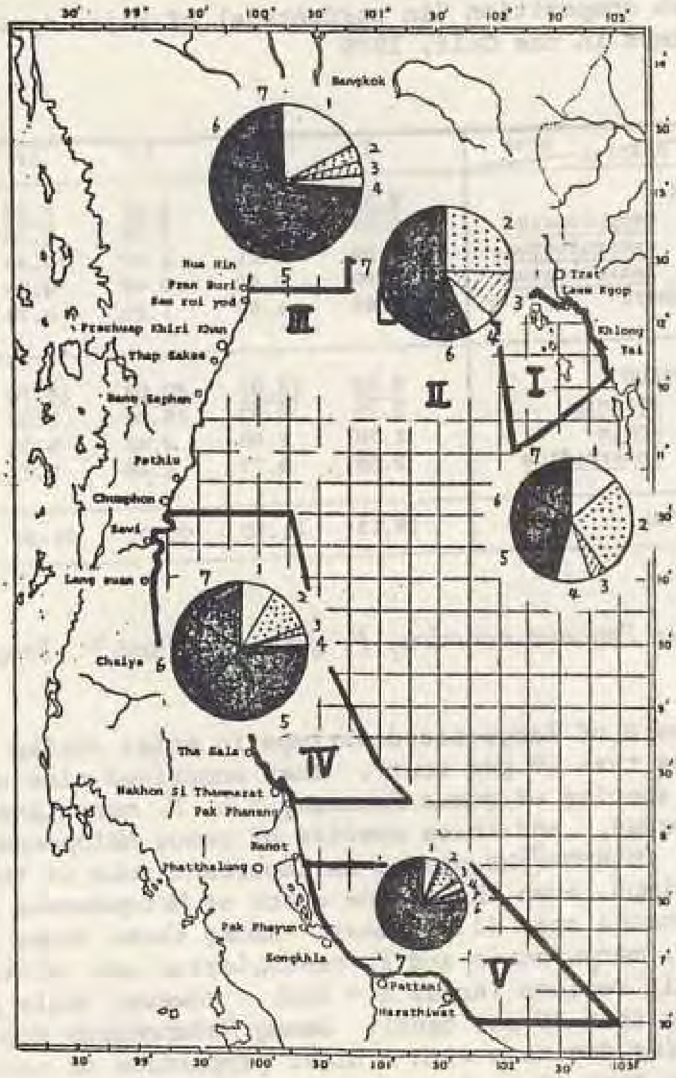

Figure 5. Species composition of large-sized shrimps caught in five fishing areas by otter-board trawls, 1979. The size of each circle is adapted from the total value in Table 9. The code number of species is given in Table 9

Concentrations of shrimps are determined by environmental factors. Shrimps, particularly in the juvenile or young stages, tend to be attracted to low salinity areas caused by the inflow from rivers. This inflow may also provide the muddy-sand material with nutrients for juvenile or young shrimps in their nursery grounds. Such conditions are found in Areas II and III, which are productive areas for small-sized shrimps in the Gulf (Fig. 4).

It is well known that large-sized shrimps of the *Penaeus* and *Metapenaeus* spp. tend to gather in areas of stagnant waters or eddies, around small islands. Such waters are found in Areas I - III, and Area IV (Fig. 5).

4.3 Squids and cuttlefishes

Table 10 gives the CPUE composition, in percentage terms, of squids and cuttlefishes. The data were obtained by a sampling survey from commercial trawlers in the Gulf in 1981. The distribution of fishing grounds for squids and cuttlefishes was somewhat different from that of shrimps (Fig. 6). The data were based on marketing research on landings at main fishing piers*.

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* Fishing piers have been established in twelve provinces, as follows: Area I: Trat and Chantaburi; Area II: Rayong; Area III: Chon Buri, Samut Sakhon, Phetchaburi and Prachuap Khiri Khan; Area IV: Chumphon, Surat Thani and Nakhon Si Thammarat; Area V: Songkhla and Pattani.

Table 10. CPUE composition (in percentage) of squids and cuttlefishes observed by sampling survey from commercial trawlers in the Gulf, 1981 (adapted from Mala, 1981)

a) Otter-board trawls

Area	I	II	III	IV	V	TOTAL
Squids	24.94	1.93	3.25	9.63	6.77	46.52
Cuttlefishes	11.26	2.20	15.60	11.85	12.57	53.48
TOTAL	36.20	4.13	18.85	21.48	19.34	100.00

b) Pair trawls

Area	I	II	III	IV	V	TOTAL
Squids	17.41	18.88	12.42	5.39	10.02	64.12
Cuttlefishes	4.43	4.31	9.95	4.83	12.36	35.88
TOTAL	21.84	23.19	22.37	10.22	22.38	100.00

Squid catches by otter-board trawls and by pair trawls in 1981 were about 19,000 and 11,000 metric tons respectively. About 65 per cent of the total squid catch by otter-board trawls and about 76 per cent of the total squid catch by pair trawls came from the coastal waters of the inner Gulf (Areas I - III in Fig. 6). Area I held the first place in catch by otter-board trawls, and Area II held the first place in catch by pair trawls, even though the productive areas by pair trawls showed a wider distribution than those by otter-board trawls.

Thus, in general, productive areas for squids were concentrated in the inner Gulf, covering the coast of Prachuap Khiri Khan up to the coast of Trat Province. Most of those areas have an average water depth of 25 metres.

a) Otter-board trawls

b) Pair trawls

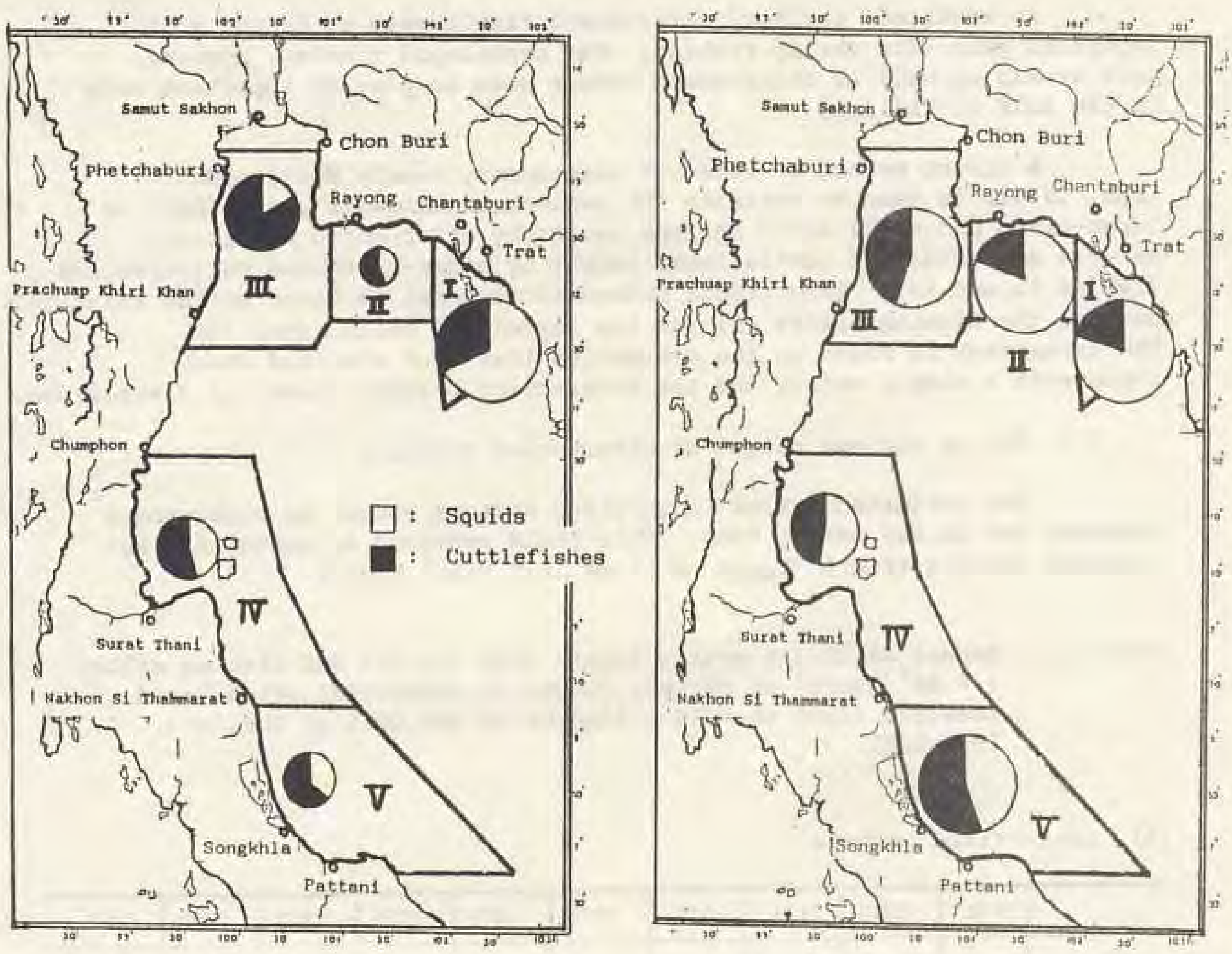

Figure 6. Fishing grounds and CPUE composition (in percentage) for squids and cuttlefishes observed by sampling survey from commercial trawlers in the Gulf, 1981 (adapted from Mala, 1981)

Cuttlefish catches by otter-board trawls and by pair trawls in 1981 were about 17,000 and 5,400 metric tons respectively. About half of the production by both gears came from the inner Gulf. Most of the cuttlefish catch was by otter-board trawls, from various coastal regions in the Gulf. The most productive areas for cuttlefishes by pair trawls were in the southern coastal regions of the Gulf (see Area V in Fig. 6-b).

5. Stock Assessment

As mentioned earlier, otter-board trawls seem to be the most important gear for shrimp fishing. For cephalopod fishing, however, pair trawls as well as otter-board trawls seem to play an important role in the Gulf of Thailand.

A direct method of resource assessment, namely Fox's model (Fox, 1970), is used to estimate the maximum sustainable yield (MSY) of large-sized and small-sized shrimps caught by otter-board trawlers, as well as squids and cuttlefishes caught by otter-board and pair-trawlers (Tables 11 and 12). This simple mathematical model is based on the relation between the fishing effort (f) and its associated catch rates (U). The assessment is based on the assumption that each examined stock represents a single entity and the interaction between stocks is disregarded.

5.1 MSY of shrimps caught by otter-board trawlers

The estimated MSY of large-sized shrimps caught by otter-board trawlers was 10,954 metric tons. This yield required an annual average standard fishing effort (f_{MSY}) of about 16.7×10^6 hours.

Table 11. Annual catch (in metric tons), CPUE (kg/hr) and fishing effort ($\times 10^6$ hours) of shrimps caught by commercial otter-board trawlers (less than 18 m length) in the Gulf of Thailand, 1972-1981

(A) Large-sized shrimps

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Catch(C)	8,773	13,569	10,818	10,746	9,654	12,783	12,428	10,229	9,098	9,631
CPUE (U)	0.767	0.739	0.700	0.899	0.820	0.893	1.223	0.536	0.649	1.114
Effort (f)	11.44	18.36	15.45	11.95	11.77	14.31	10.16	19.08	14.02	8.65

(B) Small-sized shrimps

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Catch(C)	29,316	49,209	37,565	40,836	44,579	64,486	64,052	53,570	57,543	57,958
CPUE (U)	3.955	3.757	4.084	7.122	5.411	6.535	6.986	4.131	3.272	5.938
Effort (f)	7.41	13.10	9.20	5.73	8.24	9.87	9.17	12.95	15.75	9.76

The equilibrium yield curve of large-sized shrimps is shown in Figure 7.

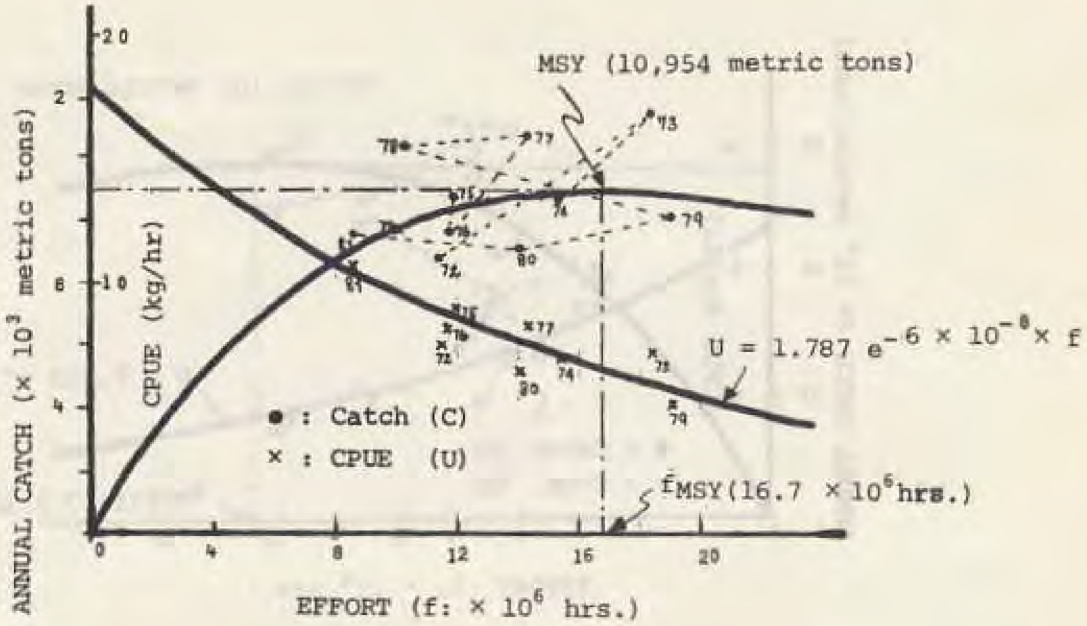

Figure 7. Annual catch (C) of large-sized shrimps by all otter-board trawlers and CPUE (U) by commercial otter-board trawlers up to 18 m length, related to the estimated total effort (f) by all otter-board trawlers in the Gulf

The shape of the curve is like a half-dome parabola. From Figure 7, it appears that the large-sized shrimp catch by otter-board trawlers in 1977-1978 was about 15.0 per cent over the MSY, and after that the catch decreased every year and reached the level of 9,600 metric tons in 1981 (Table 11-A). If we assume that the MSY obtained is a reasonable one, it is likely that the large-sized shrimps in the Gulf were exploited over their MSY level by otter-board trawlers in 1977-1978.

For the small-sized shrimps, the estimated MSY obtained by otter-board trawlers was 57,406 metric tons, which required a fishing effort of about 16.7×10^6 standard fishing hours. The estimated optimum fishing effort is the same as that for large-sized shrimps.

