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ASSESSMENT OF THE EXPLOITED SEERFISH STOCKS IN THE INDIAN WATERS

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ABSTRACT

The annual average catch of seerfishes from the Indian seas during 1990-'94 was 37,926 t, which constituted 1.7% of the total marine fish catch in India. Though there was an increasing trend in the seerfish production in the decades upto the 1990's the rate of increase through the successive decades decreased, suggesting the attainment of near optimum level of production. State-wise production showed that during the 1990's Gujarat (22.8%) followed by Maharashtra (16.9%), Kerala (16.2%), Andhrapradesh (14.3%) and Tamilnadu (11.5%) were the dominant seerfish producers. Gearwise production indicated that the gillnet landed 65.1%, trawl 11.5% and hooks and lines 6.9%, while the rest was landed by the boatseines, shoreseines and purseseines. Among the four species, *Scomberomorus commerson* (55.3%) and *S. guttatus* (43.9%) sustained the fishery, while *S. lineolatus* and *Acanthocybium solandri* formed only a negligible portion of the fishery. The growth parameters such as L ∞ and K for these three species for different centres along both the coasts showed variation.

Thompson and Bell analysis indicated that all the states on the east coast overexploited this stock by 80% higher effort than the optimum. Along the west coast, the states Karnataka and Goa overexploited it by 80%, Kerala by 60% and Maharashtra and Gujarat by 40% effort higher than the f_{MSY} levels. The spotted seer is underexploited by the gillnets but overexploited by the trawls in Tamilnadu, Karnataka and Gujarat. The streaked seer is also overexploited in the Indian waters. Stock assessment of the seerfish resources as a whole by the surplus production model revealed that except West Bengal and Kerala, in all other states this resource was either under exploited or the production was very close to the MSY level. Recommendations for proper management of the fishery have been proposed.

INTRODUCTION

SEERFISHES or Spanish mackerels belonging to the genera *Scomberomorus, Acanthocybium* and *Grammatorcynus* of the family *Scombridae* are of special interest to Indian marine fisheries because of their high commercial value. The species of the first two genera found in the Indian seas are the king seer *Scomberomorus commerson* Lacepede, the spotted seer *S. guttatus* (Bloch and Schneider), the streaked seer *S. lineolatus* (Cuvier and Valenciennes), the Korean seer *S. koreanus* (Kishinouye) and the Wahoo *Acanthocybium solandri* Gill of which, however, the fishery is sustained mostly by the first two species.

With an annual average catch of 37,926 t during 1990-'94, the seerfish formed 1.7% of the total marine fish catch in India. Increasing trend was observed in the seerfish production since 1950. The east coast contributed more (60.2%) than the west coast during 1950-'63, but subsequently the west coast became more dominant (64%) in seerfish production during 1980-'94. Among the various states Gujarat (22.8%), Maharashtra (16.9%), Kerala (16.1%), Andhrapradesh (14.3%) and Tamilnadu (11.5%) were the principal contributors of seerfish during 1989-'94. The resource is exploited mainly by the gillnets (65.1%) and hooks and lines (6.96%), but in recent years the trawls (11.4%)

also have been landing significant quantities from deeper waters beyond the 50 m depth contours.

Though literature on taxonomy, distribution and various aspects of seerfishes are available, information on the stock

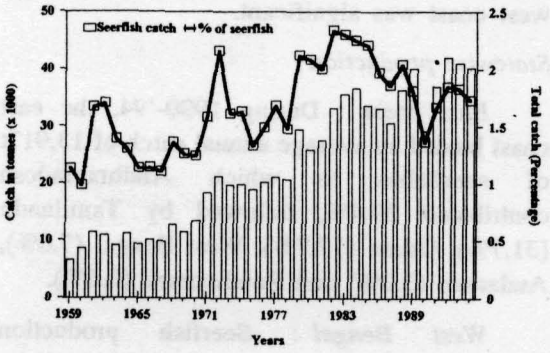


FIG. 1. *Total production and percentage composition of seerfish in the total marine fish production in India during 1959-94.*

assessment and management of the fishery is either very scanty or location-based (Devaraj, 1983; Kasim and Hamsa, 1989; Thiagarajan, 1989; Yohannan *et. al.,* 1992 and Pillai *et. al.,* 1994). There is a need to assess the status of the stocks of all the component species and their exploitation on all-India basis to provide information for optimising their production. The fishery managers, administrators and development officials should be able to use this information to formulate the required measures for the proper management of the seerfish fishery of the country.

MATERIAL AND METHODS

Statewise, gearwise, specieswise and quarterwise data on seerfish production and effort for the period 1989-'94 estimated by the Fisheries Resources Assessment Division of the C.M.F.R. Institute were used as the database. Since the resource is exploited by different gears like the gillnets, trawls, hooks and line, seines etc., the effort expended by each of these gears was standardised separately. The gillnets include the drift gillnet, surface gillnet and bottom-set gillnet with mesh size varying from 25 mm to 250 mm. Among them the gillnets with larger mesh size of 120 mm to 170 mm operated by mecahnised craft have been found to be very efficient in the exploitation of seerfishes. The standardised effort was calculated keeping the mechanized gillnetter as the standard unit, following the method adopted by Silas and Pillai (1985). In the case of hooks and lines fishery, the mechanised unit was taken as standard unit and the effort was standardised against the nonmechanised units. For the trawlers, the standard effort between the small mechanised trawlers and the large mechanised trawlers was calculated taking the former as the standard unit.

The effort of all the gears which exploit the seerfish have been further standardised and a 'relative effort' was obtained as described by Sparre and Venema (1992) for stock assessment by the Schaefer's Surplus production model (Graham, 1935).

The length frequency data collected on *S. commerson, S. guttatus* and *S. lineolatus* from the landings of different gears operated along the east and west coasts of India at different centres like Veraval (1992-'95), Mangalore (1993-'95), Calicut (1992-'95), Cochin (1993-'95), Tuticorin (1992-'95), Mandapam Camp (1967-'69), and Madras (1995) were used to study the growth parameters such as $L \infty$, K and t_o as per ELEFAN I (Pauly and David, 1981; Pauly, 1987 and Bagenal 1955) method. The natural mortality rate (M) was estimated by the empirical formula proposed by Pauly (1980) and the total mortality rate

(Z) by the catch curve method (Pauly, 1984). The fishing mortality rate (F) was obtained by subtracting the M from Z. The exploitation ratio (E) was obtained from the relation E=F/Z and the exploitation rate (U) from the equation $U=F/Z\ (1-e^{-Z})$. The total stock (P) was estimated from the relation P=Y/U where Y is the yield in t and U is the exploitation rate. The Lc 50 and Lc 75 were obtained from the probability of catch from the catch curve. The stocks were assessed as per the Schaefer's model (Graham, 1935), the Beverton and Holt (1957) and the Thompson and Bell (1934) models.

RESULTS

Status of the Fishery

Seerfish production in India exhibited an increasing trend during the past 4 decades from the sixties to the nineties but with marked year to year fluctuations. The annual catch varied from a 6,590 t in 1959 to 42,140 t in 1992 with an average annual production of 23,255 t. The contribution of seerfish to the all-India marine fish catch varied from 0.98% in 1960 to 2.34% in 1982 (Fig. 1). During the decade of 1960-'69 the average annual catch was 10,499 t, which doubled to 20,300 t (+93.4%) in the subsequent decade (1970-'79), further increased to 33,297 t (+64%) during 1980-'89 and during 1990-'94 the catch stabilised at an average annual of 37,926 t (+13.9%). This progressive decrease in the decadal increment indicated near optimum level of production currently.

The pronounced increase in the production during the 1970's and the 1980's was due to the introduction and subsequent intensification of mechanisation of the craft and the use of synthetic fishing materials for the fabrication of efficient fishing gears. Intensification of mechanised trawling into multiday operations in deeper grounds was another reason for the increase in the production. Initially, during the 1950's the east coast landed more seerfishes (60%) than the west coast. During 1964-'84 it was found to be 50:50, which changed to 37:63 during 1980-'89, and then to 35:65 during 1990-'94. Thus, though the production increased along both the coasts, the increase from the west coast was significant.

Statewise production

East coast : During 1990-'94, the east coast landed an average annual catch of 13,917t of seerfishes to which Andhrapradesh contributed 39.4%, followed by Tamilnadu (31.7%), Orissa (17.7%), West Bengal (7.6%), Andaman (3.0%) and Pondicherry (0.6%).

West Bengal : Seerfish production increased from a mere 32 t in 1977 to 1,604 t in 1991 with an average annual catch of 573 t during 1976-'94. The resource formed 7.6% of the total seerfish production from the east coast and 2.8% of the all-India catch during 1990-'94. In general the landing exhibited an increasing trend.

Orissa : The catch varied from 651 t in 1985 to 2,705 t in 1992, with an average annual catch of 1,750 t during 1976-'94. It contributed 17.7% to the total seerfish catch from the east coast and 6.4% to the total all India seerfish production.

Andhrapradesh : The production fluctuated from 2,600 t in 1978 to 8,072 t in 1984, with an average annual catch of 4,878 t during 1970-'94. Andhrapradesh contributed the maximum (39.4%) to the catch from the east coast. During 1990-'94 the average annual catch of 5,482 t formed 14.3% of the all-India seerfish catch.

