ASSESSMENT OF THE STOCK OF KINGSEER, *SCOMBEROMORUS COMMERSON* (LACEPEDE), ALONG THE WEST COAST OF INDIA

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INTRODUCTION

Seerfishes are economically important scombroids which contribute about 2% of the total marine fish production in India. Along the Indian Peninsula the resource has been more predominant along the west coast than the east coast. The status of exploitation, biology and stock structure of seerfishes from Indian waters were reviewed recently by Devaraj (1981, 1983), Thiagarajan (1989), Kasim and Hamsa (1989), Pillai et al. (1993) and Yohannan *et al.* (MS), and from the nearby Gulf area by Boughel (1985) (Djibouti), Edward et al. (1985) (Gulf of Aden), Kedidi and Abushumsha (1987) (Saudi Arabian Red Sea coast), Dudley and Aghanasinikar (1988, 1989) (Oman), Kedidi *et al.* (1993) (Saudi Arabian Gulf coast), and Bertignac and Yesaki (1993) (Oman), but information on the fishery, biology and stock assessment of the component species along the west coast of India is limited. In the context of changing fishing methods, introduction of innovative gears and increased exploitation along the narrow coastal belt, proper management of this renewable fishery resource becomes vital. Hence an attempt is made here to study the fishery, biology and status of the stock of *Scomberomorus commerson*, the dominant species of seerfishes in India.

DATA BASE AND METHODS OF ANALYSIS

Catch and effort statistics collected from Observation Centres, such as Veraval on the northwest coast and Cochin on the southwest coast (Figure 1), on the fishery for *S. commerson* by drift gillnets and trawl nets and their length-frequency distributions from these Centres during 1992-94 form the database for the present study Seerfish catch data for different states were taken from NMLRDC of CMFRI. The data on catch, effort and species composition of seerfishes were collected for 18 days in a month, and length-frequency data were obtained on 6-8 days in a month. The data on effort, catch, species composition and length composition on each observation day were weighted to obtain monthly estimates, and these were pooled to obtain annual estimates.

The length-frequency data collected from these Centres were raised to the total catches at those Centres. Such data from Cochin were raised to the catches of Kerala State to estimate the total mortality (Z) for the southwest region. Estimates for the northwest region were made using data from Veraval Centre after a similar procedure. From the length composition data the growth parameters, mortality, yield and stocks were estimated.

Growth parameters were estimated using the ELEFAN 1 programme of Pauly and David (1981). The von Bertalanffy growth function for length takes the form

$$L_t = L_\infty (1 - e^{(-k(t-t_0))})$$

Estimation of length at age was made based on the estimates of growth parameters.

Total mortality (Z) rates were estimated by length-converted catch curve analysis using the LFSA package (Sparre, 1987).

Estimation of natural mortality (M) was based on the empirical equation of Pauly (1980). The fishing mortality rate (F) was obtained by subtracting M from Z and computing the exploitation rate, Ep.

Yield-per-recruit estimates were made using the ELEFAN II programme of Gayanilo *et al.,* 1988.

Yield and stock biomass were predicted for varying levels of fishing effort following length-converted Thompson and Bell analysis (Sparre 1987). The outputs of length-converted cohort analysis, namely the recruitment and fishing mortalities by length groups, form the inputs for Thompson and Bell long-term forecast (1934) and Maximum Sustainable Yield (MSY) and the corresponding effort level are estimated.

THE FISHERY

Although the seerfish fishery contributes on average about 2% of the total marine fish production of the country, the resource is being largely exploited all along the Indian coast by both mechanised and unmechanised fishing vessels employing different types of gears. Details of the vessels and gears used in the fishery are those employed in tuna fishery, reported earlier in the IPTP Expert Consultations (1987). Details of the gears used in the traditional fishery were also given by Yohannan and Balasubramaniam (1989) and Kasim and Hamsa (1989). The major gear used in the fishery is the drift gillnet. The nets are made to catch all commercial size groups with varying mesh sizes from 6 to 18 cm in the same net. Normally a drift net has a total length of around 1000 m and a depth of 10 to 20 m. Apart from drift gillnets, troll lines, hooks and lines, small-mesh gillnets, shore seines. trawl nets and purse seines are also employed in the fishery.

