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Fishery, biology and stock assessment of carangid resources from the Indian seas

S REUBEN[1], H M KASIM[2], S SIVAKAMI[3], P N RADHAKRISHNAN NAIR[4], K N KURUP[5], M SIVADAS[6], A NOBLE[7], K V SOMASEKHARAN NAIR[8] and S G RAJE[9]

Central Marine Fisheries Research Institute, Cochin, Kerala 682 014

ABSTRACT

The estimated landings of carangids in India during 1981-88 ranged between 37 345 tonnes and 135 529 tonnes, whereas the percentage composition of carangids in the total fish landings ranged from 2.7 to 8.1. The average annual catch and the percentage of carangids in the total marine fish landings were estimated at 74 080 tonnes and 4.5% respectively. Tamil Nadu (17.7%) and Andhra Pradesh (8.8%) from east coast and Kerala (34%), Karnataka (17.6%) and Maharashtra (9.9%) from west coast yielded good catches of carangids. *Megalaspis cordyla, Decapterus russelli, Alepes kalla, Atropus atropus, Alepes djedaba, Atule mate, Caranx carangus* and *Selaroides leptolepis* contributed significantly to the fisheries of different regions. The results of stock assessment and biology of the above species are presented. *M. cordyla* along east and northwest coasts, *D. russelli* along northwest coast, and *C. carangus* and *S. leptolepis* along Tamil Nadu coast are being exploited expending much more effort than required to realize maximum sustainable yield (MSY). But *D. russelli* along east and southwest coasts and *A. kalla* and *A. djedaba* along the Kerala coast can be exploited with increased effort of trawl net to enhance their production to MSY level. Similar condition is exhibited by *M. cordyla* along southwest coast for drift gill net and *A. mate* along Kerala coast for hooks and line.

Carangid resource consists mainly of horse mackerels, round scads, queen fishes, trevallies, jacks and pompanos. Some species of the groups like queen fishes and jacks attain large sizes, whereas most others are small and abundant in the form of big schools. There has been sizable increase in the production of carangids in recent years in India forming 4.5% of the total marine fish production. Of the 35 and odd species that commonly occur along the coast of India, *Megalaspis cordyla, Decapterus russelli, Alepes kalla, Atropus atropus, Alepes djedaba, Atule mate, Caranx carangus* and *Selaroides leptolepis* contribute significantly to the fisheries of different regions. Among them, *M. cordyla* and *D. russelli* contributed to the carangid fishery all along the Indian coast. *A. kalla* and *A. atropus* formed good fisheries along the southwest and northwest coasts respectively. *A. djedaba* and *A. mate* formed a regional fishery in Kerala. *C. carangus* and *S. leptolepis* constituted the fishery in Tamil Nadu including Pondicherry.

Present address: [1]Scientist (S-3) (Retd), 9-21-6, CBM Compound, AV Post Office, Visakhapatnam 530 003.

[2]Senior Scientist, Tuticorin Research Centre of CMFRI, 90, North Beach Road, Tuticorin, T N 628 001.

[3,4]Senior Scientist; [5,8]Scientist (Selections Grade).

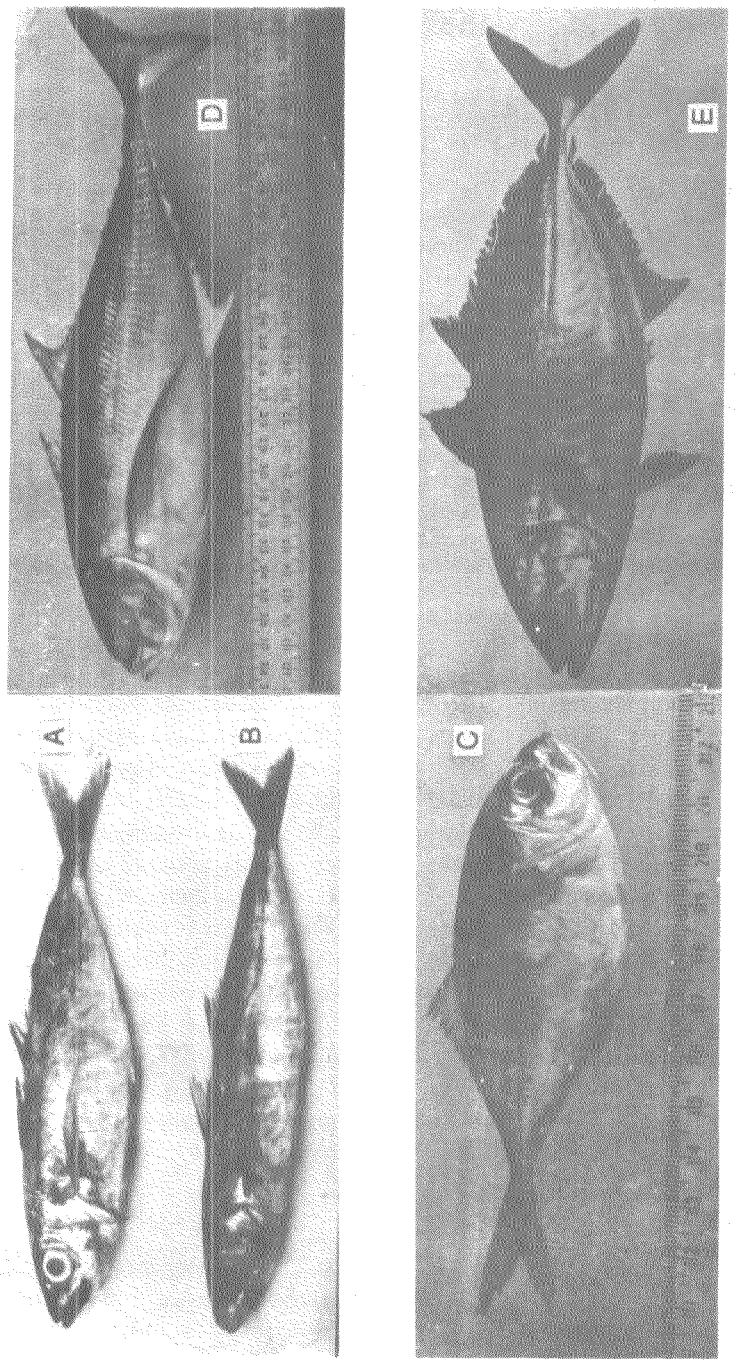
[6]Scientist, Minicoy Research Centre of CMFRI, Minicoy, U T of Lakshadweep.

[7]Principal Scientist (Retd), Edupadikal, Jawahar Road, Vyfilla, Cochin, Kerala 682 019.

[9]Scientist (Selection Grade), Bombay Research Centre of CMFRI, 148 Army & Navy Building, 2nd Floor, M G Road, Bombay, Maharashtra 400 023.

MATERIALS AND METHODS

Random sampling method was adopted to collect data on catch, effort, length frequency and biology of dominant species from



A. *Decapterus russelli*, B. *D. macrosom*, C. *Alepes kalla*, D. *Megalaspis cordyla*, E. *Atule mate*

Visakhapatnam, Mandapam and Tuticorin on the east coast; and Vizhinjam, Cochin, Mangalore and Veraval on the west coast. The period of observation and analysis of the fishery and biological data varied from centre to centre during 1981–1988. The data on length frequency of the species were obtained from different gears. The length frequency data thus obtained from landing centres at Visakhapatnam, Mandapam and Tuticorin along the east coast were pooled and raised to the monthly catch of the east coast. Similarly, the data from Vizhinjam, Cochin and Mangalore were projected to the southwest coast and monthly catch from Veraval to the northwest coast.

Length-weight relationship: Total length (mm) and weight (g) of the fish were used to estimate length-weight relationship in the form $W = a L^n$ through linear regression analysis, where W, weight of the fish; a, the value of intercept; and n, slope or regression coefficient.

Growth parameters: The length frequencies were used to estimate the von Bertalanffy growth parameters, L_∞, K, and t_0, using the modal progression analysis. The ELEFAN I programme (Pauly and David 1981) and Wetherall method (1986) were also used to estimate L_∞ and K.

Population parameters: The natural mortality co-efficient M was estimated based on Pauly's (1980) empirical formula making use of the growth parameters L_∞ and K, and the annual average surface temperature, T, taken as 27°C. The methods of Rikhter and Efanov (1976) and Sekharan (1974) were also used to estimate natural mortality coefficient. The instantaneous total mortality Z was estimated by the length converted catch curve as discussed by Pauly (1983, 1984). The raised and pooled length frequencies and the average numbers caught in each length class were used as inputs for length cohort analysis (Jones 1984) to estimate stock sizes and fishing mortalities (Sparre 1985). The instantaneous fishing mortality rate F was then computed as F = Z–M while the exploitation ratio as E = F/Z.

The method proposed by Thompson and Bell (1934) was used to assess the MSY and biomass MSY and also to forecast the long-term yields assuming recruitment to be constant.

RESULTS

Craft and gear: Catamarans, plank-built boats, mechanized boats and trawlers are the craft used all along the coast. Gill net (25–40 mm mesh), drift net (50–80 mm, 80–120 mm mesh) made of nylon or garfil, boat seine (10–15 mm mesh), trawl net (15–20 mm mesh), seine nets *kachal* (25–30 mm mesh) and *jangal* (35–40 mm mesh) in the northeast coast and purse seine (10–12 mm mesh) in the southwest coast, and hooks and line are principally used in the exploitation of carangids. Although carangids are not the target species in any of these gears, but they form a good component in the catches of these gears.

Fishery

The estimated landings of carangids in India during 1981–88 (Fig. 1) ranged between 37 345 tonnes (1981) and 137 529 tonnes (1986) while their percentage composition in the total fish production ranged from 2.7 to 8.1. The coastwise landings revealed that west coast, with a percentage contribution of 63.2 in the total catch of carangids, had an edge over east coast. Tamil Nadu (17.7%) and Andhra Pradesh (8.8%) from east coast and Kerala (34.1%), Karnataka (17.6%) and Maharashtra (9.9%) from west coast yielded good catches of carangids. The two-fold increase in the catches, during the last 8 years

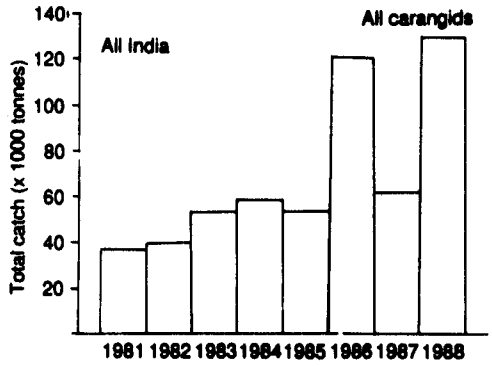


Fig. 1. Annual all-India carangid landings during 1981-88.

might be attributed not only to the general improvement in carangid resource but also to the unusually heavy landings along Kerala, Karnataka and Goa.

Statewise landings : To see the catch, catch rate and seasonal trends in different states the results of investigations at different observation centres are given below.

ANDHRA PRADESH: Annual and seasonal trends of carangid landings by different gears at Visakhapatnam are presented in Fig. 2. The landings of carangids by shore seine and boat seine showed an increasing trend during 1979–83/84 and showed declining trend later on. Landings from hooks and line and shrimp trawl showed gradual decline till 1983/1985 and slightly improved thereafter.

The peak landings were from March to April. The seasonal abundance of important species of carangids, namely *Carangoides malabaricus, D. russelli, A. djedaba* and *M. cordyla,* in the landings of gill nets are given in Fig. 3.

TAMIL NADU AND PONDICHERRY: The seasonal abundance of carangids landed by different gears at Tuticorin are presented in Fig. 4. The catch and catch rate increased from March to April in trawl net. In the case of gill net, two peaks, one in May and the other in October, were noticed both in catch and catch rate.

The annual and seasonal abundance of carangids at Rameswaram are presented in Fig. 5. The catches were good in January, declined up to May to improve gradually thereafter.

KERALA: The trends in catch and abundance of carangids at Cochin (portrayed through the trends obtained at Cochin and Vizhinjam) improved constantly and reached a peak in 1988 (Fig. 6). There were two major seasons for trawl net, March to June and October to December, whereas the drift gill net had a single season June to September (Fig. 7).

The annual landings at Vizhinjam (Fig. 8) were steady, at 1 000 – 1 100 tonnes. The gill net and hooks and line catch declined while the drift net and boat seine landings improved. The seasonal trends of catch and catch rate in different gears is given in Fig. 9. Usually two periods of abundance were noticed. The peaks were observed in the second half of the year for boat seine, hooks and line, drift net and during the first half of the year for gill net.

KARNATAKA AND GOA: The trends of catch and catch rate obtained at Mangalore were taken to represent Karnataka catches (Fig. 10). There was an improvement in the annual landings. The catches were generally good during the first half of the year.

GUJARAT: The catch details observed at Veraval were taken as representing Gujarat landings. The annual catch (Fig. 11) exhibited tremendous increase with years. Two productive periods were noted, one during January–May and the other during August–December.

Species composition: Of the principal groups of carangids, scads comprising *D. russelli* and *D. macrosoma* constituted a siz-

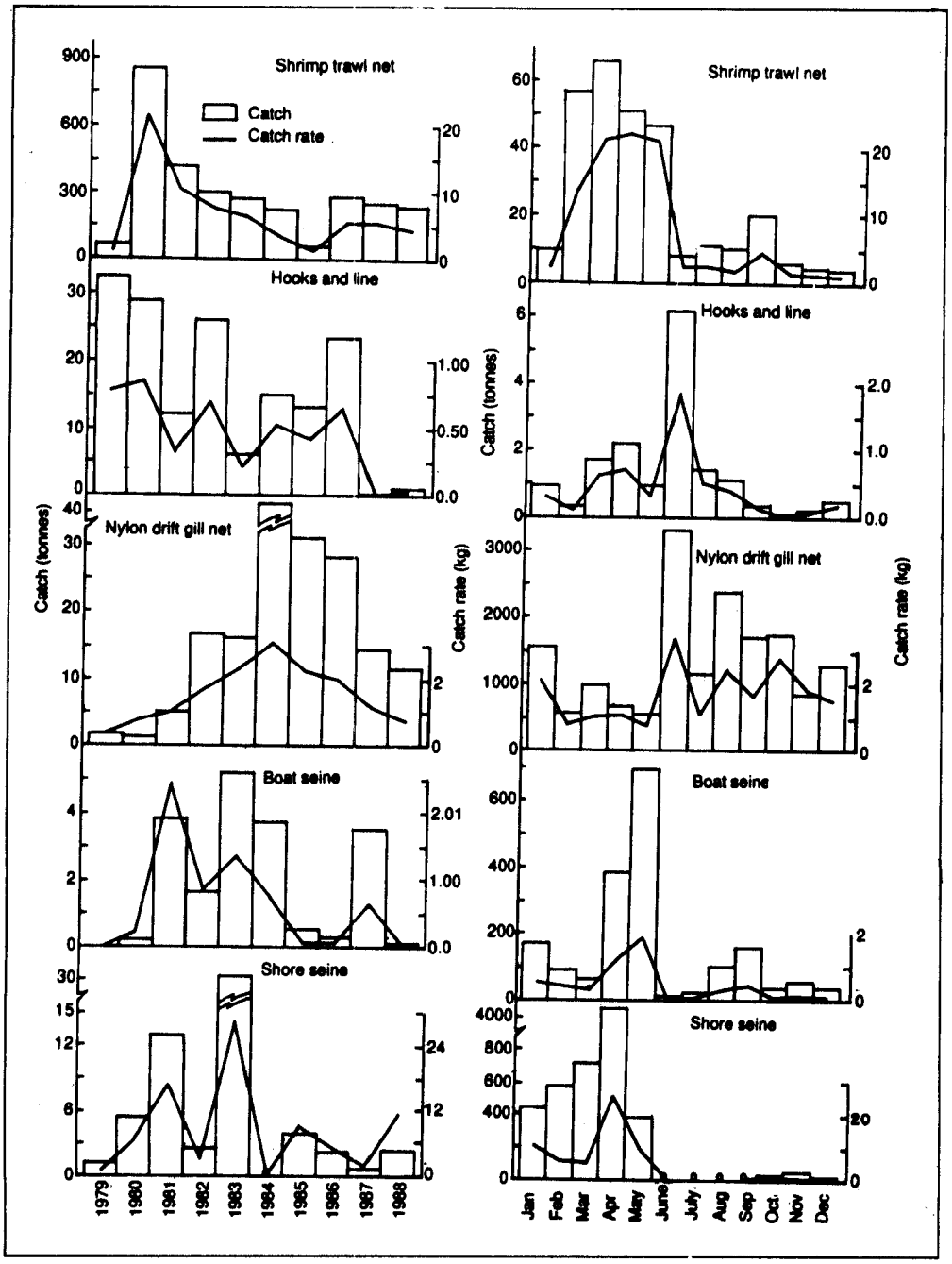


Fig. 2. Annual and seasonal catch and catch rate of carangids landed by different gears during 1979-88 at Visakhapatnam.

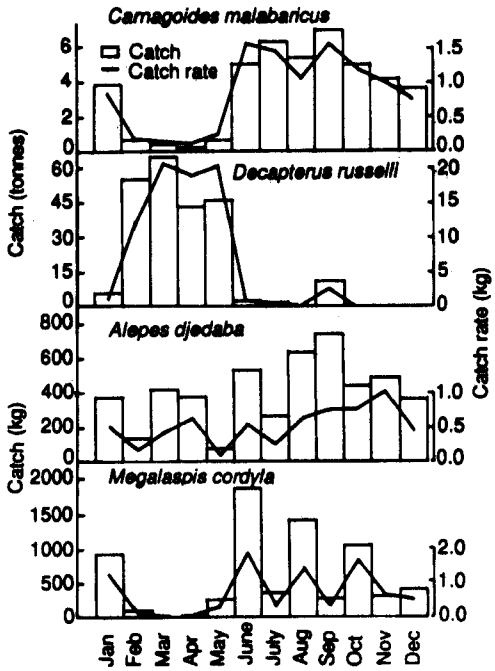


Fig. 3. Seasonal abundance of important species of carangids landed by drift gill net at Visakhapatnam.

able proportion (32.4%) of the catch, whereas horse mackerel, *M. cordyla*, contributed 10.1%, leather jackets comprising *Scomberoides* spp., *Trachynotus* spp., *Seriola* etc. constituted 7.9% and other carangids accounted for nearly half (49.6%) of the catch. The last group comprised of *S. leptolepis*, *C. carangus*, *A. mate*, *A. kalla*, *A. djedaba*, and *A. atropus*.

Specieswise analyses

Results of studies on the landings, biology and stock assessment of important carangid species are given below.

