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Investigations on the Mackerel and Scad Resources of the Malacca Straits

UNITED NATIONS DEVELOPMENT PROGRAMME
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Marine Fishery Resources Management RAS/81/051

INVESTIGATIONS ON THE MACKEREL AND SCAD RESOURCES OF THE MALACCA STRAITS

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This report summarizes the findings and results of investigations concerning the mackerel resources of the Malacca Straits undertaken during 1984-1986. These were organized by a working group established for this purpose in 1983, consisting of fishery biologists from Indonesia, Malaysia and Thailand. The objectives were to examine available data on the mackerel resources of the Malacca Straits (Indonesia, Malaysia and Thailand) to identify lacunae in the data, suggest improvement to data collection systems and analyse the present status of the resources.

The first meeting of the group was held in Penang, in December 1983. The outcome of that base line meeting was summarised in an earlier publication (BOBP/WP/30).

Following the recommendations of the first meeting, sampling programmes were improved in all three countries and sampling study tours and training programmes were conducted. Progress was monitored and discussed at the second and third meetings of the working group held in Colombo (Oct. 1985) and Phuket (Aug. 1986). This report incorporates the deliberations of these two meetings.

This report, the sampling programmes and the working group meetings were sponsored by the "Marine Fishery Resources Management" component of the Bay of Bengal Programme (BOBP). The project commenced in January 1983 and terminated December 1986. It was funded by the UNDP (United Nations Development Programme). Its immediate/objective was to improve the practice of fishery resources assessment among participating countries and to stimulate and assist in joint management activities between countries sharing fish stocks.

This document is a technical report and has not been cleared by the countries concerned or the FAO.

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SUMMARY

Mackerels and scads are an important fishery resource shared by the three nations bordering the Malacca Straits — Indonesia, Malaysia and Thailand. The estimation of fishing effort expended on various mackeral and scad species is problematic as there are continuous changes in target species with shifts in demand for them.

A joint sampling programme was undertaken by the three countries. Five sampling stations were established in each country and sampling was done to determine catch composition, catch and effort estimates, length frequencies and morphometric and other biological characteristics. Training courses and sampling study tours were also conducted with technical and financial support from the project Marine Fishery Resources Management in the Bay of Bengal (RAS/81/051), which was a component of the BOBP.

In Thailand, the production of mackerels was 28,174 and that of scads 8,205 t in 1985 Production has increased from 1983 to 1985, largely due to increasing fishing effort through addition of new craft, and the increasing popularity of luring purse seines. Malaysian production of mackerels declined from a peak of 68,966 t in 1984 to 54,982 t in 1985. Scad production also went down from a peak 9,497 t in 1982 to 6,437 t in 1984. The contribution of trawlers to the total mackerel production has been declining continuously. The production of mackerels was 22,809 t in Indonesia in 1985 and that of scads 16,163 t The production figures have increased consistently since 1976. Taking the entire Malacca Straits region as one unit, mackerel production went up by 200 per cent between 1976 (32,500 t) and 1985 (99,000 t).

Rastrelliger brachysoma appears to be more prevalent than R., kanagurta in Malaysia and Thailand while the reverse is true for Indonesia. Decapterus marcrosoma catches are well defined but recent species identification indicates that *D. maruadsi* may not occur in the Malacca Straits and that the species earlier identified as *D. maruadsi* might actually be *D. russelli.*

The catch rates for R. brachysoma and *R. kanagurfa* are reasonably similar in Malaysia and Thailand but are lower in Indonesia. Catch rates for *Decapterus* species are fairly similar in all the three exclusive economic zones (EEZs). Peak seasons far trawl catches of *R. brachysoma* are different from those for purse seine catches and the peak catch rates are generally lower for trawl catches except in the Kedah area.

The length frequency distributions in the various areas of the three countries exhibit very narrow size ranges, poor indication of entry of small sizes and poor modal progression. Size groups in trawl catches tend to be larger than in purse seine catches. In the case of peninsular Malaysia, welldefined selectivity trends were not obvious. The results of ELEFAN analysis indicate different sizes at first capture for each species in different areas implying that there could be differences in the size composition of components exploited in different areas.

Analysis of the available data on spawning and on the monthly distribution of catch per unit of effort of each mackerel and scad species suggest certain migratory patterns but do not account for all components of the stock. Recruits from different spawning areas may be intermingling — though components in the extreme northern area of Thailand of both *R. brachysoma* and *R. kanagurta* appear to be isolated from stocks south of the area. These hypothetical migratory trends need verification. Comparisons of morphometric characteristics did not lead to good correlation except in two cases (weight versus total length and weight versus total length and snout to second dorsal). Results of the comparison of these specific characters indicated that, in case of *R. brachysoma, R. kanagurta* and *D. russelli,* there were no significant differences among the areas within each group identified listed here but that there were considerable differences between the groups. For *D. maruadsi/russelli,* the groups were: 1. Thai area II + III; 2. Kedah and Langsa; 3. Perak; 4. Selangor. For *R. kanugurta,* the groups were: 1. Thai area I, Langsa, Asahan; 2. Thai Area III, Perlis; 3. Penang; 4. Banda Aceh. Limitation of results of the morphometric study calls for a more intensive tagging programme.

For both *R. brachysoma* and *R. kanagurta,* maximum sustainable yield values were exceeded in Thailand and Indonesia in 1985, and in Malaysia in 1984. In the case *of Decapterus* spp., MSY values were exceeded in 1985 in Indonesia and Thailand but not in Malaysia. However, many of these estimates are subject to various uncertainties. It is quite likely that the present level of exploitation of mackerel and scad resources could be continued without any increase in the number of boats. The three countries might wish to consider management measures such as a quota system in order to avoid an uncontrolled increase in fishing effort.

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INTRODUCTION

An objective of the regional FAO/UNDP project "Marine Fishery Resources Management in the Bay of Bengal" (RAS/80/051) was to assist in joint assessment and management of fishery resources shared by member countries. One of these shared resources, the stock of scad (Decapterus) and mackerel (Rastrelliger) in the Malacca Straits, was to be investigated jointly by Indonesia, Malaysia and Thailand.*

A working group of biologists from these three countries was established in 1983. The group first met in Penang, Malaysia, in December 1983, to examine data available, identify lacunae in the information, suggest improvements to the data collection system, and analyse the mackerel resources in the Malacca Straits. The report of this meeting was published as a working paper (BOBP/WP/30). Following the recommendations of that meeting, the sampling programmes were improved in all three countries and training programmes and sampling study tours conducted with technical and financial support from the project. Sampling was done to determine catch composition by types of craft and gear, catch and effort estimates, length frequencies for each species, morphometric characters and other biological characteristics such as sex ratio, gonad maturity, spawning seasons and areas. Data available on egg and larval surveys and tagging experiments were also used in the analysis and interpretation of results. Five stations in each country were selected for the sampling programme and systematic sampling was done on three to four consecutive days at each station once a month, except in Sumatra where the samplers were permanently stationed at the sampling centres and the sampling conducted every week. The sampling program is reported in greater detail in BOBP/WP/30.

Progress ws monitored and discussed at two subsequent meetings of the working group, held at Colombo, Sri Lanka (October 1985) and Phuket, Thailand (August 1986). The present report incorporates the deliberations of the two meetings. Information submitted to the two meetings by the biologists is contained in the papers of the respective countries annexed to this report. A review of the scads and chub mackerels in the entire Bay of Bengal region is also annexed. Participants at the two working group meetings are listed in the Appendix. Figure 1 shows a map of the area covered by the investigations.

2. RESULTS

2.1 The fisheries

The estimation of fishing effort for each species of mackerel and scad is a serious problem, because of continuing changes in target species with changes in the demand for them – particularly in Thailand but also in the other two countries. On the west coast of Thailand, over 160 purse seiners, operating Chinese, Thai or luring purse seine, contribute the bulk of the scad and mackerel production. These craft range in length from 12 to 25 m, and the majority of them are in the 18-25 m class. The purse seines used are 800-1,500m x 60-120 m with mesh sizes ranging from 18 to 90 mm. The duration of a fishing trip varies from one to five days.

The light luring purse seine continues to be the most popular among the various purse seining methods. Purse seine nets with 38 mm mesh sizes are now being used for catching R. brachysoma instead of the 25 mm mesh nets used in the past. In 1985 a considerable number of purse seiners from Phuket moved to Takuapa (Area I) to fish for R. kanagurta. In 1985, the production of mackerels was 28,174 t and that of scads, 8,205 t. There has been a significant increase in the production of R. brachysoma and R. kanagurta from 1983 to 1985. The increase in production of the latter has been helped by the shift from the Thai to the luring purse seine. The general increase in the production of both species of mackerels on the west coast of Thailand has been attributed to the increase in fishing effort through addition of fishing craft and use of some trawling vessels as purse seiners (January-April). Scad production has also been increasing in recent years. Scads have become an important component of the fisheries as

• The areas of investigation were: the west coast of Thailand, the west coast of Peninsular Malaysia and the Malacca Straits and northern coasts of Sumatra, Indonesia.

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they are one of the target species of luring purse seines. The mackerel and scad production figures for 1983-1985 are revised estimates based on available catch records and on the sampling conducted by research staff. There appears to be a significant decline in the contribution of the trawl fishery to the production of mackerel in recent years. Whether this is attributable to the shift from high opening bottom trawls to other types of trawls is, as yet, an unanswered question.

Thailand has now introduced a closed season for the purse seine fishery for mackerels around Krabi area from April 15 to June 15.

On the west coast of Peninsular Malaysia some 1,100 purse seiners, 3,000 trawlers and 9,000 gillnetters contribute to mackerel and scad production. These are grouped under the > 70' GRT, 40 GRT and 25 GRT classes. The purse seine nets are 400-800 m x 80-120 m with a mesh size of 25 mm. This gear contributes 73% of the mackerel and scad production; high opening bottom trawls contribute 22%, gillnets 4.5% and other gear, 0.5%. Most of the purse seiners conduct one-day operations. The number of purse seiners over 70 GRT alone is increasing, because licences are being granted only for this category and not for purse seiners below 40 GRT. The license of an old vessel smaller than 40 GRT may be used for obtaining a license for a new vessel, provided the new vessel is larger than 70 GRT. The larger size class of vessel is limited to fishing in areas beyond the range of the smaller size class and hence is not able to perform better than the latter.

The production of both mackerel species on the west coast of Malaysia showed a significant increase until 1984 (68,966 t) and a significant decline in 1985 (54,982 t). There is a continuing decline in the portion contributed by trawlers since 1982183. The scad production estimated for 1984 was 6,437 t which also appears to have declined since the peak in 1982 (9,407 t).

It has been estimated that about 600 purse seiners, in the size range 7-25 m , operate in Indonesia, mainly in the north and Malacca Straits coasts. When fishing for mackerel, scad and tuna, these vessels use purse seines, 400-1,000 m x 40-75 m, with mesh sizes ranging from 25 to 90 mm. Till recently, these vessels undertook only one-day trips, but have now increased the trip duration and have also started to employ light luring, systems during purse seining. Purse seiners from Asahan tend to fish off Langsa and to land their catches at Langsa or any other adjacent fishing port, depending on the market situation. There is no trawl fishery in this area and gillnets contribute to the mackerel production in a very small way.

As in the case of Thailand, production of mackerels increased in 1985. It is observed that since 1975 the Malaysian production figures increased sharply, compared to those of Thailand and Indonesia, but in 1985 the Malaysian production showed a sharp decline while those of Thailand and Indonesia increased (Figure 2).

The total production of mackerels in the Malacca Straits in 1985 (99,000 t) shows a 200% increase over the 1976 figure of 32,500 t, but the 1984 production was only about 4% higher than that of 1985. The production figures for mackerels and scads for Thailand, Malaysia and Indonesia are presented in Tables 1 and 2.

2.2 Species composition

The composition of mackerel species in the purse seine catches in 1983, 1984 and 1985 is:

(Per cent)

	R. brachysoma			*R.kanagurta*		
	1983	1984	1985	1983	1984	1985
Thailand	5 8	8 7	7 8	4 2	1 3	2 2
Malaysia	6 8	6 9	8 3	3 2	3 1	1 7
Indonesia	?	6 3	3 2	?	3 7	6 8

It is noted that the values estimated for 1983 and 1984 were quite different from those of 1985. The production of *R. kanagurta* was higher than that of *R. brachysoma* in Thailand in 1974 and 1976 and they were almost of equal proportion during previous years. It was noted that a similar trend was reported for the west coast of Malaysia also, about a decade ago (Pathansali, 1961). *R. kanagurta* has now been reported to be more abundant than *R. brachysoma* in purse seine

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catches. Earlier estimations of the species composition were not based on sampling by biologists and the validity of some of those reports must be questioned. R. *faughni* also occurs in the Malacca Straits but is not caught in commercial quantities (Figure 3a).

The production of Decapterus spp. has declined in Thailand and Malaysia since 1983 but has shown a steady increase in Indonesia (Figure 3b). The production in Malaysia comes mainly from the states of Perlis and Penang, because of the common use of palm leaf lures with purse seines.

The species composition of scads in the purse seine catches is presented below:

(Per cent)

	D. macrosoma		*D. maruadsi/russelli*		
	1984	1985	1984	1985	
Thailand	60	26	40	74	(average for 1982-85)
Malaysia	?	?	?	?	
Indonesia	57	53	43	47	

Samples of *Decapterus* spp. were sent to Dr. Smith Vaniz who identified *D. russelli* and indicated that *D.* maruadsi may not be occurring in the Malacca Straits. *D. macarellus* has been caught occasionally on the west coast of Thailand.

2.3 Catch rates and seasonallty

For each species, the peak seasons, peak catch rates and catches during the peak months in different coastal areas of the three countries bordering the Malacca Straits, are summarised in Tables 3a, 3b, 4 and 5.

During the second meeting of the working group held in September 1985, the mean catch rates (kg/boat/day) for each country were divided by the square of the length of the floatline, according to Sinoda's method (Sinoda, 1976) in order to compensate for differences in the size of the purse seine nets used. The result indicated that the mean catch rates of *R. brachysoma* and *Decapterus* spp. in Thai waters were higher than those for the other two EEZs and that those of Malaysia and Indonesia were almost the same during 1983/84. In the case of *R. kanagurta,* the Indonesian catch rate was lower than that of Thailand but higher than that of Malaysia. However, recent values (Tables 3a, 3b, 4 and 5) show that the catch rates of *R. brachysoma* and *R. kanagurta* in the Thai and Malaysian waters were reasonably similar and much lower on the Indonesian side of the Malacca Straits. The values for Decapterus spp. appeared to be fairly similar in all three EEZs, except in the northern part of Malaysia where much higher catch rates have been reported.

It was noted that peak seasons for trawl catches of *R.* brachysoma were different from those' for the purse seines in different areas (Table 3a & 3b). However, the peak catch rates were generally much lower than those for the purse seines except in the Kedah area. *Decapterus* spp. and *R. kanagurta* were represented relatively poorly in the trawl catches in all the areas. Monthly distribution of mean catch rates of each species for purse seiners within the Malacca Straits are illustrated in Figures 4-12. It must be noted that no adjustments have been made for differences in fishing efficiencies of the craft, gear and fishermen in the three countries.

2.4 Length frequency distribution

The length frequency distribution in the various areas of the three countries appeared to exhibit very narrow size ranges, poor indication of the entry of small sizes and even relatively poor modal progression. Effective inclusion of juveniles in the trash fish category and application of raising factors may help to improve their quality. General size ranges appeared to be very similar all around the Malacca Straits. Some limited data on length frequencies of trawl and purse seine catches of *R. brachysoma* are given below (in cm).

Thailand Area II (Central part of the west coast)	February	July	August
Trawl catch size range	18-21	20-21	20-22
Purse seine catch size range	18.5-20.5	16.5-I 8.5	16.5-I 8.5
		trawl	purse-seine
Malaysia Perak	(May)	18.1	18.9
Selangor	(November)	18.2	18.5
Indonesia Sumatra	(March)	22-23	18.5-20.5

The size groups in the trawl catches tend to be larger than in the purse seine catches. In the case of Malaysia, the result did not show a well-defined selectivity trend.

The size ranges caught by purse seiners during the peak season and in different areas of the three countries are indicated in Tables 3-5. With the introduction of the closed season in the juvenile grounds on the west coast of Thailand, some increase in the mean size of the catch is indicated for R. brachysoma.

The bottom trawl catches of R. brachysoma during the 'Dr. Fridtjof Nansen' cruise off Thailand and Indonesia showed a minimum size of 14 cm and a dominant size range of 16-20 cm during July/August.

The results of ELEFAN analysis indicated different sizes at first capture (L_c) for one species in different areas. Since similar mesh sizes are used in mackerel purse seines in all three areas, it is felt that the results of the ELEFAN analysis could indicate differences in the size composition of components exploited in different areas.

2.5 Maturity and spawning

The values of mean length at first maturity obtained are more or less the same in all three countries for R. kanagurta, R. brachysoma and D. macrosoma, but D. russelli in Indonesia showed a significantly smaller mean size. This is probably due to insufficient data and the consequent poor correlation. The mean lengths at first maturity are presented in Table 6.

Investigation of seasonal fluctuations in the sex ratio of R. brachysoma in Thailand and Malaysia showed predominance of males among fish smaller than 18 cm, an equal proportion of males and females in the 18-20 cm size range and predominance of females in fish larger than 20 cm.

Indonesian data on males of the three species, excluding R. brachysoma, indicate maturing of males at smaller size than females. This probably indicates a differential growth rate, with females growing faster than males. This is also supported by the predominance of males in smaller sizes and that of females in larger size groups, as observed in Thai waters. However, the number of samples examined in Indonesia was insufficient.

Examination of the seasonal changes in the gonad indices obtained from Thai and Malaysian data indicated about four peaks per annum for R. brachysoma and R. kanagurta. Peaks with mean Gonadosomatic Index (GSI) of 50 and above were considered to be indicative of spawning. Each spawning tended to be over protracted periods, probably indicating release of eggs in batches.

The mean GSI values for R. brachysoma from trawl catches in Thailand, Malaysia and Indonesia indicate a higher percentage of mature fish than in the purse seine catches. The GSI values of trawl catches also tend to be higher than those of purse seine catches. The seasons of peaks for GSI values in some areas in Thailand could be superimposed on those from some other areas in Malaysia. The peaks indicated either common spawning seasons in the different areas or that the specimens in two such areas probably originate from the same stock. The tagging experiment results showed that this species migrated from the southern waters (Area III) of Thailand to Kedah in Malaysia where the gonad index development pattern was very similar to that of the former area and the migration occurred around one of the likely spawning periods.

Juveniles of R. brachysoma and R. kanagurta have been observed along the coastlines of all three countries. Length frequencies occasionally indicate entry of very small fish (9-12 cm) into the catches but these appeared to be sporadic.

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In the case of Thailand, fish egg and larval surveys, as also the abundance of juveniles, show that the central part of the west coast (Area II) is clearly a spawning area. However, the occurrence of juveniles at various points along the coastlines of all three countries during various seasons, and the occurrence of multiple peaks in the seasonal variation in the GSI values, indicate the probability of multiple annual spawnings, perhaps at many places in the Malacca Straits. Fishermen in Indonesia have expressed the opinion that spawning of mackerels may also be occurring in the proximity of an island in the southern part of the Malacca Straits. It was suggested that egg and larval surveys should be expanded to cover more areas and seasons.

2.6 Growth

The effectiveness of the sampling conducted and the lack of length frequency samples raised to the total catch of the fleet sampled was noted. As a result of these limitations, there was no evidence of the effect of gear selectivity on the results from some areas, and even the exploitation rate obtained for one area was extremely low for a significantly exploited stock. Trawl and purse seine samples from the same area and same period resulted in significantly (100%) different growth parameters and total mortality rates. As there is no evidence of these two components belonging to separate stocks, perhaps the samples should be be raised to the total catch by the two methods and combined before such analysis. The growth constant (K) values presented for each species in different areas of each country and between countries varied significantly (Table 7).

However, a combination of length frequencies of adjacent areas in each country produced evidence of wider size distribution and improved fitness of the growth curves and the presence of a number of cohorts which should be expected if multiple spawning occurs. The combination of R. brachysoma length frequencies from the central and southern part of the Thai coast (areas II and III) and of R. kanagurta length data for the northern, central and southern areas (I, II and III) showed a possibility of fitting four cohorts for each year with growth constant (K) and asymptotic length (L_∞) values of 1.6 and 29530.0 cm for R. kanagurta (Figure 13) and two cohorts per annum with K of 1.4 and L_∞ of 25 cm for R. brachysoma (Figure 14).

The origins of cohorts matched with the peak seasons of gonad index indicating a similarity in results and supporting the occurrence of four recruitments in the case of R. kanagurta. The Bhattacharya method was applied to monthly length frequency data to obtain the mean length values for the various modal groups, and when these points were plotted on the figure for growth curves from ELEFAN I analysis, the fit with the four growth curves for R. kanagurta was remarkably high. Similarly, a good fit appeared in the analysis (by ELEFAN and Bhattacharya) of the R. brachysoma data also, although in this case not more than two growth curves could be attributed to the length frequencies, The number of mean length values of the modal groups separated by the Bhattacharya method, for any one cohort, was insufficient for a Ford-Walford plot.

2.7 Migratory trends

From the examination of the monthly differences in the distribution of catch per unit of effort (CPUE) of each mackerel and scad species (Figures 4-12) the seasons of peak catch rates in each area and the mean size groups occurring in the respective areas and during the peak seasons (Tables 3-5) certain migratory trends emerged. Those for the mackerel species are presented in Figures 15 and 16. They are highly hypothetical and require considerable verification. All components of the stock are not accounted for by these conjectures and it is felt that recruits from different spawning areas may be intermingling within the Malacca Straits. However, components in the extreme northern area of Thailand, for both R. brachysoma and R. kanagurta, appear to be rather isolated from any of the components south of that area. Whether these are related to the stocks outside the Thai waters is a matter for future consideration. It was noted that recruitment to the purse seine fishery in the southern part of Burmese waters is around February and the smallest size group entering the fishery is 16.5 cm (Druzhinin, 1970).

The hypothetical migratory patterns assume continuity in the distribution of R. brachysoma in Thai areas II and III. However it was noted that the results of the tagging experiments failed to show movement of fish between the northern part of Area II and Area III, indicating a separation. It was also conjectured, from the fact that there is a fishery for this species in this

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"no man's land", that R. brachysoma has to move in from either south or north of this area. Further, it is observed that this area of discontinuity is also part of the main area of larvel distribution and perhaps a spawning ground. Fishermen also have described the disappearance of schools which approach this area. Whether these schools move towards the bottom for spawning or whether the intensive fishing on either side depletes the component entering this area to the extent of reducing any chance of tag recovery requires further investigation.

Unusually negligible occurrence of R. kanagurta, very low catch rates of R. brachysoma in the purse seine fishery and a relatively better catch rate in the trawl fishery — these phenomena were observed in the Kedah area of Malaysia. The hypothetical migratory pattern appears to explain these by the fish movement pattern in the Kedah area and the probability that the spawners may be close to the bottom. The results of the tagging experiments conducted on the west coast of Thailand also lends support to the hypothetical migratory pattern for R. brachysoma (Figure 15).

2.8 Morphometric comparison

Linear measurements versus body length were compared for the samples from the three EEZs, using co-variance analysis. Correlation coefficients were found to be very poor in many cases and only two characteristics were found to show good fitness. The results of the comparison of these specific characteristics indicated that, in the case of R. brachysoma, R. kanagurta and D. russelli, there were no significant differences among the areas within each group listed below, but there was a significant difference between any two groups.

D. maruadsi/russelli (Characteristics: weight versus total length)

Group I Thai Area I + III combined
Group 2 Kedah Perlis, Penang (Malaysia) Langsa and Asahan (Indonesia).

R.brachysoma (Characteristics: snout to second dorsal versus total length)

Group 1 Thai area II + III
Group 2 Kedah and Langsa
Group 3 Perak
Group 4 Selangor

R. kanagurta (Characteristics weight versus total length and snout to second dorsal)

Group 1 Thai Area I, Langsa, Asahan
Group 2 Thai Area III, Perlis
Group 3 Penang
Group 4 Banda Aceh

(Thai Area II is similar to group I except for the intercept)

Though no definite conclusion was drawn from these results, it was observed that the above grouping did not create any serious conflict with the hypothetical migratory pattern discussed.

In view of the limitation of the results from the morphometric studies, it was felt that a more intensive tagging programme should be undertaken to cover all seasons of the year, preferably embracing other areas in the Malacca Straits. However, it is noted that morphometric similarity is indicated for R. brachysoma (from Area II and III of Thailand), where discontinuity in distribution of the species between these two areas was indicated by the tagging experiments.

3. STATE OF THE FISHERIES

Considering the difficulties faced in obtaining a correlation between the catch rate and effort for the data from the three countries, in spite of the attempt to standardise the effort to the length of the float line of the gear, attempts were made by the respective countries to standardise the effort of various purse seiners by standardising the sizes of the vessels. In the case of Indonesia, a steady increase in the catch rate with GRT was evident, at least in one area, but no correlation could be established in the cases of the other two countries. The effort established for a general "purse seiner" (catch per day per purse seiner) was used against the catch rate. A reasonably good correlation was observed in the cases of Thailand and Indonesia but not in the case of Malaysia, where the effort was independently guesstimated because of the

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absence of precise catch rate values for the period prior to 1983. However, the application of catch per boat per annum versus the number of boats operated gave a slightly better fit. The results obtained are presented in Table 8.

The production of Rastrelliger species in the Malacca Straits has increased by about 20% over the last five years, from 81,000 t in 1980 to about 100,000 t in 1985 while that of *Decaprerus* spp. has trebled from 10,000 t in 1980 to 30,000 t in 1985. The catch rates of R. brachysoma and R. kanagurta in the Malaysian and Thai purse seine fishery showed a declining trend but there are indications of improving catch rates on the east coast of Sumatra. In contrast, the catch rate of *Decapterus* species has in recent years, shown an increasing trend in Malaysia and the east coast of Sumatra and a fluctuating trend on the west coast of Thailand and the north coast of Sumatra.

It was observed that the Maximum Sustainable Yield (MSY) values in almost all the cases, with data available up to 1985, were higher than those estimated in 1984. The 1985 production of R. brachysoma and R. kanagurta in Thailand and Indonesia exceeded the MSY values and in Malaysia the production went beyond the MSY in 1984.

In the case of *Decapterus* spp. the MSY values were exceeded by the production estimates for 1985 in Thailand and in Indonesia but not in Malaysia. The MSY in the case of Indonesia is supposed to have increased because of increasing fishing grounds towards the north.

Though the catch rate in one country may not be applicable to the others, an attempt was made to estimate the effort for the combined production of mackerels from the three countries using the catch rates for purse seiners in Thailand. The resultant MSY values from these combined production models are presented in Table 8. This was attempted because of the finding that the catch rates in other parts of the Malacca Straits, particularly along the coast of Malaysia, were comparable to the catch rates along the coast of Thailand and on the assumption that the distribution of the mackerels in all the fishing areas is similar to that of the coast of Thailand and that the catchability coefficient would also be somewhat similar.

The production figures are generally estimated by the Statistical Division and the catch rates determined on the basis of sampling conducted by the research staff. The effort values determined from these not only tend to show extremely high annual variations but also affect the correlation. The need for reasonably good independent estimation of effort and more precise unit of effort such as the number of operations, was evident. Furthermore, for such migratory pelagic species, more intensive sampling for improving the estimation of the catch rate was also needed, in the interest of good surplus production models and more reliable MSY values.

The catch and effort estimates used have been subjected to corrections and revisions and hence will differ from those used earlier.

In view of various limitations in the estimation of catch and effort, it is considered best that the total catch and catch rate of mackerel purse seiners be used to estimate the purse seine effort. These effort values may then be used to correlate with the catch rates of each species caught in the mackerel purse seine on the basis that the target is not fixed and that the fishery is on mixed species.

The combined production model yields the following results: an MSY of 73,396 t for *R. brachysoma* and 38,453 tonnes for R. *kanagurta*. But the MSY values estimated separately by Thailand, Malaysia and Indonesia were

	MSY value (tonnes)			
	Thailand	Malaysia	Indonesia	Total
R. brachysoma	*20,900'*	*54,394*	*6,951*	82,245
R. kanagurta	4,800	11,530	12,994	29,334

These totals allow the following conclusion according to the total catch of each species: there could be some room for increase in the production of *R. brachysoma* although the catch rates decreased slightly in all three countries in the last few years. In the case of *R. kanagurta* production in 1985 is very close to its MSY (Table 8) but exceeded it in 1983 and 1984. According to the combined production model, the present production of both species would be close to the respective MSY values.

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From the management point of view, these observations, according to the combined production model, would indicate that the mackerel and scad fishery might be continued at its present level of exploitation without any increase in the number of boats. The units of effort in the combined production model cannot be applied to all three countries due to the fact that there are considerable differences in types of craft, gear,duration of trips etc.

If the mean value of the MSY for each species is taken from the results of the two production models (Schaefer and Fox), it would be 72,000 in the case of *R. brachysoma* and 35,000 in the case of R. kanagurta. The MSY values for R. brachysoma and R. kanagurta for each country, subdivided on the basis of their 1985 production levels, will be as follows:

23,000 and 7,000 for Thailand.
41,000 and 10,000 for Malaysia and
8,000 and 18,500 for Indonesia

These values may already serve as a guideline for fishery management measures through the quota system which the countries may wish to consider just in case an uncontrolled increase occurs in local fishing effort.

According to Tables 2 and 8, the Decapterus resources have been overexploited since 1983. The exploitation rates for *R. brachysoma* derived by the ELEFAN II method are very high (0.70-0.84) for all eight areas investigated (Table 7) while the production levels are below the respective MSY values for Malaysia and Indonesia; those for Thailand appear to indicate that the production for this species has only marginally exceeded the recent estimate of MSY. For *R. kanagurta* and *Decapterus* spp. the exploitation rates are between 0.45 and 0.81 (Table 7) when the production and MSY values exhibit the same relative state as that of *R. brachysoma* (Table 8) for the three countries.

4. FUTURE ACTIVITIES AND RECOMMENDATIONS

The activities already commenced ought to be continued in order to confirm the interpretations made and to acquire better knowledge and understanding of the resources enabling their proper management. The working group wished to place on record the following recommendations:

1) In the light of the information that has become available from the studies made so far, it is evident that there is a need for some form of management of the mackerel and scad resources in the Malacca Straits. It is therefore recommended that the governments concerned should continue to jointly monitor the fisheries and consider the needs and means of establishing a mechanism for joint management of these resources.
2) Though considerable improvement has been achieved in the area of sampling for catch, effort and biological data, there is clear need and scope for further Improvement of these statistics in all three countries. Confirmation of the results obtained depends heavily on this and therefore necessary assistance and support should be provided by the authorities for achieving the required level of improvement.
3) The tagging programme undertaken by Thailand has contributed valuable information. However, considering the results obtained, the participation of the other two countries in the tagging programme is also needed to cover other seasons and areas.
4) Fish egg and larval surveys should also be continued and expanded to cover other, what can now be considered probable, spawning seasons and areas.
5) Considering the problems in conducting regular fisheries research nvestigations and data collection in Sumatra — through researchers based in Jakarta and Semarang — it is necessary to establish some basic research facilities in that area.

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Table 1

Production of Rastrelliger brachysoms and *R. kanagurta*

(tonnes)

	R. brachysoma				*R. kanagurta*			
Catch	Thailand	Malaysia	Indonesia	Total	Thailand	Malaysia	Indonesia	Total
1972	5,702	6,686	—	12,388	3,966	3,077	—	7,043
1973	13,005	14,843	—	27,848	10,329	6,832	—	17,161
1974	7,979	8,432	—	13,552	6,050	3,881	—	9,931
1975	7,979	6,839	—	14,818	5,722	3,148	—	8,870
1976	3,141	8,501	6,021	17,663	5,384	3,913	5,648	14,945
1977	4,623	13,402	6,849	24,874	2,545	6,169	6,944	15,658
1978	2,354	16,300	5,979	24,633	2,392	7,503	5,253	15,148
1979	8,643	23,388	6,664	38,715	4,045	10,765	5,755	20,565
1980	13,091	35,472	7,401	55,964	3,081	16,327	6,427	25,835
1981	15,181	30,835	3,490	49,506	3,169	14,193	6,905	24,267
1982	9,714	37,472	5,215	52,401	1,890	17,247	9,879	29,016
1983	11,410	42,864	4,299	58,573	3,959	19,730	8,343	32,032
1984	16,129	47,228	4,589	67,946	3,580	21,738	9,804	35,122
1985	22,162	40,090	7,379	69,631	6,012	8,455	15,430	29,897

Table 2

Production of Decapterus spp.

(tonnes)

Year	Thailand	Malaysia	Indonesia	Total
1972	1,475	1,814	—	3,289
1973	811	4,849	—	5,660
1974	1,416	7,021	—	8,437
1975	1,535	5,332	—	6,867
1976	1,074	3,695	758	5,527
1977	1,450	6,398	1,365	9,213
1978	886	6,025	2,536	9,447
1979	1,427	6,599	2,395	10,421
1980	1,770	7,459	2,812	12,041
1981	2,397	8,194	4,397	14,988
1982	2,212	9,408	5,052	16,672
1983	13,941	11,359	7,726	33,026
1984	11,721	10,276	8,724	30,721
1985	8,205	6,437	16,163	30,810

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Table 3a

Peak catch, catch rates, peak seasons and size ranges of *R. brachysoma* in the purse seine fishery

	Peak CPUE (kg/boat/day)	Season	Peak catch (t)	Season	Size range/ mode in peak season (cm)
Thailand					
Area I	980	May	1,594	May	16.5-1 8.5/17.5
Area II	1,894	March	3,659	March	17.5-20.51/9.5
Area III	1,845	Feb.	2,613	Feb.	15.5-19.5/17.5
Malaysia					
Perlis	516	April	828	April	–
Kedah	67	Jan.	2,768	Jan.	13.5-19.5/16.3
Penang	650	Feb.	277	March	–
Perak	2,134*	Feb.	5,365	Feb.	15.5-21.5/18.7
	1,200**	Feb.	–	–	–
Selangor	2,609*	April	1,691	Jan.	12.5-15.5/14.1
	1,400**	Jan.	–	–	–
Indonesia					
Banda Aceh	68	April	18	April	–
Langsa	50	May	7	May	–
Asahan	175	June	514	June	17.5-21.5116.5

* 40 GRT purse seiners
** 25 GRT purse seiners

Table 3b.

Catch rates and peak seasons for *R. brachysoma* in the trawl fishery in Malaysia

Province	CPUE (kg/boat/day) 25 GRT	40 GRT	Season
Perlis	–	–	–
Kedah	200	240	Jan. and March
Penang	240	–	May
Perak	35		May and Dec.
Selangor	20	24	June and Nov.

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Table 4

Peak catch, peak catch rates, peak seasons and size ranges during the peak season of *R. kanagurta* in the purse seine fishery

Country	Peak CPUE (kg/boat/day)	Month	Peak Catch (t)	Month	Size Range/ Mode in Peak Season (cm)
Thailand					
Area I	552	April	1383	April	14.5-22.51/18.5
Area II	388/314	July/May	5741382	May/July	18.5-21.5/19.5
Area III	473	May	536	May	20.5-23.5/21.5
Malaysia					
Perlis	1278	March	2450	March	13.0-25.0/17.9
Kedah	—	—	—	—	—
Penang	473	February	167	February	14.5-19.5/15.6
Perak	1782*	November	1334	November	—
Selangor	—	—	—	—	—
Indonesia					
Banda Aceh	12	November	5	November	11.5-19.5/17.5
Langsa	54	May	77	May	15.5-23.5/17.5
Asahan	245	April	1068	April	16.5-23.5/19.5

* A CPUE of 12 kg/boat/day was observed in the trawl fishery in July.

Table 5

Peak catch, peak catch rates, peak seasons and size ranges during the peak season of *Decapterus* spp. in the purse seine fishery O. russelli

Country	Peak CPUE (kg/boat/day)	Month	Peak Catch (t)	Month	Size Range/ Mode in Peak Season (cm)
Thailand					
Area I					
Area II	216/209	March/May	7531958	March/May	13.5-16.5/15.5
Area III					
Malaysia					
Perlis	1452	April	1812	April	6.5-12.5/8.1
Kedah	—	—	—	—	—
Penang	246	October	143	January	13.5-17.5/15.1
Perak	8	November	24	November	—
Selangor	—	—	—	—	—
Indonesia					
Banda Aceh	50	April	13	April	—
Langsa	296	February	88	February	15.5-18.5/17.5
Asahan	190	June	90	June	9.5-19.5/15.5

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Table 6

Mean size at first maturity of scads and mackerels

(cm.)

Species	Thailand			Malaysia				Indonesia		
	I	II	III	Perlis	Kedah	Penang	Perak	Selangor	Male	Female
R. brachysoma	19.0	17.8	17.9	–	17.8	18.1	18.1	18.2	–	–
R. kanagurta	19.6	19.3	19.0	19.6	–	20.6	–	–	19.5	20.8
D. russelli	17.5	17.5	17.5	17.0	–	16.0	–	–	14.8	15.8
D. macrosoma	17.3	17.3	17.3	–	–	–	–	–	16.6	17.7

Table 7

Growth parameters of mackerels and scads

R. brachysoma		*K*	*L¥*	*LC*	*Lmean*	*M*	*Z*	F	E
Thailand	Area I	1.6	28	19.7	21	—	15.76	—	0.84
	Area II	1.25	25.1	'7.6	19.3	—	6.88	–	0.68
	Area III	1.33	25.4	17.8	19.3	—	8.68	–	0.74
Malaysia	Kedah (Tr)	1.04	24	18.8	19.68	1.92	10.21	8.29	0.81
	Perak (Ps)	0.6	26	18.9	19.78	—	7.9	–	0.81
	Perak (Tr)	0.82	25	18.8	19.84	—	6.79	–	0.76
	Selangor (Ps)	0.52	24.2	18.9	19.75	1.22	3.43	2.21	0.73
	Selangor (Tr)	1.32	24	18.8	19.82	1.89	7.15	5.26	0.74
	Indonesia (1984-85)	1.05	26.5	17.9	—	1.91	*8.94*	7.03	0.79
R. kanagurta									
Thailand	Area I	1.75	28.6	22.7	23.6	–	8.53	–	0.69
	Area II	1.9	27.5	19.7	22.5	–	5.32	–	0.48
	Area III	1.5	27.6	20.0	22.7	–	2.49	–	0.04
Malaysia	Perlis (Ps)	1.19	29.7	19.5	22.24	1.97	6.90	4.93	0.71
	Penang (Ps)	1.21	29	18.7	20.90	2.01	8.14	6.13	0.75
Indonesia	Banda Aceh	0.9	28.5	16.1	19.6	1.60	3.07	1.39	0.45
D. macrosoma									
Thailand	All areas	0.89	14.2	18.8	20.8	–	5.97	–	0.57
Indonesia	B Aceh	1.22	28.0	16.5	19.5	1.69	5.49	3.8	0.62
D. russelli									
Thailand	All areas	1.01	27.2	19.6	21.2	–	6.57	–	0.57
Malaysia	Perlis (Ps)	1.01	27	15.6	17.31	1.82	9.56	7.74	0.81
	Penang(Ps)	0.81	24	15.9	17.86	1.73	3.67	1.94	0.54
Indonesia		0.90	26	16.7	18.5	1.73	5.53	3.80	0.69

Tr: Trawl Ps: Purse seine

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Table 8

Summary of estimates of maximum sustainable yields (MSY) and optimum effort for mackerels and scads

Country	*R.brachysoma* *R. kanagurta* (combined) 1983 (Boats) Estimate (t)	*R. brachysoma* 1986 Estimate (t) (boat-days)	*R. brachysoma* 1986 Estimate (t) (boat-days)	*R. kanagurta* 1983 Estimate (t) (boatdays)	*Decapterus* spp 1986 Estimate (t) (boatdays)
Thailand (West)	20,074 10×10^4 16,172 t (1980)	20,900 41,000 (boat days) 22,162 (1985)	4,800 22,900 (boat days) 6,012 (1985)	2,700 (1980)	7,650 46,000 (boat days) 8,205
P.Malaysia (West)	21,000 285 (units) 51,799 (1980)	54,394 123,766 (boat days) 40,090 (1985)	11,530 124,732 (boat days) 8,455 (1985)	5,800 200 (units) 7,459 (1980)	7,350 1,276 6,437 (1986)
Sumatra (West)	17,691 229 (P S Units) 13,114 (1980)	6,951 550×10^3 (boat days) 7,379 (1985)	13,994 115×10^3 (boat days) 15,430 (1985)	? 2,700 (1980)	12,003 ? 16,168 (1985)
Sum of MSY Combined	58,765	82,245	30,324	?	27,033
MSY Estimate	54,841	73,396	38,453	?	?
Total Production	81,085	69,631 (1985)	29,897 (1985)	10,611	30,810 (1985)

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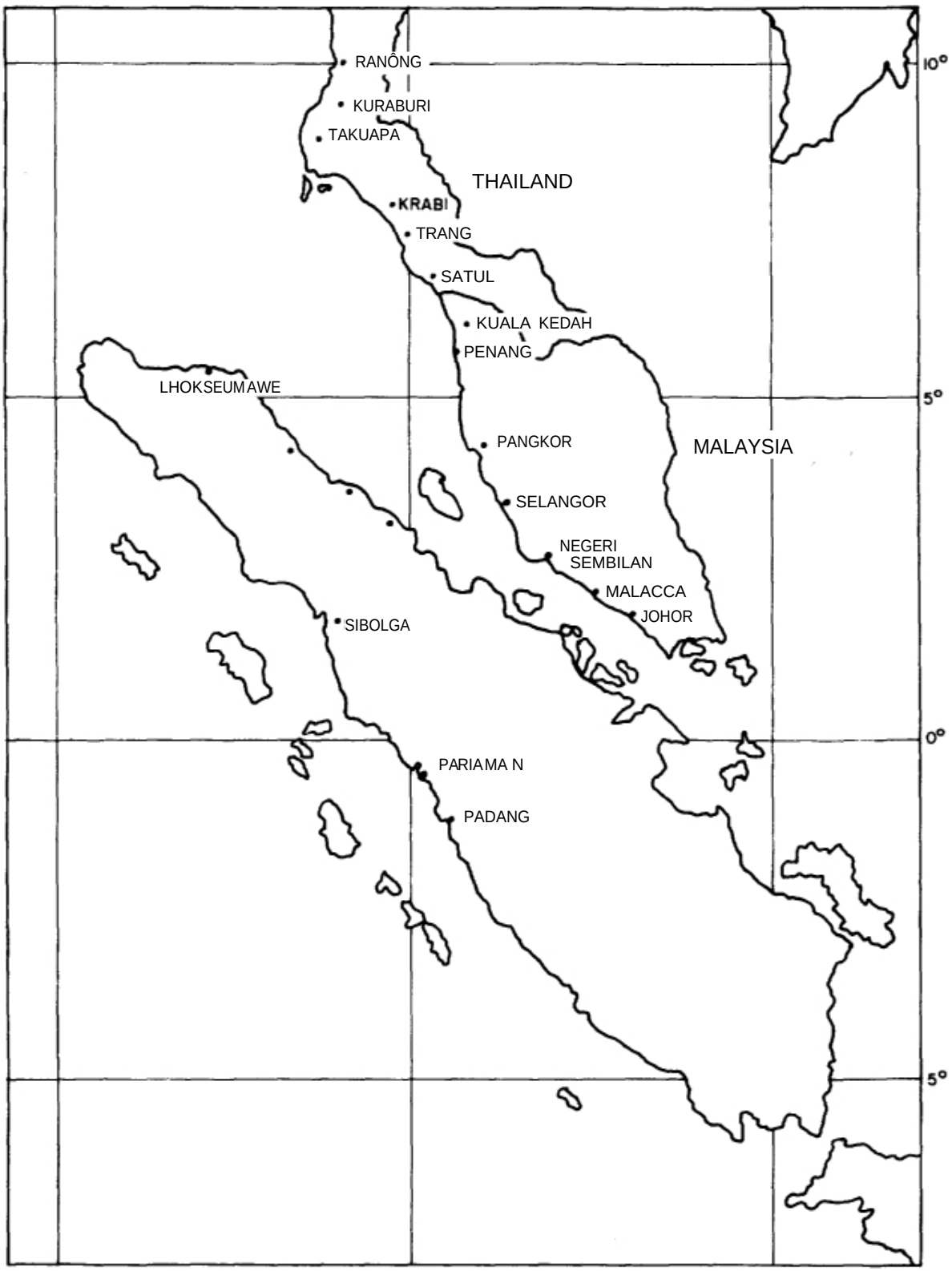

Figure 1. *Map of the Malacca Straits and the sampling locations*

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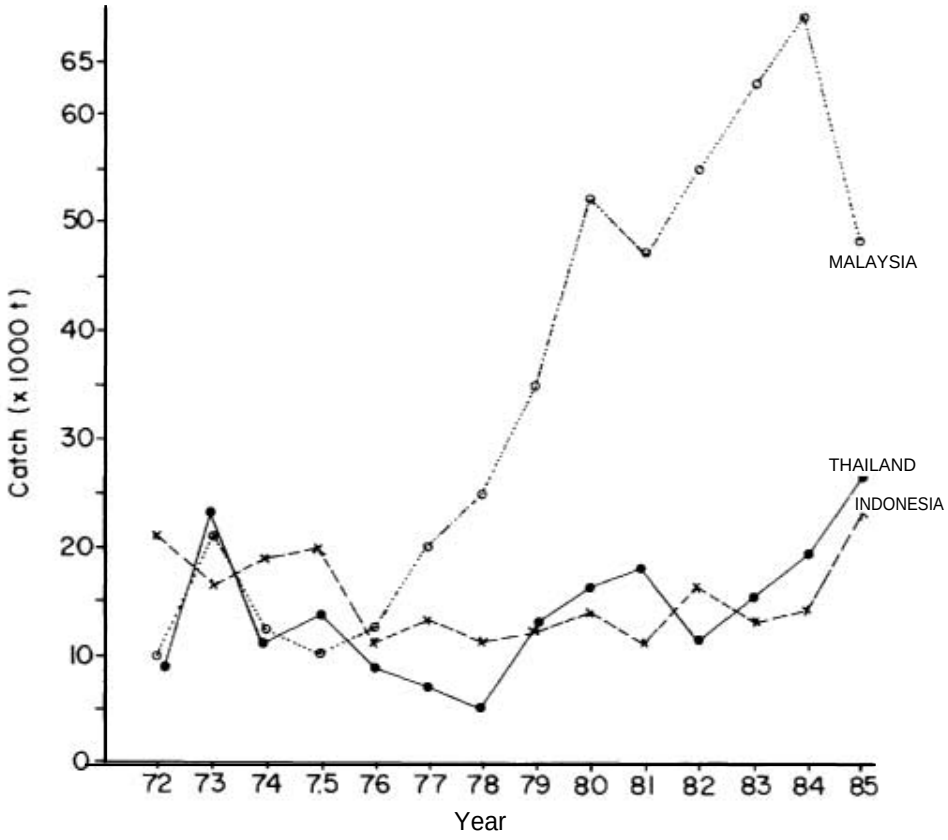
Figure 2. *The production of mackerels, by country.*



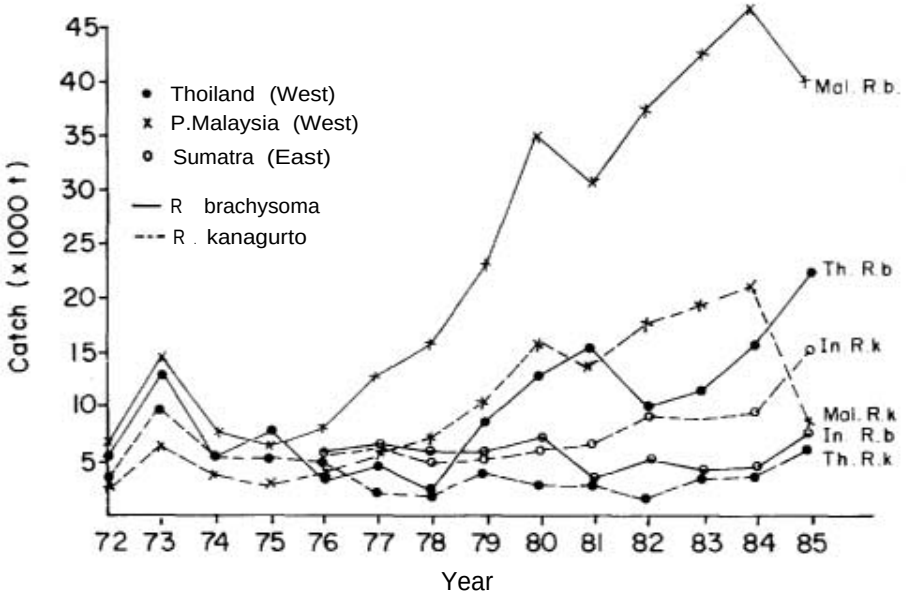


Figure 3a. *The production of* R. brachysoma *and* R. kanagurta, *by country.*

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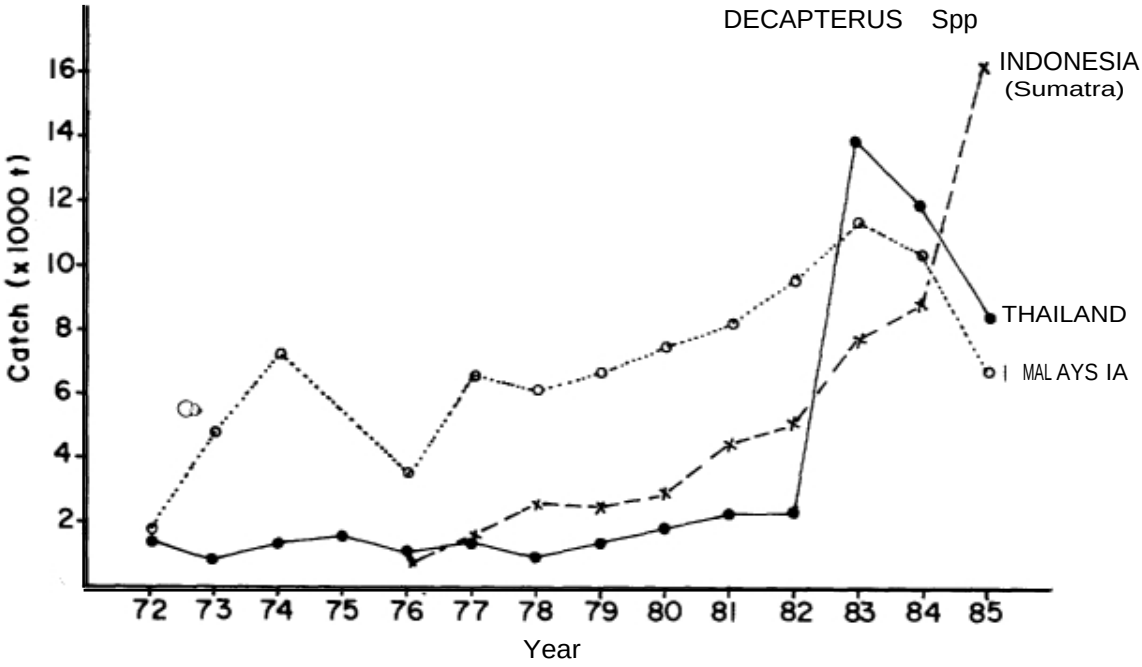

Figure 3b. *The production of* Decapterus *spp., by country*

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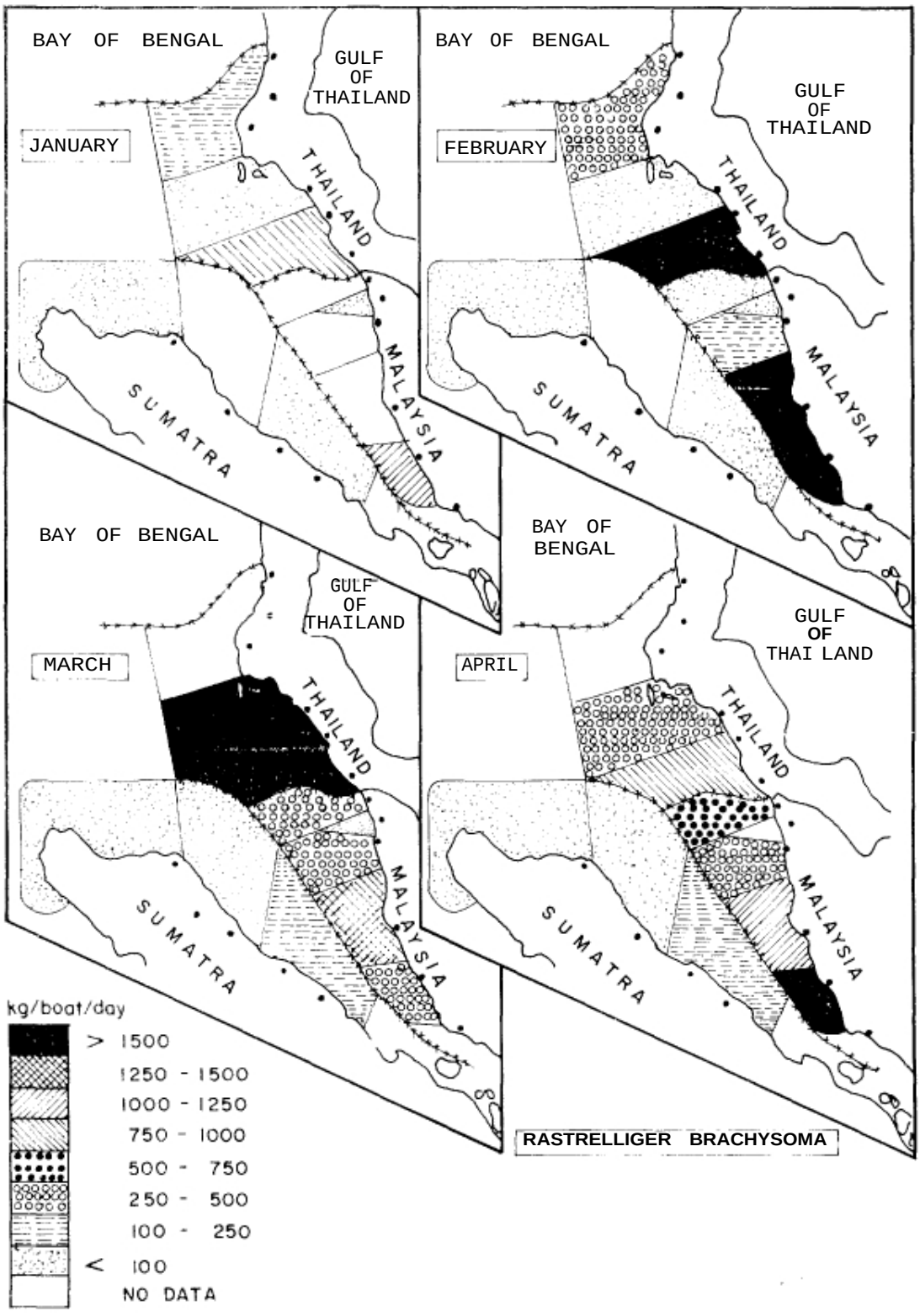
Figure 4. *Mean catch rates of* R. brachysoma, *January-April 1985.*



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Mean catch rates of Ft. brachysoma, *May-August 1985.*

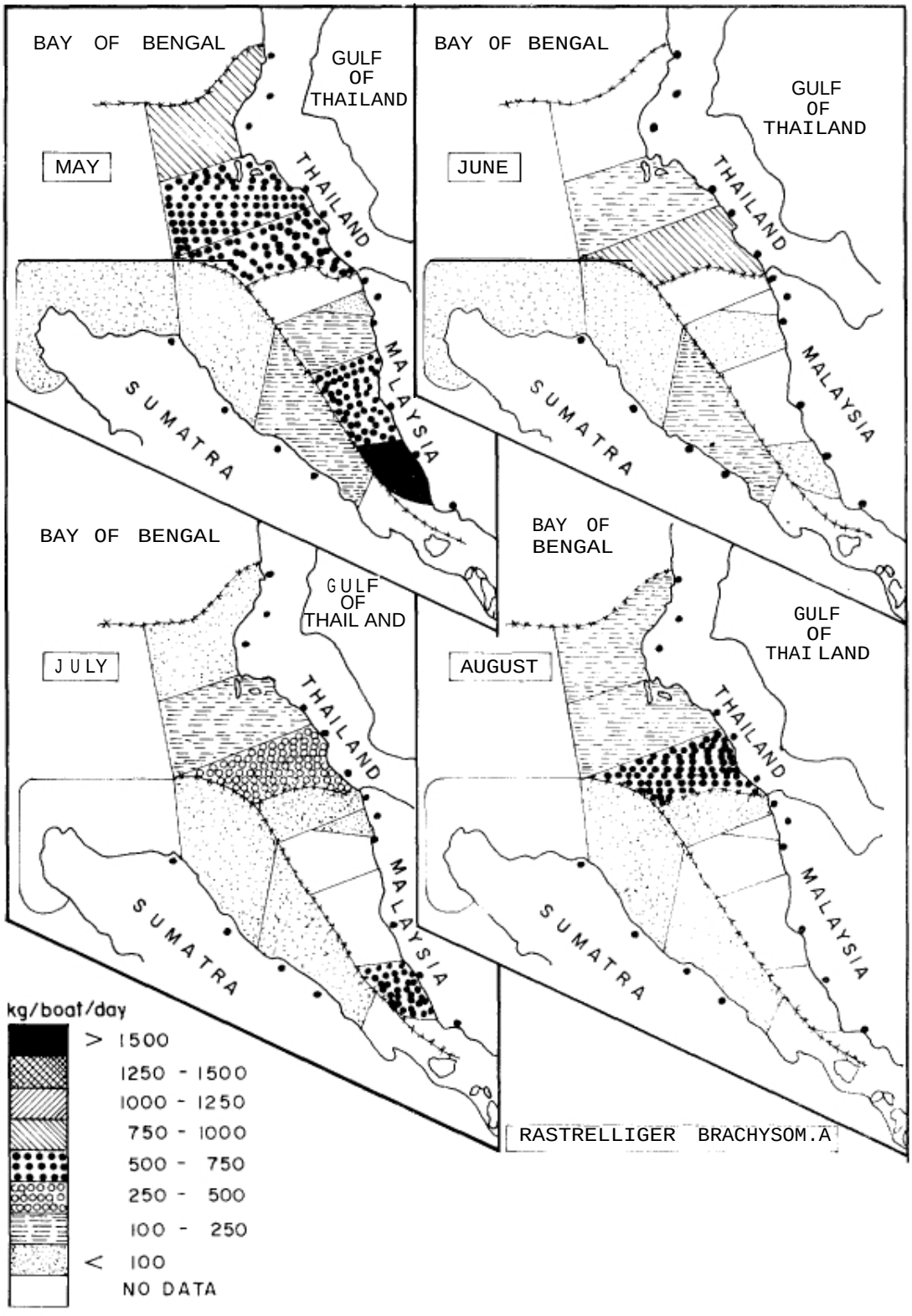

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Figure 6. *Mean catch rates of* R. brachysoma, *September-December 1985.*

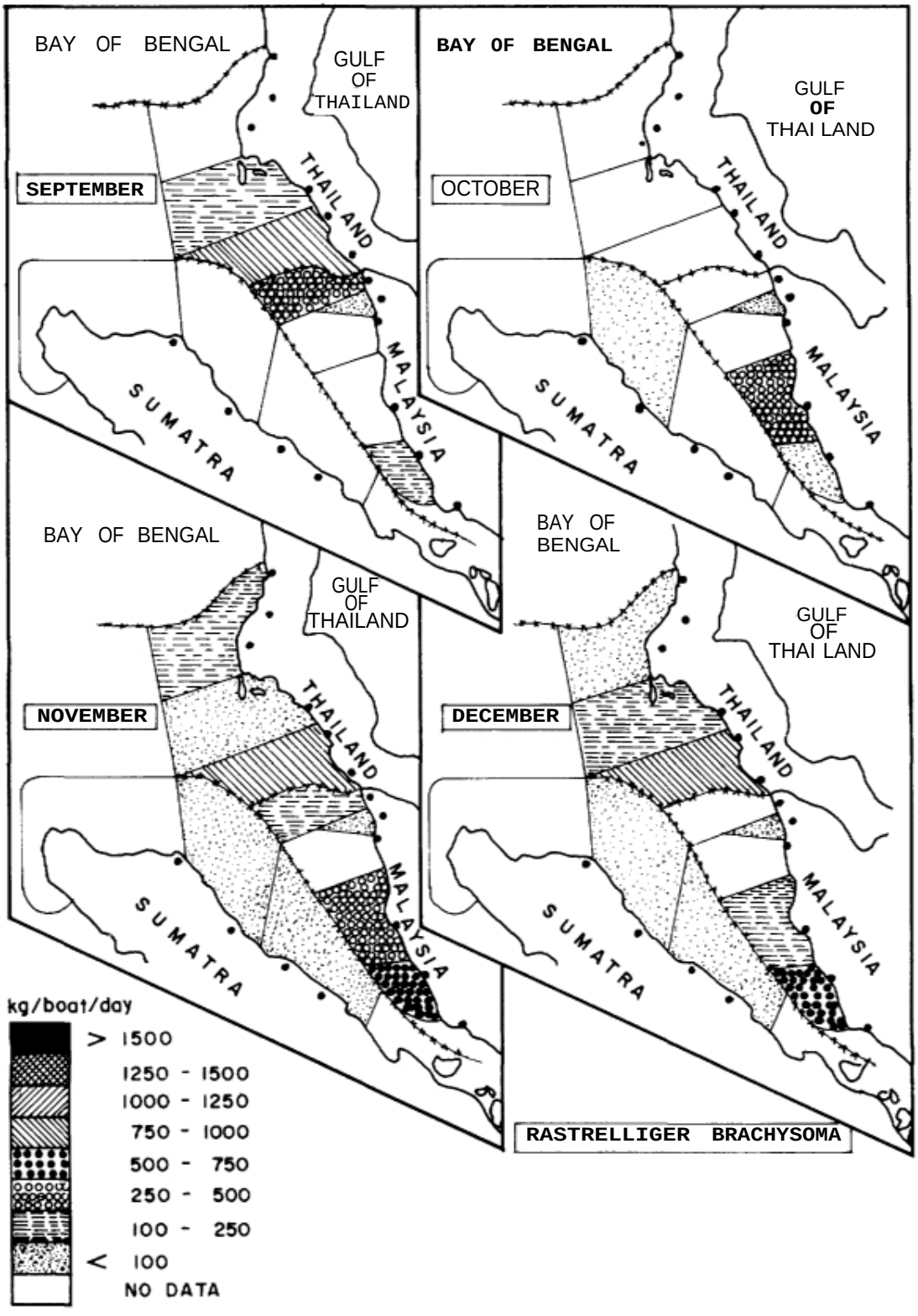

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Figure 7. *Mean catch rates of Ft.* kanagurta, *January-April 1985.*

