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THE SITUATION OF SMALL TUNA FISHERY IN THE GULF OF THAILAND FROM 1978 TO 1988 BASED ON MULTIVARIATE ANALYSIS

by

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ABSTRACT

The situation of small tuna fishery in the Gulf of Thailand was analysed by principal component analysis and cluster analysis, using the data in the SEAFDEC Fishery Statistical Bulletins and the Catch-Effort Statistics for 1978 to 1988.

In purse seine fishery, the 11 years were divided into two groups, i.e., from 1978 to 1984 and from 1985 to 1988. The first group of years (1978-1984) showed the following features: 1) a drastic reduction in sardine catches; 2) a drastic one-fifth reduction in round scad catches from 105,600 MT in 1978 to 22,300 MT in 1979; and 3) a dramatic increase in longtail tuna catches from 1983, kawakawa from 1982 and Indo-Pacific mackerel from 1981. The second group of years (1985-1988) showed the following: 1) a steadily increasing trend in longtail tuna catches; 2) stable catches of kawakawa, Indo-Pacific mackerel and sardine; 3) growth in catches of jack-cavalla-trevally, hardtail scad, black pomfret and anchovy from the previous group of years; and 4) large increases in catches of longtail tuna, kawakawa and jack-cavalla-trevally in 1985 and 1988. The situation of small tuna fishery by purse seine in the Gulf of Thailand was summarized by catches of longtail tuna and kawakawa increasing dramatically from the early 1980s, with an early peak reached in 1983; this was because much effort was spent in catching small tunas by vessels equipped with modern electronic equipment. In addition catches of small tunas increased both in 1985 and 1988 because of expansion of the fishing grounds to the central Gulf, and off Malaysia and Indonesia. A large increase in the catch of small tunas will be difficult other than by further expansions of fishing grounds, and proper management of small tuna fishery by purse seine, in the Gulf of Thailand and its vicinity, with consideration to fisheries interactions and the life histories of major species.

In drift gill net fishery, the 11 years were divided into two groups of years, i.e., from 1978 to 1981 and from 1982 to 1988. The first group of years (1978-1981) showed a steady increase in catches of narrow-barred king mackerel, longtail tuna and kawakawa, and positive catch relationships between the three species. The second group of years (1982-1988) showed increasing trends in longtail tuna and kawakawa catches with a temporary decrease in narrow-barred king mackerel, and negative relationships of CPUE values in longtail tuna and kawakawa compared to narrow-barred king mackerel. Small tuna fishery by drift gill net in the Gulf of Thailand showed catches of longtail tuna and kawakawa increasing from the early 1980s, as with purse seine; drift gill net target species then changed from narrow-barred king mackerel to longtail tuna and kawakawa between 1982 and 1985. As catches of longtail tuna, kawakawa and narrow-barred king mackerel were similar to each other after 1985 and the total catches of drift gill net fishery from 1982 to 1988 were stable, it is considered that drift gill net catches of small tunas and narrow-barred king mackerel were stable after 1985 in the Gulf of Thailand.

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I. INTRODUCTION

Small tuna fishery in the Gulf of Thailand has developed rapidly since the early 1980s because of the increasing demand of the tuna canning industry in Thailand. The three small tuna species found in the Gulf of Thailand include longtail tuna (*Thunnus tonggol*), kawakawa (*Euthynnus affinis*) and frigate tuna (*Auxis thazard*) and the three king mackerel species are narrow-barred king mackerel (*Scomberomorus commerson*), Indo-Pacific king mackerel (*S. guttatus*) and streaked seerfish (*S. lineolatus*). Longtail tuna and kawakawa are fished using two major fishing gears, i.e., purse seine and drift gill net. King mackerels are captured principally by drift gill net. In 1988, the catch of longtail tuna was 91,628 MT, that of kawakawa (including frigate tuna) 49,869 MT and that of king mackerels (three species) 13,319 MT.

Small tuna catch in 1981 was 20,198 MT (a 57% increase from the previous year), catches then doubled in 1982 and again in 1983, but decreased slightly in 1984 to 69,803 MT. After 1984, tuna catches increased steadily to 96,354 in 1987, then increased dramatically in 1988 to 141,497 MT (a 47% increase from the previous year). This big increase in small tuna catch between 1981 and 1988 showed a more rapid increase rate than the total fish catch rate for the Gulf of Thailand. Because of this, there may have been some effect upon the other fisheries. It is therefore considered important when monitoring and managing small tuna fisheries to clarify first of all the situation of small tuna fisheries in the Gulf of Thailand.

This paper presents the catch trends of small tunas and tuna-like species, catch and effort data, and the relationships between species groups, as well as the situation of small tuna fishery analysed by principal component analysis, to assess the impact of the recent upsurge in small tuna fishery and its status in the Gulf of Thailand.

II. MATERIALS AND METHODS

Data used in this analysis was obtained from the SEAFDEC Fishery Statistical Bulletins and the Catch-Effort Statistics for the South China Sea Area for 1978 to 1988.

As regards data in the Gulf of Thailand given in the Bulletins, catch of kawakawa actually includes catch of frigate tuna, and catch of narrow-barred king mackerel includes three species of king mackerels. In this paper, the species group kawakawa therefore represents catches of kawakawa and frigate tuna, and the species group narrow-barred king mackerel represents catches of three species of *Scomberomorus* (Table 1).

Furthermore, purse seine as described in this paper includes Chinese, Thai, luring and tuna purse seine.

The calculations of correlation coefficient and their tests were made using "CORRELATION", and calculations of factor loading, eigenvalue, percentage of variance (ratio of contribution) and factor score coefficient matrix using "FACTOR" in SPSS/PC+ software. Factor scores were computed by factor score coefficient calculated by "FACTOR" and generalized variables (Z-score) calculated by "DESCRIPTIVES". Cluster analysis was done with factor scores by "CLUSTER". For the principal component analysis, correlation matrix was used in this paper.

Table 1 List of small tuna species and tuna-like species from the Gulf of Thailand.

English Name	Scientific Name	Codes ISSCAAP	Codes SEAFDEC	Species groups in this study
Longtail tuna	*Thunnus tonggol*	LOT	3604	*Thunnus tonggol*
Kawakawa (Eastern little tuna)	*Euthynnus affinis*	KAW	3606	*Euthynnus affinis* *Auxis thazard*
Narrow-barred king mackerel	*Scomberomorus commerson*	COM	3609	*Scomberomorus commerson* *S. guttatus* *S. lineolatus*

III. RESULTS

1. Small Tuna Fisheries

1.1 Purse Seine Fishery

1.1.1 Principal Component Analysis

The results of the principal component analysis for lumped catches and CPUE values by purse seine fishery are shown in Table 2. Percentages of variance (ratio of contribution) for first, second, third, fourth and fifth principal components are 42.8%, 18.8%, 13.7%, 10.6% and 7.7% respectively, and the cumulated percentage from first to fifth is 93.5%. Thus, over 90% of the information in the total variation is attributable to the first five principal components.

The factor scores of the first and second principal components are plotted in Fig. 1, to show clearly the situation by purse seine fishery in each year. The cumulated ratio of contribution of the first and second principal components is 62%. The factor scores from first to fifth principal components are also shown in Table 2.

Table 2 Results of the principal component analysis on the catch quantity and the CPUE values by purse seine fishery. ROUNDS, round scad; JACATR, jack-cavalla-trevally; SELARS, selar scad; HARDTA, hardtail scad; BLACKP, black pomfret; SARDIN, sardine; ANCHOV, anchovy; LONGTA, long-tail tuna; KAWAKA, kawakawa; INDMAC, Indian mackerel; INPAMA, Indo-Pacific mackerel; MISCFI, miscellaneous fish. These abbreviations will be followed at every table and figure regarding purse seine fishery. C at the end of the species name shows catch quantity and E shows CPUE values.

Principal component	P C 1	P C 2	P C 3	P C 4	P C 5
Eigenvalue	10.28100	4.50526	3.28270	2.53537	1.83829
Perc. of variance	42.8	18.8	13.7	10.6	7.7
Cum. Percentage	42.8	61.6	75.3	85.9	93.5
Factor loading					
ROUNDSC	-0.40050	0.67217	0.60916	0.06549	0.15576
JACATRC	0.68486	0.31042	0.22991	-0.20816	-0.52401
SELARSC	-0.09420	-0.13560	0.73212	0.49929	0.47790
HARDTAC	0.59550	0.67505	-0.20883	0.16149	0.25978
BLACKPC	0.71098	0.43596	0.19760	-0.29364	0.33113
SARDINC	-0.67513	0.43049	0.06633	-0.25859	0.06104
ANCHOVC	0.75988	-0.02544	0.49737	0.02997	-0.17962
LONGTAC	0.93166	0.23345	-0.21536	-0.00606	0.14107
KAWAKAC	0.92258	-0.01798	-0.15233	0.02012	0.14902
INDMACC	0.39653	0.06526	0.09665	0.86493	-0.03195
INPAMAC	0.73320	-0.57467	0.16173	-0.13027	0.22526
MISCFIC	0.91215	-0.13413	0.18396	-0.10356	0.21856
ROUNDSE	-0.63271	0.57592	0.60136	-0.07646	0.02477
JACATRE	0.34834	0.31730	0.35347	-0.23950	-0.74954
SELARSE	-0.61833	-0.23599	0.68436	0.05626	0.21277
HARDTAE	0.25491	0.92093	-0.21237	0.12966	0.07464
BLACKPE	0.49737	0.59233	0.37538	-0.38531	0.28616
SARDINE	-0.82792	0.14490	0.12523	-0.33566	-0.08967
ANCHOVE	0.67238	-0.04098	0.55536	0.03620	-0.37907
LONGTAE	0.92685	0.17133	-0.15166	0.03521	-0.00763
KAWAKAE	0.89819	-0.15057	-0.07469	0.05413	0.02626
INDMACE	-0.01680	0.01407	0.21924	0.88883	-0.32326
INPAMAE	0.05329	-0.87198	0.35926	-0.29958	0.03674
MISCFIE	0.69332	-0.42116	0.42268	-0.22932	0.05310

For the first principal component, it is considered that jack-cavalla-trevally catches, hardtail scad catches, black pomfret catches and CPUE values, anchovy catches and CPUE values, longtail tuna catches and CPUE values, kawakawa catches and CPUE values, Indo-Pacific mackerel catches and miscellaneous fish catches and CPUE values are reflected positively; and round scad and selar scad CPUE values, and sardine catches and CPUE values are reflected negatively.