Megalaspis cordyla (east coast, northwest coast and southwest coast): The annual horse mackerel production increased from 2418 tonnes in 1981 to 20765 tonnes in 1988 with an average annual production of 6 627 tonnes. The percentage contribution of horse mackerel catch in total carangid catch in different states was: Karnataka and Goa, 29.8%; Maharashtra, 26.4%; Kerala, 16.6%; Gujarat, 13.2%; Andhra Pradesh, 9.9%; Orissa, 3%; and Tamil Nadu, 0.9%.

GROWTH: Differential growth parameters were obtained for *M.cordyla* of different regions (Fig. 12). While fish from east and southwest coasts had little difference in growth, the species from the northwest was quite different having higher growth rate. PHI' prime values of 2.94, 3.34 and 2.97 were obtained for the species of east coast, northwest coast and southwest coast respectively (Table 1).

BIOLOGY: The length-weight relationship of *M. cordyla* estimated for different region was as follows:

East coast : $W = 0.00001246271\ L^{2.9404436}$
Northeast coast : $W = 0.000127672\ L^{2.5270192}$
Southwest coast : $W = 0.00005097258\ L^{2.717717}$

The size at first maturity was estimated to be 250 mm. Accordingly the age at first maturity ($t_{m\ 50}$) was calculated as 1.81, 0.81 and 1.68 years for east, northwest and southwest coast stocks respectively (Table 1).

M. cordyla had prolonged spawning in all the regions resulting in the recruitment of young ones into the fishery during many months in a year. The east coast stock exhibited peak spawning during March–May and the recruitment peak was noted in April–May (Fig. 13). The stocks of horse mackerel from the northwest and southwest coasts had two phases of recruitment. In the case of northwest coast, one minor recruitment was in October and another major one in January while in the case of southwest coast the minor recruitment occurred in April and the major one in July. The spawning peak for the northwest coast was around July while along the southwest coast in January.

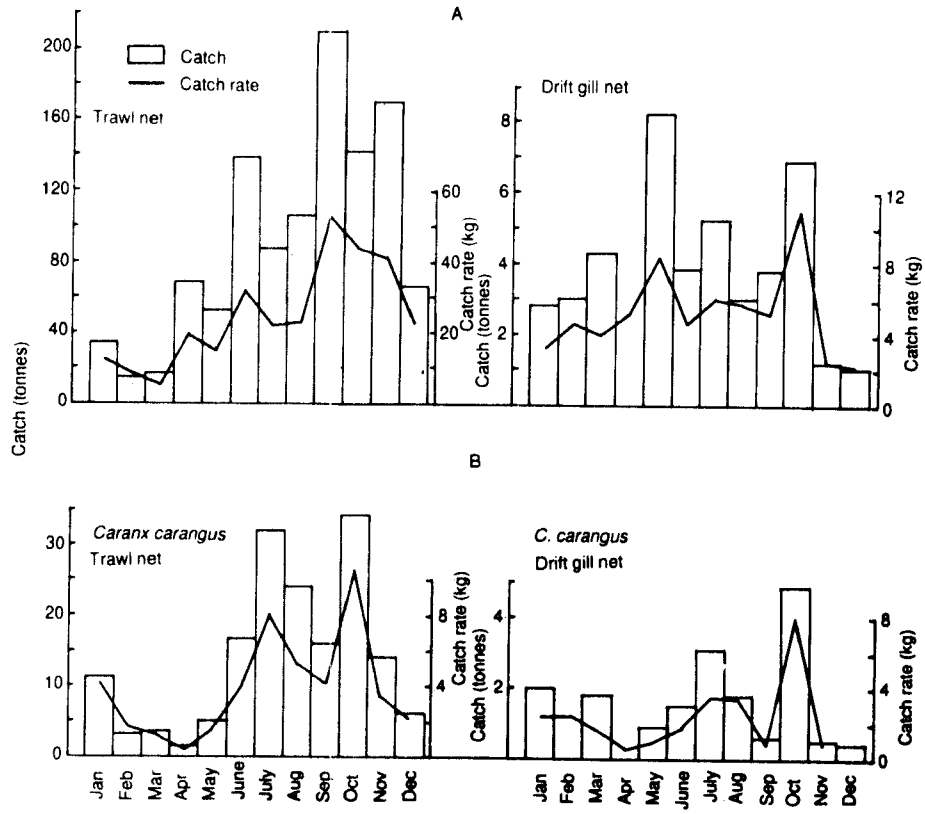


Fig. 4. Monthwise average catch and catch rate of A. carangids landed by trawl net and drift gill net at Tuticorin during 1984-87 and B. *Caranx carangus* landed by trawl net and drift gill net at Tuticorin.

MORTALITY RATES: The values of M estimated as per Pauly (1980) were 0.84, 1.04 and 0.93 for the east, northwest and southwest coast respectively (Table 1). The estimates of M obtained from t_{m50} (Rikhter and Efanov 1976) and T_{max} (Sekharan 1974) for this species showed comparatively limited variations from the above values. T_{max} was estimated from the relation $T_{max} = 3/K$. The instantaneous total mortality Z was estimated to be 3.08, 5.12 and 2.85 and F was 2.24, 4.08 and 1.92 for the east, northwest and southwest coast stocks respectively (Fig. 14).

The exploitation ratio for these coasts was estimated to be 0.73, 0.80 and 0.67 respectively, indicating that the northwest coast stock was subjected to highest fishing pressure followed by east coast and southwest coast.

COHORT ANALYSIS: The results of cohort analysis given in Table 2 for the stock of *M. cordyla* along the east coast indicated that from sizes 205 mm the exploitation ratio increased steadily and that higher length groups have been exposed to an intense fishing pressure, specially above 240 mm.

Cohort analysis for the stocks of *M. cordyla* of northwest coast indicated that at size above 240 mm the stock suffered heavy fishing mortality as the drift gill nets operated along this coast were effective in exploiting these size groups of the stock thus having higher

Table 1. Estimates of growth and population parameters, a and b values of length-weight relationship and size and age at maturity for eight species of carangids

Species	Region	L_∞ (mm)	K (per year)	M (Pauly)	Z (catch curve method)	F	E	a	b	% Exploitation +	% Exploitation —	L_{m50} (mm)	t_{m50} (yrs)	M	T_{max} (yrs)	M	PHI Prime Ø'
Megalaspis cordyla	East coast	410	0.52	0.84	0.08	2.24	0.73	1.246271E-05	2.940436	-	59%	250	1.81	0.76	5.76	0.70	2.94
	N. West coast	525	0.80	1.04	5.12	4.08	0.80	1.27672E-04	2.5270192	-	32%	250	0.81	1.53	3.75	1.23	3.34
	S. West coast	3944	0.60	0.93	2.85	1.92	0.67	5.097258E-05	2.717717	81%	-	250	1.68	0.81	4.99	0.92	2.97
Decapterus russelli	East coast	221	0.71	1.35	2.83	1.48	0.52	5.271477E-06	3.110719	80%	-	137	1.36	1.98	4.22	1.10	2.54
	N. West coast	299	0.45	0.83	2.85	2.02	0.71	3.258E-06	3.2069	-	20%	137	1.36	0.98	6.66	0.69	2.61
	S. West coast	248	0.78	1.26	3.88	2.62	0.68	4.901E-06	3.136243	-	61%	137	1.03	1.24	3.84	1.21	2.68
Caranx carangus	Tamil Nadu & Pondicherry	444	0.65	0.95	4.51	3.56	0.79	4.5947E-05	2.854923	-	39%	220	1.05	1.23	4.61	1.00	3.11
Selaroides leptolepis	Tamil Nadu & Pondicherry	202	0.82	1.35	4.88	3.52	0.72	1.7119E-05	2.893187973	-	40%	88 101	0.72 0.85	1.69 1.45	3.65	1.23	2.51
Atropus atropus	N. West coast	440	1.00	1.26	6.85	5.58	0.82	3.165E-05	2.858703	Neither+ nor—	-	210	0.65	1.84	3.0	1.54	3.29
Alepes kalla	S. West coast	171	0.83	1.40	3.08	1.68	0.55	3.971488E-06	3.244285	41%	-	129	1.70	0.89	3.62	1.28	2.38
Alepes djedaba	Kerala	326	0.61	0.99	5.15	4.16	0.81	4.914418E-06	3.146849	220%	-	180 189	1.32 1.42	1.01 0.95	4.91	0.94	2.81
Atule mate	Kerala	340	0.85	1.22	3.53	2.31	0.65	7.935E-06	3.05156	21%	-	172	0.83	1.50	3.52	1.32	2.99

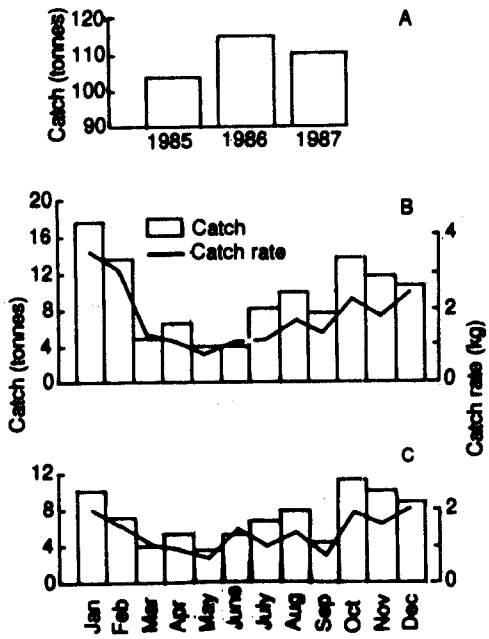


Fig. 5. Landings by trawl net at Rameshwaram. A. Annual total production of carangids. B. Seasonal catch and aubundance of carangids. C. Seasonal catch and abundance of *Selaroides leptolepis*.

exploitation ratio (Table 3).

With a terminal exploitation rate of 0.6143, *M. cordyla* stock along the southwest coast was subjected to higher fishing pressure, size groups of 230 mm and above being fished effectively by the gill nets (Table 4).

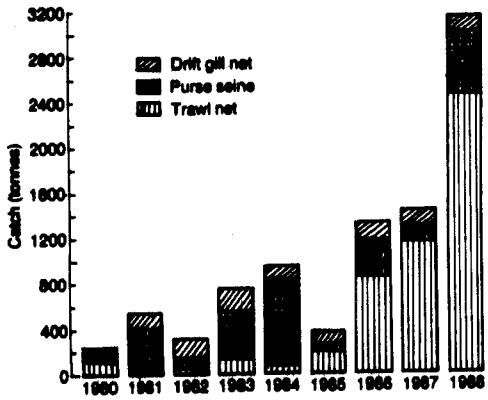


Fig. 6 A. Annual catch of carangids in different gears at Cochin during 1980-88.

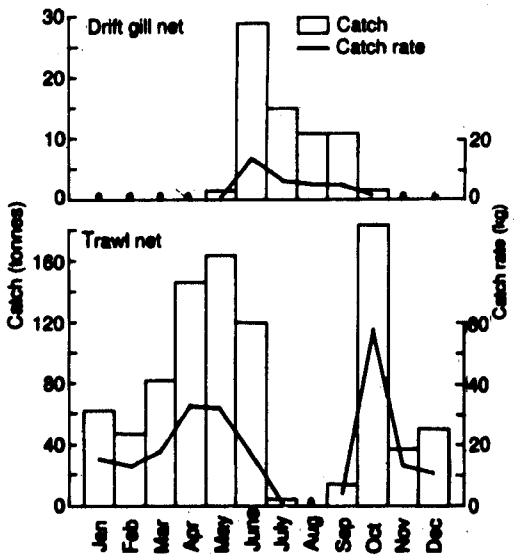


Fig. 6 B. Monthly catch and abundance of carangids in different nets at fisheries harbour, Cochin, during 1980-88.

YIELD AND MEAN BIOMASS: Thompson and Bell long-term forecast analysis of *M. cordyla* stock along the east coast indicated that the level of effort expanded during 1984–88 was nearly 59% higher than the amount of effort required to produce the MSY of 1056.7 tonnes and biomass MSY of 1055.7 tonnes. Higher effort expenditure not only lowered the production by 8.8% but also resulted in 37.9% decline in the mean biomass from MSY level and 80.2% decline from virgin biomass (Fig. 15).

Almost a similar condition was observed along the northwest coast (Fig. 16). The MSY was estimated to be 4 727 tonnes which could be realized at 31.75% less effort than the present level of effort (1984–88). An excess effort has brought down the yield by 1.2% due to decline in the CPUE and the mean biomass

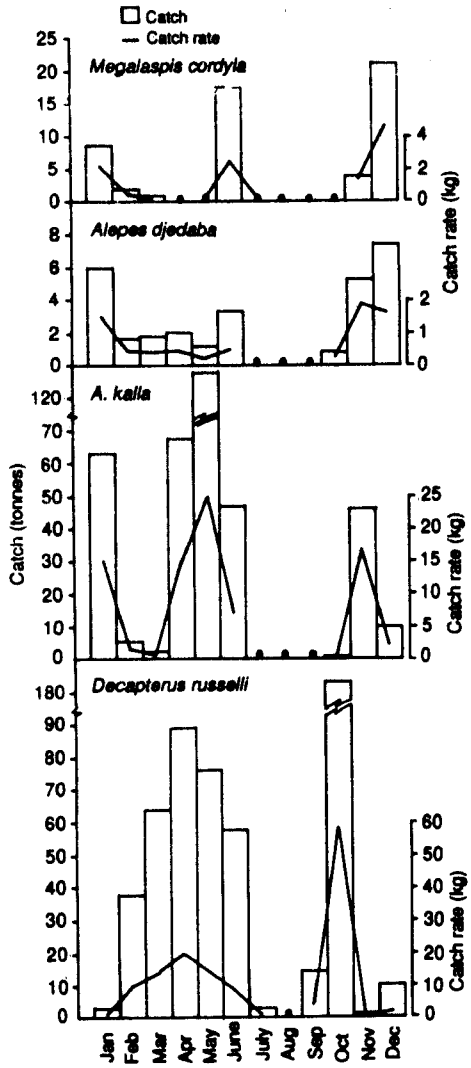


Fig. 7A. Monthly catch and abundance of *Megalaspis cordyla, Alepes djedaba, Alepes kalla* and *Decapterus russelli* in trawl net landings at Fisheries Harbour, Cochin, during 1980-88.

also decreased by about 20.7% from the MSY level (Fig. 16). The decrease in virgin biomass at the present level of fishing is 81%.

Along the southwest coast, MSY of 8 378 tonnes could be obtained by increasing the effort by 81% from the present level which will result in an increase of 205 tonnes from the present yield (Fig. 17). However, this is not viable as the increase in the yield per unit of effort will be very less.

Decapterus spp. (east, northwest and southwest coasts): The catch of round scad varied from 6 748 tonnes in 1981 to 50 958 tonnes in 1988 with an annual average catch of 19 055 tonnes. Kerala contributed to the bulk (52.9%) of the landing followed by Karnataka including Goa (19.5%), Andhra Pradesh (11.4%), Tamil Nadu including Pondicherry (6.9%) and Maharashtra (6.0%). The landings from other states were poor. The major portion of the catch of scad (90%) was contributed by *D. russelli.*

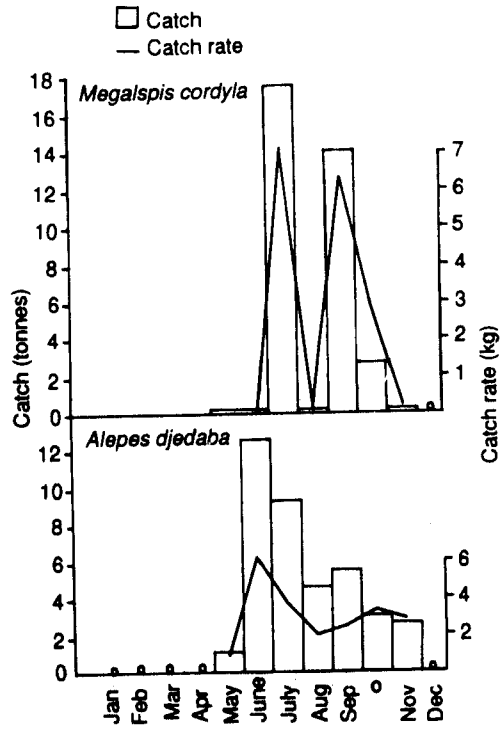


Fig. 7B. Monthly catch and abundance of *Megalaspis cordyla* and *Alepes djedaba* in drift gill net landings at Fisheries Harbour, Cochin.

Table 2. Catch (C), stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Megalaspis cordyla* off east coast

Interval	C	X*	N	F/Z	F	Z
110.00-115.00	2.097	1.0171	26 846.11	0.0023	0.0025	1.0525
115.00-120.00	2.097	1.017	25 948.24	0.0024	0.0025	1.0525
120.00-125.00	308.427	1.0177	25 065.79	0.2641	0.3767	1.4267
125.00-130.00	1 569.656	1.0180	23 897.75	0.6593	2.0317	3.0817
130.00-135.00	1 946.927	1.0184	21 516.88	0.7263	2.7863	3.8363
135.00-140.00	277.035	1.0187	18 836.27	0.2895	0.4277	1.4777
140.00-145.00	175.583	1.0191	17 879.19	0.2104	0.2798	1.3298
145.00-150.00	85.694	1.0194	17 044.63	0.1178	0.1403	1.1903
150.00-155.00	128.633	1.0198	16 317.44	0.1707	0.2161	1.2661
155.00-160.00	71.315	1.0202	15 563.88	0.1049	0.1230	1.1730
160.00-165.00	459.062	1.0206	14 883.92	0.4394	0.8230	1.8730
165.00-170.00	781.457	1.0210	13 839.18	0.5877	1.4966	2.5466
170.00-175.00	264.957	1.0215	12 509.46	0.3397	0.5401	1.5901
175.00-180.00	226.327	1.0220	11 729.42	0.3144	0.4815	1.5315
180.00-185.00	210.265	1.0224	11 009.50	0.3076	0.4665	1.5165
185.00-190.00	24.203	1.0229	10 325.92	0.0502	0.0555	1.1055
190.00-195.00	79.005	1.0235	9 844.17	0.1509	0.1865	1.2365
195.00-200.00	309.070	1.0240	9 320.45	0.4209	0.7632	1.8132
200.00-205.00	201.411	1.0246	8 586.14	0.3333	0.5248	1.5748
205.00-210.00	471.528	1.0252	7 981.79	0.5560	1.3147	2.3647
210.00-215.00	366.328	1.0259	7 133.66	0.5141	1.1108	2.1608
215.00-220.00	584.491	1.0266	6 421.05	0.6513	1.9609	3.0109
220.00-225.00	435.589	1.0273	5 523.58	0.6104	1.6452	2.6952
225.00-230.00	643.990	1.0280	4 809.99	0.7274	2.8021	3.8521
230.00-235.00	444.889	1.0289	3 924.68	0.6850	2.2838	3.3338
235.00-240.00	956.766	1.0297	3 275.25	0.8576	6.3338	7.3838
240.00-245.00	375.717	1.0306	2 159.88	0.7653	3.4246	4.4746
245.00-250.00	334.842	1.0316	1 668.96	0.7876	3.8934	4.9434
250.00-255.00	195.935	1.0326	1 243.82	0.7339	2.8954	3.9434
255.00-260.00	290.703	1.0337	976.83	0.8455	5.7467	6.7967
260.00-265.00	157.356	1.0348	633.01	0.8114	4.5159	5.5659
265.00-270.00	158.272	1.0361	439.06	0.8658	6.7762	7.8262
270.00-275.00	96.619	1.0374	256.27	0.8683	6.9196	7.9696
275.00-280.00	77.984	1.0388	144.99	0.9099	10.6028	11.6528
280.00-285.00	21.893	1.0404	59.28	0.8567	6.2748	7.3248
285.00-290.00	14.463	1.0421	33.72	0.8740	7.2863	8.3363
290.00 plus	14.973	0.0000	17.17	0.8718	7.1402	8.1902
Total	12 750.590					

*, X = ((L8-L(i))/(LB-L(i+1))) (M/2K)

The seasonal abundance of scads (Fig. 3) showed that at Visakhapatnam (Andhra Pradesh) the catches were good during February to May and at Veraval, Gujarat, (Fig. 11) during January and April.