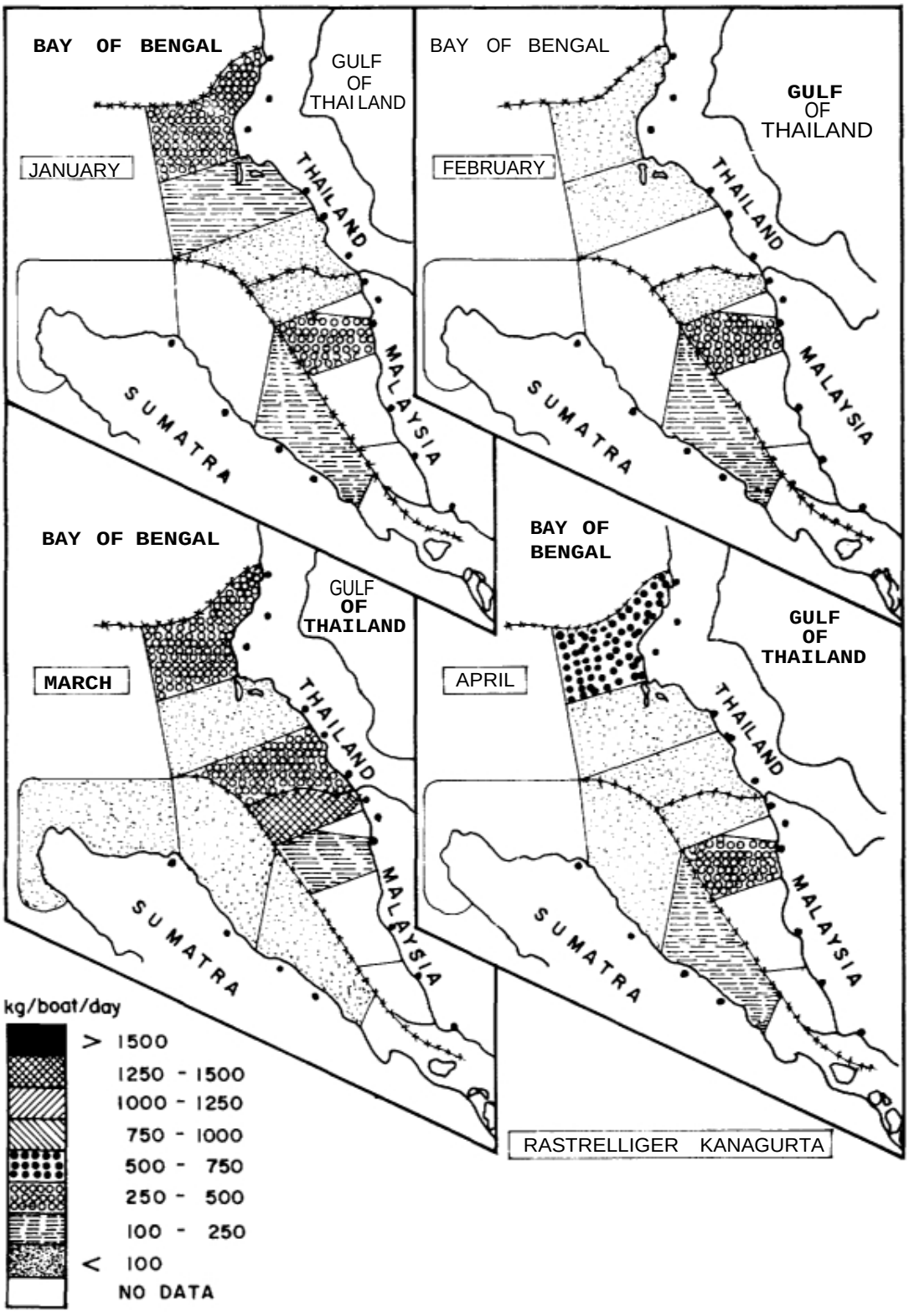

Figure 8. *Mean catch rates of A. kanagurta, May-August 1985.*

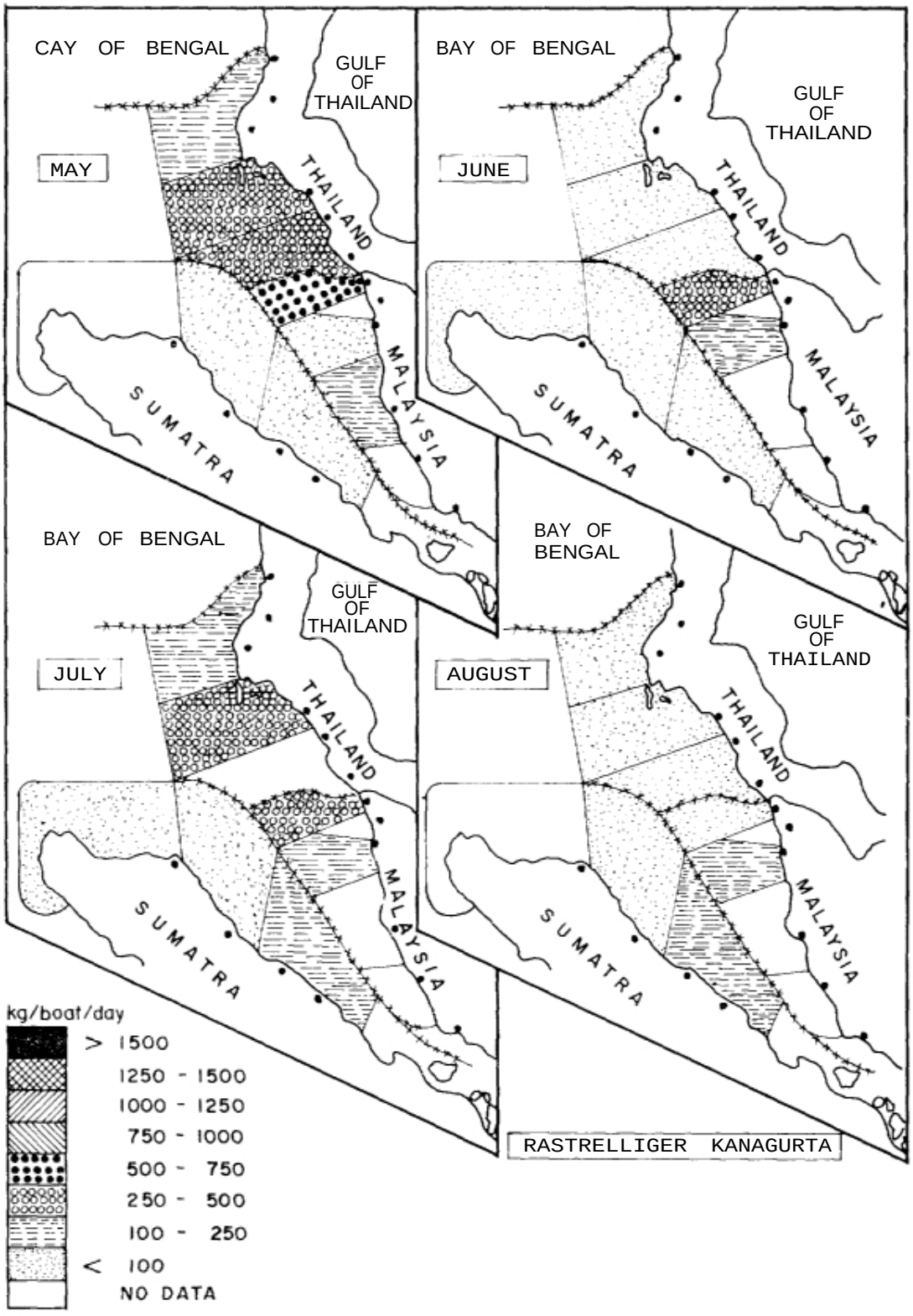

Figure 9. *Mean catch rates of* R. kanagurta, *September-December 1985.*

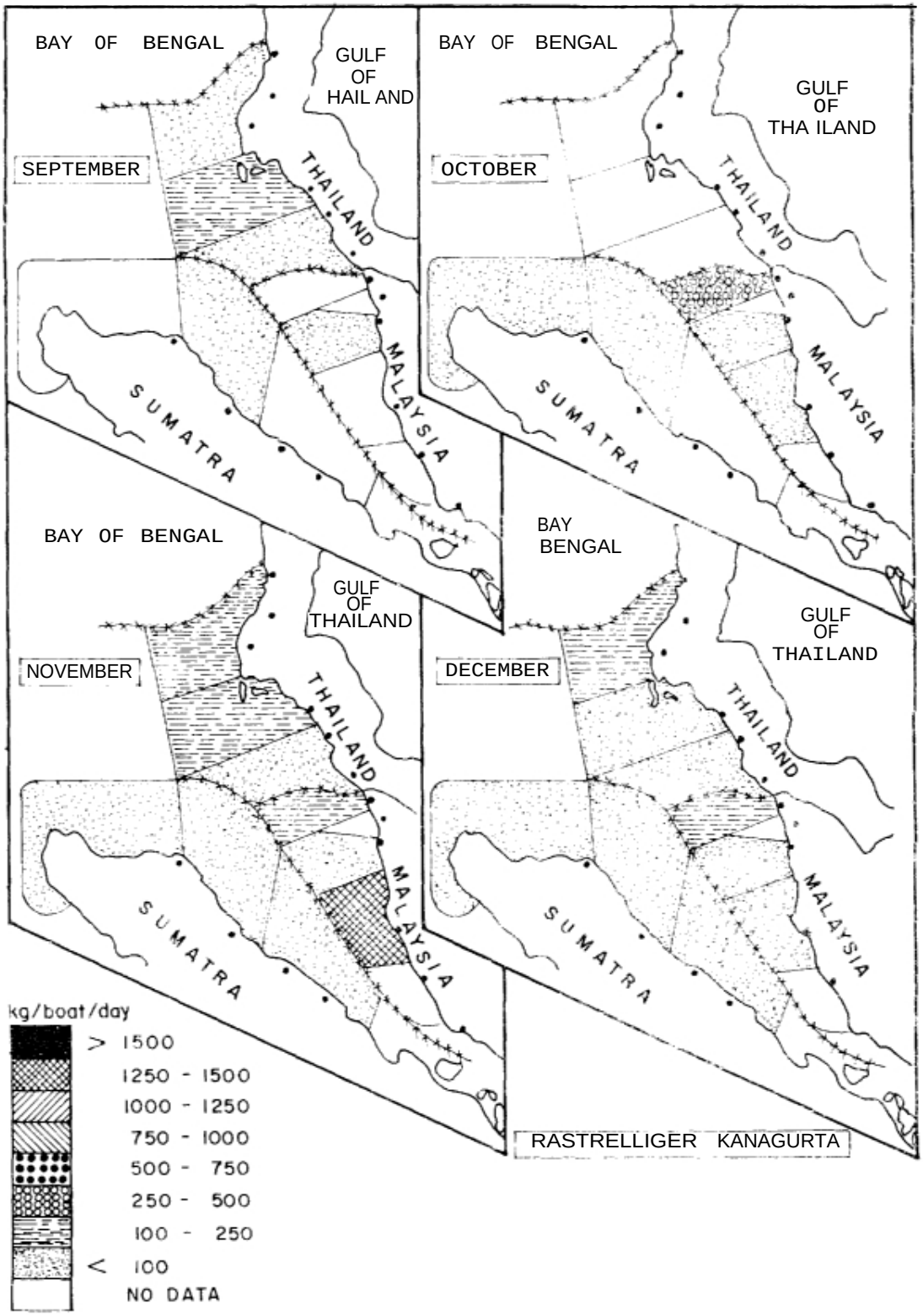

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Figure 10. *Mean catch rates of* Decapterus *spp., January-April 1985.*

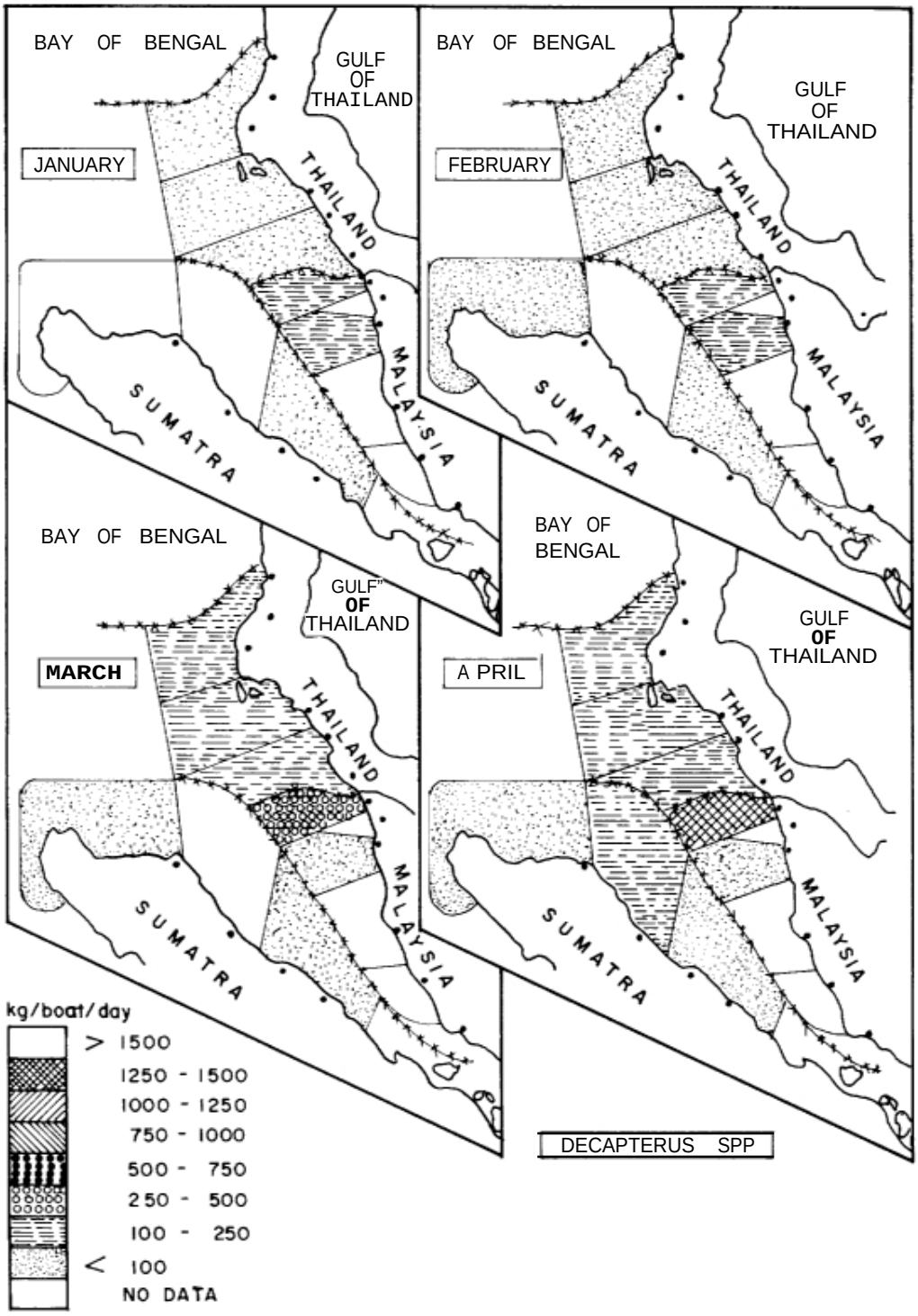

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Figure 11. *Mean catch rates of* Decapterus *spp., May-August 1985.*

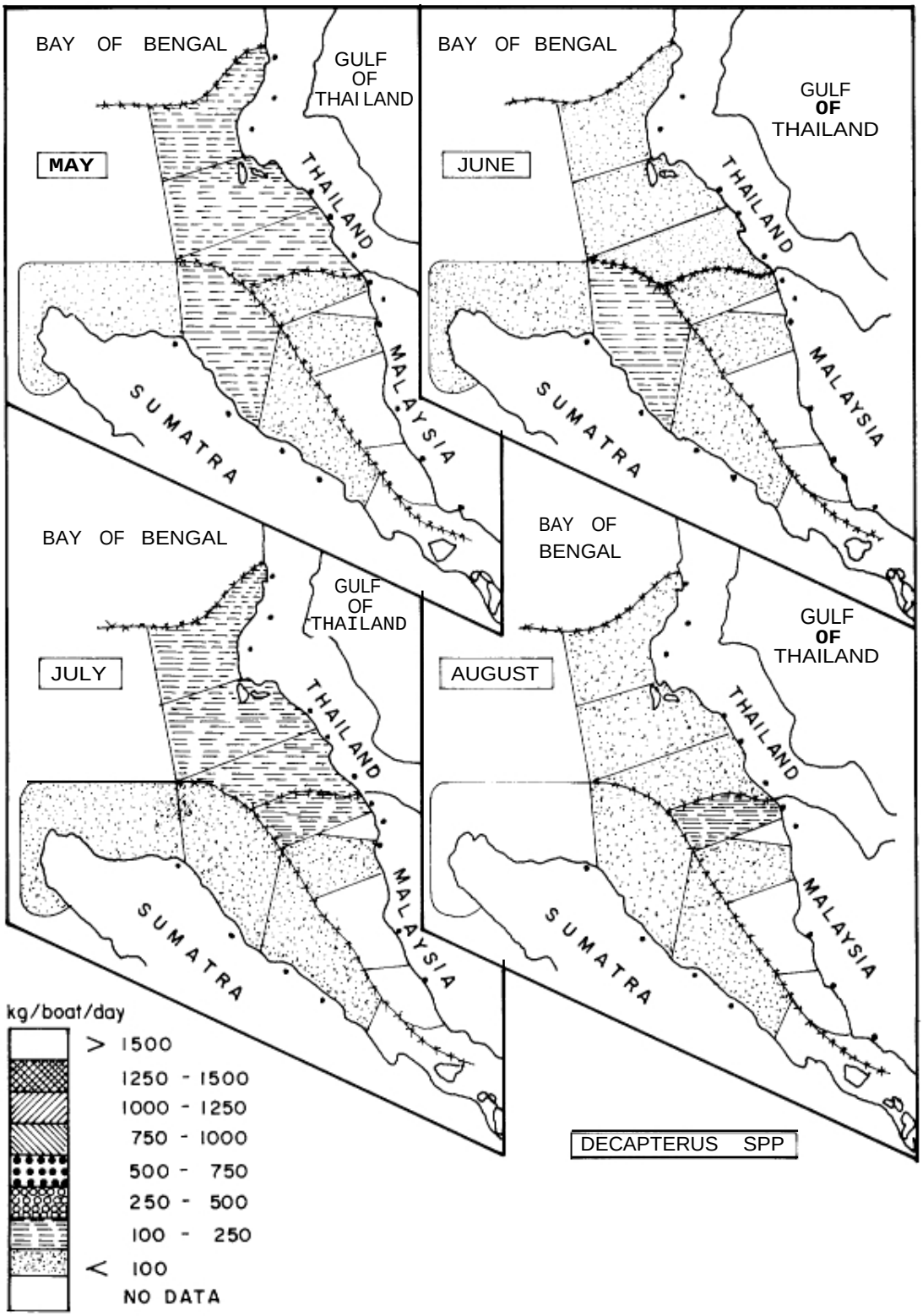

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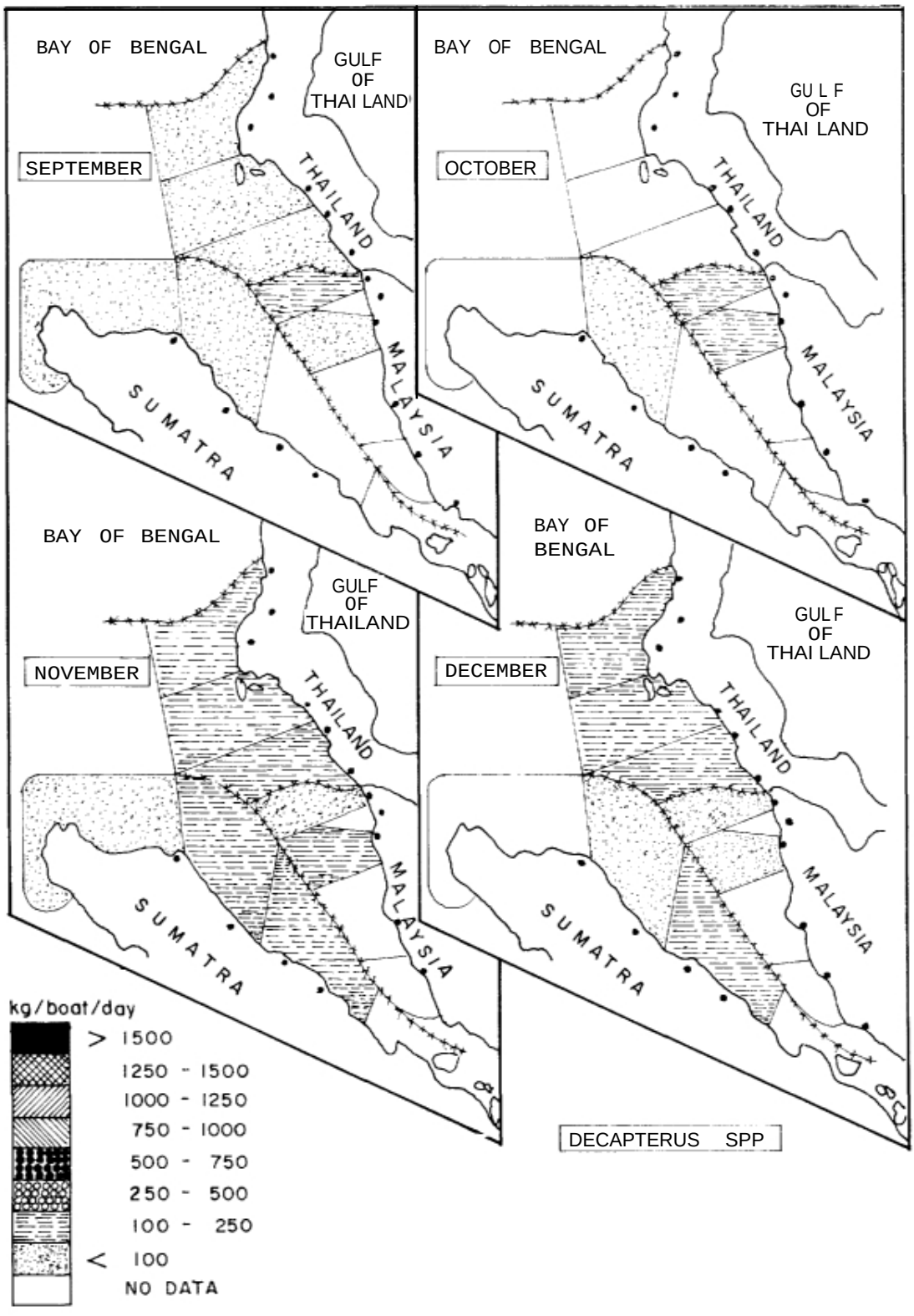
Figure 12. *Mean catch rates of* Decapterus *Spp* September December 1985



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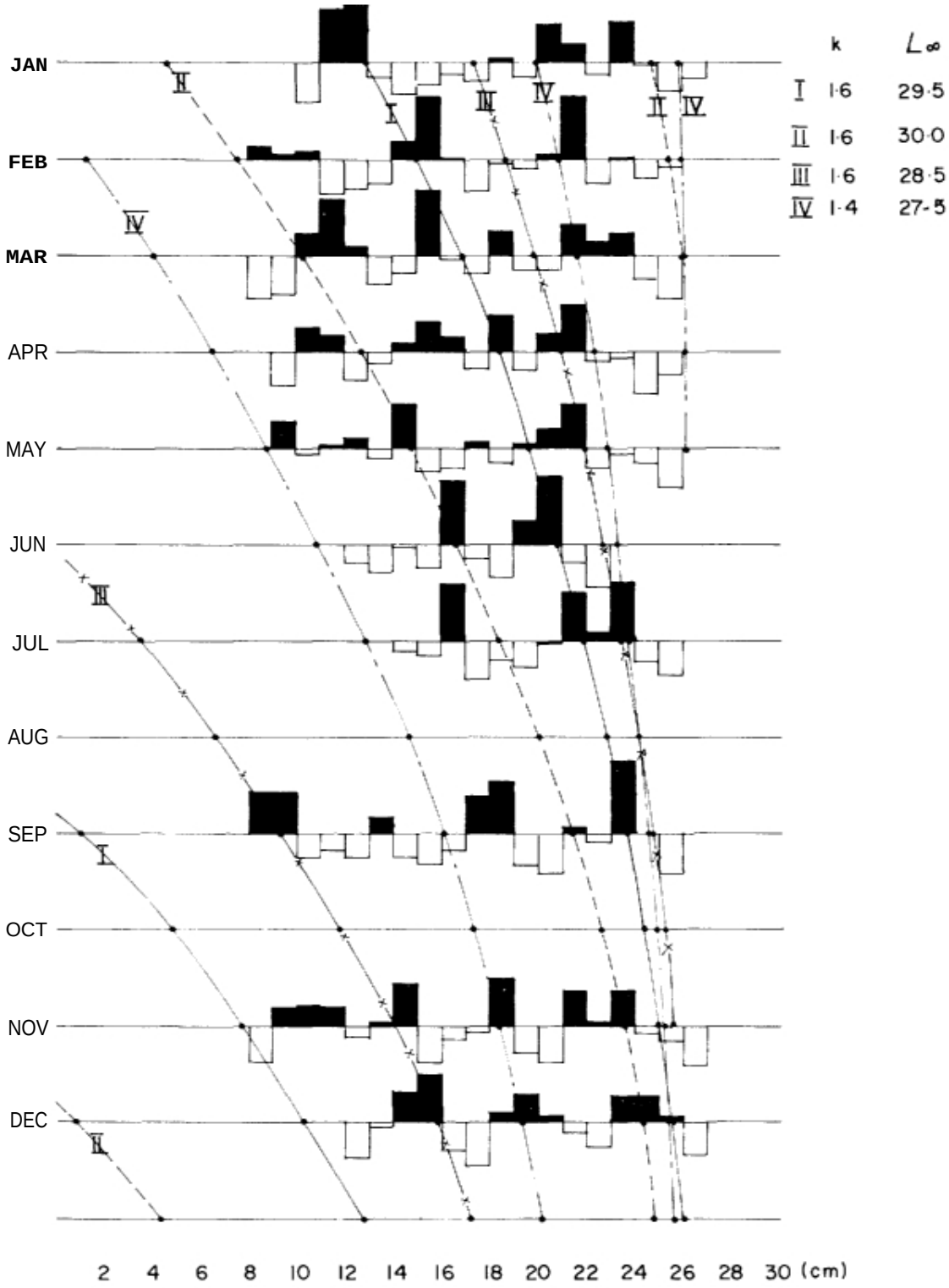

Figure 13. *Restructured frequencies and growth curves (ELEFAN I analysis) for* R. kanagurta *on the west coast of Thailand (Areas I, II & III combined).*

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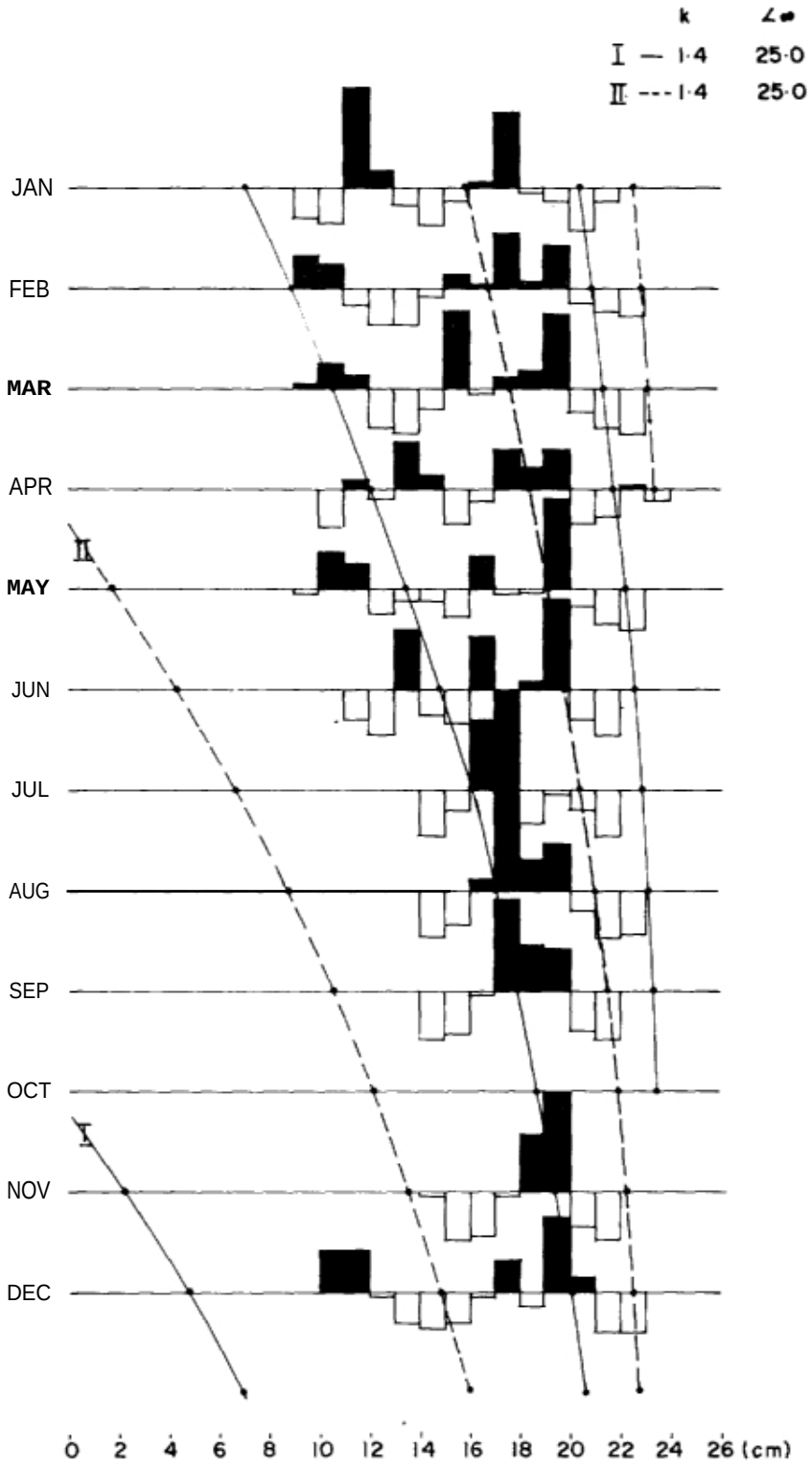

Figure 14. *Restructured frequencies and growth curves (ELEFAN / analysis) for* A. brachysoma *on the west coast of Thailand (Areas II and III combined).*

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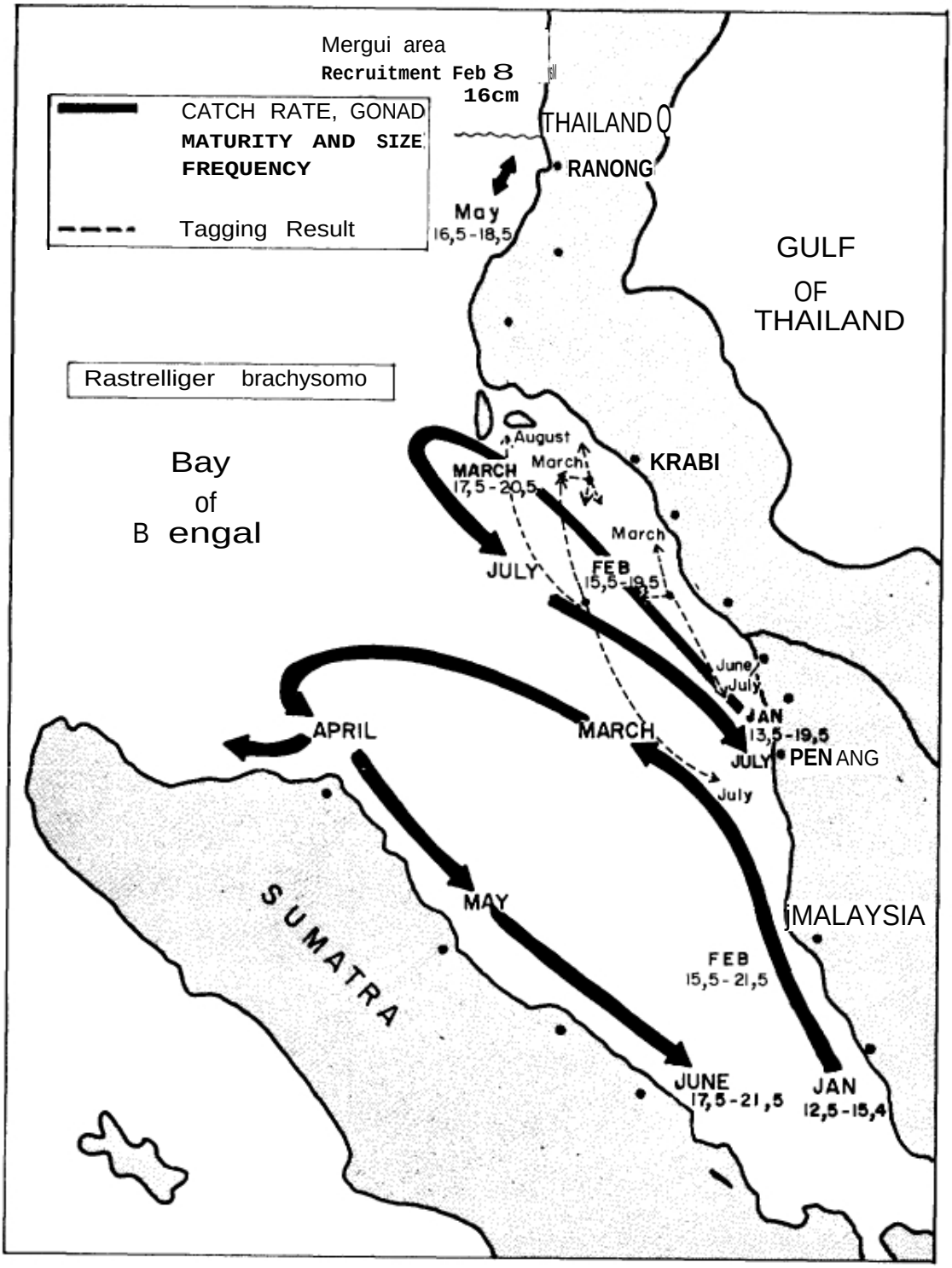

Figure 15, *Hypothetical migratory pattern for* R. brachysoma.

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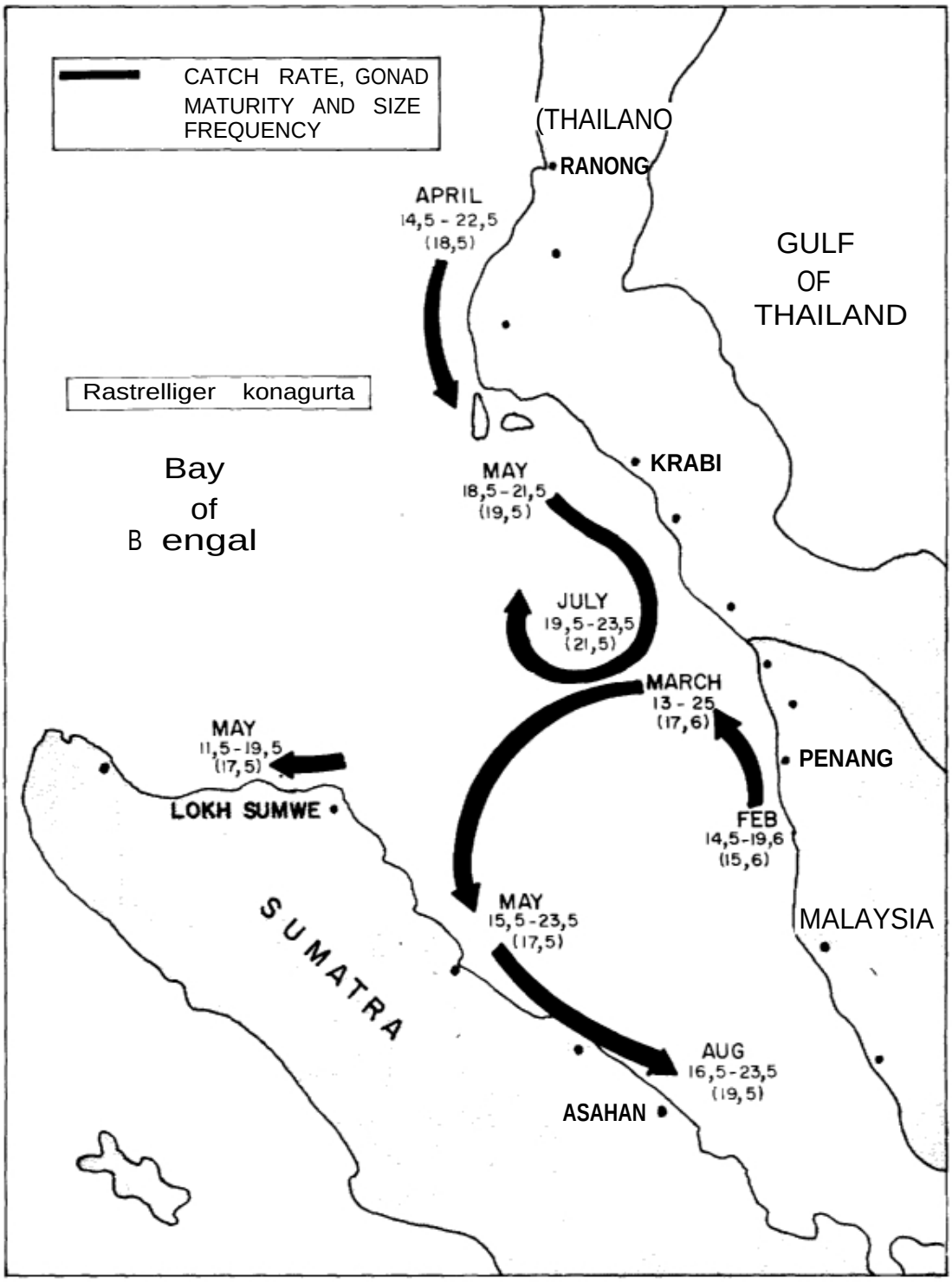

Figure 16. *Hypothetical migratory pattern for* R. kanagurta.

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Appendix

LIST OF PARTICIPANTS

Second and Third Meetings of the Working Group on Mackerels and Scads in the Malacca Straits

INDONESIA

Mr. Gomal H Tambupolon	Fishery Biologist, Fishing Technology Development Centre, Semarang, P.O. Box 218.
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Mr. Ahmad Adnan Bin Nuruddin*	
Mr. Abdul Hamid Yasin**	Fishery Officer, Fisheries Research Institute, Pulau Kambing, Kuala Terengganu, 20300, Terengganu.

THAILAND

Mr. Pairoh Sutthakorn	Fishery Biologist, Phuket Marine Fisheries Station, Phuket.
Udom Bhatia	Director, Phuket Marine Fisheries Station, Phuket.
Mr. Veera Boonragsa**	Fishery Biologist, Phuket Marine Fisheries Station, Phuket.
Mr. Tawatch Chantawong**	Fishery Biologist, Phuket Marine Fisheries Station, Phuket.
Mr. Kavi Saranakomkul**	Fishery Biologist, Phuket Marine Fisheries Station, Phuket.

OBSERVERS***

Ms. Usa Sriruangcheep	Fishery Biologist, Marine Fisheries Division, Sapanpla, Yanawa, Bangkok, Thailand.
Ms. Chuchit Tantisawetrat	Fishery Biologist, Marine Fisheries Division, Sapanpla, Yanawa, Bangkok, Thailand.
Mr. Sakul Supongpan	Fishery Biologist, Marine Fisheries Division, Sapanpla, Yanawa, Bangkok, Thailand.
Mr. Somsak Chullasorn	Fishery Biologist, Marine Fisheries Division, Sapanpla, Yanawa, Bangkok, Thailand.

FAO/BOBP (RAS/81/051)

Dr. K. Sivasubramaniam	Senior Fishery Biologist
Mr. T. Nishida	Statistician
Mr. Martin Van der Knaap**	Fishery Biologist

* Attended the second meeting of the working group only.
** Attended the third meeting of the working group only.
*** All observers attended only the third meeting.

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Annexure I

PRELIMINARY ANALYSIS OF THE MACKEREL (RASTRELLIGER AND *DECAPTERUS* SPP.) RESOURCES ON THE WEST COAST OF THAILAND

by Veera Boonragsa

1. Introduction

Prior to 1930, the marine fishery in the west coast of Thailand was basically artisanal. Several types of gears, such as bamboo stake trap, set bag net and some types of small purse seines, were used. Most of the catch consisted of small pelagic fishes caught in the inshore waters of less than 20 metres depth. In 1930, the Chinese purse seine was introduced. Target species were the Indo-Pacific and the Indian mackerel, sardines and round scads. The fishery for these resources developed rapidly after the Second World War, nylon gillnets became widespread and the fishing method of the Chinese purse seine was modified, operating the vessel itself to set the net like a Thai purse seiner, instead of using two rowing boats.

In 1973, luring techniques using drifting or anchored coconut leaves during the day or kerosene lamps at night were introduced to the purse seine fishery, which then became the most important fishery for pelagic fish. From 1982 on, kerosene lamps were replaced by electric lights (generators). The total number of Thai purse seines decreased while the number of luring purse seines increased. The number of Chinese purse seines showed small fluctuations. The fishing effort at present is directed toward all small pelagic species. This development in fishing techniques increased the total pelagic landings, which reached a peak of 65,374 t on the west coast in 1983.

2. Fisheries

The annual production of mackerels fluctuated and in 1973, the catch of Indian and Indo-Pacific mackerels {Rastrelliger kanagurta and R. brachysoma) showed peak values of 10,329 and 13,005 t respectively. Thereafter, a decreasing trend was observed year by year until the landings dropped to 2,392 and 2,354 t respectively in 1978, and then the production increased again, with only a slight drop in 1982. The production in 1985 was at the level of 6,012 and 22,162 tonnes for R. kanagurta and R. brachysoma respectively (see Table 1). The annual catches of round scads *(Decapterus* spp.) showed the same trend as those of the *Rastrelliger* species; they oscillated between the peak of 1,535 t in 1975 and the smallest catch of 886 t in 1978. Since 1978, the landings have increased and reached a level of 13,941 t in 1983 (Table 1) and the production in 1985 was around 8,205 tonnes. The fishing grounds are shown in Figure 1.

The rapid development of fishing techniques may lead to full or over-exploitation in the near future. In order to be successful in managing the resources and planning the fishery development, it is necessary to investigate the resources and determine the current status of the fisheries.

3. Species composition and distribution

The sampling survey conducted by the biologists of the Phuket Marine Fisheries Station in 1984 showed that-the mackerel resources comprised,R. brachysoma (about 87.4%),and R. kanagurta (about 12.6%), with a negligible amount of R. *faughni.* The scad landings consisted of 58.6%. *D. macrosoma* and 41.4% *D. maruadsi/russelli.* Very few *D. macarellus* were recorded along the northern part of the west coast of Thailand. Additionally, the percentage of *R. brachysoma* in the landings is higher than that of *R. kanagurta* in the southern part of this coast, while it is the reverse in the northern part. *Decapterus* spp. are found all along the coast with highest densities occuring in northern and central parts of the Thai waters.

The 1985 sampling survey showed 78.6% *R. brachysoma,* 21.4% *R. kanagurta* and again very few R. faughni. for species composition of mackerels, and 73.78% D. maruadsi/russelli and *26.22% D. macrosoma,* for the scads. The average annual percentages of *R. brachysoma, R. kanagurta* and *Decapterus* spp. in the total pelagic catch are 30.2,8.2 and 11 .0, respectively.

4. Seasonality

The fishing season for mackerels extends all the year round but it is clearly seen that the peak seasons for *R.brachysoma* are from February to April and from September to November. The *R. kanagurta* production shows a peak in March and April and also around October. The *Decapterus* spp. landings are highest from October to April, in all three areas (Table 2).

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5. Catch by area

The annual landings of the mackerels'and scads, by province, along the west coast of Thailand during 1979 to 1985 are presented in Tables 3, 4 and 5.

The annual landings of R. brachysoma are higher in Krabi (Area II), Trang and Satul (Area III) than in Area I. As for Area I, reasonable landings are recorded at Ranong where the fishing grounds are located off the Ranong river mouth, while in the upper part of Phang Nga province much less *R. brachysoma* is landed. In Area I however, landings of R. kanagurta are more important. Also, the landings of Decapterus spp. appear to be the highest in Area I,

6. Annual and monthly variation of catch rate

The catch rates (kg/boat/day) for both Rastrelliger species declined considerably after 1979. The *Decapterus* catch rate increased sharply from 1979 to 1983 but then decreased slightly. The 1985 catch rate, however, is still higher than that in 1979. The annual catch rates are presented in Figure 2.

The monthly catch rates for the various species are presented in Figures 3, 4 and 5. Catch rates for both *Decapterus* species fluctuate strongly, but, peaks may be seen in March/May, July/August and November/December. The catch rates for the two *Rastrelliger* species also fluctuate considerably. *R. kanagurta* exhibits main peaks in April, July and May in Areas I, II and III respectively. Peaks in *R. brachysoma* catch rates may be found in May, March and February for the three areas respectively. The peak catch rates are of the order of 200-250 kg/boat/day in the case of *Decapterus* species, 400-600 kg/boat/day for R. kanagurta and 1000-1900 kg/boat/day for R. brachysoma.

7. Size composition

In Area I, the smallest size in the catches of *R. brachysoma* is about 15.5 cm. The entry to the fishery occurs in March and May/June and the dominant sizes range from 19.5 to 21.5 cm. The smallest fish in the catches from area II and Area III are 9.5 and 10.5 cm respectively. The recruitment takes place in January and May in Area II and from December to March in Area III; the dominant size range is 16.5 — 19.5 cm in Areas II and III. Further, the larger fish appear in Area I and the smaller ones in Area II. It seems likely that the stock in Area I is separated from those in Area II and Area III (Figures 6-8).

The smallest size in the catches of *R. kanagurta* appears to be 10.5 cm in Areas I and III and 8.5 cm in Area II, but there are small differences in the season of recruitment. The occurrence of the small fish in Area I, Area II and Area III is in March/April, February/March and March respectively. The major recruitment occurs in Area II. The larger fish occurs in Area I with a dominant size range of 21.5 — 23.5 cm, while the length of this species in the other two areas ranges from 18.5 to 21.5 and 13.5 to 21.5 cm. respectively (Figures 9-11).

The smallest sizes of *D. maruadsi/russelli* and *D. macrosoma* observed in all three areas are 8.5 and 13.5 cm in March and February respectively. The dominant size ranges are 18.5-20.5 cm for *D. maruadsi/russelli* and 19.5 - 21.5 cm for *D. macrosoma* (Figures 12-13). The findings are summarised in Table 6.

6. Growth parameters

The growth parameters estimated by means of the ELEFAN programs are presented in Table 7. No clear modal progressions could be observed from the length frequency distributions of mackerels and scads. This might be due to sampling errors or to the migratory behaviour of the species.

The length frequencies, restructured frequencies and the growth curves for the scads and mackerels are presented in Figures 6-13.

9. Maximum sustainable yield

The Schaeffer's surplus production model was applied to the available catch and effort data. The following MSY values were obtained for the mackerel and scad species: *R. brachysoma* 20,900 tonnes, *R. kanagurta* 4,800 tonnes and *Decapterus* spp. 7,650 tonnes. The production of *R. brachysoma* appeared to have exceeded its MSY in 1985. *R. kanagurta* catches also exceeded the MSY in 1985. From 1983 to 1985, *Decapterus* spp. catches were higher than the calculated MSY. The production models are presented in Figures 14, 15 and 16 and the catch and effort data in Table 8.

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For estimating the MSY. data from the landing place survey were used for the period 1979-I 984, and that from the sampiing survey for 1985 The catch rates for the period 1979-1985 were from the sampling surveys conducted by the Phuket Marine Fisheries Station. The figures obtained, therefore, differ from the values presented in earlier reports (Anonymous 1985 a + b). In this study the correlation coefficients appeared to be higher than in earlier estimates except for the Decapterus spp.

10. References cited

Anonymous 1985(a) Review of the chub mackerel (Rastrelliger spp.) fishery on the west coast of Thailand. BOBP/WP/30. Appendix 1: 17-33

Anonymous 1985(b) Review of the scad mackerels (Decapterus spp) fishery on the west coast of Thailand BOBP/WP/30. Appendix 2: 34-41.

Table 1.
Production of *Rastrelliger* and Decapterus spp. on the west coast of Thailand, 1972-1985

(tonnes)

Year	*R. brachysoma*	*R. kanagurta*	*Decapterus spp.*
1972	5,702	**3,966**	1,475
1973	13,005	10,329	811
1974	5,120	6,050	1,416
1975	7,979	5,722	1,535
1976	3,141	5,384	1,074
1977	4,623	2,545	1,450
1978	2,354	2,392	886
1979	8,643	4,045	1,427
1980	13,091	3,081	1,770
1981	15,181	3,169	2,397
1982	9,714	1,890	2,212
1983	11,410	3,959	13,941
1984	16,129	3,580	11,721
1985	22,162	6,012	8,205

Table 2
Monthly catches of mackerels and scads on the west coast of Thailand in 1985.

(tonnes)

Year	*R brach ysoma*	*R. kanagurta*	*Decapterus spp.*
January	868	231	**297**
February	3200	232	**509**
March	2,835	756	1,101
April	4,838	1,537	1,111
May	3,620	1,439	1,509
June	687	35	16
July	676	544	561
August	1,004	7	749
September	1,098	193	62
October	1,139	316	417
November	1,180	439	772
December	1,027	283	1,101
Total	22,172	6,012	8,205

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Table 3

Landings of Indo-Pacific mackerel by major fishing ports on the west coast of Thailand, 1979-1985

Year	1979		1980		1981		1982		1983		1984		1985	
Landing Port	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%
Ranong	1593	18.43	1344	10.27	1517	9.99	1717	17.68	1617	14.17	303	1.88	2635	11.89
Takkuapa	55	0.64	–	–	–	–	–	–	–	–	–	–	29	0.13
Tarmuong			–		41	0.27	78	0.95	509	3.16	–	–	1	-
Phuket	630	7.29	1	0.01	50	0.33	–	–	237	2.08	11033	68.40	5051	22.79
Krabr	386	4.47	507	3.87	1682	11.08	1402	14.43	1973	17.29	994	6.16	1469	6.63
Trang	1822	21.08	4597	35.11	3941	25.96	2635	27.13	2675	23.44	3266	20.25	6477	29.23
Satul	4157	48.09	6642	50.74	7950	52.37	3882	39.96	4800	42.07	24	0.15	6500	29.33
Total	8643	100	13091	100	15181	100	9714	100	11410	100	16129	100	22,162	100

Source 1979-1984, The Landing Place Survey, Department of Fisheries, Thailand
1985, from the sampling survey conducted by Phuket Marine Fisheries Station

Table 4

Landings of Indian mackerel by major fishing ports on the west coast of Thailand, 1979-1985

Year	1979		1980		1981		1982		1983		1984		1985	
Landing Port	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%
Ranong	1159	28.65	443	14.38	350	11.04	39	2.06	169	4.27	298	8.33	610	10.15
Takkuapa	1332	32.93	745	24.18	535	16.88	372	19.68	647	16.34	898	25.08	1820	30.27
Taimuong	237	5.86	166	5.39	1200	37.87	782	41.38	1597	40.34	1177	32.88	858	14.27
Phuket	678	16.76	706	22.91	734	23.16	656	34.71	1394	35.21	1189	33.21	1486	24.72
Krabr	374	9.25	350	11.36	55	1.74	4	0.21	–	–	10	0.28	171	2.84
Trang	186	4.60	260	6.69	295	9.31	37	1.96	152	3.84	8	0.22	567	9.43
Satul	79	1.95	465	15.09	–	–	–	–	–	–	–	–	500	- 8.32
Total	4045	100	3081	100	3169	100	1890	100	3959	100	3580	100	6012	100

Source 19741984. The Landing Place Survey, Department of Fisheries, Thailand
1985. from the sampling survey conducted by Phuket Marine Fisheries Station

Table 5

Landings of round scad by major fishing ports on the west coast of Thailand, 1979-1985

Year	1979		1980		1981		1982		1983		1984		1985	
Landing port	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%	tonne	%
Ranong	91	6.38	383	21.64	163	6.08	6	0.27	781	5.60	259	2.21	119	1.45
Takkuapa	401	28.10	173	9.77	710	29.62	886	40.05	1333	9.56	1252	10.68	1708	20.82
Taimuong	302	21.16	369	20.85	526	21.94	388	17.54	2083	14.94	2242	19.13	3004	36.61
Phuket	486	34.06	521	29.43	519	21.65	555	21.65	8908	63.90	7658	65.33	3062	37.32
Krabr	20	1.40	98	5.54	53	2.21	243	10.99	300	2.15	57	0.49	49	0.60
Trang	127	8.90	226	12.77	426	17.77	134	6.06	520	3.73	253	2.16	179	2.18
Satul	–	–	–	–	–	–	--	–	16	0.12	–	–	84	10.00
Total	1427	100	1770	100	2397	100	2212	100	13941	100	11721	100	8205	100

Source 1979-1984, The Landing Place Survey, Department of Fisheries, Thailand
1985, from the sampling survey conducted by Phuket Marine Fisheries Station

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Table 6

Smallest observed lengths, recruitment periods, dominant size ranges and peak seasons of the fishery for mackerels and scads on the west coast of Thailand

	Smallest observed (cm.)	Seasons for small size	Dominant size range (cm.)	Peak season of the fishery
R. brachysoma				
Area I	15.5	March, May, June	19.5 — 21.5	May
Area II	9.5	Jan., May	16.5 — 19.5	March — Very high CPUE
Area III	10.5	Feb., March, Dec.	17.5 — 19.5	Feb. — Very high CPUE
R. kanagurta				
Area I	10.5	March, April	21.5 — 23.5	April — Very high CPUE
Area II	8.5	Feb.-Mar., Sep.-Nov.	18.5 — 21.5	May/July — Low CPUE
Area III	10.5	March	19.5 — 21.5	May — moderate CPUE
D. maruadsi/russelli				
All three areas	8.5	March	18.5 — 20.5	March
D. macrosoma				
All three areas	13.5	Feb., April	19.5 — 21.5	August

Table 7

Growth parameters, mortality and exploitation rates of mackerels and scads on the west coast of Thailand, obtained from the ELEFAN analysis (K annual, lengths In cm)

	K	L_∞	L_C	Observed Z		E
R. brachysoma						
Area I	1.6	28.	19.7	26	15.76	0.84
Area II	1.25	25.1	17.6	24	6.88	0.68
Area III	1.33	25.4	17.8	23	8.68	0.74
R. kanagurta						
Area I	1.75	28.6	22.7	27	8.53	0.69
Area II	1.9	27.5	19.7	25	5.32	0.48
Area III	1.5	27.6	20.0	25	2.49	0.004
D. maruadsi/russelli						
All three areas	1.01	27.2	19.6	25	6.57	0.72
D. macrosoma						
All three areas	0.89	24.2	18.8	23	5.97	0.57

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Table 8

Catch, effort and catch per unit of effort data (purse seine as standard gear) of Indo-Pacific mackerel, Indian mackerel and round scad on the west coast of Thailand

a: Indo-Pacific mackerel

Year	1979	1980	1981	1982	1983	1984	1985
Total catch (tons)	8,643	13,091	15,181	9,714	11,410	16,129	22,162
Total effort (days)	9,891	15,278	18,789	10,877	13,005	26,457	39,368
CPUE (kg/day)	873.82	856.85	807.97	893.08	577.35	609.63	562.94

B: Indian mackerel

Year	1979	1980	1981	1982	1983	1984	1985
Total catch (tons)	4,045	3,081	3,169	1,890	3,959	3,580	6,012
Total effort (days)	6,631	12,243	15,238	15,214	28,887	19,585	40,354
CPUE (kg/day)	610.01	251.65	207.97	124.23	137.05	182.79	148.98

C: Round scad

Year	1979	1980	1981	1982	1983	1984	1985
Total catch (tons)	1,427	1,770	2,397	2,212	13,941	11,271	8,025
Total effort (days)	21,667	49,915	19,790	13,377	25,503	23,984	40,353
CPUE (kg /day)	65.86	35.46	121.12	165.36	546.64	488.70	203.33

Source: 1979-1984 Total catch from the Landing Place Survey, Department of Fisheries, Thailand.

1985 Total catch from the sampling survey conducted by Phuket Marine Fisheries Station.

1979-1985 CPUE from the sampling survey conducted by Phuket Marine Fisheries Station.

