Indian Journal of Fisheries 39 (1, 2) : 9 –41, March, June 1992

Stock assessment of threadfin breams (*Nemipterus* spp.) of India

V SRIRAMACHANDRA MURTY[1], T APPARAO[2], M SRINATH[3], E VIVEKANANDAN[4], K V SOMASEKHARAN NAIR[5], S K CHAKRABORTY[6], S G RAJE[7] AND P U ZACHARIAH[8]

Central Marine Fisheries Research Institute, Cochin, Kerala 682 014

ABSTRACT

The annual average estimated landing of threadfin breams in India during 1980–83 was 22 247 tonnes which increased to 48 100 tonnes during 1984–88; a maximum of about 60 000 tonnes landed in 1986. Over 90% of threadfin bream catch in the country was obtained by commercial trawlers. Among the maritime states of India, Kerala contributed maximum (52%) to the nemipterid landings, followed by Maharashtra (13.6%), Tamil Nadu and Pondicherry (11.2%), Karnataka and Goa (8.8%), Gujarat (7.8%), Andhra Pradesh (5.5%) and Orissa (1.1%). Though a total of six nemipterid species contributed to the fishery in different states, only two species viz *Nemipterus japonicus* and *N. mesoprion* contributed significantly; the former was most abundant in Tamil Nadu - Pondicherry, Karnataka - Goa, Maharashtra and Gujarat and the latter in Andhra and Kerala. Periods of peak abundance were January–March in Andhra Pradesh, Karnataka-Goa, and Gujarat whereas April–June in Maharashtra and July–September in Tamil Nadu - Pondicherry and Kerala. The parameters of growth and mortality were estimated. The results of stock assessment from each state show that though there is scope to increase the effort by 40%–100% to get MSY from the fishing grounds, the increase in yield will be marginal (1%–12%). There is need to increase the cod end mesh size of trawl net (or length at first capture L_c) by 10–30% to get MSY. The maximum possible yield of *N. japonicus* and *N. mesoprion* from the fishing grounds along east coast (Andhra Pradesh, Tamil Nadu and Pondicherry) is around 5 000 tonnes and along west coast between 43 000 tonnes and 46 000 tonnes. These are close to the yields in 1984–88. The problems in stock assessment and different options for management of fisheries are discussed.

The threadfin breams are one of the most dominant components among the demersal fisheries resources of India being exploited by small commercial trawlers up to depths of about 50–60 m all along Indian coast. An estimated 67 677 tonnes of these fishes were landed in 1989 (Anonymous 1990) from Indian seas which formed 7.7% of total demersal fish and 3.0% of total marine fish landings of India. Though six species occur in the catches, only two species, *Nemipterus japonicus* (Bloch) and *N. mesoprion* (Bleeker) are most abundant and contribute to bulk of threadfin breams catches.

Considerable work on the distribution, taxonomy, biology and fisheries of threadfin breams was done from different regions along Indian coasts (Banse 1959; Narayanappa *et al.* 1968; Silas 1969; Kuthalingam 1971; Satyanarayana *et al.* 1972; Krishnamoorthi 1973a, 1973b; Vinci and Nair 1975; Silas *et al.* 1976; Rajagopalan *et al.* 1977; Dan 1980; CMFRI 1981; Indra 1981; Madanmohan and Gopakumar 1981; Murty 1981, 1982a, 1982b,

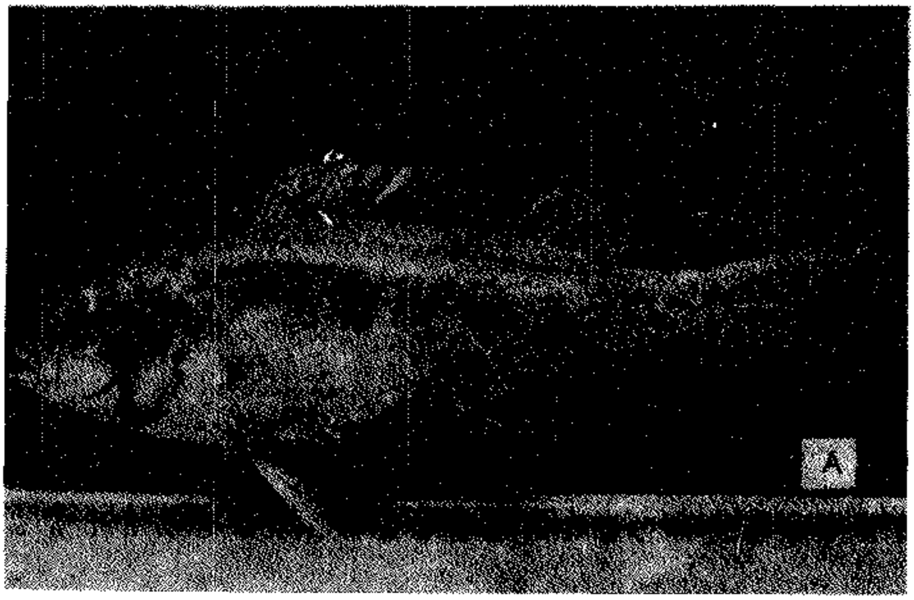
Present address: [1]Senior Scientist, [3, 5]Scientist (Selection Grade).

[2]Principal Scientist (Retd), No. 8, 54-1, China-Waltair Colony, Visakhapatnam 530 023.

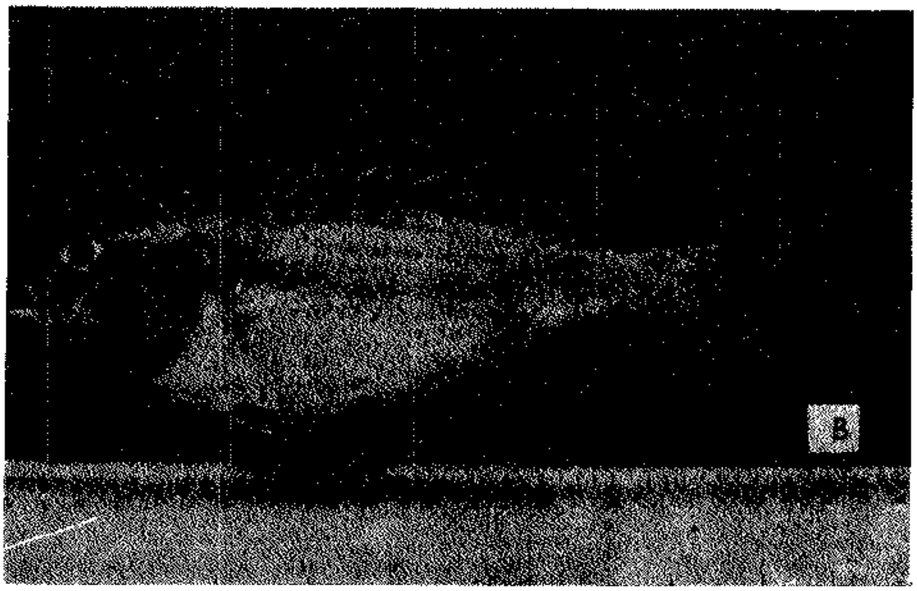
[4]Senior Scientist, Madras Research Centre of CMFRI, 141, Marshalls Road, Egmore, Madras 600 008.

[6]Senior Scientist, [7]Scientist (Senior Scale), Bombay Research Centre of CMFRI, 148, Army and Navy Building, 2nd Floor, M G Road, Bombay 400 023.

[8]Scientist, Mangalore Research Centre of CMFRI, P B No. 244, Bolar, Mangalore 575 001.



A. *Nemipterus japonicus*.



B. *Nemipterus mesoprion*.

1984; Rao 1981; Rao and Rao 1981, 1983, 1986; Vinci 1983; Acharya and Dwivedi 1984; Madanmohan and Velayudhan 1984; Muthiah and Pillai 1984; Nair and Jayaprakash 1986; Vivekanandan and James 1986, 1987; Vivekanandan 1990; James *et al.* 1987; Reuben *et al.* 1989; Rao 1989 and Nair and Reghu 1990). Detailed studies on stock assessment of threadfin breams were also made (Krishnamoorthi 1973a; Murty, 1983, 1987a, 1987b, 1989; Vivekanandan and James 1986; Devaraj and Gulati 1988; John 1989; Kasim *et al.* 1989), but they were restricted to analyses of data from particular trawl landing centres or of data from research/exploratory vessel from particular areas. These studies are, to a large extent, not able to meet the requirements of agencies engaged in management of fisheries. Therefore, concerted efforts were made to examine the data collected on dominant species of threadfin breams from over wider areas off the Indian coast for stock assessment and the results are presented in this paper.

MATERIALS AND METHODS

Detailed data on species composition, length composition of catch, and biology of dominant species collected from the trawl landing centres at Visakhapatnam, Kakinada and Madras along east coast; and Cochin, Mangalore, Bombay and Veraval along west coast during 1984–88, were considered. The Fisheries Resources Assessment Division of the Central Marine Fisheries Research Institute collects effort and catch data in the country through a well-designed Stratified Multistage Random Sampling Scheme and makes estimates of districtwise and gearwise effort, and districtwise, gearwise and group/specieswise production. These data were also taken for the present study. Two species (*Nemipterus japonicus* and *N. mesoprion*) were selected for the study.

Species composition and length frequency distribution: At each of the seven above mentioned trawl landing centres, data were collected for 4–8 days every month. In some cases, data on species composition and length composition were collected at the landing place and in others the samples were brought to the laboratory. Biological data were collected from samples brought to the laboratory. Total length, measured from tip of snout to tip of lower caudal lobe, was considered for length frequency and other studies. The data on species composition and length composition collected on each observation day were first weighted to the estimated total catch of the group (threadfin breams) and the species respectively, obtained on that day and then such estimates in a month were pooled and then raised to the estimated catch of the month following the procedure of Alagaraja (1984). The monthly estimates were pooled to get quarterly and annual estimates. The data obtained at the observation centre were suitably weighted to get estimates for each state. As the data on production were available in the form of quarterly estimates, the monthly estimates from each centre pooled for each quarter (I quarter: January–March, II quarter: April–June and so on for four quarters) were weighted to get quarterwise and statewise estimates. In the states where detailed data were collected at single centres only, the centre's data were raised to the data of states: thus the data collected at Madras, Cochin, Mangalore, Bombay and Veraval were raised respectively to the data on catches of Tamil Nadu - Pondicherry, Kerala, Karnataka - Goa, Maharashtra and Gujarat. However, in the case of Andhra Pradesh, detailed data were available from two centres : Visakhapatnam and Kakinada. In this case, the data obtained at Visakhapatnam were raised to the catches obtained in the northern districts of Srikakulam, Vijayanagaram and Visakhapatnam together and those obtained at Kakinada were raised to the total catch obtained in the remaining coastal districts (East Godavary, West Godavary, Krishna, Guntur, Prakasam and Nellore) of the state. Stock assessment was done separately for these two sets and then pooled to get estimates for the state of Andhra Pradesh.

Biology: The results of detailed studies on length-weight relationship, food and feeding habits, maturation, spawning, sex ratio and fecundity carried out at different centres were taken from published work.

Estimation of von Bertalanffy growth parameters: The length data were grouped into 10 mm-class intervals. The parameters of growth in length were estimated following the ELEFAN method (Pauly and David 1981, Gayanilo *et al.* 1988): the growth parameters were estimated using the monthly length frequency distribution of each year (from 1984 to 1988) separately from each of the seven centres. In the data of each year, different starting lengths and 'samples' were used and best fit values were taken. Thus, 1–3 estimates of growth parameters in each year from each centre were obtained. Of all such estimates in all the years, the smallest and largest lengths at infinity (L_∞) values and their associated growth coefficient (K) values were selected from each centre for all further studies. The estimates thus obtained were compared with those available in the literature from India and outside.

Mortality rates: The instantaneous total mortality rate (Z) was estimated using length-converted catch curve method (Pauly 1982), using the pooled data of all the five years and the LFSA package of Sparre (1987). The instantaneous natural mortality rate (M) was estimated using the empirical formula of Pauly (1980) and then the fishing mortality rate (F) was obtained as Z-M.

Lengths at recruitment and first capture: The midpoint of the smallest length group in the catch during the five-year period was taken as length at recruitment (L_r). The length corresponding to the first value in the descending limb of the length-converted catch curve was taken as an estimate of the length at first capture (L_c).

Yield and biomass: The raised annual length frequencies of catch of each species from each state were pooled for all the years (1984–88) and annual average values obtained; these were used as input for the study. Estimation of yield and biomass at different fishing effort levels was made, using length-converted Thompson and Bell (1934) analysis (Sparre 1985, Murty 1989) with the help of the programme MIXFISH of the LFSA package of Sparre (1987). The estimates of yield and biomass were made separately using the two sets of growth parameters (as mentioned above) and their average corresponding to each effort level was taken. These values were considered for the purpose of present study. The assessment of *N. japonicus* and *N. mesoprion* was done separately and then together from each maritime state.

For studying the effects of changes in the cod end mesh size, the following procedure was adopted.

1. For each species, the present L_c values were converted into present t_c values using VBG parameters (t_0 is taken as 0).
2. The present t_c values in the species were decreased and increased by same factor (as 10%, 20% . . . 120% . . . 200% of present t_c).
3. Using these t_c values, the present F and other required parameters, the Beverton - Holt (1957) yield-per-recruit analysis was made. This resulted in yield-mesh curve for each species.
4. Taking the value of yield-per-recruit (Y_w/R) at current F and t_c and the value of annual average yield of the species, the

recruitment in numbers R = Y/(Y/R) was estimated.

5. The Y_w/R at each t_c in each species as obtained at 3 above was weighted by the value of R (obtained as in 4 above) to obtain values of yield in weight at different t_c (i.e. percentages of present t_c) values.
6. The values of yield at different t_c values (i.e. percentage of present t_c) for the two species were pooled to get yield mesh curve for the two species together.

The estimates were made separately using the two sets of growth parameters. The average values of yield corresponding to each t_c level, for the two sets of estimates, were taken for the present study.

Similar analyses were made separately for each maritime state.

RESULTS

Fishery

Though the exploitation of threadfin breams was confined to relatively shallower areas, the results of exploratory and experimental fishing (trawling) showed that these fishes were more abundant in depths beyond 50 m (particularly in the 100–200 m depth zone) (Silas 1969; Zupanovic and Mohiuddin 1973; Silas *et al.* 1976, James *et al.* 1987, Philip and Joseph 1988, John 1989, Sudarsan *et al.* 1990, Vivekanandan 1990, Vijayakumaran and Philip 1991, Sivaprakasam *et al.* 1991) and known to move into relatively shallower areas of the depth range 35–40 m during certain seasons (Banse 1959, Nair and Jayaprakash 1986). It is for this reason that threadfin bream catch in different states of India was obtained mainly by trawlers only and not by other gears.

