Bay of Bengal Programme

Marine Fishery Resources Management

MACKERELS IN THE MALACCA STRAITS BOBP/WP/30

UNITED NATIONS DEVELOPMENT PROGRAMME

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MACKERELS IN THE MALACCA STRAITS

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This paper attempts to summarize the present knowledge of the mackerel resources in the Matacca Straits which are believed to be shared by Indonesia, Malaysia and Thailand. It contains a summary report and individual country papers.

The material was put together following a technical working group meeting of scientists from the three countries. The meeting was held 12-16 December 1983 at the Fisheries Research Institute, Penan9, Malaysia. The Director of the Institute, Mr Mohd. Shaari bin Sam Abdul Latiff, opened the meeting and welcomed the participants, whose names are listed iii Appendix 5 of the paper.

This paper, and the working group meeting on which it is based, are an activity of the project 'Marine Fishery Resources Management in the Bay of Bengal,' RAS/81/051, which is funded by the UNDP (United Nations Development Programme), and executed by the FAO (Food and Agriculture Organization of the United Nations) under its Bay of Bengal Programme. Dr. K. Sivasubramaniarn, Senior Fishery Biologist of the project, acted as convenor of the meeting.

The project has a duration of four years; it commenced in January1983. Its immediate objective is to improve the practice of fishery resources assessment among participating countries and to stimulate and assist in joint assessment and management activities between countries shnring fish stocks.

This document is a working paper and has not been officially cleared either by the governments concerned or by the FAO.

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CONTENTS

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1. INTRODUCTION

With the establishment of Exclusive Economic Zones, more than 90% of the marine fish catches of the world are taken within the jurisdictions of the coastal states. This has increased the responsibility of the coastal states for developing, utilizing and managing the fish resources in their respective EEZs. Extended jurisdiction of each coastal state over a wider area of the sea, has also increased the need for collaboration and cooperation in controlling the exploitation and management of resources shared by adjacent countries.

One of the fish resources of the latter category in the Bay of Bengal area is the mackerel. The mackerels of the Malacca Straits are exploited by Indonesia, Malaysia and Thailand.

In pursuance of the objectives of the regional FAO/UNDP project for 'Marine Fishery Resources in the Bay of Bengal'—to stimulate and assist in joint assessment and management activities of countries sharing fish stocks—a technical working group meeting was convened. It was held December 12-16, 1983 in Penang, Malaysia. (A list of participants and observers is found in Appendix 5.) It was meant to evaluate the present status of the stock and identify areas of work to further knowledge of the resource. In particular, the meeting attempted to:

- review the status of the mackerel fishery in the Malacca Straits, the collection of data and the assessments made by respective countries,
- identify gaps and constraints, and consider steps required to overcome these,
- consider similar study approaches in the respective countries to permit collective evaluation of the information compiled and interpretation of the results of the combined effort,
- standardize fishing effort units, and
- prepare a work programme for follow-up action, in accordance with the recommendations to be made.

Background material for the discussions was prepared by participants from each country. It appears in this report in Appendices 1-4.

Since only the Malacca Straits are dealt with in the report, the names of the respective countries refer to the west coast of Thailand, the west coast of Peninsular Malaysia and the northeast coast of Sumatra only, unless otherwise stated.

2. GENERAL OBSERVATIONS

Several independent populations and/or stocks of a single species may be found within a given geographical area. These populations or stocks could arise from the species under consideration using different spawning grounds or using the same grounds at different periods of time. These spatial and temporal separations may be influenced by the proximity of ideal environmental conditions or by ecological boundaries which may restrict movement into a single spawning ground.

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The stocks in a given area may also exhibit some mixing, particularly in areas where favourable feeding conditions prevail. Hence, a basic knowledge of the distribution of species, in relation to the environmental and spatial characteristics of the ecosystem of the Malacca Straits will be valuable, especially in developing a strategy for a suitable tagging programme.

If we are dealing with a common stock in the whole area, then the fishery in one part of the area will have its impact on the rest of the area in which the stock is distributed, irrespective of the EEZs involved and the degree of exploitation in other parts which may be adjacent to neighbouring states.

The effects of exploitation of young fish by one nation and older fish by another nation may not be felt by one another until the fishery on these components reduces the stock below the minimum level for maintenance of recruitment or spawning stock.

Confirmation of the *Rastrelliger* and *Decapterus* spp. in the Malacca Straits and their occurrence in the EEZs of the three participating nations are fundamental to any consideration of the shared mackerel stock.

Interaction and limitation of production models, caused by changes in the relative abundance of mixed species—as is evident in the Gulf of Thailand's demersal fishery—require examination for possible changes in the species composition patterns and catch rates of individual species in various EEZs. This should be attempted, even if some of the pelagic species are not the target species in fishing methods capturing mackerels.

Mapping of exploited areas of the EEZs and estimating the extent of their surface areas, as against the areas of the respective EEZs, is valuable for considering the relative coverage of the fishery in the respective EEZs and the possibilities for geographical expansion of the fishery in the future.

3. THE SPECIES

There are two types (genera) of mackerels in the Matacca Straits (commonly referred to as the chub mackerels and the scad mackerels (round scads)), namely *Rastreiiger* spp. and *Decapterus* spp. A list of the different species is given below:

Mackerels	
chub	scad
Rastrelliger	*Decapterus*
R. brachysoma *R. kanagurta* *R. faughni*	*D. maruadsi* *D. macrosoma* *D. russelli*

Of these species, *R. kanagurta* and *R. brachysoma* are by far the most important ones from a commercial point of view in all the three countries. *R. faughni,* although present in the Malacca Straits, does not contribute significantly to the production. The scientific name *R. neglectus,* sometimes used in the Malacca Straits area, is considered to be a synonym of *R. brachysoma.*

R. kanagurta and *R. brachysoma* are also caught around the Andaman Islands on the western side of the Malacca Straits. The abundance of *Decapterus maruadsi* and *D. macrosoma* has

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been established in Thai and Malaysian waters while Indonesia considers *O. russell* as the main species in its waters. In view of the proximity of Malaysian waters, it is considered unlikely that there could be distinctly different species on the two opposite sides of the southern part of the Straits; 0. *russelli,* reported for Indonesia, is perhaps in fact 0. *maruadsi.* Thailand had also identified *D. maruadsias O. russeii* until some years ago. It was proposed that there should be an exchange of specimens to confirm the identification.

The estimated relative contribution (in %) to the landings of mackerels by the different species is shown below:

Species	*Thailand*	*Malaysia*
R. kanagurta	40	68
R. brachysoma	58	32
R. faughni	2	0
Sub-total	100	100
O. maruadsi	60	1001
O. macrosoma	40	762
Sub-total	100	—

[1] during most of the year
[2] only around July

For Indonesia, it has not been possible to establish the relative contributions. Among the *Decapterus* spp., *D. russelli* (or possibly *D. maruadsi)* is considered to be the dominant species, but during a bottom trawl survey, 0. *macrosoma* was the only mackerel species recorded.

4. PRODUCTION AND CATCH RATES

Production records of chub and scad mackerels have been available iii the three countries since the late 60s/early 70s; only Thailand has catch records of individual mackerel species. Malaysia and Indonesia have data only down to the genus level. This has unfortunately made it impossible to examine the spatial distribution of the two *Rastrelliger* species in the entire Straits. Examination of catch data from the west coast of Thailand reveals that *R. kanagurta* is predominant most of the year along the northern half of its coastline whi!e P. *brachysoma* is conspicuous in the south. (Appendix 1, Table 5). It, therefcre, appears that *R. brachysoma* is the predominant species in Thai waters close to the boundary with Malaysia. Though Malaysia has not been able to separate the soecies distributed, *R. brachysoma* appears predominantly in the trawl catches in the northern part of its coastal area.

The values of effort are based on the number of catching units under license or considered to be operational; estimates of the actual effort are not available. Within these limitations, the catches and catch rates since 1972 for *Rastrel/iger* spp. and *Decapterus* spp. are presented in Tables 1 and 2.

Most notable is the *Rastreiiger* production of Malaysia which has increased by leaps and bounds since 1977; it is about five times higher than the production of Indonesia (Fig. la). But the catch rates have been relatively low until 1979 (Fig. ib). Even in recent years of very high production, the catch rates have not exceeded those of Thailand. Contrary to the sharp increase of production in Malaysia, the trend in Indonesia and Thailand is one of slow decline (Fig. la).

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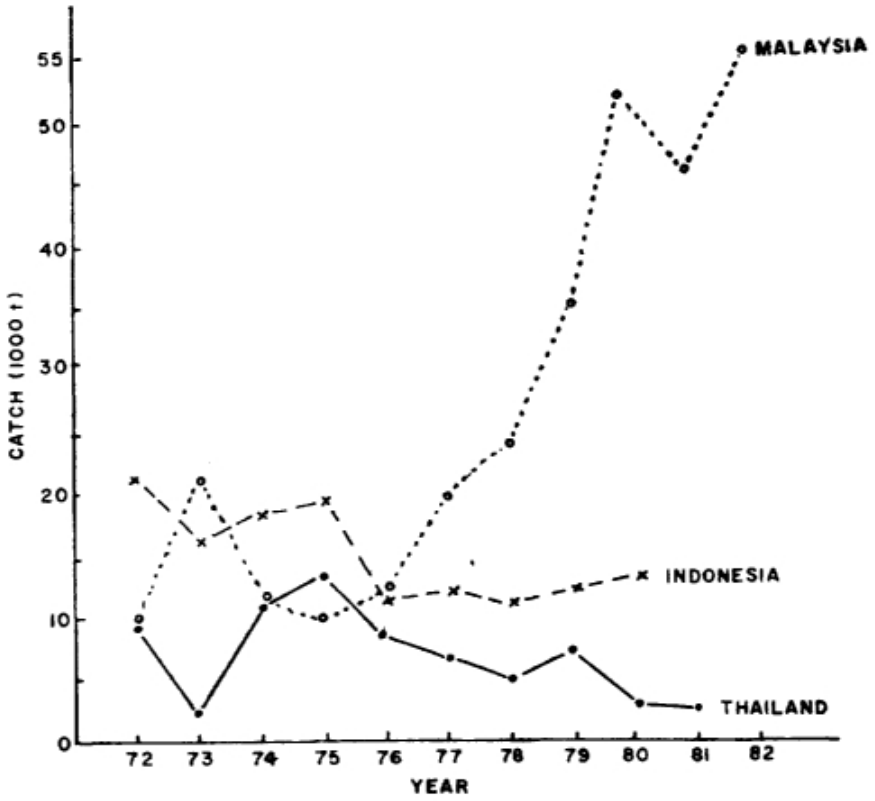

Fig. 1a. Variations in the annual production of *Rastrelliger* spp.

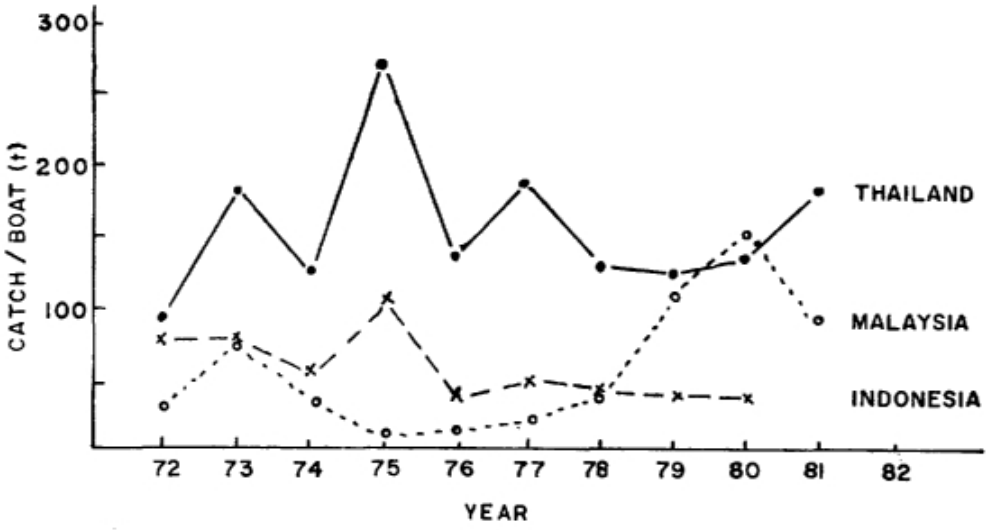

Fig. 1b. Variations in the annual catch rate of *Rastrelliger* spp.

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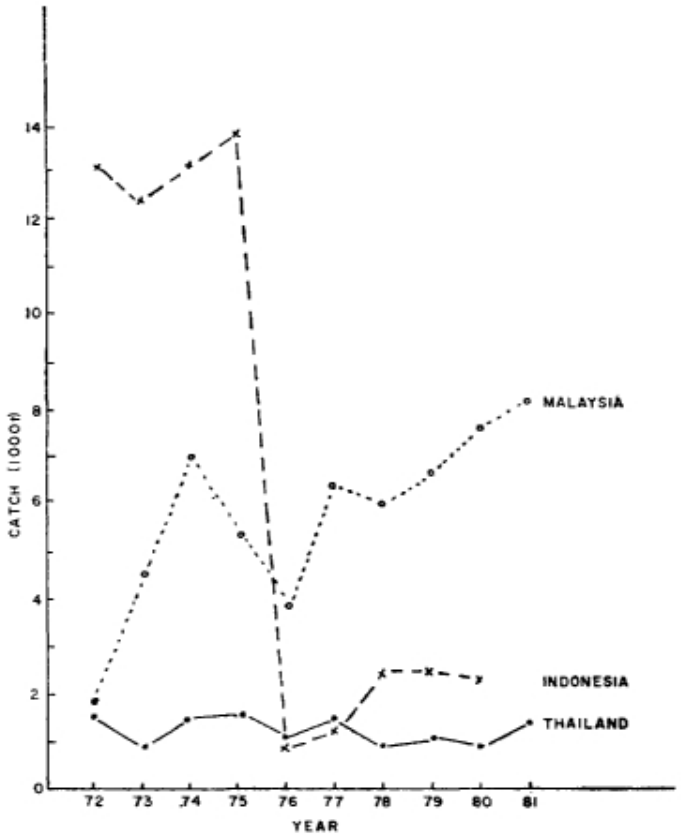

Fig. 2a. Variations in the annual production of *Decapterus* spp.

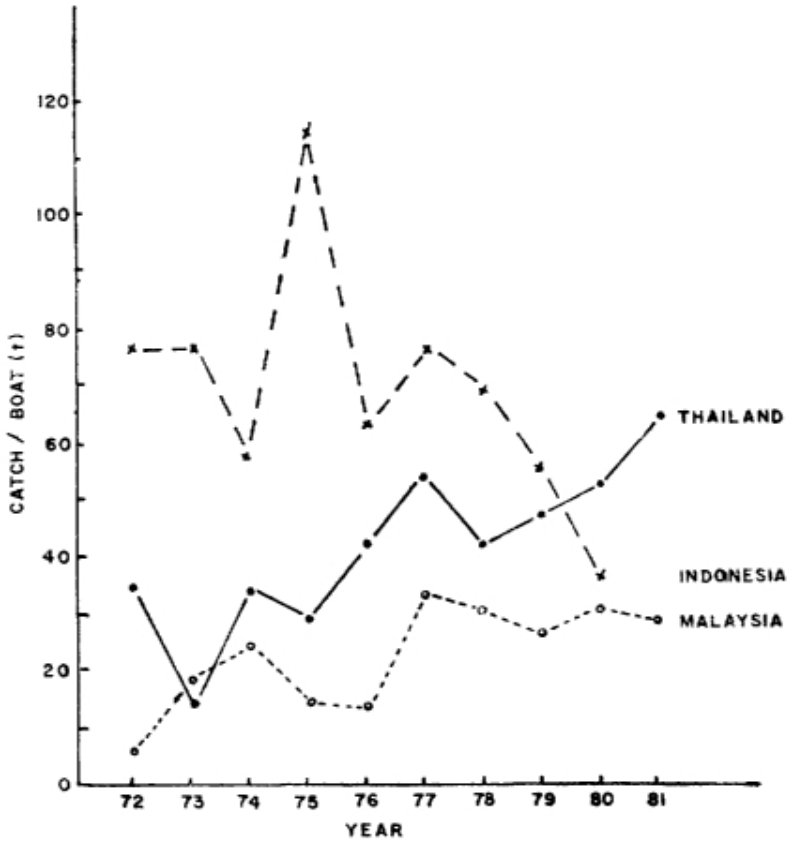

Fig. 2b. Variations in the annual catch rate of ***Decaptews***

The picture for *Decapterus* spp. after 1976 shows similarities to that of the *Rastreiiger* spp. (Fig. 2a). The upward trend in Malaysia is, however, not so pronounced and the production in Indonesia and Thailand appears to be stable rather than declining. Though Malaysian production has been much higher than those of Indonesia and Thailand, since 1977, its catch rate has been the lowest during the period excluding, perhaps, 1980 (Fig. 2b).

The Malaysian fishery for *Rastreliger* spp. extends over the entire EEZ. The relative density expressed in yield per unit area is estimated at 0-8 t/km2. In Thailand and Indonesia the *Rastreiiger* spa. fisheries cover only about half of the respective EEZ's and the relative density is about 0-3 and 0-35 t/km2, respectively.

		Thailand	Malaysia	Indonesia
EEZ	(km2)	111,000	69,413	100,000
Area covered by the fishery	(km2)	44,000	62,275	55,000
Yield per unit area* *(Rastrelliger* spp.)	(km2)	0.3	0.8	0.35

*The density estimates are based on production in the year with the highest catch rate for the respective Countries.

Table 1

Catch and catch rates of *Restre/liger* **spp. by country (1972-82)**

Year	Thailand		Malaysia		Indonesia	
	Catch (tonne)	Catch rate (tonne/boat)	Catch (tonne)	Catch rate (tonne/boat)	Catch (tonne)	Catch rate (tonne/
1972	9968	91	9763	33	21350	77
1973	23334	184	21675	76	16179	76
1974	11170	124	12313	37	18533	57
1975	13701	274	9987	24	19512	114
1976	8470	135	12414	26	11470	39
1977	6993	189	19570	45	12386	46
1978	4678	126	23804	61	10999	38
1979	7392	119	34154	120	12073	35
1980	2773	126	51869	173	13114	34
1981	2480	177	45027	91	—	—
1982	—	—	54719	81	—	—

Note: Catch rates are based on catch records and effort by all types of P. seines in Malaysia, Indonesian P. seines in Indonesia and Thai P. seines in Thailand.

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Table 2

Catch and catch rates of *Decapterus* spp. by country (1972-82)

Year	Thailand		Malaysia		Indonesia	
	Catch (tonne)	Catch rate (tonne/boat)	Catch (tonne)	Catch rate (tonne/boat)	Catch (tonne)	Catch rate (tonne/boat)
1972	1475	37	1814	6	13076	77
1973	811	14	4849	18	12264	76
1974	1416	34	7021	23	13162	57
1975	1535	28	5332	15	14053	114
1976	1074	42	3695	14	758	63
1977	1450	54	6398	33	1362	76
1978	**886**	**41**	**6025**	**30**	**2536**	**69**
1979	1044	47	6599	26	2593	55
1980	895	54	7459	30	2257	36
1981	1500	65	8194	27	—	—
1982	—	—	9408	27	—	—

Note: catch rates are based on catch records and effort by aH types of P. seines in Malaysia; Indonesian P. seines in Indonesia and Chinese P. seines in Thailand.

