Status of Demersal Fishery Resources of Malaysia

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Abstract

Research trawl surveys have been conducted in four areas of Malaysian waters (west and east coast of Peninsular Malaysia, and waters off the coast of Sarawak and off the west coast of Sabah) since 1970. Selected surveys (1972 - 98) were used to examine the status of demersal fishery resources in each area, focusing on catch rate and biomass trends, population parameters and the exploitation rates of dominant species. Annual fishery catch and effort data for Peninsular Malaysia (1971 - 96) and Sarawak (1969 - 96) were used to assess the maximum sustainable yield (MSY) and fishing effort to achieve optimum level (f_{MSY}). The results indicate over-exploitation of the demersal resources, severe depletion and excess effort in the fisheries. The catch rates have declined up to 96% in some regions, while biomass estimates are down to 6% of the virgin stock biomass. Most of the dominant species have exploitation ratios over 0.40. Analysis of the standardized fishing effort and yield using the Fox model indicates that the 1996 effort is 135 - 200% of the level needed to harvest MSY. The levels of reduction of catch and of exploitation vary among the four areas and with depth, but most show over-exploitation and severe reductions.

Introduction

Fisheries are an important sector in the Malaysian economy. Besides providing the main source of protein, the sector provides employment to about 80 000 fishers (Department of Fisheries (DOF) 1969 - 96). With the implementation of the Malaysian Exclusive Economic Zone (EEZ) in 1981, fishing grounds were extended beyond traditional areas. The total Malaysian EEZ area is 548 800 km^2, of which 45% (250 000 km^2) is off Sarawak and Sabah.

The Malaysian EEZ is generally divided into four areas, namely the west and east coast of Peninsular Malaysia, and the waters off the coast of Sarawak and off Sabah. Since the early 1970s the waters of Malaysia have been sub-divided for research survey purposes (Figs. 1 and 2). The west coast of Peninsular Malaysia was divided into six sub-areas (Fig. 1) (Mohammed Shaari et al. 1976b; Mohammed Shaari et al. 1976a): Sub-area I is between the islands of Langkawi and Penang, Sub-area II is between Penang and Pangkor Island, Sub-area III is between Pangkor Island and Bemam River, Sub-area IV is between Bemam River and Sepang river-mouth, Sub-area V is between the Bemam river-mouth and Kesang river-mouth and Sub-area VI covers the area between Kesang river-mouth and the southernmost part of Johore.

The four sub-areas on the east coast of Peninsular Malaysia (Fig. 1) have been fixed since surveys in

1970 (Pathansali et al. 1974): Sub-area I covers the entire coast of Kelantan and the northern third of Terengganu, Sub-area II covers the southern two-thirds of Terengganu state, Sub-area III covers the entire coast of Pahang state and Sub-area IV covers the entire coast of Johore.

The survey areas off the state of Sarawak, west coast of Sabah and the Federal Territory of Labuan (Fig. 2) have been divided into six sub-areas (Sub-areas I - III are in Sarawak waters, IV - VI in Labuan and Sabah) since the first survey conducted in 1972 (Mohammed Shaari et al. 1976a): Sub-area I stretches from Tanjung (Tg.) Dato to Tg. Sirik, Sub-area II is from Tg. Sirik to Tg. Kidurong, Sub-area III is from Tg. Kidurong to Kuala Baram, Sub-area IV covers the entire coast of Brunei Darussalam including the Federal Territory of Labuan, Sub-area V is from north of Labuan to Kota Kinabalu and Sub-area VI is north of Kota Kinabalu to Marudu Bay.

The waters of the west coast of Peninsular Malaysia seldom exceed 120 m depth. Physically, the sub-strate of the Straits of Malacca shows a gradual downward slope from both the coastline of East Sumatra and the west coast of Peninsular Malaysia

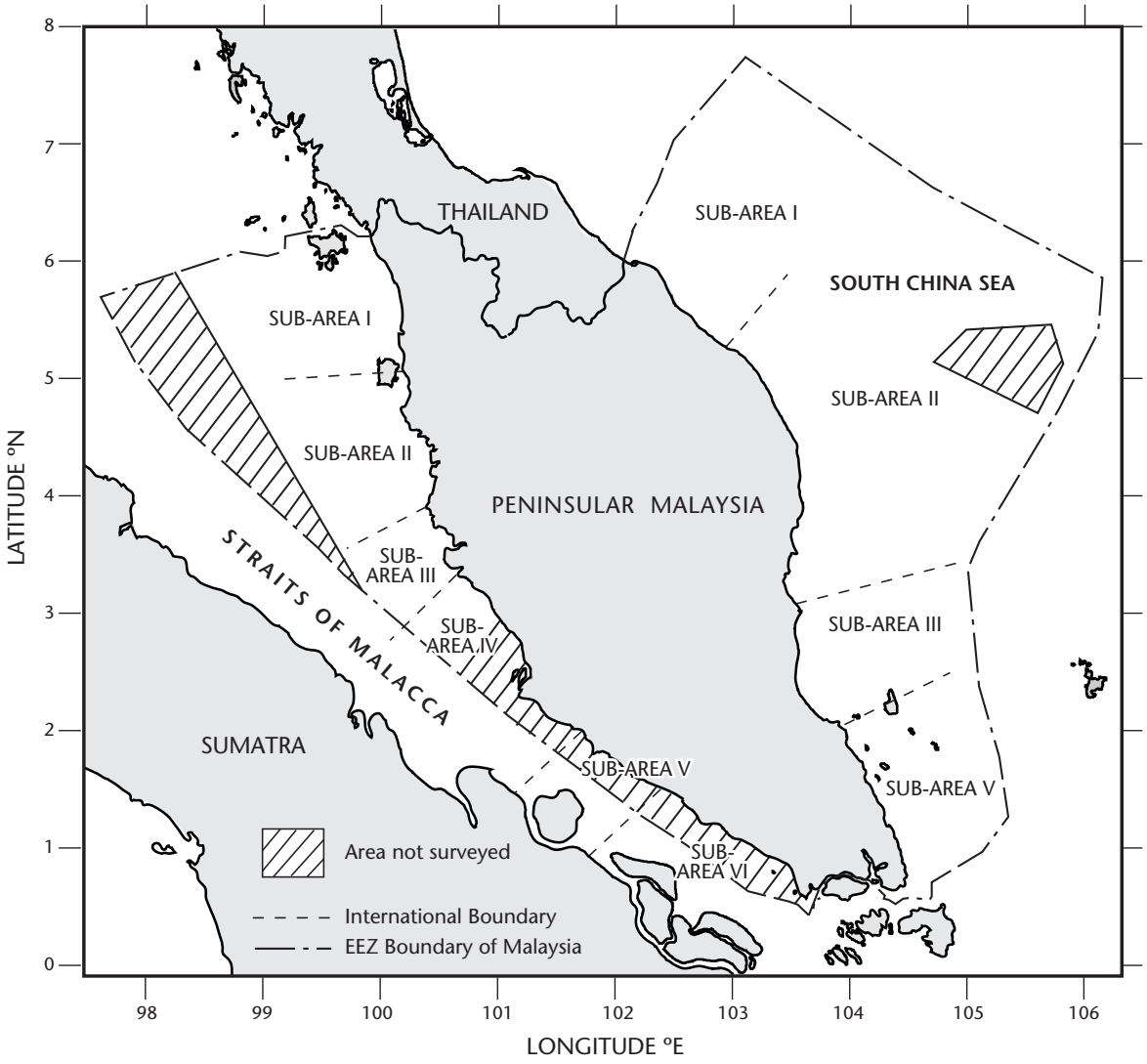

Fig. 1. Peninsular Malaysia showing the six sub-areas off the west coast and four sub-areas off the east coast.

(Liong 1974). The area can be divided into two parts by the 30 m isobath near One Fathom Bank in the middle of Sub-area IV (Fig. 1), where the bottom topography shows an increase in depth both toward the Andaman Sea in the north and the South China Sea in the south. The depth increase toward the north is however far greater and the deepest part is at the northern tip of Sub-area I (Fig. 1). Earlier surveys show a gradual transition in substrate from mud in the north to mixtures of mud/sand in Sub-areas I to IV which are suitable for trawling (Mohammed Shaari et al. 1974). Untrawlable (i.e. rocky) and uneven ground was reported for the entire Sub-area V, hence the absence of commercial trawling operations in the area.

Untrawlable ground was also reported on the northern part of Sub-area VI but not the southern part, which was predominantly muddy (Mohammed Shaari et al. 1976b).

The waters off the east coast of Peninsular Malaysia have a relatively flat topography and depths less than 100 m. The four Sub-areas (Fig. 1), though suitable for trawling, have minor patches with hard and soft corals in Sub-area II and mud-clay

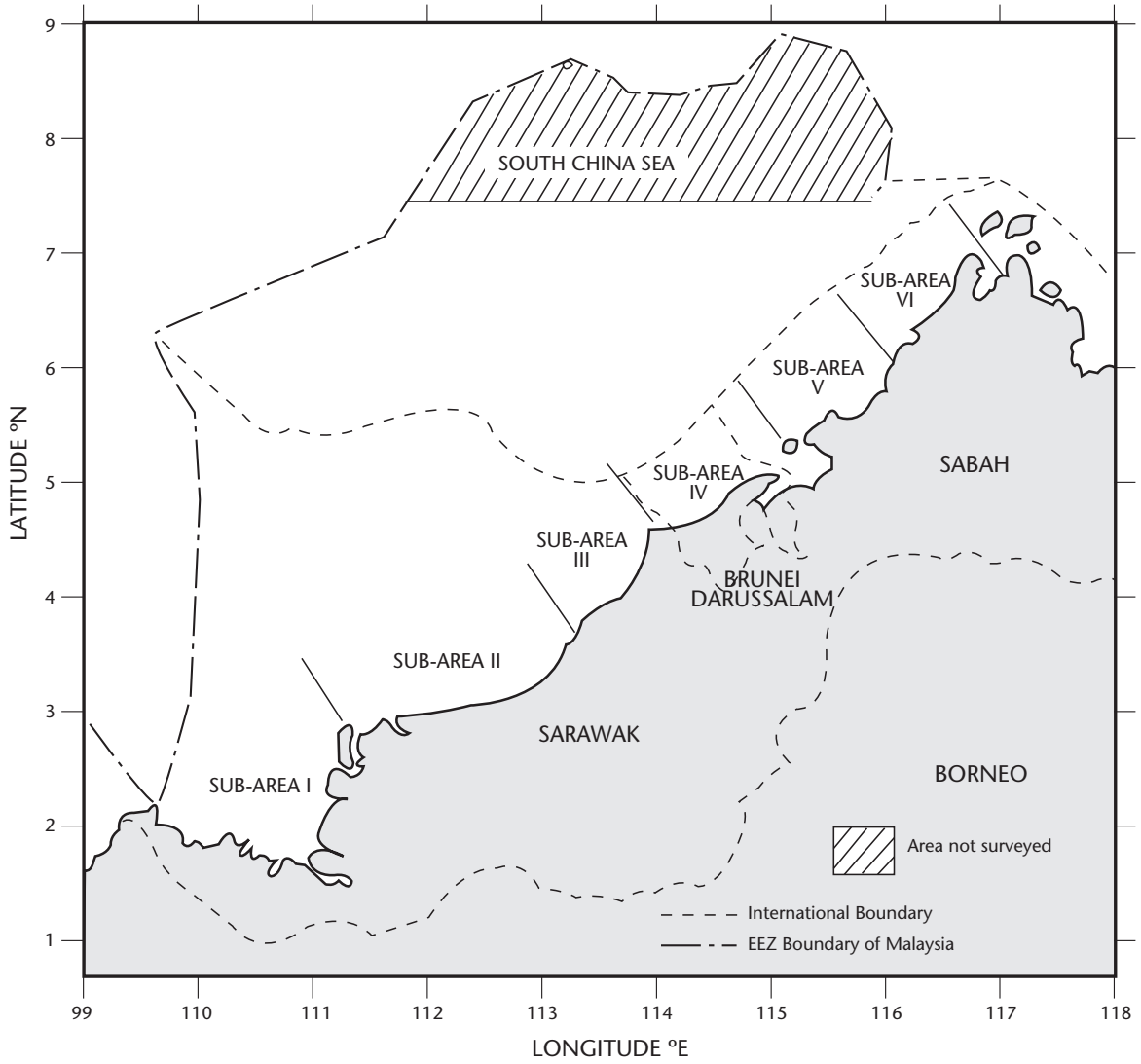

Fig. 2. The Sarawak and Sabah states showing the six sub-areas. Sub-areas I, II and III are off the coast of Sarawak and Sub-area IV, V and VI are off the coast of Sabah.

sediments in Sub-area IV (Pathansali et al. 1974). The continental shelf off Sarawak (Fig. 2) extends up to 220 nm at its furthest point north of Tg. Po in Sub-area II and its narrowest point is at 30 nm north of Tg. Baram in Sub-area III. The continental shelf extends 200 m, after which depth quickly drops to 1 000 m over a mean distance of 2.5 nm. From Sub-area IV off Brunei Darussalam waters to Kudat (on the northern tip of the west coast of Sabah) in Sub-area VI, the continental shelf extends only 30 nm from the shoreline.

Some important habitats found in Malaysian coastal waters are coral reefs, and mangroves. There is little reef along the peninsular mainland, with most of the fringing reefs occurring around offshore islands. The islands off the west coast have less extensive reefs compared to those off the east coast due to turbid conditions and muddy substrate. Along the west coast of Peninsular Malaysia, coral reefs are mainly found near Sembilan and Pangkor Island in Sub-area III, Langkawi and Payar Island in Sub-area I and off the coast near Port Dickson in Sub-area V. Redang and Perhentian Islands in Sub-area II and the area around Tioman Island in Sub-area IV are the two main reef areas off the east coast of Peninsular Malaysia. The fringing reefs off Sarawak and Sabah occur mainly along the islands off the west coast of Sabah. The continental shelf off Sarawak, especially in Sub-area II has scattered reefs and rough grounds. In Sub-areas V and VI on the west coast of Sabah, reefs and rough grounds are very extensive almost forming barrier reefs parallel to the coast. It is estimated that reefs and rough grounds comprise about 50% of the continental shelf in these Sub-areas. Mangroves are abundant in the sheltered waters off the west coast off Peninsular Malaysia and in Sub-areas I, III and VI off Sarawak and Sabah. On the east coast of Peninsular Malaysia, mangroves are found in patches within sheltered estuaries in a number of rivers.

The west coast of Peninsular Malaysia is traditionally the largest producer of marine fish in Malaysia. In 1996, this area produced 519 500 t valued at RM1 797 million (US$714.24million*) (or 46% of the total marine fish landings in the country). About 60% of the landings came from the trawl fishery, particularly from Sub-areas I, II, III and IV, which contributed 97% of total trawl landings. The east coast of Peninsular Malaysia is second in terms of total landings, contributing about 26% or 288 200 t valued at RM642 million. Landings from Sabah and Labuan totaled 218 300 t, valued at RM582 million. The trawl is second to traditional gear in catching marine fish in this area. Landings by trawlers stood at only 74 800 t. Although Sarawak has the widest fishing area, its contribution is only about 9% of the total national marine fish landings. Production in this area for 1996 was 100 700 t, valued at RM582 million, about 48% of which was landed by trawlers (Department of Fisheries (DOF) 1969 - 96).

Trawl surveys have been conducted both in traditional fishing grounds and within the Malaysian EEZ to determine demersal fish biomass, exploitation levels and species composition. Since the first survey in 1967, a total of 18 and 15 demersal surveys were conducted off the west and east coast of Peninsular Malaysia, respectively. A total of 13 surveys have been conducted off the coast of Sarawak and the west coast of Sabah since 1972. The initial aim of the surveys was to locate suitable trawling grounds and determine the size of demersal resources for development of the trawl fishery. Since 1970, surveys have been regularly conducted using local research vessels for the purpose of monitoring the status of the resources. Several foreign research vessels have also conducted demersal surveys in Malaysian waters. The RV Dharanat (Isarankura 1971), RV Fridtjof Nansen (Aglen et al. 1981) and RV Rastrelliger (Anon. 1988) have conducted surveys on the west coast of Peninsular Malaysia. On the east coast of Peninsular Malaysia, foreign vessels that have conducted surveys include RV Manihine (Ommanney 1961), RV Pramong II (Anon. 1967), RV Fridtjof Nansen (Aglen et al. 1981), MV Seafdec (SEAFDEC 1983) and RV Rastrelliger (Anon. 1988).

Two types of trawl survey have been conducted, coastal and offshore surveys. Coastal surveys cover the area from the coast to 5 nm offshore and waters 10 to 60 m deep. Offshore surveys cover the outer areas starting either from 12 nm, 30 nm or from the limit of the territorial area up to 100 fathoms (185 m) deep. The 1926 and 1927 surveys, using ST Tongkol, do not fall into either category since they were exploratory in nature (Birtwistle and Green 1927). The coastal surveys adhering to "standard procedures" were initiated in 1970 off the west coast (Mohammed Shaari et al., 1974), in 1967 off the east coast (Anon. 1967) and in 1972 off Sar-

* 1 US$ = RM2.51596 (1996)

awak and west coast of Sabah (Mohammed Shaari et al. 1976a). To date, there have been 14 coastal surveys completed off the west coast, 12 off the east coast of Peninsular Malaysia and 9 off Sarawak and west coast of Sabah. The first countrywide offshore survey was conducted in 1986 - 87 (Anon. 1988), while the second was conducted in 1997 - 98 (Anon. 2000). This report presents the results of assessments using the trawl survey data gathered during research surveys off Peninsular Malaysia, Sarawak and the west coast of Sabah. For each area, five to six surveys (including the two offshore surveys) were selected and analyzed.

Materials and Methods

Fishing Vessel and Gear Specifications

The first systematic trawl survey to monitor the status of demersal fish resources was conducted in 1967. Since then, several research vessels have been used to conduct coastal and offshore surveys in different study areas (Table 1). The vessel used for the first coastal survey off the east coast of Peninsular Malaysia in 1967 was RV Pramong II - a 23 m (LOA) wooden stern trawler (Appendix A). The vessel was owned by the Department of Fisheries, Thailand and was used under the Thai-Malaysian-German joint trawling project (Anon. 1967). The first research vessel owned by the Department of Fisheries that conducted a coastal survey was KK Jenahak, a wooden stern trawler (Pathansali et al. 1974, Appendix A). This vessel was used for coastal surveys in Peninsular Malaysia from 1970 until 1981. Within the same period, another research vessel KK Merah, also a wooden stern trawler was used for coastal surveys in Sarawak and Sabah (Lam et al. 1975, Appendix A). In 1983, KK Mersuji, a fiberglass-reinforced plastic (FRP) stern trawler replaced KK Jenahak in conducting coastal surveys in Peninsular Malaysia (Ahmad Adnan 1998, Appendix A). In 1987 KK Manchong, another FRP stern trawler replaced KK Merah (Rumpet 1994). However, KK Manchong was deployed for both coastal and offshore surveys off Peninsular Malaysia, Sarawak and Sabah as she was suitable for both purposes.

The first offshore demersal survey was conducted in 1986 - 87 using the vessel RV Rastrelliger. This vessel was owned by the Food and Agriculture Organization (FAO) of the United Nations and was chartered by the survey's executing agency on behalf of the Government of Malaysia. The second offshore survey carried out in 1997 - 98 utilized the KK Manchong. The specifications of the survey vessels and their principal equipment are given in Appendix A.

Table 1. Research vessel and method of sampling used during selected surveys in Malaysian waters, 1967 - 98. Coastal sampling covers 10 - 60 m depth, offshore sampling covers 18 - 185 m depth.

Research Vessel	Sampling Method	Survey Area	Survey Year (Selected surveys)
RV Pramong II	Systematic random (coastal)	East coast, P.M.*	1967
KK Jenahak	Systematic random (coastal)	West coast, P.M. East coast, P. M. Sarawak & Sabah	1981 1972, 1981 1972
KK Merah	Systematic random (coastal)	West coast, P.M Sarawak & Sabah	1972 1972, 1981
RV Rastrelliger	Stratified random (offshore)	West coast, P. M. East coast, P. M Sarawak & Sabah	1987 1986 1986
KK Mersuji	Systematic random (coastal)	West coast, P. M East coast, P. M.	1991 1991
KK Manchong	Stratified random (offshore)	West coast, P. M. East coast, P. M. Sarawak West coast Sabah	1997 1998 1989/92/93, 1998 1993, 1998

Note: see also Appendix C - H. * P.M. = Peninsular Malaysia.

The trawl used for the surveys was a standard German otter trawl (Anon. 1967). The net was made of nylon with cod-end mesh size of 40 mm. The exceptions were the net used by RV Rastrelliger, whose cod-end mesh size was 50 mm (Anon. 1988) and the net used by KK Manchong, which was made of polyethylene, with a cod-end mesh size of 38 mm (Rumpet 1994). Details of the fishing gear used during the surveys are given in Appendix B.

Trawl Sampling Stations

West coast of Peninsular Malaysia

Three coastal surveys were selected for this area, those conducted in 1971 - 72, 1981 and 1991, in Sub-areas I and II. The sampling stations were located 5 to 60 nm from the coastline, in 10 to 60 m depth (Appendix C). Sampling stations were selected using a systematic random technique where the number of stations in each grid of 10 x 10 nm was randomly fixed. Trawling speed was 2.8 knots during the 1971 - 72 and 1981 surveys, and 3.0 knots during the 1991 survey. Fishing was conducted during daylight with each trawl one hour in duration.

The two offshore surveys were included in the analysis (1987 and 1997). The area surveyed in 1987 extended seaward from the 30 nm boundary (roughly overlapping with the 55 m or 30 fathom depth contour) to the offshore limits of the territorial boundary (up to 12 nm from shore). The survey covered all of Sub-areas I, II, III and IV. The second offshore survey covered a wider area, from 12 nm offshore to the offshore limits of the territorial boundary. However, for the purpose of this analysis, only offshore survey data from Sub-areas I and II were used. The stations for both surveys were selected using stratified random sampling. Each sub-area was divided into three depth strata; Stratum 1 was 18 to 55 m (10 - 30 fathoms), Stratum 2 was 56 to 91 m (> 30 - 50 fathoms), and Stratum 3 was 92 to 185 m (> 50 - 100 fathoms). Within each depth stratum, trawl stations were randomly selected so that in each grid of 15 x 15 nm, one fishing station was covered. Fishing operations were conducted during daytime and were one hour in duration. Towing speed was fixed at 3.5 knots in 1987 and 4.0 knots during the second survey.

Details of the total area covered by each trawl survey and the distribution of sampling stations by sub-area are given in Table 2(a). The distribution of sampling stations for the surveys is shown in Appendix C.

East coast of Peninsular Malaysia

Four coastal and two offshore surveys were selected for analysis, covering the area from the Thai-Malaysian border in the north to the Malaysian-Singapore border in the south. The area covered by these surveys extended from 12 nm from the shore up to the 200 nm EEZ, 10 to 90 m water depth. The coastal surveys were conducted in 1967, 1972, 1981 and 1991, the offshore surveys in 1986 and 1998. Sampling stations were selected using the stratified random technique. Each Sub-area had only two depth strata, i.e. 18 to 55 m and 56 to 91 m. Survey procedures were similar to those used off the west coast.

Table 2(b) gives details of the area covered by the surveys and the distribution of sampling stations by sub-area. The distribution of the sampling stations for the surveys is shown in Appendix D.