Tamilnadu : Average annual production was 4,701 t during 1970-'94 and came down slightly to 4,406 t by 1990-'94 forming 11.5%

of the all-India's seerfish landings. Unlike in the other states, the production in Tamilnadu either stabilized or tended to decline in the recent years.

Pondicherry : The average annual catch of 53 t in the 1970's increased to 122 t in the 1980's but declined to 87 t in the 1990's, thus reflecting a trend similar to that in Tamilnadu. The production during 1990-'94 formed 0.6% of the east coast catch and 0.2% of the all-India catch.

Andaman : The production though oscillated, exhibited an increasing trend from an average annual catch of 89 t in the 1970's to 300 t in the 1980's and to 427 t in the 1990's. In recent years (1990-'94), the contribution to the east coast and all-India catch was 3% and 1.1%, respectively.

West coast : The west coast including the Lakshadweep accounted for an average annual catch of 24,476 t during 1990-'94.

Kerala : Kerala ranked first in production among the states on the west coast (28.9%), and contributed 17.2% to the all India catch. In general, the catch continued to increase from an average of 3,540 t in the 1970's to 5,864t in the 1980's and to 6,198 t in the 1990's.

Karnataka : The catch doubled from an average of 1,646 t in the 1970's to 3,480 t in the 1980's, but decreased to 1,667 t in the 1990's. During 1990-'94, Karnataka contributed 6.8% to the west coast catch and 3.2% to the all-India catch.

Goa : While the annual landing increased progressively from 36 t in 1970 to 2,604 t in 1994, the decadal average catch increased steadily from 328 t during the 1970's to 650 t during the 1980's and further to 1,272 t during the 1990's. During 1990-'94 Goa contributed 5.2% to the west coast production and 3.3% to the all-India production.

Maharashtra : During 1970-'94, the landing varied from 1,434 t in 1974 to 10,277 t in 1991, with an annual average of 4,589 t. During 1990-'94, Maharashtra accounted for 26.6% and 16.9% of the west coast and all-India seerfish production, respectively.

Gujarat : The annual catch fluctuated from 686 t in 1974 to 12,357 t in 1993, with an average annual of 4,608 t. The increase in the average annual catch from 2,316 t during the 1970's to 4,820 t during the 1980's and further to 8,766 t during the 1990's has been very spectacular. Gujarat registered the highest annual production of more than 12,000 t in the 1990's, contributing 35.8% and 22.8% to the west coast and all-India seerfish production respectively during 1990-'94.

Lakshadweep : The annual catch fluctuated widely during 1970-'94, with an average annual of 59 t, forming 0.3% and 0.2% of the west coast and all-India catch, respectively.

The chief seerfish producing states were Maharashtra (18.0%), Kerala (17.7%), Andhrapradesh (15.5%),Gujarat (14.5%) and Tamilnadu (11.5%) during the 1980's and Gujarat (22.8%) followed by Maharashtra (16.9%), Kerala (16.2%), Andhrapradesh (14.3%) and Tamilnadu (11.5%) during the nineties. Evidently the states of Gujarat, Maharashtra and Goa have been faring exceedingly well in recent years, due to effective exploitation and greater abundance of seerfish in these regions.

Gearwise Catch, Effort and CPUE

Seerfishes are exploited mainly by the traditional gillnets (65.1% of all-India seerfish catch) and the hooks and lines (6.9%). With the advent of commercial trawling, the contribution by this gear increased significantly to 11.5% while the rest (16.4%) were landed by the boatseines, shoreseines and purseseines.

Gillnet : During 1989-'94, the estimated average annual standard gillnet effort of 1.447 million units (boatdays) landed 24,905 t of seerfishes, which formed 65.1% of the total all-India seerfish catch. The east coast accounted for 0.776 million units (53.6%) which landed 8,105 t, whereas the west coast 0.671 million landing 16,800 t. The average catch per standard effort was 17.3 kg/unit during 1964-'81 and 1989-'94 (Table 1). In recent years the exploitation of seerfishes seems to have increased along the west coast, especially the northwest coast, compared to the east coast.

Hooks and lines : During 1989-'94 the estimated average annual effort of 0.944 million units landed 2,662 t at the rate of 2.7 kg/unit which constituted 7.0% of the all-India seerfish catch (Table 1).

Trawl : During 1989-'94, on an average 4,386 t of seerfishes were landed by 16.954 million standard hours of trawling at the rate of 0.3 kg/hr. The east coast landed 784 t at the rate of 0.12 kg/hr while the west coast 3,602 t at the rate of 0.3 kg/hr (Table 1).

Other gears : During this period, other gears like the boatseine, shoreseine and purseseine together landed an average annual catch of 6,295 t constituting 16.5% of the all-India seerfish catch in which the east coast accounted for 2,506 t and the west coast 3,789t. The statewise contribution varied from 15.5 t to 1,44 t in the east coast compared to 134 t to 1,559 t along the west coast.

TABLE 1. *Estimated average standard effort, catch and catch rate of seerfish landed by gillnet units during 1989-'94 in different maritime states along the east and west coast on India (one unit = one boatday).*

State	GILLNET			HOOKS & LINES			TRAWL		
	Effort (units)	Catch (t)	CPUE (kg)	Effort (units)	Catch (t)	CPUE (kg)	Effort (units)	Catch (t)	CPUE (kg)
West Bengal	86,291	1,062	12.3	No fishery			45,169	1	0.01
Orissa	1,85,451	1,695	9.1	3,68,325	339	0.9	5,91,682	56	0.09
Andhrapradesh	1,47,922	3,022	20.4	1,99,747	881	4.4	13,17,859	195	0.15
Tamilnadu	3,51,661	2,280	6.5	2,85,550	799	2.8	43,92,474	531	0.12
Pondicherry	4,823	46	9.5	1,720	28	16.3	83,595	1	0.02
East coast	7,76,148	8,105	10.4	8,55,342	2,047	2.4	64,30,779	784	0.12
Kerala	1,38,841	4,717	34.0	60,427	499	8.3	30,46,984	715	0.23
Karnataka	27,938	1,514	54.2	483	23	47.0	17,40,879	237	0.14
Goa	28,905	945	32.7	No fishery			4,73,739	26	0.05
Maharashtra	1,37,620	3,760	27.3	21,530	90	4.2	35,50,437	1,716	0.48
Gujarat	3,37,917	5,864	17.4	6,393	3	0.5	17,11,156	908	0.53
West coast	6,71,221	16,800	25.0	88,833	615	6.9	1,05,23,195	3,602	0.34
All-India	14,47,369	24,905	17.2	9,44,175	2,662	2.8	1,69,53,974	4,386	0.26

Species composition

During 1982-'94, the species composition of the all-India seerfish catch was found to be *S. commerson* 55.3% (1,974 t), *S. guttatus* 43.9% (15,676 t), *S. lineolatus* 0.6% (207 t) and *A. solandri* 0.2% (63 t) (Table 2). The species composition was more or less similar

along both coasts except that *S. lineolatus* was marginally higher along the east coast and *A. solandri* along the west coast. The abundance of *S. commerson* along the coast extends from Tamilnadu in the southeast coast to Goa in the central west coast and *S. guttatus* in the northwest, northeast and central east coasts.

TABLE 2. *Species composition of seerfish catches in tonnes (percentage given in parentheses) during 1982-94.*

State	*S. commerson*	*S. guttatus*	*S. lineolatus*	*A. solandri*
West Bengal	126.8	564.7	0.1	0.0
	(18.3)	(81,6)	(0.01)	(0.0)
Orissa	791.2	1057.2	3.3	0.0
	(42.7)	(57.1)	(0.2)	(0.0)
Andhrapradesh	2132.8	3339.5	95.2	0.0
	(38.3)	(60.0)	(1.7)	(0.0)
Tamilnadu	3744.8	445.1	95.8	4.5
	(87.3)	(10,4)	(2.2)	(0.1)
Pondicherry	107.2	5.8	0.0	0.0
	(94.9)	(5.1)	(0.0)	(0.0)
East coast	6902.8	5412.3	194.4	4.5
	(55.2)	(43.3)	(1.5)	(0.04)
Kerala	5024.7	1295.2	5.8	23.4
	(79.1)	(20.4)	(0.1)	(0.4)
Karnataka	2447.6	540.7	6.3	0.1
	(81.7)	(18.1)	(0.2)	(0.0)
Goa	512.8	370.6	0.0	0.0
	(58.1)	(42.0)	(0.0)	(0.0)
Maharashtra	2206.1	4417.2	0.2	0.5
	(33.3)	(66.7)	(0.0)	(0.0)
Gujarat	2653.5	3640.1	0.1	34.6
	(41.9)	(57.5)	(0.0)	(0.6)
West coast	12844.7	10263.8	12.4	58.6
	(55.4)	(44.3)	(0.0)	(0.3)
All India	19747.5	15676.1	206.8	63.1
	(55.3)	(43.9)	(0.5)	(0.3)

Population dynamics

Since the seerfish fishery in India is sustained mainly by the kingseer and the spotted seer and to some extent by the streaked seer, the population parameters and dynamics of the exploited stocks of all the three species have been studied from the data on length frequency, catch and effort, collected for different gears from various locations along both the east and west coasts of India. The results are presented hereunder specieswise, centrewise and statewise.