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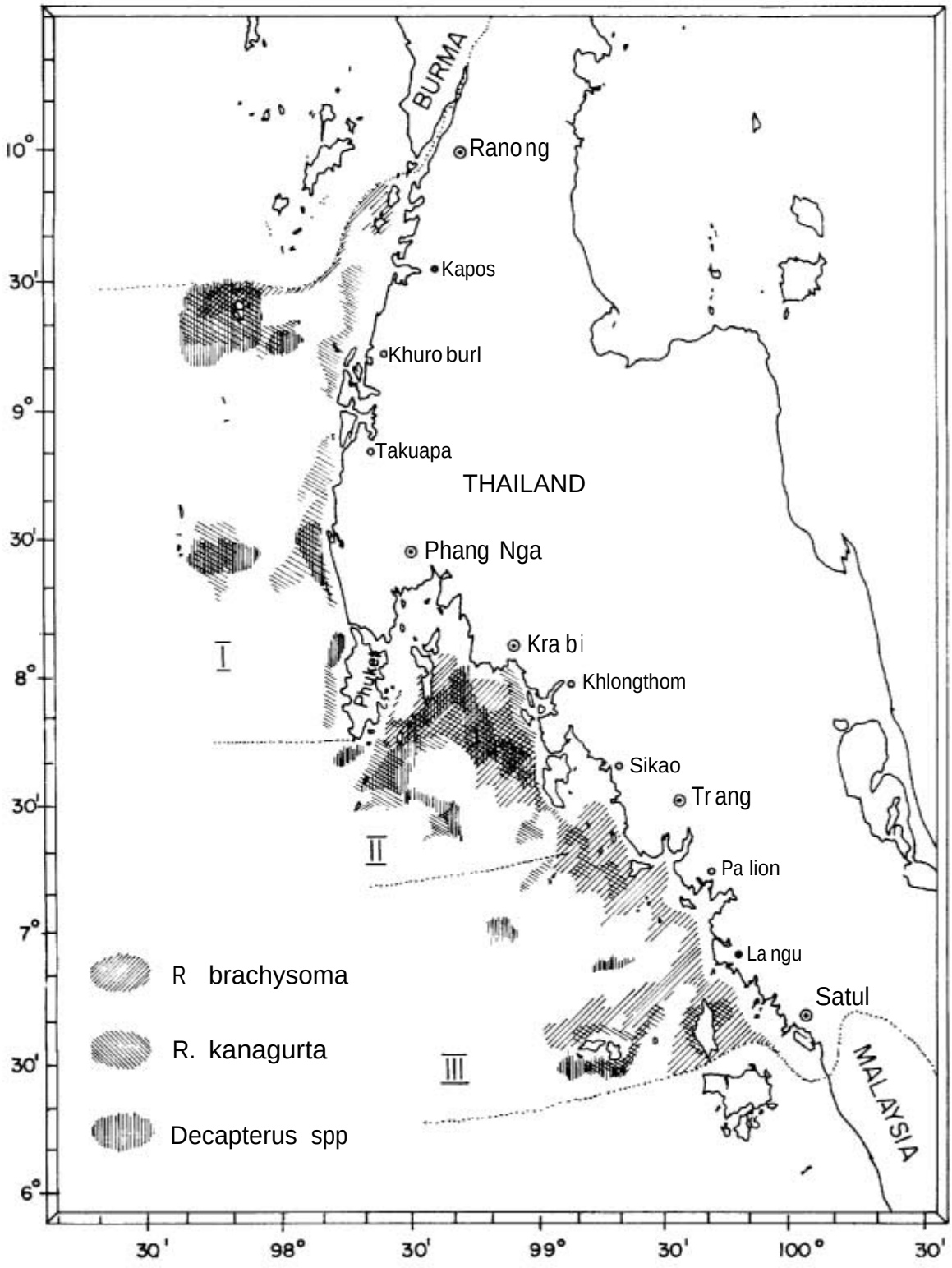
Figure 1. *Fishing areas on the west coast of Thailand.*



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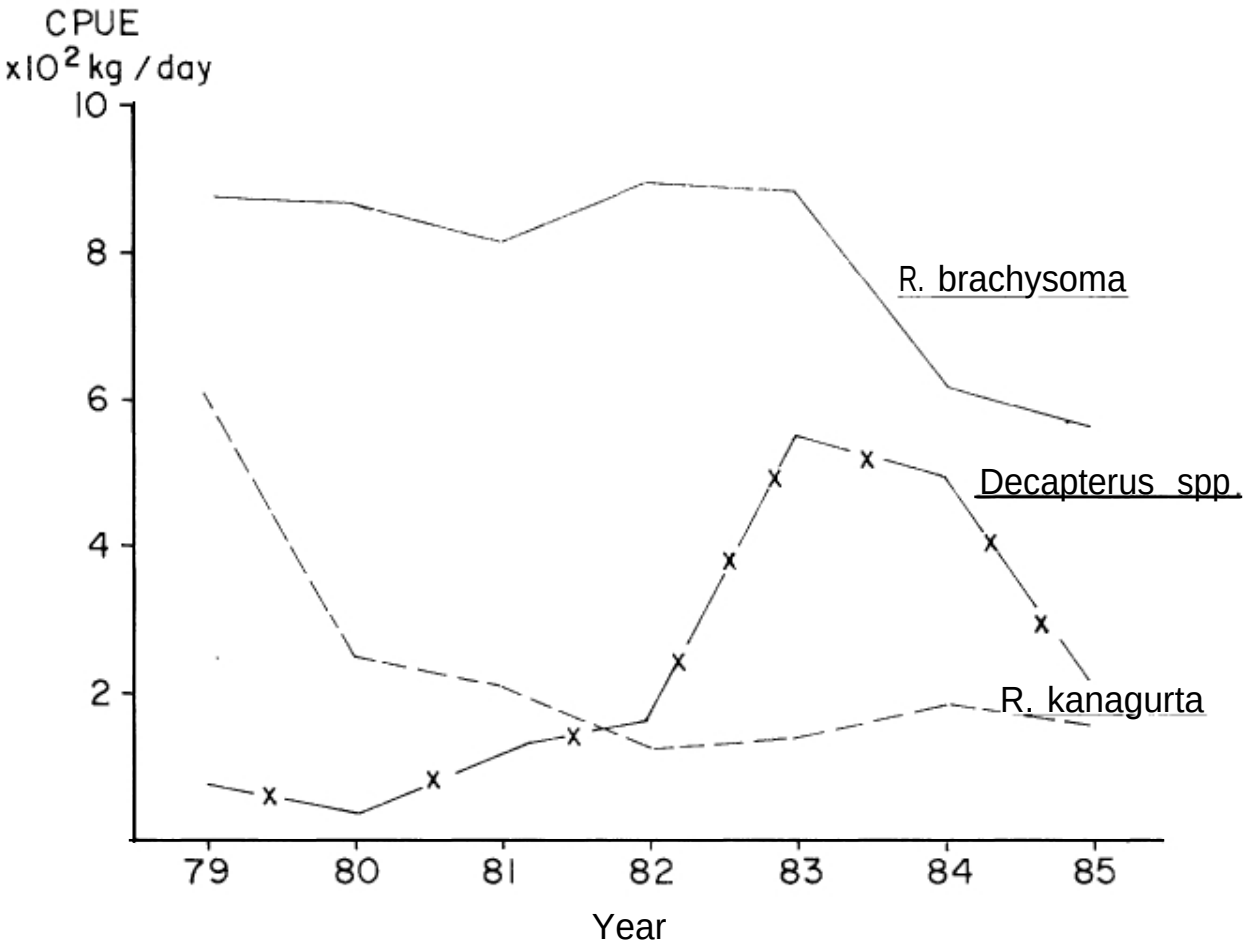

Figure2. *Annual mean catch rates for* R. brachysoma, A. kanagurta *and* Decapterus *spp. in the purse seine fishery on the west coast of Thailand.*

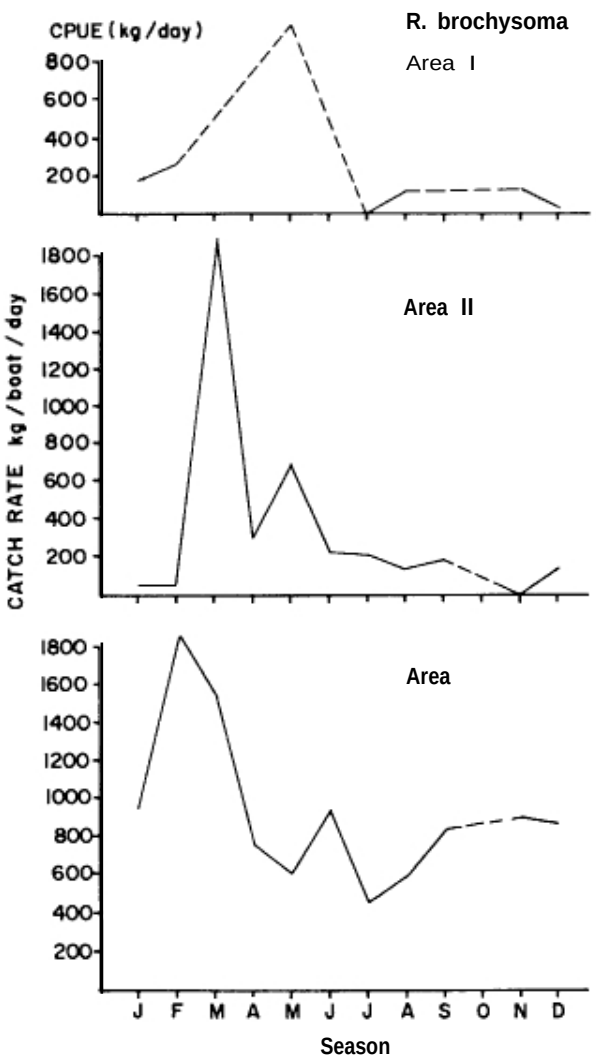

Figure 3. Monthly catch rate for R. brachysoma *in the purse seine fishery in the three areas on the west coast of Thailand.*

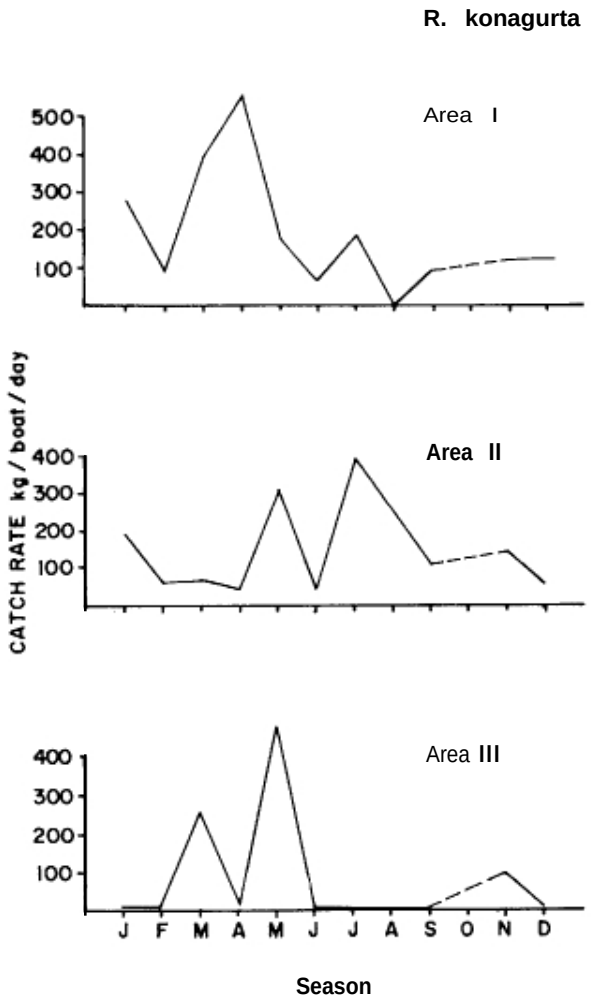

Figure 4. Monthly catch rates for R. kanagurta *in the purse seine fishery in the three areas on the west coast of Thailand (1985).*

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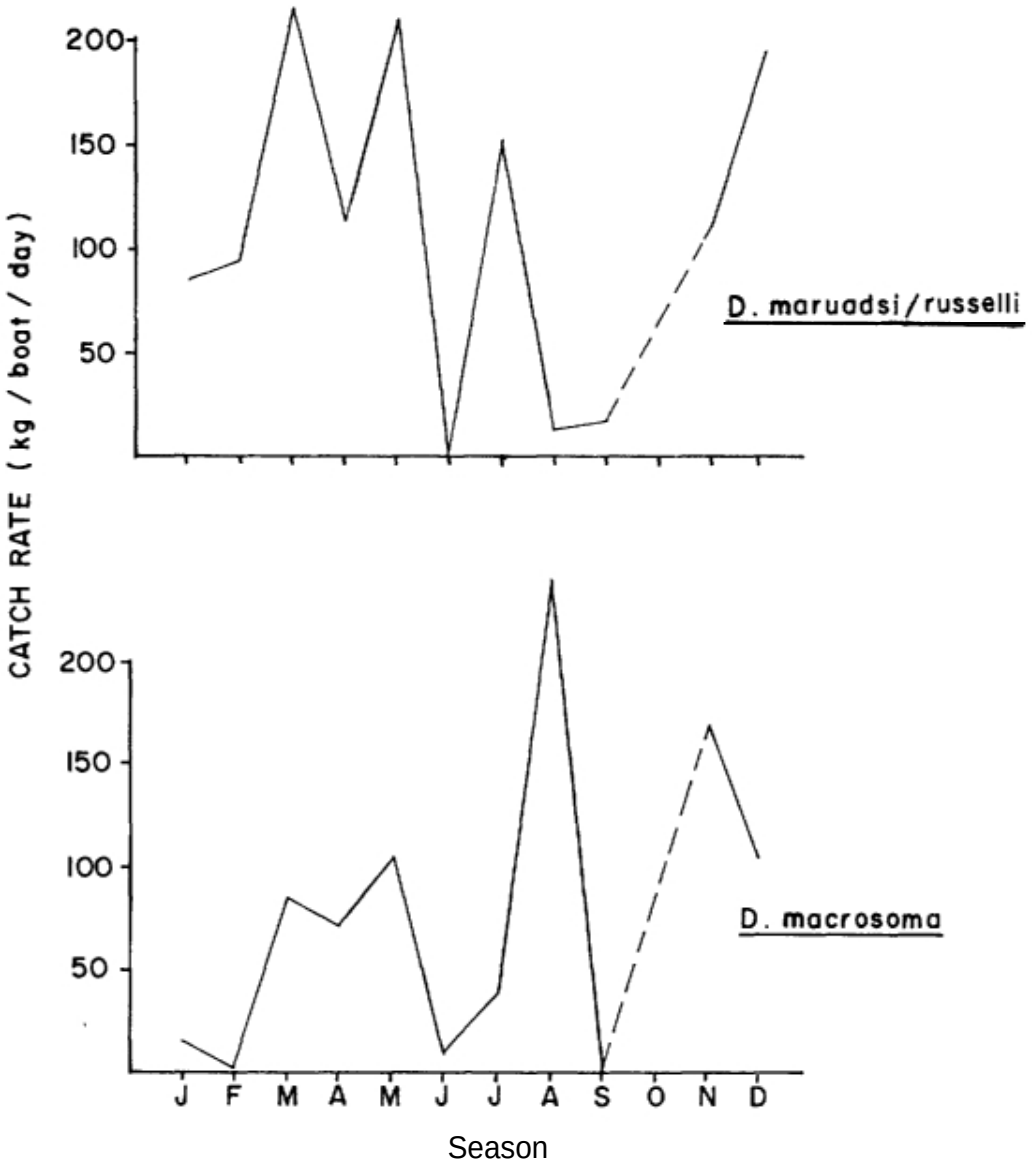

Figure 5. *Catch rates for* D. maruadsi/russelli *and* D. macrosoma *in the purse seine fishery along the west coast of Thailand (1985).*

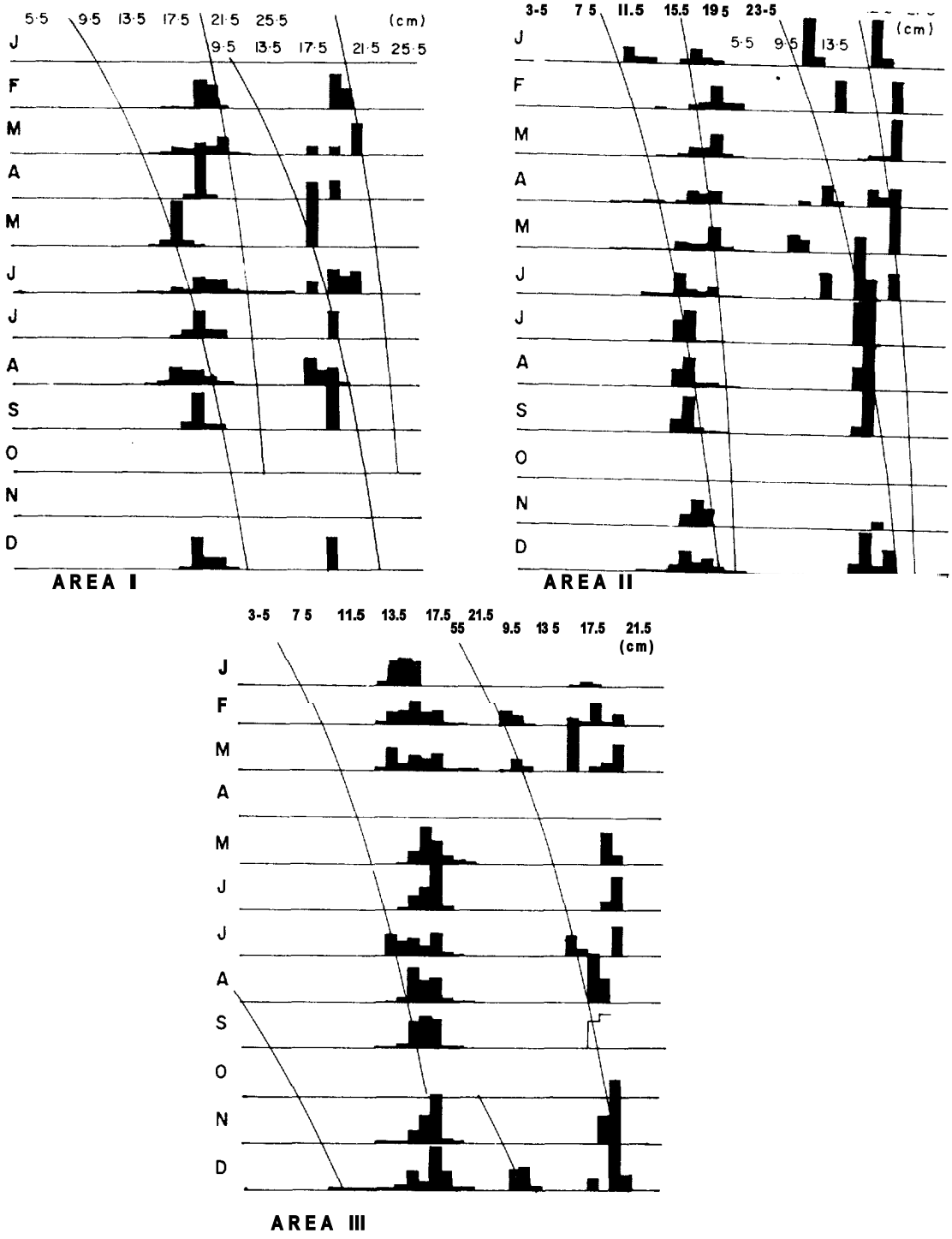

Figure 6-8 Length frequencies, restructured frequencies and growth **curves** *for* **R. brachysoma** *in Areas I, II and III on the* **west coast** *of Thailand (1985).*

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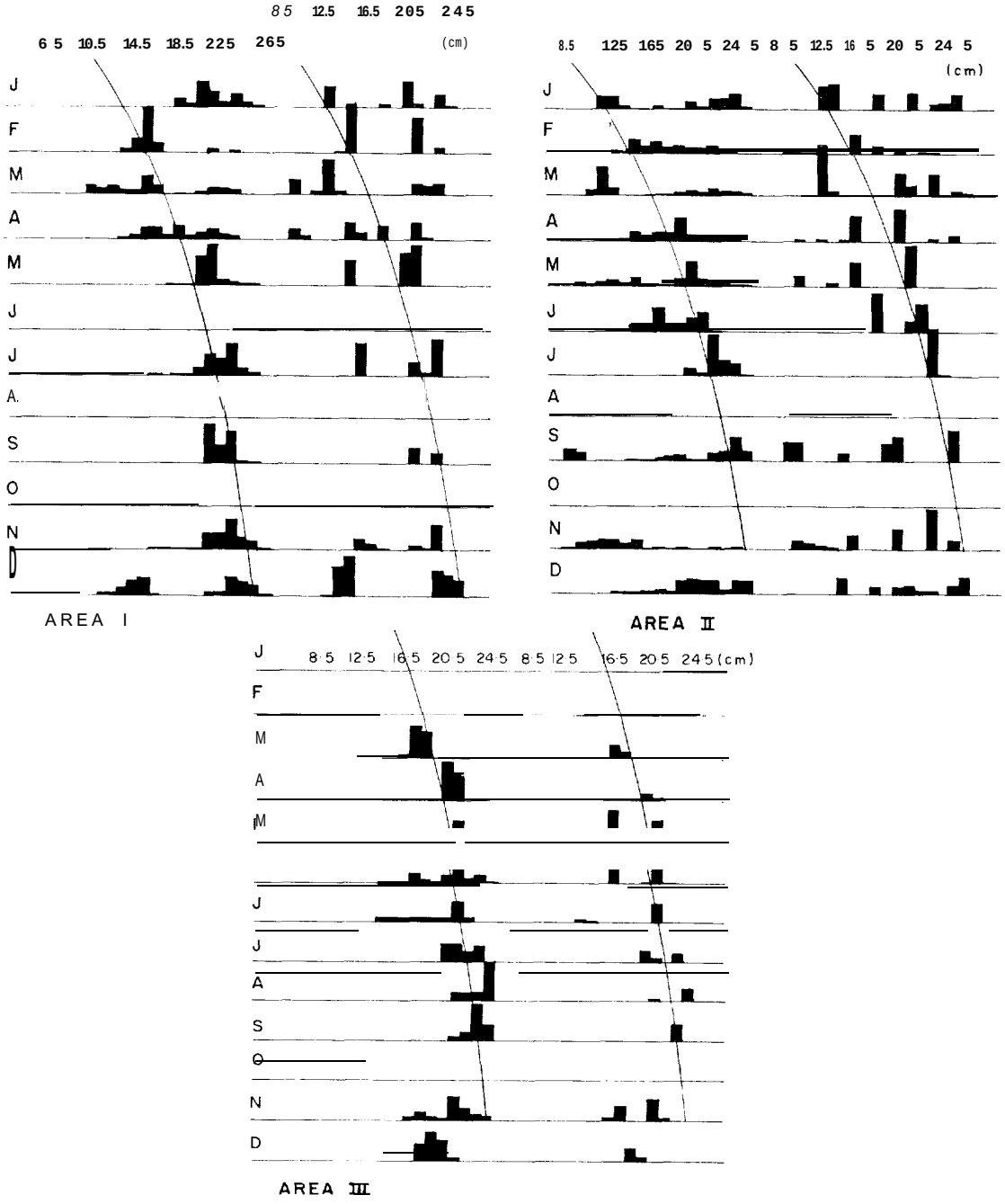

Figure 9-1 l *length frequencies, restructured frequencies and growth* curves *of* f?. kanagurta in Areas l, ll and lll on *the west coast of Thailand (1985)*

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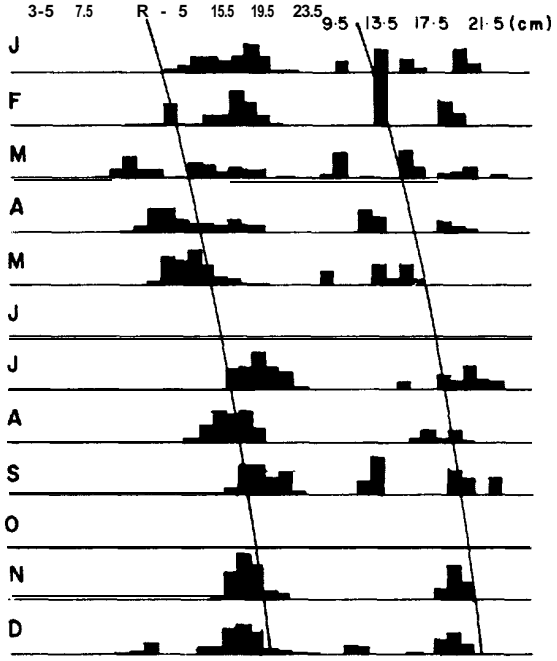
Figure 12. *Length frequencies,* restructured frequencies *and growth curves for D.* russelli (maruadsi) *in all the three areas on the* wesr coast *of Thailand (1985)*



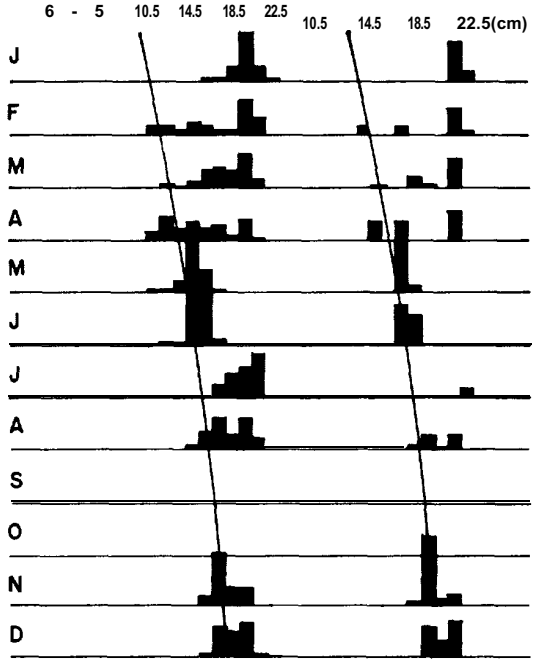


Figure *13.* *Lengrh* frequencies, restructured *frequencies* and *growth curves for* D. marcrosoma *in* all *three* areas *on the west coast of Thailand (1985).*

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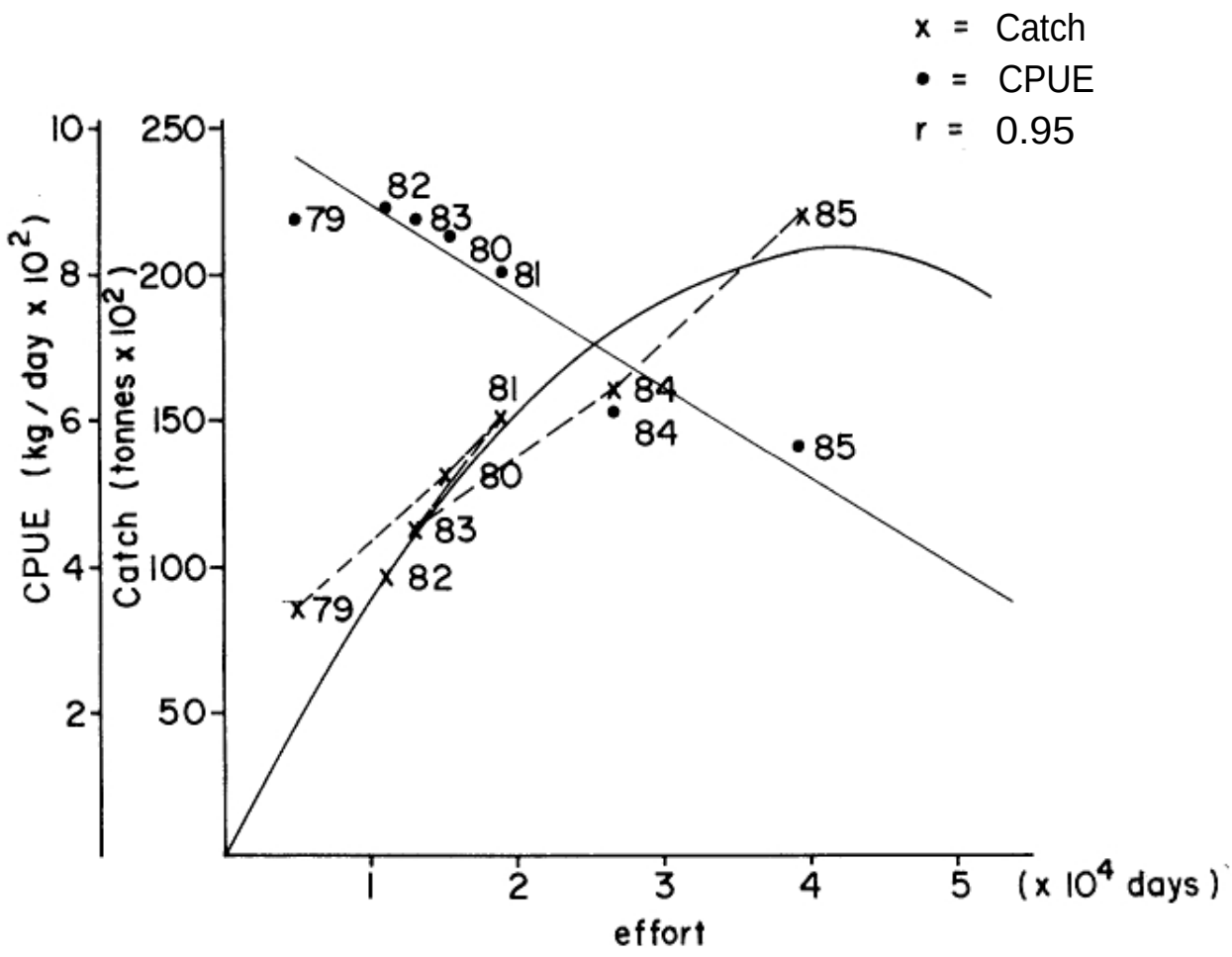

Figure 14. *Catch and catch per unit of effort related to total standardized effort for Indo-Pacific mackerel on the west coast of Thailand, 1979-1985.*

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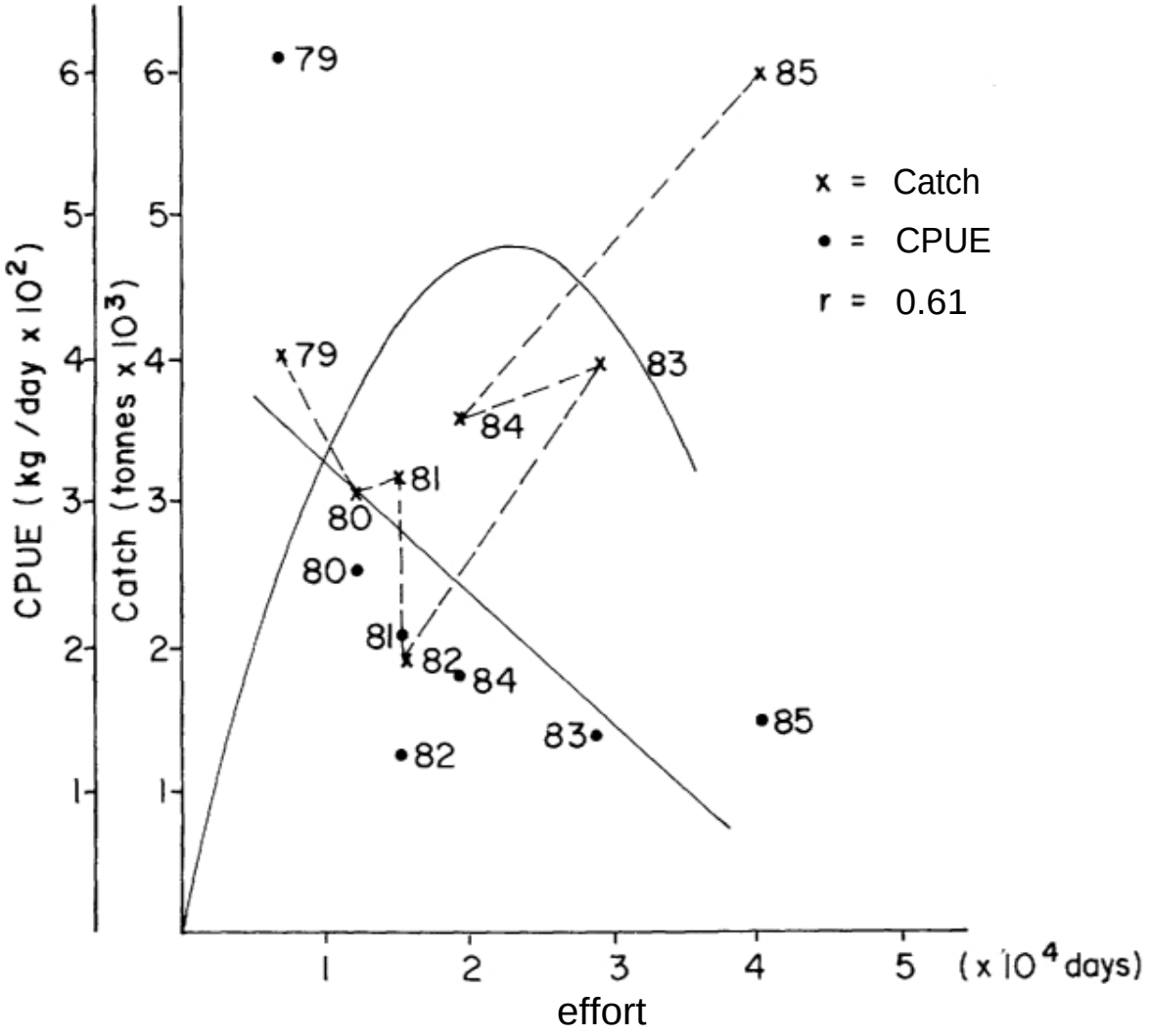

Figure 15. Catch and catch per unit of effort related to total standardized effort for Indian mackerel on the west coast of Thailand, 1979-1985.

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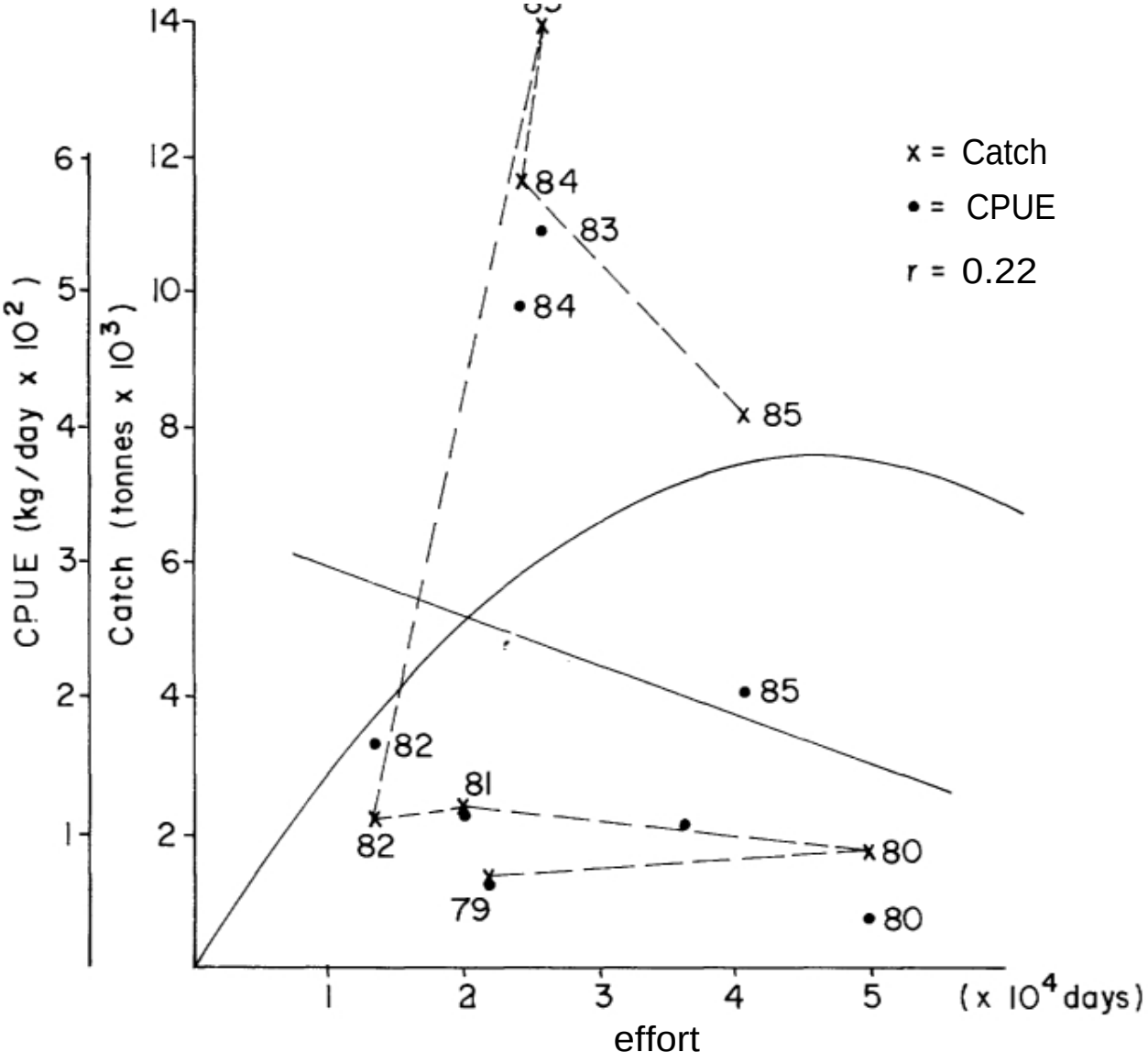

Figure 16. *Catch and catch per unit of effort related to total standardized effort for round scads on the west coast of Thailand, 1979-1985.*

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Annexure 2

BIOLOGICAL ASPECTS OF CHUB MACKERELS AND ROUND SCADS ON THE WEST COAST OF THAILAND

by Pairoh Sutthakorn and Ravi Saranakomkul

Introduction

Chub mackerels have played an important role in the marine fisheries production along the west coast of Thailand for many decades. Due to the recent introduction of the light luring purse seine as well as to the development of canning industries, round scads have also became an important species in the pelagic fisheries. Their catches increased until 1983 but started decreasing in subsequent years. The light luring purse seine fishery is concentrated in the central part of the coastline (Area II; see Figure 1 a), which is considered to contribute to the large catches of juveniles of mackerels and other species. The Department of Fisheries established a closed season from April 15 to June 15 in this area in 1985.

Egg and larval surveys were conducted to verify the hypothesis on spawning season and spawning grounds. Other biological data have also been collected. The results would be essential for management of the valuable mackerel and scad resources in the Thai part of the Bay of Bengal.

Tagging of *R brachysoma*

Mackerels are distributed all along the west coast of Thailand. *R. brachysoma* has been found abundantly in the inshore waters along the east coast of Phuket Island and from the Phang Nga Bay and Krabi Bay (Area II) downward to the southern end of Thai waters.

Tagging experiments were conducted in 1981, in Area III, close to the Thai — Malaysian boundary. Of the 6,386 fish tagged, 84 (1.32%) were recovered in that area. Some of them moved northward to Trang Province but did not enter into Area II and some moved south into Malaysian waters, north of Penang (Pu Paya and Pu Bidan).

In 1984 the experiments were conducted in Area II, where 526 fish were tagged. 107 fish (20.34%) were recaptured and it was found that most of the tagged fish were caught off the eastern coast of Phuket Island of Phang Nga Bay and in Krabi Bay and that some moved southward to Pipi Island and South Lanta Island. However, fish tagged in Area II and Area III failed to show intermingling between these two areas. The results of the tagging experiments are shown in Tables 1 and 2 and Figure 1 b.

Sex ratio (Male: Female)

For estimating the sex ratio of chub mackerels and round scads data from the sampling surveys conducted by the Phuket Marine Fisheries Station during 1985-86 were used. The results are summarized below:

Sex ratio

	Area I	Area II	Area III
R. brach ysoma	1:1 .1593	1:1.0872	1:0.968
R. kanagurta	1:0.9934	1:1.0717	1: 1.0244
D. maruadsi/russelli	1 :1.0616 for all three areas		
D. macrosoma	1:0.9709 for all three areas		

The monthly sex ratios of *R. brachysoma* and *R. kanagurta* in three areas are shown in Figures 2 and 3 and those of *D. maruadsi* and *D. macrosoma* in Figure 4. Some dissimilarities were observed between areas, for each species. The monthly sex ratio of *R. brachysoma* from commercial trawl catches is presented in Figure 5.

The monthly sex ratios by size group are presented in Figures *6-9,* for *R. brachysoma, R. kanagurta,* and the *Decapterus* species respectively. Males of *R. brachysoma* appeared to

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be predominant among fish smaller than 18 cm and females predominate in fish larger than 20 cm. Males and females were almost equally represented in the 18-20 cm size range.

In the case of R. kanagurta, the predominance of males in the size range above 21 cm was observed in Areas II and III. Even in Area I there was evidence of increasing proportion of males from <15 cm to >21 cm size group, though males were not dominant in any of the size groups.

Males of *D.* maruadsi/russelli were predominant in all size ranges caught, whereas in the case of *D. macrosoma,* the males were predominant in fish smaller than 18 cm, females in fish larger than 20 cm and both sexes were in equal proportions in the 18-20 cm size range. The percentages of males by size group are summarised in Table 3. It appears that the differences in sex ratios between different areas and seasons are influenced by the differences in the size compositions of the catch.

Maturity and spawning

The percentage of mature fish was plotted as a function of length and the mean length at which the samples represented 50% of mature fish was taken as the mean length at first maturity. The results are summarised below:

	Size at first maturity (cm)	Peak monthly mean gonad index	Seasons of occurrence	Peak percentage of ripe stage (iv)	Season of occurrence
R. brachysoma					
Area I	18.00	39.04	Feb.	38.89	Feb./Sept
Area II	17.00	41.49	Feb.	36.51	Feb.
		36.68	Aug.	26.19	Apr.
				18.32	Aug.
Area III	16.50	42.73	Jan.	50.49	Jan.
		42.27	Jun.	41.76	May
				33.13	Sept
R. kanagurta					
Area I	19.50	46.52	Dec.	70.85	Dec.
		27.20	Mar.	12.66	Mar.
Area II	19.50	40.48	Jan.	33.33	Jan.
		21.96	Aug.	5.41	Aug.
Area III	17.0	52.00	Sep.	66.67	Sept.
		23.04	Apr.	18.18	June
D. maruadsi/ russelli	17.0	38.76	Feb.	NA	
		34.50	Dec.		
D. macrosoma	17.2	72.71	Feb.	NA	
		67.56	Dec.		

The results of the study on spawning seasons, G.I. values and percentage of ripe stages with their seasons for the mackerels in each of the three areas and for round scads in all areas combined are shown in Figures 1 O-l 3 for *R. brachysoma,* and Figures 14-l *7* for *R. kanagurta* and in Figures 18-20 for the two *Decapterus* species.

The spawning seasons of R. brachysoma seem to occur from February to April (Areas I and II) and in August (Area II) and September (Area l).

An attempt has been made to sample trawl catches for R. brachysoma caught at 30-40 m depth in Area II. Although the data are rather insufficient they indicate that the spawning pattern in this area matches the data from the purse seine fishery. The mean G.I. value appears to be high (53.57) in February while some individual fish show a G.I. value of 122.81. In April, a smaller peak with a mean G.I. of 29.01 was observed (highest individual value 118.52) (Figures 21 and 22).

In Area III, spawning seems to take place in January, May and September.

The spawning seasons for R. kanagurta appear to have a peak in December and a smaller one in March. In Area I. In Area II, the peak season occurs during December and January. No clear peaks were observed during the rest of the year. Area III had its peak season in September. *D. maruadsi/russelli* probably spawns from December to June and D. ***macrosoma*** similarly from December to May in all three areas.

Egg and larval surveys

Egg and larval surveys have been conducted during March, April, June and July in Area II in 1985 and were extended to the upper part of Area III during February, March and April, 1986. The surveys were conducted in 47 grids (grids of 5 x 5 square miles) from the lower part of Phang Nga Bay, Krabi Bay to Talibong Island in Trang Province (Figure 25). Plankton net of mesh size 333 micron and larva net of mesh size 1,000 micron were used, for oblique towing, ten minutes in each grid with a speed of 2-3 knots. The salinity, surface temperature and depth of water at the locations were examined. The egg size, shape of oil globules and the important characters of the larvae during these surveys were identified following the results of the experiments on artificial fertilisation and descriptive studies of eggs and larvae of the Indo-Pacific mackerel by Boonprakob and Dhebtaranon (1971).

These authors found that the fertilized eggs of this species were transparent and spherical. The egg contained a fairly large oil globule and rather narrow perivitelline space indicating the floating character of the eggs. The diameter of the egg and oil globules depended on the size of the female, ranging from 718 to 864 micron for eggs and from 186 to 226 micron for oil globules.

The size of the hatching larvae was 1.33-2.23 mm; the larvae developed to the post larval stage (2.76-2.86 mm) in 72 hours. The larvae, after hatching, were transparent and 31 myotomes could be observed. Additionally, there were some distinct characters for this species such as the absence of a spine on the operculum and the appearance of teeth on the upper jaw with a size of 3.06 mm.

The post larval stage was foliowed by absorption of the yolk sac and opening of the mouth. At this stage, the head was short and wide, the body narrowing in posterior direction, pelvic fin large, and 15-20 pigments from anus to caudal peduncle. The number of pigments decreased to 13-l 5 when the larva grew up to 3.7-4.8 mm and the number decreased continuously to 8-l 1 pigments of size 1 O-l 1.8 mm.

Several organs were also observed while they were developing and the fish grew until the early juvenile stage, having passed the transparent stage with the pigments distribution becoming as in the adult stage. Different stages of development of larvae are shown in Figures 23 and 24.

The results of egg and larval surveys conducted during March, April, June and July 1985 (Figure 25) indicated that eggs and larvae were found in March around Pipi Islands in the highest densities and found in moderate density on the east coast of Yao Yai Island and around Lanta Island. In March the size of larvae caught by plankton net were 1.96 mm (SD 0.32)-2.04 mm (SD 0.31) and those caught by larva net had a mean length of 3.7 mm (SD 0.50). In April, the abundance of eggs and larvae appeared to have shifted southward and the highest density occurred in the south of Lanta Yai Island while the moderate density occurred in the northern part of Area III. On the east coast of Yao Yai Island the eggs and larvae still appeared to occur in moderate abundance during this month. In April, the mean length of the larvae collected by plankton net and larval net were 1.94 mm (SD 0.21) and 4.48 mm (SD 0.70) respectively. In June and July, the surveys were hampered by the heavy monsoon and the larvae were found in low densities (Figures 26 and 27).

It may be concluded that the surveys conducted during the mentioned period in 1985 indicated that the spawning grounds for ***R. brachysoma*** are in Area II, with the main grounds around Pipi Island, south of Lanta Yai Island and east of Yao Yai Island. The period of occurrence of high larval densities (March and April) matches the seasons of high mean G.I. values and the seasons with a high percentage of ripe fish.

The surveys conducted from February to April 1986 using plankton nets showed moderate Densities of the larvae distributed off the east of Yai Noi Island, and from Pipi Islands to south of Lanta Yai Island. The highest abundance in March was observed south of Lanta Yai Island (Area II) and in the area between Kradan Island and Rok Nai Island, located in the northern part of Area III. The size of larvae found by this technique ranged from 2.31 mm to 2.39 mm. The larva net catches showed results similar to those of the plankton net, except that smaller numbers of larvae were found south of Trang Province (Area III). The size of larvae caught by the larva net ranged from 3.2 mm 5.98 mm (Figures 28 and 29). From the results of the 1986 survey it seems likely that the fish may spawn before February (this may be seen from the peak in GSI also).

It may be concluded from the results of the egg and larval surveys in 1985 and 1986 that the main spawning grounds for R. brachysoma are in Area II, around Pipi Islands and south of Lanta Yai Island. The small-size larvae of 1.5 — 1.9 mm (age 3 days, according to Boonprakob and Dhebtaranon 1971) were collected from Area 'II, while most of the larger size larvae (2.0 — 4.5 mm) were observed in the inshore areas. This distribution pattern may depend on a number of factors such as wind and surface currents.

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Boonprakob, U and Y. Dhebtaranon, 1971. "Experiment on artificial fertilisation and descriptive studies of eggs and larvae of the Indo-Pacific mackerel *Rastrelliger neglectus* (Van Kampen)." In Reports on Mackerel Invest. 1963-1965, Mar. Fish. Lan., Division of Res. and Invest., Dept., of Fish., Bangkok, pp. 379-406.

Table 1

Yearly change in recapture rate of Indo-Pacific mackerel (R. brachysoma) tagged on the west coast of Thailand, 1981-1984

Area	Year	Release area	No. of released fish	Number of recaptured fish in each area: Area I Phuket	Area I Phang Nga	Area II Krabi	Area II No data	Area II Trang	Area II Satul	Area II Kedah Malaysia	Area II No data	Total no of recaptured fish	% of recaptured fish
III	1981	Satul	513	—	—	—	—	2	6	—	—	8	1.56
III	1982	Satul	1,074	—	—	—	—	1	24	3	—	28	2.61
III	1983	Satul	4,799	—	—		—	10	21	1	16	48	1 .00
Total		81-83	—	—	—	—	—	—	—	—	16	84	1.32
II	1984	Krabi	526	—	15	82	10	—	—	—	—	107	20.34

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Table 2

Results of the tagging experiment of R. brachysoma on the west coast of Thailand, 1981-1984

Released area		II		III		
Numbers released/year		1/1984	* 111981	1-2/1982	1-211983	Total
Numbers of released fish		526	513	1074	4799	6386
Days elapsed	0-30	58	1	13	23	37
	31-60	35	5	10	12	27
	61-90	11	—	2	7	9
	91-120	3	—	2	4	6
	151-150	—	-	1	2	4
	151-180	—	—	—	—	—
Numbers of recaptured fish		107	7	28	48	83
Total mortality (Z)		1.004	—	0.674	0.598	0.595
Natural mortality (M)		0.785	—	0.657	0.592	0.587
Fishing mortality (F)		0.219	—	0.017	0.006	0.007
Survival rate (S)		0.366	—	*0.509*	*0.549*	0.561
Exploitation rate (E)		0.218	—	0.026	0.011	0.013
R^2		*0.967*	—	*0.905*	*0.998*	*0.960*

* 1/1981 Area III, no analysis

Table 3

Percentage of males of scads and mackerels by size group on the west coast of Thailand

	Area I	Area II	Area III
R. brachysoma			
< 18 cm	54.88	58.02	56.50
18-20 cm	56.63	49.93	52.39
> 20 cm	49.56	45.32	41.10
I?. kanagurta			
< 19 cm	42.72	47.79	—
19-21 cm	45.34	52.80	51.82*
> 21 cm	48.16	52.26	51.65
*D. maruadsi/russelli** *			
<18 cm	—	52.36	—
18-20 cm	—	53.69	—
> 20 cm	—	52.92	—
D. macrosoma * *			
<18 cm		53.87	—
18-20 cm	—	50.71	—
> 20 cm	—	45.43	—

*<21 cm ** all areas

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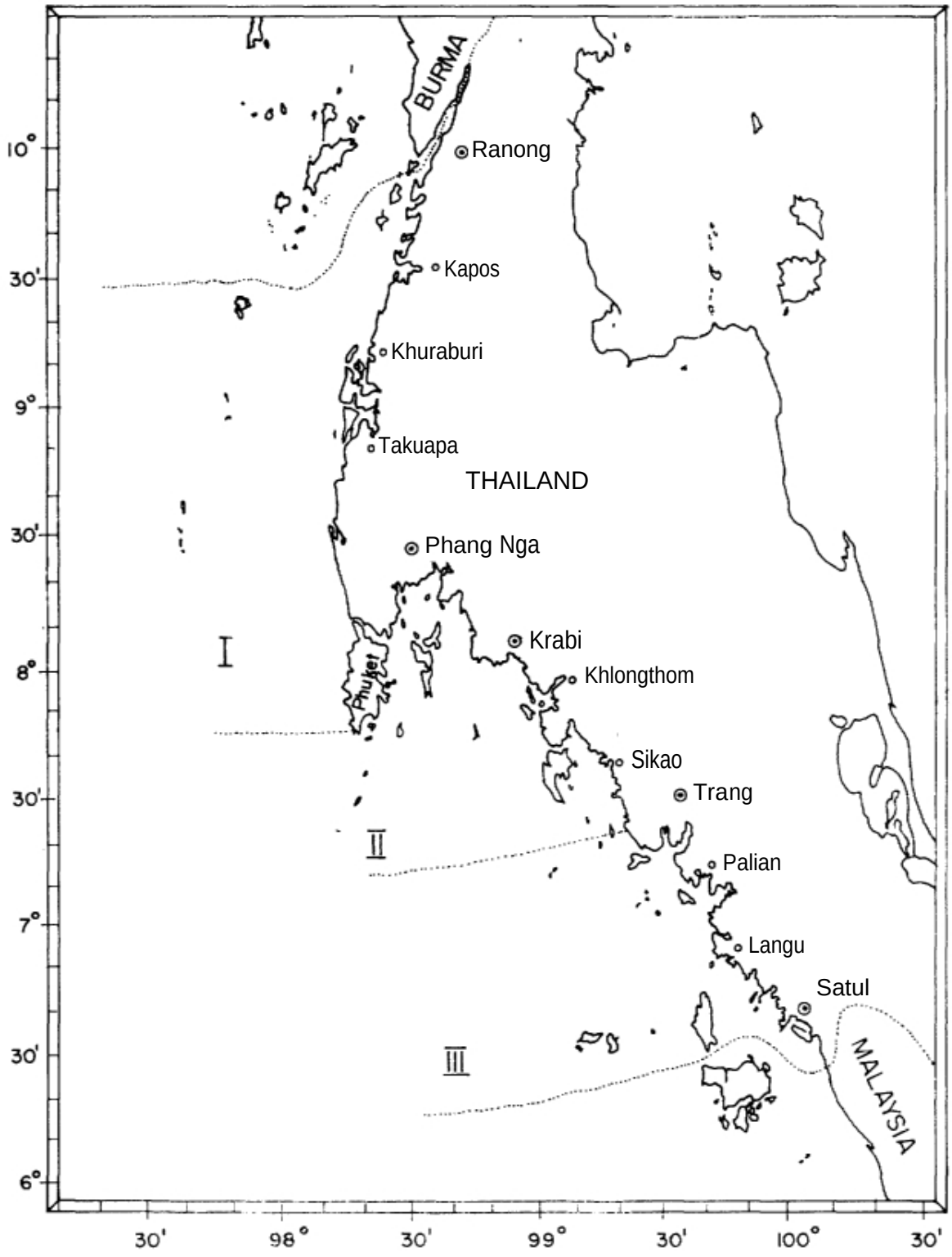
Figure 1a. *Fishing areas on the west coast of Thai/and (Area (from Ranong to Phuket, Area II from Phuket to Trang, Area III from Trang to Satul).*



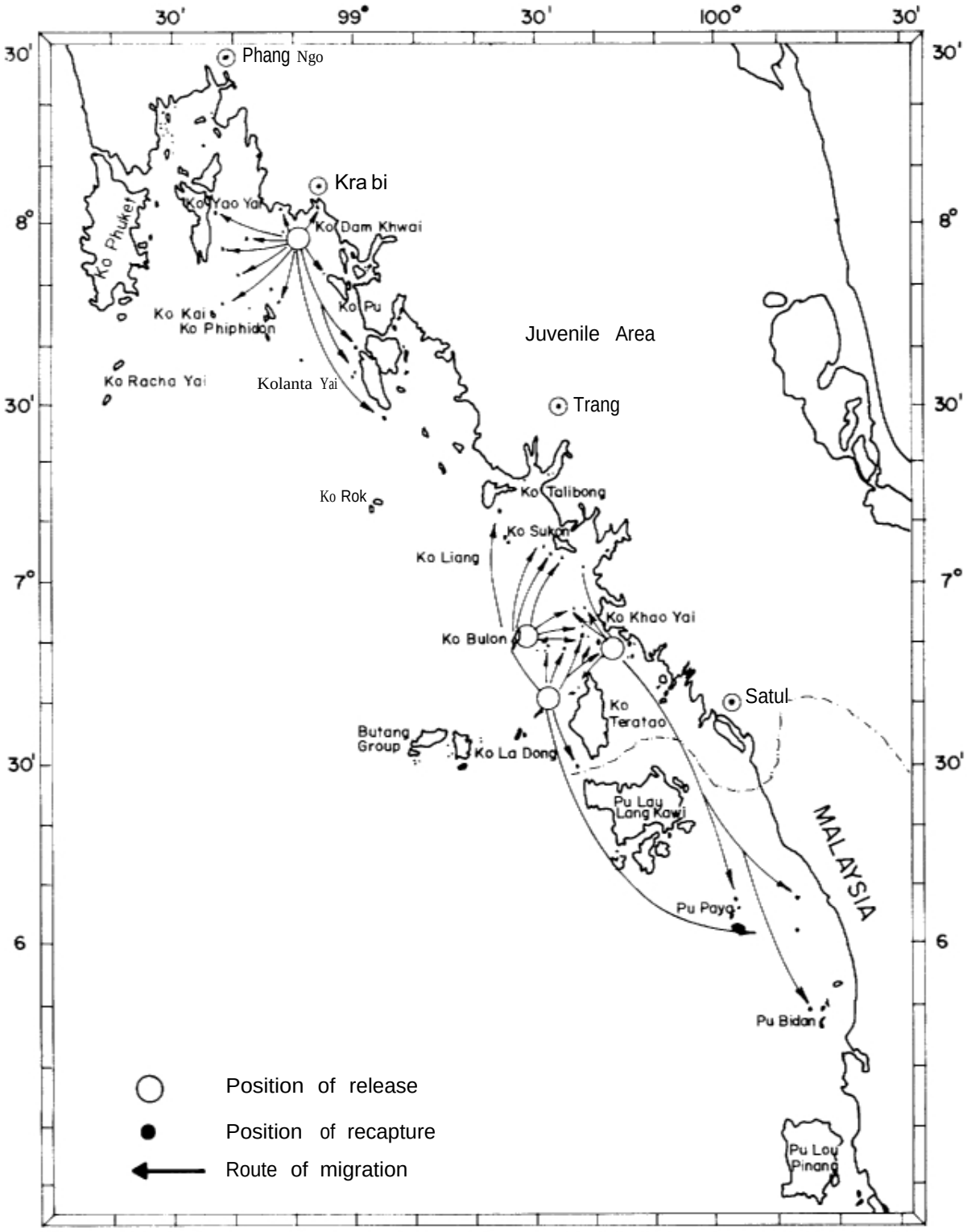


Figure lb. *Results of the tagging experiments with* R. brachysoma *on the west coast of Thailand, 1981-1984.*

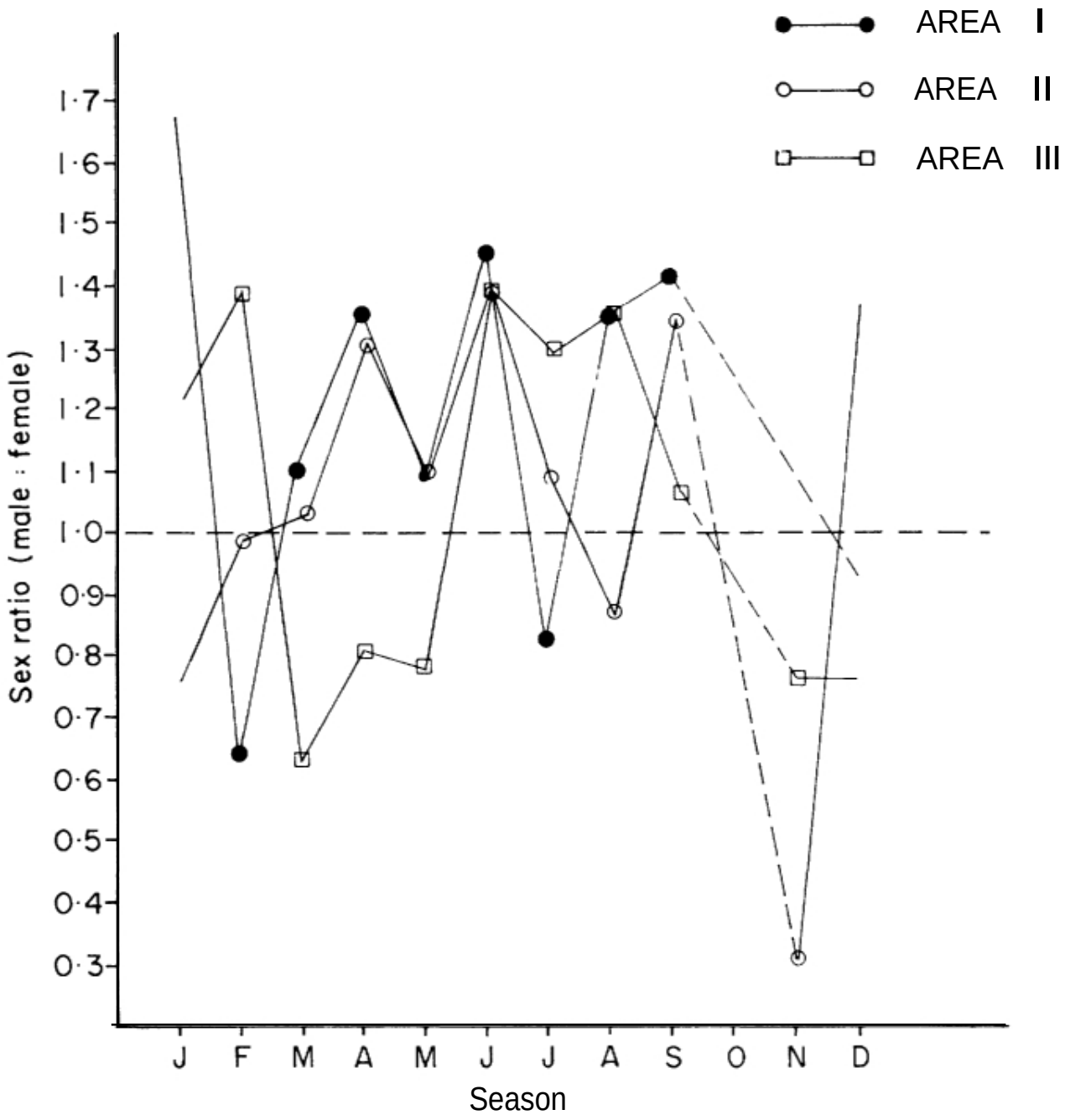


Figure 2. *Monthly sex ratio of* R. brachysoma *on the west coast of Thailand (1985).*

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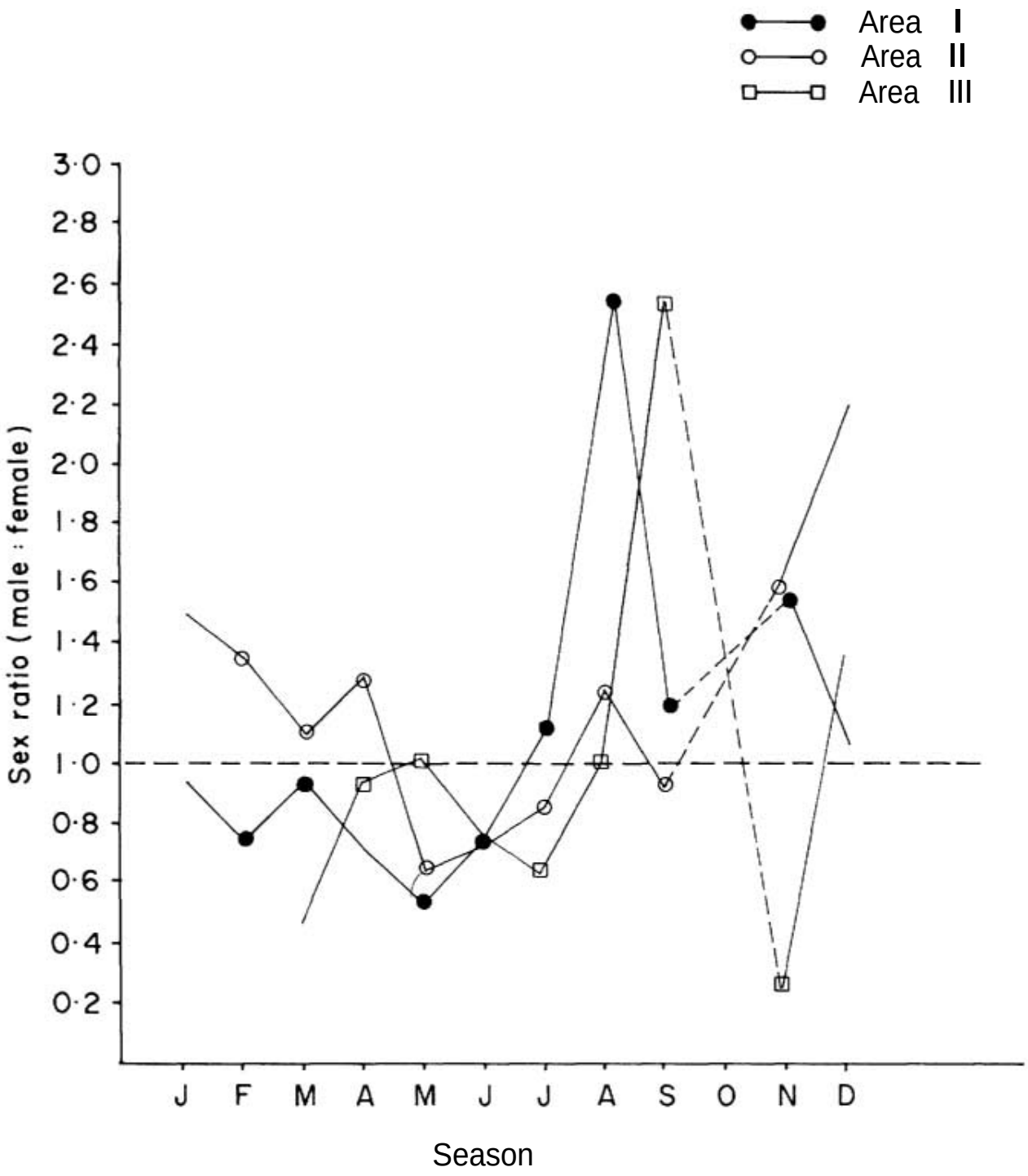

Figure 3. *Monthly sex ratio of* R. kanagurta *on the west coast of Thailand (1985).*

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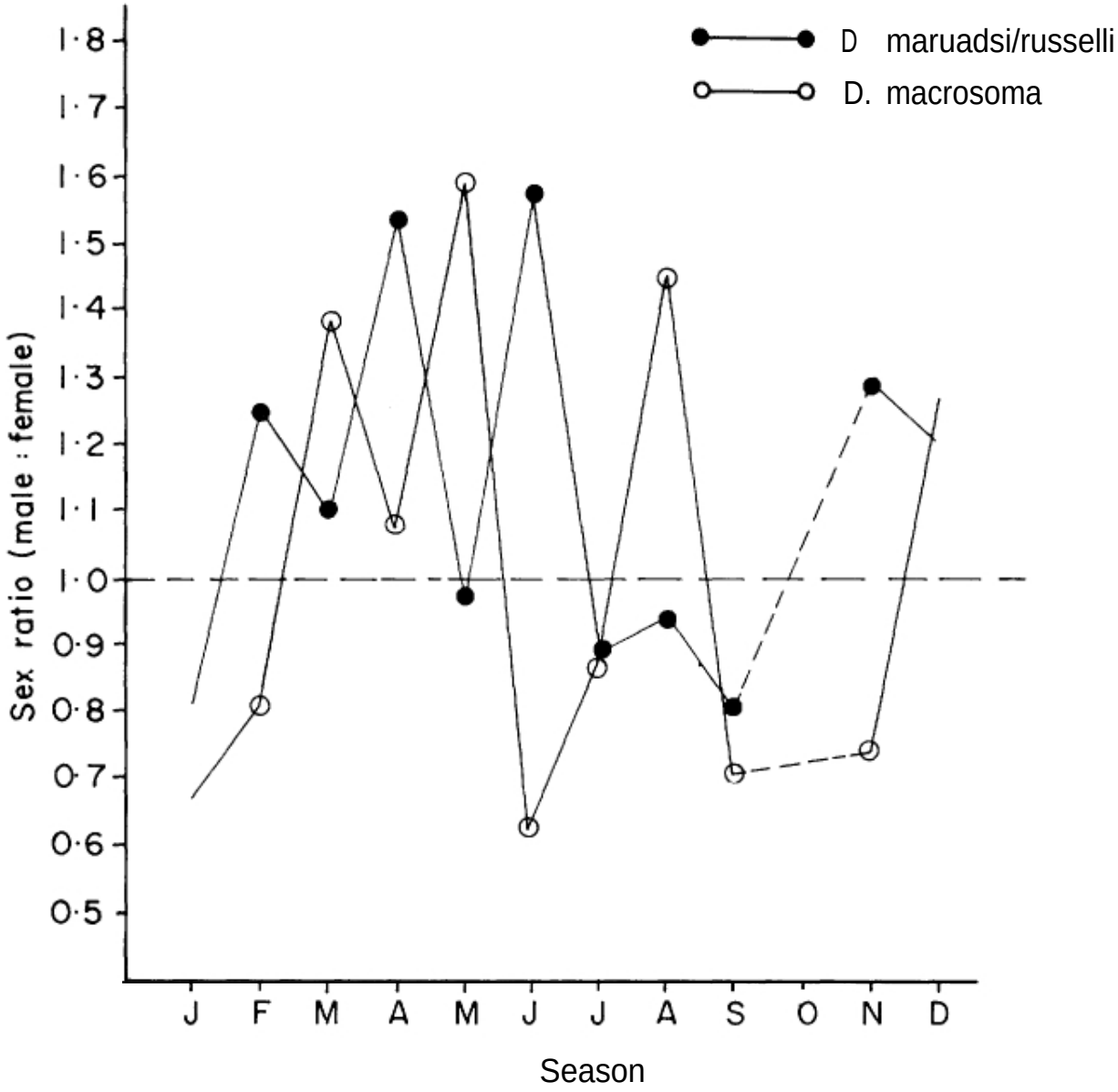

Figure 4. Monthly sex ratio of O. russelli and D. macrosoma on the west coast of Thailand (1985).