Table 1. **L, K, and age at length of *Scomberomorus commerson* from Indian waters**

Study	***L inf***	***K(yr)***	***I yr***	***II yr***	***III yr***	***IV yr***	***V yr***
Devaraj(1983)	208.1	0.181	40.2	72.6	99.5	118.6	-
Kasim and Hamsa(1989)	193.8	0.2	38.2	66.5	90.7	108.8	-
Thiagarajan(1989)	177.5	0.38	62.3	101.8	122	135.2	145
Pillai *et al* (1993)	146	0.78	80	113	132	141	142

Table 2. **Summary of growth parameter estimates of *S. commerson* from the northern Indian Ocean**

Study area	***L***	***K***	***Source***	
Palk Bay and Gulf of Mannar	208	0.18	Devaraj (1981)	3.89
Palk Bay	187	0.18	Devaraj (1983)	3.8
Djibouti	135.7	0.21	Bouhlel (1986)	3.59
Thailand	110	0.1	Cheunpan (1988)	3.08
Oman	200	0.27	Dudley and Aghanashinikar (1988)	4.03
Oman	170	0.3	Dudley and Aghanashinikar (1989)	3.94
Sri Lanka	146	0.37	Dayaratne (1989)	3.9
Tuticorin coast	193.8	0.2	Kasim and Hamsa (1989)	3.88
SE coast of India	177.5	0.38	Thiagarajan (1989)	4.08
Kenya	240	0.02	Nzioka (1991)	3.06
SW coast of India	146	0.78	Pillai et al (1993)	4.22
Saudi Arabia	195.1	0.25	Yesaki (MS)	3.98
Oman	183.5	0.28	Yesaki (MS)	3.97

Production trends

The landings of seerfishes in India during 1981-94 are presented in Figure 2. Seerfish production in this period evinced fluctuation from 29,841 t (1990) to 43,112 t (1992), with an annual average production of 36,580 t. This indicates an increasing trend in seerfish production in India.

Landings of seerfishes by state are given in Figures 2-8. Among the four different regions along the mainland coast, the north-west region, comprising the States of Gujarat and Maharashtra, recorded the maximum catch (39.3%) of seerfish, followed by the southeast region, comprising Tamil Nadu, Pondicherry and Andhra Pradesh (24.6%); the southwest region, comprising Kerala, Karnataka and Goa (23.3%); and the northeast region, comprising Orissa and West Bengal (l2.8%) (Figure 9). The contribution from Andaman & Nicobar and Lakshadweep formed only 1.4%. The average catch, effort and catch rate at Veraval and Cochin along the west coast of India are presented in Figure 10. It is evident from the figure that the maximum effort expended in the drift gillnet fishery was at Veraval (31568 units). Similarly, the effort in the trawl fishery was 70780 units at Veraval and 42114 units at Cochin. The catch rate obtained by drift gillnets at Veraval was higher (32.4 kg) than at Cochin (23.2 kg), and a similar trend in catch rate was also observed in the trawl landings at Veraval (4.2 kg) and Cochin (2.6 kg). With regard to the purse seine fishery, the catch rate at Cochin was 6.0 kg.

The overall pattern of seerfish fishing by these gears indicate that the monsoon and post-monsoon are the productive periods along the west coast of India. On the southwest coast the fishing season starts by July-August and lasts until December-January, with peak production in September-October, whereas along the northwest coast it starts by September-October and lasts until January-February, with peak catches in November-December. Along the southeast coast the season starts by June and lasts until October, with peaks in September.

Species composition

The annual species composition, by state, during 1989-1994 is shown in Figure 9. It can be seen from the figure that *S. commerson* is the dominant species of seerfish in

Table 3. ***S. commerson*** **(North west) Thompson and Bell long-term forecast.**

X	*Yield*	*Mean Biomass*
0	0	44,452.52
0.2	5,833.51	22,915.78
0.4	6,729.65	14,509.51
0.6	6,523.08	10,260.24
0.8	6,066.6	7,727.21
1	5,584.21	6051.24
1.2	5,137.19	4,866.75
1.4	4,739.54	3,992.76
1.6	4,390.82	3,328.39
1.8	4,086.39	2812.21
2	3,820.69	2404.3
MSY=6735.033	x=0.4125	Biom. MSY=13571.36

India (52.8%), and that its catch fluctuated between 15,451 t (1990) and 24,419 t (1992), with an annual average of 19,897 t. Among the various maritime states, Kerala contributed about 29% of the catch, followed by Tamil Nadu (18.3%), Gujarat (16.5%), Andhra Pradesh (9.5%), Karnataka (7.7%), with the rest from other states. The next dominant species is *S. guttatus*, which formed 46.2% of the total seerfish catch. *S. lineolatus* and *Acanthocybium solandri* together constituted only 0.95%. It is evident from the figures that *S. commerson* dominated, with 80-91% of the total seerfish catch along the southwest and southeast coasts, while *S. guttatus* forms 51 to 96% of the total on the northeast and northwest coasts.

