ON THE APPLICATION OF CATCH AND EFFORT INFORMATION FROM THE HONG KONG TRAWL FISHERY, AND ASSOCIATED PROBLEMS

by

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1. Introduction

The marine capture fishery based in Hong Kong is a multi-gear, multi-species fishery, mainly exploiting the tropical demersal resources of the northern part of the South China Sea continental shelf and supplying the bulk of the food consumption needs of the local population. About 70% of the Hong Kong fish production is obtained by trawling, with the remainder by various selective gears such as lines, gill nets and purse seines (Figure 1). The state of the Hong Kong capture fishery has been described by Gaiger and Richards (1980) and AFD (1986). Production from trawlers increased from 82 thousand mt in 1973 to 141 thousand mt in 1985 (Figure 1) despite a decline in numbers of trawlers in recent years (Table 1). This suggests changes in the fishing power and fishing patterns of these subsectors and indeed the engine powers of newly licensed vessels also show a consistent upward trend for pair trawlers and stern trawlers (Figure 2). This paper examines the factors behind these changes particularly as they relate to the manner of resource exploitation, by an analysis of the catch and effort information of the pair and stern trawl subsectors.

Table 1. The composition of the Hong Kong fishing fleet

	1973	1976	1979	1982	1985
Trawlers Pair					
Modern	88	114	231	216	379
Junk	271	231	125	39	29
Stern	73	160	447	448	289
Shrimp	1406	1365	1296	1027	996
Hang	*	64	75	69	32
Sub-total	1838	1934	2174	1799	1725
Total fleet	5382	5474	5428	4759	4714

* Data not available

2. The trawler catch and effort programme

2.1 A trawler catch and effort statistics sampling programme was initiated in 1973 with the objective of revealing temporal changes in the relative abundance of exploited demersal resources. About 10% of the stern and pair trawlers landing at two out of seven wholesale markets operated by the Fish Marketing Organization (FMO) was sampled and effort information was collected by interviewing skippers on randomly selected dates. Data on related total landed catch by commercial taxa were also complied from records of market sales transactions and, together with the effort data which were assigned to a statistical grid of 1/2 degree longitude by 1/2 degree latitude (Figure 3), were processed to produce quarterly tabulations of catch per unit effort for each taxon.

2.2 Since 1975 additional details regarding vessel power, gear dimensions, and other supplementary data such as landings outside Hong Kong were also collected. This has enabled the computation of an adjusted unit of effort (in terms of the product of days fishing, length of trawl headline and total nominal engine power of the unit) which would take account, by and large, of possible effects on fishing power resulting from changes in vessel and gear characteristics.

3. Operational characteristics of trawlers

3.1 Vessel power

Although in the early 1970's the majority of pair trawlers were junks (i.e. those with a traditional-style wooden hull) their numbers quickly dwindled either because of conversion to modern hull or because of displacement from the trawler fleet due to economic factors (including age of vessel). With the increasing number of modern pair and stern trawlers, the mean nominal engine power of vessels showed a sustained increasing trend (Figure 4), especially for modern pair trawlers, which may be expected to increase their fishing powers. While this observation is in accord with that of newly licensed trawlers shown earlier in Figure 2, a large proportion of the increase in mean nominal engine power is probably due to retrofits of additional propulsive engines such that a vessel commonly has two, or sometimes three propellers. There is however still considerable variation in the total engine power of vessels, with a range of 161-776 kwatt for modern pair trawlers and 161-649 kwatt for stern trawlers, as reported by the skippers interviewed in 1985.

3.2 Gear characteristics

Although details of the gear used were not studied in the catch and effort programme, it was recognised that the area swept by the trawl does bear an important relation to fishing power. The mean headline length of trawls however, remained steady for stern trawlers, but tended to increase slightly for modern pair trawlers since 1979 (Figure 5). There was also a wide variation in the reported length of the headline used.

3.3 Fishing duration per trip

Despite developments in the performance of trawlers, ice remains the most important catch preservative and this together with the capacity of the fish hold limits the duration of a fishing cruise. The number of days spent fishing per trip is generally less than 10 days (Figure 6). As the fishing power of modern pair trawlers increases, the duration of their fishing trips has been on the rise in recent years. The preference for shorter trips in the third quarter previously due to the typhoon season is now less obvious. Stern trawlers generally tend towards longer trips which could be due to the more distant location of their grounds.

3.4 Fishing effort and distribution

Over the past twelve years, there have been considerable changes in the distribution of fishing effort resulting from improvements in the use of navigational technology, fishing skills, and political considerations such as the declaration of Exclusive Economic Zone (EEZ) by neighbouring countries and the imposition of the 40 m trawling ban along certain areas of the coastline by China since 1980. These are further compounded by economic considerations of the value of the catch in relation to the type of species and the location of fishing grounds within the range of the vessel.

The distribution of effort of stern trawlers in the years 1973, 76, 79, 82 and 85 is summarized in Table 2. The major change seems to be a shift from grounds southwest of Hong Kong in 1973, northeastwards to 20 degrees N latitude in the late 1970's, and eventually to between 25 degrees N and 28 degrees N in the 1980's with only a small proportion of the effort spent southwest of Hong Kong. The latter pattern has meant a longer steaming distance to and from grounds and hence a higher operating cost which has to be offset by economic gains higher than obtainable in waters nearer Hong Kong.

For modern pair trawlers, the distribution of effort was quite different from the stern trawlers with fishing occurring in deeper waters down to about 130 m. In the 1970's, effort was generally spent within 450 km

of Hong Kong and to the west of 116 degree E. However, a distinctly different and scattered effort pattern was obtained in the 1980's overlapping with that of stern trawlers in areas east of 116 degrees E.

Table 3 shows the distribution of landed catch by geographical location for trawlers landing at the two sampled FMO markets, with the greater proportion of landings derived from the South China Sea area. Estimates of total production in Hong Kong by types of trawlers were available as from 1980, so that it was possible to apply the annual percentages distribution of fishing effort to obtain an estimate of production by area (Figure 7). Judging from the effort patterns, it could be that part of the recent increase in marine capture production was in fact due to an expansion in the resource base to include the East China Sea stocks and the increase in production from the Gulf of Tong King area.

4. Composition of landed catch

The landings composition for ten major taxa from 1975 is shown in Table 5. These taxa accounted for about 60% of the total landed catch by the sampled pair and stern trawlers. Considerable variations were found and over the decade a consistent change in the composition is difficult to observe. However, it is noted that yellow croaker *(Pseudosciaena crocea)* and lizard fishes *(Saurida* spp.) generally represented a significant proportion of the total landed catch from respectively the East China Sea and the other two sea areas.

5. Catch and effort

The question of the state of exploitation of fishery resources in the South China Sea has long remained unanswered partly because of inadequate statistics and partly because of slow progress in theoretical development of tropical stock assessment methodology. This paper could therefore only attempt to highlight those features relevant to an understanding of the performance of the stocks, i.e. the interrelations between catch, effort and catch per unit effort. Figure 8 shows the change in catch per unit effort from 1973 to 1985 for the two types of trawlers and expressed in two units of effort. The CPUE calculated from the adjusted effort (or product effort) may give a more unbiased measure of the stock abundance.Each of the two CPUE indices (tonnes per day and kg per product effort) for the two categories of trawlers showed similar changes in the South China Sea. The stock abundance reflected by the 1985 modern pair trawler's CPUE expressed in kg per product effort is only about 34% of what it was in 1975. Similar decreases are recorded for the five major species of the multi-species stock (Table 4). The resource levels in the Gulf of Tong King and East China Sea also tended to follow the same trend.

