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Marine Fishery Resources Management
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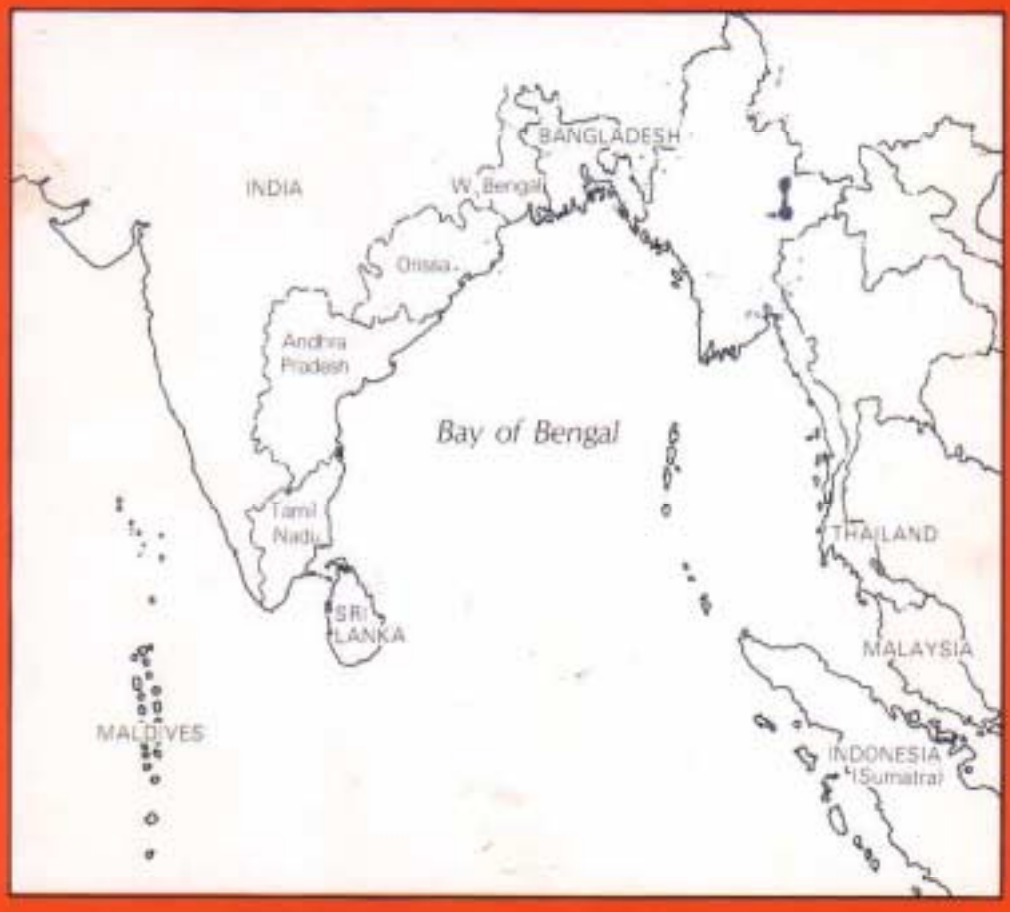
Investigations on the Mackerel and Scad Resources of the Malacca Straits



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BAY OF BENGAL PROGRAMME BOBP/REP/39

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.

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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.

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.

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

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.

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

"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

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.

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)

Catch	*R. brachysoma*				*R. kanagurta*			
	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

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.

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

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

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)