Management of Scombroid Fisheries

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Stock assessment of seerfishes in the Indian seas

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ABSTRACT

The annual average catch of seerfishes from the Indian seas was 45,060 t during 1995-'99, which constituted 1.8% of the total marine fish catch in India. State-wise Gujarat (28.5%) was the major producer followed by Tamilnadu (15.8%), Maharashtra (15.4%), Andhra Pradesh (11.4%) and Kerala (10.5%). Gill net is the dominant gear in exploiting seerfish followed by trawl, hooks & line, boat seines, shore seines and purse seines. Among the five species, the kingseer *Scomberomorus commerson* (59.0%) and the spotted seer *S. guttatus* (35.1%) sustained the fishery, while the streaked seer *S.lineolatus* and the wahoo *Acanthocybium solandri* formed only a negligible portion of the fishery. The growth parameters for these two dominant species and the mortality rates by different gears for different centres along both the coasts showed variation. The estimates of growth parameters and mortality rates obtained from pooled data for *S. commerson* and *S. guttatus* are marginally higher along the east coast than the west coast. Thompson and Bell analysis indicate that the kingseer is exposed to higher fishing pressure by all the gears in all the maritime states except by gill net in Gujarat where the effort can further be increased by 20% to attain the MSY. The spotted seer is exposed to higher fishing pressure by trawl along Mangalore and Kakinada and by gill net along Chennai and Kakinada coasts. There is scope to increase the production of this species by increasing the hooks & line effort by 60% along Chennai and the effort of trawls marginally by 10% along Veraval coast. The stock size of *S. commerson* is considerably reduced over a period of time due to continuous increase in exploitation by different gears along both the coasts of India. Suggestions for the management of the fishery have been proposed.

INTRODUCTION

The king seer *Scomberomorus commerson* (Lacepede) and the spotted seer *S.guttatus* (Bloch and Scheneider) constitute the seerfish fishery in India. The streaked seer *S. lineolatus* (Cuvier and Valenciennes), the Korean seer *S. koreanus* (Kishinouye) and the Wahoo *Acanthocybium solandri* (Gill) form negligible portion of the fishery. Seerfish production in India exhibited an increasing trend since 1950. With an annual average catch of 45,060 t during 1995-'99, the seerfish formed 1.8% of the total marine fish production. The west coast contributed 64.6% and the balance 35.4% by the east coast. Gujarat (28.5%), Tamilnadu (15.4%), Maharashtra (15.3%), Andhra Pradesh (11.3%) and Kerala (10.4%) were the principal seerfish producers during 1995-'99. This resource is exploited mainly by gill nets, trawls, hooks & line, boat seines, shore seines and purse seines.

Information on the stock assessment and management of the fishery is either scanty or location-based (Devaraj, 1983b; Kasim and Hamsa, 1989; Thiagarajan, 1989; Yohannan *et al.*, 1992, Pillai *et al.*, 1994 and Devaraj *et al.*,1999). It is essential to assess the status of the stocks of all the component species and their exploitation on national level so as to optimise the production through rational exploitation.

DATABASE, MATERIALS AND METHODS

Data on the statewise production for the period 1995-'99 was obtained from the FRA Division of the CMFR Institute. The data on catch, effort and length frequency on *S. commerson* and *S. guttatus* collected from the landings of different gears at Veraval, Mangalore, Calicut, Kochi, Tuticorin, Chennai (during 1995-'99) and Kakinada (during 1998-'99) along both the coasts of India were used. The growth parameters such as L_∞ and K were estimated as per ELEFAN I programme (Pauly and David, 1981; Pauly, 1987) and the t_0 as per the 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 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 Lc50 and Lc75 were obtained from the probability of catch from the catch curve. The stocks were assessed as per the classical model of Beverton and Holt (1957) and Thompson and Bell (1934) model.

Status of the fishery

An increasing trend is observed in the seerfish production in India since 1950s with considerable annual fluctuations. The annual catch varied from 37,394 t in 1996 to 54,876 t in 1998 with an average annual production of 45,060 t. The contribution of seerfish to the all India marine fish catch varied from 1.5% in 1997 to 2.1% in 1998 (Table 1). West coast contributed 64.6% and the balance 35.4% by the east coast.

During 1995-'99, the east coast landed an average annual catch of 15,956 t of seerfish. Tamilnadu contributed 43.5% followed by Andhra Pradesh (32.0%), Orissa (14.0%), West Bengal (4.5%), Andaman (4.4%) and Pondicherry (1.6%).

The west coast including the Lakshadweep islands accounted for an average annual catch of 29,104 t during 1995-'99. Gujarat ranked first (43.1%) in seerfish production among the states on the west coast followed by Maharashtra (23.2%), Kerala (15.8%), Karnataka (7.7%), Goa (7.5%) and Lakshadweep (0.2%).