S. commerson

Population parameters : The growth parameters ($L\infty$ and K), natural mortality rate (M), total mortality rate (Z), fishing mortality

rate (F), Lc 50 and Lc 75 for the various centres studied are given in Table 3. The software FiSAT developed by the FAO was used to estimate these parameters.

Growth parameters : The L ∝ and K were estimated to be 127 cm and 0.54 for Calicut; 146 cm and 0.6 for Cochin and Mangalore; 146.5 cm and 0.65 for Veraval; 174 cm and 0.5 for Tuticorin; and 176.8 cm. and 0.57 for Mandapam Camp.

Natural mortality rate (M) : The estimated value of M during 1992-'95 was 0.71 for Tuticorin, 0.81 for Calicut, 0.84 for Cochin and Veraval and 0.9 for Mangalore and 0.77 for Mandapam Camp during 1967-'69.

Total mortality rate (Z) : The Z varied from 4.1 for hooks and line to 11.7 for *podivalai*; 5.7 for trawl and 4.3 for *paruvalai* at Tuticorin; 6.2 for gillnet and 11.5 for trawl at Cochin; 4.3 for gillnet at Calicut; 5.3 for gillnet and 11.4 for trawl at Mangalore; 3.7 for gillnet and 4.6 for trawl at Veraval; and 3.2 for gillnet at Mandapam camp (Figs. 2 and 3).

Fishing mortality rate (F) : The value of F was 2.4 during 1967-'69 for gillnet at Mandapam Camp. During 1992-95 the F value was 5.4 for gillnet at Cochin, 11.0 for *podivalai* at Tuticorin, 3.8 for trawl at Veraval, 10.7 for trawl at Cochin and 3.4 for hooks and lines at Tuticorin.

Exploitation ratio (E) : The value of E was estimated to be higher than the E optimum for all the gears at all the centres. It varied from 0.76 during 1976-'69 for gillnet at Mandapam Camp to as high as 0.94 during 1992-'95 for *podivalai* at Tuticorin.

TABLE 3. *Estimates of Loo, K, mortality rate (M), total mortality rate (Z), fishing mortality rate (F), exploitation ratio (E) Lc50 and Lc75 for* S. commerson *obtained from different centres on both the east and west coasts of India.*

Centre/Gear	Loo(cm)	Annual values of					Lc50(cm)	Lc75(cm)
		K	M	Z	F	E		
Tuticorin								
Paruvalai	174.0	0.50	0.71	5.03	4.59	0.87	76.6	85.8
Podivalai				11.71	11.00	0.94	29.7	32.0
Trawl				5.70	4.99	0.88	10.8	13.9
Hooks & lines				4.15	3.44	0.83	105.0	119.0
Mandapam Camp								
Gillnet	176.8	0.57	0.77	3.18	2.41	0.76	43.7	50.5
Cochin								
Gillnet	146.0	0.60	0.84	6.29	5.45	0.87	75.0	82.4
Trawl				11.54	10.70	0.93	38.3	44.4
Calicut								
Gillnet	127.0	0.54	0.81	4.35	3.54	0.81	59.3	65.5
Mangalore								
Gillnet	146.0	0.66	0.90	5.33	4.43	0.83	62.6	70.3
Trawl				11.40	10.50	0.92	32.7	37.1
Veraval								
Gillnet	146.5	0.65	0.84	3.71	2.87	0.77	76.7	87.5
Trawl				4.69	3.85	0.82	42.2	49.4

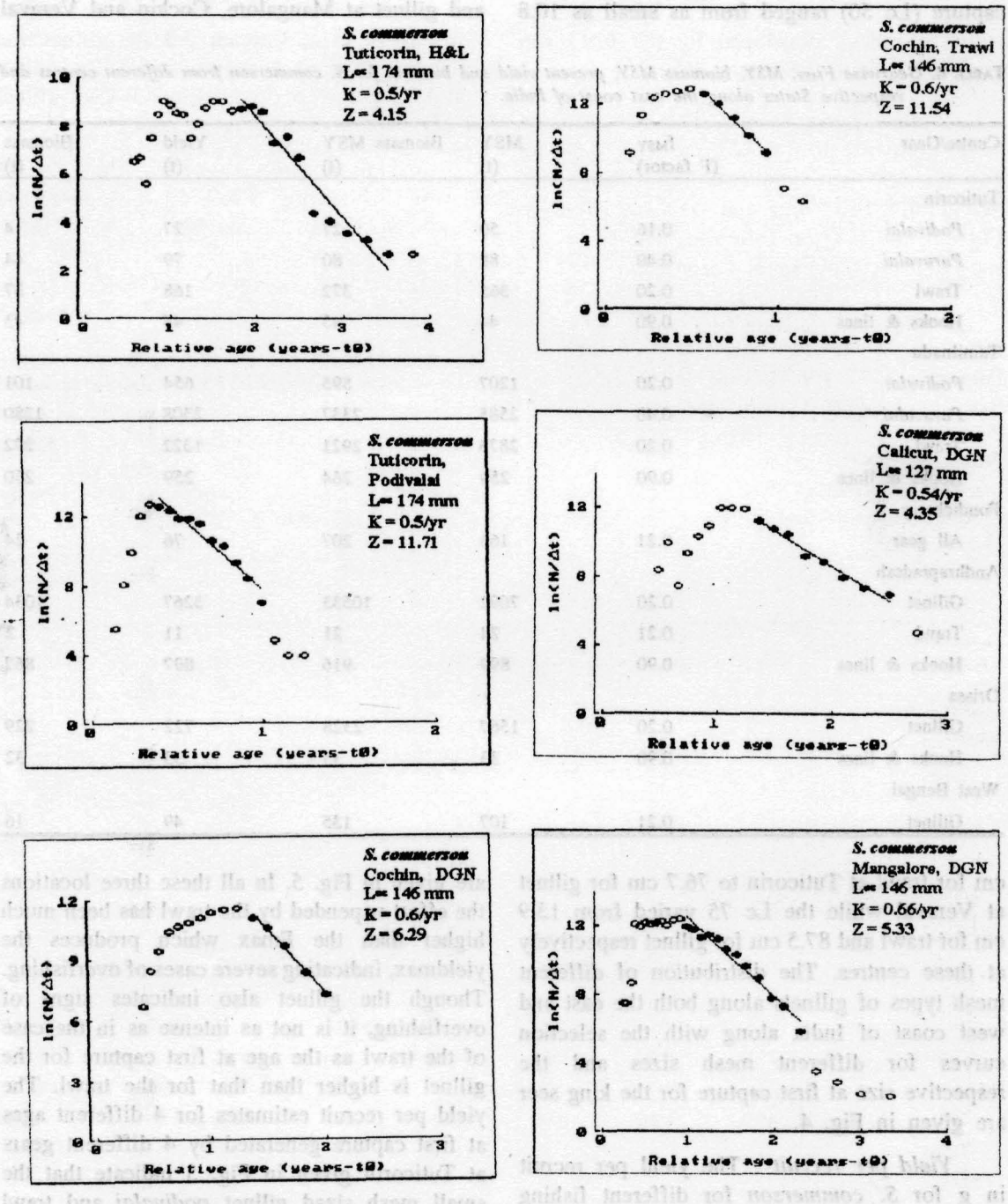


FIG. 2. *Total mortality rate (Z) estimated from the length converted catch curve for* S. commerson *at various centres.*

The Lc 50 and Lc 75 : The size at first capture (Lc 50) ranged from as small as 10.8 cm for trawl at Tuticorin to 76.7 cm for gillnet at Veraval while the Lc 75 varied from 13.9 cm for trawl and 87.5 cm for gillnet respectively at these centres. The distribution of different mesh types of gillnets along both the east and west coast of India along with the selection curves for different mesh sizes and the respective size at first capture for the king seer are given in Fig. 4.