Size composition

At Cochin, where drift gillnets landed the bulk of the catch, the length of *S. commerson* ranged from 10-100 cm, with size groups from 35-40 cm, 55-60 cm and 75-80 cm dominating the fishery. The modal value was at 35 cm and 75 cm. At Veraval, both drift gillnets and trawls landed *S. commerson,* and its size range was from 20-130 cm, but the major catch was from the 50-60 cm, 80-90 cm and 100-110 cm size groups (Figure 11).

POPULATION PARAMETERS

Length-weight relationship

The length weight relationship between fork length (cm) and weight (g) of *S. commerson* is given by Pillai *et al.* (1993) as:

$$a \text{ in } W = aL^b = 0.015424 \text{ (gm, cm)}$$

$$b \text{ in } W = aL^b = 2.8138 \text{ (gm, cm)}$$

is used in this study.

Growth parameters

Monthly length-frequency data at Veraval and Cochin Centres were subjected to analysis using the ELEFAN 1 programme, and asymptotic length and growth coefficients (L_∞ and *K*) were estimated as 148.0 cm (fork length) and 0.42 (annual), respectively, for Veraval (Figure 11). Earlier observations by Devaraj (1983), Kasim and Hamsa (1989), Thiagarajan (1989) and Pillai *et al.* (1993) are presented in Table 1 for comparison.

The yearly growth curve of this species using the above parameters indicates that it attains 50.8 cm, 84.1 cm, 106.0 cm, 120.4cm and 129.9 cm at ages 1 to 5, respectively.

Different estimates of growth parameters of *S. commerson* available from northern Indian Ocean countries are presented in Table 2.

Mortality and estimation of stocks

Length-frequency data from Cochin and Veraval were subjected to length-converted catch curve analysis for estimation of the total mortality rate (*Z*). The value was 1.34 for the northwest region (Figure 12). The natural mortality coefficient, *M*, was estimated as 0.53 with the equation of Pauly (1980):

$$\log_{10} M = 0.0066\text{-}0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.4634 \log_{10} T,$$

where *T* is the mean temperature, which was considered in this study as 29.5°C. As this species grows to a large size very fast, the *M* value obtained was seen as an overestimate, so it was multiplied by 0.8 to get a revised estimate of *M* as 0.53. Based on the length-cohort analysis using the parameters L_∞ = 148 cm, *K* = 0.42, *M* = 0.53, and a terminal exploitation rate of 0.71, the mean *F* (*L*>40) for the northwest region was 0.99, which has been weighted by stock number. The Thompson and Bell long-term forecast model gave an MSY of 6735 t with a biomass MSY of 13,571 t for the northwest region and the optimum exploitation rate of *F* = 0.41 times the present rate of exploitation (Table 3).

The same estimates of growth parameters (L_∞ = 148 cm and *K* = 0.42) were applied in the case of *S. commerson* from the southwest coast of India (Cochin). The length-frequency data were subjected to length-converted catch curve analysis for estimation of total mortality (*Z*). The value was 1.752 (Figure 13). *M* was estimated as 0.53 by employing the empirical equation of Pauly (1980), in which the mean sea surface temperature has been considered as 29°C.

Based on the length-cohort analysis using the parameters L_∞ = 148 cm, *K* = 0.42, *M* = 0.53 and a terminal exploitation rate of 0.89, the mean *F* (*L*>40 cm) for the southwest coast was observed as 1.325, which has been weighted by stock numbers. The Thompson & Bell long-term forecast model gave an MSY of 14,666 t for the southwest region and the optimum exploitation rate of F = 0.21 times the present rate of exploitation (Table 4).

Beverton & Holt (1957) yield-per-recruit analysis has been carried out to estimate the MSY of *S. commerson* in the northwest and southwest regions. The parameters used for the northwest region (Figure 14) were:

$W_\infty = 19{,}718$

$L_\infty = 148$

K= 0.42 (annual)

a in $W = aL^b$ = 0.015424 (gm, cm)

b in $W = aL^b$ = 2.8138 (gm, cm)

$t_0 = 0$

$M = 0.53$

$T_r = 0.346$

$T_c = 0.7502$

$L_r = 20$

$L_c = 40$

Present $F = 0.99$

Present catch = 5584 t (1992-94 average).

