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28 Exploited seerfish fishery resources of India - a review

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ABSTRACT

Seerfishes forming 1.7 % of the total marine fish catch of the country are considered as one of the high value resources Andhra Pradesh (14.3%) and Tami Nadu (11.5%) on the east coast and Gujarat (22.8%), Maharashtra (16.9%) and Kerala (16.1%) on the west coast are the principal contributors of seerfish. They are caught mainly in gillnet (65.12%) and hook & line (6.96%) from 25-50 m depth zone and in trawl (11.47%) operated from beyond 50 m depth. Of the five species available in Indian waters, the fishery is sustained by the king seer Scomberomorus commerson and the spotted seer S.guttatus. The stock assessment studies on the king seer revealed that the present yield in different regions of the country are closer to MSY. However there is scope for stepping up production by extending fishing operations to the deeper waters beyond 50 m depth. The paper reviews their fishery, biology and stock characteristics in Indian waters.

Introduction

Species belonging to the genera *Scomberomorus*, *Acanthocybium* and *Grammatorcynus* of the family Scombridae popularly known as seerfishes/ spanish mackerels, are esteemed food fishes in all parts of the world. Out of the 19 species known under these four genera, only five species, *viz.*, the king seer *S.commerson*, the spotted seer *S.guttatus*, the streaked seer *S.lineolatus*, the Korean seer *S.koreanus*; and the whaoo *Acanthocybium solandri* are known to occur in the Indian seas. *S.commerson* and *S.guttatus* are the most abun-

dant, while *S.lineolatus* and *A.solandri* are caught sporadically in certain parts of our seas.

The information available on the seerfishes of Indian waters pertains to taxonomy, distribution, occurrence (Chacko 1956; Day 1865a, 1865b, 1869, 1878, 1889; Fowler 1927; Pillai 1929; Spence and Prater 1931; Vijyaraghavan 1955; John 1959; Kaikini 1961; Rao 1961; Jones 1962a; Jones and Kumaran 1962; Jones and Silas 1962a, 1962b; Silas 1962a; Devaraj 1976; Dhulkhed 1981), fishery (Russel 1803; Hornell 1917; Pillai 1929; Sorley 1933; Anonymous 1951, 1958, 1959, 1960; Krishnamoorthi 1957, 1958; Nayar 1958; Kaikini 1961; Chacko *et al.* 1962; Jones 1962b; Silas 1962c; Bal and Rao 1984; Rao and Kasim 1985; Kasim and Khan 1986; Deshmukh and Sriram 1987; Yohannan and Balasubramanian 1989), food and feeding (Vijyaraghavan 1955; Anonymous 1959, 1960; Venkataraman 1961; Basheeruddin and Nayar 1962; Kumaran 1962; Rao 1962; Deshpande and Sivan 1969; Dhawan *et al.* 1972; Devaraj 1977a), age and growth (Devaraj 1981; Kasim and Hamsa 1989; Thiagarajan 1989), length-weight relationship (Krishnamoorthi 1958; Devaraj 1981), maturation and spawning (Anonymous 1959; Krishnamoorthi 1958; Devaraj 1983a, 1986b, 1987) eggs, larvae and juveniles (Vijyaraghavan 1955; Krishnamoorthi 1958; Kaikini 1961; Venkataraman 1961; Jones 1962a; Jones and Kumaran 1962; Kumaran 1962; Rao 1962; Rao and Ganapati 1997), parasites (Bassett-Smith 1898; Southwell 1929, 1930; Verma 1936; Chauhan 1953a, 1953b; Ramalingam 1951, 1961a, 1961b; Tripathi 1954, 1957; Silas 1962b; Silas and Ummer Kutty 1962), physiology (Tampi 1959), osteology (Devaraj 1977b), curing (Day 1865a, 1878; Nicholson 1930), ecology (Hora 1953), resources (Devaraj 1986a), stock assessment (Banerji 1973, Devaraj 1977a, 1983b; Kasim and Hamsa 1989; Yohannan *et al.* 1992; Pillai *et al.* 1994), sport fishing (Thomas 1897; Burton 1946; Macdonald 1947; Suter 1948) and utility as food (Pillai 1929; Day 1865a, 1865b, 1878).

The investigation carried out at the CMFRI over the past 5 decades is consolidated here under for the use of fishery managers, and entrepreneurs (fishing industry). The research results also give scope to formulate future research programmes leading to judicious management of the resource.

Data base

Statewise, gearwise and quarterwise data on estimated catch and effort

from all maritime states of India for 1989-94 collected by Fisheries Resources Assessment Division of the Institute were used for catch per unit effort analysis. As the resource is exploited by a variety of mechanised and non-mechanised gears, the effort is standardised by following the method adopted by Silas and Pillai (1985).

Fishery

Seerfishes are distributed in tropical and subtropical waters of Indian, Pacific and Atlantic Oceans. Among the seerfishes occurring in the Indian seas, *S. commerson*, is the most widely distributed species, followed by *S. guttatus*, *S. lineolatus*, *Acanthocybium solandri* and *S. koreanus*.

