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.

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.

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

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

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

Table 5a.

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

(tonne)

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Rastrelliger spp.															
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

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.

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

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.

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

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

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)

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

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 Andamanlslands 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

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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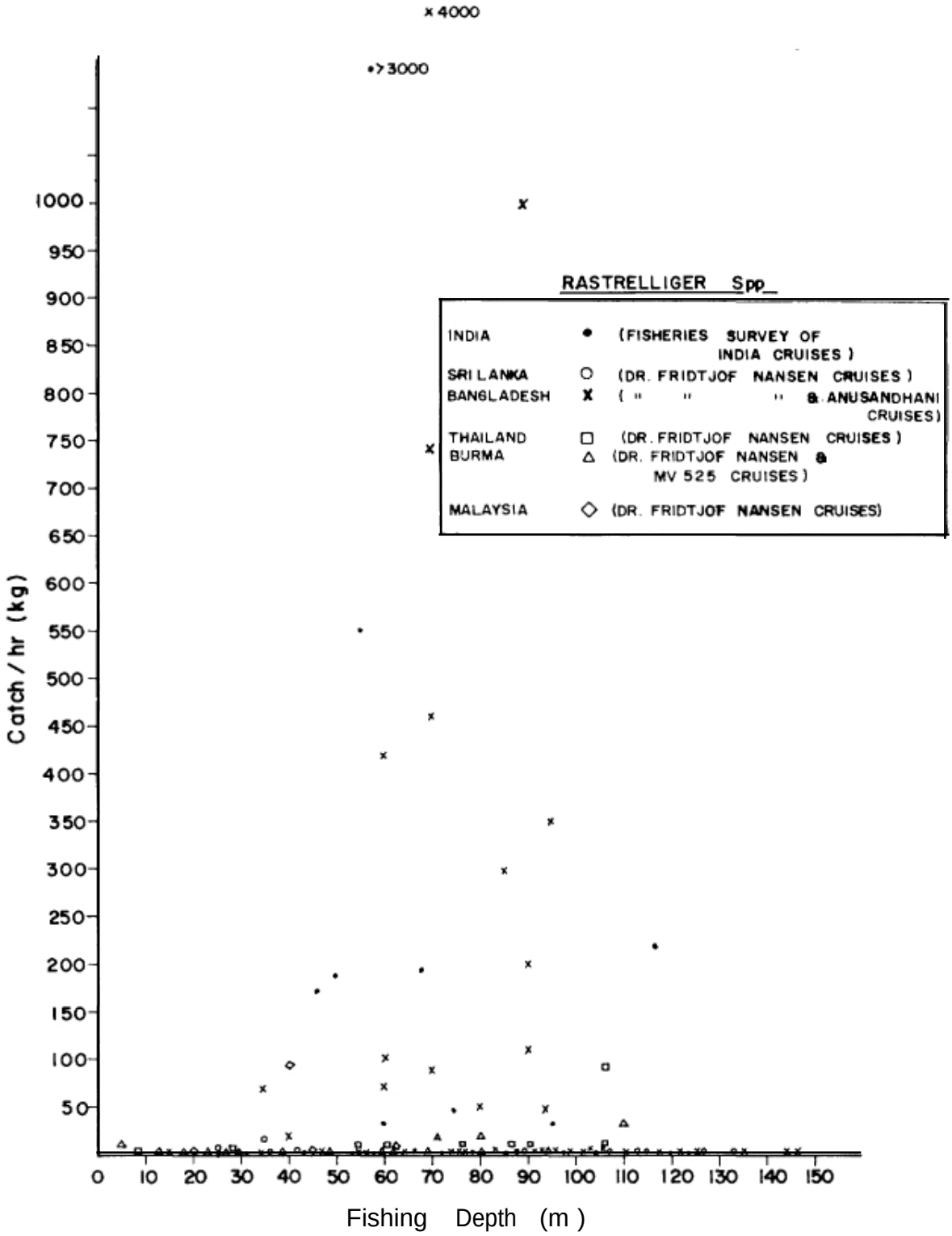

Figure 1. Distribution of bottom trawl catch rates of Rastrelliger *species, in relation to fishing depth, around the Bay of Bengal.*