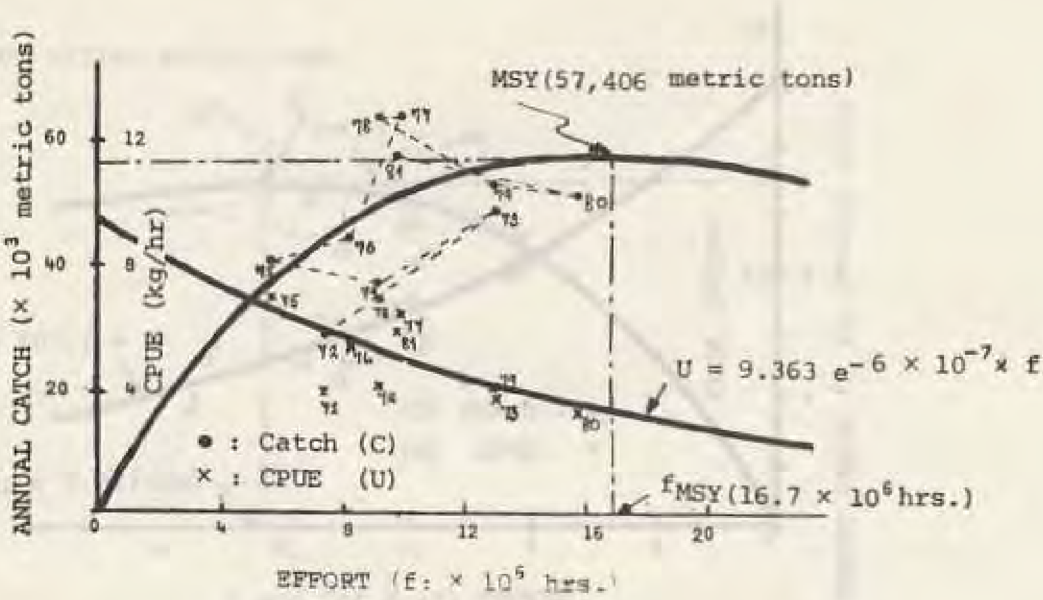

Figure 8. Annual catch (C) of small-sized shrimps by all otter-board trawlers and CPUE (U) by commercial otter-board trawlers up to 18 m length, related to the estimated total effort (f) by all otter-board trawlers in the Gulf

The shape of the equilibrium curve, as illustrated in Figure 8, is very similar to that of large-sized shrimps; however, the MSY obtained is about 5.24 times that of large-sized shrimps.

The catch of small-sized shrimps by otter-board trawlers in 1977-1978 was about 11 per cent over the MSY, and after that the catch decreased to the level of MSY (Table 11-B). This means that the small-sized shrimps in the Gulf were also exploited over their MSY level during 1977-1978.

It is therefore likely that both large-sized and small-sized shrimp stocks in the Gulf were exploited to their maximum potential yield, and no increase of shrimp production by otter-board trawls can be expected in the future.

5.2 MSY of squids and cuttlefishes caught by otter-board and pair trawlers

Table 12. Annual catch (in metric tons) by otter-board and pair trawlers, CPUE (kg/hr) by otter-board trawlers of 18-25 m length, and fishing effort ($\times 10^6$ hours) of squids and cuttlefishes in the Gulf of Thailand, 1972-1981.

(A) Squids

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Catch(C)	39,056	32,722	36,631	32.135	32.184	44,951	44,015	32,830	31,735	30,210
CPUE (U)	3.402	2.095	2.347	2.720	3.023	4.525	4.533	2.919	3.886	3.837
Effort (f)	11.48	15.62	15.61	11.81	10.65	9.93	9.71	11.25	8.17	7.87

(B) Cuttlefishes

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Catch(C)	20,883	18,868	18,308	22,573	21,010	29,437	29,974	25,616	22,768	22,607
CPUE (U)	2.658	1.692	1.776	2.285	2.452	3.143	3.362	2.189	2.813	3.085
Effort (f)	7.86	11.15	10.31	9.85	8.57	9.37	8.92	11.70	8.09	7.33

The estimated MSY of squids caught by otter-board and pair trawlers was 34,342 metric tons. This yield corresponds to an annual effort of 11.1×10^6 standard fishing hours (Fig. 9).

The average catch of squids by otter-board and pair trawlers in 1977-1978 was about 29.5 per cent over the MSY and after that the catch decreased below the MSY (Table 12-(A)). This suggests that the squid stock is now being overfished.

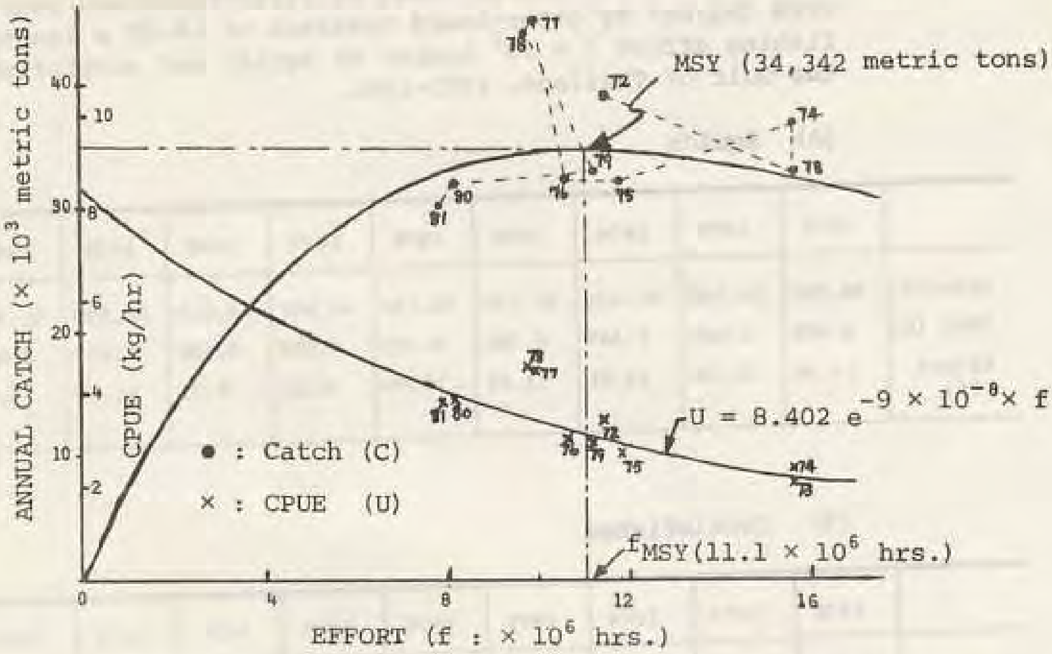

Figure 9. Annual catch (C) of squids by all otter-board and pair trawlers and CPUE (U) by commercial otter-board trawlers of 18-25 m length, related to the estimated total effort (f) by all otter-board trawlers in the Gulf, 1972-1981

For cuttlefishes, the MSY was 22,493 metric tons, which required a fishing effort of 8.33×10^6 standard fishing hours (Fig. 10). The average catch of cuttlefishes in 1977-1978 was about 32 per cent over the MSY, and the catch decreased to the MSY level (Table 12-B). This suggests that the current situation of the cuttlefish stock shows some trends of overfishing.

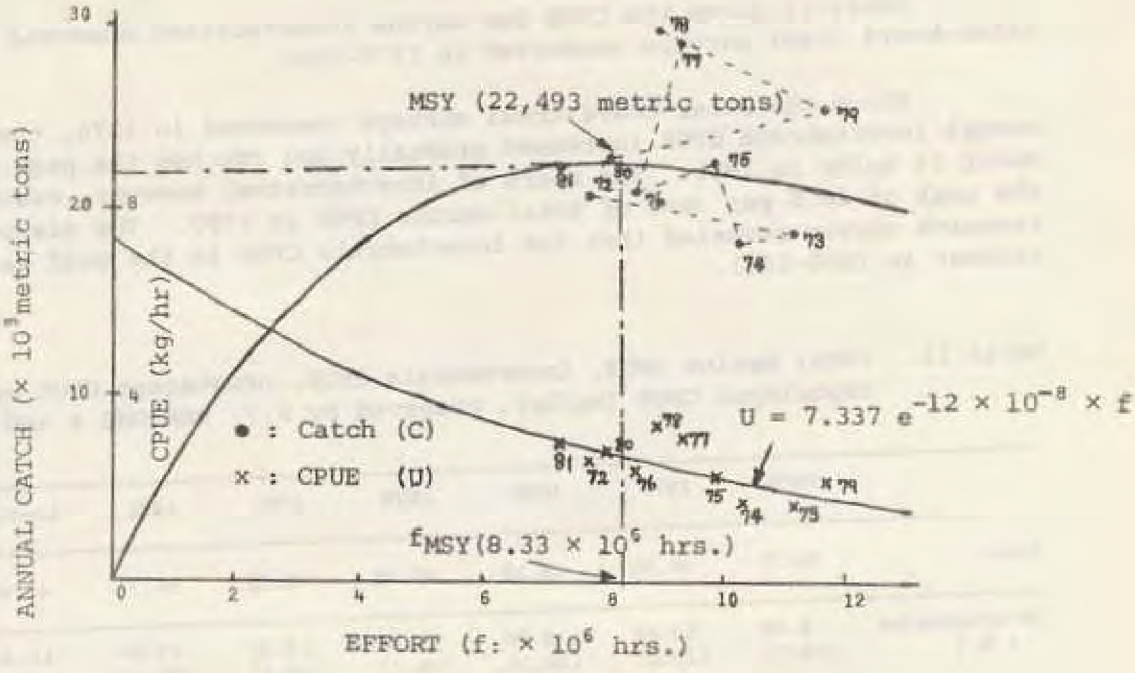

Figure 10. Annual catch (C) of cuttlefishes by all otter-board and pair trawlers and CPUE (U) by commercial otter-board trawlers of 18-25 m length, related to the estimated total effort (f) by all otter-board trawlers in the Gulf, 1972-1981

Part II. CPUE data

1. General situation of CPUE for marine invertebrates

Table 13 gives the CPUE for marine invertebrates observed by otter-board trawl surveys conducted in 1976-1981.

Since the otter-board trawl surveys commenced in 1976, the annual invertebrate CPUE increased gradually and reached the peak of about 14 kg/hr in 1981. The share of invertebrates, however, reached the peak of 26.5 per cent of total marine CPUE in 1980. The six-year research survey revealed that the invertebrate CPUE in the Gulf was highest in 1980-1981.

Table 13. Total marine CPUE, invertebrate CPUE, crustacean CPUE and cephalopod CPUE (kg/hr), observed by R.V. PRAMONG 4 and 5

	1976	1977	1978	1979	1980	1981	Average
Total	56.72	44.98	48.19	45.48	49.81	54.74	44.99
Invertebrates (%)	9.48 (16.7)	10.44 (23.2)	9.68 (20.1)	11.86 (26.1)	13.20 (26.5)	13.99 (25.6)	11.44 (22.9)
Crustaceans (%)	4.54 (8.0)	5.39 (12.0)	5.62 (11.7)	7.78 (17.1)	8.68 (17.4)	8.04 (14.7)	6.67 (13.4)
Cephalopods (%)	4.94 (8.7)	5.05 (11.2)	4.06 (8.4)	4.08 (9.0)	4.52 (9.1)	5.95 (10.9)	4.77 (9.5)

Cephalopods : Squids and cuttlefishes

Among invertebrates, crustacean and cephalopod CPUE accounted for about 7 kg/hr for crustaceans, and 5 kg/hr for cephalopods, which shared 13.4 per cent and 9.5 per cent of the total marine CPUE, respectively.

The general situation as regards CPUE for marine animals differs in several aspects when compared with the figures of commercial catch as illustrated in Table 2 and Figure 11-A.

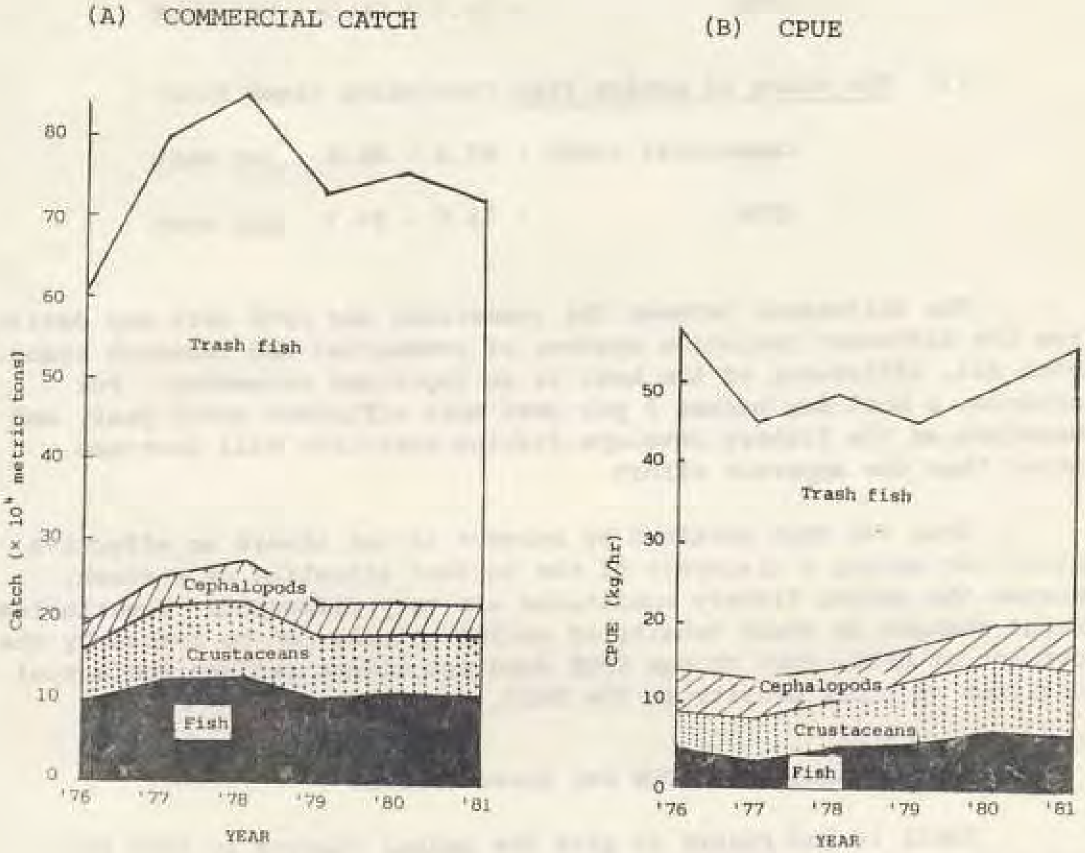

Figure 11. Annual changes in relative abundance of marine animals in the Gulf of Thailand, 1976-1981

The following distinct differences can be identified:

(1) <u>The peak period for invertebrate abundance</u>

Commercial catch by otter-board trawlers	: 1977-1978
CPUE by research vessels	: 1980-1981

(2) The share of invertebrates (the proportion of invertebrate catch)

Commercial catch	: 11.4 - 16.6	per cent
CPUE	: 16.7 - 26.5	per cent

(3) The share of marine fish (including trash fish)

Commercial catch	: 83.4 - 88.6	per cent
CPUE	: 73.5 - 83.3	per cent

The difference between the commercial and CPUE data may derive from the different operation systems of commercial and research boats. Above all, efficiency of the boat is an important parameter. For instance, a boat may become 5 per cent more efficient every year, and therefore, as the fishery develops, fishing mortality will increase faster than the apparent effort.