TABLE 4. *Gearwise F_{MSY}, MSY, biomass MSY, present yield and biomass for S. commerson from different centres and respective States along the east coast of India.*

Centre/Gear	f_{MSY} (F factor)	MSY (t)	Biomass MSY (t)	Yield (t)	Biomass (t)
Tuticorin					
Podivalai	0.16	50	27	27	4
Paruvalai	0.40	88	80	79	44
Trawl	0.20	365	372	168	37
Hooks & lines	0.90	44	45	44	43
Tamilnadu					
Podivalai	0.20	1207	595	654	101
Paruvalai	0.40	2585	2337	2308	1280
Trawl	0.20	2873	2921	1322	292
Hooks & lines	0.90	259	264	259	250
Pondicherry					
All gear	0.21	163	207	76	24
Andhrapradesh					
Gillnet	0.20	7092	10533	3267	1034
Trawl	0.21	24	21	11	2
Hooks & lines	0.90	899	916	897	867
Orissa					
Gillnet	0.20	1567	2328	722	229
Hooks & lines	0.90	33	33	33	32
West Bengal					
Gillnet	0.21	107	135	49	16

Yield per recruit : The yield per recruit in g for *S. commerson* for different fishing mortality rates keeping the age at first capture constant at the prevailing effort levels by trawl and gillnet at Mangalore, Cochin and Veraval are given in Fig. 5. In all these three locations the effort expended by the trawl has been much higher than the Fmax which produces the yieldmax, indicating severe cases of overfishing. Though the gillnet also indicates signs of overfishing, it is not as intense as in the case of the trawl as the age at first capture for the gillnet is higher than that for the trawl. The yield per recruit estimates for 4 different ages at first capture generated by 4 different gears at Tuticorin given in Fig. 5 indicate that the small mesh sized gillnet *podivalai* and trawl overexploit the king seer, the large mesh sized

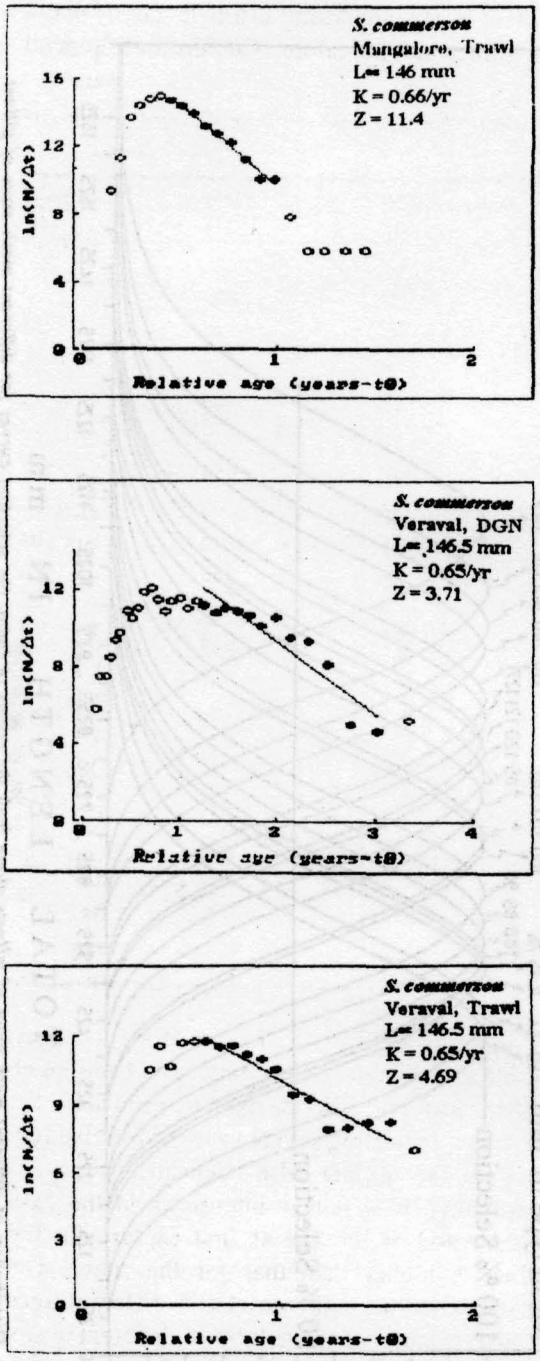


FIG. 3. *Total mortality rate (Z) estimated from the length converted catch curve for* S. commerson.

gillnet *paruvalai* overexploits moderately while the hooks and lines exploit optimally. The yield per recruit for the stock exploited by gillnet at Calicut during 1993-'95 and Mandapam Camp during 1967-'69 (Figs. 5 and 6) indicate more intensive exploitation at Mandapam Camp than at Calicut. All these evidences, thus point to the fact that the king seer stocks are overexploited by all the gears in all the areas on both the coasts of India, except the stock fished by the hooks and lines at Tuticorin, which seems to exploit the king seer optimally.

Present status of exploitation

East coast : The gearwise f_{MSY}, MSY, biomass MSY (biomsy) etc., for different centres and states along the east coast based on the Thompson and Bell long-term forecast analysis, are given in Table 4, together with the values of average yield and biomass.

Tamilnadu and Pondicherry : Under the prevailing conditions, the current fishing effort of *podivalai* operating along the Tuticorin coast (covering approximately an area of 1,000 square km) in Tamilnadu has to be reduced, or the age at first capture may be increased from the present level by increasing the mesh size of *podivalai*, which means nothing but employing the large mesh sized *paruvalai*.

Since the stock is moderately exploited the need for the reduction in the *paruvalai* effort at Tuticorin to reduce fishing pressure or an increase in the age at first capture by increasing the mesh size further as in the case of *podivalai* is suggested. The present mesh size of *paruvalai* varies from 100 mm to 170 mm. Therefore, the operation of the smaller meshed (say 100 mm to 130 mm) *paruvalai* could be restricted or phased out and the mesh size of above 130 mm encouraged in order to progressively increase the size at first capture to the optimum. The trawl fishery is yet another case of serve overexploitation as the *podivalai*

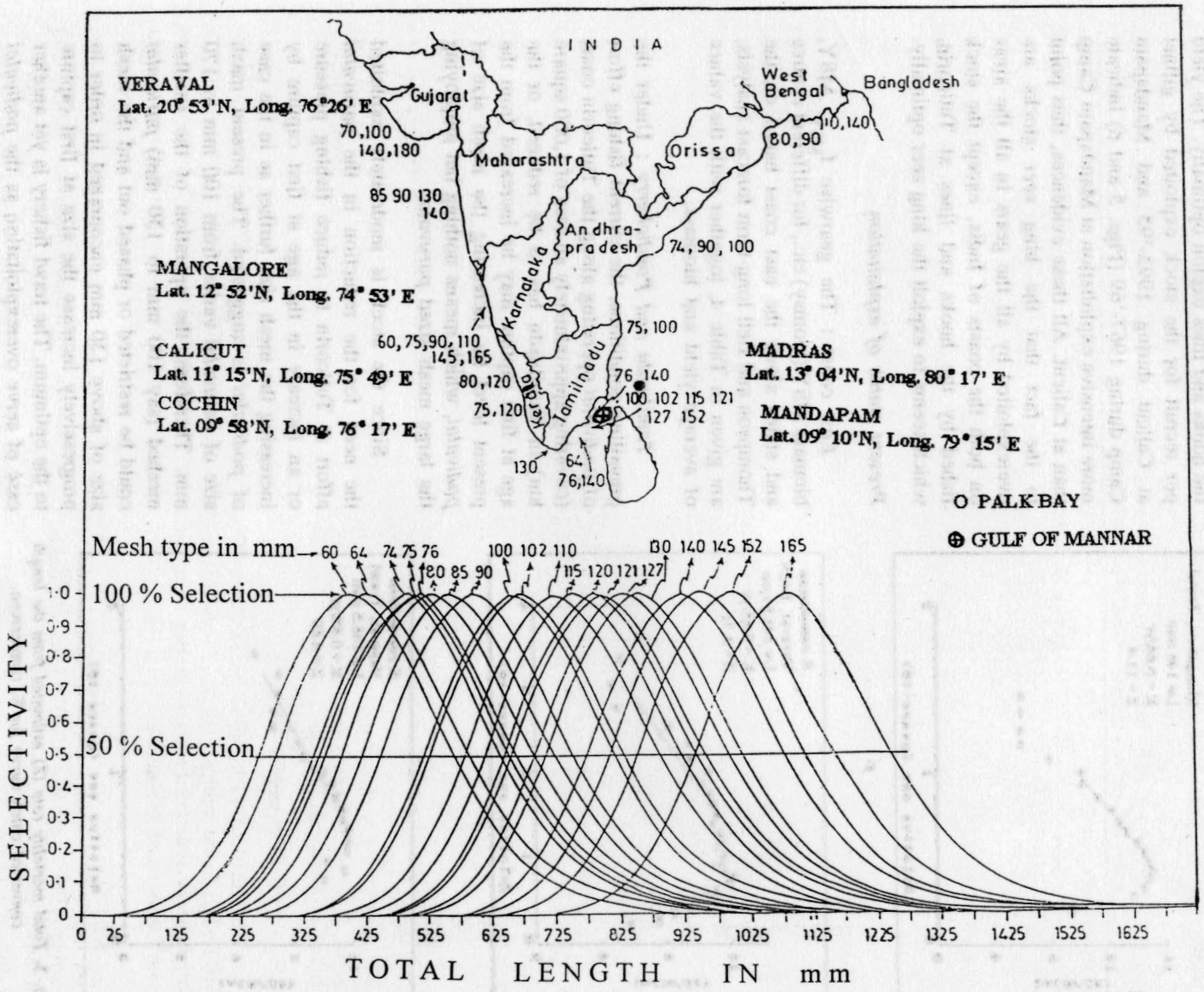


FIG. 4. *Distribution of different mesh types of gillnets along both the coasts of India, the selection curves for different mesh sizes of gillnet and respective size at first capture for S. commerson.*

fishery. The exploitation of *S. commerson* by hooks and lines at Tuticorin is much more effective than by the three gears mentioned above. Stock assessment for the entire Tamilnadu coast reflects the same trend as observed for all 4 gears dealt with above (Table 4).