6. Stock assessment

6.1 With the foregoing limitations in mind, the state of exploitation of South China Sea demersal resources can be assessed by referring the present fishery to a point on the 'yield curve'. Construction of the latter necessarily entails gross assumptions, the major ones being that the stock may be described by a simple form of surplus production model, and that changes in the pattern of exploitation by neighbouring countries on the same stocks but for which data are unavailable are at similar rates to those of Hong Kong. Using the exponential form of the surplus production model (Gulland 1983), i.e.

$$\ln U = a - bf$$

where U = pooled CPUE for South China Sea using adjusted effort for all taxa for all trawlers, (kg per 1 000 m HL. HP. day)

f = total equivalent effort for South China Sea, i.e. assuming production by all other non-trawl gears as from South China Sea (in million 1 000 m HL. HP. days)

The plot of ln U against f shown in Figure 9 gives estimates of

$a = 4.39$ (in CPUE units)

$b = 1.96 \times 10^{-7}$

from which the maximum yield $Y_{max} = \frac{U}{be} = \frac{e^a}{be} = \frac{e^{(a-1)}}{b} = 151{,}400$ tonnes

6.2 The equivalent yield curve for Hong Kong is shown in Figure 10 from which the exploitation state of the resource in 1985 may be infefred. On this basis, it is evident that any future increase in demand may not be met from existing resources in the South China Sea, but may have to be obtained through geographical expansion of the resource base. Meanwhile, appropriate management measures should be taken to conserve the existing resources.

7. Discussion

7.1 The present programme from which the catch and effort data have been derived has several recognised deficiencies which may directly affect the accuracy of the output. These include the large unit area of a statistical rectangle; the limited coverage afforded by sampling at only two wholesale markets; the small sampling ratio of only 10%; possible errors in assigning effort data into statistical rectangles; and the averaging effect in partitioning landed catch between rectangles as a computational routine. One may indeed also call into question the practice of using the adjusted (product) effort as a common unit to permit pooling of stern trawl and pair trawl data, although the mathematical advantage so afforded in combining two indices would outweigh the disadvantage of relying on one data set as the standard with consequence of limited geographical and resource coverage.

7.2 Most fishing vessels in Hong Kong are also licensed in China and in the past, this was on condition that a proportion of their catch, a quota, is landed there. The quota level set may vary with the vessel, and the mean reported values are shown in Table 6. However, skippers are seldom able to report the quota volume for any particular occasion and, as a result, quota landings are a systematic omission from landed catch per effort data. Recently, this deficiency in the data has been further complicated by sales of catches at sea. The volume of such sales is difficult to estimate, but whenever such information is available from the skippers, it is included in data analysis so as to minimize such bias.

7.3 These problems aside, it must be pointed out that the distinction between the three geographical fishing areas used in this paper is arbitrary insofar as the unit nature of their respective stocks is concerned. Further analyses would require more detailed consideration of the dynamics of tropical systems and interspecific interactions under exploitation, as well as fishery statistics from other countries fishing these common stocks.

References

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Table 2. Quarterly and annual percentage distribution of fishing effort (fishing days) in three main fishing areas, Gulf of Tong King (GTK), South China Sea (SCS) and East China Sea (ECS).

		Modern Stern Trawler			Modern Pair Trawler			Junk Pair Trawler		
		GTK	SCS	ECS	GTK	SCS	ECS	GTK	SCS	ECS
1973	01	6.5	93.5	-	14.2	85.8	-	-	100.0	-
	02	5.4	90.1	4.5	10.2	89.9	-	-	100.0	-
	03	-	98.3	1.7	-	100.0	-	-	100.0	-
	04	0.4	99.6	-	8.6	91.4	-	-	100.0	-
	Annual	2.8	95.9	1.4	8.5	91.5	-	-	100.0	-
1976	Q1	10.4	81.9	7.8	27.9	72.1	-	-	100.0	-
	Q2	-	80.5	19.5	5.6	94.4	-	-	100.0	-
	Q3	-	54.5	45.5	-	100.0	-	-	100.0	-
	Q4	0.5	99.5	-	6.4	93.6	-	-	100.0	-
	Annual	2.0	77.1	21.0	9.8	90.2	-	-	100.0	-
1979	Q1	3.9	51.6	44.6	15.2	84.1	0.7	-	100.0	-
	Q2	5.0	21.6	73.4	17.4	82.6	-	-	-	-
	Q3	4.2	64.3	31.5	6.2	93.8	-	-	-	-
	Q4	15.0	51.5	33.5	21.3	78.7	-	-	-	-
	Annual	6.4	46.5	47.1	15.0	84.8	0.2	-	100.0	-
1982	Q1	-	13.2	85.9	2.6	97.4	-	-	-	-
	Q2	-	30.9	68.2	9.4	90.6	-	-	-	-
	Q3	-	43.3	56.7	14.4	85.7	-	-	-	-
	Q4	3.9	7.0	89.1	7.8	83.5	8.7	-	-	-
	Annual	0.6	27.8	71.6	8.7	89.1	2.1	-	-	-
1985	Q1	37.7	41.0	21.2	16.9	76.1	7.0	-	-	-
	Q2	18.9	34.0	47.0	9.5	86.3	4.2	-	-	-
	Q3	-	59.6	40.4	25.9	64.9	9.2	-	-	-
	Q4	-	67.7	32.3	38.9	54.9	6.2	-	-	-
	Annual	12.8	51.1	36.2	22.6	70.7	6.6	-	-	-

Table 3. Quarterly and annual percentage distribution of landed catch by three main fishing areas as estimated by the catch and effort programme (GTK - Gulf of Tong King, SCS - South China Sea, ECS - East China Sea).

		Modern Stern Trawler			Modern Pair Trawler			Junk Pair Trawler		
		GTK	SCS	ECS	GTK	SCS	ECS	GTK	SCS	ECS
1973	Q1	1.9	19.7	-	9.1	46.8	-	-	22.5	-
	Q2	0.6	13.3	0.4	7.5	60.8	-	-	17.4	-
	Q3	-	26.9	0.3	-	54.2	-	-	18.6	-
	Q4	0.1	21.6	-	8.0	59.4	-	-	11.0	-
	Annual	0.6	20.6	0.2	6.1	55.3	-	-	17.3	-
1976	Q1	1.9	14.6	1.2	17.4	48.1	-	-	16.8	-
	Q2	-	14.5	2.7	3.5	62.4	-	-	17.0	-
	Q3	-	18.3	4.7	-	60.0	-	-	17.0	-
	Q4	0.1	20.7	-	3.2	61.6	-	-	14.5	-
	Annual	0.5	17.3	2.1	5.9	58.1	-	-	16.2	-
1979	Q1	1.3	10.3	8.6	13.8	63.3	0.7	-	2.8	-
	Q2	1.6	5.3	18.6	7.8	66.7	-	-	-	-
	Q3	1.2	16.2	9.4	3.6	69.6	-	-	-	-
	Q4	3.3	9.0	7.3	17.3	63.1	-	-	-	-
	Annual	1.8	10.0	11.2	10.6	65.6	0.2	-	0.5	-
1982	Q1	-	1.2	11.1	1.6	86.2	-	-	-	-
	Q2	-	3.4	8.8	5.0	82.8	-	-	-	-
	Q3	-	4.0	7.6	11.5	76.8	-	-	-	-
	Q4	0.4	0.3	10.7	6.2	75.6	6.8	-	-	-
	Annual	0.1	2.1	9.7	5.9	80.4	1.8	-	-	-
1985	Q1	3.4	2.1	1.2	17.5	68.7	7.1	-	-	-
	Q2	0.8	2.2	1.8	7.5	83.7	4.5	-	-	-
	Q3	-	3.7	1.4	19.6	69.5	5.7	-	-	-
	Q4	-	2.4	1.3	40.2	53.1	3.0	-	-	-
	Annual	1.1	2.6	1.4	21.4	68.5	5.0	-	-	-

Table 4. Annual catch per unit effort (kg per 1000 m HL. HP. day) for three major fishing areas, estimated for all taxa and five individual taxa using results pooled for all types of trawlers.