Decapterus russelli: This is the largest contributor among scads. The results of its study are presented below.

GROWTH: Three different growth parameters have been obtained for *D. russelli* for

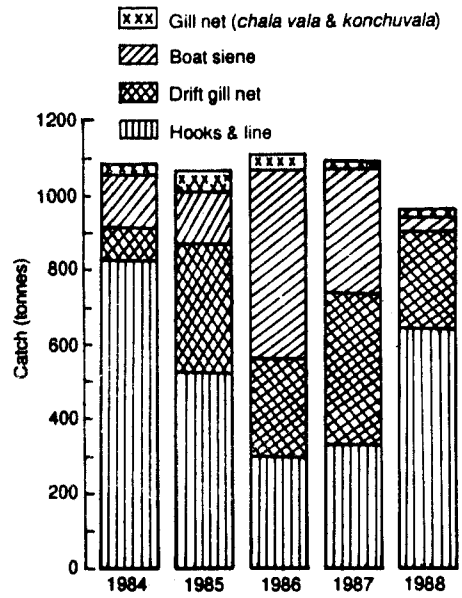


Fig. 8. Annual catches of carangids in different gears at Vizhinjam during 1984-88.

east, northwest and southwest coasts (Fig. 18) and the estimates are given in Table 1. There is some difference in the growth performance of this species along east, northwest and southwest coasts as indicated by the PHI' prime (Ø') values obtained, i.e. 2.54 for east coast, 2.61 for northwest coast and 2.68 for southwest coast.

BIOLOGY: The regionwise length-weight relationship obtained for *D. russelli* was as follows:

East coast : $W = 0.000005271477\ L^{3.119719}$
Northwest coast : $W = 0.000003258\ L^{3.2069}$
Southwest coast : $W = 0.00004901\ L^{3.136242471}$

The length at first maturity was estimated as 137 mm for *D. russelli*. Based on the growth estimation obtained for the three different regions, the age at first maturity (t_{m50}) was 1.36 year along east and northwest coast and 1.03 year along the southwest coast.

The life span, T_{max}, of this species was 4.2 years along east, 6.7 years along northwest and 3.8 years along southwest coast.

Ova diameter studies conducted at Visakhapatnam indicated that this species

Table 3. Catch (C), stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Megalaspis cordyla* off northwest coast

Interval	C	X*	N	F/Z	F	Z
120.00-140.00	25.602	1.0344	48 664.70	0.0080	0.0086	1.0786
140.00-160.00	23.200	1.0363	45 452.76	0.0074	0.0079	1.0779
160.00-180.00	2.114	1.0384	42 300.30	0.0007	0.0007	1.0707
180.00-200.00	41.960	1.0407	39 227.21	0.0137	0.0149	1.0849
200.00-220.00	253.251	1.0434	36 175.51	0.0794	0.0923	1.1623
220.00-240.00	1 507.854	1.0464	32 986.63	0.3505	0.5775	1.6475
240.00-260.00	5 536.813	1.0499	28 685.04	0.6979	2.4716	3.5416
260.00-280.00	10 798.720	1.0539	20 751.21	0.8769	7.6244	8.6944
280.00-300.00	4 146.330	1.0586	8 437.02	0.8593	6.5366	7.6066
300.00-320.00	1 009.492	1.0642	3 611.96	0.7361	2.9845	4.0545
320.00-340.00	548.641	1.0711	2 240.55	0.6861	2.3384	3.4084
340.00-360.00	347.450	1.0795	1 440.87	0.6602	2.0786	3.1486
360.00-380.00	357.197	1.0903	914.57	0.7555	3.3067	4.3767
380.00-400.00	304.761	1.1043	441.79	0.8573	6.4259	7.4959
400.00 plus	65.302	0.0000	86.28	0.7569	3.3312	4.4012
Total	24 903.390					

*, X = ((LB-L(i))/(LB-L(I+1))) (M/2K)

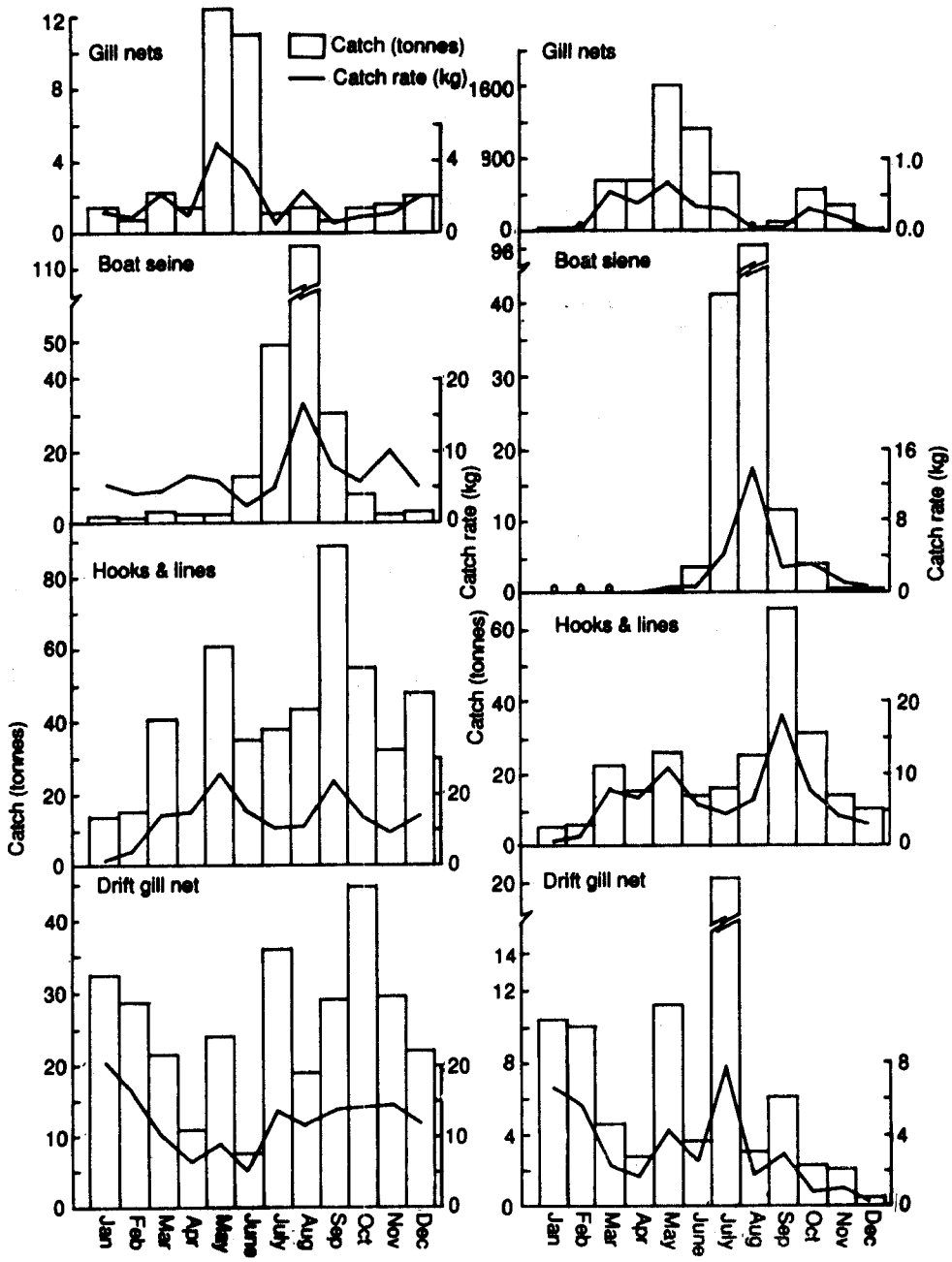


Fig. 9. Monthly catch and abundance of carangids in different gears operated off Vizhinjam during 1982-88.

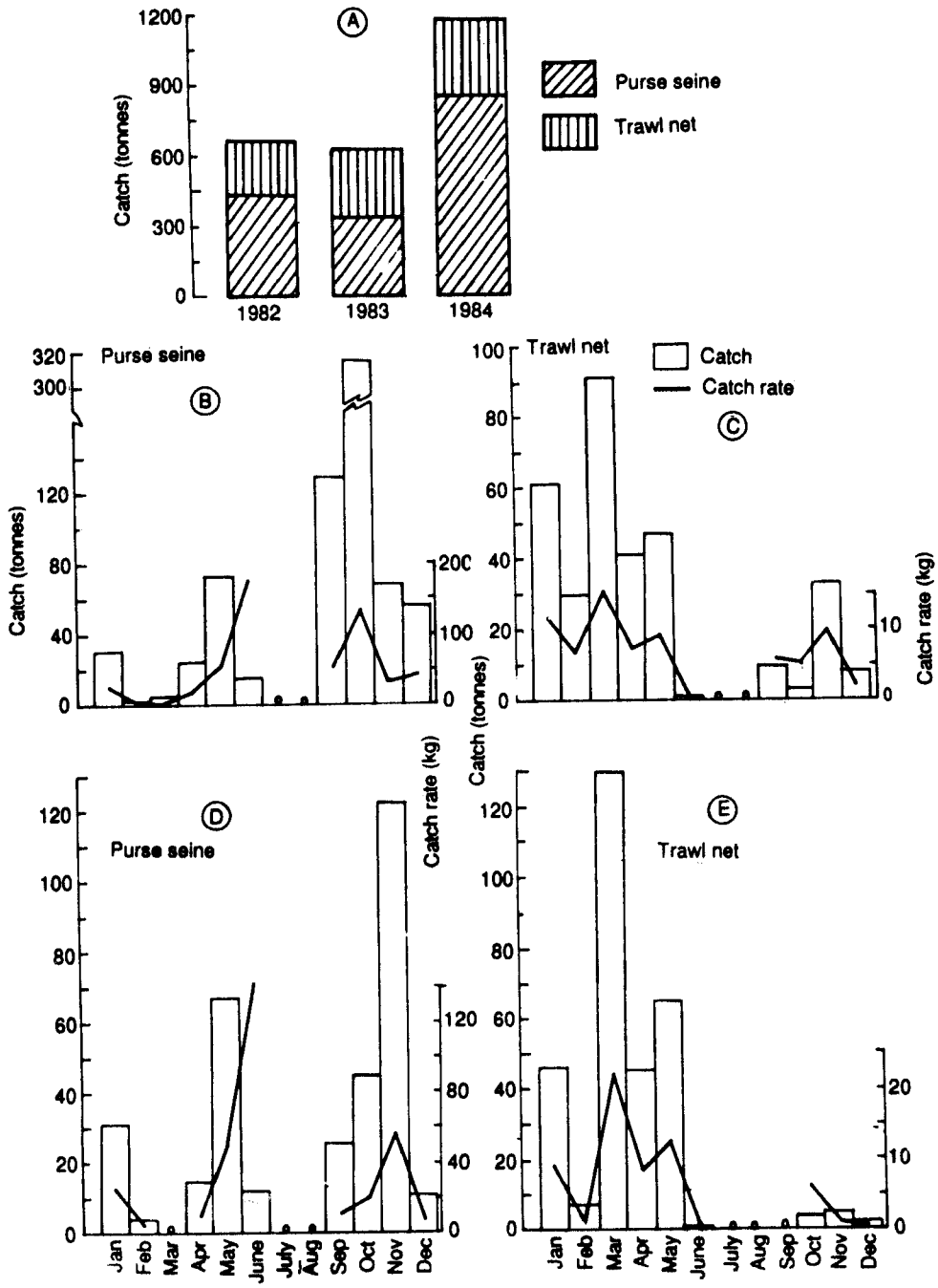


Fig. 10. A. Annual landings of carangids in purse seine and trawl net landings at Mangalore during 1982-84. B and C. Monthly catch and abundance of carangids in purse seine and trawl net landings at Mangalore during 1982-84. D and E. Monthly catch and abundance of *Alepes kalla* in purse seine and trawl net landings.

Table 4. Catch (C), stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Megalaspis cordyla* off southwest coast

Interval	C	X*	N	F/Z	F	Z
130.00-140.00	103.608	1.0304	136 032.09	0.0129	0.0122	0.9422
140.00-150.00	105.703	1.0316	128 028.51	0.0135	0.0127	0.9427
150.00-160.00	105.703	1.0330	120 198.41	0.0138	0.0130	0.9430
160.00-170.00	696.903	1.0344	112 547.12	0.0867	0.0883	1.0183
170.00-180.00	1 317.369	1.0360	104 506.57	0.1566	0.1726	1.1026
180.00-190.00	2 258.089	1.0378	96 092.91	0.2496	0.3094	1.2394
190.00-200.00	2 510.738	1.0397	87 047.13	0.2809	0.3632	1.2932
200.00-210.00	1 872.863	1.0419	78 108.27	0.2356	0.2867	1.2167
210.00-220.00	2 397.031	1.0443	70 159.24	0.2953	0.3898	1.3198
220.00-230.00	4 054.571	1.0469	62 042.73	0.4354	0.7173	1.6473
230.00-240.00	9 160.034	1.0500	52 731.27	0.6724	1.9086	2.8386
240.00-250.00	7 087.569	1.0534	39 107.77	0.6691	1.8801	2.8101
250.00-260.00	2 777.686	1.0574	28 514.38	0.4928	0.9034	1.8334
260.00-270.00	3 391.461	1.0620	22 877.37	0.5863	1.3178	2.2478
270.00-280.00	3 642.871	1.0673	17 092.42	0.6621	1.8227	2.7527
280.00-290.00	5 983.544	1.0737	11 590.79	0.8416	4.9400	5.8700
290.00-300.00	1 256.721	1.0815	4 480.78	0.6936	2.1052	3.0352
300.00-310.00	794.600	1.0911	2 668.88	0.6878	2.0490	2.9790
310.00-320.00	410.178	1.1032	1 513.62	0.6391	1.6470	2.5770
320.00-330.00	363.605	1.1191	871.83	0.7263	2.4685	3.3985
330.00 plus	228.070	1.1407	371.24	0.6143	1.4815	2.4115
Total	8 181.043					

*, X = ((LB-L(i))/(LB-L(i+1))) (M/2K)

released eggs in two spurts (Fig. 19)

Though spawning and recruitment was a prolonged and continuous process in *D. russelli*, two peak periods of spawning and recruitment in all the 3 regions were recorded with some variations from region to region (Fig.20). East coast stock of *D. russelli* had a major pronounced peak period of recruitment in July (21.65%) followed by a less pronounced one in November (6.38%). Based on the minimum size observed in the fishery and time of origin of the brood, from the growth curves, this species exhibited an intensive spawning behaviour in April and another less pronounced spawning season in August. The recruitment pattern along northwest coast was continuous with peak recruitment in June and January (Fig. 20) which were related to the peak spawning period in December and August respectively. Along the southwest coast, the January recruitment was highly pronounced and the July recruitment was a feeble one and these recruitments are correlated to the spawning in December and September respectively. As such the spawning and recruitment along the northwest and southwest coast had similarity but differed from that along the east coast.

MORTALITY RATES: The instantaneous natural mortality M was estimated to be 1.35, 0.83 and 1.26 for the east, northwest and southwest coast respectively as per Pauly (1980) and values of the M estimated from t_{m50} and T_{max} for southwest coast stock closely agreed with the values obtained by Pauly's empirical formula, whereas there was some limited variations in the estimates of east and northwest coasts stock (Table 1).

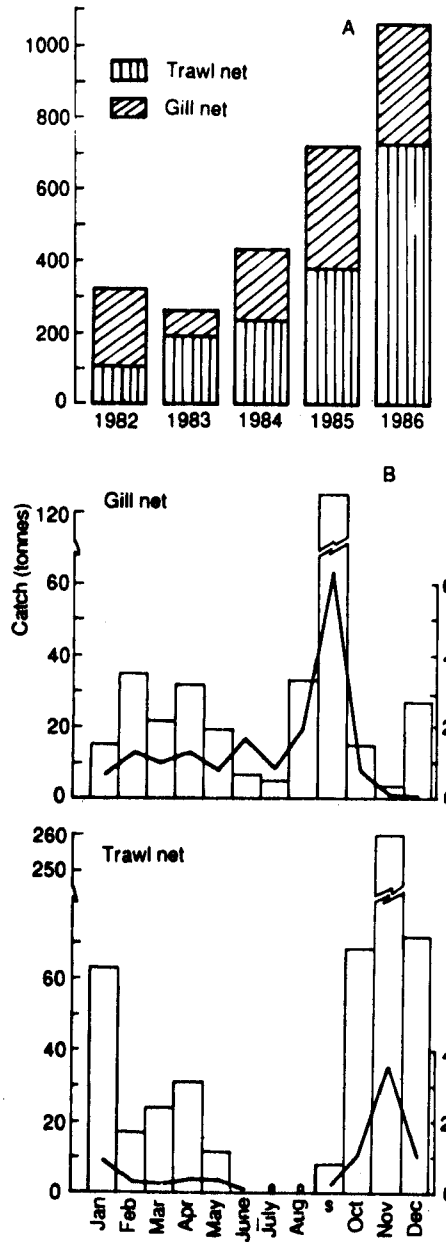


Fig. 11. A & B. A. Annual landings of carangids in trawl net and gill net at Veraval. B. Monthly catch and abundance of carangids in gill net and trawl net landings at Veraval.