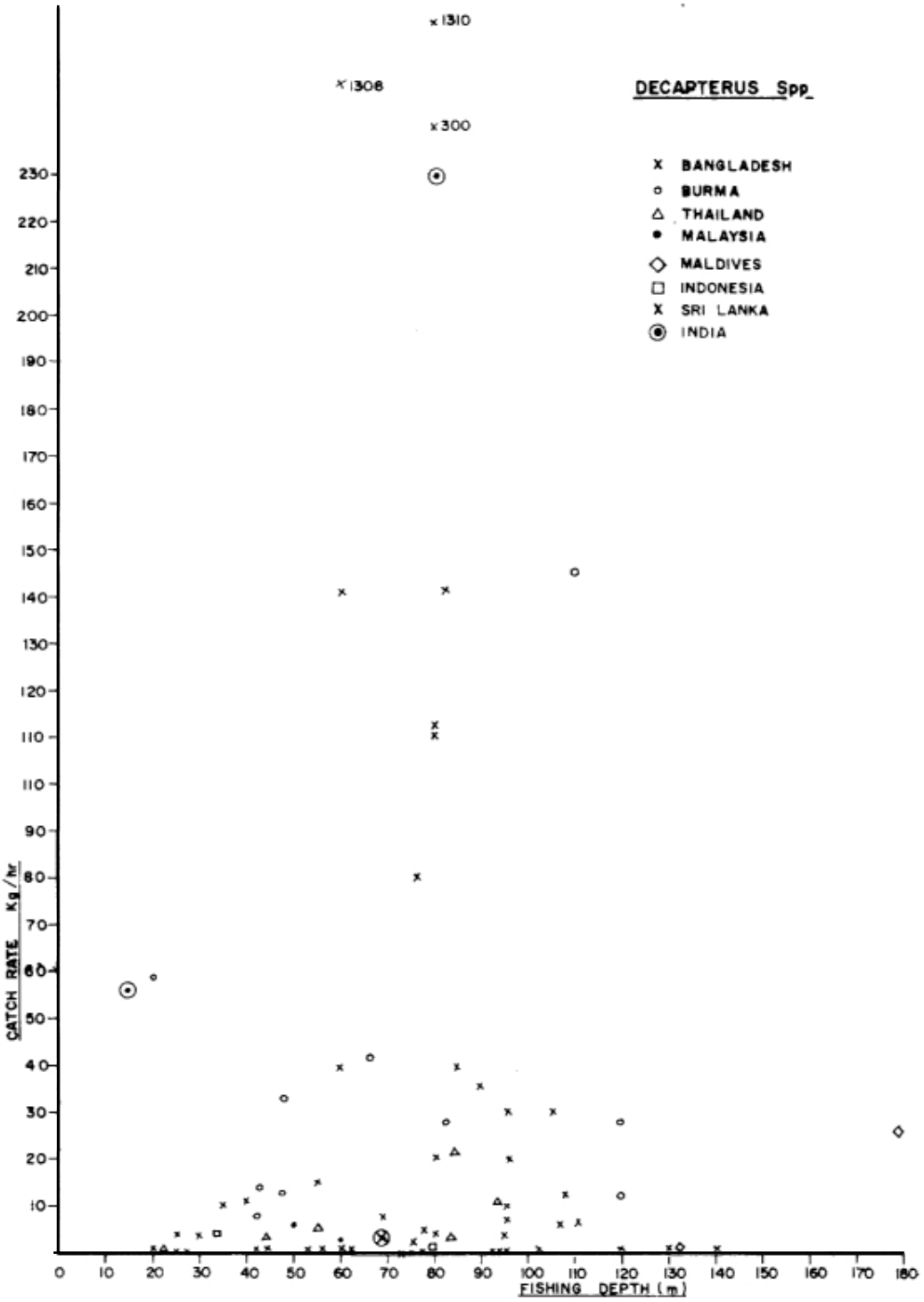

Figure 2. *Distribution of bottom trawl catch rates of* Decapterus *spp, in relation to fishing depth around the Bay of Bengal.*