		75	76	77	78	79	80	81	82	83	84	85
All taxa	GTK	44.7	51.3	47.1	41.2	32.1	28.1	24.3	22.1	22.4	25.6	17.5
	SCS	52.3	55.4	51.6	41.2	41.2	39.5	41.2	34.6	36.2	29.2	17.9
	ECS	28.0	19.9	21.5	31.4	31.4	30.3	29.7	37.0	27.9	33.3	14.7
Big-eyes	GTK	5.6	4.5	3.9	3.2	3.4	4.3	2.4	3.5	3.9	4.0	2.8
(Priacanthus spp.)	SCS	5.2	8.4	3.2	2.9	5.5	7.5	6.5	8.4	4.8	2.6	2.1
	ECS	0.1	0.0	0.2	0.2	1.0	0.4	0.4	0.1	0.1	0.2	0.1
Scads	GTK	1.1	1.3	0.6	0.8	0.3	0.4	0.4	0.3	1.1	0.2	0.2
(Decapterus spp.)	SCS	5.5	6.5	3.7	4.9	2.6	4.1	3.1	3.2	3.3	2.7	1.3
	ECS	0.8	0.0	0.1	0.3	0.7	0.1	0.1	0.0	0.4	0.1	0.1
Yellow Belly	GTK	2.0	2.2	0.9	2.4	3.5	1.4	2.4	1.9	2.2	1.0	0.4
(Nemipterus	SCS	3.8	3.0	3.5	3.2	3.5	5.0	2.5	2.4	1.9	1.4	0.6
bathybius)	ECS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow croaker	GTK	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1
(Pseudosciaena	SCS	0.4	0.3	0.4	0.9	0.4	0.2	0.1	0.2	0.8	0.8	0.5
crocea)	ECS	10.3	7.8	4.6	6.5	6.6	10.7	13.0	9.2	9.2	8.4	6.3
Squid	GTK	0.6	0.6	0.9	0.5	0.3	0.3	0.4	0.5	0.4	0.2	0.7
(Loligo spp.)	SCS	4.5	4.9	2.0	2.4	4.0	2.9	3.1	3.0	2.2	1.4	1.1
	ECS	1.1	0.1	0.1	0.2	0.2	0.1	0.2	0.1	0.7	0.1	0.2

Table 5. Percentage landings composition of ten major taxa from three major fishing areas.

		75	76	77	78	79	80	81	82	83	84	85
Big-eyes	GTK	12.5	8.8	8.3	7.8	10.6	15.3	9.9	15.8	17.7	15.6	16.0
(Priacanthus spp.)	SCS	9.9	15.2	6.2	7.0	13.9	18.2	18.8	23.2	16.4	11.0	11.7
	ECS	0.4	0.0	0.9	0.6	3.3	1.4	1.1	0.4	3.0	1.2	0.7
Scads	GTK	2.5	2.5	1.3	1.9	0.9	1.4	1.7	1.4	5.0	0.8	1.1
(Decapterus spp.)	SCS	10.5	11.7	7.2	11.9	6.6	10.0	9.0	8.8	11.3	11.4	7.3
	ECS	2.9	0.0	0.5	1.0	2.3	0.3	0.3	0.0	1.2	0.6	0.7
Yellow belly	GTK	4.5	4.3	1.9	5.8	10.9	5.0	9.9	8.6	10.0	3.9	2.3
(Memipterus	SCS	7.3	5.4	6.8	7.8	8.9	12.1	7.2	6.6	6.5	5.9	3.4
bathybius)	ECS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Yellow croaker	GTK	0.0	0.2	0.2	0.0	0.3	0.0	0.0	0.0	0.0	0.5	0.6
(Pseudosciaena	SCS	0.8	0.5	0.8	2.2	1.0	0.5	0.3	0.6	2.7	3.4	2.8
crocea)	ECS	36.8	39.2	21.4	20.7	21.8	36.0	35.1	33.0	27.6	49.1	42.9

Table 5. (continued)

		75	76	77	78	79	80	81	82	83	84	85
Squid	GTK	1.3	1.2	1.9	1.2	0.9	1.1	1.7	2.3	1.8	0.8	4.0
(Loligo spp.)	SCS	8.6	8.8	3.9	5.8	10.1	7.0	9.0	8.3	7.5	5.9	6.2
	ECS	3.9	0.5	0.5	0.6	0.7	0.3	0.5	0.4	2.1	0.6	1.4
Golden thread	GTK	1.4	1.4	-	-	2.2	2.5	3.3	3.2	2.7	5.9	5.1
(Nemipterus	SCS	4.2	4.3	-	-	5.8	7.5	8.1	8.3	7.2	6.8	10.1
virgatus)	ECS	0.0	1.5	-	-	0.3	0.3	0.3	0.0	0.9	0.2	0.7
Lizardfishes	GTK	3.8	4.3	-	-	11.5	10.3	9.1	11.3	8.6	11.3	10.3
(Saurida spp.)	SCS	6.5	7.6	-	-	9.6	8.5	9.8	9.1	6.9	10.6	10.1
	ECS	1.1	0.5	-	-	1.3	0.3	0.5	0.4	0.9	0.6	0.7
Hairtails	GTK	3.6	2.3	-	-	0.3	0.7	0.8	2.3	3.2	5.5	3.4
(Trichiurus	SCS	5.2	3.8	-	-	1.8	1.5	3.8	3.3	3.8	4.2	5.6
haumela)	ECS	3.6	3.5	-	-	2.6	3.4	4.9	2.9	2.7	2.3	0.7
Conger pike-eels	GTK	4.3	2.3	-	-	2.8	2.9	2.5	2.7	2.7	2.7	4.0
(Muraenesocidae	SCS	2.9	2.2	-	-	3.8	2.2	2.3	2.2	2.1	2.5	2.9
spp.)	ECS	9.6	7.5	-	-	10.6	9.4	16.0	14.7	10.2	7.6	4.8
Croakers	*GTK*	*1.3*	*1.0*	-	-	*0.6*	*1.1*	*0.4*	*1.4*	*0.9*	*4.7*	*10.3*
(Sciaenidae)	*SCS*	*1.9*	*1.6*	-	-	*2.0*	*1.5*	*1.5*	*1.1*	*1.4*	*2.5*	*3.4*
	ECS	*6.1*	*17.6*	-	-	*12.2*	*11.5*	*16.5*	*9.0*	*12.0*	*8.2*	*6.1*

Table 6. Annual mean quota (tonnes per vessel) as reported for stern, modern pair and junk pair trawlers sampled in the catch and effort programme.

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Stern Trawler	43.1	42.1	42.5	42.2	42.5	41.6	42.8	46.7	49.8	35.9
Junk Pair Trawler	42.3	50.0	47.1	36.3	36.3	-	-	-	-	-
Modern Pair Trawler	47.8	54.6	57.4	56.3	54.2	55.0	57.9	71.4	57.5	58.1