Sarawak

The three coastal surveys selected for this study were those conducted in 1972, 1981 and 1989/92/93. These surveys covered the area from the shoreline of Sarawak up to 80 nm from the coast. The survey in 1989/92/93 was done in three stages. The first stage carried out in 1989 covered Sub-area I, the second stage in 1992 covered Sub-area II, and the final stage in 1993 covered Sub-area III. The sampling stations were selected using a systematic random technique and were located in areas with depths of 10 to 60 m. The trawling speed was 2.8 knots for the 1972 and 1981 surveys and 3.5 knots for the 1989/92/93 survey. All fishing operations were done during daylight with trawl durations of one hour. The offshore surveys were conducted in 1986 and 1998. Both covered the same area, from the territorial limit (roughly between 12 to 25 nm offshore) up to the 185 m (100 fathom) depth contour.

The total area covered by each survey and the distribution of the sampling stations by sub-area are given in Table 2(c). The distribution of sampling stations for the surveys is shown in Appendix E.

West Coast of Sabah

The 1972 coastal survey was selected for analysis. The survey covered coastal waters up to 50 m deep and stations were determined using the systematic random technique. Trawling speed was 2.8 knots over the standard one hour towing duration and all fishing operations were done during daylight. The offshore surveys were conducted in 1986, 1993 and in 1998. All three surveys covered the same area, 12 nm offshore up to the 185 m depth contour. Trawling speed was 3.5 knots during the 1987 and 1993 survey and 4.0 knots during the 1998 survey.

The total area covered by the surveys and the distribution of sampling stations by Sub-area are given in Table 2(d) and illustrated in Appendix F.

Table 2. Total survey area and number of sampling stations during the coastal and offshore surveys off the (a) west coast of Peninsular Malaysia, (b) East coast of Peninsular Malaysia, (c) Sarawak and (d) west coast of Sabah. The Sub-areas are shown in Figs. 1 and 2.

(a) West coast of Peninsular Malaysia: total survey area is the area between 5 nm from the shoreline to the offshore limit of the territorial waters.

Survey Area	Survey Strata	Area (km²)	Stations (No.)				
			Dec. 1971	Oct. 1981	Jan. 1987	Jan. 1991	Sept. 1997
Sub-area I	I.1 (5nm - 55m)	6 187	46	41	2	25	4
	I.2 (56 - 91m)	6 252	–	–	10	11	8
	I.3 (92 - 185m)	3 853	–	–	10	–	4
	TOTAL	16 292	46	41	22	36	16
Sub-area II	II.1 (18 - 55m)	5 508	51	36	–	18	4
	II.2 (56 - 91m)	10 449	–	–	18	4	14
	TOTAL	15 957	51	36	18	22	18
Total survey area		32 249	97	77	40	58	34

(b) East coast of Peninsular Malaysia: total survey area is the area between 5 nm from the shoreline to the limit of the EEZ.

Survey Area	Survey Strata	Area (km²)	Stations (No.)					
			March 1967	Aug. 1972*	June 1981	Oct. 1986*	Aug. 1991*	Apr. 1998
Sub-area I	I.1 (5nm - 55m)	19 832	29	48	22	24	26	22
	I.2 (56m - EEZ)	10 100	–	–	–	10	–	13
	TOTAL	29 932	29	48	22	34	26	35
Sub-area II	II.1 (5nm - 55m)	9 243	48	24	16	–	25	1
	II.2 (56m - EEZ)	52 857	–	–	–	65	–	61
	TOTAL	62 100	48	24	16	65	25	62
Sub-area III	III.1 (5nm - 55m)	10 312	45	35	21	2	8	3
	III.2 (56m - EEZ)	7 408	–	–	–	9	–	10
	TOTAL	17 720	45	35	21	11	8	13
Sub-area IV	IV.1 (5nm - 55m)	10 503	28	37	19	–	3	4
	IV.2 (56m - EEZ)	3 104	–	–	–	4	–	4
	TOTAL	13 607	28	37	19	4	3	8
Total survey area		123 359	150	144	78	114	62	118

Note: * Pre-Northeast Monsoon.

(c) Sarawak: total survey area is the area between the shoreline to the 185 m isobath.

Survey Area	Survey Strata	Area (km²)	Stations (No.)						
			April 1972	May 1981	April 1986	Aug. 1989*	April 1992	March 1993	Sept. 1998*
Sub-area I	I.1 (0 - 55m)	22 467	56	51	14	30	–	–	11
	I.2 (56 - 91m)	10 166	13	–	13	13	–	–	13
	I.3 (92 - 185m)	892	–	–	1	–	–	–	1
	TOTAL	33 525	69	51	28	43	–	–	25
Sub-area II	II.1 (0 - 55m)	21 030	54	39	18	–	11	–	16
	II.2 (56 - 91m)	16 417	–	–	21	–	18	–	20
	II.3 (92 - 185m)	22 909	–	–	28	–	–	–	30
	TOTAL	60 356	54	39	67	-	29	-	66
**Sub-area III	III.1 (0 - 55m)	11 242	47	30	3	-	-	3	6
	III.2 (56 - 91m)	11 765	7	-	15	-	-	13	11
	III.3 (92 - 185m)	15 556	-	-	16	-	-	-	19
	TOTAL	38 563	54	30	34	-	-	16	36
Total survey area		132 444	177	120	129	43	29	16	127

Note: * Pre-Northeast Monsoon.
**** Inclusive of southern portion of Sub-area IV which is off the coast of Sarawak.**

(d) West coast of Sabah: total survey area is area between the shoreline to the185 m isobath.

Survey Area	Survey Strata	Area (sq. km²)	Stations (No.)			
			April 1972	April 1986	May 1993	Oct. 1998*
**Sub-area V	V.1 (0 - 55m)	11 558	36	2	4	4
	V.2 (56 - 91m)	2 881	–	4	6	6
	V.3 (92 - 185m)	1 872	–	3	1	1
	TOTAL	16 311	36	9	11	11
Sub-area VI	VI.1 (0 - 55m)	8 652	59	2	13	13
	VI.2 (56 - 91m)	3 642	–	4	7	7
	VI.3 (92 - 185m)	2 334	–	2	3	3
	TOTAL	14 628.76	59	8	23	23
Total survey area		30 939	95	17	34	34

Note: * Pre-Northeast Monsoon.
**** Inclusive of northern portion of Sub-area IV which is off the coast of Sabah.**

On Board Catch Sampling Procedure

Once the catch was landed on board, large-sized fish as well as dangerous and poisonous species were separated for later identification and recording. Poisonous but non-commercial specimens were counted and disposed. The remaining portion of the catch was evenly distributed into boxes with a 50 kg capacity, to estimate the weight of the catch. One out of every five boxes (20% of the catch) was selected as a sub-sample for further sorting. If the total catch per haul was less than 100 kg, the whole catch was sampled. All sub-samples were grossed-up to estimate the total catch per haul.

In the sub-sample, genuine trash species (i.e. non-commercial species) were sorted, weighed, counted and later discarded. All commercial species, irrespective of size, were weighed and individual lengths measured on board or placed in labeled plastic bags for further work in the laboratory. Length measurements (dorsal extreme length) by 0.5 cm class (except for some larger species where 1.0 cm intervals were used) were recorded by station for dominant species. For fishes with filaments on their caudal fins, the total length was measured from the tip of the snout to the tip of the caudal lobe without the filament.

Catch-per-unit Effort by Area and Year

Data from coastal and offshore surveys were grouped together by Sub-area and depth stratum. The shallowest depth stratum, covering the area 5 nm from the coast up to 55 m depth, is mostly investigated during coastal surveys. Offshore surveys normally cover areas in depth stratum 2 (56 to 91 m) and 3 (92 to 185 m). However, a few stations during some of the offshore surveys were located in depth stratum 1. To investigate trends in mean catch rate over the study period, the cod-end mesh size was also standardized. The standard cod-end mesh size used for the west and east coast of Peninsular Malaysia was 40 mm, while that for Sarawak and the west coast of Sabah was 38 mm.

Stock Density and Biomass Estimates

The swept area method was used to estimate demersal stock density (D) and biomass (B) using the NAN-SIS software (Strömme, 1992). The equations used for the calculation were:

$$D = (C/f) / (a \cdot x_1)$$
$$B = ((C/f) \cdot A) / (a \cdot x_1)$$
$$a = t \cdot v \cdot h \cdot x_2$$

where

- C/f = catch-per-unit effort or CPUE ($kg \cdot hr^{-1}$)
- A = total survey area
- a = area swept by the trawl in time t
- x_1 = proportion of fish in path of the gear that escapes from the net (0.5 in Southeast Asian waters)
- t = time spent trawling
- v = trawling speed
- h = length of head-rope
- x_2 = effective head-rope length (0.5 in Southeast Asian waters).

Pelagic fish species were excluded from the calculations because (1) their pelagic nature affects their availability to the demersal trawl, and (2) they tend to show schooling behavior and thus are not uniformly distributed.

Length Frequency Data Analysis

Length frequency data for selected species and surveys were analyzed using FiSAT (FAO-ICLARM Stock Assessment Tools) (Gayanilo et al. 1996) to estimate growth parameters, mortalities and exploitation rates. Length frequency data from surveys conducted in 1997 off the west coast of Peninsular Malaysia and in 1998 off the east coast of Peninsular Malaysia, Sarawak and west coast of Sabah were used to estimate growth and mortality parameters. For the west coast of Peninsular Malaysia and Sabah where the surveys were completed within one month, the data were grouped as a single length-frequency distribution for that month. This was then repeated as sample data for the same month in the following year, making two months of sample data over two years for analysis using the FiSAT software. The length-frequency data collected during the 1998 survey off the east coast of Peninsular Malaysia and Sarawak were plotted as a time series over three months. These were then repeated for the following year and the set used as input for FiSAT analysis. The value of L_∞ (estimated from the Powell-Wetherall plot was used as an input to the ELEFAN I program. The seasonal oscillation level (C) and minimum growth period or winter period (WP) were not considered in the analyses. Similarly, no attempt was made to estimate the value of t_0 (the age of fish at zero length).

Using the growth parameters (L_∞ and K) obtained from the above procedure, total mortality (Z) was estimated using length-converted catch curves.

The Z estimation is based on pooling of percent samples from all or part of the length frequency data. The aim here is to simulate a steady-state population. Selection of points included in the estimation of Z were made by taking the points to the right of the highest point in the catch curve.

The estimate of Z was split into its fishing mortality (F) and natural mortality (M) components. The estimate of M for each species was calculated using Pauly's equation (Pauly 1980; Pauly 1984a; Pauly 1984b)

$$\log_{10} M = - 0.0066 - 0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.463 \log_{10} T$$

Where T is the mean habitat temperature (°C) of the fish (Pauly 1983). The mean (surface) temperature used in this study was 27.9° C for waters off the west coast of Peninsular Malaysia and 29.0° C for waters off the east coast of Peninsular Malaysia, Sarawak and West Sabah. Subtracting the estimate of M from Z gives an estimate of fishing mortality F. The exploitation rate (E) for each species was estimated by dividing F with Z.

The parameters a and b of the length-weight relationship (of the form $W = aL^b$) were estimated through base-10 logarithmic transformation of the length-weight data pairs and ordinary least-squares linear regression (Sparre and Venema 1992; Sparre et al. 1989). The goodness of fit index was determined using the correlation coefficient.

Analysis of Demersal Yield and Effort

The fishery catch data for demersal fishes (including trash fish and cephalopods) from 1971 to 1996 for the west and east coast of Peninsular Malaysia and from 1969 to 1996 for Sarawak (as compiled by the Department of Fisheries) were used in the analyses. In the case of Sabah, the annual Fisheries Statistics provide catches of demersal fishes by type of gear aggregated for the whole state. Analysis for Sabah was not possible as the research surveys were only conducted off the west coast.

The CPUE of research vessels used during surveys off the west and east coast of Peninsular Malaysia were standardized into the CPUE of KK Jenahak. The CPUE of KK Manchong was used as standard for surveys done in Sarawak. The size of the trawl head-rope and towing speed were two factors considered in converting the CPUE of other research vessels into CPUE of the standard vessel. The annual fishing effort was calculated based on the linear change of CPUE for the selected surveys by area. A weighted running average was used for approximating equilibrium fishing effort. The following formula was used:

$$f_{wt} = \frac{Kf_t + (K-1)f_{t-1} + (K-2)f_{t-2}}{K + (K-1) + (K-2)}$$

where f_{wt} = weighted average effort in year t,
f_t = actual effort in year t,
K = number of years (3) included in weighted average calculation.

The maximum sustainable yield (MSY) and F_{MSY} for demersal fishes (including trash fish and cephalopods) was estimated by fitting the time series data of annual catch (Y) and annual fishing effort (f_{wt}) using the Fox model (Fox 1970). The model assumes that catch-per-unit effort (Y/f_{wt}) declines exponentially as the effort (f_{wt}) increases.

Results and Discussion

Catch-per-unit Effort by Area and Year

Mean catch rate by depth stratum and Sub-area for the four study areas is given in Appendix G and H, and key results are illustrated in Figs. 3 to 6. These indicate a general trend of decline in resource abundance across the four areas. Geometric means provide a better estimate of average catch rate from trawl surveys. These were the values used for the detailed area analyses below.

West coast of Peninsular Malaysia

There has been a prominent reduction in mean catch rate of demersal fish in depth stratum 1 since 1971 - 72, especially when only coastal surveys are compared. The offshore surveys in 1987 and 1997 do not show such a similar trend, due to the limited number of sampling hauls (Fig. 7).

Mean catch rate in the coastal area of Sub-area I was reduced from 74.5 kg•hr^{-1} in 1971 - 72 to only 22.7 kg•hr^{-1} in 1991 and further down to 18.6 kg•hr^{-1} in 1997 (Appendix H). This is a reduction of 75% over the period considered. The 101.8 kg•hr^{-1} recorded in 1987 cannot be accepted since this was derived from only two sampling stations. In Sub-area II, the mean catch rate of 67.2 kg•hr^{-1} in 1971 - 72 was reduced to 21.00 kg•hr^{-1} by 1991. The higher value recorded in 1997 at 29.1 kg•hr^{-1} is misleading due to the limited sampling stations. This indicates that during the period between 1991 - 72 and 1991, resource abundance was reduced by 69%.

Offshore areas deeper than 55 m have been surveyed three times since 1987. In Sub-area I, catch rate for the stratum with depths of 56 to 91 m was reduced from 116.7 kg•hr^{-1} in 1987 to 33.3 kg•hr^{-1} in 1997. This is a 72% reduction in catch rate over a ten-year period. The decline for the same depth stratum in Sub-area II was more drastic, from 184.8 kg•hr^{-1} in 1987 to 47.1 kg•hr^{-1} in 1991 and to 33.6 kg•hr^{-1} in 1997, or a reduction of 82%. However, for the deepest stratum (92 to 185 m), which only exists in Sub-area I, the reduction was only 24% over a period of ten years. This may indicate less fishing activities in this area.

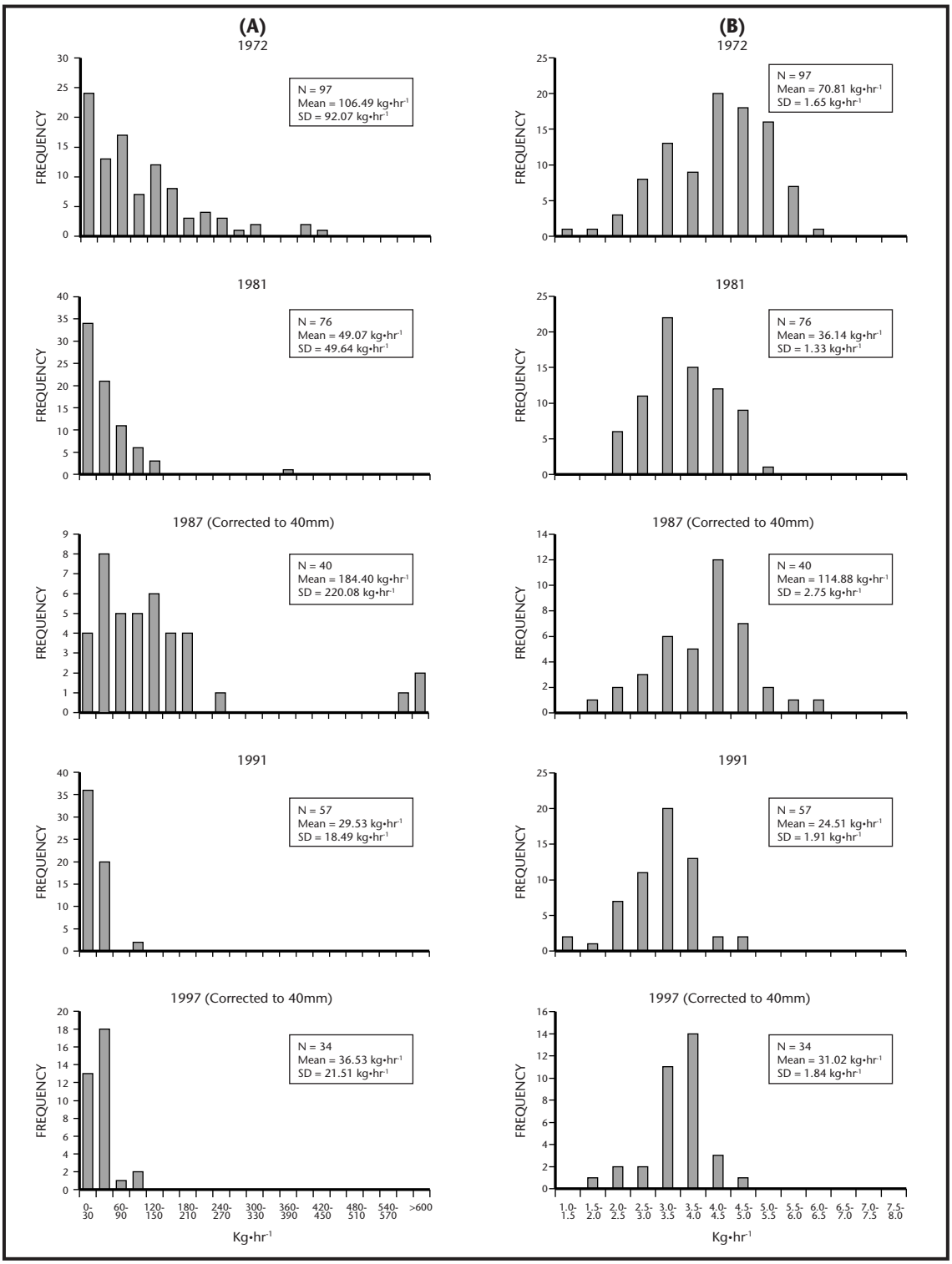

Fig. 3. Frequency distribution of CPUE (A) and log-transformed CPUE (B) from selected trawl surveys in Sub-area I and II off the west coast of Peninsular Malaysia from 1971 to 1997.

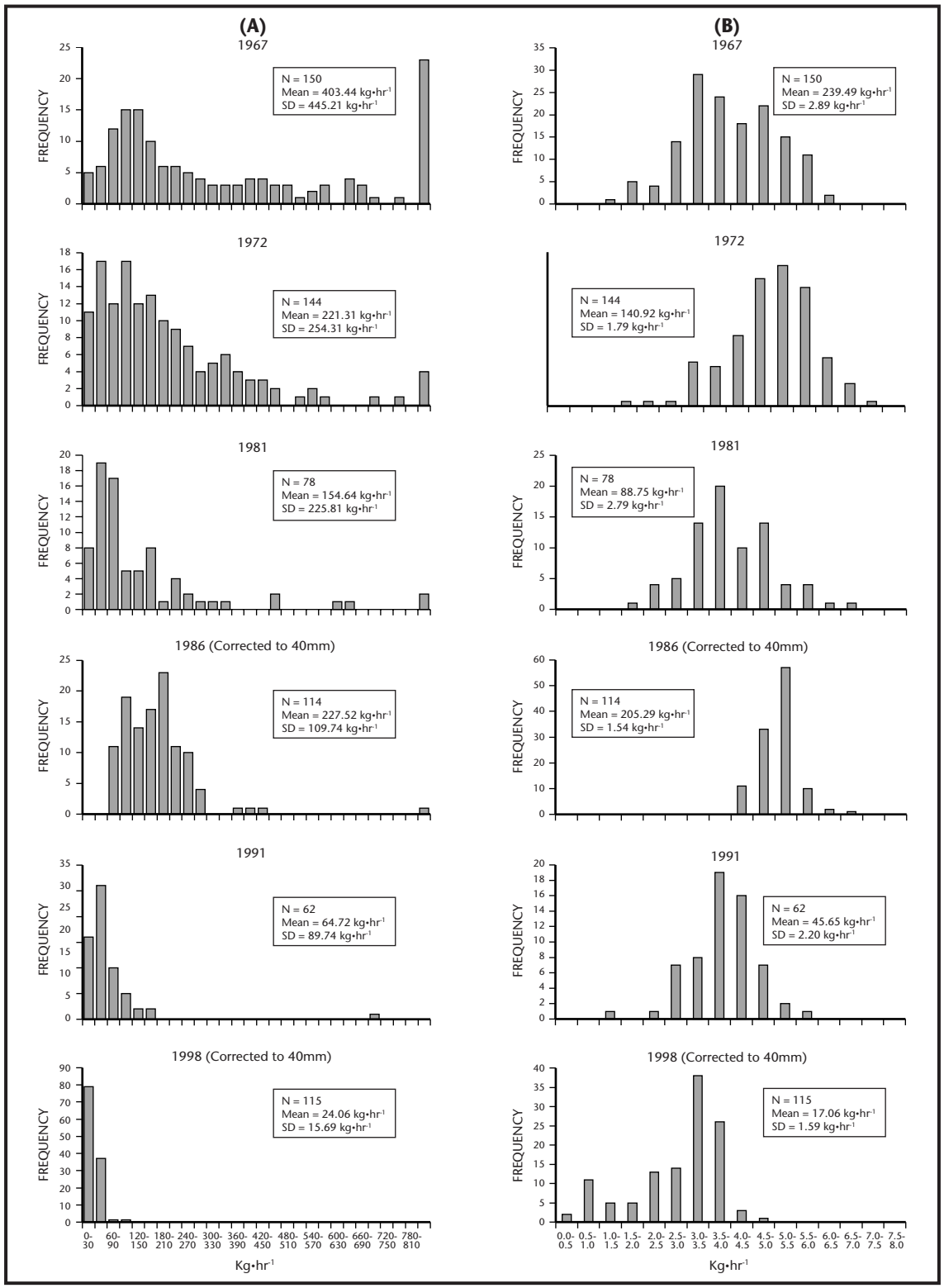

Fig. 4. Frequency distribution of CPUE (A) and log-transformed CPUE (B) from selected trawl surveys off the east coast of Peninsular Malaysia from 1967 to 1998.