In Andhra Pradesh, commercial trawlers of three different sizes (ranging from 10 to 11.4 m O A L) operated in the depth range 5–50 m during greater part of the year and during November–February in depths extending up to 80 m. Most of the boats returned the same day after fishing but some boats stayed in the sea and conducted fishing for 2–4 days and then returned. Shrimp trawl with cod end mesh size of 15–20 mm was operated by all the boats. In Tamil Nadu, the small vessels (9.8–11 m OAL) operated shrimp trawl with cod end mesh size ranging from 15 to 18 mm. In this state, some boats conducted daytime fishing and some night fishing in different depths up to 50 m. In Kerala also, the trawlers operated shrimp trawl in the 5–50 m depth zone; some returned to the base every day while some returned after 3–4 days. In Karnataka, however, boats of varying lengths of 6.7–15.0 m OAL operated in the depths extending up to 70 m; the smaller-sized boats used shrimp trawl with cod end mesh size of 18–20 mm and conducted fishing during day time whereas the bigger ones conducted stay fishing up to 4 days using shrimp trawl of 25–28 mm cod end mesh size during nights and with fish trawl of 30–40 mm cod end mesh size during day time. In Maharashtra, boats of 13.5 m length operated shrimp trawl in depths extending up to 60 m; these boats stayed in the sea for 2–3 days and after fishing for about 36 hours returned to the base. In Gujarat also, the commercial trawlers (14 m OAL) used shrimp trawl with cod end mesh size of 15–20 mm; trawling was conducted in 20–70 m depth zone and most of the boats conducted fishing and returned the same day whereas a few boats returned after 3–4 days of fishing.

All-India catches: The landings of threadfin breams increased considerably during 1980–88, consistent with increased effort. The average annual landing of threadfin breams during 1980–83 was 22 247 tonnes whereas the same during 1984–88 was 48 104 tonnes. Starting from about 22 600 tonnes in 1980 the landings showed considerable increase (except a minor decline in 1981) over

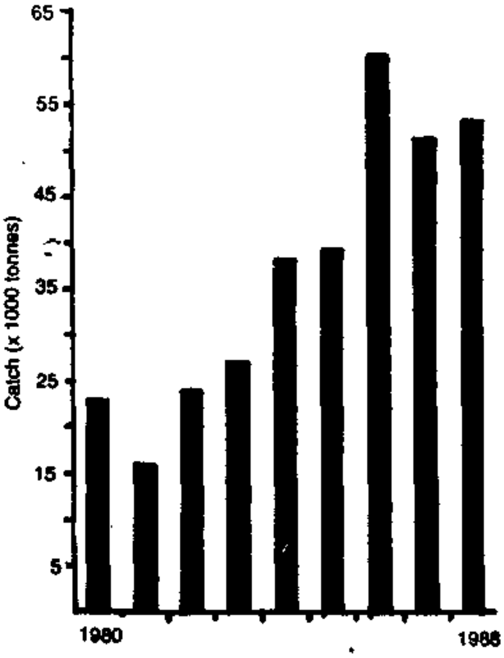


Fig. 1. Estimated annual landings of threadfin breams in India during 1980–88.

the years and reached a maximum of over 60 000 tonnes in 1986, the catches declined to about 50 600 tonnes in 1987 but in 1988 they increased to over 53 000 tonnes (Fig. 1).

Statewise catch effort and catch rates: Among the maritime states and union territories, West Bengal did not contribute to threadfin bream landings. Among the remaining, Kerala contributed the maximum (52%) of all India nemipterid catch, followed by Maharashtra (13.6%), Tamil Nadu - Pondicherry (11.2%), Karnataka - Goa (8.8%), Gujarat (7.8%), Andhra Pradesh (5.5%) and Orissa (1.1%). The total landings in each state along with the catches and catch rates by trawl are dealt with here.

ANDHRA PRADESH: During 1980–88 the estimated landings from *all gears* varied from about 1 130 tonnes in 1988 to about 3 000 tonnes in 1983, with the annual average during this period at 2 030 tonnes. The catch increased from 1980 till 1983 but from 1984 it fluctuated.

Major trawling in this state took place off Visakhapatnam and Kakinada. The trawling effort in the state during 1981–88 ranged from 98 200 to 124 000 boat-days (Fig. 2) with an annual average of 112 450. The nemipterid landings varied from a minimum of 1 100 tonnes in 1988 to a maximum of 2 800 tonnes in 1983 with an annual average of about 2 000 tonnes. During the period, two peaks in the landings, one in 1983 and the other in 1987, were observed. The catch per unit effort in different years varied from about 11 kg in 1988 to 23 kg in 1983. There were two peaks in catch rates also, in 1983 and 1987, in conformity with those in catches.

TAMIL NADU AND PONDICHERRY: The estimated annual landings of threadfin breams by *all gears* during 1980–88 ranged from 2 100 tonnes to 6 800 tonnes with the annual average at 4 100 tonnes. There were two peaks, one in 1982 and the other in 1987.

Major trawling took place off Madras, Cuddalore, Nagapattanam, Mandapam, Rameswaram, Tuticorin, Pondicherry and Karaikal and the total trawling effort varied from 412 000 to 558 000 boat-days (Fig. 2) with the annual average at 487 500. At all the

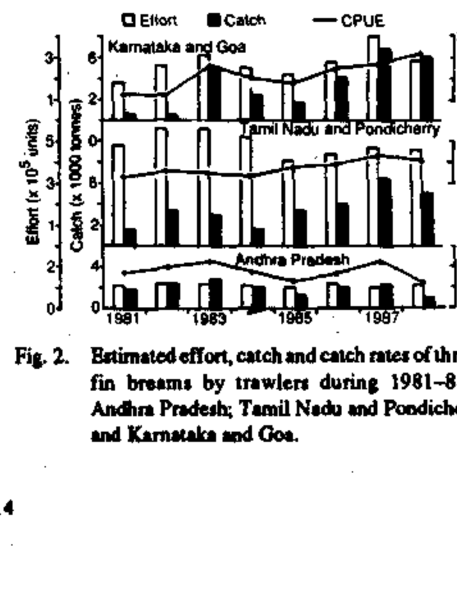


Fig. 2. Estimated effort, catch and catch rates of threadfin breams by trawlers during 1981–88 in Andhra Pradesh; Tamil Nadu and Pondicherry; and Karnataka and Goa.

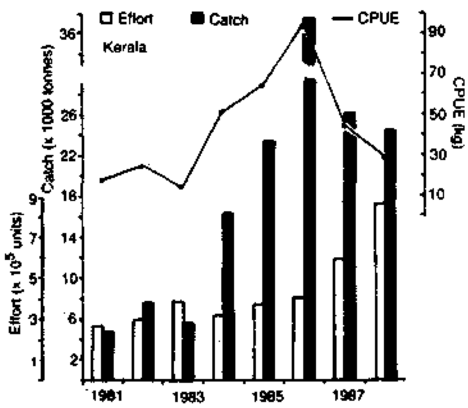


Fig. 3. Estimated effort, catch and catch rates of threadfin breams by trawlers during 1981–88 in Kerala.

trawl landing centres, threadfin breams were landed in considerable quantities but at Mandapam and Rameswaram the landings were negligible. The estimated annual landings of threadfin breams by trawlers during 1981–88 varied from 1 500 tonnes to 6 400 tonnes (Fig. 2) with the annual average at 3 600 tonnes. The catch per unit of effort varied between 3 kg and 13 kg. During 1981–88 the peaks in effort, catch and catch rate were more or less in the same periods (Fig. 2).

KARNATAKA AND GOA: An estimated annual average of 3 200 tonnes of nemipterids were landed with the yearly estimated catches by *all gears* varying from a minimum of 700 tonnes to a maximum of 6 800 tonnes during 1980–88. Starting from 1980, the landings increased slowly, but suddenly showed a fivefold increase in 1983. The landings declined in 1984 and 85 and showed increase in 1986 and the maximum catch of 6 800 tonnes was obtained in 1987.

There was considerable trawling along Karnataka-Goa coast and the trawling effort ranged from 179 000 boat-days to 397 000 boat-days in different years (Fig. 2) during 1981–88, with an annual average of 271 000 boat-days. The estimated threadfin bream catch from trawlers varied from about 600 to 6 700 tonnes with an annual average of 3 400 tonnes during 1981–88. The catch per unit of effort varied from 2 to 22 kg in different years. The effort and catch showed more or less similar trends but the catch rate in 1988 was the highest though the effort and catch were less than in some previous years.

KERALA: The yearly estimated threadfin bream landings by *all gears* in this state ranged from 6 400 tonnes to 38 000 tonnes with the annual average at 19 000 tonnes.

Apart from the two major fishing harbours at Cochin and Sakthikulangara, mechanized boats operated all along the coastline and the estimated annual trawling effort varied from 268 000 to 863 000 boat-days in different years during 1981–88 (Fig. 3). The catch of nemipterids by trawlers varied from abut 4 900 tonnes in 1981 to 37 500 tonnes in 1986 with an average of 18 300 tonnes. The catch per unit of effort varied from 14 to 93 kg. It is clear that over the years, the catches and catch rates showed considerable increase. It could also be seen that the effort variation among different years was not as significant as among landings of the threadfin breams by trawlers (Fig. 3).

MAHARASHTRA: In this state, the estimated annual threadfin bream landings by *all gears* varied from about 2 200 to 12 300 tonnes. Starting from 1980, the landings increased with a peak in 1983; the landings showed decline in 1984 and 1985 and increased further with highest landings in 1988.

The annual trawling effort varied from 73 000 to 245 000 boat-days (Fig. 4) with an average of 174 000. The estimated threadfin bream landings during the same period varied from 2 100 to 12 300 tonnes with an annual average of 5 100 tonnes. The catch rates fluctuated between 14 and 54 kg. The trawling effort and catch showed more or less same trend over the period as also the catch rates.

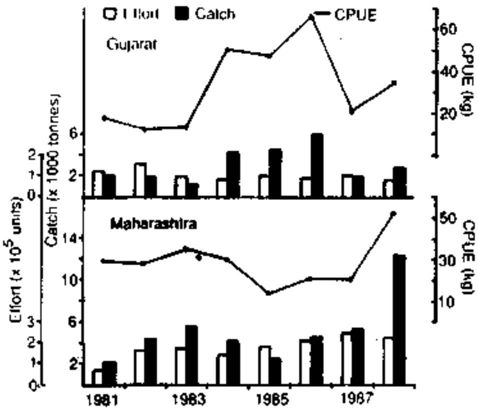


Fig. 4. Estimated effort, catch and catch rates of threadfin breams by trawlers during 1981–88 in Maharashtra and Gujarat.

GUJARAT: The annual trawling effort varied from 82 000 to 149 000 boat-days (Fig. 4) with an annual average of 101 000 boat-days. The nemipterid catch ranged from 1 200 to 5 900 tonnes with an average of 31 000 tonnes. The catch per unit of effort ranged from 12 to 67 kg. The period 1984–86 recorded good annual catches from trawls with highest in 1986. The catch rates by trawls showed increasing trend up to 1986.

Species composition: A total of six species, *Nemipterus japonicus, N. mesoprion, N. tolu, N. delagoae, N. luteus* and *N. metopias*, contributed to the fishery along Indian coast during the period. Of these, the first two species contributed to the fishery significantly all along the coast whereas the others occurred in the catches occasionally in small quantities. The last mentioned species contributed to the fishery in small quantities along southern Tamil Nadu and Kerala regions only.

In Andhra Pradesh five species (excepting *N. metopias*) contributed to the fishery and *N. japonicus* and *N. mesoprion* together formed over 90% of nemipterid catch. Along Tamil Nadu and Pondicherry also the same five species occurred in the catches; here also, the above two species formed the bulk of the catches and the other three species formed about 40% of nemipterid catch. In Kerala, *N. japonicus, N. mesoprion* and *N. metopias* occurred in the catches but the first two species together formed about 99% of threadfin bream catch. In Karnataka-Goa and Maharashtra only two species (*N. japonicus* and *N. mesoprion*) contributed to the fishery. In Gujarat, in addition to the above two species, *N. delagoae* also occurred in the catches but in very small quantities forming about 2.0% of threadfin bream catches.

It is thus clear that only two species are of any importance to the fishery. Of these, *N. mesoprion* is more dominant in Andhra Pradesh and Kerala and *N. japonicus* in the remaining states.

Seasonal variations: The data on estimated catches in each month were pooled for periods of three successive months from January (4 quarters) and were then converted into percentages in each year. These values are shown in Fig. 5 for each state separately for the years from 1985 to 1988. Though there were slight variations in the periods of peak landings within each state, the first quarter appeared to be the peak period in Andhra Pradesh, Karnataka and Goa, and Gujarat, second quarter in Maharashtra and third quarter in Tamil Nadu and Kerala. While there was trawling round the year along east coast, there was no fishing along Karnataka and Gujarat on the west coast, and only very poor fishing in Maharashtra during monsoon (June–August) months. In Kerala, however, there was trawling during monsoon also and major portion of threadfin bream catch was obtained during this period.