For the second principal component, it is considered that round scad catches and CPUE values, hardtail scad catches and CPUE values and black pomfret CPUE values are reflected positively; and Indo-Pacific mackerel catches and CPUE values are reflected negatively.

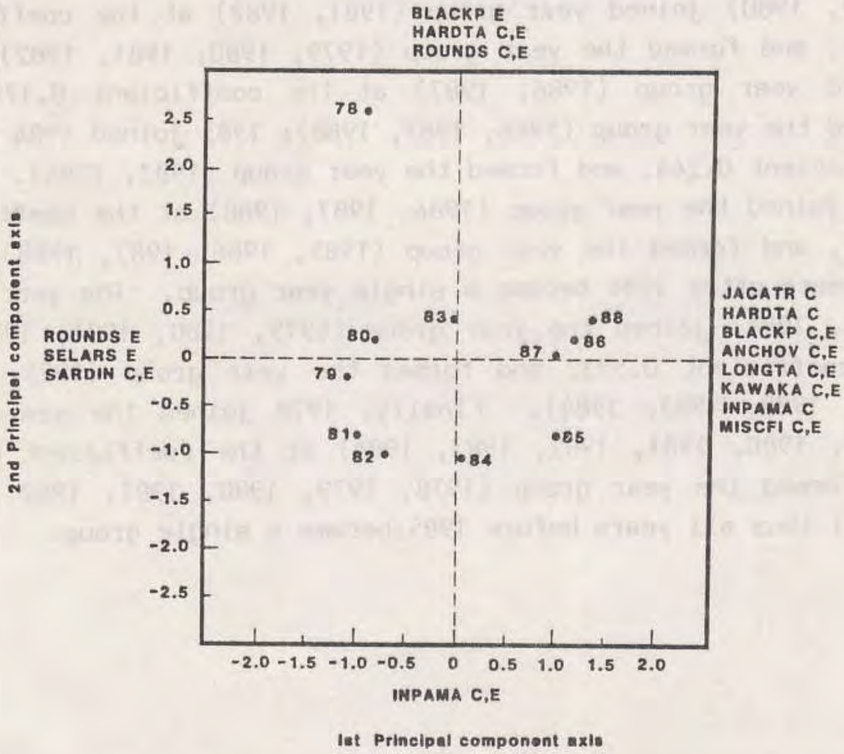

Fig. 1 Year plots of factor scores for catch quantity and the CPUE values by purse seine fishery on the first and the second principal component. Each species name is shown as a reflection of each axis. Years in the figure are omitted for thousand and hundred units.

1.1.2 Cluster Analysis

For the purpose of combining the year groups which are closely related each other, cluster analysis with factor scores from the first to the fifth with weights according to the ratio of contribution was done.

The result of the cluster analysis for combining the year groups is shown in Fig. 2. First, 1986 joined 1987 at the coefficient 0.005, and formed the year group (1986, 1987). Next, 1979 joined 1980 at the coefficient 0.023, and formed the year group (1979, 1980); 1981 joined 1982 at the coefficient 0.058, and formed the year group (1981, 1982); the year group (1979, 1980) joined year group (1981, 1982) at the coefficient 0.116, and formed the year group (1979, 1980, 1981, 1982); 1988 joined year group (1986, 1987) at the coefficient 0.179, and formed the year group (1986, 1987, 1988); 1983 joined 1984 at the coefficient 0.244, and formed the year group (1983, 1984). Then, 1985 joined the year group (1986, 1987, 1988) at the coefficient 0.341, and formed the year group (1985, 1986, 1987, 1988); thus all years after 1984 became a single year group. The year group (1983, 1984) joined the year group (1979, 1980, 1981, 1982) at the coefficient 0.592, and formed the year group (1979, 1980, 1981, 1982, 1983, 1984). Finally, 1978 joined the year group (1979, 1980, 1981, 1982, 1983, 1984) at the coefficient 0.889, and formed the year group (1978, 1979, 1980, 1981, 1982, 1983, 1984); thus all years before 1985 became a single group.

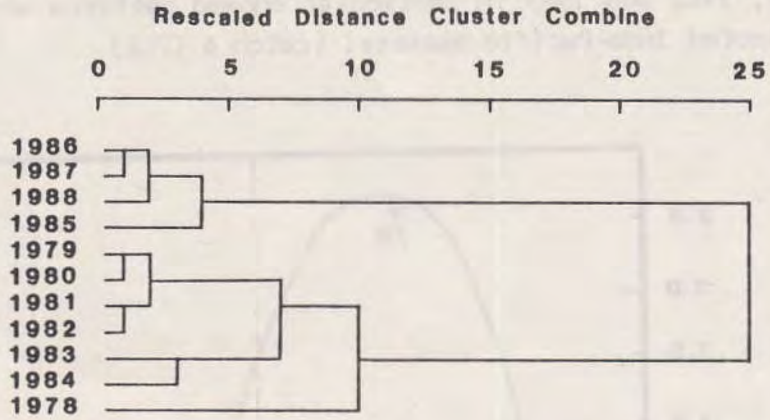

Fig. 2 Dendrogram from Ward method cluster analysis on the distance matrix computed from five factor scores by purse seine fishery.

1.1.3 Conclusion of the Analyses

From the results of the principal component analysis and the cluster analysis, the situation of purse seine fishery during the 11 years from 1978 to 1988 are presumed as follows (Fig. 3). The 11 years are divided into two major year groups, i.e., from 1978 to 1984 and from 1985 to 1988.

In the first group of years, 1978 showed a catch and CPUE pattern which reflected round scad (catch & CPUE), hard-tail scad (catch & CPUE) and black pomfret (catch). The years from 1979 to 1984 showed different patterns to 1978, and 1979 showed a patern which reflected sardine (catch & CPUE), round scad (CPUE) and selar scad (CPUE). This pattern then gradually changed to a pattern which reflected small tunas (longtail tuna and kawakawa catch and CPUE), mackerels, jack-cavalla-trevally (catch), hardtail scad (catch), black pomfret (catch & CPUE), anchovy (catch & CPUE) and miscellaneous fish (catch & CPUE); 1981, 1982 and 1983 in particular showed patterns which strongly reflected Indo-Pacific mackerel (catch & CPUE).

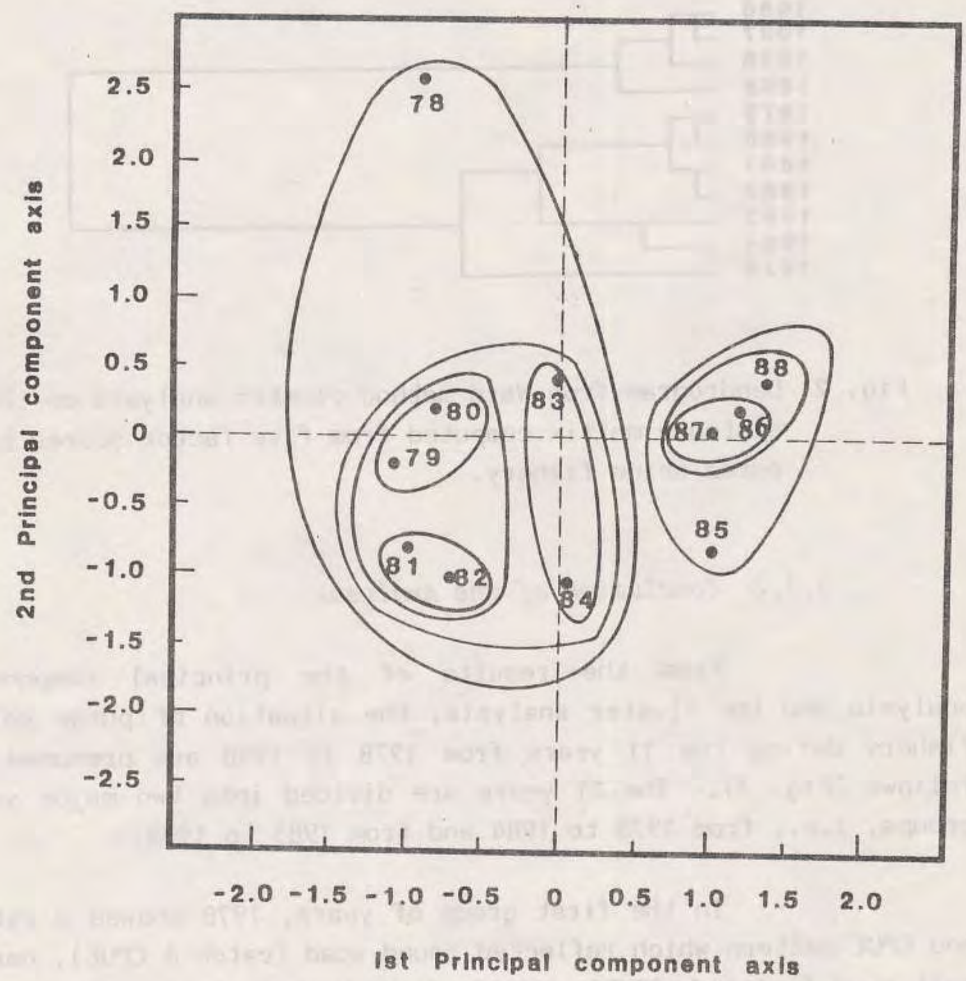

Fig. 3 The two major clusters and sub-clusters in years, in purse seine fishery. The factors are extracted from catch quantity and the CPUE value, and cluster analysis was done by the Ward method using the first five factor scores.