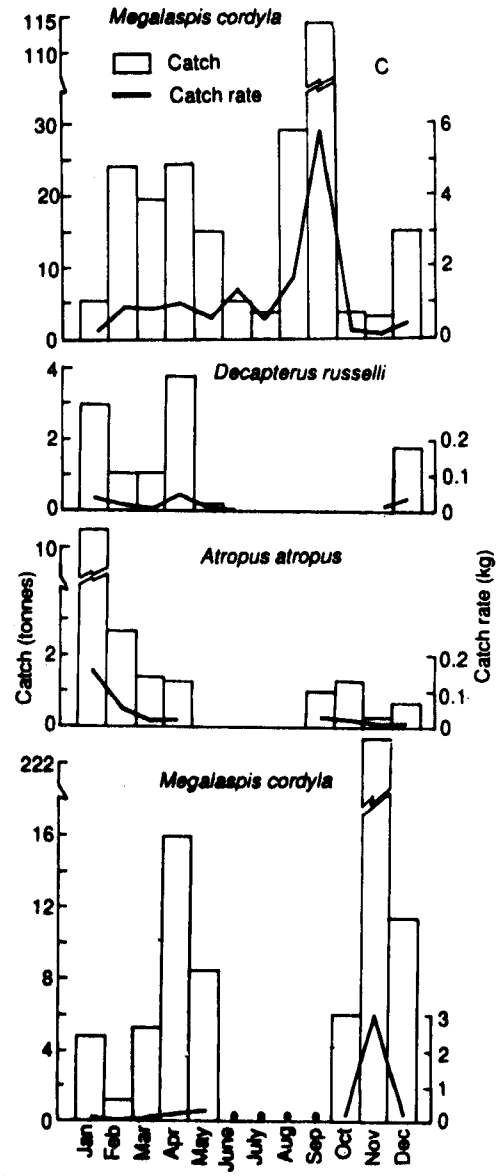


Fig. 11 C. Monthly catch and abundance of *Megalaspis cordyla* in drift gill net and *Decapterus russelli*, *Atropus atropus*, and *Megalaspis cordyla* in trawl net at Veraval.

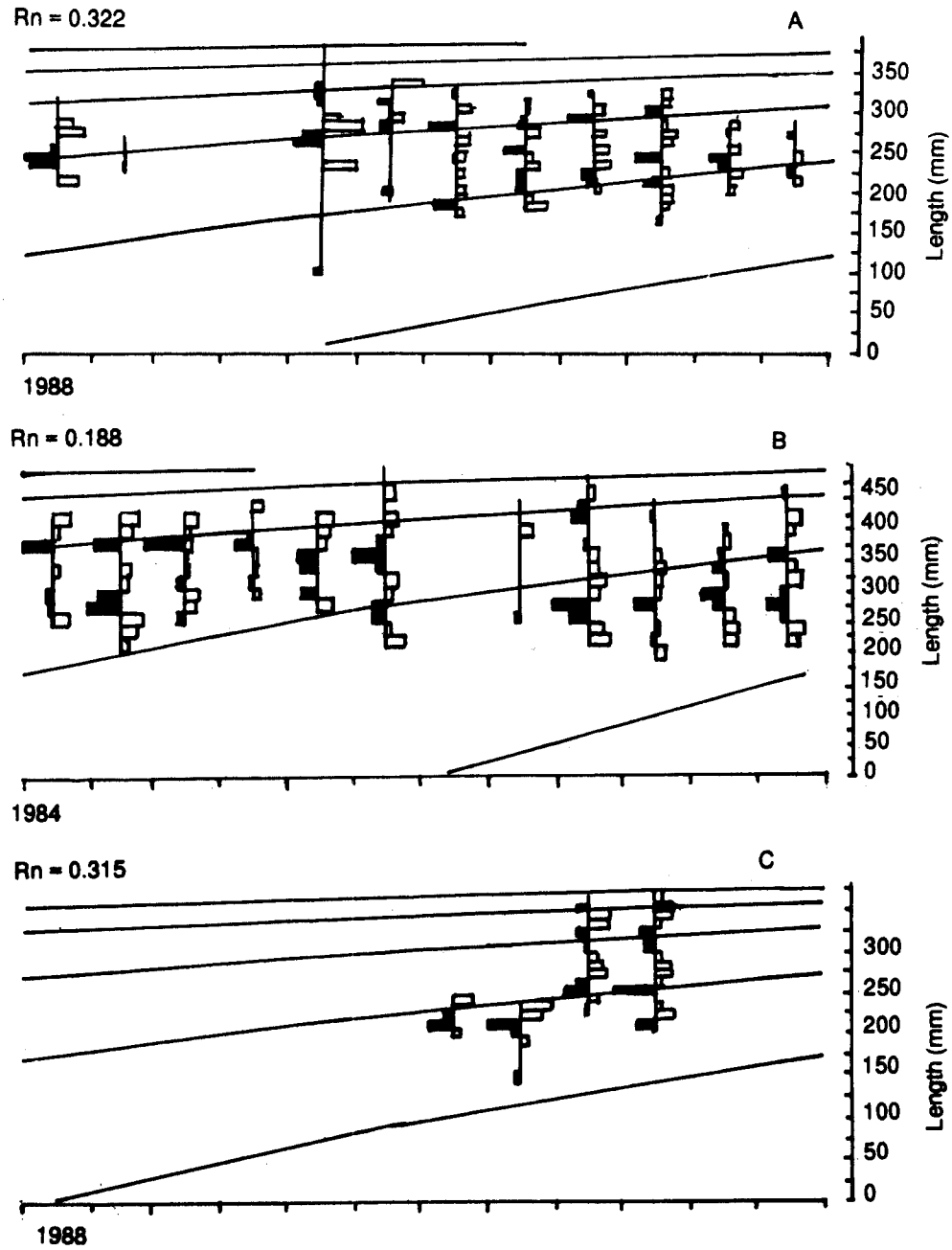


Fig. 12. Growth curve of *Megalaspis cordyla* obtained from the pooled length frequency data collected from drift gill net landings off (A) Visakhapatnam, (B) Veraval and (C) Cochin, as per ELEFAN I programme.

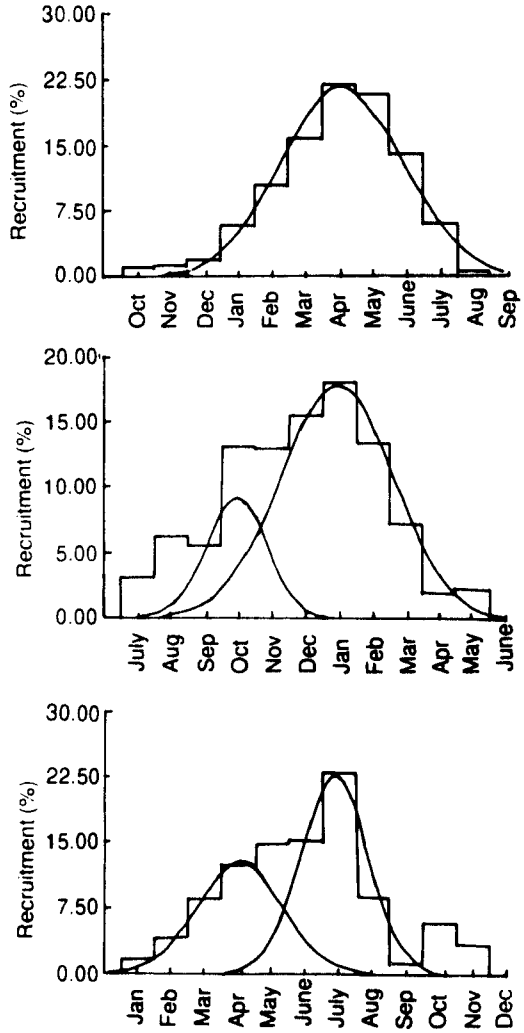


Fig. 13. Absolute percentage recruitment pattern of *Megalaspis cordyla* exhibiting one recruitment peak along the east coast (top), two recruitment peaks along the northwest coast (middle) and two recruitment peaks along the southwest coast (bottom).

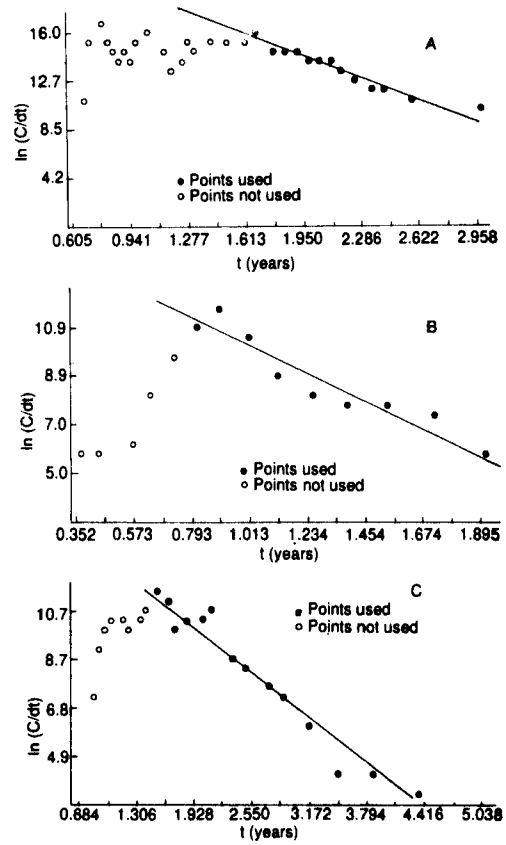


Fig. 14. Estimation of total mortality rate Z by length converted catch curve analysis for *Megalaspis cordyla*. A. Along the east coast (L_∞ = 410 mm, K = 0.52 year, Z = 3.08). B. Along the northwest coast (L_∞ = 525 mm, K = 0.8 year, Z = 5.12). C. Along the southwest coast (L_∞ = 394 mm, K = 0.6 year, Z = 2.85).

The Z was estimated to be 2.83 for east coast 2.85 for northwest coast and 3.88 for southwest coast stocks (Fig. 21) and F was 1.48, 2.02 and 2.624 for these three stocks respectively. The exploitation ratio E was 0.52, 0.71 and 0.68 for east, northwest and southwest coast respectively.

COHORT ANALYSIS: The cohort analysis of the stock of *D. russelli* along the east coast (Table 5) showed that except 130–150 mm, and 185 mm and above, all other size ranges are not exposed to higher fishing pressure, indicating roughly that there is scope for intensifying the exploitation of this stock further along the east coast by trawl net.

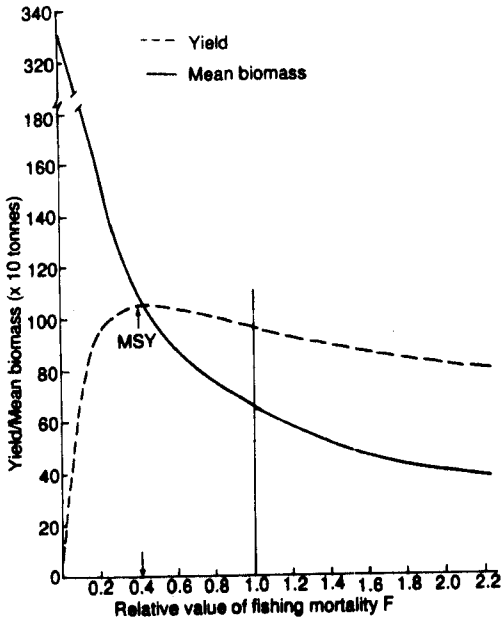


Fig. 15. Yield and mean biomass curves for *Megalaspis cordyla*, exploited by drift gill net along the east coast, in relation to fishing effort as percentage of the current effort.

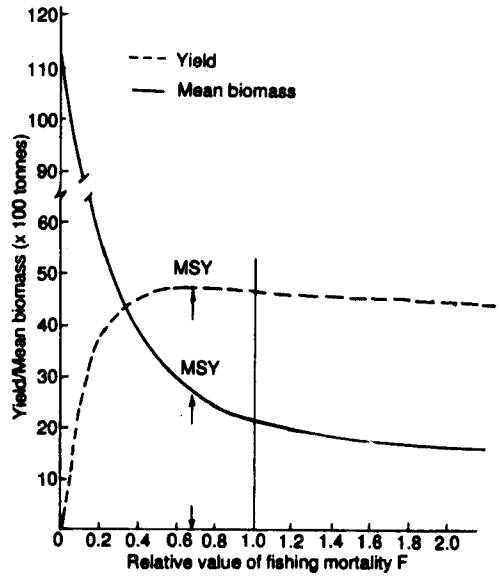


Fig. 16. Yield and mean biomass curves for *Megalaspis cordyla*, exploited by drift gill net along northwest coast, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

As seen from the results of cohort analysis of the northwest coast stock of *D. russelli* (Table 6), size groups below 170 mm are not exposed to higher fishing pressure.

Similarly the cohort analysis of southwest coast stock shows that fish below 180 mm did not face the full burnt of the fishing pressure and only the older individuals measuring more than 180 mm suffered intensive fishing mortality (Table 7).

YIELD AND MEAN BIOMASS: The MSY of 2 799 tonnes obtainable in east coast is over 5.7% more than the present yield and to secure this the effort has to be raised by 80%. But this reduces the mean biomass by 30.8% over the present level and by 72.12% over the virgin mean biomass level causing considerable decline in mean biomass. When the strength of biomass and potential brooders is reduced to the extent observed here, there can be recruitment overfishing (Fig. 22).

The short life span, the short time within which the species attains maturity, and the high natural mortality of this species, all indicated that high fishing pressure can be applied to obtain MSY. But, the economic feasibility of increasing the effort by 80% and its effect on the fisheries of other major species in the multispecies gear is to be considered.

The stock along the northwest coast shows that the present level of fishing effort is 17% more than the effort needed to obtain the MSY. The mean biomass MSY is marginally higher than the present level of production (Fig. 23). Further increase in the effort will adversely affect the stock biologically resulting in low production and decline in catch rate. Therefore, the effort should either be decreased or maintained at the present level.

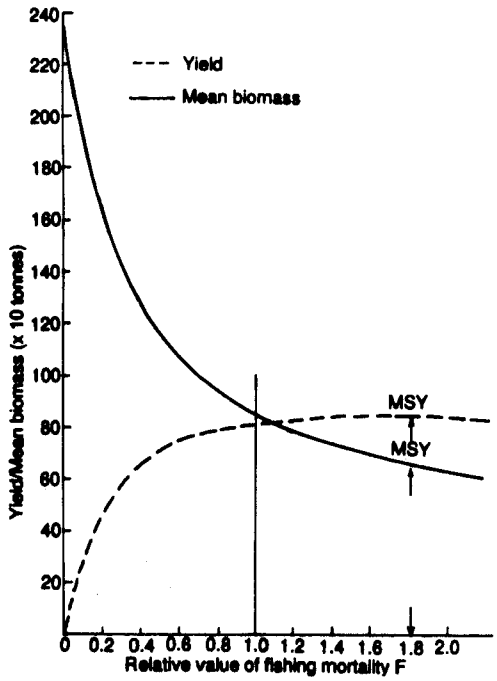


Fig. 17. Yield and mean biomass curves for *Megalaspis cordyla*, exploited by drift gill net along the southwest coast, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

The results of Thompson and Bell analysis with regard to the stock of southwest coast indicated that the fishing effort has to be increased by 61% from present level to realize the MSY of 22 208 tonnes which is 2% higher than the present production. On the other hand the decrease in the mean biomass is 20.5% (Fig. 24). However, considering the short life span and short period of attaining maturity, the stock of *D. russelli* along the southwest coast will be able to withstand further increase in the fishing effort.

Caranx carangus (Tamil Nadu and Pondicherry): The catch of *C. carangus* in Tamil Nadu and Pondicherry ranged from 1 735.7 tonnes in 1986 to 4 276.7 tonnes in 1988 with an annual average catch of 2 719.9 tonnes. The landings did not show any trend. *C. carangus* landings in trawl net and drift gill net showed three peaks in January, July and October with increasing abundance (Fig. 4).

GROWTH: Estimated growth parameters for *C. carangus* were as L_{∞} = 444 mm and K = 0.65/yr (Fig. 25) and the PHI' prime (ø) was 3.11.

BIOLOGY: The length-weight relationship of *C. carangus* was $W = 0.000045947\ L^{2.854923}$

The size at first maturity was 220 mm and the corresponding age at maturity (t_{m50}) was 1.05 years. The life span of this species was assessed to be 4.6 years (Table 1).

Percentage recruitment of *C. carangus* (Fig. 26) indicated two dominant recruitment periods in a year i.e. one highly pronounced in February and March and a feeble one in September. The young ones of this species get recruited into the fishery at the size range of

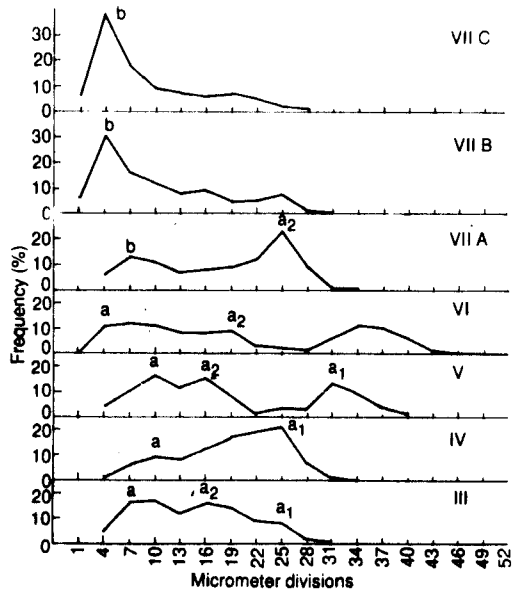


Fig. 19. Percentage frequency of ova diameter of *Decapterus russelli* at Visakhapatnam.