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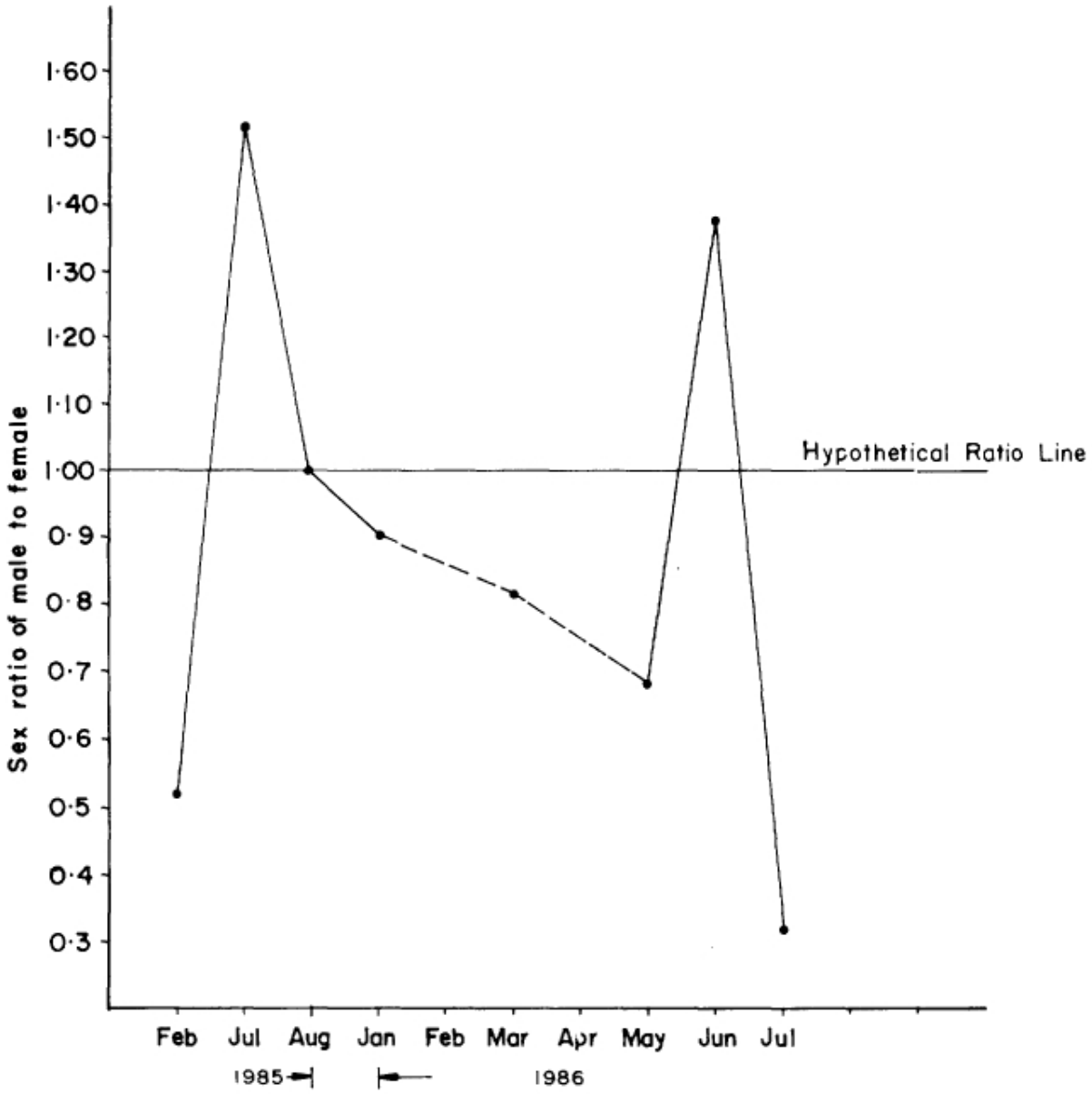

Figure 5. *Sex ratio of* R. brachysoma *from trawl catches in Area II on the west coast of Thailand (1985-1986).*

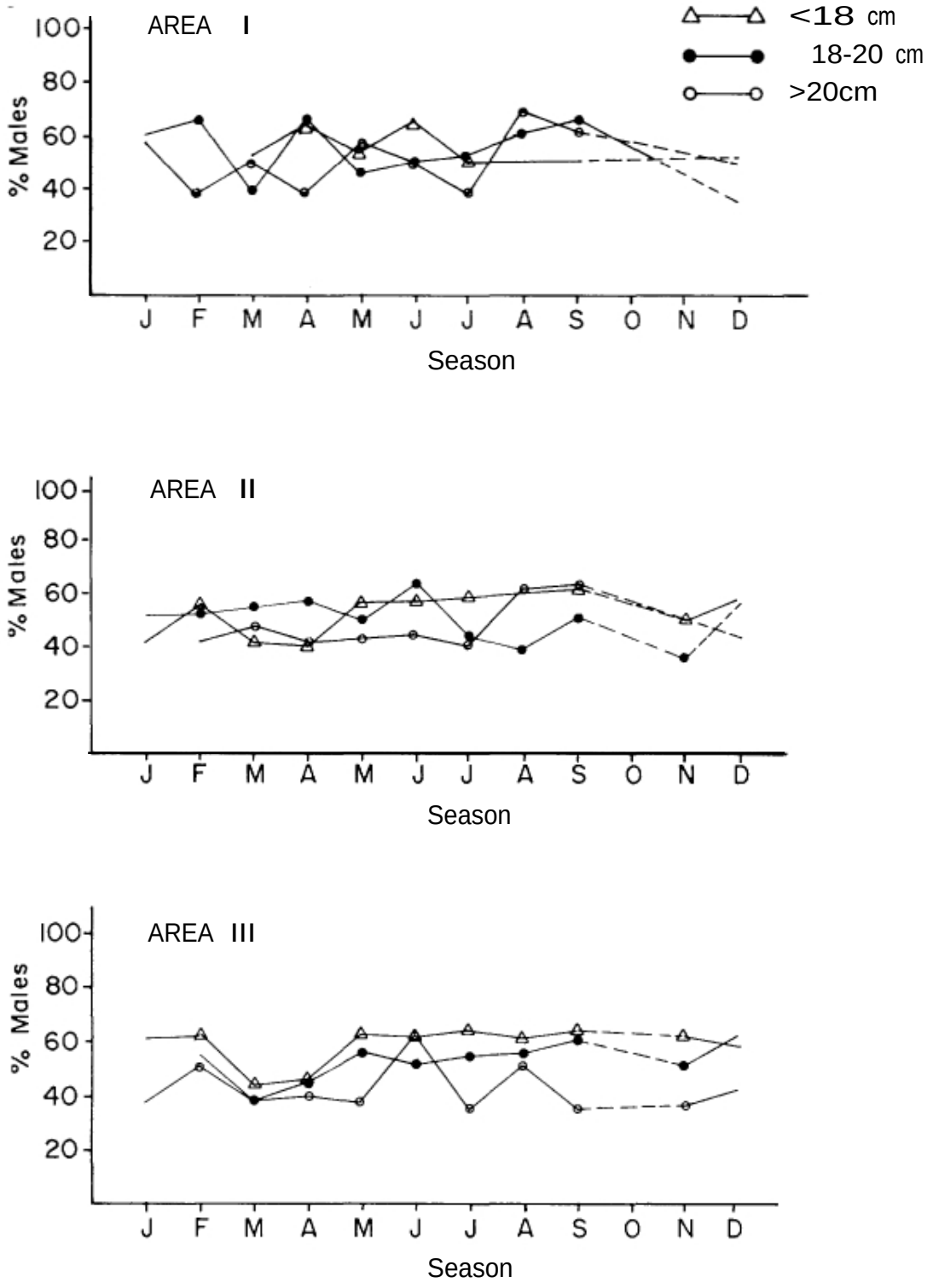

Figure 6. Monthly sex ratio bysize group of R. brachysoma *on the west coast of Thailand(1985).*

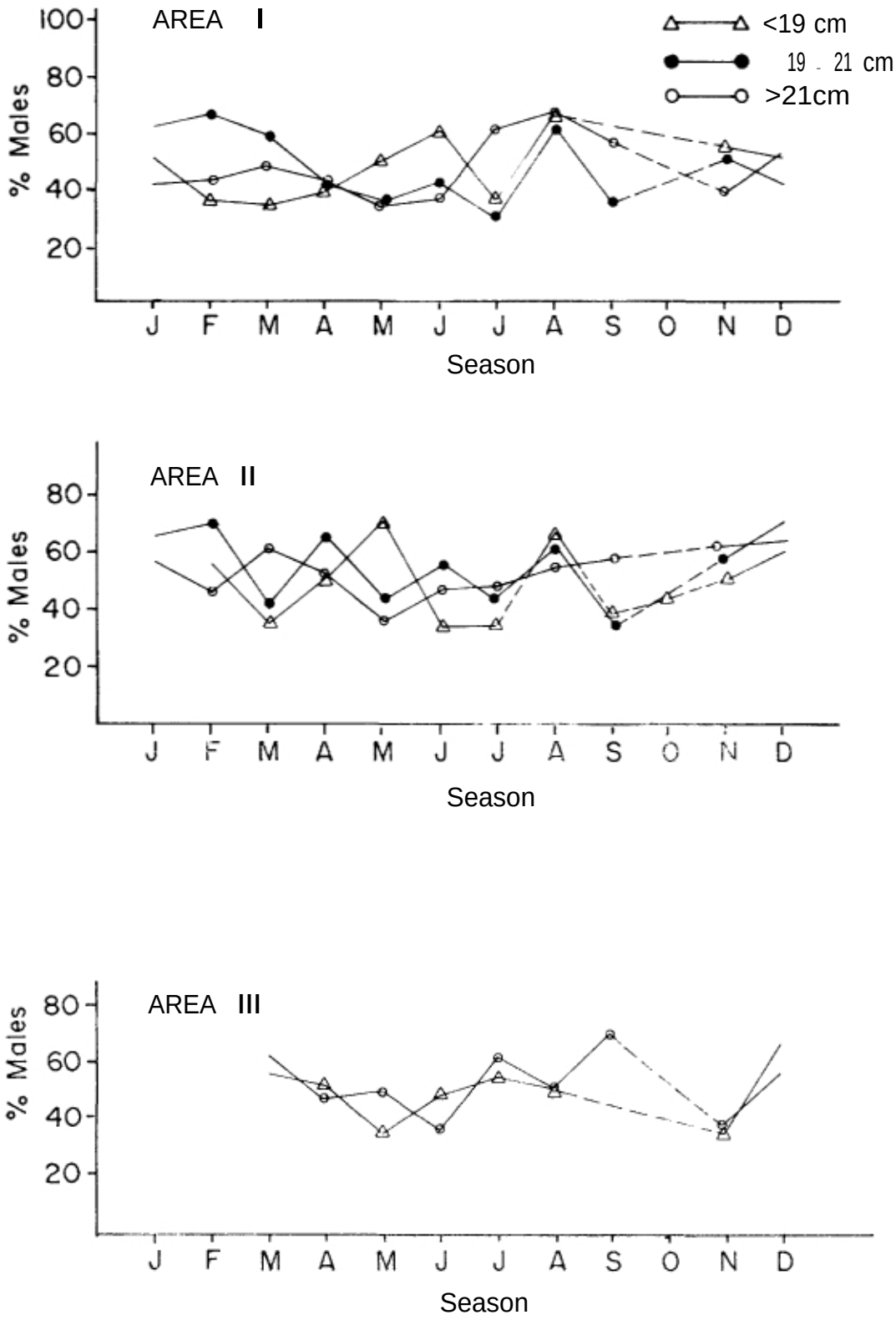

Figure 7. Monthly ratio by size group of R. kanagurta on the west coast of Thailand (1985)

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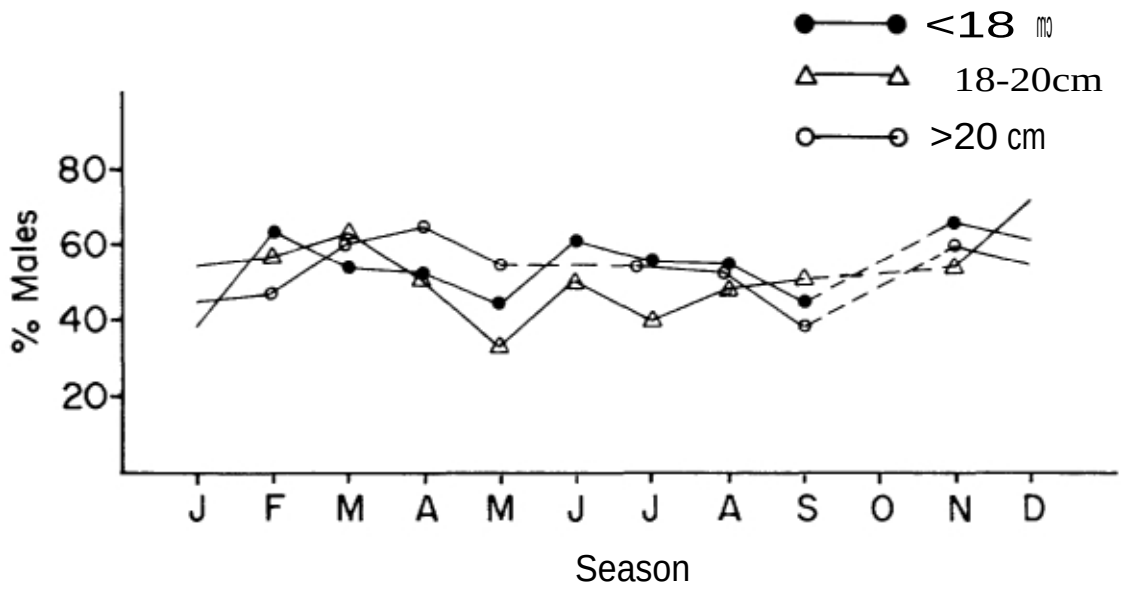

Figure 8. Monthly sex ratio by size group of D. russelli *the west coast of Thailand (1985).*

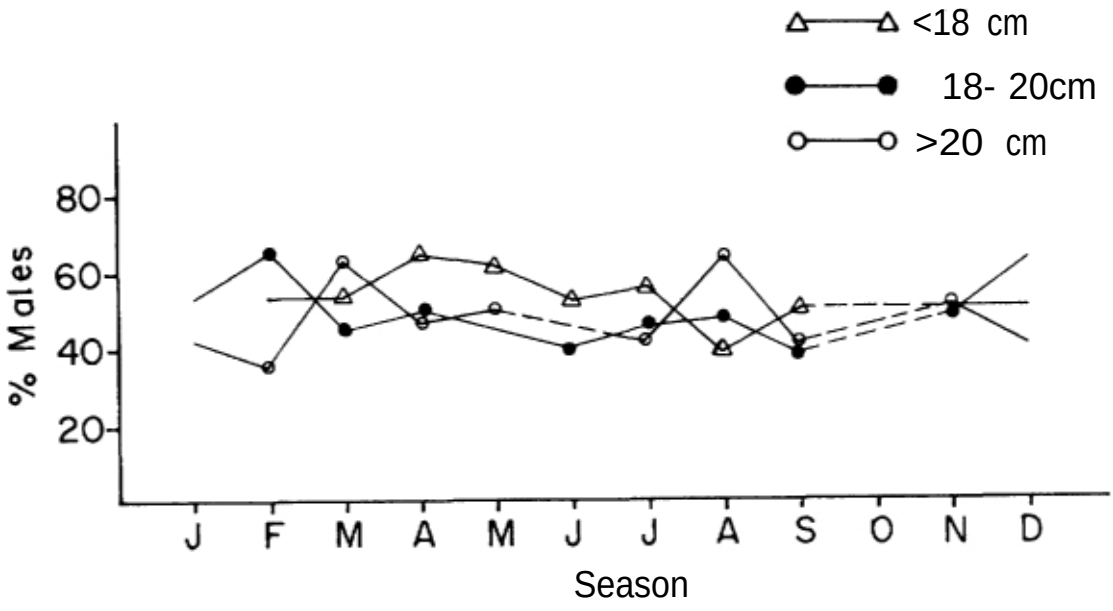

Figure 9. Monthly sex ratio by size group of D. macrosoma *on the west coast of Thailand (1985).*

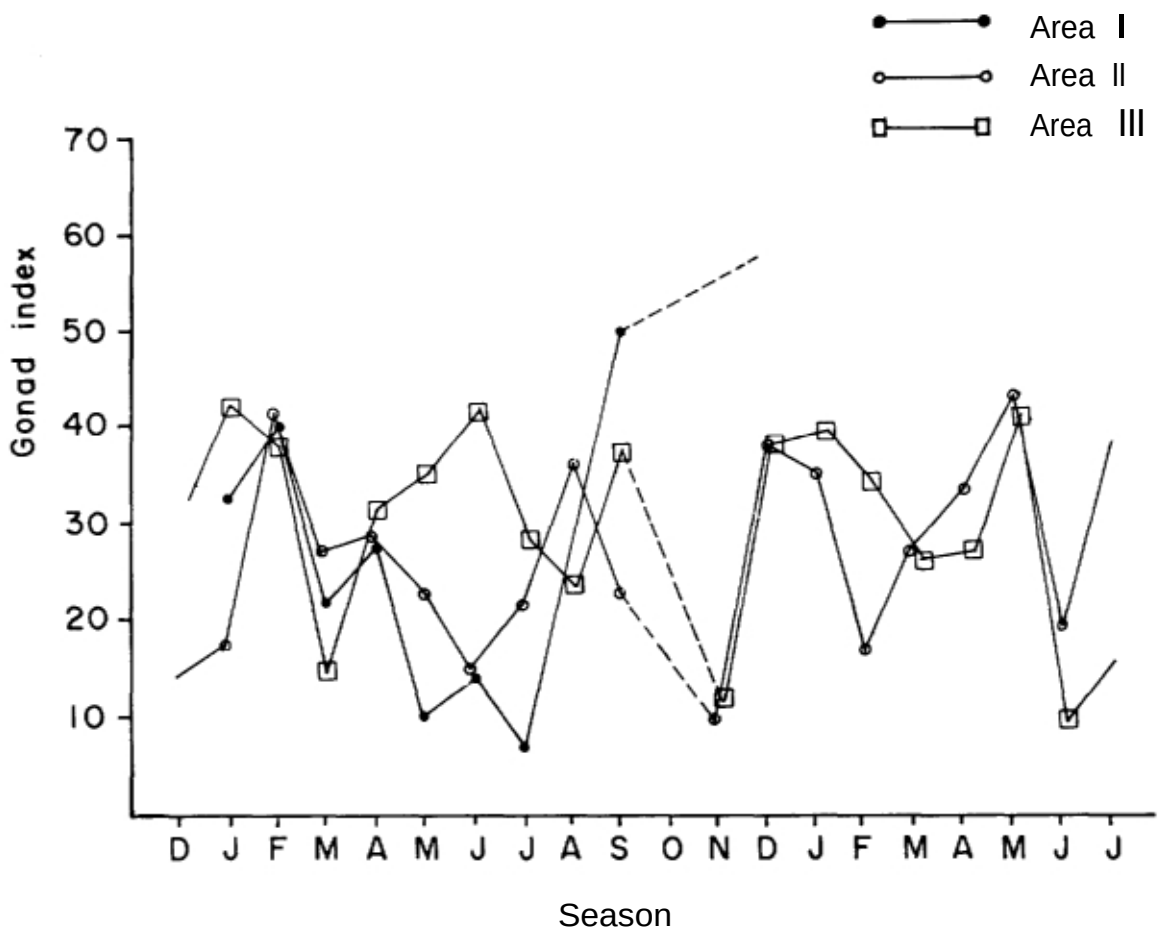

Figure 10. Variation in the mean gonad index of R. brachysoma *on the west coast of Thailand (1985).*

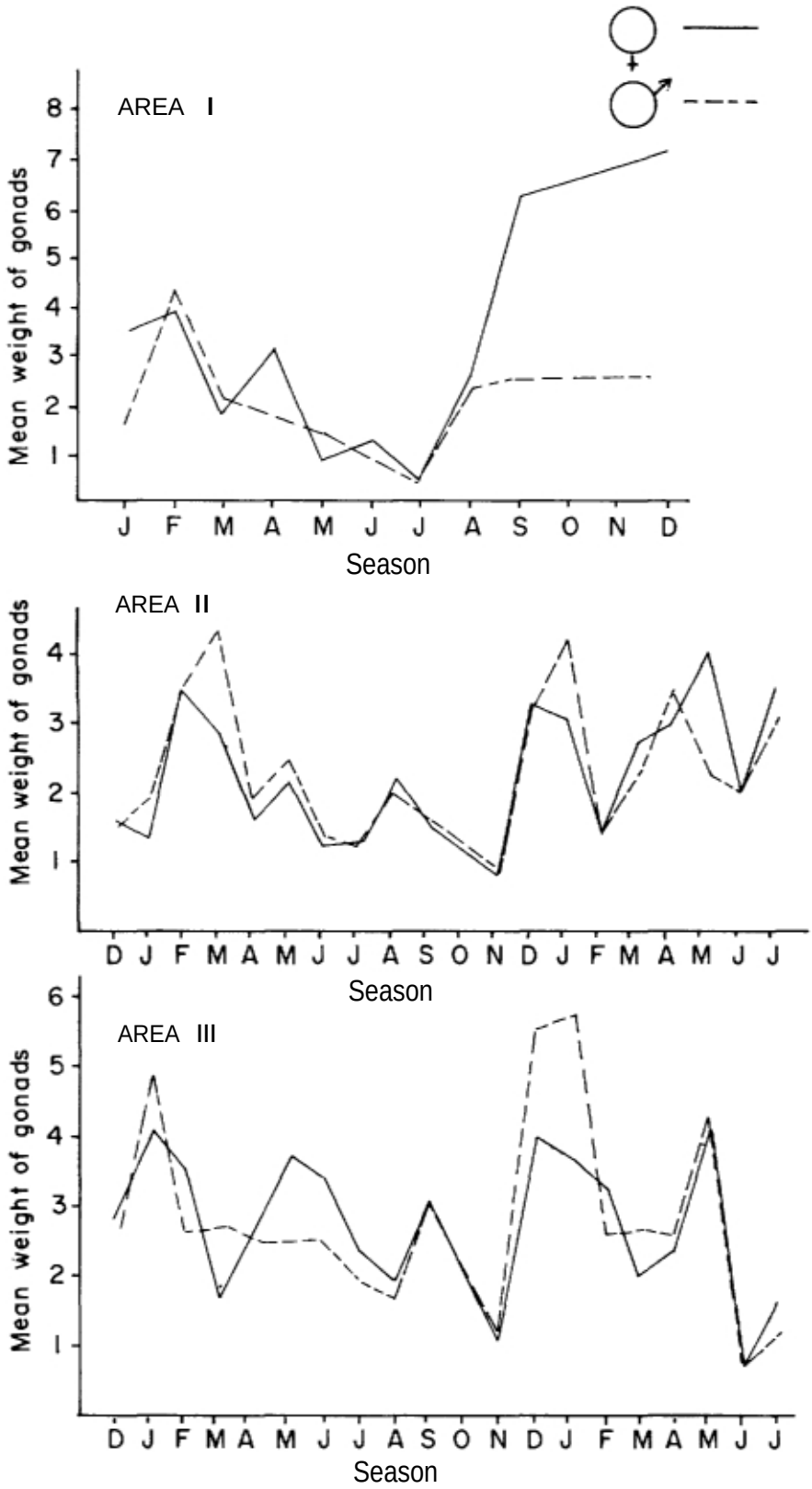

Figure 11. Variation in the mean weight of ovary sacs and sperm sacs of R. brachysoma *on the west coast of Thailand (1985).*

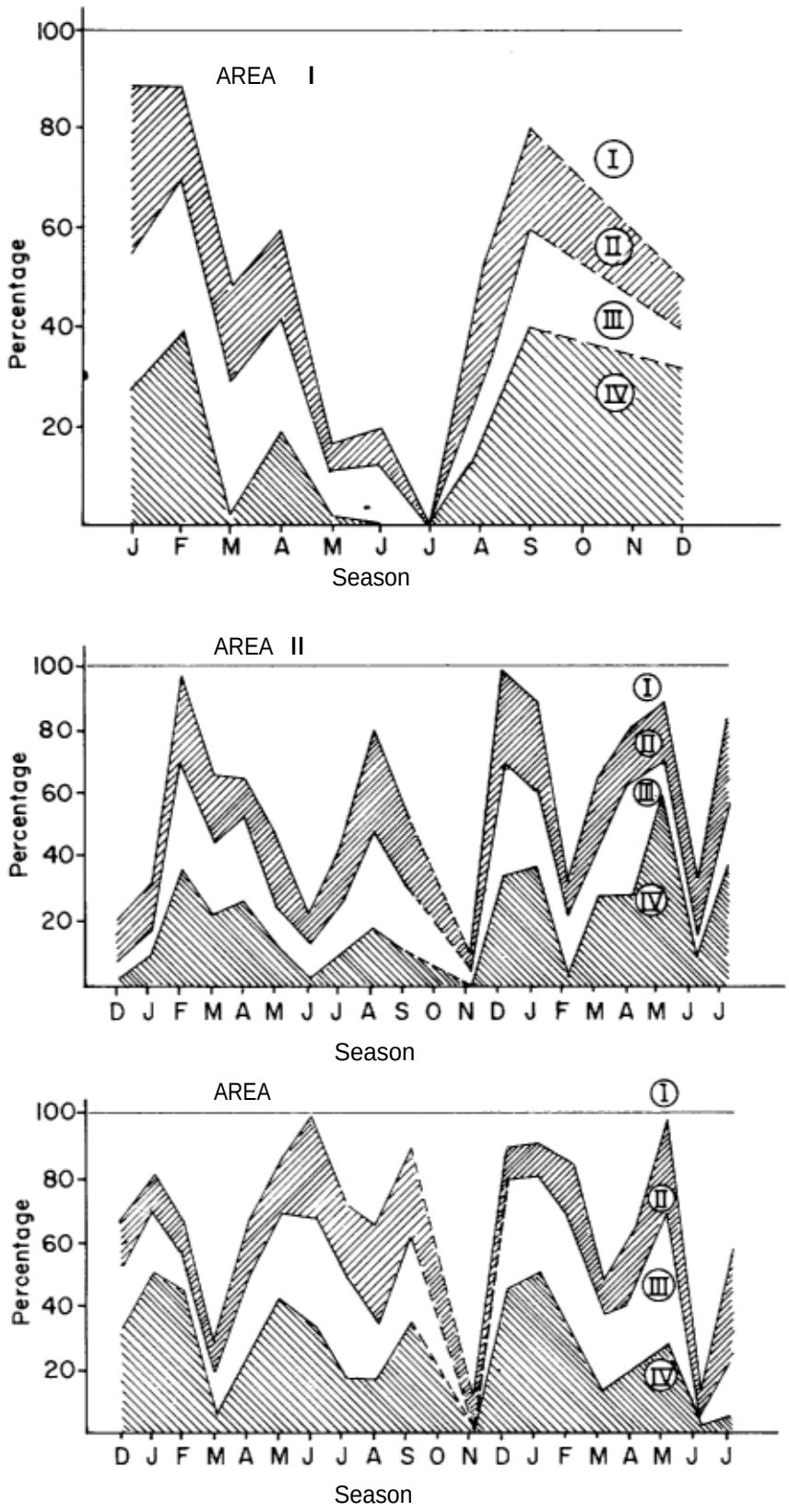

Figure 12. *Variation in thepercentage ofstages ofmaturity of* R. brachysoma *on the west coast of Thailand (1985).*

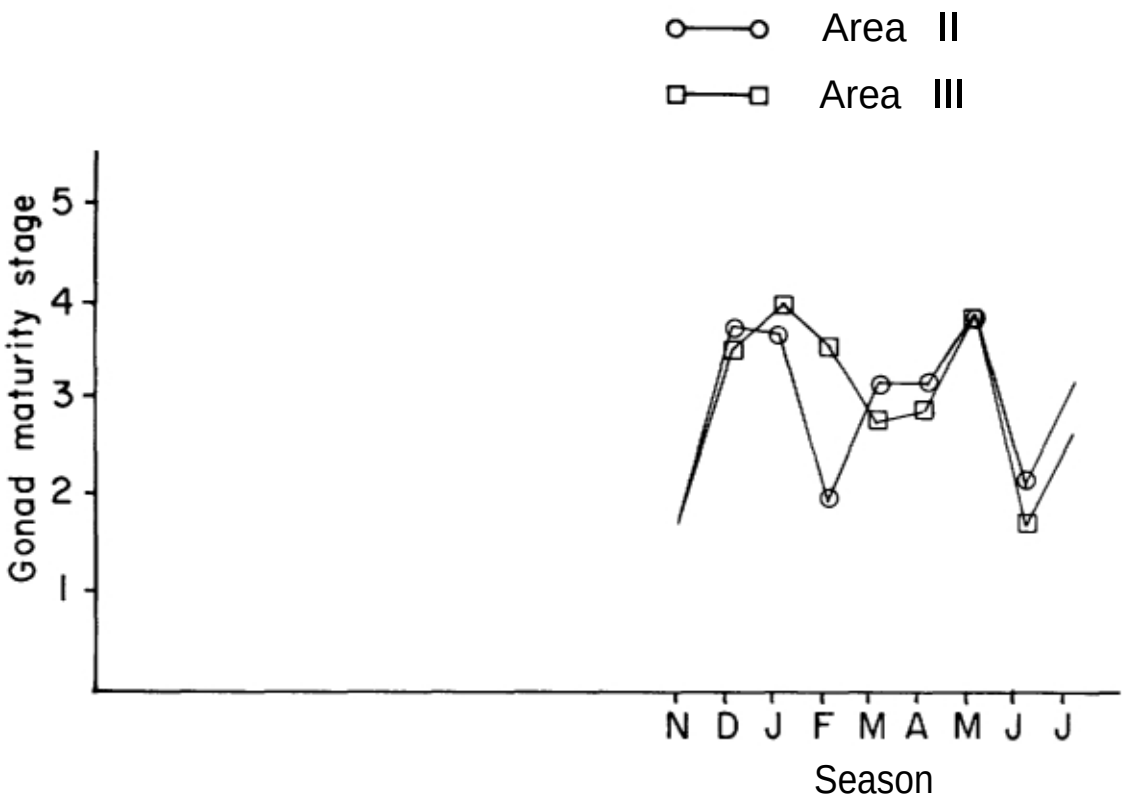

Figure 13. Variation in the mean gonad maturity stages of R. brachysoma *on the west coast of Thai/and (1985).*

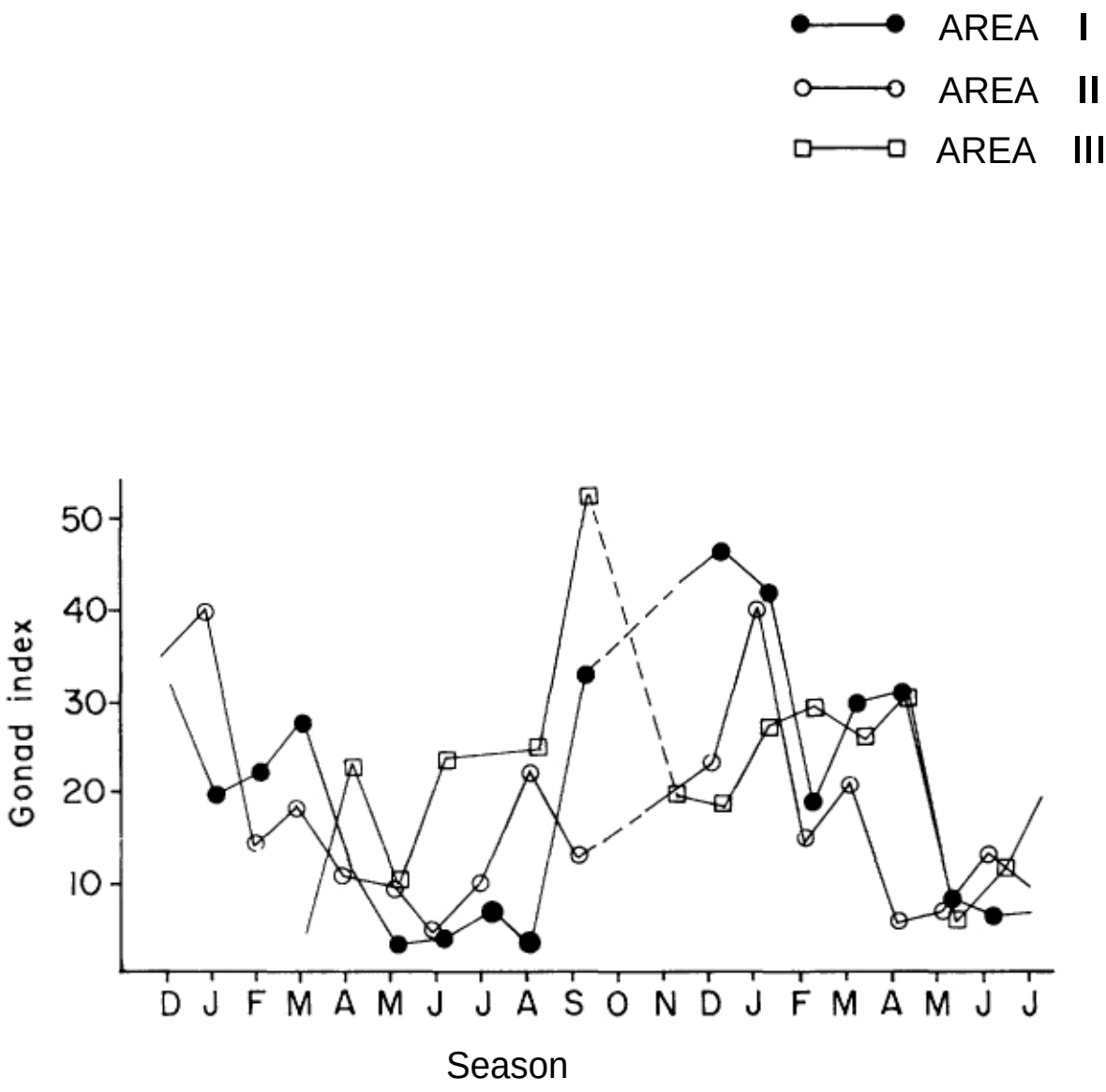

Figure 14. Variation in the mean gonad index of R. kanagurta *on the west coast of Thailand (1985).*

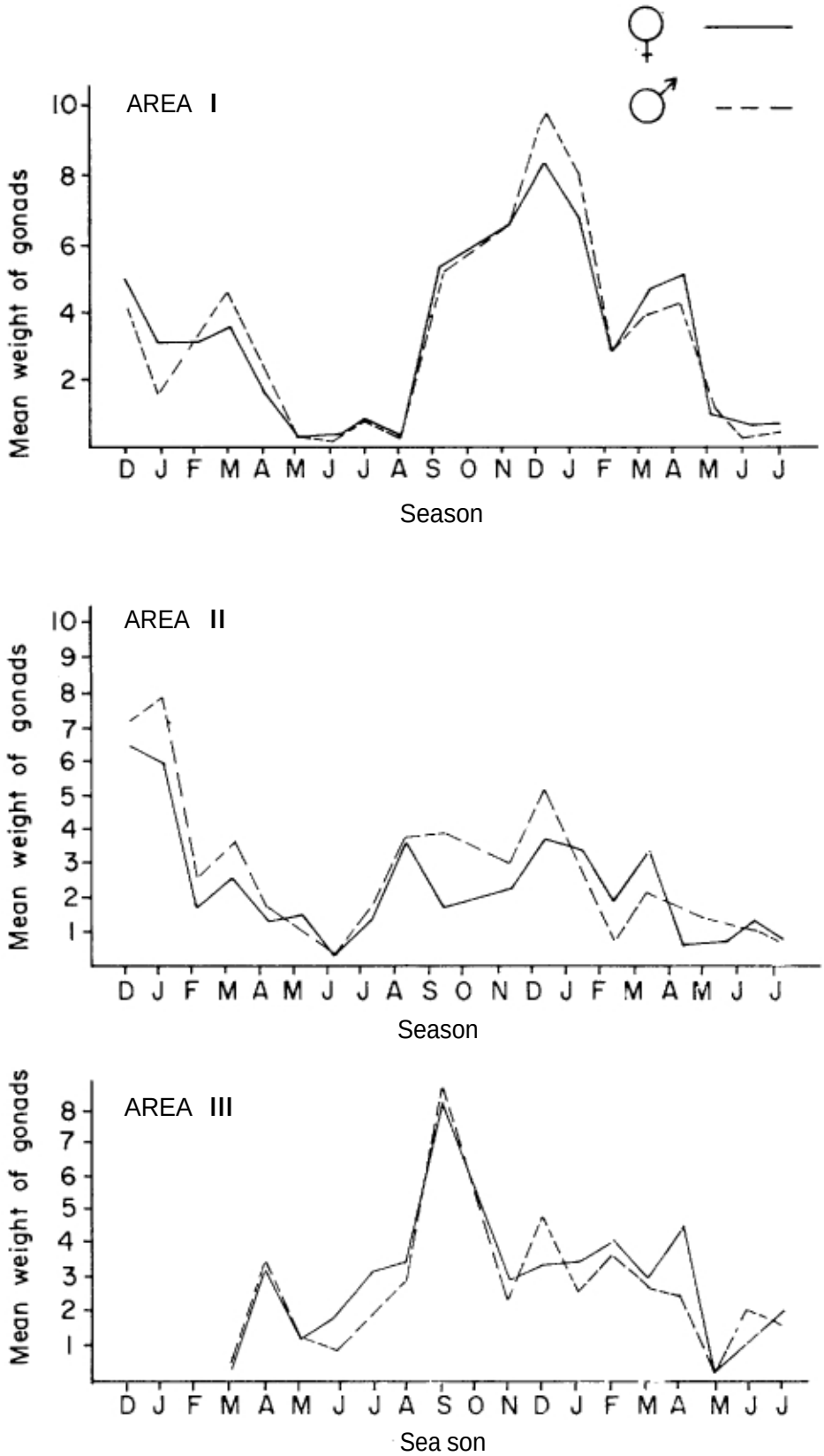

Figure 15. Variation in the mean weight of ovary sacs and sperm sacs of kanagur *on the west coast of Thailand (1985).*

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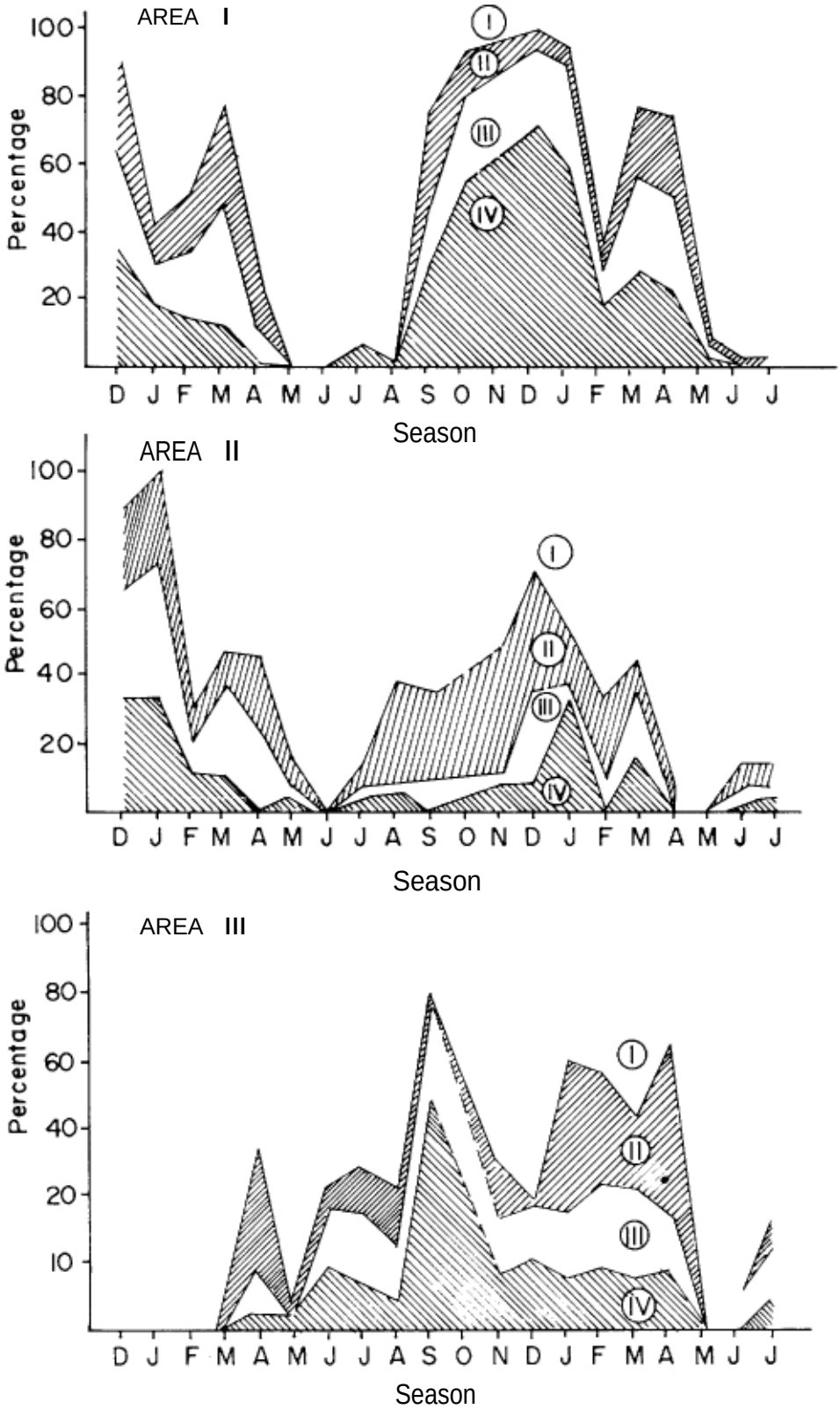


Figure 16. *Variation in the percentage of stages of maturity of* R. kanagurta *on the west coast of Thai/and (1985).*

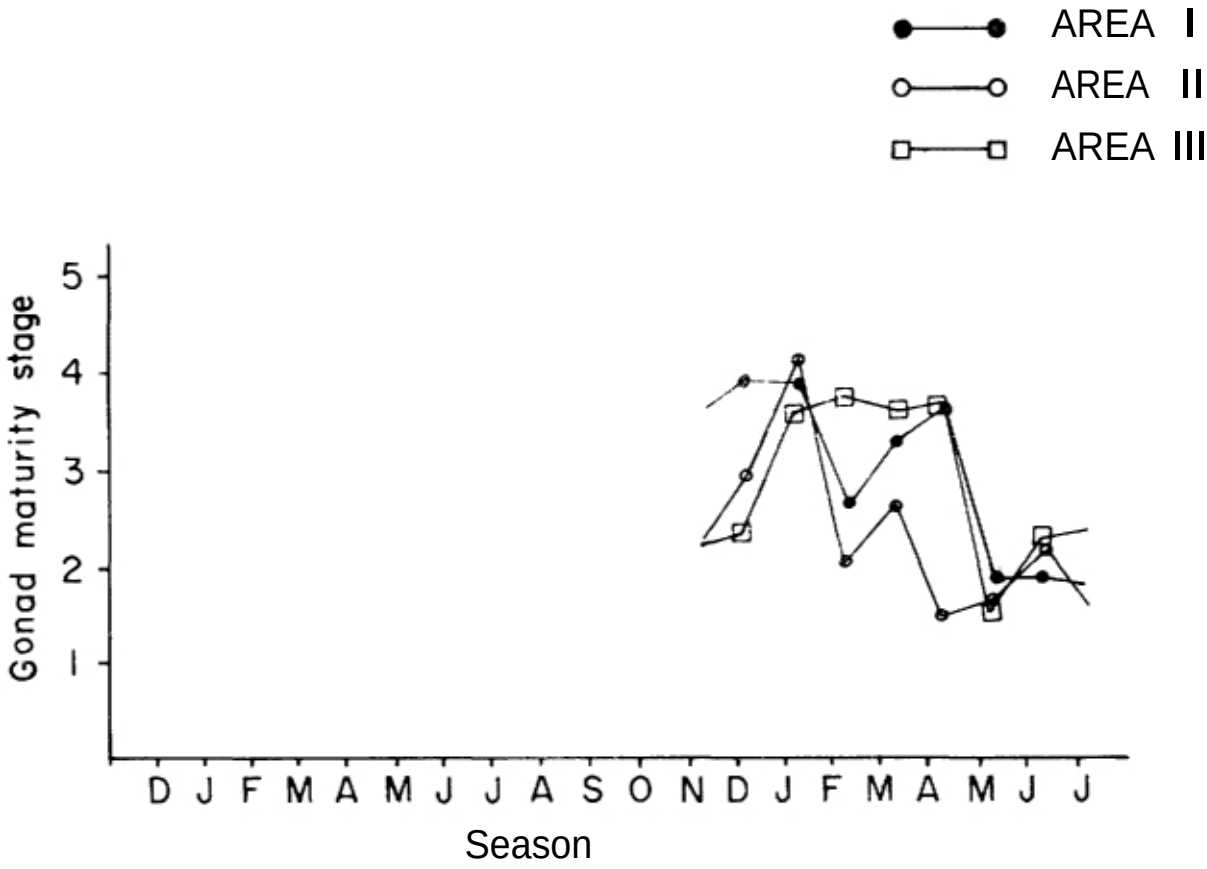


Figure 17. *Variation in the mean gonad maturity stages of R.* kanagurata *on the west coast of Thai/and (1985).*

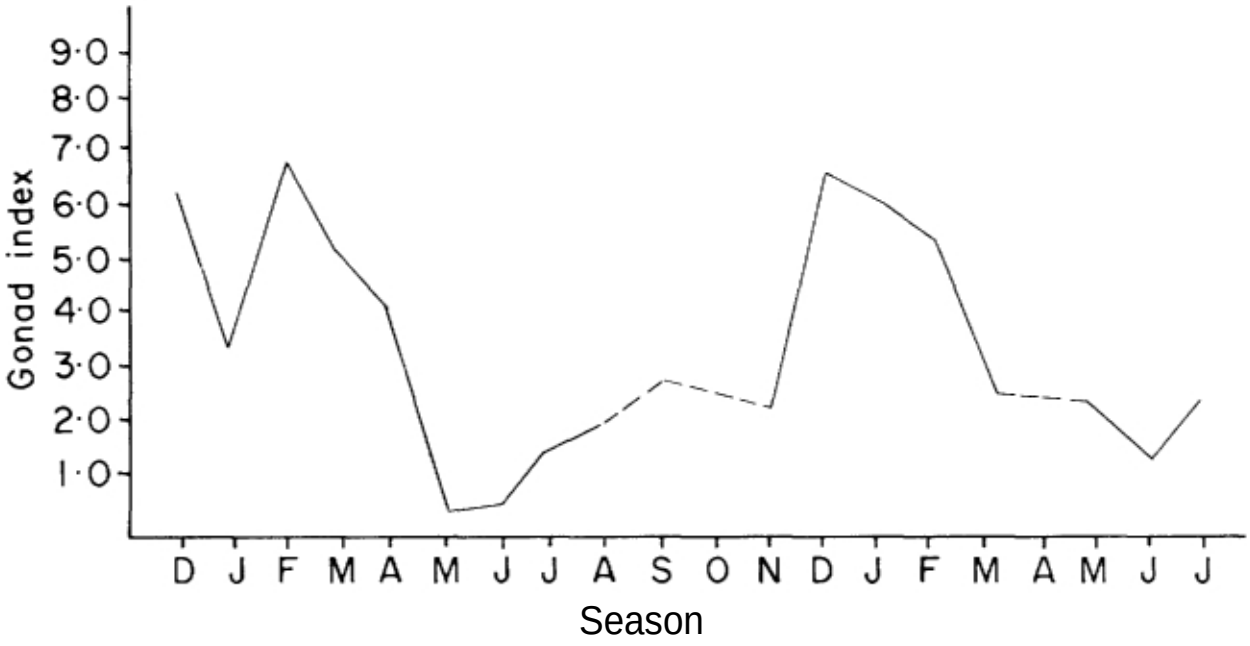


Figure 18a. *Variation in the mean gonad index of* D. macrosoma *on the west coast of Thailand (1984-1986).*

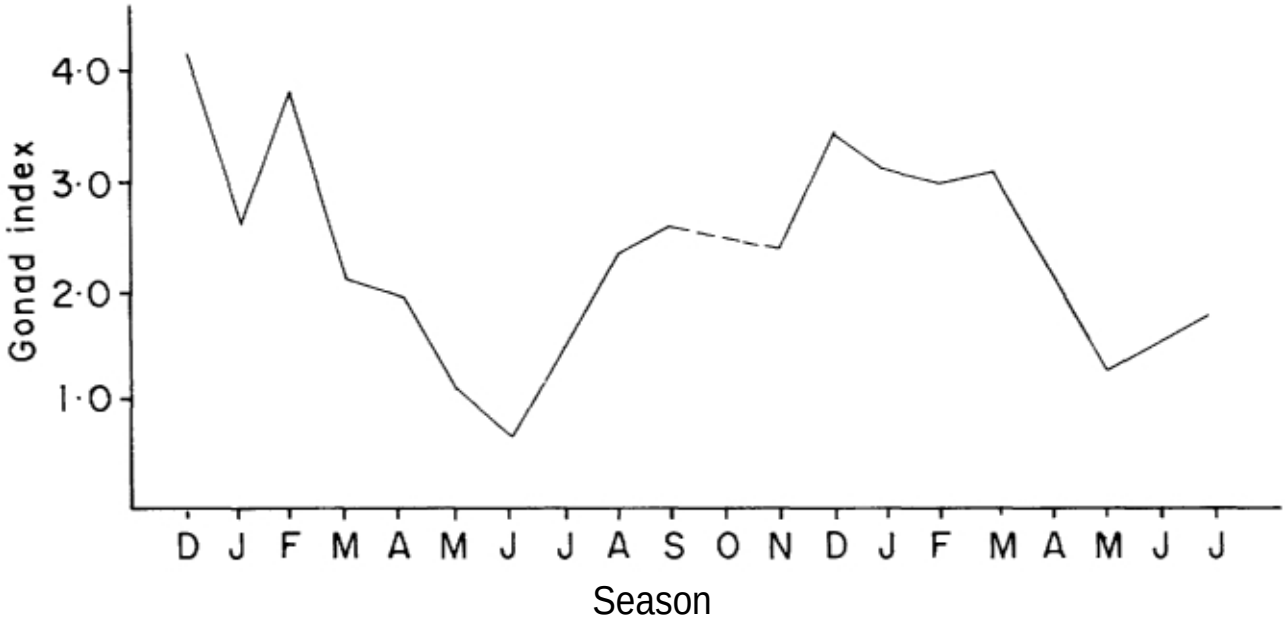


Figure 18b. *Variation in the mean gonad index of D.* russelli *on the west coast of Thailand (1984-1985).*

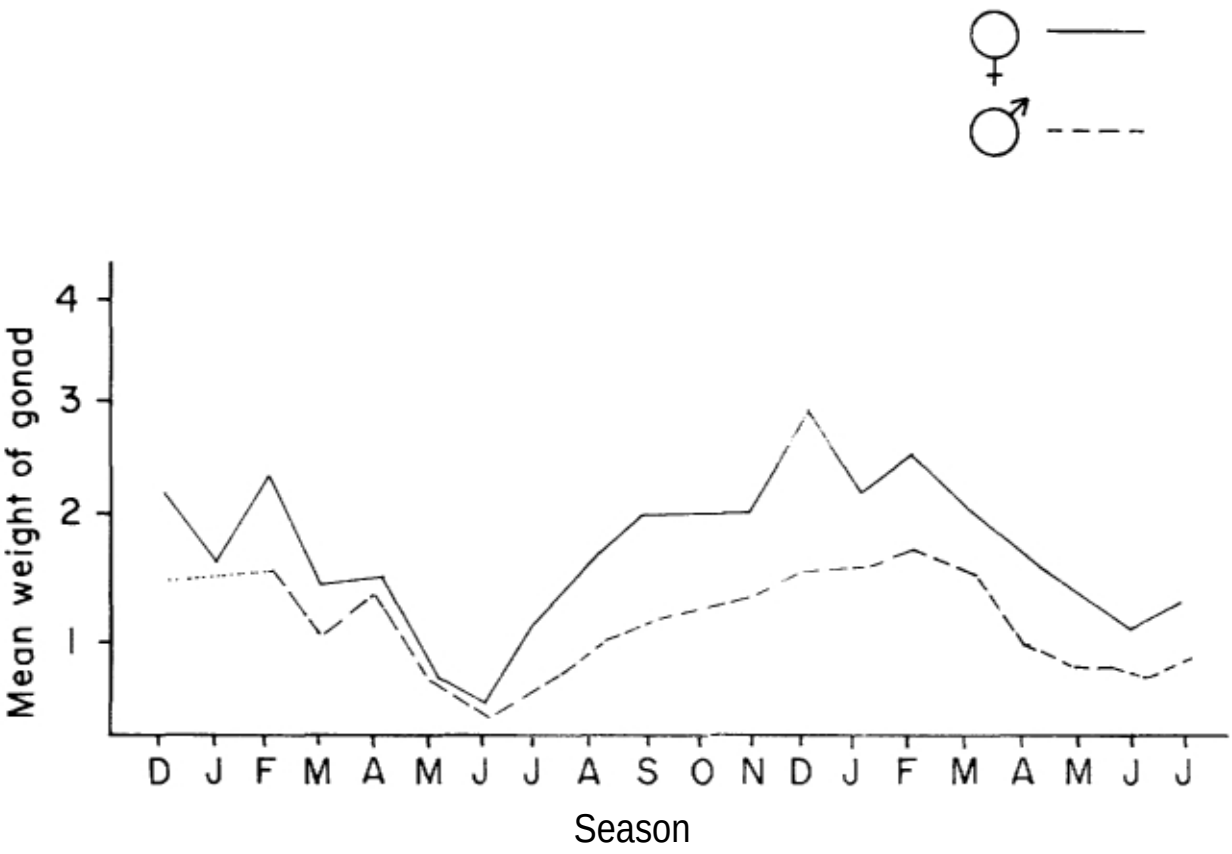


Figure 19a. *Variation in the mean weight of ovary sacs (female) and sperm spacs (male) of* D. russelli *on the west coast of Thailand (1984-1986).*

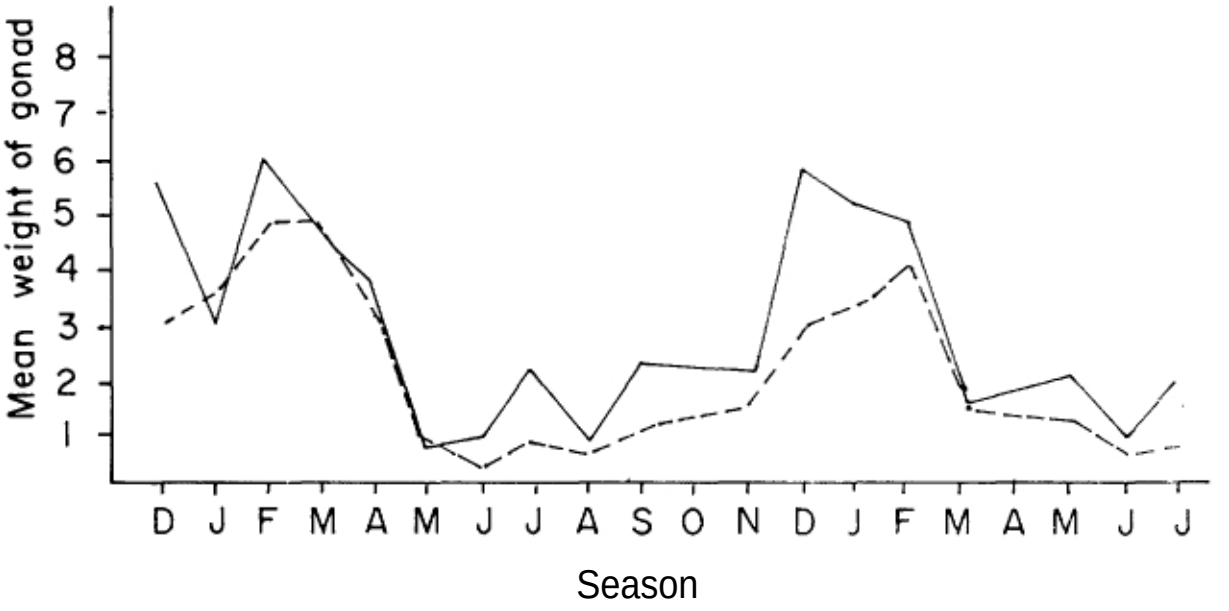


Figure 19b. *Variation in the mean weight of ovary sacs (feiriale) and sperm sacs (male) of* D. macrosoma *on the west coast of Thailand (1984-1986).*

