

A review of the demersal fishery of Indonesia in the Malacca Strait, based on recent surveys and catch and effort data.

by

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Abstract:

The results of demersal surveys in the Malacca Strait area by the research trawlers Mutiara-1, -2, and -4 especially gave an estimate of the standing stock of 73,000 tons, or 1.33 tons/km². Comparing with other areas, the virgin stock was estimated to have been 146,000 tons or 2.66 tons/km². Catch rates and catch composition by depth, and some length frequencies are given.

The commercial trawl fishery in the Indonesian Malacca Strait was analysed on the basis of the statistics in Provincial Reports and of field work. The maximum sustainable yield for two distinct fisheries, Aceh and North Sumatra-Riau, was calculated to be 8,000 tons and 77,000 tons, respectively. The stock is probably slightly overfished.

Recommendations concerning a redistribution of the fishing effort are given.

Indonesian Summary and Recommendations

1. Ringkasan

Dari hasil 2 survey penelitian perikanan demersal di daerah Selat Malaka dengan kapal 2 Mutiara-1, -2, dan terutama Mutiara-4, telah dapat dibuat suatu estimasi stock ikan 2 demersal di daerah tersebut, yaitu sebesar 73,000 ton atau 1.33 ton/km².

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Dengan membandingkan terhadap nilai2 daerah2 lain di perairan Dataran Sunda, dapatlah diperkirakan bahwa "stock awal" (virgin stock) ikan2 demersal adalah sebesar 146,000 ton atau 2.66 ton/km².

Hasil tangkapan per jam tarikan trawl (catch rates), komposisi hasil tangkapan, serta frekwensi panjang beberapa ikan disajikan dalam tulisan ini.

Analisa terhadap perikanan trawl didasarkan atas data dari Laporan Perikanan Propinsi serta data yang dikumpulkan di lapangan. Hasil "maximum yang lestari" (maximum sustainable yield) untuk dua daerah, yaitu Aceh dan Sumatra Utara-Riau telah dihitung masing2 sebesar 8,000 ton dan 77,000 ton. Ada gejala bahwa tingkat penangkapan terhadap stock sudah berlebih.

Saran untuk mengadakan penyebaran usaha2 penangkapan juga diketengahkan dalam tulisan ini.

2. Rekomendasi

2.1 Pemakaian data statistik untuk analisa stock perikanan harus dilakukan dengan hati2.

2.2 Perlu diadakan klasifikasi terhadap jumlah kapal motor dalam data statistik sesuai dengan alat utama yang digunakan seperti trawler, seiner, gillnetter, dll.

2.3 Pencatatan ganda terhadap suatu data hasil tangkapan perlu dicegah.

2.4 Nilai estimasi "hasil maximum yang lestari" untuk daerah2 Aceh, Sumatra Utara-Riau, dan Selat Malaka secara keseluruhan masing2 sebesar 8,000 ton, 77,000 ton, dan 85,000 ton seyogyanya digunakan sebagai pegangan untuk tujuan management.

2.5 Jumlah kapal dalam tahun 1975 yang sesuai dengan jumlah usaha (effort) yang diperlukan untuk memperoleh hasil maximum yang lestari seyogyanya tidak ditambah. Penambahan kapal, jika ada, supaya merupakan kapal2 besar yang mampu beroperasi pada kedalaman 40m atau lebih dari 50%, dan terutama terdapat di daerah utara.

2.6 Penangkapan dengan trawl pada kedalaman lebih dangkal dari 10m supaya dicegah.

2.7 Sebagian kapal2 trawl yang besar2 dari daerah Sumatra Utara dan Riau, seyogyanya dipindahkan daerah operasinya ke L. Cina Selatan, perairan Selat Karimata, dan L. Jawa. Daerah2 ini umumnya belum padat dengan trawl, dan hasil tangkapanpun masih relatif tinggi.

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1. Introduction

Menasveta (1970) gives a summary of the scientific surveys conducted in the Malacca Strait and reports the results of trawling by the "Tongkol" (Birtwistle & Green, 1928), the "Manihine" (Ommaney, 1961), and the "Selayang" (Pathansali et al, 1966). Later surveys were conducted with the "K.M. Jenahak" (Latiff, 1973). Additionally, several papers and reports have been presented of research conducted under the auspices of a Malaysian-German Demersal Fisheries Development Project. Most of these surveys were conducted in what is now Malaysian territorial waters.

On the other hand, there has been up to now no publication in English dealing with the demersal fisheries in the Indonesian waters of the Malacca Strait. A first report on catch per unit of effort and catch composition related to depth obtained by two Indonesian research boats, the Mutiara-1 and -2, containing valuable information on the Malacca Strait stock was published in Indonesian by Martosubroto (1973). As this work is largely unknown outside Indonesia, its main results are incorporated in the present paper.

Further data for this review originate from the survey conducted by the Mutiara-4 in the Malacca Strait in January and February 1975, where 40 successful hauls of one hour each were made. These data have been published and discussed, together with data from the South China Sea, Karimata Strait, and Java Sea, in Saeger, Martosubroto, and Pauly (1976).

The third source of material for this review is the landing and effort statistics of the Provincial Fisheries Offices of the Provinces of Aceh, North Sumatra, and Riau. Additionally, interviews with skippers of commercial trawlers operating in the area were conducted towards the end of 1975 by the first author.

Map A and B show the area under discussion.

2. Summary of the data obtained by the Indonesian research trawlers, Mutiara-1 and Mutiara-2 (from Martosubroto, 1973)

2.1 Boats and gear

The specifications of the three research vessels and the gear used from them for the surveys are set out in Table .