Species composition

During 1995-'99, the species composition of the all-India seerfish catch was *S. commerson* 59.0% (26,564 t), *S. guttatus* 35.1% (15,821 t), *S. lineolatus* 0.6% (262 t) and other species 5.4% (2,413 t)(Table 2). There was very little difference in the species composition of seerfish along the east and west coasts. However, the landing *S. lineolatus* was considerably high along the east coast and that of *A. solandri* along the west coast. *S.commerson* was the dominant species along both the coasts in India.

Population dynamics

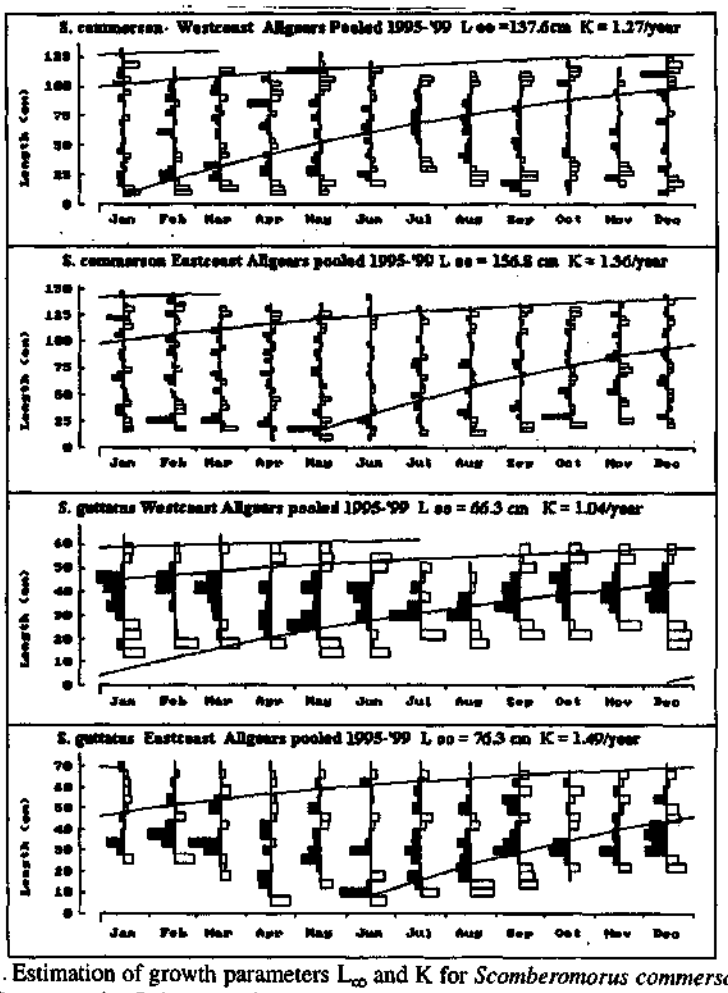

Fig.1. Estimation of growth parameters L_{∞} and K for *Scomberomorus commerson* and *S. guttatus* by fitting growth curves through the restructured length frequency histograms derived by ELEFAN I from the data collected at different fishery centres along the Indian coast during 1995-'99

S. commerson

Population parameters: The growth parameters (L_∞ and K), natural mortality rate (M), Total mortality rate (Z), fishing mortality rate (F) and Lc50 for the various centres studied are given in Fig. 1 and Table. 3.

Growth parameters: The L_∞ and K obtained from the pooled length frequency data for the west coast were 137.6 cm and 1.27(annual) respectively and for the east coast 156.8 cm and 1.36 (annual) respectively.

Age and growth: The estimates of length at different ages obtained for this species based on the above said growth parameters at different centres along both the coasts are given in Table 4.

Recruitment: The recruitment pattern of *S. commerson* is given in Fig. 2 for east and west coast separately. There is only one recruitment period on both the coasts and this period extends from November to March along the west coast with peak during December and January. On the east coast the recruitment period extends from March to July with peak during April and May.

Natural mortality rate (M): The M is estimated to be 1.37 and 1.39 respectively for the west and east coasts from the pooled data (Table 3).