5. FISHING EFFORT

Many different fishing methods, craft and gear are employed in the capture of mackerels in the three countries. The main characteristics are summarized in Table 3.

There is a large variation in the effectiveness of the unit effort values even within each category and, of course, more so between the different categories. No serious attempts have been made to correlate size and power of craft to gear, or catch rate to size of craft and gear, of the units operating in the Malacca Straits.

In Thailand, data on catching units are available for different types of purse seiners (Thai purse seiner, Chinese purse seiner and luring seiner). The efficiency of the Chinese type has, for instance, been estimated to be two-thirds of the Thai type. Some information from the Gulf of Thailand fishery might also be relevant to the west coast in attempts to correlate the variables. An example is the relationship between length of vessel and length of net for lamp luring purse seiners in the Gulf of Thailand established by the Marine Fisheries Division.

Length of net (m) x 35.23 > length of vessel (m) — 105 with a correlation factor of 0.91.

There is also other information available from the same area on, for instance, catch per haul and catch per day for different sizes of vessels.

In Malaysia, there is an indication that the non-luring purse seine is 40% more effective than the luring purse seine. But, this result is only an unconfirmed preliminary observation because it was based on a comparison of the catches by non-luring purse seine fishery in the central part with those of the luring purse seine fishery in the northern part of the west coast. The

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former is primarily a night operation and the latter tends to be more of a day time operation with coconut leaf as lure. Even night luring with lights is conducted vvith the help of petromax kerosene lamps placed above water (on rafts). In Thailand, luring purse seiners use underwater and above-surface electric lamps powered by generators on board. Light attraction contributes very significantly to higher catch rates for mackerels in Thailand.

The trawl catches of mackerel in Malaysia have increased substantially since 1976, although there have been great fluctuations from year to year (Table 1, Appendix 3). There might have been a slight increase in the trawl fleet but reliable information to this effect is not available. The catch rates of mackerels by high opening bottom trawls have increased, and the mackerel is the target species of this trawl fishery. Even the drift/gillnet fishery has shown an increase in mackerel catches though not to the same degree as that of the trawl fishery. In view of the increasing contribution to the mackerel production by high opening trawls in Malaysia, sampling of trawl catches needs to be incorporated in the mackerel study programme.

The characteristics presented in Table 3 show that none of the gear categories is compatible for the three countries. The luring purse seines and the vessels for their operation are compatible in Thailand and Malaysia but unfortunately this system of fishing does not exist in Indonesia. Another system with fewer differences between countries and applied in all three is the 'purse seine' (Thai purse seine, Malaysian purse seine and Indonesian purse seine). The total effort for mackerel production standardized to this method of capture was considered to bring the effort units of the three countries to the highest level of compatibility with the information available at present.

In view of the fact that the Thai purse seine is specifically directed to the capture of *Rastrelliger* spp. and Chinese purse seine to the capture of *Decapterus* spp. in Thailand waters, that country standardizes the effort on the two varieties to the respective gears mentioned. In Malaysia, the effort is brought to an average level for all types of purse seines, as catch rates cannot as yet be estimated for any particular type of purse seine. In fact, the effort values are not direct estimates in these cases and have been obtained by dividing the total production of chub or scad mackerels by all types of geers, by the catch rate of mixed purse seines in Malaysia, Thai purse seine or Chinese purse seine (for chub and scads, respectively) in Thailand, and the only type of purse seine in Indonesia. The catch rates are derived by using the number of units of the gear as the index of effort and the number of trips or number of fishing days estimated through sampling procedures. (Thailand is also measuring the effort by number of boat-days.) In fact, the catch rate estimated by sampling conducted by the Research Institute in Penang for a particular year was found to be 50-60% higher than that derived by the normal procedure adopted. The very high production of mackerel in Malaysia from 1980 to 1982 has resulted in proportionate increase in the fishing effort values estimated by the procedure that has been adopted but this large increase in the fishing effort will not be evident if the catch rates derived from the sampling programme of the Research Institute are applied.

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Table 3

Main characteristics of craft and gear contributing to the mackerel production

		THAILAND			MALAYSIA			INDONESIA		
								Encircling		
		P.S.	*T.*	*G.N.*	*P.S.*	*T.*	*G.N.*	*P.S.*	*T.*	*G.N.*
Craft	Size (m)	14 - 25	10 - 30	10 - 18	15 - 25	18 - 25	10	15	15	12
	Power (hp)	120 - 420	50 - 500	50 - 200	120 - 250	200 - 350	6 - 36	32 - 42	15 - 33	7 - 33
	Endurance (days)	1	4 - 5	1	1	1	1	1	1	1
P. Seine	Target spp.	Mackerel, Sardine			Mixed pelagic			Small & medium pelagic		
	Size (m)	(800-1200) × (70-120)			(400-800) × (80-120)			(400-600) × (40-60)		
	Mesh (mm)	18 - 90			25			25 - 90		
	Operation	Day & night; echo sounder, sonar			Day & night, 1			Night		
C.P. Seine	Target spp.	Mackerels			Mixed pelagic					
	Size (m)	(600-1200) × (60-80)								
	Mesh (mm)	18-25								
	Operation	Day & Night								
L.P. Seine	Target spp.	Scads, sardines			Mixed pelagic					
	Size (m)	(400-800) × (50-80)								
	Mesh (mm)	18-25								
	Operation	Day & night								
Trawl										
(2-seam)	Target spp.	Mixed								
	Size (m)	12-40 (headrope)			25 (headrope)					
	Mesh (mm)	20-25 (cod-end)			25 (cod-end)					
D. Seine	Target spp.							Demersal		
	Mesh (mm)							12-18 (cod-end)		
Gillnet	Target spp.				Mixed pelagic			Mixed pelagic (small)		
	Size (m)				800 (variable)			600		
	Mesh (mm)				25-100			25-50		
Gillnet	Target spp.	Sardine, mackerel						Small pelagic		
(encircl.)	Size (m)	(300-500) × (20-30)						600 × 40		

P.S. — purse seiner; T — trawler; G.N. — gillnetter; C — Chinese; L — Luring; D — Danish.

6. MAXIMUM SUSTAINABLE YIELD

Using the 'purse seine' as the common gear, the total effort standardized at that level and the total production of *Rastreliger,* an attempt was made to examine the overall trend in the Malacca Straits. The maximum sustainable yield (MSY) derived was 54,841 tonnes which is slightly less than that derived by addition of the separate estimates for the three countries (Table 4). All the effort points were found to be on the right hand side of the parabola. The calculations were also repeated by standardizing the total effort on chub mackerel in the Malacca Straits to the levels of the Thai purse seine, Malaysian purse seine and Indonesian purse seine. The MSY in terms of Thailand and Indonesia standards was less than the first estimate and that by Malaysia standard was almost the same as the first estimate (Table 4). The correlation coefficient was equally significant in two estimates with equally high MSY values. This indicates that the total production in the Straits exceeded the MSY in 1973 and is close to or above the MSY since 1979.

The estimates also indicate that Thailand exceeded her MSY only in 1973 but the production since then has been nearly half or less than half the MSY. Yet the effort put into this fishery has continuously diminished.

Malaysia exceeded her MSY in 1978 but the production has continued to increase to two to two and a half times the MSY in 1980, 1981 and 1982. The validity of the figures for the last three years may have to be reconfirmed.

Indonesia exceeded her MSY as far back as 1972, but the production has been close to the MSY since 1976. The abnormality of the figures for the pre-1976 period has caused some difficulties even in fitting a production model and perhaps needs rechecking.

In the case of *Decapterus* spp. the Indonesian catch data for 1972 to 1975 could not be used due to certain abnormalities and hence data for 1976-1980 were used in the pooled analyses. The combination of effort, as determined for the Thailand, Malaysia and Indonesia purse seines, gave an MSY of 9,121 tonnes and the effort standardized to the level of the Malaysian purse seine also gave a very similar value (Table 5). The total effort at the level of the Indonesian purse seine standard, gave an MSY of 11,326 tonnes which is very close to the MSY estimated independently for the three countries (11,200 tonnes). Standardization of effort at the level of the Chinese purse seine in Thailand, failed to produce any reasonable correlation with catch rates and hence the MSY estimation with this series of effort values was abandoned.

The MSY for Thailand and Indonesia have not been exceeded yet. Malaysia's production has exceeded its MSY since 1977 but the catch appears to be stable at a slightly lower level from 1980. The overall production in the Malacca Straits does not appear to have exceeded the overall MSY.

It is noted that the MSY for *Restrelliger* in the Malacca Straits was estimated to be about 95,000 tonnes and that of *Decapterus* about 24,000 tonnes in **1976.1** However, the estimated production of *Restreliger* by Thailand for the years 1971-1973 was overestimated during the 1976 workshop, as can be seen from the revised figures available now for the same period.

'Report of the Workshop on the Fishery Resources of (he Ma/acca Straits—Part I, March 29 to April 2 1979, Jakarta. SCS/Gen/76/2. Part II. SCS/Gen/76/6

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Table 4

MSY of *Rastreiiger* spp. in the Malacca Straits, as estimated for effort standardized to the effIciencies of various types of purse seiners employed in the respective countries

Year	Total Catch	Malacca Straits Purse seine standard		Thailand Purse seine standard		Malaysia Purse seine standard		Indonesia Purse seine standard	
		Effort	CPUE	Effort	CPUE	Effort	CPUE	Effort	CPUE
	(t)	(PS)	Ct/PS)	(PS)	(t/PS)	(PS)	(t/PS)	(PS)	(t/PS)
1972	40781	680	59.97	448.1	91	1236.5	32.98	531	76.8
1973	61188	623	98.22	332.5	184	800.5	76.44	802	76.3
1974	42011	747	56.24	338.8	124	1126.6	37.29	741	56.7
1975	43200	632	68.35	157.7	274	1775.6	24.33	379	114.1
1976	32354	837	38.65	239.7	135	1240.6	26.08	840	38.5
1977	38949	743	52.42	206.1	189	870.4	44.75	847	46.0
1978	39481	719	54.91	313.3	126	644.9	61.22	1053	37.5
1979	53618	691	77.59	450.6	119	447.1	119.92	1528	35.1
MSY(t)		54841		48476		54356		49094	
Optimal effort (no of PS)		498		333		914		1,104	
(corr. coeff.)		—0.84		—0.80		—0.83		—0.706	
MSY(t) (Estimate by country)		58765		20074		21000		17691	

Note: Effort according to standards mentioned in Table 1
PS—Purse seiners

Table 5

MSY of *Decapterus* spp. in the Malacca Straits, as estimated for effort standardized to the efficiencies of the various types of purse seiners employed in the respective countries

Year	Total Catch	Malacca Straits Purse seine standard		Thailand Chinese Purse seine standard		Malaysia Purse seine standard		Indonesia Purse seine standard	
		Effort	CPUE	Effort	CPUE	Effort	CPUE	Effort	CPUE
	(t)	(PS)	(t/PS)	(PS)	(t/PS)	(PS)	(t/PS)	(PS)	(t/PS)
1976	5527	308	17.94	131.3	42.1	406.4	13.6	87.45	63.2
1977	9210	242	33.06	171.2	53.8	283.4	32.5	121.50	75.8
1978	9447	259	36.47	228.2	41.4	314.9	30.0	137.91	68.5
1979	10236	323	31.69	216.9	47.2	393.1	26.0	185.43	55.2
1980	10611	332	31.96	198.3	53.5	359.7	29.5	291.51	36.4
MSY(t)		9121				9724		11326	
Optimal effort (no of PS)		292		Cannot be		292		258	
(corr. coeff)		—0.539		determined		—0.797		—0.889	
MSY(t) (Estimate by country)		11.200		2,700		5,800		2,700	

Note: Effort according to standards mentioned in Table 2.
PS—purse seiners

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7. PROBLEMS AND LIMITATIONS

Having reviewed and analyzed the available information and data on the mackerels in the Malacca Straits, the working group discussed the many problems and limitations encountered during their work. Several gaps will have to be filled and errors rectified in order to improve the assessment of the stocks and their exploitation.

It is felt that as regards accuracy, the data obtained from routine statistics are far from satisfactory. It is a crucial deficiency since most of the stock assessment work is based on such catch and effort data. There is, for instance, no breakdown of the catch by species except for the *Rastrel/iger* spp. in Thailand; the actual effort in number of units is unknown since the statistics are geared to administrative requirements. The problem lies both in the classification and the collection of data. The drastic revisions in catch and effort values made in the past illustrate this point. A higher degree of reliability of data could probably be attained by close cooperation between research and statistics units. The problem concerns all the countries.

A serious limitation encountered during analysis is the inadequacy of the gear classification and the correlation between different gears. It concerns the individual countries, particularly Malaysia, as well as the area as a whole.

Sampling programmes are conducted by the research institutes in Phuket and Penang while Indonesia is yet to establish such programmes for the north-east coast of Sumatra. The ongoing sampling programmes, however, suffer from insufficient frequency and meagre content. A particular gap in Malaysia is the absence of sampling of *Rastre/liger* spp. at trawl landing sites. The sites of existing and proposed sampling stations are indicated in Fig. 3.

Very little biological work, e.g., egg and larvae studies, morphometric measurements, tagging, etc., has been undertaken of the species under investigation. Shortage of funds and manpower is said to be the main cause of these problems and limitations.

In exploring remedial action, the possibilities of employing some of the recently introduced methodologies based on the length structure approach were considered. Although some reservations were exoressed, it was agreed that the information to be collected would permit various analytical approaches and, therefore, did not restrict the group to the application of only simplified approaches to the study of the mackerel stock(s). In view of the difficulties in obtaining certain variables—such as age structure and mortality rates—for the numerous species in the tropical ecosystem, without prolonged investigation, the length structure approach could be applied to evaluate the status and determine the yield of the stocks. This would also be useful for comparison with the estimates obtained by conventional approaches, until the sampling programme becomes effective and vital variables such as age, growth and mortality are determined.

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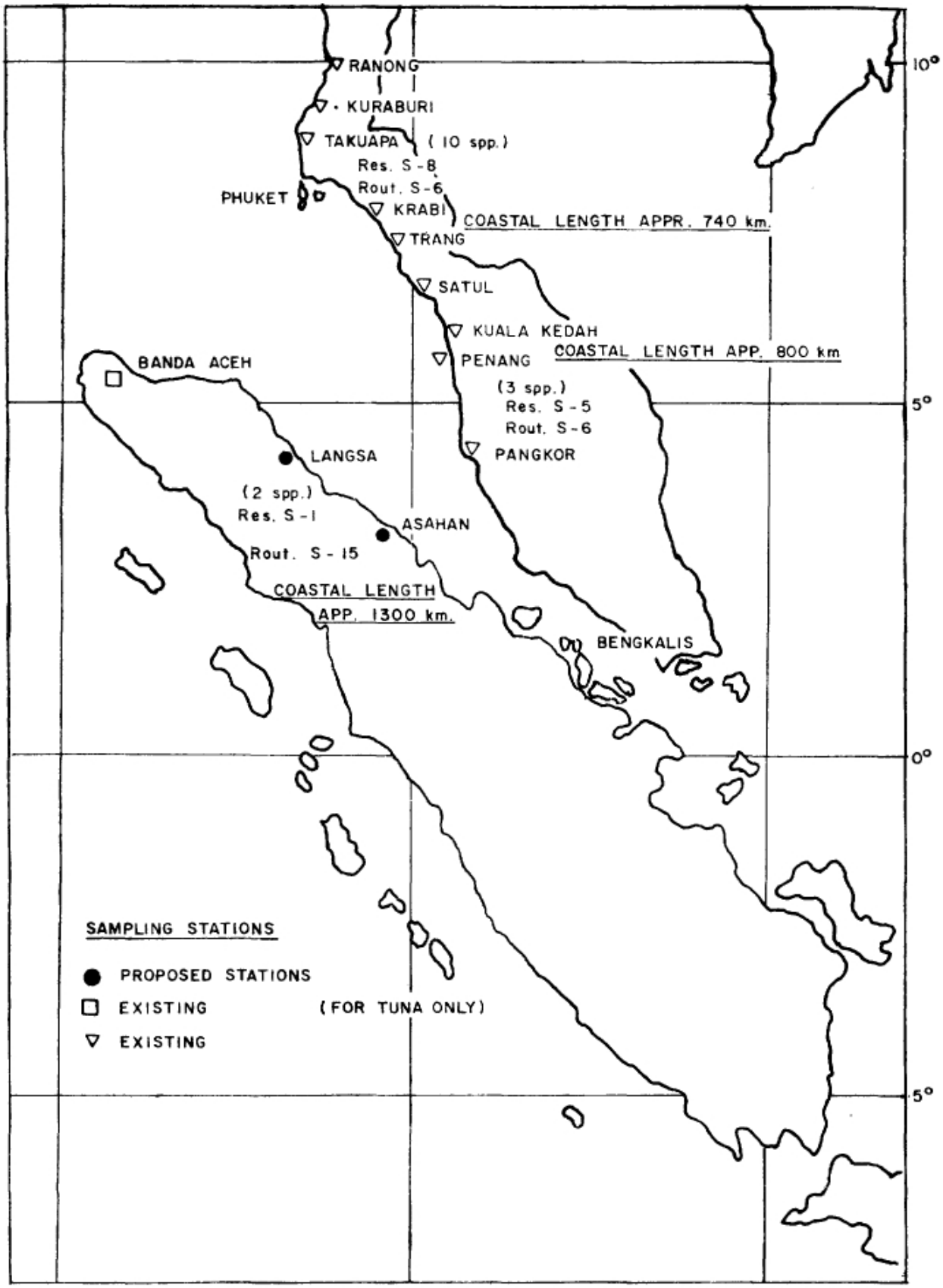

Fig. 3. Locations of existing and proposed sampling Stations for mackerels in the Malacca Straits.

8. WORK PROGRAMME

The existing systems for collecting data for research purposes were reviewed in respect of each of the participating countries. The sampling stations and the staff available were discussed in the light of the data to be collected. It was believed that the existing sampling stations in Malaysia were sufficient but occasional sampling close to the southern end would be advisable. In the case of Thailand, one of the two sampling stations close to Phuket would not be needed. In Indonesia, there is a need to establish research sampling stations in the Malacca Straits.

The specific work items to be carried out and standards to be adopted were identified as follows;

1. Routine sampling at identified landing sites. At least 10% of the total number of boats should be sampled. The frequency of sampling should be monthly, some time between new moon and full moon.

2. Determination of catch composition by size and type of fishing boats and fishing gear (purse seine, luring and non-luring, trawl and drift/gillnets). The weight should be recorded at landing sites, before sorting by size at stations where price varies with size of fish.

3. Landing records of *Rastre/liger* and *Decapterus* by species and by type of gear as specified in (2) above. If species of each variety are not separated before sale, eye estimates of proportions are to be made.

4. Length measurements (standard, total or fork) of *Rastre/liger* and *Decapterus* by species and type of gear. Standard, total or fork length can be measured, provided each country independently calibrates one length against another for conversion purposes. This will facilitate the use of data already collected. Measuring boards are to be used and measurements are to be at 5 mm intervals.

5. Estimates of fishing effort (number of vessels, number of trips, number of days) and if possible number of settings of hauls per day. These can be obtained from the national statistics but the researchers will check on the effort periodically to correct and supplement the data as found necessary.