The MSY value estimated was 6170 t, which is higher than the present catch at an F_{MSY} of 0.5. For the southwest region the parameters used were the same as for northwest area except T_r = 0.1665, T_c = 0.7502, L_r = 10 and L_c = 40. The MSY estimated was 10,726 t, and average catch during 1992-94 was 8759 t (Figure 15). The MSY value was obtained at an F_{MSY} value of 0.5. This indicated that with reference to the effort expended the catches in both regions exceeded the MSY level.

Table 4. S. commerson *(South west) Thompson and Bell long-term forecast*

X	*Yield*	*Mean Biomass*
0	0	72,455.46
0.05	8,995.61	49,024.87
0.1	12,641.95	36,616.12
0.15	14,133.45	29,031.83
0.2	14,625.51	23,957.41
0.25	14,619.32	20,340
0.3	14,357.52	17,636.04
0.35	13,966.04	15,538.83
0.4	13,513.25	13,863.42
0.45	13,037.22	12,492.37
0.5	12,559.38	11,347.87
0.55	12,091.69	10,376.58
0.6	1,1640.6	9,540.78
0.65	11,209.33	8,813.1
0.7	10,799.18	8,173.25
0.75	10,410.32	7,605.83
0.8	10,042.27	7098.98
0.85	9,694.19	6,643.37
0.9	9,365.07	6,231.59
0.95	9,053.82	5,857.64
1	8,759.33	5,516.62
MSY=14665.75	X=.2125	Biom. MSY=21,310.66

DISCUSSION

The nature of the fishery for *S. commerson* indicates that this species is being exploited by different gears from the inshore area in both regions. At Veraval and Cochin the fishing effort was found to be at a higher level than the optimum. It appears that this species is highly migratory, and juveniles and young ones are mostly caught along the southeast and southwest coasts. Medium-sized fishes (50-70 cm) are being caught in abundance, especially in the middle region (Kerala, Karnataka and Goa) of the west coast of India. As is evident from the size distribution, the specimens caught from Veraval are of larger size (80 cm), indicating a northern movement of this species when they attain an age of 2 years and above.

The difference in the growth parameters estimated by earlier workers (Table 1) may be due to the fact that the data used for different analytical methods by them were obtained by different gears such as drift gill nets, hooks and lines, troll lines and trawls. In the present study the size-frequency data obtained from both the drift gillnets and trawl fisheries were used for deriving L_∞ and K values and subsequent mortality rates and stock assessments.

The total mortality (Z) for *S. commerson* estimated by length-converted catch curve analysis from the northwest and southwest coasts of India were 1.34 and 1.75, respectively. Higher size groups were used in the analysis for the northwest coast (40-44 cm to 120-124 cm) and smaller size groups (35-40 cm to 95-100 cm) for the southwest coast. When compared to the previous study by Pillai *et al.* (1993) of the southwest coast (3.289), the total mortality rate observed during the present study was relatively low (1.75). The mean F at length >40 cm was 0.99 and 1.32 for the northwest and southwest coasts, respectively.

The Thompson and Bell long-term forecast model has been applied for estimating the MSY in both regions. It was observed that MSY was 6375 t and biomass MSY 13571 t at an exploitation rate E which is 0.41 times the present rate of exploitation in the northwest region. This indicates that in order to reach the MSY the present exploitation rate should be reduced by 59%. Similarly, for the southwest coast the MSY has been observed as 14,665 t and biomass MSY as 21,310 t at an exploitation rate E which is 0.21 times the present rate of exploitation. Hence it is inferred that in order to reach the MSY level the exploitation rate should be reduced by 79%. The yield-per-recruit analysis also indicated the same trend. In this analysis the MSY was observed as 6171 t at an F_{MSY} of 0.5 and present F of 0.99 for the northwest region. For the southwest region the MSY has been estimated as 10725 t at an F_{MSY} of 0.5 and present F of 1.3. This indicates that at both these centres the present exploitation rates are far above the optimum.

Devaraj (1983) has observed that the length at first maturity of *S. commerson* is 75 cm. At present they are heavily fished before attaining this size, especially by bottom trawls with small-mesh codends. Exploitation at the present high rates before the fish attain the age of first maturity can affect the spawning stock and recruitment. This calls for urgent measures to regulate the mesh size of trawls and drift gillnets, which may reduce the exploitation of the young fish and improve the catch. By expanding the fishery beyond the traditional fishing grounds, the fishing pressure presently exerted in the inshore waters could be considerably reduced. This requires a close monitoring of the condition of the fishery for *S. commerson* in India in the coming years.