The present (1989-'94) yield, biomass, MSY, f_{MSY} and biomsy of *S. commerson* in Pondicherry indicate heavy over fishing as in Tamilnadu coast (Table 4).

Andhrapradesh : Compared to the gillnets and trawls, the hooks and line fishery with a current (1989-'94) yield of 897 t from a biomass of 867 t indicates optimum exploitation, as in Tamilnadu (Table 4).

West Bengal and Orissa : In Orissa and West Bengal also the gillnet fishery is in a state of overexploitation,but the hooks and lines fishery in Orissa is operating at the optimum level (Table 4).

TABLE 5. *Gearwise f_{MSY}, MSY, biomass MSY, present yield and biomass for* S. commerson *from different centres and respective States along the west coast of India.*

Centre/Gear	f_{MSY} (F factor)	MSY (t)	Biomass MSY (t)	Yield (t)	Biomass (t)
Cochin :					
Gillnet	0.66	199	137	195	114
Trawl	0.20	85	48	54	11
Calicut :					
Gillnet	0.51	179	159	170	107
Kerala :					
Gillnet	0.70	4652	3173	4564	2661
Trawl	0.20	1250	716	791	161
Mangalore :					
Gillnet	0.44	400	307	361	168
Trawl	0.21	672	365	362	67
Karnataka :					
Gillnet	0.40	1280	1043	1157	537
Trawl	0.21	717	389	387	72
Goa :					
Gillnet	0.40	1060	864	958	445
Trawl	0.21	61	33	33	6
Maharashtra :					
Gillnet	0.70	1047	959	1030	763
Trawl	0.50	1556	946	1369	474
Veraval :					
Gillnet	0.70	388	355	381	283
Trawl	0.46	72	45	63	22
Gujarat :					
Gillnet	0.70	3659	3350	3599	2667
Trawl	0.50	465	283	409	142

West coast : The gearwise f_{MSY}, MSY, biomsy, present yield and biomass for *S. commerson* are given in Table 5 for the different landing centres and states along the west coast of India.

Kerala : Although both the gillnet and trawl fisheries at Cochin overexploit *S. commerson*, the damage caused by the trawl

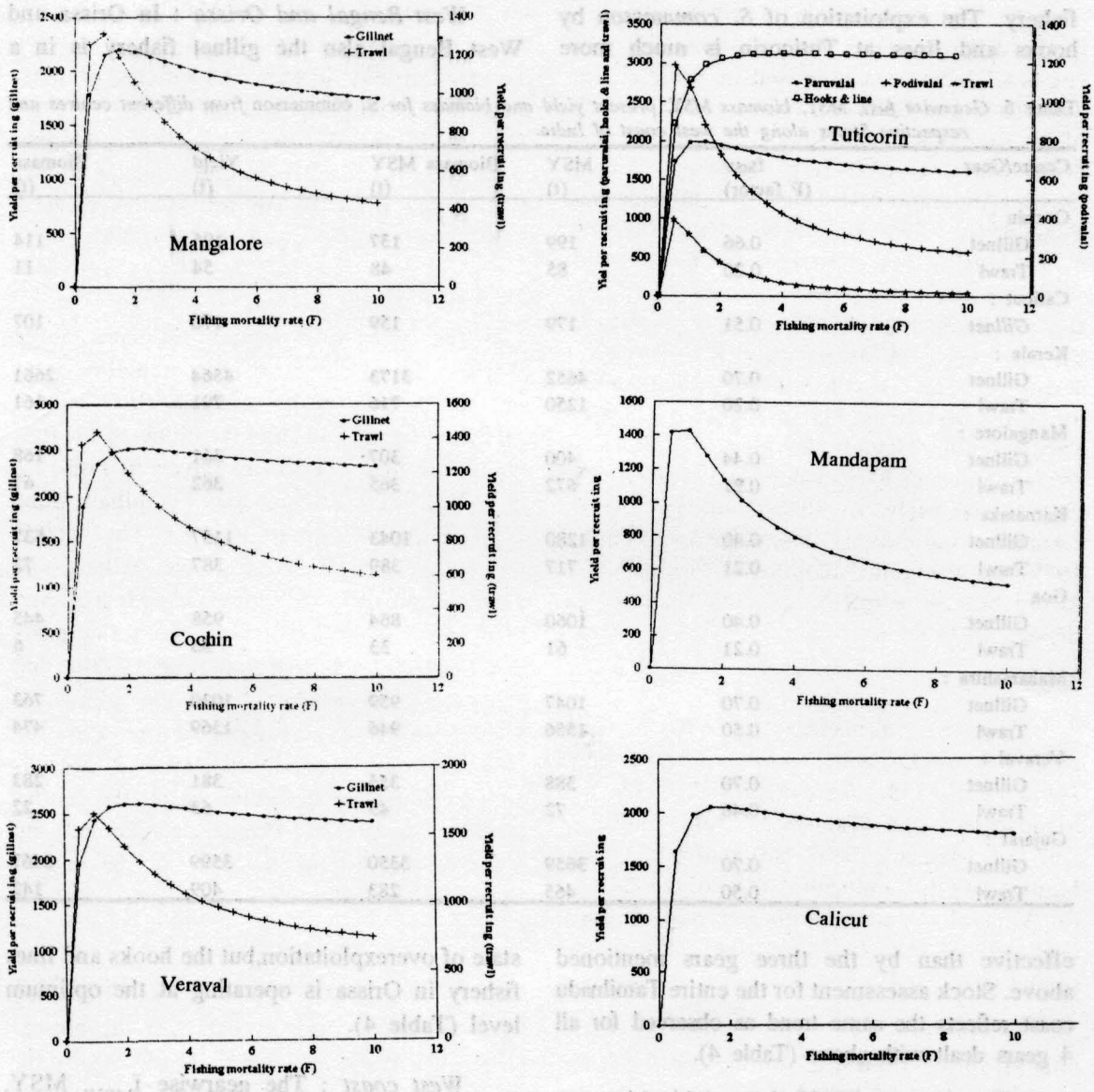


FIG. 5. *Yield per recruit at different fishing mortality rates keeping the age at first capture constant for* S. commerson *exploited at different centres*

has been found to be more adverse than that by the gillnet. At Calicut the resource is overexploited by the gillnets. The king seer fishery of the Kerala coast indicates a trend similar to that observed at Cochin.

Karnataka, Goa, Maharashtra and Gujarat: The trawl fishery overexploits the king seer stock more intensively than the gillnet fishery along the Karnataka, Maharashtra and Gujarat coasts. Overexploitation by gillnets is moderate along the Karnataka and Goa coasts (Table 5).

The status of exploitation of the king seer in the different states along the east and west coasts of India is summarised in Table 6. The Thompson and Bell long term forecast analysis of king seer fishery in Kerala, Karnataka, Goa, Maharashtra, Gujarat (Fig. 7), West Bengal, Orissa, Andhrapradesh (Fig. 8) Tamilnadu and Pondicherry (Fig. 9) indicate that in all the states along the east coast, the current (1989-'94) yield has been much less than the MSY, but the effort much higher than the f_{MSY}. Along the west cost, the exploitation in the states of Karnataka and Goa has been as intense as along the east coast, but in Kerala it has been very intense. Though the king seer stock is overexploited in Maharashtra and Gujarat it is not as intensely overfished as in Kerala, Karnataka and Goa, as the annual yield during 1989-'94 was only marginally less than the MSY, but the effort moderately higher than the f_{MSY} (Table 6).

S. guttatus

Growth parameters : The growth parameters of $L\infty$ and K were estimated to be 109.2 cm and 0.85/yr respectively for Mandapam Camp (Tamilnadu: Palk Strait and Gulf of Mannar), 73.0 cm and 0.72/yr for Madras (north Tamilnadu), 69 cm and 0.84/yr for Veraval (Gujarat, northeast coast) and 68 cm and 0.80/yr for Mangalore (Karnataka, southwest coast).

Mortality rates : The natural mortality rate M varied from 1.29 during 1993-'95 for Mangalore to 1.14 for Madras and Mandapam Camp during 1967-'69. The total mortality rate Z, the fishing mortality F and the exploitation ratio E for various gears at different centres are given in Table 7.

Lc50 and Lc75

The size at first capture (Lc50) for the gillnet fishery was estimated to be 40.2 cm for Madras, 46.1 cm for Mandapam Camp, 40.7 cm for Mangalore and Veraval and for the trawl fishery it was 29.4 cm for Madras, 34.2 cm for Mangalore and 39.9 cm for Veraval. The Lc 75 varied from 42.3 cm for Madras to 49.2 cm for Mandapam Camp for the gillnet fishery and from 32 cm for Madras to 43.5 for Veraval for the trawl fishery (Table 7).

Yield per recruit

The yield per recruit estimates in g obtained for different fishing mortality rates and at the prevailing age at first capture generated by the trawl and the gillnet at Madras, Mangalore and Veraval are given in Figs. 10, 11 and 12 respectively, and by gillnet alone at Mandapam Camp in Fig. 13. The spotted seer is underexploited by the gillnet and overexploited by the trawl at Madras and Mangalore, while at Veraval both the gears underexploited this fishery during 1992-95 but moderately overexploited by the gillnet at Mandapam Camp as early as during 1967-'69 (Fig. 13). In general, the spotted seer is underexploited by the gillnet at all the centres studied except at Mandapam Camp, but overexploited by the trawl at all the centres except at Veraval.