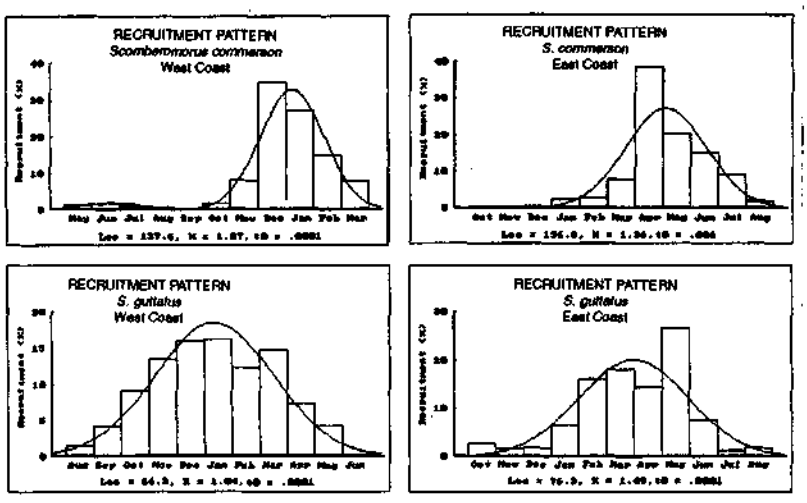

Fig.2. Recruitment pattern of *Scomberomorus commerson* and *S. guttatus* obtained using pooled length frequency data collected along the east and west coasts of India during 1995-'99

Total mortality rate (Z): The Z value was found to vary from 3.15 for gillnet at Veraval to as high as 11.15 for trawl at Mangalore along the west coast and from 5.48 for gillnet at Chennai to 12.11 for *podivalai* (small

mesh gillnet) at Tuticorin. The Z is estimated to be 5.39 and 5.9 respectively for the west and east coast (Table 3).

Fishing mortality rate (F): The value of F varied from 1.98 for gillnet at Veraval to 9.57 for trawl at Mangalore along the west coast and from 4.2 for gillnet at Chennai to 10.76 for *podivalai* at Tuticorin along the east coast. The F is estimated to be 4.01 respectively for the west and east coast. (Table 3).

Exploitation rate (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 0.63 for gillnets at Veraval to as high as 0.86 for trawl at Mangalore and from 0.77 for gillnet at Chennai and Kakinada to 0.89 for *podivalai* at Tuticorin. The E is estimated to be 0.75 and 0.76 respectively for the west and east coast. (Table 3).

The Lc50: The size at first capture (Lc50) ranged from as small as 19.9 cm for trawl at Mangalore to 68.0 cm for gillnet at Cochin along the west coast and from 17.5 cm for trawl at Tuticorin to 68.2 cm for hooks & line at Chennai along the east coast. The size at first capture is estimated to be 20 and 17.6 cm for the west and east coast (Table 3).

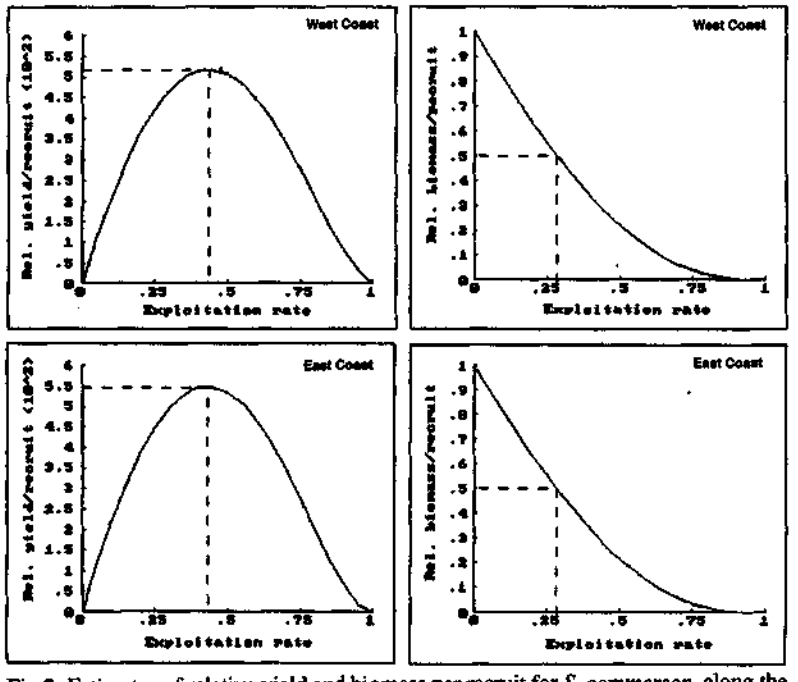

Fig.3. Estimates of relative yield and biomass per recruit for *S. commerson* along the east and west coast of India during 1995-'99. The E max which can produce the maximum yield (Y max) along the west coast is 0.4363 based on L_{∞} 137.6 cm and M/K ratio 1.08 and 0.4318 on the east coast based on L_{∞} 156.8 cm and M/K ratio 1.02

Yield and biomass per recruit: The estimates of relative yield and biomass per recruit obtained for *S. commerson* at different fishing mortality rates keeping the age at first capture constant at the prevailing level along the west and east coasts are given in Fig.3. The E max which can produce the yield max are 0.4363 and 0.4318 respectively for the west and east coasts (shown in dotted line in figures) and these values are much lower than the prevailing E of 0.75 and 0.76. This shows that this species is exposed to higher fishing pressure along both the west and east coasts of India.