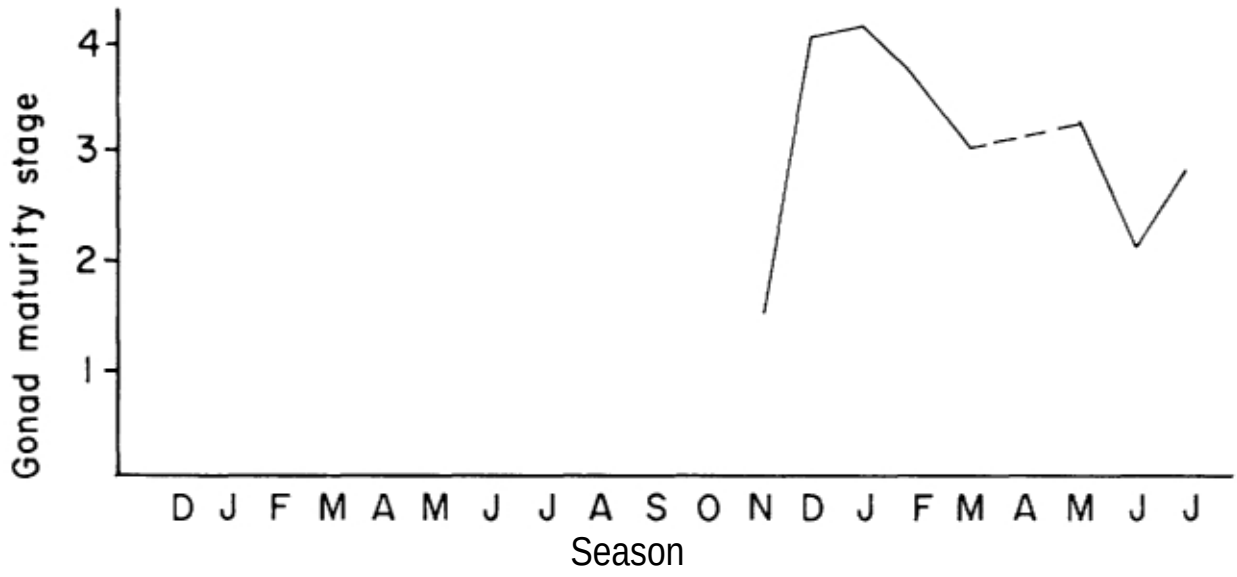


Figure 20a. *Variation in the mean gonad maturity stages of* D. macrosoma *on the west coast of Thailand (1985-1986).*

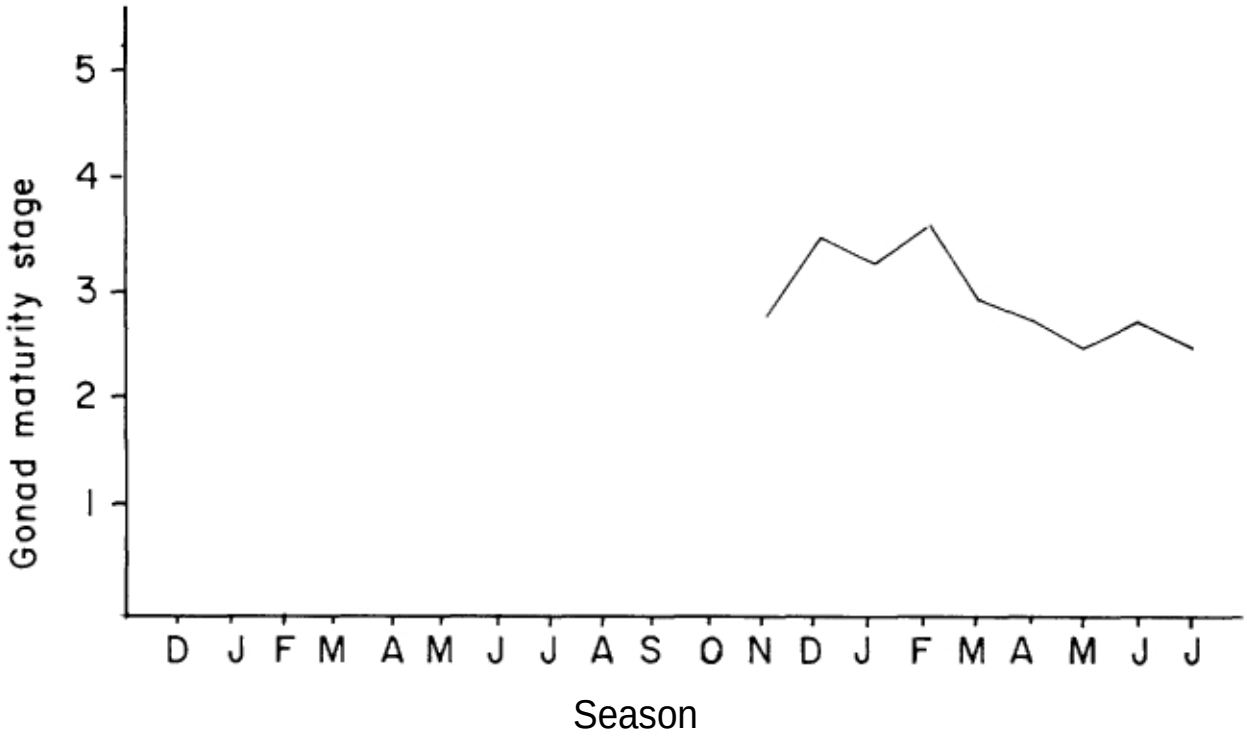


Figure 20b. *Variation in the mean gonad maturity stages of* D. russelli *on the west coast of Thailand (1985-1986).*

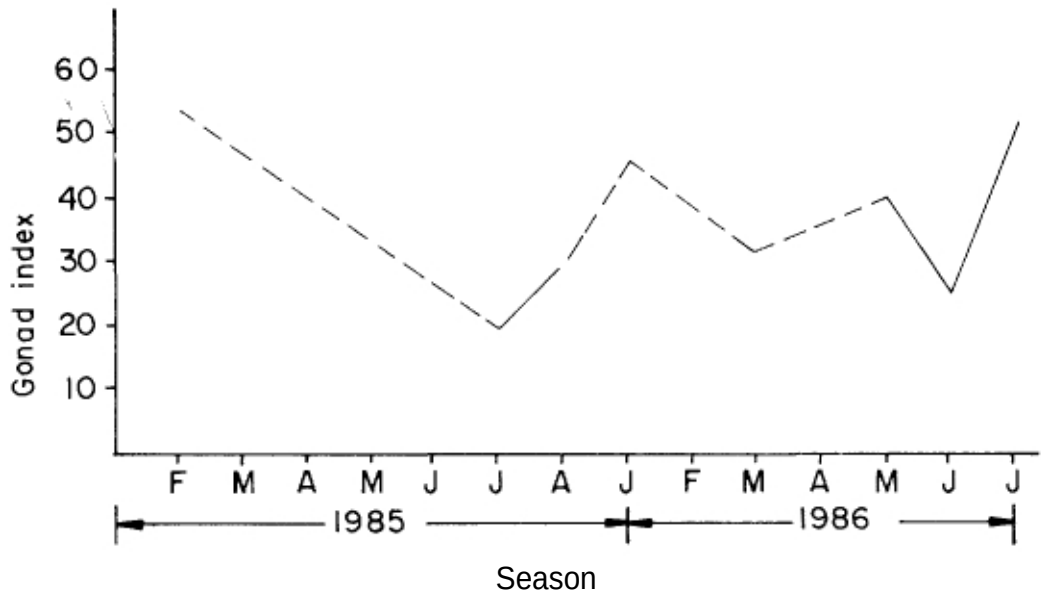


Figure 21. *Variation in the mean gonad index of* R. brachysoma *from trawl catches in Area II on the west coast of Thailand (1985)*

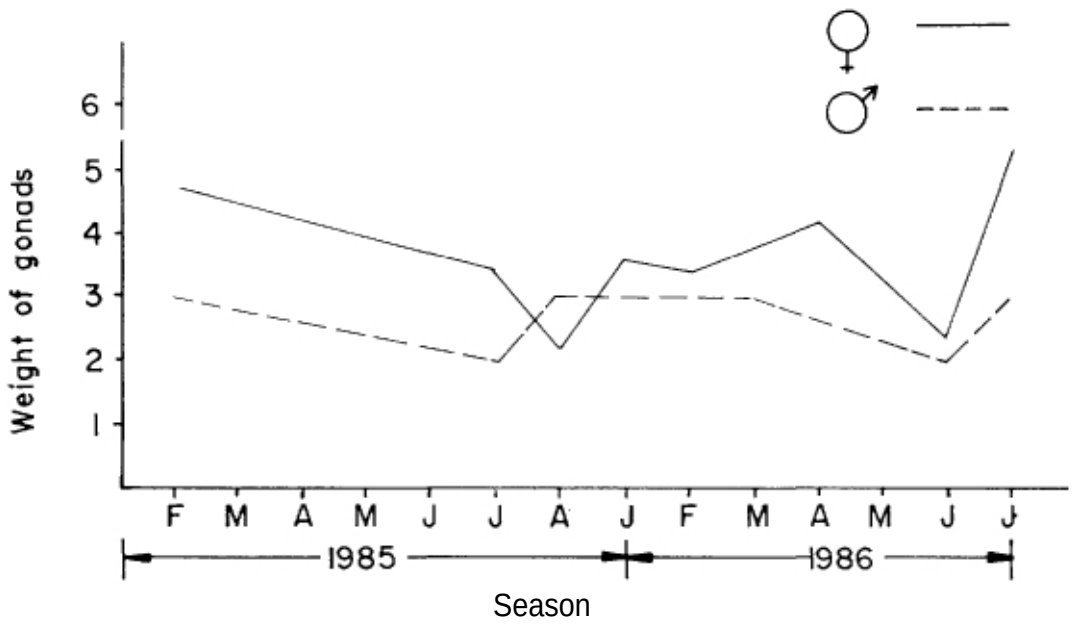
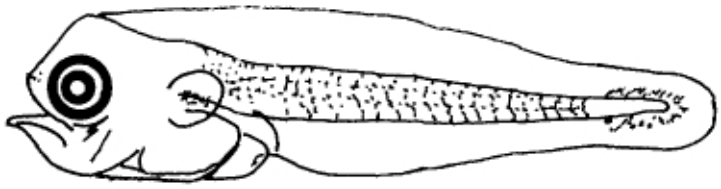
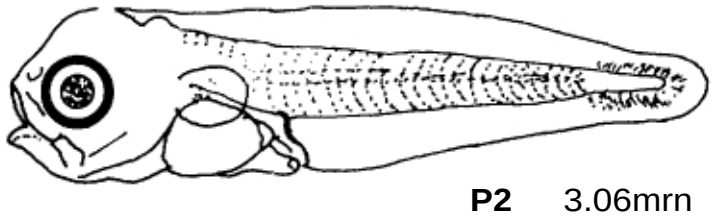


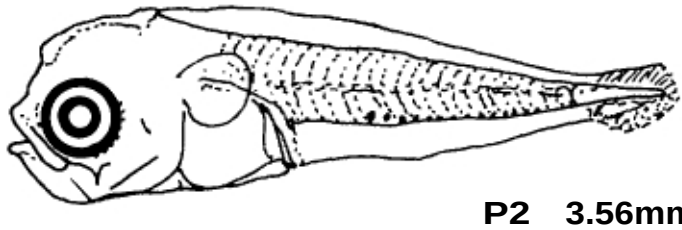
Figure 22. *Variation in the mean weight of ovary sacs (female) and sperm sacs (male) of* R. brachysoma *from trawl catches in area II on the west coast of Thiland (1985).*



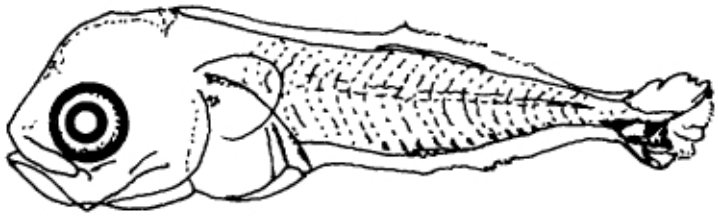
P1 2.42mm



P2 3.06mrn



P2 3.56mm



P3 4.17mm

Figure 23. *Postlarval stages of* Rastrelliger *spp. caught during egg and larval surveys on the west coast of Thailand in 1985.*

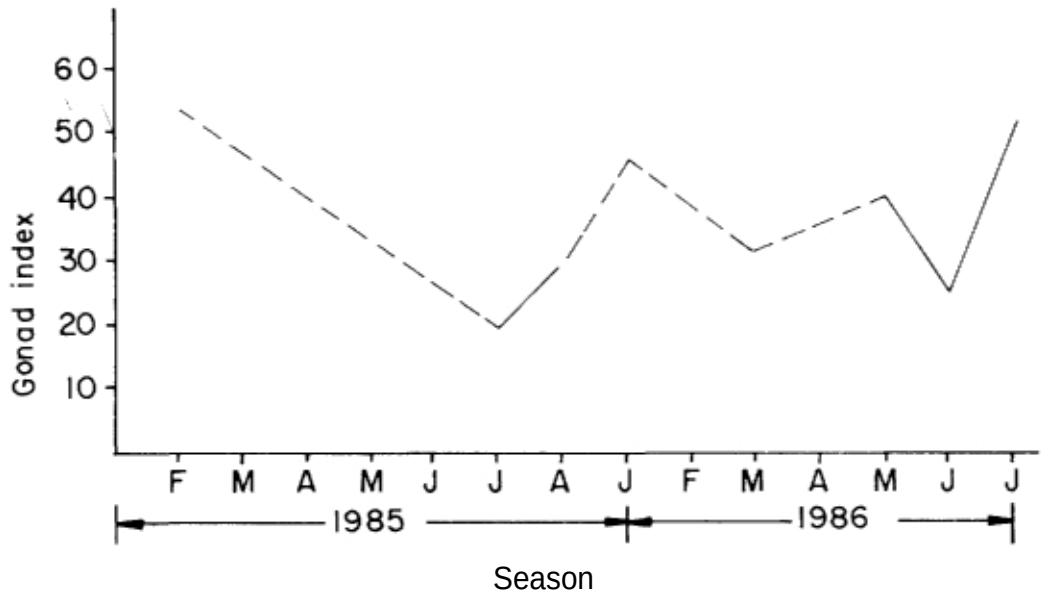


Figure 21. *Variation in the mean gonad index of* R. brachysoma *from trawl catches in Area II on the west coast of Thailand (1985).*

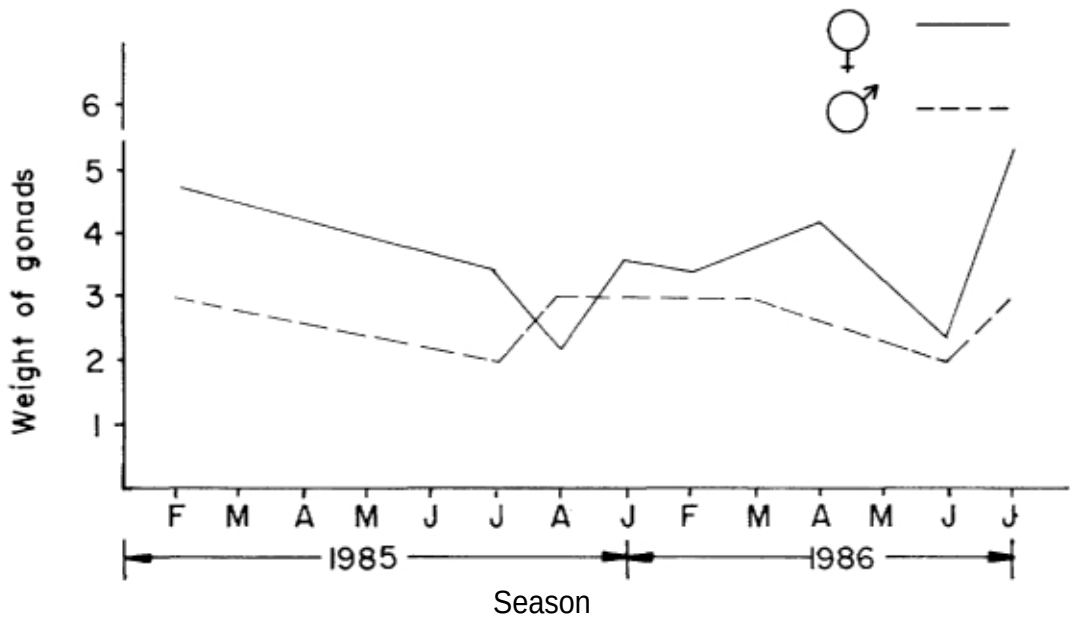
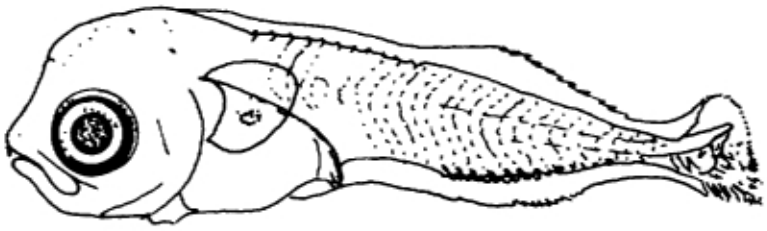
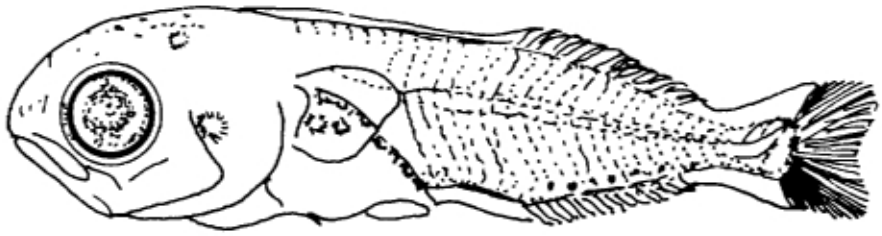


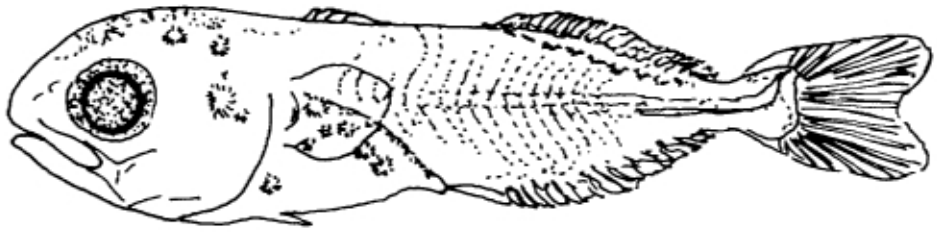
Figure 22. *Variation in the mean weight of ovary sacs (female) and sperm sacs (male) of* R. brachysoma *from trawl catches in area II on the west coast of Thiland (1985).*



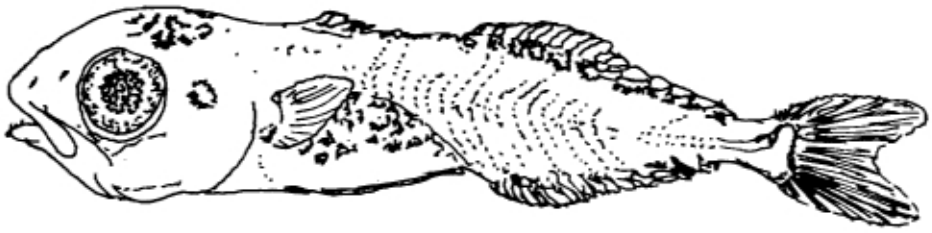
P3 **4.71mm**



P4 6.67mm



P4 8.00mm



P4 11.80 mm

Figure 24. *Postlarval stages of* Rastrelliger *spp. caught during egg and larval surveys on the west coast of Thailand in 1985 (after Boonprakob et al, 1971).*

Figure 25. *The area covered by egg and larval surveys along the west coast of Thailand March-July 1985 (grids of 25 NM^2).*

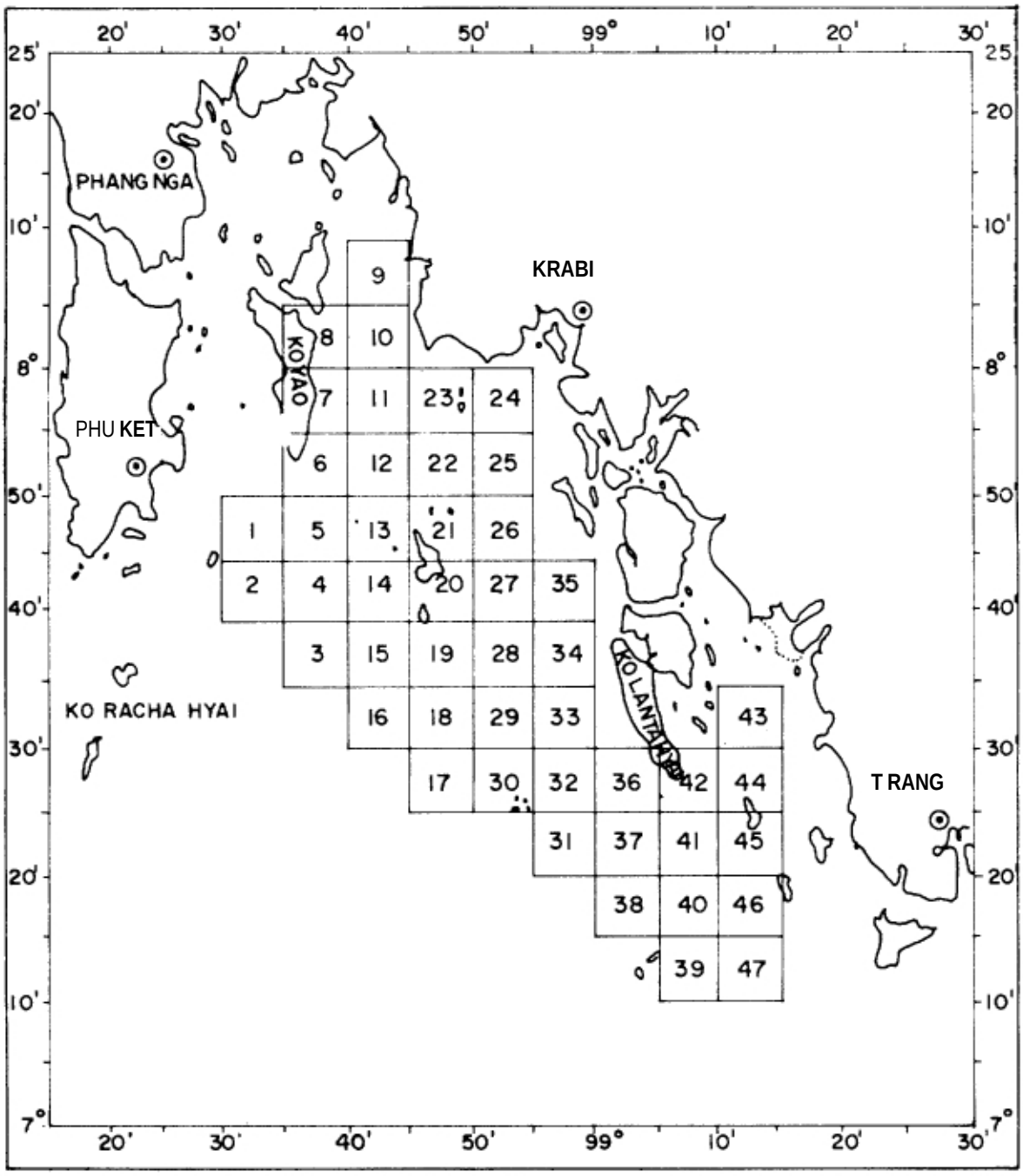


Figure 26. Occurrence of Rastrelliger spp. larvae (per 1000 NM^3) from oblique hauls of plankton nets during egg and larval surveys on the west coast of Thailand in 1985.

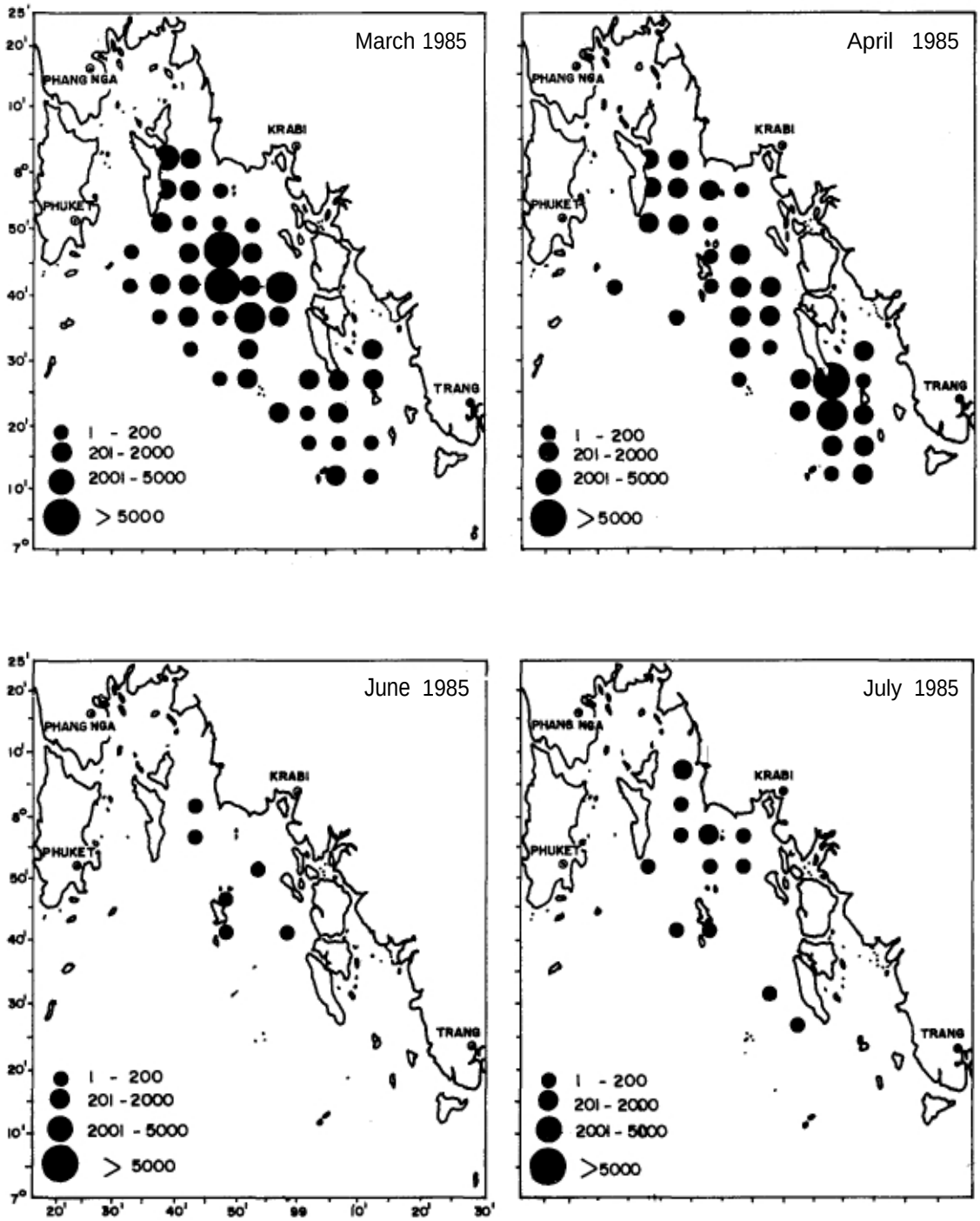


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Figure 27. Occurrence of Rastrelliger spp. larvae (per 1000 NM^3) from oblique hauls of larvae nets during egg and larval surveys on the west coast of Thailand in 1985.

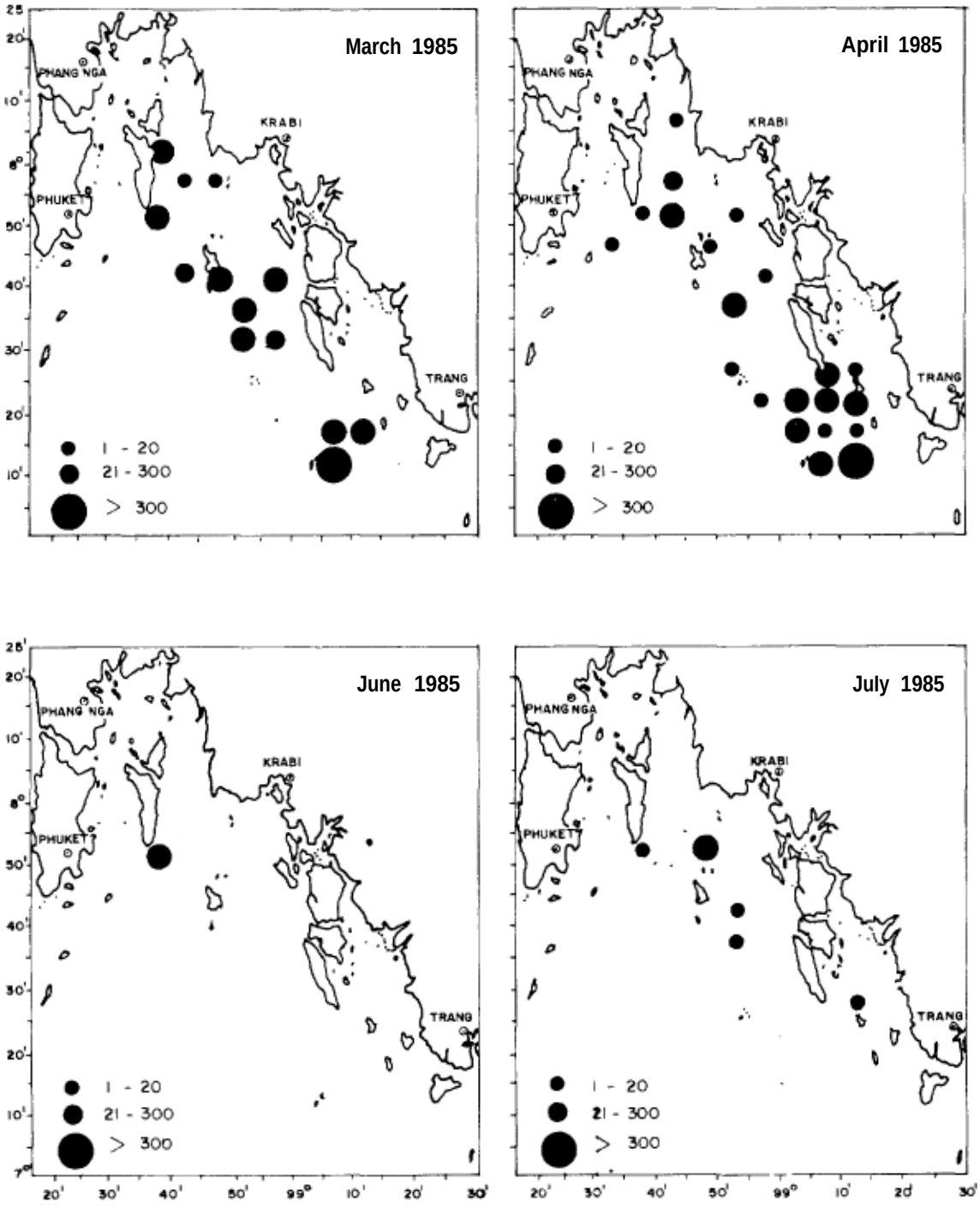


Figure 28. The area covered by egg and larval surveys along the west coast of Thailand. February-April 1986 (grids of 220 NM^2), and the occurrence of Rastrelliger spp. larvae (per 1000 NM^3) from oblique hauls of plankton nets during these surveys.

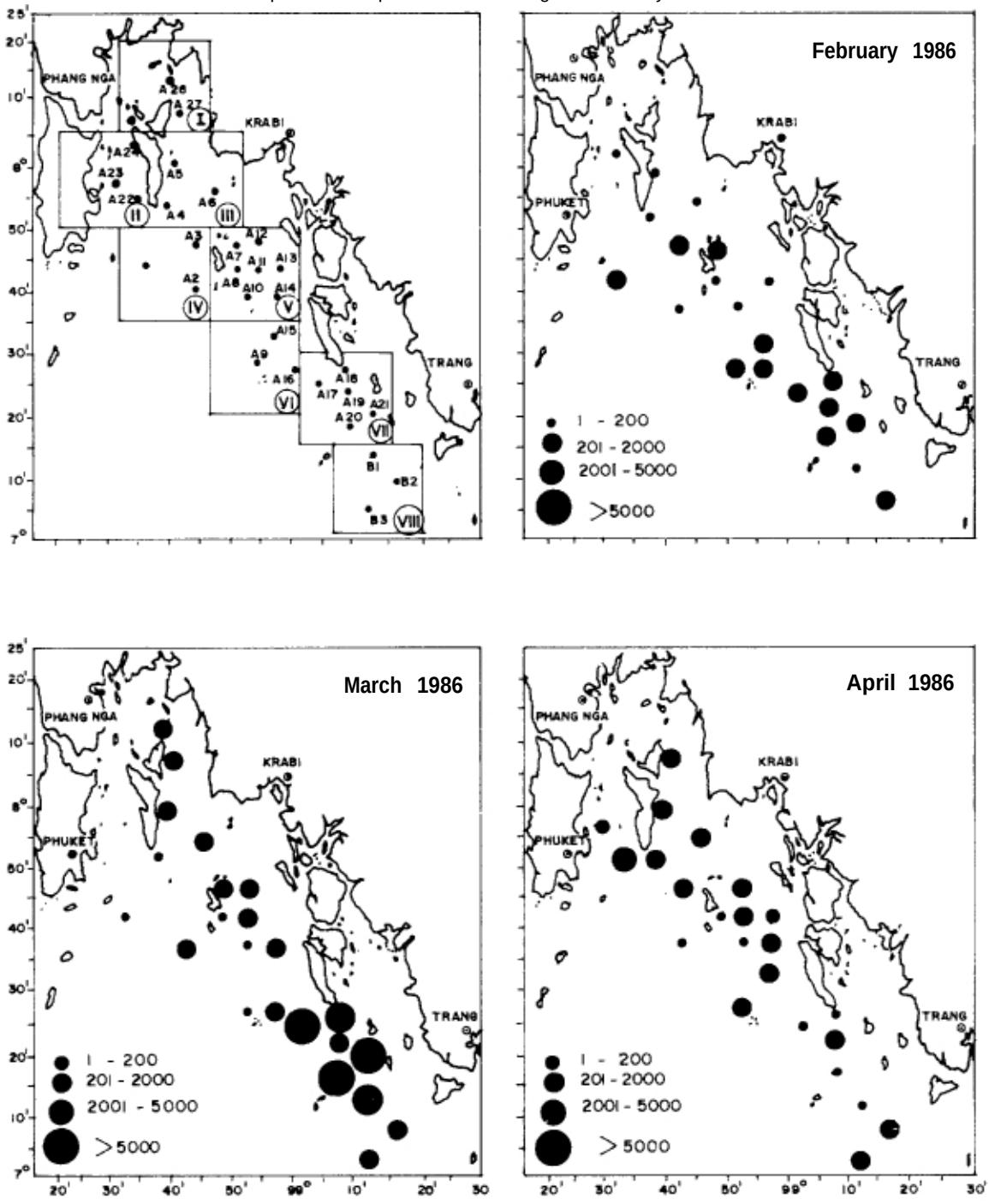
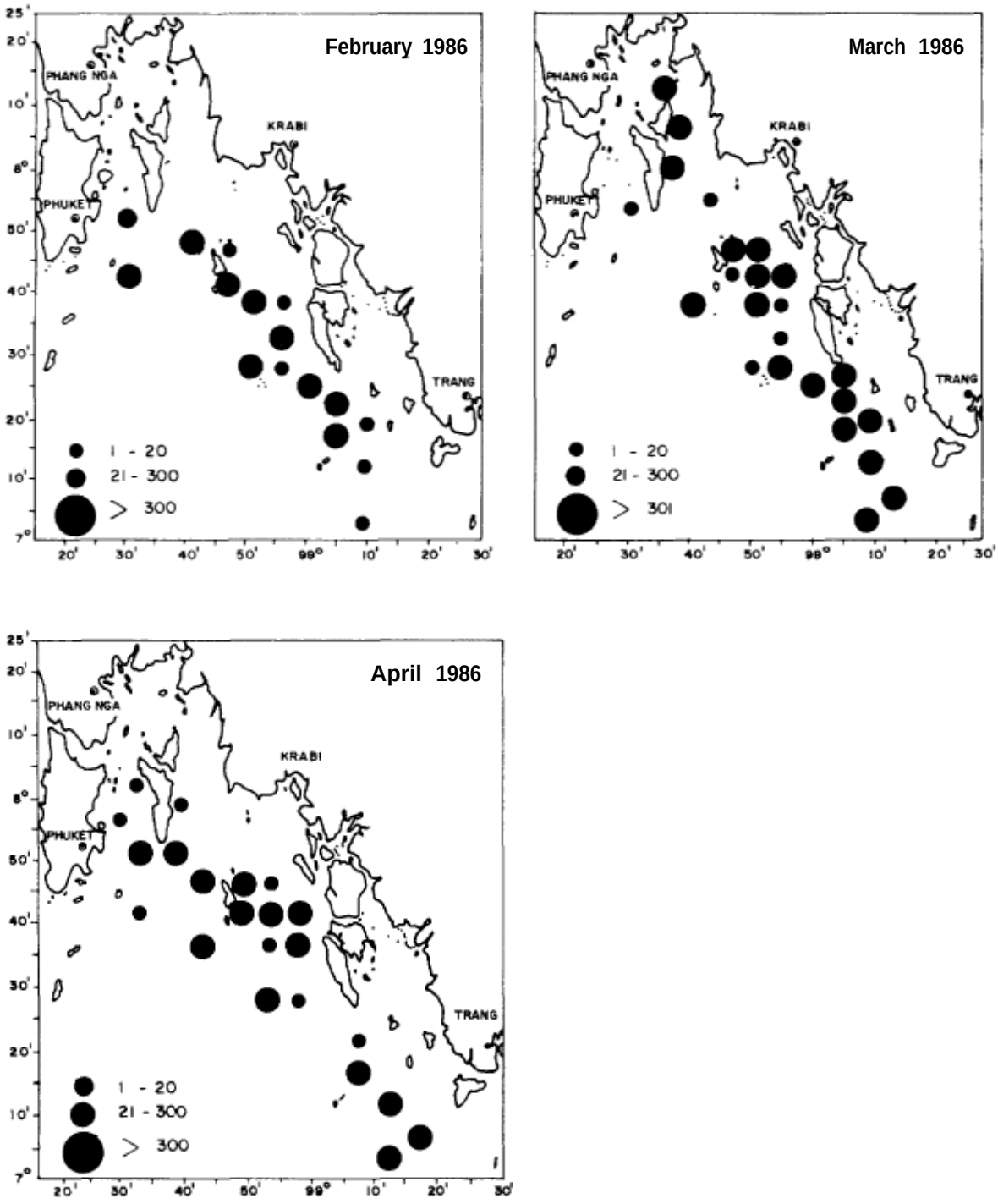


Figure 29. *Occurrence of* Rastrelliger *spp. larvae from oblique hauls of plankton nets during egg and larval surveys on the west coast of Thailand in 1986.*



Annexure 3

ON THE STATUS OF THE *RASTRELLIGER AND DECAPTERUS* FISHERIES OF THE WEST COAST OF PENINSULAR MALAYSIA IN 1984.1985.

by Mansor Mat Isa

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1. Introduction

It is well known that the mackerel is the most important fishery resource on the west coast of Peninsular Malaysia in Malaysia. In the first meeting of the working group on mackerels in Penang (1983) organised by the BOBP, the maximum sustainable yields (MSY) of Rastrelliger spp. and Decapterus spp. were estimated at 21,000 and 5,800 tonnes respectively (Chee 1984).

Following the recommendations made by the working group at its first meeting, biological studies were carried out with special emphasis on catch rates, production, MSY, length frequency analysis, maturity, gonadosomatic and morphometric studies. This working paper includes information collected during the Second and Third meetings of the working group on mackerels and scads in the Malacca Straits.

2. Sampling sites and gear

The study was conducted on the west coast of Peninsular Malaysia and five landing sites were chosen. These centres were Kuala Perlis (State of Perlis), Kuala Kedah (Kedah), Teluk Bahang (Penang), Pulau Pangkor (Perak), and Sungai Besar (Selangor). The fishing areas for these landing centers are shown in Figure 1. Sampling for catch rates of each species was carried out at all five centres.

The length frequency samples were taken from purse seines and highopening bottom trawls. Sampling of luring purse seine catches **was** done in Perlis, Penang, Perak and Selangor while that from highopening trawl catche were taken at Kedah, Perak and Selangor. Monthly sampling for gonad maturity studies of R. brachysoma were conducted at Kedah: Perak and Selangor and those for R. kanagurta and D. maruadsi/russelli were conducted at Perlis and Penang.

3. Catch rates

R. brachysoma

Trawlers: In Perlis, high catch rates by 25 GRT trawlers were recorded in March (see Figure 2a). In Kedah, catch rates between January and March were much higher than those between April and December, for both 25 and 40 GRT trawlers (Figure 2b). In Penang, a sharp increase in catch rate was observed from March to June in 25 GRT trawlers {Figure 2b). In Perak, the catch rate of the 25 GRT trawlers increased from February to May, whereas that of the 40 GRT class fluctuated throughout the year with peaks In May and in December (Figure 2d). In Selangor, catch rate by the 25 GRT trawlers fluctuated from January to July and September to December with peaks in June and October. On the other hand, the 40 GRT vessels produced the highest catch rates (26.1 kg/day/boat) in November (Figure 2e). Kedah and Penang showed higher catch rates than the other three centres. The peak catch rate was the lowest in Selangor.

Purse seiners: In Perlis, two high peaks for catch rates were recorded in April (40 kg/h/boat for 25 GRT and 500 kg/h/boat for 40 GRT) and in September (280 kg/h/boat) for 40 GRT and 350 kg/h/boat for 25 GRT (Figure 3a). In Kedah, January and February showed high catch rates (60-70 kg/h/boat for 25 and 40 GRT) with much lower rates for other months (less than 20 kg/h/boat) (Figure 3b). In Penang, the peak catch rate by 25 GRT purse seiners was in February (620 kg/h/boat), with other months showing less than 300 kg/h/boat (Figure 3c). In Perak, February to May was a period for higher catch rates (700-2100) kg/h/boat) and other months yielded less than 400 kg/h/boat (Figure 3d). In Selangor, 40 GRT provided significantly high catch rates in April (2600 kg/h/boat) and May (2400 kg/h/boat) and during other months it was less than 1400 kg/h/boat for both classes of vessels (Figure 3e). The highest peak catch rate was observed in the southern centre at Selangor and lowest peak catch rate was in Kedah, in contrast to the patterns by the trawl fishery.

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R. kanagurta

Trawlers: In Perak, catch rates of 40 GRT were higher than those of 25 GRT. The peak month for 40 GRT was in July (12 kg/h/boat) (Figure 4).

Purse seiners: In Perak a significant peak by 40 GRT was observed in July (1400 kg/h/boat) (Figure 5a). In Perlis, March was the significant month for 40 GRT (1300 kg/h/boat), whereas other months were less than 500 kg/h/boat (Figure 5b). In Penang, the catch rates of the vessels declined from February (475 kg/h/boat) to December (50 kg/h/boat) (Figure 5c).

D. maruadsi/russelli

Purse seiners. In Perlis, the monthly catch rates by 25 GRT vessels fluctuated throughout the year with high CPUE in March (564.13 kg/day), whereas for the 40 GRT boats a high CPUE was achieved in April (1452.7 kg/day) (Figure 6a). In Penang, significantly high catch rates by 40 GRT purse seiners were observed in February (180.38 kg/day) and in October (246.23 kg/day) (Figure 6b).

4. Production

The total mackerel production by type of gear for the period 1972-1985 is presented in Table la. Since the first working group meeting the production of mackerels increased considerably up to a level of 68,966 tonnes in 1984 which, however, declined to 54,982 tonnes in 1985. The composition of the fishing fleet is shown in Table 1 b.

The estimated monthly landings of mackerels at various landing centres, in 1984 and 1985, are shown in Table 2. There were no *R. kanagurta* landings recorded in Kedah and Selangor. This was probably because of the operation of mainly the high opening trawls and night time purse seiners which contribute mainly to the production of *R. brachysoma,* in contrast to luring purse seines (daytime luring purse seine with coconut leaves) which generally catch *R. kanagurta* and *Decapterus* spp.

The estimated monthly landings of scads in 1984 are shown in Table 3. The table shows that 89.2% of the total landings of scads were in Perlis, followed by Penang with 9.8%, Perak, 0.91 % and Selangor, 0.19%.

The major portion of the mackerel landed in all the states on the west coast of Peninsular Malaysia was caught by purse seiners except in Kedah where mackerels were mainly caught by trawlers. In Selangor, purse seines and gillnets are the major gear used in mackerel production.

As shown in Table 2, in 1984, there was no significant variation in the monthly landing of mackerel in Perlis, except in May, when only 343 t were landed compared to over 500 t in other months. On the other hand, in 1985, a large production (3095 tonnes) was recorded in March and those of other months varied between 200 and 900 t.

In Kedah, the landings of *Rastrelliger* spp. in 1984 oscillated between 4,788 t (in April) and 500 t (in August), while it varied between 2,710 t (February) and 376 t (June) in 1985. There are no data available for mackerel production in Penang during 1984, but in 1985 available data showed variation between 4 t (November) and 410 t (February).

In Perak, the landings fluctuated widely between about 4 to 5 tonnes in November and December to 2,500 t in August in 1984, but in 1985 higher ranges were observed from 121 (August) to 5,373 t (February).

5. MSY and optimum effort

MSY and optimum effort were estimated using Schaeffer and Fox production models, with the help of FAO stock assessment computer programs for Apple IIe. Results are shown in Table 4a and 4b for *Rastrelliger* spp. with two types of standardized units of effort (Number of purse seine boat days and number of purse seine boats), in Table *4* for *R. brachysoma* (effort in purse seine boat days), in Table 4d for *R. kanagurta* (Effort in boat days) and Table 4e for *Decapterus* spp. (effort in number of purse seine boats).

The annual catch rates of *Rastrelliger* spp. *(R. brachysoma* and *R. kanagurta* combined) exhibited satisfactory correlation with fishing effort expressed as number of purse seine boats in operation,

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But showed relatively very poor correlation when effort was expressed in terms of number of purse seine boat-days. The purse seine fishery being a mixed target species fishery, the entire effort by any one purse seiner cannot be considered to have been applied to catch only Rastrelliger species. This factor contributed to the poor correlation observed.

In spite of the differences in the correlation coefficients (as a result of expressing effort values in two different ways), and irrespective of whether the maximum sustainable yield values are estimated for the two species together or separately, the overall MSY for chub mackerels on the west coast of Peninsular Malaysia works out to 60,000 — 70,000 t per annum, with an optimum effort value of some 2,000 purse seine boats.

6. Length frequency distribution

Length frequency sampling (total length) for R. brachysoma and R. kanagurta were carried out monthly in 1984-85. Random samples were taken at various landing places. The length frequency distribution exhibits a polymodal appearance. The fishery exploited R. brachysoma off Kuala Kedah (Figure 7a) and Pulau Pangkor (Figure 7b) in sizes ranging from 13 to 22.5 cm and R. kanagurta in Kuala Perlis from 10.5 to 22.5 cm (Figure 7c). The size range of R. brachysoma caught by trawlers was similar to that for the purse seiners and the modal sizes failed to show significant difference (Figures 8a-8e). D. maruadsi caught off Perlis and Penang ranged between 8 and 20 cm (Figures 8h-8i).

7. Estimated growth, mortality and related parameters

The growth, mortality and related parameters (L_∞, K, Z, L_c, L) for the five landing centres obtained from the detailed analysis of the length frequency data of 1985 using the ELEFAN program (I — Post Sicily version and II) are tabulated in Table 5.Figures for length frequency distribution, growth curves, recruitment patterns (%), catch curves and selection patterns are depicted for R. brachysoma (Figures 8a-8e), R. kanagurta (Figures 8f-8g) and D. maruadsi (Figures 8h-8i) by area and by gear.

8. Maturity study and mean length at maturity

Monthly random sampling for gonad maturity studies was done at Perak, Kedah and Selangor for R. brachysoma, and in Perlis and Penang for R. kanagurta and Decapterus spp. (July 1985-June 1986).

The percentage composition of maturity stages (I to V) for R. brachysoma and R. kanagurta are as shown in Table 6a and 6b respectively (January 1984-July 1985).

Previous studies on R. brachysoma by Chong (1974) showed that the spawning period of R. brachysoma extends from August to December. Chong observed that about 40% or more of the fish had ripe or spent gonads.

According to Pathansali (1962), mature R. kanagurta were found from October to April with the maximum occurrence from January to March.

In the case of R. brachysoma, spent gonads were observed in January/February and from August to October (1984), which was only partly observed by Chong (1974).

Concerning R. kanagurta, the high percentage of spent gonads in March 1584 corroborates Pathansali's conclusions (Pathansali, 1962) although in March 1985 no spent gonads were observed.

Table 7 shows numbers of matured fish (maturity stage IV and V) in the samples examined, by sex, by species and by area over a period of 10-12 months. For R. brachysoma a higher percentage of matured fish was observed among females than among males in all areas. Percentages of mature fish were greater in Kedah and Perak than in Selangor (Table 7).

R. kanagurta showed a slightly higher percentage of mature fish among males than among females. A higher percentage of mature fish was observed in Perlis than in Penang (Table 7).

For Decapterus spp. the percentages of mature females and males were not significantly different.

In Perlis a higher percentage of mature fish was recorded than in Penang (Table 7)

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Overall, there was a higher percentage of mature R. brachysoma than of *R. kanagurta* or Decapterus spp. in the samples taken over the periods indicated.

The mean lengths at first maturity of R. brachysoma in Kedah, Perak and Selangor were estimated as 17.85 cm, 18.15 cm and 18.1 cm respectively. Those for R. *kanagurta* in Perlis and Penang were found to be 19.6 cm and 20.6 cm respectively, whereas for *D. maruadsi/russelli* it was 17 cm in Perlis and 16 cm in Penang.

9. Sex ratio (January 1984 — July 1985)

From the examination of fish throughout the year, there appears to be no segregation of sexes. Of the total *553 R. brachysoma* specimens from random samples examined between January 1984 and July 1985, 337 were females and 216 were males, giving a percentage of 60.9% and 39.1 % respectively. Of the 599 sample of *R. kanagurta* examined, 47.2% were females and 52.8% were males. Monthly and size-wise differences in sex ratios were not examined.

10. Gonadosomatic index study (July 1985 — June 1986)

The gonadosomatic index (GSI) was estimated by taking the ratio of gonad weight to body weight for samples of R. *brachysoma* caught in Kedah, Perak and Selangor and *R. kanagurta* and Decapterus samples caught in Perlis and Penang.

R. brachysoma: In Perak peak GSI values were seen in July 1985, in Kedah in March 1986 and in Selangor during December 1985/March 1986. Perak shows higher peak values of GSI throughout the year than Kedah and Selangor (Figure 9a).

R. kanagurta: The seasonal sampling was incomplete. Peak values of GSI appeared to be in August/September 1985 (Perlis) and in August 1985 (Penang). A declining though fluctuating trend was observed from October to May in both locations (Figure 9b).

D. maruadsi/russelli: Data are rather incomplete for many months and the available data indicate that peaks were in August 1985 and February — March 1986 (Penang) and in February 1986 (Perlis) (Figure 9c).

11. Conclusions

As may be seen in this paper, there are some data which could not be analysed and some which could not be collected due to unforeseen circumstances. Some of the findings are not conclusive.

1) Catch and effort data should be improved for more reliable estimation of CPUE, production and MSY.

2) Length frequency data were re-appraised as easy and useful information to grasp basic parameters for the population dynamics of mackerels. Data collection should be continued.

3) Maturity studies should also be continued to elucidate the life history and migration patterns of mackerels in the Malacca Straits.

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Table Ia

Trends in mackerel production on the west coast of Peninsular Malaysia, by gear group, during 1972/1985

(tonnes)

Year	Purse seines	Trawls	Gillnets	Other gears	Total catch
1972	9,334	329	24	13	9,763
1973	21,021	553	78	21	21,675
1974	11,299	721	279	13	12,313
1975	8,175	1,520	277	14	9,987
1976	7,042	4,989	365	18	1,244
1977	8,592	10,450	384	143	19,570
1978	11,936	10,962	728	122	23,803
1979	28,300	5,395	352	105	34,153
1980	41,635	6,683	2,884	529	51,799
1981	27,235	1,401	3,375	403	45,027
1982	27,921	20,470	5,928	301	54,719
1983	37,510	19,545	5,252	277	62,594
1984	50316	14,474	3,080	224	68,966
1985	?	?	?	?	54,982

Table Ib

Estimated number of purse seiners, trawlers, gillnetters and vessels with other gears in operation in 1972-1984 on the west coast of Peninsular Malaysia

Year	Purse seiners	Trawlers	Gillnetters	Other gear
1972	1,488	4,068	3,698	1.385
1973	1,446	3,267	3,530	1.185
1974	1,353	3,909	4,091	1,160
1975	1,687	3,873	4,359	1,200
1976	1,425	4,008	5,092	1,151
1977	1,204	4,195	5,951	1,066
1978	1,294	4,463	6,656	1,017
1979	1,450	5,112	7,878	1,458
1980	1,854	5,265	8,453	1,698
1981	1,985	5,266	8,525	2,235
1982	2,032	5,257	8,689	2,175
1983	874	3,289	10,825	2,706
1984	7,146	2,906	9,761	2,285

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Table 2

Monthly production of Rastrelliger spp. by area for 1984 and 1985 (by all gears)

(tonnes)

Area/	Perlis		Kedah		Penang		Perak		Selangor	
Month	1984	1985	1984	1985	1984	1985	1984	1985	1984	1985
January	522	172	1,162	2,768		133	219	180	198	1.691
February	541	183	2,141	2.010		410	61	5,373	92	766
March	545	3,095	2,561	1,489		314	509	3.006	76	514
April	546	858	4.788	1,357		330	958	3,790	143	1,033
May	343	891	2 931	559		231	253	2,929	104	972
June	543	726	1,417	376		139	619	238	258	222
July	544	617	2,433	581		84	353	199	319	232
August	539	191	500	544		41	2,514	121	2,092	—
September	547	536	1971	689		5	362	157	2,766	180
October	553	548	1,589	694		36	29	741	2,821	172
November	550	499	1,412	599		4	5	1,850	2,115	54
December	565	344	1,806	698		31	4	447	2,067	375

Table 3

Landing of *Decapterus* spp. in the west coast of Peninsular Malaysia by state and month in 1984

(tonne)

Month	(P S.) Perlis	Kedah	Penang	Perak	Selangor	Total
January	396.25		142.8	2.48		541.53
February	534.21		112.56	1.09	0.96	648.82
March	666.84		16.8	21.43	0 . 5	705.57
April	1.812.91		5.46	2.42	0.03	1,820.82
May	157.11		3.36	0.55	1.15	162.17
June	202.22		38.01	0.88		241 .11
July	422.16		14.49	5.53	0.09	442.27
August	236 88		45.99			282.87
September	443.03		44.31			487 34
October	376.15		136.68			512.83
November	348.97		56.28	24.43	2.91	432.59
December	1 44.8		14.28			159.08
Total	5,741.53		631.02	58.81	5.64	6,437.00
%			(89.2)	(0.9)	(9.8)(0.09)	(100)

Table 4

Summary of the various production model analysis applied to data from the west coast of Peninsular Malaysia

	Schaefer model			Fox model		
	MSY (tonnes)	Optimum effort	r^2	MSY (tonnes)	Optimum eflort	r^2
Rastrelliger spp	69,229	2321 boats	0.8613	62.301	1983 boats	0.9132
Rastrelliger spp	66,161	123.928 boat days	0.4685	72.502	174.089 boat days	0.4630
R. brachysoma	*54,394*	123.766 boat days	0.4653	59.532	173.771 boat days	0.4686
R kanagurta	11,530	124.732 boat days	0.4651	12.664	175.881 boat days	0.4593
Decapferus spp	7,350	12,276 boats	0.3125	6,131	1670 boats	0.1481

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Table 5

List of parameters estimated by ELEFAN method, for mackerels and scads in the west coast of Peninsular Malaysia

Area	Species	L_∞	K	M	F	Z	E	L'	L_c	ESP/ASP
Perlis	R. kanagurta (PS)*	29.7	1.19	1 97	4.93	6.90	0.71	20	19.5	0.260352
	D. maruadsi/russelli (PS)	27	1.01	1.82	7.74	9.56	0.81	16	15.6	0.353693
Kedah	*R. brachysoma* (Tr)**	24	1.04	1.92	8.29	10.21	0.81	19	18.8	0.299018
Penang	R. kanagurta (PS)	29	1.21	2.01	6.13	8.14	0.75	19	18.7	0.316294
	D. maruadsi/russelli (PS)	24	0.81	1.63	1.94	3.67	0.54	17	15.9	0.60564
Perak	R. brachysoma (PS)	26	0.6	1.31	5.59	7.9	0.81	19	18.9	0.562807
	R. brachysoma (Tr)	25	0.82	1.62	5.17	6.79	0.76	19	18.8	0.236961
Selangor	R brachysoma (PS)	24. 2	0.52	1.22	3.21	3.43	0.73	19	18.9	0.405238
	R brachysoma (Tr)	24	1.02	1.89	5.26	7.15	0.74	19	18.8	0.223843

*PS – Purse Seines
** Tr – Trawls

Table 6a

Percentages of maturity stages of *R. brachysoma* off Kedah (January 1984.July 1985)

Stage Month	I	II	III	IV	V
January 1984	2.27	—	56.82	29.54	11.36
February	20.00	33.33	33 33	6.67	6.67
March	—	—	—	—	—
April	—	—	—	—	
May	**29.33**	9.33	32.00	29.33	
June	**2.94**	91.18	5.88	—	
July	—	—	—	—	—
August	24.13	41.38	27.59	3.45	3.45
September	40.00	13.33	23.33	16.67	6.67
October	63.27	8.16	12.24	4.08	12.24
November	20.00	40.00	28.00	12.00	—
December	—	—	—	—	—
January 1985	—	—			—
February	4.35	8.70	65.22	21.74	—
March	—		—	—	—
April	3.28	-32.79	47.54	14.75	1.64
May	11.11	13.89	72.22	2.78	—
June	2.94	91.18	5.88	—	—
July	—	6.67	43.33	50.00	—

<<

Table 6b

Percentages of maturity stages of R. kanagurta off Perlis (January 1984.July 1985)

Stage Month	I	II	III	IV	V
January 1984					
February	94.74		5 26		
March	34.60	11.54	7.69	15.38	30.77
April	96.3	—	3.70	-	
May					
June					
July	32.00	16.00	44 00	8.00	
August	4.00	40.00	48.00	8.00	
September					
October					
November					
December					
January 1985		-			
February	—				
March	50.00	8.33	36.67	5.00	
April					
May	77 50	10.00	10.00	2 50	
June	91.49	2.13	6.38		
July	87.50	12 50	—	—	

Table 7

Observation on the percentages of mature (Stage IV & V) males and females of each species in different areas

Area	Observation pcwds	No of female Observed	Matured	%	No. of Males Observed	Matured	%	Combined average (%)
R brachysoma								
Kedah	July 1985-June 1986	239	87	36.4	468	87	18.6	24.6
Perak	July 1985-May 1986	551	174	31.6	615	94	153	23.0
Selangor	July 1985-Aprli 1986	487	77	15.8	614	89	14.5	15.1
			Average	26.5			15.9	20.4
R kanagurta								
Perlis	July 1985-May 1986	300	59	19.7	348	47	13.5	16.4
Penang	June 1985-May 1986	497	23	14.6	318	5	1.6	3.4
			Average	10.2			7.8	9.2
Decapterus								
Perils	August 1985-May 1986	163	12	7.4	189	20	10.6	9.1
Penang	July 1985-April 1986	275	12	4.3	276	12	4.3	4.4
			Average	5.5			6.9	7.6

<<

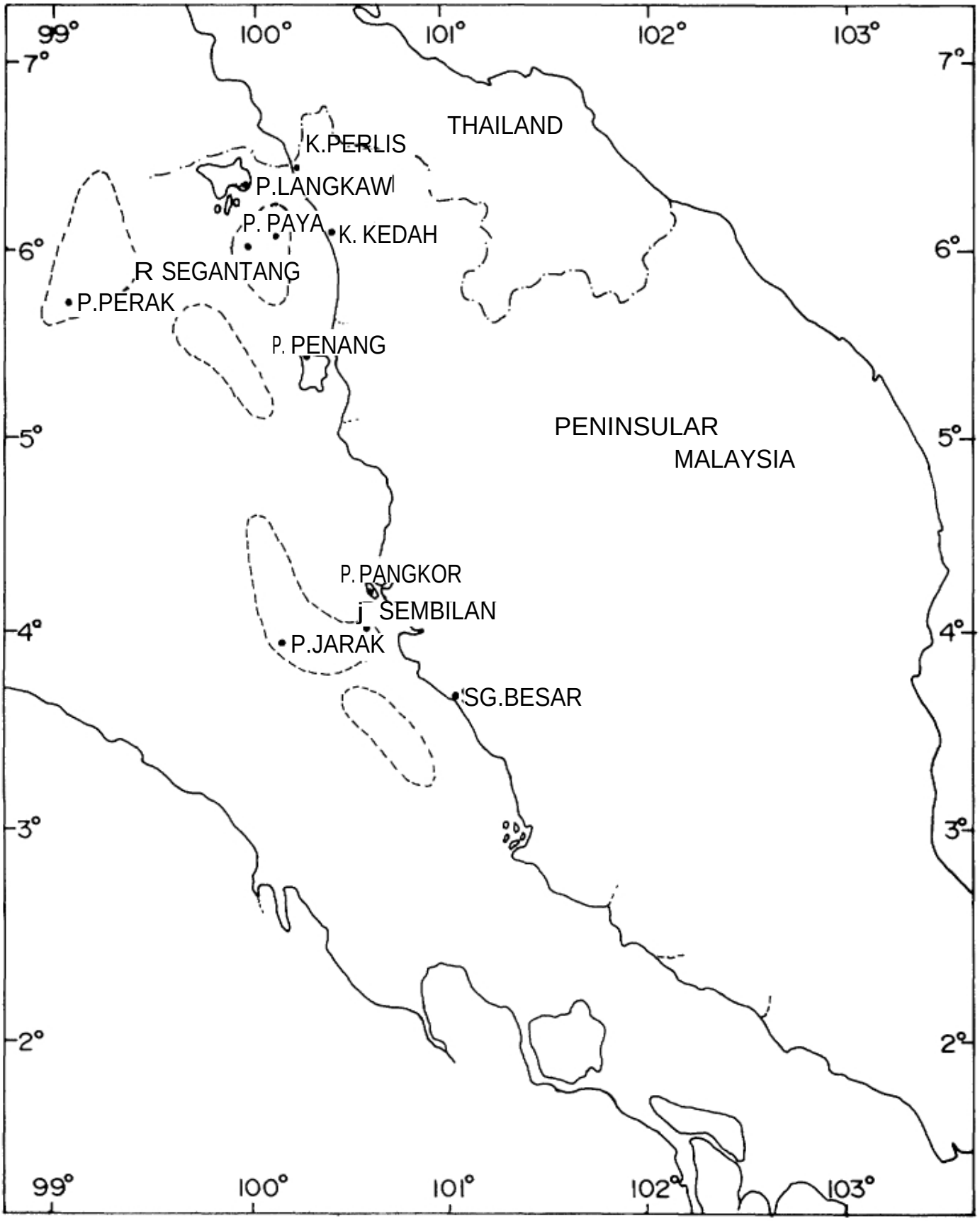


Figure 1. Fishing areas of mackerels and scads on the west coast of Peninsular Malaysia.