Biology

Considerable work on various aspects of biology of different species of threadfin

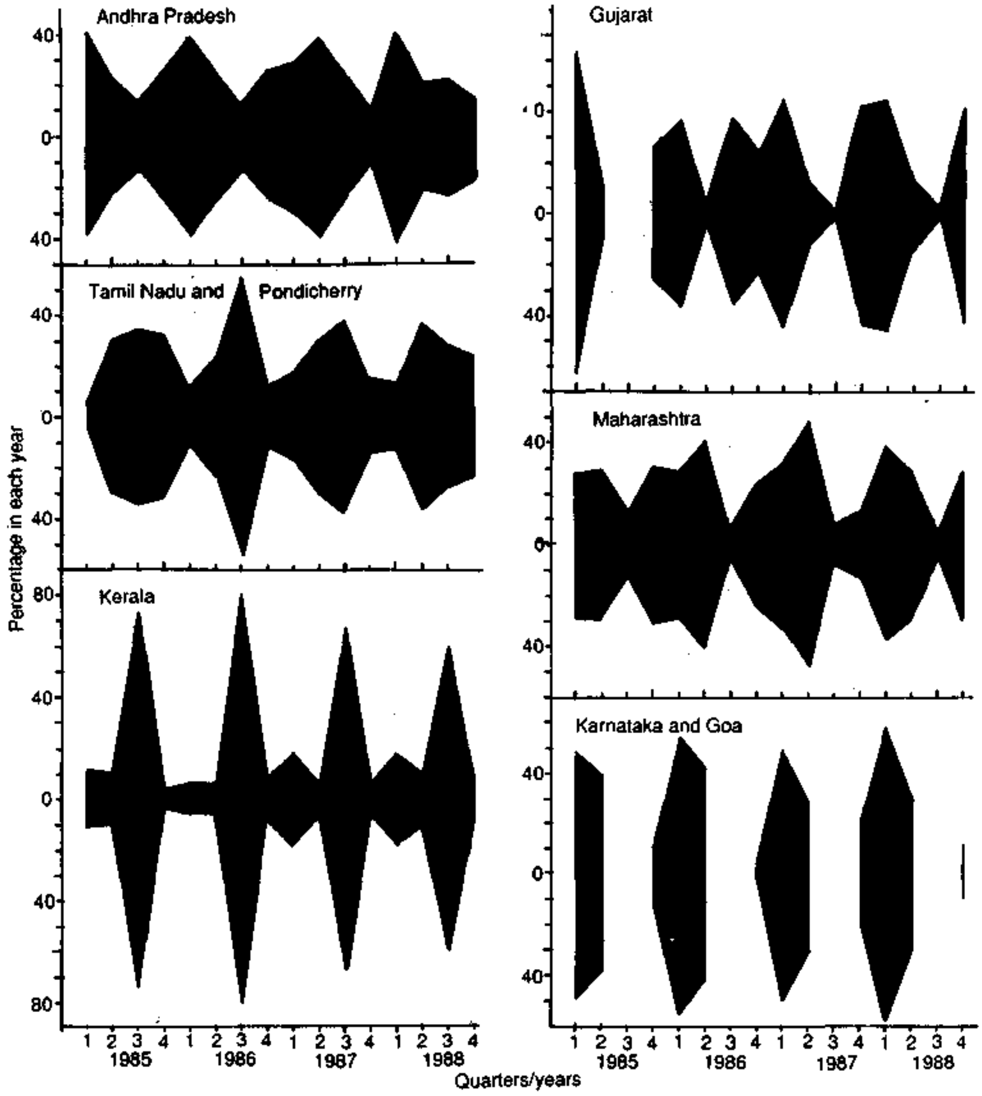


Fig. 5. Quarterly variation in catches of threadfin breams in different years in Andhra Pradesh; Tamil Nadu and Pondicherry; Kerala; Karnataka and Goa; Maharashtra; and Gujarat. 1. January–March 2. April–June 3. July–September 4. October–December.

breams was carried out on the basis of data collected from particular centres along Indian coasts. The results are briefly given below in the case of *N. japonicus* and *N. mesoprion*.

Nemipterus japonicus

FOOD: According to Krishnamoorthi (1973b), the chief items of food of this species from off Andhra-Orissa coasts are *Squilla*, crabs, carried prawns, squids and fishes in the order of dominance; this species is a bottom feeder.

LENGTH AT FIRST MATURITY: From off Andhra-Orissa coast, Krishnamoorthi (1973b) studied the data obtained by exploratory fishing vessels and taking females in stages V and VI of maturation as mature, determined the length at first maturity of the species as 165 mm. Based on data from commercial trawlers from off Kakinada, Murty (1984) determined the length at first maturity as 125 mm; for this purpose he considered the data of spawning season only and took females of stages III–VI as mature. From off Madras, Vivekanandan and James (1986) estimated the length at first maturity as 145 mm on considerations similar to those of Murty (1984).

SPAWNING: The data of Krishnamoorthi (1973b) showed that fishes in stage IV of maturation were available from August to March with peaks in September–October and January–February; stage V fish occurred from September to February and stage VI (Ripe) from September to November. According to the author, September–November is the "probable" period of spawning in the sea off north Andhra and Orissa coasts.

Dan (1980) used a part of the material and data of Krishnamoorthi (1973b); he examined 38 ovaries of fish of length range 130–209 mm collected during November–February (4 months) of 1965-66. According to him "the fish breeds over a short and definite period from December to February. Since about three months time is necessary for the second mode [in the ova diameter frequency distribution] to become ready for spawning, it appears that the fish may breed for a second time in June–July period". However, looking at the data on ova diameters presented and the above conclusions, one would conclude that the second batch will be released after three months starting from March since the first batch is released starting from December. This means that the second batch of ova will be released during March–May period. Since the first batch is released during December–February, the spawning period becomes continuous from December to May, each fish releasing the ripe ova in two spawning acts.

Murty (1984) studied the gross structure of ova of different diameters and the ova diameter frequency distribution in several ovaries of different stages of maturation and concluded that *N. japonicus* was a fractional spawner releasing the ripe eggs in two spawning acts during August–April in the sea off Kakinada. In the sea off Madras (Vivekanandan and James 1986), the spawning season was determined as June–March with peak during December–March. From off Cochin, the study by Vinci (1983) and the present data showed that spawning in *N. japonicus* takes place during June–January with peak during June–August (monsoon). From the findings of Kuthalingam (1971) and the present data, it appeared that off Mangalore the spawning period extended from November to May with peak during November–February. Off Bombay, mature and spent fish occured almost throughout the year but their proportion was highest during monsoon months (June–August). Off Veraval, spawning appeared to take place during October–April with peak during October–December.

FECUNDITY: Dan (1980) examined 38 ovaries and estimated the fecundity as ranging from 13 900 to 58 400 in fishes of 135 to 205 mm in total length. The author knew that this species spawns in two batches but did not consider this fact for estimating fecundity. The estimates given, therefore, are to be taken as 'batch fecundity' estimates only.

Murty (1984) estimated the total annual fecundity (two batches together) as ranging from 23 000 to 139 200 in fishes of the length range 134–199 mm. Two relationships obtained were:

$$F = -116.56711 + 1.11909\,L;\ R^2 = 0.69$$
$$F = -0.75615 + 1.11380\,W;\ R^2 = 0.85$$

where F, fecundity; L, total length (mm); and W, total weight of fish (g)

SEX RATIO: According to Krishnamoorthi (1976) and Murty (1984) males were predominant in almost all lengths and beyond 215 mm there were no females; the mean length of males was always greater than that of females.

Nemipterus mesoprion

FOOD: According to Rao (1989) this species is carnivorous subsisting mainly on crustaceans and teleosts. Among the former, small prawns, stomatopods and crabs were dominant.

MATURATION AND SPAWNING: The length at first maturity was estimated in females as 100 mm (Murty 1982a). This species is also a fractional spawner spawning in two batches during the season which off Kakinada extended from December to April with peak in January (Murty 1982a).

Though results of investigations from other centres on spawning in *N. mesoprion* were not published, the available data indicated that off Cochin spawning takes place during June–September with peak in June. Along the Bombay coast mature and spent fish occur almost throughout the year with peak during June–August. Off Veraval there was no trawling during June–August, the proportion of mature and gravid fish in each month showed that spawning in this region takes place during October–March with peak during December–February.

Stock assessment

For this study, only *N. japonicus* and *N. mesoprion* were considered as these two species contributed over 90% of threadfin bream catches.

Growth parameters: The smallest and largest L_∞ values and their associated K values pertaining to the two species are shown in Tables 1 and 2. The corresponding length frequency data (restructured) with the growth curves are shown in figures 6–13. The values of L_∞ and K of *N. japonicus* from all the centres in both the sets (Table 1) varied from 305 to 351 mm and from 0.40 to 0.70/year respectively. While the maximum recorded length (L_{max}) in India is 350 mm (Krishnamoorthi 1973b), the L_{max} values observed at different centres (Table 1) are close to the estimated values of L_∞. Further, the values of L_∞ and K in each set from different centres are closer. The growth parameters estimated by earlier workers (Table 3) from the Indo-Pacific region show wider range in both L_∞ (235–382 mm) and K (0.12–1.00/year).

In *N. mesoprion*, the values of L_∞ and K from different centres vary from 222 to 297 mm and from 0.405 to 0.84/year (Table 2) respectively and the L_{max} observed at different centres are close to L_∞ values considered. The values of lower L_∞ from different centres are more or less close to each other but in higher L_∞, the range is slightly larger.

Mortality rates: Taking the two sets of growth parameters (Tables 1 & 2), the total mortality rates were estimated using the length converted catch curve. The Z values obtained by using each set of parameters from different centres varied from 1.80 to 3.02 (lower parameters) and 2.12 to 3.39 (higher parameters) in *N. japonicus* (Table 1) and from 2.01 to 3.76 (lower parameters) and 2.25 to 5.37 (higher parameters) in *N. mesoprion* (Table 2) (Here and elsewhere in the text the estimates obtained by using smallest L_∞ and related K are referred to as having been ob-

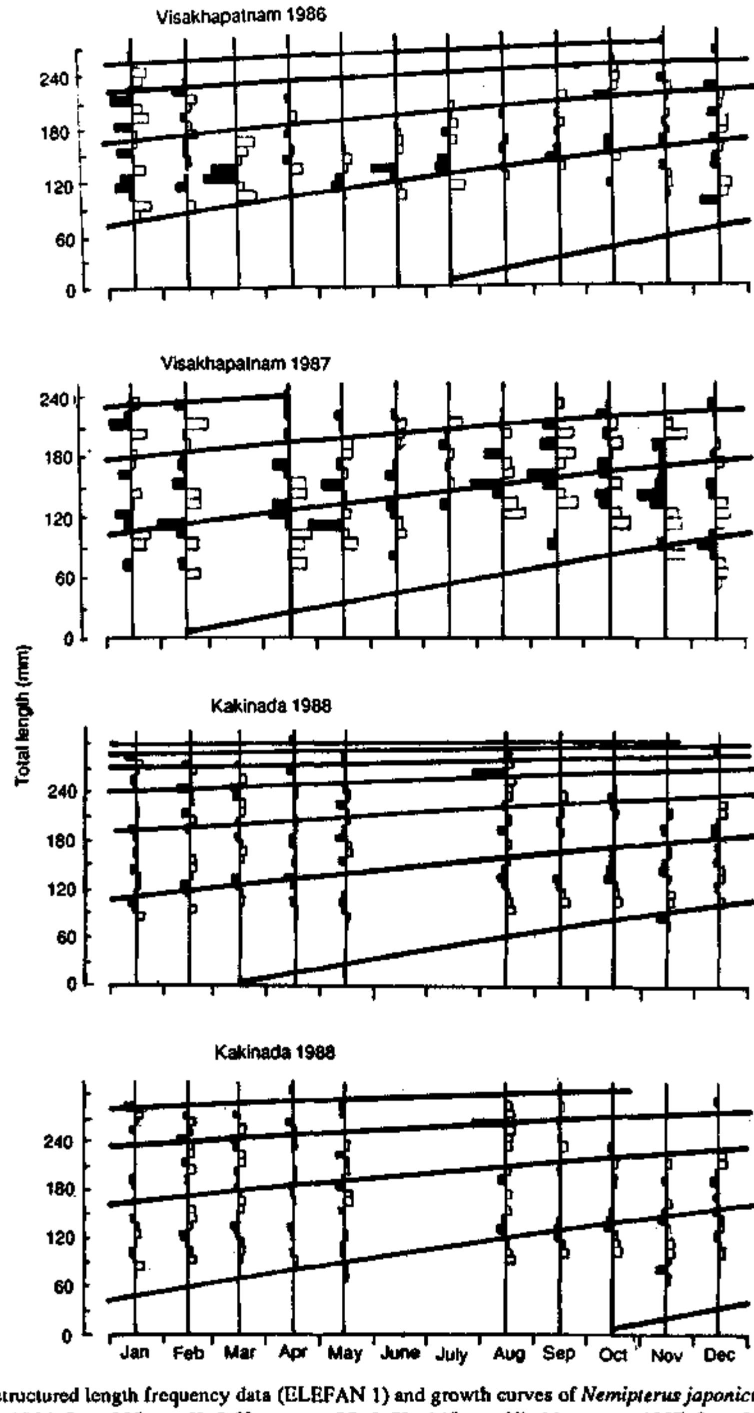


Fig. 6. Restructured length frequency data (ELEFAN 1) and growth curves of *Nemipterus japonicus*. Visakhapatnam 1986 : L_∞ = 305 mm, K=0.52 per year, SS=9, SL=145 mm; Visakhapatnam 1987 : L_∞ = 335 mm, K=0.40 per year, SS=2, SL=115 mm; Kakinada 1988: L_∞ = 315 mm, K=0.51 per year, SS=2, SL=120 mm; Kakinada 1988: L_∞ = 351 mm, K=0.49 per year, SS=6, SL=125 mm.

Table 1. Estimated values of growth parameters, mortality rates, ages at recruitment and first capture, and other parameters used in the assessment of *Nemipterus japonicus* from different centres

	Parameters	Visakha-patnam	Kakinada	Madras	Cochin	Mangalore	Bombay	Veraval
	L_{max}	350	315	295	305	285	325	345
Lower L_∞ and related K	L_∞	305	315	305	323	323	320	320
	K	0.52	0.51	0.62	0.70	0.43	0.56	0.60
	M	1.14	1.12	1.28	1.37	0.99	1.18	1.23
	Z	2.29	1.80	2.14	3.02	2.72	1.95	2.70
	F	1.15	0.68	0.86	1.77	1.81	0.77	1.47
	t_c	1.06	0.99	0.60	0.41	1.14	0.88	1.10
	t_r	0.23	0.30	0.32	0.16	0.52	0.48	0.19
	Terminal F/Z	0.548	0.500	0.500	0.624	0.683	0.500	0.500
Higher L_∞ and related K	L_∞	335	351	350	350	–	350	345
	K	0.40	0.49	0.58	0.68	–	0.50	0.55
	M	0.94	1.06	1.18	1.30	–	1.07	1.14
	Z	2.12	2.16	2.92	3.39	–	2.16	3.05
	F	1.18	1.10	1.74	2.19	–	1.09	1.91
	t_c	1.22	0.89	0.58	0.38	–	0.88	1.10
	t_r	0.28	0.28	0.29	0.15	–	0.48	0.19
	Terminal F/Z	0.676	0.500	0.500	0.770	–	0.500	0.500
	log a	–4.2441	–4.2441	–4.8665	4.4793	4.4793	–5.5272	–5.5272
	log b	2.702	2.702	2.9661	2.8487	2.8487	3.2839	3.2839

All lengths are in mm, weights in grams and ages in years; log a and b are the constants of length-weight relationship.

tained from "lower parameters" and similarly for largest L_∞ and K from "higher parameters"). The estimated value of M from different centres in *N. japonicus* ranged as 0.99–1.37 with lower parameters and 0.94–1.30 with higher parameters (Table 1). In *N. mesoprion* the range of M values was 1.02–1.59 with lower parameters and 1.12–1.67 with higher parameters (Table 2).

Length-based Thompson and Bell analysis: The results pertaining to each maritime state are presented first followed by those of east coast and west coast and then all India.

ANDHRA PRADESH: In *N. japonicus* the yield increases with increased effort and reaches a maximum of 617 tonnes at 160% of the present effort. In *N. mesoprion*, maximum yield of 1 023 tonnes can be obtained at 140% of the present effort. In both the species together the highest yield of 1 636 tonnes each be obtained at 140% of the present effort (Fig. 14.A). Thus the effort should be increased by 40% to get MSY. The present yield of these two species is 1 600 tonnes and a maximum increase of 2% in the yield can be attained from the present fishing grounds through increasing the effort by 40%. This means a drastic reduction in catch per unit effort as also indicated by low biomass values at this effort level (Fig. 14.A).