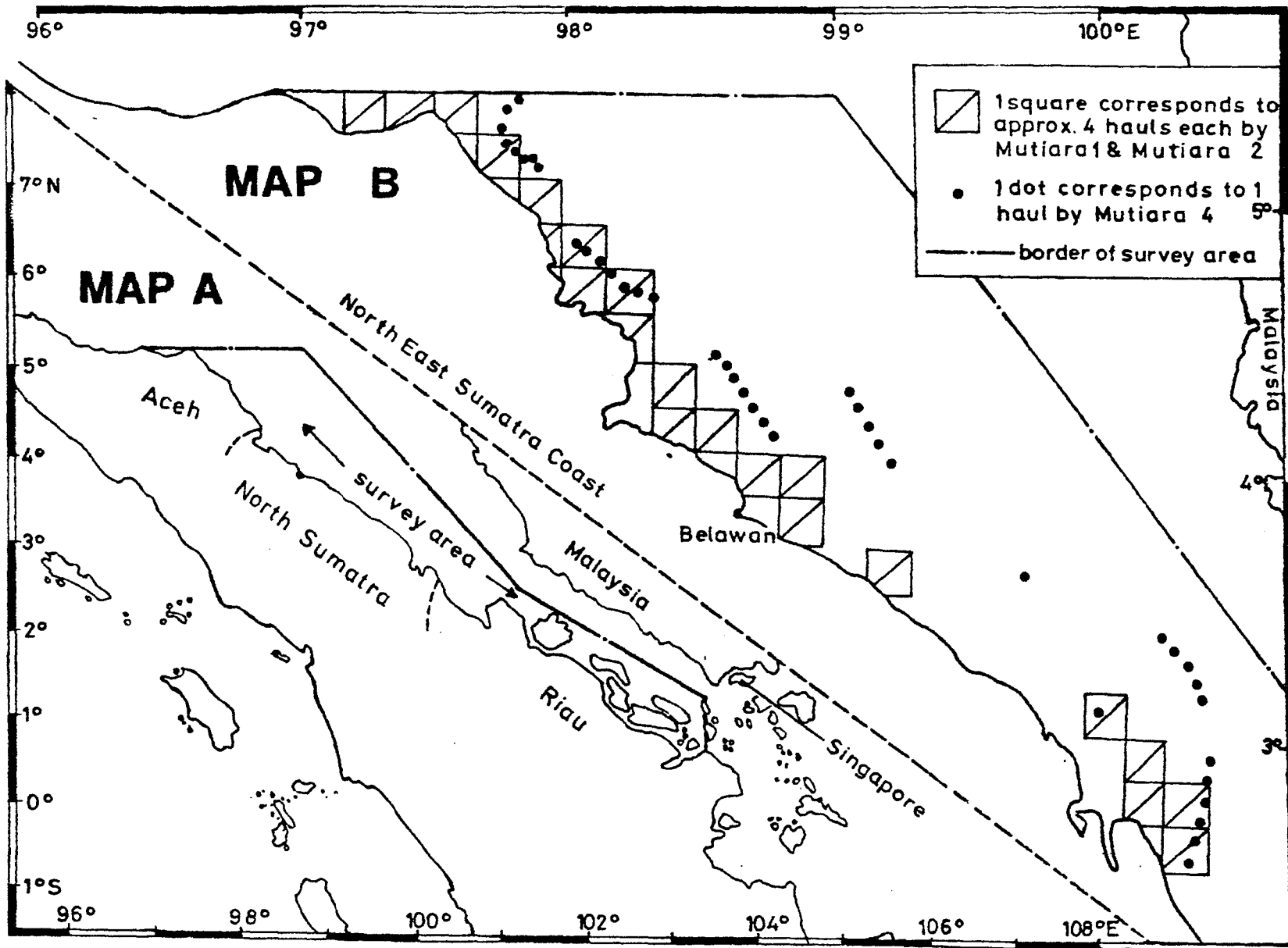


Table 1. Specifications of the research vessels and their gear

Name of boat	Gross tonnage	H.P.	Length (m)	G e a r	Length of head rope (m)	Mesh size of codend (mm)
Mutiara-1	124	365	23.6	double rig +)	23.4 (each)	30
Mutiara-2	53.4	165	18.9	double rig +)	19.0 (each)	30
Mutiara-4	110	316	24.0	Thailand trawl	36.0	40

+) shrimp trawl

2.2 Survey area

The area covered by the surveys is shown in Maps A and B.

2.3 Duration of survey and number of stations

The survey by Mutiara-1 and -2 in the Malacca Strait lasted from July to September 1973. A total of 148 hauls were made, 61 by Mutiara-1 and 87 by Mutiara-2. The distribution of the stations by depth is given in Table 2, which also includes the stations of the Mutiara-4. The Table also shows the relative distribution and total surface area of each depth horizon (from Saeger *et al.*, 1976) which were used for the estimates of the total stock.

Table 2. Depth horizon and station distribution

Depth range (m)	0 - 9	10-19	20-29	30-39	40-49	50-59	60-69	70+	Total
Surface area (Z)	13.4	12.5	7.6	9.8	8.6	14.2	15.6	18.4	100
Surface area (km ²)	7,354	6,860	4,170	5,378	4,719	7,792	8,561	10,197	54,931
No. of hauls by Mutiara-1	2	31	16	12	-	-	-	-	61
No. of hauls by Mutiara-2	5	44	38	-	-	-	-	-	87
No. of hauls by Mutiara-4	-	-	1	7	11	14	4	3	40

2.4 Catch rates

The catch rates were as follows (Table 3):

Table 3. Catch rates of Mutiara-1 & -2 related to depth

Depth range (m) ¹⁾	0 - 9	10-19	20-29	30-39
Mutiara-1 (kg/h) ²⁾	36.7	77.8	77.7	68.4
Mutiara-2 (kg/h) ²⁾	65.3	45.4	41.0	no fish

- 1) The depth horizons were originally 1-10m, 11-20m, etc., but have been changed to correspond to those of Mutiara-4 survey.
- 2) The original data were based on 2-hour hauls. They have been halved for better comparison with the other data.