6. Correlation of size of craft/horsepower with size of gear and with catch rates for standardization of effort. Cross calibration experiments with a boat of a size common to all the three countries will be difficult because a vessel of the size of the largest purse seiner in Indonesia will not be able to sail out with one standard net to cover the fishing grounds of all the three countries. Hence, it was decided that standardizing the catch rates of the mackerel species in each country to a particular range in the size of craft, size of gear and operational technique would be a reasonable and practicable approach. The specification proposed for standardization is as follows:

Length of craft (m)	15 – **20**
Power of craft (hp)	**150** – 200
Gear	'Purse seine'
Length of net (m)	600 – **800**
Mode of operation	non-luring

7. Morphometric measurements to determine the length-weight relationship. These should include standard length of fish, snout to eye, snout to first dorsal fin, pectoral fin length, and height of fish (just behind the operculum). A caliper should be used.

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8. Information on fishing grounds and operations. Researchers should go out with fishing vessels to observe the fishing area, modes of operation, number of schools fished, etc., at least once or twice a year.

9. Egg and larval surveys. These are not vital for the time being and should only to be implemented if funds permit.

10. Tagging. Thailand will continue her annual tagging programme on *A. brachysoma.* Further tagging experiments need not be implemented, unless ample funds are available, before more basic biological information has been collected.

It was considered possible to undertake the above work within the present staff and funding limitations of the research establishments of member countries, with a minor supplementary input from the regional project.

9. CONCLUSIONS

The analysis of available information on mackerels in the Malacca Straits does not indicate clearly whether the *Rastrelliger* spp. and *Decapterus* spp. exploited by the three nations belong to common stocks or not. Tagging experiments conducted by Thailand show that *R. brachysoma* in the southern coast of Thailand does migrate into the northern waters of Malaysia. It is also observed that the north-south migration of this species was limited to the Trang area in Thailand and to Kedah in Malaysia. This is in conformity with the coastwise production trend shown for *R. brachysoma.* The length frequency data made available are limited to one year and the number of samples from some of the stations is low. Though some trends are indicated, no definite conclusion could be drawn at this stage, except for general observations made in the reports of the respective countries. A noteworthy observation is the reversal of the production and catch rate trends for *Rastreiiger* in Malaysian waters as against those of Thailand and Indonesia, the latter exhibiting similar variations. The peak production year for *Rastre//ige,* in Thailand and Indonesia was 1975 whereas this was the year of the least production in Malaysia.

The applied estimates of effort values are indices rather than absolute effort figures. Hence the derived catch rates also have the same degree of validity. Unusual results were observed in some instances, such as the production trend of *Decapterus* in Indonesia and the production and effort estimates for the *Rastre/liger* catches for 1980-82 in Malaysia. These data had to be left out of the analysis and have to be reassessed.

The results indicate that Malaysia's production of *Rastrelliger* spp. exceeded the MSY in 1978 but production seems to have continued to increase up to recent years; Indonesia's production exceeded the MSY in 1972 but has subsequently been fluctuating close to this value; Thailand exceeded its MSY in 1973 but the production since then has been nearly half or less than half the MSY.

It appears that Thailand's effort on the mackerels has been shifted to other target species such as tunas and hardtail scads. The overall production of *Rastreiiger* spp. seems to have exceeded the MSY only in 1973, excluding the production by Malaysia in 1980-1982.

The production of *Decapterus* spp. by Thailand and Indonesia does not appear to have exceeded their respective MSY's but it has done so in the case of Malaysia, since 1977. The overall production does not present evidence of having exceeded the overall MSY.

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These estimations are based on available data, with limited reliability, which do not permit much further analysis or interpretations. The most serious information gaps are found in Indonesia where very little research sampling on the mackerels is being, or has been, carried out systematically; it is understood that Indonesia is likely to commence activities along the recommended lines, beginning early 1984.

10. RECOMMENDATIONS

In finalizing the deliberations of the Penang meeting the working group put forward the following **recommendations.**

1. The work programme, as proposed and agreed to by the participants, should be implemented to improve the reliability and to obtain additional information required for better assessment of the mackerel stocks.

2. Improvement of the national fisheries statistics should be undertaken in order to increase the reliability of data used by the stock assessment workers. This will enhance the analysis and supplement the data collected by the research units. There should be regular consultations between the scientific officers and the fisheries statisticians and the data collected by the research division should be used for adjustments and corrections of the data collected by the statistical units.

3. In the case of Indonesia, sampling stations should be established and officers recruited for the execution of sampling programmes as soon as possible, if meaningful research work on the mackerels is to be carried Out. The Sumatra area does not appear to be on the priority list in Indonesia, as far as fisheries research is concerned.

4. The regional project should assist and provide necessary facilities to the participating institutions, and to the personnel concerned with this specific study in the Malacca Straits, on matters concerning standardized analytical approaches, independent and collective analysis of data and collection of information by them.

5. The concerned scientists in the three countries should maintain regular contact with one another, and also the project, regarding progress and problems connected with the execution of the work programme.

6. There should be opportunities for the scientists to meet one another, as and when it is found necessary, for effective implementation of the work programme. Regular meetings should be held to review and assess progress, depending on the extent of progress and on the emergence of serious problems that call for joint discussion and cannot be solved by correspondence.

7. The national expertise in stock assessment and resource management should be upgraded through training courses at various levels.

8. The project should assist in obtaining financial support for a joint tagging programme, if **the participating countries are unable to provide necessary funds.**

9. The project should assist in arranging for financial support for satisfactory execution of **the work programme.**

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Appendix 1

REVIEW OF THE CHUB MACKEREL FISHERY (*RASTRELL/GER* SPP.) ON THE WEST COAST OF THAILAND

Introduction

It is well known that small pelagic fish, especially the mackerels, are very important for marine fisheries in Thailand. The exploitation of these resources has developed rapidly during the last two decades. This rapid development may, in the near future, lead to over-exploitation of resources unless regulatory measures are taken. In order to be successful in resource management and fishery development planning, it is necessary to analyze the resources and the current status of the fisheries.

Some research and biological studies on these resources have been carried out by the Phuket Marine Fisheries Station of the Department of Fisheries, but a comprehensive review of the resources and of the research results at this station has not been made. The present paper, therefore, aims at reviewing present information available on the biology of the *Rastre/liger* resource and the status of their fisheries.

Taxonomy

There are at least three species of *Rastre/liger* spp. being caught off the west coast of Thailand, namely *R. brachysoma* (locally referred to as Pla-tu), *R. kanagurta* (Pla-lung) and *R. faughni* (Pla-lung-ching-chok).

Results from a study on the identification of mackerels showed that the two later species exhibited a body length slightly more than that of *R. brachysoma,* in the fish caught by trawlers (Sukhavisidh, 1978).

Distribution

Mackerels are distributed throughout the coastal area of the west coast of Thailand. Their distribution and fishing grounds are shown in Fig. 1 and Fig. 2.

R. brachysoma is found in most of the areas and it is the most abundant among mackerels, accounting for 16% of the total pelagic catch or about 58% of the total mackerel catch. *R. kariagurta,* also found throughout the area, accounted for 13% of the total pelagic catch or about 40% of the total mackerel catch. *R. faughni* is found mainly in the upper west coast and has been of minor importance compared to the two other species.

It is believed that *R. brachysoma* is a coastal form or neritic in nature while *R. kanagurta* and *A. faughni* are open sea or offshore species.

Spawning

R. brachysoma has a long spawning season, from June to March. However, the information on the seasonal change in the gonadosomatic. index (GI) indicates that there are two peaks of spawning, one between January and March and the other from June to August, for the upper west coast and, one from December to March and a second from August to September, for the lower west coast. As for *R. kanagurta,* the spawning may take place from December to April (Pimoljinda, *et. al.,* **1977).**

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Up to the present, there is no temporal/spatial coverage of the spawning survey; the spawn-irg grounds of mackerels in this area cannot, therefore, be determined with any certainty.

Maturatinn and fecundity

A. brachysorna is believed to mature at 16.5 and 17.0 cm LX for the fish found along the upper and lower west coast, respectively. Sex of the fish could be distinguished when they reach about 12 cm LX.

The fecundity of *R. brachysoma* was estimated to range from 118,685 to 222,455 with an average of 170,570 for fish ranging from 15.2 to 19.5 cm LX.

The size at first maturity of *R. kanagurta* has been reported as 20.0 cm LX and its fecundity was estimated to be 96,712 to 224,633, or an average of about 160,672 for fish ranging from 15.3 to 22.3 cm LX. Based on the frequency distribution of ova diameters, the matdrity stage of *Rastrelliger* spp. has been classified as follows:

Maturity stage	Ova diameter
1	<0.25 mm
2	0.25 — 0.45 mm
3	0.46 — 0.60 mm
4	0.61 — 0.87 mm
5	>0.88 mm

It should be noted that the fecundity figures given for mackerels do not indicate that all the eggs spawn in a single season. It seems that during a spawning season, a female releases eggs in batches of approximately 25,000 to 40,000 for *R. brachysoma* and 15,000 to 30,000 for A. *kanagurta.*

Growth

Growth of *R. brachysoma* is very rapid. The results of tagging experiments indicated that the growth increment of small and medium sized fish averaged about 1.2 cm per month. Since the data obtained from the investigation of seasonal change in the length distribution was far from adequate, the analysis to estimate the parameters of growth function has not been carried out.

Food

Mackerels are well known as plankton feeders. This is indicated by the feature of the gill rakers as well as by their swimming behaviour when they form a big school.

R. brachysoma feeds mainly on phytoplankton. The results of an investigation of stomach contents showed that the food items comprised phytoplankton (64%), dinoflagellates (30%), copepods (5%) and other planktonic organisms (1%).

R. kanagurta is a species with a marked preference for zooplankton. Its food items comprise zooplankton (52%), dinoflagellates (31%), crustaceans (10%), fish and squid larvae (2%) and other planktonic organisms (5%) (Suthakorn, 1977).

Migration

The results of the tagging experiments which were carried out by the Phuket Marine Fisheries Station during 1981-1983 showed that of 6,383 *R. brachysoma* tagged and released in Ko Langu, Ko Bulon and Ko Terutao of Satul province, 84 fishes (1.3%) were recaptured at various

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locations (Fig. 3 and Table 1). Although most of the recaptured fish had moved only short distances from the released areas, a small component showed northward migration to Trang province during March-April and August-October and southward migration to Kedah state in Malaysia during June-July. It is assumed therefore, that the *R. brachysama* along these areas of Thailand and Malaysia intermingle to some degree, or that this particular stock may be shared by Thailand and Malaysia.

However, the information on migration is scanty due to the poor recapture; further tagging experiments should be carried out both in Thailand and Malaysia to provide more information.

Stock identity

Due to lack of information, it is difficult to identify with any degree of certainty the unit stocks present along the west coast of Thailand. However, the tagging data showed that some tagged fish released on the lower west coast have moved into the area and some others moved into Malaysian waters. It is conjectured that Thailand harvests more than one stock of the *R. brachysoma—one* off the upper west coast and the other off the lower west coast.

Hence, the stock off the lower west coast might be exploited by both Thailand and Malaysia. Similarly, the stock off the upper west coast might be shared with Burma. This hypothesis should be tested through intensive tagging experiments in the future.

A preliminary examination of the length frequency distribution of *R. brachysorna* in the two different areas seems to show signs of a certain modal progression of each brood in each area. This phenomenon, therefore, may support the idea of the occurrence of two stocks.

Fishing gears

The mackerel fisheries on the west coast of Thailand expanded after some fishermen from the Gulf of Thailand had moved into the area and introduced fishing gear like purse seines, and gillnets, to catch inshore pelagic fish. Since 1969, Thai fishermen have modified trawl nets for catching pelagic fish in substantial quantities. With the gradual mechanization of fishing boats and improvement of gears, the mackerel fishing grounds were extended further offshore to waters up to 100-200 m depth.

The most important fishing gears used are the purse seine and its modifications, i.e., Chinese purse seine, Thai purse seine and luring purse seine. The description of these gears follows:

1. *Chinese purse seine:* The Chinese purse seine was introduced to Thailand around 1925, employing a sail boat (which is now motorized) with two small rowing boats for setting the net. The size of boat varies from 14 to 25 m in length. The net is rectangular without a bag but with the purse line. The size of the net is 600-1,200 m in length and 60-80 m in depth. The mesh size of the net is usually between 18 and 25 mm. The operation is carried out so that when a fish school is spotted by the master fishermen, it is surrounded with the net and the purse line is closed so that fish cannot escape toward the bottom; then the net is hauled. The Chinese purse seine is operated in the coastal areas where the depth of water ranges from 10 to 50 m. The favourite time for operation is during moonless nights.

2. *Thai purse seine:* The Thai purse seine is a gear which evolved from the Chinese purse seine and is being widely used in Thailand, particularly after 1957. Instead of using two rowing boats to set the net, the main boat, which is now motorized, sets the net by itself. Other operations are very similar to those of the Chinese purse seine. The gear employed is usually larger than that used for Chinese purse seining which was widely used two decades ago. Thai purse seine fishing is carried out from an engine-powered boat of a size ranging from 12 to 25 m *in* length. The size of the net is 800-1,500 m in length. The mesh size of the net used varies from 18 to 90 mm.

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Recently, large purse seiners have been equipped with power-saving devices such as the durse line winch and power block, thus enabling a boat to reduce its crew nearly by half. In addition, more medium and large size purse seiners are now equipped with echo sounder or sonar for fish school detection, radar, wireless equipment and refrigeration.

3. *Luring purse seine:* The luring purse seine is very similar to Thai purse seine but the operation is carried out by luring techniques using palm leaves by day and lamp by night in order to attract the fish school. After throwing the lure into the sea for 7-10 days or attracting fish with lamps for 3-6 hours, fishermen will wait until they are sure that fish gathers around the lure in a big school; then the fish is surrounded by the net and the net is hauled. This type of fishing gear was developed from the luring liftnet around 1971 and has been widely used in the Gulf since 1973 due to its high fishing efficiency. It was introduced in the west coast of Thailand and has gained popularity since 1975. The luring purse seine fishing is carried out by using a one-engine powered boat in the size range of 16-25 m in length and one small rowing boat for setting the lures. The rectangular net ranges from 400 to 800 m in length and 50-80 m in depth. The mesh size of the net ranges from 18 to 25 mm. The power of the generator varies from 20 to 50 kilowatt. It can be operated in both shallow and deep waters during day time and at night.

Table *2* gives the total number of fishing vessels and number of major pelagic gears registered with the Department of Fisheries from 1971 to 1981. The fluctuation in the number of units is indicative of the development of the marine fisheries. A significant decreasing trend is clearly observed in the number of Thai purse seines, especially after 1976, while there is an increasing trend in the number of luring purse seines. As for the numbers of Chinese purse seines, it shows a decreasing trend after 1973, but a small fluctuation in numbers was observed from 1975 to 1981.

The majority of the purse seiners operated in the area are of medium size, i.e., between 14 and 25 m in length; there are very few small purse seiners.

Production

It is seen from Table 3 that the total production of mackerels obtained from major fishing gears from 1971 to 1981 shows large fluctuations. The maximum catch for both *R. brachysoma* (13,005 tonne) and *R. kanagurta* (10,329 tonne) was in 1973. The catch value has declined since then to reach the minimum value in 1981.

Mackerels are caught by a variety of fishing gears, but the major portion of the catch was contributed by Thai purse seines and trawl nets for *R. brachysoma* and by Thai purse seines and Chinese purse seines for *R. kanagurta* (Table 4).

Taking into account the catch by type of fishing method, there is no doubt that luring purse seines have recorded an increase in numbers in recent years, but there is no catch recorded except in 1979. The reason could be sampling errors in the data collection; the multi-purpose fishing nature of the Thai purse seiner might have caused the enumerators some confusion; it might also be due to the fact that luring purse seiners on the west coast return to the middle Gulf during some seasons to catch coastal tuna and hardtail scad, which are available in greater quantity and have higher value, but are still being registered as luring purse seiners on the west coast.

If we look at the monthly landings of the mackerels in various provinces along the west coast (Table 5), it can be seen that the fishing season of mackerels extends throughout the year. The peak season for *R. brachysoma* on the upper and lower west coast are from August to February and May to October, respectively. For *R. kanagurta,* the best fishing season seems to be during January-April and April-June for the upper and lower west coast, respectively.

In 1980, substantial quantities of *R. brachysoma* were obtained from the lower west coast (Satul, Trang and Krabi), while the amount obtained from the upper west coast (Ranong,

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Phang Nga and Phuket) was minor. On the contrary, the majority of the *R. kanagurta* was landed in the upper west coast while the amounts in the lower west coast were minor.

Stock assessment

Many studies have been made to assess the potential of mackerel resources on the west coast of Thailand (Bhatia, et al. 1979, Bhatia and Chullasorn, 1980). In their analysis, the data on the basis of which the assessments are made come from annual catch and effort obtained from the Annual Fisheries Statistics. These data, however, are not in the ideal form required for precise analysis. But in spite of their shortcomings, they provide some useful information enabling a preliminary analysis to be made. In addition, these assessments are based on the assumption that only one stock exists or else that the stocks examined behave as a single entity and without any interaction.

As mentioned earlier, there will be some justification for treating the *A. brachysoma* as two unit stocks, namely, the upper west coast stock (Area I) and the lower west coast stock (Area II). Therefore, the present assessment has been carried out for each local unit area. Based on the figures of catch, effort and catch per unit effort in each area, given in Table 6, the potential yields are estimated as 4,542 and 7,014 tonnes at optimum fishing effort of about 19,848 and 22,256 days fishing by Thai purse seine unit for Area I and Area II, respectively (Fig. 4 and Fig. 5). This result indicates that A. *brachysoma* stocks in the two areas are not in a state of heavy exploitation.

For A. kanagurta, the estimate of potential yields in Area I and Area II are 6,237 and 2,281 tonnes at the optimum fishing effort of 20,899 and 40,555 days fishing of Thai purse seine unit, respectively (Fig. 6 and Fig. 7). This indicates that the level of exploitation of *R. kanagurta* in Area I is heavy, a level which was reached between 1973 and 1975. As regards the stock in Area II, it seems to be lightly exploited.