Seerfish landings in India during 1959-1994 indicate an increasing trend over the years from 6,590 t in 1959 to 42,140 t in 1992 with annual fluctuations (Fig.1). The average annual landing of 10,499 t during the decade 1960-69, has almost doubled to 20,300 t in the next decade 1970-79 and further increased to 33,297 t in 1980-89. In the recent five-year period, 1990-94, the average annual landing stood at 37,926 t which is about 5.5 times more than that of 1959, 3.6 times more than that of 1960s and about 2 times that of 1970s. This remarkable increase from 1971 was due to intensification of mechanisation of crafts and gears and also the vulnerability of this resource to the trawling operations especially by multiday trawling in the deeper waters beyond 50 m depth.

The annual average seerfish yield of 29,058 t during the 25-year period of 1970-94 was constituted by east coast and west coast at about 40% and 60% respectively. During 1950s more seerfishes were caught along the east coast (60%) (Jones, 1962b). During the seventies the seerfish production by both coasts was at 50:50 level (Devaraj, 1986a) which changed to 37:63 in 1980-89 and continued at the same level (35:64) in the current five-year period of 1990-94. This clearly shows that the growth of seerfish production along the east coast is declining whereas an increasing trend is seen on the west coast.

In the east coast bulk of the seerfish catch during 1970-94 period was made by Andhra Pradesh (41%) and Tamil Nadu (40%). Along the west coast Kerala (28.93%), Maharashtra (26.55%) and Gujarat (26.66%) were the prime contributors.

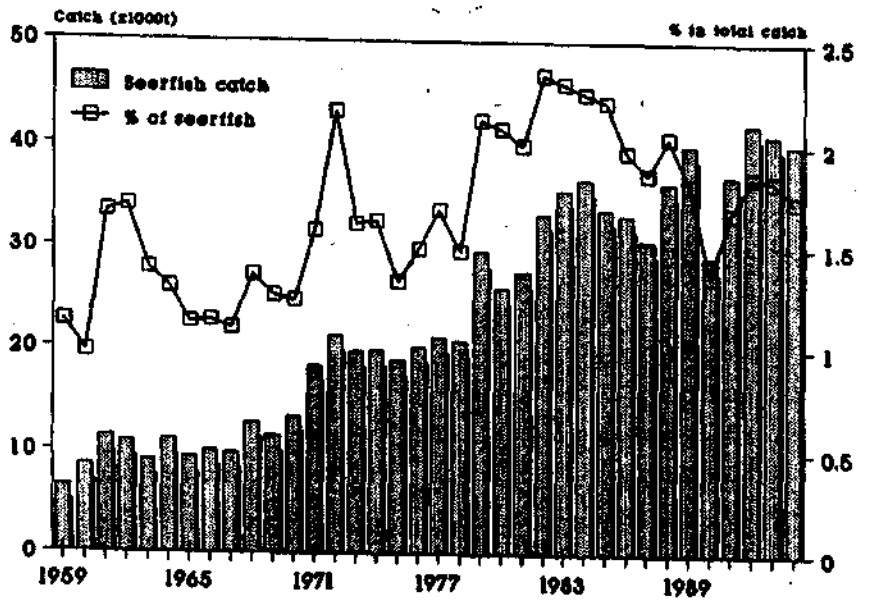

Fig.1 Estimated annual seerfish landings in India during 1959-'94

Craft and gear

Different types of crafts are employed for seerfish fishery depending upon the prevailing regional environmental conditions. They are dugout canoes, plank built canoes, FRP canoes, outrigger canoes and small/medium trawl type boats of 6.75-14.5 m. Besides, catamarans are also common crafts for seerfish along the east coast. While all the small/medium trawl boats and indigenous plank built/FRP boats are mechanised, the small canoes and catamarans have also recently been motorised with outboard engines. Consequent to the motorisation the number of the non-mechanised plank-built boats, canoes and catamarans are on the decline.

Among a variety of gears used for the capture of seerfish the gillnets are the most popular along both east and west coasts of India, hooks & lines are common on the east coast. In recent years trawls are emerging as one of the important gears for juvenile seerfish exploitation in many of the states. Seerfishes are also taken along with other fishes by various gears like shoreseines, boatseines, longlines and surface trolling. Purse seines along

the west coast also land them as incidental catches. Gillnets with larger mesh size of 120-170 mm have been found very efficient for seerfish exploitation. Hook & lines are also found to be efficient and highly selective. Trawls and shore seines are non-selective and usually catch small sized seerfishes (Kasim and Hamsa, 1989).