Present status of exploitation: The estimates on gearwise F_{MSY}, yield MSY, biomass MSY (bio MSY), value MSY etc., obtained as per the Thompson and Bell long term forecast analysis for different Centres along both the coasts are given in Table 5.

S. guttatus

Growth parameters: Unlike the king seer, the spotted seer occurs only on the northwest and northeast coast. The growth parameters of L_∞ and K were estimated to be 65 cm and 1.6 (annual) respectively at Veraval and 65 cm and 1.5 (annual) respectively at Mangalore along the west coast. The estimates along the east coast are 75.2 cm and 1.18(annual) respectively at Chennai and 75.5 cm and 1.125(annual) respectively at Kakinada. The estimates obtained from the pooled data are 66.3 cm and 1.04 (annual) respectively for west coast and 76.3 cm and 1.49 (annual) respectively for east coast (Table 6 and Fig. 1).

Age and growth: The estimates of length at different ages obtained for this species based on the above said growth parameters at different Centres along both the coasts are given in Table 7.

Recruitment: The recruitment pattern obtained during 1995-'99 for this species along both the east and west coasts are given in Fig 2. The recruitment of this species appears to be a prolonged one when compared to the king seer. Along the west coast the recruitment period is observed to be from August to May with peak period during November-March and along the east coast it was from October to June with peak period during February-May.

Mortality rates: The M did not vary much along both the coasts. The estimate was 1.48 and 1.8 for the west and east coast respectively. The Z varied from 7.32 by trawl at Veraval to 9.28 by gill nets at Mangalore along the west coast and from 3.7 by gillnet to 9.95 by trawl at Chennai. Similarly F also varied as in the case of Z at the same places (Table 6).

Lc 50: The Lc50 obtained from the pooled data was 34.7 cm for the west coast and 25.0 cm for the east coast (Table 6).

Yield per recruit: The E max which can produce the Yield max is estimated to be 0.5861 along the west coast, whereas the prevailing E is 0.69 which is higher than the estimated E max indicating that this species is ex-

posed to higher fishing pressure along the west coast (Fig. 4). Similarly along the east coast also the present E (0.68) is higher than the E max (0.4852).

Present status of exploitation: The gearwise F_{MSY}, yield MSY, biomass MSY (bio MSY), value MSY etc., for different centres along both the coasts based on the Thompson and Bell long term forecast analysis are given in Table 8.

Stock assessment

The annual stock size of *S. commerson* was estimated to be 19 t for West Bengal, 2,063 t for Orissa, 4,114 t for the Andhra Pradesh, 7,159 t for Tamilnadu, 247 t for Pondicherry and 459 t for Andaman along the east coast during 1995-'99. It was 5,423 t for Kerala, 1,744 t for Karnataka, 2695 t for Goa, 3,519 t at Maharashtra and 8,539 t for Gujarat along the west coast (Table 9).

The annual stock size of *S. guttatus* was estimated to be 6,235 t and 15,229 t for the east and west coasts respectively giving a total of 21,464 t for the country as a whole, during 1995-'99.