2.5 Catch composition

The composition of the catch of Mutiara-1 and -2 is given in Table 5 together with that of Mutiara-4. To facilitate comparison, all data have been converted into percentages of the total catch. For the same reason, those groups of fishes recorded on only one or two of the boats have been added to "other fishes".

A feature discussed by Menasveta (1970), namely the increase with depth of the percentage of more valuable fish groups was confirmed for the Lutjanidae, Serranidae, Carangidae, Pomadasidae, and others. Less valuable groups such as the Leiognathidae, Siganidae, Sciaenidae, Platycephalidae, and "other fishes" decreased with increasing depth.

When selling the fish catch of Mutiara-1 and -2 in Belawan (North Sumatra), the prices obtained were often as high as in Singapore.

2.6 Stock assessment

An attempt was made to calculate the stock density in the survey area, based on the catch rate of Mutiara-1 and -2 (in Martosubroto, 1973), and using the swept area method. The results are presented in Table 6 and discussed further below.

3. Summary of results obtained by the Indonesian-German research trawler Mutiara-4 (from Saeger et al, 1976)

Mutiara-4, the research trawler of the Indonesian-German Demersal Fisheries Project, has been used for a demersal survey, now still in progress, covering all the Indonesian waters of the Sunda Shelf. During this survey, the Malacca Strait was covered from January to February 1975.

3.1 The boat, gear and stations

The specifications of the boat and gear are given in Table 1. The position of the 40 successful hauls is shown on Map B, while their distribution by depth is given in Table 2.

3.2 Catch rates

The catch rates were as follows (Table 4):

Table 4. Catch rate related to depth (Mutiara-4)

Depth range (m)	20-29	30-39	40-49	50-59	60-69	70+	Average off all-sta.
Catch rate (kg/h)	45.3	63.9	158.2	100.1	84.1	94.4	106.3

3.3 Catch composition

The percentage catch composition is given in Table 5, and was discussed previously, together with that of Mutiara-1 and 2.

3.4 Length frequency measurements

A total of 295 fishes and shrimps were measured. The results are given in Table 7.

Table 5. Catch composition (%) grouped according to depth

No.	Depth range (m)	0 - 9		10 - 19		20 - 29			30	- 39	- 49	- 59	- 69	70+
		M-1	M-2	M-1	M-2	M-1	M-2	M-4	M-1	M-4	M-4	M-4	M-4	M-4
1.	Shark & Rays	0.2	0.4	0.7	1.7	3.1	0.8	3.3	1.1	0.5	15.7	1.4	1.0	0.9
2.	ENGRAULIDAE	0.2	0.1	1.4	2.6	1.4	1.4	-	0.8	1.7	1.2	0.1	8.0	-
3.	CLUPEIDAE	1.7	4.9	1.1	4.1	0.8	2.5	41.9	0.1	3.9	4.1	3.9	12.8	0.7
4.	<u>Chirocentrus</u> spp.	0.6	1.0	4.1	1.6	2.9	1.6	-	1.8	0.1	0.4	0.1	0.1	0.8
5.	<u>Anadontosma chacunda</u>	-	-	0.3	0.1	0.1	-	-	0.1	-	-	-	-	-
6.	SYNODONTIDAE	0.4	1.5	2.3	5.3	1.8	3.9	-	9.8	2.0	0.5	2.6	2.4	2.8
7.	ARIIDAE	-	0.7	0.9	0.4	2.6	0.5	-	2.9	0.7	4.3	1.8	7.0	0.2
8.	<u>Sphyraena</u> spp.	0.3	0.3	0.6	0.5	1.2	0.6	-	0.7	6.9	1.5	0.2	-	-
9.	SERRANIDAE	-	0.1	0.5	0.7	1.5	0.1	-	1.9	0.4	0.1	2.1	-	0.6
10.	THERAPONIDAE	0.9	6.4	2.2	3.8	10.4	1.9	0.9	9.0	0.9	0.3	1.1	2.6	0.3
11.	PRIACANTHIDAE	-	-	0.1	0.1	1.4	0.1	-	0.9	0.5	1.3	2.0	0.3	0.3
12.	<u>Rachycentron canadus</u>	-	-	0.1	0.5	-	-	-	-	-	0.4	0.1	-	-
13.	CARANGIDAE (excl. <u>Decapterus</u> spp.)	1.9	8.3	4.3	6.6	3.5	4.6	4.4	3.2	16.5	11.5	6.2	7.3	15.5
14.	<u>Formio niger</u>	-	0.2	0.3	0.3	0.4	0.1	-	0.1	0.5	0.2	0.1	0.1	0.9
15.	LUTJANIDAE (incl. <u>Caesio</u> spp.)	-	-	1.0	0.5	0.9	0.8	-	2.4	1.3	5.4	14.4	8.4	17.9
16.	NEMIPTERIDAE (incl. <u>Scolopsis</u> spp.)	-	-	2.1	2.8	1.8	3.5	-	2.8	7.5	5.6	6.4	6.8	3.5
17.	LEIOGNATHIDAE	0.5	7.5	26.8	5.1	20.7	12.6	17.7	8.8	2.9	8.4	7.8	0.3	0.3
18.	GERRIDAE	0.9	1.6	1.3	0.6	0.8	0.6	-	1.1	-	2.4	9.5	0.6	17.6
19.	POMADASYDAE (incl. <u>Plectorhynchus</u> spp.)	10.9	6.9	5.8	1.7	5.9	1.6	-	4.6	3.9	7.5	4.3	19.4	4.9
20.	SCIAENIDAE	15.7	11.2	4.4	10.0	3.8	8.8	0.9	4.5	-	4.2	0.9	7.7	-
21.	MULLIDAE	-	0.9	3.3	2.4	4.5	5.1	-	8.9	6.4	10.7	10.0	1.3	22.9
22.	<u>Siganus</u> spp.	3.4	-	3.9	-	1.9	-	-	1.0	2.1	1.1	0.1	-	0.1
23.	TRICHYURIDAE	1.4	0.9	4.0	5.4	2.5	3.0	8.8	6.1	2.2	3.3	8.8	6.5	1.4
24.	<u>Rastrelliger</u> spp.	1.4	-	0.2	0.6	0.1	-	-	-	-	0.2	1.3	-	-
25.	<u>Scomberomorus</u> spp.	0.3	0.8	0.9	0.4	1.0	0.7	-	1.3	-	-	-	-	-
26.	<u>Pampus argenteus</u>	-	3.1	0.5	0.9	0.2	0.8	9.9	0.1	2.0	0.2	-	0.2	-
27.	PLATYCEPHALIDAE	0.5	2.3	0.5	0.4	1.5	-	-	2.7	0.1	0.1	0.1	-	-
28.	<u>Psettodes erumei</u>	-	0.3	2.1	0.9	0.8	0.8	-	1.3	0.3	0.1	0.9	0.6	0.3
29.	BOTHIDAE/SOLEIDAE/ GLOSIDAE	13.2	8.9	1.7	4.1	2.5	1.9	0.4	1.9	-	0.1	0.1	0.2	-
30.	Other fishes	45.4	21.9	19.7	26.3	17.3	28.9	4.4	18.4	24.5	7.4	6.5	4.1	3.7
31.	LOLIGOIDAE	-	1.3	-	1.8	1.3	2.5	0.4	0.3	10.1	3.6	5.3	2.1	3.7
32.	SEPIOIDAE	-	1.3	0.9	2.2	1.3	0.9	-	0.1	0.8	0.5	0.8	0.3	0.2
33.	PENAEIDAE	1.0	1.0	0.2	5.0	0.4	7.8	4.0	0.2	0.1	0.1	-	0.6	-
34.	<u>Thenus orientalis</u>	-	-	0.3	0.1	0.7	-	-	1.1	0.1	0.1	0.2	0.1	-
35.	Other Crustacean	-	1.7	1.0	1.0	0.3	0.6	2.6	-	0.1	0.1	-	0.1	-