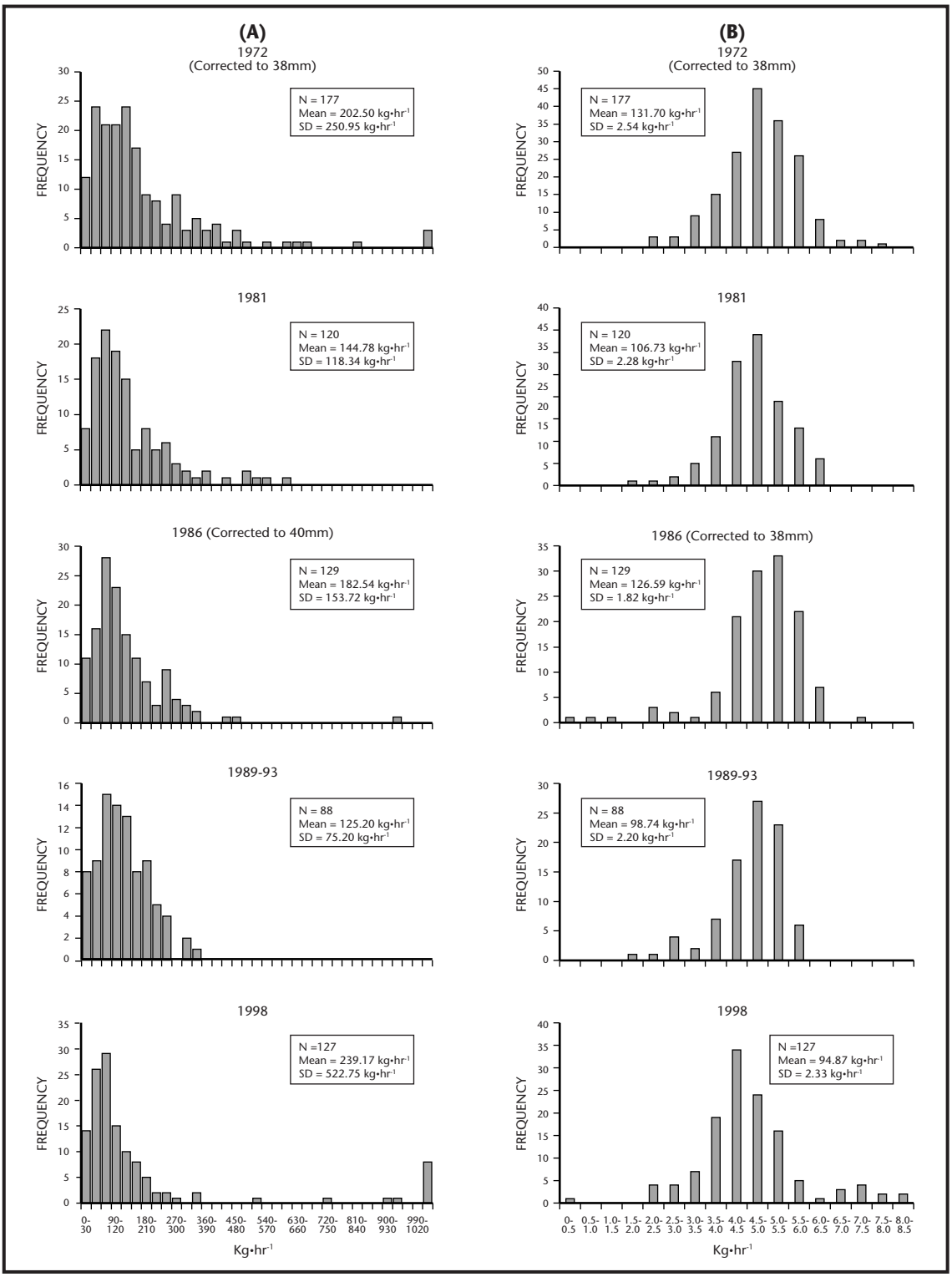

Fig. 5. Frequency distribution of CPUE (A) and log-transformed CPUE (B) from selected trawl surveys off the coast of Sarawak from 1972 to 1998.

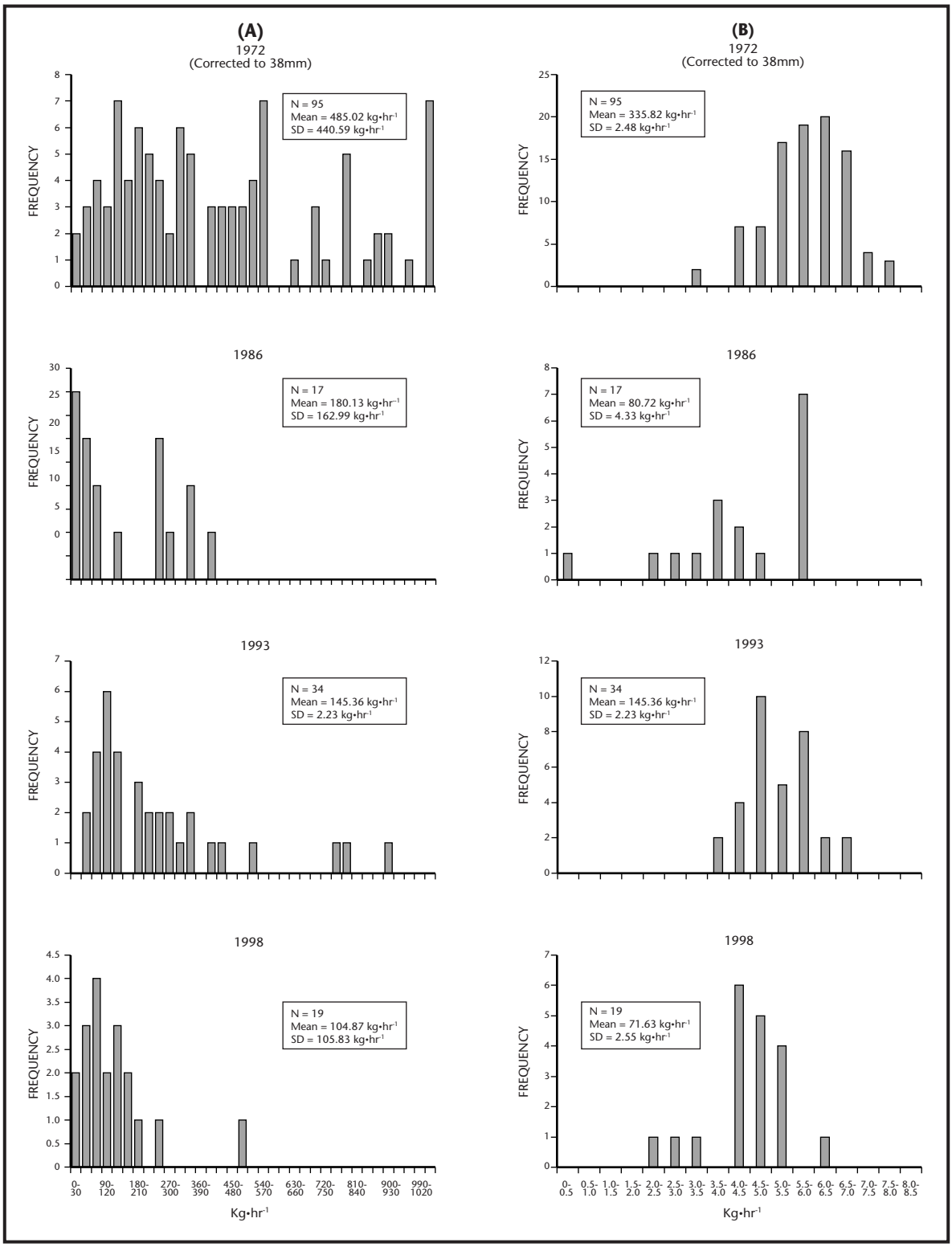

Fig. 6. Frequency distribution of CPUE (A) and log-transformed CPUE (B) from trawl surveys off the west coast of Sabah from 1972 to 1998.

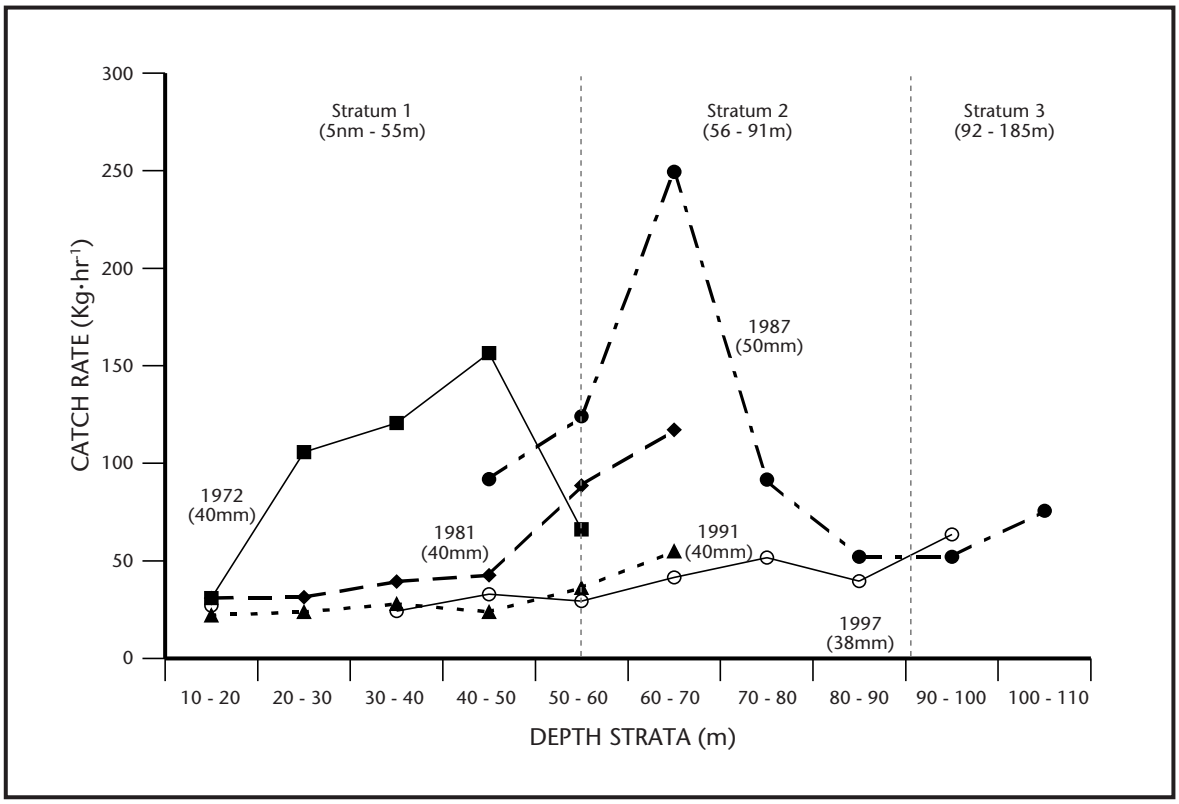

Fig. 7. Demersal fish abundance in (kg·hr^{-1}) by depth in Sub-area I and II off the west coast of Peninsular Malaysia during the trawl surveys from 1971 to 1997.

The coastal area of Sub-area I was more productive than those in Sub-area II. This is evident in all surveys except for the last survey in 1997. The most productive fishing grounds were located between Langkawi and Penang Island, as reported earlier by (Mohammed Shaari et al. 1974). The current catch rate in Sub-area I is lower than Sub-area II as the former has been, and currently is, heavily fished. The results reflect the high resource decline in both the areas. (Mohammed Shaari and Chai 1976) estimated a 30% reduction of the resource in Sub-area I and II by 1974. This is consistent with the sharp decline of abundance noted in the coastal area from results of the five surveys compared here (Figs. 3 and 7)

East coast of Peninsular Malaysia

Fig. 8 shows the catch rates (by 10 m depth interval) for the surveys included in the study. Overall, higher catch rates were recorded at depths of 20 to 40 min Stratum I. There is a continuous decline in catch rates over the survey period.

(Pathansali et al. 1974) noted the marked effect of the monsoons on abundance, distribution and species composition in this area. The surveys, therefore, were normally carried out during the interval between monsoons (August to October) to minimize such seasonal variability. However, surveys in 1967, 1981 and 1997 were conducted during the post-northeast monsoon period, while surveys in 1972, 1986 and 1991 were carried out during the pre-northeast monsoon period (Appendix H(b)).

The coastal area under depth stratum 1 (except for Sub-area II and IV) was covered during the six selected surveys. Sub-area II and IV was also not covered during the offshore survey in 1986. The offshore area in depth stratum 2 was only investigated during the offshore surveys in 1986 and 1997. Results of the analysis are therefore discussed by Sub-area rather than considering the whole area.

In Sub-area, I there was a clear decline of catch rate from 1967 to 1997 for the coastal area and from 1986 to 1997 for the offshore area. There are variations between high values recorded from pre-northeast monsoon surveys and low values from the post-northeast monsoon surveys. The reduction in catch rate for the coastal area (depth stratum 1) and offshore area (depth stratum 2) was 90% and 87%, respectively (Appendix H). The decline in catch rate was also observed for Sub-area II, Catch rate in 1997 was only 11% of that recorded in 1967. In Sub-area III, the catch rates fluctuated with no clear indication of monsoon effect. Both depth strata were heavily exploited with the 1997 catch rate only 5% of that in 1967. Sub-area IV is the poorest area in terms of demersal fish abundance. The decrease in catch rate in the coastal area was 96% over the 1967 - 97 period. Overexploitation has also taken place in the offshore area as evidenced by the sudden drop in catch rate from 266.6 $kg \cdot hr^{-1}$ in 1986 to only 7.7 $kg \cdot hr^{-1}$ in 1997.

Sarawak

Catch rate by 10-m depth interval is shown in Fig. 9. In the Sarawak area, on the whole the declining trend in catch rate was only evident in depth stratum 1. There was no clear trend in depth stratum 2 and in depth stratum 3 the catch rate obtained in 1998 was higher than in 1986. The high catch rate obtained in this depth stratum during 1998 was probably due to sampling in rough (coral and uneven) grounds where high concentrations of fish are normally found.

The three coastal surveys and the offshore survey in 1986 were all conducted during the post-northeast monsoon (Appendix H). The only pre-northeast monsoon survey was the one conducted in September 1998. During the offshore surveys in 1986 and 1998, all three depth strata in the 3 Sub-areas were covered even though they were done during different monsoon periods. The coastal surveys on the other hand covered only depth stratum 1 and 2 in the three sub-areas. Results indicate a reduction of catch rate in coastal areas (stratum 1) of Sub-area I, II and III of about 64%, 48% and 26%, respectively. For depth stratum 2 the reduction was 40% while an increase in catch rate was noted for depth stratum 3, particularly in Sub-area II and III.

West coast of Sabah

Catch rate by 10-m depth interval is shown in Fig. 10. Declining catch rate was pronounced in the coastal area during the 1972 - 98 period. In the deeper strata, no clear trend was observed. The high catch rate obtained in Stratum 3 in 1993 was probably due also to sampling in rough (coral and uneven) ground.

The first demersal fish survey in 1972 was confined to the coastal area. The 1986 and 1998 surveys were offshore surveys covering the area from the reef barrier, about 12 nm from the coastline. The survey in 1993 covered both the coastal and offshore grounds in the two Sub-areas. As in Sarawak, all surveys were carried out during the post-northeast monsoon season, except for the survey in 1998, which was done in October, or pre-monsoon. Drastic declines in catch rates were recorded in depth stratum I of both Sub-areas (Appendix H). Catch rates obtained in the most recent survey were only 12% and 18% of those obtained during the 1972 survey in Sub-areas V and VI respectively. However, catch rates in depth stratum 2 and 3 of Sub-area V were higher than those recorded during the first offshore survey in 1986. Mean catch rate in the offshore strata in Sub-area VI showed a slight decrease (Appendix H).

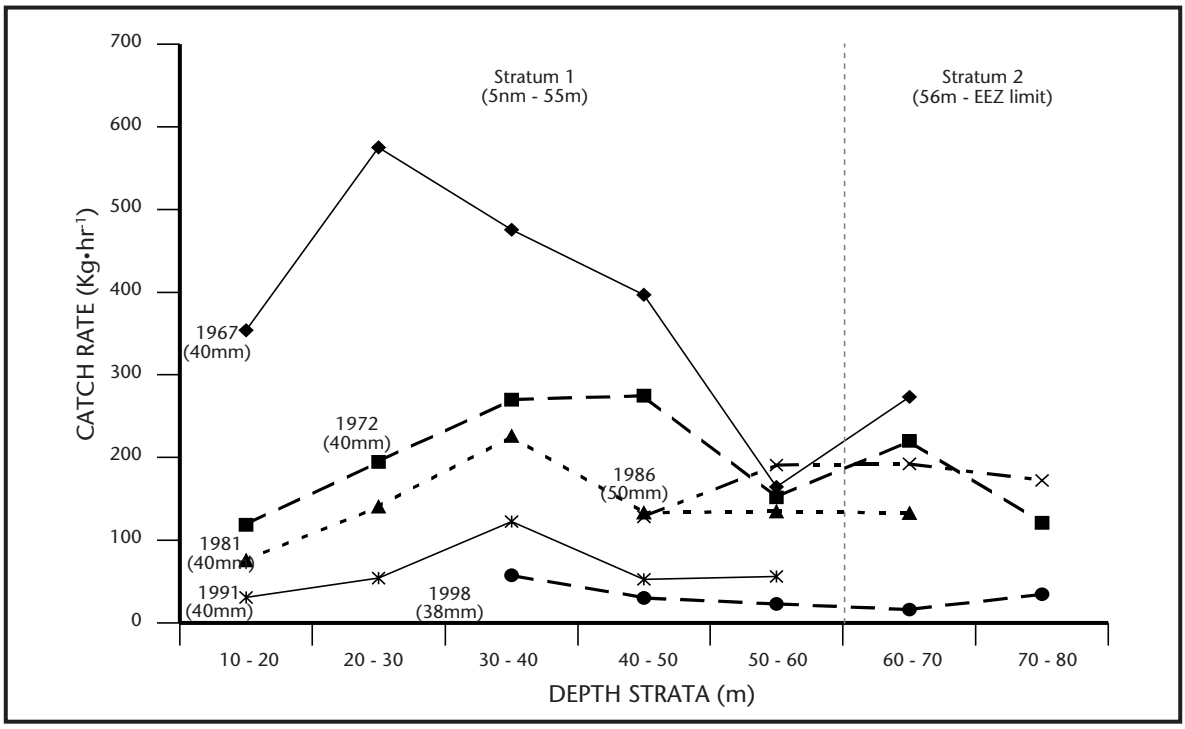

Fig. 8. Demersal fish abundance in (kg·hr^{-1}) depth strata off the east coast of Peninsular Malaysia during the trawl surveys from 1967 to 1998.

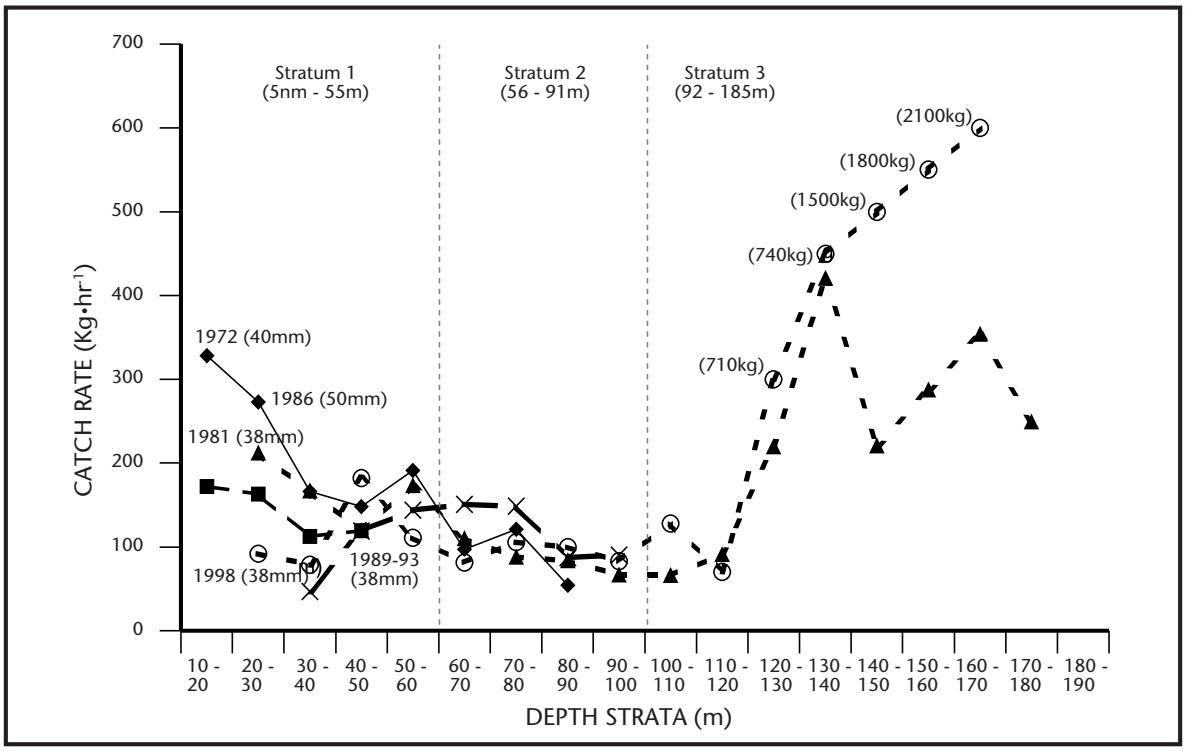

Fig. 9. Demersal fish abundance in (kg·hr^{-1}) by water depth off the coast of Sarawak during the trawl surveys from 1972 to 1998.

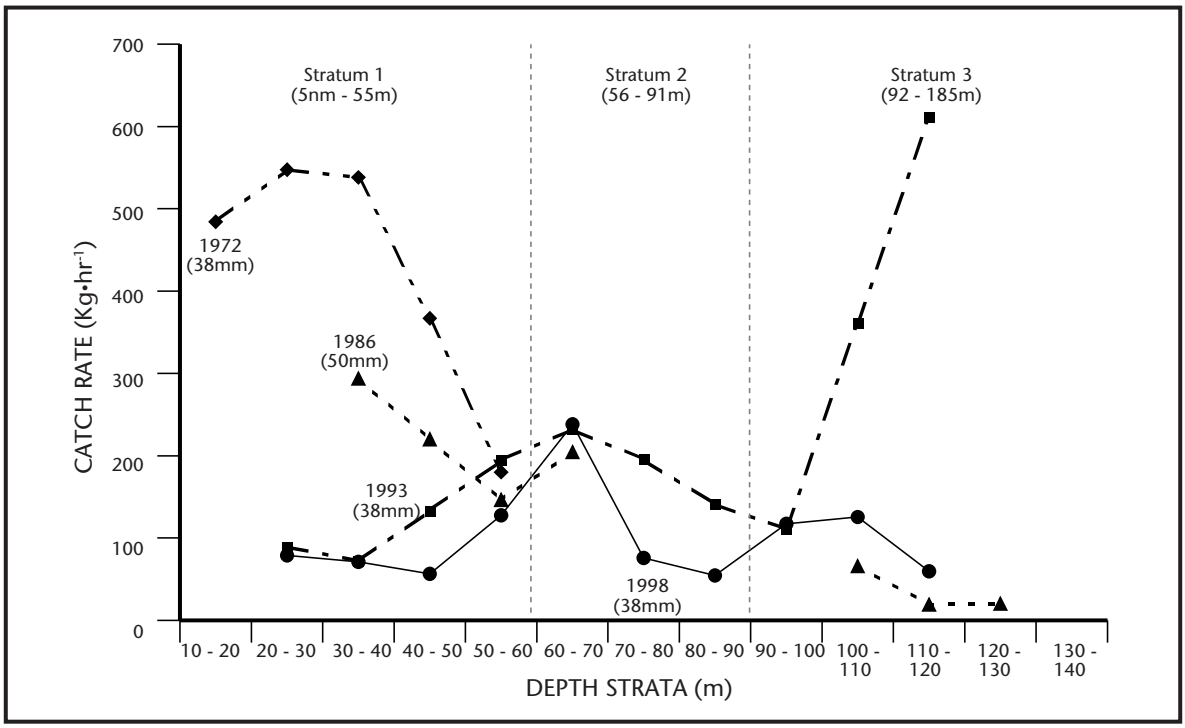

Fig. 10. Demersal fish abundance in (kg·hr^{-1}) by water depth off the west coast of Sabah during the trawl surveys from 1972 to 1998.