TAMIL NADU - PONDICHERRY: In this region, maximum yield of 1 850 tonnes can be obtained at 140% of present effort in *N.*

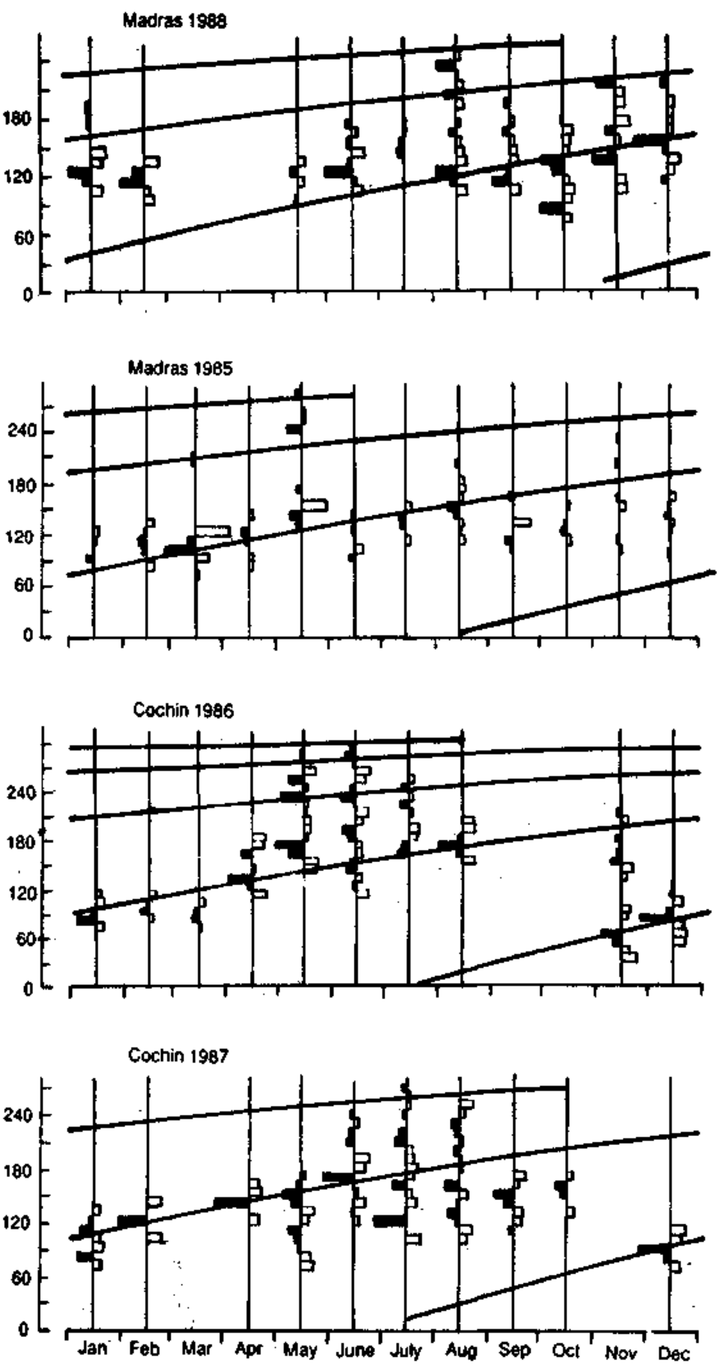


Fig. 7. Restructured length frequency data (ELEFAN 1) and growth curves of ***Nemipterus japonicus*. Madras 1988:** L_∞ = 305 mm, K=0.62 per year, SS=6, SL=120 mm; Madras 1985: L_∞ = 350 mm, K=0.58 per year, SS=3, SL=105 mm; Cochin 1986: L_∞ = 323 mm, K=0.70 per year, SS=4, SL=135 mm; Cochin 1987: L_∞ = 350 mm, K=0.68 per year, SS=2, SL=125 mm.

Table 2. Estimated values of growth parameters, mortality rates, ages at recruitment and first capture and other parameters used in the assessment of *Nemipterus mesoprion* from different centres

	Parameters	Visakhapatnam	Kakinada	Madras	Cochin	Mangalore	Bombay	Veraval
	L_{max}	229	215	195	265	205	255	295
Lower L_∞ and related K	L_∞	240	225	223	244	222	246	255
	K	0.65	0.76	0.61	0.62	0.74	0.77	0.405
	M	1.41	1.59	1.38	1.36	1.57	1.56	1.02
	Z	3.76	2.91	2.01	2.04	2.28	2.21	2.09
	F	2.35	1.32	0.63	0.68	0.71	0.65	1.07
	t_c	1.13	0.62	1.11	1.30	0.99	0.92	1.76
	t_r	0.24	0.29	0.46	0.25	0.47	0.47	0.36
	Terminal F/Z	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Higher L_∞ and related K	L_∞	267	255	238	273	260	288	297
	K	0.72	0.465	0.84	0.51	0.60	0.58	0.65
	M	1.47	1.12	1.67	1.36	1.31	1.24	1.33
	Z	5.37	2.47	3.39	2.25	2.88	2.57	5.06
	F	3.90	1.35	1.72	1.09	1.57	1.33	3.73
	t_c	0.88	0.94	0.79	1.34	1.03	1.04	0.89
	t_r	0.19	0.42	0.31	0.27	0.48	0.52	0.19
	Terminal F/Z	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	log a	−4.650917	−4.650917	−4.79260	−4.83784	−4.83784	−4.25225	−4.25225
	log b	2.87707	2.87707	2.9692	2.9840	2.9840	2.89912	2.89912

All lengths are in mm, weights in grams and ages in years; log a and b are constants of length-weight relationships.

japonicus. In *N. mesoprion* and in both the species together, the yield increases with increased effort up to 200% of present (Fig. 15.A) and the yields are 1 670 tonnes and 3 470 tonnes respectively. The increase in yield of the two species will be only 7% with 100% increase in effort. Thus, the increase in effort can result in decline of catch per unit effort from the present fishing grounds.

KERALA: The MSY of *N. japonicus* corresponds to 11 900 tonnes at 60% of the present effort. In *N. mesoprion* and in both the species together, the yield increases to 23 230 tonnes and 31 125 tonnes respectively at 200% of present effort (Fig. 16.A). Thus there is scope to increase yield of *N. mesoprion* and 36% increase in yield can be obtained through increasing the effort by 100%. However, at this effort level, the increase in yield of both the species together will be only 12%. Though this means a decline in catch per unit effort, the yield of *N. mesoprion* can still be increased by suitably deploying the effort in the grounds during monsoon. It may be noted that threadfin breams are principal group in the fishing grounds at depths of 30–40 m during monsoon period (Nair and Jayaprakash 1986, Murty *et al.* 1992).

KARNATAKA-GOA: In this region the MSY of *N. japonicus* corresponds to 80% of present effort whereas the yield increases with increased effort up to 200% of present effort in *N. mesoprion*. In both the species together

Table 3. Von Bertalanffy growth parameters and mortality rates estimated by different authors from different localities in the Indo-Pacific region for *Nemipterus japonicus* and *N. mesoprion*

Locality	L_∞ (mm)	K per year	t_0 (year)	Z	M	F	L_{max} (mm)	Method of estimation of growth parameters	Source
				Nemipterus japonicus					
Andhra - Orissa coast	305	0.3141	−1.1079	0.5166	0.5037	0.0129	350	Modal progression	Krishnamoorthi 1973a
Visakhapatnam	290	0.6244	0.1439				305	Scale studies	Rao and Rao 1986
Kakinada	314	0.7514	−0.1731	1.86	1.14	0.72	285	Modal progression	Murty 1983, 1984
"	339	0.52	−0.16	2.64	1.11	1.53	305	Integrated method	Murty 1987a
Madras	305	1.004	0.2257	2.9853	2.5254	0.4599	301	Integrated method	Vivekanandan and James 1986
Cochin	302	0.47	−0.27	1.37	1.0	0.37	315	Model progression	John 1989
"	326	0.51	–	–	–		315	ELEFAN	John 1989
Maharashtra-Gujarat	298	0.8214	−0.0426	1.6690	1.3186	0.3504	285	Modal progression	Devaraj and Gulati 1988
Kuwait Male	303	0.542	0.19	–				Otoliths	Samuel 1991
Female	265	0.595	0.03	–				"	
Sexes pooled	277	0.580	0.10	0.84				"	
Aden	291	0.31	0.05	0.67				Scales	Edwards *et al.* 1985
Hong Kong (Female)	341	0.190	–	1.32				Scales & otoliths	Lee 1975
" " (Male)	382	0.130	–	1.43				Scales & otoliths	Lee 1975
Manila Bay-Philippines	300	0.70	–	3.31	1.41	1.90			Ingles and Pauly 1984
Carigara Bay-Philippines	235	0.73	–	2.49	1.52	0.98			Corpuz *et al.* 1985
Samar sea-Philippines	265	0.60	–	2.09	1.29	0.80			Corpuz *et al.* 1985
Java sea	235	0.7	–	2.17	1.53	0.64		ELEFAN	Dwiponggo *et al.* 1986
Gulf of Thailand (Male)	–	0.160	–	-	5.48	-			Amornchairojkul and
" (Female)	–	0.121	–						Boonwanich 1982
Peninsula of Malaysia	315	0.530	–	4.02	1.18	2.84		ELEFAN	Isa 1988
"	314	0.550	–	3.72	1.21	2.51		ELEFAN	Isa 1988
Northern Burma	370	0.235	–	0.92				ELEFAN	Pauly and Aung Sann 1984
Southern Burma	370	0.243	–	0.94				ELEFAN	Pauly and Aung Sann 1984
Northern Borneo	289	0.470	–	2.28					Weber and Jothy 1977
				Nemipterus mesoprion					
Kakinada	219	0.83	−0.256		1.70			Modal progression	Murty 1982
Java sea	215	0.80		3.25	1.73	1.54		ELEFAN	Dwiponggo *et al.* 1986

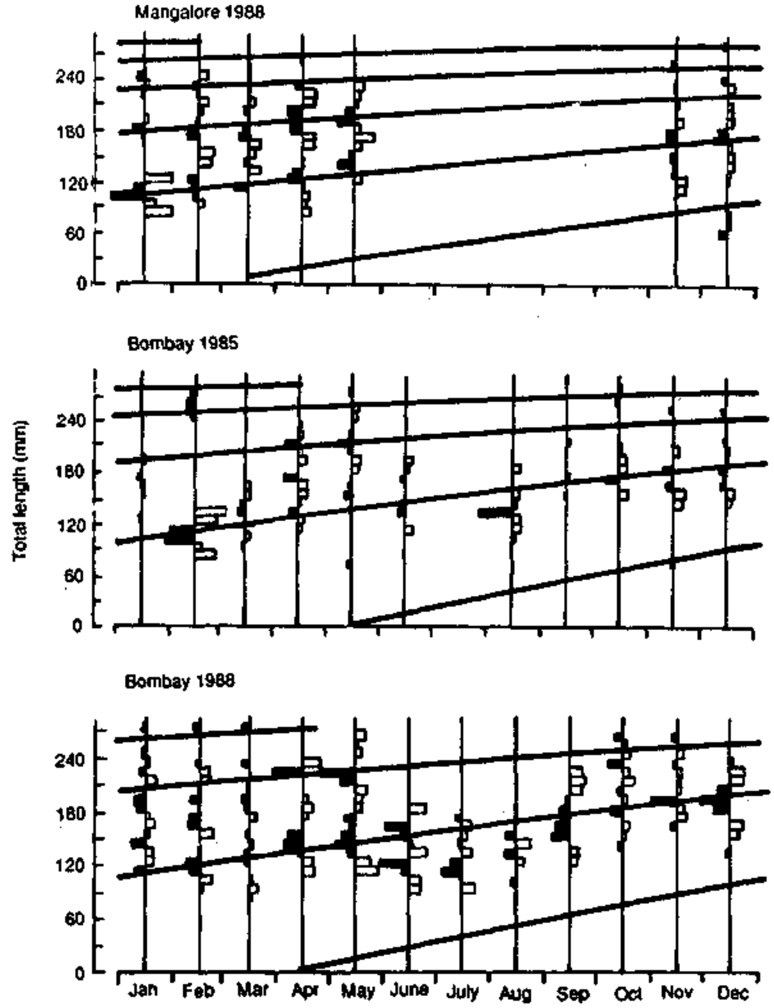


Fig. 8. Restructured length frequency data (ELEFAN 1) and growth curves of *Nemipterus japonicus*. Mangalore 1988: L_∞ = 323 mm, K=0.43 per year, SS=1, SL=105 mm; Bombay 1985: L_∞ = 320 mm, K=0.56 per year, SS=4, SL=130 mm; Bombay 1988: L_∞ = 350 mm, K=0.50 per year, SS=1, SL=115 mm.

MSY corresponds to 140% of the present effort (Fig. 17.A). The increase in yield at this effort level will only be about 1%, indicating a drastic decline in CPUE.

MAHARASHTRA: In *N. japonicus* the MSY corresponds to 140% of present effort whereas in *N. mesoprion* the yield increases up to 200% of present effort. In both the species also maximum yield corresponds to 200% of present effort (Fig. 18.A); the increase in yield is, however, 9% only.