In the second group of years, 1985 and 1988 showed different patterns from the year group of 1986 and 1987. However, the second group of years essentially showed a pattern which reflected small tunas (longtail tuna and kawakawa catch and CPUE), Indo-Pacific mackerel (catch & CPUE), jack-cavalla-trevally (catch), hardtail scad (catch), black pomfret (catch & CPUE), anchovy (catch & CPUE) and miscellaneous fish (catch & CPUE). The year 1985 showed a pattern which reflected not only small tunas (catch & CPUE) but also mackerels, especially Indo-Pacific mackerel (Catch & CPUE), as similar to 1984 figures, but 1985 showed a greater reflection of small tunas than the previous years (the first group of years from 1978 to 1984). The year group of 1986 and 1987 retained the pattern reflected by small tunas, but showed less reflection for Indo-Pacific mackerel. In 1988 a pattern showing greater reflection for the two kinds of small tunas (longtail tuna and kawakawa) from the previous years, was evident.

1.2 Drift Gill Net Fishery

1.2.1 Principal Component Analysis

The results of the principal component analysis for lumped catches and CPUE values by drift gill net fishery are shown in Table 3. Percentages of variance (ratio of contribution) for first, second, third, fourth, fifth and sixth principal components are 40.5%, 23.9%, 20.9%, 12.3%, 7.0% and 4.9% respectively, and the cumulated percentage from first to fifth is 100%. Therefore, 100% of the information in the total variation is attributable to the first six principal components.

The factor scores of the first and second principal components are plotted in Fig. 4, to show clearly the situation by drift gill net fishery in each year. The cumulated ratio of contribution of the first and second principal components is 64%. The factor scores from first to sixth principal components are also shown in Table 3.

Table 3 Results of the principal component analysis on the catch quantity and the CPUE values by drift gill net fishery. JACATR, jack-cavalla-trevally; SELARS, selar scad; HARDTA, hardtail scad; BLACKP, black pomfret; WOLFHE, wolf herring; LONGTA, long-tail tuna; KAWAKA, kawakawa; NBKMAC, narrow-barred king mackerel; INDMAC, Indian mackerel; INPAMA, Indo-Pacific mackerel; MISCFI, miscellaneous fish. These abbreviations will be followed in every table and figure regarding drift gill net fishery. C at the end of the species name shows catch quantity and E shows CPUE values.

Principal component	P C 1	P C 2	P C 3	P C 4	P C 5	P C 6
Eigenvalue	8.90637	5.25898	4.60775	2.71590	1.55007	1.08622
Perc. of variance	40.5	23.9	20.9	12.3	7.0	4.9
Cum. Percentage	40.5	64.4	85.3	97.7	100.0	100.0
Factor loading						
JACATRC	0.78731	-0.53203	-0.04123	-0.35324	0.14510	0.20802
SELARSC	0.76146	0.40962	-0.28615	0.55433	-0.06170	-0.13348
HARDTAC	-0.62419	0.21850	-0.55039	0.44602	0.10013	0.19979
BLACKPC	-0.89130	-0.02370	-0.09346	-0.04660	0.39244	-0.15830
WOLFHEC	-0.25517	0.72279	-0.57081	-0.23237	-0.05343	0.31748
LONGTAC	-0.68912	0.04042	0.54140	0.21232	-0.29099	0.34791
KAWAKAC	-0.91471	0.07146	0.30119	0.17539	0.06388	-0.02783
NBKMACC	-0.46130	0.51875	-0.49317	-0.03399	0.42835	0.35323
INDMACC	0.64895	0.07754	0.59482	0.60824	0.29710	0.13345
INPAMAC	0.26416	0.94624	0.23634	-0.34375	-0.06115	-0.03956
MISCFIC	-0.87803	0.32659	0.22510	0.09692	0.21687	0.26676
JACATRE	0.78902	-0.54831	-0.07236	-0.36049	0.08746	0.12484
SELARSE	0.79177	0.38432	-0.24929	0.60793	0.00280	-0.12711
HARDTAE	-0.26800	0.34932	-0.70678	0.60635	-0.15247	-0.23379
BLACKPE	-0.59460	0.01116	0.06440	-0.28944	0.57646	-0.49537
WOLFHEE	0.34331	0.83725	-0.44789	-0.46068	-0.31304	-0.15807
LONGTAE	0.08132	0.43345	0.88202	0.03923	-0.35512	0.06607
KAWAKAE	-0.52551	0.21514	0.71436	0.00150	-0.15676	-0.25984
NBKMACE	0.81752	0.41772	-0.22243	-0.18529	0.22883	-0.06889
INDMACE	0.82087	-0.05954	0.45669	0.42132	0.42217	0.06390
INPAMAE	0.50090	0.82095	0.36902	-0.27136	0.28713	0.21787
MISCFIE	0.05284	0.77193	0.58748	-0.06333	0.14869	-0.19308

For the first principal component, it is considered that jack-cavalla-trevally catch and CPUE values, selar scad catch and CPUE values, Indian mackerel catch and CPUE values, narrow-barred king mackerel CPUE values and Indo-Pacific mackerel CPUE values a .. ɩeflected positively; and hardtail scad catch, black pomfret catch and CPUE values, longtail tuna catch, kawakawa catch and CPUE values, narrow-barred king mackerel catch and miscellaneous fish catch are reflected negatively.

For the second principal component, it is considered that wolf herring catch and CPUE values, narrow-barred king mackerel catch, Indo-Pacific mackerel catch and CPUE values and miscellaneous fish CPUE values are reflected positively; and jack-cavalla-trevally catch and CPUE values are reflected negatively.

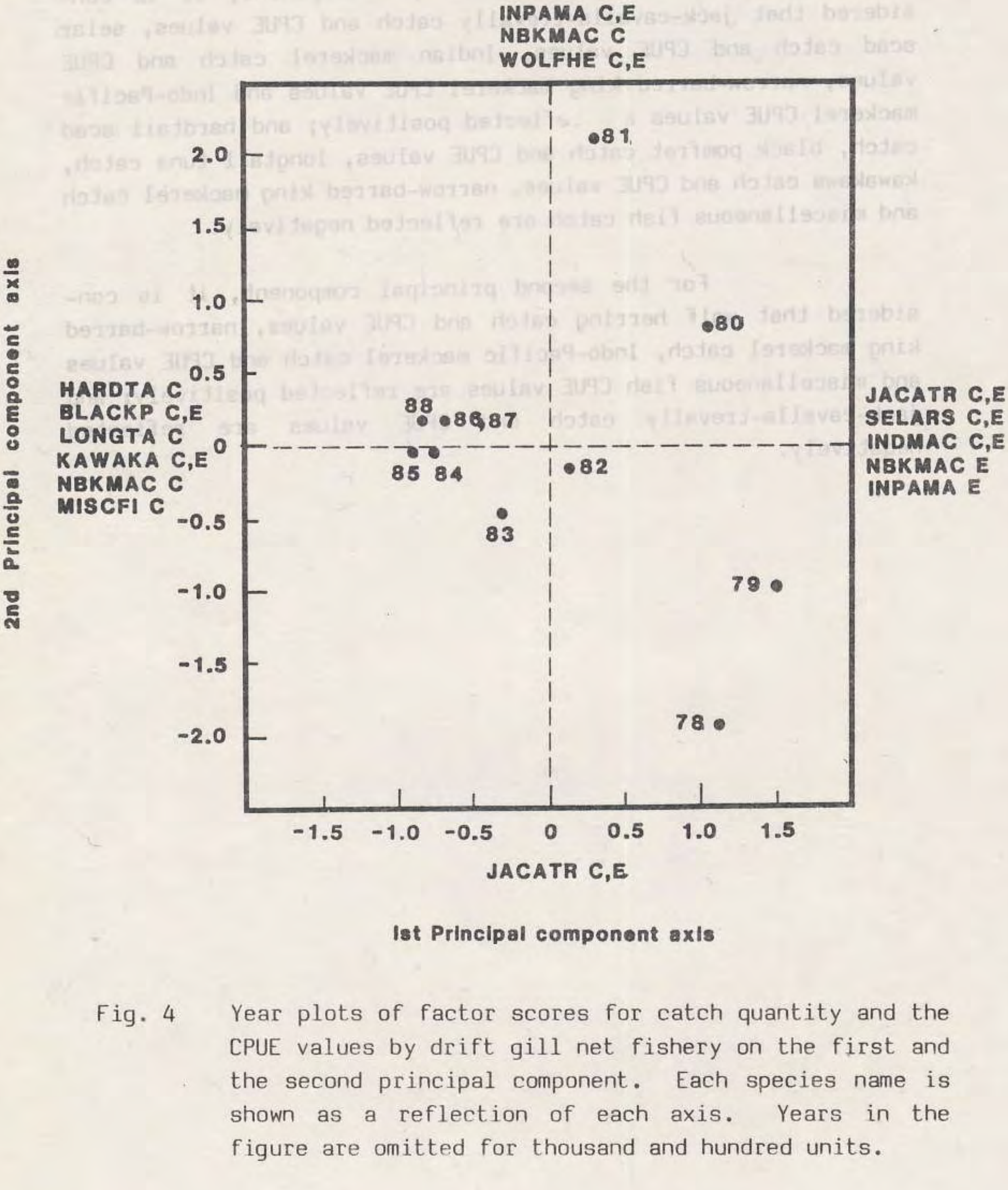

Fig. 4 Year plots of factor scores for catch quantity and the CPUE values by drift gill net fishery on the first and the second principal component. Each species name is shown as a reflection of each axis. Years in the figure are omitted for thousand and hundred units.