" - " Data not available

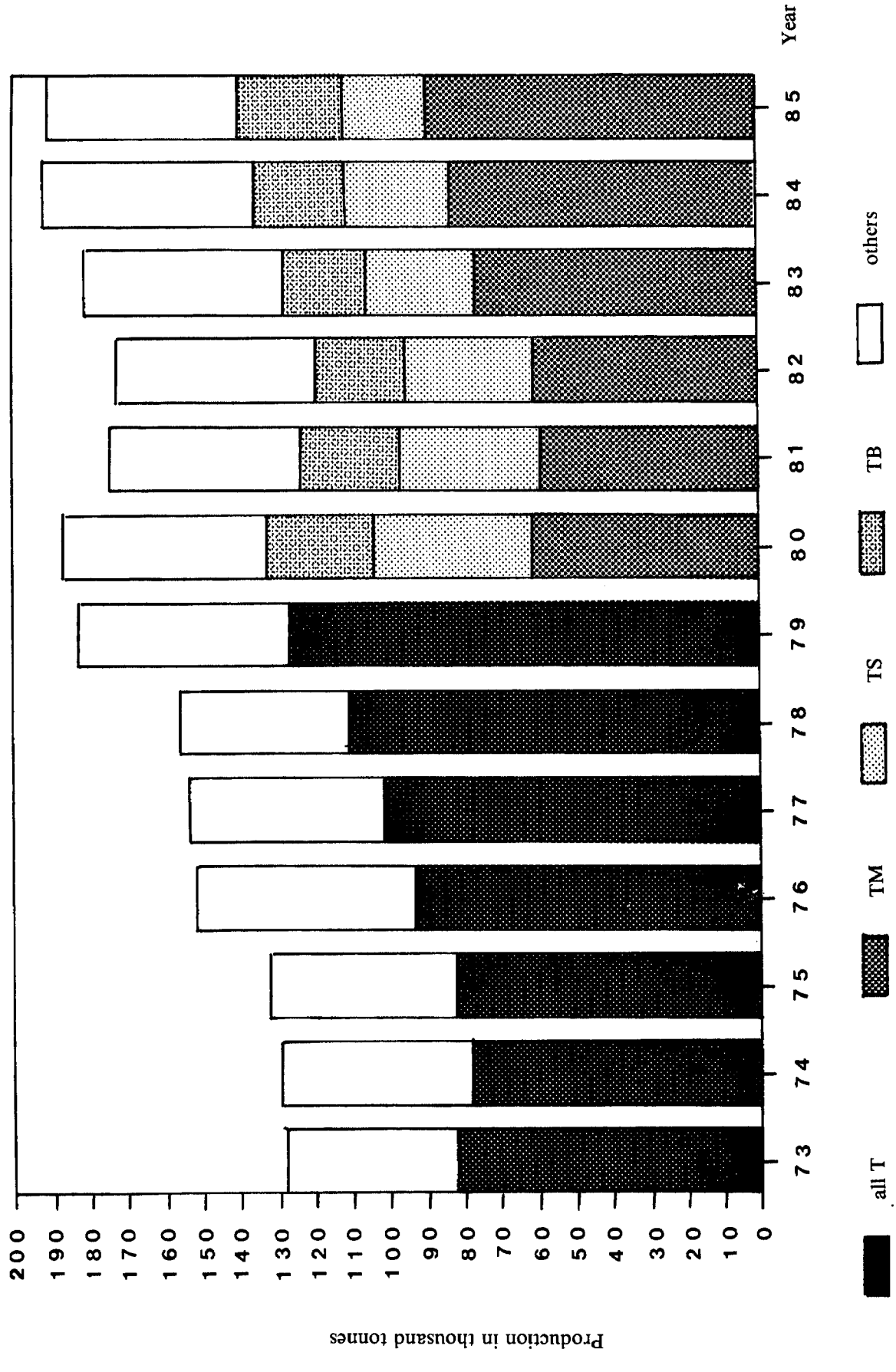


Fig. 1. Annual marine capture fisheries production of Hong Kong.
(T = trawl; TM = pair trawl; TS = stern trawl; TB = shrimp trawl; others = other gears.)

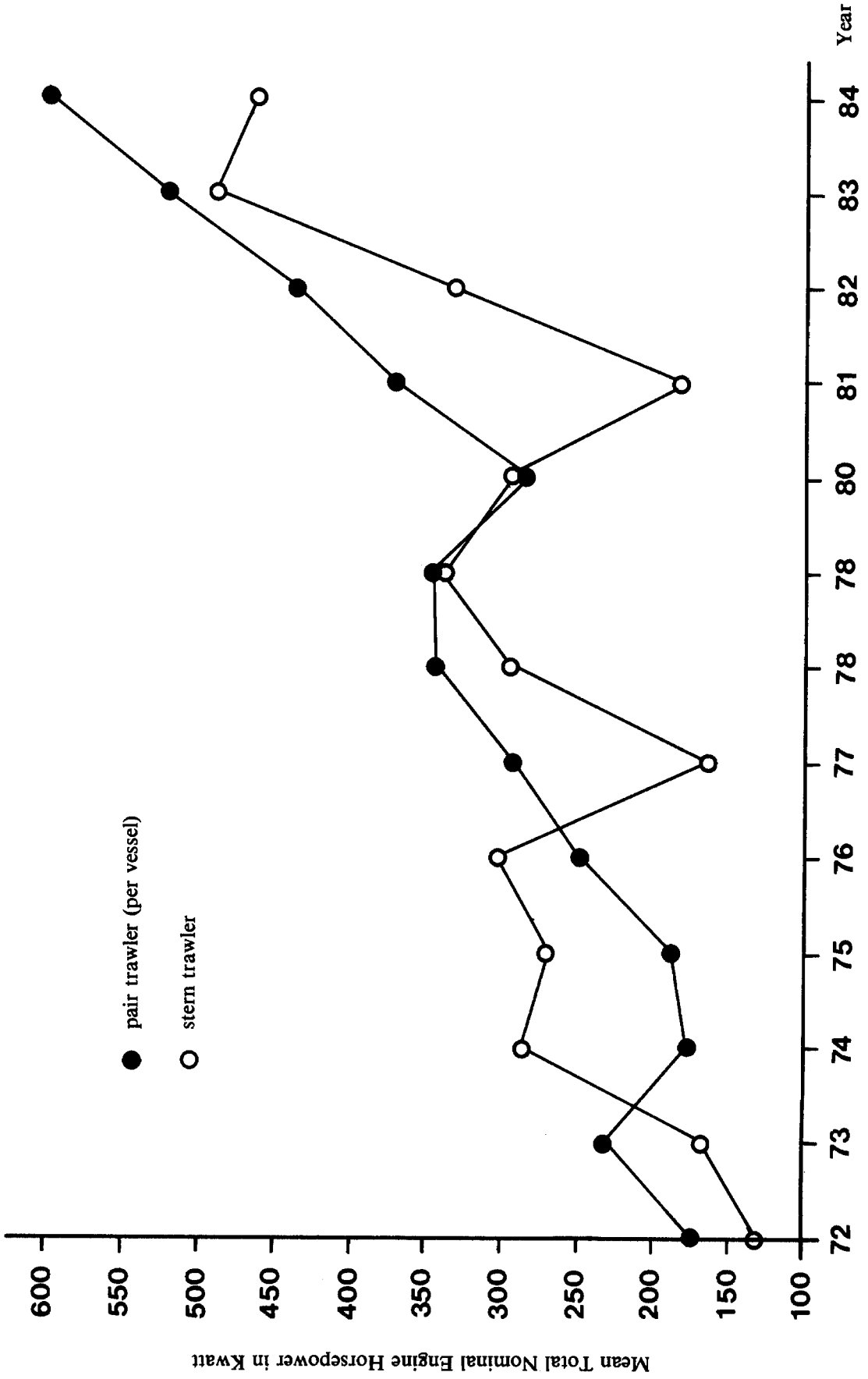


Fig. 2. Mean total nominal engine horse-power of trawlers newly licensed in Hong Kong.

