Multi-Species Fish Stock Assessment by Acoustic Method in the South China Sea Area I: Gulf of Thailand and East Coast of Peninsular Malaysia

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ABSTRACT

Acoustic resource surveys were conducted by M/V SEAFDEC in the Gulf of Thailand and off the east coast of Peninsular Malaysia from September 5 to 28, 1995 for pre-NE monsoon season and from April 24 to May 17, 1996 for post-NE monsoon season, using the scientific echosounder FQ-70 (Furuno Electric Co.) .

Collected raw values of backscattering strength (SV) from the 200 kHz were carefully corrected and filtered to eliminate the influence of plankton. These corrected SV values were classified into pelagic and demersal fish, and were used to estimate the biomass of pelagic and demersal multi-species fish. Biomass of pelagic and demersal fish for each season was only estimated in the east coast of Peninsular Malaysia within Malaysian EEZ waters due to the availability of previous fisheries statistics and biological data. Dominant species were selected based on the fisheries statistics and landing place survey. Length (L) and weight were obtained from previous literatures. Target strength (TS) of these dominant species were calculated as TS =20 log (L) -66.

The distribution of the SV values for pelagic fish showed a distinct difference between pre- and post- monsoon seasons. Greater concentrations of SVs were observed from offshore compared to the nearshore waters in pre-monsoon season. The distribution for the demersal fish showed that there was no clear difference between pre- and post-monsoon. The estimated biomass of multi-species fish off the east coast of Peninsular Malaysia within Malaysian EEZ for the pre-and post-monsoon seasons was 4.4×10^5 tonnes (2.3×10^5 tonnes of pelagic fish and 2.1×10^5 tonnes of demersal fish) and 3.1×10^5 tonnes (1.9×10^5 tonnes of pelagic fish and 1.2×10^5 tonnes of demersal fish), respectively.

Key words: Acoustic survey, Multi-species biomass estimation, East coast of Peninsular Malaysia

Introduction

Fish stock assessment in the South China Sea waters is a growing necessity in many countries in Southeast Asian countries. However, suitable multi-species fish stock assessment methods have not been facilitated in this region due to the complexity of biological characteristics, such as the multitude of fish species and spawning throughout the year. Furthermore, the inherent characteristics of fisheries in this region hinder the collection of reliable landing statistics. In such a situation, an acoustic method, which is independent of the fishery, is appropriate to grasp overall fish biomass in this region, although such a method may not be able to solve completely problems in tropical multi-species fish stock assessment. SEAFDEC has begun to make an effort to develop multi-species fish biomass estimation in South China Sea by means of acoustic method. This report presents one of the approaches to estimate tropical multi-species fish biomass estimation by acoustic method, and discusses the effect of Northeast monsoon season.

Materials and Methods

Two acoustic surveys, using FQ-70 (Furuno Electric Co.), were carried out simultaneously with oceanographic studies by M/V SEAFDEC in the Gulf of Thailand and off the east coast of Peninsular Malaysia. The first survey was conducted during the pre-Northeast(NE) monsoon season from September 5 to 28, 1995. The second survey was carried out during the post-NE monsoon season from April 24 to May 17, 1996. These timing of the surveys were primarily to examine whether the NE monsoon season (November to March) affects the abundance and distribution of fish in the survey area.

Calibration of FQ-70 was done prior to each survey near Luan Island (12 ^{o} 57 ' N, 100 ^{o}37 ' E) on the upper coast of the Gulf of Thailand in September 4, 1995 for the first survey, and in April 23, 1996 for the second survey. The source level, receiving sensitivity, and the gain of amplifier were measured by means of a hydrophone. Parameter settings of the acoustic system were shown in Table 1.

Survey transect was set between oceanographic stations. Both surveys were conducted along the same transect as shown in Figure 1. The transects were accorded with grids of 30 ' in latitude by 30 ' in longitude throughout day- and night-time at a cruising speed of approximately 10 knots.