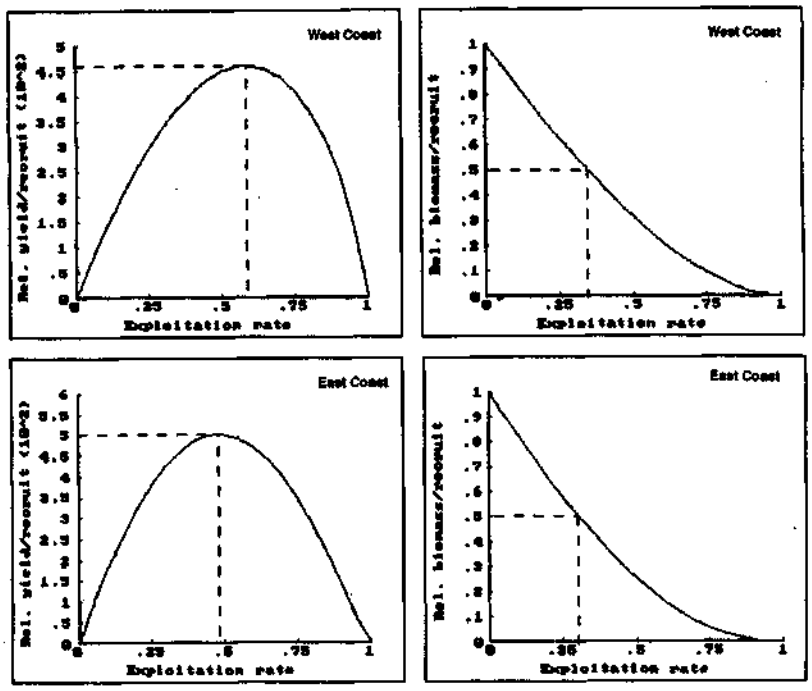

Fig.4. Estimates of relative yield and biomass per recruit for *S. guttatus* along the east and west coast of India during 1995-'99. The E max which can produce the maximum yield (Ymax) along the west coast is 0.5861 based on L_{∞} 66.3 cm and M/K ratio 1.42 and 0.4852 on the east coast based on L_{∞} 76.3 cm and M/K ratio 1.21

DISCUSSION

The earlier estimates obtained by Devaraj (1981) and Kasim and Hamsa (1989) on the growth parameters of king seer are higher than those obtained by Krishnamoorthi (1958) and lower than the estimates given by Devaraj *et al.* (1999) but agree with the estimates obtained by Rao (1978). This species has been reported to attain a total length of 623 mm during the first year (Thiagarajan, 1989; Yohannan *et al.*, 1992; Pillai *et al.*, 1994). Dudley *et al.* (1992) reported from Oman waters that the fish of 40 cm in length entering the fishery were 1 year old, as also observed by Devaraj (1981) and Kasim and Hamsa (1989) in the Indian waters. Bouhlel (1985), Cheunpan (1988), Kedidi and Abushusha (1987) also reported from different regions of the world observations similar to that of Devaraj (1981) and Kasim and Hamsa (1989). However, based on the daily growth rings, Dudley *et al.* (1992) reported that the king seer had grown to 500 to 600 mm in 6 months and about 800 mm in 1 year. Similar faster growth was reported from Sri Lanka by Dayaratne (1989), by McPherson (1992) from Australia and by Brothers and Mathews (1987) from Kuwait. In the present study the size attained by this species in one year varied from 74.4 cm at Calicut to 114.3 cm at Tuticorin which is close the estimates given by above referred workers and higher than all the earlier estimates from Indian waters. The K varied from 0.87 at Calicut to 1.45 at Mangalore, which are higher than the earlier reports from Indian waters. The lower L_∞ and higher K obtained for the king seer in this study may be attributed to the reduction the average size due to continued increase in the exploitation along both the coasts on this species.

The L_∞ obtained in this study for the spotted seer are lower than the estimates given by Devaraj *et al.* (1999) at all the centres except at Chennai and the estimates of K are higher than that reported by Devaraj *et al.* (1999) at all the centres. Higher K values for pelagic species is quite common in tropical waters in view of their poikilothermic nature and resultant higher metabolic rate in relation to ambient high temperature.

The natural mortaity coefficient (M) for *S. commerson* varies from 1.11 for Calicut to 1.58 for Mangalore, which are higher that the estimates reported by earlier workers (Devaraj, 1983b; Kasim and Hamsa, 1989; Yohannan *et al.*, 1992 and Pillai *et al.*, 1994). According to Muthiah *et al.* (1999) the estimates of Z (generated by gill net) 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 (1983b) and Kasim and Hamsa (1989). The estimates obtained in this study are marginally higher (3.15 for Veraval to 6.99 for Tuticorin) than those reported above for the earlier periods. Kasim and Hamsa (1989) reported the Z to be 0.83 for the hooks and line fishery, 2.23 for the *podivalai* (gill net) fishery and 2.49 for the trawl fishery at

Tuticorin. Later Devaraj *et al.* (1999) reported 4.15 for hooks and line, 11.71 for *podivalai*, 5.03 for large-mesh gill net *paruvalai* and 5.7 for trawl at Tuticorin. Present estimates are still higher than the earlier estimates indicating a progressive increase in the exploitation in due course of time.