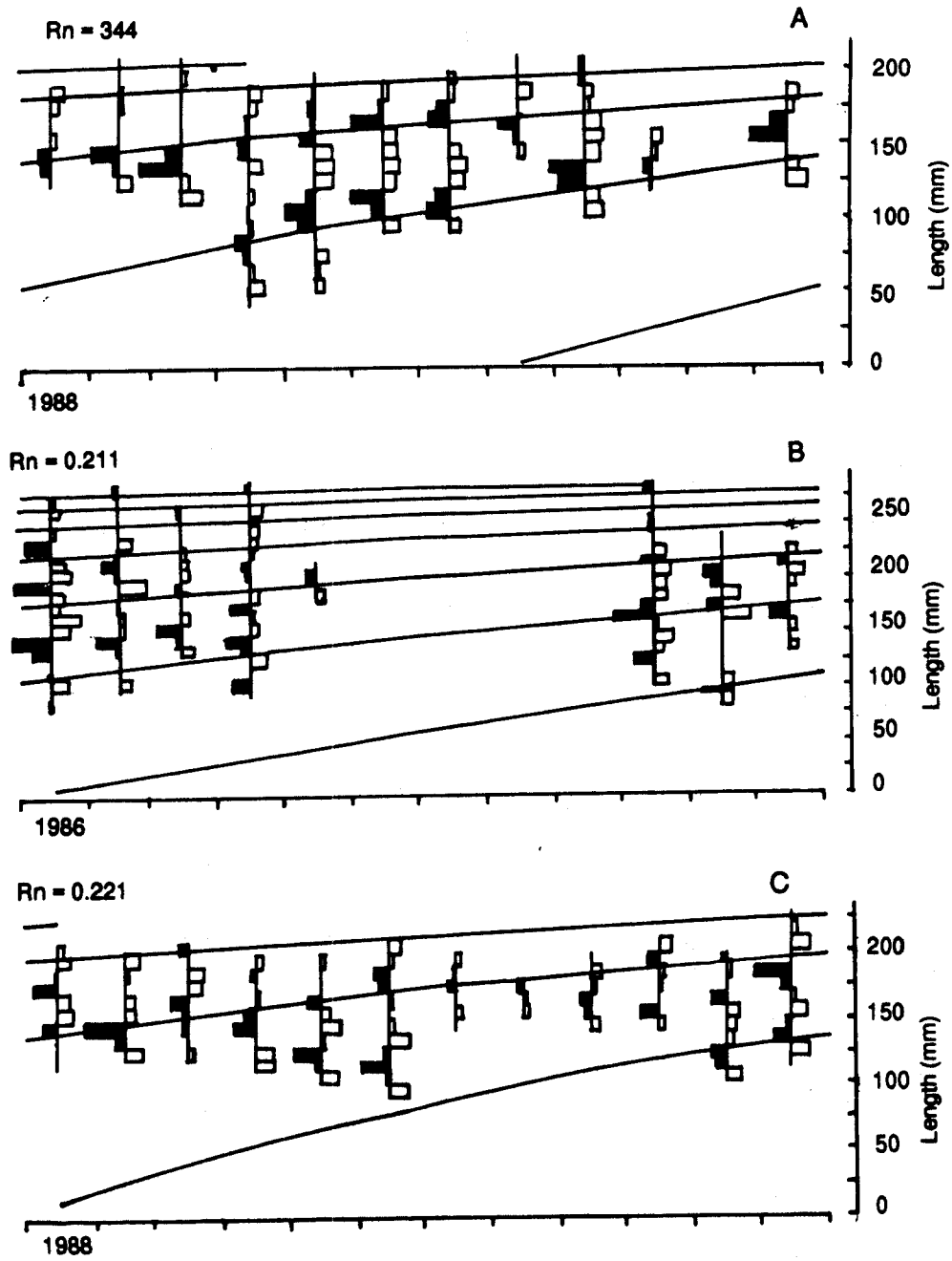


Fig. 18. Growth curve of *Decapterus russelli* obtained from the pooled length frequency data collected from shrimp trawl net landings off (A) Visakhapatnam, (B) Veraval and (C) Cochin as per ELEFAN I programme.

Table 5. Catch (C) stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Decapterus russelli* off east coast

Interval	C	X*	N	F/Z	F	Z
45.00-50.00	1 114.127	1.0278	557 543.81	0.0362	0.0506	1.4006
50.00-55.00	70.529	1.0286	526 728.81	0.0024	0.0033	1.3533
55.00-60.00	640.001	1.0295	497 762.28	0.0223	0.0307	1.3807
60.00-65.00	1 567.550	1.0304	469 020.47	0.0544	0.0776	1.4276
65.00-70.00	1 768.177	1.0315	440 191.66	0.0628	0.0905	1.4405
70.00-75.00	3 609.811	1.0325	412 039.06	0.1243	0.1916	1.5416
75.00-80.00	1 411.010	1.0337	382 988.50	0.0544	0.0777	1.4277
80.00-85.00	7 099.856	1.0349	357 069.91	0.2324	0.4087	1.7587
85.00-90.00	8 481.305	1.0363	326 519.19	0.2769	0.5169	1.8669
90.00-95.00	6 328.246	1.0377	295 888.03	0.2326	0.4093	1.7593
95.00-100.00	7 974.423	1.0392	268 686.09	0.2891	0.5490	1.8990
100.00-105.00	8 541.264	1.0409	241 102.78	0.3188	0.6317	1.9817
105.00-110.00	10 814.510	1.0428	214 307.16	0.3919	0.8701	2.2201
110.00-115.00	8 934.757	1.0448	186 713.97	0.3689	0.7892	2.1392
115.00-120.00	4 706.117	1.0470	162 495.56	0.2509	0.4521	1.8021
120.00-125.00	4 268.094	1.0495	143 736.97	0.2468	0.4423	1.7923
125.00-130.00	10 446.480	1.0522	126 442.55	0.4715	1.2044	2.5544
130.00-135.00	13 476.370	1.0552	104 286.65	0.5760	1.8340	3.1840
135.00-140.00	11 612.290	1.0586	80 890.38	0.5901	1.9439	3.2939
140.00-145.00	9 350.451	1.0624	61 213.48	0.5924	1.9617	3.3117
145.00-150.00	5 745.669	1.0668	45 428.25	0.5271	1.5050	2.8550
150.00-155.00	3 348.713	1.0719	34 528.69	0.4406	1.0633	2.4133
155.00-160.00	2 107.283	1.0778	26 928.21	0.3696	0.7915	2.1415
160.00-165.00	2 549.825	1.0847	21 226.87	0.4606	1.1526	2.5026
165.00-170.00	2 079.900	1.0930	15 690.44	0.4664	1.1801	2.5301
170.00-175.00	1 784.315	1.1031	11 231.27	0.4931	1.3134	2.6634
175.00-180.00	1 307.182	1.1156	7 612.85	0.4900	1.2970	2.6470
180.00-185.00	754.210	1.1316	4 945.10	0.4310	1.0226	2.3726
185.00-190.00	734.292	1.1528	3 195.23	0.5143	1.4295	2.7795
190.00-195.00	676.313	1.1820	1 767.51	0.6294	2.2924	3.6424
195.00-200.00	177.340	1.2251	692.90	0.4716	1.2051	2.5551
200.00 plus	168.157	0.0000	316.89	0.5306	1.5263	2.8763
Total	143 480.400					

*, X = ((L8-L(i))/(L8-L(i+1)) (M/2K)

60–70 mm when they are 3 months old. Taking this into consideration, the spawning periods are reduced i.e. an intensive spawning in November and a less pronounced spawning in April during each year along the Tamil Nadu coast.

MORTALITY RATES: M was estimated to be 0.95 as per Pauly (1980) and the estimates obtained from t_{m50} and T_{max} were marginally higher.

Total mortality Z was estimated to be 4.505 (Fig. 27) and the F was 3.56. The exploitation ratio was 0.79 roughly indicating over exploitation by trawl net.

COHORT ANALYSIS: A different pattern of exploitation by trawl net is discernible from the results of cohort analysis given in Table 8 for *C. carangus* along Tamil Nadu coast. Mostly small sized groups from 70 to 260 mm were exposed to higher fishing mortality rates

Table 6. Catch (C), stock size (N), total mortality (Z), fishing mortality and exploitation ratio (F/Z) obtained from length cohort analysis of *Decapterus russelli* off northwest coast

Interval	C	X*	N	F/Z	F	Z
80.00-90.00	722.386	1.0442	232 840.94	0.0362	0.0312	0.8632
90.00-100.00	2 288.015	1.0464	212 873.59	0.1109	0.1038	0.9358
100.00-110.00	1 581.304	1.0488	192 238.86	0.0833	0.0756	0.9076
110.00-120.00	6 077.719	1.0515	173 252.41	0.2720	0.3108	1.1428
120.00-130.00	7 618.594	1.0546	150 905.81	0.3395	0.4277	1.2597
130.00-140.00	12 237.430	1.0580	128 465.16	0.4843	0.7814	1.6134
140.00-150.00	19 235.930	1.0619	103 198.41	0.6456	1.5159	2.3479
150.00-160.00	8 860.662	1.0663	73 404.84	0.5164	0.8885	1.7205
160.00-170.00	6 052.257	1.0715	56 247.18	0.4691	0.7352	1.5672
170.00-180.00	12 286.910	1.0774	43 346.22	0.7057	1.9950	2.8270
180.00-190.00	4 323.938	1.0845	25 935.12	0.5493	1.0139	1.8459
190.00-200.00	6 081.306	1.0930	18 063.02	0.7148	2.0852	2.9172
200.00-210.00	4 337.518	1.1034	9 555.30	0.7693	2.7739	3.6059
210.00-220.00	2 404.169	1.1165	3 916.81	0.8211	3.8186	4.6506
220.00-230.00	281.655	1.1333	988.82	0.6026	1.2614	2.0934
230.00-240.00	203.883	1.1557	521.39	0.6631	1.6377	2.4697
240.00-250.00	52.522	1.1873	213.93	0.4936	0.8109	1.6429
250.00-260.00	41.267	1.2349	107.52	0.5859	1.1772	2.0092
260.00-270.00	12.553	1.3151	37.09	0.4984	0.8267	1.6587
270.00 plus	6.204	0.0000	11.90	0.5214	0.9065	1.7485
Total	94 700.020					

*, X = ((LB-L(i))/(LB-L(i+1))) (M/2K)

than the larger specimens.

YIELD AND MEAN BIOMASS: The results obtained by Thompson and Bell analysis of the stock of *C. carangus* indicated that this species is exposed to higher fishing pressure which is 39% higher than that required to produce the MSY. Further, the present production of 2 314.9 tonnes is (13.5%) lower than the MSY (Fig. 28). The decline in the mean biomass is about 56.9% from the MSY level and 92.6% from the virgin biomass level suggesting an alarming decline in the biomass. A reduction in the fishing effort from the present level by trawlers will not only increase the yield of this species but will also save the stock from impending recruitment overfishing.

Selaroides leptolepis: The magnitude of landings ranged from 3 654 tonnes in 1986 to 9 004 tonnes in 1988 with an annual average catch of 5 726 tonnes. This was mainly landed by trawl nets. The catches were good in January and then gradually declined till May and subsequently showed an increasing trend till December inspite of ups and downs in catch rate from June onwards.

GROWTH: The growth parameters of *S. leptolepis* were estimated to be as L_∞ = 202 mm and K = 0.8/year along the Tamil Nadu coasts (Fig. 29). The PHI' prime (ø) was estimated to be 2.51.

BIOLOGY: The length-weight relationship of this species observed was

$$W = 0.000017119\ L^{2.893187973}$$

The size at which 50% of the population of *S. leptolepis* was mature, varied from 88 to 101 mm and the equivalent age at 50% matu-

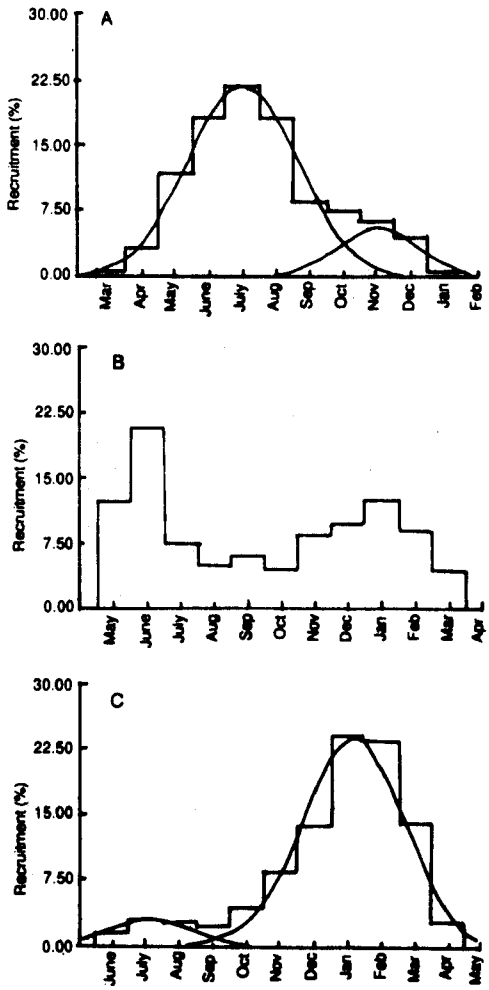


Fig. 20. Absolute percentage recruitment pattern of *Decapterus russelli* exhibiting two recruitment peaks along the (A) east coast, (B) northwest coast and (C) southwest coast.

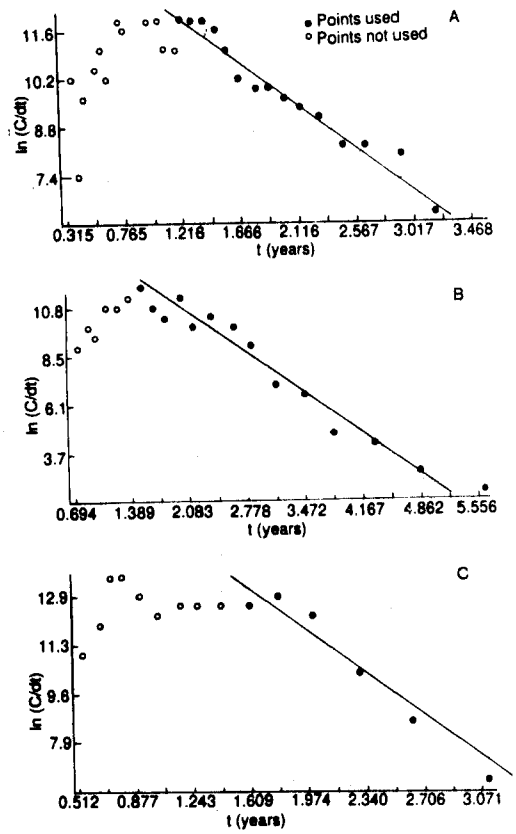


Fig. 21. Estimation of the mortality rate Z by length converted catch curve analysis for *Decapterus russelli* along the (A) east coast (L_∞ = 221 mm, K = 0.71/year, Z = 2.83), (B) northwest coast (L_∞ = 299 mm; K = 0.45/year, Z = 2.85) and (C) southwest coast (L_∞ = 247 mm; K = 0.78/year; Z = 3.88).

rity was estimated to be 0.72 to 0.85 year.

The life span of *S. leptolepis* exhibited a peak period of recruitment in January and a feeble recruitment in October (Fig. 30). From the size at recruitment, it was understood that a brood takes at least 2 to 3 months to get recruited into the fishery. Based on this finding, the time of intensive spawning was judged to be October every year and another less intensive one in July.

MORTALITY RATES: The M was estimated as 1.35 as per Pauly's empirical formula. The M estimated from t_{m50} was higher and that from T_{max} was lower than the above estimate. The instantaneous total mortality Z was estimated to be 4.878 (Fig. 31) and the F to be 3.52 which gave an exploitation ratio of 0.72 indicating a higher rate of exploitation.

Table 7. Catch (C), stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Decapterus russelli* off southwest coast

Interval	C	X*	N	F/Z	F	Z
80.00-90.00	4 088.511	1.0510	1 840 619.88	0.0230	0.0295	1.2855
90.00-100.00	15 513.340	1.0544	1 662 521.13	0.0853	0.1171	1.3731
100.00-110.00	68 798.711	1.0584	1 480 635.63	0.3074	0.5575	1.8135
110.00-120.00	75 843.531	1.0629	1 256 837.38	0.3515	0.6809	1.9369
120.00-130.00	48 438.379	1.0683	1 041 081.38	0.2782	0.4840	1.7400
130.00-140.00	26 432.850	1.0746	866 942.25	0.1878	0.2904	1.5464
140.00-150.00	32 841.320	1.0822	726 175.13	0.2406	0.3980	1.6540
150.00-160.00	38 792.809	1.0916	589 700.94	0.2977	0.5324	1.7884
160.00-170.00	49 905.988	1.1033	459 390.28	0.3922	0.8106	2.0666
170.00-180.00	53 923.531	1.1185	332 158.34	0.4694	1.1113	2.3673
180.00-190.00	85 507.156	1.1390	217 287.44	0.6848	2.7285	3.9845
190.00-200.00	58 492.711	1.1680	92 419.45	0.7825	4.5175	5.7735
200.00-210.00	9 190.028	1.2124	17 664.04	0.6948	2.8591	4.1151
210.00-220.00	2 332.795	1.2888	4 436.89	0.6524	2.3575	3.6135
220.00 plus	430.632	0.0000	861.26	0.5000	1.2560	2.5120
Total	570 101.600					

*, X = ((L8-L(i))/(L8-L(i+1))) (M/2K)

COHORT ANALYSIS: The fishing mortality rates obtained for different size ranges of *S. leptolepis* by cohort analysis (Table 9) indicated that fish of 30–50 mm and above 100 mm were subjected to higher fishing pressure along Tamil Nadu coast.

YIELD AND MEAN BIOMASS: Thompson and Bell analysis of *S. leptolepis* stock along Tamil Nadu coast indicated that this species is being exposed to high fishing intensity since the effort expended at present is 39% higher than the effort required for producing the MSY of 6 583 tonnes. The present production is 5 956 tonnes which is 627.5 tonnes (9.5%) lower than the MSY (Fig. 32). The decline in the mean biomass is 32.6% lower than the mean biomass available at MSY level and 71.7% lower than the virgin biomass level thus rendering considerable loss in the strength of biomass and potential breeders. This situation if not corrected might lead to overfishing. This situation can be reversed and the yield can also be increased through reducing the effort by about 39% from the prevailing level.

Atropus atropus (northwest coast): The landing of *A. atropus* from northwest coast ranged from 461 tonnes in 1981 to 1 651 tonnes in 1986. Of the annual average total landings of 977 tonnes, Maharashtra accounted for the bulk (67.5%). The seasonal abundance of *A. atropus* showed two good periods, one during January–April with a peak in January and the other during September–December with a peak in October (Fig. 11).

GROWTH: The growth parameters of *A. atropus* were estimated to be as L_{∞} = 440 mm and K = 1.0/year along the northwest coast (Fig. 33). The PHI prime (ø) was estimated as 3.29.