The acoustic system was set up to process echo and output of the volume backscattering strength (SV in dB/m^3) in real time from depth of 10m to 80m at horizontal intervals of 0.1 nautical mile. The depths were set into 10 layers as shown in Table 2. Layers 1 to 8 were set from the surface, while layers 9 and 10 were set from the bottom.

The SV values from the low frequency (50kHz) and the high frequency (200kHz) transducers were both recorded. However, only the values from the high frequency transducer were used in data processing and consequently in the fish biomass estimation. The data were recorded in the following forms:

1) Numeric data of integrated result of echo signals which were recorded in a floppy disk through data analyzer FQ-770
2) Print-out of the numeric data from the results of the integrated echoes (This output was also recorded simultaneously in a floppy disk).
3) Echo signals including echo of vertical distribution curve, which were traced on the recording paper through the recorder unit FQ-706.
4) Analog data for echo signals and log data which were recorded on a video tape.

Only the numeric data on a floppy disk and in printed form were used to process the SV values. The traced echo signals were only used as a reference. Analog data on the video tape were not utilized due to the absence of a post data analyzer.

Noise from other electric devices and unlocked echoes due to rough sea conditions may create errors to the collected raw SV values. Besides noise and unlocked echoes, the raw SV values may also be affected by plankton and other dense micronecton. Therefore, these raw SV values need to be corrected prior to further analysis.

The graphical method was used to correct erroneous SV values obtained by chance from noise of other electric devices and unlocked bottom echoes. The SV values were plotted against integration

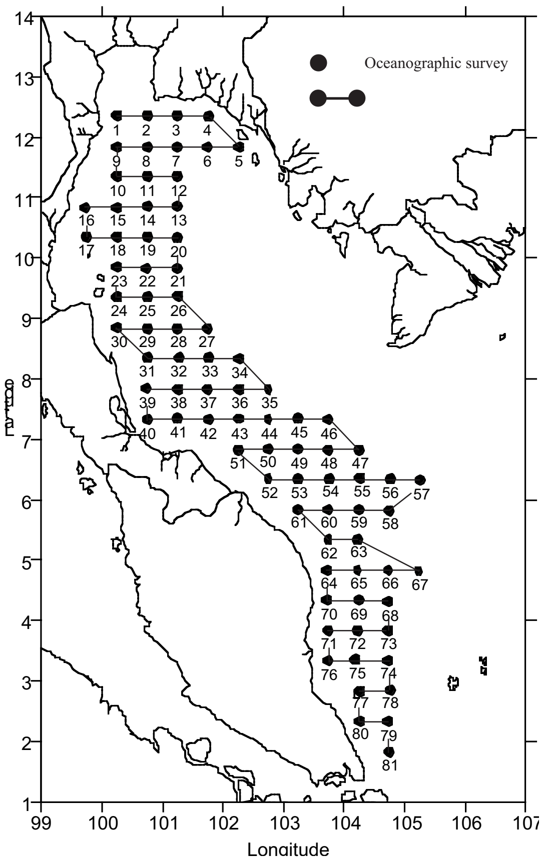

Fig. 1. Survey transects for the acoustic survey in the Gulf of Thailand and off the east coast of Peninsular Malaysia in September 1995 and April/May 1996. Number indicates the oceanographic survey station.

Table 1. Settings and calibration parameters of the acoustic system FQ-70.

Parameters	Sep. 1995		April/May 1996	
Frequency (kHz)	50	200	50	200
Source Level(dB)	215.3	219.5	212.5	218.8
Pulse Duration(ms)	1.2	1.2	1.2	1.2
Beam Width(dB)	-14.5	-16.1	-14.5	-16.1
Absorption Coefficient(dB)	9.9	92.7	9.9	92.7
Receiving Sensitivity(dB)	-186.0	-194.9	-185.6	-194.2
Amplifier Gain(dB)	49.0	50.1	49.0	50.2

Table 2. Depth layers and depth ranges of SV integration.

Depth Layer	Ranges (m)
1	10-80
2	10-20
3	20-30
4	30-40
5	40-50
6	50-60
7	60-70
8	70-80
9	10-5 (from Bottom)
10	5-1 (from Bottom)

number for each depth layer of 1 to 8 and average of layers 9 and 10. From the graphs, doubtful high echo traces were carefully corrected by referring to the recording paper. These were termed as the Corrected SV values.