The exploitation rate E for the gill net fishery along the west coast was 0.51 during 1969-'74 (Devaraj, 1983b), it increased to 0.81 during 1984-'88 and further increased to 0.77 (Veraval) and 0.87 (Cochin) during 1989-'94. Currently during 1995-'99 it ranged from 0.63 for gill net at Veraval to 0.86 for trawl at Mangalore. Along the east coast, the E was estimated to be 0.42 to 0.53 by Devaraj (1983b) and 0.71 by Kasim and Hamsa (1989) for the Gulf of Mannar, but it increased to 0.76 for Mandapam (Palk Bay and Gulf of Mannar) and 0.87 for Tuticorin (Gulf of Mannar) during 1989-'94. It is evident from the present study also that the rate of exploitation has increased tremendously and nowwhere is it less than 0.63 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 over fished along both the east and west coasts of India, warranting a 16% reduction in the exploitation rate to bring the fishery back to the MSY level. Devaraj *et al.* (1999) revealed that during 1989-'94 the effort input was nearly 80% higher than the F_{MSY} level along the east coast and along the west coast the excess effort was ranging from 40% in Maharashtra and Gujarat to 80% in Karnataka and Goa. This study also reveals that the effort input for the exploitation of this species was higher than the F_{MSY} in all the places. It ranged from 40% at Calicut and Kochi by gill net to 70% by trawl at Mangalore along the west coast and from 30% by gill net at Kakinada to 80% by trawl and *podivalai* at Tuticorin along the east coast.

The fishing (F), natural (M) and total mortality (Z) rates obtained in this study for the spotted seer are much higher than the estimated reported by Devaraj *et al.* (1999) for the period 1989-'99. Devaraj (1977) assessed the exploitation ratio (E) of *S. guttatus* to be 0.52 for Palk Bay and the Gulf of Mannar respectively and 0.42 and 0.46 for the east and west coasts respectively. According to him *S. guttatus* was under-exploited along both the coasts of India during 1967-'74. Later Devaraj *et al.* (1999) reported that during 1989-'94 this species was only marginally underexploited by the gill net fishery and overexploited by the trawl fishery by 60%. In Karnataka, the exploitation of this species by gill net was at the near optimum level while the trawl fishery overexploited it marginally by 20%. In Gujarat there was scope to increase the gill net effort by 20%, while the trawl fishery overexploited the stock by 70%. Present study on this species reveals that this species is fished at the optimum level at all the centres along both the coasts except by gill net at Chennai and by trawl at Kakinada. In general this species is under fished along the west coast and marginally over fished along the east coast.

Devaraj (1983a) assessed the average annual stock of this species to be 17,545 t for the east coast and 22,629 t for the west coast amounting to a total of 40,174 t for the country as a whole during 1967-'74. Yohannan *et al.* (1992) estimated the annual stock to be 10,776 t for the east coast and 18,303 t for the west coast, giving a total of 29,079 t for the country as a whole, during the 1980s. The estimates of Yohannan *et al.* (1992) are lower than those given by Devaraj (1983 a) while the present estimates are 14,072 t for the east coast and 21,919 t for the west coast amounting to a total of 35,991 t which is closer to the estimates given by Devaraj (1983a).

Devaraj (1977) estimated the annual stock of the spotted seer to be 919 t and 958 t for the east and west coasts respectively, giving a total of only 1,877 t for the entire country during 1967-'74. This seems to be an underestimate as the current average yield itself is 15,820 t. However, if it is not an underestimate, it might mean the emergence of the spotted seer fishery into prominence as a result of the decline in the king seer fishery.

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Table 1. State-wise seerfish production and its percentage composition in all India marinefish catch , in all-India seerfish catch (in parenthesis) and seerfish catch along both the coasts in India during 1995-'99

States	1995	1996	1997	1998	1999	Average	Allfish	% of Seerfish	% in Coast
W.Bengal	582	945	662	861	555	721.0	73434.8	1.0 (1.6)	4.5
Orissa	1099	2340	1653	2785	3285	2232.4	48982.4	4.6 (5.0)	14.0
Andhra	3872	5880	4814	4187	6795	5109.6	185608.6	2.8 (11.3)	32.0
Tamilnadu	5742	4092	7493	9230	8145	6940.4	425375.6	1.6 (15.4)	43.5
Pondicherry	153	210	245	98	555	252.2	16948.4	1.5 (0.5)	1.6
Andaman	700	700	700	700	700	700.0	26120.0	2.7 (1.6)	4.4
East coast	12148	14167	15567	17861	20035	15955.6	776469.8	2.1 (35.4)	
Kerala	5910	4828	4216	5669	2941	4712.8	560389.0	0.8 (10.5)	15.8
Karnataka	2430	2129	2491	2160	2292	2300.4	167115.0	1.4 (5.1)	7.7
Goa	1833	1353	2223	2955	2834	2239.6	49088.0	4.6 (5.0)	7.5
Maharashtra	5612	6644	4202	10346	7833	6927.4	351689.6	2.0 (15.3)	23.2
Gujarat	17910	8204	13121	15816	9225	12855.2	585106.0	2.2 (28.5)	43.1
Lakshadweep	69	69	69	69	69	69.0	7684.0	0.9 (0.2)	0.2
West coast	33764	23227	26322	37015	25194	29104.4	1721072.0	1.7 (64.6)	
Total	45912	37394	41889	54876	45229	45060.0	2497541.0	1.8	
All fish	2258832	2414649	2726230	2669480	2418514	2497541			
% of seerfish	2.0	1.6	1.5	2.1	1.9	1.8			