Thus the CPUE obtained by surveys is not always an effective method for making a diagnosis of the current situation of a stock, because the actual fishery conditions are very different. Nevertheless, annual changes in stock density of marine animals can be traced by the movement of CPUE, even though CPUE does not always reflect the actual condition of stock density in the Gulf.

2. Annual changes in CPUE for invertebrates

Table 14 and Figure 12 give the annual changes in CPUE for invertebrates in all research areas.

Table 14. Annual changes in CPUE (kg/hr) for seven major groups of invertebrates surveyed by research vessels in the Gulf of Thailand, 1976-1981.

	1976		1977		1978		1979		1980		1981	
Code*	CPUE	R.I.**	CPUE	R.I.	CPUE	R.I.	CPUE	R.I.	CPUE	R.I.	CPUE	R.I.
1	0.27	-	0.36	1.33	0.30	0.83	0.38	1.27	0.44	1.16	0.33	0.74
2	2.37	-	3.22	1.36	4.32	1.34	6.22	1.44	6.38	1.03	5.62	0.88
3	2.16	-	1.99	0.92	1.54	0.77	1.60	1.04	1.71	1.07	2.56	1.50
4	2.02	-	1.97	0.98	1.63	0.83	1.54	0.94	1.87	1.21	2.10	1.12
5	0.52	-	0.75	1.44	0.52	0.69	0.88	1.69	0.74	0.84	0.86	1.16
6	0.17	-	0.11	0.65	0.07	0.64	0.04	0.57	0.03	0.75	0.05	1.67
7	1.41	-	1.16	0.82	0.82	0.71	1.10	1.34	1.45	1.32	1.10	0.76
Total	8.92	-	9.56	1.07	9.20	0.96	11.76	1.28	12.62	1.07	12.62	1.00

* Code 1 : Large-sized shrimps
2 : Small-sized shrimps
3 : Squids
4 : Cuttlefishes
5 : Octopus
6 : Spanish lobster
7 : Swimming crabs

** R.I. : Rate of increment

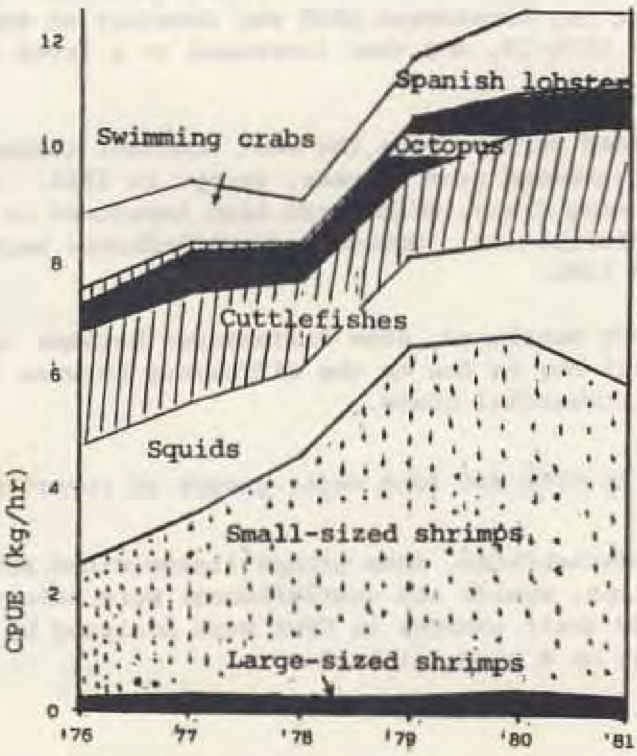

Figure 12. Annual changes in CPUE for seven major groups of invertebrates in the Gulf of Thailand, 1976-1981

The changes in CPUE can be summarized as follows;

(1) During the period 1976-1978, the annual fluctuation of total CPUE showed a small variation with an increment rate from 0.96 to 1.07. In other words, the CPUE for all invertebrates sustained a stable level of about 9.0 - 9.6 kg/hr. This small fluctuation of total CPUE nearly coincides with CPUE for all crustaceans, despite the continuous increase in CPUE for small-sized shrimps.

(2) In 1979, the total CPUE increased to 11.8 kg/hr, in accordance with the rapid increase in CPUE for small-sized shrimps.

(3) In 1980 and 1981, the total CPUE increased again, with a slight fluctuation.

Thus, on the whole, the total CPUE of invertebrates has been increasing since 1979. The increase may have been mainly due to crustaceans, that is, crustacean CPUE was constant at the level of 4-6 kg/hr during 1976-78, and then increased to a level of about 8 kg/hr in 1979.

Small-sized shrimps were the most abundant throughout all years and their CPUE increased year by year, except in 1981. Large-sized shrimps and swimming crabs, which were also important in the CPUE, showed a small fluctuation. Squids and cuttlefishes kept a stable state, except in 1981.

As already mentioned, some differences between landings (Fig. 1) and CPUE (Fig. 12) may be due to the difference between the operations of research and commercial boats.

3. Changes in CPUE for four major groups of invertebrates

Among invertebrates, four groups (large-sized shrimps, small-sized shrimps, squids and cuttlefishes) were selected as major invertebrates and their changes in CPUE were analysed by selected statistical areas on a biennial basis.

3.1 Small-sized shrimps

3.1.1 CPUE in general

In general, the six-year average in all research areas showed that the small-sized shrimp CPUE accounted for about 53.5 per cent of the total invertebrate CPUE (Fig. 13)

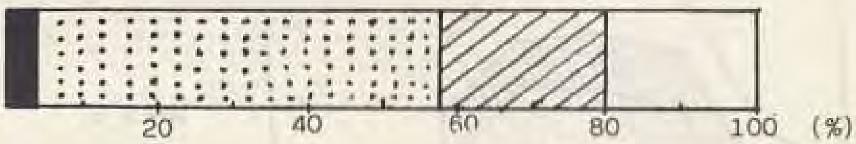

Figure 13. CPUE composition (in percentage) of four groups of invertebrates (from left to right, large-sized shrimps, small-sized shrimps, squids and cuttlefishes) indicated as a six-year average in all research areas

3.1.2 Changes in CPUE in all research areas

The CPUE for small-sized shrimps in all research areas increased yearly, while there was an insignificant fluctuation in the CPUE for large-sized shrimps (Fig. 12).

3.1.3 Annual changes in CPUE in five selected research areas

Among all research areas, five areas were important in terms of the CPUE for small-sized shrimps (Fig. 14).

Comparative studies between five sampling areas revealed that the CPUE for small-sized shrimps fluctuated in Area III and Area V. In these two areas, the proportion of small-sized shrimp CPUE in the total invertebrate CPUE was constantly high (about 70 per cent on an average) throughout the period and the CPUE value became larger year by year with some minor exceptions. Other areas (Areas I, II and IV) showed nearly the same pattern of fluctuation in the CPUE for small-sized shrimps.

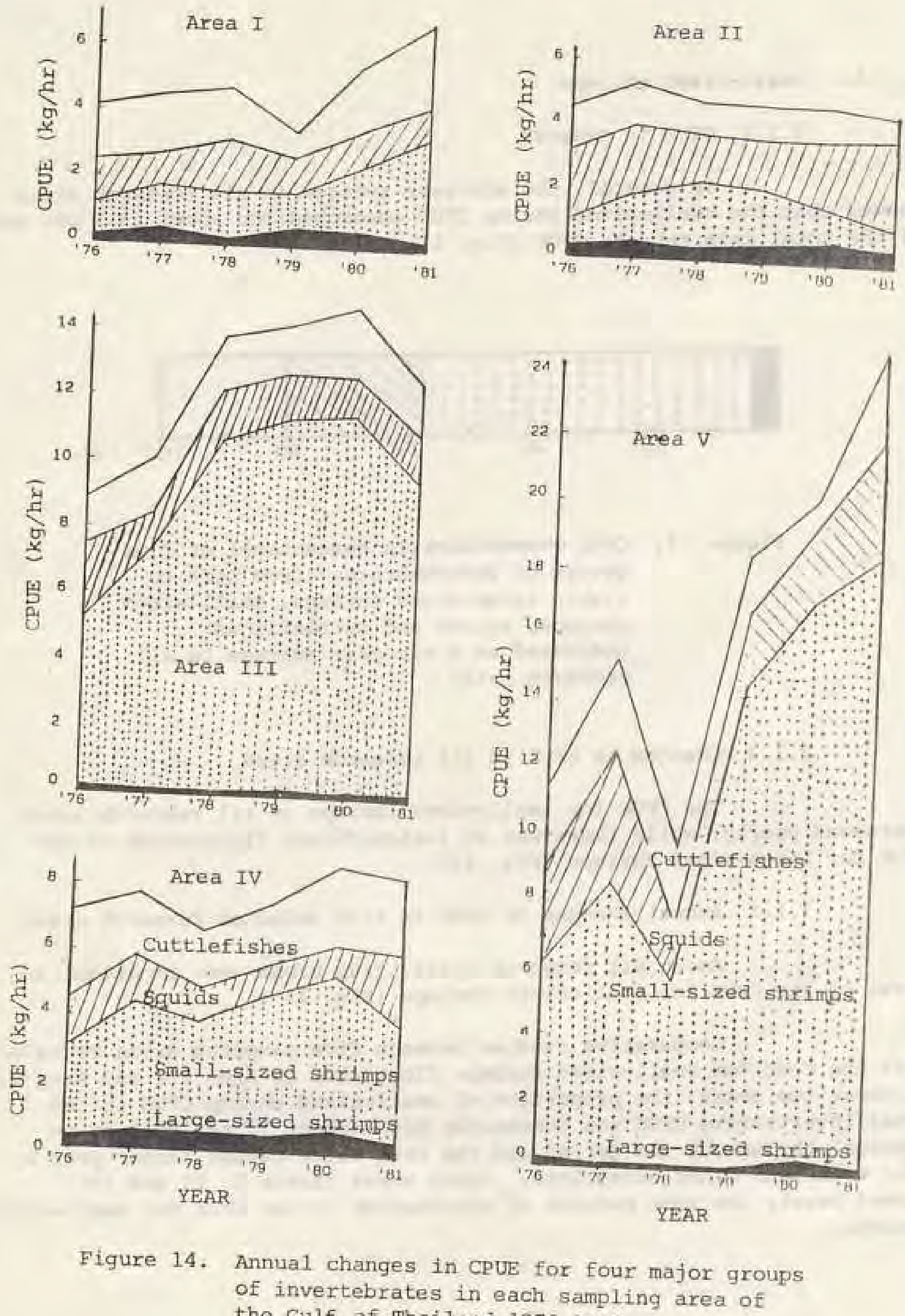

Figure 14. Annual changes in CPUE for four major groups of invertebrates in each sampling area of the Gulf of Thailand 1976-1981

3.1.4 Productive areas

For comparison with the commercial data (Table 8), the relative abundance of small-sized shrimps in terms of CPUE in the five sampling areas was calculated (Table 15).

Table 15. CPUE composition (in percentage) of large-sized and small-sized shrimps observed by the 1979 survey in the Gulf

Area	I	II	III	IV	V	TOTAL
Large	1.74	1.60	0.78	1.62	0.64	6.38
Small	2.96	4.84	31.99	12.27	41.56	93.62
TOTAL	4.70	6.44	32.77	13.89	42.20	100.00

The average CPUE for small-sized shrimps in those five areas in 1979 was about 6 kg/hr. About 40 per cent of the accumulated shrimp CPUE came from the inner Gulf, and the remaining 60 per cent was produced from the southern coastal waters of the Gulf (especially from Area V as illustrated in Figure 15).

Thus the distribution pattern of relative abundance of small-sized shrimps derived from both commercial catch and CPUE data differs considerably (see Figs. 4 and 15).

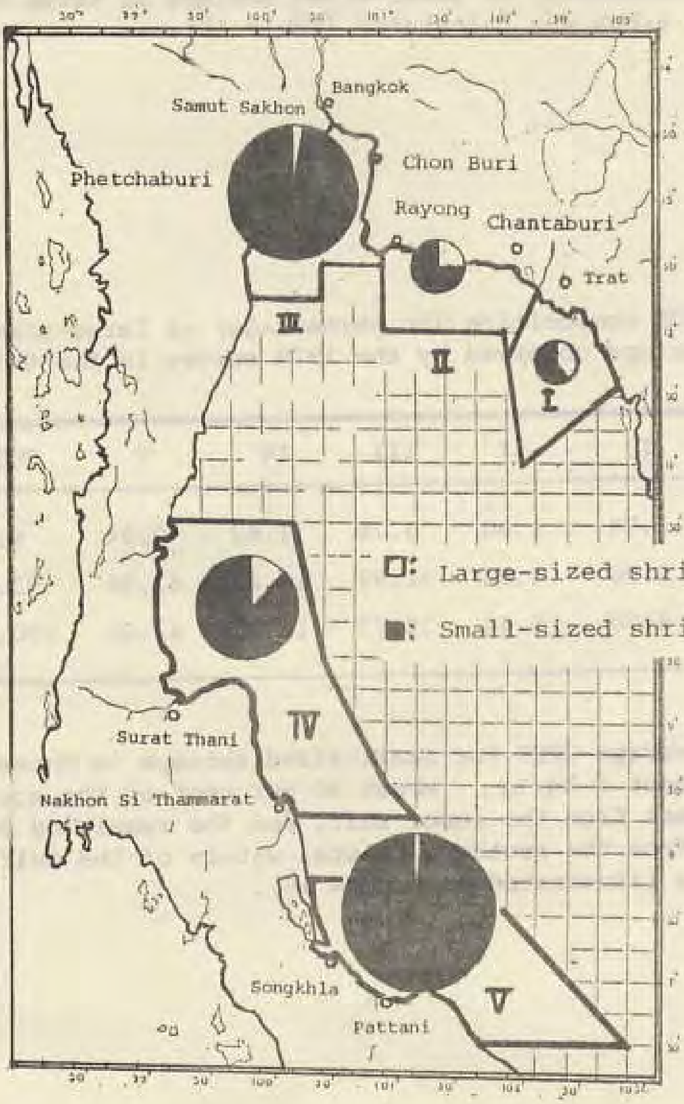

Figure 15. Relative abundance of shrimps in terms of CPUE observed in each sampling area of the Gulf, 1979

The distinct differences in the relative abundance of small-sized shrimps between the inner Gulf and the southern Gulf suggest the following: in the areas located in the inner Gulf (Area II and Area III), wide-ranging shallow regions prevail in the coastal waters. For this reason, trawl surveys by large vessels might be limited to small areas of particular fishing grounds. Therefore, the outcome of CPUE based on small research areas may result in an underestimation of CPUE. Secondly, the data used for calculating the catch composition of shrimps in Area V in Figure 4 was collected at Songkhla and Pattani fishing piers. At these piers, however, the proportional composition of small-sized shrimps does not play a very important role in landings, because most of the small-sized shrimps are landed in other small ports for local consumption. Therefore, the relative value shown for Area V in Figure 4 is underestimated and does not represent the real condition of the commercial catch. It can thus be concluded that the difference will be solved by employing a bigger value, namely a value between that shown in Figure 4 and the one in Figure 15.