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Table 1

Results of tagging experiments on *Rastrelliger brachysoma,* **on the west coast of Thailand, 1981-1983.**

Year	Tagged fish released (nos.)	Recapture (nos.)	Recapture (%)	Time between release and recapture (days)	Area of release
1981	513	8	1.56	22-131	Ko Terutao, Satul
1/1982	242	4	1.65	14-71	Ko Langu, Satul
2/1982	832	24	2.88	10-179	Ko Langu, Satul
(1982)	1074	28	2.61	10-179	
1/1983	478	7	1.46	1-111	Ko Terutao, Satu
2/1983	694	3	0.43	13-21	Ko Terutao, Satul
3/1983	722	2	0.28	21-?	Ko Bulon, Satul
4/1983	697	2	0.29	14-20	Ko Bulon, Satul
5/1 983	**659**	**26**	**3.94**	**1-140**	**Ko Terutao, Satul**
6/1983	546	5	0.91	4-146	Ko Terutao, Satul
7/1 983	544	2	0.37	5-31	Ko Bulon, Satul
8/1 983	459	1	0.217	?	Ko Bulon, Satul
(1983)		**48**	**1.0**	**1-146**	

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Table 2

Number of registered fishing vessels and fishing gear units by vessel size operating on the west coast of Thailand

Year		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Type	Length of vessel (m)											
Fishing vessels		434	614	987	901	773	818	1347	1689	2565	2970	2207
	<14	145	235	440	343	265	388	813	1151	1900	2122	1437
	14-18	176	248	375	352	339	289	365	399	415	544	471
	18-25	109	131	172	206	167	140	166	127	225	283	273
	>25	2	—	—	—	2	1	3	12	25	21	26
Unknown		2	—	—	—	—	—	—	—	—	—	—
Thai purse seine		61	54	68	112	85	89	22	47	4	12	17
	<14	7	15	8	10	13	6	12	16	1	7	5
	14-18	37	23	31	60	35	41	10	31	3	4	9
	18-25	17	16	29	42	37	42	—	—	—	1	3
	>25	—	—	—	—	—	—	—	—	—	—	—
Chinese purse seine		27	32	50	37	17	15	22	15	15	12	14
	<14	—	2	4	2	—	—	—	1	—	—	—
	14-18	10	20	23	19	10	7	9	6	7	9	7
	18-25	17	10	23	16	7	8	13	8	8	3	7
	>25	—	—	—	—	—	—	—	—	—	—	—
Luring purse seine		2	—	—	1	—	—	95	68	69	114	127
	<14	1	—	—	—	—	—	—	1	3	9	13
	14-18	1	—	—	—	—	—	56	37	38	54	46
	18- 25	—	—	—	1	—	—	39	30	28	51	68
	>25	—	—	—	—	—	—	—	—	—	—	—
Encircling gilinet		—	—	1	5	—	—	—	1	1	2	1
	<14	—	—	1	4	—	—	—	1	1	2	1
	14-18	—	—	—	1	—		—	—	—	—	—
	18-25	—	—	—	—	—	—	—	—	—	—	—
	>25	—	—	—	—	—	—	—	—	—	—	—

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Table 3

Total annual marine catch, pelagic catch and mackerel catches from the west coast of Thailand, 1971-1981

Year	Total marine catch (t)	Total pelagic (t)	Total pelagic (% of total marine)	*R. brachysoma* (t)	*R. brachysoma* (% of pelagic)	*R. kanagurta* (t)	*R. kanagurta* (% of pelagic)
1971	237,568	45,632	19	12,313	27	3,856	8
1972	230,097	43,359	19	5,702	13	3,966	19
1973	291,194	56,265	20	13,005	23	10,329	18
1974	244,492	31,108	13	5,120	16	6,050	19
1975	222,188	35,874	16	7,979	22	5,722	16
1976	256,050	24,554	10	3,141	13	5,384	22
1977	218,861	33,593	15	4,623	14	2,545	8
1978	218,014	18,881	9	2,354	12	2,392	13
1979	237.668	34,551	15	4,511	13	2,881	8
1980	186.211	15,157	8	1,794	12	976	6
1981	184.389	13,926	8	1,780	13	577	4

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Table 4

The mackerel catch on the west coast of Thailand, by major fishing gears, 1971-1981

(tonne)

(a) *R. brachysoma:*

Gear	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
OTT	927	753	1,149	622	335	544	2,101	1,239	2,220	770	1,081
TPS	11,375	4,053	10,874	4,318	5,371	2,437	2,162	1,036	346	986	1,095
cPS	0	838	605	967	950	145	352	12	17	39	44
LPS	0	0	0	0	0	0	0	0	0	0	0
DGN	0	0	9	1	12	2	6	0	25	0	0
BST	11	58	0	6	0	13	0	0	0	0	0
SSF	0	0	368	106	951	0	2	67	18	—	—
Total	12,313	5,702	13.005	5,120	7,979	3,141	4,623	2,354	2.626	1,795	2,220

(b) *R. kanagurta*

OTT	0	173	288	492	0	9	71	131	60	27	69
TPS	3,856	853	2,416	745	872	3,573	1,192	1,731	300	516	241
cpS	—	2,940	7,531	4,511	4,848	1,744	1,251	526	729	433	526
DGN	0	0	0	217	2	3	0	3	27	0	0
BST	0	0	0	—	1	0	0	0	0	0	0
SSF	0	0	94	4	0	55	31	1	0	—	—
Total	3,856	3,966	10,329	6.050	5.722	5,384	2.545	2,392	2,881	976	836

OTT = Otter board trawl
SSF = Small-scale fisheries
BST = Bamboo stake trap
TPS = Thai purse seine
CPS = Chinese purse seine
LPS = Luring purse seine
DGN = Drift/gilinet

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Table 5

Monthly landings of mackerels by province along the west coast of Thailand, 1980

(tonne)

(a) *R. brachysome*

Province	Total	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Ranong	1344	**208**	**139**	**60**	**8**	**30**	**23**	**33**	**152**	**164**	**109**	**243**	**175**
PhangNga	—	—	—	—	—	—	—	—	—	—	—	—	—
Phuket	1	—	—	—	—	—	—	—	1	—	—	—	—
Krabi	507	—	—	1	10	33	—	5	151	133	59	39	76
Trang	4598	282	209	395	386	839	730	228	439	155	361	137	437
Satul	6642	251	642	923	263	306	439	800	720	958	645	531	164
Total	13092	741	990	1379	667	1200	1192	1066	1463	1410	1174	950	852

(b) *R. kanagurta*

Ranong	443	90	17	49	62	50	23	66	61	10	10	—	5
Phang Nga	866	55	123	196	125	17	51	35	118	45	33	45	23
Phuket	706	52	44	63	55	52	74	65	78	46	53	59	65
Krabi	350	10	27	29	115	39	70	54	3	—	—	3	—
Trang	206	5	1	20	31	114	30	5	—	—	—	—	—
Satul	465	—	—	—	—	465	—	—	—	—	—	—	—
Total	3036	212	212	357	388	737	248	225	260	101	96	107	93

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Table 6

Total catch (A), fishing effort (B) and catch per day (C) of mackerel in area I (upper) and II (lower) on the west coast of Thailand, 1972-1981

A. Total catch (ton)

Species	1972		1973		1974		1975		1976		1977		1978		1979		1980		1981	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
R. brachysoma	1331	4371	4776	7861	2351	2448	1953	5042	936	1769	2271	491	621	819	1800	342	1177	183	64	1716
R. kanagurta	816	3150	9385	850	3673	1313	5180	542	3359	160	2151	11	1688	196	2410	166	708	8	232	575

B. Fishing effort[1] (days)

Species	1972		1973		1974		1975		1976		1977		1978		1979		1980		1981	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
R. brachysoma	3578	15177	6489	11510	6477	6857	4846	6599	4313	3922	1394	1269	989	2536	5751	523	2200	235	145	1902
R. kanagurta	6182	75000	28526	14655	33697	22254	36738	6302	7193	3137	2815	80	1408	879	22523	1092	3955	92	407	25000

C. Catch per day (kg/day)

Species	1972		1973		1974		1975		1976		1977		1978		1979		1980		1981	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
R. brachysoma	372	288	736	683	363	357	403	764	217	451	1629	387	628	323	313	654	535	778	441	900
R. kanagurta	132	42	329	58	109	59	141	84	467	51	746	137	1199	223	107	152	179	87	570	23

[1]Estimated numbers of days fishing standardized to Thai purse seine.

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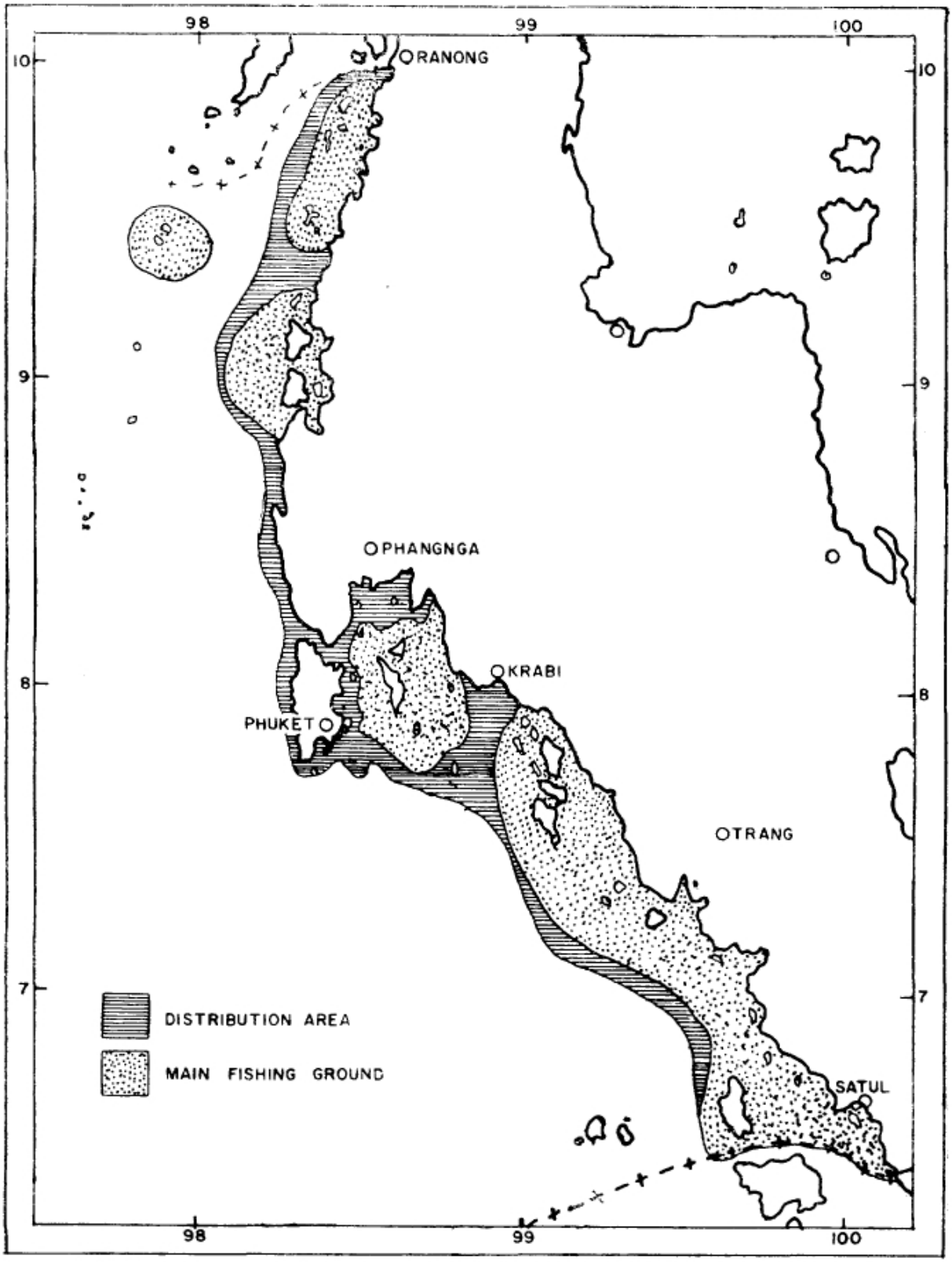

App. 1, Fig. 1. Distribution area and fishing grounds of *Rastrelliger brachysoma* on the west coast of Thailand.

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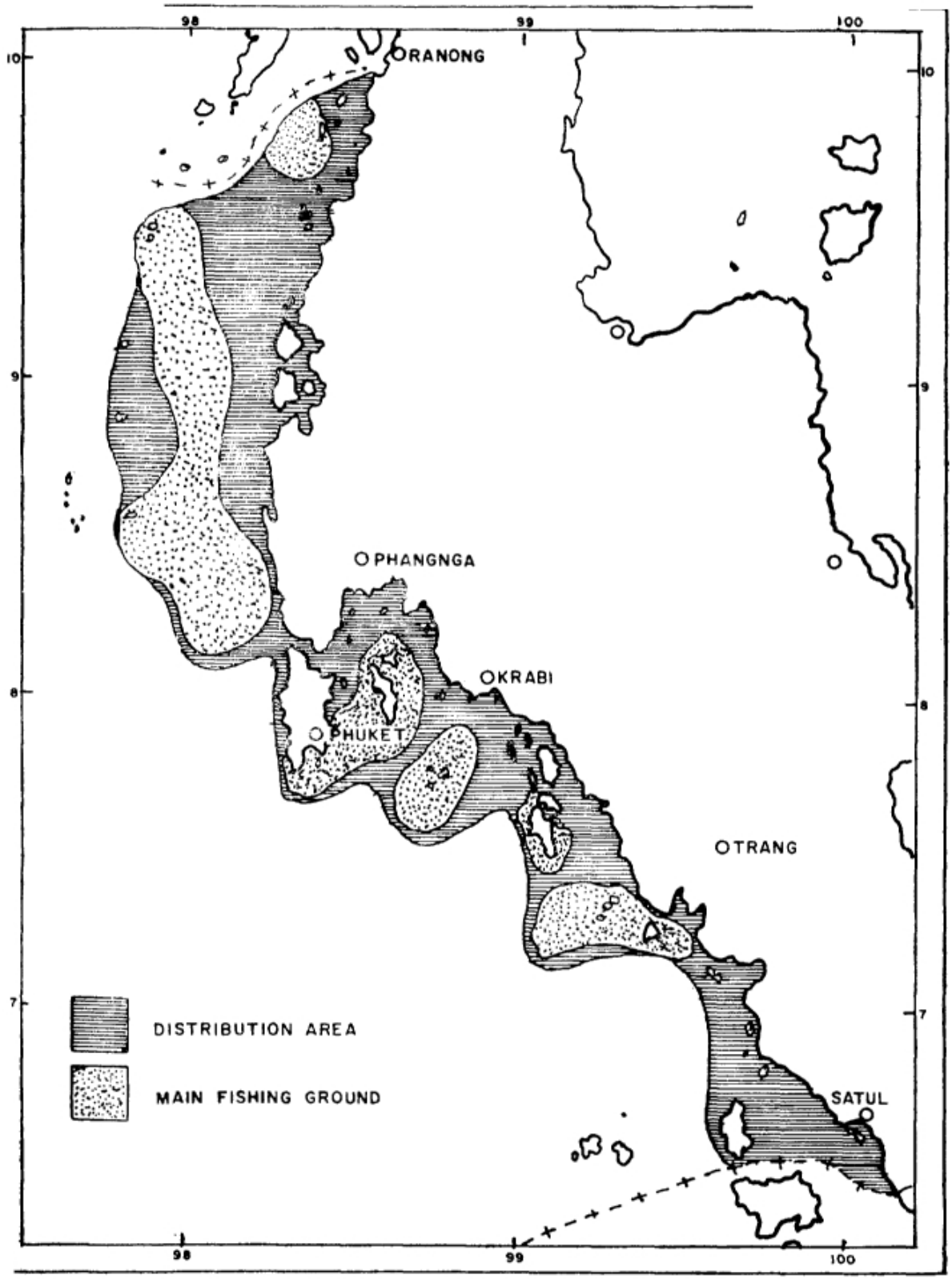

App. 1, Fig. 2. Distribution area and fishing grounds of *Rastrelliger kanagurta* on the west coast of Thailand.

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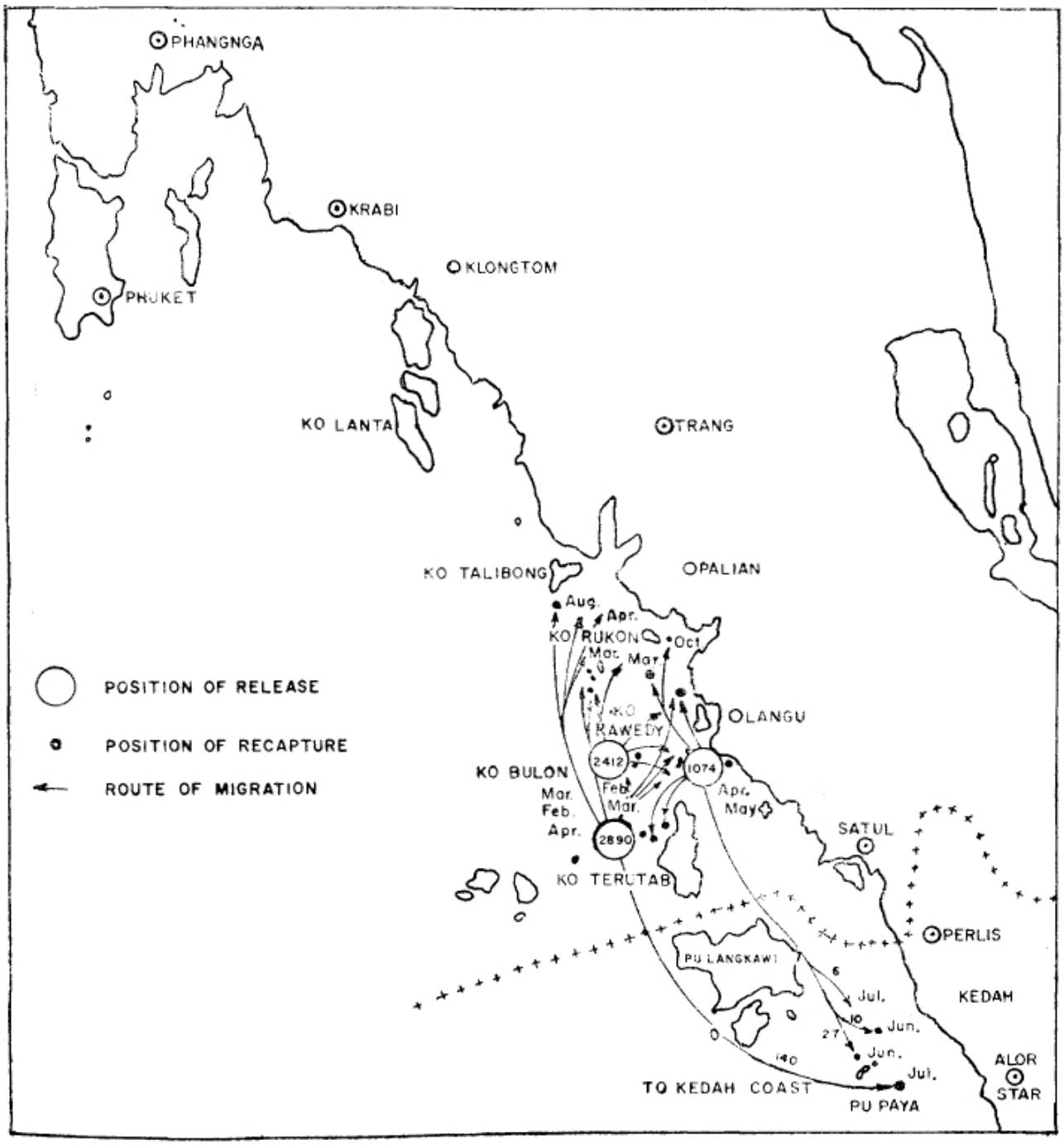

App. 1, Fig. 3. Results of the tagging experiment on *Rastrelliger brachysoma* on the west coast of Thailand during 1981—83.