Figure 2a-2e. *Monthly catch areas of* R. brachysoma *caught by trawlers at each cerrtre.*

25 GRT ——————

40 GRT - - - - - - -

Fig 2a - PERLIS

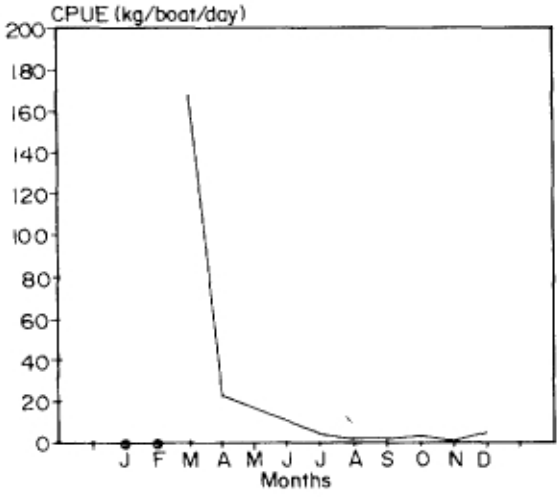


Fig 2b – KEDAH

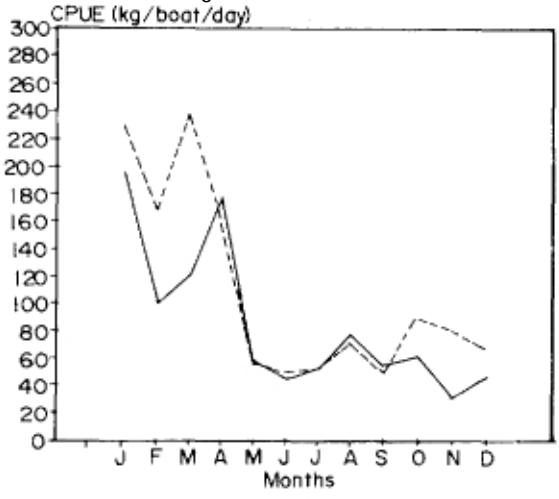


Fig2c - PENANG

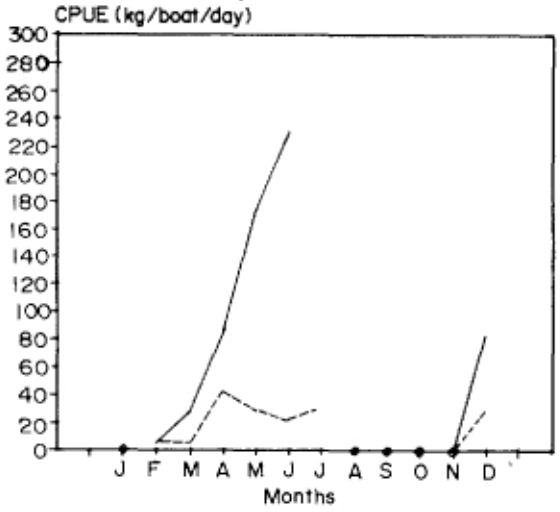


Fig 2d- PERAK

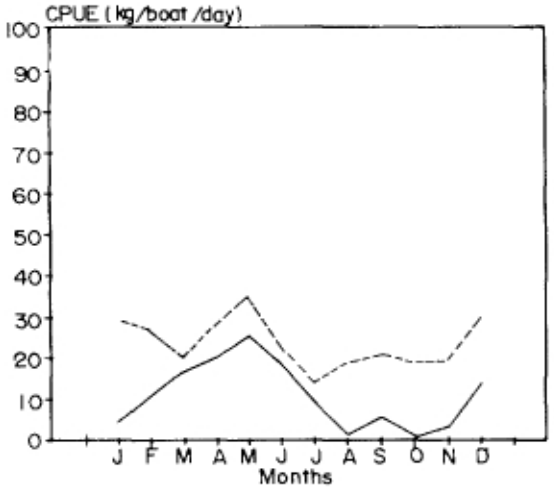


Fig 2e-SELANGOR

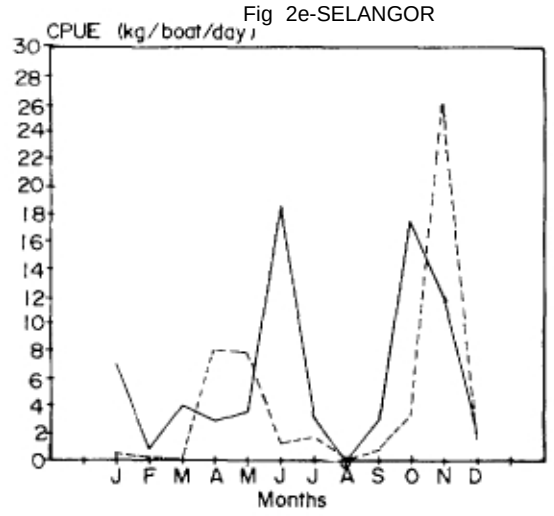


Figure 3a-3e. *Monthly catch areas of* R. brachysoma *cauqht by purse seiners at each centre.*

25 GRT ——————

40 GRT - - - - - - -

Fig 3a- PERLIS

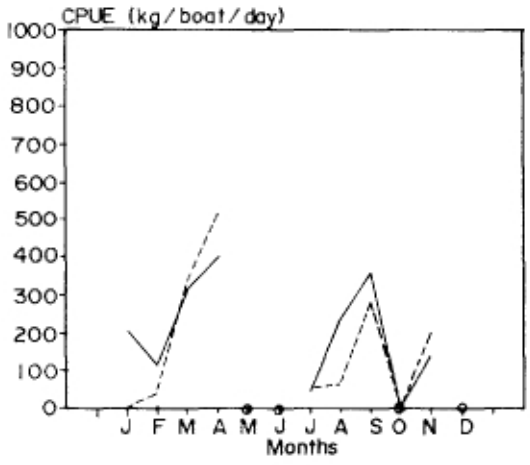


Fig 3b – KEDAH

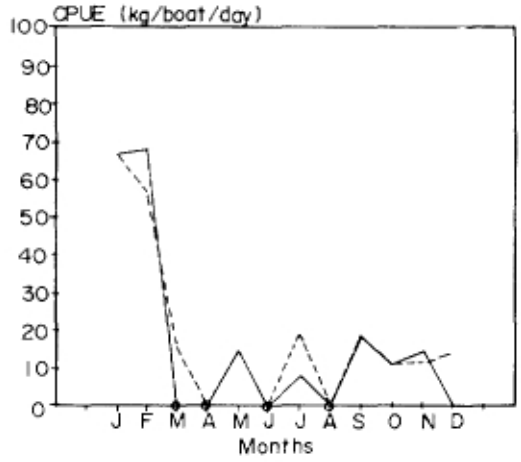


Fig 3c - PENANG

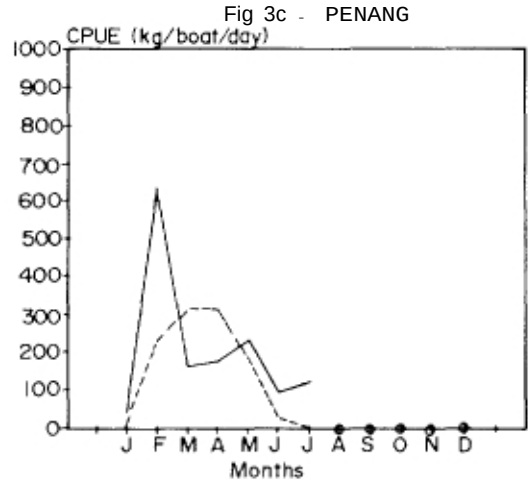


Fig 3d– PERAK

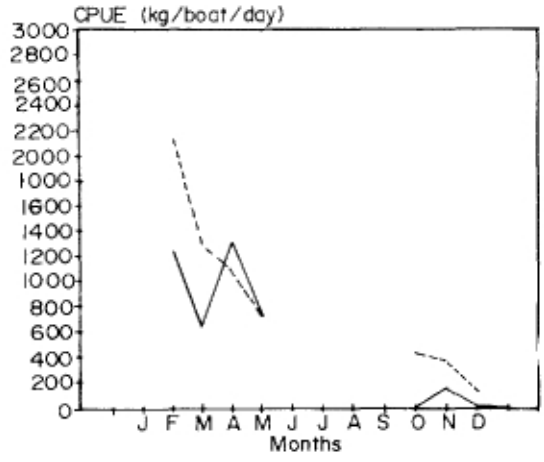


Fig 3e–SELANGOR

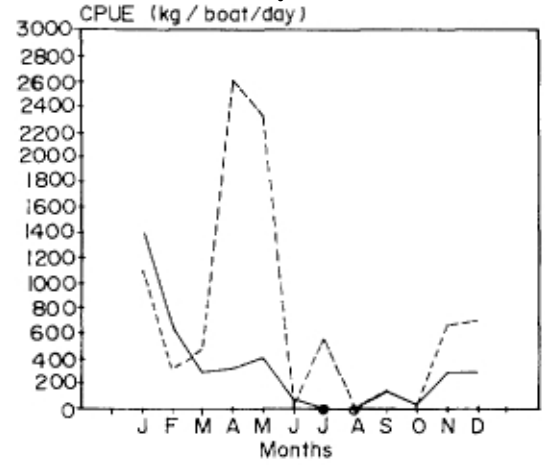


Figure 4, 5a-5c. *Monthly catch areas of* R. kanagurta *caught by trawlers and purse seiners at each centre.*

Fig4 -TRAWLERS- PERAK

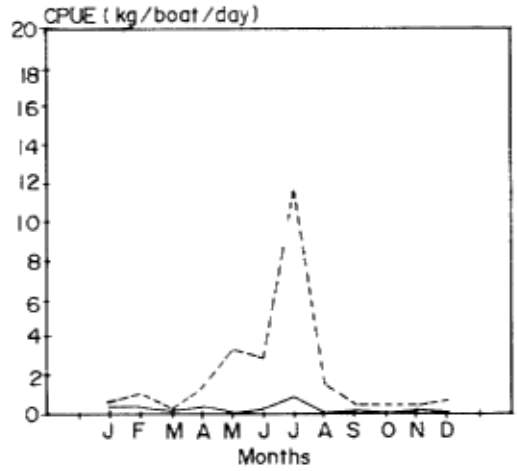


Fig 5b- PURSE SEINERS- PERLIS

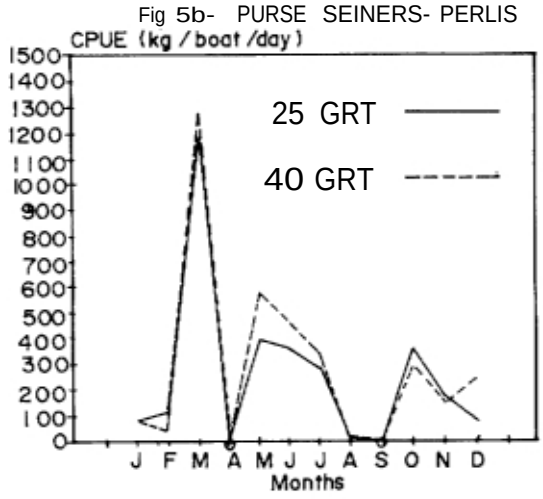


Fig 5a- PURSE SEINERS- PERAK

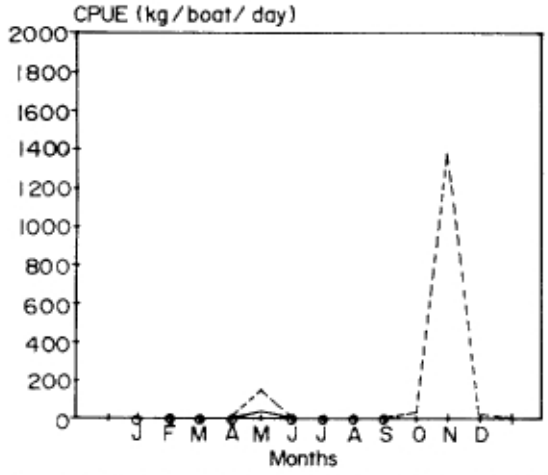


Fig 5c - PURSE SEINERS- PENANG

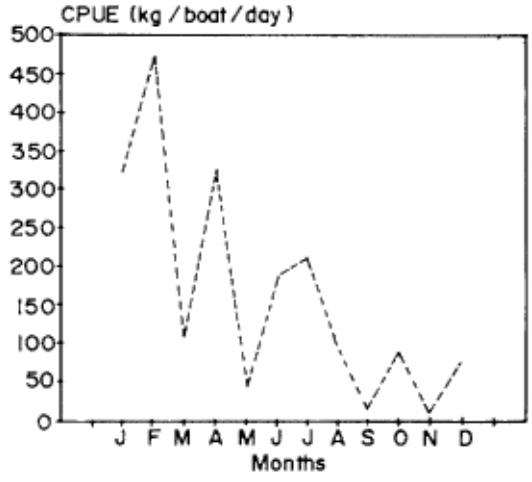


Fig Ga - PURSE SEINERS PERLIS

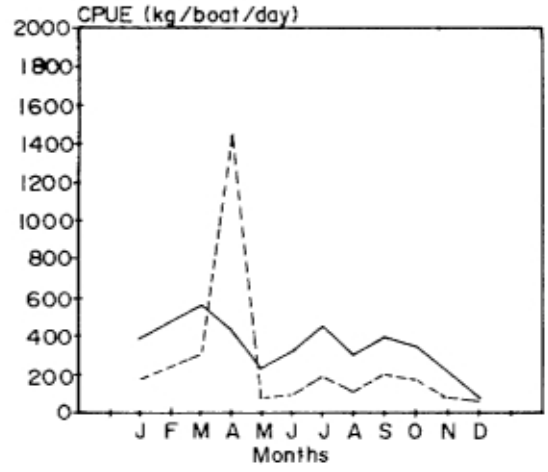


Fig 6b PURSE SEINERS – PENANG

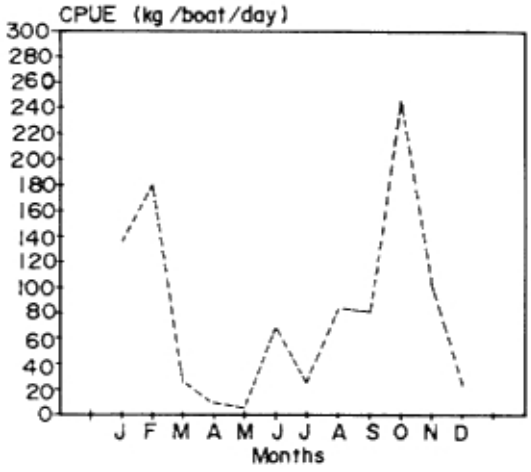


Figure 6a-6b, *Monthly catch areas of* D. russelli *caught by purse seiners at Per/is and Penang.*

Figure 7a. *Seasonal changes in length composition of* R. brachysoma *in Kuala Kedah, 1984/1985.*

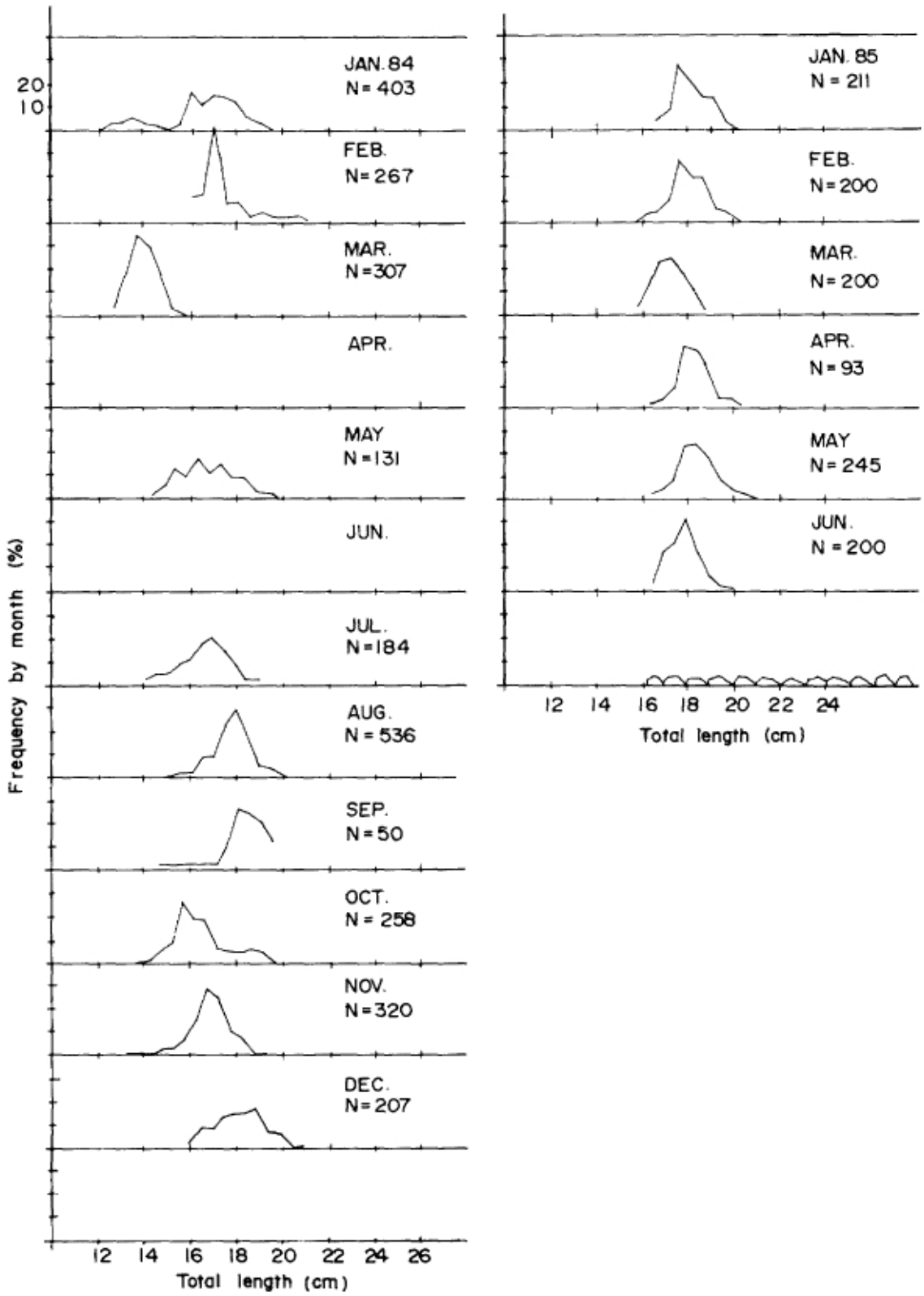
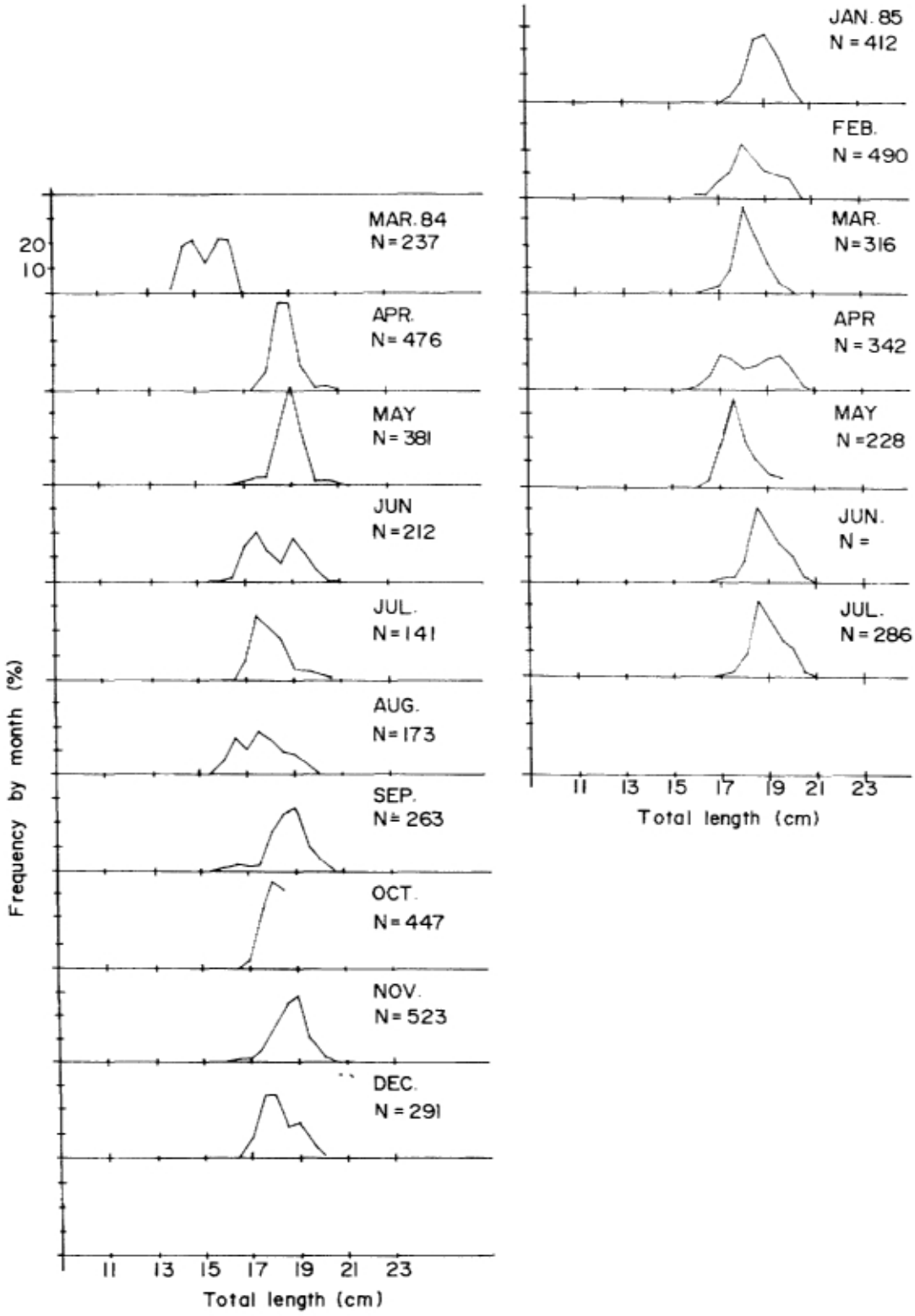


Figure 7b. *Seasonal changes in length composition of* R. brachysoma *in Pulau Pangkor, 1984 1985.*



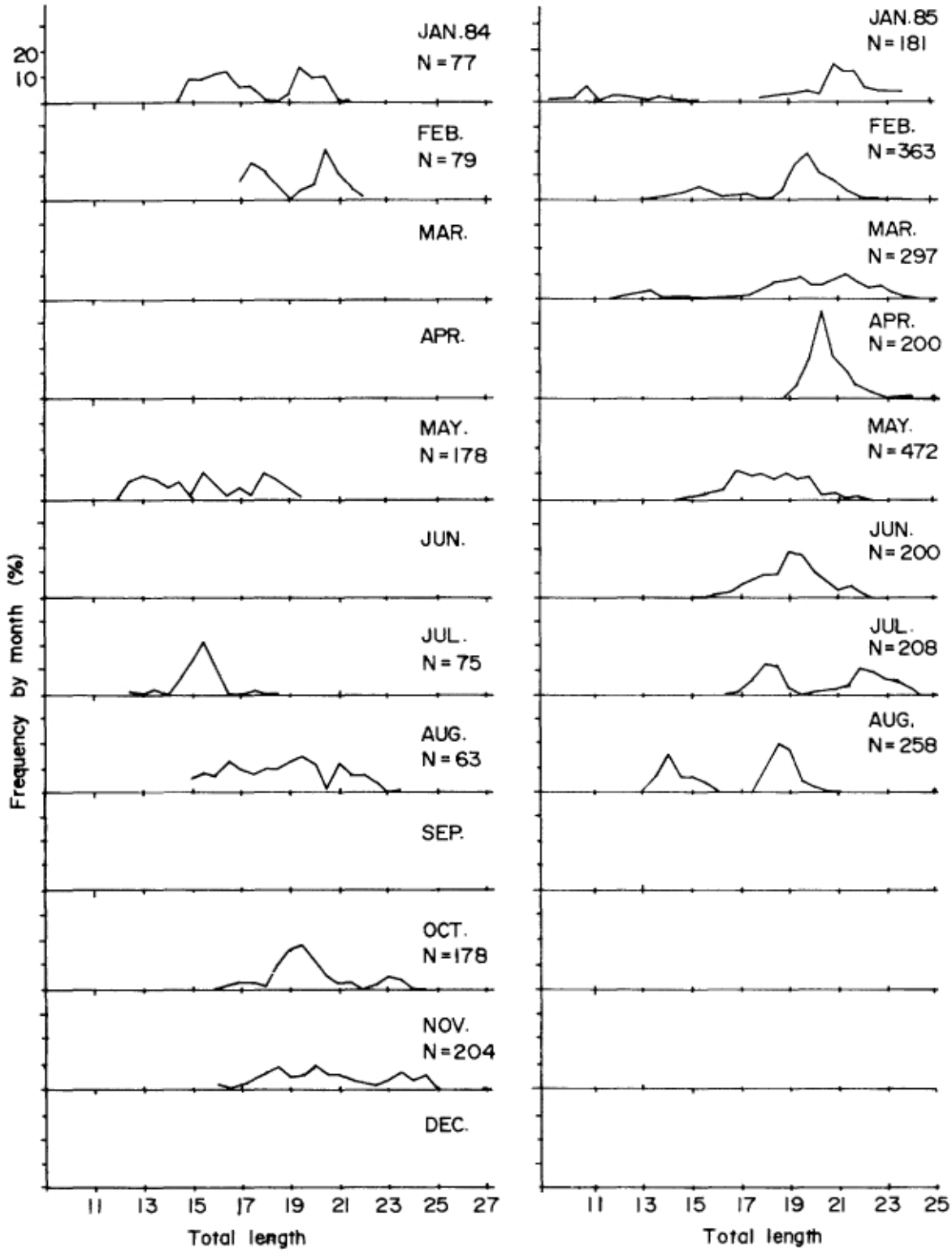


Figure 7c. Seasonal changes in length composition of R. kanagurta *in Kuala Perlis, 1984/1985.*

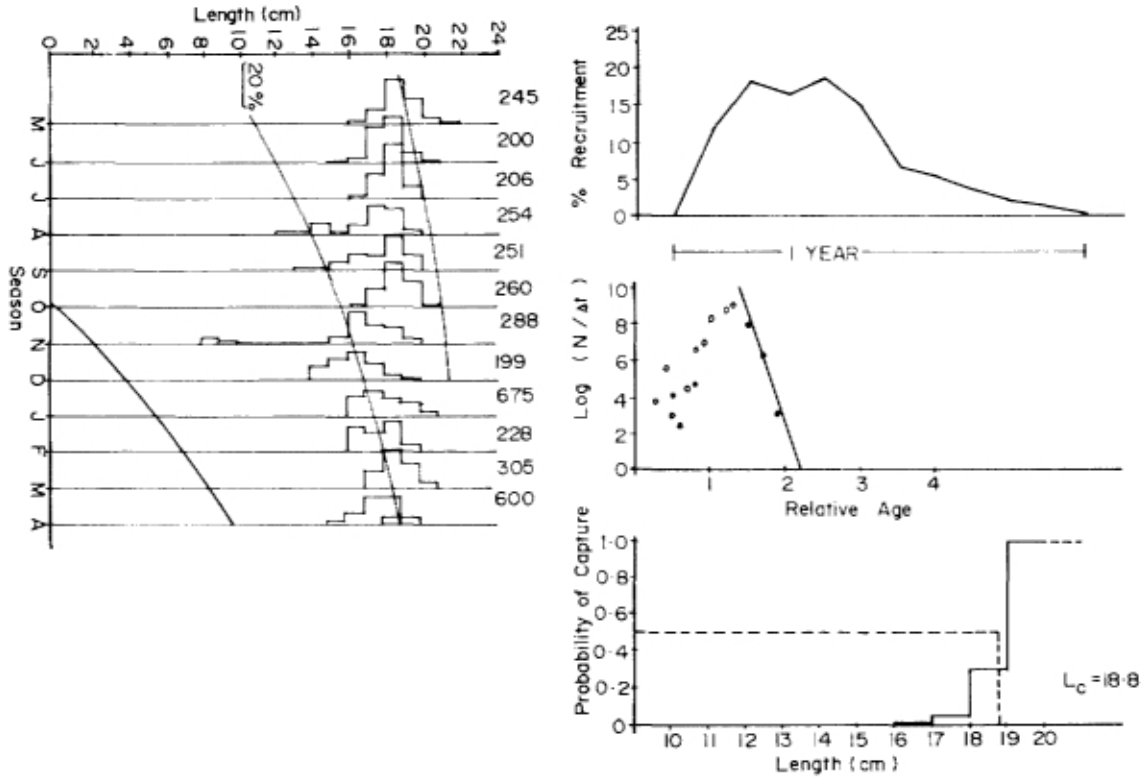


Figure Ba. ***Length frequency distribution, growth curve, recruitment, catch curve and*** *selection* ***pattern of*** R. **brachysoma** ***from Kedah, trawlers,***

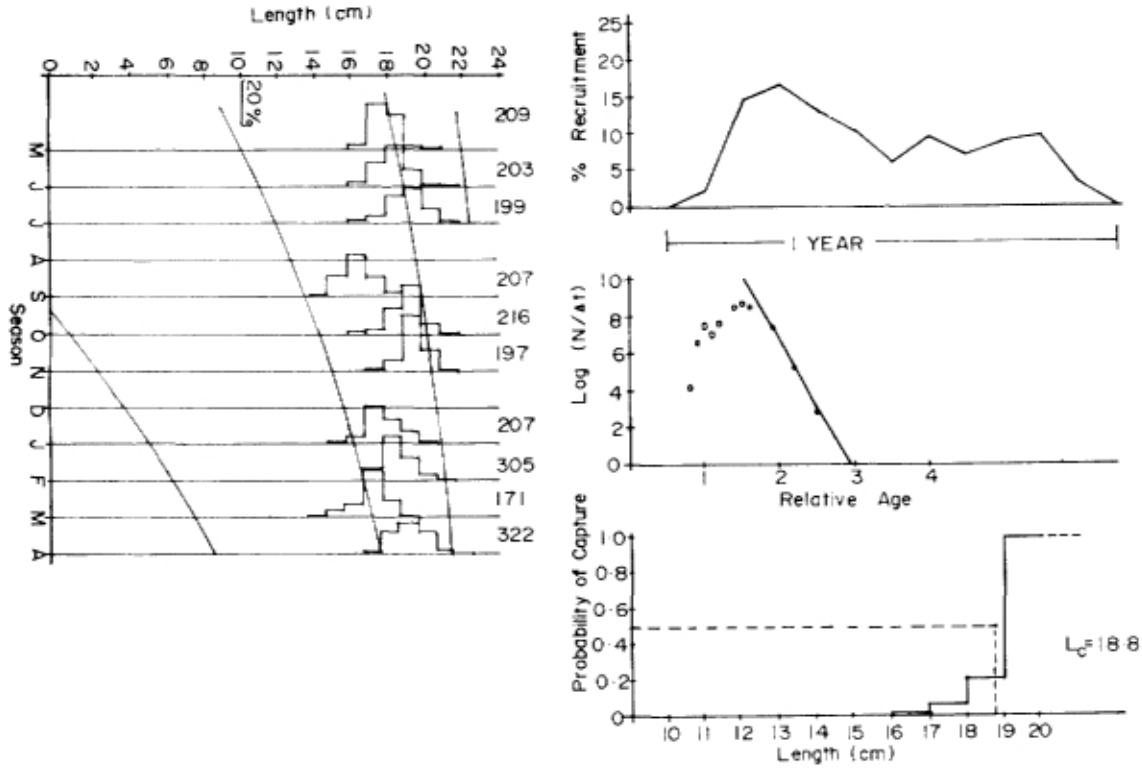


Figure 8b. *Length frequency distribution, growth curve, recruitment, catch curve and selection* ***pattern of*** R. **brachysoma** ***from Perak, trawlers.***

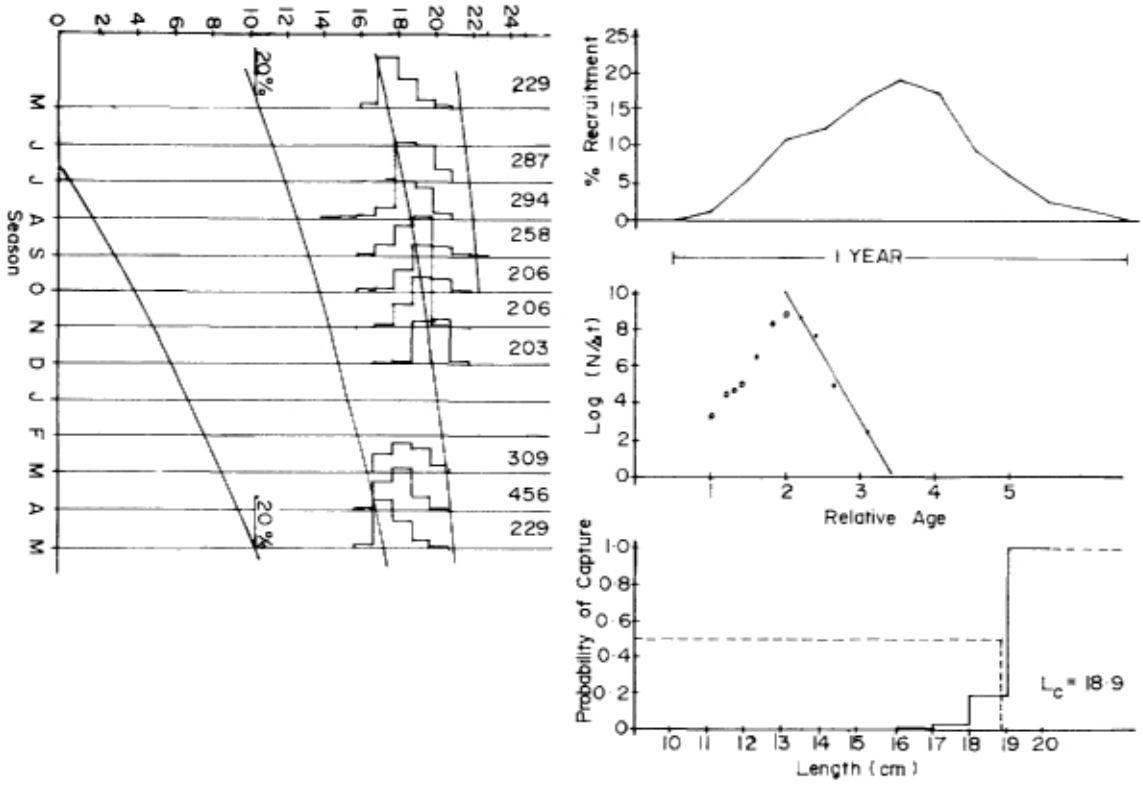


Figure 8c. *Length frequency distribution, growth curve, recruitment, catch curve and selection pattern of* **R. brachysoma** *from Perak, purse seiners,*

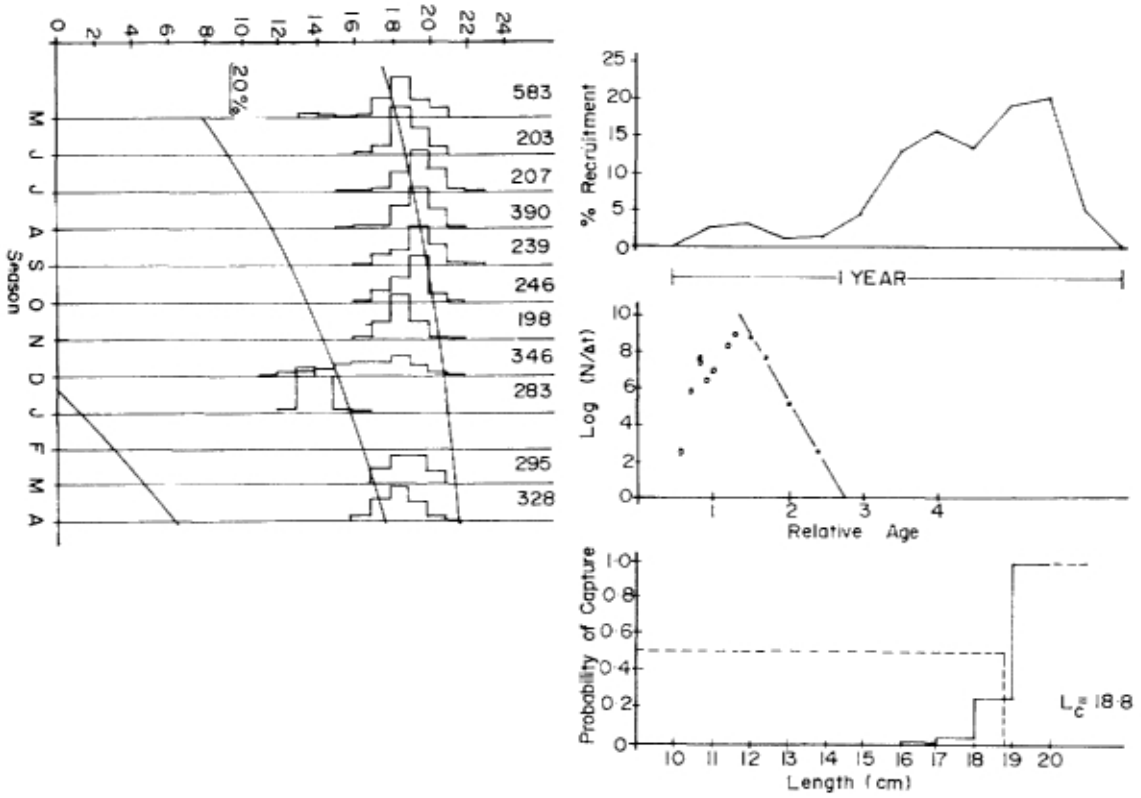


Figure 8d. *Length frequency distribution, growth curve, recruitment, catch curve and selection pattern of* **R. brachysoma** *from Selangot, trawlers.*

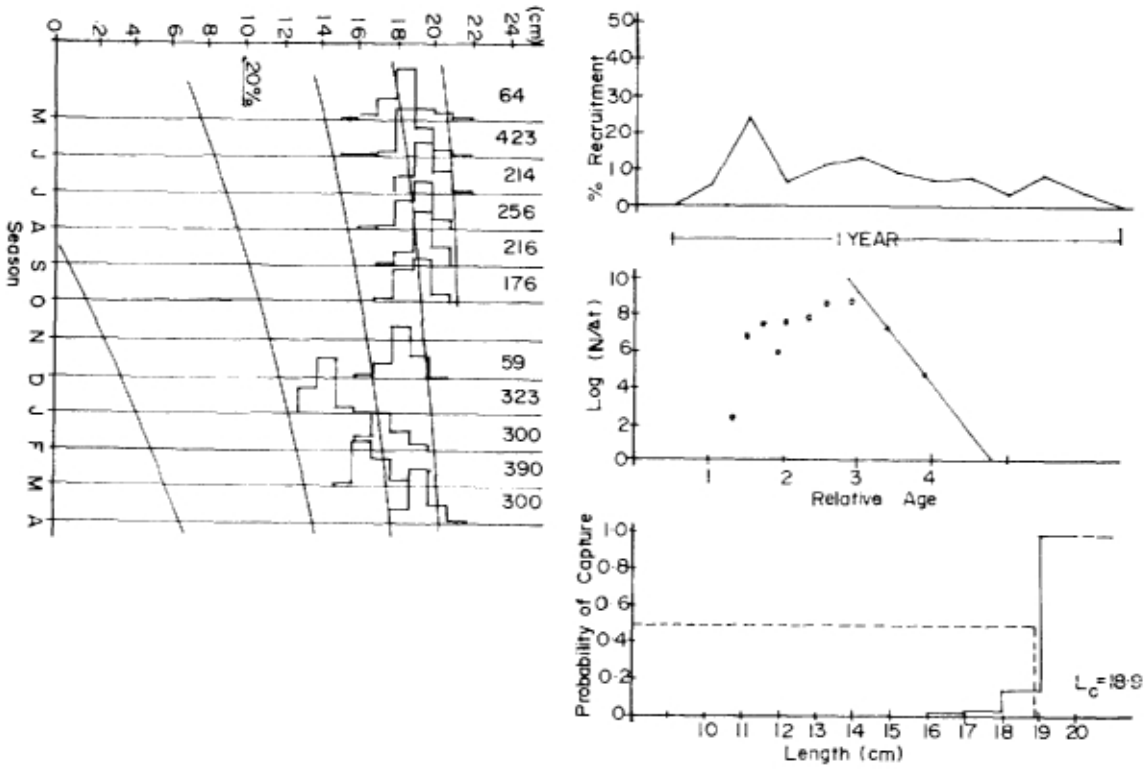


Figure 8e. *Length frequency distribution, growth curve, recruitment, catch curve and selection pattern of* R. brachysoma *from Selangor, purse seiners.*

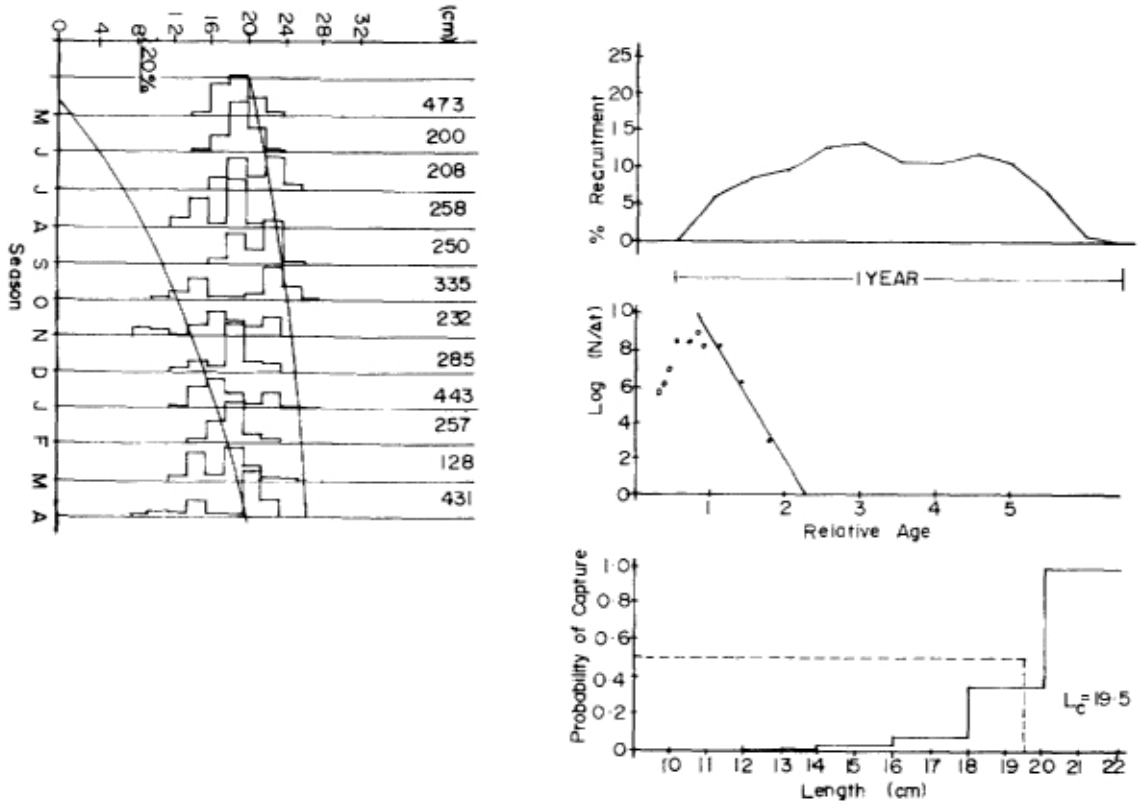


Figure 8f, *Length frequency distribution, growth curve, recruitment, catch curve and selection pattern of* R. brachysoma *from Perlis, purse seiners.*

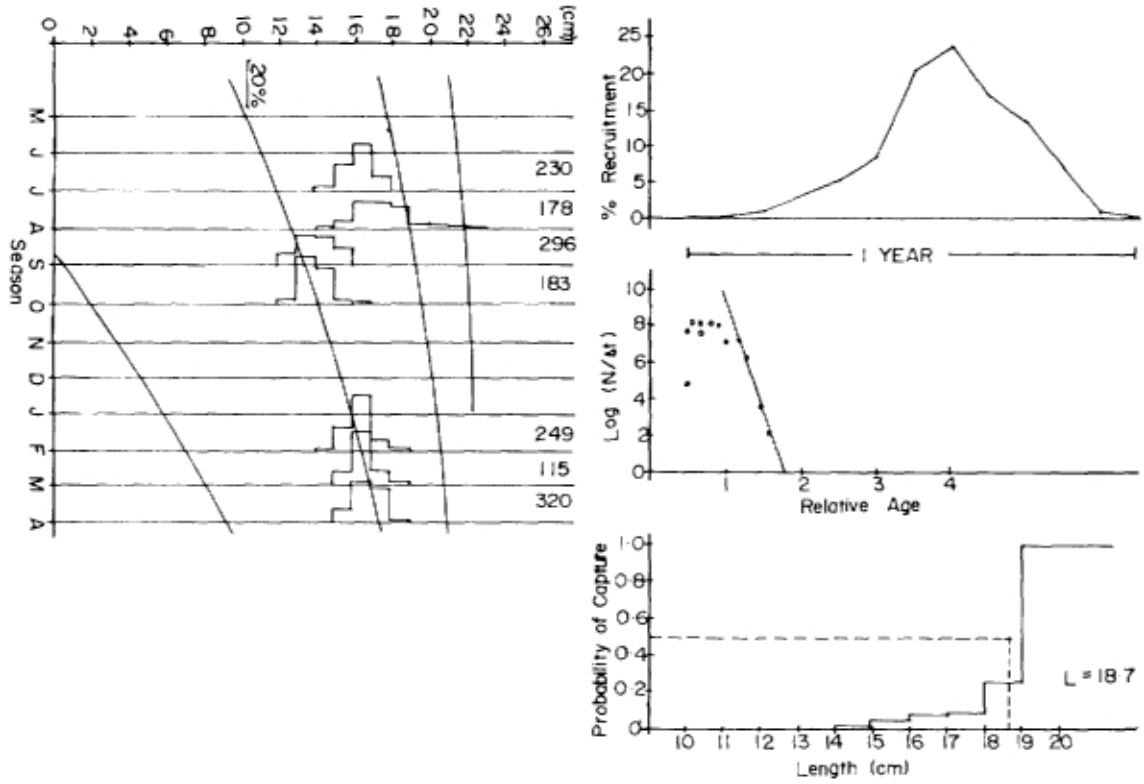


Figure 8g. *Length frequency distribution, growth curve, recruitment, catch curve and selection pattern of* R. kanagurta *from Penang, purse seiners.*

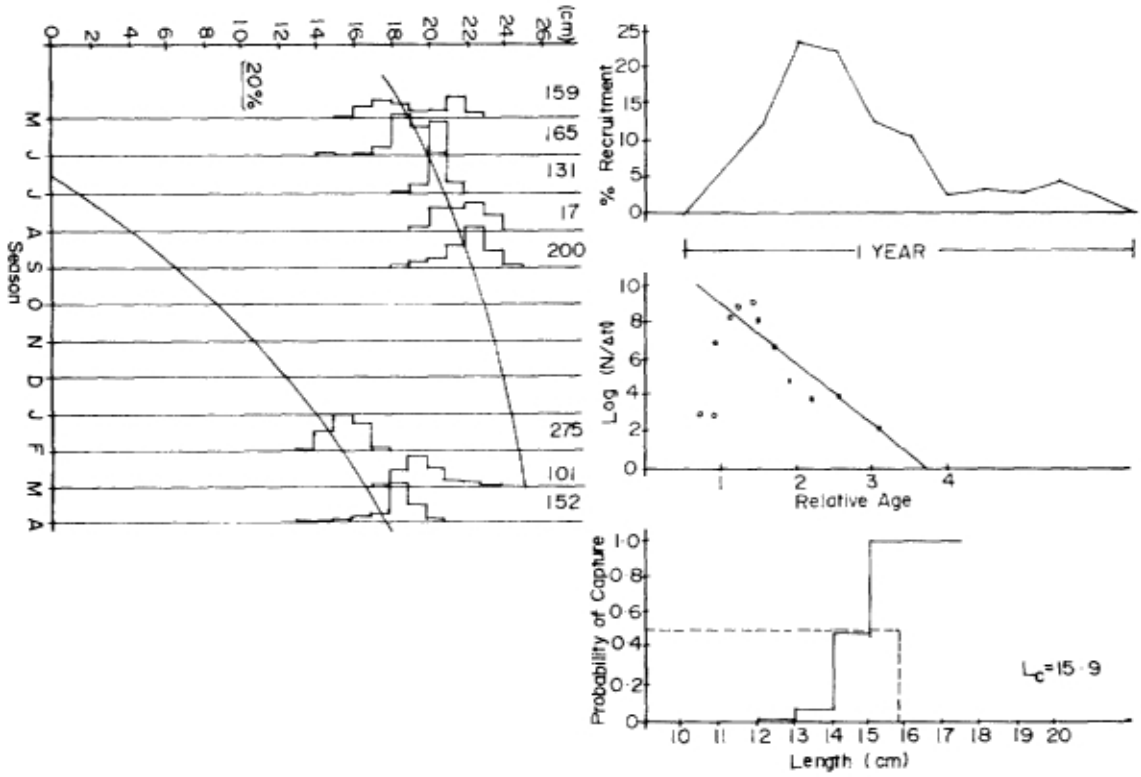


Figure 8h. *Length frequency distribution, growth curve, recruitment, catch curve and selection pattern of* D. russefli *from Penang, purse seiners.*

Figure 8i *Length frequency distribution, growth curve, recruitment, catch curve and selection pattern of* D. russelli *from Perlis, purse seiners.*

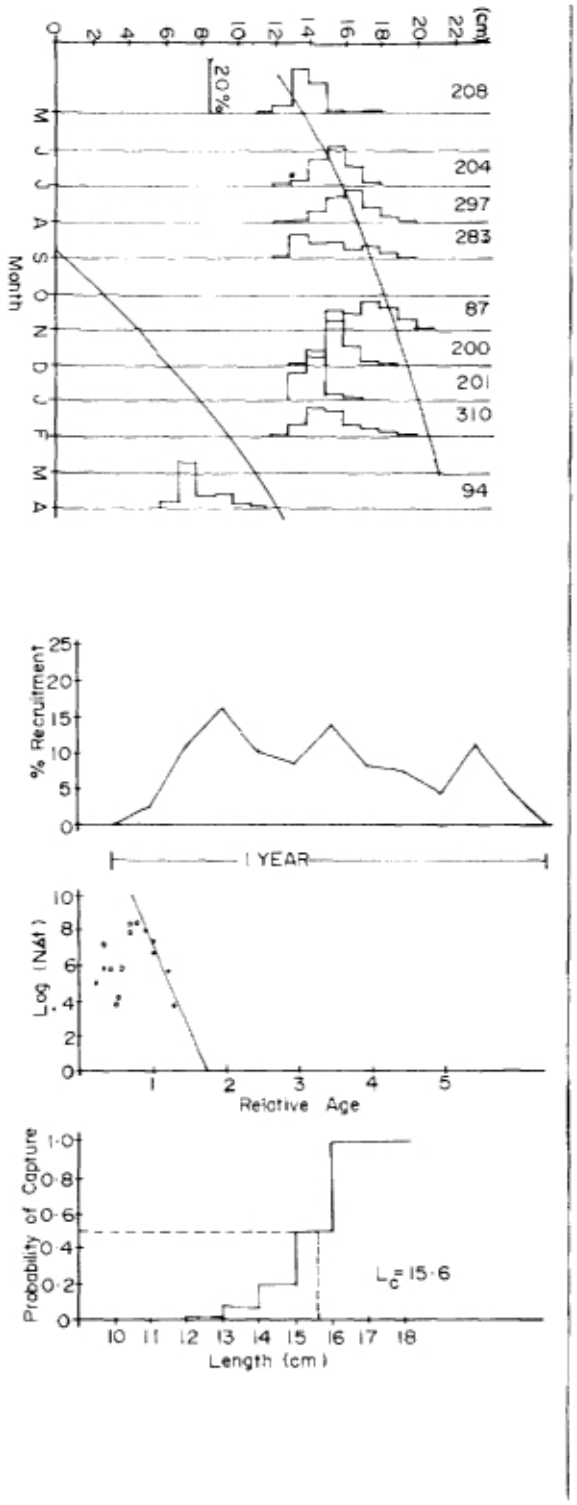
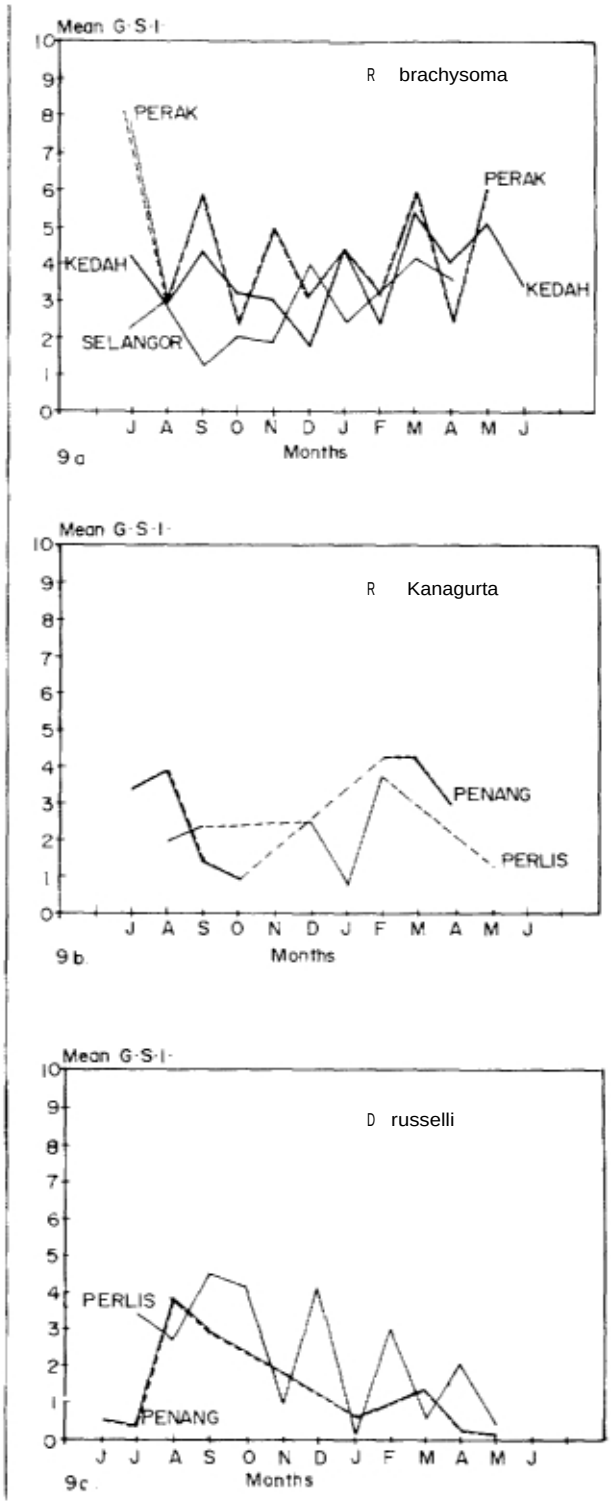


Figure 9a-9c, *Mean gonadosomatic index of* R. brachysoma R. kanagurta *and* D. russelli,



Annexure 4

MACKEREL FISHERIES IN THE MALACCA STRAITS

by Gomal H. Tampubolon

Fishing Technique Development Center, Semarang, Indonesia

I. Gede Sedana Merta

Research institute for *Marine Fisheries, Jakarta, Indonesia*

Introduction

The surface area of the Indonesian part of the Malacea Straits is estimated a? 100,000 sq km or just around 1 .7% of the total marine waters of Indonesia The fishing area is estimated at 55.000 sq. km or about 0.9%. However, the Malacca Straits is very important, being the shortest route for ships sailing from the West to the Far East. The Malacca Straits is also one oi the most important fishing zones, and its resources are exploited by Indonesia, Malaysia anti Thailand. The Indonesian coast along the Mafacca Straits is a **densely** populated area, where the number of fishermen IS about 85,735, 16.5% of the total number of fishermen in Indonesia. The number of motorized boats is increasing very rapidly, at about 18.0% per annum (from less than 5 to 30 GHT class). The most important gear used in this area is the purse seine, its number increasing annually by 25 6%.

Since 1984. sampling has been carried out in Banda Aceh, Lhok Sumawe Langsa, Belawan and Asahan. The sampling activities aim at collecting data on:

— catch by species by boat
— fishing grounds
— number of sets
— number of days per trip
— number of boats landing.

In Lhok Sumawe and Belawan, sampling was discontinued before the end of the project, because of personnel problems.

Species caught

Usually, two species of *Rastrelliger* are caught, i e.. R kanagurta and R. brachysoma, and two species of *Decapterus* i.e *D. macrosoma* and D. russelli Although Malaysia and Thailand refer to one of the Decapterus species as D. *maruadsi,* the name D. *russelli* will continue to be **used** until the taxonomical problem is solved In order to solve this problem, sample!; have been sent to Dr Smith-Vaniz as **suggested** by Dr. Sivasubramaniam, and his reply is awaited.

Although four species are caught. they are lumped together into two groups: the “kembung” group for *Rastrelliger* spp and the “layang” group for *Decapterus* spp. No other species of *Rastrelliger* or Decapterus have been reported from this area, but *R. faughni* has been reported from Thai waters and D kurroides and D. macarellus have been reported from the Eastern Indian Ocean

Fishing gears and vessels

For catching pelagic fish on the Indonesian side of the Malacca Straits. the main gear types used are purse seine, Danish seine and gillnet. The rapid development of purse seine in this area has led to a decrease in the number of Danish seines, and in Langsa (East Aceh) Danish seines are not operated any more

The purse seine used in the Indonesian part of the Malacca Straits is of the American type where the bunt is located at one side of the net Target species of this fishery are small tunas;

Presented at the third Working Group Meeting on mackerels in the Malacca Straits.19-23 August, 1985. Phuket. Thailand

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In the absence of small tunas the fishing directs its effort towards other small pelagics like scads, mackerels or sardines.

Gillnets are mainly used near the coast (for instance in Asahan) to catch Indo-Pacific mackerels.

In Banda Aceh, the purse seine is used without any lures or fish aggregating devices (FADs). Fishing trip generally have a duration of one day The distance to the fishing grounds is about 15-20 miles In 1985, a small number (2 or 3) of purse seiners operated off the west coast of Sumatra The size of the vessels operating off Banda Aceh ranges between 7 and 18 m (LOA) and between 5 and 10 GRT, while the (inboard) engine power ranges from 12 to 17 hp.

The fishermen landing their catches at the Langsa Harbour and Idi Fishery Auction Centre use FADS made of bamboo and coconut leaves. Around the new moon period, fishing is carried out with kerosene or battery lamps as lures The size of vessels at this centre varies between 7 and 25 m (LOA), 5 and 25 GRT and with inboard engine of 33 to 120 hp.

The length of the nets used between 600 and 800 m In Lhok Surnawe, there are some mini purse seiners of 1.8 to 5.4 GRT, with a crew of 8-12 men and using outboard motors of about 15 hp, while bigger vessels have a size of 16-20 GRT (Anonymous, 1984). In Lhok Sumawe, the size of the big purse seine used is 800 to 1000 m in length, 45 to 75 m in depth and operated by 15 to 25 fishermen

FADS are used in the Asahan district also to congregate fish for the purse seine fishery. Vessels landing in the Asahan District are of a bigger size than those in the other areas, the biggest vessels steaming a greater distance to reach the fishing grounds. The size of vessels and the engine power range from 13 to 35 GRT and from 33 to 240 hp, respectively. The purse seines used are to 450 to 600 m length. 259 purse seiners are landing their catches in the Asahan area.

In general, it was observed that there is hardly any relationship between the size of the vessel and the size of the gear used. Neither is there any relation between the size of the vessel and the power of the engine. Higher horse power engines are mainly used in order to reduce the steaming time to the fishing grounds.

Monthly catch rates

The monthly catch rates by species, for the purse seine fleet operating in the Indonesian part of the Malacca Straits, are presented in Figures 1 to 4. Peaks in catch rate may be seen for D. russelli in May/June in Langsa, for D. macrosoma in January/February in Langsa, for R. brachysoma from April to June in Banda Aceh, Langsa and Asahan, and for R. kanagurta in July/August in Asahan.

Catch rates by vessel size

At the three main harbours, catch rates (kg/boat/day) were obtained for several sizes of vessels, consequent to the attempt to get fishermen to complete fishing log sheets provided by the BOBP project (RAS/81/051).