Stock Density and Biomass

West coast of Peninsular Malaysia

Appendix I details the estimates of stock density and biomass by depth stratum for Sub-area I and II off the west coast of Peninsular Malaysia. Changes over the study period are illustrated in Fig. 11. The 50% reduction level in density for the coastal area of Sub-area I and II was reached around 1981 - 82. In depth stratum 2, the 50% reduction in density and biomass for both Sub-areas occurred around 1993, only six years after introduction of deep-sea fishing.

Reduction in biomass of demersal fish can be very rapid especially in coastal areas. The estimated density in 1997 in the coastal area of Sub-area I and II was only 8% and 14%, respectively, of the value in 1971-72 (Mohammed Shaari et al. 1974). If the density of 3.59 t·km^{-2} for Southeast Asia given by (Tiews 1966) is taken as unexploited (or virgin) density, then the 1997 density of 0.35 t·km^{-2} for the study area represents only 9.8% of the virgin stock level. This indicates decimation of demersal fish resources in the area, compared to levels prescribed by surplus production models (Fox 1970; Schaefer 1954).

East coast of Peninsular Malaysia

Estimates of stock density and biomass are detailed in Appendix J and illustrated in Fig. 12. The density of demersal fish in 1998 showed a decline of more than 95% in coastal waters of all four Sub-areas. The same degree of reduction was observed in offshore areas of Sub-area III and IV. Stock density declined by 83% and 91% over the 1986 - 98 period in the offshore areas of Sub-areas I and II, respectively. If the density of 3.59 t·km^{-2} for Southeast Asia given by (Tiews 1966) is taken as unexploited density, the 1998 estimate for the whole study area of 0.20 t·km^{-2} represents only 6% of the virgin stock level. The east coast of Peninsular Malaysia shows greater exploitation and resource decline than the west coast.

Sarawak

Estimates of density and biomass by depth stratum for the three Sub-areas are given in Appendix K and illustrated in Fig. 13. Reduction in demersal stock density was observed in coastal waters of all three Sub-areas. Stock density was either gradually decreasing or increasing in the offshore areas.

West coast of Sabah

A substantive reduction in density and biomass was observed in coastal waters of Sub-area V and VI (Appendix L and Fig. 14). The 1998 densities in offshore areas are higher than estimated values from the first offshore survey in 1986, but this maybe an artifact of the limited number of stations and high catch rate variability typical of trawl surveys.

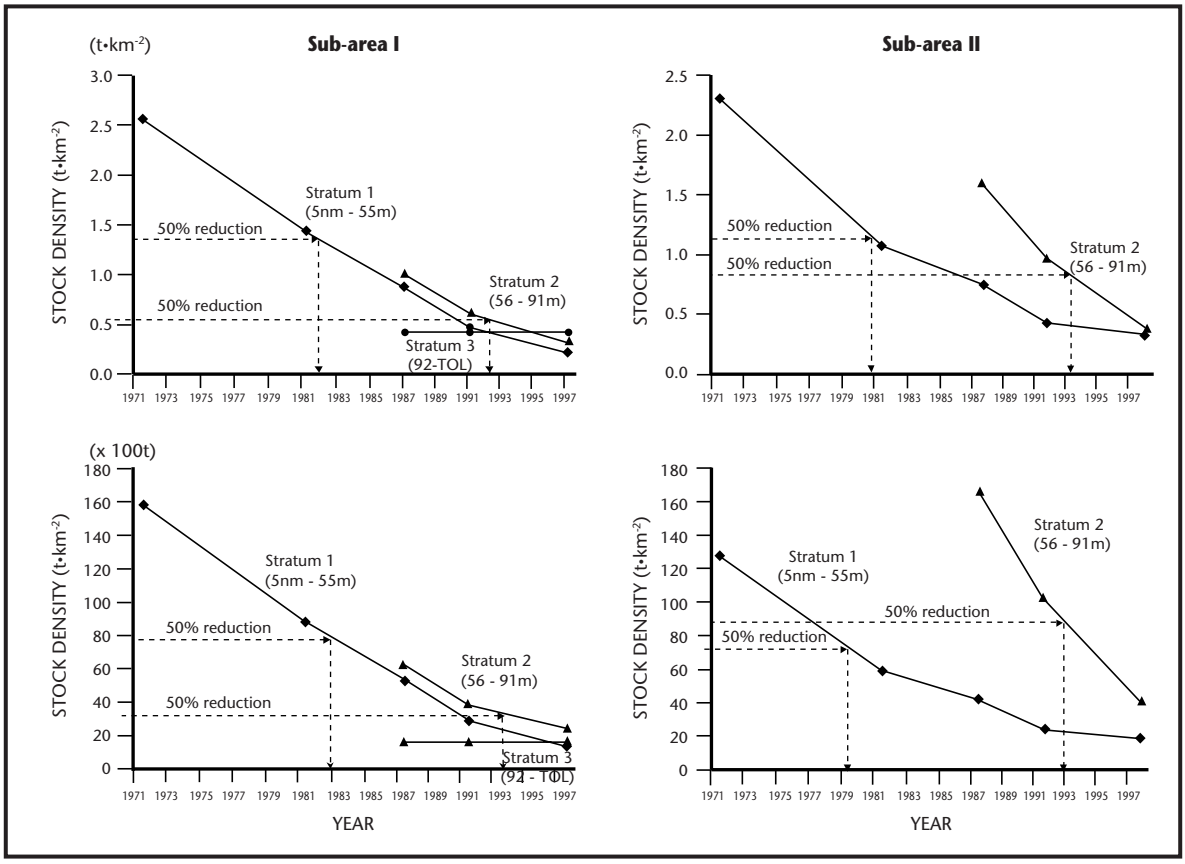

Fig. 11. Estimates of stock density (t·km^{-2}) and biomass (t) of demersal fish in Sub-area I and II off the west coast of Peninsular Malaysia obtained from surveys conducted from 1971 to 1997.

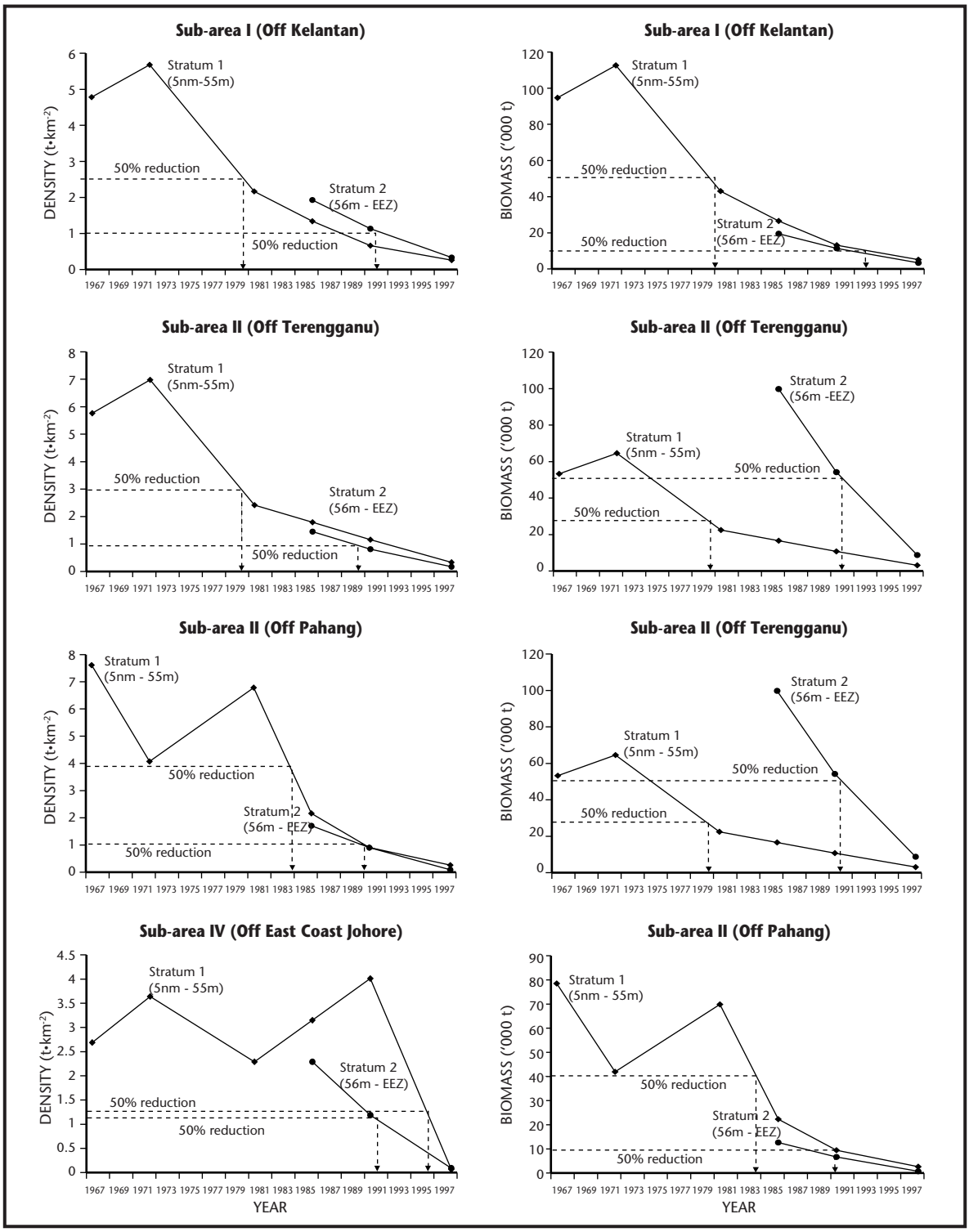

Fig. 12. Estimates of stock density (t·km^{-2}) and biomass (t) of demersal fish off the east coast of Peninsular Malaysia obtained from surveys conducted from 1967 to 1998.

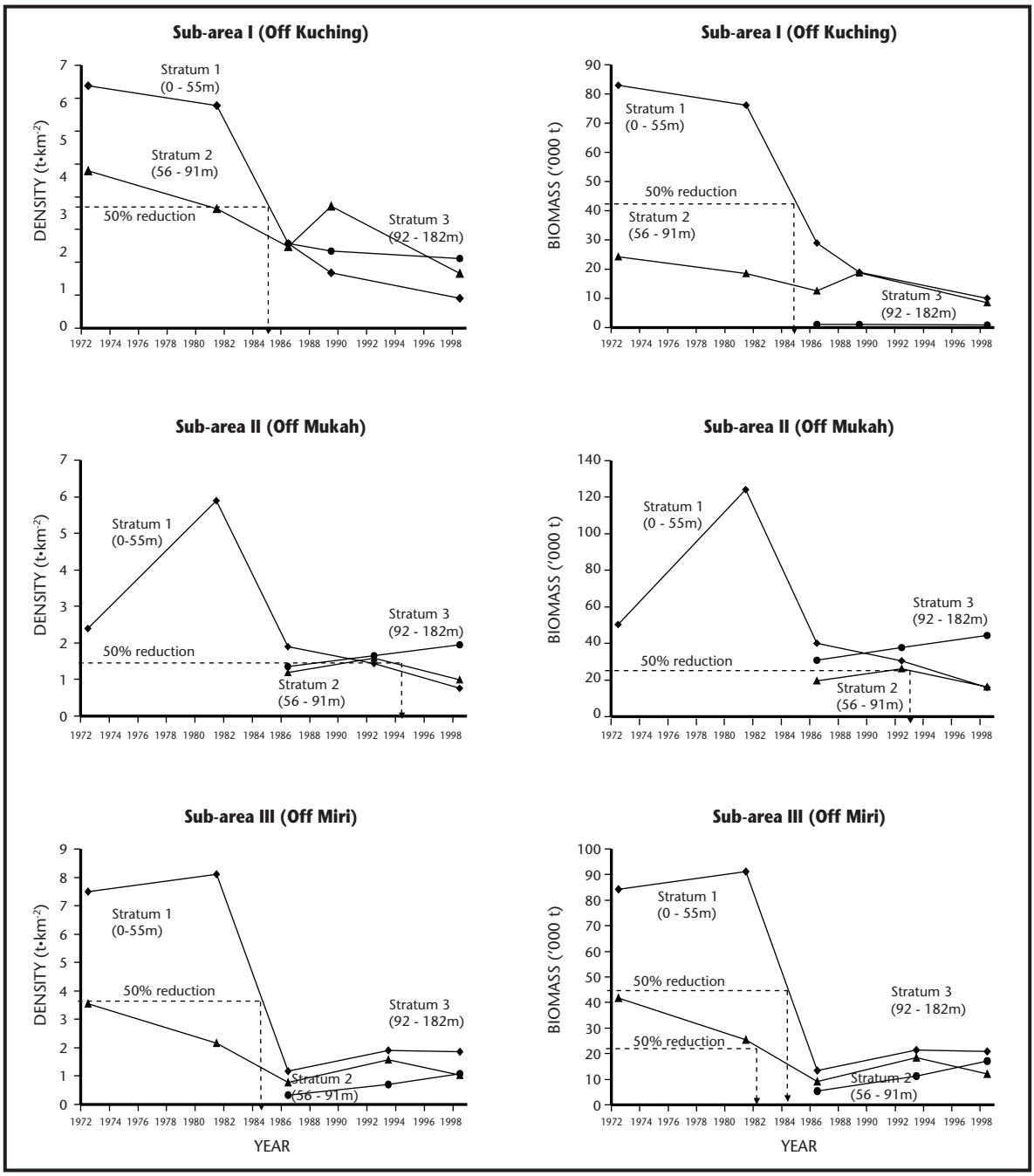

Fig. 13. Estimates of stock density (t·km^{-2}) and biomass (t) of demersal fish off the coast of Sarawak obtained from surveys conducted from 1972 to 1998.

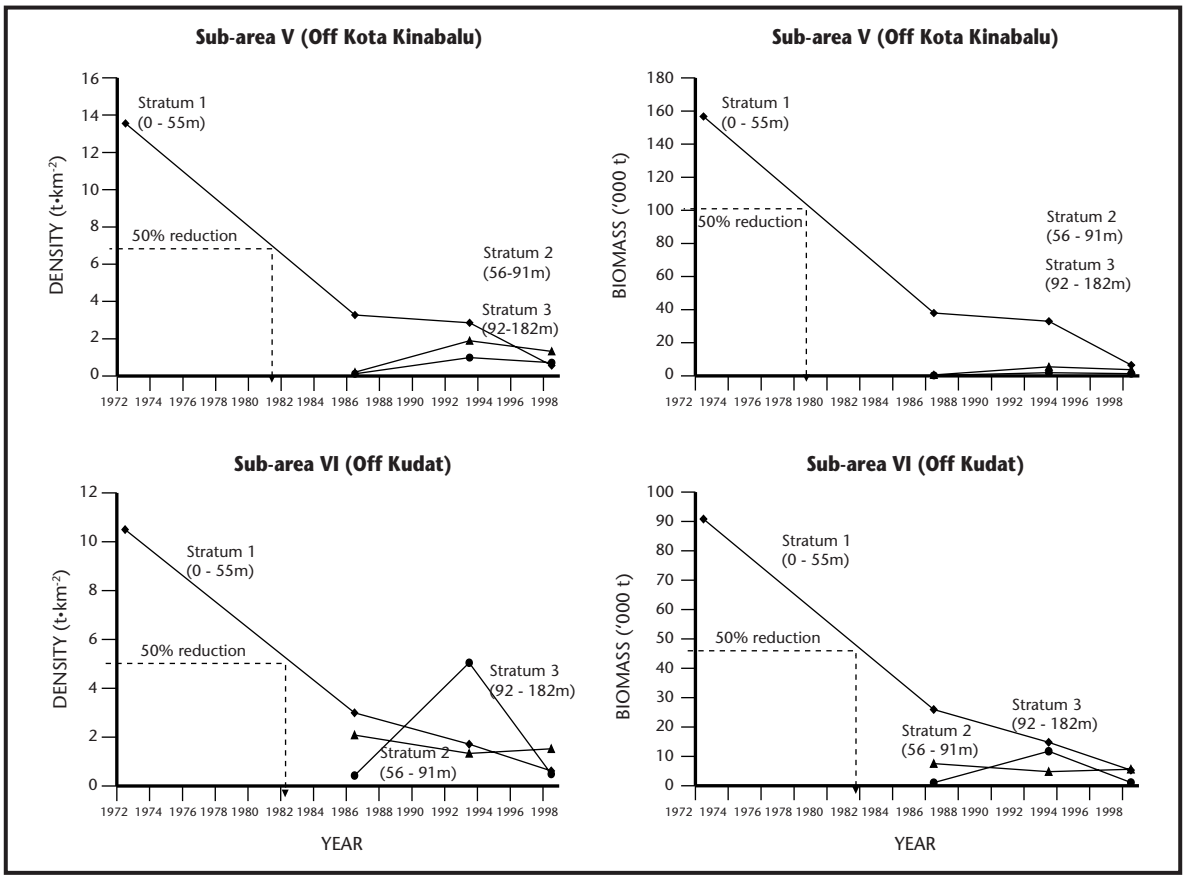

Fig. 14. Estimates of stock density (t·km^{-2}) and biomass (t) of demersal fish off the west coast of Sabah obtained from surveys conducted from 1972 to 1998.

Growth and Mortality Parameters

West coast of Peninsular Malaysia

Estimates of growth parameters (L_∞ and K) obtained using the FiSAT software for all 15 demersal fishes and three cephalopods are given in Table 3. These species represent 48% of demersal abundance in the area. The M/K values for most species are between 1.5 and 2.5, which are acceptable values for most tropical species (Beverton and Holt 1959). The only exception is *Upeneus luzonius* with an M/K value of 2.64.

The mortality rates (Z, M and F) for the 18 species are also given in Table 3. The fishing mortality rate (F) ranges from 0.59 to 7.16. The F value for 13 species were higher than 1.50. Only five species exhibit F below 1.50 : *Nemipterus delagoae (N. bipunctatus*), Saurida tumbil, Siganus oramin (S. canaliculatus*), Upeneus luzonius and Loligo sighalensis*. These species, except *Saurida tumbil*, are rarely seen in the market.

The exploitation ratio (E) for the species varies from 0.27 *(Nemipterus delagoae)* to 0.77 *(Upeneus sulphureus)*. Only 2 of the 18 species have E values below 0.40. Fig. 15 shows the distribution of the E values. The mean E for all the species (including cephalopods) was 0.62 and the weighted mean E was also 0.62. The high exploitation ratios are indicative of the heavy fishing pressure off the west coast Peninsular Malaysia.

* Valid name in FishBase

East coast of Peninsular Malaysia

Estimates of growth, mortality and exploitation parameters for 31 species caught off the east coast of Peninsular Malaysia are given in Table 4. These species constitute 33% of the total catch during the survey. Fishing mortality (F) ranges from 0.81 in *Pentaprion longimanus* to 6.0 in *Sphyraena obfusafa*. The F estimates for 17 demersals and four cephalopods were greater than 1.50 The exploitation ratio varies from 0.34 (Brachypleura novaezeelandiae) to 0.82 (Priacanthus macracanthus) The mean E for all species (including cephalopod) was estimated at 0.57 and the weighted mean E value was slightly higher at 0.59 (Fig. 16). These high E values indicate heavy fishing pressure (and overfishing) on the demersal resources off the east coast of Peninsular Malaysia.

Sarawak

Estimates of growth, mortality and exploitation parameters for 28 species caught off Sarawak are presented in Table 5. The 26 demersal fish and 2 cephalopod species represent 76% of the total catch during the survey. Values of M/K for the species are within the normal range of 1.5 to 2.5, except for 3 fish species *(Lutjanus linoelatus, Thamnaconus hypargyneus* and *Upeneus taeniopterus)*. Fishing mortality varies from 0.12 (*Nemipterus nemurus*) to 6.63 *(Carangoides malabaricus)*. Fishing mortality for 18 demersal fishes (69% of the total) was higher than 1.50.

The exploitation ratios range from 0.10 in *Nemipterus nemurus* to 0.82 in *Carangoides malabaricus* and *Pentaprion longimanus*. Only two species *(Nemipterus nemurus* and *Priacanthus tayenus)* have E less than 0.40 but thirteen have E values beyond 0.50. The mean E for all species (including cephalopods) was 0.60 and the weighted mean E was slightly higher at 0.61 (Fig. 17). These E values indicate very heavy fishing pressure on most species comprising the bulk of demersal resources off Sarawak.

West coast of Sabah

The parameter estimates for 10 demersal and 1 cephalopod species are summarized in Table 6. These species comprise 58% of the total catch obtained during the survey. The M/K values for all species are within the range of 1.5 to 2.5. Nine of the 11 species have F greater than 1.50. The exploitation ratio varies from 0.44 *(Saurida tumbil)* to 0.76 *(Upeneus bensasi)*. The mean E for all species (including cephalopods) is 0.60 and the weighted mean E is also 0.60 (Fig. 18).

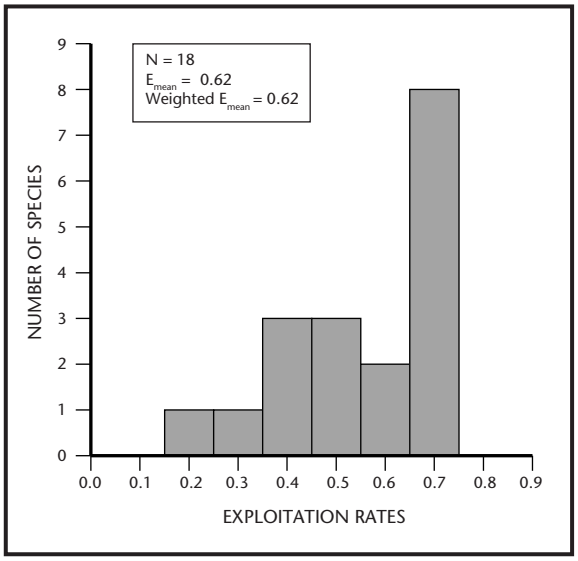

Fig. 15. Distribution of exploitation ratio (E) of 18 demersal species obtained during the 1997 survey off the west coast of Peninsular Malaysia.

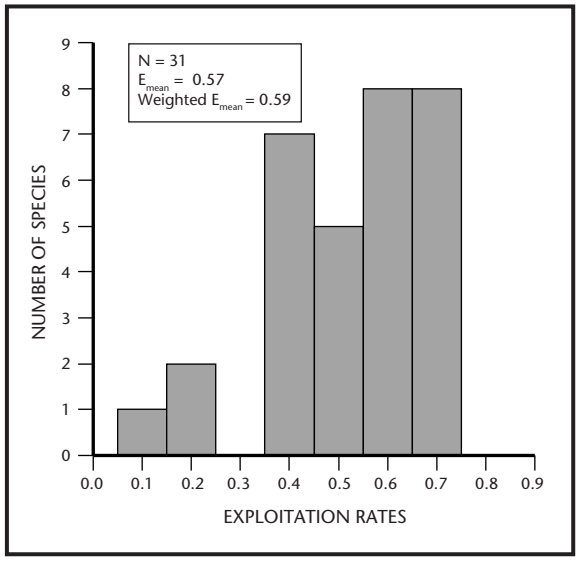

Fig. 16. Distribution of exploitation ratio (E) of 31 demersal species obtained during the 1998 survey off the east coast of Peninsular Malaysia.