3.2 Large-sized shrimps

3.2.1 CPUE in general

As shown in Figure 13, large-sized shrimp CPUE was more or less 5 per cent of the total invertebrate CPUE. It can therefore be stated that large-sized shrimp CPUE is too small to be taken into account.

3.2.2 Annual changes in CPUE in five selected research areas

In general, the annual change of CPUE for large-sized shrimps was also so small that it can be disregarded (see Table 14). Nevertheless, some specific characters in CPUE were shown when the selected sampling areas were compared (see Figure 14). Among the five areas, Area I, Area II and Area IV were grouped together as fairly productive areas for large-sized shrimps with a six-year average of 7 to 10 per cent of the total invertebrate CPUE, although the total invertebrate CPUE in those areas was less than half of the CPUE of the other areas.

3.2.3 Species composition and productive areas

Table 16 and Figure 16 give the percentage of CPUE for the major species of large-sized shrimps. Among the identified large-sized shrimps, three species of *Penaeus*, and three species of *Metapenaeus* predominated in the CPUE as well as in the commercial catch. Thus the species composition itself is similar to that obtained from the landings data. The relative abundance of each species in each area showed some differences as seen in Table 16 and Figure 16.

Table 16. CPUE composition (in percentage) of major species of large-sized shrimps in the Gulf, 1979

Code No.	Species \ Area	I	II	III	IV	V	TOTAL
	PENAEUS	20.08	13.71	6.38	5.96	2.55	48.68
1	*P. merguiensis*	1.05	0.00	1.09	0.73	0.04	2.91
2	*P. semisulcatus*	6.60	8.52	0.32	3.73	2.14	21.31
3	*P. latisulcatus*	12.02	4.23	4.24	0.41	0.23	21.13
4	Others	0.41	0.96	0.73	1.09	0.14	3.33
	METAPENAEUS	7.01	11.38	6.01	19.59	7.33	51.32
5	*M. affinis*	0.55	0.00	2.96	10.34	0.00	13.85
6	*M. ensis*	0.77	7.15	2.41	7.29	0.32	17.94
7	*M. intermedius*	5.69	4.23	0.64	1.96	7.01	19.53
	TOTAL	27.09	25.09	12.39	25.55	9.88	100.00

Others: *Penaeus monodon, P. japonicus* and *P. longistylus*

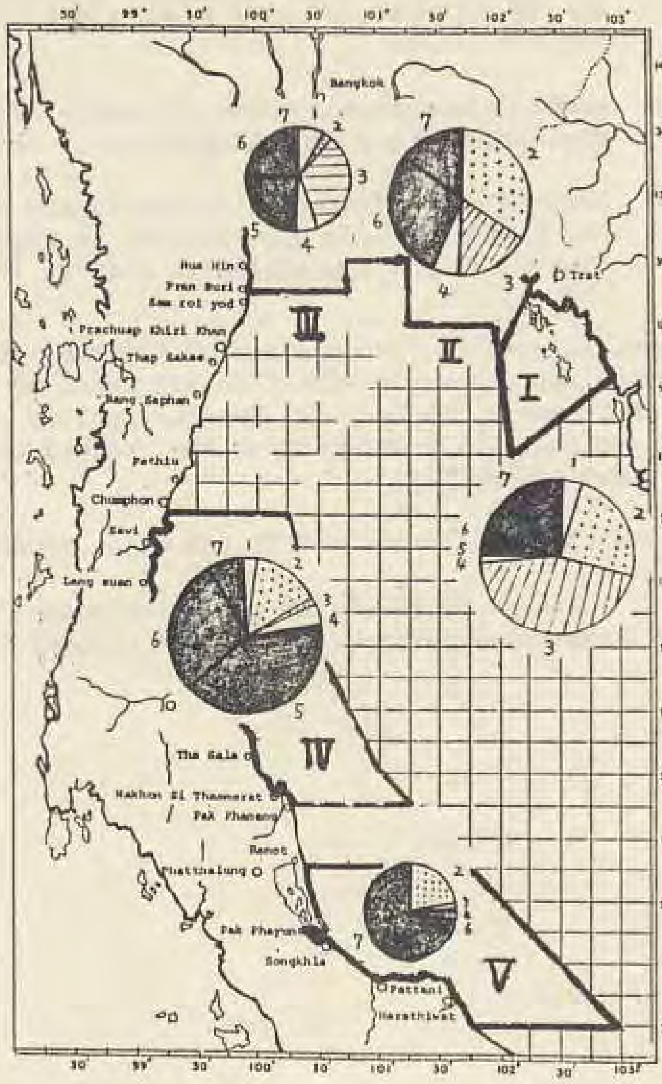

Figure 16. Species composition of large-sized shrimps in terms of CPUE observed by research vessels in 1979. The size of each circle and the code number are adapted from Table 16

Table 16 and Figure 16 show that

(1) the occurrence ratio between *Penaeus* spp. and *Metapenaeus* spp. was nearly the same;

(2) among *Penaeus* spp., two species, i.e., *P. semisulcatus* and *P. latisulcatus* occurred predominantly in the inner Gulf regions (Areas I, II and III);

(3) among *Metapenaeus* species, *M. ensis* and *M. intermedius* dominated with a high proportion of occurrence in all areas;

(4) *Metapenaeus affinis*, which was ranked first in catch and had a wide-ranging distribution in Figure 5, occurred in limited areas, especially in Area IV (Fig. 16).

Thus, in general, two species of *Penaeus* spp. and three species of *Metapenaeus* spp. occurred widely in all areas of the Gulf. If anything, there was a tendency for *Penaeus* spp. to concentrate in the inner Gulf regions, while *Metapenaeus* spp. tended to concentrate in the southern waters of the Gulf.

3.2.4 Annual changes in CPUE for major species

Figure 17 shows the annual changes in CPUE for major species of large-sized shrimps, where CPUE is computed as a whole area average.

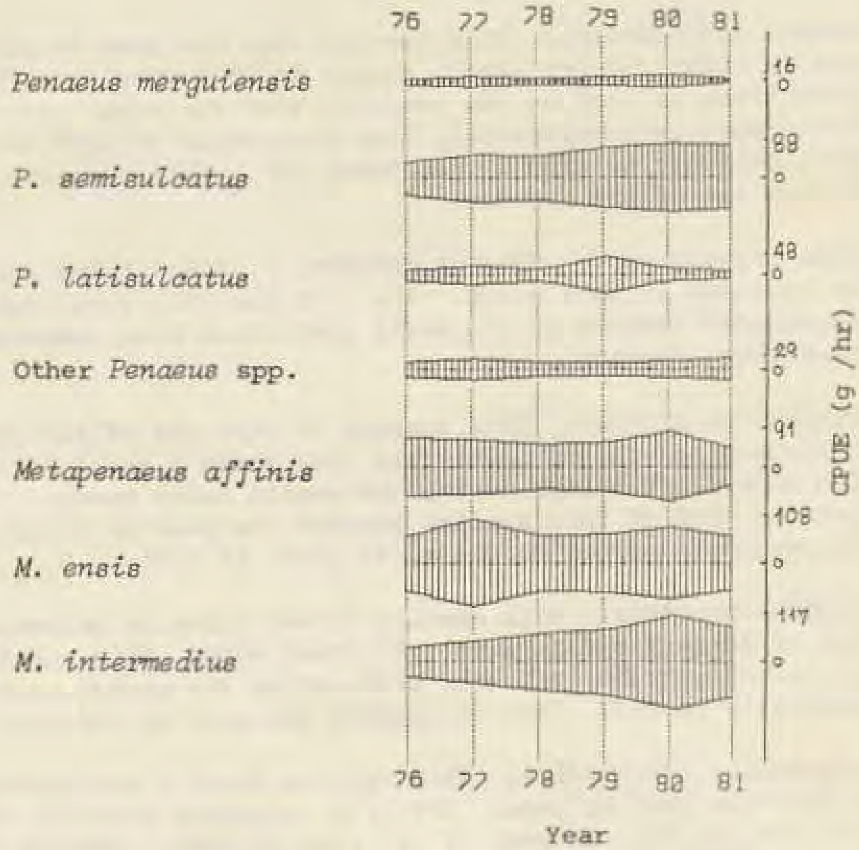

Figure 17. Annual changes in CPUE for major species of large-sized shrimps

The outline of the change in CPUE for each species of large-sized shrimps is as follows:

Penaeus merguiensis: This species seems to be less important for CPUE (2-4 per cent) throughout all research years, in spite of significant catches (10 per cent) obtained by commercial trawlers in 1979 (see Table 9).

Penaeus semisulcatus: This species is one of the important components of large-sized shrimp CPUE as well as in commercial catches. During 1976-1978, its CPUE sustained the same level of 40-60 g/hr after which it increased to the level of 80-90 g/hr.

Penaeus latisulcatus: This species does not seem to play an important role in CPUE (3-7 per cent), except in 1979 when its CPUE was about three times as high as the average value for other years. In 1979 furthermore, a conspicuously high proportion of CPUE for this species was shown only in Area I (see Table 16). This suggests a peculiarity in the habitat of the species.

Other *Penaeus* spp.: *Penaeus monodon, P. longistylus* and *P. japonicus* are included in this group. The CPUE for this group might will be disregarded because of its small proportion when compared with the other three species.

Metapenaeus affinis: This species is also one of the important components of large-sized shrimp CPUE. Its CPUE shows a small decreasing trend with some fluctuations during the period under study. It should be noted that the CPUE of this species reached the peak of 91 g/hr in 1980, followed by a marked decrease (69 g/hr) in 1981.

Metapenaeus ensis: This species ranked first on an average in the total CPUE of large-sized shrimps. In other words, this species always maintained a higher value of CPUE during the period under study, especially in 1977, when it reached the peak of 108 g/hr.

Metapenaeus intermedius: This species shows a most remarkable trend to increase year by year. Its CPUE increased annually at the rate of 1.4, and reached the peak of 117 g/hr in 1980. However in 1981, this CPUE, as well as that of the majority of other species, decreased to the level of 85 g/hr.

Thus, in general, the CPUE for major species of large-sized shrimps fluctuated with the peak in 1980. We can say that 1980 seems to be the turning point of CPUE for large-sized shrimps. We cannot explain the precise reason why this happened. It is possible, as already mentioned, that the calculated value of CPUE in 1980 was overestimated owing to lack of data.

3.2.5 Monthly changes in CPUE for major species

Figure 18 gives the monthly change of CPUE for major species of large-sized shrimps, where CPUE is computed as a six-year average of all research areas.

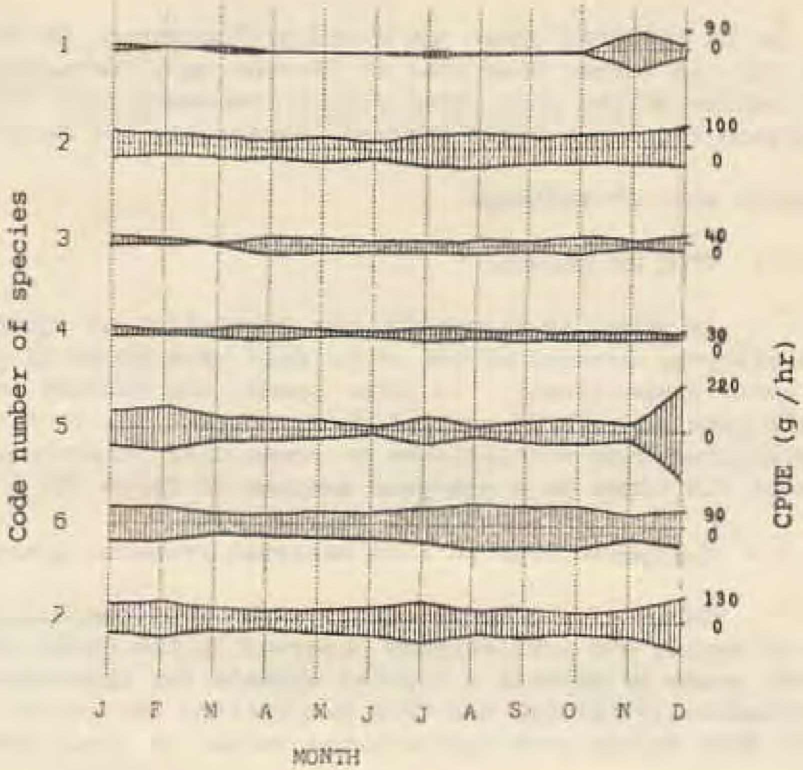

Figure 18. Monthly changes in CPUE for major species of large-sized shrimps. Code no. of species is the same as in Table 16

The monthly change of CPUE for major species of large-sized shrimps shows two patterns: one is an almost steady pattern, and the other is a single or multi-summiting fluctuation pattern.

All species of genus *Penaeus* (Code Nos. 1-4) seem to belong to the first pattern. This means that *Penaeus* spp. seem to have a rather low productivity all the year round. *Metapenaeus* spp., (codes 5-7) give a different pattern. Among *Metapenaeus* spp., both *M. affinis* (code 5) and *M. intermedius* (code 7) show a similar figure of two-summiting fluctuation pattern, i.e., one peak occurring in December-February, and the other in July. Of these two summits, the first is higher than the second. In other words, this means that the most productive months for *M. affinis* and *M. intermedius* cover the dry season from December to February.