Catch, effort and catch rates

Gillnet: On an average this dominant gear landed 24,904 t of seerfish forming 65.11% of the total seerfish production of the country during 1989-94 (Table 1). The bulk of the catch, 67.73% (16,799.5 t) was landed along the west coast and the rest on the east coast. The annual landings by the gear varied from 46 t in Pondicherry to 3,021.8 t in Andhra Pradesh along the east coast and from 944.8 t in Goa to 5,863.5 in Gujarat on the west coast. The percentage contribution of seerfish by the gear varied from 53.30 (Pondicherry) to 98.51 (West Bengal). The total average standard gillnet effort for seerfish during 1989-94 was 14.47 lakh units comprising 53.62% on the east coast and 46.38% on the west coast. The effort was lowest along the Pondicherry coast (4,823 units) and highest along the Orissa coast (1,85,451 units). Along the west coast minimum effort was in Karnataka (27,938 units) and maximum in Kerala (1,38,841 units) (Table 2). The average catch rate (C/SE) for all-India was 17.21 kg during 1989-94 and it was 17.30 kg during 1964-81 (Devaraj, 1986a). The catch rate for the east coast (10.44 kg) was much lower than that for west coast (25.03 kg). Along the east coast, the catch rate was highest for Andhra Pradesh (20.43 kg) and lowest for Tamil Nadu (6.48 kg). Among the west coast states, highest catch rate was recorded in Karnataka (54.18 kg) and lowest in Gujarat (17.35 kg). Analysing the catch and effort data for 1964-81, Devaraj (1986a) reported the C/E for east coast and west coast as 14.9 kg and 20.5 kg respectively (Table 3). Highest C/E was recorded by Andhra Pradesh (26.5 kg) followed by Tamil Nadu (11.9 kg), Orissa (10.2 kg) and West Bengal (6.5 kg) on the east coast sector and on the west coast it was highest for Maharashtra and Gujarat (41.3 kg each) followed by Karnataka and Goa (31.9 kg each) and Kerala (11.76 kg). Comparing the C/E of the above two periods, it is seen that in recent years the abundance of seerfish has slightly increased along the west coast with proportionate reduction in the east coast.

Table 1. **Gearwise average (1989-'94) Catch of seerfishes (t) in different states (figures in parenthesis indicate %)**

State	Gillnet	Hook&line	Trawl	Other gears	Total
West	1061.6	0	0.5	15.5	1077.6
Bengal	(98.51)	(0)	(0.05)	(1.44)	
Orissa	1695.5	339.0	56.0	376.3	2466.8
	(68.73)	(13.74)	(2.27)	(15.26)	
Andhra	3021.8	881.2	195.3	1440.3	5538.6
Pradesh	(54.56)	(15.91)	(3.53)	(26.00)	
Tamil	2280.0	799.0	531.0	663.0	4273.0
Nadu	(53.35)	(18.70)	(12.43)	(15.52)	
Pondi-	46.0	28.0	1.3	11.0	86.3
cherry	(53.30)	(32.44)	(1..51)	(12.75)	
East	8104.9	2047.2	784.1	2506.1	13442.3
coast	(60.30)	(15.23)	(5.83)	(18.64)	
Kerala	4717.0	498.8	714.5	538.0	6468.3
	(72.92)	(7.71)	(11.05)	(8.32)	
Karnataka	1513.7	22.7	237.3	176.0	1949.7
	(77.64)	(1.16)	(12.17)	(9.03	
Goa	944.8	0	25.9134.3	1105.0	
	(85.50)	(0)	(2.34)	(12.15)	
Mahara-	3760.5	90.0	1715.8	1381.0	6947.3
shtra	(54.13)	(1.29)	(24.70)	(19.88)	
Gujarat	5863.5	3.3	908.0	1559.4	8334.2
	(70.35)	(0.04)	(10.90)	(18.71)	
West	16799.5	614.8	3601.5	3788.7	24804.5
coast	(67.73)	(2.48)	(14.52)	(15.27)	
Total	24904.4	2662.0	4385.6	6294.8	38246.8
	(65.11)	(6.96)	(11.47)	(16.46)	

Table : 2 **Estimated effort, catch and catch rates of seerfishes by gillnetters during 1989-'94 (average) in different maritime states.**

State	Standard effort (units)	Catch (c) (T)	C/SE (KG)	C/E* (KG)
West Bengal	86,291	1,061.6	12.30	6.50
Orissa	1,85,451	1,695.5	9.14	10.20
Andhra Pradesh	1,47,922	3,021.8	20.43	26.50
Tamil Nadu	3,51,661	2,280.0	6.48	11.90
Pondicherry	4,823	46.0	9.54	-
East coast	**7.76,148**	**8,104.9**	**10.44**	**14.90**
Kerala	1,38,841	4,717.0	33.97	11.76
Karnataka	27,938	1,513.7	54.18	31.90
Goa	28.905	944.8	32.69	31.90
Maharashtra	1,37,620	3,760.5	27.33	41.30
Gujarat	3,37,917	5,863.5	17.35	41.30
West coast	**6,71,221**	**16,799.5**	**25.03**	**20.50**
All-India	**14,47,369**	**24,904.4**	**17.21**	**17.30**

SE=Standard effort

*Catch per boat days as reported by Devaraj (1986a) 1964-'81 period

Table : 3 **Estimated effort, catch and catch rates of seerfishes by hook and lines during 1989-94 (average) in different maritime states.**

State	Standard effort (units)	Catch (c) (T)	C/SE (KG)
West Bengal	No HL fishery		
Orissa	3,68,325	339.0	0.92
Andhra Pradesh	1,99,747	881.2	4.41

Tamil Nadu	2,85,550	799.0	2.80
Pondicherry	1,720	28.0	16.28
East coast	**8,55,342**	**2,047.2**	**2.39**
Kerala	60,427	498.8	8.25
Karnataka	483	22.7	47.00
Goa	No HL fishery		
Maharashtra	21,530	90.0	4.18
Gujarat	6,393	3.3	0.52
West coast	**88,833**	**614.8**	**6.92**
All-India	**9,44,175**	**2,662.0**	**2.82**