Table 3. Growth, mortality and exploitation parameters of demersal species estimated using the 1997 survey data obtained off the west coast of Peninsular Malaysia. Terms are defined in the methods section.

Species	Sample size (n)	Growth parameters				Mortality parameters			M/K	Exploit Ratio (E = F/Z)
		$W = aL^b$		L_∞	K	Z	M	F		
		a	b	(cm)	(yr^{-1})	(yr^{-1})	(yr^{-1})	(yr^{-1})		
Demersal fish:										
Leiognathus splendens	124	0.028	2.73	19.0	0.85	7.16	1.87	5.29	2.20	0.74
*Nemipterus delagoae (N. bipunctatus)**	321	0.014	2.92	30.0	0.80	2.18	1.59	0.59	1.99	0.27
Nemipterus japonicus	1 061	0.029	2.73	34.8	0.85	3.76	1.58	2.18	1.86	0.58
Pennahia macropthalmus	552	0.010	3.12	30.0	1.30	7.76	2.18	5.58	1.68	0.72
Pentaprion longimanus	421	N/A	N/A	20.0	0.80	7.13	1.78	5.35	2.23	0.75
Priacanthus macracanthus	1 181	0.048	2.56	37.0	1.30	8.45	2.06	6.39	1.58	0.76
Priacanthus tayenus	1 930	0.027	2.72	23.0	0.55	3.85	1.34	2.51	2.44	0.65
Saurida longimanus	1 463	0.005	2.97	30.0	1.00	5.14	1.84	3.30	1.84	0.64
Saurida tumbil	863	0.002	3.34	46.0	1.30	3.40	1.93	1.47	1.48	0.43
Saurida undosquamis	4 956	0.004	3.15	34.0	1.20	4.25	2.00	2.25	1.67	0.53
Siganus oramin	257	N/A	N/A	23.0	0.60	2.60	1.42	1.18	2.37	0.45
Trichiurus lepturus	1 307	0.0002	3.26	70.0	0.85	2.94	1.30	1.64	1.53	0.56
*Upeneus bensasi (U. japonicus)**	1 073	0.008	3.14	25.0	0.55	5.40	1.31	4.09	2.38	0.76
Upeneus luzonius	255	N/A	N/A	19.0	0.50	2.22	1.32	0.90	2.64	0.41
Upeneus sulphureus	1 295	N/A	N/A	21.0	0.60	6.28	1.45	4.83	2.42	0.77
Cephalopods:										
Loligo chinensis	891	N/A	N/A	38.0	1.00	5.94	1.72	4.22	1.72	0.71
Loligo duvaucelli	3 419	N/A	N/A	23.0	1.30	9.51	2.35	7.16	1.81	0.75
Loligo sighalensis	1 755	N/A	N/A	42.0	1.40	3.00	2.08	0.92	1.49	0.31

Note: * Valid name in FishBase. N/A = Not available.

Table 4. Growth, mortality and exploitation parameters of demersal species estimated using the 1998 survey data obtained off the east coast of Peninsular Malaysia. Terms are defined in the methods section.

Species	Sample size (n)	Growth parameters				Mortality parameters			M/K	Exploit Ratio (E = F/Z)
		$W = aL^b$		L_∞	K	Z	M	F		
		a	b	(cm)	(yr^{-1})	(yr^{-1})	(yr^{-1})	(yr^{-1})		
Demersal fish:										
Brachypleura novaezeelandiae	1 714	0.001	2.96	21.9	0.71	2.43	1.61	0.82	2.27	0.34
Carangoides malabaricus	834	0.041	2.67	28.7	0.88	3.76	1.72	2.04	1.95	0.54
Lutjanus lineolatus (L. lutjanus)*	637	0.010	3.08	27.6	0.54	3.79	1.24	2.55	2.30	0.67
Nemipterus balinensoides	1 148	0.018	2.81	23.8	0.46	4.08	1.17	2.91	2.54	0.71
Nemipterus bathybius	156	0.025	2.77	29.4	0.41	3.04	1.03	2.01	2.51	0.66
Nemipterus marginatus	2 429	0.015	2.98	30.1	0.52	3.42	1.21	2.21	2.33	0.65
Nemipterus nematophorus	1 954	0.013	3.01	35.0	0.34	1.69	0.86	0.83	2.53	0.49
Nemipterus nemurus	1 690	0.012	3.03	31.5	0.71	3.17	1.45	1.72	2.04	0.54
Nemipterus peronii	647	N/A	N/A	34.1	0.60	2.67	1.25	1.42	2.08	0.47
Nemipterus tambuloides	1 472	0.017	2.87	33.0	0.61	2.48	1.30	1.18	2.13	0.48
Nemipterus thosaporni	4 917	0.015	2.95	34.0	0.36	2.18	0.91	1.27	2.53	0.58
Parupeneus pleurospilus (P. heptacanthus)*	527	0.011	3.08	35.2	0.92	3.18	1.64	1.54	1.78	0.48
Pentaprion longimanus	5 021	0.009	3.19	22.5	0.46	1.99	1.18	0.81	2.57	0.41
Priacanthus macracanthus	4 825	0.023	2.82	39.0	0.56	6.60	1.17	5.43	2.09	0.82
Priacanthus tayenus	1 529	0.033	2.66	31.4	0.78	2.46	1.55	0.91	1.99	0.37
Saurida longimanus	4 615	0.003	3.20	37.9	0.35	1.93	0.87	1.06	2.49	0.55
Saurida tumbil	1 390	0.002	3.36	62.6	0.80	2.62	1.54	1.08	1.93	0.79
Saurida undosquamis	5 263	0.006	3.05	40.5	0.98	5.05	1.67	3.38	1.70	0.67
Sphyraena jello	439	0.004	3.11	41.0	1.52	4.55	2.19	2.36	1.44	0.52
Sphyraena obtusata	581	0.007	2.87	54.6	0.96	7.52	1.52	6.00	1.58	0.80
Synodus hoshinonis	3 489	0.005	3.12	25.8	0.58	3.47	1.33	2.14	2.29	0.62
Trichiurus lepturus	564	0.001	3.08	109.0	0.78	2.71	1.08	1.63	1.38	0.60
Upeneus bensasi (U. japonicus)*	2 904	0.013	2.94	23.4	0.86	4.15	1.79	2.36	2.08	0.57
Upeneus moluccensis	235	0.012	3.01	39.5	0.32	3.60	0.81	2.79	2.53	0.77
Upeneus sulphureus	1 952	0.010	3.10	19.4	0.56	2.74	1.40	1.34	2.50	0.49
Xiphocheilus typus	549	N/A	N/A	17.8	0.76	4.98	1.75	3.23	2.30	0.65

Table 4. Growth, mortality and exploitation parameters of demersal species estimated using the 1998 survey data obtained off the east coast of Peninsular Malaysia. Terms are defined in the methods section. (continued)

Species	Sample size (n)	Growth parameters				Mortality parameters			M/K	Exploit Ratio (E = F/Z)
		$W = aL^b$		L_∞	K	Z	M	F		
		a	b	(cm)	(yr^{-1})	(yr^{-1})	(yr^{-1})	(yr^{-1})		
Cephalopods:										
Loligo chinensis	7 587	N/A	N/A	42.0	0.96	4.51	1.61	2.90	1.68	0.64
Loligo duvaucelli	500	N/A	N/A	23.2	0.85	4.68	1.75	2.93	2.06	0.59
Loligo singhalensis	3 819	N/A	N/A	23.2	0.80	5.06	1.69	3.37	2.11	0.67
Loligo tagoi	454	N/A	N/A	9.2	0.95	6.16	2.44	3.72	2.57	0.60
Sepia aculeate	104	N/A	N/A	17.0	0.45	2.13	1.25	0.88	2.78	0.41

Note: * Valid name in FishBase. N/A = Not available.

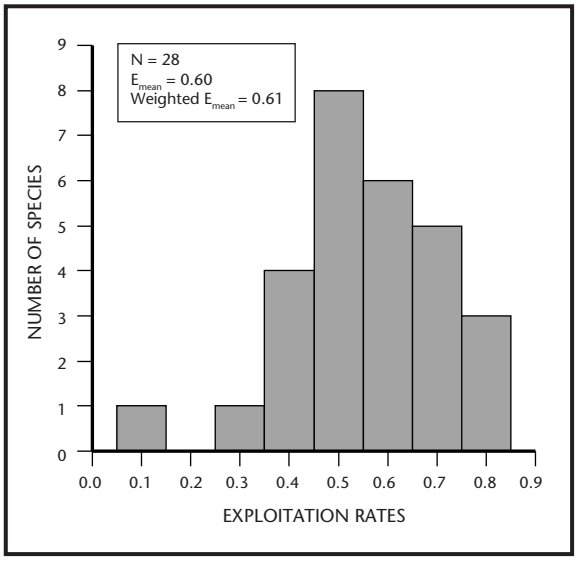

Fig. 17. Distribution of exploitation ratio (E) of 28 demersal species obtained during the 1998 survey off the coast of Sarawak.

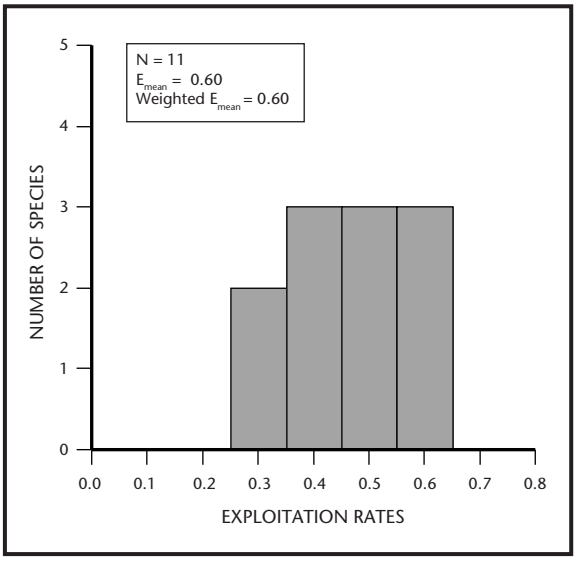

Fig. 18. Distribution of exploitation ratio (E) of 11 demersal species obtained during the 1998 survey off the west coast of Sabah.

Table 5. Growth, mortality and exploitation parameters of demersal species estimated using the 1998 survey data obtained off the coast of Sarawak. Terms are defined in the methods section.

Species	Sample size (n)	Growth parameters				Mortality parameters			M/K	Exploit Ratio (E = F/Z)
		$W = aL^b$		L_∞	K	Z	M	F		
		a	b	(cm)	(yr^{-1})	(yr^{-1})	(yr^{-1})	(yr^{-1})		
Demersal fish:										
Carangoides equula	680	0.090	2.44	30.5	0.40	2.38	1.01	1.37	2.53	0.58
Carangoides malabaricus	646	0.019	2.92	38.1	0.78	8.11	1.48	6.63	1.90	0.82
Leiognathus bindus	867	N/A	N/A	13.0	0.74	8.38	1.91	6.47	2.58	0.77
Leiognathus lineolatus	1 046	N/A	N/A	17.0	0.77	4.31	1.82	2.49	2.36	0.58
*Lutjanus lineolatus (L. lutjanus)**	565	N/A	N/A	22.5	0.33	1.69	0.97	0.72	2.94	0.43
Lutjanus lutjanus	416	N/A	N/A	32.0	0.89	5.20	1.68	3.52	1.89	0.68
Nemipterus bathybius	2 826	0.015	2.96	33.5	0.82	4.13	1.57	2.56	1.91	0.63
Nemipterus marginatus	1 160	0.010	3.12	29.2	0.60	3.21	1.33	1.88	2.22	0.59
Nemipterus mesoprion	595	N/A	N/A	27.5	0.41	3.86	1.05	2.81	2.56	0.73
Nemipterus nematophorous	1 030	0.015	2.97	35.0	0.92	5.15	1.67	3.48	1.82	0.68
Nemipterus nemurus	1 138	0.013	2.98	28.0	0.45	1.23	1.11	0.12	2.47	0.10
Nemipterus peronii	590	0.011	3.04	31.5	0.49	2.02	1.14	0.88	2.33	0.44
Nemipterus tambuloides	498	N/A	N/A	35.0	0.74	3.06	1.45	1.61	1.96	0.53
Nemipterus virgatus	392	0.018	2.74	32.4	0.76	3.60	1.51	2.09	1.99	0.58
Pentaprion longimanus	1 574	N/A	N/A	28.5	0.51	6.55	1.20	5.35	2.35	0.82
Priacanthus macracanthus	2 904	0.021	2.83	42.0	0.71	6.10	1.34	4.72	1.89	0.78
Priacanthus tayenus	779	0.017	2.90	32.0	0.68	2.15	1.41	0.74	2.07	0.34
Psenopsis anomala	292	N/A	N/A	28.0	0.54	6.50	1.26	5.24	2.33	0.81
Saurida tumbil	3 654	0.003	3.29	63.5	0.44	2.75	0.87	1.88	1.98	0.68
Saurida undosquamis	1 415	0.005	3.04	55.5	0.41	3.00	0.87	2.13	2.12	0.71
Scolopsis taeniopterus	516	N/A	N/A	30.5	0.47	2.74	1.12	1.62	2.38	0.59
Thamnaconus hypargyreus	716	N/A	N/A	18.0	0.47	4.40	1.30	3.10	2.77	0.70
*Upeneus bensasi (U.japonicus)**	2 292	0.010	3.04	29.0	0.58	2.53	1.30	1.23	2.24	0.49
Upeneus moluccensis	2 014	0.006	3.27	25.3	0.57	2.54	1.34	1.20	2.35	0.47
Upneus sulphureus	1 091	0.005	3.39	22.0	0.65	4.88	1.52	3.36	2.34	0.69
Upeneus taeniopterus	198	N/A	N/A	22.5	0.42	2.57	1.13	1.44	2.69	0.56
Cephalopods:										
Loligo chinensis	1 682	N/A	N/A	35.5	0.54	2.45	1.18	1.27	2.19	0.52
Loligo duvaucelli	670	N/A	N/A	31.0	0.51	3.38	1.18	2.20	2.31	0.65

Note: * Valid name in FishBase. N/A = Not available.

Table 6. Growth, mortality and exploitation parameters of demersal species estimated using the 1998 survey data obtained off the coast of Sabah. Terms are defined in the methods.

Species	Sample size (n)	Growth parameters				Mortality parameters			M/K	Exploit Ratio (E = F/Z)
		$W = aL^b$		L_∞	K	Z	M	F		
		a	b	(cm)	(yr^{-1})	(yr^{-1})	(yr^{-1})	(yr^{-1})		
Demersal fish:										
Carangoides equula	138	0.016	3.01	22.0	0.80	3.59	1.74	1.85	2.18	0.52
Nemipterus bathybius	538	0.026	2.73	32.0	0.80	5.25	1.57	3.68	1.96	0.70
*Nemipterus bleekeri (N. bipunctatus)**	267	0.005	3.31	31.0	0.75	3.27	1.51	1.76	2.01	0.54
Nemipterus nemurus	193	0.013	2.99	31.0	0.80	3.01	1.58	1.43	1.98	0.48
Pentaprion longimanus	300	N.A.	N/A	28.0	1.30	6.41	2.23	4.18	1.72	0.65
Priacanthus macracanthus	192	0.009	3.13	31.0	0.75	4.93	1.51	3.42	2.01	0.69
Priacanthus tayenus	148	0.019	2.90	32.0	0.55	3.06	1.22	1.84	2.22	0.60
Saurida tumbil	267	0.011	2.89	36.0	0.95	3.03	1.69	1.34	1.78	0.44
Saurida undosquamis	359	0.004	3.14	42.0	1.20	3.95	1.89	2.06	1.58	0.52
*Upeneus bensasi (U. japonicus)**	505	0.016	2.91	24.0	0.80	7.11	1.70	5.41	2.13	0.76
Cephalopods:										
Loligo chinensis	615	N/A	N/A	37.0	0.80	5.26	1.50	3.76	1.88	0.71

Note: * Valid name in FishBase. N/A = Not available.

Demersal Yield and Effort

West coast of Peninsular Malaysia

For the west coast of Peninsular Malaysia, calculation of MSY and f_{MSY} for demersal fishes based on 26 years of landings data and the CPUE of the research vessel KK Jenahak is given in Appendix M. The trends in demersal catch and catch-per-unit effort are illustrated in Figs. 19 a and b, respectively. The estimate of MSY is about 273 000 t obtained at 7.06×10^6 towing hours of KK Jenahak, the vessel taken as standard. The results indicate that the MSY level of the demersal resources was reached around 1994. The 1996 landings of about 305 000 t were 11 % above the MSY value. The 1996 effort, of about 9.55×10^6 towing hours, is 35% more than the f_{MSY} level. This indicates that the fisheries off the west coast are over-exploiting the demersal fish resources.

East coast of Peninsular Malaysia

The catch and effort time series for the demersal fisheries is given in Appendix N and illustrated in Figs. 20 a and b. There appears to be a discontinuity in the rate of decline in CPUE around the mid-1980s (Fig. 20b), with a slower decline during 1986 - 96 compared to 1971 - 85. This can be due to a number of reasons (including technological improvements and expansion to deeper areas) that require further investigation. The immediate implication is that the effort time series requires more vigorous standardization prior to use in Fox modeling. The data and results are documented here for purposes of future follow-up. The MSY and f_{MSY} values given in Appendix 14, therefore should not be used, pending the results of the follow-up studies.

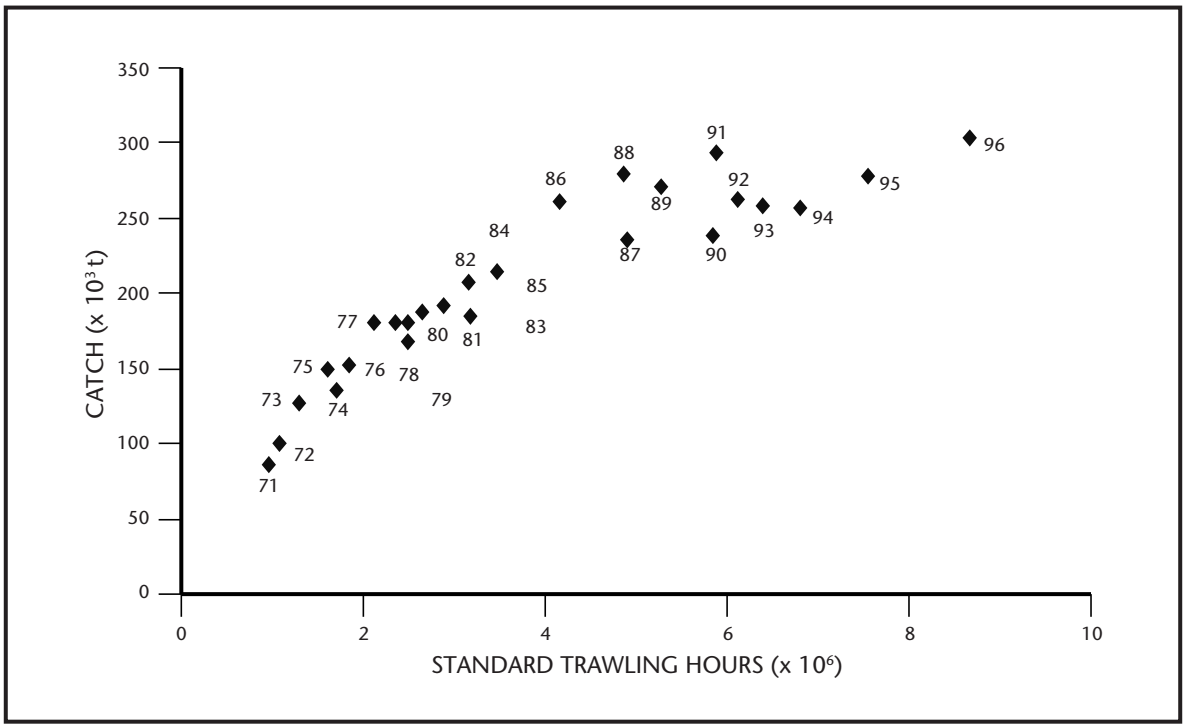

Fig. 19a. Catch and effort for the fisheries exploiting demersal resources off the West coast of Peninsular Malaysia from 1971 to 1996.

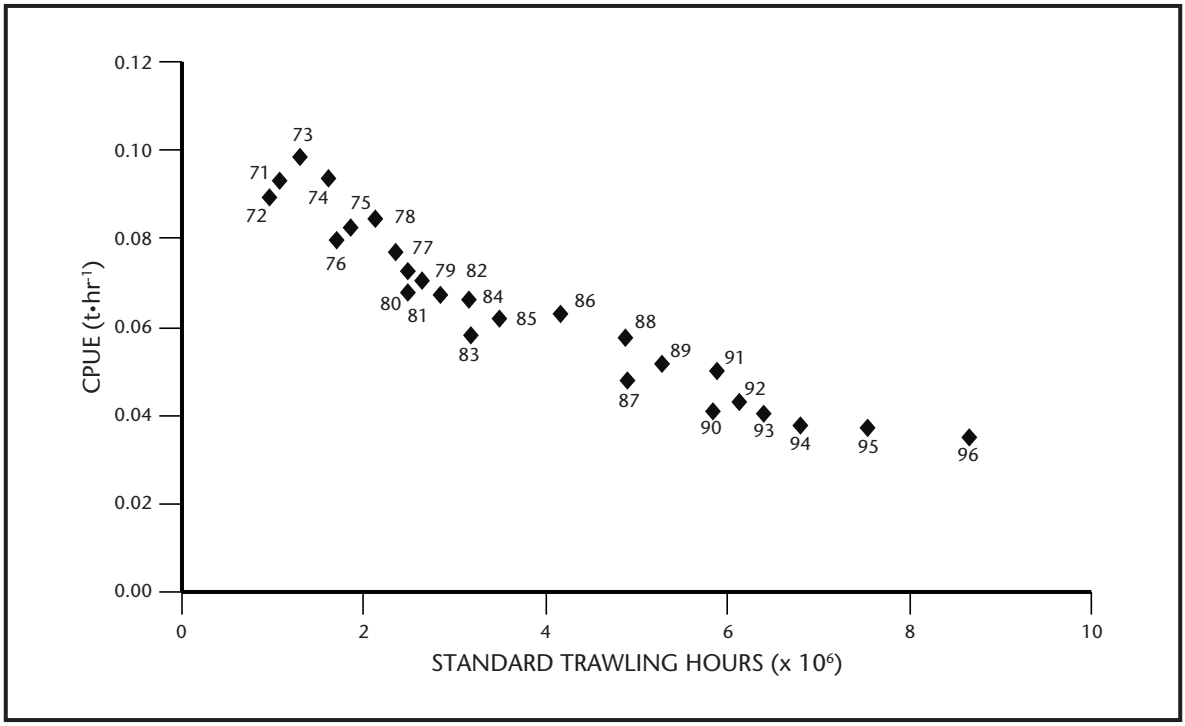

Fig. 19b. Catch-per-unit effort (CPUE) for the fisheries exploiting demersal resources off the West coast of Peninsular Malaysia from 1971 to 1996.