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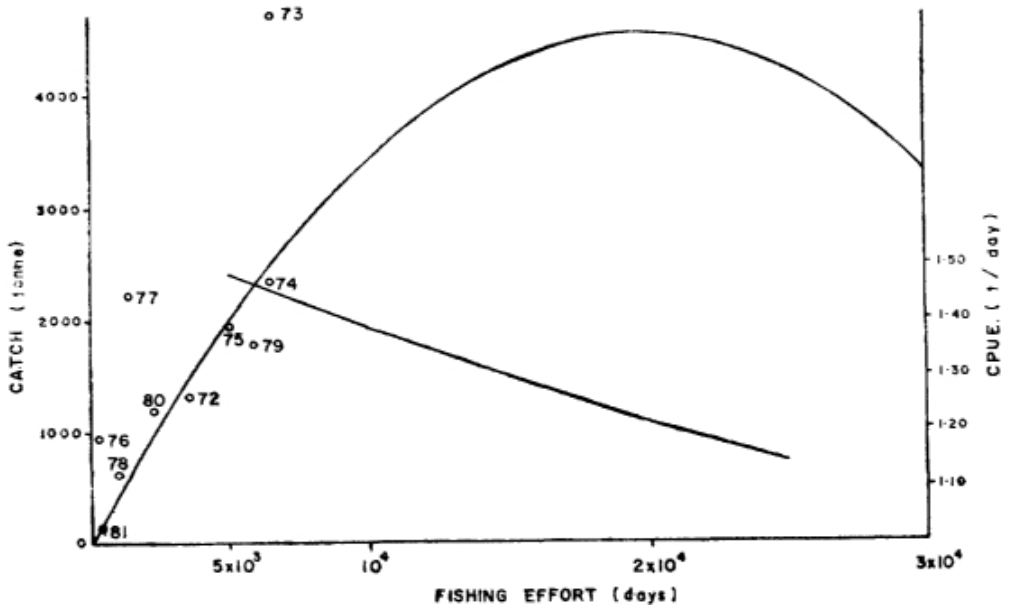
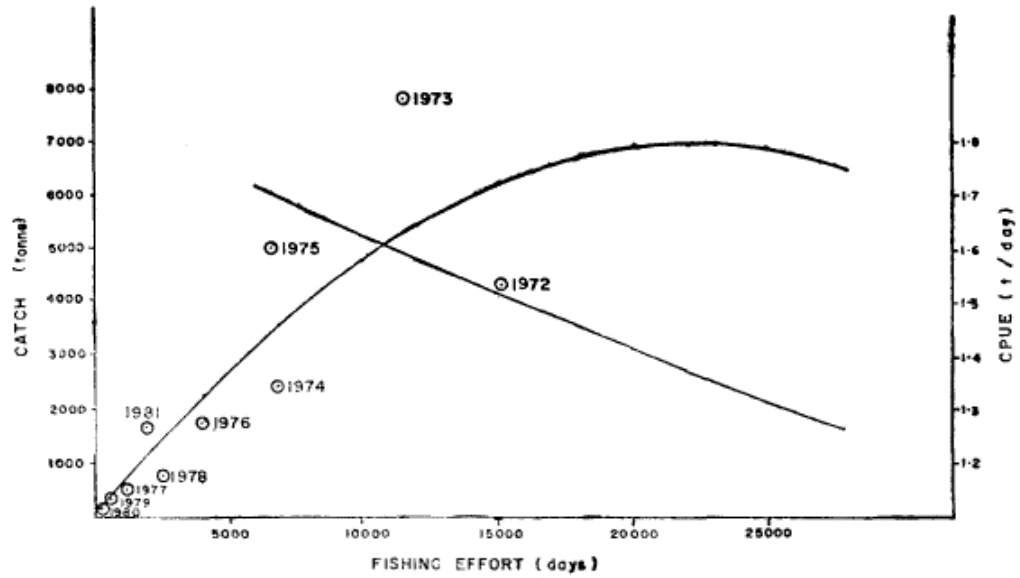


App. 1. Fig. 4. catch and catch per unit effort related to effort in the Thai purse seine fishery for *Rastiel/iger brachysoma* on the upper west coast of Thailand (Area I), 1972–81.



App. 1. Fig. 5. Catch and catch per unit effort related to effort in the Thai purse seine fishery for *Rastrel/iger brachysoma* on the lower west coast of Thailand (Area II), 1972—81.

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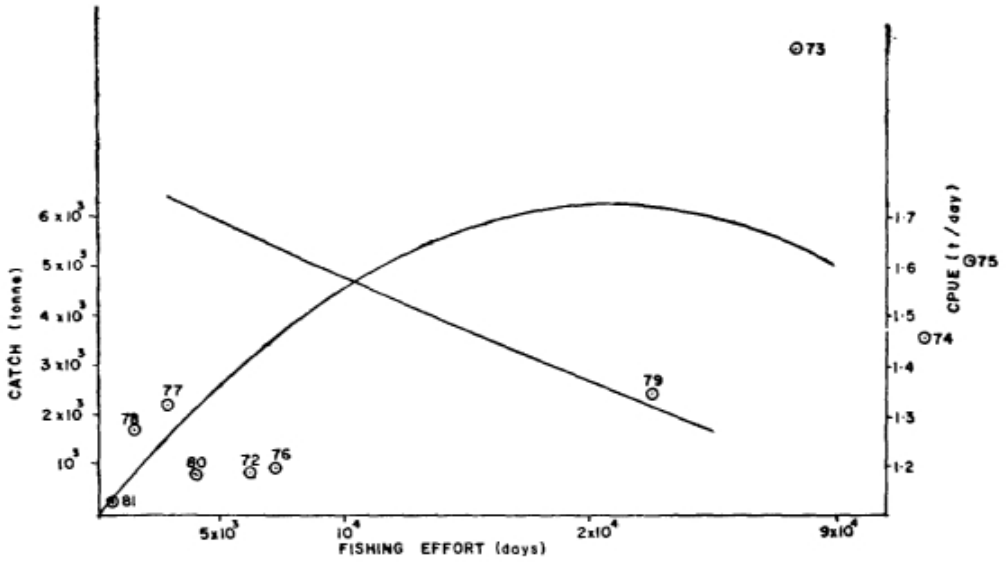
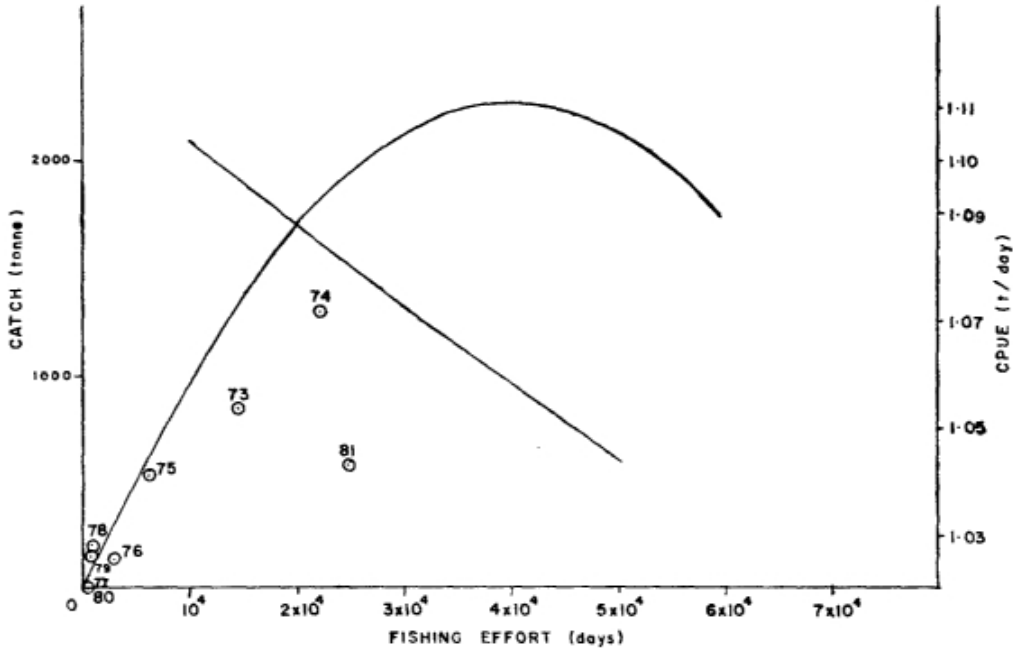


App. 1, Fig. 6. Catch *and catch* per unit effort related to effort in the Thai purse seine fishery for *Rastrel/iger /ranagurta* on the upper west coast of Thailand (Area I), 1972—81.



App. 1, Fig. 7. catch and catch per unit effort related to effort in the Thai purse seine fishery for *Rastre/liger kana,gurta* on the lower west coast of Thailand (Area II). 1972—81.

Appendix 2

REVIEW OF THE SCAD MACKEREL FISHERY (*DECAPTERUS* SPP.) ON THE WEST COAST OF THAILAND

General information

The round scad or scad mackerel *(Decapterus* spp.) is one of the economically important pelagic fishes in the Malacca Strait. In Thailand it has been observed to inhabit waters of 30-80 m depth and it has been caught mainly by the Chinese and Thai purse seines since the beginning of the pelagic fisheries development in 1963. Since 1977, the luring purse seines have played an important role in the fishery. In the period 1972 to 1981, the annual Iandirlgs of the scad mackerels on the west coast of Thailand ranged from 1,475 to 2,370 tonne or 1 .525 tonne on an average.

Before the research survey of *Decapterus* spp. on the west coast of Thailand, carried out by the Phuket Marine Fisheries Station since 1978, little was known about the biology of the fish in this area. An attempt had been made to point out some biological aspects from the available data.

Species exploited

Two species of *Decapterus* dominate the landings, namely *D. maruadsi* and 0. *macrosoma,.* of which the former is more important, comprising about 60% of the scad mackerel catch.

Distribution

Decapterus spp. appear throughout the coastal area of the west coast of Thailand. The fishing grounds are located in the waters of 30-80 m depth (Fig. 1).

Maturity and spawning

The size at majority of mature *0. maruadsi* and 0. *macrosoma* range from 1 5.5-21 .5 cm and 17.3-22.2 cm in total length, respectively.

The spawning season, as determined from the gonad index of data collected from November 1978 to September 1981, shows that *D. maruadsi* has a long spawning season from December to April. The peak of spawning for 0. *macrosoma* lies between February and April but in 1980 the peak of its spawning season occurred from January to June (Fig. 2).

Length frequency distribution

The length data of *Decapterus* spp. have been sampled from the commercial catch at various landing places by measuring the body length. The data are collected from all types of purse seines, categorized by area (the upper west coast as Area I and the lower west coast as Area II) and month.

The length frequency distribution (Figs. 3, 4) exhibits a multimodal appearance and it was applied to determine the general pattern of recruitment. The fishery has exploited small *D. maruadsi* ranging in size from 11.5 to 25 cm (in Area I) and 12.0 to 24cm (in Area II). *D. macrosoma* was caught in sizes ranging from 14.0 to 18.5cm (in Area I) and 13.5 to 19.0cm (in Area II).

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The major marketable size of *Decapterus* spp. in both areas was in the range between 14.0 cm and 18.0 cm.

Taking into account the monthly variation of length distribution, from the data obtained, it is concluded that the possibility of utilizing a length-structured approach to determine growth and mortality parameters is very low unless there is a more effective sampling programme.

Production

Decapterus spp. are not the target species of purse seiners on the west coast of Thailand and the catch obtained is incidental among many other species.

On the west coast of Thailand, the production of *Decapterus* spp. decreased from 1,780 tonne in 1971 to 811 tonne in 1973. Since then the production has fluctuated around a level of about 1,000 tonne (Table 1).

According to monthly landing statistics collected by Fisheries Statistics Section in a survey in 1980 (Fig. 5), *Decapterus* spp. were exploited all year round. The best fishing season was August to November which is the inter-monsoon period.

Stock assessment

Table 2 shows the annual catch and effort data for *Decapterus* spp. from 1972 to 1980. The data were collected from commercial fisheries by the Fisheries Statistics Section, Dept. of Fisheries, through the sampling survey system. Estimates of the total standardized fishing effort for use in the yield calculation were derived by dividing the total catch obtained from the major fishing gears by the CPUE of the standard gear, i.e., Chinese purse seine.

The annual catch (tonne) and catch per unit of effort (tonne/day) are plotted against the fishing effort in number 31 days fishing of Chinese purse seine units (Fig. 6). The result shows that the maximum sustainable yield for the *Decapterus* spp. on the west coast of Thailand is about 1,500 tonne at the optimum fishing effort of about 9,000 days fishing.

It is obvious that the fishing effort exceeded the optimum level in 1973 and 1975 and that the production exceeded the MSY in 1975. It is concluded, therefore, that the *Decapterus* spp. were fully exploited in the period from 1972 to 1975. Thereafter, the fishing effort has been lower than the optimum level and the production is also lower than the MSY.

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Table 1

Annual catch of *Decapterus* spp. in the west coast of Thailand by type of major fishing gear, 1971-1981

(tonne)

Gear \ Year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
OTT	0	0	0	0	29	3	1	0	0	0	0
TPS	1780	0	72	12	97	224	134*	14	19	112	47
CPS	0	1475	739	1403	1409	820	1315*	869	941	783	1137
LPS	0	0	0	0	0	0	0	0	83	0	0
EGN	0	0	0	1	0	0	0	3	0	0	0
Total	1780	1475	811	1416	1535	1047	1450	886	1044	895	1184

* estimated figure

OTT—Otter board trawl
TPS—Thai purse seine
CPS—Chinesr purse seine
LPS—Luring purse seine
EGN–Encircling gillnet

Table 2

Total catch, fishing effort and catch per unit of effort' of *Decapterus* spp. on the west coast of Thailand

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Total catch (t)	1475	811	1416	1535	1074	1450	886	1044	895	1184
Fishing effort (days)	7749	11322	8080	10360	4900	5179	4105	4247	3214	3496
CPUE (kg/day)	190	72	175	148	219	280	216	246	278	339

'Estimated numbers of fishing days of chinese purse seine.

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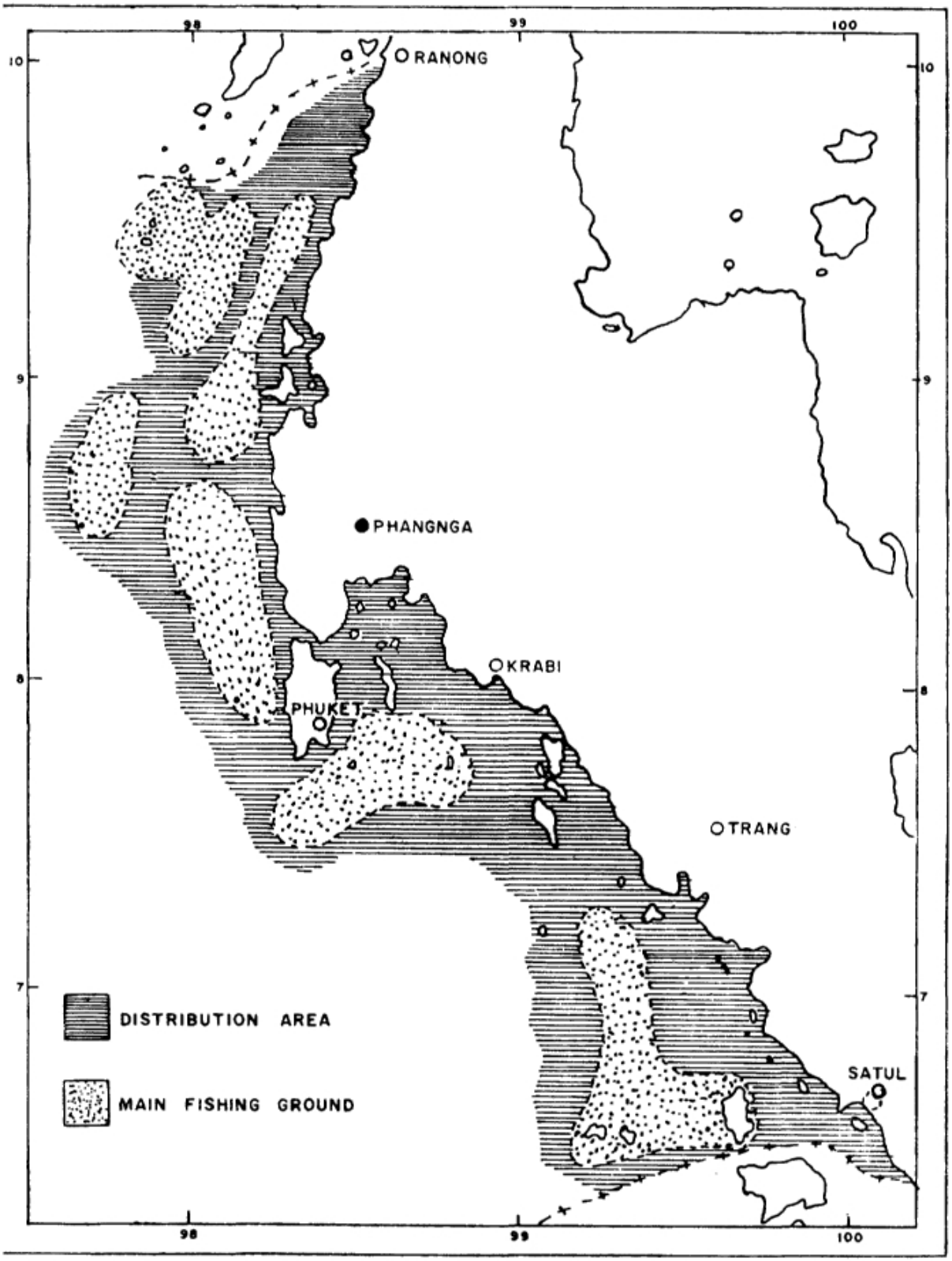

App. 2, Fig. 1. Distribution area and fishing grounds of round scads (*Decapterus* spp.) on the west coast of Thailand.