BIOLOGY: The length-weight relationship of *A. atropus* along the northwest coast was:

$$W = 0.00003165\ L^{2.85703}$$

The size at 50% maturity was observed to be 210 mm for this species and based on the above mentioned growth parameters, the age

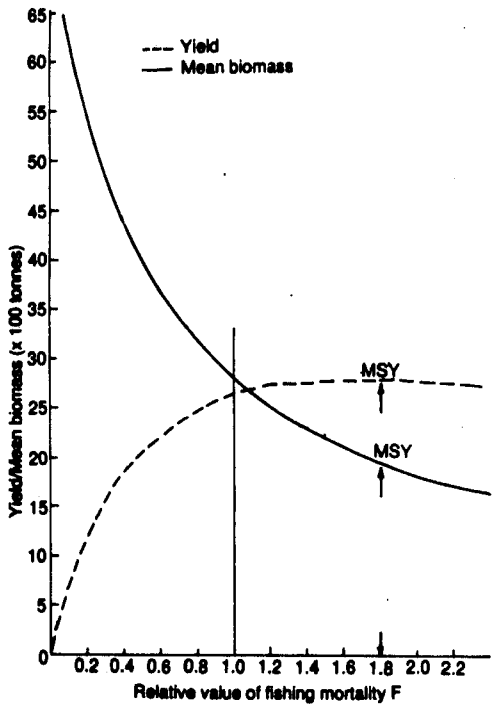


Fig. 22. Yield and mean biomass curves for *Decapterus russelli* exploited by trawlers along the east coast, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

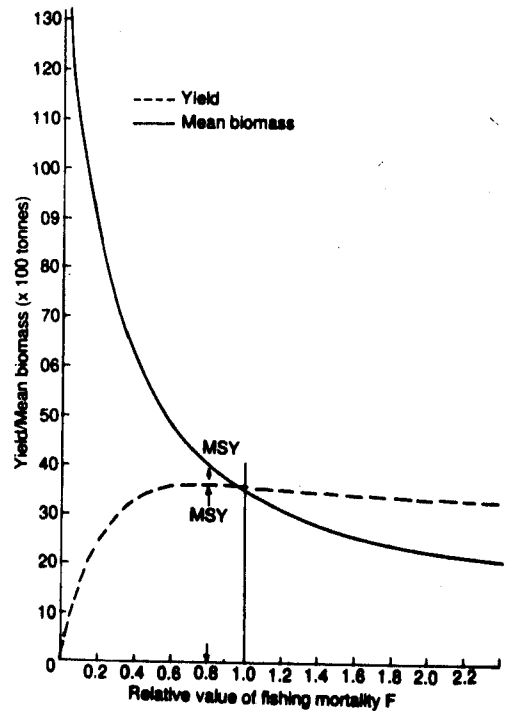


Fig. 23. Yield and mean biomass curves for *Decapterus russelli* exploited by trawlers along the northwest coast, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

at 50% maturity was estimated as 0.65 years. This species was assessed to have a life span of 3 years.

Unlike other species, *A. atropus* appeared to have only one peak period of spawning and recruitment. The recruitment pattern (Fig. 34) indicated that the peak recruitment took place in the month of April and the recruitment period extended from March to June. Based on the time and size at recruitment the spawning period was deduced to be around November or December.

MORTALITY RATES: The M was estimated to be 1.26 as per Pauly's empirical formula, whereas both the estimates obtained from t_{m50} and T_{max} were higher than the above said estimate. The Z was estimated to be 6.85, the highest among all the species studied (Fig. 35), and F was 5.58, which produced an exploitation ratio of 0.82.

COHORT ANALYSIS: The results of the cohort analysis are given in Table 10. The fishing mortality generated by the trawl net indicated that the size ranges between 200 and 325 mm suffered heavy fishing mortality ranging from 2.5370 to 5.4775. This shows that either the smaller and larger size groups are not being exploited well by the trawl net or these size groups are not abundant in the fishing ground of trawlers.

YIELD AND MEAN BIOMASS: Thompson and Bell long-term forecast analysis of the stock of *A. atropus* along the northwest coast indicated that this species was exploited at the

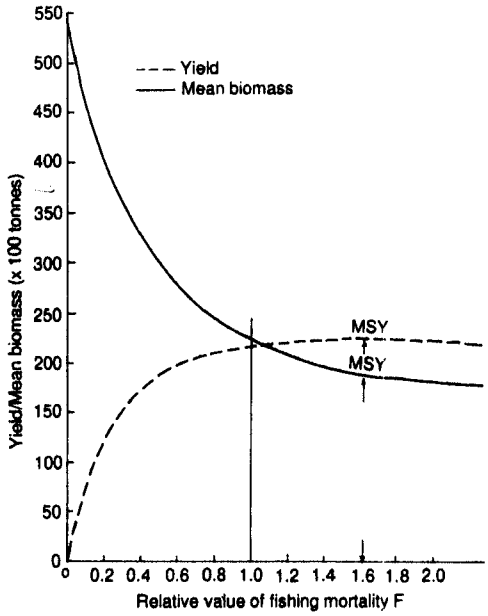


Fig. 24. Yield and mean biomass curves for *Decapterus russelli* exploited by trawlers along the southwest coast, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

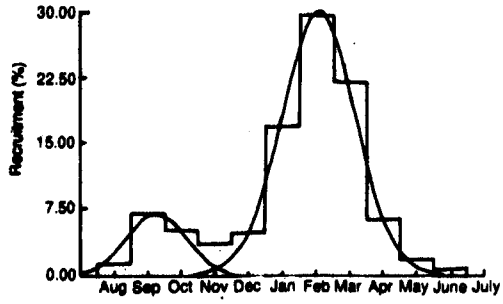


Fig. 26. Absolute percentage recruitment pattern of *Caranx carangus* exhibiting two recruitment peaks along Tamil Nadu and Pondicherry coasts.

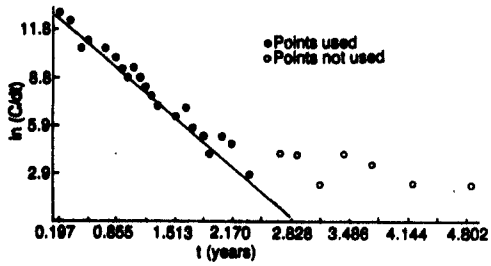


Fig. 27. Estimation of total mortality rate Z by length converted catch curve analysis for *Caranx carangus* along Tamil Nadu and Pondicherry coasts (L_∞ = 444 mm, K = 0.65/year, Z = 4.51)

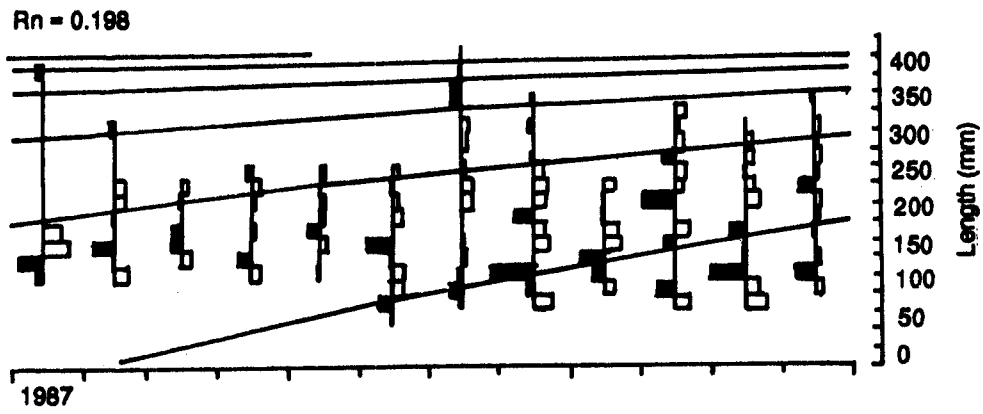


Fig. 25. Growth curve of *Caranx carangus* obtained from pooled length-frequency data collected from trawl net landings off Tuticorin as per ELEFAN I programme.

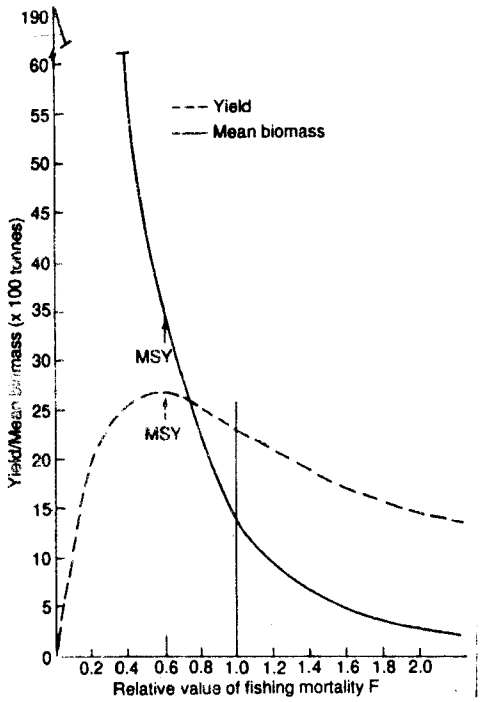


Fig. 28. Yield and mean biomass curves for *Caranx carangus* exploited by trawlers along Tamil Nadu and Pondicherry coasts, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

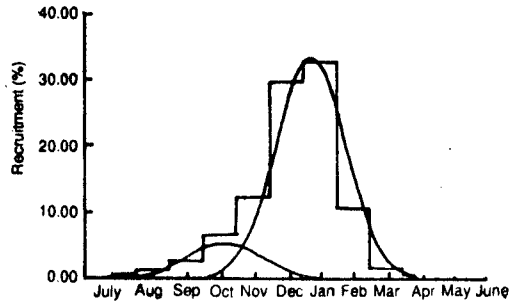


Fig. 30. Absolute percentage recruitment pattern of *Selaroides leptolepis* (exhibiting one recruitment peak) along the Tamil Nadu and Pondicherry coasts.

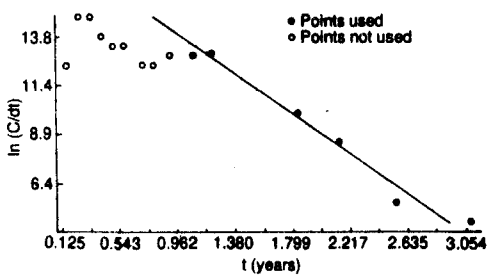


Fig. 31. Estimation of total mortality rate Z by length converted catch curve analysis for *Selaroides leptolepis* along Tamil Nadu and Pondicherry coasts (L_∞ = 202 mm, K = 0.82/year, Z = 4.878).

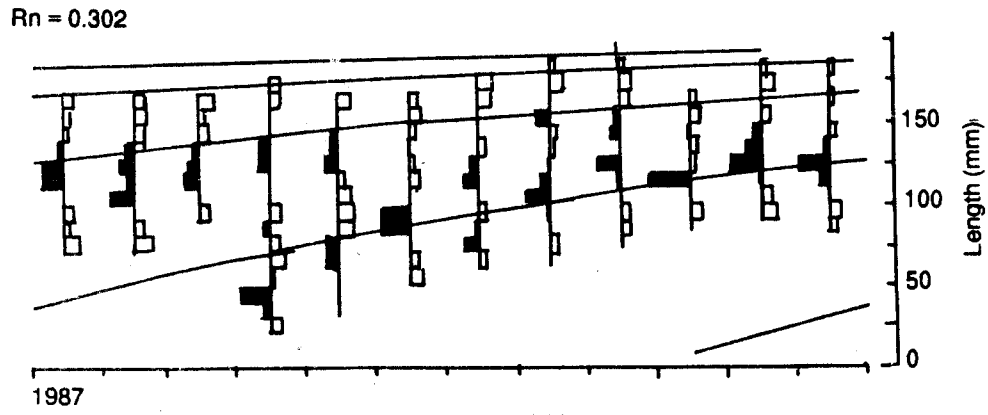


Fig. 29. Growth curve of *Selaroides leptolepis* obtained from the pooled length frequency data collected from trawl net landings off Rameswaram as per ELEFAN I programme.

Table 8. Catch (C), stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Caranx carangus* off Tamil Nadu and Pondicherry coasts

Interval	C	X*	N	F/Z	F	Z
60.00-70.00	1 281.128	1.0195	53 568.54	0.3902	0.6079	1.5579
70.00-80.00	9 921.344	1.0200	50 285.33	0.8495	5.3604	6.3104
80.00-90.00	1 997.256	1.0206	38 605.67	0.5711	1.2650	2.2150
90.00-100.00	1 363.447	1.0212	35 108.45	0.4913	0.9175	1.8675
100.00-110.00	1 712.107	1.0218	32 333.26	0.5632	1.2248	2.1748
110.00-120.00	3 605.080	1.0225	29 293.20	0.7512	2.8690	3.8190
120.00-130.00	3 275.901	1.0232	24 494.39	0.7621	3.0427	3.9927
130.00-140.00	2 590.349	1.0239	20 195.68	0.7480	2.8204	3.7704
140.00-150.00	2 265.588	1.0247	16 732.81	0.7529	2.8944	3.8444
150.00-160.00	2 260.751	1.0256	13 723.61	0.7847	3.4619	4.4119
160.00-170.00	2 050.181	1.0265	10 842.47	0.8038	3.8922	4.8422
170.00-180.00	1 307.100	1.0275	8 291.88	0.7641	3.0774	4.0274
180.00-190.00	1 007.668	1.0286	6 581.27	0.7516	2.8738	3.8238
190.00-200.00	653.636	1.0298	5 240.50	0.7002	2.2187	3.1687
200.00-210.00	381.780	1.0311	4 306.99	0.6101	1.4863	2.4363
210.00-220.00	631.693	1.0324	3 681.18	0.7525	2.8880	3.8380
220.00-230.00	441.855	1.0339	2 841.69	0.7234	2.4840	3.4340
230.00-240.00	322.271	1.0356	2 230.85	0.6977	2.1927	3.1427
240.00-250.00	166.137	1.0374	1 768.96	0.5820	1.3230	2.2730
250.00-260.00	120.852	1.0394	1 483.52	0.5331	1.0848	2.0348
260.00-270.00	71.898	1.0417	1 256.83	0.4290	0.7138	1.6638
270.00-280.00	70.950	1.0442	1 089.25	0.4484	0.7724	1.7224
280.00-290.00	88.749	1.0470	931.03	0.5329	1.0836	2.0536
290.00-300.00	41.979	1.0503	764.48	0.3768	0.5743	1.5243
300.00-310.00	22.217	1.0540	653.06	0.2575	0.3294	1.2794
310.00-320.00	7.069	1.0583	566.77	0.1049	0.1113	1.0613
320.00-330.00	33.817	1.0634	499.36	0.3776	0.5765	1.5265
330.00-340.00	13.304	1.0694	409.81	0.2082	0.2498	1.1998
340.00-350.00	3.792	1.0767	345.91	0.0743	0.0763	1.0263
350.00-360.00	0.000	1.0857	294.87	0.0000	0.0000	0.9500
360.00-370.00	9.512	1.0971	250.17	0.1866	0.2179	1.1679
370.00-380.00	17.835	1.1119	199.20	0.3295	0.4669	1.4169
380.00-390.00	3.277	1.1322	145.07	0.0942	0.0988	1.0488
390.00-400.00	19.642	1.1614	110.28	0.4323	0.7234	1.6734
400.00-410.00	10.476	1.2073	64.84	0.3608	0.5362	1.4862
410.00-420.00	6.547	1.2899	35.81	0.3382	0.4854	1.4354
420.00-430.00	6.547	1.4827	16.45	0.4893	0.9102	1.8602
430.00 plus	1.225	0.0000	3.06	0.3996	0.6324	1.5824
Total	37 783.740					

*, X = ((LB-L(i)/(L8-L(i+1))) (M/2K)

MSY level of 953 tonnes (Fig. 36).

At the MSY level of exploitation, the virgin biomass is reduced by 83%. It is also seen that the vulnerable mature groups of fish are subjected to very high fishing mortalities. It is not advisable to increase the effort any further.

Alepes kalla (southwest coast): The land-

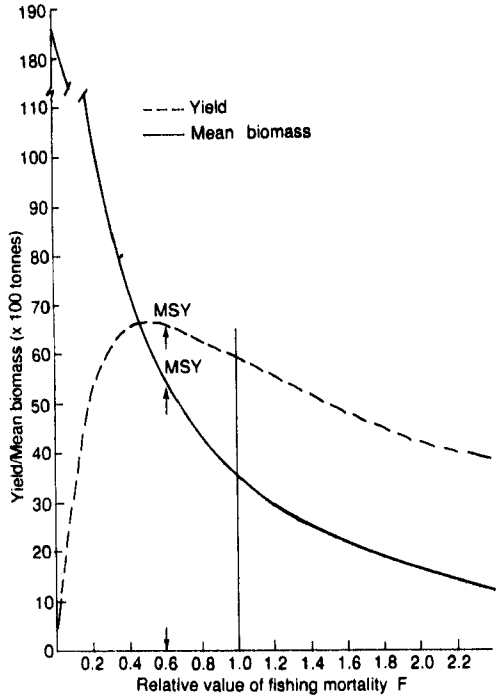


Fig. 32. Yield and mean biomass curves for *Selaroides leptolepis* exploited by trawlers along Tamil Nadu and Pondicherry coasts, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0

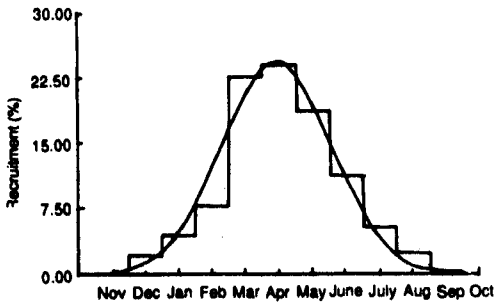


Fig. 34. Absolute percentage recruitment pattern of *Atropus atropus* exhibiting single recruitment peak along the northwest coast.

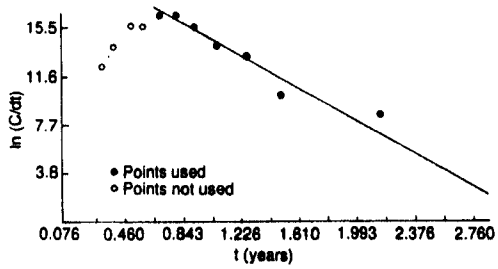


Fig. 35. Estimation of total mortality rate Z by length converted catch curve analysis for *Atropus atropus* along the northwest coast (L_∞ = 440 mm, K = 1.0/ year, Z = 6.85).