3.5 Stock assessment

On the basis of the catch rates of the Mutiara-4, using the swept area method, a catchability factor of 0.5, and 2/3 of the head rope (Shindo, 1973), a total standing stock of 79,415 tons were estimated for the Indonesian waters of the Malacca Strait, as delimited in Map A. The depth range 0-9m has been excluded, and the total reference area is, thus, 47,599 km² (Saeger et al, 1976). This corresponds to a mean stock density of 1.67 tons/km². Here, however, the value for the depth range 10-19m, where the Mutiara-4 had not been fishing, was assumed to correspond to the relatively high average value of the same depth range from other, mostly virgin areas of the Mutiara-4 survey.

In the specific case of the Malacca Strait, the assumption was probably too optimistic, as heavy trawling is already taking place in the shallow waters. Thus, to correct this figure, the stock density obtained from the catch rates of Mutiara-1 and -2 were also calculated (Table 6). These estimates were then used for the depth ranges missing in the Mutiara-4 survey, while overlapping data of the three boats were averaged. The results are also presented in Table 6, from which an average weighted mean stock density of 1.33 tons/km² was derived (including depth range 0-9m). The corrected stock estimate, thus, amounts to 73,058 tons, over a surface area of 54,931 km².

Table 6. Distribution of stock density
(ton/km²)

Depth range (m)	Mutiara-1	Mutiara-2	Mutiara-4	Mean
0 - 9	0.5	1.4	-	0.9
10 - 19	1.1	1.0	-	1.0
20 - 29	1.1	0.9	0.7	0.9
30 - 39	1.0	-	1.0	1.0
40 - 49	-	-	2.5	2.5
50 - 59	-	-	1.6	1.6
60 - 69	-	-	1.3	1.3
70+	-	-	1.5	1.5

Mean, weighted per surface area of each depth horizon = 1.33

Table 7. Length frequency measurements (total lengths, measured to the whole cm. below).

Cms.	Species	Anadontostoma chacunda						Saurida undosquamis		Lutjanus malabaricus	Pomadasys maculatus	Petraeus merguensis
		43			48	34	35	34		48	43	
10						3	4					
11						4	3					
12						3	3					
13	2					2	1		1	4		2
14	8								6	6		7
15	5							7	8	13		16
16	1				1			4	11	10		4
17					2			7	6	3		8
18								9	5			2
19					2			2	1	3		1
20				1	2			5		1		
21					1			1				
22					1					1		
23				2								
24			1	1								
25			1	1	1	1						
26			1	1		1						
27			3	1	1		4					
28			3	1		2				1		
29			10	2	1					1		
30			7	2	1	2						
31			3	4		1				1		
32			8	4								
33			2	5						1		
34			2	4								
35												
36			2									
37				1						1		
38										2		
39				1						1		
40										2		
41				3								
42				2						1		
43			1	1								
48										2		
No. of specimens		16	44	37	13	19	15	35	40	11	51	30
Weight of sample in kg		0.69	9.96	10.27	1.09	1.27	0.85	1.22	1.08	9.0	3.5	1.03