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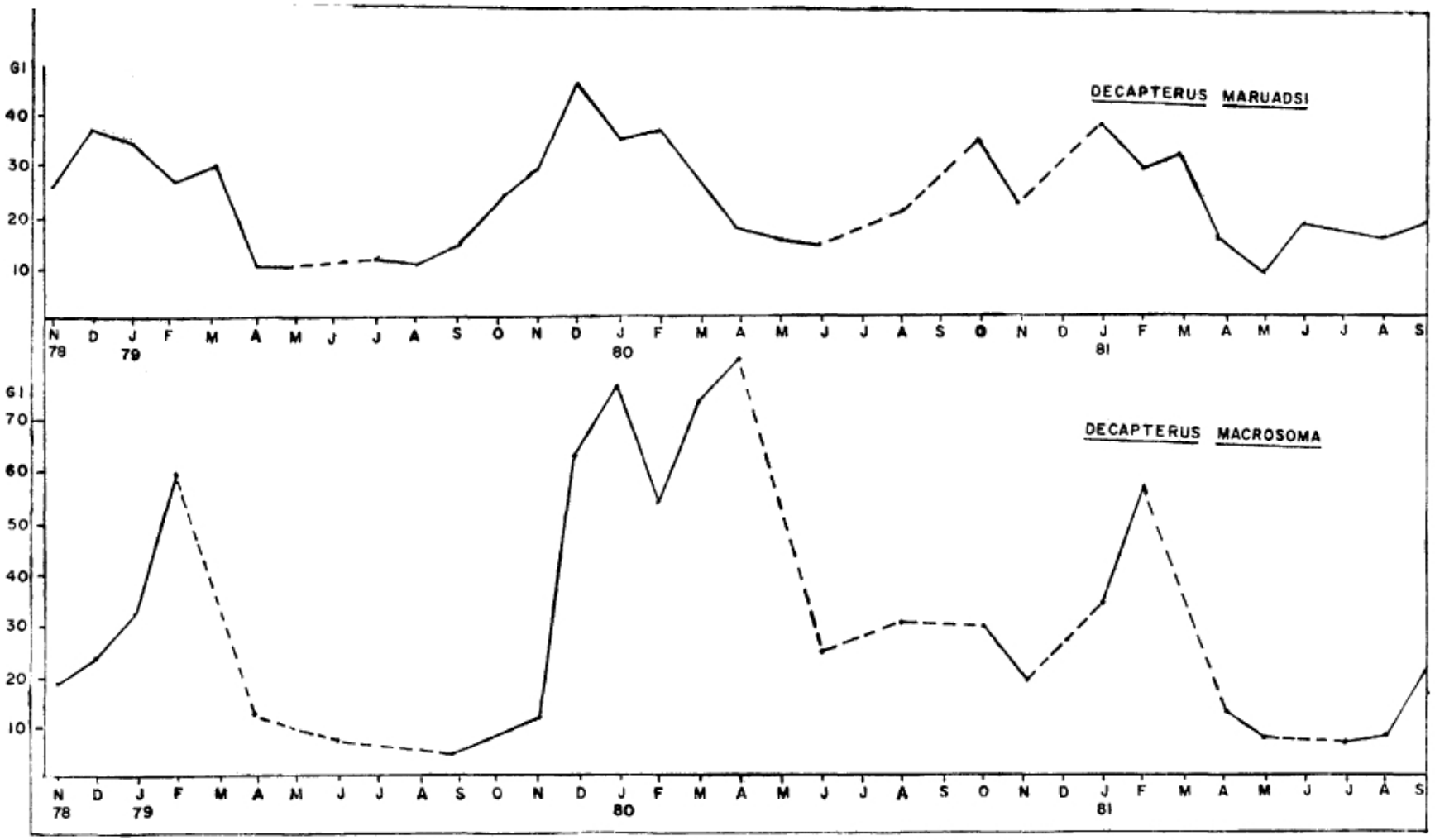
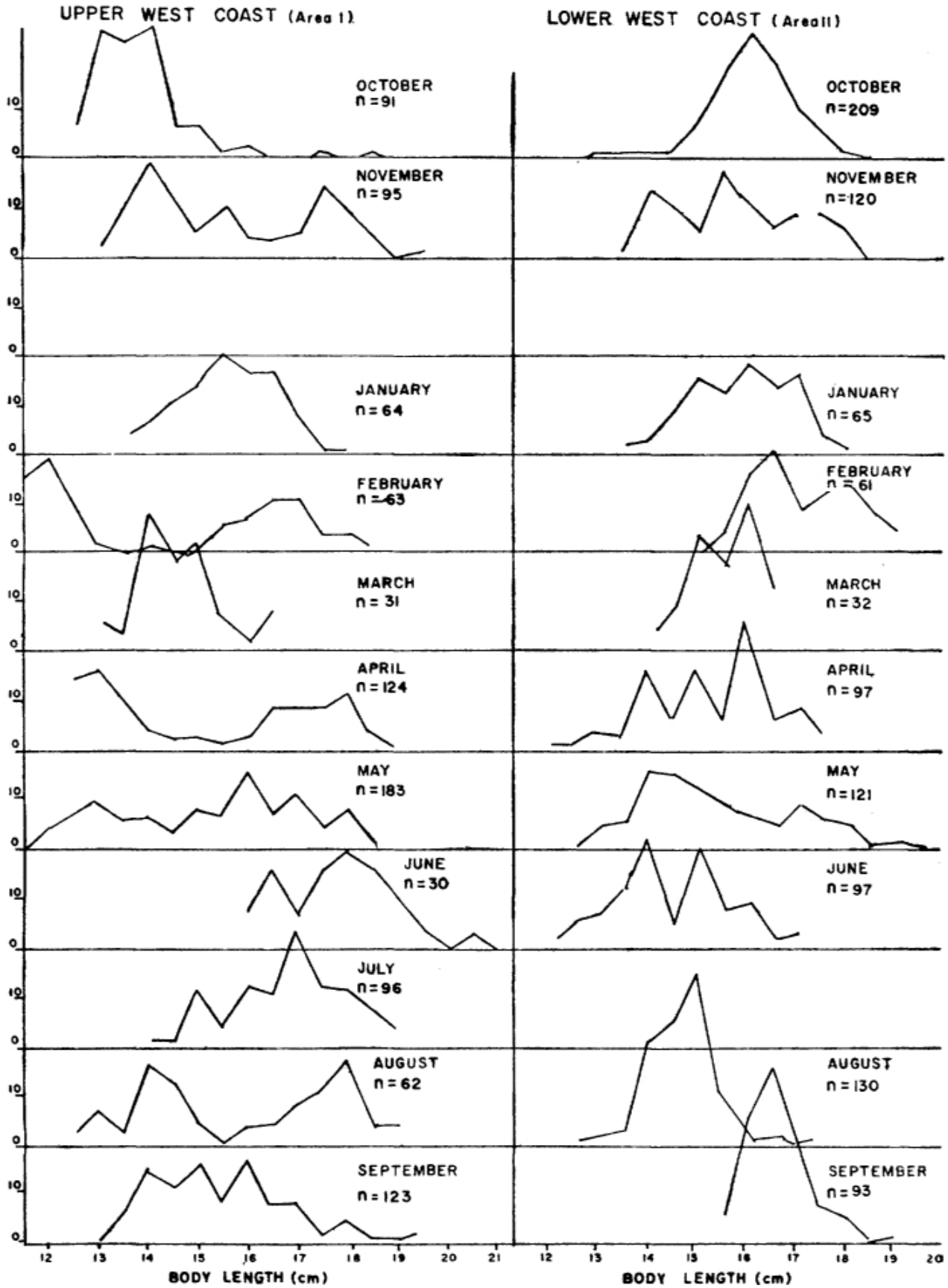


App. , 2 Fig. 2. Monthly change in the mean gonad index of *Decapterus maruadsi* and *Decapterus macrosoma* in the west coast of Thailand, November 1978–September 1981.



App. 2, Fig. 3. Length frequency distribution of O. *maruadsi* in the upper and lower west coast of Thailand, October 1979—September 1980.

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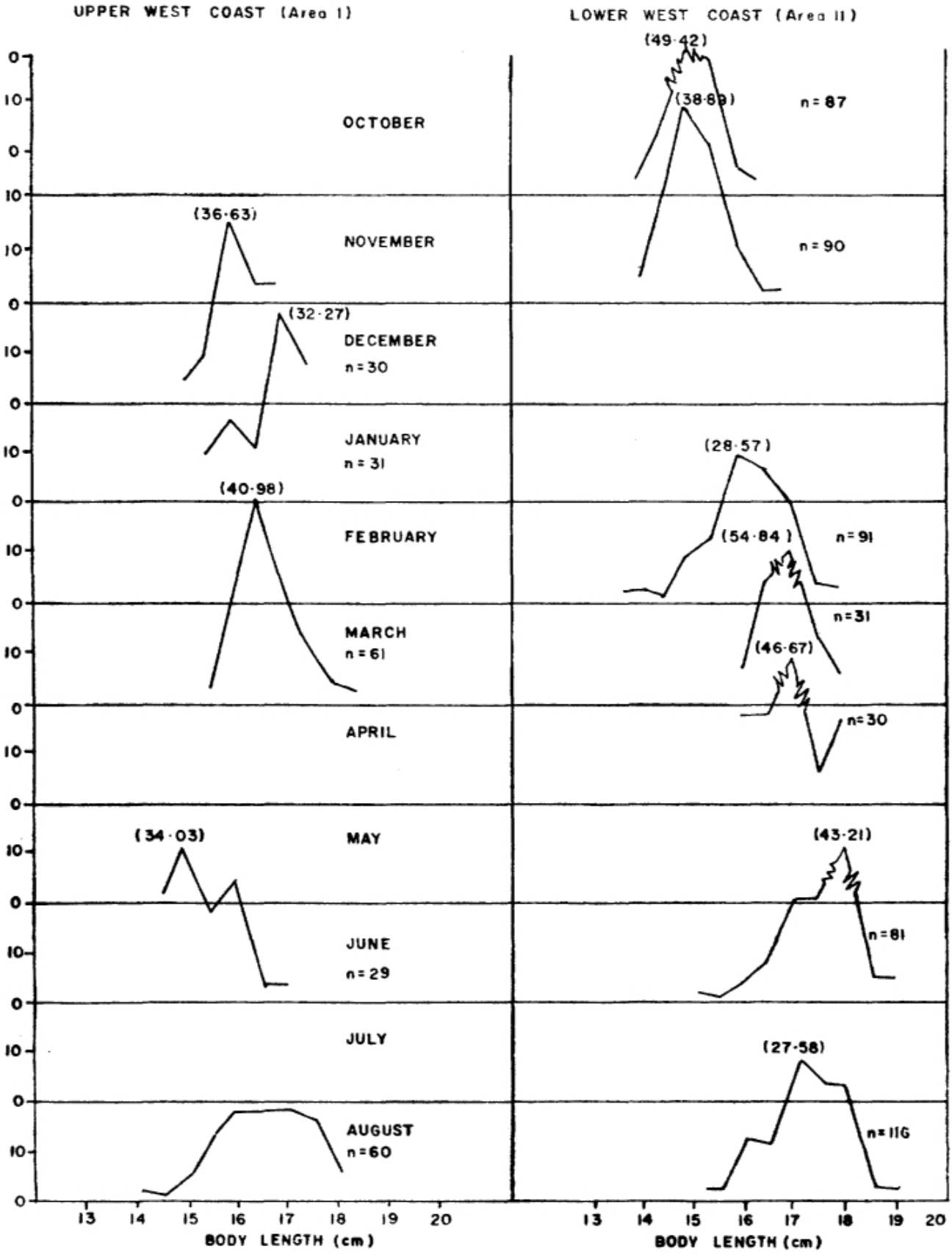

App. 2, Fig. 4. Length frequency distribution of O. *macrosoma* in the upper and lower west coast of Thailand, October 1979—September 1980.

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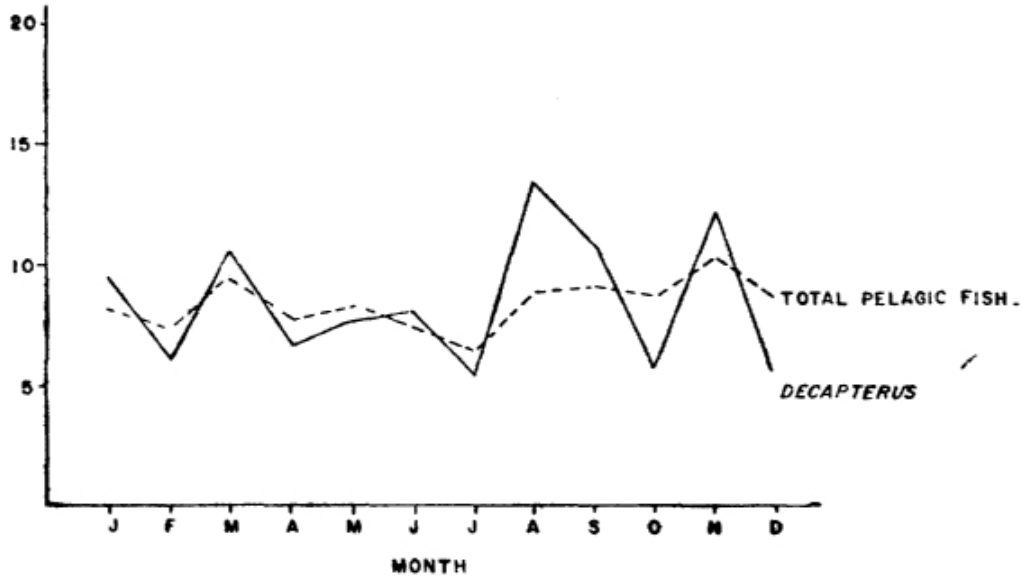
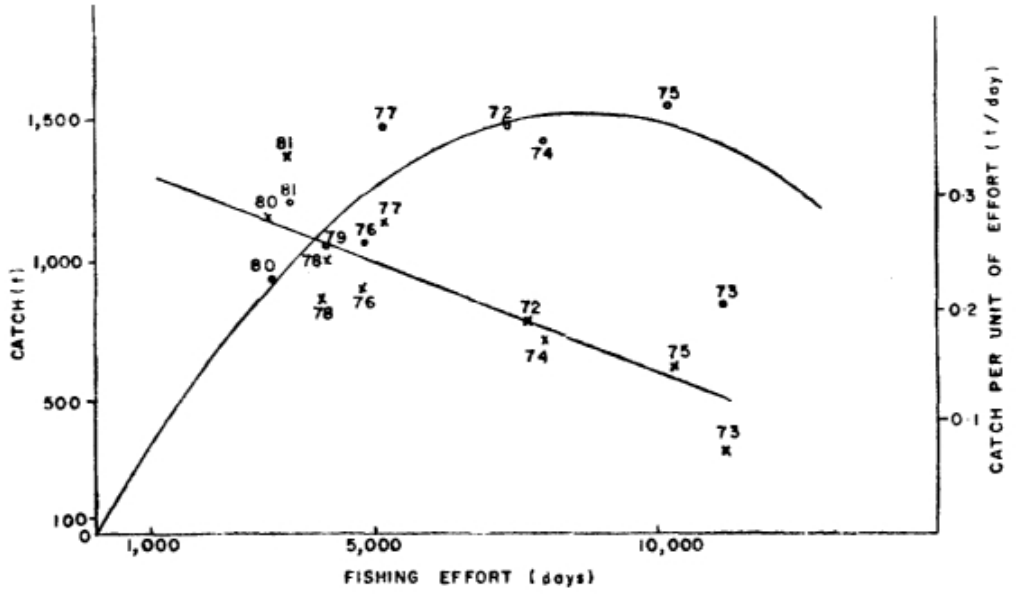


App. 2, Fig. 5. Monthly landing of *Decapterus* app. and total pelagic fishes (in per cent) on the west coast of Thailand, 1980.



App. 2, Fig. 6. Catch and catch per unit effort in the fishery for *Decaptews* spp. on the west coast of Thailand, 1972—81.

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Appendix 3

THE *RASTRELL/GER* AND *DECAPTERUS* FISHERIES OF THE WEST COAST OF PENINSULAR MALAYSIA

By Chee Phaik Ean
Fisheries Research Institute, Penang, Malaysia.

Introduction

Pelagic fish is a major resource that is currently being exploited in the various states of Peninsular Malaysia. On the west coast, the bulk of the pelagic fish landings come from the States of Perils, Kedah, Penang, Perak and Selangor. In the other west coast states, the pelagic fishery is not as substantial as in the five states mentioned above. There exists a small but important gillnet fishery for wolf herring, Spanish mackerel, thread fin, pomfret and a few other pelagic species.

The pelagic fish that is being exploited come from about a dozen families. Of major importance on the west coast of Peninsular Malaysia are the chub mackerel *(Rastrelliger* spp.) which as an individual genus contributed approximately 25% to the total marine landings of Peninsular Malaysia in 1 968. Next in importance in terms of quantities landed are the anchovies *(Stolephorus),* round scad *(Decapterus),* sardines *(Sardine//a)* and hardtails *(Mega/aspis cordyla).*

The principal gear for catching pelagic fish in Peninsular Malaysia is the purse seine. It can be divided into three main types: (i) the anchovy purse seine with a mash of about 7.5 mm which is used in shallow waters: (ii) the night purse seine that operates at night without any lures and has a mesh size of 25 mm; and (iii) the luring purse seine that is similar to the night purse seine but can be operated in the daytime or at night depending on whether coconut leaf lures or lights are being used as the luring device. Also since the early 1 970s, trawlers have begun to harvest substantial quantities of pelagic fish together with their demersal catch. This has been particularly true of the large number of trawlers that have adopted the 'high-opening' trawls in Kedah. Other less important gears used for harvesting pelagic fish are gillnets, liftnets, fishing stakes and the hook and line.

In this paper, only the *Rastrel/iger* and *Decapterus* fisheries are discussed.

Rastreiiger spp.

This fishery is undoubtedly the most important fishery in Peninsular Malaysia. No other species or group has overtaken it in importance.

Three species of *Rastre/liger* are being caught by our local fishermen. Of these *R. kanagurta* and *R. brachysoma* are being landed in much larger quantities than *R. faughni.* All three species are caught mainly by the purse seine (Table 1). In recent years, however, trawis, in particular the high-opening trawls in Kedah, have been landing increasing quantities of mainly *R. brachysoma* (Table 1). This suggests that *R. brachysoma* is a more coastal species because our local trawlers do not venture very far out to sea. *R. kanagurta* and *R. faughni* are more oceanic as they are also caught together by the luring purse seines that operate further out in addition to the night purse seines. Lures that are used by our fishermen are made from coconut leaves. Lamps are also commonly used as a luring device.

The fishery for *Rastreiiger* spp. and other pelagic fish exploited by the purse seine on the west coast of Peninsular Malaysia is predominantly located in the northern Malacca Straits area. The fishing grounds stretch from Pulau Langkawi in the north to Puiau Jarak in the south (Fig. 1). Fishing is popularly carried out around islands. There is no substantial purse seine fishery in the southern Malacca Straits.

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Fishing for *Rastreiiger* spp. and other pelagic fish by the purse seine goes on throughout the year. Generally, for the west coast purse seine fishery, fishing activity slackens at the end of the year from November and picks up again in February or March the following year. Though fishing goes on throughout the year, there usually are one or two peaks in a year when more fish are caught.

The landings of *Rastrelliger* spp. over the years are given in Table 1. The highest landing, of 91,000 tonne was in 1968. Prior to this, landings were only between 20,000 and 30,000 tonne. Landings declined to 10,000 tonne in 1972. Between 1973 and 1975, between 10,000 and 20,000 tonne were landed. From 1975 onwards *Rastreiiger* spp. showed an increase.

Using historical catch and effort data (Table 2) the maximum sustainable yield (MSY) for *Rastrelliger* on the west coast of Peninsular Malaysia was estimated at 21,000 tonne. The optimum effort was estimated to be 285 units of purse seines (Fig. 2).

This indicates that the *Rastrelliger* fishery on the west coast of Peninsular Malaysia has been over-exploited.

Decapterus **spp.**

The round scad fishery is next in importance after the chub mackerel and the anchovy fisheries. Two major species of *Decapterus* are caught by the purse seine fishermen. They are *D. maruadsi* that constitutes the bulk of the round scad landings and *D. macrosoma* which is caught in smaller quantities. The two species are often caught together. Earlier reports recorded *D. russell/to* be the most abundant in Peninsular Malaysia (Chong 1976). It appears that there could have been some misidentification of *D. maruadsi* and *D. russell.*

The luring purse seine is the chief gear used for catching round scads. Other gears land only very small quantities of this fish. Just as for the *Rastrelliger* spp. fishery, there is no specific fishery for *Decapterus* spp., since a few types of pelagic fish are usually caught together in the same haul of the purse seine.

The fishing grounds and fishing season for *Decapterus* spp. are similar to that of *Rastreiiger* spp. However, the *Decapterus* spp. fishery is more important in Penang than in the other west coast states. Penang is probably the largest centre of operation for the luring purse seines on the west coast of Peninsular Malaysia.