Present status of exploitation

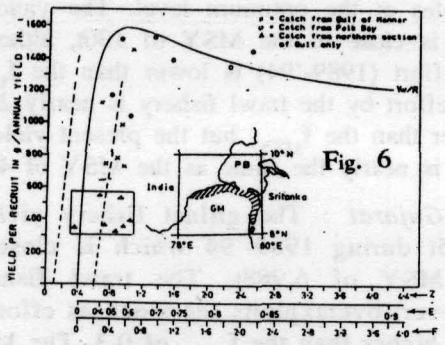
Tamilnadu: The Thompson and Bell long term forecast analysis reveals that the present (1989-'94) average annual yield of 290t by the drift gillnet fishery in Tamilnadu could be increased by 4t more by a 60% increase in the effort, as the f_{MSY} is estimated to be 1.6125. The present (1989-'94) average annual yield of 129t from the trawl fishery is lower than the MSY of 146t for the f_{MSY} of 0.4125. The average (1989-'94) annual effort by the trawl fishery is 59% higher than the f_{MSY} 0.4125 thus indicating overexploitation.

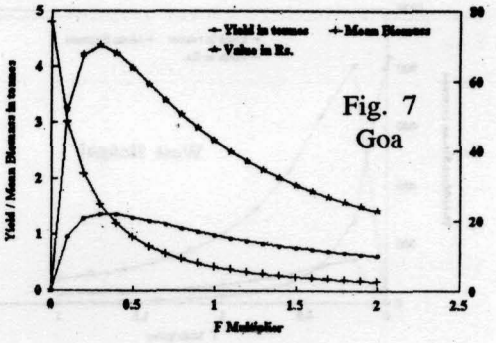
TABLE 6. *Statewise* f_{MSY}, *MSY, biomass MSY, average yield and biomass for* S. commerson *along the east and west coasts of India.*

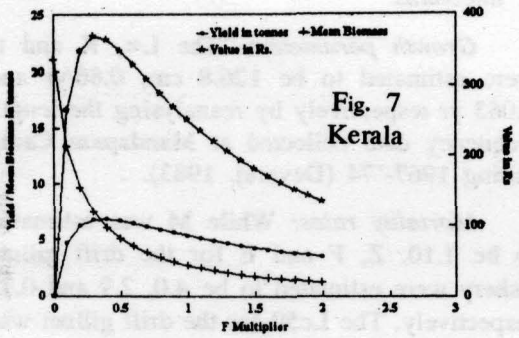
State	f_{MSY} (F factor)	MSY (t)	biom.MSY (t)	yield (t)	biomass (t)
		West coast			
Kerala	0.4	8164	7238	6416	3201
Karnataka	0.2	2615	3702	1519	514
Goa	0.2	2467	3493	1433	485
Maharashtra	0.6	1833	2080	1749	1387
Gujarat	0.6	5721	6493	5458	4329
		East coast			
West Bengal	0.2	148	237	64	25
Orissa	0.2	2186	4085	946	367
Andhrapradesh	0.2	4317	8066	1867	725
Tamilnadu	0.2	10505	19630	4543	1765
Pondicherry	0.2	241	385	104	40

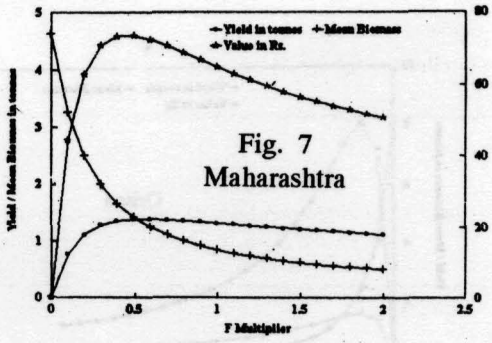
TABLE 7. *Estimates of Loo, K, natural mortality rate (M), total mortality rate (Z), fishing mortality rate (F), Lc50 and Lc75 for* S. guttatus *obtained from different gears at various centres on the east and west coasts of India along with the estimates for S. lineolatus at Mandapam Camp.*

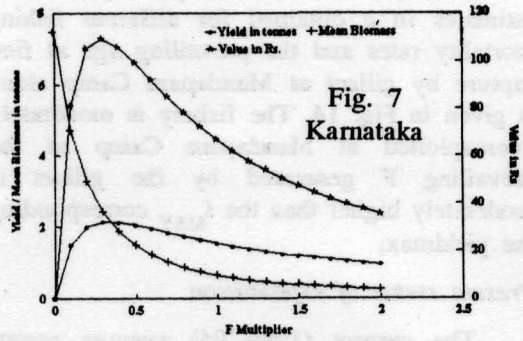
Centre/Gear	Loo(cm)	Annual values of					Lc50 (cm)	Lc75 (cm)
		K	M	Z	F	E		
	S. guttatus							
Chennai								
Gillnet	73.0	0.72	1.14	3.93	2.79	0.71	40.2	42.3
Trawl				6.94	5.80	0.84	29.4	32.0
M. Camp								
Gillnet	109.2	0.85	1.14	9.50	8.36	0.88	46.1	49.2
Mangalore								
Gillnet	68.0	0.84	1.29	6.00	4.71	0.79	40.7	43.3
Trawl				5.45	4.14	0.76	34.2	36.5
Veraval								
Gillnet	69.0	0.80	1.19	5.90	4.61	0.78	40.7	43.4
Trawl				3.28	2.09	0.64	39.9	43.5
	S. lineolatus							
M. Camp								
Gillnet	126.8	0.86	1.10	4.00	2.90	0.73	56.3	64.4











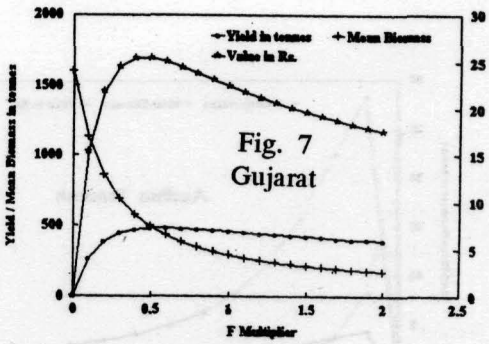


FIG. 6. *Annual yield in tonnes (X = entire Gulf of Mannar, 0 = entire Palk Bay) plotted against Z 1 to Tmax estimated from age compsition for the 76 mm mesh type gillnet, together with the annual yield per recruit in grams curve for tb = 2 years as a function of Z. F and E. Closed triangles within compartments relate to catches from northern section of the Gulf.*

FIG. 7. *Yield, mean biomass in tonnes and value in rupees obtained from Thompson and Bell long term forecast analysis for* S. commerson *for Kerala, Karnataka, Goa, Maharashtra and Gujarat.*

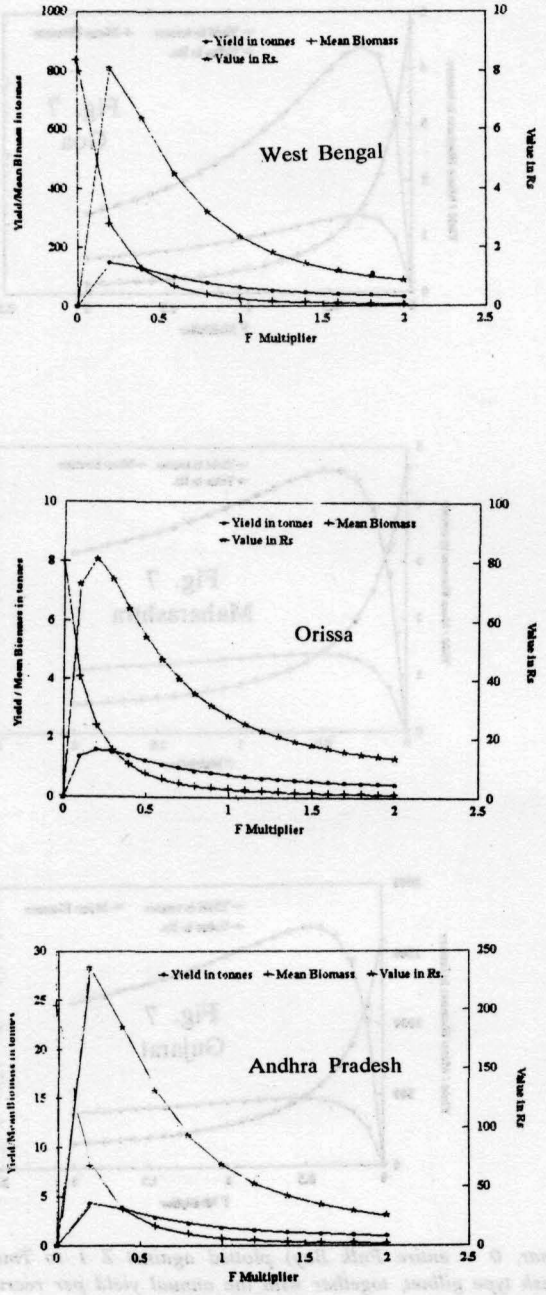


FIG. 8. *Yield, mean biomass in tonnes and value in rupees obtained from Thompson and Bell long term forecast analysis for* S. commerson *for West Bengal, Orissa and Andhra Pradesh*

Karnataka: The drift gillnet fishery operates at the optimum level. The yield of 129t is close to the MSY of 130t, although the effort (1989-'94) is lower than the f_{MSY}. The effort by the trawl fishery is nearly 20%, higher than the f_{MSY}, but the present yield of 411t is nearly the same as the MSY of 412t.