SE=Standard effort, HL = Hook and Line

Hook & line: This gear contributed 2,662 t of seerfish annually during 1989-94 forming 6.96% of the total all-India seerfish landings (Table 1). East coast recorded higher landings (2,047.2 t) by about 3 times more than the west coast (614.8 t). There was no landing of seerfish by this gear in West Bengal and Goa. In other states it accounted 0.04% (Gujarat) to 32.44% (Pondicherry). The catch was highest in Andhra Pradesh (881.2 t) followed by Tamil Nadu (799 t). Along the west coast Kerala landed the maximum catch of 498.8 t. The average annual hook & line effort was 9.44 lakh units. Of this, about 91% (8.55 lakh units) of the efforts were expended by the east coast states and the rest by the west coast states. Among all states Orissa, Tamil Nadu, Andhra Pradesh and Kerala expended 39.01%, 30.24%, 21.16% and 6.40% of total effort respectively (Table 3). The average annual catch per unit effort was 2.82 kg, 2.39 kg and 6.92 kg for all-India, east coast and west coast respectively. It was highest for Karnataka (47.00 kg) followed by Pondicherry (16.28 kg) and Kerala (8.25 kg).

Trawl : Seerfish landings by trawl amounted to 4,385.6 t annually during 1989-94. West coast contributed (3,601.5 t), nearly 4.5 times more than east coast (784.1 t). Along the east coast Tamil Nadu recorded the highest landing of 531 t. In the west coast higher catches were from Maharashtra (1,715.8 t), Gujarat (908 t) and Kerala (714.5 t). The percentage contribution

by this gear was lowest in West Bengal (0.05) and highest in Maharashtra (24.7). The total annual all-India trawling effort was about 169.54 lakh hours (Table 4). West coast states expended more effort (105.23 lakh hours - 62%) than the east coast states (64.31 lakh hours - 38%). Tamil Nadu expended highest effort (43.92 lakh hours) on the east coast. Along the west coast Maharashtra (35.50 lakh hrs.) and Kerala (30.47 lakh hrs.) expended higher efforts. The annual catch per hour (C/H) of seerfish was 0.26 kg for all-India, 0.12 kg for east coast and 0.34 kg for west coast and the C/H was higher for Gujarat (0.53 kg) and Maharashtra (0.48 kg).

Table : 4 **Estimated effort, catch and catch rates of seerfishes by trawlers during 1989 - '94 (average) in different maritime states.**

State	Standard effort (units)	Catch (c) (T)	C/SE (KG)
West Bengal	45,169	0.5	0.01
Orissa	5,91,682	56.0	0.09
Andhra Pradesh	13,17,859	195.3	0.15
Tamil Nadu	43,92,474	531.0	0.12
Pondicherry	83,595	1.3	0.02
East coast	**64,30,779**	**784.1**	**0.12**
Kerala	30,46,984	714.5	0.23
Karnataka	17,40,879	237.3	0.14
Goa	4,73,739	25.9	0.05
Maharashtra	35,50,437	1,715.8	0.48
Gujarat	17,11,156	908.0	0.53
West coast	**1,05,23,195**	**3,601.5**	**0.34**
All-India	**1,69,53,974**	**4,385.6**	**0.26**

SE=Standard effort

Other gears: The other artisanal gears and purse seine (Kerala and Karnataka) together contributed 6,294.8 t (16.46%) annually (1989-94) to all-India catch of seerfishes. These gears accounted for 18.64% (2,506.1 t) in the east coast and for 15.27% (3,788.7 t) in the west coast. Among the states,

landings varied from 15.5 t in West Bengal to 1440.3 t in Andhra Pradesh along the east coast and from 134.3 t in Goa to 1,559.4 t in Gujarat along the west coast.

Table 5: **Average quarterwise seerfish landing in tonnes in different states (1989-1994)**

Quarter/ State	I	II	III	IV	Total
West Bengal	175.3	12.3	389.5	500.5	1077.6
	(16.27	(1.15)	(36.14)	(46.44)	
Orissa	885.0	80.3	334.0	1167.5	2466.8
	(35.88)	(3.25)	(13.54)	(47.33)	
Andhra Pradesh	2076.5	859.3	927.5	1675.3	5538.6
	(37.49)	(15.51)	(16.75)	(30.25)	
Tamil Nadu	981.5	675.5	1415.7	1263.3	4273.0
	(12.5)	(15.81)	(33.13)	(29.56)	
Pondicherry	19.5	23.7	35.8	7.3	86.3
	(22.6)	(27.46)	(41.48)	(8.46)	
East Coast	**4074.8**	**1651.1**	**3102.5**	**4613.9**	**13442.3**
	(30.31)	**(12.28)**	**(23.08)**	**(34.32)**	
Kerala	1253.8	533.0	1027.3	3654.2	6468.3
	(19.38)	(8.24)	(15.88)	(56.49)	
Karnataka	272.5	111.7	205.3	1360.2	1949.7
	(13.98)	(5.73)	(10.53)	(69.76)	
Goa	166.8	67.1	228.3	642.8	1105.0
	(15.10)	(6.07)	(20.66)	(58.17)	
Maharashtra	1686.7	1088.6	895.5	3276.5	6947.3
	(24.28)	15.67)	(12.89)	(47.16)	
Gujarat	2189.0	951.7	500.8	4692.7	8334.2
	(26.26)	(11.42)	(6.01)	(56.31)	