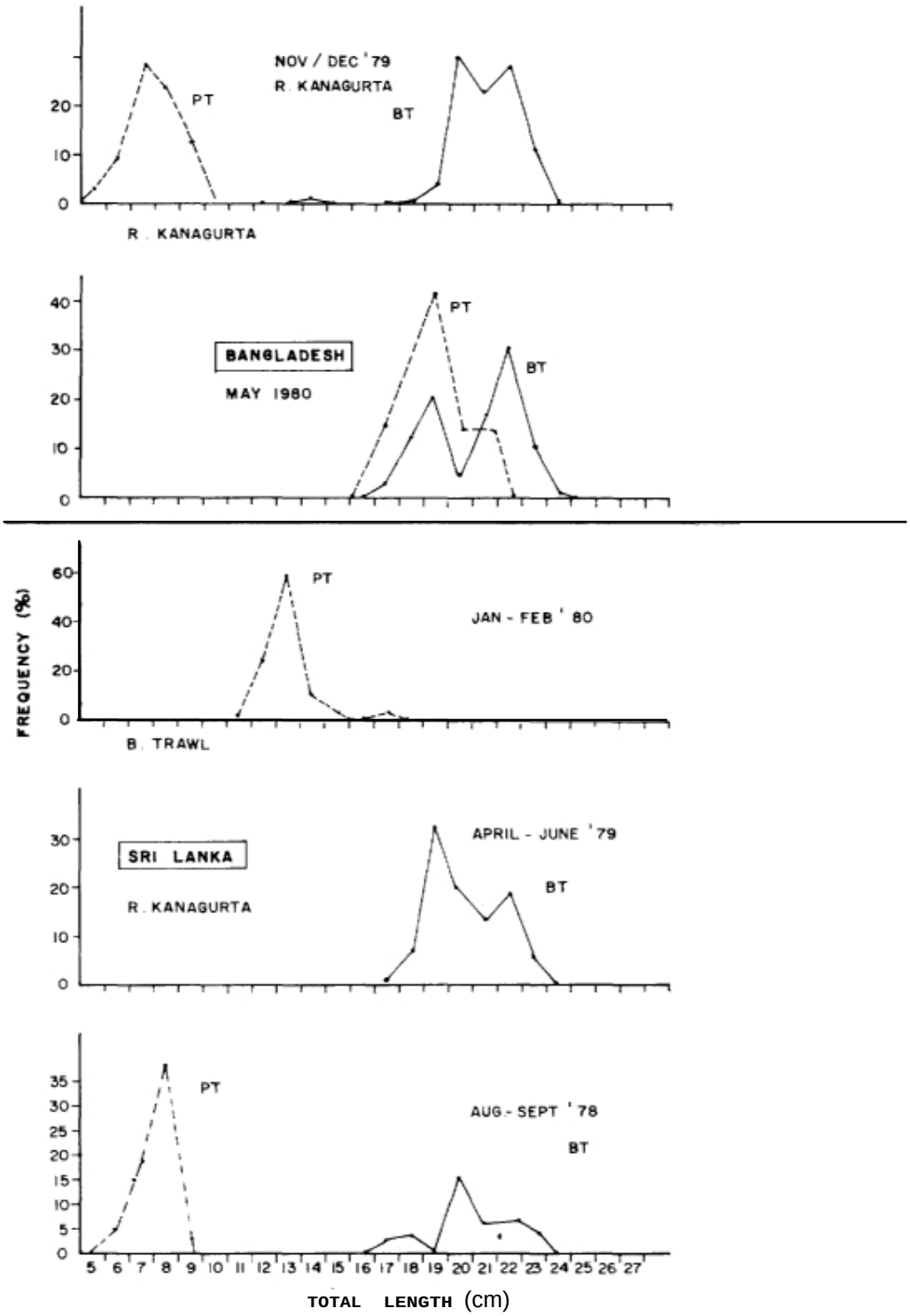

Figure 3. *Length frequency distributions of mackerels in the pelagic and bottom trawl catches by RV "Dr. Fridtjof Nansen", off Bangladesh and Sri Lanka.*