1.2.2 Cluster Analysis

For the purpose of combining the year groups which are closely related each other, cluster analysis with factor scores from the first to the sixth with weights according to the ratio of contribution was done.

The result of the cluster analysis for combining the year groups is shown in Fig. 5. First, 1987 joined 1988 at the coefficient 0.002, and formed the year group (1987, 1988); then 1986 joined the year group (1987, 1988) at the coefficient 0.006, and formed the year group (1986, 1987, 1988). Next, 1984 joined 1985 at the coefficient 0.012, and formed the year group (1984, 1985); 1983 joined the year group (1984, 1985) at the coefficient 0.060, and formed the year group (1983, 1984, 1985). 1978 joined 1979 at the coefficient 0.109, and formed the year group (1978, 1979); year group (1983, 1984, 1985) joined the year group (1986, 1987, 1988) at the coefficient 0.201, and formed the year group (1983, 1984, 1985, 1986, 1987, 1988); and 1980 joined 1981 at the coefficient 0.465, and formed the year group (1980, 1981). Then, 1982 joined the year group (1983, 1984, 1985, 1986, 1987, 1988) at the 0.736, and formed the year group (1982, 1983, 1984, 1985, 1986, 1987, 1988); thus all years after 1981 became a single year group. Finally, the year group (1978, 1979) joined the year group (1980, 1981) at the coefficient 1.299, and formed the year group (1978, 1979, 1980, 1981); thus all years before 1982 became a single group.

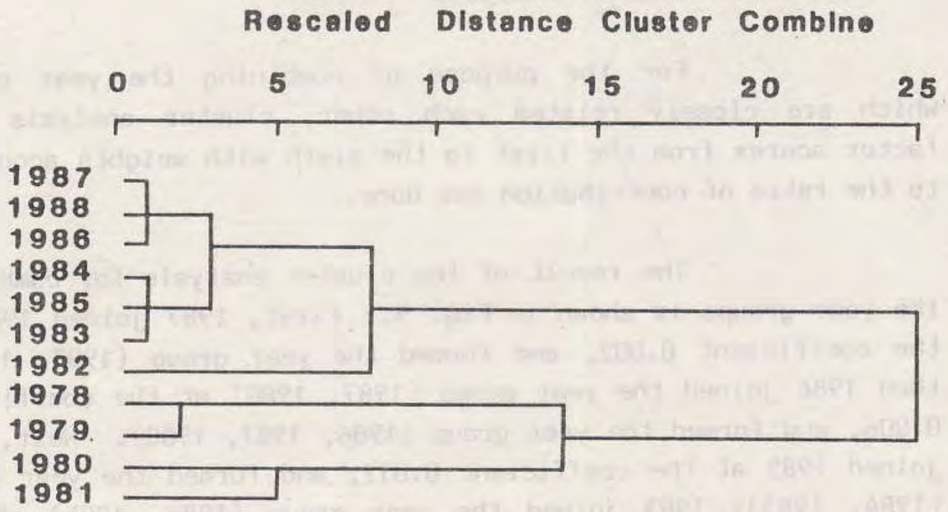

Fig. 5 Dendrogram from Ward method cluster analysis on the distance matrix computed from five factor scores by drift gill net fishery.

1.2.3 Conclusion of the Analyses

From the results of the principal component analysis and the cluster analysis, the situation of drift gill net fishery during the 11 years from 1978 to 1988 are presumed as follows (Fig. 6). The 11 years are divided into two major year groups, i.e., from 1978 to 1981 and from 1982 to 1988.

In the first group of years, progressing from 1978 to 1981, there was a change in catch and CPUE pattern from one which reflected jack-cavalla-trevally (catch & CPUE), to a pattern which reflected wolf herring (catch & CPUE), mackerels (narrow-barred king mackerel catch and Indo-Pacific mackerel catch & CPUE) and miscellaneous fish (CPUE), through jack-cavalla-trevally (catch & CPUE), selar scad (catch & CPUE) and mackerels (narrow-barred king mackerel CPUE, Indian mackerel catch & CPUE and Indo-Pacific mackerel CPUE).

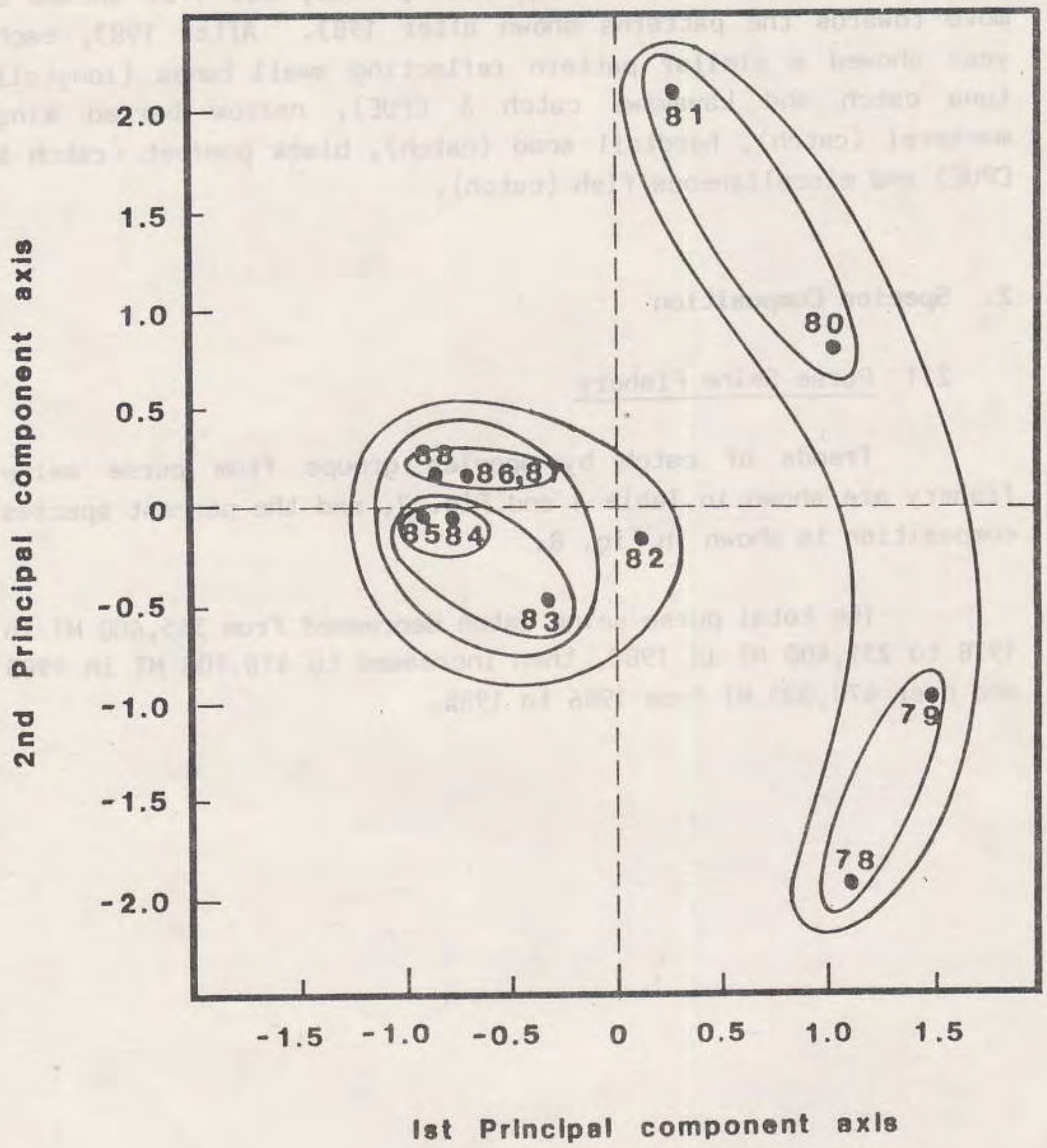

Fig. 6 The two major clusters and sub-clusters in years, in drift gill net fishery. The factors are extracted from catch quantity and the CPUE value, and cluster analysis was done by the Ward method using the first six factor scores.

In the second group of years, 1982 showed a pattern which reflected no typical species, but 1983 showed a move towards the patterns shown after 1983. After 1983, each year showed a similar pattern reflecting small tunas (longtail tuna catch and kawakawa catch & CPUE), narrow barred king mackerel (catch), hardtail scad (catch), black pomfret (catch & CPUE) and miscellaneous fish (catch).