For Banda Aceh the following information was obtained:

Size of Vessel (GRT)	CPUE (kg/boat/day)
Smaller than 6	725
6-7	828
7-8	736
Larger than 8	528

Vessels of 6-7 GRT appeared to have higher catch rates than larger vessels

Vessels landing in Langsa range from 5 to 25 GRT As in Banda Aceh, hardly any relationship exists between the size of the vessel and the catch rate The available catch and effort data are summarised below.

<<

Size of vessel GRT	No. of days operating	Total catch (kg)	CPUE (kg/day)
5	42	17,200	410
7	448	179.565	401
8	512	208,430	407
9	243	91,795	378
10	127	36,055	284
11	95	16,785	177
12	105	28,745	274
13	138	44,140	320
24	9	4,400	489
25	35	6,900	200

The catch rates of 5-9 and 24 GRT vessels were remarkably high Though the 24 GRT vessels showed the highest catch rate, the number of samples for this estimate was very small

The CPUE data (kg/boat/day) collected in Teluk Nibuing (Asahan District) were as follows:

Size of Vessel (GRT)	CPUE (kg/boat/day)
13	400
14	450
15	450
17	618
22	625
25	650
27	700
28	767
30	800
34	1,017
35	1,350

It may be concluded that the larger vessels exhibited higher catch rates It is assumed that the larger vessels exploit fishing grounds different from those frequented by the smaller vessels and also have a greater endurance.

The monthly catch rates for the three areas are presented in Figure 5

Production and level of exploitation

From 1976 to 1985, the production of Rastrelliger fluctuated between 10,396 (1981) and 22,809 tonnes (1985). The Decapterus landings increased from 758 tonnes in 1976 to 16,168 tonnes in 1985 (Table 1) The data collected from sampling sites are presented in Tables 2, 3 and 4. From Lhok Sumawe and Banda Aceh, only small quantities of mackerels were reported during the sampling period This is probably because the target species of the purse seiners in this area are tuna and tuna-like fish rather than mackerel.

For the calculation of ?he MSY for Rastrelliger and Decapterus, the data used were those for the period 1979 to 1985.

Application of Schaeffer's production model to the catch and catch rate data resulted in MSY values of 6,750 tonnes for *R.* brachysoma, 12,306 tonnes for R kanagurta and 10,767 tonnes for both Decapterus species, but the production of these species in 1985 was of the order of 7,379, 15,430 and 16,168 tonnes respectively.

For each species, the production models were initially applied to catch and catch rate data separately for the northern and southern parts of the Malacca Straits Since no evidence was available to justify separating these into two stocks, it was considered more reasonable to calculate the MSY for the total Indonesian production (by species) in the Malacca Straits but

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to use the catch rates obtained from the southern part because of greater reliability of the estimates from this area (Table 1).

The production models for both Rastrelliger species are presented in Figures 6 and 7. It must be noted that no production models for the Decapterus species are presented because of very low correlation coefficients for the available data.

Biology

For biological purposes, length, weight and morphometric measurements were collected. The length frequencies for the various species and landing sites obtained from the purse seine fishery in 1985 are presented in Figures 8 to 11. The modal progressions were not clearly evident and the sampling was insufficient because the biologists had practical difficulties in making regular visits from their distant base stations. During trawl surveys by research vessel BAWAL PUTIH II on the east coast of Sumatra in March 1985 and October 1986, 160 specimens of R. kanagurta and R. *brachysoma* were obtained. Their lengths varied between 11 and 24 cm and 17 and 23 cm in fork length, respectively The modal groups for R. kanagurta were 20-22 cm in March and 15-16 cm in October. That for R. *brachysoma* was 22-23 cm in march and there was no catch in October The modal sizes of both species during March were higher than those observed in the purse seine catches made during the same period but most of the *R. kanagurta* samples from October were smaller than the model size of the purse seine samples for that month. Length frequency data collected were analyzed at the Research Institute for Marine Fisheries using ELEFAN programmes provided by BOBP (Post Sicily version), to estimate growth parameters. The results obtained are presented in Table 5 The L values for D. *macrosoma, D. russelli, R.* kanagurta and *R. brachysoma* were 280, 260,285 and 265 mm respectively. The K values were 1.22, 0.9, 0.9 and 1.05 respectively for the four species (Table 5).

Maturity

Studies were carried out on the maturity of scads and mackerel species. Samples were collected from commercial vessels at the landing places and during surveys of the research vessel BAWAL PUTIH II. The total number of fish (by species) examined and their size ranges are summarised in Table 6. The length at first maturity (50%) for R. kanagurta was 195 mm for males and 208 mm for females.

In the case of R. *brachysoma* the length at first maturity could not be properly determined, because of the small size of the sample. The lengths at 50% maturity for D. *macrosoma* and D *russelli* were observed at 166 and 148 mm respectively for males and at 177 and 158 mm respectively for females.

Discussion

The MSYs for *Rastrelliger kanagurta, R. brachysoma, Decapterus* macrosoma and *D. russelli* obtained using Shcaeffer's model appear to have been surpassed by the respective production estimates only recently (1985).

Growth parameters were estimated independently with the length frequency samples from each sampling centre for each species, and these exhibited a wide range of values. Only those considered to be reasonable in terms of modal progression in the frequency distribution and fitness of the growth curve are presented in Table 5.

References

Anonymous, 1984. Country report from Indonesian mackerels of the Malacca Straits. In Mackerels in the Malacca Straits, BOBP/WP/30, RAS/81/051 p. 50-59.

Directorate General of Fisheries, 1981-l 984. Fisheries Statistics of Indonesia 1981-1984. Dir. Gen. Fish. Min Agri. Jakarta.

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Table 1

Production of scads and mackerels and catch rates in the Indonesian part of the Malacca Straits

Year	*R. kanagurta*		*R. brachysoma*		Total *Rastrelliger*
	Catch (t)	CPUE (kg/trip)	Catch (t)	CPUE (kg/trip)	(t)
1976	5,648	—	6,021	—	11,669
1977	6,944	–	6,849	–	13,793
1978	5,253	–	5,979	–	11,232
1979	7,335	215	4,392	22.9	11,942
1980	8.074	75	4,838	7.9	12,987
1981	9,879	114	3,490	12.2	10,510
1982	9,879	154	5,215	16.5	15,248
1983	8,344	174	4,300	18.5	12,818
1984	9,804	444	4,589	47.4	14,837
1985	15,430	449	7,379	47.4	23,258

Year	*D. macrosoma*		*D. russelli*		Total Decapterus
	Catch (t)	CPUE (kg/trip)	Catch (t)	CPUE (kg/trip)	(t)
1976		—	—	—	758
1977	—	—	–	–	1,365
1978	—	—	–	–	2,536
1979	1,677	92.6	719	89.4	2,489
1980	1,941	32.0	872	31.0	2,813
1981	2,542	49.0	1,855	47.6	4,397
1982	2,989	66.1	2,064	64.1	5,119
1983	4,623	74.5	3,103	72.2	7,800
1984	5,881	190.8	2,843	185.1	8,915
1985	8,529	77.9	7,612	75.5	16,219

Table 2

Catch and effort data collected in Banda Aceh in 1985

Month	No of Trios	No. of Sets	*D macrosoma* (kg)	*D. russelli* (kg)	*R. brachysoma* (kg)	*R. kanagurta* (kg)	Others (kg)	Total (kg)
January	*429*	1,339	*1,010*	—	1,100	—	107,047	109,157
February	384	1,336	*590*	*275*	1,040	—	112,465	114,370
March	297	1,112	—	12,950	14,275	600	32,205	60,030
April	269	1,056		13,262	18,025		36,945	68,232
May	136	556	–	2,540	3,590	–	59,305	65,435
June	51	136		375	400	450	6,630	7,855
July	193	—	–	055	—	2,645	32.045	35,545
August	–	—	–		—	–	–	0
September	297	—	–	1,785	—	–	70,645	72,430
October	408	—		–	—	4,080	144,335	148,415
November	374	—	–	2,405	—	5,145	83,325	90,875
December	330	—	–		—	2,675	74,820	77,495
Total	3,168	5,535	1,600	34,447	38,430	15,595	759,767	849,839

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Table 3

Catch and effort data collected at Idi, East Aceh district (1984-1986)

Month	No. of Days	No of Sets	*D. macrosoma* (kg)	*D. russelli* (kg)	*R. brachysoma* (kg)	*R. kanagurta* (kg)	Total (kg)
November 1984	66	80	56,400	1,650	–	–	56,050
December	129	198	70,950	1,500	–	–	72,450
Total	195	278	127,350	3,150	0	0	130,500
January 1985	84	109	65,300	–	–	–	65,800
February	179	239	114,175	–	–	–	114,175
March	216	286	68,650	29,850	1,575	75	100,150
April	128	171	48,325	13,675	1,225	3,525	66,750
May	143	201	45,445	8,150	7,725	6,915	68,235
June	44	69	8,285	8,150	925	825	18,185
July.	74	104	8,495	5,750	350	2,225	16,820
August	143	198	16,390	10,435	1,425	1,325	29,575
September	249	323	29,125	20,075	3,950	3,125	56,275
October	163	204	8,890	6,905	1,450	1,225	18,470
November	210	291	30,627	21,013	2,470	4,130	58,240
December	224	296	15,190	11,285	1,185	1,767	29,427
Total	1,857	2,491	459,397	135,288	22,280	25,137	642,102
January 1986	179	232	22,450	24,980	1,520	2,440	51,390
February	299	388	69,245	88,495	4,910	10,170	172,820
March	261	342	44,215	56,515	4,785	7,045	112,560
April	273	359	60,640	43,955	1.625	2,690	108,910
May	156	188	47,080	29,850	1,605	1,360	79,895
June	132	146	39,915	23,345	2,705	1,095	67,060
Total	1,300	1,655	283,545	267,140	17,150	24,800	592,633

Table 4

Catch and effort data collected in Asahan (1984-1985)

Month	No. of Trips	*R. kanagurta* (kg)	*R. brachysoma* (kg)	*Decapterus* spp. (kg)	Total (kg)
January 1984	614	75,529	23,515	300,622	399,666
February	329	53,620	7,853	185,024	246,497
March	609	114,465	9,749	423,924	548,138
April	952	172,259	20,543	857,770	1,050,572
May	1,105	436,886	22,556	760,491	1,219,933
June	2,636	913,453	3,884	673,749	1,591,086
July	1,636	558,260	16,462	938,913	1,513,635
August	1,614	1,068,353	1,635	394,243	1,464,231
September	1,418	965,235	4,067	322,529	1,291,831
October	1,344	802,711	10,035	250,419	1,063,165
November	1,144	388,235	368,076	262,700	1,019,011
December	788	249,497	159,080	234,910	643,487
Total	14,189	5,798,503	647,455	5,605,294	12,051,252

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Month	No. of Trips	*R. kanagurta* (kg)	*R. brachysoma* (kg)	*D. macrosoma* (kg)	*D. russelli* (kg)	Total (kg)
January 1985	825	263,561	115,739	133,130	**98,890**	611,320
February	698	271,490	177,385	97,824	41,926	488,625
March	678	196,061	204,064	56,889	52,661	509,675
April	1,023	391,867	320,608	67,024	32,126	811,625
May	828	31,500	348,200	87,223	84,577	551,500
June	991	26,850	514,080	93,087	90,236	724,253
July	1,334	937,651	27,650	53,375	118,525	1,137,201
August	1,367	1,005,162	1,538	13,972	135,480	1,156,152
September	–	–	—	—	—	0
October	–	–	—	—	—	0
November	1,011	274,334	151,915	353,333	342,616	1,122,198
December	763	177,380	98,170	253,444	245,756	774,750
Total	9,518	3,575,856	1,959,349	1.209,301	1,242,793	7,987,299

Table 5

Growth parameters, mortality and exploitation rates obtained by means of the ELEFAN programs

Species	Location	L_∞	K	Z	F	M	E	L_c	L	L'
R kanagurta	B Aceh	86,285	0.9	3.07	1.39	1.69	0.45	161.02	196.4	170
R brachysoma	Asahan	84,265	1.05	8.84	7.03	1.91 85	0.79	178.98	–	180
D macrosoma	B Aceh	84,280	1.22	5.4	3.37	2.11 85	0.62	165.08	195.64	170
D russelli	Idi	84,260	0.90	5.5	3.80	1.73	0.69	166.68	185.41	170

Table 6

Summary of the numbers of scads and mackerels and their size ranges (in mm) examined during Gonad maturity studies

Males	*R. kanagurta*	*R. brachysoma*	*D. macrosoma*	*D. russelli*
0	10	0	0	3
I	34	3	19	10
II	27	0	26	40'
III	20	42	2	60
IV	20	11	0	27
Total	111	56	47	140
	Range	135-235	125-235	

Females	*R. kanagurta*	*R. brachysoma*	*D. macrosoma*	*D. russeili*
0	1	0	0	0
I	13	0	17	4
II	28	4	30	25
III	16	18	8	31
IV	4	5	0	21
Total	62	27	55[1]	81
	Range	135-295	165-245	

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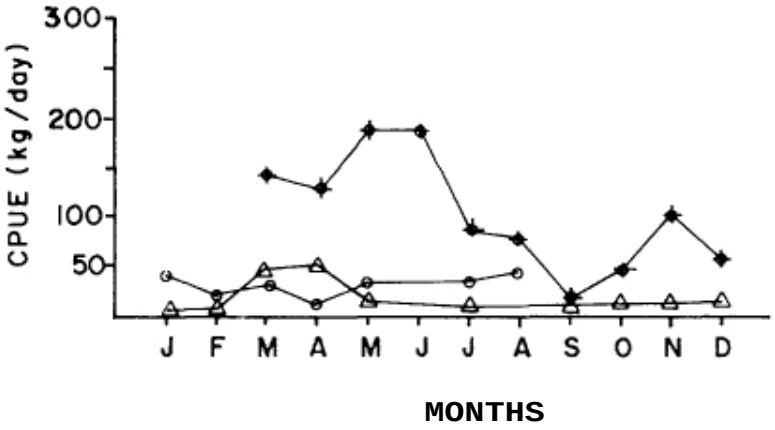

Figure 1. Monthly catch rates of D. russelli collected at several landing sites along Sumatra.

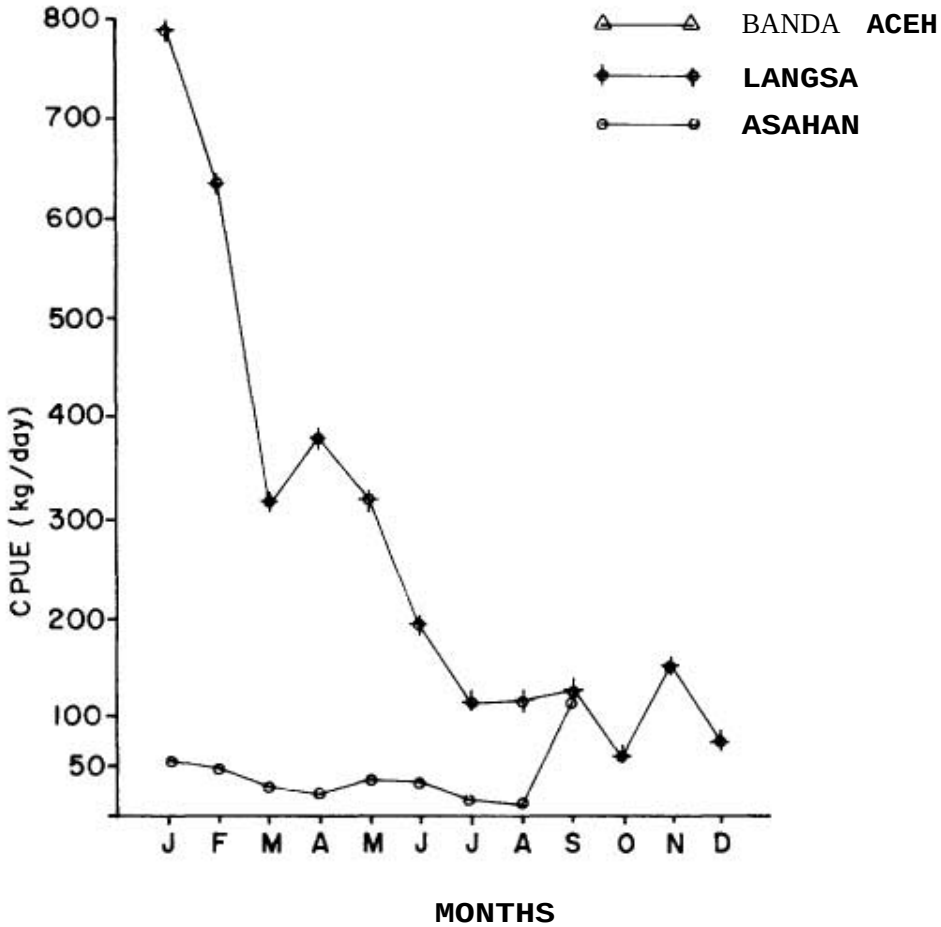

Figure 2. Monthly catch rates of D. macrosoma *collected from the purse seine fishery operating in the Indonesian part of the Malacca Straits.*

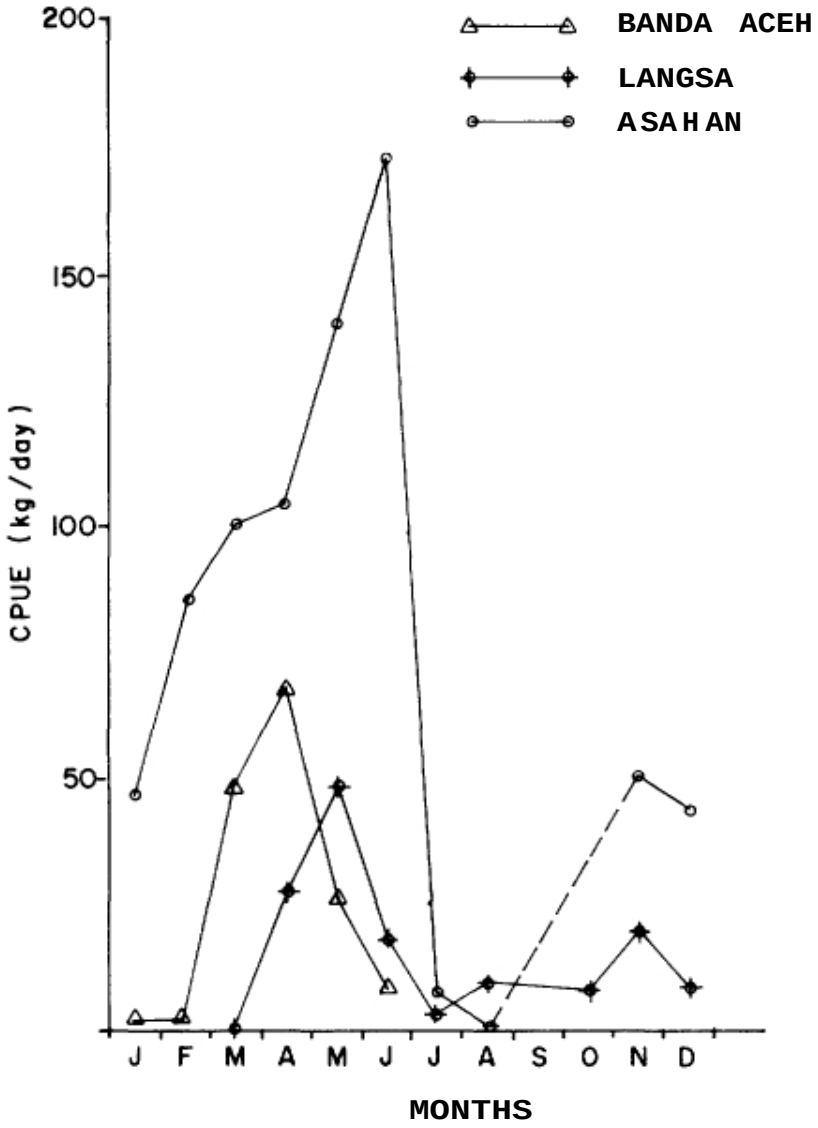

Figure 3. *Monthly catch rates of* R. brachysoma *collected from the purse seine fishery operating in the Indonesian part of the Malacca Straits.*

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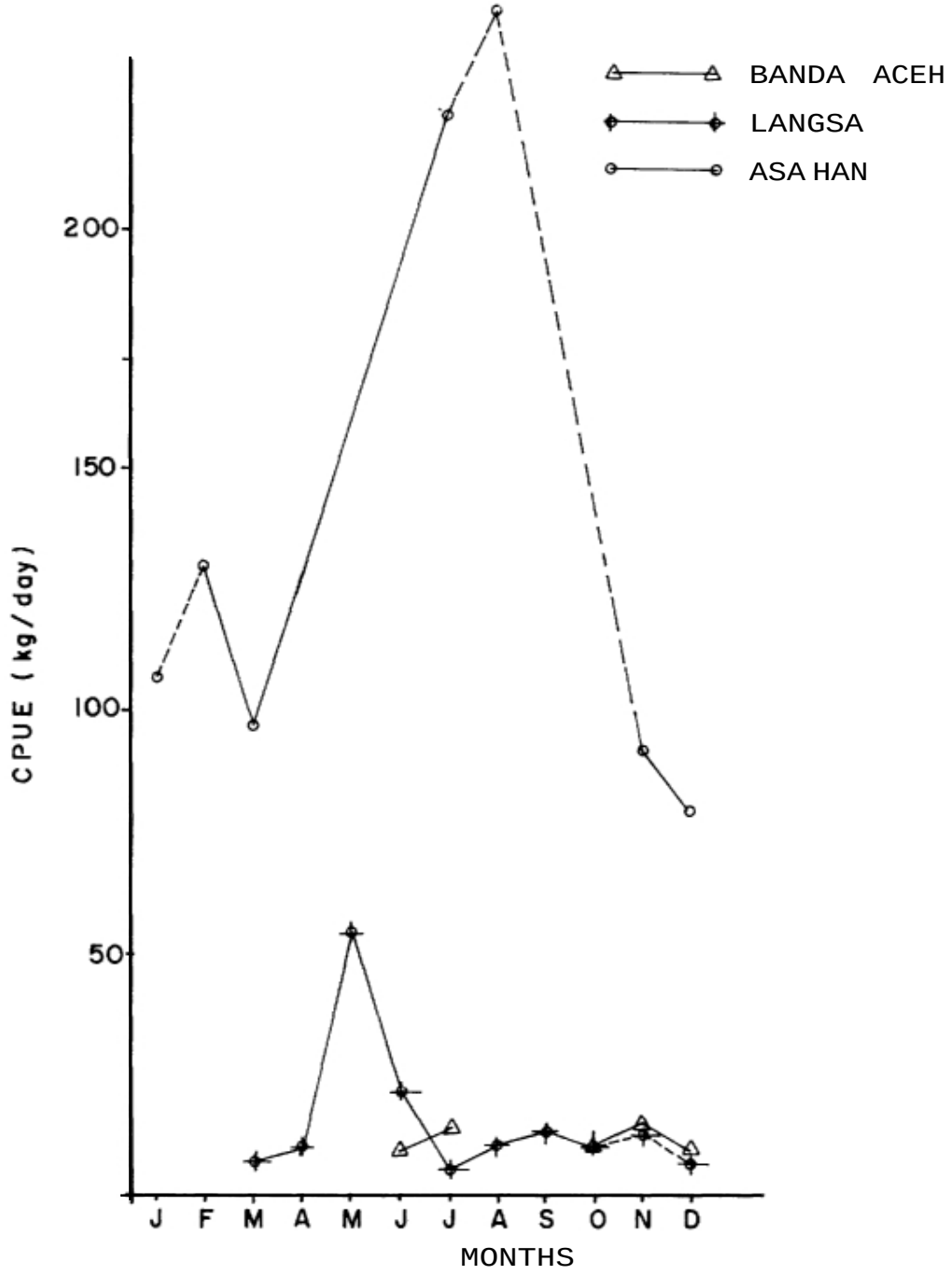

Figure 4. *Monthly catch rates of* R. kanagurta *collected from the purse seine fishery operating* in the Indonesian part of the Malacca Straits.

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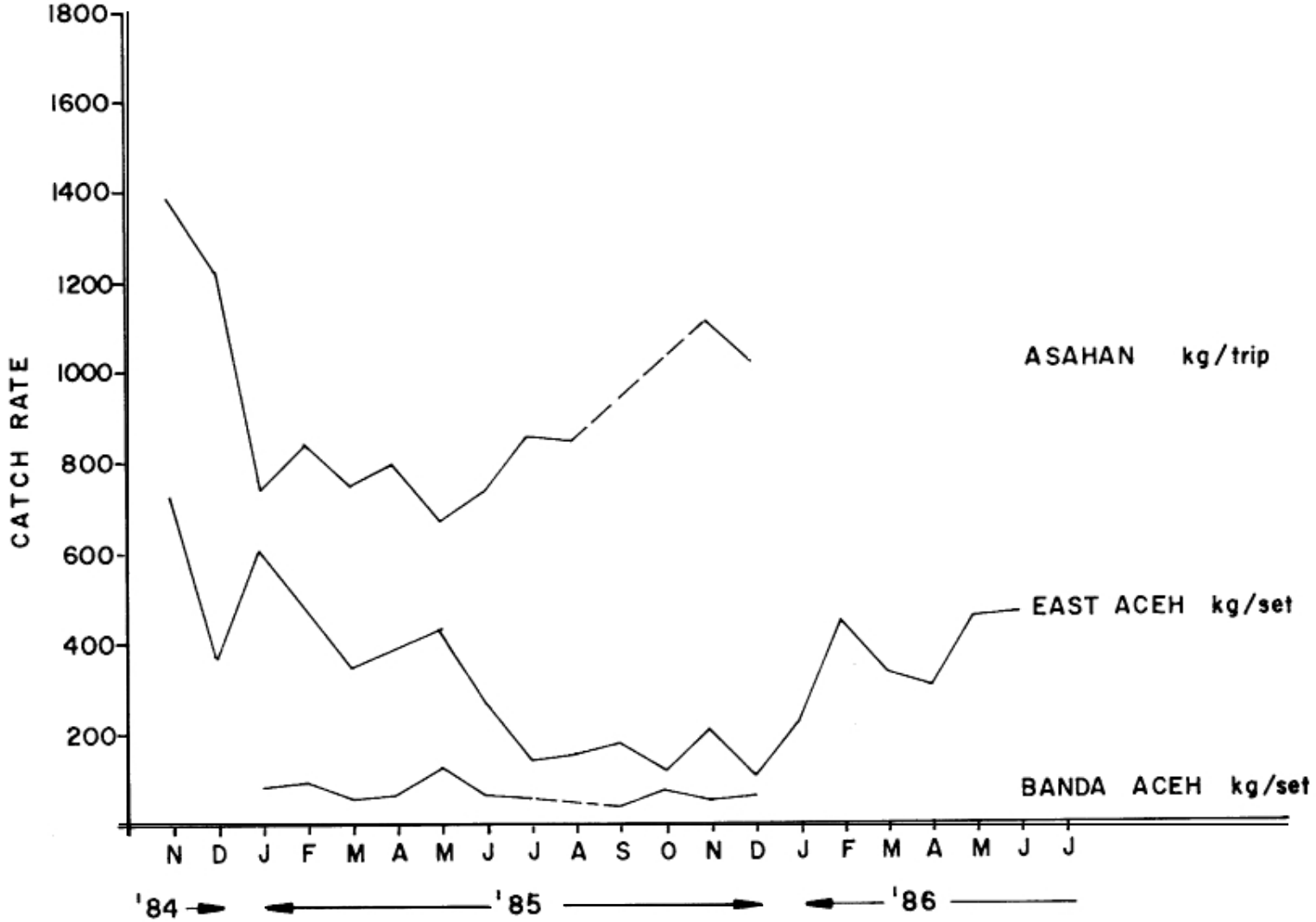
Figure 5. *Monthly catch rates in the Indonesian part of the Malacca Straits. Purse seine total catches (kg) per trip or set.*



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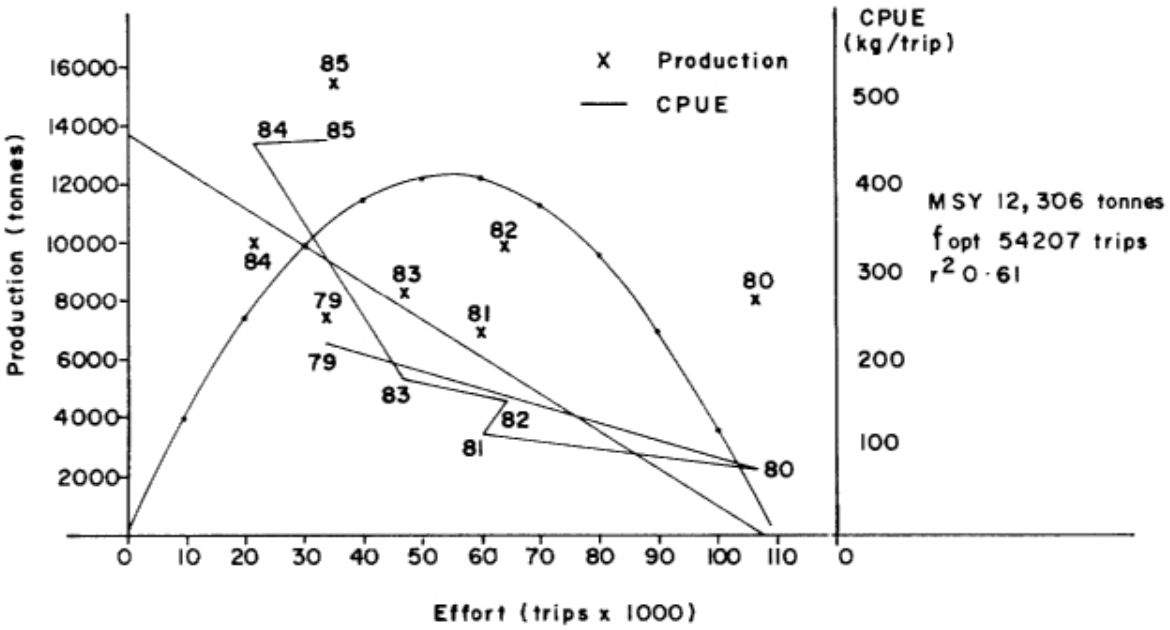

Figure 6. *Shaeffer's production model applied to Indonesian catch and effort statistics for* R. kanagurta.

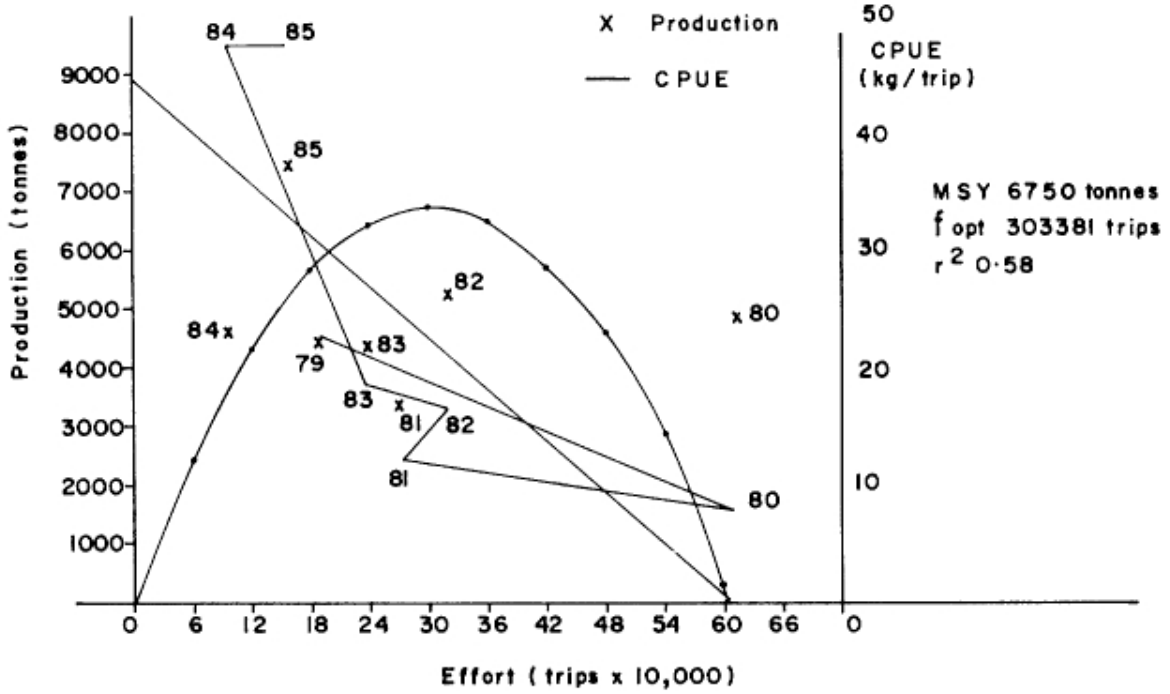

Figure 7. *Shaeffer's production model applied to Indonesian catch and effort statistics for* R. brachysoma.

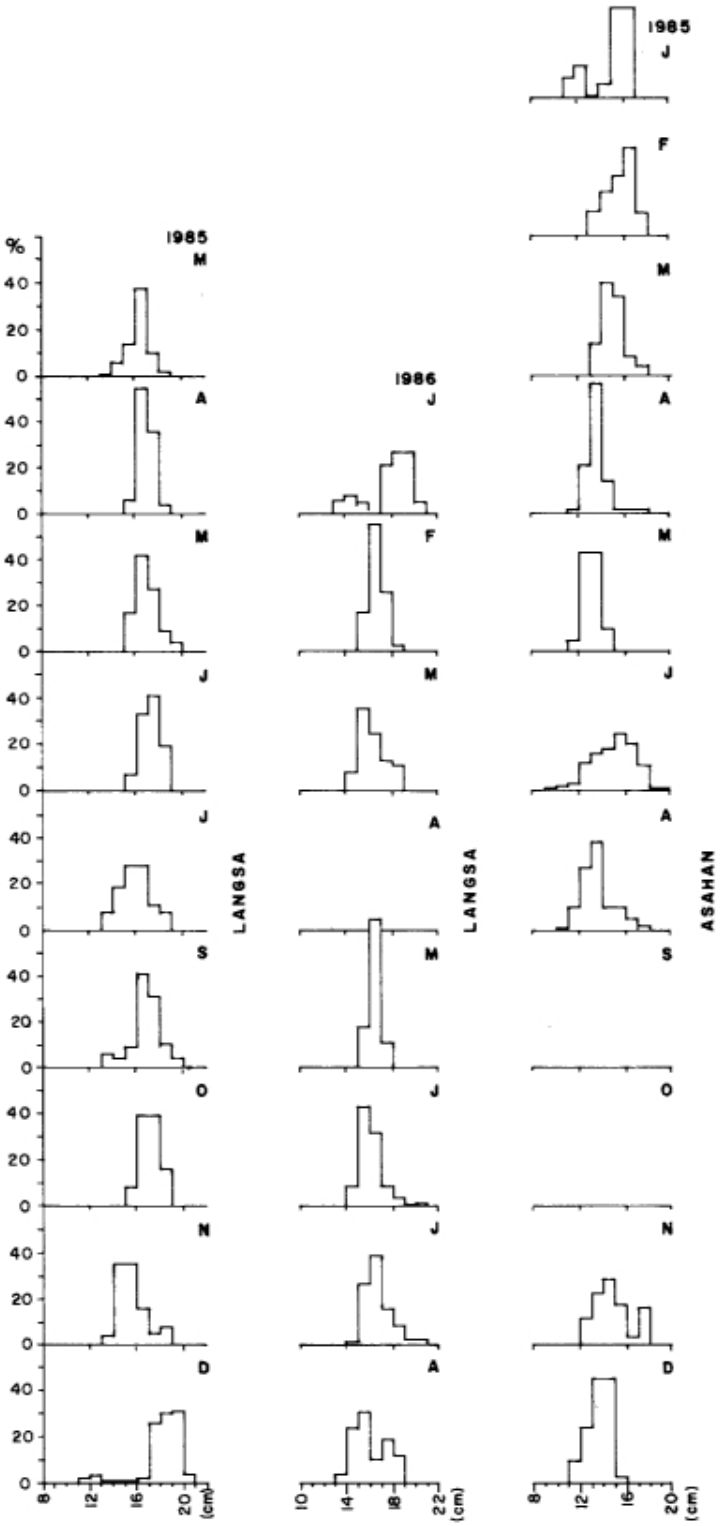

Figure 8. Length frequencies of D. russelli caught by purse seine in Langsa (1985-1986) *and in Asahan (1985) Indonesia.*

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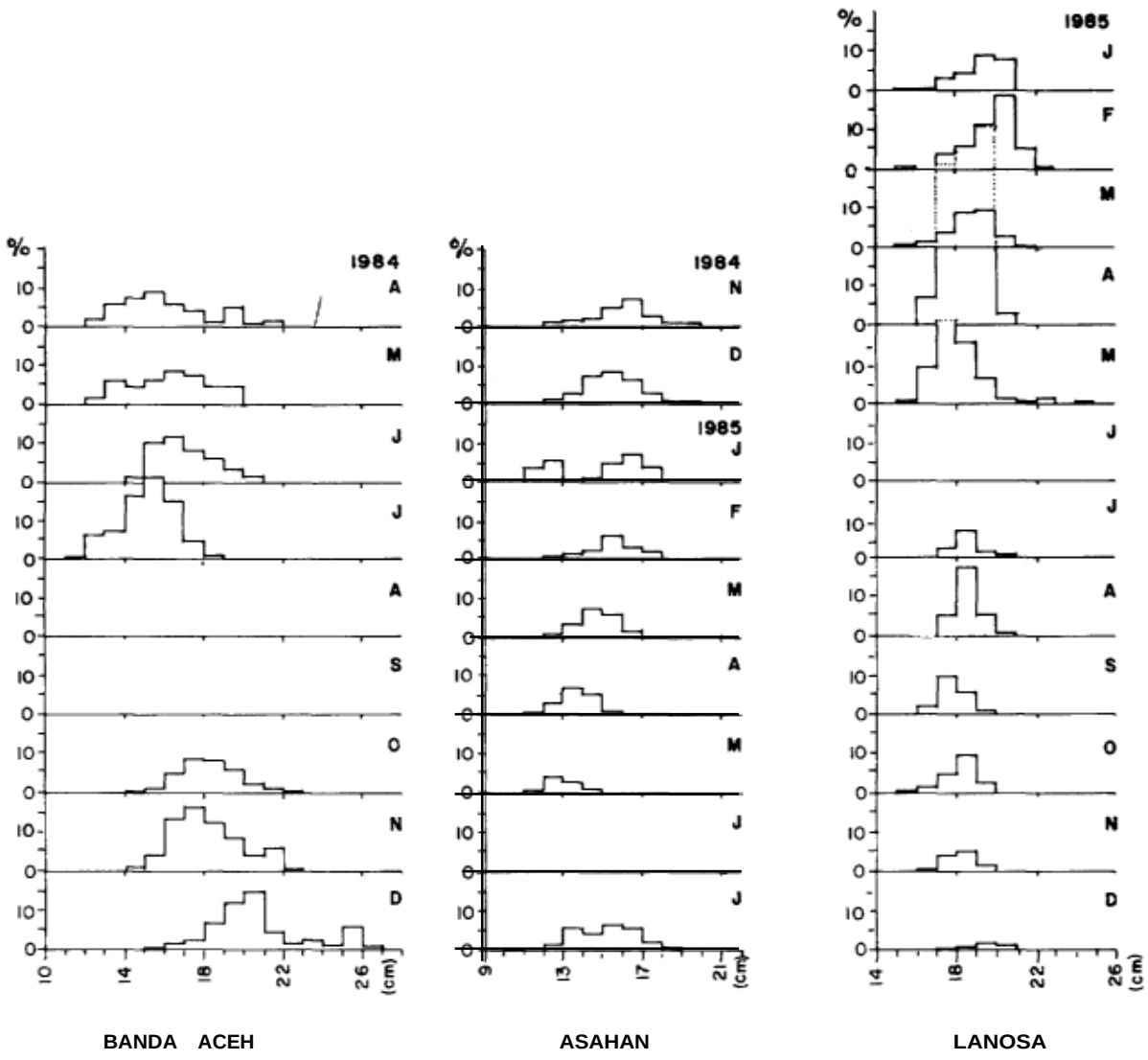

Figure 9. *frength frequencies of* D. macrosoma *caught by purse seine in Banda Aceh (1984), Asahan (1984-1985) and Langsa (1985).*

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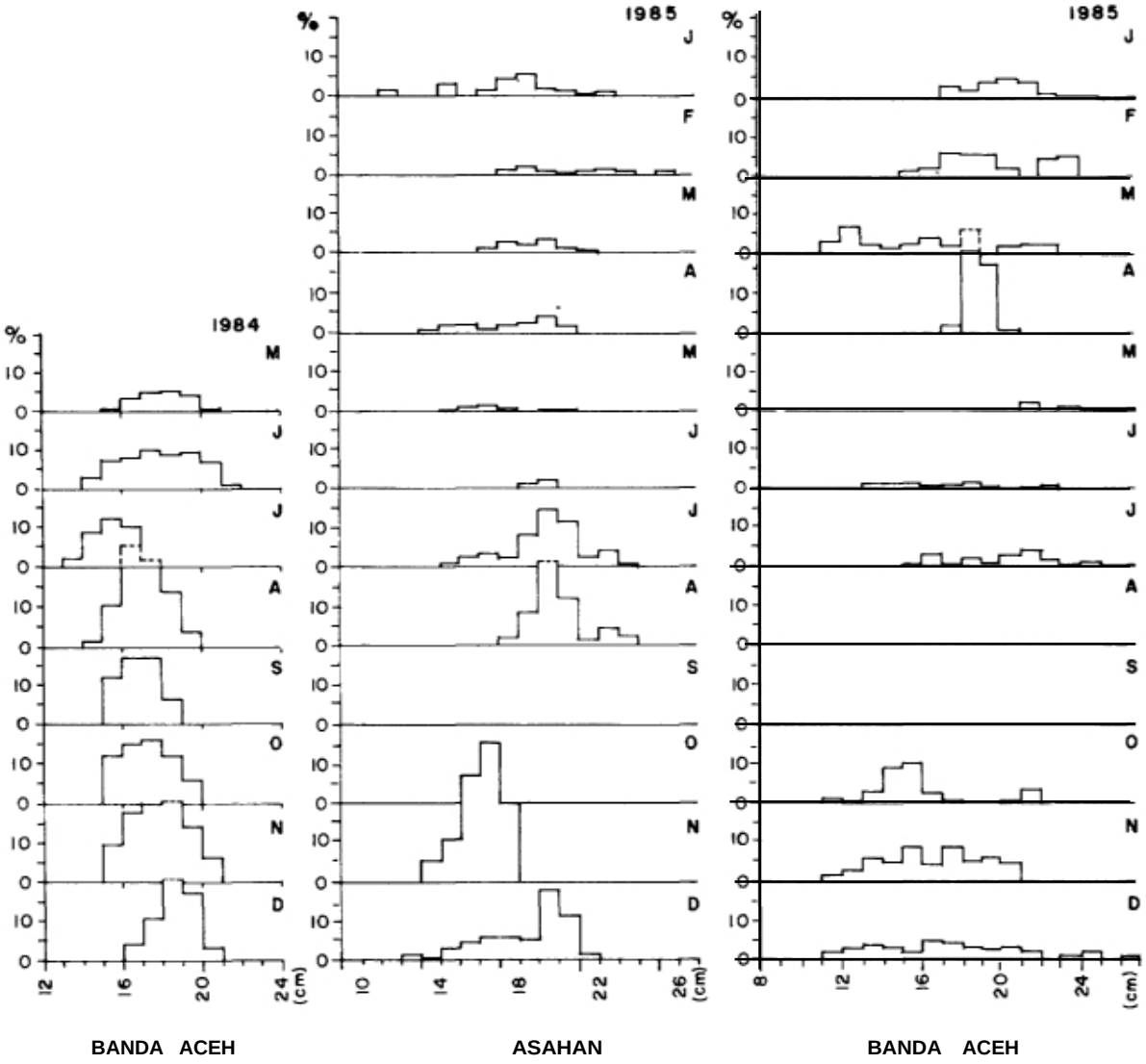

Figure 10. *Length frequencies of* R. kanagurta *caught by purse seine in Banda Aceh (1984-1985) and Asahan (1985).*

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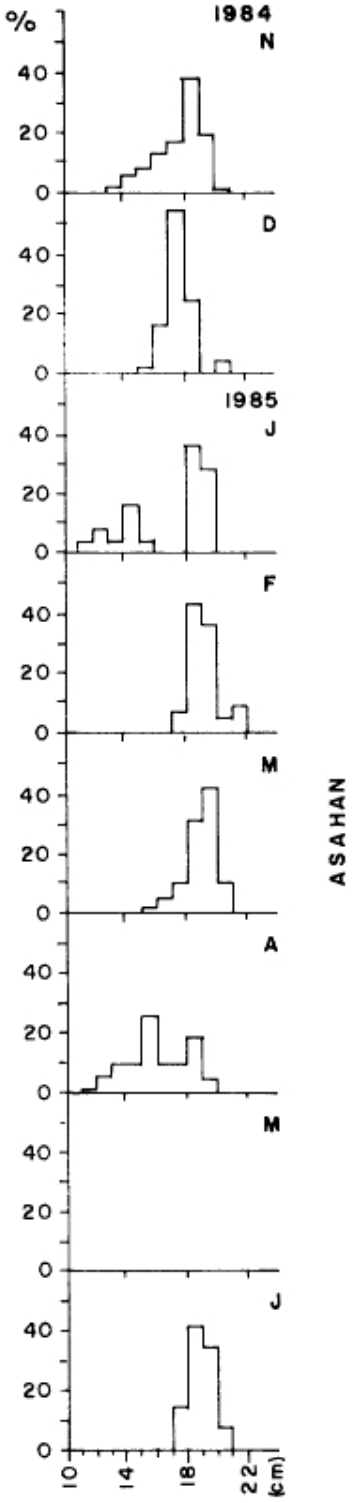

Figure 11. *Length frequencies of* R. brachysoma *caught by purse seine in Asahan (1984-1985), Indonesia.*

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Annexure 5

SCADS AND CHUB MACKERELS (DECAPTERUS SPP. AND *RASTRELLIGER* SPP.) IN THE BAY OF BENGAL

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Introduction

Scad and chub mackerels are commercially valuable fish in the Bay of Bengal region and contribute significantly to the marine fish production of most countries. In Indonesia, Malaysia and Thailand, where major fishing effort is directed at the exploitation of these species, a substantive attempt is being made to collect statistics on these species and assess the status of their resources for management purposes. However, in Sri Lanka and Burma, which have an established fishery for these species, even crude estimates of production are not available and exploitation continues without any knowledge of the trend. Since 1983, Sri Lanka has been attempting to show catch estimates separately for Indian mackerel.

This report attempts to put together available information from the fisheries, and findings from the results of fishery surveys, and to express views that are likely to stimulate further investigation to better understand and manage these resources.

Species in the Bay of Bengal

Among the countries in the Bay of Bengal, there appear to be significant differences in the predominant scad and chub mackerel species, according to published records and reports.

Chub Mackerels	Reported in commercial and survey catch records
Rastrelliger *brachysoma* (Bleeker, 1851) (Short bodied mackerel/Indo-Pacific mackerel) Synonym: *R. neglectus*	Bangladesh, Burma, West coast of Thailand and P. Malaysia, Sumatra (Indonesia) and *Andamans (India).*
R. *faughni* (Matsui 1967) (Faughn's mackerel)	Sri Lanka, Andamans (India), Thailand (West).
R. kanagurta (Cuvier. 181 7) (Indian mackerel)	Maldives, Sri Lanka, India, Bangladesh, Burma West coast of Thailand and P. Malaysia, (Sumatra) Indonesia.
Scads	
Decapterus macfosoma (Bleeker, 1851) (Shortfin scad)	Maldives, Burma, West coast of Thailand and P. Malaysia, Indonesia.
D. *macarellus* (Cuiver, 1833)	Maldives and Thailand.
D. *kurroides* (Bleeker, 1855) (Red tail scad).	Bangladesh
D. russelli (Ruppell, 1830) (Indian scad/Russell's scad) (Synonym *D. lajang* Bleekar 1885)	Sri Lanka, India. Indonesia (Sumatra)
D. maruadsi (T. & S., 1842) (Round scad)	Bangladesh, Burma, West coast of Thailand and P. Malaysia.

Catch records show that *R. kanagurta* and *D. russelli* are the most common chub mackerel and scad species on the western side of the Bay of Bengal, while *R. brachysoma* and *D. macrosoma* are the most common mackerels and scads on the eastern side of the Bay.

In Bangladesh and the west coast of Thailand and Peninsular Malaysia, *D. russelli* was reported until about a decade ago but *D. maruadsi* has been instituted since then. However, Indonesia continues to record *D.* russelli in the Malacca Straits and not *D. maruadsi.* This has resulted in some doubt about the validity of the identification of these species, particularly, the last two

species, in the Malacca Straits. During the Dr. F. Nansen survey around the south and west coasts of Sumatra, D. maruadsi was recorded. D. *maruadsi* recorded in the Malacca Straits has recently been identified as D. russelli by Smith Vaniz (personal communication).

Though there is very little doubt about the identification of *Rastrelliger* species in this area, there appears to be some mixing of these species in catch statistics because of the difficulty in separating the catches of particularly the small juveniles of these species.

Confirmed identification of the species is the first step to assessment of the stocks, particularly if they are considered to be shared by two or more nations.

2. Fishery

Table 1 summarises the various fishing methods that capture these mackerels, the spread of the fishery and the types of craft involved in the mackerel fishery in the various countries bordering the Bay of Bengal.

Table 1

Fishing methods and types of craft used in the mackerel fishery

Country	Gears catching scad	Exploitation range	Craft used
Maldives	Lift net, beach seines, hand-lines (incidental)	Reef waters	Mainly non-mechanised traditional craft.
Sri Lanka	Gillnets, shore seines purse seines	Coastal waters 25 miles	Non-mech. traditional craft, 17' F.R.P. boats with out-board engines, kattumarams and purse seiners.
India (E. coast)	Gillnets, shore seines, and trawls	Coastal waters 25 miles	Mainly non-mechanised traditional craft and trawlers.
Bangladesh	Gillnets and set bagnets (?)	Coastal waters	Mainly mechanised craft.
Burma	Purse seines, gillnets and lift nets	Inshore and around islands	Mechanised and non-mechanised craft.
Thailand (W. coast)	Purse seines (luring and non-luring), trawls, traps and gillnets	About 50% of EEZ	Almost entirely specialised purse sines and trawlers with echo sounders.
P. Malaysia (W. Coast)	Purse seines, trawls, gillnets and others	90% of the EEZ	Similar to Thailand.
(Indonesia) Sumatra	Purse seines, gillnets lift nets, handtines	About 50% of the EEZ	Purse seines and mecha-nised craft No trawlers.

There are no specific fisheries for mackerels in Bangladesh and the Maldives and any'landings of these species are only incidental. In Sri Lanka, beach seine fishery which was the primary contributor to mackerel production, is declining but recent introduction of purse seining for sardines and mackerels appears to be increasing on the west coast. Gillnetting by non-mechanised traditional craft is steadily being replaced by mechanised F.R.P. boats

In India (east coast), gillnetting and beach seining with traditional non-mechanised craft are continuing steadily and mechanised crafts and trawlers are gradually increasing their contribution to this fishery. Information from Bangladesh and Burma on this subject is scanty. In Thailand (west coast), more and more Thai purse seiners are shifting from mackerel fishery to fishery for other species such as hardtails and tunas but luring purse seines are increasingly contributing to mackerel production. On the west coast of Peninsular Malaysia, there is very significant increase in the contribution to mackerel production by high-openirfg trawls. In fact at the present stage, mackerel may be considered to be a target species for this trawl fishery. In Sumatra, there has been an increase in the number of purse seiners operating around the north and north-east coasts for mackerels, scads and tunas.

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2.1 Production trend

It is estimated that the production of scads and chub mackerels from the Bay of Bengal area is in the region of 28-32,000 t and 118-l 30,000 t per annum, respectively (Table 2). No estimates on the production of these species are available for the Maldives, Bangladesh and Burma. Projections for these countries have been made on the basis of verbal communications and estimates given in some old reports. Estimated production of scads in India and chub mackerels in Sri Lanka are available only for 1982 and 1983, respectively. About 41 % of the chub mackerels produced from the area is contributed by the west coast of P. Malaysia followed by Thailand (west) (23.8%) and east coast of Sumatra (19.2%). The order observed in respect of scad production is — Sumatra (north and east) (42%) Thailand (west) (21 .7%). P. Malaysia (west) (17%) and India (east) (13%).

India has reported (Anon. 1983) that her mackerel production in 1982 was the lowest for the last ten years or more. The state of Tamil Nadu, which contributes about 50% of the chub mackerel production on the east coast, has not been able to reach 10,000 t since 1976. Around Andaman islands, production of chub mackerels, though very small has risen from 77 t in 1976 to 348 t in 1982. Scad production statistics have been separated from the general carangid group only since 1981 and there is no significant change in the production between 1981 and 1982 (Tables 3a & 3b).

For Bangladesh, West (1973) stated that annual production of mackerels etc. was about 1800 t, from 1965 to 1970, but no other details are available. Shimura's (1984) estimation of production by various fisheries in Bangladesh, for the period September 1983 — August 1984, show about 80,000 t production by gillnet and seine net production in the marine sector but nearly 70% of this is considered to be hilsa. It is possible that a small portion of the balance 30% may be mackerels but there is no evidence.

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Table 2

Scad and chub mackerel production estimates

(t/annum)

Country	*Rastreiliger* species (year)		*Decapterus* species
Maldives (5)	100-200 (?)	Mainly *R. kanagurta*	(?) Mainly *D macarellus*
Sri Lanka (1)	4663 (1983)	Mainly *R. kanagurta* and some *R. faughni*	(?) Manly *D russelli*
India (east coast and Andamans)	8907 (1982)	Mainland almost entirely *R. kanagurta* Andaman *— 80%* of *R. kanagurta* 20% of brachysoma	5015 (1982) Mainly *D. russelli*
Bangladesh (2)	2000 (?)	Projected from 1800 t Average estimated for 1965-70	**500 (?)**
Burma (3), (6)	**3000 (?)** (1982)	*R. brachysoma — 63%* *R. kanagurta — 37%*	1500 (?)
Thailand (4) (west coast)	6012 22,162 (1985)	*R. kanagurta* — 21.3 % *R. brachysoma 78.7%* *R. faughni — ?*	8205 (1985) *D. maruadsi 73* 8% *D. macrosoma — 26.2%*
P. Malaysia (1) (west coast)	8455 40,090 (1985)	*R. kanagurfa* — 17.5% *R. bracnysoma — 82.5%* *R. faughni*	6437 (1985) *D. maruadsi* more than *D. macrosoma*
Sumatra (1) (north of equator)	15,430 7379	*R. kanagurta — 67* 6% *R. brachysoma — 32* 4% *R. faughni ?*	16,168 (1985) *D. macrosoma — 53%* *D. russelli — 47%*
Total	118,198		37825
Est. Production	118,000-130,000		38,000.42,000 t

Source. 1. Annual Fisheries Statistics Bulletin of the respective countries 1981-1983
2. West (1973)
3. Druzhinin (1970) and Naumov (1971)
4. Anonymous (1986)
5. Personal communication — Hassan Maniku
6. Personal communication — Soe Win

Table 3a.

Chub mackerel production by the states on the east coast of India

(tonne)

State	1976	1977	1978	1979	1980	1981	1982
W. Bengal			—	—	—	—	—
Orissa	425	195	196	306	265	823	620
Andhra Pradesh	2,084	1,040	2,520	2,621	6,203	3,255	2,971
Tamil Nadu	10,488	5,674	1,453	3,521	7,229	3,916	4,441
Pondicherry	1,598	398	179	424	445	316	527
Andaman islands	77	111	106	92	183	156	348
Total (east coast)	19,672	7.418	4,454	6,964	14,325	8,466	8,907
Total (India)	65,497	62,136	85,233	71,514	55,279	48,660	28,000

Source: Anonymous (India) 1982 and 1983

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Table 3b.

Scad production by states on the east coast of India, trawl catch in parentheses

(tonnes)

Year	W. Bengal	Orissa	Andhra Pradesh	Tamil Nadu	Pondicherry	Andamans	Total
1981182		—	3,302 (2,814)	1,320	162	—	4,831
1982183	—	225	3.712 (2,764)	703	1,618		6,258

Source. Anonymous (India) 1982 and 1983

Druzhinin (1970) and Naumov (1971) sampled the mackerel landings in Burma and estimated that the purse seine catches in the Mergui area (Tenasserim coast) are as follows:

1965 — 308,655 kg. (Druzhinin 1970)
1966 — 359,297 kg. (Druzhinin 1970)
1976 — 21 1.615 kg. (Druzhinin 1970)
1968 — 235,229 kg. (Naumov 1971)
1969 — 111,988 kg (Naumov 1971)

The contribution by other fishing methods from other fishing areas and the reason for the decline in the above mentioned annual catches are unknown However, it is assumed that mackerel production would have gone up during the last decade (verbal communication by Soe Win) with the annual increase in total production.

On the west coast of Thailand, annual production of chub mackerels showed a declining trend between 1975 and 1981 but has steadily increased since then. Scad production fluctuated without significant decline until 1982, increased sharply in 1983 and declined in 1984 and 1985 (Tables 4a, b & c)

On the west coast of P Malaysia, chub mackerel production declined to 10,000 t in 1975, increased to 68,966 t in 1984 and then declined to 48.545 t in 1985. Scad production declined to 3700 t in 1976, increased to 11,000 t in 1983 and then declined to 6437 t in 1985 (Tables 5a & b)

In the northwest and Malacca Straits coasts of Sumatra (Indonesia) annual production of scad and chub mackerel from 1970 to 1985 showed an increasing trend A drastic drop in the level of production, particularly of the scads, is seen during 1976. This is attributed to changes and improvements in the statistical system in that country However the production improved very markedly in recent years (Table 6).

Table 4a.

Annual production of chub mackerel species by different gears on the west coast of Thailand

(tonnes)

Gear	Species	1971	1972	1973	1974	19.75	'1976	1977	1978	1979	1980	1981
Trawl	*R kanagurta*	*0*	173	280	492	0	9	71	131	60	27	69
	R brachysoma	*927*	753	1.149	622	335	544	2,101	1.239	2.220	770	1,081
Purse seine	R kanagurta	3,856	3,793	9,947	5,256	5,720	5,217	2,443	2.257	1,029	949	70
	R brachysoma	11,375	4,891	11,479	5,285	6,321	2,582	2,414	1.048	363	1.025	1,139
Others	*R kanagurta*	*0*	*0*	*94*	221	2	58	31	4	27	0	0
	R brachysoma	*11*	58	377	113	963	15	8	67	43	0	0
Total	R kanagurta	3,856	3,966	10.329	6.050	5.722	5,284	2,545	2 392	1.116	976	836
	R *brachysoma*	12.313	5,702	13.005	5.120	7.979	3,141	4,623	2.354	2,626	1.795	2,220

Source. Anonymous (Thailand) 1984a

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Table 46.

Annual production of scads by different gears on the west coast of Thailand

(tonne)

Gear	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Trawls	0	0	0	0	29	3	1	0	0	0	0
Purse seines	1.780	1,475	811	1,415	1,506	1,044	1,449	883	1.043	835	1,184
Others	0	0	0	1	0	0	0	3	0	0	0
Total-	1,780	1,475	811	1,416	1,535	1,047	1,450	886	1,043	895	1,184

Source- Anonymous(Thailand)(1984b)

Table 4c.

Annual production of chub mackerels and scads on the west coast of Thailand, 1982-1985

(tonne)

Species	1982	1983	1984	1985
R. brachysoma	9,714	11,410	16,129	22,162
R. kanagurta	1,890	3,959	3,580	6,012
Decapterus spp.	2,212	13,941	11,721	8,205

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Table 5a.

Annual production of mackerels by different gears on the west coast of Peninsular Malaysia

(tonne)

Rastrelliger spp.	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Purse seine	86,621	56,485	28,844	33,692	9,334	21,021	11,299	8,175	7,042	8,592	11,936	28,300	41,704	27,235	27,920
Trawl	526	255	230	195	392	553	721	1,520	4,989	10,450	10,962	3,595	6,683	14,013	20,570
Gillnet	749	20	13	37	23	78	279	276	364	384	782	352	2,883	3,374	5,927
Others	3,108	548	34	27	12	21	13	14	17	142	121	104	528	403	300
Total	91,005	77,310	29,122	33,953	9,762	21,674	12,312	9,987	12,413	19,570	23,802	34,153	51,799	45,027	54,719
Decapterus spp.															
Total Purse seine	11,810	3,578	3,680	2,308	1,814	4,848	7,021	5,332	3,694	6,398	6,025	6,599	7,459	8,193	9,407
	1,690	3,489	3,578	2,275	1,790	4,809	7,019	5,173	3,678	6,231	5,839	6,141	7,109	7,970	9,220
Trawl	117	67	93	17	20	34	1	153	2	155	184	458	350	223	187
Others	3	22	9	16	4	5	1	6	14	12	2	–	–	–	–

Source: Chee (1984)

Table 5b.

Annual production of chub mackerel and scads on the west coast of Peninsular Malaysia 1982-1985

(tonne)

Species	*1982*	*1983*	*1984*	*1985*
R. brachysoma	37,472	42,864	47,228	40,090
R. kanagurta	17,247	19,730	21,738	8,455
Decapterus spp.	9,408	11,359	10,276	6,437

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Table 6

Scad and chub mackerel production from the N. Sumatra and Malacca Straits coasts of Indonesia

(tonne)

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Chub (Rastrelliger)	16,173	17,723	20,237	21,349	16,178	18,532	19,512	11,669	1.373	11,232	12,439	13,828	10,395	15,094	12,642	14,393	2,280
Scad *(Decapterus)*	*9,808*	10,765	12,193	13,705	12,263	13,612	14,053	758	1,365	2,536	2,593	812	4,397	5,052	7,726	8,724	1,016

Source.Anon 1983,Anon 1984 and Anon 1986.