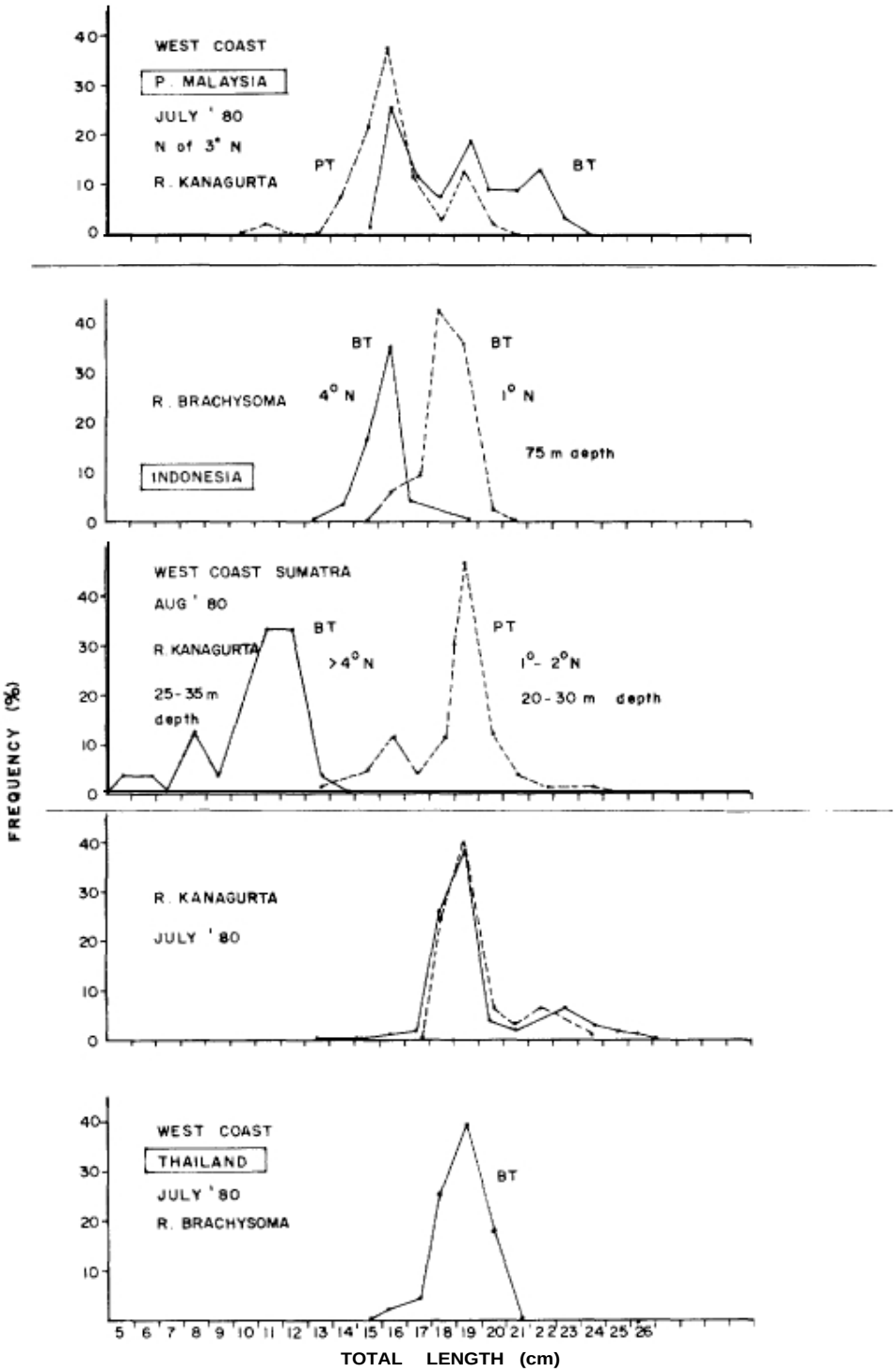

Figure 4. *Length frequency distributions of mackerels in the pelagic and bottom trawl catches by RV "Dr. Fridtjof Nansen", off P. Malaysia, Indonesia (Sumatra) and Thailand (West).*