GUJARAT: In this region the MSY of *N. japonicus* corresponds to 160% of present effort and in *N. mesoprion* the yield increases up to 200% of present effort. In the two species together the MSY corresponds to 180% of

Table 4. Yield (tonnes) of *Nemipterus japonicus*, *N. mesoprion* and both the species together along east coast, west coast and both the coasts combined at different levels of effort

Effort as per cent of present	East coast			West coast			All India		
	Nemipterus japonicus	*Nemipterus mesoprion*	Both species	*Nemipterus japonicus*	*Nemipterus mesoprion*	Both species	*Nemipterus japonicus*	*Nemipterus mesoprion*	Both species
20	1 253	1 169	2 422	16 220	7 206	23 426	17 473	8 375	25 848
(−80)	(−48.1)	(−51.9)	(−50.1)	(−20.6)	(−67.2)	(−44.7)	(−23.5)	(−65.7)	(−45.3)
40	1 860	1 757	3 617	20 157	12 425	32 582	22 017	14 182	36 199
(−60)	(−23.0)	(−27.8)	(−25.4)	(−1.3)	(−43.4)	(−23.1)	(−3.6)	(−41.8)	(−23.3)
60	2 172	2 091	4 263	21 014	16 384	37 396	23 186	18 473	41 659
(−40)	(−10.1)	(−14.1)	(−12.1)	(+2.9)	(−25.4)	(−11.7)	(+1.5)	(−24.2)	(−11.8)
80	2 334	2 298	4 632	20 887	19 472	40 359	23 221	21 770	44 991
(−20)	(−3.4)	(−5.5)	(−4.5)	(+2.3)	(−11.3)	(−4.7)	(+1.7)	(−10.7)	(−4.7)
100 (Present)	2 417	2 433	4 850	2 420	21 951	43 271	22 837	24 384	47 221
(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
120	2 453	2 524	4 977	19 842	23 928	43 770	22 295	26 452	48 747
(+20)	(+1.5)	(+3.7)	(+2.6)	(−2.8)	(+9.0)	(+3.3)	(−2.4)	(+8.5)	(+3.2)
140	2 463	2 587	5 050	19 245	25 557	44 802	21 708	28 144	49 852
(+40)	(+1.9)	(+6.3)	(+4.1)	(−5.8)	(+16.4)	(+5.7)	(−4.9)	(+15.4)	(+5.6)
160	2 455	2 628	5 083	18 665	26 899	45 564	21 120	29 527	50 647
(+60)	(+1.9)	(+8.0)	(+4.8)	(−8.6)	(+22.5)	(+7.5)	(−7.5)	(+21.1)	(+7.3)
180	2 439	2 658	5 097	18 117	28 012	46 129	20 556	30 670	51 226
(+80)	(+0.9)	(+9.2)	(+5.1)	(−11.3)	(+27.6)	(+8.9)	(−10.0)	(+25.8)	(+8.5)
200	2 416	2 677	5 093	17 605	28 938	46 544	20 021	31 615	51 636
(+100)	(−0.04)	(+10.0)	(+5.0)	(−13.8)	(+31.8)	(+9.8)	(−12.3)	(+29.7)	(+9.3)

Highest values underlined; values in parentheses indicate percentage increase or decrease over present values.

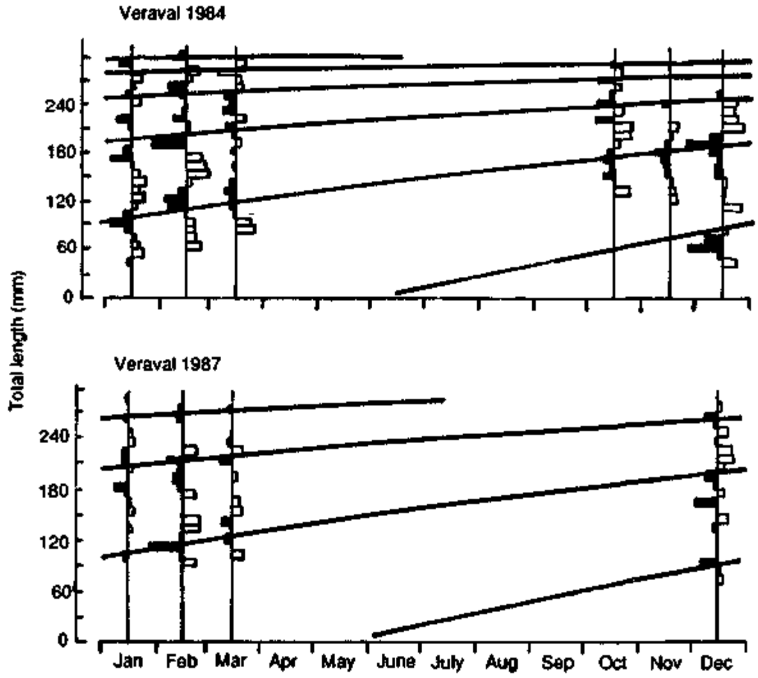


Fig. 9. Restructured length frequency data (ELEFAN I) and growth curves of *Nemipterus japonicus*. Veraval 1984: L_∞ = 320 mm, K=0.60 per year, SS=1, SL=100 mm; Veraval 1987: L_∞ = 345 mm, K=0.55 per year, SS=4, SL=200 mm.

present effort (Fig. 19.A). The total yield of the two species (at 3 900 tonnes) at 180% of present effort gives only 5% increase in yield, thus suggesting decline in catch per unit effort.

EAST COAST OF INDIA: The results of stock assessment off east coast (except Orissa and West Bengal) of *N. japonicus* showed that MSY is obtained at 140% of the present effort (Table 4). In *N. mesoprion* the yield increases with increased effort up to 200%. In both the species together MSY is obtained at 180% of present effort. At this effort level, increase in the yield of *N. japonicus* will be 1%, in *N. mesoprion* 9%, and in both the species together 5%, over the present yield.

WEST COAST OF INDIA: In *N. japonicus* the yield is maximum at 60% of the present effort whereas in *N. mesoprion* the same is at 200% (Table 4). In both the species together the yield is maximum at 200% of the present effort. At this effort level, however, there will be 14% decline in the yield of *N. japonicus* though 32% increase in the yield of *N. mesoprion* and thus about 10% increase in the yield of both the species together over the yield at the present effort level.

ASSESSMENT ON ALL-INDIA BASIS: In *N. japonicus* the MSY corresponds to 80% of present effort whereas the yield increase continues till 200% of the present effort in *N. mesoprion* and both the species together. By increasing the effort by 100% the yield of *N. japonicus* decreases by 12.3% (Table 4). In *N. mesoprion* the yield increases by about 30% and, by 9% in both the species. Thus the

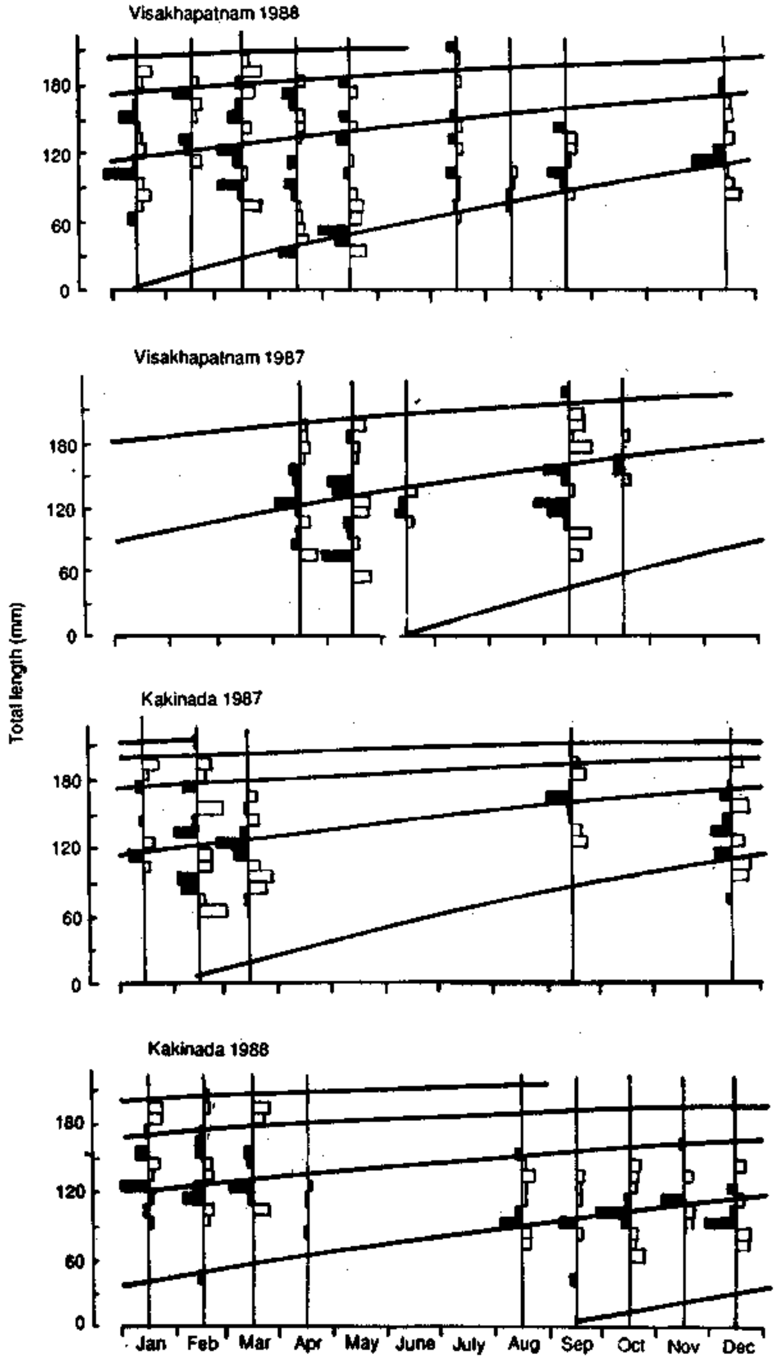


Fig. 10. Restructured length frequency data (ELEFAN 1) and growth curves of *Nemipterus mesoprion*. Visakhapatnam 1988: L_∞ = 240 mm, K=0.65 per year, SS=5, SL=50 mm; Visakhapatnam 1987: L_∞ = 267 mm, K=0.72 per year, SS=2, SL=130 mm; Kakinada 1987: L_∞ = 225 mm, K=0.76 per year, SS=5, SL=110 mm; Kakinada 1988: L_∞ = 255 mm, K=0.465 per year, SS=2, SL=50 mm.

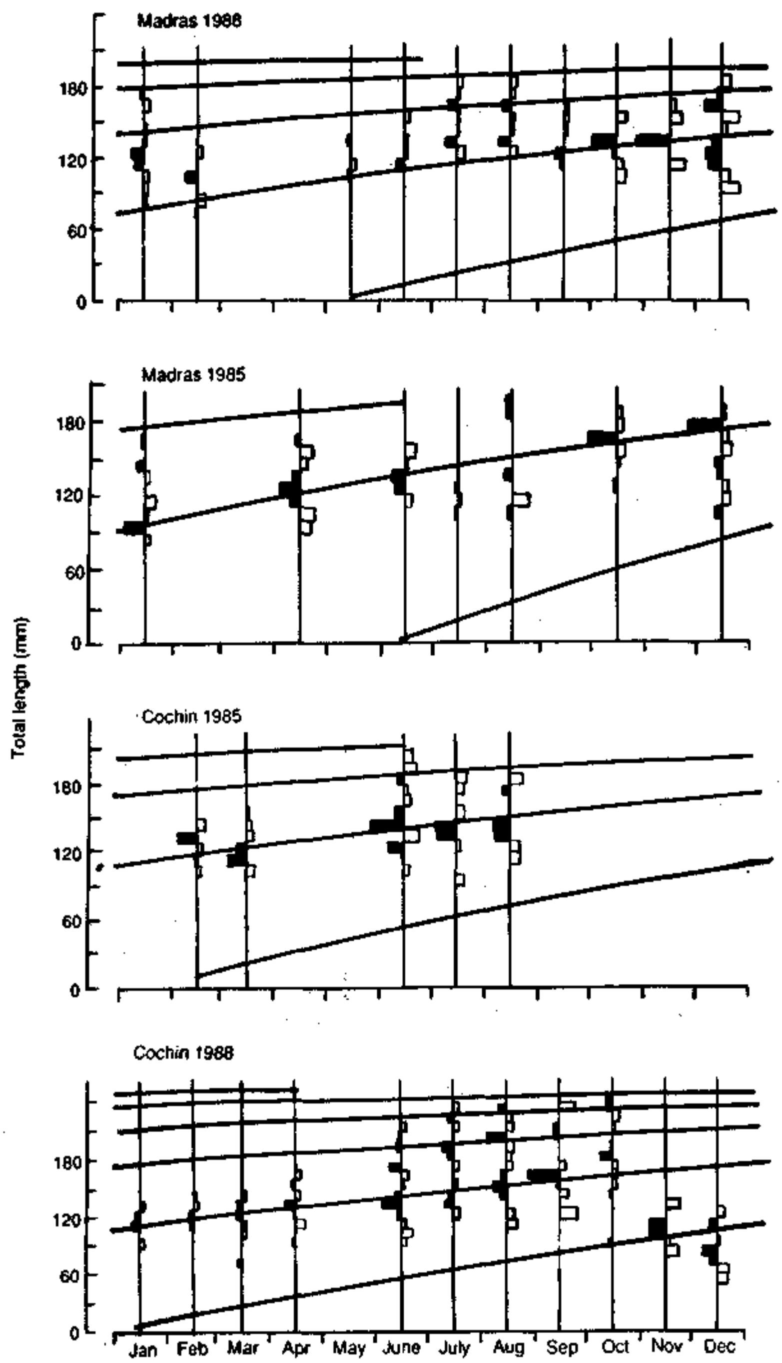


Fig. 11. Restructured length frequency data (ELEFAN I) and growth curves of *Nemipterus mesoprion*. Madras 1988: L_∞ = 223 mm, K=0.61 per year, SS=4, SL=110 mm; Madras 1985: L_∞ = 238 mm, K=0.84 per year, SS=1, SL=95 mm; Cochin 1985: L_∞ = 244 mm, K=0.62 per year, SS=2, SL = 125 mm; Cochin 1988: L_∞ = 273 mm, K=0.51 per year, SS=7, SL=155 mm.

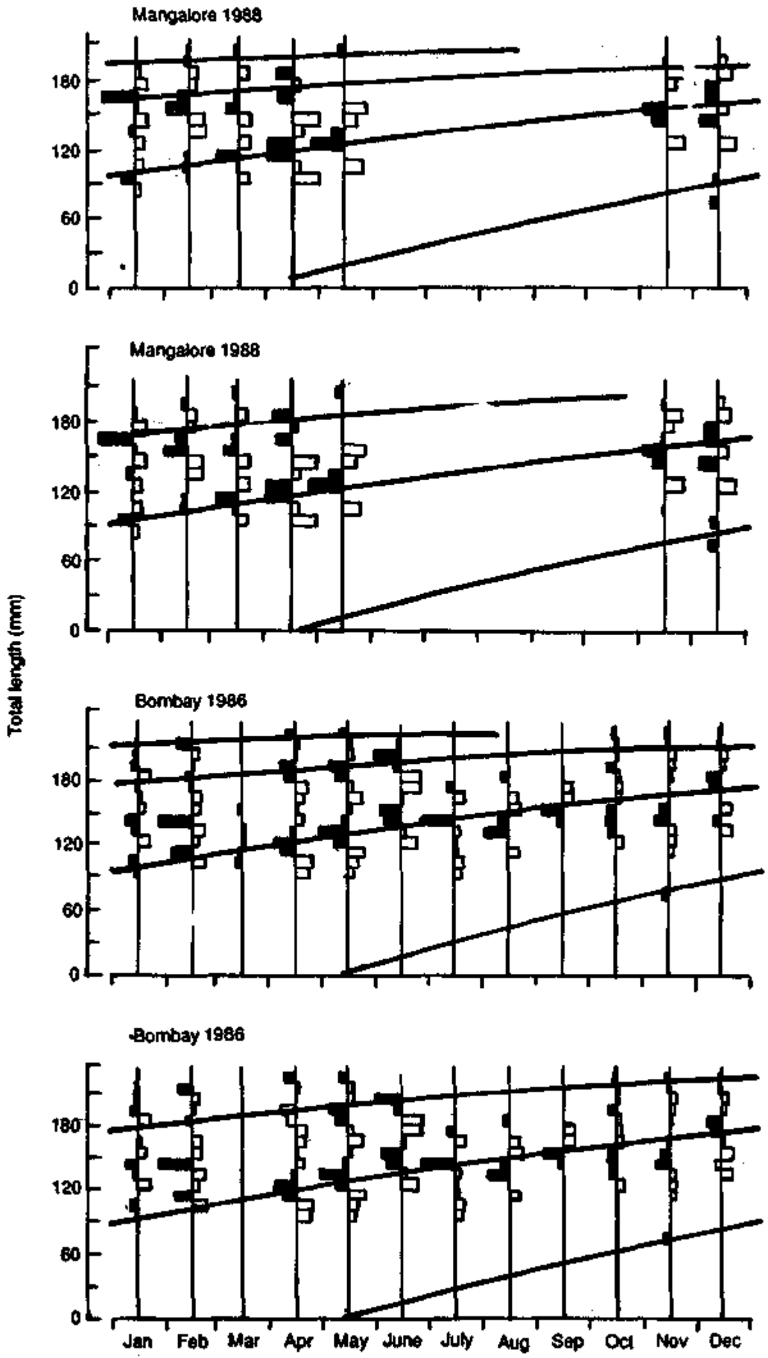


Fig. 12. Restructured length frequency data (ELEFAN I) and growth curves of *Nemipterus mesoprion*. Mangalore 1988: L_∞ = 222 mm, K=0.74 per year, SS=7, SL=160 mm; Mangalore 1988: L_∞ = 260 mm, K=0.60 per year, SS=1, SL=95 mm; Bombay 1986: L_∞ = 246 mm, K=0.77 per year, SS=2, SL=110 mm; Bombay 1986: L_∞ = 288 mm, K=0.58 per year, SS=11, SL=75 mm.