West coast	**5568.8**	**2752.1**	**2857.2**	**13626.4**	**24804.5**
	(22.45)	**(11.09)**	**(11.52)**	**(54.94)**	
All-India	**9643.6**	**4403.2**	**5959.7**	**18240.3**	**38246.8**
	(25.21)	**(11.51)**	**(15.58)**	**(47.69)**	

Seasonal abundance

The abundance of seerfish over space and time during 1989-94 are given in Table 5. The landings in the states along the east coast showed no clear seasonal trend, whereas along the west coast the 4th quarter contributed higher landings.

Species composition

During 1982-94, the all-India seerfish catch was constituted by *S.commerson*, 55.32%, *S.guttatus*, 43.92%, *S.lineolatus*, 0.58% and *A.solandri* 0.18%. The percentage contribution of the first two dominant species along both the east and west coasts was more or less same as the all-India figure (Table 6). The earlier study by Devaraj (1986) using the data for 1964-81 reported higher national average for *S.commerson* (64.05%) and *S.lineolatus* (2.65%) and lower for *S.guttatus* (33.30%). This shows that exploitation of the latter species is on the increasing trend. In general the two dominant species show good agreement between the east and west coasts for similar latitudes (Devaraj, 1986a). The king seer is predominant along the southeastern (Tamil Nadu and Pondicherry coast), southwestern (Kerala coast) and mid-western (Karnataka and Goa coasts) regions. The spotted seer dominates along the northeastern region (West Bengal and Orissa coasts) and northwestern region (Maharashtra and Gujarat coasts). The dominance of spotted seer in regions of northern latitudes on both coasts coincides with the prevailing low salinity conditions due to heavy river discharges (Devaraj, 1986a).

Table 6: **Species composition of seerfishes during 1982-1994 (average) (Figures in parenthesis indicates percentages)**

State	*S. commerson*	*S. guttatus*	*S. lineolatus*	*A. solandri*
West Bengal	126.8	564.7	0.1	0
	(18.33)	(81.65)	(0.01)	(0.00)

Orissa	791.2	1057.2	3.3	0
	(42.73)	(57.10)	(0.17)	(0.00)
Andhra Pradesh	2132.8	3339.5	95.2	0
	(38.31)	(59.98)	(1.71)	(0.00)
Tamil Nadu	3744.8	445.1	95.8	4.5
	(87.29)	(10.37)	(2.23)	(0.10)
Pondicherry	107.2	5.8	0	0
	(94.87)	(5.13)	(0.00)	(0.00)
East coast	**6902.8**	**5412.3**	**194.4**	**4.5**
	(55.16)	**(43.25)**	**(1.55)**	**(0.04)**
Kerala	5024.7	1295.2	5.8	23.4
	(79.14)	(20.40)	(0.09)	(0.37)
Karnataka	2447.6	540.7	6.3	0.1
	(81.73)	(18.06)	(0.21)	(0.003)
Goa	512.8	370.6	0	0
	(58.05)	(41.95)	(0.00)	(0.00)
Maharashtra	2206.1	4417.2	0.2	0.5
	(33.30)	(66.68)	(0.003)	(0.008)
Gujarat	2653.5	3640.1	0.1	34.6
	(41.93)	(57.52)	(0.001)	(0.55)
West coast	**12844.7**	**10263.8**	**12.4**	**58.6**
	(55.41)	**(44.28)**	**(0.05)**	**(0.25)**
All-India	**19747.5**	**15676.1**	**206.8**	**63.1**
	(55.32)	**(43.92)**	**(0.58)**	**(0.18)**
All-India*	**(64.05)**	**(33.30)**	**(2.65)**	
(1964-81)				

* Source : Devaraj (1986a)

Migration

No direct evidence is available on the migratory movements of seerfishes. But they seem to move to inshore waters for feeding and to protected bays and coves in the shallow waters for breeding. These observations are based on the abundance of seerfish spawners and on the duration of fishing seasons in the different locations. King seer spawners move from the fishing grounds off Gulf of Mannar and Coramandal coasts into the inshore bays for spawning during the 2nd quarter and re-enter the fishing ground in the 3rd

quarter (Devaraj, 1986a). Maturing and ripe spotted seer occur in good abundance every year during March-June period in the fishing grounds of the Gulf of Mannar and by November-December the spent recovering fish migrate south towards the coast of Mundal and form appreciable fishery there. The occurrence of this cycle every year signifies an annual spawning migration (Devaraj, 1987). The peak fishing season for *S.commerson* during July-September at Tuticorin in the Gulf of Mannar, August-September at Cochin and September at Calicut in the southwest coast, in October at Mangalore-Malpe in the mid-west coast, October-January at Bombay and November-January at Veraval in the northwest coast (CMFRI annual reports for 1992-93, 1993-94, 1994-95) is indicative of a south to north migration of the species. Devaraj (1986a) also reported that the uniformly high abundance of seerfish along the entire west coast in the last annual quarter and the progressive northward increase in the annual instantaneous mortality from the minimum off Cape Comorin to maximum for the Gujarat coast indicates that at least the king seer stock originates around Cape Comorin and spreads (migrates) therefrom towards north.