The landings of *Decapterus* spp. are of less importance than those of chub mackerel (Table 3). The production has fluctuated over the years but has generally shown an increasing trend. Landings in 1968 were only 2,000 tonne, while they reached 9,500 tonne in 1981.

The MSY for *Decapterus* determined by using catch and effort data (Table 4) is 5,800 tonne and has, therefore, been exceeded on the west coast of Peninsular Malaysia (Fig. 3).

Conclusion

It has been generally acknowledged that in this region, the mackerels *(Rastrei/ger* spp.) and round scads *(Decapterus* spp.) are the two most important pelagic fishes that are commercially exploited. The fisheries of these two genera are widely distributed in the Malacca Straits and the South China Sea area. These fisheries developed fairly rapidly over the years and there are some indications that the stocks might have been fully or even over-exploited in certain areas. This was the main concern voiced at the 'Workshop on the Biology and Resources of Mackerels *(Rastre/ilger* spp.) and Round Scads *(Decapterus* spp.) in the South China Sea area" (SCSP 1978). A thorough review of the biology and the status of these two resources in the area were made. For the Malacca Straits, an assessment of the resources of *Rastreiiger* spp. and *Decapterus* spp. has also been done (SCSP 1976). These two fishery resources are also believed to be shared by countries in the region.

In the Malacca Straits, the area of relevance to the Bay of Bengal Programme—Thailand, Indonesia and Malaysia—may be sharing the same stocks of *Rastreiiger* spp. and *Decapterus* spp. The fishing activities exploiting these resources may affect the fisheries in the neighbouring countries. It is, therefore, important that the existing knowledge on these two genera be updated, pooled together and analyzed on a regional basis in order to provide the information that is needed for proper management and control of two very important fisheries.

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Table 1

Landings of *Rastrel/iger* **spp. on the west coast of peninsular Malaysia by gear group**

(tonne)

Year	Purse seine	Trawl	Gillnet	Other gear	Total catch	% Total pelagic fish
1968	86621	526	749	3108	91005	70
1969	56485	255	20	548	77310	56
1970	28844	230	13	34	29122	36
1971	33692	195	37	27	33953	41
1972	9334	392	23	12	9762	21
1973	21021	553	78	21	21674	32
1974	11299	721	279	13	12312	21
1975	8175	1520	276	14	9987	21
1976	7042	4989	364	17	12413	21
1977	8592	10450	384	142	19570	27
1978	11936	10962	782	121	23802	27
1979	28300	3595	352	104	34153	30
1980	41704	6683	2883	528	51799	39
1981	27235	14013	3374	403	45027	39
1982	27920	20570	5927	300	54719	40

Table 2

Catch of *Rastreiiger* **spp. on the west coast of peninsular Malaysia and estimated effort**

Year	Total catch by all gears (ton)	Annual catch per purse seine (ton)	Calculated **ffrt** e
1971	33953	—	—
1972	9762	33	296
1973	21675	76	283
1974	12313	37	330
1975	9987	24	410
1976	12414	26	476
1977	19570	45	437
1978	23804	61	389
1979	34153	120	285
1980	51869	173	300
1981	45027	90	498
1982	54719	81	672

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Table 3

Landings of *Decapterus* spp. on the west coast of peninsular Malaysia by gear group

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1E81	1982
Purse seines	1690.39	3489.36	3578.94	2275.20	1790.69	4809.62	7019.54	5173.38	3678.04	6231.46	5839.63	6140.89	7109.19	7970.38	9220.52
Trawls	117.30	67.15	93.47	17.66	20.15	34.42	1.09	153.72	2.36	155.35	184.33	458.37	349.97	223.49	187.22
Other gears	3.20	21.85	8.22	15.97	3.51	4.84	0.73	4.90	14.15	11.49	1.09	—	—	—	—
Total catch	1810.89	3578.36	3680.63	2308.83	1814.35	4848.88	7021.36	5332.00	3694.55	6398.31	6025.05	6599.26	7459.16	8193.87	9407.74
% Total pelagic fish	1	3	5	3	4	7	12	11	6	9	7	6	6	7	7

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Table 4

Estimated catch, catch rate and effort values for *Decapterus* spp.

Year	Total catch by all gears (ton)	Catch per purse seine (ton)	Calculated effort
		(Y)	(X)
1972	1814.35	6.33	286.63
1973	4848.88	17.49	277.24
1974	7021 .36	23.17	303.04
1975	5332.00	15.40	346.23
1976	3694.55	13.62	271.26
1977	6398.31	32.46	197.11
1978	6025.04	29.95	201 .17
1979	6599.28	26.02	253.62
1980	7459.17	29.50	252.85
1981	8193.87	26.48	309.44
1982	940.74	26.88	349.99

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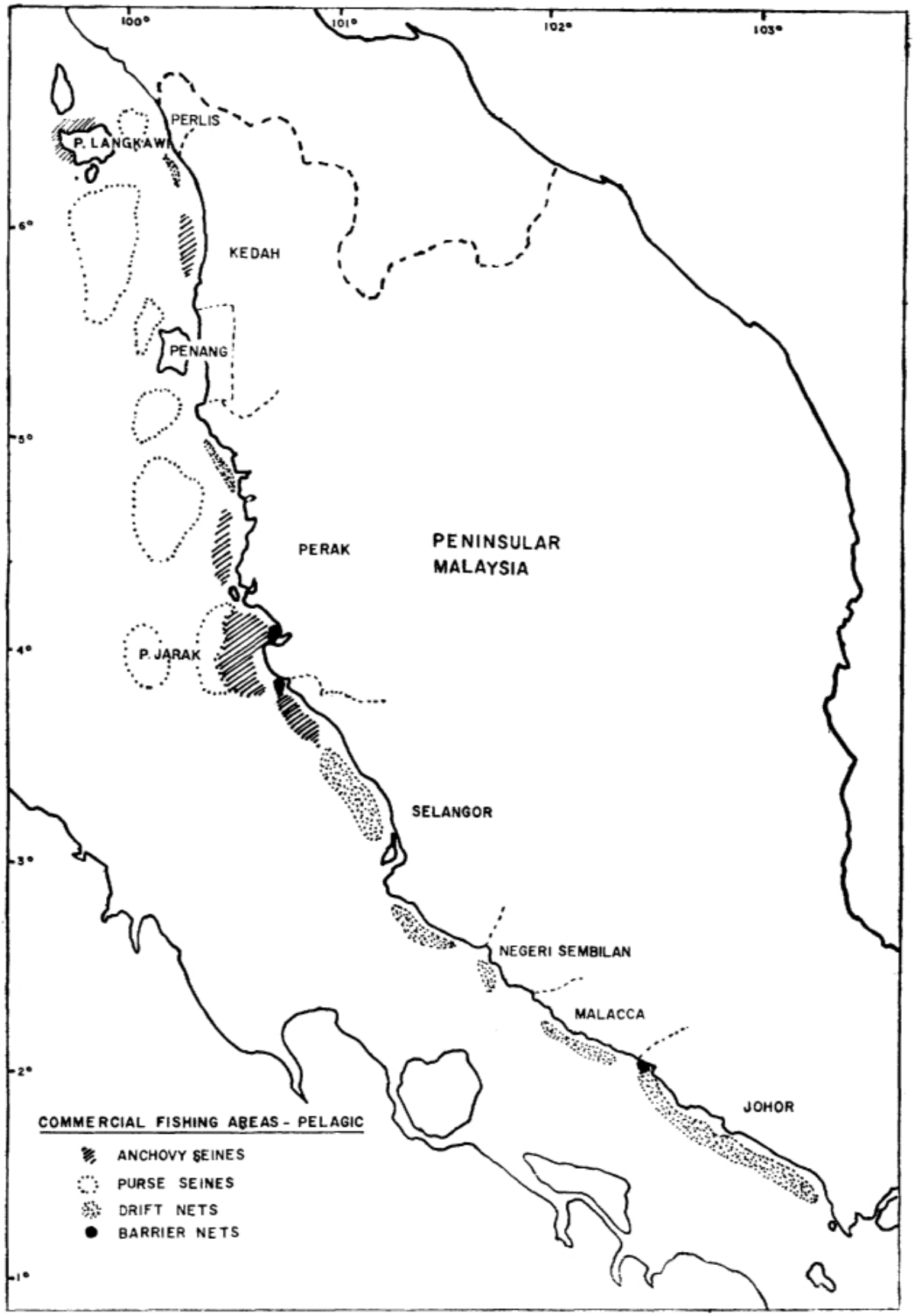

App. 3, Fig. 1. Commercial fishing areas for pelagic fish in the Malacca Straits.

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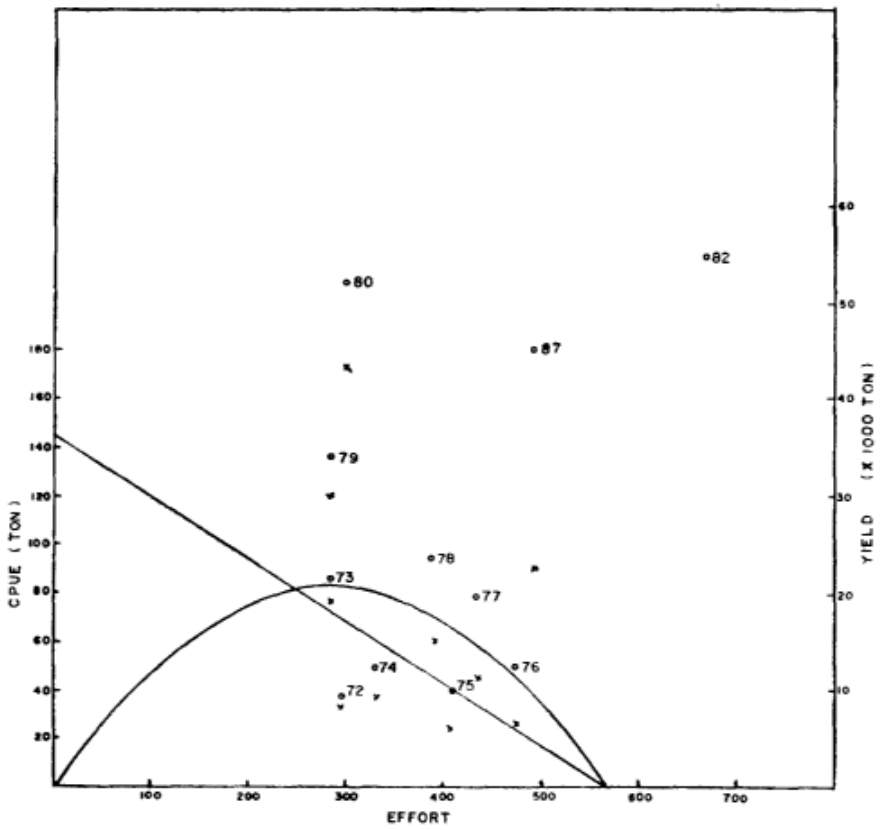
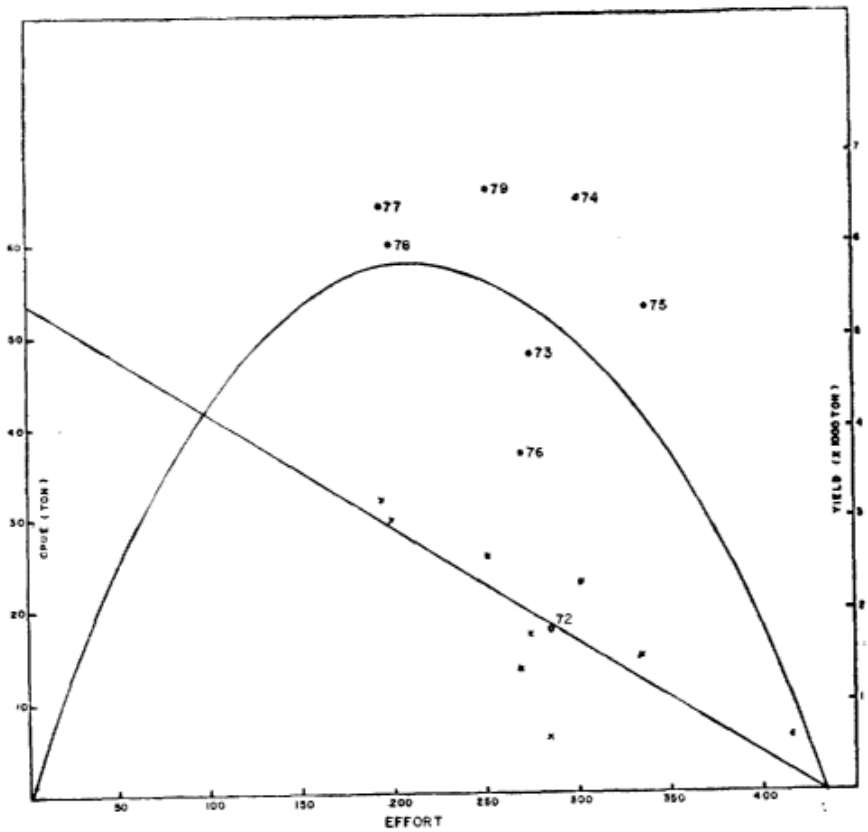


App. 3, Fig. 2. *Rastrelliger* fishery off the west coast of Peninsular Malaysia.



App. 3, Fig. 3. *Decapterus* fishery off the west coast of Peninsular Malaysia.

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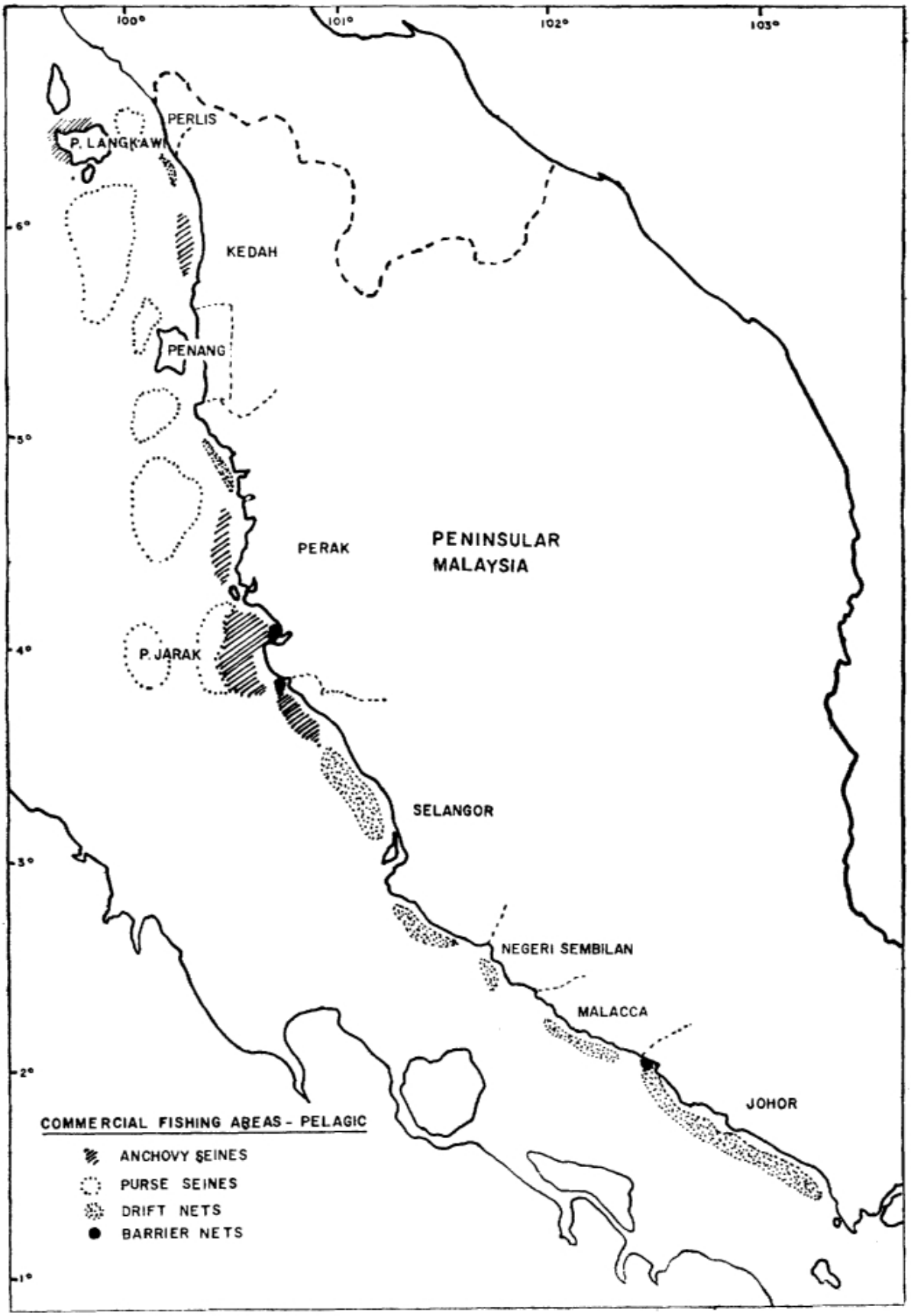

App. 3, Fig. 1. Commercial fishing areas for pelagic fish in the Malacca Straits.

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considerable fluctuation from year to year. The average yearly catch of *Rastrelliger* spp. from 1969 to 1980 was 15,812 tonne, ranging from 10,999 tonne in 1978 to 21,350 tonne in 1972.

2.1.2. *Scad fishery*

The scad fishery exploits *Decapterus* spp. with *D. russell/as* the main species (Sujastanj, 1975), although they are lumped together in the existing fishery statistics. The largest portion of *Decapterus* catch was from North Sumatra province and only very little was reported from Riau province (Table 1). The largest catches were reported in 1975 and 1976. They then fell dramatically from 14,053 tonne to only 758 tonne. It has thereafter shown a slow increase. The average catch of *Decapterus* was 12,189 tonne (9,808-1 4,053) during the period 1969-1975 and 1,902 tonne (758-2,593) during the period 1976-1980, respectively. There is no simple explanation for the decline after 1975-76.

2.2. Fishing effort

The utilization of powered boats began in 1976, in the Regency of Asahan (North Sumatra province) through the introduction of converted old type gasoline engines, such as those of Chevrolet, Dodge, Ford, etc. (Sujastani, 1975). These boats were first used for surface seining (pukat banting). Purse seiners are of a uniform type, being 15 >(3.5 >(1.5 metres (7 GT) in size with a 33-42 hp engine. Since purse seiners are not equipped with power blocks, the crew has 25 members. Fishing takes place at night.

The number of fishing boats operating in the Malacca Straits of Indonesia, especially of boats less than 5 GT with inboard motors, has increased from year to year (Table 2). The type and number of gears used and their respective catch is presented in Table 3.

2.3. Level of fishing

2.3.1. *Materials*

In order to know the level of fishing for small pelagic fish in the Malacca Straits, mainly *Rastieiiger* spp. and *Decapterus* spp., an analysis is attempted on the basis of the existing fishery data. The fisheries data used in this study are compiled from:

(a) For the years 1969 to 1974, the data used are from Sujastani (1975).

(b) For the years 1975 to 1980 the data used are from *Fisheries Statistics of Indonesia* and from Anonymous (1981).

Because of the many gears used in the *Rastrel/iger* and *Decapterus* fishery, the effort has been based on the purse seine unit, since this gear is the most effective one for catching these species (Table 4).