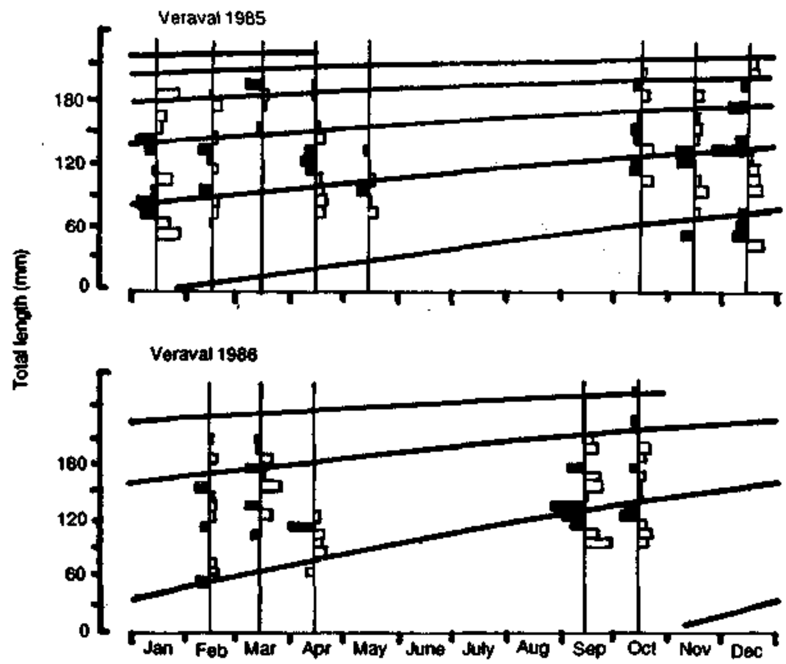


Fig. 13. Restructured length frequency data (ELEFAN I) in *Nemipterus mesoprion*. Veraval 1985: L_∞ = 255 mm, K=0.405 per year, SS=1, SL=85 mm; Veraval 1986: L_∞ = 297 mm, K=0.65 per year, SS=1, SL=55 mm.

present effort is beyond the one that corresponds to MSY of *N. japonicus* along west coast and both the coasts together. However, the present effort is less than that which gives MSY in *N. japonicus* along east coast; in *N. mesoprion* along both coasts; and in both the species together along both the coasts.

Yield assessment with reference to cod end mesh size of trawl: In Andhra Pradesh (Fig. 14.B) for both the species, the assessment shows that there is need to increase the age at first capture by 10%. In Tamil Nadu-Pondicherry (Fig. 15.B), for *N. japonicus* there is need to increase the cod end mesh size of trawl net by 80% to harvest the MSY whereas for *N. mesoprion* the same has to be decreased by 20%; for both the species together, maximum yield is obtained by increasing the age at first capture by 20%. In Kerala (Fig. 16.B), the yield is maximum at 200% of present t_c for *N. japonicus* and at only 70% of the present t_c for *N. mesoprion*. For both the species together, the yield is maximum at 90% of present t_c thus indicating that 10% decrease in cod end mesh size is necessary. In Karnataka and Goa (Fig. 17.B) the MSY is obtained at 140% of present t_c for *N. japonicus* whereas the same can be taken at 80% of the present t_c for *N. mesoprion*. The highest yield of the two species together can be harvested at 130% of the present t_c. In Maharashtra the present t_c of *N. japonicus* is 20% smaller than the one that gives MSY whereas the same is 20% larger in *N. mesoprion*. In the

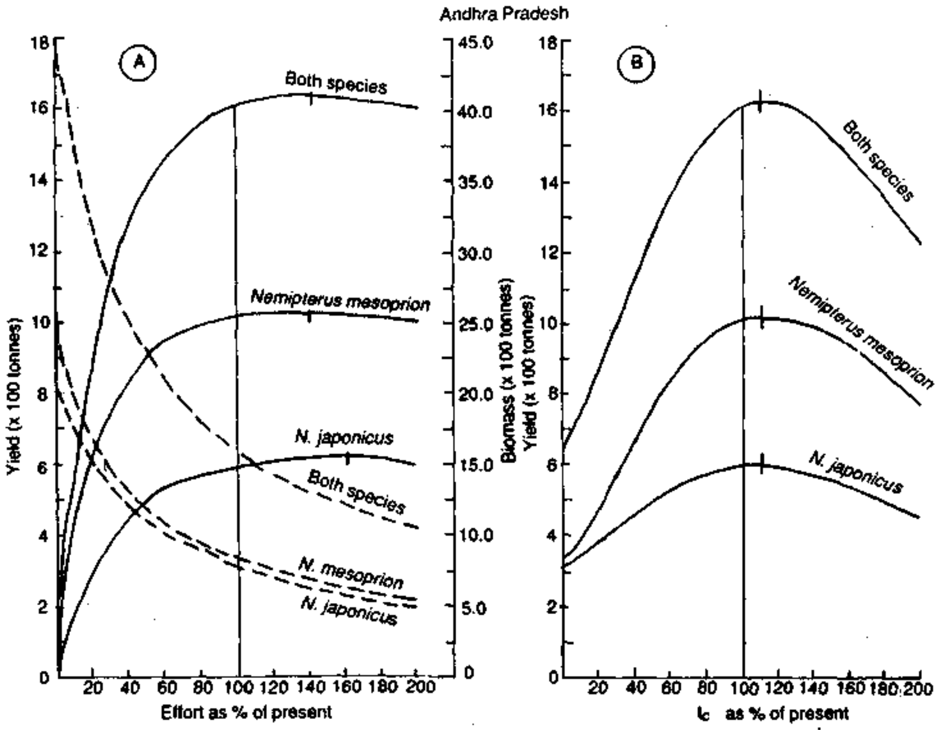


Fig. 14. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Andhra Pradesh (small vertical lines on the curves indicate MSY and the long vertical line the current effort level and yield). B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) (small vertical lines indicate MSY and the long vertical line the current t_c and yield).

two species together the yield is maximum at the present level of t_c (Fig. 18.B) indicating that there is no need to change the present cod end mesh size. In Gujarat (Fig. 19.B), the MSY corresponds to the present t_c in both the species.

The analysis thus shows that except in Kerala, there is need to either increase the cod end mesh size of trawl net by 10–30% or to maintain the currently used mesh size. In Kerala, however, the analysis shows that there is need to decrease the cod end mesh size by 10%; as the increase in yield is only 0.3% by this regulation, the present cod end mesh size has no adverse effect on the stocks.

DISCUSSION

The present assessment is based on the data collected from seven centres along Indian coasts. Only two species were considered because these two species form over 90% of threadfin bream catches and the results of assessment of these two species are believed to reflect the situation in the threadfin breams as a whole.

It is essential in a study of this kind, to first ensure whether a species from all along the coast line belongs to one unit stock or not. There is, however, no information on this aspect except in *N. japonicus* from east coast (Rao and Rao 1983) which is not conclusive.

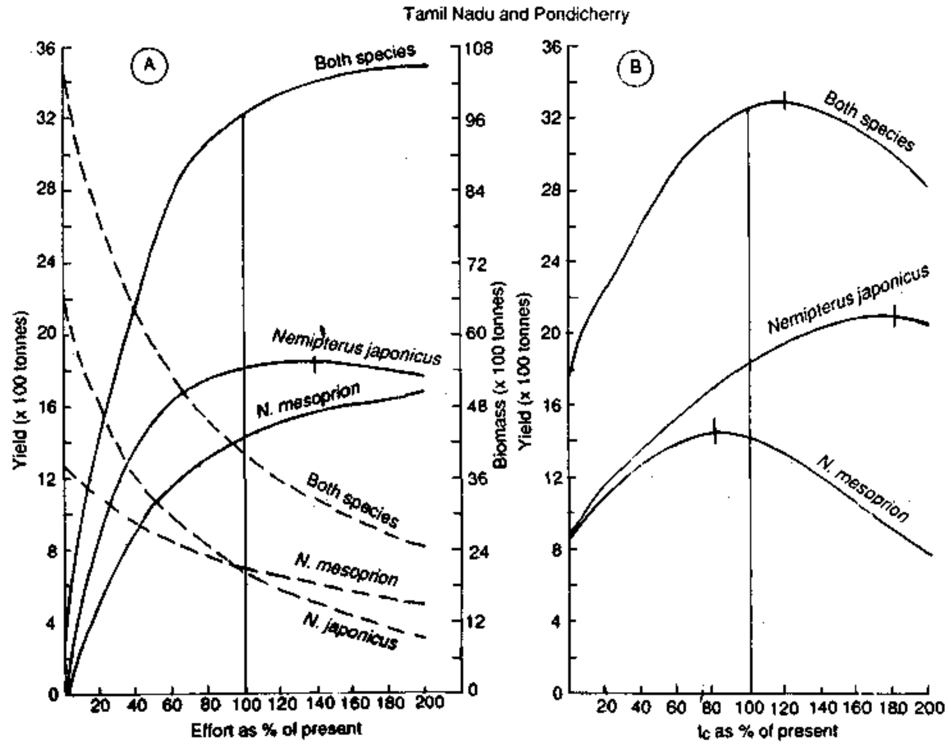


Fig. 15. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present) in Tamil Nadu and Pondicherry. B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Tamil Nadu and Pondicherry.

As data were obtained from centres in different maritime states and as the management of the fishery is within the purview of the administration of different maritime states of India, the estimation of growth parameters and resource assessment was done for stocks of each state separately. Yield estimates for the country as a whole, however, were also made.

The estimation of parameters of growth and mortality using the length-based methods is beset with problems and there is criticism against almost every available method which uses length frequency data as input. It was decided to use the ELEFAN method for extracting the growth parameters and then to compare the results with those already available. It was, however, found difficult to arrive to *a* set of *true* growth parameters because, in each year's data from any centre, 2–3 seemingly 'best estimates' of growth parameters were obtained. Therefore, the smallest and largest values of L_∞ and their related K from among the sets of values from each centre were, perforce, selected and stock assessment was done separately using both the sets of parameters. The average yield values corresponding to each effort level were taken. This was done under the belief that the true values fall somewhere between the ranges considered and the stock assessment thus made

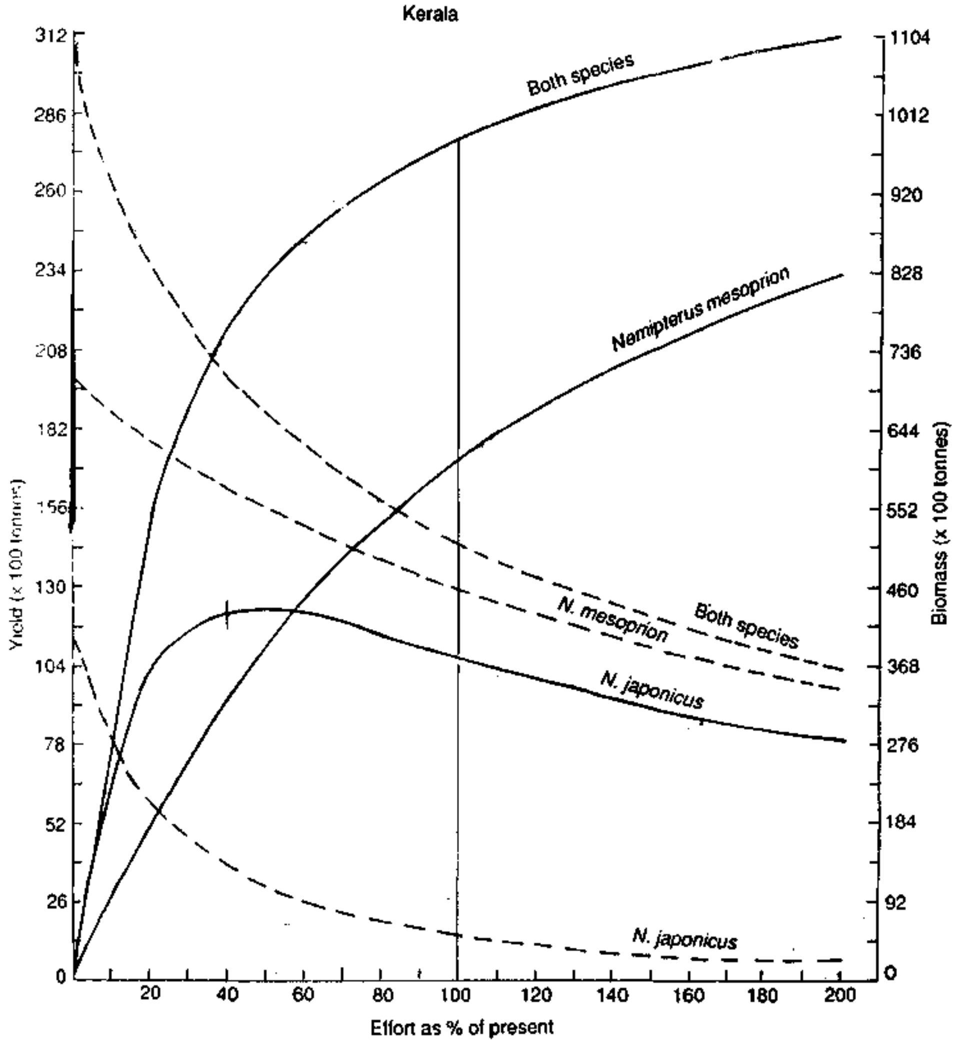


Fig. 16A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Kerala.

would hopefully lead to more meaningful conclusions. This was also done to account for possible uncertainties associated with the procedures of estimation of parameters and the consequent uncertainties in the conclusions arrived at on the basis of only one set of parameters.