Table 2. Average species composition of seerfish (in t) from different maritime states in India during 1995-'99

States	*S.commerson*	*S.guttatus*	*S.lineolatus*	Other spp.	Total
W.Bengal	13.6	706.4	1.0	-	721.0
Orissa	1444.4	788.0	-	-	2232.4
Andhra	2879.8	2149.6	75.6	4.6	5109.6
Tamilnadu	5798.8	518.2	180.4	443	6940.4
Pondicherry	195.2	52.0	-	5	252.2
Andaman	363.0	337.0	-	-	700.0
East coast	10694.8	4551.2	257.0	452.6	15955.6
%	67.0	28.5	1.6	2.9	
Kerala	4175.4	110.4	5	422.0	4712.8
Karnataka	1325.6	277.6	-	697.2	2300.4
Goa	2048.4	191.2	-	152.4	2392.0
Maharashtra	2428	3727.4	-	619.6	6775.0
Gujarat	5891.8	6962.8	-	0.6	12855.2
Lakshadweep	-	-	-	69.0	69.0
West coast	15869.2	11269.4	5.0	1960.8	29104.4
%	54.5	38.7	0.1	6.7	
Total	26564	15820.6	262	2413.4	45060
Percentage	59.0	35.1	0.6	5.4	

Table 3. Estimates of L_∞, K, natural mortality rate (M), total mortality rate (Z), fishing mortality rate (F), exploitation ratio (E) and Lc 50 value for *S.commerson* obtained from different centres on the east and west coast of India

Centres	Gears	L_∞ (cm)	K	M	Z	F	E	Lc50
Veraval	Trawl	124.6	1.0	1.17	5.19	4.02	0.77	47.6
	Gill net				3.15	1.98	0.63	66.3
Mangalore	Trawl	120.0	1.45	1.58	11.15	9.57	0.86	19.9
	Gill net				4.73	3.15	0.66	46.2
Calicut	Gill net	128.0	0.87	1.11	4.42	3.32	0.75	48.0
Kochi	Gill net	132.5	1.05	1.24	6.34	5.1	0.8	68.0
Tuticorin	Trawl	156.0	1.32	1.35	10.38	9.03	0.87	17.5
	Paruvalai				6.99	5.64	0.81	67.2
	Podivalai				12.11	10.76	0.89	23.1
	Hooks & line			6.24	3.55	0.72	86.2	
Chennai	Gill net	144.6	1.18	1.28	5.48	4.2	0.77	52.1
	Hooks & line			6.73	5.45	0.81	76.8	
Kakinada	Trawl	148.5	1.18	1.25				
	Gill net				5.7	4.41	0.77	81.3
West coast	All gears	137.6	1.27	1.37	5.38	4.01	0.75	20.0
East coast	All gears	156.8	1.36	1.39	5.9	4.51	0.76	17.6

Table 4. Estimates of length at age (in cm) for *S.commerson* from different Centres on the east and west coasts of India based on the growth parameters

Age (Years)	Veraval	Mangalore	Calicut	Kochi	Tuticorin	Chennai	Kakinada
1	78.8	91.9	74.4	86.1	114.3	100.2	102.9
2	107.7	113.4	105.5	116.3	144.9	131	134.5
3	118.4	118.5	118.6	126.8	153	140.4	144.2
4	122.3	119.6	124.1	130.5	155.2	143.3	147.2
5	123.8	119.9	126.4	131.8	155.8	144.2	148.1
L_∞ cm	124.6	120	128	132.5	156	144.6	148.5
K/year	1	1.45	0.87	1.05	1.32	1.18	1.18

Table 5. MSY estimates of *S.commerson* obtained by Thompson and Bell long term forecast analysis