The corrected SV values were further filtered to select the values from fish, using five-point moving average. These filtered SV values will be called the Calculated SV values.

The calculated SV values for each transect were averaged vertically from depth layer 2 to 8 for each integration number, and horizontally from the first integration number to the end. The calculated SV were sorted out into pelagic and demersal fish. Average SV values of layers 9 and 10 were considered as demersal fish. The values remained from the subtraction of the SV values of layers 9 and 10, from the total SV values of layers 2 to 8, were considered as pelagic fish. The overall averaged calculated SV values throughout transects within the specified area for pelagic and demersal fish were used for fish biomass estimation.

The pelagic and demersal multi-species fish biomass off the east coast of Peninsular Malaysia within Malaysian EEZ was only estimated due to the availability of necessary information. For simplicity, the areas within the oceanographic station 45 to 81 was considered as Malaysian EEZ off the east coast of Peninsular Malaysia. The total survey areas was estimated by the method of Johnnesson and Mitson (1983). The following expression was applied to estimate fish biomass:

$$Q = (sv / ts)\ w\ a\ d$$

where Q : Biomass

$sv = 10^{(SV/10)}$: Backscattering strength

$ts = 10^{(TS/10)}$: Target strength

w : average fish weight(g)

a : survey area(m^2)

d : layer depth(m)

Target strength (TS) was estimated using the following equation from Furusawa (1990):

$$TS = 20 \log SL - 66$$

where TS : Target strength(dB)

SL : Fish Standard length(cm)

To determine single TS for biomass estimation, a representative species was used in this report. The representative species were determined in two steps. A representative fish group was selected based on the catch statistics of the major fishing gears operating in the survey area within Malaysian EEZ off the east coast of Peninsular Malaysia. Then the representative species was determined using the previous landing statistics and literatures. After determining the representative species, necessary information on standard length and average weight were extracted from the previous literatures.

Results

The distribution of the calculated SV values of pelagic and demersal fish for pre- and post-NE monsoon seasons for each transect were shown in Figures 2 to 5.

Distribution of SV values in Figures 2 and 3 for pelagic fish showed an apparent difference between seasons and area. There are higher SV values during pre-NE monsoon season than post-NE monsoon season. Higher SVs were observed especially in the shallower waters towards the upper part of Gulf of Thailand during pre-NE monsoon season. There is a tendency for higher SVs towards offshore waters during pre-NE monsoon season. In contrast, during the post-NE monsoon season, there is a relatively low SVs throughout the survey area and the concentration of SVs were rather towards the shore.

Distribution of SV values of demersal fish for the pre- and post NE monsoon season are shown

Table 3. Selected fishing gears operating in the survey area of Malaysian EEZ in the east coast of Peninsular Malaysia.

Fishing Gear	Size Class
Otter Board Trawl	40-69.9 ton over 70 ton
Purse Seine	40-69.9 ton

in Figures 4 and 5. There were no distinct difference between the seasons.

Major fishing gears operating off the east coast of Peninsular Malaysia within the survey area are listed in Table 3. The major fishing gears are otter board trawl and purse seine.

Table 4 showed the landings of both pelagic and demersal fish by the two gear groups off the east coast of Peninsular Malaysia for three years period between 1992-1994 (Department of Fisheries Malaysia,1993, 1994, and 1995). The major fish group landed in descending order were *Decapterus* spp., *Selaroides* sp., and *Rastrelliger* spp. for pelagic fish and *Nemipterus* spp, *Lutjanus* spp., and Marine catfish(*Tachysurus* spp., *Arius* spp., *Osteogenius* spp.) for demersal fish. Being the most dominant in landing (Mansor and Abdullah, 1995; Kimoto and Ibrahim, 1996), *Decapterus russelli* of the *Decapterus* spp. and *Nemipterus peronii* of the *Nemipterus* spp. were designated as the representative species for further analysis. Standard length and average weight for pelagic fish and demersal fish were obtained from Mansor and Abdullah (1995) and Kimoto and Ibrahim (1996) in Table 5, including estimated TS