A comparison of the growth parameters and mortality rates estimated (Tables 1, 2) with those available in the literature (Table 3) showed that they were in close agreement with those obtained earlier from India and, barring a few from other areas in the Indo-Pacific region also.

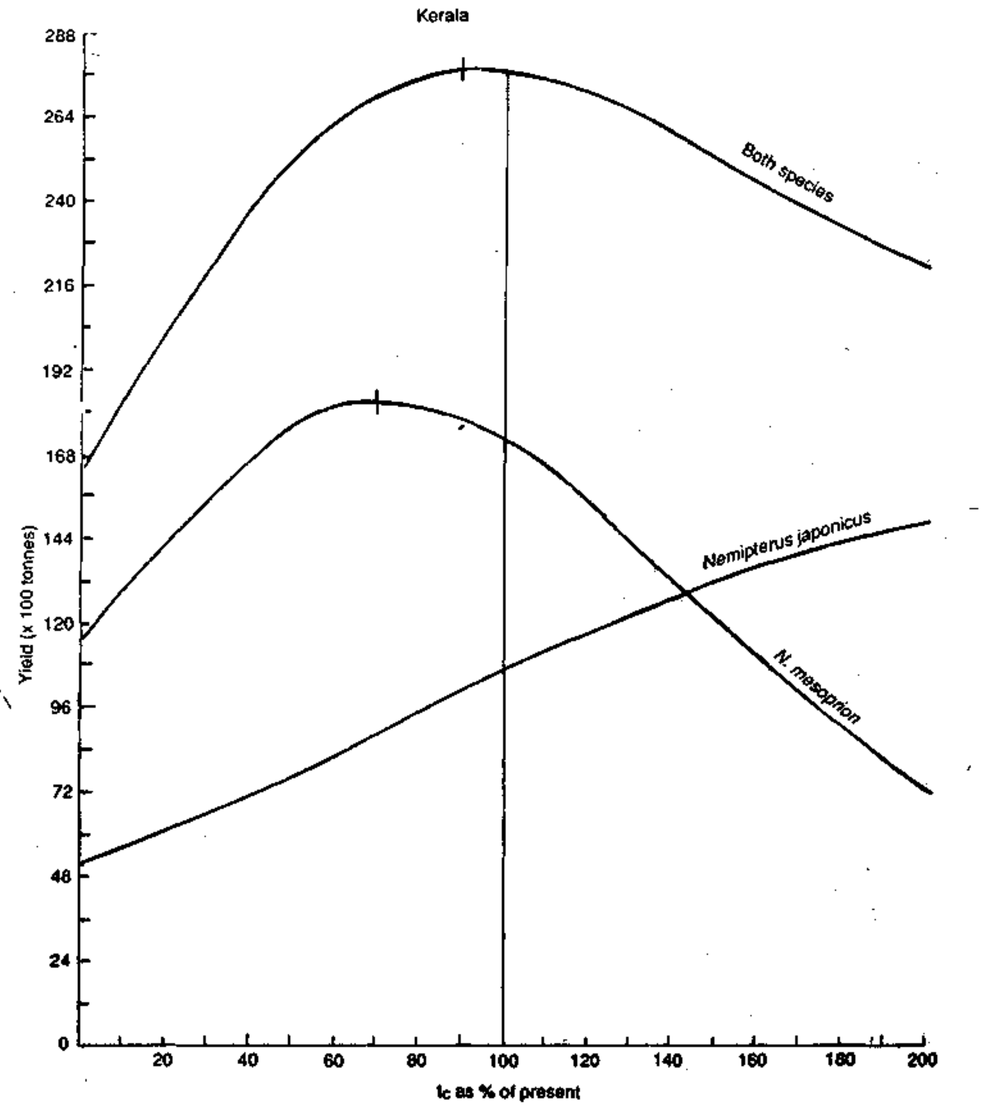


Fig. 16B. Yield of *Nemipterus japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Kerala.

The Thompson and Bell long-term forecast of yield gave conflicting management options for individual species (Fig 14–19). In one species the present effort was greater than that giving MSY and in the other, smaller, thus making it difficult to formulate regulatory measures. Such conflicting options are not uncommon while dealing with assessment of single species stocks in a mixed fishery because the growth and natural mor-

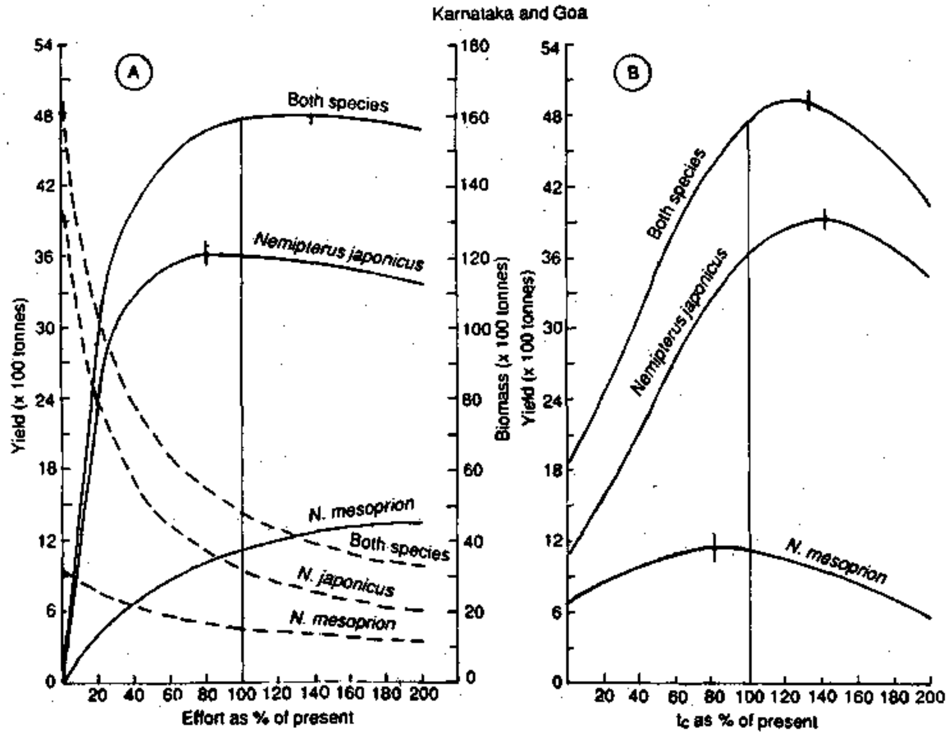


Fig. 17. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Karnataka and Goa. B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Karnataka and Goa.

tality rates are different in different species and there is no knowledge of the effective effort for any one species in the fishery. The simplest solution to such situations is mixed fisheries assessment which gives maximum yield and the corresponding effort level for all the species together in the fishery, that is, the effort which gives maximum yield (or value) of all the species in the mixed fishery together has to be taken into account for resource management. It may so happen, however, that such an option results in reduction in yield of species whose economic value may be greater. Such a reduction (some times drastic) in yield of species (by exceeding F_{msy} of these species) caused by increasing the effort to get MSY of the required species together is likely to be viewed seriously in the context of over-fishing of those species. It is believed that such a fear need not be entertained in multispecies or mixed fisheries because even if the yield of one species crosses the MSY level because of increased effort, the same gets stabilized at particular stabilized effort level according to steady state assumption. As long as the yield of other species in the fishery is increased the total yield will automatically increase and there is no biological wastage. The management decisions, however, often depend upon the economic returns of a fishery. Then the simplest option is to stabilize the effort which gives MSY of economically important

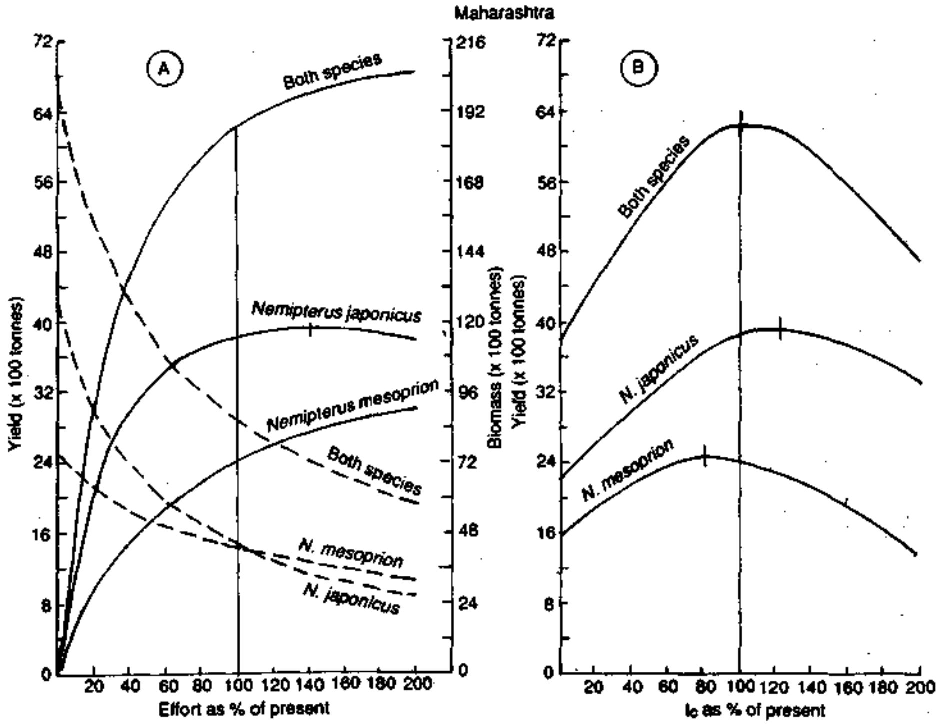


Fig. 18. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Maharashtra. B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Maharashtra.

species. This of course can result in biological wastage because certain species may be underexploited. While there is presently no solution to this problem, a sound knowledge of the biological interactions between species contributing to the mixed fishery is essential to understand the dynamics of the species better and to effectively formulate regulatory measures.

The assessment of the two species of threadfin breams (Figs 14–19), on the basis of the present knowledge, indicated that maximum yield of the two species together can be taken through increasing the effort by 40%–100% in different states and in the country as a whole. The increase in yield, however, will only be 2%–12% and will not be proportional to increased effort leading to reduction in catch per unit effort. It, therefore, appears that in the present fishing grounds, there is no scope for increasing effort to increase the yield of threadfin breams. However, the threadfin breams are known to be more abundant in the relatively deeper areas of the sea beyond the present grounds and yield can be substantially increased by deploying the additional effort beyond 50 m depth. It has been estimated that vast potential of these fishes exists beyond 50 m depth (125 000 tonnes of perches of which threadfin breams is a dominant component, Anonymous 1991). Moreover, off Kerala coast (Fig. 5C), it is known that peak landings are obtained during July–September mainly due to movement of threadfin breams into shallower areas to avoid oxygen deficient waters in the

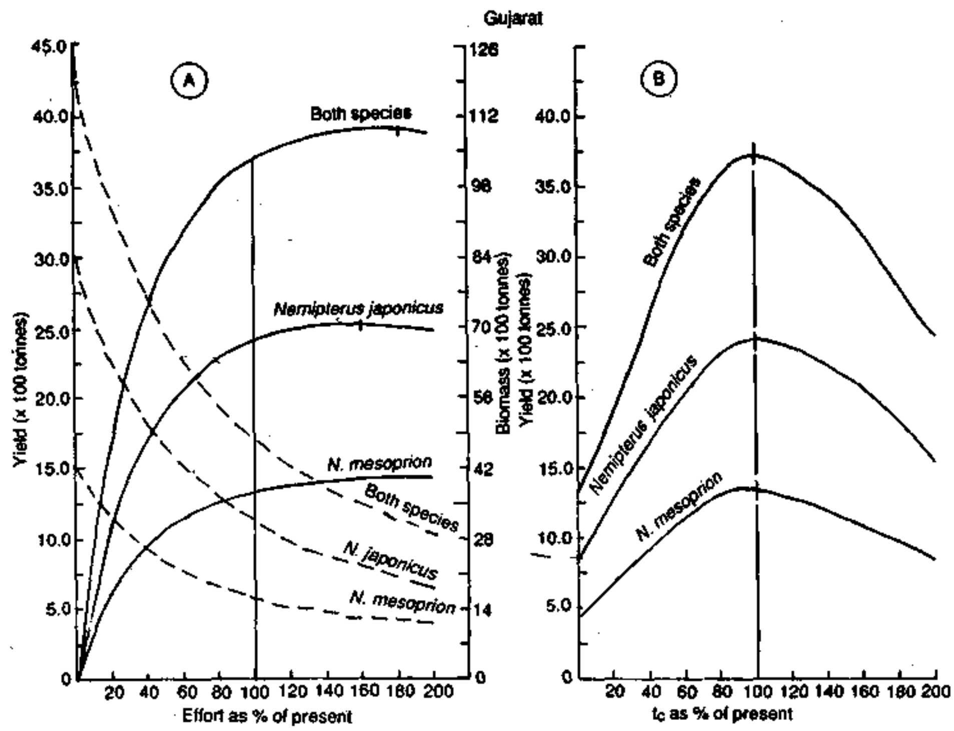


Fig. 19. A. Yield and biomass of *Nemipterus japonicus* and *N. mesoprion* at different effort levels (expressed as percentage of present effort) in Gujarat. B. Yield of *N. japonicus* and *N. mesoprion* at different t_c levels (expressed as percentage of present t_c) in Gujarat.

deeper waters (Banse 1959). Hence suitable deployment of trawlers during the monsoon period is likely to result in substantial increase in the landings of threadfin breams off Kerala.

The assessment of yield as a function of cod end mesh size (Figs 14–19) showed that there is need to increase the same in all states except Kerala. It is known that smaller cod end mesh sizes in trawl fisheries can lead to recruitment overfishing and adversely affect the exploited stocks in the long run and, therefore, efforts to regulate the mesh size by suggesting at least 20% increase, will help improve the threadfin bream stocks in the presently fished grounds.

ACKNOWLEDGEMENTS

The authors thank Dr P S B R James, Ex-Director, CMFRI, Kochi, for encouragement; Mr K Narayana Kurup, Mr K Balan and Mr T V Sathianandan, Scientists, CMFRI, Cochin, for help in analysis of data at the computer centre in the Institute.