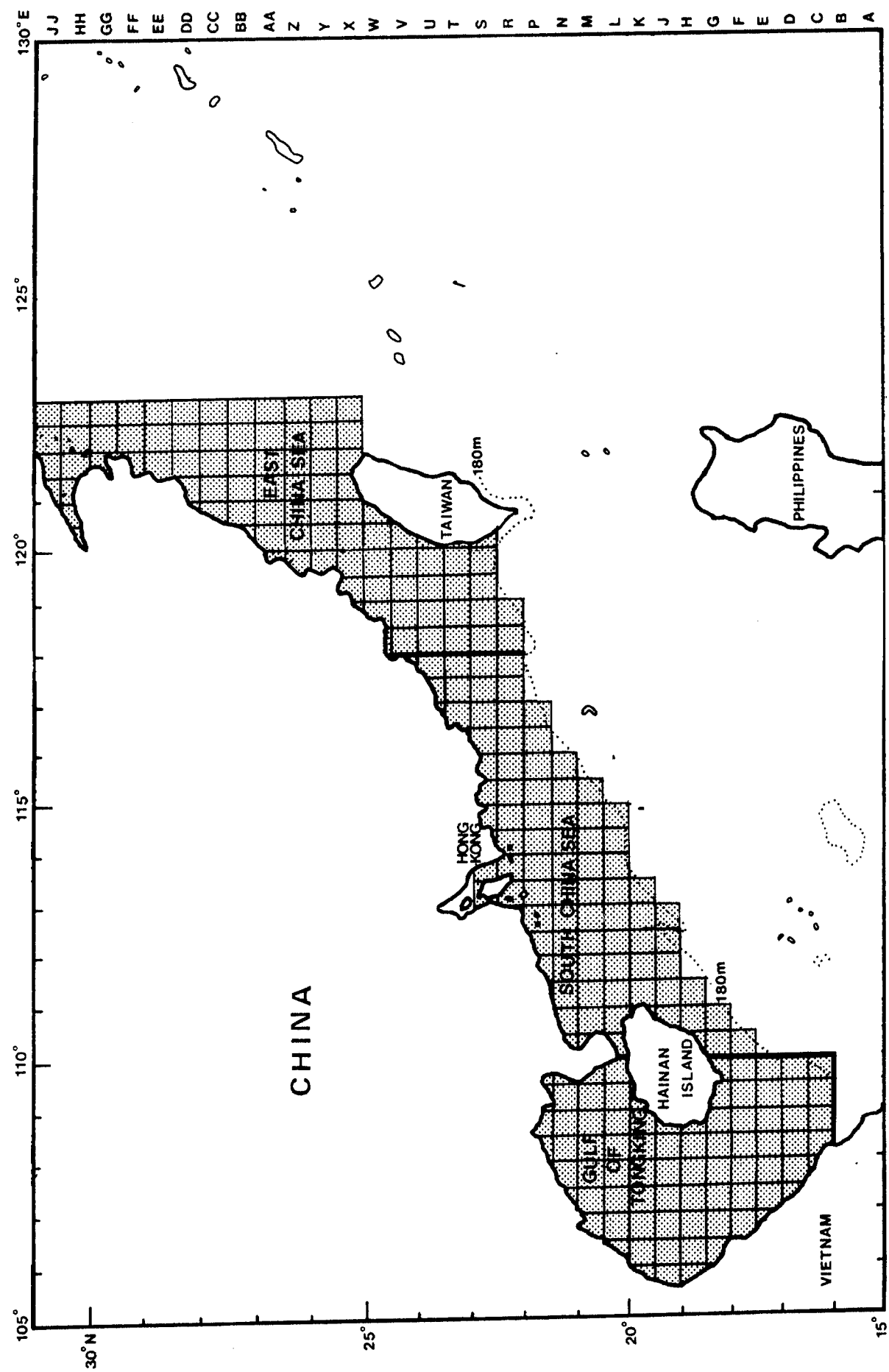


Fig. 3. Chart of statistical rectangles and fishing areas used in the catch and effort programme.

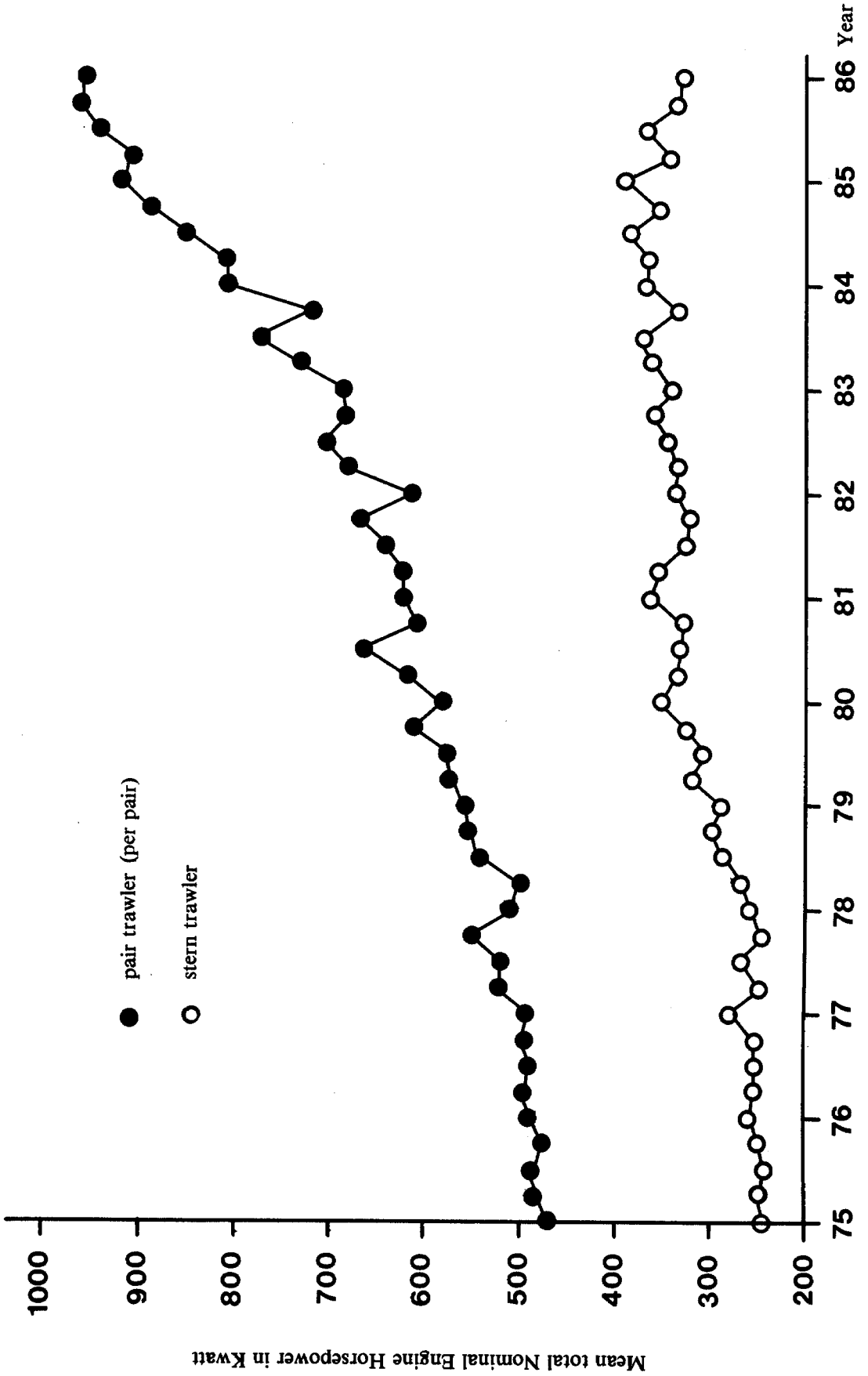


Fig. 4. Mean total nominal engine horse-power of trawlers sampled in the catch and effort programme.