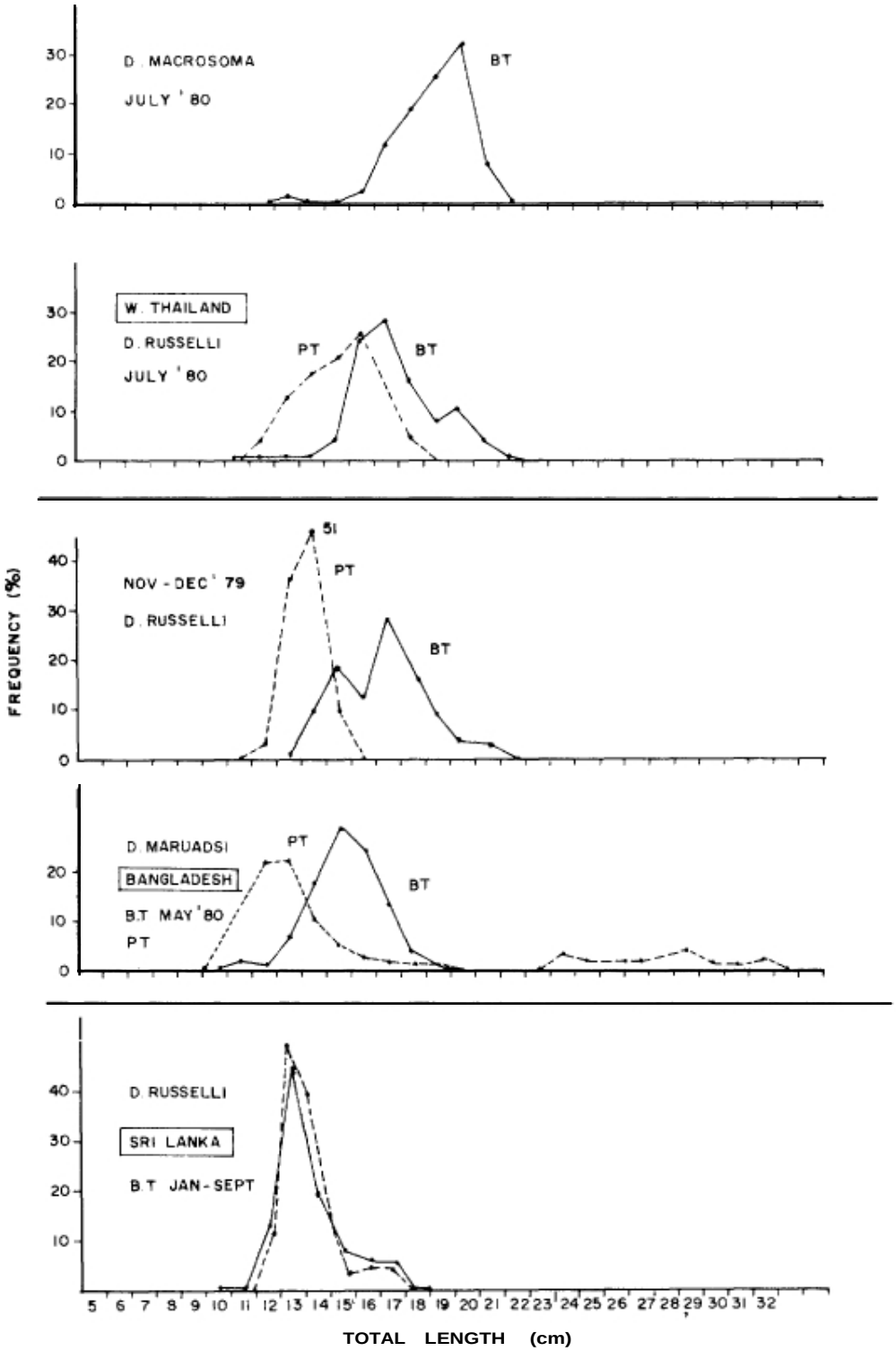

Figure 5. Length frequency distributions of scads in the pelagic and bottom trawl catches by RV "Dr. Fridtjof Nansen", Thailand (West), Bangladesh, and Sri Lanka.