Size distribution

The size of *S.commerson* in the bigger mesh size gillnet (120-170 mm) at Madras, Tuticorin, Mandapam and Mangalore-Malpe and along the Kerala coast ranged from 220 to 1500 mm. The fishery was mainly supported by 300-1060 mm size groups, constituting 89-97.5% of the estimated number of fish landed in different centres. The proportion of fish below the length at first maturity (lm) of 750 mm ranged from 34.58% (Mandapam) to 77.57% (Mangalore-Malpe) (Table 7). In the small mesh size gillnet (60-100 mm) along the southeast coast centres, Tuticorin and Mandapam, the length range was 50-1250 mm. Bulk of the catch consisted of fish below minimum size at maturity (80.65-99.99%). In trawl the size varied from 50 to 1150 mm at Madras, Tuticorin and Mangalore-Malpe. The dominant size groups were between 120 mm and 620 mm. Almost all fishes (99.22-99.99%) caught by this gear from all centres were below the size at first maturity. The hook & line catch at Tuticorin and Mandapam showed a wide range, 300-1500 mm. The fishery was sustained mainly by 350-1150 mm size groups (88.25-97.80%). Exploitation of immature fish below lm was minimum at Tuticorin (26.29%) and maximum at Mandapam (54.36%). In the shore-seine fishery at Mandapam, the size varied from 50 to 1350 mm. The main size groups were

between 150 and 1000 mm (97.9%). Immature fish contributed as much as 90%, as in the small mesh size gillnet and trawl. Studies on the monthly size distribution of king seer in different gears at Tuticorin showed that youngfish (below 350 mm) occurred in good numbers during May-September in '*paruvalai*'(gillnet with 120-170 mm mesh size), April-November in trawl and throughout the year in '*podivalai*' (gillnet with 70-100 mm mesh size). In hook & line immature fish (450-750 mm) occurred in all months. At Mangalore-Malpe, youngfish appeared in the gillnet (65-135 mm mesh size) landings during January and September-December and are very common in all months of the fishery (August-January) in trawl. These observations indicate that recruitment to the fishery takes place almost throughout the year (Muthiah, per.com.).

Table : 7 **Size distribution of *S.commerson* by different gears and at different centres**

Centre/ Area	Gear	Size range (mm)	Dominant Size group (mm)	Proportion of dominant size group %	Proportion of Size group upto Im (750mm) %	Period	Source
Madras	Gillnet	100-1200	300-900	88-89	71-24	1987	Thiagarajan (1989)
	Trawl	50-1150	150-500	79.47	99.22	"	"
Mandapam	Gillnet (140mm)	250-1500	500-1050	89.24	34.58	1984-87	Thiagarajan (1989)
	Gillnet (60mm)	50-750	150-550	93.63	99.98	"	"
	Gillnet (76mm)	300-1250	350-1050	98.99	80.65	"	"
	Hook & line	300-1500	350-1150	97.8	54.36	"	"
	Shore seine	50-1350	150-1000	97.9	89.99	"	"
Tuticorin	'Paruvalai' (Gillnet, 120-170 mm)	240-1380	360-1060	97.5	61.74	1992-95	Kasim (Per.com.)
	'Podivalai' (Gillnet,	120-780	180-600	99.32	99.59	"	"

70-100 mm)							
	Hook & line	440-1460	600-1120	88.25	26.29	"	"
	Trawl	120-1000	120-600	97.77	99.30	"	"
Kerala	Gillnet	300-1300	500-890	-		1984-88	Yohannan et al.(1992)
Mangalore	Gillnet	220-1280	320-920	96.74	77.57	1992-95	(Muthiah (Per.com.)
(65-135 mm)							
	Trawl	120-880	200-620	99.38	99.99	"	"

Age and growth

The published accounts on the age and growth of seerfish of Indian waters are very few. The earliest study was by Krishnamoorthi (1958) on the spotted seer from Palk Bay. Later Rao (1978) studied the spotted seer from Waltair waters. Devaraj (1981) studied the age and growth of all the three species from the southeast and southwest coasts using length frequency method and otolith readings. Recently Kasim and Hamsa (1989), Yohannan *et al.* (1992), Pillai *et al.* (1994) and Thiagarajan (1989) have determined age and growth of *S.commerson* using length frequency data. The growth parameters of the three species as estimated by different authors are given in Table 8.