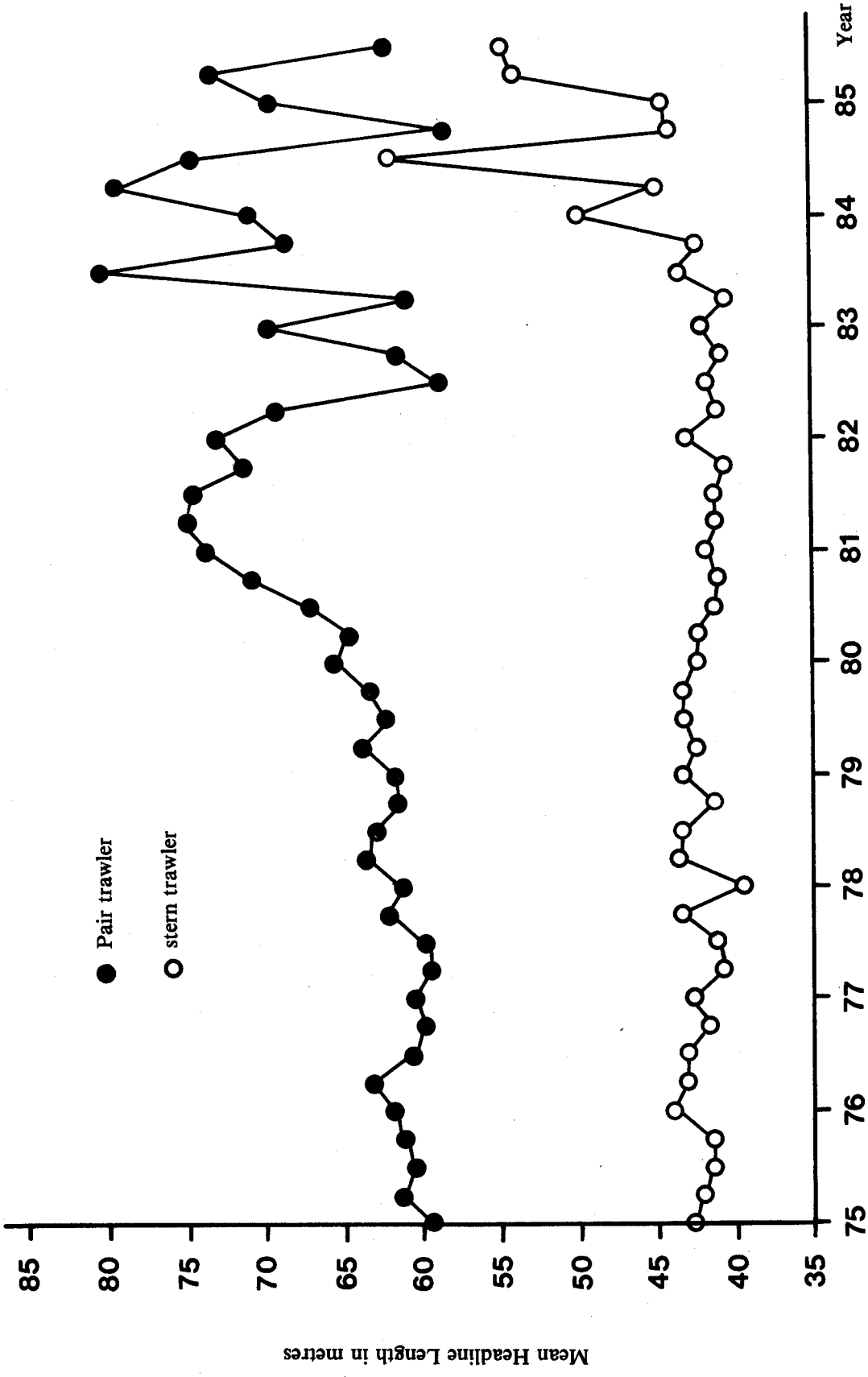


Fig. 5. Mean headline length of trawl used by trawlers sampled in the catch and effort programme.

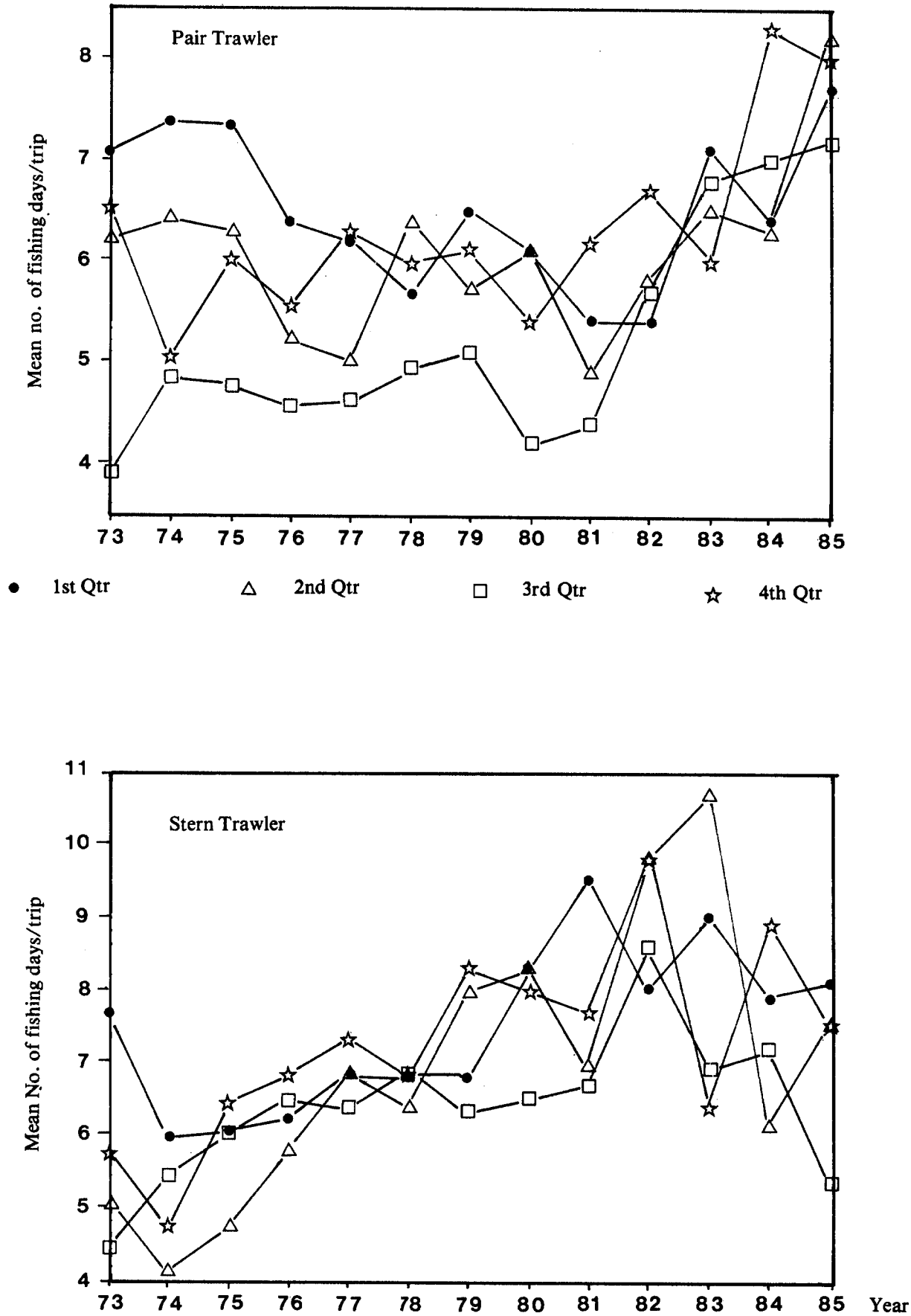


Fig. 6. Mean fishing days per trip for modern pair and stern trawlers sampled in the catch and effort programme.