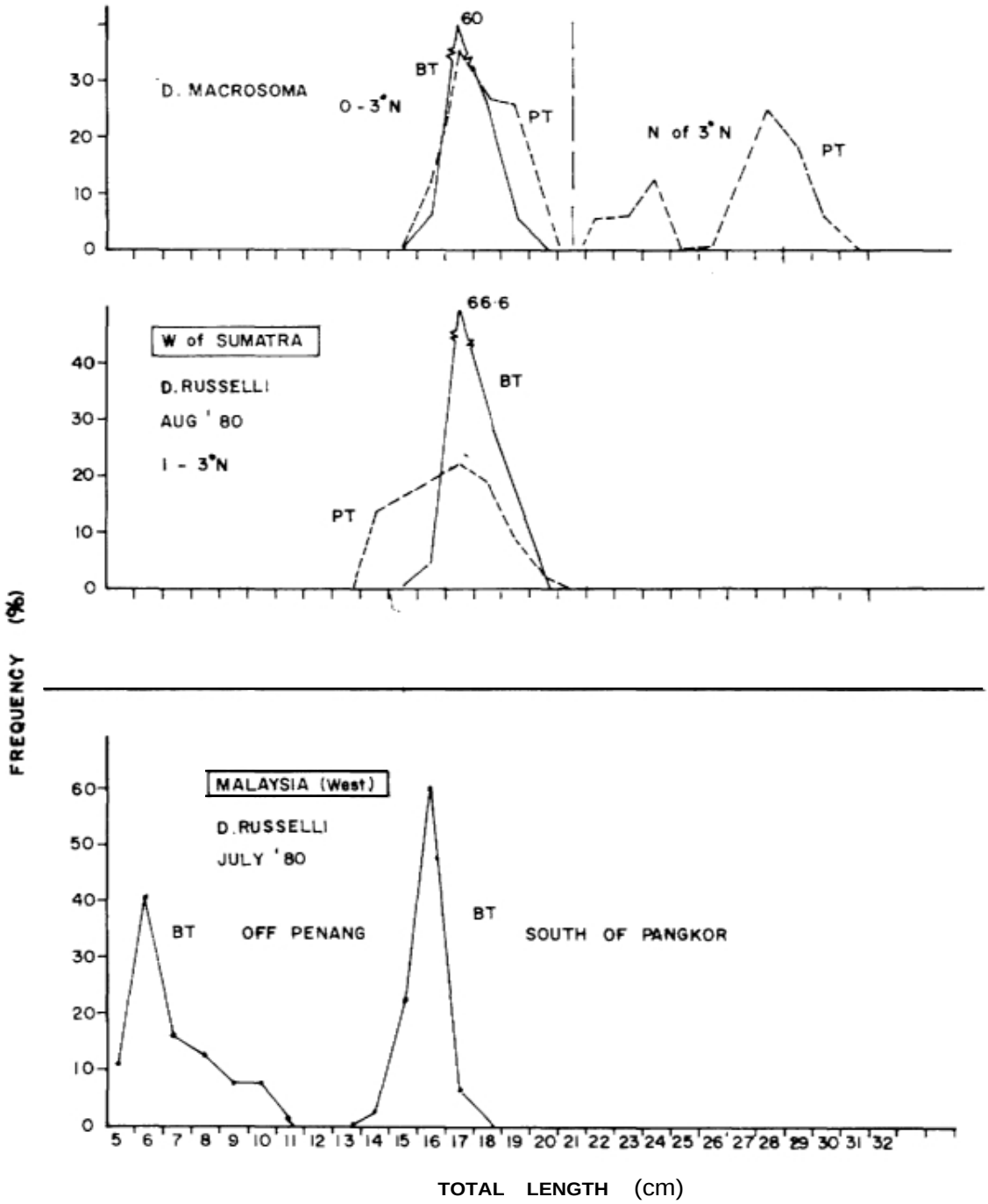

Figure 6. *Length frequency distributions of scads in the bottom trawl and pelagic trawl catches by RV "Dr. Fridtjof Nansen", off Sri Lanka, Sumatra and P. Malaysia,*