Metapenaeus ensis, on the one hand, is especially productive at the end of the rainy season, from August to October.

It can be inferred that the monthly fluctuation of CPUE for *Metapenaeus* spp. is larger than that of *Penaeus* spp. Generally speaking, about eight months of the year, from July to February, are the most important season for large-sized shrimps, especially for *Metapenaeus* spp.

3.3 Squids and cuttlefishes

3.3.1 CPUE in general

As shown in Figure 13, the proportion of squids and cuttlefishes in a six-year average of the whole Gulf were about 22 per cent and 21 per cent, respectively. In other words, the density of squids is nearly the same as that of cuttlefishes, despite the fact that squids were more plentiful than cuttlefishes in commercial otter-board trawl catches (about 1.2 times in a six-year average in Table 7).

3.3.2 Changes in CPUE in five selected research areas

Table 17 and Figure 19 give the CPUE composition, in percentage of squids and cuttlefishes observed in the Gulf, in 1981. The year 1981 seems to provide a typical example for understanding the results statistically because the CPUE proportions for squids and for cuttlefishes show fairly good approximated values to their six-year average.

In 1981, the proportion of CPUE for squids and for cuttlefishes was nearly equal, with the same density in the whole of the Gulf, even though the data from commercial trawlers gave the reverse relationship between squid CPUE and cuttlefish CPUE (see Table 10-a).

Comparative studies of sampling areas, however, reveal that the occurrence ratio of CPUE for squids and for cuttlefishes differs among areas.

Table 17. CPUE composition (in percentage) of squids and cuttlefishes observed by the research survey using otter-board trawl in the Gulf, 1981

Area	I	II	III	IV	V	TOTAL
Squids	5.05	12.52	9.32	9.74	17.57	54.14
Cuttlefishes	11.09	3.22	8.34	10.19	13.02	45.86
TOTAL	16.14	15.74	17.66	19.93	30.53	100.00

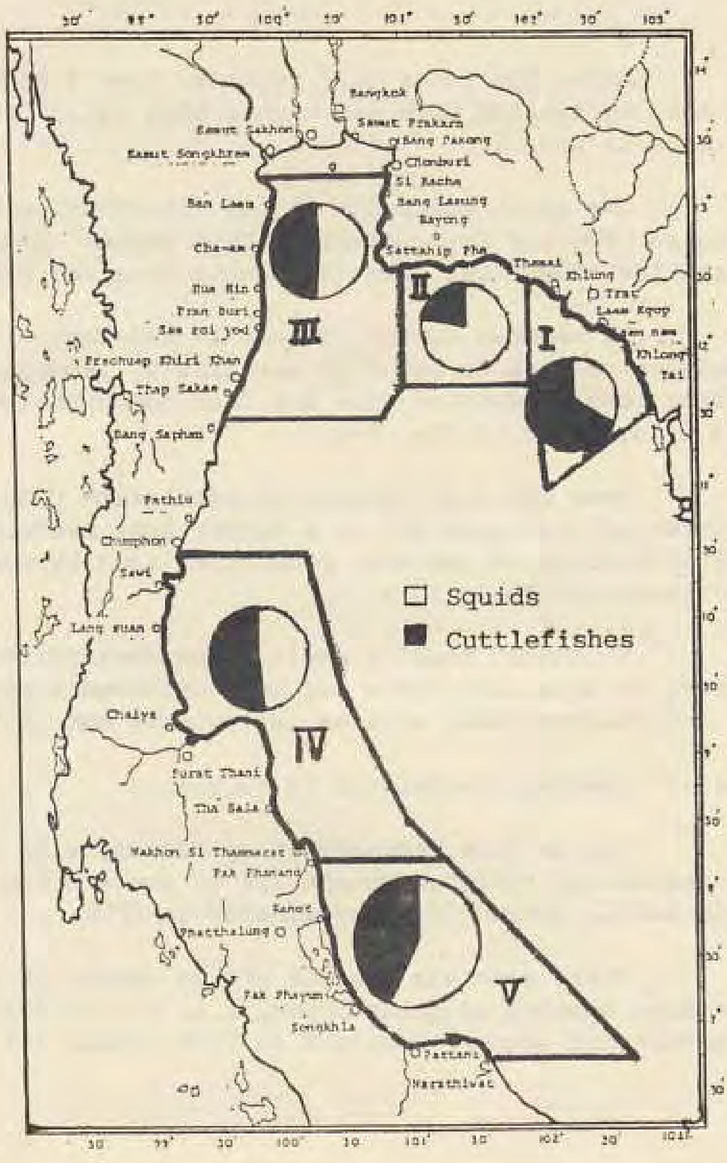

Figure 19. CPUE composition of squids and cuttlefishes observed by the research survey in the Gulf, 1981

The CPUE for both squids and cuttlefishes was the highest in Area V, whereas both CPUEs sustained the same level in the other four areas.

Among the inner Gulf regions, Area I contrasted with Area II in that cuttlefish CPUE was higher that squid CPUE in Area I, and the reverse in Area II.

The great contrasts in the distribution of productive areas for squid CPUE and for cuttlefish CPUE become clear when compared with the commercial data (see Table 10-a and Fig. 6-a).

As regards squids, Figure 19 and Table 17 suggest that the most productive area in the Gulf was Area V. However, Area V seems to be a rather less productive area for Thai commercial otter-board trawlers as illustrated in Fig. 6-a.

From the distribution of cuttlefish CPUE in Table 17 it can be inferred that Area III is a rather less productive area, despite the indication of the most productive area by commercial otter-board trawls in Table 10-a.

We cannot readily explain the contradiction between these two sets of data, but there may be a difference between the commercial and research data sources, as pointed out above.

3.3.3 Species composition in each area

Squids were represented by four species of two genera. Among four species of squids, two species of genus *Loligo*, i.e. *L. chinensis* and *L. duvauceli* predominated in CPUE.

There were six species of two genera of cuttlefishes. Among them three species of genus *Sepia*, i.e. *S. aculeata*, *S. pharaonis* and *S. recurvirostra* were predominant in CPUE (Table 18).

Table 18. CPUE composition (in percentage) of major species of squids and cuttlefishes in the Gulf, 1976-1981

Code No. Species \ Area	I	II	III	IV	V	TOTAL
Squids	6.63	11.29	9.84	7.66	15.43	50.85
1 *Loligo duvauceli*	2.13	2.82	2.55	4.95	4.35	16.80
2 *L. chinensis*	3.70	7.15	5.60	2.04	9.60	28.09
3 *L. uyii*	0.10	0.07	0.19	0.28	0.44	1.08
4 *Sepioteuthis lessoniana*	0.70	1.25	1.50	0.39	1.04	4.88
Cuttlefishes	9.65	5.61	9.62	11.53	12.74	49.15
5 *Sepia pharaonis*	0.80	1.60	2.95	1.06	3.67	10.08
6 *S. recurvirostra*	1.33	1.60	2.95	0.23	2.33	8.08
7 *S. aculeata*	6.69	2.04	3.63	9.11	1.56	23.03
8 Others	0.83	0.37	0.45	1.13	5.18	7.96
TOTAL	16.28	16.90	19.45	19.19	28.18	100.00

Others: *Sepia lycidas*, *S. brevimana* and *Sepiella inermis*

The figure of occurrence of each species in each area can be summarized as follows (Figure 20):

Area I

One species of cuttlefishes, i.e. *Sepia aculeata* (code 7), is conspicuous in CPUE composition. Two species of squids, *Loligo chinensis* (code 2) and *L. duvauceli* (code 1), follow with a small proportion of occurrence. Therefore, it would appear that this area is the best habitat for *Sepia aculeata*.

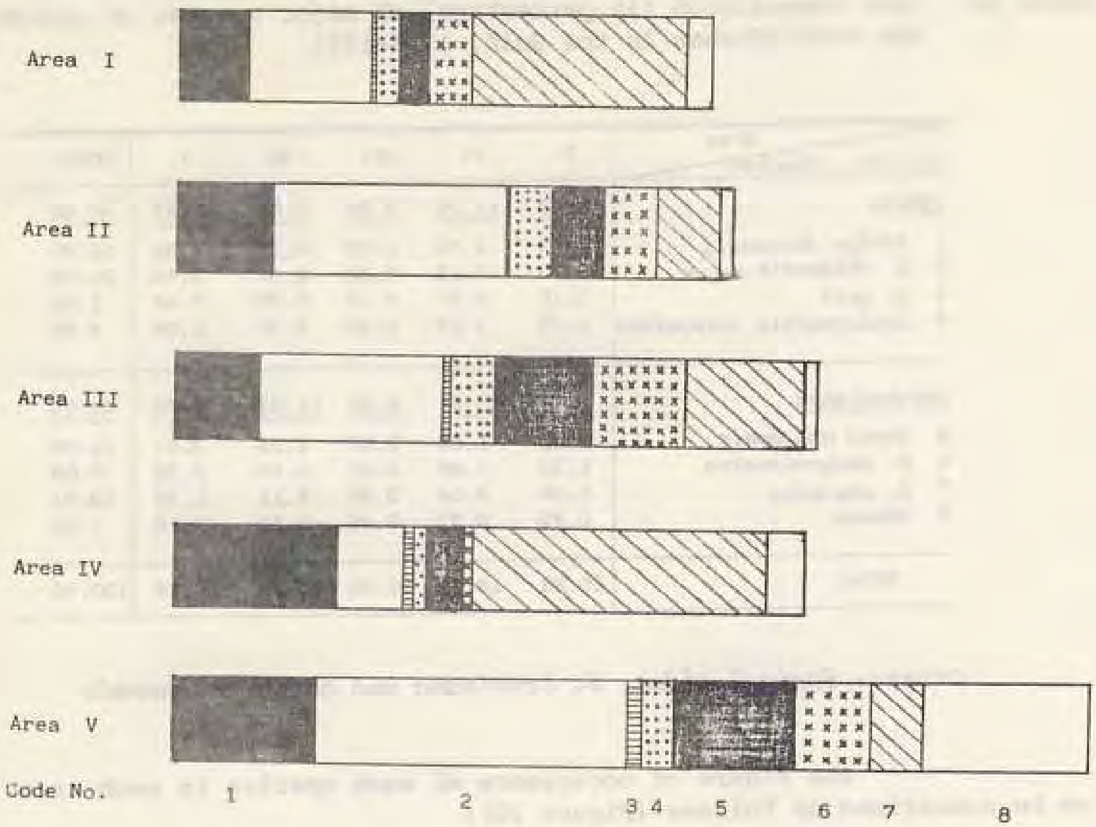

Figure 20. CPUE composition of major species of squids and cuttlefishes in the Gulf, 1976-81.
Code no. of species is adapted from Table 18

Area II

One species of squids, *Loligo chinensis* (code 2), is conspicuous in CPUE composition. Other squids such as *Loligo duvauceli* (code 1) and *Sepioteuthis lessoniana* (code 4) follow with a small proportion of occurrence. Cuttlefish CPUE is extremely small.

Therefore we can say that this area is a fairly good habitat for squids, particulary for *Loligo chinensis*.

Area III

In this area the proportion of each CPUE is similar to that in Area II, and the CPUE ratio between squids and cuttlefishes is nearly the same. That is, three species of squids (*Loligo chinensis* (code 2), *L. duvauceli* (code 1) and *Sepioteuthis lessoniana* (code 4)) and three species of cuttlefishes (*Sepia aculeata* (code 7), *S. pharaonis* (code 5) and *S. recurvirostra*(code 6))occur more or less in the same proportions.

Therefore we can say that this area is fairly good, with a high diversity of species both of squids and cuttlefishes.

Area IV

Two species of squids and cuttlefishes, i.e. *Loligo duvauceli* (code 1) and *Sepia aculeata* (code 7), predominated in CPUE. These two dominant species account for about 73 per cent of the total CPUE in this area.

Therefore we can say that Area IV is a higher productive area for specific species of squids and cuttlefishes, particularly for *Sepia aculeata* and for *Loligo duvauceli* .

Area V

Two species of squids, i.e. *Loligo chinensis* (code 2) and *L. duvauceli* (code 1), are conspicuous in CPUE composition. For cuttlefishes, there is no specific character in CPUE composition, and each species keeps a relatively high value of CPUE. But others (code 8) show a higher CPUE.

Therefore we can say that this area is the most productive area, with a high diversity of species both of squids and cuttlefishes.

3.3.4 Annual changes in CPUE for major species

Figure 21 gives the annual change in CPUE for major species of squids and cuttlefishes, where CPUE is computed as a whole area average.

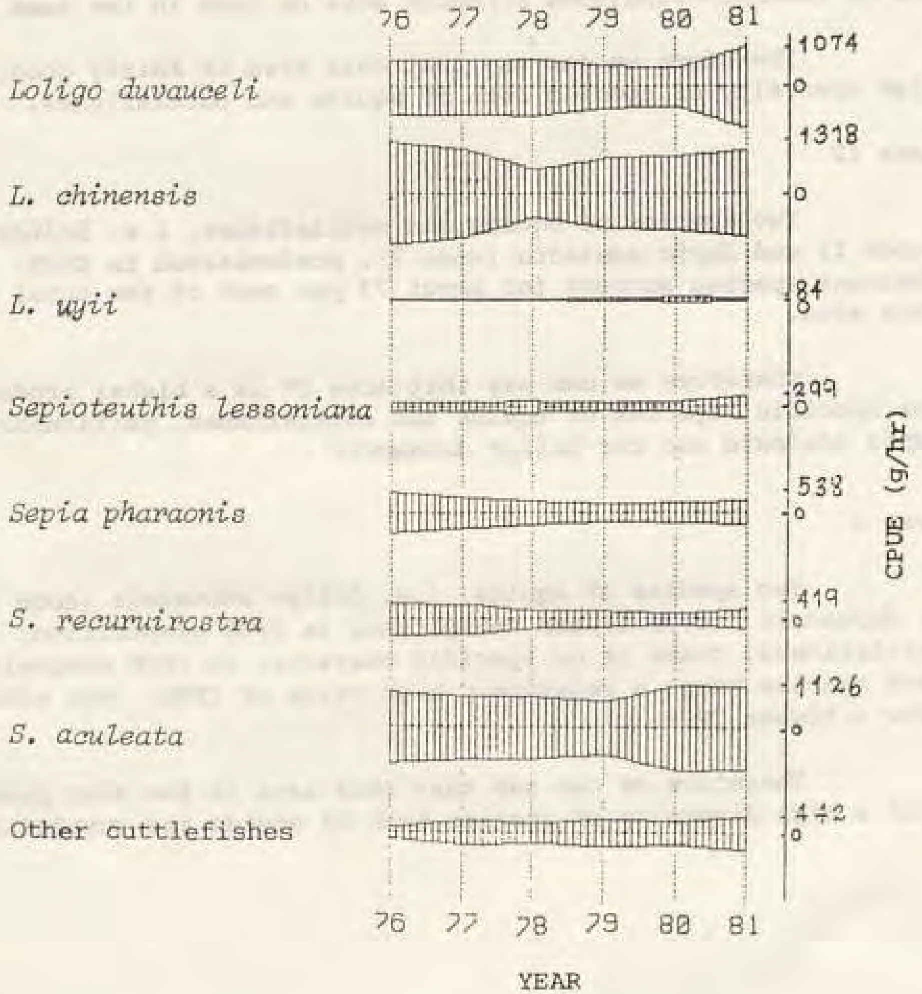

Figure 21. Annual changes in CPUE for major species of squids and cuttlefishes

The outline of the change of CPUE for each species of squids and cuttlefishes is given as follows:

Loligo duvauceli This species is one of the important components of squid and cuttlefish CPUE. During 1976-1978, its CPUE remained at a relatively constant value of about 700 g/hr. In the following period of 1979-1980, it decreased and reached the level of about 500 g/hr. In 1981 however, it increased to the level of about 1,100 g/hr.