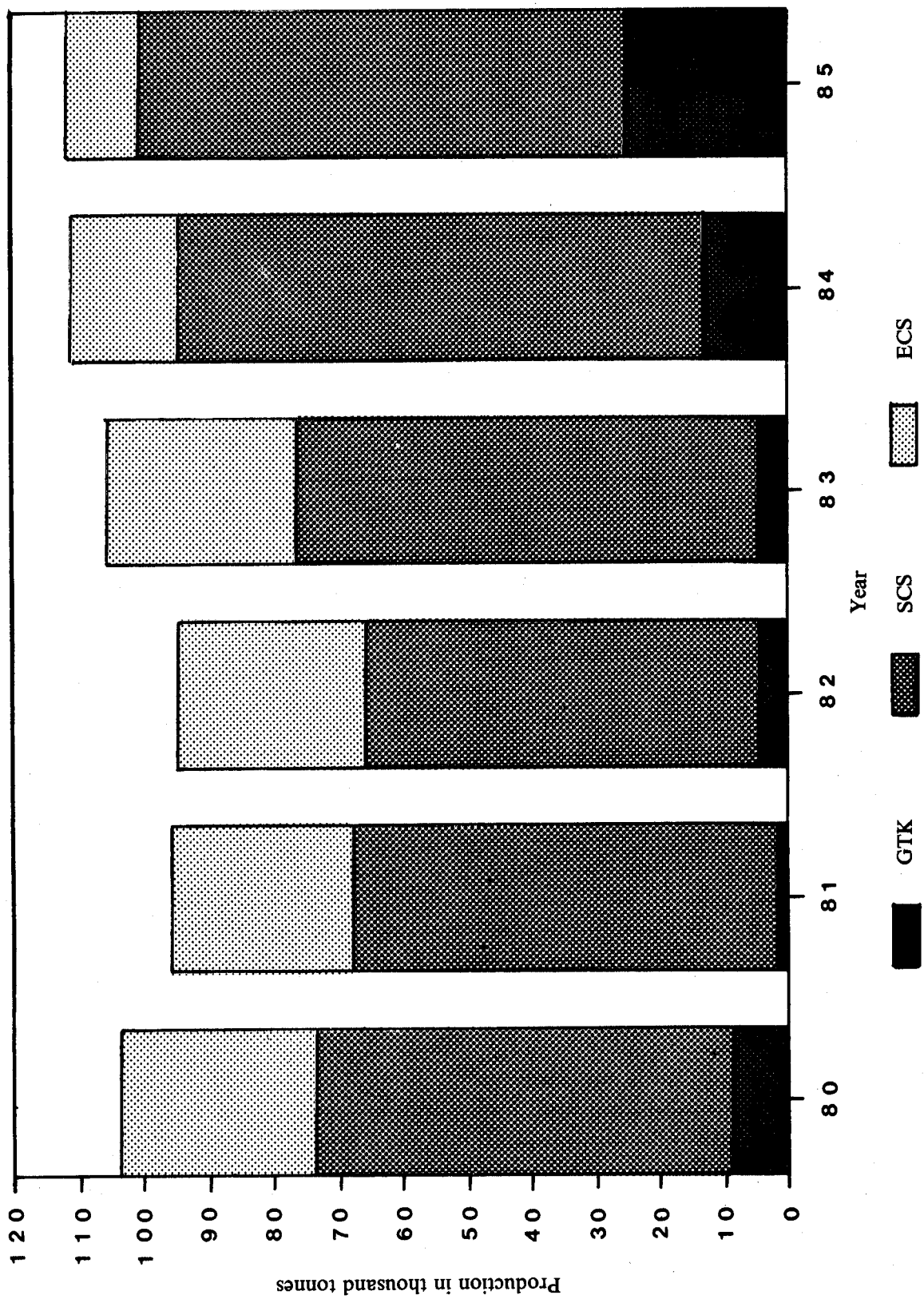
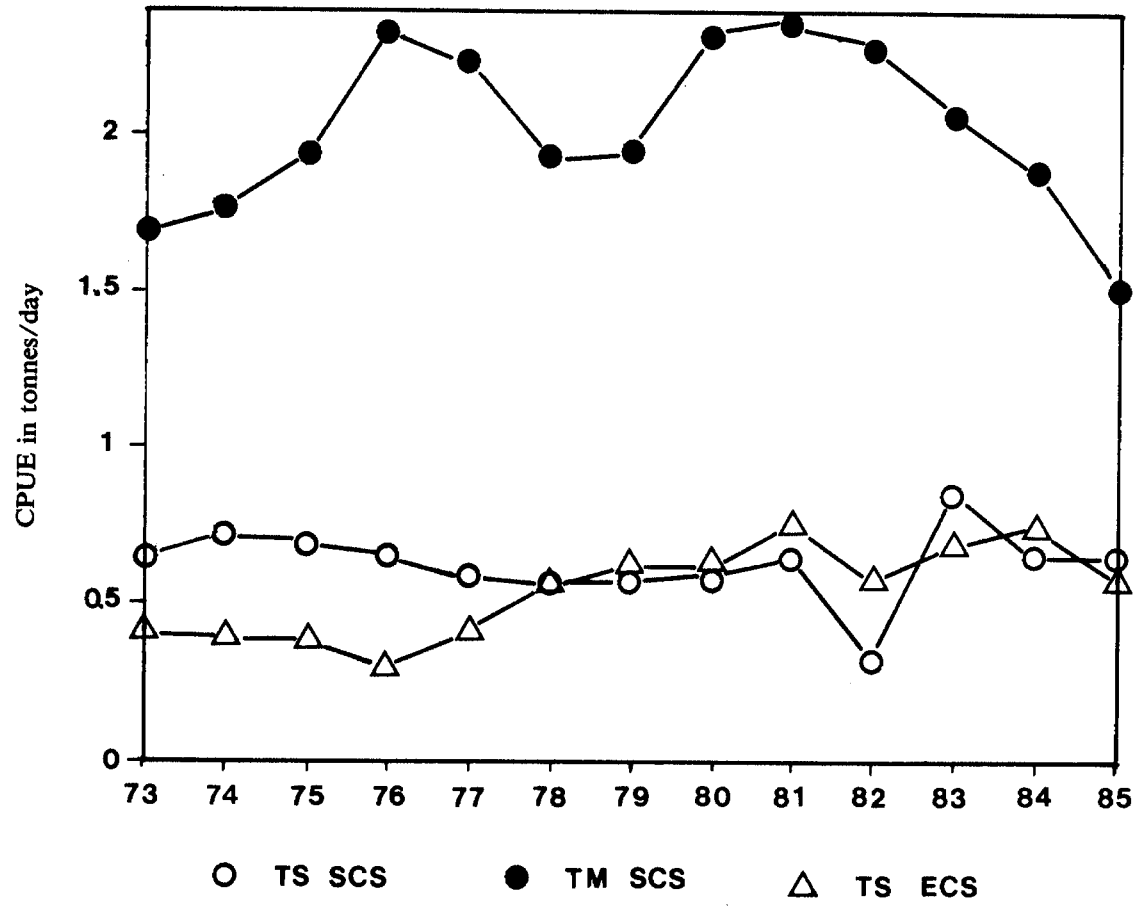


Fig. 7. Total annual production of pair and stern trawlers in three main fishing areas. (GTK = Gulf of Tong King; SCS = South China Sea; ESC = East China Sea.)



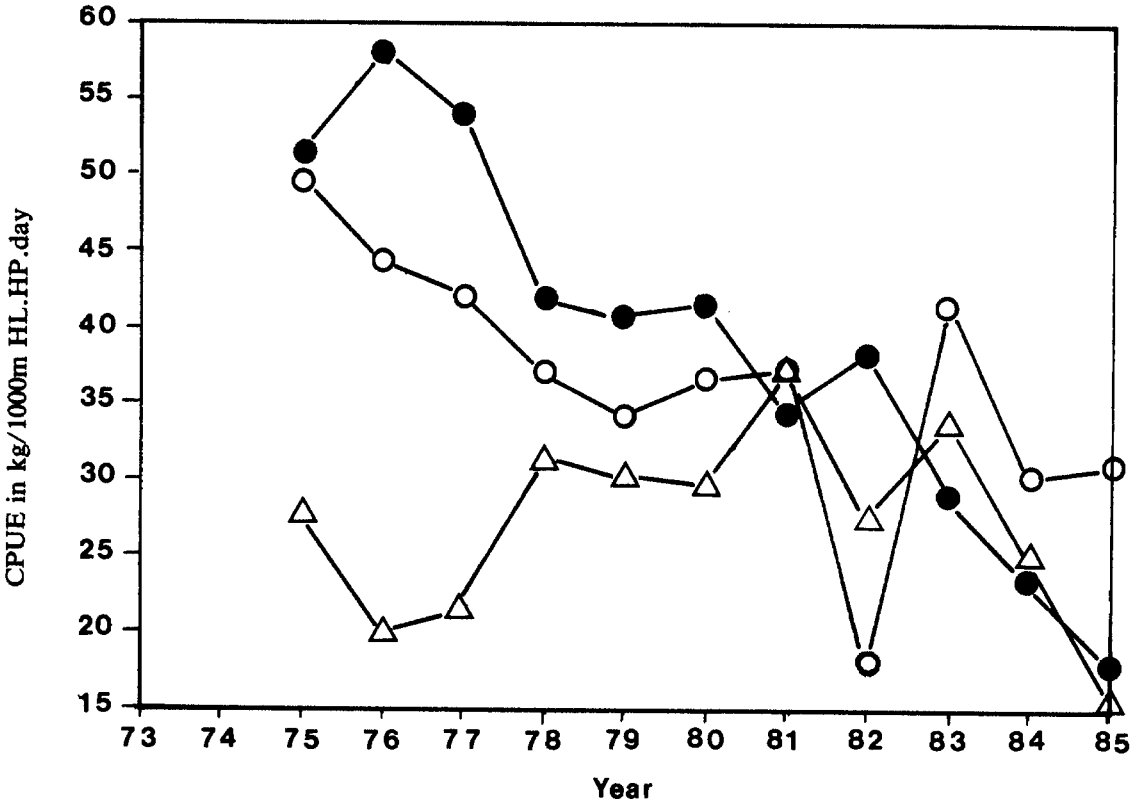


Fig. 8. **Changes in annual mean landed catch per unit effort of pair (TM) and stern (TS) trawlers between 1973 and 1985. SCS = South China Sea; ESC = East China Sea.)**