2. Species Composition

2.1 Purse Seine Fishery

Trends of catch by species groups from purse seine fishery are shown in Table 4 and Fig. 7, and the percent species composition is shown in Fig. 8.

The total purse seine catch decreased from 345,600 MT in 1978 to 231,400 MT in 1980, then increased to 418,100 MT in 1985 and over 470,000 MT from 1986 to 1988.

Table 4 Total catch and the major species catches by purse seine fishery in the Gulf of Thailand from 1978 to 1988.

Species	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
ROUNDS	105,661	22,328	30,003	34,280	32,051	24,519	27,396	25,536	23,940	41,811	13,916
JACATR	24,606	11,100	11,928	9,372	4,148	14,882	10,067	41,734	30,048	13,863	33,691
SELARS	-	10,134	14,693	26,090	16,033	20,754	22,375	16,925	18,641	21,894	9,922
HARDTA	13,445	4,918	9,023	3,029	3,091	16,707	4,863	4,741	16,497	16,126	18,513
BLACKP	1,317	243	184	572	340	373	613	605	2,272	1,578	1,848
SARDIN	129,592	125,888	75,575	115,144	86,008	92,923	72,876	64,535	87,145	69,534	77,850
ANCHOV	3,635	210	1,914	608	121	133	5,149	14,827	13,269	14,430	4,472
LONGTA	-	5,811	3,906	4,102	4,841	43,916	30,455	37,973	39,131	57,721	82,929
KAWAKA	3,800	1,736	2,319	4,589	13,282	23,398	18,203	22,785	31,838	22,321	40,741
INDMAC	19,319	13,346	17,104	13,986	15,430	47,970	27,595	29,775	35,546	29,932	11,533
INPAMA	12,233	27,372	16,925	36,753	39,102	26,541	48,958	47,341	51,036	46,166	47,385
MISCFI	32,009	37,921	47,807	63,828	61,299	57,419	77,069	111,329	147,251	157,812	132,403
Total	345,617	261,007	231,381	312,353	275,746	369,535	345,619	418,106	496,614	493,188	475,203

In the major target species groups by purse seine fishery, catches of round scad and sardine were over 100,000 MT each, and accounted for 68% of total purse seine catch in 1978, but in 1979, round scad catches decreased to one fifth of the previous year. The sardine catch declined to 75,600 MT in 1980 (accounting for 33% of the total purse seine catch), then increased to 115,100 MT (accounting for 37%) in 1981. Sardine was the most dominant, except for miscellaneous fish, with catches of between 64,500 and 92,900 MT during the years 1982 to 1987. Catches of Indo-Pacific mackerel increased from 1981, kawakawa from 1982, and longtail tuna and Indian mackerel from 1983. In 1987, catches of these four species groups accounted for 32% of the total purse seine catch and equaled the catch of miscellaneous fish which started to increase in 1984. Catch of longtail tuna at 82,900 MT was the second most abundant after miscellaneous fish in 1988.

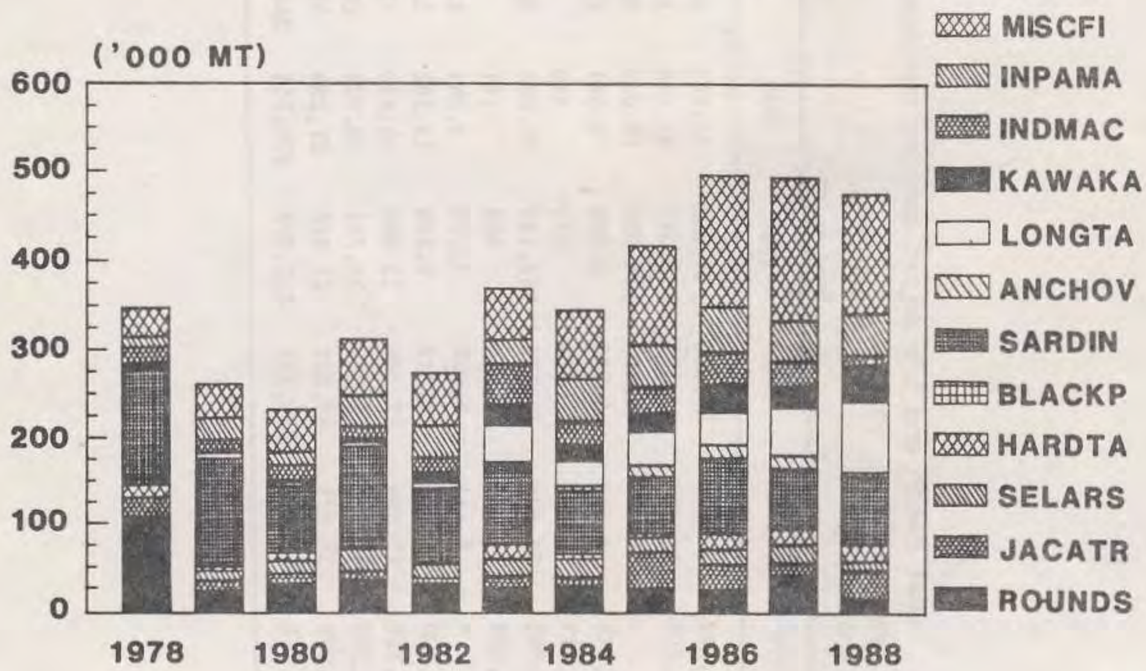

Fig. 7 Catches of major species by purse seine fishery in the Gulf of Thailand from 1978 to 1988.

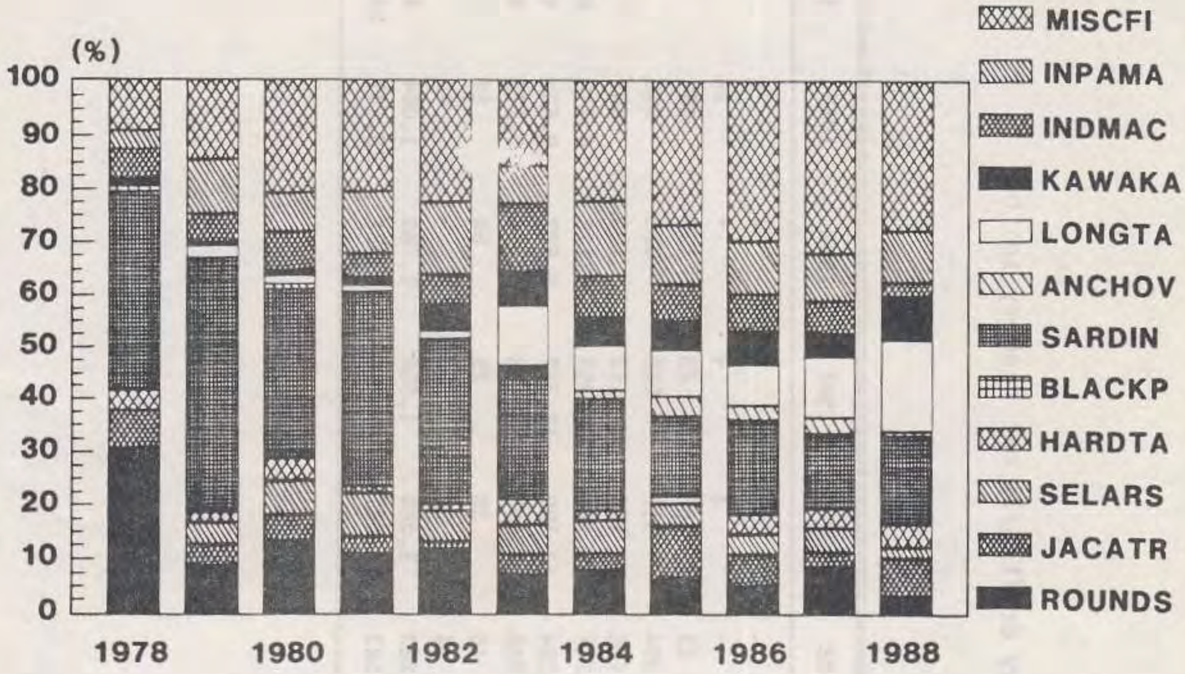

Fig. 8 Percent species composition by purse seine fishery in the Gulf of Thailand from 1978 to 1988.

2.2 Drift Gill Net Fishery

Trends of catch by species group from drift gill net fishery are shown in Table 5 and Fig. 9, and the percent species composition is shown in Fig. 10.

Total gill net catches increased from 6,000 MT in 1978 to 24,300 MT in 1982, and were then constant between the years 1983 to 1988 at 23,500 to 25,900 MT with the exception of 1983 when it was 18,500 MT.

Table 5 Total catch and major species catches by drift gill net fishery in the Gulf of Thailand from 1978 to 1988.