The value of 1.33 tons/km² and the corresponding standing stock are very low when compared with the data from other areas of the Sunda Shelf covered by the Mutiara-4. The average stock density of these areas was 2.66 ton/km², exactly double the Malacca Strait figure (Table 8). It is considered that the low density in the Malacca Strait is the result of the present trawl fishery, an assumption backed by the fact that it is mainly the shallow waters (down to 39m) of the Malacca Strait (where almost all, if not all the trawling takes place) that the stock densities differ from those of other areas (Table 9). It seems, therefore, legitimate to assume, as a first approach, that the virgin standing stock, before the onset of the present trawl fishery, was also double the present stock, namely about 146,000 tons.

Table 8. Mean stock densities in various areas of the Sunda Shelf

A r e a	East Java	West & Central Java	Karimata Strait	South China Sea	Average (excl. Malacca Str.)	Malacca Strait
Weighted mean stock density (ton/km ²)	2.89	2.15	3.24	2.36	2.66	1.33

Table 9. Percentage stock density of the Malacca Strait as compared to other areas

Depth range (m)	0 - 9	10-19	20-29	30-39	40-49	50-59	60-69	70+
Malacca Str.	0.9	1.0	0.9	1.0	2.5	1.6	1.3	1.5
Other areas [†])	-	2.1	2.7	2.3	2.1	2.8	2.3	1.5
Malacca Str. as % of other areas	-	48	33	43	119	57	57	100

†) East Java, West & Central Java, Karimata Strait, and South China Sea (see Saeger *et al*, 1976)

4. The Fishery in the Malacca Strait

4.1 Material

The data used in this section originate mainly from the Provincial Fisheries Offices of the Provinces of Aceh, North Sumatra, and Riau. Earlier Reports before 1969 were not available. The first author also collected field data in the three provinces named above from November to December 1975. In Aceh Province, four large landing places were visited with about three interviews of trawler skippers at each landing site. In North Sumatra Province, landing sites were visited with the same rate of interviews. In Riau Province, only three landing places were visited with four interviews each. The catch per unit of effort (c.p.u.e.) data and the data on the actual fishing days of the large and medium trawlers in the three provinces (Table 10) have been derived from these interviews.

Table 10. Fishing effort

Boat classification by gross tonnage (GT)	Mean gross tonnage	Average catch (kg/day)	Power Factor ⁺⁾	A c e h		North Sumatra		R i a u	
				Fishing days per year (uncorrected)	Fishing days per year (corrected)	Fishing days per year (uncorrected)	Fishing days per year (corrected)	Fishing days per year (uncorrected)	Fishing days per year (corrected)
Large (L) 20GT	30	276	1.27	264	335	288	366	280	356
Medium (M) 10-20GT	20	217.8	1.0	-	(264)	264	264	-	(280)
Small (S) 10GT	10	(160) ⁺⁾	0.74	-	-	240	178	-	-

⁺⁾ as based on Fig. 1

4.2 Treatment of effort data

The reports of the number of boats do not state whether the boats are trawlers or seiners, etc. It was assumed, therefore, that the large, medium and small motorized boats are trawlers, and that all the sailing boats do not trawl. As it is known that the small motorized boats in Riau Province are mainly gillnetters, these have not been included. Some unregistered motorized boats in North Sumatra are purse seiners; these are also included. The reports also do not give a precise tonnage for the three categories of motorized boats.

On the basis of the field data, it appears that the large trawlers have an average gross tonnage of 30 tons, the medium trawlers of 20 tons, and the small trawlers of 10 tons (Table 10). The medium sized trawlers, have been selected as the standard trawler, and the others were converted to this by means of their c.p.u.e. (Fig. 1). Table 10 gives the power factors used.

The fishing days for each type of trawler in each province were multiplied by their perspective power factor, and the resulting corrected fishing days are also given in Table 10. The data used for the three provinces cover only the area shown in Map A.