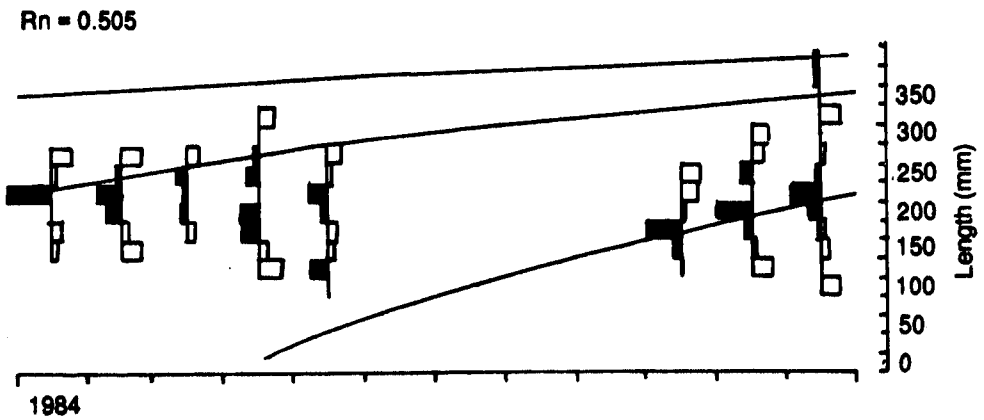


Fig. 33. Growth curve of *Atropus atropus* obtained from the pooled length frequency data collected from trawl net landings off Veraval as per ELEFAN I programme.

Table 9. Catch (C), stock size (N), total mortality (Z), fishing mortality (F), and exploitation ratio (F/Z) obtained from length cohort analysis of *Selaroides leptolepis* off Tamil Nadu and Pondicherry coast

Interval	C	X*	N	F/Z	F	Z
20.00-30.00	13 689.240	1.0486	2 013 153.38	0.0697	0.1013	1.4533
30.00-40.00	173 857.594	1.0519	1 816 731.38	0.5111	1.4133	2.7653
40.00-50.00	222 990.797	1.0553	1 476 552.63	0.6159	2.1682	3.5202
50.00-60.00	92 922.023	1.0592	1 114 516.75	0.4450	1.0840	2.4360
60.00-70.00	55 362.172	1.0636	905 703.25	0.3522	0.7350	2.0870
70.00-80.00	61 447.371	1.0688	748 501.00	0.4075	0.9298	2.2818
80.00-90.00	30 680.039	1.0749	597 705.13	0.2815	0.5298	1.8818
90.00-100.00	33 394.219	1.0822	488 728.97	0.3264	0.5651	2.0071
100.00-110.00	58 834.949	1.0911	386 419.81	0.5083	1.3974	2.7494
110.00-120.00	61 149.012	1.1021	270 661.25	0.5919	1.9606	3.3126
120.00-130.00	65 570.313	1.1162	167 344.98	0.7145	3.3842	4.7362
130.00-140.00	33 367.621	1.1347	75 579.46	0.7209	3.4926	4.8446
140.00-150.00	13 919.040	1.1602	29 295.17	0.7127	3.3540	4.7060
150.00-160.00	5 260.717	1.1978	9 765.36	0.7157	3.4030	4.7550
160.00-170.00	1 632.102	1.2583	2 414.60	0.7464	3.9788	5.3308
170.00 plus	163.080	1.3725	227.92	0.7155	3.4005	4.7525
Total	924 077.200					

*, X = (LB-L(i))/(LB-L(i+1))) (M/2K)

ings of *A. kalla* ranged from 3 230 tonnes in 1981 to 35 508 tonnes in 1986 with an annual average of 14 264 tonnes. The bulk of the catch (61.1%) was contributed by Kerala. The seasonal abundance of this fish in the trawl landings showed peaks in January, May and November.

GROWTH: The growth estimates of *A. kalla* showed that the L_∞ was 170.8 mm and the K was 0.828/year (Fig. 37). The PHI' prime (ø) was estimated to be 2.48, the lowest among all the species studied.

BIOLOGY: The length-weight relationship of *A. kalla* was:

$$W = 0.000003971488\ L^{3.244285}$$

The size at which the 50% of the population of *A. kalla was* mature was 129 mm and the corresponding age was estimated to be 1.70 year based on the growth parameters given above. The life span (T_{max}) of *A. kalla* was estimated as 3.6 years.

The percentage recruitment of *A. kalla* (Fig. 38) indicated two recruitment peaks, a major one in April and a minor one in January. Taking into consideration the size at recruitment and the time of origin of the broods it was ascertained that the corresponding peak period of spawning was in October and the less pronounced spawning was in July every year.

MORTALITY RATES: The M was estimated to be 1.4 as per Pauly (1980) and the values of M obtained from t_{m50} was higher and from T_{max} was lower than the above said estimates.

The Z was estimated to be 3.08 (Fig. 39) and the F as 1.68 which generated an exploitation ratio of 0.55 roughly indicating moderately higher exploitation as the E was higher than the $E_{opt.}$

COHORT ANALYSIS: The results of cohort analysis (Table 11) indicated that for size groups above 90 mm, the F ranged from 1.0186 to 2.0370 giving moderately a higher

Table 10. Catch (C), stock size (N), total mortality (Z), fishing mortality (F), and exploitation ratio (F/Z) obtained from length cohort analysis of *Atropus atropus* off northwest coast

Interval	C	X*	N	F/Z	F	Z
25.00-50.00	0.000	1.0400	5336E+07.00	0.0000	0.0000	1.2640
50.00-75.00	0.000	1.0428	4478E+07.00	0.0000	0.0000	1.2640
75.00-100.00	0.000	1.0459	5314+07.00	0.0000	0.0000	1.2640
100.00-125.00	13 691.020	1.0495	7928E+07.00	0.0141	0.0181	1.2821
125.00-150.00	121 309.297	1.0537	9411 111.00	0.1156	0.1653	1.4293
150.00-175.00	375 909.000	1.0586	8361 971.00	0.2994	0.5401	1.8041
175.00-200.00	723 714.125	1.0646	7106 311.00	0.4773	1.1541	2.4181
200.00-225.00	1 283 391.000	1.0720	5 589 944.50	0.6675	2.5370	3.8010
225.00-250.00	1 519 020.000	1.0813	3 667 127.25	0.7849	4.6121	5.8761
250.00-275.00	894 912.813	1.0933	1 731 801.75	0.8125	5.4775	6.7415
275.00-300.00	255 587.797	1.1094	630 375.06	0.7332	3.4735	4.7375
300.00-325.00	112 159.797	1.1324	281 780.31	0.6963	2.8980	4.1620
325.00-350.00	6 628.984	1.1676	120 701.11	0.1752	0.2685	1.5325
350.00-375.00	0.000	1.2283	82 864.85	0.0000	0.0000	1.2640
375.00-400.00	3 303.388	1.3591	54 919.97	0.1196	0.1717	1.4357
400.00 plus	3 303.388	0.0000	27 300.62	0.1210	0.1740	1.4380
Total	5 309 628.000					

*, X = ((LB-L(i))/(LB-L(i+1))) (M/2K)

exploitation ratio than the E_{opt} in all the size ranges except in 100–110 mm, 140–150 mm, 160 mm and above.

YIELD AND MEAN BIOMASS: As seen from the results of Thompson and Bell analysis the effort has to be increased by 41% to get a meagre 1.36% increase. Further, the increase in the effort may affect the mean biomass more adversely bringing it down by 75.5% over the virgin biomass level (Fig. 40) which in turn might affect the recruitment of the young ones into the fishery. Therefore, it is better to maintain the effort inputs at the present level as the increase in the effort may be uneconomical due to a possible decline in the catch rate.

Alepes djedaba (Kerala): The landings of *A. djedaba* in Kerala ranged from 858.5 tonnes in 1981 to 12 169 tonnes in 1986 with an annual average catch of 4 297 tonnes. The seasonal trend of *A. djedaba* in trawl net and drift gill net are presented in Fig. 7. There were three peaks in catch rate, in January,

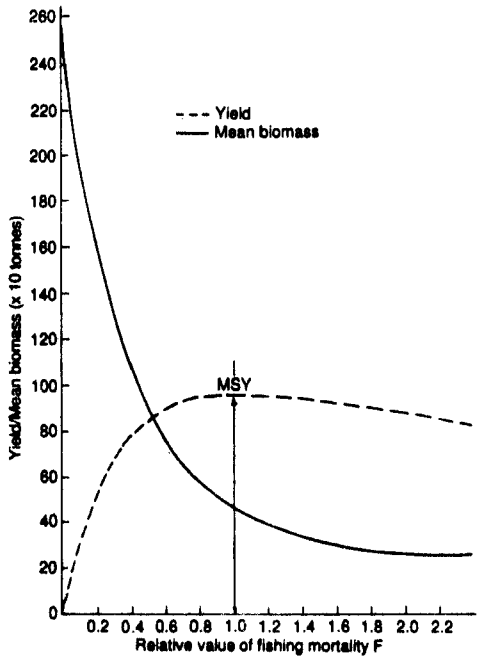


Fig. 36. Yield and mean biomass curves for *Atropus atropus* exploited by trawlers along the northwest coast, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

Table 11. Catch (C), stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Alepes kalla* off southwest coast

Interval	C	X*	N	F/Z	F	Z
60.00-70.00	3 883.318	1.0833	2 825 688.50	0.0092	0.0130	1.4130
70.00-80.00	4 851.638	1.0923	2 404 471.50	0.0123	0.0175	1.4175
80.00-90.00	112 488.500	1.1037	2 010 670.75	0.2435	0.4507	1.8507
90.00-100.00	332 741.906	1.1182	1 548 745.13	0.5476	1.6947	3.0947
100.00-110.00	181 599.000	1.1374	941 116.38	0.4865	1.3263	2.7263
110.00-120.00	164 779.906	1.164	567 830.88	0.5676	1.8374	3.2374
120.00-130.00	100 348.602	1.2036	277 495.59	0.5927	2.0370	3.4370
130.00-140.00	35 647.531	1.2683	108 177.83	0.5164	1.4947	2.8947
140.00-150.00	11 459.510	1.3936	39 141.16	0.4212	1.0186	2.4186
150.00-160.00	6 231.251	1.7404	11 931.33	0.5385	1.6333	3.0333
160.00 plus	176.599	0.0000	358.80	0.4922	1.3569	2.7569
Total	14 662.040					

*, X = ((LB-L(i))/(LB-L(i+1))) (M/2K)

June and November, in the landings of trawl nets while there were two peaks, in June and October, in the drift gill net landings.

GROWTH: The growth parameters of *A. djedaba* were estimated as L_{∞} = 326 mm and K = 0.61/year (Fig. 41). The PHI' prime (Ø) was estimated as 2.81.

BIOLOGY: The length-weight relationship of *A. djedaba* was:

$$W = 0.000004914418\ L^{3.14689}$$

Fifty per cent of the population of this species were mature for the first time at 180–189 mm. The life span (T_{max}) of this species was deduced to be 4.9 years.

SPAWNING AND RECRUITMENT: The recruitment pattern of *A. djedaba* (Fig. 42) indicated that there were two recruitments, a highly pronounced one in June and a feeble one in March which overlap each other giving an appearance that there is only one peak

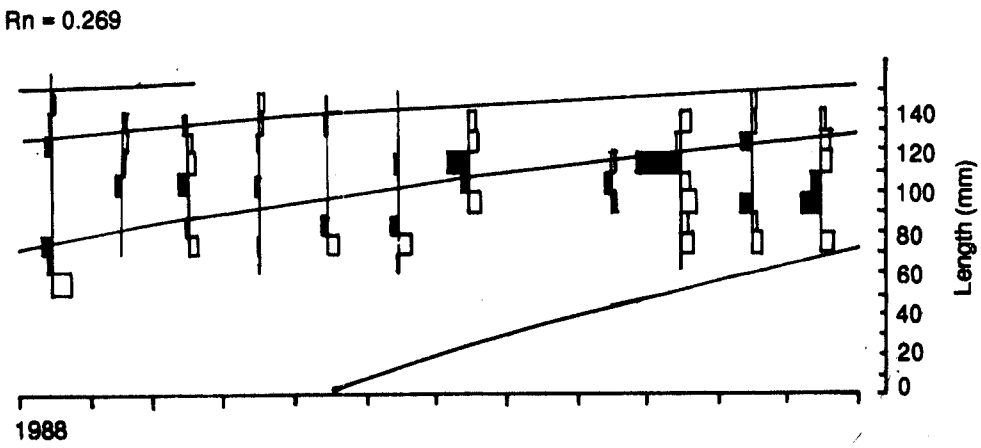


Fig. 37. Growth curve of *Alepes kalla* obtained from the pooled length frequency data collected from trawl net landings off Cochin as per ELEFAN I programme.

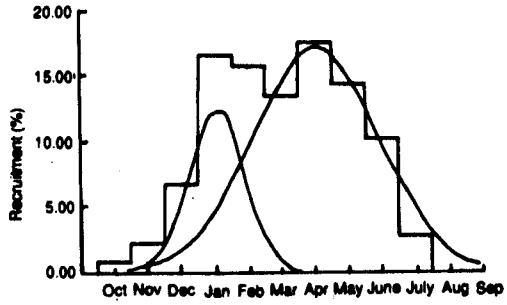


Fig. 38. Absolute percentage recruitment pattern of *Alepes kalla* (exhibiting two recruitment peaks) along the southwest coast.

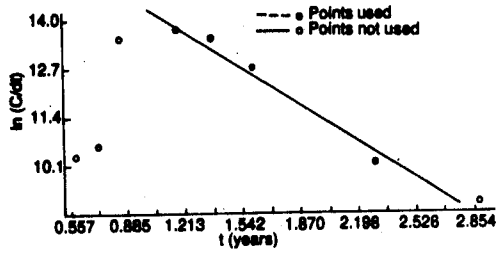


Fig. 39. Estimation of total mortality rate Z by length converted catch curve analysis for *Alepes kalla* along the southwest coast (L_∞ = 170.8 mm, K = 0.828/year, Z = 3.08).

period of recruitment. Considering the size at recruitment and the time it takes to get recruited in to the fishery, the probable peak time of spawning was deduced to be in December followed by a less pronounced spawning in September.

MORTALITY RATES: The M was estimated to be 0.99 as per Pauly (1980) and the estimates obtained with t_{m50} and T_{max} were very close to that estimate. The Z was estimated as 5.15 from the catch curve (Fig. 43) and the F as 4.16 which gave an exploitation ratio of 0.81 roughly indicating that the stock of *A. djedaba* was overfished.

COHORT ANALYSIS: The results of cohort analysis with regard to *A. djedaba* are given in Table 12. The F generated over the entire size range of 90–290 mm and above varied from 0.0265 to 0.9360 and the resultant exploitation ratio E did not exceed the E_{opt} at any of the size ranges suggesting that the stock of *A. djedaba* was not exposed to higher fishing pressure.

YIELD AND MEAN BIOMASS: The results of Thompson and Bell analysis for *A. djedaba* indicated that this species is underfished and the catch can be increased by 40.83% by increasing the present level of effort by 220% (Fig. 44). But the virgin biomass left at F_{MSY} level will be only 24.3%. So, care has to be taken to see that virgin biomass level is not reduced to such low levels while increasing

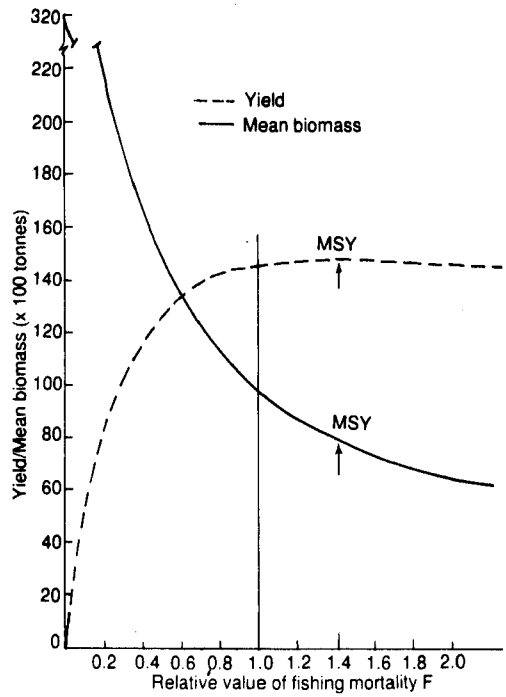


Fig. 40. Yield and mean biomass curves for *Alepes kalla* exploited by trawlers along the southwest coast, in relation to fishing effort as percentage of the current effort expenditure which is indicated by a straight line at 1.0.

Table 12. Catch (C), stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Alepes djedaba* off Kerala coast

Interval	C	X*	N	F/Z	F	Z
90.00-100.00	1 293.581	1.0358	42 866.60	0.3111	0.4471	1.4371
100.00-110.00	2 506.139	1.0374	38 708.90	0.4860	0.9360	1.9260
110.00-120.00	994.353	1.0392	33 551.90	0.2890	0.4023	1.3923
120.00-130.00	192.878	1.0412	30 110.67	0.0765	0.0820	1.0720
130.00-140.00	379.214	1.0434	27 589.28	0.1452	0.1682	1.1582
140.00-150.00	553.213	1.0459	24 977.89	0.2071	0.2585	1.2485
150.00-160.00	796.912	1.0486	22 306.24	0.2866	0.3978	1.3878
160.00-170.00	1 005.942	1.0517	19 526.02	0.3555	0.5461	1.5361
170.00-180.00	878.298	1.0552	16 696.61	0.3466	0.5250	1.5150
180.00-190.00	634.671	1.0593	14 162.22	0.2966	0.4175	1.4075
190.00-200.00	231.097	1.0639	12 022.65	0.1428	0.1649	1.1549
200.00-210.00	111.927	1.0694	10 403.90	0.0793	0.0853	1.0753
210.00-220.00	111.927	1.0759	8 992.62	0.0843	0.0911	1.0811
220.00-230.00	30.468	1.0837	7 664.60	0.0261	0.0265	0.0165
230.00-240.00	0.000	1.0934	6 497.87	0.0000	0.0000	0.9900
240.00-250.00	178.851	1.1055	5 435.49	0.1555	0.1824	1.1724
250.00-260.00	251.739	1.1213	4 285.66	0.2285	0.2933	1.2833
260.00-270.00	171.633	1.1426	3 184.13	0.1917	0.2347	1.2247
270.00-280.00	184.887	1.1731	2 288.63	0.2361	0.3060	1.2960
280.00-290.00	102.753	1.2201	1 505.52	0.1777	0.2139	1.2039
290.00 plus	219.908	0.0000	927.17	0.2372	0.3078	1.2978
Total	544.227					

*, X = ((LB-L(i)/(LB-L(i+1))) (M/2K)

the effort.