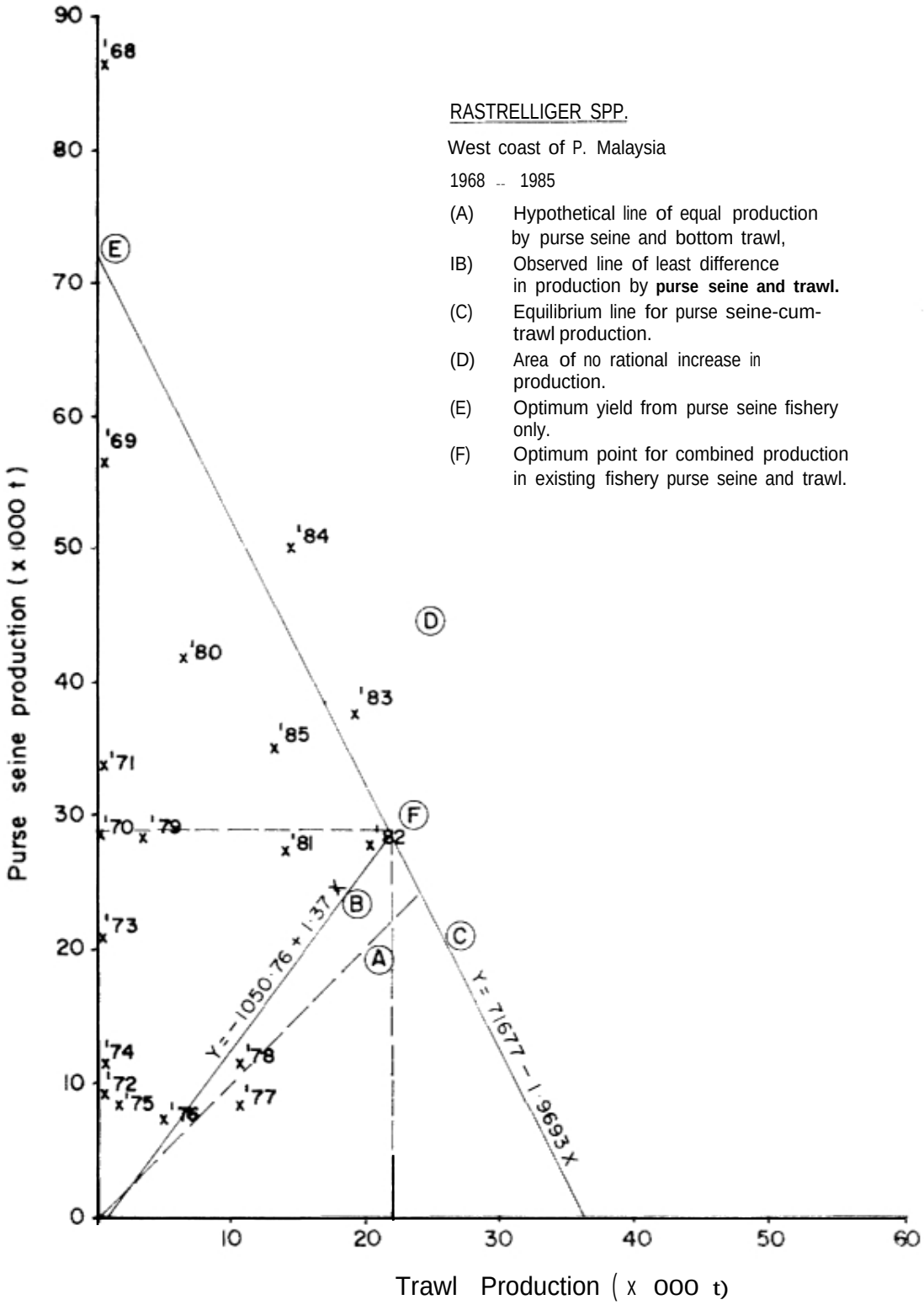

Figure 7. *Correlations between oroduction of mackerels by purse seiners and bottom trawis on me west coast of P. Malaysia, 1968- 1985.*