Gujarat : The gillnet fishery yielded 6,985t during 1989-'94 which is close to the MSY of 6,988t. The trawl fishery, however, overexploits the stock as effort is 70% higher than the f_{MSY} of 0.3. The MSY is 1069t, but the present (1992-'95) yield is only 42t.

S. lineolatus

Growth parameters: The $L\infty$, K and t_o were estimated to be 126.8 cm, 0.86/yr and 0.063 yr respectively by reanalysing the length frequency data collected at Mandapam Camp during 1967-'74 (Devaraj, 1983).

Mortality rates: While M was estimated to be 1.10. Z, F and E for the drift gillnet fishery were estimated to be 4.0, 2.9 and 0.73 respectively. The Lc50 for the drift gillnet was 56.3 cm and the Lc75 64.4 cm (Table 7).

Yield per recruit: The yield per recruit estimates in g obtained for different fishing mortality rates and the prevailing age at first capture by gillnet at Mandapam Camp alone is given in Fig. 14. The fishery is moderately overexploited at Mandapam Camp as the prevailing F generated by the gillnet is moderately higher than the f_{MSY} corresponding the yieldmax.

Present status of exploitation

The current (1989-'94) average annual yield was estimated to be 207t. The Thompson and Bell long term forecast analysis indicates overfishing as the current (1989-'94) F is higher than the f_{MSY} of 0.6375 for the MSY of 214t. The biomsy was estimated to be 159t, but the current biomass was only 111t.

Stock Assessment

During the period 1989-'94 the annual stock size of *S. commerson* along the east coast was estimated to be 60t for West Bengal; 921t for Orissa; 5,091t for Andhrapradesh; 5,167t for Tamilnadu and 92t for Pondicherry. It was 6,097t for Kerala; 1,814t for Karnataka; 1,191t for Goa; 3,063t for Maharashtra and 5,303t for Gujarat along the west coast (Table 8). Devaraj (1983) assessed the average annual stock of this species to be 17,545t for the east coast and 22,629t for the west coast amounting to a toal of 40,174t for the country as a whole during 1967-'74. Yohannan *et al.* (1992) estimated the annual stock to be 10,776t for the east coast and 18,303t for the west coast, giving a total of 29,079t for the country as a whole,during the 1980s. The estimates of Yohannan *et al.* (1992) are lower than those given by Devaraj (1983) while the present estimates are still lower, obviously due to the progressively increasing fishing pressure on the stocks of *S. commerson* from the 1960s to the 1990s.

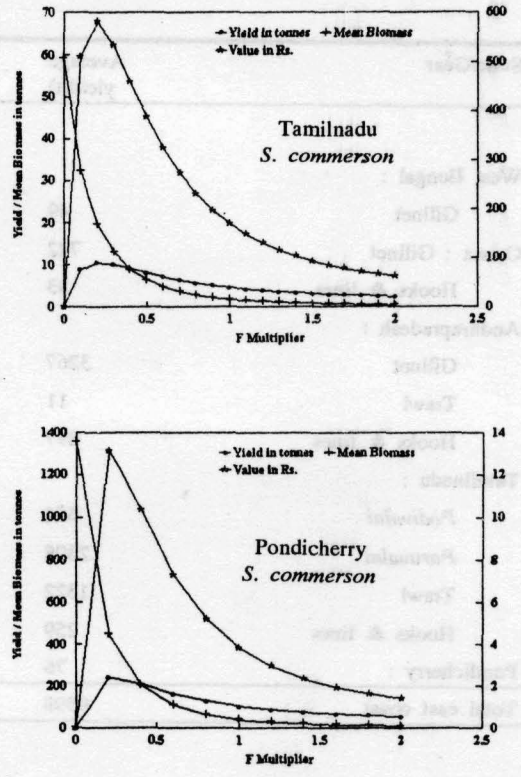


FIG. 9. *Yield, mean biomass in tonnes and value in rupees obtained from Thompson and Bell long term forecast analysis for* S. commerson *for Tamilnadu and Pondicherry.*

The annual stock size of *S. guttatus* was estimated to be 8,492t and 12,184t for the east and west coasts respectively giving a total of 18,676t for the country as a whole, for the period 1989-'94. The stock of *S. lineolatus* for the two coasts was estimated to be only 287t for the same period (Table 9). Devaraj (1977) estimated the annual stock of the spotted seer to be 919t and 958t for the east and west coasts respectively, giving a total of 1,877t for the entire country during 1967-'74. This seems to be an underestimate as the current average yield itself is 13,826t. If, however, it is not an underestimate, it might mean the emergence of the spotted seer fishery into prominence.

The results of assessment of the seerfish stocks as a whole for the states on both the east and the west coasts of India, obtained

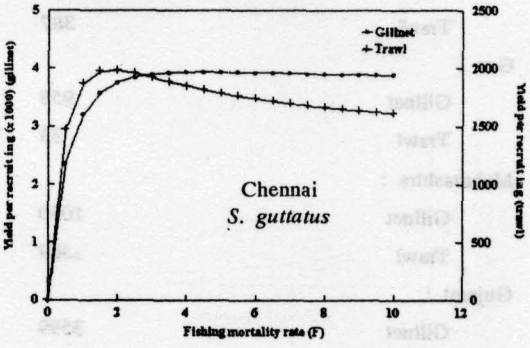


FIG. 10. *Yield per recruit at different fishing mortality rates keeping the age at first capture constant for* S. guttatus *exploited at Chennai.*

TABLE 8. *Statewise estimates of stocks of* S. commerson.

State/Gear	Average yield(t)	Exploitation rate(U)	Stock (P) (t)	Total stock (t)
		East coast		
West Bengal :				
Gillnet	49	0.82	60	60
Orissa : Gillnet	722	0.82	881	
Hooks & lines	33	0.82	40	921
Andhrapradesh :				
Gillnet	3267	0.82	3984	
Trawl	11	0.88	13	
Hooks & lines	897	0.82	1094	5091
Tamilnadu :				
Podivalai	654	0.94	696	
Paruvalai	2308	0.87	2653	
Trawl	1322	0.88	1502	
Hooks & lines	259	0.82	316	5167
Pondicherry :	76	0.82	92	92
Total east coast	9598			11331
		West coast		
Kerala :				
Gillnet	4564	0.87	5246	
Trawl	791	0.93	851	6097
Karnataka :				
Gillnet	1157	0.83	1394	
Trawl	387	0.92	420	1814
Goa :				
Gillnet	958	0.83	1155	
Trawl	33	0.90	36	1191
Maharashtra :				
Gillnet	1030	0.75	1373	
Trawl	1369	0.81	1690	3063
Gujarat :				
Gillnet	3599	0.75	4798	
Trawl	409	0.81	505	5303
Total west coast	14295		17468	17468
Total All-India	23893		28799	28799

from the surplus production model, indicate the average annual yield to be lower than the MSY for all the states. (Table 10). Compared to other states the average annual standard efforts expended by West Bengal and Kerala were found to be higher than their respective f_{MSY}, indicating overexploitation in these two states. Consequently, their current yields are on the descending limb of the yield curve. The standard average annual effort spent by all the other states were lower than their respective f_{MSY}, and hence there seems to be scope for increasing the yield (Table 10).

DISCUSSION

Earlier studies on the age and growth of the king seer in India and other areas have been reviewed by Devaraj and Kasim (1998). The moderately lower K values observed by various authors in India could be attributed to the recruitment of several broods (into the fishery), common in tropical seas.

The estimates of $L\infty$ obtained for Madras, Mangalore and Veraval for the spotted seer are lower than the estimate obtained for Mandapam. Since, there is not much difference in the growth rate, the lower $L\infty$ value obtained in other locations may be due to the non-occurrence of larger size ranges in the fishery in these regions.

Devaraj (1983) and Kasim and Hamsa (1989) reported lower natural mortality coefficient (M) for *S. commerson* (0.37 to 0.57) compared to that obtained by Yohannan *et al.* (1992) and Pillai *et al.* (1994) (0.79 to 1.20) and in the present study (0.71 to 0.9). The recent estimates of Z (generated by gillnet) reported by Yohannan *et al.* (1992) and Pillai *et al.* (1994) are higher (3.09 to 4.08) than the earlier estimates (0.81 to 1.28) of Devaraj (1983) and Kasim and Hamsa (1989). The estimates obtained in this study are much higher than those reported above for the earlier periods. However, there has not been any progressively increasing trend in the Z from the south (Cape Comorin) to the north (Gujarat) as reported by Devaraj (1983). Kasim and Hamsa (1989) reported the Z to be 0.83 for the hooks and line fishery, 2.23 for the *podivalai* (gillnet) fishery and 2.49 for the trawl fishery at Tuticorin compared to higher values obtained in the present study. Similar trend has been observed in the fishing mortality rates and exploitation ratio also.