Atule mate (Kerala): The landings of *A. mate* in Kerala ranged from 757.5 tonnes in 1981 to 10 738 tonnes in 1986 with an annual

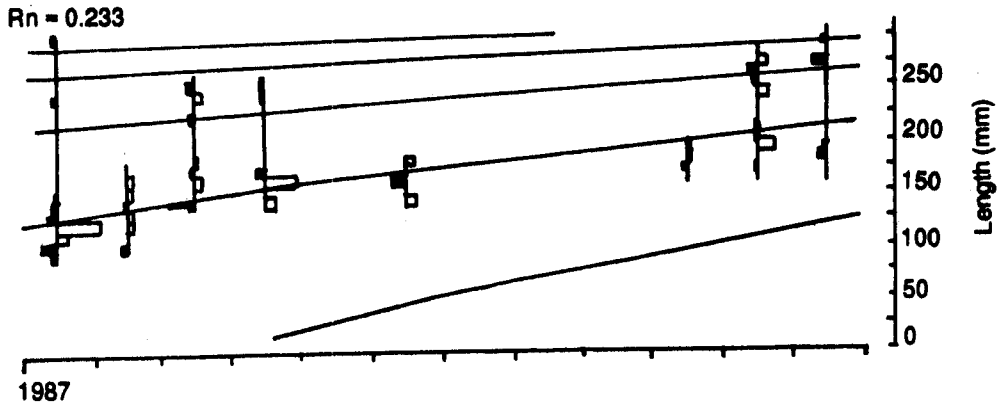


Fig. 41. Growth curve of *Alepes djedaba* obtained from the pooled length frequency data collected from trawl net landings off Cochin as per ELEFAN I programme.

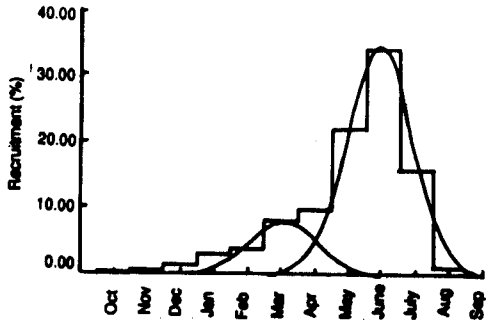


Fig. 42. Absolute percentage recruitment pattern of *Alepes djedaba* (exhibiting two recruitment peaks) along the Kerala coast.

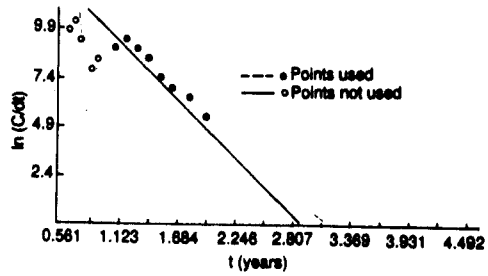


Fig. 43. Estimation of total mortality rate Z by length converted catch curve analysis for *Alepes djedaba* along the Kerala coast (L_∞ = 326 mm, K = 0.61/ year, Z = 5.15).

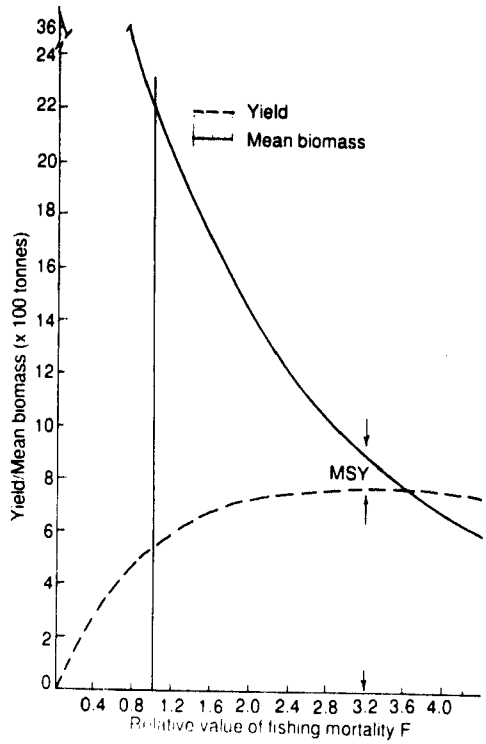


Fig. 44. Yield and mean biomass curves for *Alepes djedaba* exploited by trawlers along the Kerala coast, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

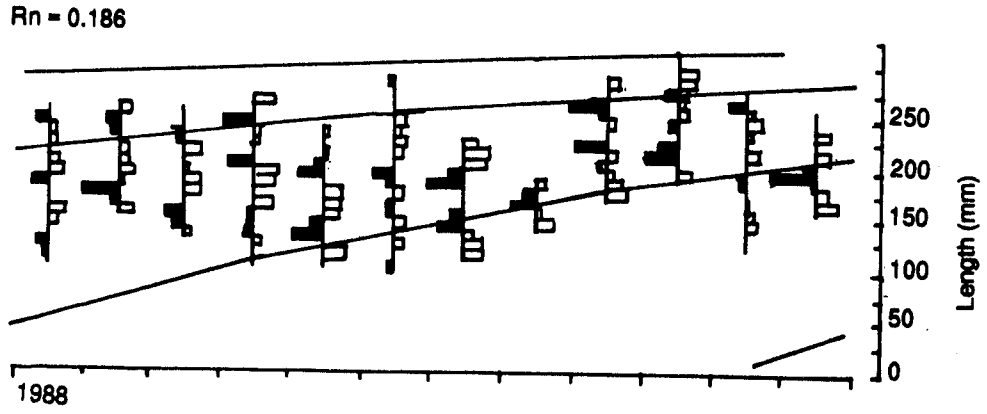


Fig. 45. Growth curve of *Atule mate* obtained from the pooled length frequency data (1981-86) collected from hooks and line landings off Vizhinjam as per ELEFAN I programme.

Table 13. Catch (C), stock size (N), total mortality (Z), fishing mortality (F) and exploitation ratio (F/Z) obtained from length cohort analysis of *Atule mate* off Kerala coast

Interval	C	X*	N	F/Z	F	Z
100.00-105.00	13 859.240	1.0152	2546E+08.00	0.0042	0.0052	1.2212
105.00-110.00	4 182.461	1.0155	9697E+08.00	0.0013	0.0016	1.2176
110.00-115.00	7 134.662	1.0158	7247E+08.00	0.0022	0.0027	1.2187
115.00-120.00	5 718.189	1.0162	0507E+08.00	0.0018	0.0022	1.2182
120.00-125.00	247 288.094	1.0166	2152E+07.00	0.0729	0.0956	1.3116
125.00-130.00	40 746.039	1.0170	2956E+07.00	0.0129	0.0159	1.2319
130.00-135.00	47 841.988	1.0174	8023E+07.00	0.0153	0.0189	1.2349
135.00-140.00	139 640.594	1.0178	5702E+07.00	0.0439	0.0559	1.2719
140.00-145.00	478 137.313	1.0183	7741E+07.00	0.1376	0.1940	1.4100
145.00-150.00	554 447.813	1.0188	0289E+07.00	0.1585	0.2290	1.4450
150.00-155.00	803 896.125	1.0193	0381E+07.00	0.2179	0.3387	1.5570
155.00-160.00	791 271.375	1.0198	1393E+07.00	0.2190	0.3410	1.5570
160.00-165.00	677 570.875	1.0204	0073E+07.00	0.1971	0.2986	1.5146
165.00-170.00	2 017 334.000	1.0210	6377E+07.00	0.4303	0.9185	2.1345
170.00-175.00	1 991 136.000	1.0216	7582E+07.00	0.4382	0.9483	2.1643
175.00-180.00	1 659 878.000	1.0223	3148E+07.00	0.4034	0.8221	2.0381
180.00-185.00	893 375.813	1.0230	3886E+07.00	0.2752	0.4617	1.6777
185.00-190.00	785 838.875	1.0237	9269E+07.00	0.2562	0.4188	1.6348
190.00-195.00	952 829.125	1.0245	2497E+07.00	0.3014	0.5247	1.7407
195.00-200.00	689 815.813	1.0254	6399E+07.00	0.2442	0.3928	1.6088
200.00-205.00	1 319 961.000	1.0264	3872E+07.00	0.3915	0.7823	1.9983
205.00-210.00	1 919 742.000	1.0274	6706E+07.00	0.4982	1.2071	2.4231
210.00-215.00	1 979 337.000	1.0285	1345E+07.00	0.5243	1.3404	2.5564
215.00-220.00	2 031 330.000	1.0296	3844E+07.00	0.5516	1.4959	2.7119
220.00-225.00	3 511 076.000	1.0309	5591E+07.00	0.7067	2.9294	4.1454
225.00-230.00	3 069 934.000	1.0323	8739E+07.00	0.7143	3.0404	4.2564
230.00-235.00	2 031 831.000	1.0338	8965E+07.00	0.6614	2.3751	3.5911
235.00-240.00	1 301 588.000	1.0355	1756E+07.00	0.5893	1.7448	2.9608
240.00-245.00	1 636 413.000	1.0374	0884E+07.00	0.6762	2.5393	3.7553
245.00-250.00	1 810 768.000	1.0394	9 488 801.00	0.7396	3.4535	4.6695
250.00-255.00	664 423.125	1.0417	7 040 455.00	0.5581	1.5355	2.7515
255.00-260.00	353104.313	1.0443	5 849 858.00	0.4285	0.9116	2.1276
260.00-265.00	1 216 197.000	1.0472	5 025 765.00	0.7580	3.8079	5.0236
265.00-270.00	1 027 855.000	1.0506	3 421 194.50	0.7907	4.5943	5.8103
270.00-275.00	432547.500	1.0544	2 121 289.50	0.6936	2.7531	3.9691
275.00-280.00	1 039 869.000	1.0589	1 497 690.00	0.9089	12.1376	13.3536
280.00-285.00	192 527.094	1.0642	353 642.50	0.8661	7.8631	9.0791
285.00 plus	105 444.180	0.0000	131 341.80	0.8028	4.9510	6.1670
Total	38 331 450.000					

*, X = ((LB-L(i)/(L8-L(i+1))) (M-2K)

average of 3 364 tonnes. There were two peaks of abundance, the major in May and the minor in October, in the landings of hooks and lines. Four peaks were noticed in the gill net landings in January, April, July and October.

GROWTH: The growth parameters of *A. mate* were estimated as L_∞ = 340 mm and K =0.85/year (Fig. 45). The PHI' prime (Ø) was

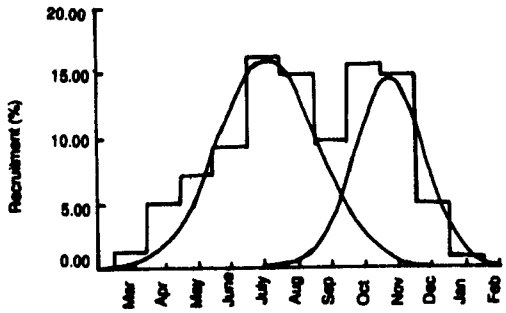


Fig. 46. Absolute percentage recruitment pattern of *Atule mate* (exhibiting two recruitment peaks) along the Kerala coast.

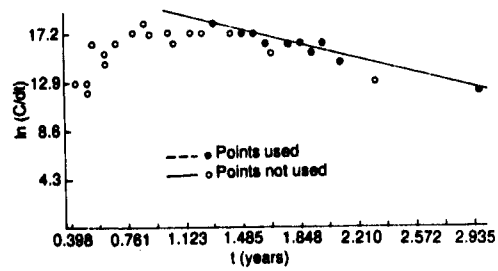


Fig. 47. Estimation of total mortality rate Z by length converted catch curve analysis for *Atule mate* along the Kerala coast (L_∞ = 340 mm, K = 0.85/year, Z = 3.50)

estimated as 2.99.

BIOLOGY: The length-weight relationship of *A. mate* observed was:

$$W = 0.000007933\ L^{3.05686}$$

The size at which 50% of the population of *A. mate* matured for the first time was 172 mm and the corresponding age estimated using the above said growth parameters was 0.83 years. The T_{max} or life span of this species was estimated as 3.5 years.

SPAWNING AND RECRUITMENT: The recruitment pattern of *A. mate* shown in Fig. 46 indicated the recruitment as a continuous process throughout the year with two equally important peaks of recruitment in July and October. Based on the size at recruitment it was deduced that the time of peak spawning was April and May in the first instance and January and February in the second instance.

MORTALITY RATES: The natural mortality M estimated from Pauly's empirical formula was 1.22 and the values of M obtained from t_{m50} and T_{max} were marginally higher than the above said estimate (Table 1). The Z was estimated to be 3.53 from length converted catch curve (Fig. 47) and the F was 2.31 which gave an exploitation ratio E of 0.65 roughly indicating that *A. mate* was marginally overexploited.

COHORT ANALYSIS: The results of cohort analysis given in Table 13 indicated that the exploitation ratio generated from 100–210 mm size group was lower than the E_{opt}, roughly suggesting that these size ranges were not exposed to higher fishing pressure whereas the sizes above 210 mm were under higher

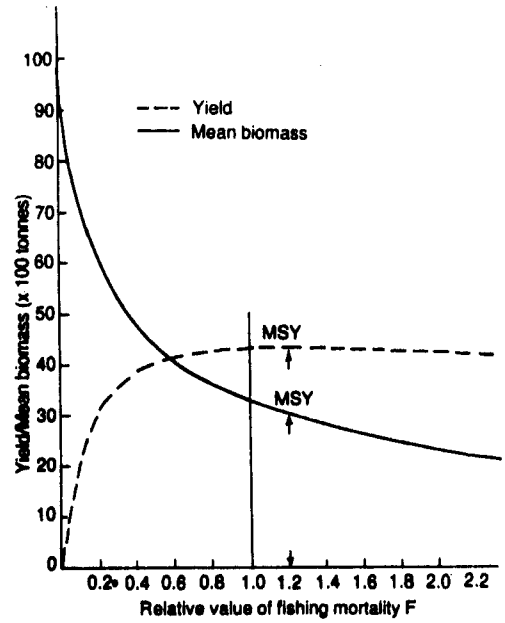


Fig. 48. Yield and mean biomass curves for *Atule mate* exploited by hooks and line along Kerala coast, in relation to fishing effort as percentage of the current effort indicated by a straight line at 1.0.

fishing pressure.

YIELD AND MEAN BIOMASS: The results obtained as per Thompson and Bell analysis for *A. mate* suggest that an increase of 21.0% of effort over present effort is necessary to realize the MSY of 4 305.7 tonnes which is a meagre 12.4 tonnes (0.3%) above the present yield (Fig. 48). On the other hand there will be a further decline of 9.2% in the mean biomass. Since there is no economic advantage, the present level of effort input can be maintained for the optimum exploitation of *A. mate* along the Kerala coast.

DISCUSSION

Differential growth was observed not only among the 8 species studied but within the species from region to region. Such variation was observed in *M. cordyla* and *D. russelli* along east, northwest and southwest coasts. PHI' prime value (Ø') suggested by Pauly and Munro (1984) is expected to indicate growth performance among the species.

Kasim and Hamsa (1994) reported the growth parameters of *C. carangus* and *S. leptolepis* as L_∞ = 498 mm, K = 0.7689/year and L_∞ = 213 mm, K = 1.4233/year respectively which are higher than the estimates obtained in this study for these species.

The natural mortality coefficient obtained as per Pauly's empirical formula closely agrees with the estimates of M obtained from age at 50% maturity (t_{m50}) and life span T_{max} (Table 1). The total mortality rate obtained from catch curve method ranged from 0.08 (*M. cordyla* along east coast) to 6.85 (*A. atropus* along northwest coast) and the exploitation ratios obtained from these estimates were higher than the E_{opt}, i.e. 0.5, for all the species, roughly indicating that all the eight species presently studied are exposed to higher fishing pressure.

However, a detailed study on the stocks of these species by Jones' length cohort analysis and Thompson and Bell long-term forecast analysis provided more information on the exploitation of these species. These studies indicated underexploitation of *M. cordyla* along southwest coast, *D. russelli* along east and southwest coasts and *A. kalla, A. djedaba* and *A. mate* along the southwest coast. The fishing effort of the respective species can be increased from the present level (1984–88) varying from 21% in the case of *A. mate* to 220% in the case of *A. djedaba,* both from Kerala coast. However, the increase in the production from the existing level ranges from 12.4 tonnes in *A. mate* to 441.6 tonnes in *D. russelli* along southwest coast and the percentage increase in production varied from 0.3% in *A. kalla* to 29.4% in *A. djedaba.* The virgin biomass is reduced to critical levels at F_{msy} level in all the species except in *M. cordyla* (31.94%) from east coast, *D. russelli* (32.71%) from southwest coast and *A. mate* (31.74%) from Kerala coast though in these species also the reduction in virgin biomass is high if not critical. This clearly shows that the exploitation of these species has already reached optimum and even over-optimum levels in the case of some species possibly leading to recruitment overfishing. Hence, further increase in the effort of the gears in which these species are caught may be considered only after critically studying economic feasibility of such increase in the effort under prevailing situation.

The information on the sizewise exposure of the fish to fishing mortality obtained from Jones' cohort analysis indicated that larger individuals of *M. cordyla* above 205 mm are exposed to highest fishing pressure by drift gill net. *D. russelli* above 170 mm are exposed to intensive exploitation by trawl net. Similarly sizes above 210 mm of *A. mate* are exposed to overexploitation by hooks and line. On the

other hand, middle-sized groups i.e. 110–140 mm of *A. kalla* and 200–325 mm of *A. atropus* are well exploited by trawl net, whereas *C. carangus* is exposed to growth overfishing , since smaller young ones ranging from 70–260 mm suffer higher fishing mortality by trawl net. This kind of unusual selective exploitation by a non-selective gear like trawl net may be either due to a possible migration of larger size groups of these species away from the fishing area or altogether non-availability of these size groups in the fishing grounds of trawlers.

Kasim and Hamsa (1994) have reported that *C. carangus* is also exposed to overfishing by trawlers off Tuticorin whereas *S. leptolepis* is not exposed to higher fishing mortality by trawlers in the same region. Present estimates have been obtained for the entire region i.e. northwest and Tamil Nadu coast likewise employing cohort analysis and Thompson and Bell model and the results agree with the earlier work.

Since the principal aim of the three gears studied here is not to exploit the carangid resource as the target resource, a demand to reduce the effort of any one of the three gears from the present level of effort as in the case of *M. cordyla* along east and northwest coast, *D. russelli* along northwest coast and *C. carangus* and *S. leptolepis* along Tamil Nadu coast will not be appreciated unless the target resources of the concerned gear also exhibit a similar situation demanding a reduction in effort.

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