Species	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
JACATR	62	68	16	-	12	-	3	1	-	8	7
SELARS	-	23	150	18	-	-	3	4	-	14	2
HARDTA	2	6	95	7	31	22	83	65	135	157	159
BLACKP	61	156	95	191	120	304	418	556	351	396	449
WOLFHE	-	55	186	241	52	100	124	112	195	201	217
LONGTA	-	2,336	3,108	5,640	10,174	5,711	6,961	7,327	7,172	6,112	8,426
KAWAKA	2,873	1,992	2,614	5,578	9,202	7,394	11,300	11,367	9,832	9,623	8,688
NBKMAC	2,576	3,914	4,496	5,082	3,086	3,738	4,097	4,158	5,577	5,273	6,307
INDMAC	33	177	-	-	214	16	35	25	56	27	37
INPAMA	4	23	-	306	-	15	20	19	-	46	4
MISCFI	409	682	745	1,371	1,457	1,223	1,583	1,538	1,763	1,684	1,628
Total	6,020	9,432	11,505	18,434	24,348	18,523	24,627	25,172	25,081	23,541	25,924

Catches of the three major species groups, i.e., longtail tuna, kawakawa and narrow-barred king mackerel, accounted for over 87% of the total gill net catch between 1978 to 1988. Catch trends of longtail tuna and kawakawa were similar to those of the total drift gil. net catch. However, in 1982 the catch trend of narrow-barred king mackerel showed a drastic reduction of 39% from the previous year. Narrow-barred king mackerel constituted only 13% of the total catch by drift gill net; compared to 40% in the years before 1981. From 1983 to 1988, the catch of narrow-barred king mackerel showed an increasing trend, but its actual contribution to the total drift gill net catch remained low at 16% to 24%. On the other hand, the percentage of longtail and kawakawa exceeded 60% of the total drift gill net catch in 1981, then stayed at between 66% and 80% until 1988. The major target species groups of drift gill net fishery therefore changed from narrow-barred king mackerel which dominated before 1981, to longtail tuna and kawakawa thereafter.

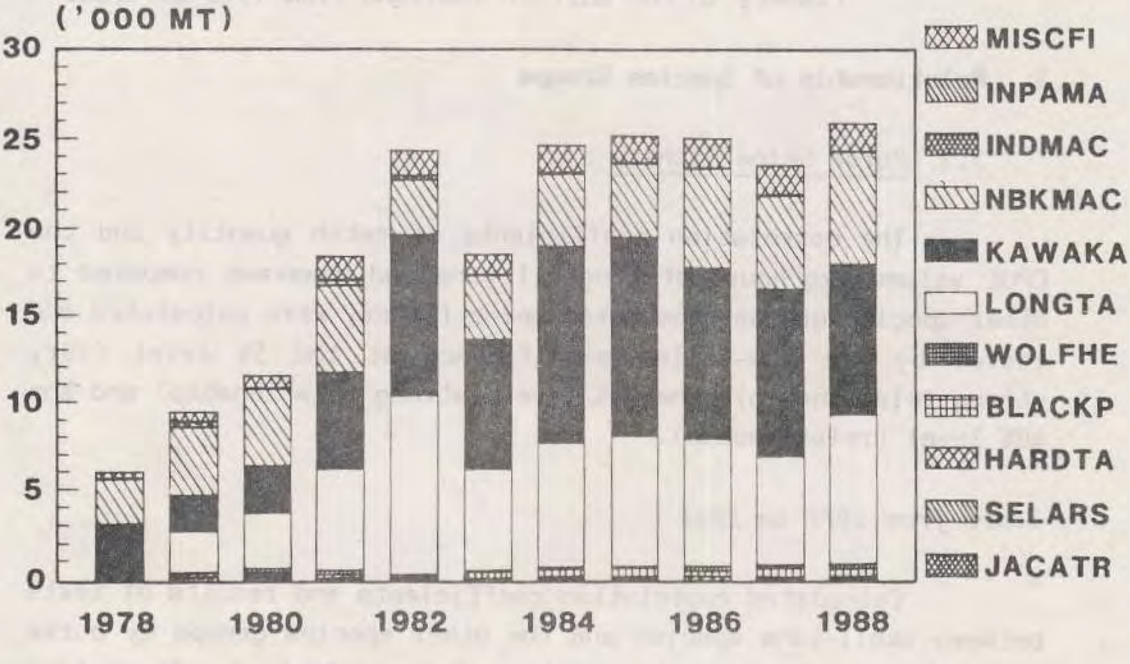

Fig. 9 Catches of major species by drift gill net fishery in the Gulf of Thailand from 1978 to 1988.

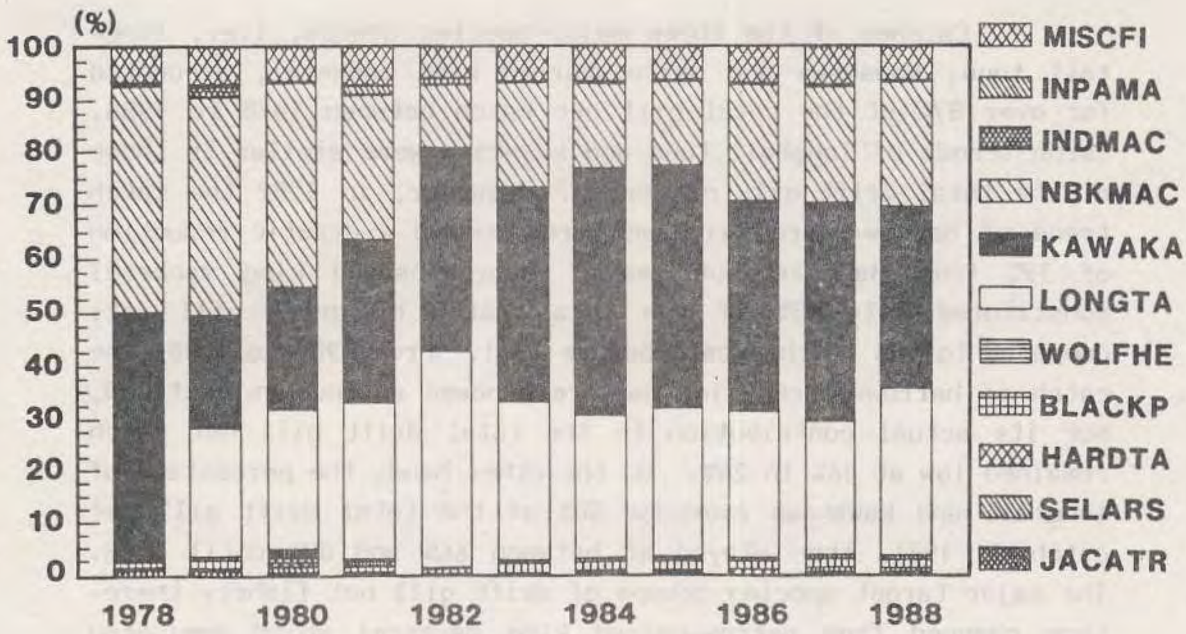

Fig. 10 Percent species composition by drift gill net fishery in the Gulf of Thailand from 1978 to 1988.

3. Relationship of Species Groups

3.1 Purse Seine Fishery

The correlation coefficients of catch quantity and the CPUE values (kg/hour) of longtail tuna and kawakawa compared to other species groups from purse seine fishery were calculated and tested by the two-tailed significance at the 5% level (very strong relationship), the 25% level (strong relationship) and the 40% level (relationship).

Years from 1978 to 1984

Calculated correlation coefficients and results of tests between small-tuna species and the other species groups by purse seine fishery from 1978 to 1984 are shown in Table 6. There is a very strong positive relationship in catch quantity between longtail tuna and kawakawa and a strong positive relationship in CPUE values.

Table 6 Correlation coefficients of catch quantity and the CPUE values between small tuna species and major species by purse seine fishery in the first group of years (1978-1984). Figures in parentheses represent the probability.

1978-1984		ROUNDS	JACATR	SELARS	HARDTA	BLACKP	SARDIN	ANCHOV	LONGTA	KAWAKA	INDRAC	INPAMA	MISCFI
Longtail	Catch	-0.4845	0.5726	0.3720	0.7185	0.3416	-0.3207	0.2814	-	0.8885	0.9608	0.1924	0.4092
tuna		(0.330)	(0.235)	(0.468)	(0.108)	(0.508)	(0.535)	(0.589)	-	(0.018)	(0.002)	(0.715)	(0.420)
	CPUE	-0.8128	-0.1425	-0.2660	0.3900	-0.1195	-0.6007	0.2212	-	0.7782	0.8760	-0.3512	-0.4555
		(0.049)	(0.788)	(0.610)	(0.445)	(0.822)	(0.207)	(0.674)	-	(0.068)	(0.022)	(0.495)	(0.364)
Kawakawa	Catch	-0.3204	-0.1768	0.4245	0.3035	-0.1072	-0.5329	0.0638	0.8885	-	0.8408	0.4989	0.6402
		(0.484)	(0.705)	(0.401)	(0.508)	(0.819)	(0.218)	(0.892)	(0.018)	-	(0.018)	(0.254)	(0.121)
	CPUE	-0.4844	-0.6238	-0.1781	-0.2121	-0.2933	-0.7800	-0.1060	0.7782	-	0.5619	0.1094	-0.0057
		(0.271)	(0.134)	(0.736)	(0.648)	(0.523)	(0.039)	(0.821)	(0.068)	-	(0.189)	(0.815)	(0.990)

Longtail tuna when compared to jack-cavalla-trevally and hardtail scad, showed strong positive relationships in catch quantity; and compared to Indian mackerel showed very strong positive relationships in both catch quantity and CPUE values. Longtail tuna against round scad showed a negative relationship in catch quantity and a very strong negative relationship in CPUE values; against sardine a strong negative relationship in CPUE values; and against miscellaneous fish a negative relationship in CPUE values.