The exploitation ratio E for the west coast gillnet fishery was 0.51 during 1969-'74 (Devaraj, 1983), which increased to 0.81 during 1984-'88 and to 0.77 (Veraval) to 0.87 (Cochin) currently (1989-'94). For the east coast, the E was estimated to be 0.42 to 0.53 by Devaraj (1983) and 0.71 by Kasim and Hamsa (1989) for the Gulf of Mannar and Palk Bay, but it has increased to as high as 0.76 for Mandapam (Palk Bay and Gulf of Mannar) and 0.87 for Tuticorin (Gulf of Mannar) during 1989-'94). It is evident that the rate of exploitation has increased tremendously and nowhere is it less than 0.76 for any of the gear presently employed along the east and west coasts of India. According to Yohannan *et al.* (1992) the stocks of *S.commerson* are overfished along both the coasts of India, warranting a 16% reduction in the exploitation ratio to bring the fishery back to the MSY level. The present study reveals that currently all along the east coast the effort is nearly 80% higher than the f_{MSY} level while along the west coast it is 60% higher than the f_{MSY} in Kerala, 80% higher in Karnataka and Goa and 40% higher in Maharashtra and Gujarat (Table 6).

According to Devaraj (1977) *S. guttatus* was underexploited along both the coasts of India during 1967-'74. The present 1989-'94 study, however, reveals that this species is only

marginally underexploited by the gillnet fishery and overexploited by the trawl fishery by 60%. In Karnataka the gillnet fishery for this species is at the near optimum level while the trawl fishery overexploits it marginally by 20%. In Gujarat there is scope to increase the current gillnet effort by 20%, while the trawl fishery overexploits the stock by 70%. *S. lineolatus* is currently (1989-'94) overexploited by 37% in the Indian waters as was also reported by Devaraj (1977).

Management of Seerfish Fishery

Except the large meshed gillnets and the hooks and lines the other gears do not target the seerfish. The trawls and the small meshed gillnets exploit the juvenile seerfsh incidentally causing recruitment overfishing. It is difficult to regulate these gears, except discouraging their operation in the shallow nursery grounds during recruitment. At the same time, the operation of hooks and lines and large meshed (150 to 200 mm) gillnets may be encouraged.

TABLE 9. *Estimates of stocks of* S. guttatus *and* S. lineolatus *along the east and west coasts of India.*

Region	Average yield (t)	Exploitation rate (U)	Stock (P) (t)
	S. guttatus		
West coast :			
Gillnet	7480	0.70	10686
Trawl	1258	0.84	1498
Total	8738		12184
East coast :			
Gillnet	4051	0.79	5128
Trawl	387	0.76	509
Hooks & lines	650	0.76	855
Total	5088		6492
All-India Total :	13826		18676
	S. lineolatus		
All-India :	207	0.72	287

The estimates of stocks by the surplus production model suggest that the seerfish are

TABLE 10. *Statewise estimates of average yield, average standard effort, f_{MSY}, MSY, a and b values in the Surplus Production Model) obtained from the stock assessment of entire seerfish resource in different maritime States in India.*

State	Average yield (t)	Average standard effort in lakh hrs	f_{MSY} standard effort in lakh hrs	MSY (t)	a	b
West Bengal	1078	12.36	11.35	1246	2.1955E-3	-9.6735E-10
Orissa	2467	21.88	24.67	2543	2.0610E-3	-4.1767E-10
Andhrapradesh	5539	50.45	88.81	7041	1.5857E-3	-8.9275E-11
Tamilnadu	4273	36.95	75.41	5943	1.5761E-3	-1.0450E-10
Pondicherry	86	0.74	1.04	100	1.9321E-3	-0.2995E-09
Kerala	6470	52.06	50.06	6582	2.4352E-3	-2.2524E-10
Karnataka	1950	13.24	13.73	2110	3.0729E-3	-1.1187E-11
Goa	1105	10.02	19.10	1513	1.5837E-3	-4.1452E-10
Maharashtra	6947	67.54	157.42	10772	1.3686E-3	-4.3470E-11
Gujarat	7104	87.15	310.45	20344	1.3106E-3	-2.1108E-11

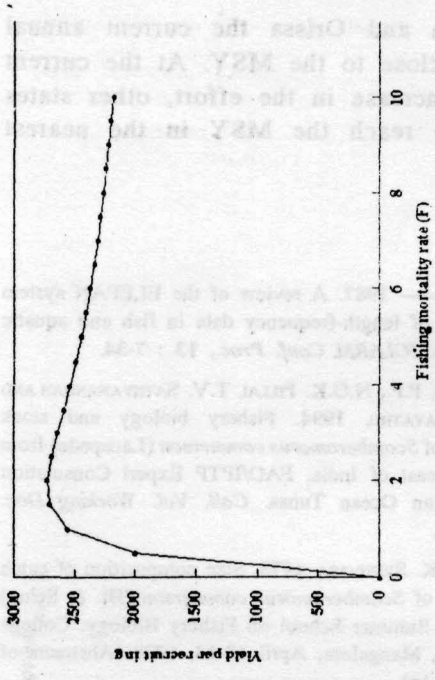


FIG. 13. *Yield per recruit at different fishing mortality rates keeping the age at first capture constant for* S. guttatus *exploited at Mandapam.*

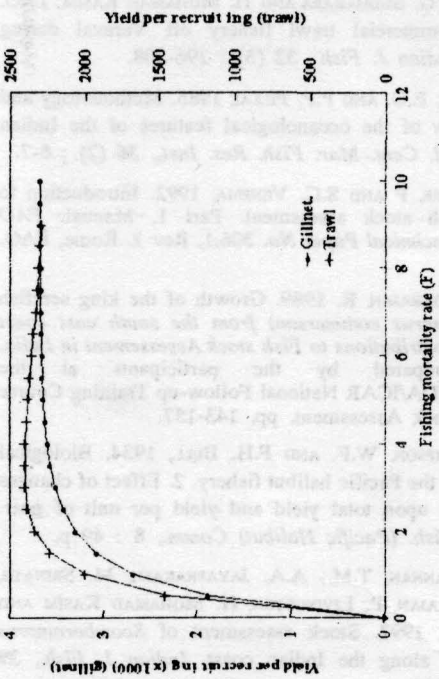


FIG. 11. *Yield per recruit at different fishing mortality rates keeping the age at first capture constant for* S. guttatus *exploited at Mangalore.*

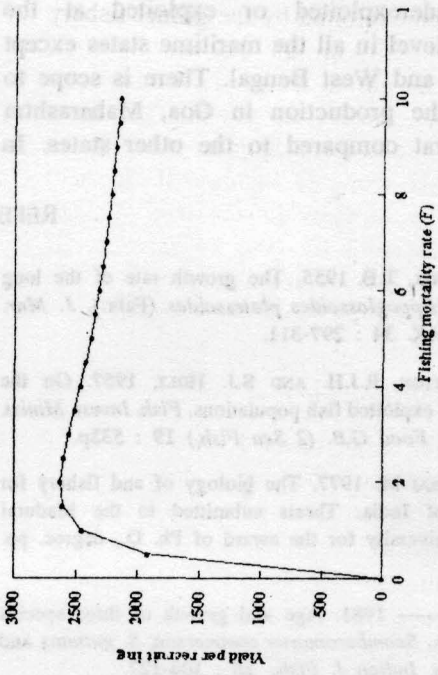


FIG. 14. *Yield per recruit at different fishing mortality rates keeping the age at first capture constant for* S. lineolatus *exploited at Mandapam.*

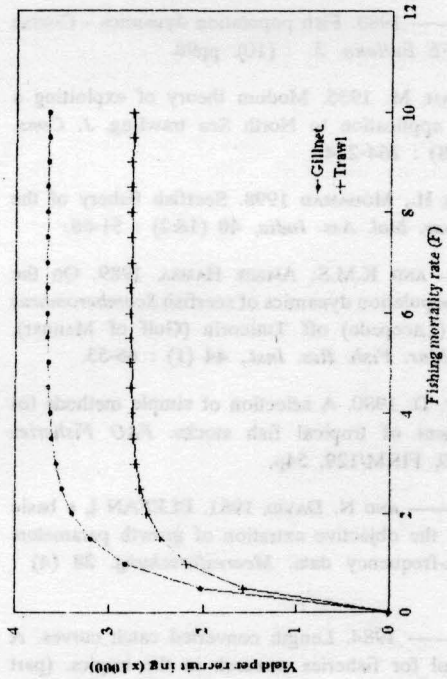


FIG. 12. *Yield per recruit at different fishing mortality rates keeping the age at first capture constant for* S. guttatus *exploited at Veraval.*

either underexploited or exploited at the optimum level in all the maritime states except in Kerala and West Bengal. There is scope to increase the production in Goa, Maharashtra and Gujarat compared to the other states. In Karnataka and Orissa the current annual yield is close to the MSY. At the current rate of increase in the effort, other states may also reach the MSY in the nearest future.

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