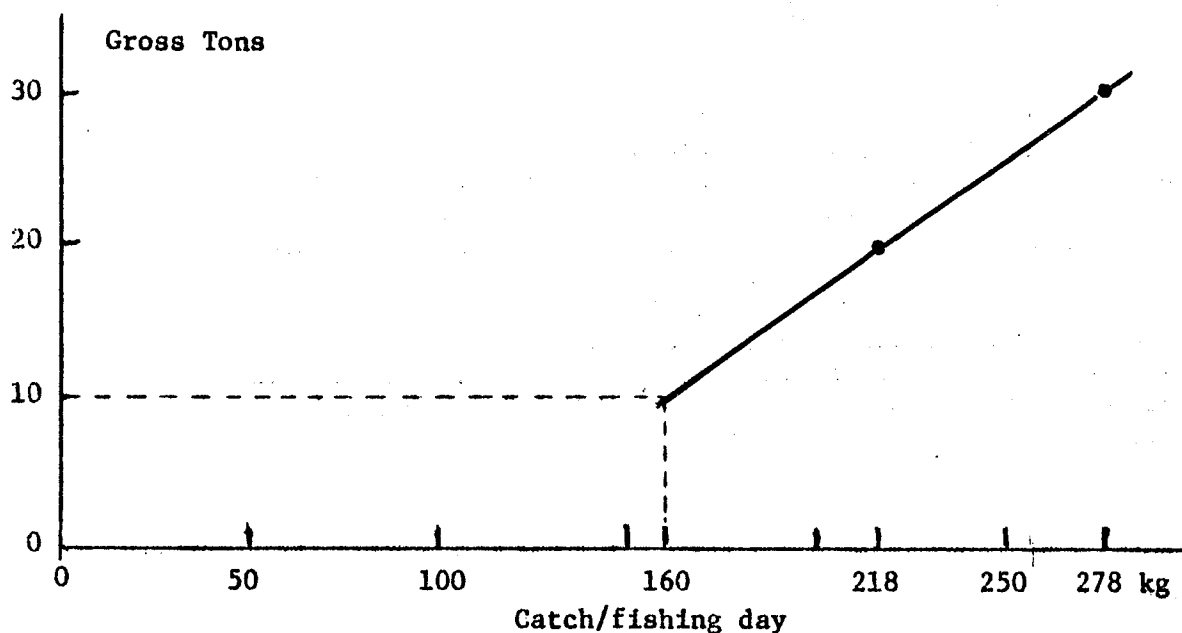


Figure 1. Estimate of c.p.u.e. for 10 G.T. trawlers

4.3 Treatment of catch data

The provincial reports do not separate the landed fish and shellfish according to the catching gear. It was, thus, necessary to select from the catch data those groups of fish and shellfish which could safely be assumed to originate from trawl catches. This was done on the base of Table 5, which shows the catch composition of Mutiara-1, -2, and -4. Here fishes occurring in more than negligible amounts (more than 2%) were assumed to be mainly demersal. Those fishes were then selected from the reports' lists. The list of fish and shellfish compiled this way is shown in Table 11. Tables 12 and 13 list the same fishes, but only their reference numbers are given.

When presenting the data, care has to be taken to avoid double accounting. It is known that there is a large amount of double accounting between the Province of North Sumatra, where many trawlers from Riau land their catch, and the latter province. As there is no figure available on the amount of this double accounting, the arbitrary figure of 50% was chosen, and accordingly, the landings reported from Riau Province have been cut by half, as it was assumed that the half removed had already been reported in North Sumatra.

The landing data of the three provinces used originate from the area shown in Map A.

4.4 Maximum sustainable yield

The catch was plotted against effort for the Malacca Straits, Aceh Province, and North Sumatra-Riau Provinces, but owing to the double accounting mentioned above, it was not possible to separate the fisheries of these two latter provinces meaningfully. From the plots, it was deduced that the maximum sustainable yield was approximately 8,000 tons for Aceh Province, 77,000 tons for North Sumatra and Riau combined, while a total potential maximum sustainable yield of 85,000 tons was derived for the whole Indonesian waters of the Malacca Strait.

Table 11. The Province of Aceh: Annual landings (tons). Number of landings (tons). Number of trawlers. Corrected days' fishing. Catch per unit effort (kg per day).

No.	Specification	1969	1970	1971	1972	1973	1974	1975
1.	Shark	162.1	61.1	358.1	562.7	456.1	403.6	191.0
2.	Rays	68.0	7.7	104.9	272.3	151.6	171.4	86.0
3.	Ariidae	195.4	90.9	111.0	408.4	438.9	462.0	231.0
4.	Mugilidae	212.9	18.7	152.9	419.6	346.5	396.	198.0
5.	Polynemidae	4.5	1.0	15.5	125.7	53.2	61.2	31.0
6.	Serranidae	69.9	24.5	90.8	244.7	105.5	127.0	64.0
7.	Carangidae*	231.8	470.6	340.2	639.4	578.8	609.1	400.0
8.	Stromateidae	146.6	293.6	270.0	214.5	250.7	126.0	84.0
9.	Lutjanidae	64.9	124.2	336.0	761.1	291.6	642.1	719.0
10.	Leiognathidae	142.4	31.5	281.1	455.3	378.3	2170.9	1761.0
11.	Sciaenidae	89.4	7.5	102.0	220.9	109.3	209.2	105.0
12.	Trichiuridae	138.8	79.5	439.4	711.8	697.1	497.5	514.0
13.	Other Fishes	3753.5	4612.7	4877.7	2433.6	2393.5	2147.2	1407.0
14.	Total Demersal - Fishes	5280.2	5823.5	7379.5	7470.0	6247.1	8023.2	5791.0
15.	Shrimps	474.0	488.4	490.3	866.2	540.4	647.9	511.0
16.	Squids & Cuttlefish	3.2	40.3	47.0	90.5	120.7	84.0	54.0
17.	Total Demersal - Resources	5757.4	6352.2	7916.8	8426.7	6908.2	8755.1	6356.0
18.	Large Boat (30GT): > 20 GT	41	47	71	71	72	134	137
19.	Medium Boat (20GT): 10 - 20 GT	24	28	42	41	43	79	81
20.	Small Boat (10GT): < 10 GT	-	-	-	-	-	-	-
Corrected Fishing Days:								
21.	Large Boat	13735	15745	23785	23785	24120	44890	48772
22.	Medium Boat	6336	7392	11088	10824	11352	20856	21384
23.	Small Boat	-	-	-	-	-	-	-
24.	Total	20071	23139	34873	34609	35472	65746	70156
25.	Catch/Unit Effort (kg/day)	286.9	274.8	227.4	243.5	194.8	133.2	90.6

* Excluding Decapterus

Table 12. The Province of North Sumatra: Figures in brackets are extrapolations.