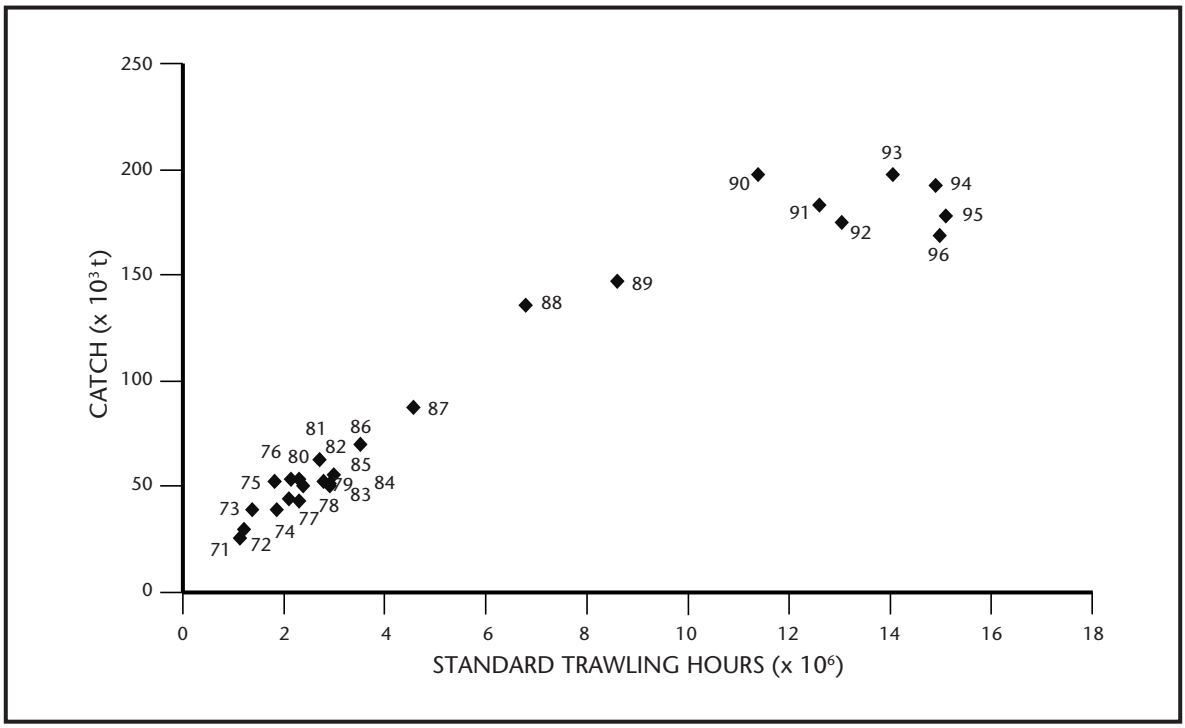

Fig. 20a. Catch and effort for the fisheries exploiting demersal resources off the East coast of Peninsular Malaysia from 1971 to 1996.

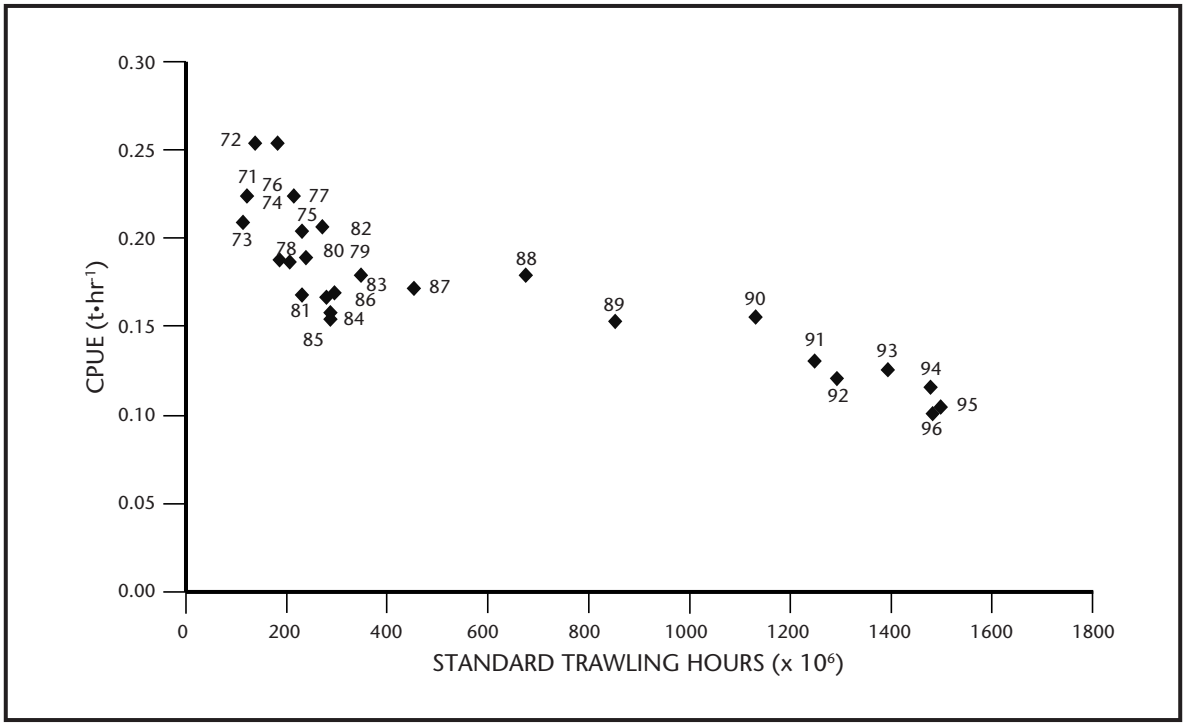

Fig. 20b. Catch-per-unit effort for the fisheries exploiting demersal resources off the East coast of Peninsular Malaysia from 1971 to 1996.

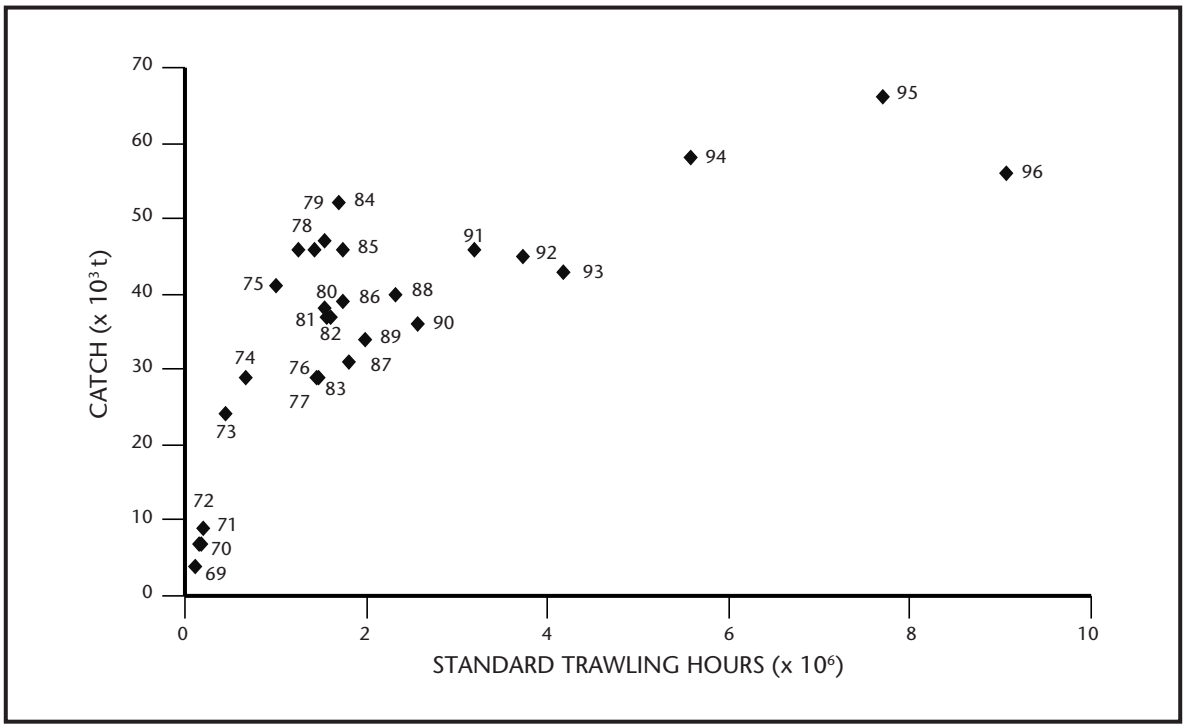

Fig. 21a. Catch and effort for the fisheries exploiting demersal resources off Sarawak from 1969 to 1996.

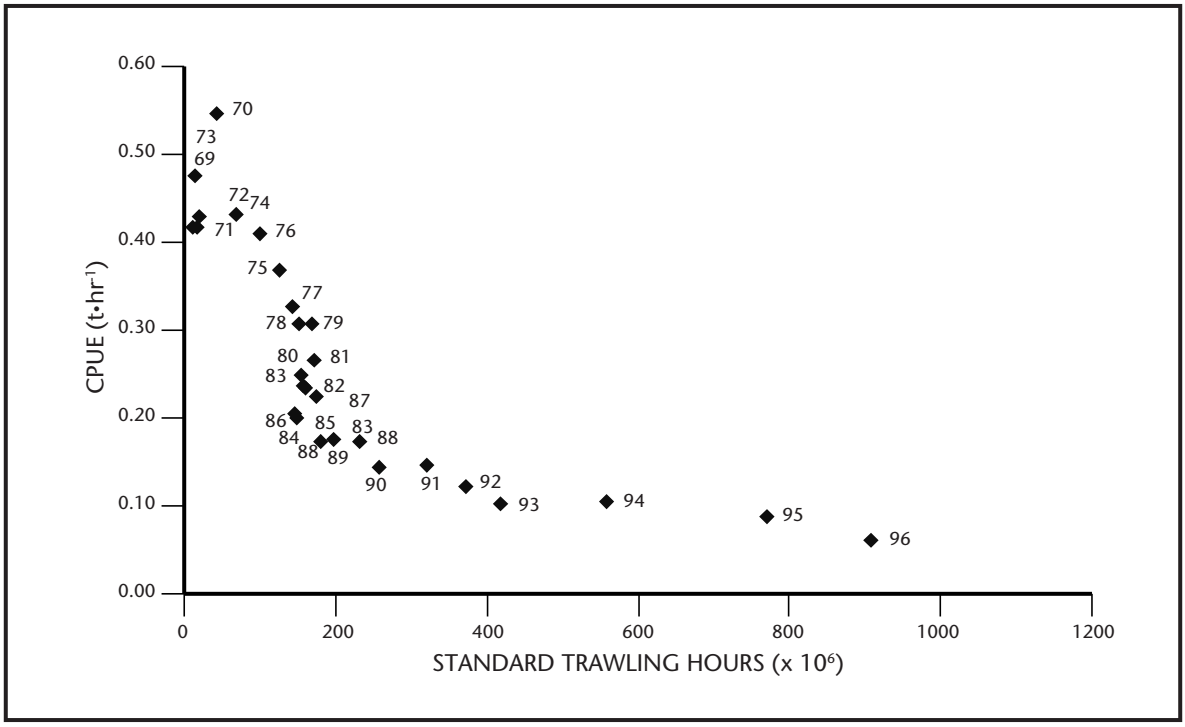

Fig. 21b. Catch-per-unit effort (CPUE) for the fisheries exploiting demersal resources off Sarawak from 1969 to 1996.

Sarawak

Most of the catch in Sarawak comes from coastal areas less than 91 m deep, or within 30 nm of the coastline. Statistics show that in 1986 there were 732 licensed trawlers in Sarawak, 70% below 20 gross tons or GT, 82% with engines below 99 HP, r and 99% less than 25 m long. The number decreased to 506 in 1996, around 50% of which were below 20 GRT and only 5% above 70 GRT. In Sarawak, even fishing vessels above 70 GRT are allowed to operate within 30 nm from the coastline. Hence the catch is mostly from the coastal area less than 100 m deep. Based on this, calculation of MSY and f_{MSY} only included data for strata 1 and 2 (areas less than 91 m deep). Only CPUE from research vessels obtained in these two depth strata were used.

The 28-year catch and effort time series used in estimating MSY and f_{MSY} is given in Appendix O and illustrated in Figs. 21 a and b. The MSY and f_{MSY} value obtained was about 60 000 t and 0.42 million towing hours, respectively. It appears that the f_{MSY} level was reached around 1993 in the coastal area of Sarawak and by 1996 the fishing effort may have been twice the level necessary to harvest MSY.

Conclusion

The first trawl survey conducted during 1926 - 27 by S/T Tongkol attempted to assess the demersal fish resources in order to introduce trawling. However, the unfavorable results obtained did not lead to any serious development of trawling until the late 1960s. The first monitoring survey was initiated off the east coast of Peninsular Malaysia under a bilateral agreement with the Federal Republic of Germany in 1967. Since then a total of 13 surveys have been carried out in this area. Similar surveys were also carried out off the northern part of the west coast of Peninsular Malaysia, Sarawak and the west coast of Sabah. To date, a total of 14 surveys have been conducted off the west coast of Peninsular Malaysia and 9 surveys off Sarawak and Sabah. Analysis of data from selected surveys for these four study areas provides major conclusions that are summarized below.

West coast of Peninsular Malaysia

- The average catch rate in 1997 of demersal fish in coastal waters of Sub-area I and II was only 25% and 30% respectively, of the values obtained in 1971 - 72. The 1997 average catch rate in offshore areas from 56 to 91 m depth (stratum 2) was only 28% in Sub-area I and 18% in Sub-area II as compared to values in 1987. The catch rate in the deeper offshore areas from 91 to 185 m (Stratum 3) in Sub-area I had also decreased.The 1997 catch rate was about 76% of the value obtained in 1987.
- Demersal stock density in coastal waters of Sub-areas I and II were only 8% and 14%, respectively, of the estimated values in 1971 - 72. Density in stratum 2 in Sub-area I and Sub-area II was 38% and 25% respectively, of the values estimated in 1987. The density in stratum 3 of Sub-area I was similar to the density obtained in 1987.
- Length-based analyses of 15 demersal fish and 3 cephalopod species give a mean E value of 0.62 confirming over-exploitation of the resources. These selected species comprise 48% of the demersal fish caught during the survey in 1997.
- The calculated MSY and f_{MSY}. were 273 000 t and 7.06×10^6 standard towing hours respectively. The 1997 catch and effort values indicate that the demersal resources were already over-exploited then.

East coast of Peninsular Malaysia

- Reduction of mean catch rate in the coastal area (depth stratum 1) since 1967 is 91% in Sub-area I, 89% in Sub-area II, 95% in Sub-area III and 96% in Sub-area IV. The offshore area (depth stratum 2) is also heavily exploited. The 1997 catch rate was only 13%, 7% 4% and 3% in Sub-area I, II, III and IV respectively, of the values obtained in 1987.
- In 1998, stock density of demersal fish in coastal waters was only 5% of the 1967 level and off shore stock density was 5 - 10% of the 1986 level.
- Length-based studies of 24 demersal fish and 4 cephalopod species (comprising 33% of the catch during the 1998 survey) provide a mean exploitation ratio of 0.58, thus confirming over-exploitation.

Sarawak

- The coastal area showed reductions in average catch rate of 64%, 48% and 26% in Sub-area I, II and III respectively, over the period 1972 to 1998. However, both offshore depth strata show either a slight reduction or increase in average catch rate of demersal fish.
- The coastal demersal stock density obtained in the latest (1998) survey was only 23% to 32% of the value recorded in 1972. The offshore area of Sub-area I and II still has 60% to 85% of the density obtained in 1986, while the offshore area of Sub-area III indicates some increase.
- Length-based studies of 26 demersal fish and 2 cephalopod species (comprising over 50% of total catch during the 1998 survey) provide a mean exploitation ratio of 0.62 and confirm the over-exploitation in coastal areas.
- The MSY estimate for the coastal area is about 60 000 t at a f_{MSY} of about 0.42 million towing hours. Results indicate that there is over-exploitation of the demersal fish resources in the coastal area off Sarawak.

West coast of Sabah

- The average catch rate obtained in the latest (1998) survey in the coastal area was only 12% and 18% of those recorded in the first survey in 1972 in Sub-area V and Sub-area VI, respectively.
- The 1998 demersal stock density in the offshore areas was higher than the densities obtained in the 1986 survey. Coastal demersal stock density was only 4 to 6% of the values recorded in 1972.
- Length-based studies of 10 demersal fishes and 1 cephalopod species (comprising 45% of total catch during the 1998 survey) provide a mean exploitation ratio of 0.60 and confirms over-exploitation in the coastal area.

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Appendix A. Specifications of the research vessels used for demersal resource surveys in Malaysian waters, 1967 - 98.

Specification	RV Pramong II	KK Jenahak	KK Merah	RV Rastrelliger	KK Mersuji	KK Manchong
Owner	DoF, Thai*	DoF**	DoF**	FAO***	DoF**	DoF**
Type	Wood	Wood	Wood	Steel	FRP****	FRP****
Length overall (m)	23	23.23	23	46.4	23.25	27.50
Breadth moulded (m)	–	–	5.7	9.01	5.80	6.40
Depth moulded (m)	–	–	–	5.09	2.35	3.00
Designed Draft (m)	–	–	–	–	1.95	2.20
Gross Tonnage	76	80.2	73.5	390.94	97.03	150
Speed on trials (knots)	–	–	–	12.2	11.1	12.48
Towing Speed (knots)	2.5	2.8	2.8	3.5	3.0	4.0
Main engine:						
Make	Cumming	M.W.M	Caterpillar	Wichmann	Yanmar	Yanmar
Type	–	Diesel	Diesel	8 ACAT	500ps	Diesel
Horse power (bhp)	320	325	365	1320	550	900
RPM	–	900	1800	–	900	–
Deck Machinery:						
Main Fishing Winch	–	–	–	Brattvaag	–	Awakumi
Net hauler	–	–	–	Triplex	–	Awakumi
Net Drum	–	–	–	Brattvaag	–	–
Navigation equipment:						
Radar	–	–	–	Decca	Furuno	Furuno
Sounder	Atlas	Atlas	–	Simrad	Furuno	Furuno
Sonar	–	–	–	Simrad	–	Furuno
Satellite Navigator	–	–	–	Furuno	JRCJLE	Furuno
Capacities:						
Fishroom/Fishhold	14 t	20 t	–	200 m^3	9.62 m^3	28 m^3
Fresh water	–	–	–	46 m^3	11.52 m^3	14 m^3
Accomodation:						
Officers	–	4	–	12	6	6
Crew	–	10	–	16	12	16

Note: * DoF, Thai - Department of Fisheries, Thailand.
**** DoF - Department of Fisheries, Malaysia.**
***** FAO - Food & Agriculture Organization.**
****** FRP - Reinforced-Fiberglass Plastic.**

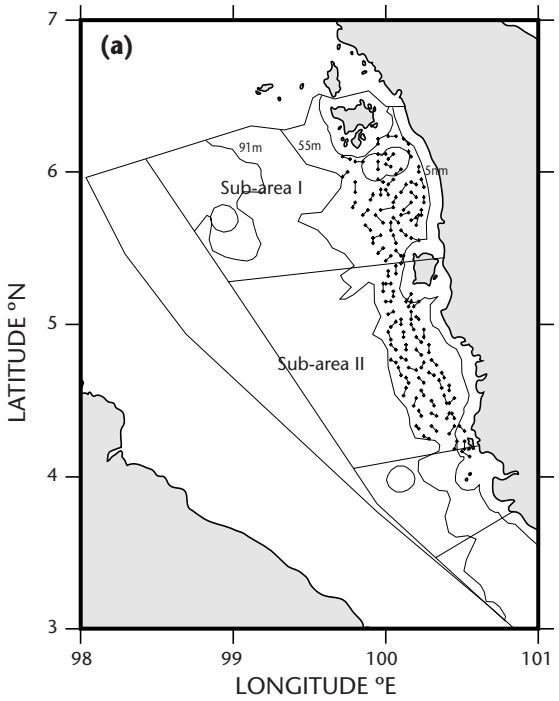
Appendix B. Specifications of the trawl net and otter-board used by research vessels during the surveys conducted in Malaysian waters, 1967 - 98.

Specification	Pramong II	KK Jenahak	KK Merah	RV Rastrelliger	KK Mersuji	KK Manchong
Trawl Net:						
Design	*SGOT	SGOT	SGOT	HLEBT**	SGOT	SGOT
Type	Nylon	Nylon	Nylon/PE	Nylon	Nylon	PE
Circumference (m)	23.5	23.5	23.5	112.6	23.52	40.50
Length of head-rope (m)	39.5	22.4	22.4/16.3	71.9	34.8	47.10
Length of foot-rope (m)	48.0	29.6	29.6/19.9	80.5	–	55.50
Cod-end length (m)	10.0	10.0	10.0/10.0	12	10.0	11.40
Cod-end mesh (mm)	40.0	40	40/38.1	50	40	38
Effect. Horizontal Opening (m)	17.0	20	20	26	20	19
Effect. Vertical Opening (m)	3.5	–	–	6	–	2.3
Sinkers	Iron chain	Iron chain	Iron chain	Rubber disc & Iron chain	Tire Disc	Tire Disc
Otter Board:						
Net length (m)	47.7	–	–	79.5	–	69.75
Material	Wood	Wood	Wood	Steel	Wood	Steel
Size (m x m x cm)	2 x 1 x 2	–	–	3 x 1.8	2.5 x 1.1	–
Total weight (kg)	–	–	–	1 000	250	350
Type	Rectangular	Rectangular	Rectangular	Polyvalent	Rectangular	Polyvalent
Wire warp ratio (Depth: wire rope out)						
Soft ground	1 : 5	–	–	–	–	–
Hard ground	1 : 6	–	–	–	–	–
Shallow area (< 50m)	–	1 : 5	1 : 5	–	1 : 5	1 : 5
Deep area (> 50m)	–	1 : 3	1 : 4	–	1 : 4	1 : 4

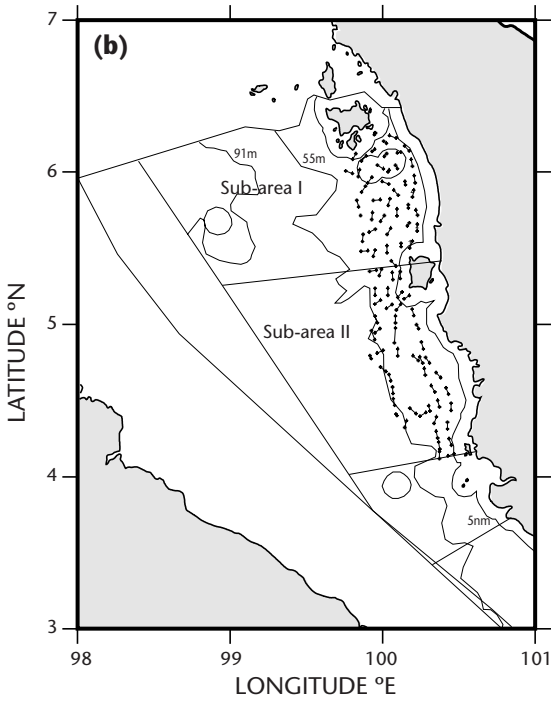
Note: * SGOT - Standard German Otter-Trawl.
**** HLEBT - High Lift Engel Balloon Trawl.**

Appendix C. Distribution of sampling stations during the demersal resource surveys in Sub-areas I and II off the west coast of Peninsular Malaysia: (a) 1971 - 72 - KK Merah, (b) 1981 - KK Jenahak, (c) 1987 - RV Rastrelliger, (d) 1990 - 91 - KK Mersuji and (e) 1997 - KK Manchong.