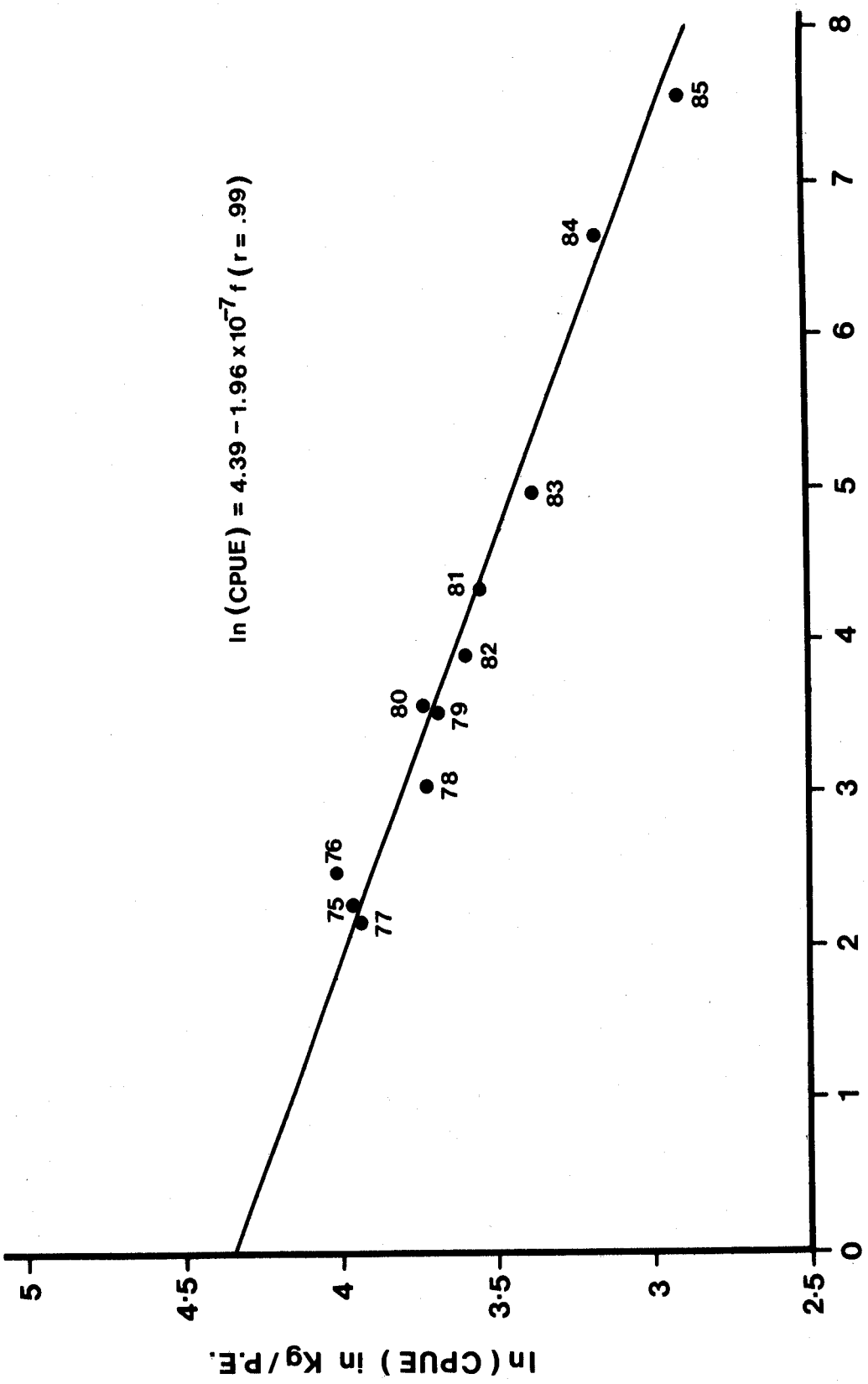


Fig. 9. Plot of ln (CPUE) against total equivalent effort by Hong Kong vessels for the South China Sea.

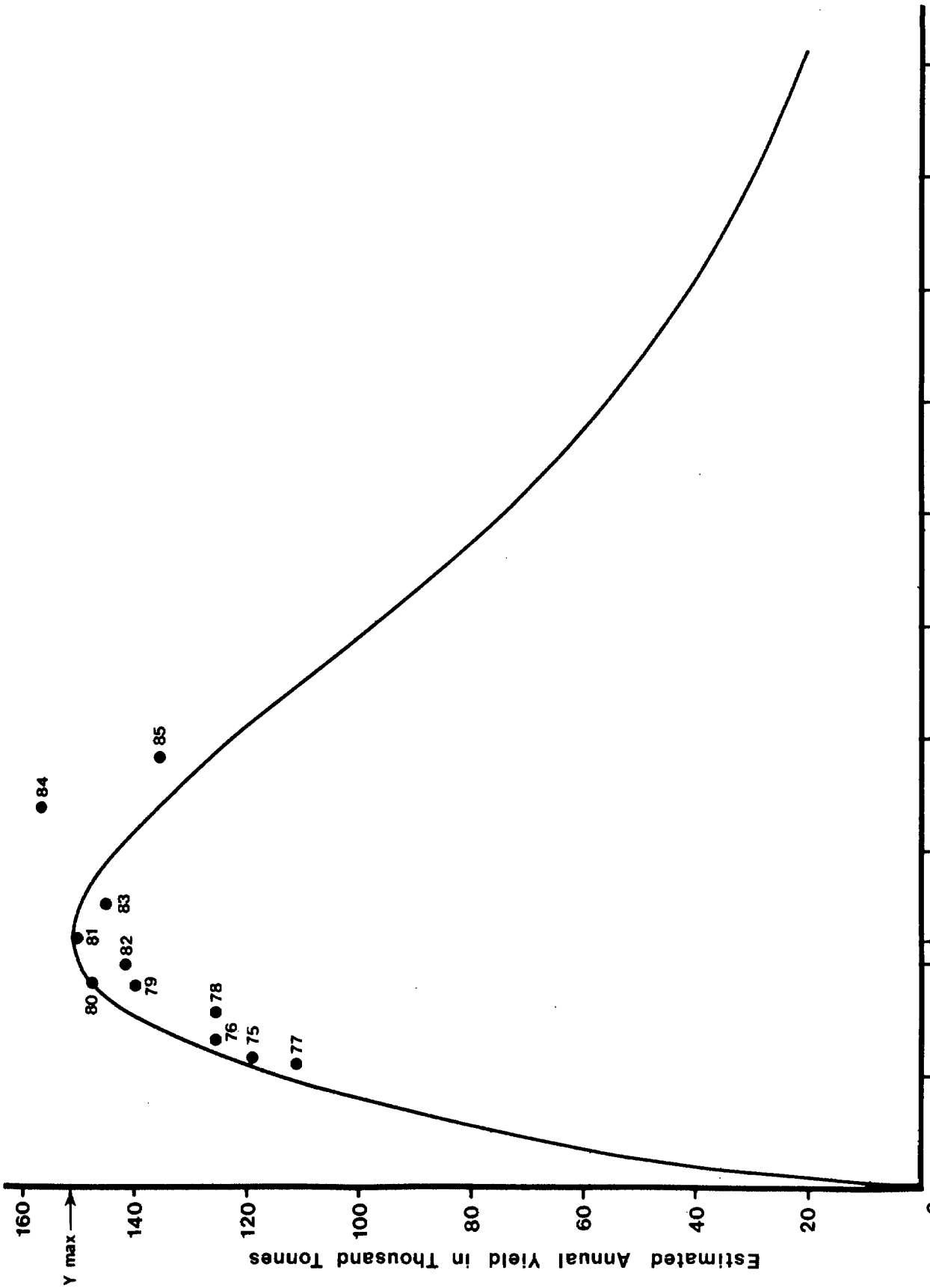


Fig. 10. Yield curve of South China Sea stocks based on data from the Hong Kong fishery.