No.	Specification	1969	1970	1971	1972	1973	1974	1975
1.		-	-	-	-	-	-	1327.2
2.		-	-	-	-	-	-	847.9
3.		-	-	-	-	-	-	1168.5
4.		-	-	-	-	-	-	1418.1
5.		-	-	-	-	-	-	1407.0
6.		-	-	-	-	-	-	810.5
7.		5150.5	7008.0	7908.7	8337.6	9138.7	10235.4	3336.9
8.		1207.4	5589.5	6039.8	6637.0	4569.4	5105.7	2063.2
9.		6433.4	1379.6	1585.7	1667.5	3652.6	4092.2	1521.5
10.		-	-	-	-	-	-	-
11.		-	-	-	-	-	-	2646.0
12.		-	-	-	-	-	-	-
13.	11.	7156.9	8737.1	9538.2	8769.2	14622.0	1646.6	18133.6
14.		19948.2	22714.2	25072.4	25411.3	31982.7	36079.9	34680.4
15.		6323.2	6888.0	7928.0	8337.6	6397.1	7164.9	16656.2
16.		1902.9	2072.9	2388.7	2511.4	2741.6	3068.7	1754.0
17.	Table	28174.3	31675.1	35389.1	36260.3	41121.4	46313.5	53090.6
18.		(37)	(44)	(45)	(47)	(48)	(48)	55
19.		(288)	(335)	(345)	(361)	(368)	(371)	426
20.	as	(380)	(441)	(456)	(477)	(486)	(491)	563
21.		13542	16104	16470	17202	17568	17568	20130
22.		76032	58440	91080	95309	97152	97944	112464
23.	Same	67640	78498	81168	84906	86508	87398	100214
24.		157214	183042	188718	197412	201228	202910	232808
25.		-	-	-	-	-	-	-

Table 13. The Province of Riau: The figures for annual landings have not been corrected for double accounting. Figure in brackets is an estimate.

No.	Specification	1969	1970	1971	1972	1973	1974	1975
1.	Table 11. as	-	121.8	43.1	45.2	94.2	51.3	54.4
2.		772.6	915.1	578.3	794.6	1107.4	1109.5	718.6
3.		79.4	104.5	67.1	79.0	67.7	76.8	76.1
4.		121.4	142.9	90.6	133.4	192.8	178.8	112.2
5.		-	-	-	-	-	-	-
6.		-	-	-	-	-	-	-
7.		175.2	48.0	56.0	-	88.4	18.8	17.0
8.		485.0	537.0	357.0	441.4	576.7	584.9	394.2
9.		-	8.0	7.2	6.5	-	0.2	0.1
10.		-	0.4	208.1	3176.8	3092.6	3133.4	3133.5
11.		2829.7	3224.9	2065.7	2938.7	3996.1	4067.6	2555.4
12.		-	-	-	-	-	-	-
13.		33620.0	35811.0	25202.7	44388.4	62676.5	50637.5	33848.9
14.		38083.3	40913.6	27900.4	50955.5	70344.8	58570.7	39499.7
15.		7355.3	9518.6	6006.3	7945.9	9713.8	10101.8	6852.1
16.		-	-	-	-	-	-	-
17.		45438.6	50432.2	33906.7	58901.4	80058.6	68672.5	46351.8
18.	Same	125	156	160	250	270	253	271
19.		325	963	965	985	641	641	(641)
20.		-	-	-	-	-	-	-
21.		44500	55536	56960	89000	96120	90068	96476
22.		85800	176525	254760	260040	169224	169224	169224
23.		-	-	-	-	-	-	-
24.		232061	415368	311720	349040	265344	259292	265700
25.		-	-	-	-	-	-	-

Table 14. Summary of data: The Malacca Strait
and the North Sumatra-Riau Provinces

No.	Specification	1969	1970	1971	1972	1973	1974	1975	Remarks
I.	St. Malacca								
17.	Total Demersal - Landings	79370.3	88459.5	77212.6	103588.4	128088.2	123741.1	105798.4	tons
-	Corrected for double accounting	56651.0	63243.4	60259.2	74137.7	88058.9	89404.8	82622.5	
24.	Total Corrected - Fishing Effort	307535	438240	535311	581061	502044	527948	(562256)	days
25.	C.P.U.E.	184.2	144.3	112.6	127.6	175.4	169.3	147.0	kg/day
II.	N. Sumatra & Riau								
17.	Total Demersal - Landings	73612.9	82107.3	69225.9	95161.7	121180.0	114986.1	99442.4	tons
-	Corrected for double accounting	50893.6	56891.2	52272.5	65711.0	81150.7	80649.8	76266.5	
24.	Total Corrected - Fishing Effort	287514	415103	500438	546452	466572	462202	(498508)	days
25.	C.P.U.E.	177.0	137.1	104.5	120.3	173.9	174.5	153.0	kg/day

5. Discussion

5.1 The surveys

The data provided by Mutiara-4 seem to be fairly reliable, especially when compared with and supplemented for certain depth ranges with the Mutiara-1 and Mutiara-2 data.

The "Thailand trawl" used in the Mutiara-4 survey also is a well-known gear, which allows for direct comparison of the results with those from other areas, such as the Gulf of Thailand, where this gear is widely used, or the Java Sea where a survey was recently conducted (Saeger et al, 1976).

Additionally, the catch rates of the Mutiara-1, -2 and -4 showed that the deeper part of the Malacca Strait are largely untouched, while the shallower waters are noticeably depleted. This latter fact could be explained during our field work, as we learnt that practically all trawling takes place close inshore, mainly in order to catch as many shrimps as possible.

The estimate of the virgin biomass in the Malacca Strait of 146,000 tons, as based on the average value from the neighboring areas of the Mutiara-4 survey, might be considered bold. It is derived, however, from approximately 350 hauls made with the same gear, in areas where trawlers were rarely, if ever, seen.