Table : 8 **Estimates of growth parameters of *Scomberomorus* spp. in India water centres**

Species	Length			Weight					
	L_∞ (mm)	K/year	t_0(year)	W_∞ (kg)	K/(year)	t_0 (year)	Method of estimation of growth parameters	Locality	Source
S.commerson	2081 (TI)	0.21185	-0.15955	39.027	0.21185	-0.03002	Rafail method	Palk Bay & Gulf of Mannar	Devaraj (1981)
	1870 (FL)								
	1938 (FL)	0-2006	-0.0835	32.002	0.2214	-0.1237	Petersen & Modal Progression & Bagenal method	Tuticorin coast	Kasim and Hamsa (1989)
	1775	0.38	-0.231	-	-	-	Ford-Walford plot	Palk Bay &	Thiagarajan

	(FL)							Gulf of Mannar	(1989)
	1460	0.78	-	-	-	-	Modal progression	Southwest coast	Pillai *et al.*
	(FL)							of India	(1994)
	1460	0.78	-	-	-	-	ELEFAN	East & south	Yohannan *et al*
	(FL)							west coasts of	(1992)
								India	
S.guttatus	1278	0.18007	-0.4654	8.54	0.21256	-0.45267	Rafail method	Palk Bay &	Devaraj (1981)
								Gulf of Mannar	
S.lineolatus									
Male	1683	0.18232	-0.66433	15.7	-	-	Bagenal method	Palk Bay &	Devaraj (1981)
	(TL)							Gulf of Mannar	
Female	1447	0.22314	-0.51225	24.3	-	-	Bagenal method	Palk Bay &	Devaraj (1981)
	(TL)							Gulf of Mannar	

TL-Total length, FL-Fork length.

Devaraj (1981) used two methods *viz.*, Rafail (1973) and Bagenal (1955) for the study of growth in length and weight and found that the first method gives a better fit for the von Bertalanffy equation in the case of *S.commerson* and *S.guttatus*. For *S. lineolatus*, the Bagenal method appears to fit the growth better. His results on the study of back-calculated length of fish at the time of ring formation on otolith agree closely with the result of length frequency analysis. He has shown that all the three species develop two rings a year in their otolith at intervals of six months. He found that in *S.commerson* the length at age derived from otolith studies agreed well with those obtained from length frequency studies. In the case of spotted seer, the lengths at 1, 2 and 3 years estimated from length frequency analysis corresponded to the lengths at 1.5, 2.5 and 3.5 years respectively estimated from otolith studies and he attributed these differences to the limitation of the length frequency data to meet the requirements of Petersen's method fully as advocated by Watson (1964). According to him, Krishnamoorthi's (1958) estimation of third year class at 385 mm (= 491 mm TL) appears under estimated. The studies made by Rao (1978) indicated that the lengths at ages 1-7 as 280 mm, 425 mm, 530 mm, 610 mm, 670 mm, 720 mm and 770 mm in S.L respectively. The corresponding TL equivalents upto 1-4 years (337 mm, 513 mm, 641 mm & 738 mm respectively) agree with the result obtained from the length fre-

quency analysis by Devaraj (1981).

In the case of streaked seer Devaraj (1981) has shown that the length at age from length frequency analysis was closer to the back-calculated estimates for males than for females.

According to Devaraj (1981) there is no significant difference in growth between male and females of all the three species. It is seen from Table 9 that in *S.commerson*, low growth rate was reported by Devaraj (1981) and Kasim and Hamsa (1989) during the 1st year of its life at 402 mm and 382 mm respectively as compared to very fast growth rate obtained by Pillai *et al.* (1994) and Thiagarajan (1989) at 800 mm and 623 mm respectively. Recently Dudley *et al.* (1992) while studying the age and growth of this species from Oman waters reported that fish of 40 cm in length entering the fishery were 1 year old and this observation is in close agreement with that of Devaraj (1981) and Kasim and Hamsa (1989) on the species from Indian seas and Bouhlel (1985), Cheunpan (1988), Kedidi and Abushusha (1987) from other regions of the world. However, age and growth studies by Dudley *et al.* (*op. cit.*) based on daily growth rings have shown that the species grow very rapidly reaching a size of about 500-600 mm in 6 months and to about 800 mm in 1 year. Similar findings from Sri Lanka (Dayaratne, 1989), Australia (McPherson, 1992) and Kuwait (Brothers and Mathews, 1987) also have been reported in recent years.

Table 9. **Length (mm) at age of *Scomberomorus* spp. in Indian Waters**

Species/ Age (Years)	1	2	3	4	5	6	7	Type of length	Source
S.commerson	402	726	995	1186				TL	Devaraj (1981)
S.commerson	382	665	907	1088				FL	Kasim & Hamsa (1989)
S.commerson	623	1018	1220	1352	1450			FL	Thiagarajan (1989)
S.commerson	800	1130	1322	1410	1420			FL	Pillai et al. (1994)
S.guttatus	369	532	640					TL	Devaraj (1981)
S.guttatus	280	425	530	610	670	720	770	SL	Rao (1978)

	(337	513	641	738	811	872	993)	TL	
S.lineolatus	350	713	835	965				TL	Devaraj (1981)

TL - Total length. FL - Fork length. SL - Standard length.

The estimates of K reported by Devaraj (1981) and Kasim and Hamsa (1989) are very low as compared to that given by Thiagarajan (1989). though the study area was the same in all the three cases. Yohannan *et al.* (1992) also reported higher K value of 0.78 for the species. According to Thiagarajan (1989) the low K values may be due to the existence of several broods in tropics as yearly cohorts for estimation of K following the modal progression analysis.

Length-weight relationship

The length-weight relationship of *S.commerson* of the Gulf of Mannar and Palk Bay was studied by Silas (1962c) Devaraj (1981), Kasim and Hamsa (1989), Thiagarajan (1989). Pillai *et al.* (1994) also worked out the length-weight relationship equations of this species from southwest coast of India. The only study made on the length-weight relationship of the other two species, *S.guttatus* and *S.lineolatus* was Devaraj (1981) from the above area. It is seen from the Table 10 that the exponential values in the length-weight relationship for all the three species is found to be close to 3 indicating isometric growth pattern.