Kawakawa compared to Indian mackerel showed a very strong positive relationship in catch quantity and a positive relationship in CPUE values; against Indo-Pacific mackerel a positive relationship in catch quantity; and against miscellaneous fish a strong positive relationship in catch quantity. Kawakawa compared to round scad showed a negative relationship in CPUE values; against jack-cavalla-trevally a strong negative relationship in CPUE values; and against sardine a strong negative relationship in catch quantity and a very strong negative relationship in CPUE values.

Years from 1985 to 1988

Calculated correlation coefficients and results of the tests between small tuna species and the other species groups by purse seine fishery from 1985 to 1988 are shown in Table 7. There is a positive relationship in catch quantity between longtail tuna and kawakawa.

Table 7 Correlation coefficients of catch quantity and the CPUE values between small tuna species and major species by purse seine fishery in the second group of years (1985-1988). Figures in parentheses represent the probability.

1985-1988		ROUNDS	JACATR	SELARS	HARDTA	BLACKP	SARDIN	ANCHOV	LONGTA	KAWAKA	INDMAC	INPAMA	MISCFI
Longtail	Catch	-0.3474	-0.1917	-0.6566	0.6341	0.2932	0.0794	-0.8816	-	0.6745	-0.9203	-0.4437	0.1597
tuna		(0.653)	(0.808)	(0.343)	(0.366)	(0.707)	(0.921)	(0.118)	-	(0.326)	(0.080)	(0.556)	(0.840)
	CPUE	-0.3327	-0.0077	-0.5743	0.3541	-0.1008	-0.3297	-0.5799	-	0.5772	-0.7739	-0.1769	-0.2795
		(0.667)	(0.992)	(0.426)	(0.646)	(0.899)	(0.670)	(0.420)	-	(0.423)	(0.226)	(0.823)	(0.721)
Kawakawa	Catch	-0.8301	0.2563	-0.8344	0.6333	0.6043	0.6546	-0.9218	0.6745	-	-0.7073	0.3213	-0.0089
		(0.170)	(0.744)	(0.166)	(0.367)	(0.396)	(0.345)	(0.078)	(0.326)	-	(0.293)	(0.679)	(0.991)
	CPUE	-0.8264	0.4913	-0.7377	0.0628	0.0275	0.3218	-0.5414	0.5772	-	-0.5682	0.0919	-0.7310
		(0.174)	(0.505)	(0.262)	(0.937)	(0.973)	(0.678)	(0.459)	(0.423)	-	(0.432)	(0.908)	(0.269)

Longtail tuna compared to hardtail scad showed a positive relationship in catch quantity. Longtail tuna against selar scad showed a negative relationship; against anchovy a strong negative relationship in catch quantity; and against Indian mackerel strong negative relationships both in catch quantity and CPUE values.

Kawakawa compared to hardtail scad, black pomfret and sardine showed positive relationships in catch quantity. Kawakawa against round scad showed strong negative relationships in both catch quantity and CPUE values; against selar scad a strong negative relationship in catch quantity and a negative relationship in CPUE values; against anchovy a strong negative relationship in catch quantity; against Indian mackerel a negative relationship in catch quantity; and against miscellaneous fish a negative relationship in CPUE values.

3.2 Drift Gill Net Fishery

The correlation coefficients of catch quantity and the CPUE values (kg/hour) of longtail tuna and kawakawa compared to the other species groups from drift gill net fishery were calculated and tested by the two-tailed significance at the 5% level (very strong relationship), the 25% level (strong relationship) and the 40% level (relationship).

Years from 1978 to 1981

Calculated correlation coefficients and results of the test between small tuna species and the other species groups by drift gill net fishery from 1978 to 1981 are shown in Table 8. There is a very strong positive relationship in catch quantity and a strong positive relationship in CPUE values between longtail tuna and kawakawa.

Table 8 Correlation coefficients of catch quantity and the CPUE values between small tuna species and major species by drift gill net fishery in the first group of years (1978-1981). Figures in parentheses represent the probability.

1978-1981		JACATR	SELARS	HARDTA	BLACKP	WOLFHE	LONGTA	KAWAKA	NBKMAC	INDMAC	INPAMA	MISCFI
Longtail	Catch	-	-0.3257	-0.2846	0.6185	0.8628	-	0.9981	0.9564	-	-	0.9899
tuna		-	(0.789)	(0.816)	(0.575)	(0.337)	-	(0.040)	(0.189)	-	-	(0.091)
	CPUE	-	-0.2267	-0.1776	0.2250	0.8115	-	0.9944	0.3481	-	-	0.9808
		-	(0.854)	(0.886)	(0.856)	(0.397)	-	(0.068)	(0.774)	-	-	(0.125)
Kawakawa	Catch	-0.3327	-0.3839	-0.2519	0.5657	0.8297	0.9981	-	0.5579	-	0.9570	0.8581
		(0.784)	(0.749)	(0.748)	(0.434)	(0.377)	(0.040)	-	(0.442)	-	(0.187)	(0.142)
	CPUE	0.0180	-0.3285	-0.2874	0.1554	0.7451	0.9944	-	0.0247	-	0.8443	0.6597
		(0.989)	(0.787)	(0.713)	(0.845)	(0.465)	(0.068)	-	(0.975)	-	(0.360)	(0.340)

Longtail tuna compared to wolf herring showed positive relationships in both catch quantity and CPUE values; against narrow-barred king mackerel a strong positive relationship in catch quantity; and against miscellaneous fish strong positive relationship in both catch quantity and CPUE values.

Kawakawa compared to wolf herring showed a positive relationship in catch quantity; and against Indo-Pacific mackerel and miscellaneous fish strong positive relationships in catch quantity and positive relationship in CPUE values.

Years from 1982 to 1988

Calculated correlation coefficients and results of the test between small tuna species and the other species groups by drift gill net fishery from 1982 to 1988 were shown in Table 9. A strong positive relationship in CPUE values between longtail tuna and kawakawa is shown.

Table 9 Correlation coefficients of catch quantity and the CPUE values between small tuna species and major species by drift gill net fishery in the second group of years (1982-1988). Figures in parentheses represent the probability.

1982-1988		JACATR	SELARS	HARDTA	BLACKP	WOLFHE	LONGTA	KAWAKA	NBKMAC	INDMAC	INPAMA	MISCFI
Longtail	Catch	0.6047	-0.8212	-0.1346	-0.4612	-0.3227	-	0.0572	-0.1782	0.8530	-0.5981	0.0878
tuna		(0.280)	(0.179)	(0.774)	(0.298)	(0.480)	-	(0.903)	(0.702)	(0.015)	(0.287)	(0.851)
	CPUE	0.7577	-0.6819	-0.5601	-0.3770	-0.8464	-	0.6992	-0.3255	0.9467	-0.3962	0.8732
		(0.138)	(0.318)	(0.191)	(0.404)	(0.016)	-	(0.080)	(0.476)	(0.001)	(0.509)	(0.010)
Kawakawa	Catch	-0.8283	-0.1896	0.1349	0.5037	-0.0193	0.0572	-	-0.0464	-0.0832	0.2287	0.5196
		(0.083)	(0.810)	(0.773)	(0.249)	(0.967)	(0.903)	-	(0.921)	(0.859)	(0.711)	(0.232)
	CPUE	0.1285	-0.1735	-0.4947	0.2607	-0.7188	0.6992	-	-0.3926	0.5182	0.2322	0.9135
		(0.837)	(0.826)	(0.259)	(0.572)	(0.069)	(0.080)	-	(0.384)	(0.233)	(0.707)	(0.004)

Longtail tuna compared to jack-cavalla-trevally showed a positive relationship in catch quantity and a strong positive relationship in CPUE values; against Indian mackerel very strong positive relationships in both catch quantity and CPUE values; and against miscellaneous fish a very strong positive relationship in CPUE values. Longtail tuna against selar scad showed a strong negative relationship in catch quantity and a negative relationship in CPUE values; against hardtail scad a strong negative relationship in CPUE values; against black pomfret and Indo-Pacific mackerel negative relationships in catch quantity; and against wolf herring a very strong negative relationship in CPUE values.

Kawakawa compared to black pomfret showed a strong positive relationship in catch quantity; against Indian mackerel a strong positive relationship in CPUE values; and against miscellaneous fish a strong positive relationship in catch quantity and a very strong positive relationship in CPUE values. Kawakawa compared to jack-cavalla-trevally showed a strong negative relationship in catch quantity; against hardtail scad and narrow-barred king mackerel a negative relationship in CPUE values; and against wolf herring a strong negative relationship in CPUE values.

IV. DISCUSSION

In the decade from 1978 to 1988, small tuna catches in the Gulf of Thailand increased dramatically because of a rise in demand from the Thai tuna canning industry. Small tunas were caught mainly by purse seine and drift gill net fisheries in the Gulf of Thailand.

Before discussing small tuna catches by each fishing gear, the following should be mentioned concerning the conditions of Thai fisheries. Many Thai fishing vessels are designed for multipurpose fisheries (Yanagawa, 1990), and are equipped with multipurpose gears for catching pelagic fishes (Cheunpan, 1987), and so target species groups and their fishing gears can easily be changed depending on the fishing conditions, fish prices and catch quantity. Owners of fishing vessels therefore consider catchability and the price of the targeted species group, and change their fishing gear and target species as appropriate.