The virgin stock estimated from the trawling survey, related to the calculated maximum sustainable yield, gives a value of $M = 1.5$, when

$$M = \frac{P_y}{0.4 B_0} \quad (\text{Gulland, 1968}).$$

Latiff (1973) proposed the value for M of 1.25, while Gulland (1968) used $M = 0.5$ to 1.0. Saeger et al (1976), in their survey of the Indonesian Sunda Shelf used $M = 1.0$. The latter value combined with the virgin stock estimate of 146,000 tons gives a potential yield for the Indonesian Malacca Strait of 58,000 tons. It was shown that both the actual landings and the calculated maximum sustainable yield are higher than this figure.

5.2 Investigation of the fishery

The published statistical data available were not adequate for stock assessment and, therefore, these were supplemented by extensive field work. Additionally, several rather bold assumptions were made.

It is anticipated that the improvements in the fishery statistics now being put into effect under the guidance of Dr. T. Yamamoto, UNDP Fishery Statistician, will make accurate assessments possible in the future.

The data allowed for the investigation of only two separate fisheries, namely Aceh Province with a maximum sustainable yield of 8,000 tons/year, and North Sumatra-Riau Provinces with a maximum sustainable yield of 77,000 tons/year. The fishing effort in both fisheries, and consequently, the Indonesian part of the Malacca Strait as a whole, has gone slightly beyond that which will give the maximum sustainable yield. It seems, in any case, that the effort should not be increased. Should, however, such an increase be unavoidable, then the additional trawlers should be large ones and operate in the deep water areas (>40m) only, preferably in the northern region.

A decrease of effective effort by means of an increase of mesh size (presently 1.2 to 1.9 cm) would only result in the loss of the valuable "rebon" (mixed small crustaceans), with no noticeable effect on the fish and shrimp stocks.

Trawling in the close inshore waters (<10m), however, should be abandoned altogether, as these areas are already under heavy pressure from the artisanal fishery, and are important regeneration areas for many stocks.

The Malacca Strait demersal fishery seems to belong to the few demersal fisheries in Indonesia which are already beyond their maximum sustainable yield. Another fishery with the same characteristics is the shrimp fishery off Cilacap (South Central Java) where the effort also has surpassed its optimum (van Zalinge, in prep.). Here also, it is the large amount of shrimps in the trawlers' catch which provide the main incentive for the increase of effort.

We feel that a significant part of the large trawler fleet now operating in the North Sumatra-Riau areas should be redirected toward the above mentioned areas. There, their catch rate could be as high as they were obtaining at the start of the Malacca Strait fishery.

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7. Recommendations

7.1 Catch and effort statistics

7.1.1 Care should be taken to relate the fish and shellfish landing data to the gear that caught them.

7.1.2 The boat counts should indicate the main gear used, hence, list "trawlers", "seiners", "gillnetters", etc.

7.1.3 Double accounting such as discussed in this paper should be avoided.

7.2 Stock management

7.2.1 The maximum sustainable yield for Aceh, North Sumatra-Riau Provinces, and for the whole of the Malacca Strait amounts to 8,000 tons, 77,000 tons, and 85,000 tons respectively. These figures should be used as reference for management purposes.

7.2.2 The present (1975) number of boats causes the effort which corresponds to the maximum sustainable yield, and possibly should not be increased. Additional boats, if any, should consist only of large trawlers which would be able to tap the resources in waters of a depth of 40m and more. These waters make up more than 50% of the area, especially in the north.

7.2.3 Trawling in water of less than 10m depth should be discontinued.

7.2.4 Some of the large trawlers from North Sumatra and Riau should be redirected toward the South China Sea, the Karimata Strait Areas, and the Java Sea. These areas are now largely unfished and would yield larger catches.

References

- Birtwistle, W.
1928 Report of the working of the S. T. Tongkol for the year 1927. Government Printing Office, Singapore.
- Gulland, J. A.
1968 Some notes on the demersal resources of South East Asia. Proc. I.P.F.C., 13 (III): 51 - 60.
- Latiff, S. S.
1973 Resource survey and problems of fishery (Resource) management. Ann. Meeting of Fish. Officers, March 1973. Mimeographed manuscript, 17pp. (Malaysia)
- Martosubroto, P.
1973 Studies on demersal fish stocks in the Malacca Strait and Jambi Bay. Laporan Penelitian Perikanan Laut, No. 1: 1-33 (in Indonesian).
- Menasveta, D.
1970 Potential demersal fish resources of the Sunda Shelf. In: The Kuroshio, a symposium on the Japan Current, J. Marr (ed.), Honolulu, East West Center Press: 525 - 559.
- Ommaney, F. D.
1961 Malayan offshore trawling grounds. The experimental and exploratory fishing cruises of the F.R.V. Manihine, in Malayan and Borneo waters, 1955-56, etc.
- Pathansali, D., K. S. Ong, S. S. Latiff, and J. L. Carvalho
1966 Preliminary results of trawling investigations off Penang. Proc. I.P.F.C., 12, Tech. Pap. 7: 22pp.
- Saeger, J., P. Martosubroto, and D. Pauly
1976 First report of the demersal fisheries project: (Results of a trawl survey in the Sunda Shelf area). Laporan Penelitian, L.P.P.L., Contrib. Demersal Fish. Proj., No. 1, 75pp.
- Shindo, S.
1973 General review of the trawl fishery and the demersal fish stocks of the South China Sea. FAO Fish. Tech. Pap. No. 120: 49pp.

Unar, M.
1968 The "chantrang" danish seine fishery of the North
Coast of Java. Proc. I.P.F.C., 13 (III): 546-553.

Van Zalinge, N. P.
in prep. Investigation of Cilacap shrimp fishery.

Provincial and Regencies Reports for 1969 to 1975 from:

- Aceh Province
- North Sumatra Province
- Riau Province