Results of biomass estimation of pelagic and demersal fish off the east coast of Peninsular Malaysia within Malaysia EEZ between the two seasons were shown in Table 5. Total estimated survey area was 111, 129 km^2 . The estimated density and biomass of pelagic fish for pre- and post NE monsoon seasons were 2.07 tonnes/km^2 and 230,000 tonnes, and 1.74 tonnes/km^2 and 190,000 tonnes, respectively, based on *Decapterus* r*usselli*. The estimated density and biomass of demersal fish for pre- and post NE monsoon were 1.88 tonnes/km^2 and 210,000 tonnes and 1.10 tonnes/km^2 and 120,000 tonnes, respectively, based on *Nemipterus peronii*. Total biomass of multi-species fish in the east coast of Peninsular Malaysia within Malaysian waters for the pre-and post-NE monsoon seasons were 430,000 tonnes and 310,000 tonnes, respectively.

Discussion

Distribution of SV in Figures 2 and 3 for pelagic fish showed apparent difference between seasons and areas. There is higher SV values during pre-NE monsoon season than post-NE monsoon season. This trend is similar to the monthly landing patterns from both Malaysia and Thai EEZ of the survey area as shown in Figures 6 and 7 (Department of Fisheries Malaysia, 1993, 1994, and 1995; Department of Fisheries Thailand, 1995). Higher fish landing occurred from June to October (pre-NE monsoon season) and landings started to decline in November until May (post-NE monsoon season). Mansor and Abdullah (1995) and Anon (1987) suggested that during pre-NE monsoon season, pelagic fish would move towards the east coast of Peninsular Malaysia and to the Gulf of Thailand and later disperse to the offshore waters of the South China Sea during post-NE monsoon season. Since a relative change of SV values seem to effect patterns in the availability of fish, the SV values could be used as an index to indicate the availability of fish resource, therefore fish abundance within survey area.

Off the east coast of Peninsular Malaysia within Malaysian EEZ, two acoustic surveys have been carried out. The survey results by R/V DR F. Nansen during off NE monsoon between June and August in 1980 showed that the density of pelagic fish in this area was 2.68 tonnes/km^2 (Aglen *et al*.,

Table 4a. Landing (tonnes) of pelagic fish from selected fisheries along the east coast of Peninsular within Malaysian EEZ from 1992 to 1994.

Fish Group	Year			Average
	1992	1993	1994	
Decapterus spp.	22,743	32,245	26,662	27,217
Selaroides leptolepis	9,533	10,738	9,860	10,044
Rastrelliger spp.	6,646	6,066	5,152	5,955
Thunnus tonggol/Euthynnus affinis/Auxis thazard	5,790	8,041	2,285	5,372
Sardinela spp.	4,703	5,124	5,202	5,010
Selar spp.	5,489	5,365	2,983	4,612
Scomberomorus spp.	3,954	3,321	577	2,617
Megalaspis cordyla	2,629	2,684	2,041	2,451
Alectis indica/Caranx spp.	1,338	1,091	650	1,026
Trichiurus lepturus	566	520	632	573
Carangoides spp.	552	823	342	572
Sphyraena jello/S. optusa	593	517	222	444
Rachycentrom canadus	373	414	149	312
Fomio niger/Pompus spp.	181	502	204	296
Chirocentrus dorab	247	169	208	208
Elagatis bipinnulatus	203	114	34	117
Istiophorus spp/Makaira spp.	72	55	2	43
Megalops cyprinoides	106	6	11	41
Stolephorus spp.	19	66	10	32
Scomberoides commersonianus	31	29	23	28
Polynemus spp./*Eleutheronema tetradactylum*	19	33	2	18
Liza spp./Valamugil spp.	1	2	1	1
Total	**65,788**	**77,925**	**57,252**	**66,988**

Table 4b. Landing (tonnes) of demersal fish from selected fisheries along the east coast of Peninsular within Malaysian EEZ from 1992 to 1994.