2.3.2. *Methods*

To get the total effort in purse seine units for all gears, a method proposed by Gulland (1969) and Anonymous (1980b) was used as follows:

$$TE = \frac{TC_{AG}}{C_{PS}} \times E_{PS}$$

Where, *TE* =total fishing effort: *TC* total catch for all gears, *C* nominal catch of purse seines and *E* effort of purse seine units *(AG-all* gears; PS-purse seine).

The Maximum Sustainable Yield (MSY) was calculated by using the well-known surplus production model assuming that the catch per Unit of effort *(C/E)* and effort *(E)* has a linear relationship and is shown by the equation : $C/E = a—bE$. The result of the present analysis is shown in Figs. 1-4.

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In an earlier study by Sujastani (1975), the MSY of total pelagic fish (including skipjack and tuna-like fishes) in the Malacca Straits of Indonesia was about 70,000 tonne, with an optimum effort of 1,300 purse seiners. The second study in 1981 indicated that the MSY for all small pelagic fish (without skipjack and tuna-like fishes) was 61,848 tonne, with an optimum effort of 787 purse seiners (Anonymous, 1981). The present study, by using data from 1969 to 1980, generates a MSY of 74,155 tonne with an effort optimum of 1,483 purse seiners. This value is higher than those in the previous analysis. The use of exponential relationship of *C/f* and *E,* on the other hand, resulted in a MSY of 68,764 tonne and effort optimum of 1,575 purse seiners. The exponential relationship of C/E on *E* gives a correlation coefficient of 0.70 which is higher than that of the linear relationship (Figure 1).

The MSY of *Rastrelliger* spp. is 17,691 tonne with the effort optimum of 229 purse seiners. The use of exponential relationship for *Rastrelliger* spp. gave a similar MSY value, but at a lower effort of 181 purse seiners (Fig. 4). Sujastani (1975) estimated the MSY for *Rastrelliger* spp. at 20,000 tonne while a later analysis mentioned 11,936 tonne (Anonymous, 1981).

No analysis for *Decapterus* has been made using data from 1969 to 1980, since different statistical collection systems in the years prior to 1976 and thereafter may cause discrepancies.

The exploitation of small pelagics as a whole in this areas exceeded the MSY in 1980, meaning that the level of fishing is too high (Fig. 2). The level of fishing for *Rastrelliger* spp. is also too high (Figures 3 8 4).

A fisheries resource evaluation (1983) by the Directorate General of Fisheries and the Research Institute for Marine Fisheries, Jakarta, showed a potential yield for pelagic resource in the Malacca Straits of Indonesia of 126,500 tonne per year. The catch during 1980 was only 69,623 tonne, indicating that efforts could be increased, mainly for operating in offshore waters in the northern part of the Malacca Straits.

3. Marine fishery resource survey

Survey vessels owned by Indonesia are, among others, *R/V* Bawal Putih I, Mutiara IV, *f/V* Bawal Putih II and Tenggirio, but no comprehensive pelagic survey has been made in the Malacca Straits so far. In 1975, a pelagic fish survey was conducted by a FAO Research Vessel, *R/V* Lemuru, using accoustic instruments, purse seine, mid-water trawl as well as bottom trawl, but the results were not sufficient for them to be used for stock assessment purposes. Detailed biological studies of *Rastrelliger* spp. and *Decapterus* spp. in the Malacca Straits have also not been conducted.

In the near future, biological studies should be started in order to get more accurate information about the dynamics of the population of *Rastrelliger* spp. and *Decapterus* spp. in the Malacca Straits to obtain a basis for rational exploitation and management of the fisheries in countries bordering the Malacca Straits.

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Table 1

Marine fishery production of Indonesia

(tonne)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Total Indonesian production	—		—	—			996,856	1,081,589	1,157,691	1,227,386	1,317,744	1,394,810	1,408,272
Production in the Malacca Straits of Indonesia	—	—	—	—	—	—	291,874	158,925	264,964	266,822	271,305	288,194	252,774
(%)	—	—	—		—	—	29.3	14.7	22.9	21.7	20.6	20.7	17.9

Mackerel production by province and species, 1969-1980

(tonne)

Province	Species	1969*	1970*	1971 *	1972*	1973*	1974*	1975	1976	1977	1978	1979	1980	1981
Aceh	*Decapterus*	174,1	379.5	300.7	568.9	1,297.0	899.6	1,362	661	485	832	1.345	1,023	—
	Rastre/liger	258.4	480.6	418.5	508.3	643.0	532.5	1,272	1,411	1.118	998	1,234	1,133	—
North Sumatra	*Decapterus*	9,633.9	10,385.9	11,593.1	12,506.6	10,966.5	12,262.5	12,691	97	56	1,704	1,248	1,234	—
	Rastrel/iger	15,914,8	17,242.5	19,818.8	20,841.3	15,535,9	18,001.1	18,239	10,043	11,202	9,755	10,677	11,756	—
Riau	*Decapterus*	—	—	—	—	—	—	—	—	824	—	—	—	—
	Rastre/figer	—	—	—	—	—	—	1	16	66	246	162	225	—
Total	*Decapterus*	9,808.0	10,765.4	12,193.8	13,075.5	12,263.5	13,162.1	14,053	758	1,365	2,536	2,593	2,257	
	Rastrelliger	16,173.2	17,723.1	20,237.3	21,349.6	16,178.9	18,532.6	19,512	11,470	12.386	10,999	12,073	13,114	—
	Total pelagics	42,352	45,926	50,902	50,071	61,603	68,261	123.806	70,231	69,649	61,375	61,701	69,623	—

•Sou,ce: Sujastani (1975).

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Table 2
Number of fishing boats operating in the Malacca Straits of Indonesia by category (1975-1980)

No.	Boat category	1975	1976	1977	1978	1979	1980
1.	Dug out boat	451	–	–	–	–	–
2.	Plank built boat	8,661	25,698	25,289	21,058	20,968	20,005
3.	With outboard motor	435	582	506	540	775	867
4.	With inboard motor:						
4.1	<5 GT	1,171	2,261	2,525	3,534	4,392	6,061
4.2	5 - 10 GT	600	907	1,300	704	821	1,471
4.3	10- 20 GT	282	470	373	671	615	749
4.4	20 - 30 GT	94	78	104	201	336	327
4.5	30- 50 GT	26	41	53	48	–	102
4.6	50 - 100 GT	6	45	58	69	–	–
4.7	100-200 GT	1	–	–	–	–	–
4.8	>200 GT	6	–	–	–	–	–

<<

Table 3

Types and numbers of fishing, gears operating in the Malacca Straits of Indonesia and their respective catch, 1975-1980

No.	Gear group	1975	1976	1977	1978	1979	1980
1	Trawl nets:						
	— Otter trawls	768 (58,812)	1,189 (53,353)	1,300 (50,590)	935 (50,725)	790 (61,178)	978 (76,393)
2.	Seine nets:						
	— Payang/Iampara	1,433 (19,253)	794 (2,180)	193 (5,272)	235 (5,682)	194 (6,840)	322 (7,095)
	— Danish seine	—	—	—	—	225 (971)	490 (1,256)
	— Beach seine	763 (18,425)	1,295 (7,558)	1,530 (6,777)	1,439 (9,135)	1,244 (8,479)	887 (6,955)
3.	Purse seines	114 (12,401)	180 (25,781)	211 (23,051)	234 (22,568)	291. (23,288)	612 (22,291)
4.	Gillnets:						
	— Drift gillnets	5,112 (23,865)	5,754 (28,01 5)	6,697 (29,730)	7,559 (21,343)	7,411 (22,750)	8,971 (28,214)
	— Encir. gilinets	521 (4,094)	136 (753)	151 (658)	120 (6,326)	138 (571)	95 (476)
	— Shrimp gillnets	506 (1,993)	1,146 (2,261)	1,891 (2,307)	1,773 (4,647)	1,984 (3,496)	1,943 (4,699)
	— Set gilinets	534 (2,479)	217 (3,128)	175 (6,357)	176 (670)	646 (3,023)	662 (5,034)
5.	Lift nets	2,473 (14,121)	282 (2,745)	302 (3,175)	451 (4,153)	1,080 (3,284)	1,131 (7,606)
6.	Hooks and lines:						
	— Drift longline		1,278 (2,400)	1,243 (2,550)	1,125 (2,547)	192 (217)	260 (438)
	—Set longline	762 (2,853)	110 (625)	135 (2,343)	182 (1,387)	840 (3,278)	455 (1,943)
	—Troll lines	917 (1,076)	766 (3,991)	298 (3,722)	285 (3,429)	86 (2,676)	617 (2,499)
7.	Traps:						
	— Guilding barriers	882 (3,438)	1,941 (22,543)	1,206 (21,161)	1,325 (23,055)	1,140 (29,235)	1,196 (30,838)
	— Stor nets	1,117 (51,507)	1,197 (21,857)	1,149 (22,856)	602 (18,640)	1,479 (22,088)	1,502 (25,183)
	— Portable traps	900 (2,522)	987 (749)	1,126 (878)	1,321 (424)	431 (424)	559 (1,405)

Remarks: Figures in brackets represent catch in tons.

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Table 4

Catch *(C).* **effort (E) and catch per unit of effort** *(C/E,)* **of total small pelagic fishes,** *Rastreiiger* **and** *Decapterus* in **the Malacca Straits of Indonesia, 1969-1 980**

Year	Items	Total small pelagic	*Rastrelfiger*	*Decapterus*
1969	*C*	40,382	16,1 73	9,808
	E	546	219	133
	C/E	73.96	73.85	73.74
1970	*C*	43,158	17,723	10,765
	E	581	239	145
	C/E	74.28	74.15	74.24
1971	*C*	47,761	20,237	12,194
	E	618	262	158
	C/E	77.28	77.24	77.18
1972	*C*	55,383	21,350	13,076
	E	721	278	170
	C/E	76,81	76.80	76.92
1973	*C*	57,060	16,179	12,264
	E	748	212	161
	C/E	76,28	76.32	76.17
1974	*C*	64,335	18,533	13,162
	E	1,134	327	232
	C/E	56.73	56.68	56.73
1975	*C*	109,350	19,512	14,053
	E	956	171	123
	C/E	114.38	114.11	114.25
1976	*C*	59,541	11,470	758
	E	947	298	12
	C/E	62.87	38.49	63.17
1977	*C*	59,550	12,386	1,365
	E	770	269	18
	C/E	77.34	46.04	75.83
1978	*C*	52,889	10,999	2,536
	E	773	293	37
	C/E	68.42	37.54	68.54
1979	*C*	50,962	12,073	2,593
	E	919	344	47
	C/E	55.45	35.10	55.17
1980	*C*	60,092	13,114	2,257
	E	1,650	391	62
	C/E	36.42	33.54	36.40

Remarks: *C* = tons; *E* purse seine unit; *C/s* = tons.

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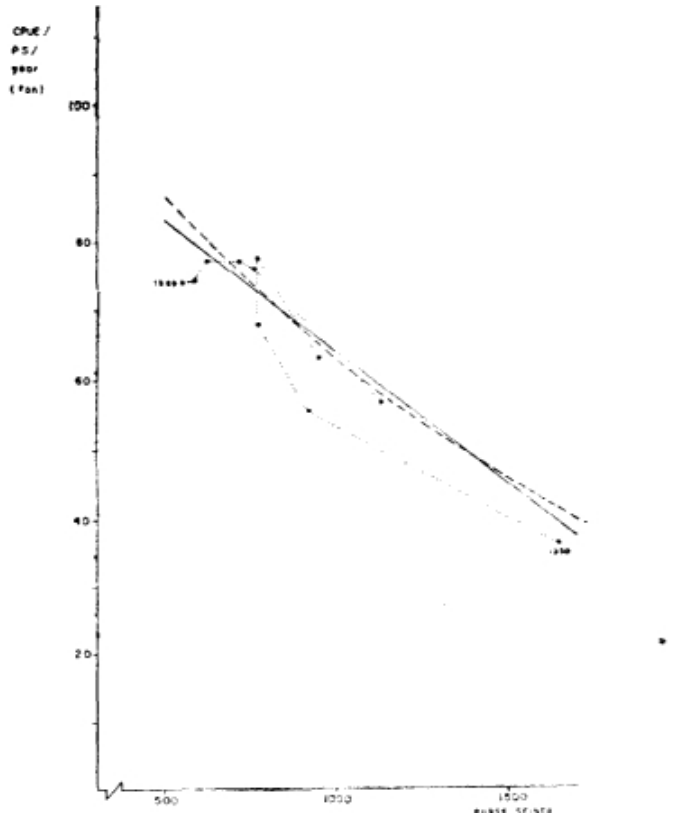
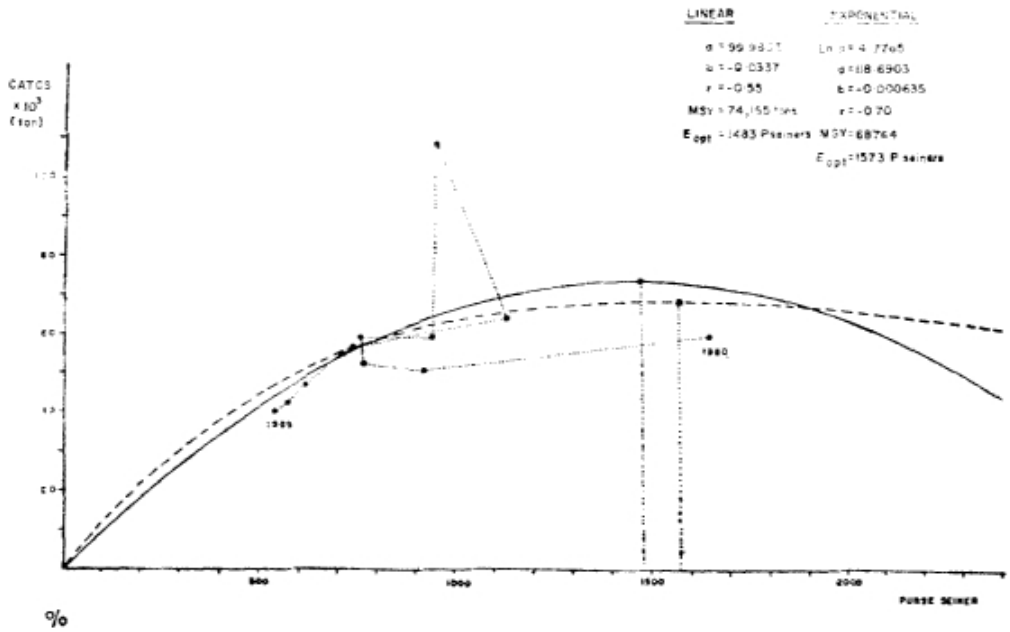


App. 4, Fig. 1. Cstclr per unit effort and effort relationship of total pelagic fishes in the Maleccs Straits of Indonesia



App. 4, Fig. 2. Yield curve of total pelagic fishes in the Malscca Straits of Indonesia.

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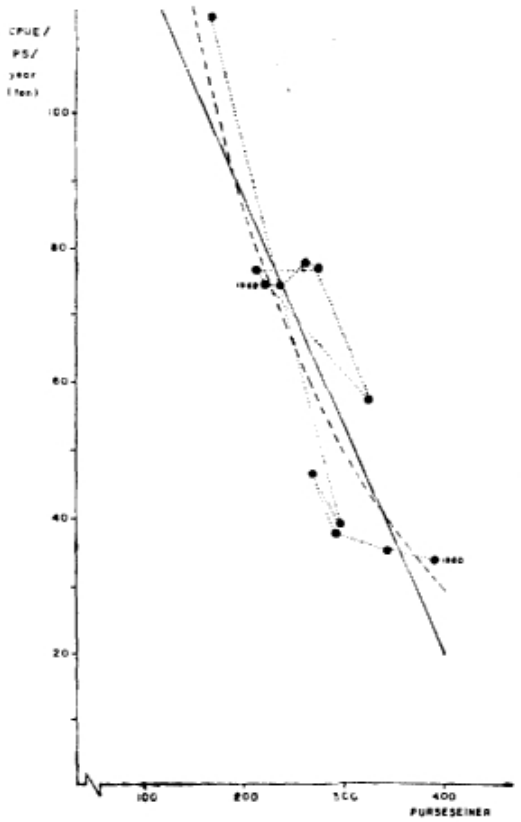
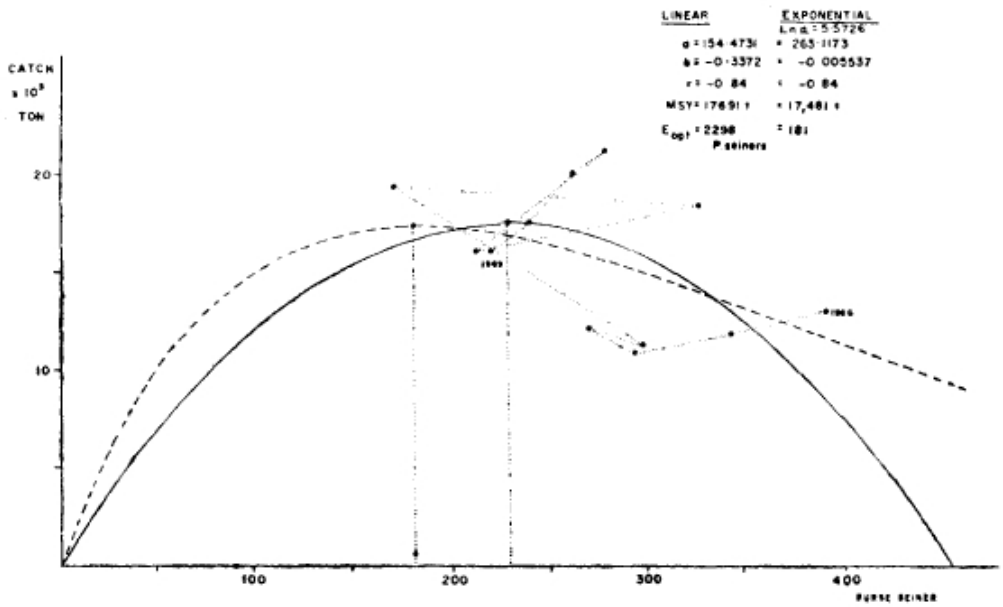


App. 4, Fig. 3. Catch per unit effort and effort r&ationship of *Rastreftiger* in the Malacca Straits of Indonesia.



App. 4, Fig. 4. Yield curve of *Rastrel/iger* in the Malacca Straits of Indonesia.

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Appendix 5

LIST OF PARTICIPANTS AND OBSERVERS: WORKING GROUP MEETING, 12-16 DECEMBER 1983, PENANG, MALAYSIA

Participants

Indonesia

Mr Dikdik Sodikin	Fisheries Officer Directorate General of Fisheries Jakarta
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Mr Mohd. Fadzil Shuhaimi b. Ramli	Fisheries Officer Management and Conservation Section Fisheries Division Kuala Lumpur

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Publications of the Bay of Bengal Programme (BOBP)

Reports *(BOBP/REP/....)*

1. Report of the First Meeting of the Advisory Committee. Colombo, Sri Lanka, 28–29 October 1976. (Published as Appendix 1 of IOFC/DEV/78/44.1, FAO, Rome, 1978)
2. Report of the Second Meeting of the Advisory Committee. Madras, India, 29–30 June 1977. (Published as Appendix 2 of IOFC/DEV/78/44.1, FAO, Rome, 1978)
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