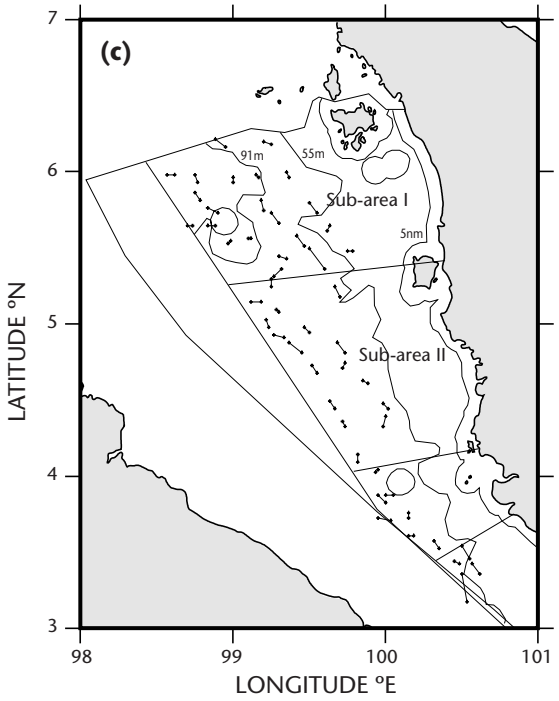
(a) 1971 - 72 - KK Merah.



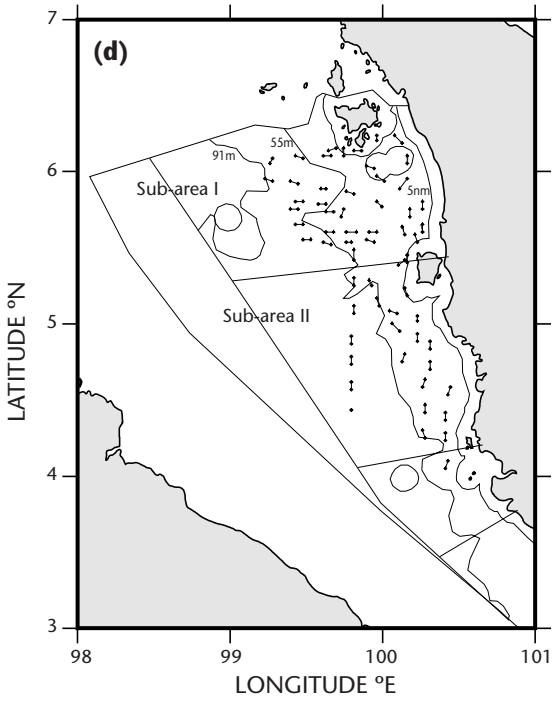
(b) 1981 - KK Jenahak.



(c) 1987 - RV Rastrelliger.

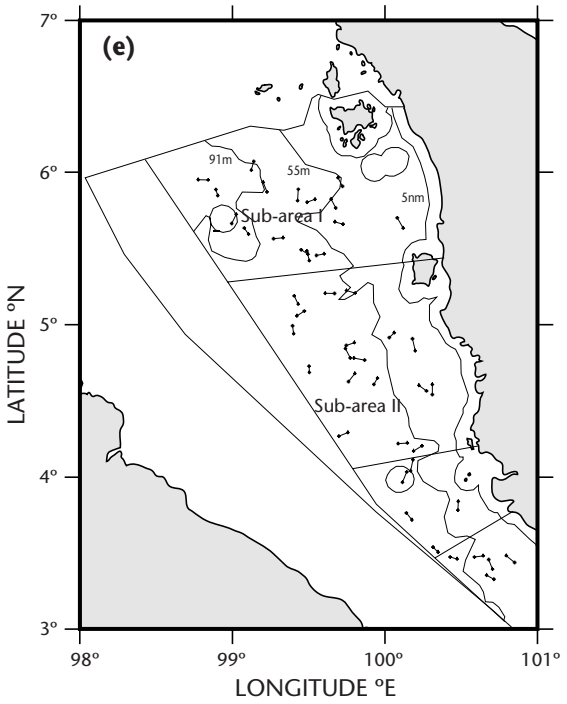


(d) 1990 - 91 - KK Mersuji.



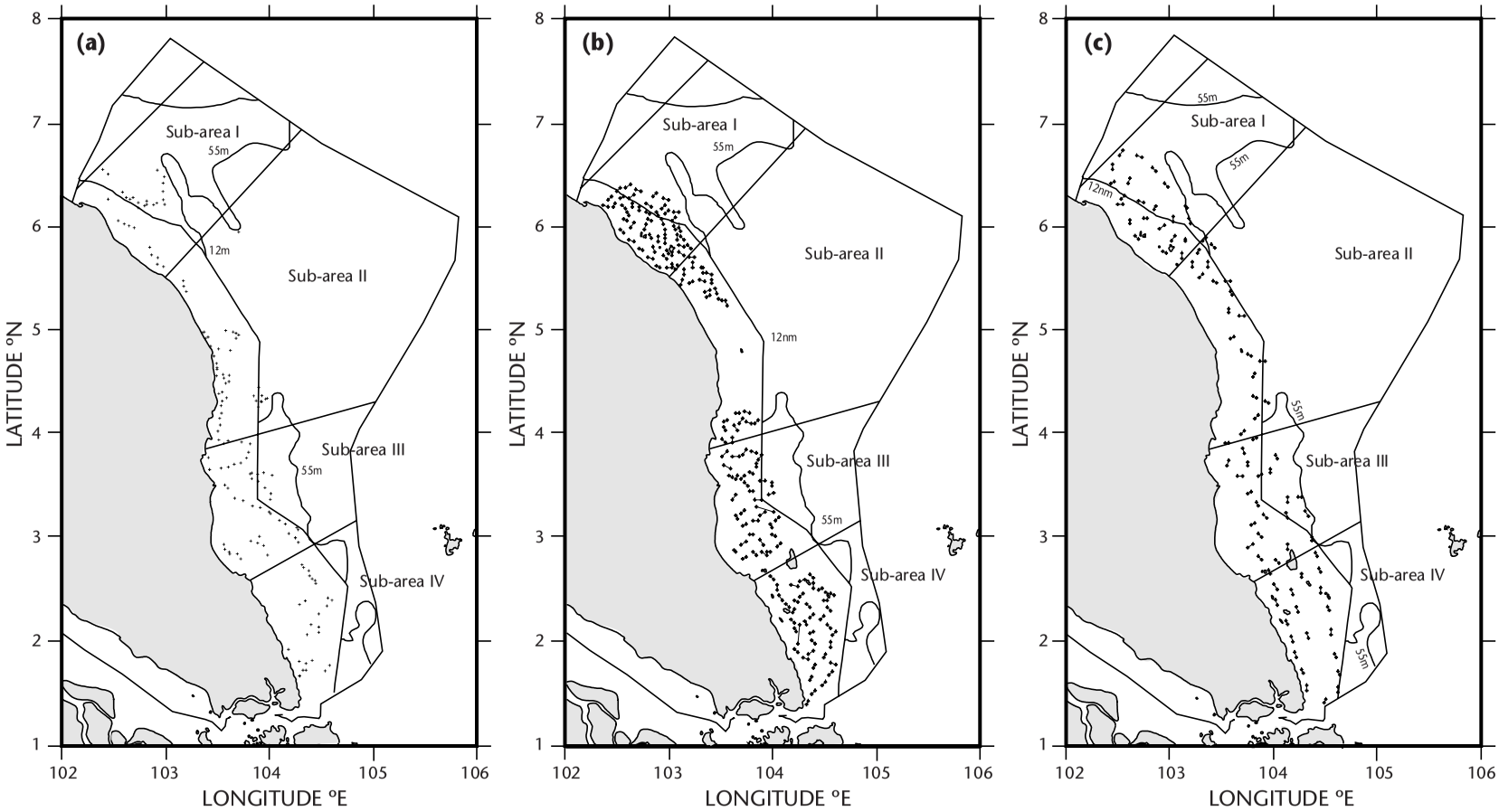
Appendix C. Distribution of sampling stations during the demersal resource surveys in Sub-areas I and II off the west coast of Peninsular Malaysia. (continued)

(e) 1997 - KK Manchong.



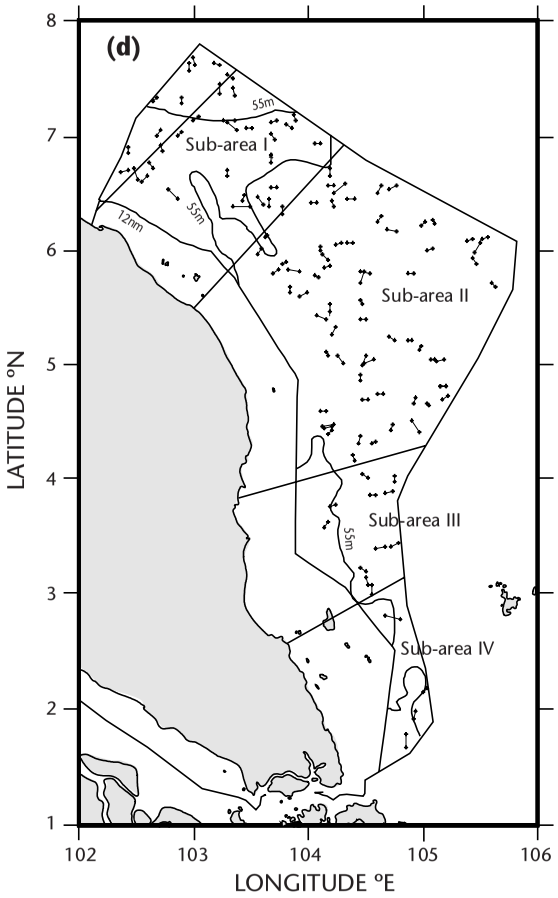
Appendix D. Distribution of sampling stations during the demersal resource surveys off the east coast of Peninsular Malaysia: (a) 1969 - Pramong II, (b) 1972 - KK Jenahak and (c) 1981 - KK Jenahak, (d) 1986 - RV Rastrelliger and (e) 1991 - KK Mersuji.

(a) 1969 - Pramong II. **(b) 1972 - KK Jenahak.** **(c) 1981 - KK Jenahak.**

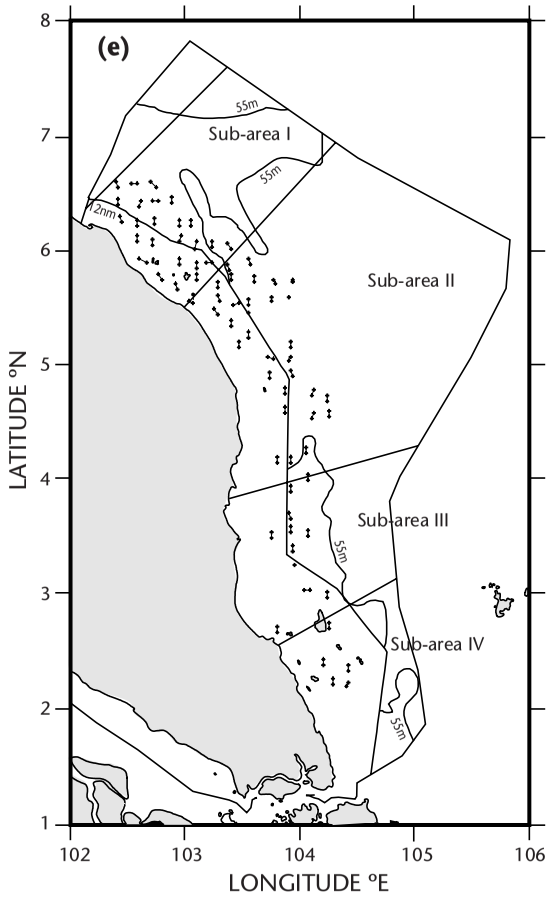


Appendix D. Distribution of sampling stations during the demersal resource surveys off the east coast of Peninsular Malaysia: (a) 1969 - Pramong II, (b) 1972 - KK Jenahak and (c) 1981 - KK Jenahak, (d) 1986 - RV Rastrelliger and (e) 1991 - KK Mersuji. (continued)

(d) 1986 - RV Rastrelliger.

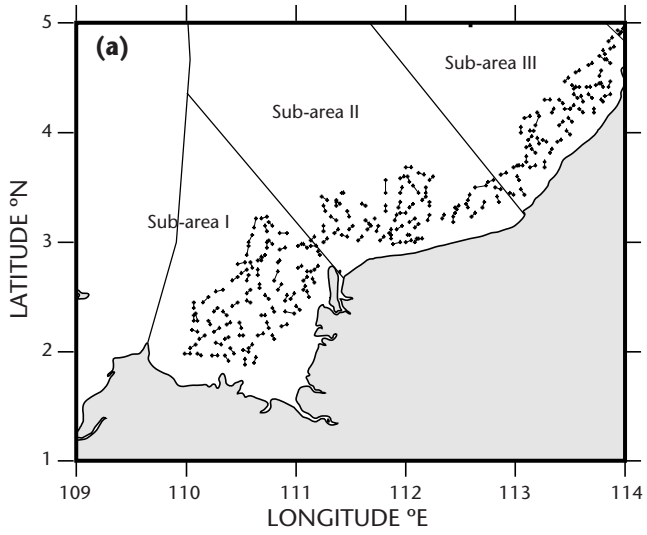


(e) 1991 - KK Mersuji.

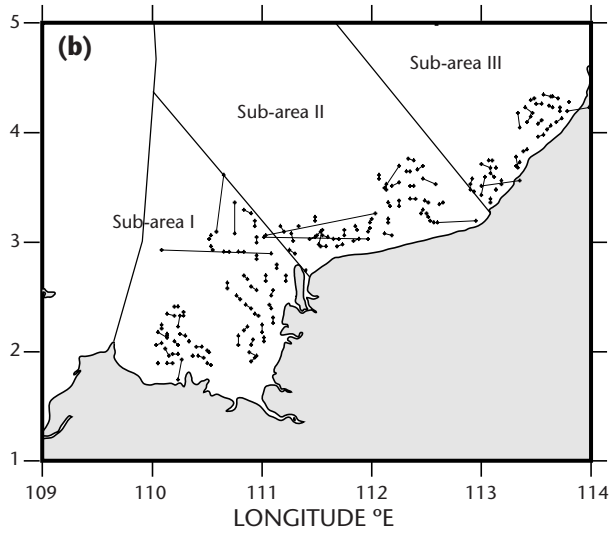


Appendix E. Distribution of sampling stations during the surveys off the coast of Sarawak: (a) 1972 - KK Jenahak/KK Merah, (b) 1981 - KK Merah and (c) 1986 - RV Rastrelliger.

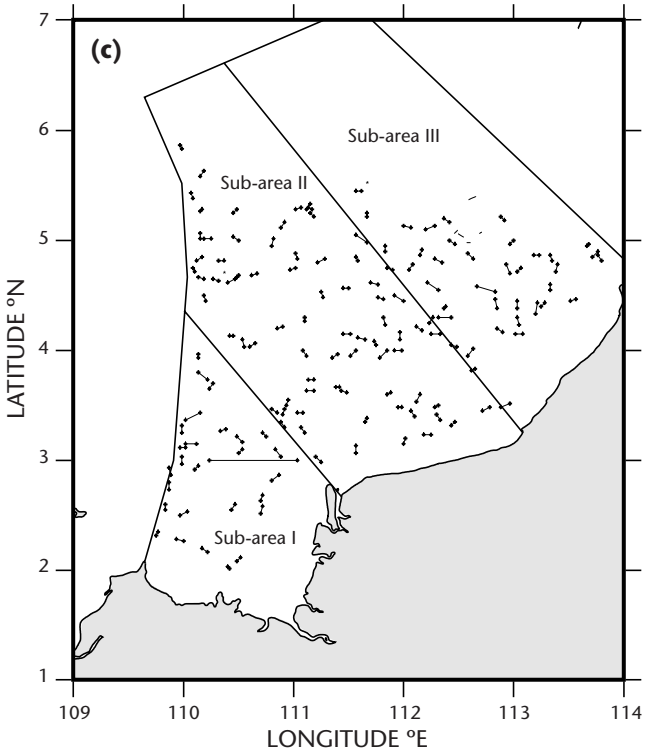
(a) 1972 - KK Jenahak/KK Merah.



(b) 1981 - KK Merah.

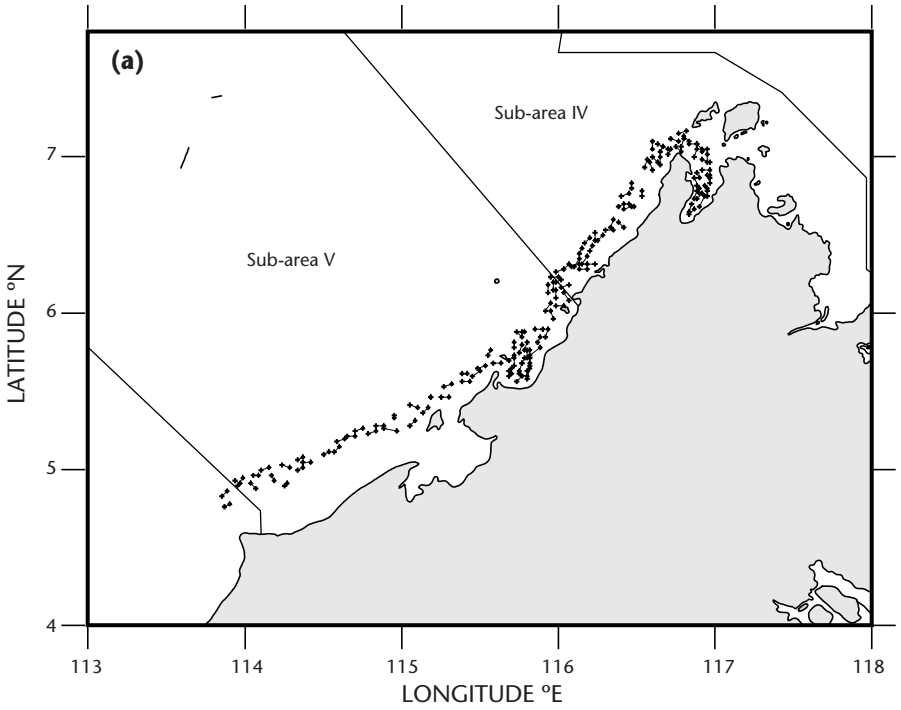


(c) 1986 - RV Rastrelliger.

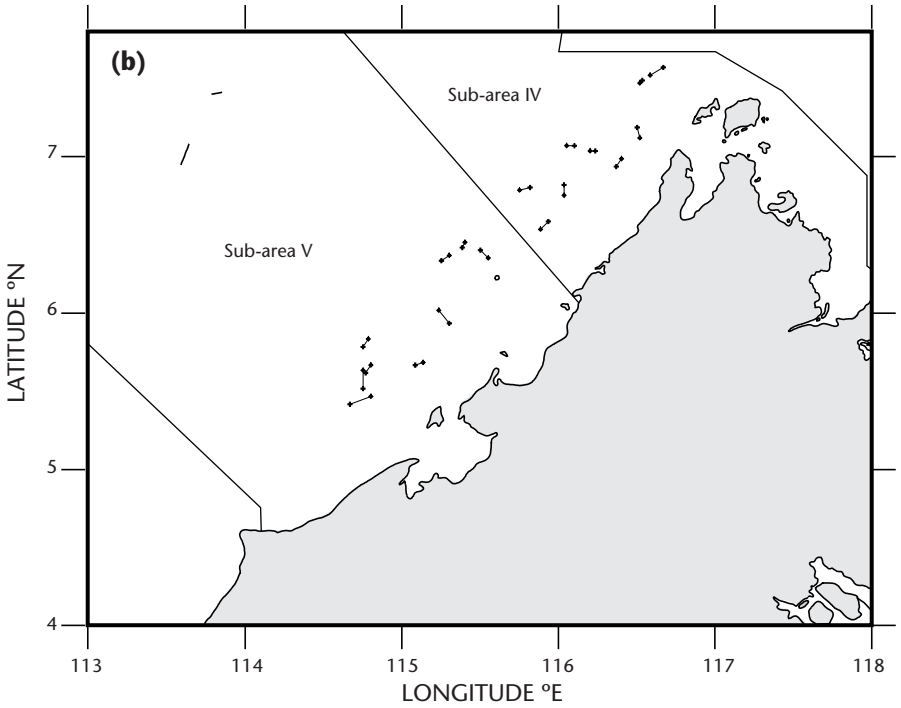


Appendix F. Distribution of sampling stations during the demersal resource surveys off the west coast of Sabah: (a) 1972 - KK Jenahak/KK Merah and (b) 1986 - RV Rastrelliger.

(a) 1972 - KK Jenahak/KK Merah.



(b) 1986 - RV Rastrelliger.



Appendix G. Mean CPUE (kg·hr^{-1}) by sub-area and by year off the (a) west coast of Peninsular Malaysia, (b) east coast of Peninsular Malaysia, (c) Sarawak and (d) west coast of Sabah.

(a) West coast of Peninsular Malaysia.

Sub-area	1971		1981		1987*		1991*		1997*	
	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD
I.1	112.9	89.9	55.6	59.6	114.9	60.2	28.4	12.0	22.8	15.7
I.2	–	–	–	–	190.3	223.5	38.9	31.3	34.9	11.4
I.3	–	–	–	–	65.5	42.7	–	–	52.5	46.9
II.1	100.7	94.5	41.9	35.0	–	–	25.3	13.2	30.4	11.2
II.2	–	–	–	–	228.5	188.2	47.4	6.5	38.6	21.6
All	106.5	92.1	49.1	49.6	184.4	220.1	29.5	18.5	36.5	21.5

Note: * The catch rate was corrected to the rate for cod-end mesh size of 40 mm.

(b) East coast of Peninsular Malaysia.

Sub-area	1967		1972		1981		1986*		1991		1998*	
	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD
I.1	312.6	312.6	222.1	185.1	85.5	62.2	166.2	47.1	39.4	24.0	28.5	17.8
I.2	–	–	–	–	–	–	319.7	305.0	–	–	33.3	13.8
II.1	439.7	441.3	360.1	468.4	111.0	99.1	–	–	66.8	39.2	30.7	–
II.2	–	–	–	–	–	–	235.2	71.6	–	–	21.3	15.0
III.1	-546.7	-534.0	-187.8	-151.2	328.4	372.2	252.8	20.1	49.1	23.2	30.1	22.2
III.2	–	–	–	–	–	–	208.7	48.4	–	–	17.9	17.4
IV.1	189.3	313.5	161.8	186.4	79.3	52.0	–	–	307.9	346.2	6.1	–
IV.2	–	–	–	–	–	–	268.6	30.4	–	–	24.2	30.2
All	403.4	445.2	221.3	254.3	154.6	225.8	227.5	109.7	64.7	89.7	24.0	15.6

Note: * The catch rate was corrected to the rate for cod-end mesh size of 40 mm.

Appendix G. Mean CPUE (kg·hr^{-1}) by sub-area and by year off the (a) west coast of Peninsular Malaysia, (b) east coast of Peninsular Malaysia, (c) Sarawak, and (d) west coast of Sabah. (continued)

(c) Sarawak.