Centre	Gear	F_{MSY} (f - factor)	MSY (t)	Bio MSY (t)	Value MSY (*1000 Rs)	Yield (t)	Biomass (t)	Value (*1000 Rs)
Veraval	Trawl	0.5	108.96	92.8	4434.2	100.428	37.38	3476.6
	Gill net	1.2	253.84	330.14	12022	252.94	217.86	11946.2
Mangalore	Trawl	0.3	627.42	411.94	24660	383.82	39.782	8994.6
	Gill net	0.6	382.18	316.48	16399.8	376.2	144.364	15217.8
Calicut	Gill net	0.6	72.52	71.214	292.3	68.758	27.662	236.06
Kochi	Gill net	0.5	356.48	308.68	19869	334.02	132.928	17422.2
Tuticorin	Trawl	0.2	1819.4	341.62	26964	249.88	27.916	6453.8
	Paruvalai	0.4	244.64	169.456	13509.2	213.58	53.886	10028.8
	Podivalai	0.2	70.908	33.592	19073.6	34.018	23.092	631.64
	Hooks&line	0.6	74.492	54.866	4545.8	71.818	27.648	4054.6
Chennai	Gill net	0.5	176.408	1412.02	8656.6	156.404	48.808	11557.6
	Hooks&line	0.5	220.22	180.67	11557.6	202.8	123.572	6691.2
Kakinada	Trawl	0.2	78.034	191.47	2702.4	23.241	3.5087	484.38
	Gill net	0.7	274.5	250.39	16453	267.43	118.47	15449
West coast	All gear	0.3	28608	19618.2	1501820	17075.2	42504	603140
East coast	All gear	0.3	17847.8	14290.8	954220	10752.4	25558	451380

Table 6. Estimates of growth and mortality parameters for *S.commerson* along the Indian coast

			Annual values of					
Centres	Gears	L_∞ (cm)	K	M	Z	F	E	Lc50
Veraval	Trawl	65.0	1.60	1.91	7.32	5.41	0.74	39.1
	Gill net				7.53	5.62	0.75	39.7
Mangalore	Trawl	65.0	1.50	1.92	8.00	6.08	0.76	30.8
	Gill net				9.28	7.36	0.79	37.7
Chennai	Trawl	75.2	1.18	1.54	9.95	8.41	0.85	26.4
	Gill net				3.70	2.16	0.58	36.5
Kakinada	Trawl	75.5	1.125	1.52	6.42	5.32	0.78	9.2
	Gill net				4.82	3.30	0.68	39.8
West coast	All gear	66.3	1.04	1.48	4.76	3.27	0.69	34.7
East coast	All gear	76.3	1.49	1.80	5.61	3.81	0.68	25.0

Table 7. Estimates of length at age (in cm) of *S.guttatus* along the Indian coast obtained using the given growth parameters

Age (Years)	Veraval	Mangalore	Chennai	Kakinada
1	51.9	50.5	52.1	51
2	62.4	61.8	68.1	67.5
3	64.5	64.3	73.0	72.9
4	-	-	74.5	74.7
L_∞ cm	65	65	75.2	75.5
K/yr	1.6	1.5	1.18	1.125

Table 8. MSY estimates of *S.guttatus* obtained by Thompson and Bell long term forecast analysis

Centre	Gear	F_{MSY} (f - factor)	MSY (t)	Bio MSY (t)	Value MSY (Rs*1000)	Yield (t)	Biomass (t)	Value (*1000 Rs)
Veraval	Trawl	1.1	235.48	147.796	9401.6	235.76	92.746	9297.4
	Gill net	1.0	716.42	412.76	29730	716.42	279.64	28602.00
Mangalore	Trawl	0.8	38.80	23.268	979.54	38.60	10.8106	921.94
	Gill net	1.0	28.20	16.3332	1190.7	28.20	99.57	1155.64
Chennai	Gill net	0.5	128.846	85.714	4500	114.614	22.966	3490
	H & L	1.6	66.074	52.784	3078.8	63.748	41.854	3083.2
Kakinada	Trawl	0.3	126	93.279	4041.3	74.00	14.024	1817.1
	Gill net	0.8	149.88	113.92	7160.8	149.00	71.899	6776.5
West coast	All gear	1.2	11977.8	10620.8	290120	11948	7379	290120
East coast	All gear	0.6	4509.4	3459.6	152358	4239	1216.32	123468

Table 9. Estimated yield (t), exploitation rate (U) and total stock (P) for *S.commerson* and *S.guttatus* along the Indian coast

	S.commerson			*S.guttatus*		
States	Yield (t)	Exp. Rate (U)	Total stock (P)	Yield (t)	Exp. Rate (U)	Total stock (P)
W.Bengal	14	1	19	706	1	981
Orissa	1444	1	2063	788	1	1094
Andhra	2880	1	4114	2150	1	2986
Tamilnadu	5799	1	7159	518	1	700
Pondicherry	195	1	247	52	1	70
Andaman	363	1	459	337	1	455
East coast	10695	1	14072	4551	1	6235
Kerala	4175	1	5423	110	1	143
Karnataka	1326	1	1744	278	1	361
Goa	2048	1	2695	191	1	248
Maharashtra	2428	1	3519	3727	1	5037
Gujarat	5892	1	8539	6963	1	9409
West coast	15869	1	21919	11269	1	15229