Fish Group	Year			Average
	1992	1993	1994	
Nemipterus spp.	9,950	10,063	4,604	8,206
Lutjanus spp.	4,191	2,811	1,575	2,759
Tachysurus spp./*Arius* spp./ *Osteogenius* spp.	2,039	3,100	821	1,987
Gymnura spp./*Dasyatis* spp.	1,664	1,908	1,219	1,597
Pristipomoides typus	1,355	1,130	644	1,043
Epinephelus spp./ *Plectropormus* spp.	1,174	1,193	582	983
Saurida spp.	571	891	1,098	853
Upeneus spp.	785	690	810	762
Galeorhinidae	876	648	428	651
Plectrorhinchus pictus	500	429	327	419
Scolopsis spp.	462	535	165	387
Sciaena spp./*Otolithoides* spp./ *Otolithus* spp./*Johnius* spp.	398	380	350	376
Siganus spp.	409	370	154	311
Sillago sihama/S. maculuta	263	186	178	209
Flatfish	214	207	184	202
Caesio spp.	154	81	125	120
Muraenesox spp.	114	109	62	95
Pomadasys spp.	36	54	113	68
Leiognathus spp./*Gazza* spp./ *Secutor* spp.	46	55	87	63
Callyodon spp./*Thalassoma* spp.	59	54	6	40
Tonguefish	49	39	30	39
Drepane punctata	26	33	25	28
Plotosus spp.	34	11	2	16
Lactarius lactarius	1	0	1	1
Total	**25,370**	**24,977**	**13,590**	**21,312**

Table 5. Estimated biomass with necessary information for pelagic and demersal fish along the east coast of the Peninsular Malaysia within Malaysian EEZ in pre and post Northeast monsoon seasons, using FQ-70.

	Northeast Monsoon	
	Pre (Sep, 1995)	**Post (Apr/May, 1996)**
Survey area (km2)	111,129	
Pelagic	*Decapterus russelli*	
Depth layer (m)	61	61
SV (dB)	-73.14	-74.07
SL (cm)	15.1	16.7
TS (dB)	-42.42	-41.55
Weight (g)	40	51
Density (tonnes/km2)	2.07	1.74
Biomass (1,000 tonnes)	230	190
Demersal	*Nemipterus peronii*	
Depth layer (m)	9	9
SV (dB)	-69.34	-70.83
SL (cm)	16.7	13.9
TS (dB)	-41.55	-43.14
Weight (g)	126	72
Density (tonnes/km2)	1.88	1.1
Biomass (1,000 tonnes)	210	120
Total biomass (1,000 tonnes)	440	310

1981). The other survey by R/V Rastrelliger during June and July in 1986 showed the density of pelagic fish in this waters was 1.02 tonnes/km^2 (Anon., 1987). From the present survey, the average of estimated fish density of pelagic fish in this waters during off NE monsoon season was 1.97 tonnes/km^2 (2.07 tonnes/km^2 and 1.74 tonnes/km^2 for the pre-NE monsoon season and the post-NE monsoon season respectively). The average of estimated biomass for pelagic fish was 210,000 tonnes. It could be speculated that the magnitude of biomass for pelagic fish in this waters may not exceed an order of 10^6.

This report shows one of the approaches of the point estimate of the fish biomass. Even though the report is also based on many assumptions or presumption, it is a step towards introducing the hydro-acoustic method in this region. Further efforts will be necessary to improve precision and accuracy of multi-species biomass estimation. For example, the main target species need to be identified for representative TS and weight. Geostatistical method (Pititgas, 1993) can be applied to infer the confidence interval of the fish biomass.