Loligo chinensis This species seems to have been the most important for CPUE (20-32 per cent) during the period under study. Once in 1978 its CPUE levelled down to about 600 g/hr, but soon recovered to the level of about 1,100 g/hr in 1981.

Loligo uyii This species can be disregarded because its CPUE accounts for a negligible proportion when compared with that of other species.

Sepioteuthis lessoniana This species seems to have been less important for CPUE (3-8 per cent) throughout all research years. Annual fluctuation of CPUE is also very small.

Sepia pharaonis This species seems to play a not very important role for CPUE (7-13 per cent). Its CPUE has been gradually decreasing year by year, and reached the level of about 330 g/hr in 1981.

Sepia recurvirostra This species also seems to play a less important role for CPUE (4-10 per cent). Its CPUE has been gradually decreasing year by year, reaching the level of about 280 g/hr in 1981.

Sepia aculeata This species is one of the most important cuttlefishes for CPUE (22-32 per cent), during the period under study. During the period of 1976-1979, its CPUE gradually decreased and reached the level of about 700 g/hr in 1979. In 1980 however, it increased to the level of about 1,100 g/hr, and remained the same until 1981.

Other cuttlefishes. *Sepia lycidas*, *Sepia brevimana* and *Sepiella inermis* are included in this group. The CPUE for this group may be disregarded because of its small proportion when compared with other dominant species.

Thus in general, the CPUE of major species of squids and cuttlefishes showed slight fluctuations around the period 1978-1979. As mentioned on the subject of stock assessment of Part I, the current catch of squids and cuttlefishes by otter-board trawls shows a trend towards overfishing. We feel this is correct, but it might be better to say that the major species of squids and cuttlefishes in the Gulf may have been slightly over-exploited in 1977-1978 thus affecting the future decrease of their CPUE, because the range of fluctuation in CPUE around the period of 1978-1979 is not so considerable as to pose a serious problem as regards the potential of the stock.

3.5.5 Monthly changes in CPUE for major species

Figure 22 gives the monthly changes in CPUE for major species of squids and cuttlefishes, where CPUE is computed as a six-year average in all research areas.

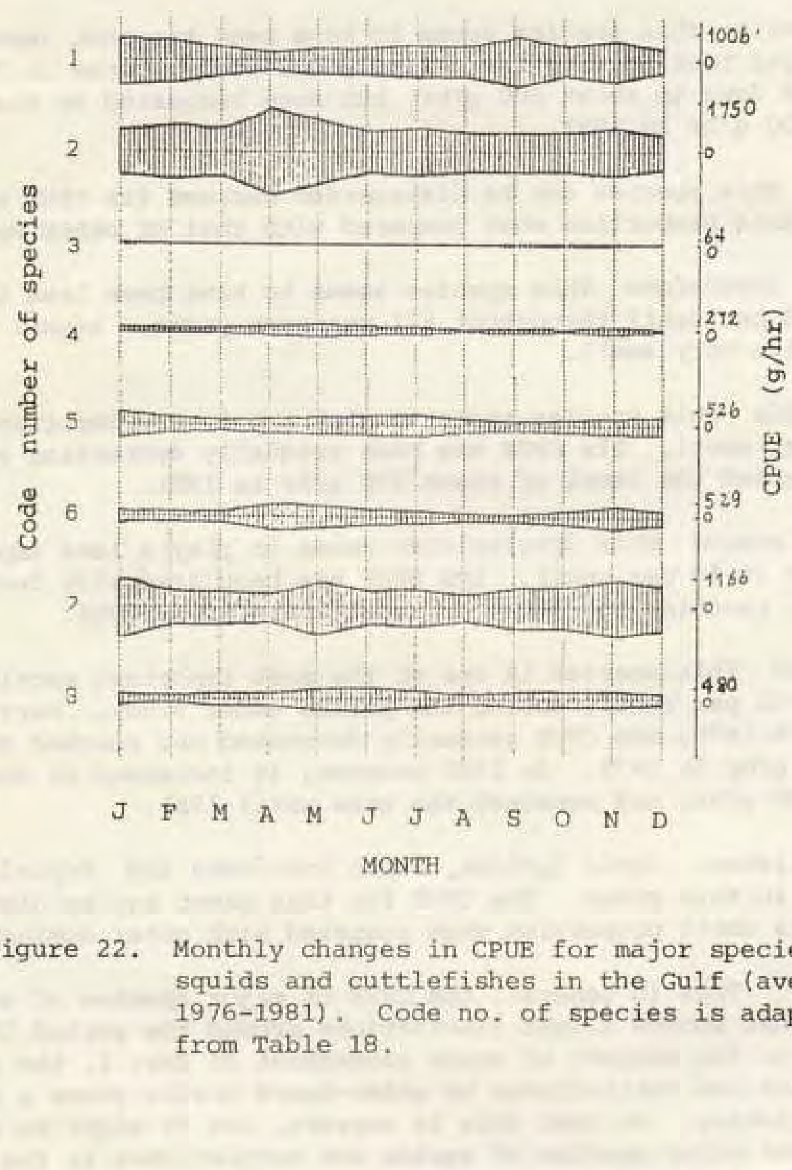

Figure 22. Monthly changes in CPUE for major species of squids and cuttlefishes in the Gulf (average 1976-1981). Code no. of species is adapted from Table 18.

The monthly changes of CPUE for major species of squids and cuttlefishes are somewhat clearer than that for large-sized shrimps. It is as follows:

Among the species of squids, *Loligo duvanceli* (code 1) and *L. chinensis* (code 2) show some specific fluctuations, i.e. the former has rather a long productive season from September to February (peak is in September), and the latter occurs from November to May (peak is in April-May) Thus these two species of squids co-occur during several months of the dry and summer seasons.

Among cuttlefishes, *Sepia aculeata* (code 7) has a fairly distinct figure of fluctuation. This species occurs productively in the dry season from November to January and in May (summer season). Other species of cuttlefishes keep a rather constnat low value of CPUE all the year round.

It can therefore be concluded that the monthly fluctuation of squid and cuttlefish CPUE is similar to that of large-sized shrimps, and that the nine months from September to May of the following year are in general the most important months for squid and cuttlefish productivity. If anything, the period of productivity of squids is slightly longer than that of cuttlefishes.

4. Conclusions

4.1 Variations in CPUE

Table 19 gives summarized CPUEs abstracted from various biological aspects of occurrence of major species of invertebrates in the Gulf.

Table 19. Biological aspects of occurrence of major species of invertebrates in terms of CPUE induced from the research surveys in the Gulf, 1976-1981

Group	Species (share of total catch:%) \ Predominant	Year (CPUE: g/hr)	Month (CPUE: g/hr)	Area (CPUE: g/hr)	
Shrimps (10.7)	Small-sized shrimps (10.0)	1980 (6,377)	June-July (5,822 - 5,903)	III (9,122)	V (9,722)
	Large-sized shrimps (0.7) *Penaeus semisulcatus*	1979-1981 (82-88)	Jan. - Dec. (42-95)	I (145)	II (187)
	Metapenaeus affinis	1980 (91)	Dec. - Feb. (87-222)	IV (227)	
	M. ensis	1977 (108)	Aug. - Oct. (102-112)	II (157)	IV (160)
	M. intermedius	1980 (117)	Dec. - Feb. (70-131)	I (125)	V (154)
Squids and Cuttlefishes (8.0)	Squids (4.1) *Loligo duvauceli*	1981 (1,074)	Sept. - Feb. (438-1,006)	IV (775)	V (883)
	L. chinensis	1976 (1,318)	Apr. - May (1,315-1,750)	II (1,274)	V (1,712)
	Cuttlefishes (3.9) *Sepia aculeata*	1980-1981 (1,053-1,126)	Nov.-Dec., May (901-1,166) (1,064)	I (1,193)	IV (1,622)

From this table, we can infer the following:

4.1.1 Periodic variation

As regards small-sized shrimps, they occurred predominantly in 1980. The occurrence of large-sized shrimps was also predominant in 1980, with a small variation by species.

Squids and cuttlefishes, on the other hand, showed a different occurrence pattern by species. For example, with respect to the two major species of squids, *Loligo chinensis* occurred dominantly in 1976, while *Loligo duvauceli* occurred dominantly in 1981. Cuttlefishes occurred predominantly in 1980-1981.

4.1.2 Seasonal rhythm

The six-year average in all research areas (Table 19) suggests that small-sized shrimps were captured essentially at the middle (June-July) of the year. Large-sized shrimps, in contrast to small-sized ones, had a wide variety of seasonal rhythms by species in catch. Among *Metapenaeus* spp., *M. affinis* and *M. intermedius* were caught essentially from December to February, while *M. ensis* was caught predominantly during August to October.

Squids and cuttlefishes had a longer term occurrence rhythm than large-sized shrimps, and the nine months from September to May of the following year seemed to be the most important months for their occurrence.

4.1.3 Geographical variation

According to Table 19, the most abundant areas of small-sized shrimps were found both in the inner and the southern Gulf. Among large-sized shrimps, generally speaking, *Penaeus semisulcatus* and three species of *Metapenaeus* occurred widely in all areas of the Gulf with some variation such as *Penaeus* which tended to concentrate in the inner Gulf regions, while *Metapenaeus* predominanted in the southern waters of the Gulf.

Squids and cuttlefishes had a wide range of distribution; however, two dominant species of squids were fairly abundant in the most southern waters (Area V), while one dominant cuttlefish occurred both in inner (Area I) and southern (Area IV) waters.

Part III General remarks for stock evaluation of invertebrates in the Gulf of Thailand

1. Comparison of commercial and research data

Table 20 gives periodic, seasonal and geographical variations in commercial invertebrate catch in the Gulf, which are summarized from the results of Part I.

Table 20. Biological aspects of occurrence of major species of commercial invertebrate catch by otter-board trawlers in the Gulf, 1976-1981

	Species (share of total catch(%)) \ Predominant	Year (catch: metric tons)	Month (catch: metric tons)	Main fishing areas (% by area from sampling survey)
Shrimps (8.9)	Small-sized shrimps (7.5)	1977 - 1978 (≈ 64,000)	June-July (≈ 5,600) Oct. (≈5,750)	III (48.65)
	Large-sized shrimps (1.4) *Penaeus merguiensis*	1978 (≈ 5,500)	Nov. - Jan. (≈ 380)	III (52.44)
	Penaeus semisulcatus	1979 (≈ 4,000)	July Oct. - Nov. (≈ 220)	II (35.83) I (33.63)
	Metapenaeus spp. (*M. affinis*, *M. ensis* and *M. intermedius*)	1977 - 1978 (≈ 11,000)	July - Aug. (≈ 806) Jan. - Feb. (≈ 835)	III (31.71) IV (25.35)
Squids + Cuttlefishes (5.1)	Squids (2.7)	1978 (≈ 26,500)	Mar. - May (2,200)	I (53.61)
	Cuttlefishes (2.4)	1978 (≈ 22,500)	May - Oct. (≈ 1,900) Jan. (≈ 1,850)	III (29.17) V (23.50)

Commercial data with regard to the biological aspects of occurrence of major species in invertebrate catch is very different from that of CPUE data (see Table 20 and Table 19).

The differences are as follows:

(a) Proportion of invertebrates in total catch;

(b) Dominant species, especially among large-size shrimps;

(c) Predominant occurrence by species/groups of invertebrates (CPUE data has a two to three year's time lag);

(d) Distribution of abundant areas for each species.

2. Source of variations in abundance between commercial and research data

It is generally recognized that the difference in the systems of operation (including type of boat and gears, and fishing effort both in terms of time and in space) is the main source of error in abundance estimates.

Detailed information on the operation systems of both commercial and research trawlers is given below.

Table 21. Operation systems of commercial and research trawlers

	Commercial trawlers	Research trawlers
Length of boats (m)	14 - 18 (as a standard unit)	23 - 25 (PRAMONG 4 & 5)
Fishing effort – Net – Design	2-sheet(German) & 4-sheet(Japanese)	German
Fishing effort – Net – Whole length (m)	30 - 40	46.5 - 47.7
Fishing effort – Net – Mesh size (mm) of cod end	15 - 26	25
Fishing effort – Operation – in space	Irregular distribution	Uniform distribution by grid system
Fishing effort – Operation – in time	Day and night	Night
Fishing effort – Operation – trawling duration (hr)	4 - 5	1
Fishing effort – Operation – No. of oper./day	3 - 4	6 - 7
Target animals	Fishes & invertebrates	Shrimps, squids and cuttlefishes

From this table, we can infer the source of variations between commercial and research data on the abundance of invertebrates.

a) Proportion of invertebrates in total marine catch

As already mentioned, the proportion of invertebrates observed by research surveys is always about 1.1 to 2.2 times as high as the proportion indicated in data from commercial trawlers. This is due to the following three reasons. Firstly, the difference in the size of boats and gears is the most important parameter in this kind of variation. The bigger-sized research boats equipped with more effective gears (German style trawl nets), may be more efficient in invertebrate catch than the smaller-sized commercial boats equipped with small-sized less effective gears (two or four sheet style nets). Secondly, as shown in this table, research surveys were conducted only at night-time, whereas commercial trawlers usually operated both at night and during the day. It is well known that most invertebrates tend to aggregate or show full activity at night-time (catches of shrimps are generally plentiful during the night). In other words, there is a better distribution of effort in time by research boats that engage in night fishing to catch invertebrates. And thirdly, the commercial trawlers aim to catch fish as well as invertebrates. Therefore, the large catch of fish by commercial trawlers has the effect of reducing the relative proportion of invertebrates in the total marine catch.