REFERENCES

Acharya P and Dwivedi S N. 1984. Condition factor and length-weight relationship of *Nemipterus japonicus* (Bloch) off Bombay coast. *Journal of Indian Fisheries Association* 10 & 11 : 37–44.

Alagaraja K. 1984. Simple methods for estimation of parameters for assessing exploited fish stocks. *Indian Journal of Fisheries* 31 : 177–95.

Amornchairojkul S and Boonwanich T. 1982. Growth and mortality of *Nemipterus japonicus* off the west coast of Gulf of Thailand (Chumpornko Samui), 1981. *Technical Report, Demersal Fisheries Unit, Marine Fisheries Division*, Bangkok (7/2525). 12 pp.

Anonymous. 1990. *Annual Report 1989-90*. Central Marine Fisheries Research Institute, Kochi, 95 pp.

Anonymous 1991. *Report of the Working Group on Revalidation of the Potential Marine Fisheries Resources of Exclusive Economic Zone of India*. Ministry of Agriculture, Govt. of India, New Delhi.

Banse K. 1959. On upwelling and bottom trawling off the south west coast of India. *Journal of Marine Biological Association of India* 1 : 33–49.

Beverton R J H and Holt S J. 1957. On the dynamics of exploited fish populations. *Fishery Investigation Series, London* 19 : 533.

CMFRI. 1981. Commercial trawl fisheries off Kakinada during 1969-1978. *Marine Fisheries Information Service, Technical and Extension Series* 31 : 1–6.

Corpuz A, Saeger J and Sambilay V. 1985. Population parameters of commercially important fishes in Philippine waters. Department of Marine Fisheries, University of Philippines in the Visayas. *Technical Report No. 6*. 99 pp.

Dan S S. 1980. Intra ovarian studies and fecundity in *Nemipterus japonicus* (Bloch). *Indian Journal of Fisheries* 24 : 48–55.

Devaraj M and Deepak Gulati. 1988. Assessment of the stock of the threadfin bream (*Nemipterus japonicus*) in the northwest continental shelf of India. (Ed.) Mohan Joseph M. *The First Indian Fisheries Forum Proceedings*. Asian Fisheries Society, Indian Branch, Mangalore, pp xv + 494.

Dwiponggo A, Hariati T, Banon S, Palomares M L and Pauly D. 1986. Growth, mortality and recruitments of commercially important fishes and penaeid shrimps in Indonesian waters. *ICLARM Technical Report No. 17*, 91 pp.

Edwards R R C, Bakader A and Shabeer S. 1985. Growth, mortality, age composition and fisheries yields of fish from the Gulf of Aden. *Journal of Fish Biology* 27 : 13–21.

Gayanilo F C Jr, Soriano M and Pauly D. 1988. A draft guide to the COMPLEAT ELEFAN. *ICLARM Software Project* 2. 65 pp.

Ingles J and Pauly D. 1984. An atlas of the growth, mortality and recruitment of the Philippines fishes. *ICLARM Technical Report 13*, 127 pp.

Isa M B M. 1988. Population dynamics of *Nemipterus japonicus* (Pisces: Nemipteridae) off Kedah State, Malaysia. *Contributions to Tropical Fisheries Biology*, pp 126–40. (Eds) Venema S, Moller J Christenseon and Pauly D. Papers by the participants of FAO/DANIDA follow-up training courses in stock assessment in the tropics. FAO/fish. Rep (389), 519 pp.

Indra T J. 1981. A note on the occurrence of *Nemipterus metopias* (Bleeker) from Madras coast. *Indian Journal of Fisheries* 28 : 290–91.

James P S B R, Alagarswamy K, Narayana Rao K V, Muthu M S, Rajagopalan M S, Alagaraja K and Mukundan C. 1987. Potential Marine Fishery Resources of India. *CMFRI Special Publication* 30 : 44–74.

John M E. 1989. Population dynamics and stock estimates of the threadfin bream (*Nemipterus japonicus*) off Kerala, India. *Contributions to Tropical Fish Stock Assessment in India*. pp 45–62. (Eds). Venema S C and Van Zalinge N P. Papers prepared by the participants at the FAO/DANIDA/ICAR National follow up training course on fish stock assessment. FI: OCP/INT/392/DEN/1: 157 pp.

Kasim H Md, Ameer Hamsa K M S and Sam Bennet P. 1989. Present status of perch fishery resources in India and its prospects. National Symposium on Research and Development in Marine Fisheries, Mandapam Camp, 16-18 September, 1987. *Bulletin of Central Marine Fisheries Research Institute* 44 : 226–37.

Krishnamoorthi B. 1973a. An assessment of *Nemipterus* fishery of Andhra-Orissa coasts based on exploratory fishing. Proceedings of the Symposium on Living Resources of the Seas around India, 1968. *CMFRI Special Publications*. pp 496–516.

Krishnamoorthi B. 1973b. Biology of threadfin bream, *Nemipterus japonicus* (Bloch). *Indian Journal of Fisheries* 18 : 1–21.

Krishnamoorthi B. 1976. A note on the size difference between males and females of *Nemipterus japonicus* (Bloch). *Indian Journal of Fisheries* 23 : 252–56.

Kuthalingam M D K. 1971. Notes on some aspects of the fishery and biology of *Nemipterus japonicus* (Bloch) with special reference to feeding behaviour. *Indian Journal of Fisheries* 12 : 500–06.

Lee C K C. 1975. Exploitation of *Nemipterus japonicus* (Bloch) by Hong Kong Vessels in 1972-73. *Papers presented in Special Symposium on Marine Science* held by Pacific Sciences Assn. in December 1973, Hongkong. (Ed.) Morton B. pp 48–52.

Madanmohan and Gopakumar G. 1981. On the occurrence of *Nemipterus metopias* (Bleeker) (Nemipteridae, Pisces) from the south west coast of India, *Indian Journal of Fisheries* 28 (1&2) : 280–82.

Madanmohan and Velayudhan A K. 1984. A few observations on the taxonomy and biology of *Nemipterus delagoae* Smith from Vizhinjam. *Indian Journal of Fisheries* 31 : 113–21.

Murty V S. 1981. *Nemipterus mesoprion* (Bleeker, 1953) (Nemipteidae, Pisces) a new record from the seas around India. *Indian Journal of Fisheries* 25 : 207–13.

Murty V S. 1982a. Observations on some aspects of biology of the threadfin bream *Nemipterus mesoprion* (Bleeker) from Kakinada along the east coast of India. *Indian Journal of Fisheries* 28 : 199–207.

Murty V S. 1982b. *Nemipterus luteus* (Schneider, 1801) (Nemipteridae, Pisces), the valid name for a threadfin bream from the Indo-Pacific region. *Journal of Marine Biological Association of India* 19 (1) : 107–14.

Murty V S. 1983. Estimates of Mortality, population size and yield per recruit of *Nemipterus japonicus* (Bloch) in the trawling grounds off Kakinada. *Indian Journal of Fisheries* 30 : 255–60.

Murty V S. 1984. Observations on the fisheries of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada. *Indian Journal of Fisheries* 31 : 1–18.

Murty V S. 1987a. Further studies on growth and yield per recruit of *Nemipterus japonicus* (Bloch) from the trawling grounds off Kakinada. *Indian Journal of Fisheries* 34 : 265–76.

Murty V S. 1987b. Multispecies stock assessment with particular reference to major demersal fish species in the trawling grounds off Kakinada. *Journal of Marine Biological Association of India*. 27 : 39–48.

Murty V S. 1989. Mixed fisheries assessment with reference to five important demersal fish species landed by shrimp trawlers at Kakinada. *Contributions to Tropical Fish Stock Assessment in India.* (Eds) Venema S C and Van Zalinge N P. pp 69–86. Papers prepared by the participants at the FAO/DANIDA/ICAR National training course on fish stock assessment, Cochin 2-28 Nov. 1987. FI: GCP/INT/392/DEN/1:1989, 157 p.

Murty V S, Nair K V S, Thomas P A, Lazarus S, Chakraborty S K, Raje S G, Gopal C, Zacharia P U and Velayudhan A K. 1992. Present status of exploitation of fish and shellfish resources: Threadfin breams. Monsoon Fisheries of the west coast of India: Prospects, Problems and Management. (Eds). Rao P V, Murty V S and Rengarajan K. *Bulletin of Central Marine Fisheries Research Institute* 45 : 154–68.

Muthiah C and Krishna Pillai S. 1984. A new distributional record of *Nemipterus delagoae* smith from Bombay waters with notes on its biology. *Journal of Marine Biological Association of India* 21 : 174–78.

Nair K V S and Reghu R. 1990. Studies on the threadfin bream and the lizard fish resources in the exclusive economic zone of India based on the demersal trawling operations of FORV *Sagar Sampada*. *Proceedings of the First Workshop on Scientific Result of FORV Sagar Sampada*, 5-7 June 1989, pp 239–55.

Nair K V S and Jayaprakash A A. 1986. A note on the monsoon fishery for threadfin breams off Cochin. *Indian Journal of Fisheries* 33 : 106–12.

Narayanappa G, Raju D A N and Satyanarayan A V V. 1968. Certain observations on the otter trawl operations carried out in the inshore and deeper waters off Kakinada. *Proceedings of the Indo-Pacific Fisheries Council* 13 (III). pp 450–55.

Pauly D. 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 1975 fish stocks. *Journal du conseil* 39 : 175–92.

Pauly D. 1982. Studying single species dynamics in a tropical multispecies context. Theory and Management of Tropical Fisheries. (Eds) Pauly D and Murphy G I. *ICLARM Conference Proceedings*. No. 9. 360 pp.

Pauly D and David N. 1981. ELEFAN 1, a Basic programme for the objective extraction of growth parameters from length frequency data. *Meeresforschung* 28 : 205–11.

Pauly D and Aung Sann. 1984. *Population Dynamics of Some Fishes of Burma Based on Length Frequency Resources Survey and Exploratory Fishing Projects*. FI: DP/BUR/77/003 Field Dec. 7, FAO, Rome.

Philip K P and Joseph P J. 1988. Fishery Resources of the offshore and deep sea waters of Karnataka and the fishing effort suggested for exploitation. *Problems and Prospects of Marine Fishing and Fish Processing in Karnataka*. 179 pp. (Eds) Karunasagar I and Sripathy N V. Forum of Fishery Professionals, Mangalore.

Rajagopalan M, Karuppusamy P and Regunathan A. 1977. *Nemipterus delagoae* Smith (Nemipteridae: Pisces) a new record from the Indian seas. *Indian Journal of Fisheries* 22 : 274–76.

Rao D M. 1981. 'Studies on the biology and biometry of the threadfin bream *nemipterus japonicus* (Bloch) with observations on the nemipterid fishery off Visakhapatnam (Bay of Bengal).' Ph. D. thesis, Andhra University, 224 pp.

Rao D M and Rao K S. 1983. Biometric comparison of *Nemipterus japonicus* (Bloch). Populations along the east coast of India. *Proceedings of the Indian Academy of Sciences (Animal Sciences)* 92 (5) : 351–60.

Rao D M and Rao K S. 1986. Studies on the age determination and growth of *Nemipterus japonicus* (Bloch) off Visakhapatnam. *Indian Journal of Fisheries* 33 : 426–39.

Rao K S and Rao D M. 1981. On the occurrence of *Nemipterus delagoae* Smith (Nemipteridae, Pisces) off Waltair. *Matsya* 7 : 84–85.

Rao T A. 1989. Fisheries of threadfin breams at Waltair with notes on some aspects of biology of *Nemipterus mesoprion* (Bleeker). *Journal of Marine Biological Association of India* 31 : 103–09.

Reuben S, Sudhakara Rao G, Luther G, Rao T A, Radhakrishna K, Sastry Y A and Radhakrishna G. 1989. An assessment of bottom-trawl fishery resources of the north east coast of India. *Bulletin of Central Marine Fisheries Research Institute* 44 : 59–77.

Samuel M. 1991. Biology, age, growth and population dynamics of threadfin bream *Nemipterus japonicus*. *Indian Journal of Fisheries* 32 : 66–76.

Satyanarayana A V V, Narayanappa G and Raju D A N. 1972. On the comparative fishing experiments with a four-seam and a two-seam trawls on the east coast. *Fishery Technology* 9 : 169–79.

Silas E G. 1969. Exploratory fishing by R V Varuna. *Bulletin of Central Marine Fisheries Research Institute* 12 : 1–86.

Silas E G, Dharmaraja S K and Rengarajan K. 1976. Exploited marine fishery resources of India. A synoptic survey with comments on potential resources. *Bulletin of Central Marine Fisheries Research Institute* 27 : 25 pp.

Sivaprakasam T E, Parasuraman P S, Premchand, Rajkumar S A and Nagarajan G. 1991. Marine fishery resources off the lower east coast of India. *Bulletin of Fishery Survey of India* 21 : 29.

Sparre P. 1985. *Introduction to Tropical Fish Stock Assessment*. FAO. Rome. Denmark Funds-in-trust. FI; GCP/INT/392/DEN Manual 1.338 pp.

Sparre P. 1987. Computer programmes for fish stock assessment. Length based fish stock assessment (LFSA) for Apple II computers. *FAO Fisheries Technical Paper* 101 (Suppl 2). 217 pp.

Sudarsan D, John M E and Somavanshi V S. 1990. Marine fishery resources potential in the Indian exclusive economic zone. *Bulletin of Fishery Survey of India* 20 : 27.

Thompson W F and Bell F H. 1934. Biological statistics of the halibut fishery 2. Effect of changes in intensity upon total yield and yield per unit of gear. *Reports International Fisheries (Pac. Halibut) Commission* 8 : 49 pp.

Vijaykumaran K and Philip K P. 1991. Demersal Fishery Resources of the north Kerala, Karnataka and Konkan coasts. *Journal of Marine Biological Association of India* 32 : 177–86.

Vinci G K. 1983. Threadfin bream (*Nemipterus*) resources along the Kerala coast with notes on biology of *Nemipterus japonicus*. *Indian Journal of Fisheries* 29 : 37–49.

Vinci G K and Nair A K K. 1975. Length-weight relationship in the threadfin bream, *Nemipterus japonicus* along the Kerala coast. *Indian Journal of Fisheries* 21 : 299–302.

Vivekanandan E. 1990. Distribution pattern of threadfin breams along Tamil Nadu and south Andhra coasts. *Indian Journal of Fisheries* 37 : 269–80.

Vivekanandan E and James D B. 1986. Population dynamics of *Nemipterus japonicus* (Bloch) in the trawling grounds off Madras. *Indian Journal of Fisheries* 33 : 145–54.

Vivekanandan E and James D B. 1987. Length-weight relationship in four species of threadfin breams from Madras. *Journal of Marine Biological Association of India* 26 : 132–35.

Zupanovic S and Mohiuddin S Q. 1973. A survey of the fishery resources in the north eastern part of the Arabian sea. *Journal of Marine Biological Association of India* 15 (2) : 496–537.