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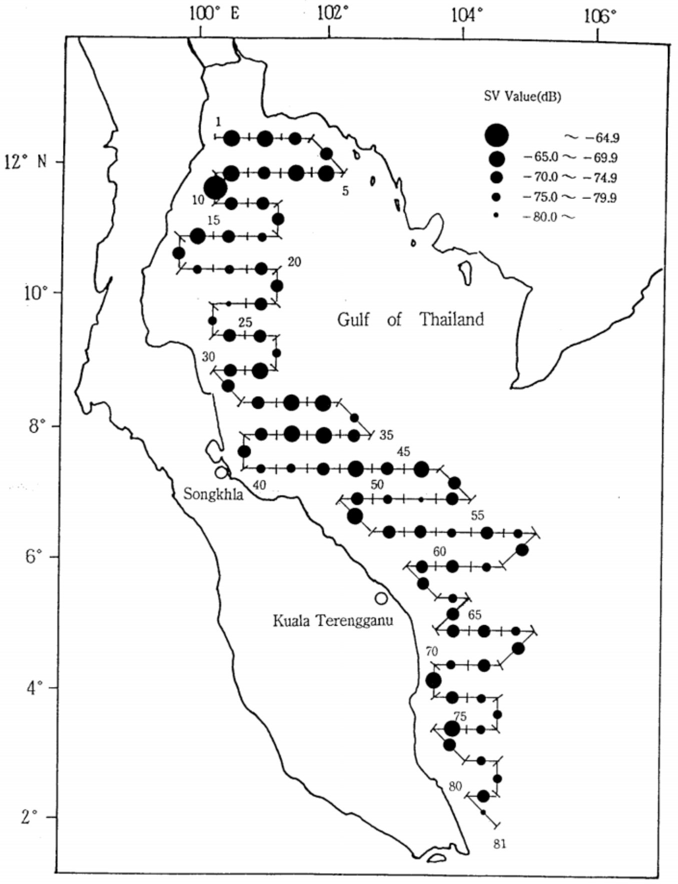

Fig. 2. SV values distribution for pelagic fish along transects in the Gulf of Thailand and off the east coast of Peninsular Malaysia in September 1995 during the pre-Northeast monsoon season. Number indicates the oceanographic survey station.

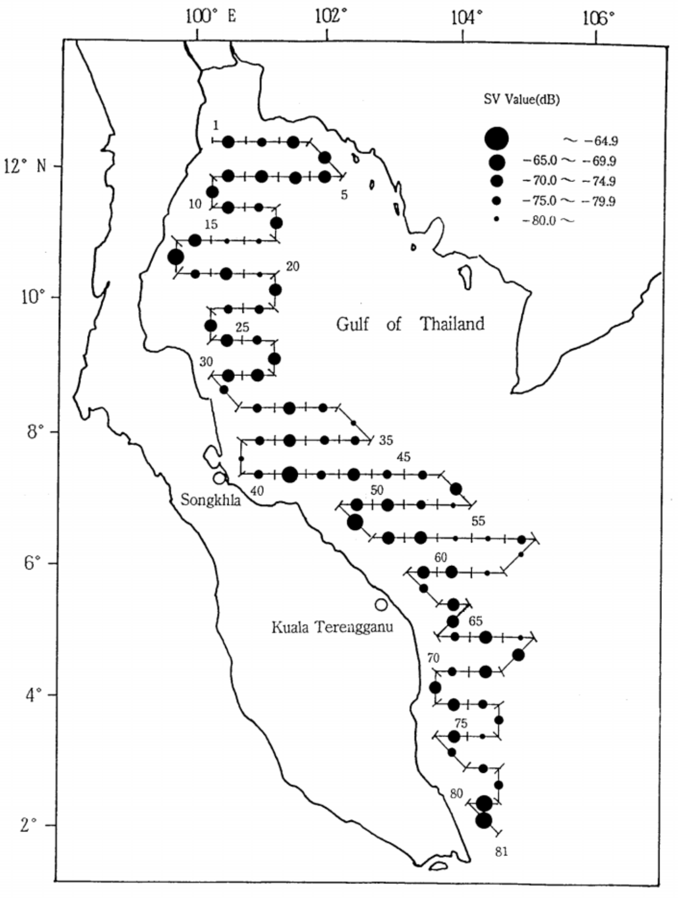

Fig. 3. SV values distribution for pelagic fish along transects in the Gulf of Thailand and off the east coast of Peninsular Malaysia in April/ May 1996 during the post-Northeast monsoon season. Number indicates the oceanographic survey station.