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2.2 Catch rates

Hardly any reliable and systematic estimates are available of the catch rates of scads and chub mackerels fisheries on the western and northern sides of the Bay of Bengal.

In India, purse seining for mackerels is only on the west coast and reports indicate that catch rates of 677 kg/haul were realized in 1975 off Karnataka state, 5-l 0 kg/hr for trawlers in Calicut and 16.1 kg/trip for gillnetters in the Palk Bay area (Noble 1979).

Druzhinin (1970) reported the following catch rates for purse seine catches in Burma.

1965 — 744 kg/boat/day
1966 — 750 kg/boat/day
1967 — 723 kg/boat/day

However, his data on the purse seine fishery sampling, conducted between August 1966 and September 1968 (36 days), gave mean catch rates of 117.2 kg/boat/day for R. kanagurta and 197 kg/boat/day for R. brachysoma. According to Rijavec (1983) purse seine catch rates during the main seasons of 1982 were as follows:

April — 640 kg/boat/month
May — 558 kg/boat/month
June — 7400 kg/boat/month
July — 18080 kg/boat/month
August — 16060 kg/boat/month

Druzhinin also states that purse seiners (19 m, 240 h.p., 22 crew) operating 300-400 m long, 30 m deep and 1 1/2" mesh nets caught l-2 tons of mackerel/day during the southwest monsoon. off the Tenasserim coast (10 41'-12 N).

On the west coast of Thailand, chub mackerel catch rates in 1985 ranged from 1000 to 2000 kg/boat/day during the peak season. Catch rates of scads appear to be around 200 kg/boat/day during the peak seasons (Anonymous, 1986).

On the west coast of P. Malaysia, chub mackerel catch rates in 1985 were similar to those on the Thailand (west) coast. Trawl catch rates of mackerels were also high (1200 kg/boat/day) during the peak season off Perak (Anonymous, 1986).

Catch rate of scad appears to be high in the northwest coast (Perak) with 1400 kg/boat/day in the peak season (Anonymous 1986).

In the Sumatra area under consideration, chub mackerel catch rates in 1985 ranged from 100 to 200 kg/boat/day during the peak seasons while those of scads were higher, with 200-290 kg/boat/day. Higher catch rates of both varieties were observed on the east coast than in the north (Anonymous, 1986).

2.3 Seasonality and occurrence

In the Maldives, chub mackerels are reported to be caught only in the northern atolls and hardly any landings are reported in the central Male Atoll. The scad production appears to be more sparsely scattered. In Sri Lanka, chub mackerels are caught all around the coastline. R. kanagurta is considered to be the predominant species around the island but it is suspected that R. faughni also occurs on the south and east coasts (verbal communication — T.P. Goonewardene).

On the east coast of India, production of R. kanagurta off the Orissa coast is high in February and November. Off Visakhapatnam, it is high in March and further south, the peak period is June, but production is high in February/March and October as well. Around An'daman Islands, 40% of the annual production of chub mackerels is obtained in June/July. The southern state of Tamil Nadu produces 49% of the chub mackerels from the east coast and the production declines, in the northerly direction, to no catches in the northermost state of West Bengal. Scad production is highest in the state of Andhra Pradesh.

Off Burma, May to October is considered to be a good season for mackerels on the Tenasserim coast, close to the Thai-Burmese border, where R. brachysoma is the predominant species. On the west coast of Thailand, the catch records indicate that the peak season is variable with fishing area and May-September appears to be good for *R. brachysoma* while March-May is good for *R.* kanagurta. In 1980 51 % of the *R. brachysoma* was produced by the Satul province adjoining the Thai-Malaysian border and 52% of *R. kanagurta* was from Phang Nga and Phuket

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provinces in the central west coast of Thailand which have reported almost no catches of R. brachysoma. There is a strong possibility that there is significant intermingling of R. brachysoma at the Thai-Malavsian boundary.

On the west coast of P. Malaysia, production of both scad and chub mackerels is high in the area north of Penang but declines sharply in the south and almost touches nil in the area south of Selangor state. In 1981 and 1982, the scad production exceeded 1000 t per month only in July but the peak season in 1985 was March-May. However, in the case of chub mackerels, 5000 t/month production level was exceeded between February and July in the period 1981-1985.

The Malacca Strait coast of north Sumatra province (Indonesia) records the highest production of both scads and chub mackerel for Sumatra Island. This is followed by Aceh province for scads and western side of north Sumatra province for chub mackerels. On the Malacca Strait side of Sumatra, the production of both types of fish declines southwards, in the Riau province, as in the corresponding area on the west coast of P. Malaysia. Similarity in the decline on both sides of the southern part of Malacca Strait indicates that these mackerels in the Malacca Strait may not be freely intermingling with those in the south China Sea. The peak season for mackerels was May-August and February-June for scads on the east coast of Sumatra (Anonymous, 1986).

3. General Distribution

Scads and chub mackerels are widely distributed in the Bay of Bengal area and the production trend indicates that chub mackerels are more abundant than scads, in the exploited ranges of all the countries bordering this area. The present yield per unit area of the continental shelf is about 0.27 t/km, for chub mackerels in the Bay of Bengal. Only Malaysia showed a yield of 0.788 t/km while others showed values close to or less than the average.

In Malaysia, trawl fishery has contributed to the significant increase in mackerel production in recent years and in view of this observation an attempt is made here to review the production of mackerels by pelagic and demersal gears in the various countries.

On the east coast of India, about 55% of the scads and about 3% of the chub mackerels caught appear to have been landed by trawlers, in 1981 and 1982. The trawler landings of scads have been reported to be almost entirely from the state of Andhra Pradesh (Table 3b). In the case of chub mackerels, 2% was from Andhra Pradesh(15º-18ºN) and 1 % from Tamil Nadu (10-15ºN). As a result, the scad'production was highest in Andhra Pradesh and it declined both southwards and northwards.

The relative proportions of in e mackerel catches by pelagic and demersal gears on the west coast of Thailand are given below. No significant changes in the relative proportions were observed during the period 1976-1981 (see Tables 4a and 4b).

On the west coast of P. Malaysia, during 1968, the chub mackerel production by purse seines was 95%, trawlers 1 % and gillnetters 1 % but by 1982 the contributions by purse. seiners declined to 51 % and that by trawlers and gillnetters increased to 38% and 11 %, respectively. *Decapterus* has continued to be produced mainly by purse seiners with a small contribution by trawlers (Table 5). Prior to the suspension of trawling in Indonesia, in 1980, the percentage contribution to mackerel production in Sumatra was: Purse seiners 90%, trawlers 4%, gillnets 4%. In view of the small contribution by trawlers at that time, suspension of trawling does not appear to have any drastic effort on the mackerel production. In the case of scads too, the purse seiners contributed 99% of the production in 1979.

Catch records of bottom trawl surveys conducted by 'Dr. Fridtjof Nansen' in all the countries in the area excluding India and those of recent national surveys in India, Bangladesh and Burma were examined. Of about 1500 tows made in the area about 10% were successful in catching mackerels and scads, in the depth range of 10-150 m. As the successful hauls were relatively few, the catch rates of scads and chub mackerels in each of the successful hauls were plotted against fishing depth. Relatively higher catch rates occurred in the depth range of 50-90 m, for both varieties of fish. In the Bangladesh and Indian (east coast) waters, the catch rates were very high compared to the other countries, for both scads and chub mackerels (Figures 1 & 2). In fact trawling conducted by the Fisheries Survey of India has shown that mackerel catch rates off the northeast coast (Orissa and West Bengal) in the 100-120 m depth are much higher than in the 50-100 m depth Mackerels appeared throughout the year in the trawl catches but the period from June to December was relatively better than the rest of the year; June and October were the peak months: Catch rates were higher closer to the Swatch of No Ground.

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Bangladesh also exhibited a similar seasonal trend for mackerels and scads. The trawl catch rates for mackerel tends to be less in the southerly direction, along the east coast of India. In spite of the large production of these species by trawlers in Malaysia, the catch rates during the trawl surveys were not high. It was also observed that the catch rates of these species were relatively very poor in the pelagic trawl operated at the same time in all the countries It is particularly noteworthy that very high catch rates are obtained with bottom trawls in Bangladesh and Burma, but there was little evidence of the presence of mackerels at or near the surface at the same time. In most cases the trawl surveys were limited to a short period and seasons of coverage were different between countries. Hence, direct comparisons of the results from the various countries could not be attempted. However, on the basis of information from commercial catches and survey results, it is clear that the vertical distribution of scads and mackerels in the Bay of Bengal area can be considered as two components, according to their vulnerability to the pelagic and demersal fishing gears. Except in Malaysia and perhaps Thailand, the demersal component is unexploited or under-exploited. It also appears that Rastrelliger species close to the bottom are concentrated within a relatively narrow depth range and that *Decapterus* species are spread over a wider depth range and extend into greater depths also. Examination of available catch data from Malaysia failed to show any correlation between the annual production of mackerels by purse seines and trawls.

It is observed from trawl catch rates that the relative abundance of mackerels seems to be greater than that of scads, in the depth range and areas surveyed around the Bay of Bengal. The catch rates also tend to be higher during the day than at night.

It is noted that the primary species off the coast of Bangladesh and east coast of India is R. *kanagurta* while it is *R. brachysoma* on the west coasts of Thailand and P. Malaysia. This factor may influence the differences in the depth at which the two species may be concentrated. That is, *R. kanagurta* being more oceanic, may occur close to the bottom at greater depth than *R. brachysoma.* This may contribute to the good trawl catches of the latter species in the shallow waters off P. Malaysia

4. Biological characteristics

4.1 Size composition

Available information from commercial landings is summarised below. This information has been based on limited observations and those for Burma and India are from references already inserted.

R. kanagurta

Country	Size range	Modal size
Sri Lanka	5-24 cm	13 cm in Jan/Feb.
India (S. east)	20-28 cm	21 cm
Andaman Island	4-33 cm	17-32 cm
Burma	14-24 cm	20-22 cm
Thailand	10-24 cm	20-22 cm
Malaysia	8-24 cm	16-23 cm
Indonesia	11-26 cm	16-20 cm
R. brachysoma		
Burma	15-24 cm	19-20 cm
Thailand	10-22 cm	15-20 cm
Malaysia	8-23 cm	17-20 cm
Indonesia	12-20 cm	18-19 cm
D. macrosoma		
Thailand	13-23 cm	14-19 cm
Malaysia	13.5-19 cm	14-18 cm
Indonesia	12-24 cm	14-20 cm
D. maruadsi/*D. russelli*		
Thailand	11.5-25 cm	14-18 cm
Malaysia	8-19 cm	12-18 cm
Indonesia	12-19 cm	14-18 cm

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Data collected during the survey cruises of 'Dr. Fridtjof Nansen' were analysed and these are presented in Figures 3, 4, 5 and 6. Again, irregularity in the seasons of coverage fails to give a complete picture The general size range of *R.* kanagurta are more or less similar in all the countries (5-25 cm) In the case of D. maruadsi/D. russilli it was generally in the range of 5-22 cm but the samples from Bangladesh and north west coast of Sumatra had fish of 22-32 cm size range also, from the surface waters. Except these two instances, the bottom trawl generally caught larger mean sizea of both varieties than the pelagic trawl (Figures 3-6). Probably these species tend to move into deeper waters as they grow larger in size. Comparisons of the size compositions of R. brachysoma caught by purse seines and trawls on the east coast of Sumatra and the west coast of Thailand also tend to support this (Anonymous 1986) but the sizes of the trawl samples were rather small However, the data from commercial purse seines and trawls on the west coast of P. Malaysia failed to show distinct differences in the size composition Probably there is an even vertical distribution of the mackerel population by size in this shallow area, and the deep purse seine nets and the high-opening bottom trawls may be exploiting overlapping columns of the water Ronguillo (1972) observed this phenomenon in the *Decapterus* species in the Philippine waters and considered that larger fish become more sedentary, feed on benthos and become available to the trawl fishery The bottom characteristics and configuration may influence the distance from shore and the depth at which they tend to concentrate. This behaviour also may explain the disappearance of larger sizes from the traditional fisheries, as reported by various mackerel biologists (Banerji 1964).

On the west coast of P. Malaysia the size compositions of the commercial purse seines and trawls failed to exhibit noticeable differences (Anonymous, 1986). However, it is noticed that the seasons of peak catch rates from the two gears tend to be different even in the same area and that the trawls exhibit the highest catch rate in the Kedah area, where purse seine catch rates are relatively very poor (Mansor 1986) In fact 87% of the mackerels caught by trawlers off the west coast of P Malaysia was contributed by Kedah alone. It is suspected that spawning may be occurring near this area.

4.2 Age and growth

Attempts to determine the age of R. kanagurta using scales and otoliths failed because of irregularities in the formation of rings that were found to be spawning marks appearing clearly during the second year of life (Seshappa, 1969) Hence separation of modal groups and their progression with time have been the basis of age and growth determination.

Udupa and Bhat (1984). applying the Bhattacharya method on monthly samples of *R. kanagurta* from purse seine catches on the west coast of India, identified mean lengths of age 1, 2 and 3 as 19.45, 23 45 and 25 20 cm respectively. This age classification fits fairly well with the results from previous studies by Rao (1964) Seshappa (1969), George and Banerji (1964) Luther (1973) and Menon and Radhakrishnan (1974) (20 cm — 1 st year, 20-24 cm — 2nd year, and 24-26 cm — 3rd year)

Within the Bay of Bengal, Luther (1973) identified five age groups for R. kanagurta from the Andaman Sea 1 — 14 8. II — 21 8, III — 26.5, IV — 30.2 and V — 33.0 cm He also estimated that K = 0 74 and L = 39 *cm* and showed that growth is slow during Feb.-June/July and fast during Aug/Jan. Pauly and Sann Aung (1984), using the ELEFAN method on R. *brachysoma* data from Burma,, estimated K = 1.6 and L = 27.0 cm.

However, Udom and Veera (1986). using the ELEFAN method, estimated K = 1.4 and L = 24 0 cm for *R. brachysoma* from the west coast of Thailand. For the west coast of P. Malaysia, Lui and Nuruddin (1986) also estimated fairly similar values of K = 1.3 and L = 23.4.

The analysis during the third meeting of the working group on mackerels in the Malacca Straits gave a K value of 1.4 and L of 25 cm (Anonymous *1986)* For *R. kanagurta* it was K = 1 6 and L = 29.5-30 cm

Growth estimations have not been attempted for *Decapterus* species in this area, which are very scanty. Preliminary estimates available are as follows:

3 2874 W = 0.000002164 L
or Log W = 5.6647 + 3 2874 Log L

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There **was** no significant difference in this relationship for the two sexes. The regression for the same species on the east coast of India was reported (Rao 1964) as follows:

$$\text{Male } W = 0.004983\ L^{3.2623}$$

$$\text{Female } W = 0.004784\ L^{3.2785}$$

The growth estimates for Rastrelliger species from adjacent areas vary widely (Table 7), particularly for *R. brachysoma (neglectus).*

The length-weight relationship for *R. kanagurta* from Andaman sea area was estimated (Luther 1973) as:

The regression for *R. brachysoma* on the west coast of Thailand (SEAFDEC 1981) is given as Log W = 1.8874 + 3.2140 Log L.

Rastrelliger species are considered to be short lived and fast growing.

Table 7

Growth parameters estimated for Rastrelliger species in area adjacent to the Bay of Bengal

(* Monthly basis)

Area	Species	K	L_∞	t_O	Remarks	Author
West coast of India	*R. kanagurta*	0.30	22.8	**0**		George & Banerji (1964)
West coast of India	*R. kanagurta*	0.26	23.5	+ 0.35		Menon & Radha-krishnan (1984)
Gulf of Thailand	*R. kanagurta*	0.23*	23.89			SEAFDEC (1981)
Indonesia	*R. kanagurta*	0.23*	23.9			FAO/SCS (1978)
Gulf of Thailand	*R. neglec tus*	0.29*	19.96	0.22	April/May brood	Kurogane (1 972)
	R. neglec tus	0.34*	19.62	0.58	Oct. brood	
Inner Gulf Thailand	*R. neglectus*	3.38	20.9			Hongskul (1974)
Inner Gulf of Thailand	**R neglectus**	4.2	**20.9**			Somjai Wong et al (1972)
Gulf of Thailand	*R. neglectus*	3.53 4.14	20.0 19.6		Jan. brood July brood	Sucondharman et al (1972)
Malaysia	*R.* neglectus	0.37 0.36 0.44 0.38	19.60 20.10 19.78 20.05	+ 0.366 + 0.400 + 0.393 + 0.533	Brood I Brood II Brood III Brood IV	Chong & Chua (1981)
Indonesia (Tanjung)	*R. neglectus*	2.28	22.9			Sudjastani (1974)
Indonesia	*R. neglectus*	0.19	22.1			FAO/SCS (1978)
Burma	*R.* neglectus	1.6	27.0			Pauly + Sann Aung (1984)
P. Malaysia (west)	*R. neglectus*	1.3	23.4			Lui + Nuruddin (1986)
Thailand (west)	*R. neglec tus*	1.4	24.0			Udom + Veera (1986)

4.3 Maturity and spawning

Again, there is more information from adjacent areas than from the Bay of Bengal itself.

Close to the Indian mainland and even around the Andaman Islands, the male-female sex ratio has been reported to be equal for *R. kanagurta* (Luther, 1973), but close to Burma and Thailand, there appears to be a slightly higher proportion of females, with ratios of 1.4:1 and 1.2:1

respectively (Druzhinin, 1970 and SEAFDEC, 1981). In the latter two areas, R. brachysoma shows equal and much higher proportions of females, with a ratio of 1.7:1. Recent investigations into significant variation in the sex ratio of R. *brachysoma* on the west coasts of Thailand and Malaysia showed males to be predominant among fish less than 18 cm length, equal proportions in the 18-20 cm range and female predominance among fish over 20 cm (Anonymous 1986).

Size at first maturity, as determined by various authors, are presented in Table 8.

According to these authors, it appears that fecundity of R. kanagurta is about 1000,000 eggs of over 100 mucrons and these may be spawned in at least two batches or probably three. Each batch may contain about 30,000 eggs and the interval between spawning of these batches could be between one and three months. On these points there is reasonable similarity in the results from various authors and areas.

The spawning seasons identified for these species in the Bay of Bengal area are presented in Table 9. There is quite a bit of overlap in spawning seasons among various countries within the Bay of Bengal. The spawning seasons are rather protracted, and only in a few cases separated into two periods. Whether there are two or more distinctly separated spawnings is not clearly evident. It is felt that multiple spawnings occur in most areas.

Table 8

Size at first maturity for scad and chub mackerels in the area

(cm)

Area	*R kanagurta*	*R. brachysoma*	*D maruadsi/ russelli*	*D macrosoma*	Author
India	19-224	—	—	—	Menon & Radhakrishnan (1972)
India	22	—	—	—	Rao (1967)
Andaman Sea	25-25 9 o	—			
	24-24 9 o	—	—	—	—
Luther (1973)					
Thailand	20*	16.5-17	15 5-21.5**	17 3-22.2**	Anonymous * 1984a ** 1984b
	1919.6	178190	17.5	173	Pirch (1966)
Malaysia (west)	16.7-17.2	—		—	Pathansali (1967)
Malaysia	16.6 (std length)				Chee 1977
Malaysia	19	17.5		—	SEAFDEC (1981)
Malaysia	18 XL			—	scs (1978)
Malaysia	17.5	—			
P Malaysia (west)	20.6	17.8-18.1	16.0-17.0		Mansor (1966)
E Sumatra	—	19.5	14.88	166	Gomal + Merta
		20.8	15.8	17.7	(1986)

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Table 9

Spawning seasons for scads and chub mackerels in the area

Area	Species	Spawning	Author
Sri Lanka	R. kanagurta	March/April	Goonewardene (verb. comm.)
India (east)	R. kanagurta	Oct.-March	Rao (1967)
Andaman Sea	R. kanagurta	Oct.-April	Luther (1973)
Burma	*R.* kanagurta	February	Naumov (1971)
Thailand (west)	R. kanagurta	Dec.-April	Anonymous (1984a)
P. Malaysia (west)	***R. kanagurta***	Oct.-April	Pathansali (1967)
P. Malaysia	***R. kanagurta***	May-Feb.	Chee (1977)
P. Malaysia	***R. kanagurta***	Jan.-March	FAO/SCS (1978)
Indonesia	***R. kanagurta***	Oct.-Feb. and June-Sept	SEAFDEC (1981)
Burma	***R. neglec tus***	Oct.-May and Sept.-March	Druzhinin (1970)
Thailand (west)	***R. brachysoma***	June-March	Anonymous (1984a)
Malaysia	***R. brachysoma***	Aug.-Dec.	FAO/SCS (1978)
Thailand (west)	***D. maruadsil russeili***	Dec.-April	Anonymous (1984b)
Thailand (west)	***D. macrosoma***	Feb.-April	Anonymous (1984b)

Rao (1967 stated that ripe conditions are rare in near-shore catches, and he believes that mackerels move away with advanced maturity. Luther (1973) observed that fully ripe and running conditions were not found but partially spent and fully spent fish were found. Dhebtaranon and Chotiyaputta (1972) observing mackerels in the Gulf of Thailand, note that mature fish may not school to spawn near the surface and that spawners were observed at 18-25 m depth. Running conditions were more at night than during daytime. Pathansali (1966) also commented that mature and spent ovaries have been recorded in the purse seine catches but ripe ovaries have not been observed. Chee (1977) reported that mature fish can be obtained for most months of the year but there was no significant change in the gonad index throughout the year.

When the catch records of Dr. Fridtjof Nansen's surveys in the Bay of Bengal were analysed it was observed that in Bangladesh, ***D. maruadsi*** caught by bottom trawl were in a higher advanced stage of maturity than those caught by pelagic trawl, during the same period.

Boko West (1973) reported that spawning concentration of ***R. kanagurta,*** D. russelli and ***D. kurroides*** have been taken in large quantities on the middling trawl grounds, sometimes, at the rate of over a ton/hr, during the period August-December. Examinations of a few samples taken from trawl and purse seine catches (during the study tour of mackerel sampling programme) in the Malacca Straits also showed that ripe ova occur quite commonly in the mackerels caught by trawlers. Indian bottom trawl survey data also indicates peak catch rates in June and October. This approximately coincides with the two spawning seasons indicated for the countries in the Bay of Bengal (Table 9) (Sivaprakasan 1986). These observations probably mean that spawners are generally concentrated close to the bottom in the depth range already identified and hence the failure to observe samples with ripe ova in the general pelagic fisheries for these species. Peak spawning periods may then be clearly identified by examining samples taken with trawl nets also. Somavanshi and Joseph (1983) have reported that very good yields of mackerel were obtained during trawling surveys on the east coast during the northeast monsoon, and this coincides with the general spawning season. Dhebtaranon and Chotiyaputta (1972) described the conditions in the mackerel spawning grounds as follows:

Salinity 32-32.5%
Oxygen: 3.8112-4.2425 ml/1
Temperature: 28-29.34 C
Transparency: 13-16 m
Bottom: muddy sand

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5. Exploited population and stocks

The exploitation in Maldives is negligible and there is no evidence of any intense fishing. In Sri Lanka, though the declining beach seine fishery may be contributing less to the mackerel production in recent years, the expanding gillnet fishery probably compensates for this. The developing purse seine fishery on the west coast certainly shows signs of increasing production from areas that have hitherto been less important for these species. Hence it appears that these resources have not yet been intensively exploited and perhaps could stand further expansion.

Banerji (1964) reported that Indian mackerel fishery depends on the strength of the fish in their second year of life, and hence fluctuations in catch are due to fluctuations in the strength of this age group. Fishery-independent factors such as environmental variations have greater effect than the effect of fishing gear. Whether these statements are valid at present is not known because, the mackerel production has since increased and reached a stage of heavy fluctuation with some signs of decline in the production by major fishing locations on the east coast of India (Table 3a). Absence of mackerel in the fisheries of West Bengal in the Upper Bay of Bengal resembles the situation in the adjacent Bangladesh waters. Perhaps there is a demersal component of the mackerels off West Bengal, as in Bangladesh waters, and they may have something in common. Likewise, the mackerels fished from the southern end of India and the northern part of Sri Lanka may have common components in the Palk Bay and Gulf of Mannar areas. Whether there is more than a single stock on the east coast of India is not possible to say but the peak season for mackerel fishery seems to be more or less the same (Noble 1979) in Orissa, Visakhapatnam and Pondicherry, which are representative of the northern, central and southern parts of the east coast of India.

In Burma, the purse seine fishery for mackerels is concentrated on the Tenasserim coast, close to the Burma-Thailand border. This fishery has been reported to be poor on the Rakhine coast. However, trawl surveys indicate a higher percentage of mackerels and scads on the Rakhine coast than on the Tenasserim or delta coasts. The Rakhine coast is adjacent to the Bangladesh waters and hence tends to have a similar mackerel distribution pattern. Whether the Rakhine coast is the spawning area for the mackerels on the Tenasserim coast or the two coasts have separate stocks is not clear. R. kanagurta and ***R.*** brachysoma are caught close to the Burmese-Thai border and R. ***kanagurta*** is the predominant species towards the northern end of Thailand. This raises the possibility of transmigration or intermingling at the border. It has been reported that R. brachysoma (neglectus) from Burmese waters are longer than those from Thai waters and that the reverse is true for ***R. kanagurta*** (Vanichkul and Hongskul, 1966). Similarity has also been reported in the morphometrics of mackerel from Burmese and Thai waters.

It was observed from tagging results (Anonymous, 1983a) that ***R. brachysoma*** generally exhibits localised migration on the west coast of Thailand but with some movements northwards and southwards. The study conjectured !ha? there is more than one stock of this species and proposes two stocks on this coast, based on length frequencies and modal progressions. ***R. brachysoma*** is predominant in the southern part of the west coast of Thailand, and tagging showed transmigration of the species across the Thai-Malaysian border, into Malaysian waters.

On the west coast of P. Malaysia, R. ***kanagurta*** was the predominant species until the 1960s but ***R. brachysoma*** superceded since then (FAO/SCS, 1978). The reasons are unknown. R. kanagurta was reported to be larger sized in the northern part while small and medium-sized fish were from Palau Jarak area (Pathansali 1961). Chee (1977) stated that production of chub mackerels declined from 95,570 t in 1968 to 19,585 t in 1975 and the average size too had decreased. However, the production has recovered to about 540,005 in 1983, with nearly 38% contribution by the trawl fishery. It is considered possible that mackerel spawned off the west coast of P Malaysia might have a northward feeding migration into Thai waters (Pathansali 1967). Some mackerels tagged around Langkawi Island were caught in Thai waters also.

Mackerel production in Sumatra (Indonesia) is more on the Malacca Strait coast than on the west and north coasts. The Malacca Strait coast of Sumatra being very close to the west coast of P. Malaysia, there is every likelihood of their sharing the mackerel stocks in the southern half of the Malacca Straits. On the both the Malaysian and Indonesian coasts of the Malacca Strait, the mackerel production declines steeply towards the southern end where catches are negligible. This tends to show that mackerel stocks in the Malacca Strait may be independent of those in the South China Sea area.

The Indian mackerels caught around the Andaman Islands are supposed to be larger than those caught around the mainland of India and this is partially attributed to the virgin state of the stock. It is stated that Indian mackerel stock around AndamanIslands is independent of those close to the mainland of India and Malaysia (Luther 1973).

Balakrishna (1965) reported that the number of rays on the first dorsal fin of R. kanagurta decreases with increase in size of fish and the endoskeletal structure remains unchanged Decrease or increase in dorsal fillets were also noticed but this was always compensated by corresponding increase or decrease in the number of dorsal and anal rays. Kurogane (1972) found that separation of mackerel stocks is not possible with vertebral and gillraker counts or with length of gillrakers. Length-weight relationships, tagging, spawning grounds and other racial analyses showed evidence of more than a single stock in the Gulf of Thailand

6. Potential

Maximum sustainable yield estimates available for some of the countries are presented below

Country	Species	MSY (t)	Author
India (Mainland)	*R. kanagurta*	73,500	Menon & Radhakrishnan (1972)
Thailand (West coast)	*R. brachysoma*	11,556	Anonymous (1984 a)
	R. brachysoma	20,900	Veera Boonragsa (1986)
	R. kanagurta	8,518	Anonymous (1984 a)
	R. kanagurta	4,800	Veera Boonragsa (1986)
	Decapterus spp.	1,500	Anonymous (1984 b)
	Decapterus spp.	7,650	Veera Boonragsa (1986)
P. Malaysia (West coast)	*Rastrelliger* spp	21,000	Chee (1984)
	R. brachysoma	54,394	Mansor (1986)
	R. kanagurta	11,530	Mansor (1986)
	Decapterus spp.	5,800	Chee (1984)
	Decapterus spp.	7,350	Mansor (1986)
Indonesia (Sumatra)	Ras trelliger spp.	17,691	Anonymous (1984,
	R. kanagurta	6,951	Gomal & Merta (1986)
	R. brachysoma	13,994	Gomal & Merta (1986)
	Decapterus spp.	12,003	Gomal & Merta (1986)

In the Maldives, which do not have a proper neritic province in which these species are normally distributed, there is very little encouragement for a significant development of mackerel fishery. However, chub mackerels are being caught in highly localised areas where beach seines are used and scads are caught incidentally and during trawl surveys. Therefore, there should be at least a small resource for these in the Maldives which is not being exploited because common methods of capturing mackerels are not in use at present and the beach seine method is also 'limited to a small area of its waters The potential cannot be estimated at present.

in Sri Lanka, the fishery for mackerels and scads has never been intensive or specialised. It is anticipated that there is room for further expansion but it is impossible to give any quantitative estimates. The demersal components of these species do not appear to be large, considering the frequency of occurrence and the catch rates during the trawl survey by 'Dr. Fridtjof Nansen' Development of marine purse seiner fishery on the west coast also appears to indicate possibility of increasing mackerel production

In India, the MSY had beed exceeded in 1978 (85,233 t) and the production declined to 28,000 t in 1982. There is very little encouragement for expansion of the pelagic fishery but there appears to be room for further increase through bottom trawl fishery. Very good yields of Indian mackerels have been obtained during trawl surveys in almost all areas on the east coast, in 40-80 m deep waters 10% of the catches during the trawl surveys were Indian mackerels. In March 1983, a 3 1/2-hour haul resulted in a catch of 12 t of mackerel. Trawl surveys revealed that mackerels

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generally occur in the areas off Gopalpaur up to Sandhead in the depth range of 40-80 m (Somavanshi and Joseph 1983). Decapterus spp. contributed 13.6% of the important varieties landed during a trawl survey's catches along the Andhra Pradesh coast. A maximum of 2000 kg/hr was netted between Kakinada and Pentakota. Areas of abundance are around 16º-17ºN. 82ºE and in depths of 70-90 m but scads are available in appreciable quantities up to 150 m (Nair and Joseph 1984). Expansion of the trawl fishery, which is taking place at present, should result in a significant contribution to the production of scad and chub mackerels on the east coast of India.

In Bangladesh. Shahidulah (1983) reported that Kinki *Maru's* survey with gillnets showed the presence of pelagic resources for commercial exploitation and that **5.5%** of the catches were mackerels while the others were mainly demersal species, Frequent occurrence and very high catch rates observed during the 'Dr. Fridtjof Nansen' cruises present very encouraging evidence for production of mackerels and scads through demersal fishery in deep waters. Considering the toal biomass and percentage of mackerels and scads in the catches as in the report of 'Dr. Fridtjof Nansen' survey, an annual yield of 5-7 thousand tons may be the lower limit of the potential.

Off the coast of Burma, there appears to be room for expanding of the purse seine fishery on the Rakhine coast and development of the trawl fishery could also contribute to the increase in production of scads and chub mackerels.

On the west coast of Thailand.and the east coast of Sumatra, production of R. brachysoma and R. kanagurta exceeded their most recent estimates of the MSY in 1985. This happened in 1984 on the west coast of P. Malaysia and there was a decline in production in 1985. In Thailand, the contribution by the trawl fishery to the mackerel production is not comparable to that of Malaysia, though trawling is intensive in the EEZ. Hence, further increase in the contribution by trawl fishery to the mackerel production is also not evident. Perhaps more transformation from traditional trawls to high-opening bottom trawls will result in some increase.

On the west coast of Thailand and the east coast of Sumatra, the production levels of scads and mackerels exceeded the MSY in 1985 but it is not so in west P. Malaysia. Between 1980 and 1982, the mackerel catches by Malaysian purse seiners have declined by 33% while bottom trawl catches have increased by about 300% (Table 5). The interaction between the two fisheries is not clearly evident-but recent levels of production and MSY are more than twice the levels around 1980, and this had been achieved by the exploitation of the demersal component of the stock, If the demersal component is mainly the spawning stock, then could it sustain this level of exploitation? Further investigations are necessary to assess the situation.

In the absence of a *time* series of **Catch** and effort data for the mackerels caught with high opening trawls, a simple analysis of the interaction was attempted by plotting the annual purse seine catch of mackerels versus trawl catch of the mackerels, for the corresponding years on the west coast of P Malaysia (Figure 7). The grasp appear to indicate that interaction is reflected by the production figures for the period after 1980. The purse seine fishery tends to be more efficient than the trawl fishery, as far as mackerel production is concerned. In view of the high levels of fishing effort through bottom trawls and purse seines in Malaysian waters, it is assumed that the dynamics of the population are reflected in the relative changes in the production by the two methods. Hence, the regression line drawn with the points for recent years (1982-1985) when the effort and production showed sharp increase and also including the points for earlier years that showed equally high or higher production from only the purse seine fishery (1968 and 1969) is expected to represent the equilibrium line for the production of mackerels by combinations of purse seiners and trawlers. The intercept of the regression line on the Y axis shows the production level attainable solely by the purse seine fishery. This value of 71,600 t is slightly higher than the MSY of 69,200 t estimated recently by Mansor (1986). In fact this estimate of attainable level had been exceeded in 1968 when high-opening trawl fishery was not active in this area.

In Sumatra where bottom trawl fishery is prohibited exploitation of demersal component on the east coast of Sumatra cannot be considered. The existence of a demersal component is evident from the mackerels caught during bottom trawl surveys conducted in recent years.

Considering the evidence available, it appears that potential for increasing production exists through exploitation of the demersal components off the east coast of India, Bangladesh and Burma Expansion of the existing pelagic fisheries for these species may also be possible at

least off Sri Lanka, Bangladesh and Burma. The existing fishery in the Maldives should be studied for any further consideration. The mackerel and scad fisheries on the Malacca Strait coast of Thailand, Malaysia and Indonesia are well developed and perhaps require management of these resources

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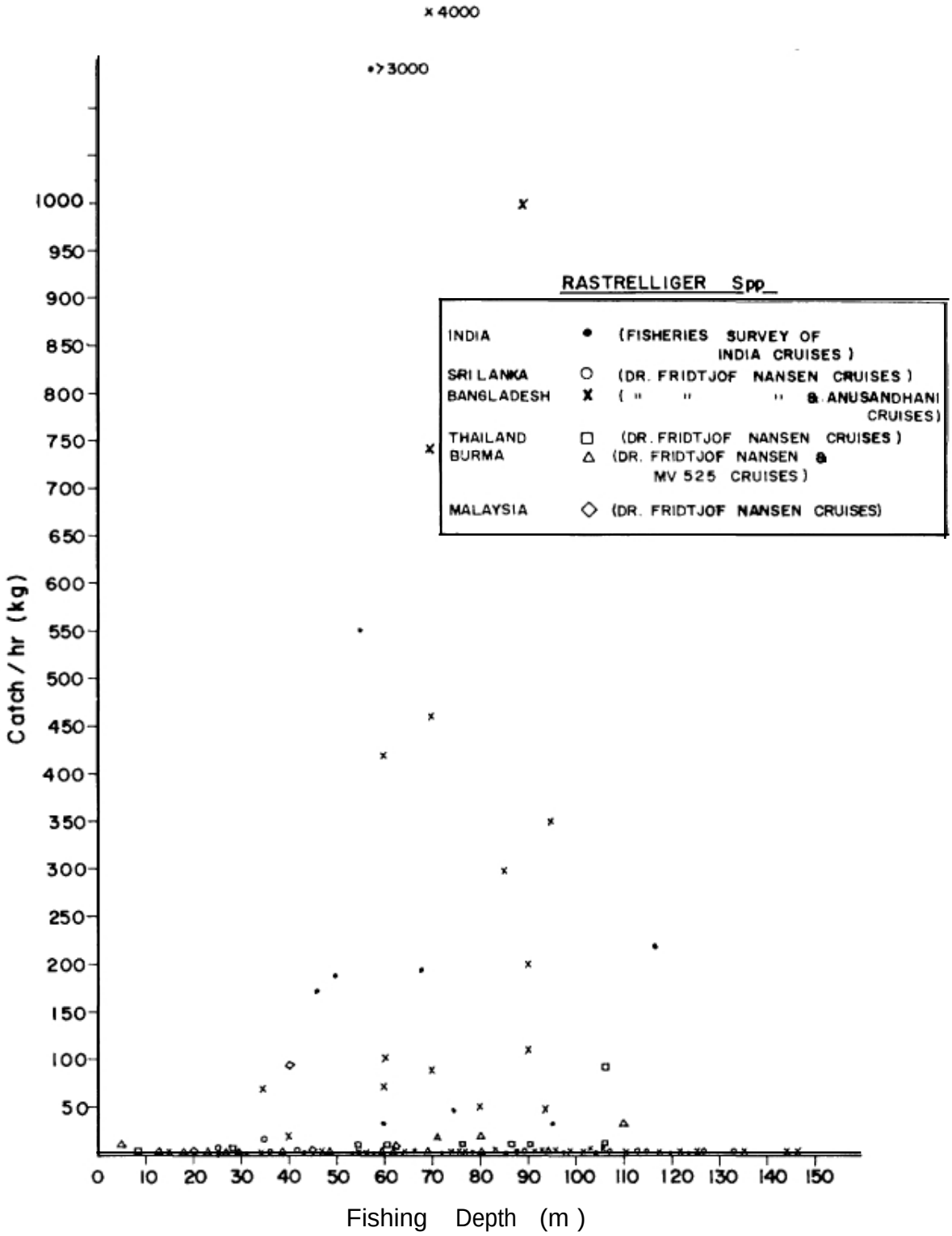

Figure 1. Distribution of bottom trawl catch rates of Rastrelliger *species, in relation to fishing depth, around the Bay of Bengal.*

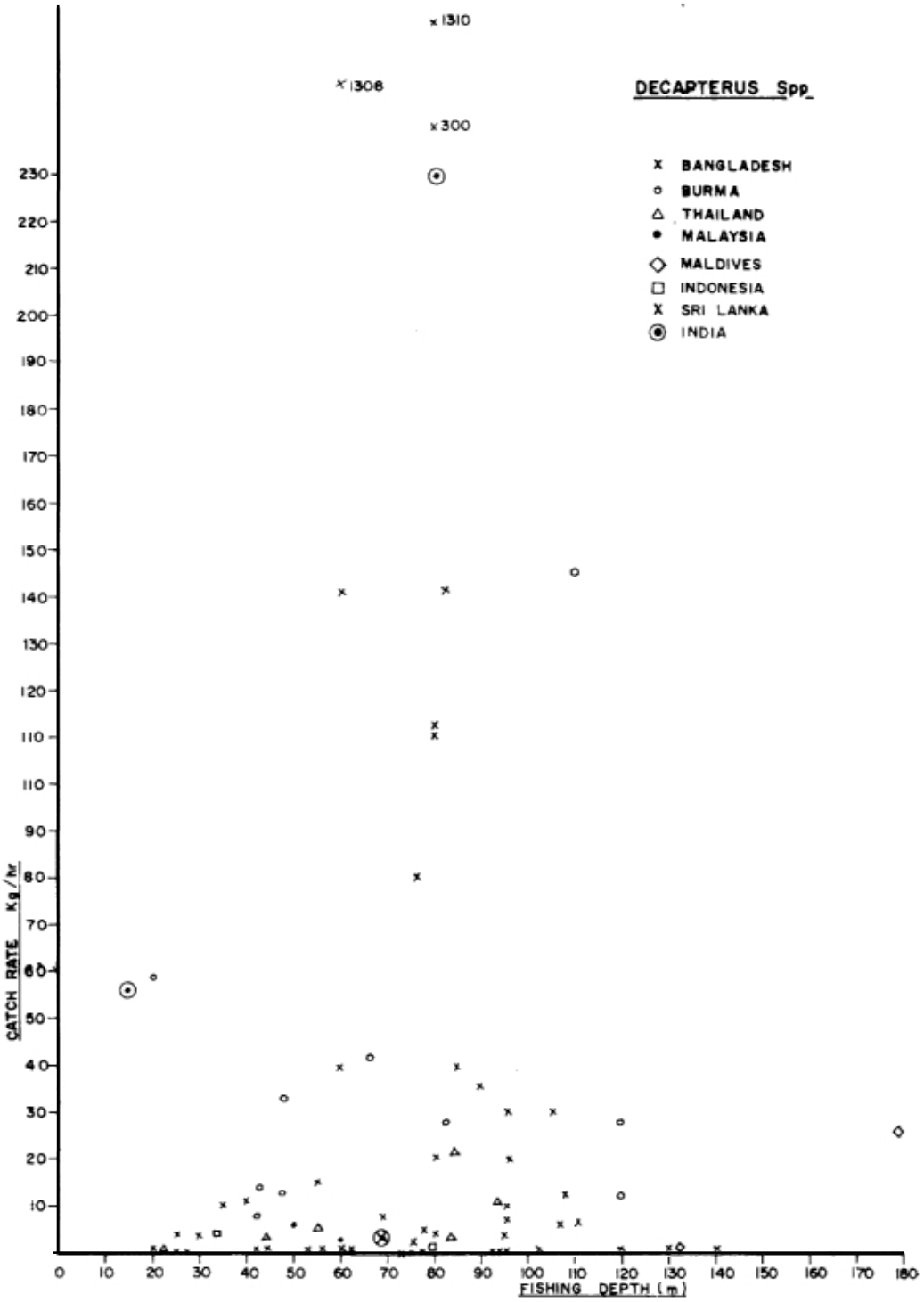

Figure 2. *Distribution of bottom trawl catch rates of* Decapterus *spp, in relation to fishing depth around the Bay of Bengal.*

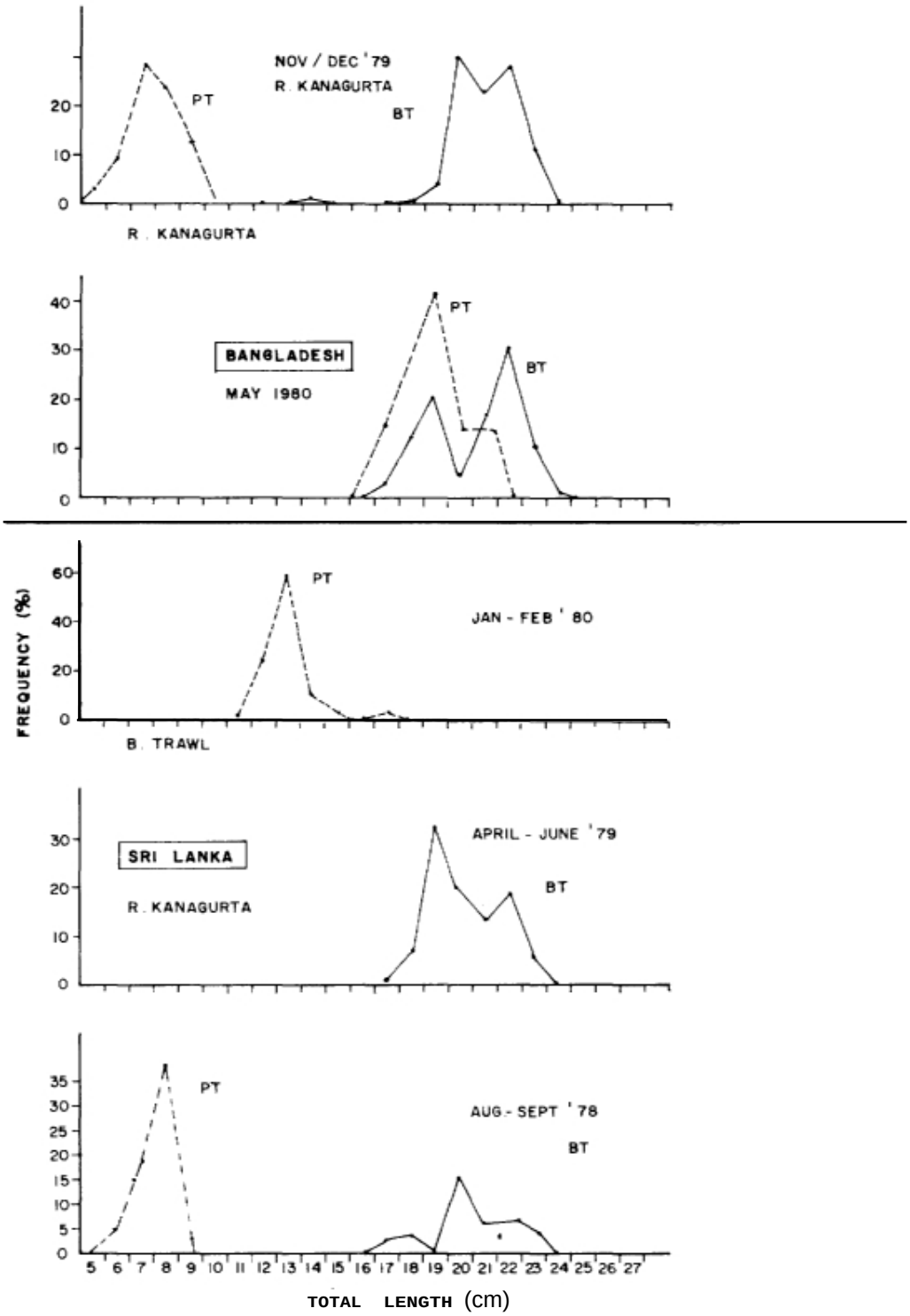

Figure 3. *Length frequency distributions of mackerels in the pelagic and bottom trawl catches by RV "Dr. Fridtjof Nansen", off Bangladesh and Sri Lanka.*

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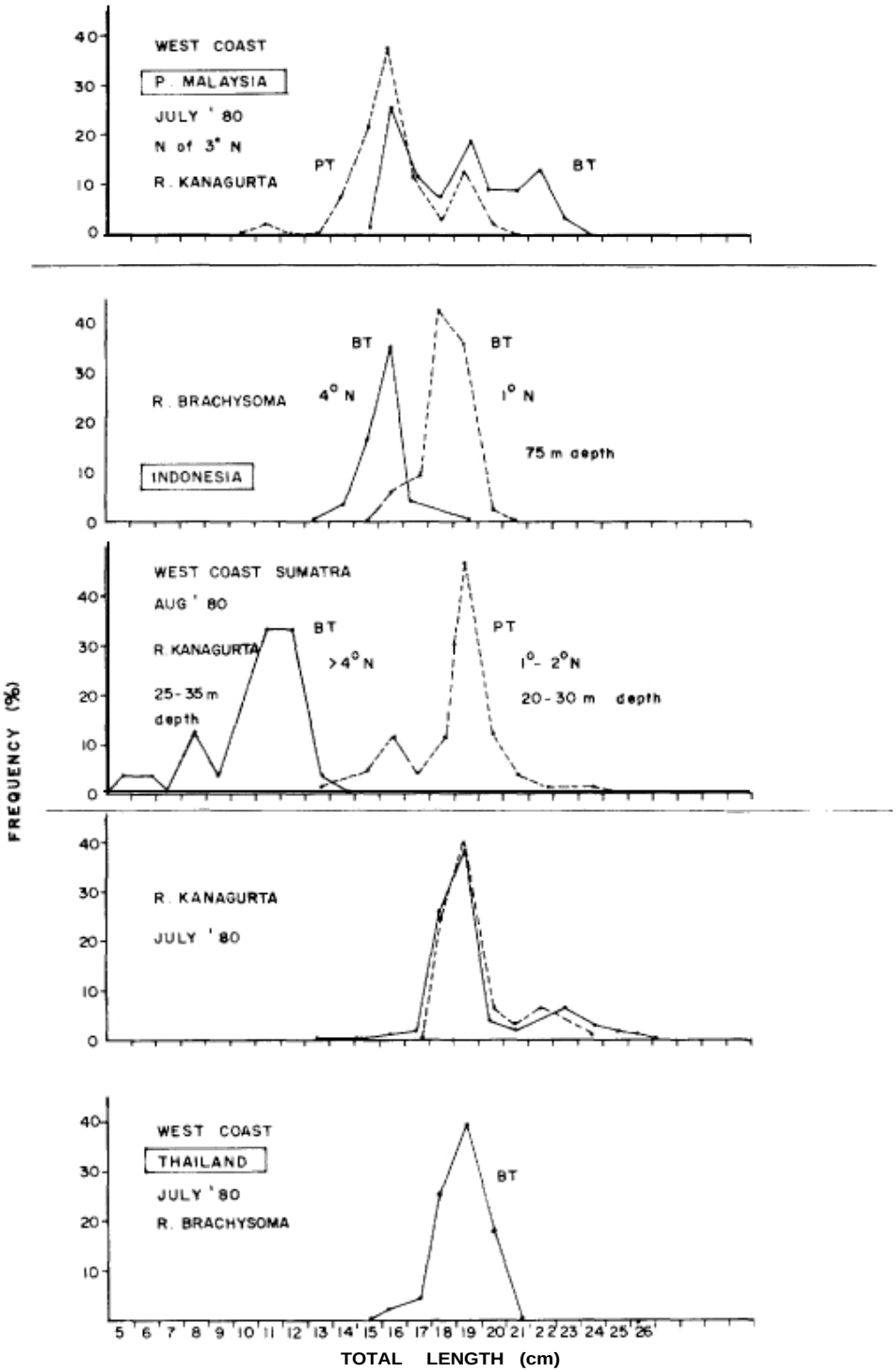

Figure 4. *Length frequency distributions of mackerels in the pelagic and bottom trawl catches by RV "Dr. Fridtjof Nansen", off P. Malaysia, Indonesia (Sumatra) and Thailand (West).*

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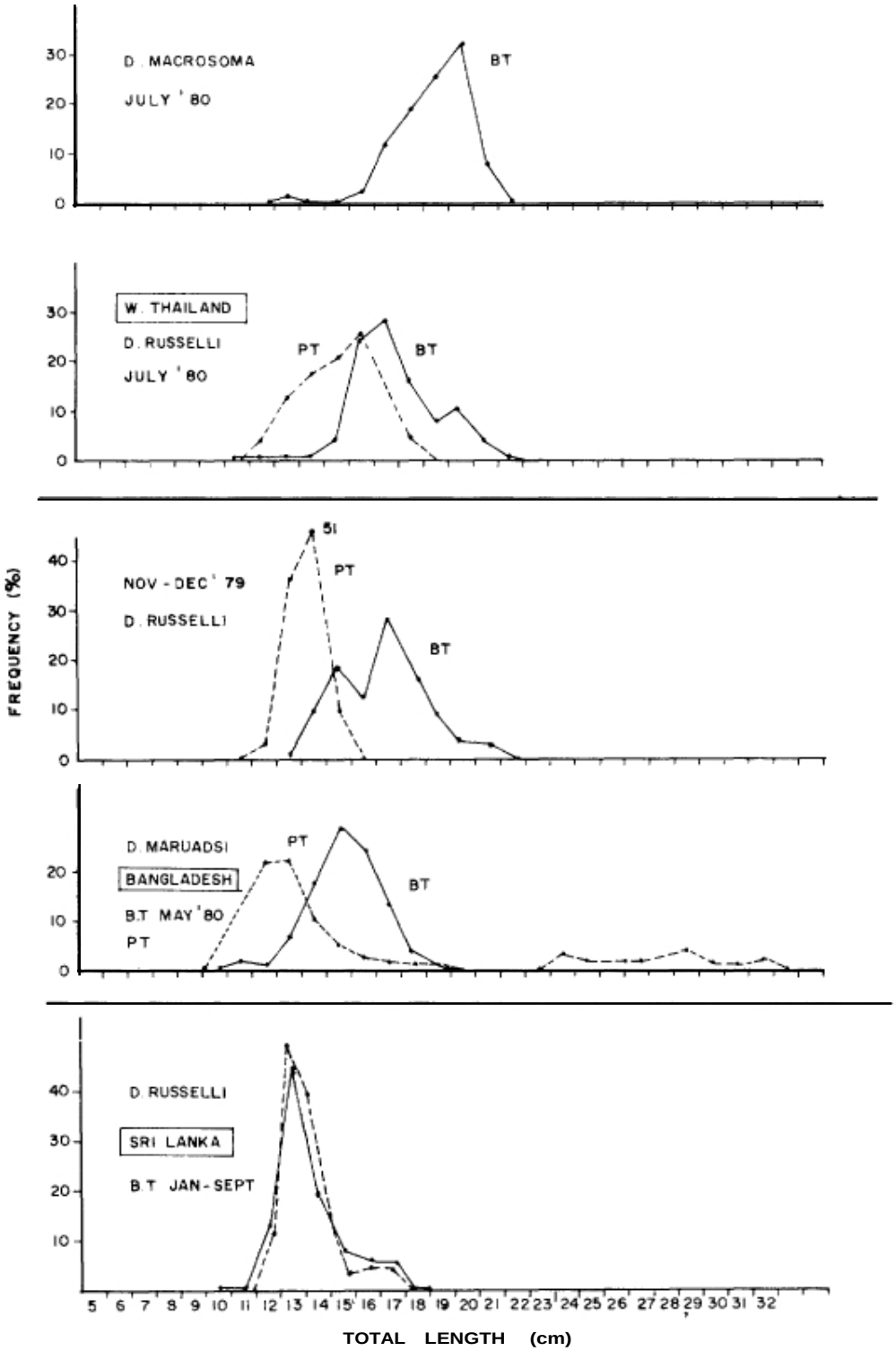

Figure 5. Length frequency distributions of scads in the pelagic and bottom trawl catches by RV "Dr. Fridtjof Nansen", Thailand (West), Bangladesh, and Sri Lanka.

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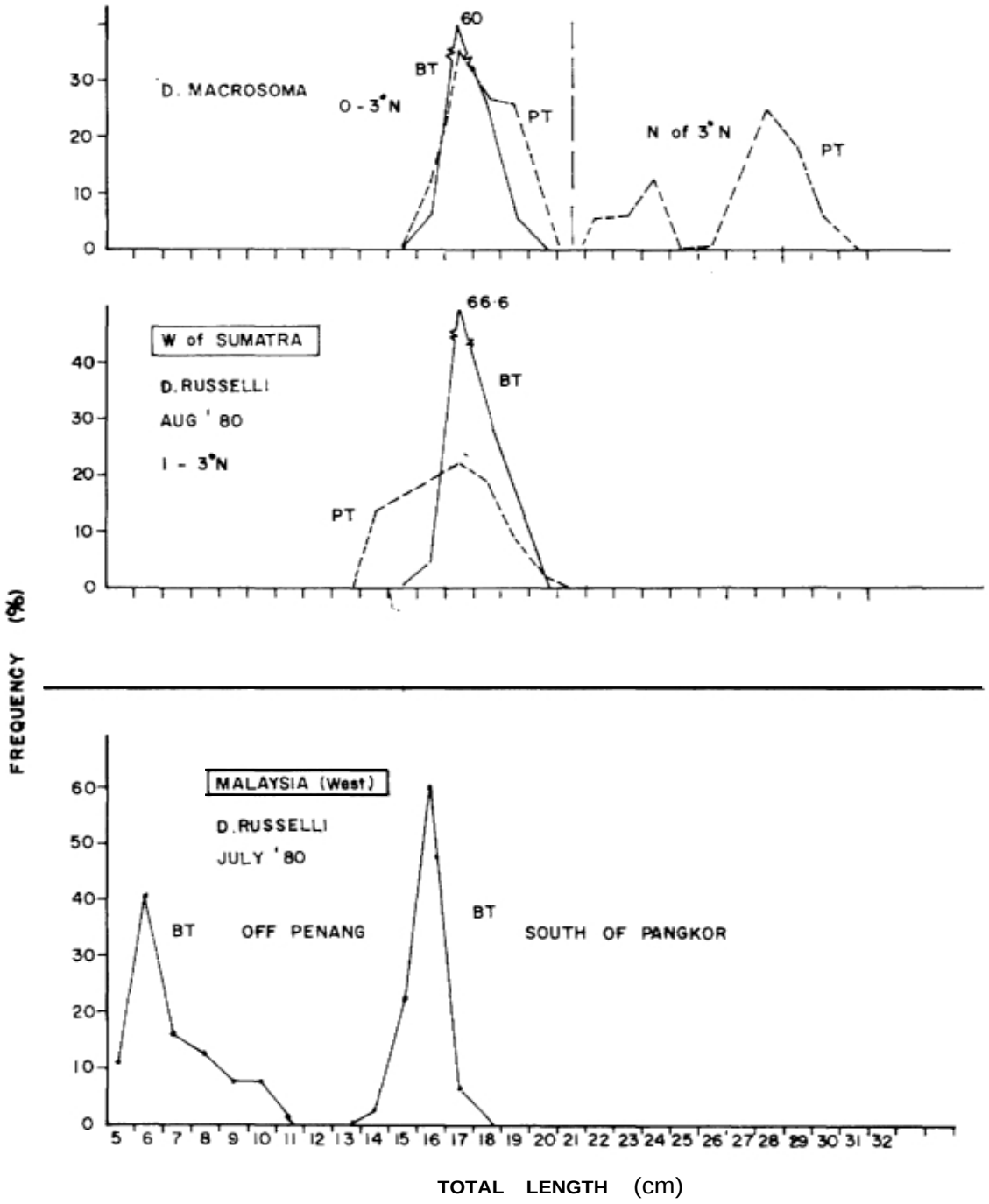

Figure 6. *Length frequency distributions of scads in the bottom trawl and pelagic trawl catches by RV "Dr. Fridtjof Nansen", off Sri Lanka, Sumatra and P. Malaysia,*

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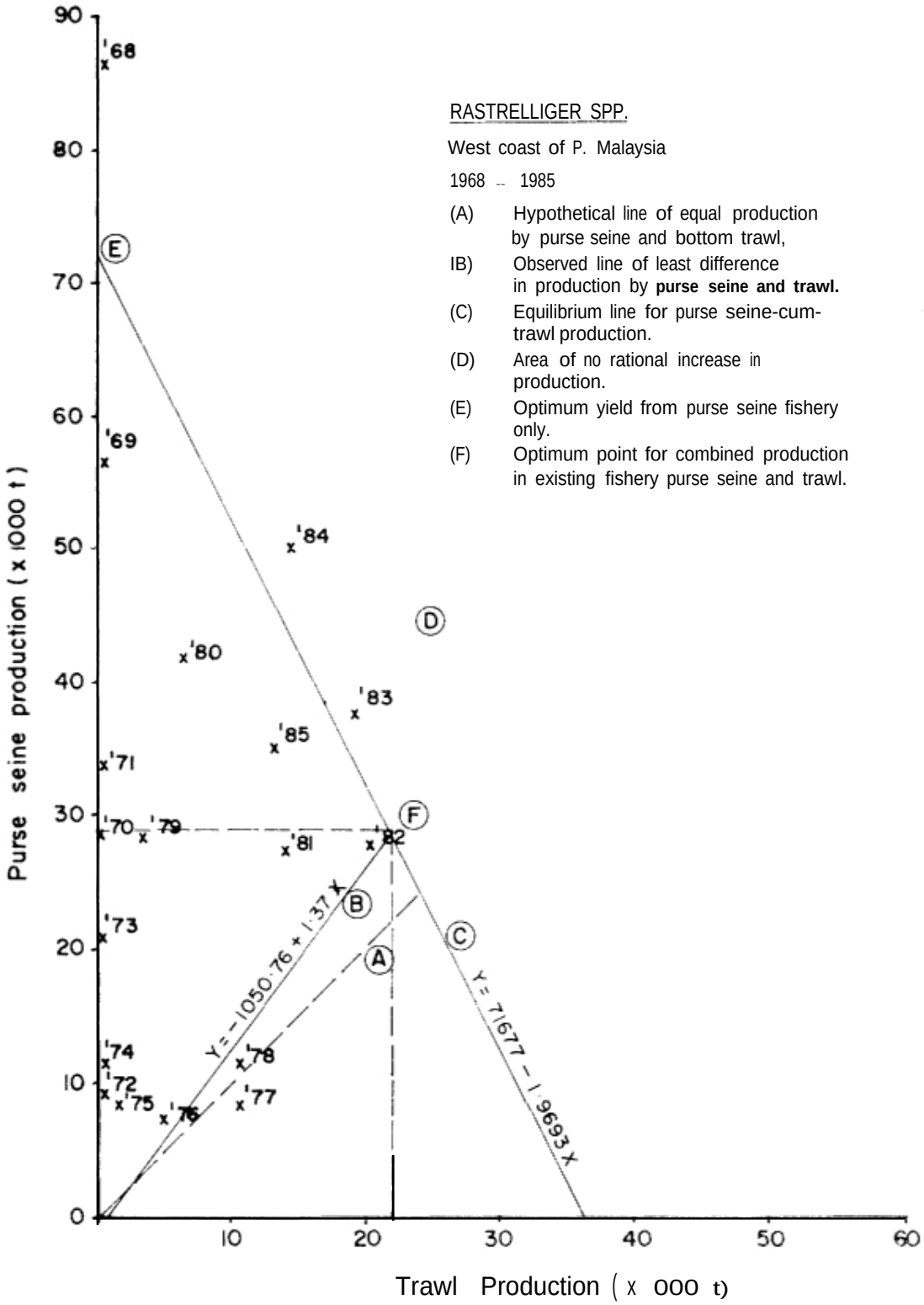

Figure 7. *Correlations between oroduction of mackerels by purse seiners and bottom trawis on me west coast of P. Malaysia, 1968- 1985.*

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The BGBP brings out six types of publications:

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Newsletters (Bay of Bengal News), issued quarterly, contain illustrated articles and features in non-technical style on BOBP work and related subjects.

A list of publications follows:

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