Thus these individual differences in operations between research and commercial boats resulted in the difference in invertebrate catches. It can therefore, be concluded that research boats may have some advantages, such as greater effectiveness and efficiency for catching invertebrates, especially for shrimp catch, because of a more concentrated effort as regards time and target species.

b) Dominant species, and d) their distribution in space

By comparing Table 19 with Table 20 differences appear in the data on some dominant species of large-sized shrimps. For instance, *Penaeus merguiensis* was caught in large numbers only by commercial trawlers. This species was caught plentifully in Area III, which is the most inner area in the Gulf. Most of this area has an average water depth of 25 m. Water depth is one of the very important factors in determining species distribution.

Table 22 gives the estimated size of potential fishing areas (km^2) swept by both commercial and research trawlers in the Gulf.

Table 22. Estimated size of potential fishing areas (km^2) swept by both commercial and research trawlers in the Gulf, 1976-1981

Area[1]	Shrimps			Squids and cuttlefishes		
	Commercial[2] 1976-81	Research[3] 1976-79	Research[3] 1980-81	Commercial[2] 1976-81	Research[3] 1976-79	Research[3] 1980-81
I	7,720	6,060	3,150	7,720	6,060	3,150
II	8,490	6,330	3,150	8,490	6,330	3,150
III	9,260	7,380	3,480	21,610	13,050	6,240
IV	27,780	14,500	6,890	27,780	14,500	6,890
V	21,610	7,900	3,950	24,700	9,430	4,740
Total	74,860	42,170	20,620	90,300	49,370	24,170

1 Source: Shrimps adapted from Fig. 4; squids and cuttlefishes adapted from Fig. 5

2 Calculated from: No. of grids × 771.75 km^2

3 Data adapted from an average number of monthly operations, and calculated from: (No. of op./Area/Month) × 771.75 km^2. This is based on the assumption that each trawl operation represents one block of the grid.

In Area III, as shown in Table 22, the estimated size of potential fishing areas swept by commercial boats was about 1.25 to 2.66 times as large as that swept by research boats. In other words, research boats could cover effectively only 38 to 80 per cent of the areas covered by commercial boats.

If the research boats could conduct their fishing operations in the whole area of shallow inshore waters within Area III, they could be expected to include *Penaeus merguiensis* in their catch.

It is notable that, among *Penaeus* spp., *P. merguiensis* have a specific behaviour, i.e. they like to feed in broad day light and tend to aggregate in daytime or are in full activity during the day. These activities may account for the more efficient catch by commercial trawlers which operated both during the day and at night-time.

Therefore, it seems that variations in species occurrence are mainly due to the different operation systems (particularly in space and in time) of commercial and research boats.

c) Periodic variation of occurrence

For almost every kind of species, the peak period of occurrence as shown in commercial as opposed to research data differs by two to three years. For instance, small-sized shrimps were caught most abundantly by commercial trawlers in 1977-1978, while their CPUE value, calculated from research data, showed a peak in 1980 (see Tables 19 and 20).

This variation may be due to the significant difference in the number of operations by research boats. As regards the research surveys, random survey operations were carried out almost monthly with about eight hauls per area during 1976-1979. In 1980 and 1981, however, only about four operations per area were carried out once every two months. Consequently, the average number of operations per year varied considerably within those two periods (Table 23).

Table 23. Number of operations conducted by research surveys in the Gulf of Thailand, 1976-1981

Year	76	77 78 79	80 81
No. of operations	995	658 591 639	197 171
Average (77-79), (80-81): $\bar{x}$		629.3 ± 34.5 (S.D.: *s*)	184 ± 18.38 (S.D.: *s*)
C.V. value		0.055	0.100
Average (77-81)		451.2 ± 219.4 (S.D.: *s*)	

S.D. (*s*): Standard deviation

C.V.: Coefficient of variation, calculated from C.V. = $s/\bar{x}$

The small number of operations (about 184 units) in 1980-1981 also resulted in increasing the value of the coefficient of variation (Table 23) and diminish the reliability of CPUE estimates owing to a lack of databases. Therefore, the calculated value of CPUE in 1980-1981 may possibly have been over-estimated.

As mentioned above, there is a great difference between the fishing operation systems of commercial and research boats, as well as between the two periods 1976-1979 and 1980-1981 of the research surveys. Therefore, it can be concluded that the research surveys were more effective in invertebrate catch, but the number of their fishing operations was too small to make CPUE estimates, especially for 1980-1981.

3. Recommendations

3.1 Management of trawl fisheries for shrimps, squids and cuttlefishes

As mentioned in the section on stock assessment of this paper, the current situation is that the invertabrate stock has either been over-exploited or shows a trend towards overfishing by Thai trawlers. It should, therefore, be stressed that recomendations concerning the management of trawl fisheries for invertebrates, for the purpose of avoiding further overfishing, are urgently required.

3.1.1 Number of boat units

Table 24 gives annual changes in the number of otter-board trawl units, and corresponding catch of invertebrates in the Gulf.

Table 24. Number of otter-board trawl units (A), invertebrate catch (B: x 10^3 metric tons) and CPUE (C: ton/boat) in the Gulf, 1973-1981

	1973	1974	1975	1976	1977	1978	1979	1980	1981	Average
A	3,843	3,507	3,307	3,666	4,455	4,487	6,118	7,046	5,136	4,619
B	115	102	100	92	131	141	115	109	110	113
C	29.9	29.1	30.2	25.1	29.4	31.4	18.8	15.5	21.4	25.6

During the four years from 1973 to 1976, the number of trawl units remained almost at the same level of 3,300 to 3,800 units, corresponding the catches of 90,000 to 115,000 metric tons of invertebrates. This represents an annual catch of 25-30 metric tons produced by each boat in those years. During the two years of 1977-1978, the number of trawl units increased gradually and reached the level of about 4,500 units. In that period, the substantial income in terms of catch per unit of boats was found to give the highest value of about 30 ton/boat. A most drastic increase of boats was seen in 1979-1980, but during that period the catch of invertebrates decreased compared with the previous two years. An abrupt CPUE reduction (16-19 ton/boat) was also found in 1979-1980.

According to Boonyubol and Pramokechutima (1984), the investment of fishing effort in the Gulf by Thai trawlers in 1981 was found to exceed by 82 per cent the estimated optimum effort of 8.6 million trawling hours. Consequently, the overall stock size of demersal resources decreased drastically, in accordance with the reduction of catch rate, from approximately 290 kg/hr in 1963 to less than 50 kg/hr.

Thus, owing to the deterioration of the demersal resources and the change in catch composition by trawls, the number of registered fishing boats has decreased since 1981 (Table 23), and small-sized trawlers were compelled to convert to purse seiners or squid fishing boats with cast nets.

It is therefore appropriate to recommend that the number of otter-board trawl units in the Gulf of Thailand should be reduced to the level (4,500 units) of 1977-1978.

3.1.2 Duration of fishing operations

Table 25 and Figure 23 give the CPUE for shrimps and cephalopods in experimental surveys at different towing durations. Those experimental surveys were carried out by M.V. PRAMONG 5 in 1983, for the purpose of estimating the optimum mesh size of a shrimp trawl-net, as well as studying the effects of towing duration on the fishing efficiency of a shrimp trawl-net. Those surveys aimed mainly to ascertain the net's catching efficiency for shrimps. Therefore, surveys were carried out in a limited part of Area IV as illustrated in Fig. 16, because this area was known as a productive area for large-sized shrimp, especially *Metapenaeus affinis* (see Table 16).

Table 25. CPUE for shrimps (a), for cephalopods (b) and for invertebrates (c), from experimental surveys at different towing durations, 1983.

a) Shrimps

Towing duration (hr)	1	2	3	4	Average
February	4.20	3.71	2.59	2.71	3.30
April	5.78	11.43	7.39	3.33	6.98 (5.50)
June	2.65	3.57	5.54	7.31	4.77
August	6.76	7.61	6.16	6.92	6.86
Average	4.85	6.58	5.42	4.84	5.42

b) Cephalopods (squids, cuttlefishes and octopus)

Towing duration (hr)	1	2	3	4	Average
February	1.87	1.79	1.45	1.27	1.60
April	3.03	1.58	2.87	2.38	2.46
June	3.19	1.89	1.88	1.65	2.15
August	2.26	4.61	3.11	1.02	2.75
Average	2.59	2.47	2.33	1.58	2.24

c) Invertebrates (shrimps + cephalopods)

Towing duration (hr)	1	2	3	4	Pooled
Pooled average	7.44	9.05	7.75	6.42	7.66

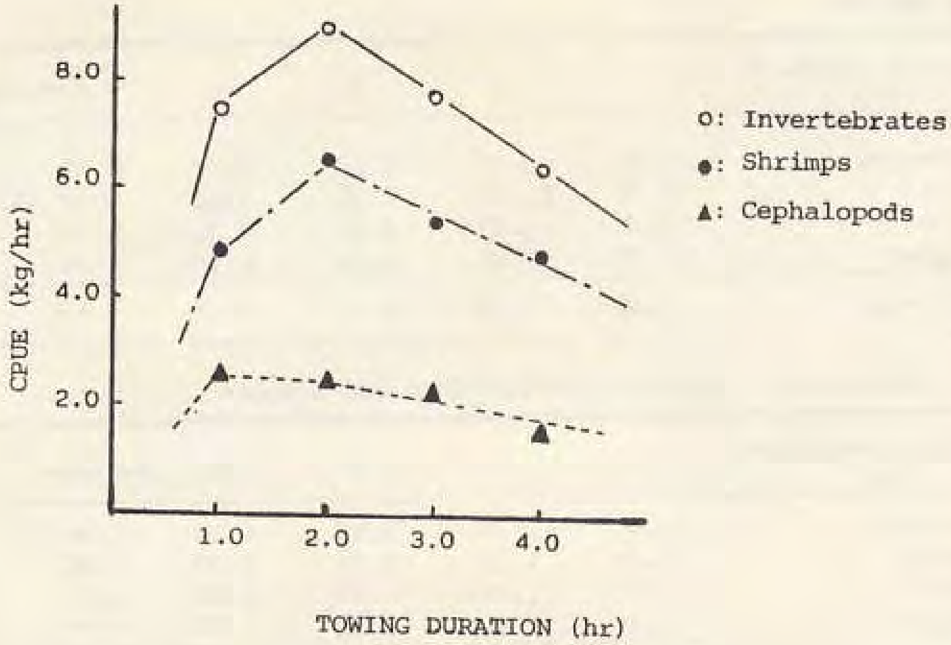

Figure 23. Relationship between CPUE and towing duration.

From Figure 23, it can be concluded that the CPUE for invertebrates decreased lineally at two hours' towing corresponding to the protraction of towing duration. In other words, this means that the optimum towing duration for increasing fishing efficiency is about two hours.

3.1.3 Mesh size

Table 26 and Figures 24 (a) and (b) show the rate of retained invertebrates in catch and the CPUE caught by trawl nets with various mesh sizes of cod end.

Table 26. Rate of retained invertebrates in catch and CPUE, by trawl nets with various sizes of cod end,1983

(A) Shrimps

Mesh size (mm)	20	30	40	50	60
a) Rate of retained					
Small-sized shrimps	1.00	0.91	0.77	0.52	0.32
Large-sized shrimps	1.00	0.95	0.92	0.67	0.37
b) CPUE (kg/hr)					
Small-sized shrimps	7.12	6.40	5.49	3.23	1.71
Large-sized shrimps	1.30	1.14	0.89	0.87	0.61

(B) Squids and cuttlefishes

Mesh size (mm)	20	30	40	50	60
a) Rate of retained					
Squids	1.00	0.97	0.89	0.38	0.38
Cuttlefishes	1.00	0.99	0.99	0.94	0.93
b) CPUE (kg/hr)					
Squids	0.91	0.87	0.82	0.33	0.27
Cuttlefishes	0.91	0.89	0.70	0.58	0.56

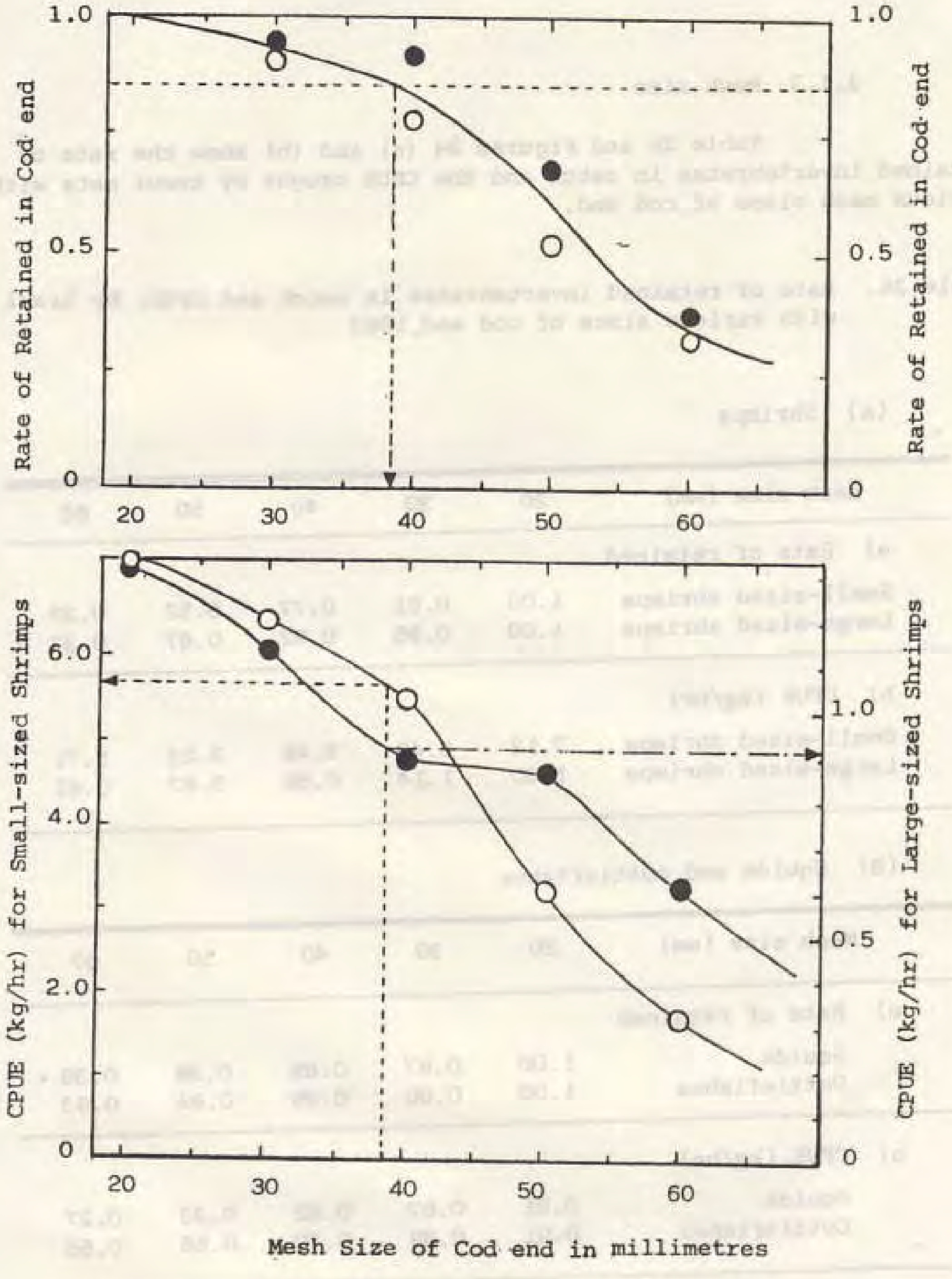

Figure 24-a. **Decreases in catch of shrimps by increasing the mesh size of shrimp trawl nets**