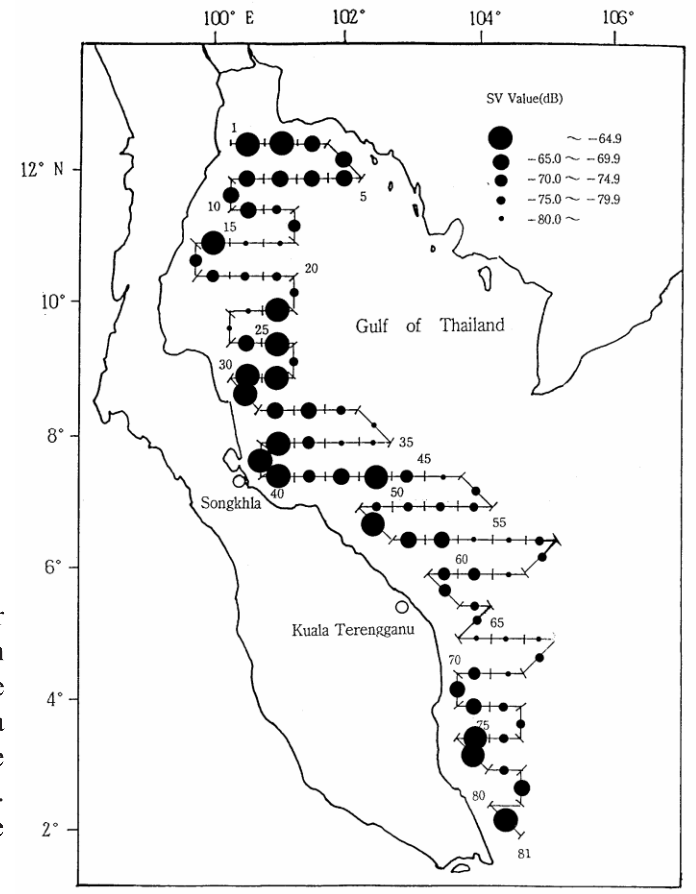

Fig. 4. SV values distribution for demersal fish along transects in the Gulf of Thailand and off the east coast of Peninsular Malaysia in September 1995 during the pre-Northeast monsoon season. Number indicates the oceanographic survey station.