Sub-area	1972*		1981		1986*		1989/92/93		1997*	
	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD
I.1	135.1	85.8	96.5	83.6	178.1	105.5	88.0	65.8	59.0	38.7
I.2	81.0	41.0	–	–	157.1	66.3	152.9	71.3	86.3	55.8
I.3	–	–	–	–	150.2	–	–	–	92.6	-
II.1	224.2	296.0	159.5	118.5	253.5	125.5	144.5	99.6	146.5	224.3
II.2	–	–	–	–	173.9	92.9	139.3	58.3	90.4	30.8
II.3	–	–	–	–	230.0	244.6			531.8	873.4
III.1	301.7	329.7	207.7	136.7	173.6	150.2	165.8	94.8	169.0	56.9
III.2	134.7	88.2	–	–	138.4	94.2	138.2	72.9	105.1	53.9
III.3	–	–	–	–	100.7	150.5	–	–	328.3	639.5
All	202.5	251.0	144.8	118.3	176.2	116.0	125.2	75.2	239.2	522.8

Note: * The catch rate was corrected to the rate for cod-end mesh size of 38 mm.

(d) West coast of Sabah.

Sub-area	1972*		1986*		1991		1998	
	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD
V.1	496.4	6.0	386.3	74.0	298.5	286.3	71.4	51.9
V.2	–	–	63.4	77.5	173.5	124.7	196.0	241.4
V.3	–	–	34.2	47.6	–	–	203.1	32.2
VI.1	478.1	504.2	349.9	19.7	164.3	129.1	56.4	23.3
VI.2	–	–	283.3	146.8	146.8	131.5	147.9	73.8
VI.3	–	–	50.4	0.4	464.5	326.8	70.0	78.7
All	485.0	440.6	180.1	163.0	202.0	186.3	104.9	105.8

Note: * The catch rate was corrected to the rate for cod-end mesh size of 38 mm.

Appendix H. Mean CPUE (kg·hr^{-1}) obtained from log-normal frequency distribution by sub-areas and by year off the (a) west coast of Peninsular Malaysia, (b) east coast of Peninsular Malaysia, (c) Sarawak and (d) west coast of Sabah.

(a) West coast of Peninsular Malaysia.

Sub-area	1971		1981		1987*		1991		1997*	
	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD
I.1	74.5	2.9	41.5	2.1	101.8	2.0	22.7	1.7	18.6	2.2
I.2	–	–	–	–	1116.7	4.0	29.4	2.2	33.3	1.4
I.3	–	–	–	–	49.2	2.2	–	–	36.2	3.0
II.1	67.2	2.6	31.0	2.2	–	–	21.0	2.1	29.1	1.8
II.2	–	–	–	–	184.8	1.7	47.1	1.2	33.6	1.8
All	70.6	15.2	36.1	3.8	114.9	15.6	24.5	1.9	31.0	1.8

Note: * The catch rate was corrected to the rate for cod-end mesh size of 40 mm.

(b) East coast of Peninsular Malaysia.

Sub-area	1967		1972@		1981		1986*@		1991		1998*@	
	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD
I.1	218.3	2.5	165.0	2.2	63.0	2.5	156.3	1.4	32.0	2.0	22.3	2.0
I.2	–	–	–	–	–	–	224.5	2.2	–	–	28.8	1.6
II.1	263.3	3.0	202.7	3.3	70.4	3.0	–	–	56.1	1.9	29.2	–
II.2	–	–	–	–	–	–	219.9	1.5	–	–	14.4	2.6
III.1	348.1	1.7	118.1	3.3	196.8	2.8	252.2	1.1	44.1	1.7	22.3	2.6
III.2	–	–	–	–	–	–	199.5	1.4	–	–	8.1	4.5
IV.1	122.9	2.2	105.7	2.1	66.5	1.8	–	–	193.7	3.3	5.8	–
IV.2	–	–	–	–	–	–	266.6	1.2	–	–	7.7	6.6
All	239.5	18.0	140.9	1.8	88.8	2.8	205.3	1.5	45.7	2.2	17.1	1.6

Note: * The catch rate was corrected to the rate for cod-end mesh size of 40 mm.
@ Pre-Northeast Monsoon.

Appendix H. Mean CPUE (kg·hr^{-1}) obtained from log-normal frequency distribution by sub-areas and by year off the (a) west coast of Peninsular Malaysia, (b) east coast of Peninsular Malaysia, (c) Sarawak and (d) west coast of Sabah. (continued)

(c) Sarawak.

Sub-area	1972*		1981		1986*		1989/92/93		1998@	
	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD
I.1	107.2	2.2	71.7	2.3	150.5	1.8	64.1	2.4	38.9	3.5
I.2	69.5	1.9	–	–	144.4	1.6	141.3	1.5	72.7	1.8
I.3	–	–	–	–	150.2	–	–	–	92.6	–
II.1	126.8	3.0	124.8	2.1	222.0	1.7	109.9	2.5	66.2	3.8
II.2	–	–	–	–	138.8	2.3	121.3	1.9	85.9	1.4
II.3	–	–	–	–	156.7	2.4	–	–	169.3	4.5
III.1	217.6	2.2	171.2	1.9	137.2	2.3	145.9	1.9	161.0	1.4
III.2	103.1	2.4	–	–	89.9	3.9	120.1	1.8	90.1	1.9
III.3	–	–	–	–	39.9	4.9	–	–	95.3	4.9
All	131.7	2.5	106.7	2.3	119.3	1.8	98.7	2.2	94.9	2.3

Note: * The catch rate was corrected to the rate for cod-end mesh size of 38 mm.
@ Pre-Northeast Monsoon.

(d) West coast of Sabah.

Sub-area	1972*		1986*		1991		1998	
	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD	Kg·hr^{-1}	SD
V.1	393.8	2.1	382.7	1.2	217.3	2.4	48.7	3.2
V.2	–	–	24.7	6.8	144.1	1.9	115.0	3.4
V.3	–	–	14.5	5.3	–	–	63.2	1.6
VI.1	304.8	2.7	349.6	1.1	131.1	1.9	54.0	1.5
VI.2	–	–	242.2	2.1	101.9	2.6	133.9	1.7
VI.3	–	–	50.4	1.0	384.3	2.2	42.5	4.6
All	335.8	2.5	80.7	4.3	145.4	2.2	71.6	2.6

Note: * The catch rate was corrected to the rate for cod-end mesh size of 38mm.
@ Pre-Northeast Monsoon.

Appendix I. Demersal biomass by year and depth stratum in Sub-area I and II off the west coast of Peninsular Malaysia.

Year	Vessel/ mesh-size	Sub-area	Stratum[1]	No. of Stn.	Area (km^2)	Catch rate [2] $kg \cdot hr^{-1}$	Stock Density ($t \cdot km^{-2}$)	Biomass (t)
1971 - 72	KK Merah (40 mm)	I	1	46	6 187	74.47	2.56	15 866
		II	1	51	5 507	67.21	2.31	12 747
1981	KK Jenahak (40 mm)	I	1	41	6 187	41.45	1.43	8 831
		II	1	36	5 507	31.03	1.07	5 885
1987	RV Rastrelliger (corrected to 40mm)	I	1	2	6 187	101.79	0.87	5 405
			2	10	6 251	116.68	1.00	6 260
			3	10	3 852	49.24	0.42	1 628
		I	All strata	22	16 291	89.24	0.61	9 981
		II	2	18	10 449	184.81	1.59	16 574
1991	KK Mersuji (40 mm)	I	1	25	6 187	22.66	0.47	2 900
			2	11	6 251	29.41	0.61	3 803
		II	1	18	5 507	20.98	0.43	2 390
			2	4	10 449	47.07	0.97	10 175
		II	All strata	22	15 957	34.03	0.70	11 232
1997	KK Manchong (corrected to 40 mm)	I	1	4	6 187	18.57	0.21	1 317
			2	8	6 251	33.33	0.38	2 388
			3	4	3 852	36.22	0.42	1 599
		I	All strata	16	16 291	29.37	0.34	5 774
		II	1	4	5 507	29.12	0.33	1 838
			2	14	10 449	33.59	0.39	4 024
		II	All strata	18	15 957	31.36	0.36	6 037
		I - II	All area	34	32 248	30.17	0.35	11 739

Note: [1] Stratum 1 = 5 nm - 55 m; Stratum 2 = 56 - 91 m; Stratum 3 = 92 - Territorial Water Limit.

[2] Estimates are from log-transformed catch-per-unit effort.

Appendix J. Demersal fish biomass by year and depth stratum off the east coast of Peninsular Malaysia.

Year	Vessel/ mesh-size	Sub-area	Stratum[1]	No. of Stn.	Area (km^2)	Catch rate [2] $kg \cdot hr^{-1}$	Stock Density ($t \cdot km^{-2}$)	Biomass (t)
1967	Pramong II (40 mm)	I	1	29	19 832	218.33	4.78	94 702
		II	1	48	9 243	263.29	5.76	53 226
		III	1	45	10 312	348.09	7.61	78 51
		IV	1	28	10 502	122.86	2.69	28 222
1972	Jenahak (40 mm)	I	1	48	19 832	165.03	5.68	112 705
		II	1	24	9 243	202.69	6.98	64 514
		III	1	35	10 312	118.12	4.07	41 946
		IV	1	37	10 502	105.70	3.64	38 229
1981	Jenahak (40 mm)	I	1	22	19 832	2.17	63.02	43 038
		II	1	16	9 243	70.42	2.42	22 414
		III	1	21	10 312	196.78	6.78	69 879
		IV	1	19	10 502	66.47	2.29	24 040
1986	Rastrellier (corrected to 40 mm)	I	1	24	19 832	156.25	1.34	26 595
			2	10	10 100	224.51	1.93	19 462
		I/	All	34	29 932	190.38	1.63	48 908
		II	1	–	9 243	–	–	–
			2	65	52 856	219.86	1.89	99 741
		II	All	65	62 099	–	2.16	–
		III	1	2	10 312	252.19	1.71	22 320
			2	9	7 407	199.49	1.94	12 683
		III	All	11	17 720	225.84	–	34 716
		IV	1	–	10 502	–	2.29	–
			2	4	3 104	266.64	–	
		IV	All	4	13 607	–	–	–
		I - IV	All Area	114	123 359	–	–	–
1991	Mersuji (40 mm)	I	1	26	19 832	32.02	0.66	13 137
		II	1	25	9 243	56.09	1.16	10 725
		III	1	8	10 312	44.12	0.91	9 412
		IV	1	3	10 502	193.71	4.01	42 090
1998	Manchong (corrected to 40 mm)	I	1	22	19 832	22.30	0.26	5 069
			2	13	10 100	28.81	0.33	3 336
		I	All	35	29 932	25.56	0.29	8 769
		II	1	1	9 243	29.21	0.33	3 095
			2	61	52 856	14.42	0.17	8 738
		II	All	62	62 099	21.82	0.25	15 530
		III	1	3	10 312	22.32	0.26	2 638
			2	10	7 407	8.07	0.09	684
		III	All	13	17 720	15.19	0.17	3 086
		IV	1	4	10 502	5.82	0.07	701
			2	4	3 104	7.70	0.09	273
		IV	All	8	13 607	6.76	0.08	1 054
		I - IV	All Area	118	123 359	17.33	0.20	24 509

Note: [1] Stratum 1 = 5 nm - 55 m; Stratum 2 = 56 - EEZ Limit.

[2] Estimates are from log-transformed catch-per-unit-effort.

Appendix K. Demersal fish biomass by year and depth stratum off the coast of Sarawak, Malaysia.

Year	Vessel/mesh-size	Sub-area	Stratum[1]	No. of Stn.	Area (km^2)	Catch rate [2] $kg \cdot hr^{-1}$	Stock Density ($t \cdot km^{-2}$)	Biomass (t)
1972	Jenahak	I	1	56	22 467	107.21	3.69	82 945
	(Corrected to 38 mm)		2	13	10 166	69.45	2.39	24 313
		II	1	54	21 029	126.8	2.39	50 294
		III	1	47	11 242	217.61	7.49	84 245
			2	7	11 764	103.13	3.55	41 781
1981	Merah (38 mm)	I	1	51	22 467	71.74	3.39	76 274
		II	1	39	21 029	124.75	5.90	124 150
		III	1	30	11 242	171.2	8.10	91 081
1986	Rastrelliger	I	1	14	22 467	150.49	1.29	29 018
	(corrected to 38 mm)		2	13	10 166	144.42	1.24	12 601
			3	1	892	150.18	1.29	1 150
		I	All	28	33 525	148.36	1.27	42 689
		II	1	18	21 029	221.9	1.90	40 060
			2	21	16 417	138.815	1.19	19 558
			3	28	22 908	156.73	1.35	30 816
		II	All	67	60 355	172.50	1.48	89 355
		III	1	3	11 242	137.23	1.18	13 241
			2	15	11 764	89.94	0.77	9 081
			3	16	15 555	39.98	0.34	5 337
		III	Al	34	38 562	89.05	0.76	29 472
		I - III	All Area	129	132 444	136.64	1.17	155 318
1989	Manchong (38 mm)	I	1	30	22 467	64.12	0.84	18 874
			2	13	10 166	141.25	1.85	18 813
1989 - 92		II	1	11	21 029	109.95	1.44	30 294
			2	18	16 417	121.34	1.59	26 099
		III	1	3	11 242	145.93	1.91	21 494
1993			2	13	11 764	120.05	1.57	18 504
1998	Manchong (38 mm)	I	1	11	22 467	38.92	0.45	10 024
			2	13	10 166	72.73	0.83	8 476
			3	1	892	92.57	1.06	946
		I	All	25	33 525	68.07	0.78	26 163
		II	1	16	21 029	66.19	0.76	15 957
			2	20	16 417	85.93	0.99	16 172
			3	30	22 908	169.29	1.94	44 460
		II	All	66	60 355	107.14	1.23	74 130
		III	1	6	11 242	160.99	1.85	20 748
			2	11	11 764	90.13	1.03	12 156
			3	19	15 555	95.33	1.09	17 000
		III	All	36	38 562	115.48	1.32	51 053
		I - III	All Area	127	132 444	96.90	1.11	147 124

Note: [1] Stratum 1 = 5 nm - 55 m; Stratum 2 = 56 - 91 m; Stratum 3 = 92 - Territorial Water Limit.
[2] Estimates are from log-transformed catch-per-unit-effort.

Appendix L. Demersal fish biomass by year and depth stratum off the west coast of Sabah.

Year	Vessel/mesh-size	Sub-area	Stratum[1]	No. of Stn.	Area (km^2)	Catch rate [2] $kg \cdot hr^{-1}$	Stock Density ($t \cdot km^{-2}$)	Biomass (t)
1972	Jenahak	IV	1	6	11 557	393.75	13.56	156 716
	(Corrected to 38 mm)	V	1	59	8 652	304.75	10.49	90 797
1986	Rastrelliger	IV	1	2	11 557	382.69	3.28	37 962
	(Corrected to 38 mm)		2	4	2 881	24.71	0.21	611
			3	3	1 874	14.50	0.12	233
		IV /	All	9	16 313	140.63	1.2	19 691
		V	1	2	8 652	349.59	3.00	25 959
			2	4	3 641	242.23	2.08	7 570
			3	2	2 334	50.39	0.43	1 009
		V	All	8	14 627	214.07	1.84	26 875
		IV - V	All Area	17	30 941	177.35	1.52	47 097
1993	Manchong (38 mm)	IV	1	4	11 557	217.3	2.85	2 905
			2	6	2 881	144.14	1.89	5 440
			3	1	1 874	75.68	0.99	1 858
		IV /	All	11	16 313	145.71	1.91	31 142
		V	1	13	8 652	131.11	1.72	14 862
			2	7	3 641	101.98	1.34	4 865
			3	3	2 334	384.33	5.04	11 753
		V	All	23	14 627	205.81	2.7	39 442
		IV - V	All Area	34	30 941	175.76	2.31	46 673
1998	Manchong (38 mm)	IV	1	4	11 557	48.65	0.56	6 446
			2	6	2 881	114.98	1.32	3 797
			3	1	1 874	63.19	0.72	1 357
		IV /	All	11	16 313	75.61	0.87	14 139
		V	1	13	8 652	53.99	0.62	5 355
			2	7	3 641	133.87	1.53	5 588
			3	3	2 334	42.48	0.49	1 136
		V	All	23	14 627	115.17	0.88	12 875
		IV - V	All Area	34	30 941	76.19	0.87	20 233

Note: [1] Stratum 1 = 0 - 55 m; Stratum 2 = 56 - 91 m; Stratum 3 = 92 - Territorial Water Limit.
[2] Estimates are from log-transformed catch-per-unit effort.

Appendix M. Annual demersal catch, CPUE of the research vessel KK Jenahak and estimated total effort off the west coast of Peninsular Malaysia.

Year	Demersal catch (t)	CPUE * KK Jenahak ($t \cdot hr^{-1}$)	Estimated Total effort ($t \cdot hr^{-1}$)	Weighted average Total effort ($t \cdot hr^{-1}$)
1971	86 514	0.089 4	967 718	967 718
1972	100 405	0.087 1	1 152 755	1 078 740
1973	127 351	0.084 8	1 501 780	1 296 428
1974	150 342	0.082 5	1 822 327	1 603 883
1975	135 944	0.080 2	1 695 062	1 705 270
1976	152 597	0.077 9	1 958 883	1 848 183
1977	180 007	0.075 6	2 381 044	2 125 993
1978	181 658	0.083 3	2 478 281	2 359 302
1979	180 813	0.071 0	2 546 661	2 496 265
1980	168 873	0.068 7	2 458 122	2 490 995
1981	187 661	0.066 4	2 826 221	2 656 928
1982	192 449	0.064 1	3 002 324	2 852 923
1983	208 168	0.061 8	3 368 414	3 156 019
1984	185 298	0.059 5	3 114 254	3 180 319
1985	215 500	0.057 2	3 767 482	3 483 228
1986	261 212	0.054 9	4 757 959	4 153 849
1987	279 749	0.052 6	5 318 422	4 873 111
1988	235 168	0.050 3	4 675 308	4 903 455
1989	271 876	0.048 0	5 664 083	5 276 881
1990	294 931	0.045 7	6 453 632	5 894 062
1991	239 023	0.043 4	5 507 442	5 848 946
1992	263 985	0.041 1	6 422 992	6 122 915
1993	258 878	0.038 8	6 672 113	6 394 961
1994	257 318	0.036 5	7 049 808	6 819 440
1995	278 976	0.034 2	8 157 192	7 540 551
1996	304 668	0.031 9	9 550 721	8 669 393

Note: * Values calculated from linear relationship obtained from changes in catch rate over time during the surveys conducted in 1971, 1981, 1987, 1991 and 1997 in Sub-areas I and II off the west coast of Peninsular Malaysia.

$\ln (c/f_{wt}) = -2.250\ 3 - 1.42E - 07 f_{wt}$ $\quad r^2 = 0.945\ 5$

Fox Model : MSY = 273 374 t

$f_{MSY} = 7.06 \times 10^6$ towing hours of KK Jenahak

Appendix N. Annual demersal catch, CPUE off the research vessel KK Jenahak and estimated total effort off the east coast of Peninsular Malaysia.

Year	Demersal catch (t)	CPUE * KK Jenahak ($t \cdot hr^{-1}$)	Estimated Total effort ($t \cdot hr^{-1}$)	Weighted average Total effort ($t \cdot hr^{-1}$)
1971	30 534	0.224 3	136 130	136 130
1972	26 418	0.219 4	120 410	126 698
1973	39 158	0.214 5	182 555	154 103
1974	52 019	0.209 6	248 182	205 011
1975	39 540	0.204 7	193 161	209 734
1976	54 099	0.199 8	270 766	241 134
1977	44 133	0.194 9	226 439	235 668
1978	53 336	0.190 0	280 716	260 965
1979	50 727	0.185 1	274 052	268 338
1980	43 457	0.180 2	241 160	258 717
1981	63 061	0.175 3	359 734	305 929
1982	52 480	0.170 4	307 981	314 095
1983	56 736	0.165 5	342 816	334 024
1984	51 398	0.160 6	320 041	325 623
1985	50 069	0.155 7	321 574	324 603
1986	70 693	0.150 8	468 786	394 925
1987	87 892	0.145 9	602 413	511 064
1988	136 269	0.141 0	966 447	762 159
1989	147 691	0.136 1	1 085 165	965 134
1990	198 307	0.131 2	1 511 486	1 278 539
1991	183 962	0.126 3	1 456 548	1 412 964
1992	175 980	0.121 4	1 449 588	1 462 224
1993	198 084	0.116 5	1 700 292	1 576 100
1994	192 702	0.111 6	1 726 720	1 671 722
1995	178 109	0.106 7	1 669 250	1 693 580
1996	169 660	0.101 8	1 666 601	1 677 504

Note: * Values calculated from linear relationship obtained from changes in catch rate over time during the surveys conducted in 1967, 1972, 1981, 1986 and 1991 off the east coast of Peninsular Malaysia.

$n\ (c/f_{wt}) = -1.5316 - 3.85E - 07f_{wt}$ $\quad r^2 = 0.7835$

Fox Model : MSY = 206 412 t

$f_{MSY} = 2.59 \times 10^6$ towing hours of KK Jenahak

Appendix O. Annual demersal catch, CPUE of the research vessel KK Manchong and estimated total effort off the coast of Sarawak.

Year	Demersal catch (t)	CPUE * KK Jenahak ($t \cdot hr^{-1}$)	Estimated Total effort ($t \cdot hr^{-1}$)	Weighted average Total effort ($t \cdot hr^{-1}$)
1969	4 757	0.417 3	11 399	11 399
1970	7 403	0.404 0	18 324	15 554
1971	7 126	0.390 7	18 239	17 127
1972	9 132	0.377 4	24 197	21 232
1973	24 483	0.364 1	67 243	44 727
1974	29 726	0.350 8	84 738	68 816
1975	41 134	0.337 5	121 879	100 393
1976	46 396	0.324 2	143 109	126 304
1977	46 870	0.310 9	150 756	143 394
1978	47 392	0.297 6	159 247	153 727
1979	52 487	0.284 3	184 618	170 517
1980	46 256	0.271 0	170 686	173 424
1981	37 315	0.257 7	144 800	160 065
1982	38 749	0.244 4	158 547	155 988
1983	37 138	0.231 1	160 701	157 333
1984	29 880	0.217 8	137 190	148 587
1985	29 778	0.204 5	145 614	145 321
1986	39 248	0.191 2	205 272	174 039
1987	31 072	0.177 9	174 660	180 023
1988	34 796	0.164 6	211 397	198 131
1989	40 092	0.151 3	264 983	232 067
1990	36 943	0.138 0	267 703	257 412
1991	46 669	0.124 7	374 250	320 523
1992	45 212	0.111 4	405 853	372 294
1993	43 078	0.098 1	439 123	417 221
1994	58 460	0.084 8	689 387	558 710
1995	66790	0.071 5	934 126	770 046
1996	56 053	0.058 2	963 110	907 828

Note: * Values calculated from linear relationship obtained from changes in catch rate over time during the surveys conducted in 1972, 1981, 1986, 1989 - 93 and 1998 in areas less than 91 m depth off the coast of Sarawak.

$\ln (c/f_{wt}) = -0.9566 - 2.36E - 06 f_{wt}$ $\quad r^2 = 0.7993$

Fox Model : MSY = 59 878 t

$f_{MSY} = 0.423 \times 10^6$ towing hours of KK Manchong