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Figure 1. *Location of the Observation Centres of Veraval and Cochin.*

Figure 2. *Landings of seerfish in India during the period 1981-1994.*

Figure 3. *Landings of seerfish in Maharashtra and Goa during the period 1981-1994.*

Figure 4. *Landings of seerfish in Karnataka and Kerala during the period 1981-1994.*

Figure 5. *Landings of seerfish in Tamil Nadu and Pondichery during the period 1981-1994.*

Figure 6. *Landings of seerfish in Andhrapradesh and Orissa during the period 1981-1994.*

Figure 7. *Landings of seerfish in West Bengal and Lakshadweep during the period 1981-1994.*

Figure 8. *Landings of seerfish in Andamans during the period 1981-1994.*

Figure 9. *Average production of seerfish by regions and states during the period 1989-1994.*

Figure 10. *Average catch, effort and catch rates of seerfish at Veraval and Cochin along the west coast of India..*

Figure 11. Results of ELEFAN I for S. commerson *at Veraval.*

Figure 12. *Estimation of total mortality of* S. commerson *for the Northwest Region.*

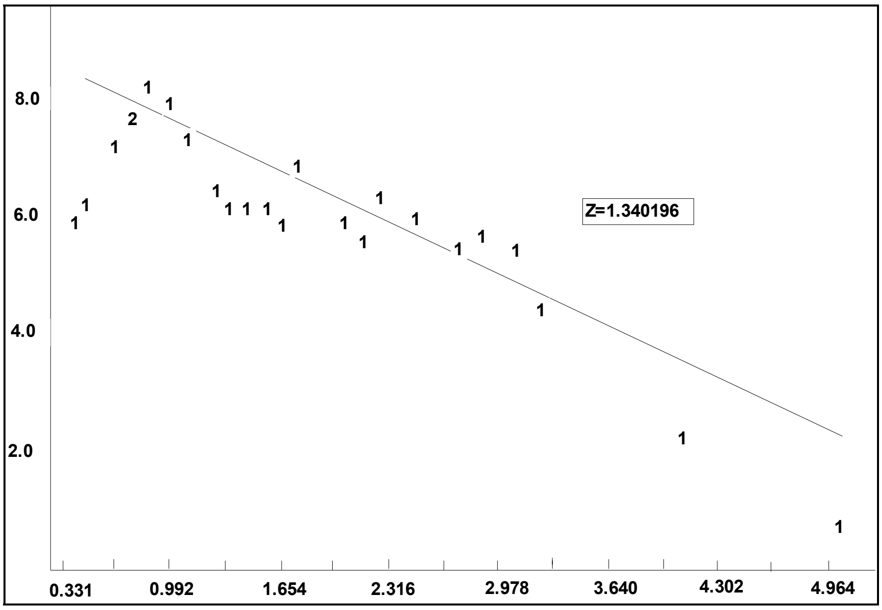

Figure 13. *Estimation of total mortality of* S. commerson *for the Southwest Region*

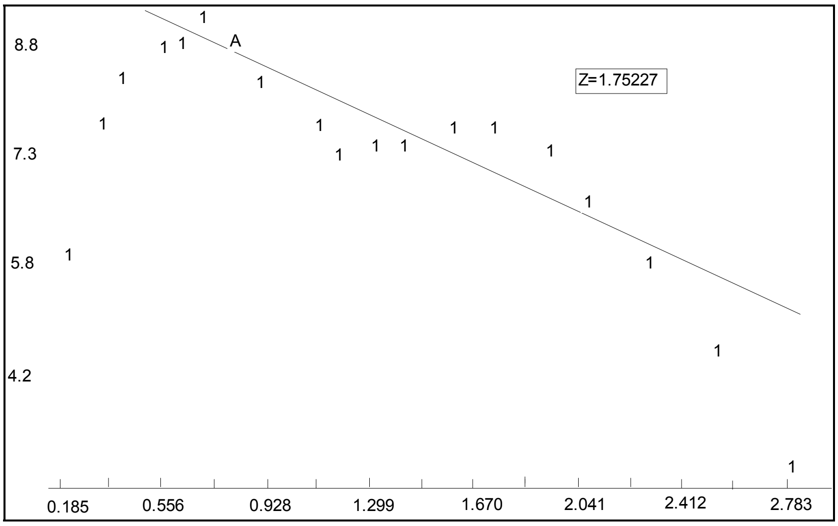

Figure 14. *Beverton & Holt's yield-per-recruit analysis for* S. commerson *on the Northwest coast.*

Figure 15. *Beverton & Holt's yield-per-recruit analysis for* S. commerson *on the Southwest coast.*