Purse Seine Fishery

Based on the results of multivariate analyses - principal component analysis and cluster analysis - purse seine fishery in the Gulf of Thailand, from 1978 to 1988, was divided into two major year groups, i.e., from 1978 to 1984 and from 1985 to 1988. The first group of years (1978-1984) showed: a dominance of sardine catch despite a drastic decrease in weight; a substantial decrease in round scad catch in 1979 from the previous year; dramatic increases of both longtail tuna and kawakawa catches in 1983 and 1982 respectively; an increase of Indo-Pacific mackerel catch in 1981. The second group of years (1985-1988) showed: a steady rise in the catch of longtail tuna; stable catches of kawakawa, Indo-Pacific mackerel and sardine; increased catches of jack-cavalla-trevally, hardtail scad, black pomfret and anchovy; a considerable increase in catches of longtail tuna, kawakawa and jack-cavalla-trevally in 1985 and 1988.

These changes in species composition between the first and second group of years, may be due to the expansion of fishing grounds for small tuna catches. This is assumed from the fact that the purse seine catches increased in area off Pattani and Songkhla, and in the central Gulf of Thailand in 1985 as compared to the previous year (Cheunpan, 1987). This expansion of the purse seine fishing grounds led to increased catches of longtail tuna, kawakawa and jack-cavalla-trevally with a low variation in other species. In addition in 1988, expansion of the fishing grounds to offshore Malaysia and Indonesia during the second/third quarters, was noted (IPTP, 1990). A possible reason for this concomitant increase of jack-cavalla-trevally catch with that of small tunas, after expansion of the fishing grounds, could be that the mesh sizes of purse seine targeted for small tunas and jack-cavalla-trevally are the same (Okawara et al., 1986). In addition the modern purse seiner equipped with technology such as sonar, can adjust the length of its net (a school of jack-cavalla-trevally is smaller than that of small tuna) to the size of the target species. The changes of species composition should also be examined from the biological point of view.

Catches of Indo-Pacific mackerel and anchovy also increased. The possible reasons for this were examined. There are several reports regarding the biology of small tunas: Yesaki compiled a biology on longtail tuna (1987), and kawakawa (1989); studies on the stomach contents of longtail tuna, find anchovies (Serventy, 1956; Silas, 1967) and mackerels (Jones, 1963; Silas, 1967) in their stomachs; Shindo and Chullasorn (1980) described longtail tuna and kawakawa feeding on small pelagic fishes such as sardines, mackerels, anchovies and carangids; anchovies are also used as bait for longtail tuna (Wilson, 1981). It is therefore clear that longtail tuna and kawakawa are the predators for small mackerels and anchovies. The increase of Indo-Pacific mackerel and anchovy catches could therefore be attributed to the decrease of the predators, longtail tuna and kawakawa, through large catches of these small tunas by purse seine fishery.

Next, to be considered are catch trends for sardine and round scad, which used to be the target species for purse seine fishery. The trend for sardine catches, which dominated purse seine fishery until 1987 with the exception of miscellaneous fish catches, was examined. There was a decrease from 129,600 MT in 1978 to 86,000 MT in 1982, and it then remained constant at around 80,000 MT and just below. However, the total purse seine fishery catch showed a steady increase from 345,600 MT in 1978 to

475,200 MT in 1988 (a peak of 496,600 MT was reached in 1986) with large increases of small tunas, mackerels and miscellaneous fish. Sardine fishery is therefore considered to be declining, with a steady decrease in its percentage of the total purse seine catch despite catches remaining constant between 1982 and 1988. The relationship between small tunas and sardines, showed a negative relationship of CPUE values against longtail tuna, and strong negative relationships of both catch and CPUE values against kawakawa in the first group of years. However, sardines showed no relationship against longtail tuna and a strong positive relationship of catch against kawakawa in the second group of years. It can therefore be considered that there have been no real effects from the increase of small tuna catches on sardine catches after 1984. In addition, the trends of sardine catch were examined using the MSY which was estimated at 150,000 MT or over (Menasveta, 1978). The catch of sardine in 1971 was 28,400 MT (DOF, 1973) increasing to 100,200 MT in 1976. In 1977 sardine catch in the Gulf of Thailand doubled from the previous year and peaked at 211,100 MT. It can be assumed that the decline of sardine fishery has been caused not only by increases of small tunas but also the decrease of sardine resources which have been exploited in the past. In addition, the limited processing capacity of sardine canning factories for fisheries in the eastern part of the Gulf of Thailand sometimes caused an excess of sardine supply, which was treated as trash fish (Ikenoue et al., 1990). The last reason for the decrease of sardine catch, as recorded in the statistics, is that small or stale supplies of sardines are also classified as trash fish.

The catch trends of round scad, which decreased by one-fifth in 1979 from the previous year's catch of over 100,000 MT, were examined. After the drastic decreases of 1979, catches remained constant at between 22,300 MT in 1979 and 23,900 MT in 1986. They then increased to 41,800 MT in 1987 before decreasing to 13,900 MT in 1988. Round scad showed a strong negative relationship of CPUE values against longtail tuna in the first group of years and showed strong negative relationships of catch and CPUE values against kawakawa in the second group of years.

The estimated MSY of round scad was over 100,000 MT (Menasveta, 1978), and the catch reached 106,000 MT in 1978. Stocks of round scad in the eastern part of the Gulf of Thailand were depleted by 1982 and the proportion of this fish in the fishing grounds decreased (Ikenoue et al., 1990). It can be assumed that constant low level catches after 1978, and the drastic decrease of round scad catch in 1979, were caused by heavy exploitation in previous years, as well as the low price of round scad compared with small tunas.

In summary catches of longtail tuna and kawakawa increased dramatically after the early 1980s as shown in the first group of years (1978-1984), but with the peak reached in 1983 at the earliest. Thai purse seiners were well equipped with radar, depth sounders, sonar and satellite navigation systems (Cheunpan, 1987), and purse seine fishery for longtail tuna and kawakawa was therefore carried out very efficiently. Catches of longtail tuna and kawakawa increased both in 1985 and 1988, because of expansion of the fishing grounds from coastal areas to the central Gulf of Thailand (Cheunpan, 1987) and seas off Malaysia and Indonesia (IPTP, 1990). The availability of small tunas in the coastal waters of Thailand and Malaysia has been greatly reduced by exploitation of small tunas by Thai purse seiners in offshore waters (Yesaki, 1991). A further large increase in the catches of longtail tuna and kawakawa in the Gulf of Thailand will therefore be difficult other than by expansion of the fishing grounds to the South China Sea area. Proper management of longtail tuna and kawakawa fishery by purse seine, taking into consideration fisheries interactions and the life histories of major species, is essential not only in the Gulf of Thailand but also its vicinity.

Drift Gill Net Fishery

Based on the results of multivariate analysis - principal component analysis and cluster analysis - drift gill net fishery in the Gulf of Thailand between 1978 and 1988 was divided into two major year groups, from 1978 to 1981 and 1982 to 1988. The first group of years (1978-1981) showed steady increases of narrow-barred king mackerel, longtail tuna and kawakawa catches, with positive catch relationships among these small tuna and tuna-like species. The second group of years (1982-1988) showed catch trends of longtail tuna and kawakawa increase with a temporary decrease of narrow-barred king mackerel, and negative relationships of longtail tuna and kawakawa CPUE values against narrow-barred king mackerel.

From 1978 to 1988, the total catches for drift gill net fishery showed a dramatic 4.3 times increase, caused mainly by the catches of longtail tuna and kawakawa. On the other hand, in 1982 the catch trend of narrow-barred king mackerel showed a considerable decrease of 39% from the previous year. The percentage of narrow-barred king mackerel declined in 1982, accounting for only 13% of the total drift gill net catch; prior to 1981 it had accounted for around 40%. From 1983 to 1988, the catch trend of narrow-barred king mackerel showed an increase, but as a percentage of the total drift gill net catch, was still low at 17% to 24%. In comparison, the percentage of small tunas exceeded 60% of the total drift gill net catch in 1981, and then stayed at 66% to 80% up to 1988. The major target species of drift gill net therefore changed between 1982 and 1985, from narrow-barred king mackerel, which dominated before 1981, to longtail tuna and kawakawa.

Narrow-barred king mackerel fishery was therefore examined. It would appear from these analyses that narrow-barred king mackerel fishery by the drift gillnetter declined, however, the fishery itself showed no decline, despite a decrease of catch in 1982. In fact the catch of narrow-barred king mackerel from other fishing gears, especially from trawl (pair trawl gear had been modified for more efficient targeting of pelagic fishes), was fairly constant with slight increases from 1982 to 1985, and thereafter a steady increase. Major reasons for this can be considered as follows: catches of narrow-barred king mackerel from trawl were at good levels; there was no serious structural difference in the drift gill nets targeted for narrow-barred king mackerel and the nets targeted for longtail tuna and kawakawa (Yanagawa, 1989; Yesaki, 1991); the price of narrow-barred king mackerel remained constant, and at a higher level than two small tuna species obtained by auction at Bangkok Fish Market (DOF, 1982, 1985, 1988; Fish Marketing Organization).

The situation of small tuna fishery by drift gill net in the Gulf of Thailand can be summarized as follows: catches of longtail tuna and kawakawa increased from the early 1980s, the same as for purse seine, and then, between 1982 and 1985, the target species of drift gill net fishery changed from narrow-barred king mackerel to longtail tuna and kawakawa. As catches of longtail tuna, kawakawa and narrow-barred king mackerel were similar to each other after 1985 and the total catches of the drift gill net fishery from 1982 to 1988 were stable at between 23,500 MT to 25,900 MT with the exception of 18,500 MT in 1983, it is considered that catches of longtail tuna, kawakawa and narrow-barred king mackerel by drift gill net were stable after 1985 and up to 1988 in the Gulf of Thailand.

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