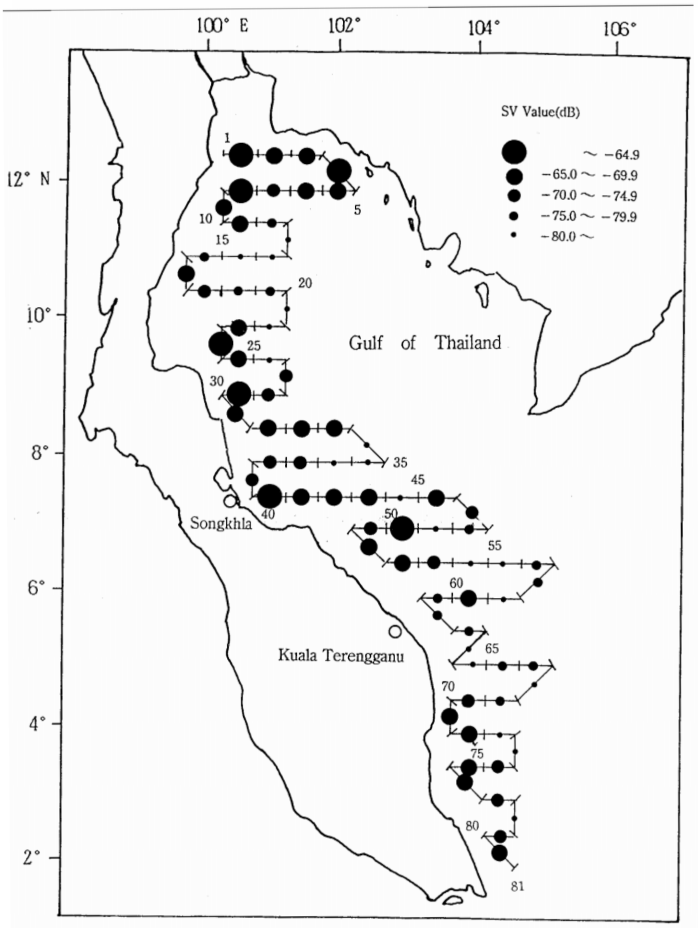

Fig. 5. SV values distribution for demersal fish along transects in the Gulf of Thailand and off the east coast of Peninsular Malaysia in April/May 1996 during the post-Northeast monsoon season. Number indicates the oceanographic survey station.

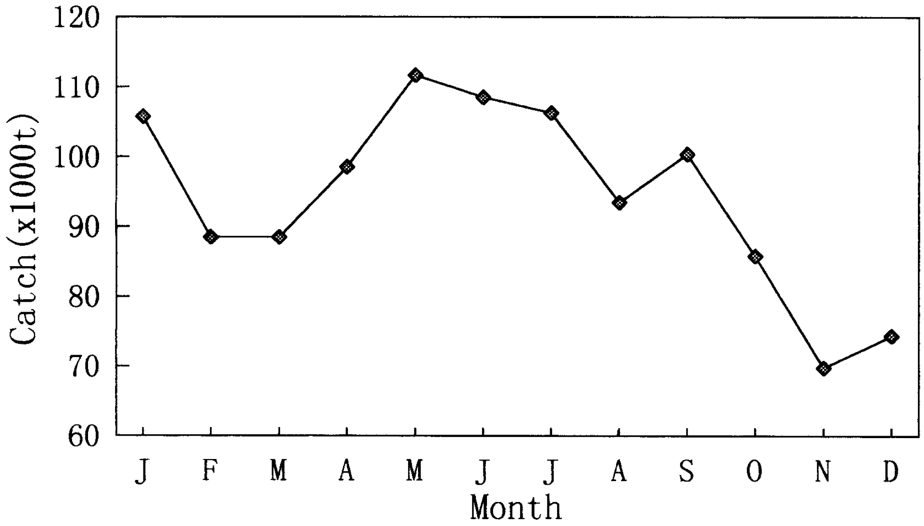

Fig. 6. Monthly fish catch in the Gulf of Thailand within Thai EEZ by selected fishing gear in 1992.

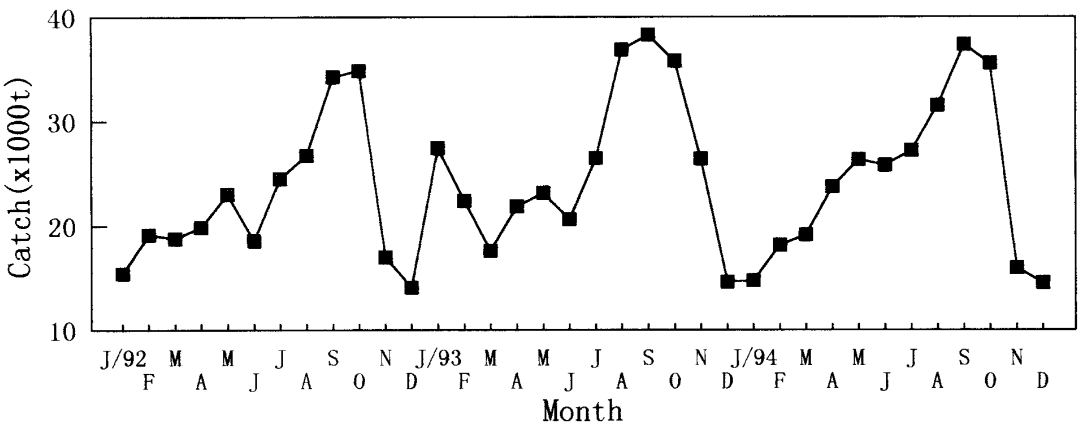

Fig. 7. Monthly fish catch off the east coast of Peninsular Malaysia within Malaysian EEZ by selected fishing gear during 1992 and 1994.

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