O : Small-sized shrimps
● : Large-sized shrimps

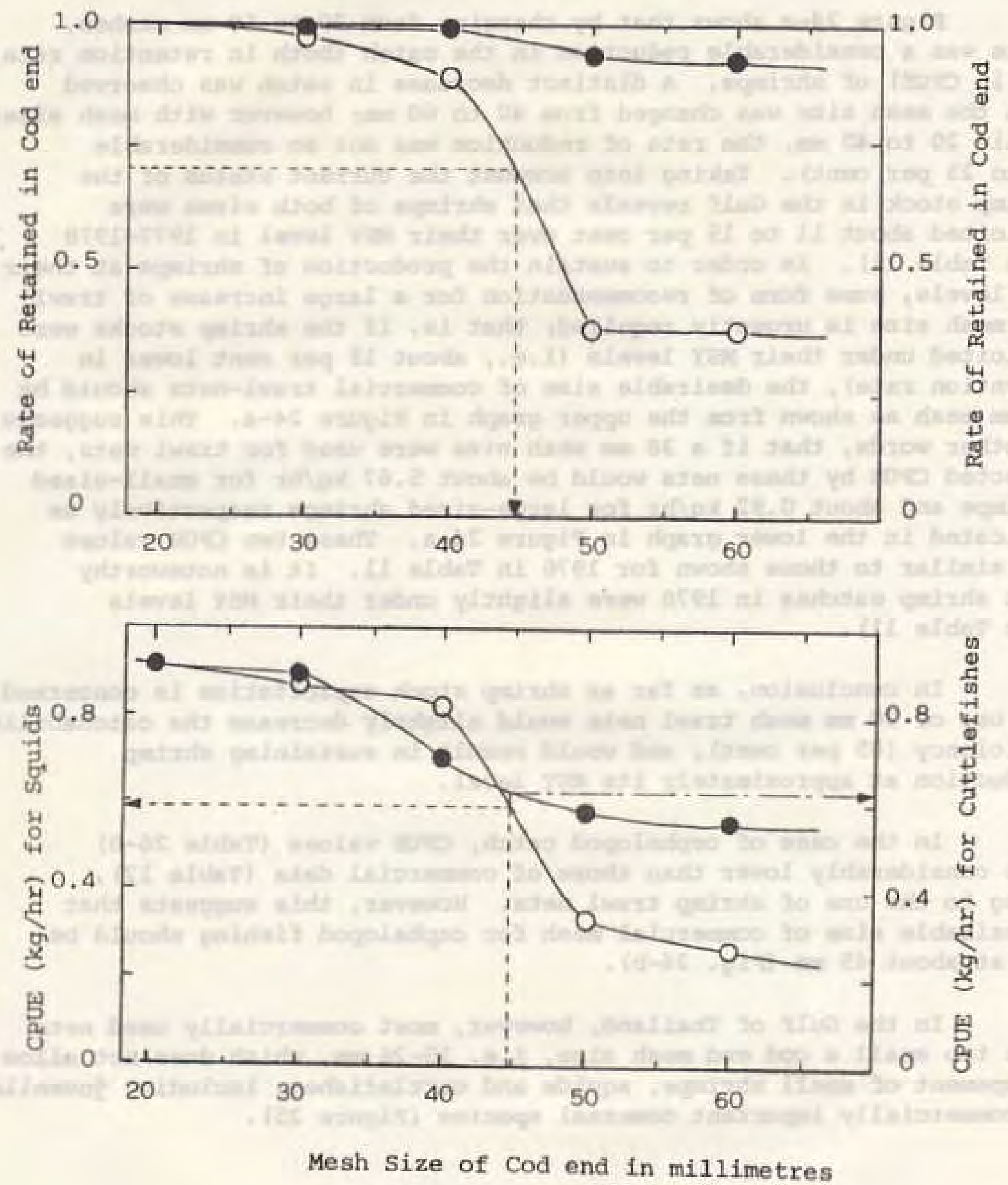

Figure 24-b. Decreases in catch of squids and cuttlefishes by increasing the mesh size of shrimp trawl nets

O : Squids
● : Cuttlefishes

Figure 24-a shows that by changing from 20 to 60 mm meshes, there was a considerable reduction in the catch (both in retention rate, and in CPUE) of shrimps. A distinct decrease in catch was observed when the mesh size was changed from 40 to 60 mm; however with mesh sizes within 20 to 40 mm, the rate of reduction was not so considerable (9 to 23 per cent). Taking into account the current status of the shrimp stock in the Gulf reveals that shrimps of both sizes were exploited about 11 to 15 per cent over their MSY level in 1977-1978 (see Table 11). In order to sustain the production of shrimps at their MSY levels, some form of recommendation for a large increase of trawl net mesh size is urgently required; that is, if the shrimp stocks were exploited under their MSY levels (i.e., about 15 per cent lower in retention rate), the desirable size of commercial trawl-nets should be 38 mm mesh as shown from the upper graph in Figure 24-a. This suggests, in other words, that if a 38 mm mesh size were used for trawl nets, the expected CPUE by these nets would be about 5.67 kg/hr for small-sized shrimps and about 0.92 kg/hr for large-sized shrimps respectively as indicated in the lower graph in Figure 24-a. These two CPUE values are similar to those shown for 1976 in Table 11. It is noteworthy that shrimp catches in 1976 were slightly under their MSY levels (see Table 11).

In conclusion, as far as shrimp stock exploitation is concerned, the use of 38 mm mesh trawl nets would slightly decrease the catchability efficiency (85 per cent), and would result in sustaining shrimp production at approximately its MSY level.

In the case of cephalopod catch, CPUE values (Table 26-B) were considerably lower than those of commercial data (Table 12), owing to the use of shrimp trawl nets. However, this suggests that a desirable size of commercial mesh for cephalopod fishing should be set at about 45 mm (Fig. 24-b).

In the Gulf of Thailand, however, most commercially used nets have too small a cod end mesh size, i.e. 15-26 mm, which does not allow escapement of small shrimps, squids and cuttlefishes, including juveniles of commercially important demersal species (Figure 25).

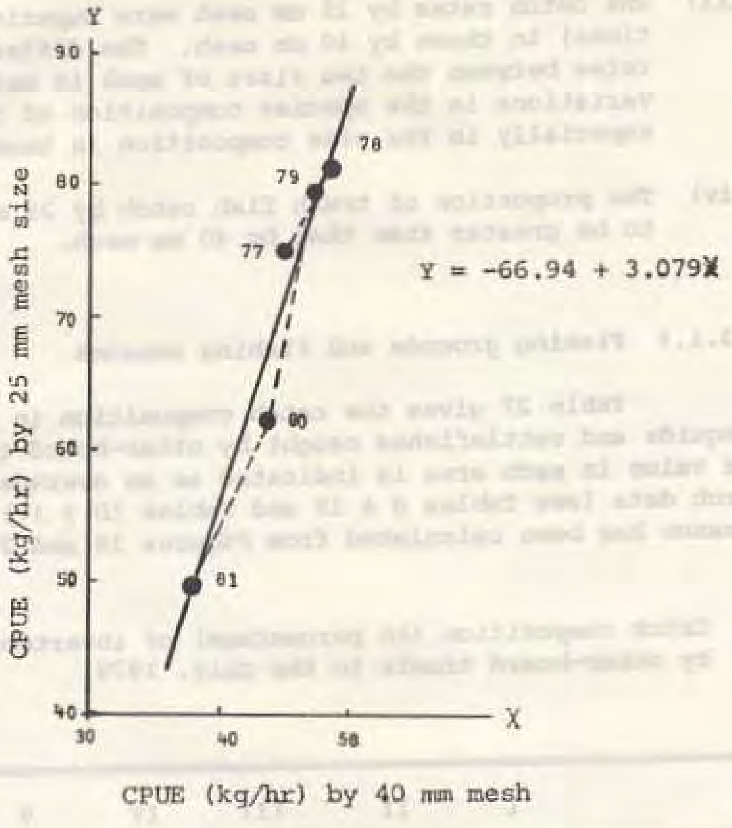

Figure 25. Differences in catch rate (CPUE: kg/hr) of demersal species by using cod end meshes of two sizes. The estimations of catch rate have been made from the annual monitoring surveys conducted by the Department of Fisheries using M.V. PRAMONG 2 in the Gulf (redrawn from Boonyubol & Pramokechutima, 1984).

This figure indicates the following:

(i) The catch rates have decreased year by year. For example, the catch rates in 1981 were 38 kg/hr for 40 mm (optimum size) mesh, and 50 kg/hr for 25 mm mesh (most commonly used in commercial operations), which represent 78 per cent and 61 per cent of the catch rates in 1978, respectively.

(ii) Demersal resources in the Gulf have therefore been over-exploited.

(iii) The catch rates by 25 mm mesh were superior (1.3 to 1.7 times) to those by 40 mm mesh. The difference in catch rates between the two sizes of mesh is mainly due to variations in the species composition of the catch, especially in the size composition in terms of length.

(iv) The proportion of trash fish catch by 25 mm mesh seems to be greater than that by 40 mm mesh.

3.1.4 Fishing grounds and fishing seasons

Table 27 gives the catch composition in percentage of shrimps, squids and cuttlefishes caught by otter-board trawls in the Gulf. The value in each area is indicated as an average of commercial and research data (see Tables 8 & 15 and Tables 10 & 17), and the value in each season has been calculated from Figures 18 and 22.

Table 27. Catch composition (in percentage) of invertebrates caught by otter-board trawls in the Gulf, 1979.

Area	I	II	III	IV	V	Total
Shrimps	4.6	14.3	39.8	13.4	27.9	100.0
Squids Cuttlefishes	26.2	9.9	18.3	20.7	24.9	100.0

Season	Dry Oct.-Feb.	Summer Mar.-May	Rainy June-Sept.	Whole
Shrimps	48.5	19.6	31.9	100.0
Squids Cuttlefishes	42.1	26.9	31.0	100.0

From this table, we can infer the following. If the fishing efficiency were to be increased through a better distribution of effort both in space and in time, the fishing activities should be concentrated in limited areas (Areas I, III, IV and V) and limited to certain seasons (June-February) as shown in Table 27. Such fishing regulations both in space and in time may have the effect of decreasing the catch of invertebrates (about 20 per cent). However, at the same time, they may result in increasing the productivity of invertebrate resources to a satisfactory level (MSY), because the current situation shows that invertebrate stocks have been over-exploited.

SUMMARY AND OVERVIEW

The rapid expansion of trawl fisheries during 1977-1978 has put great pressure on the available invertebrate resources in the Gulf of Thailand. Hence the overall stock size of invertebrate resources has decreased drastically, as shown in the reduction of total invertebrate catch from approximately 141,000 metric tons in 1978 to 110,000 metric tons in 1981 (Table 24).

As far as otter-board trawl fishing is concerned, the stocks of shrimps, squids and cuttlefishes in the Gulf are seen to have been over-exploited (Figs. 7-10). Therefore, the development of trawl fisheries should be carefully controlled and managed since, under natural circumstances, there exist wide fluctuations in the abundance of these invertebrate resources, especially if they are subjected to intense fishing pressure (Table 24).

The Government is therefore obligated to give serious consideration to finding suitable measures to regulate the trawl fisheries in the Gulf. However, no appropriate action has yet been taken to effectively manage these marine invertebrate resources.

As mentioned in the previous section, possible actions for effective management/control of trawl fisheries should be considered.

In order to increase the productivity of invertebrate resources to a satisfactory level, i.e., to maintain them at their MSY level (Figure 7-10), action should be taken without delay to limit the entry of new trawlers into the fisheries. A long-term plan should be formulated to gradually reduce the number of trawlers operating in the Gulf to approximately the same number as in 1977-1978 (about 4,500 units as shown in Table 24). It is hoped that a suitable licensing system will be adopted in order to effectively regulate the number of otter-trawl fishing boats.

The regulation of towing duration (trawling hours) in each fishing operation would also seem to be an effective action to increase the fishing efficiency for invertebrate fisheries. It is indicated in section 3.1.2 of Part III of this study, that the optimum towing duration is about two hours' trawling (Figure 23). Otter-board trawl fishing in the Gulf of Thailand is, however, usually done in the course of four or five hours' towing both during the day and at night-time. If the fishing operations were done commercially in the course of two hours' towing, it is expected that they would bring about a large profit to the management of invertebrate fisheries, owing to a saving in the total costs incurred in the fishing activities.

In order to effect such savings, fishing seasons and grounds should be restricted to some particular time and space. As far as invertebrate resources are concerned, fishing activities should be done during the nine months from June to the following February. Furthermore it would seem preferable to concentrate fishing activities in limited areas both in the inner and southern waters of the Gulf (Table 27).

According to Figure 11, the composition (in percentage by weight) of the catch by Thai trawlers in 1976-1981 indicated that almost 70 per cent of the otter-board trawl catch was trash fish, which comprised a great number of young invertebrates as well as juveniles and fry of several economically important fish species. This is because the majority of the Thai trawlers use a small cod end mesh size of less than 26 mm. Therefore, it appears that the present mesh size regulation is not effective since the major cause of the decline in the abundance of invertebrates is due to the high fishing intensity that includes a large proportion of trash fish. In order to reduce wastage in exploiting these valuable invertebrate resources, the regulation on cod end mesh size (38 mm as shown in Fig. 24) for trawl nets used by commercial trawlers should be strictly enforced.

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