The relationship between the total length and standard length of the spotted seer of the Rameswaram coast was studied by Krishnamoorthi (1958) as log Y = -0.0665 + 0.9771 log X where Y and X are the total and standard lengths respectively.

Table 10. **Length-weight relationship ($W=aL^b$) parameters of seerfishes in Indian waters.**

Species	Group	a		b	Length	Region of study	Reference
S.commerson	Male &	8.37E-08	L in cm	2.7536	FL	Gulf of Mannar	Silas (1962c)
	Females		W in lbs				
	Males &	0.009614	L in cm	2.8577	TL	Palk Bay & Gulf	Devaraj (1981)

	Females		W in g			of Mannar	
	"	0.01097	L in mm	2.8479	FL	Gulf of Mannar	Kasim & Hamsa (1989)
			W in g				
	"	0.138	L in cm	2.8296	FL	Palk Bay & Gulf	Thingarajan (1989)
			W in g			of Mannar	
	"	0.015424	"	2.8138	FL	Southwest coast	Pillai *et.al.* (1994)
						of India	
S.guttatus	"	0.01011	"	2.8605	TL	Palk Bay & Gulf	Devaraj (1981)
						of Mannar	
S. lineolatus	Males	0.004394	"	3.0372	TL	Palk Bay & Gulf	Devaraj (1981)
						of Mannar	
	Females	0.004167	"	3.0443	TL	"	Devaraj (1981)

TL = Total length, FL= Fork length

Food and feeding

S.commerson: According to Devaraj (1977a) *S.commerson* from the Gulf of Mannar and Palk Bay feeds mainly on teleosts of a large number of taxa forming 99.36%. It prefers *Sardinella* spp., carangids, *Rastrelliger kanagurta*, *Hilsa kanagurta*, *Chirocentrus* and *Anchovtella* spp. (2.05%). King seer of Goa region feed on *Sardinella* spp.(*S.gibbosa*, *S.fimbriata*, *S.sindensis*, *S.longiceps*), *Opisthopterus* sp. *R.kanagurta*, whitebaits and cuttlefish (Deshpande and Sivan, 1969; Dhawan *et al.* 1972). Juveniles of 51-150 mm (TL) prefer *Anchovtella* spp. and above 151 mm size onwards, *Sardinella* spp. form the targeted food (Devaraj 1977a). Devaraj (1977a) observed that the king seers of all length are aggressive predators. Rao (1962) found that juveniles below 50 mm feed more actively than the bigger size groups and the feeding gradually decreases with growth. Adults feed in coastal waters near the surface.

S.guttatus: Devaraj (1977a) reported that the food of *S.guttatus* from Gulf of Mannar and Palk Bay consists of teleosts *Sardinella* spp., *Anchovtella* spp., squids and prawns.

Basheeruddin and Nayar (1962) reported that juveniles of 40-120 mm

of the Madras region feed on young bony fishes, while Devaraj (1977a) observed that *Anchoviella* is the sole food of juveniles of 61-300 mm from the Gulf of Mannar & Palk Bay. It is a passive predator as compared to king seer but juveniles up to 300 mm are aggressive predators. Juveniles feed in the nearshore areas whereas, adults beyond 20 m depth line. Generally larger fish do not compete with smaller fish unlike the king seer (Devaraj, 1977a).

S.lineolatus: The streaked seer from the Gulf of Mannar and Palk Bay area is known to feed exclusively on fishes such as *Sardinella* spp., *Anchoviella*, *Selar* and *Leiognathus* (Devaraj 1977a). Unlike the other two species, this species is found to feed more frequently on *Anchoviella*. Juveniles of 41-120 mm of Gulf of Mannar and Palk Bay prefer only *Anchoviella* spp. Streaked seer is a moderate predator. In the nature of predation, it resembles greatly its cogener, the king seer.

Size and age at first maturity

Devaraj (1983a) determined the length at first maturity in *S.commerson* in the seas around the Indian peninsula at 701-800 or 750 mm (TL). Devaraj (1987) fixed the minimum size at first maturity of *S. guttatus* of Gulf of Mannar and Palk Bay at 400 mm (TL). Devaraj (1986b) has reported that the minimum size at maturity of *S.lineolatus* from the Gulf of Mannar and Palk Bay as 700 mm when the age is about 2 years (Table 11).

Table 11. **Maturity, spawning, sex-ratio and fecundity details of seerfishes (Source : Devaraj, 1983a, 1986b, 1987)**

Parameters	*S.commerson*	*S.guttatus*	*S.lineolatus*
1.Size at first maturity (mm)	750 (TL)	400(TL)	700 (TL)
2.Age at first maturity	2 Years	20 Months	2 Years
3.Spawning broods in a season	3	3	3
4.Spawning periodicity	2.27 Batches 1:1.0:27	2.23 Batches 1:0.23:1	2 Batches
5.Duration from the onset of	Spawns all ova in a month's	112 Days	75 Days

maturity to first major spawning	time		
6. Duration between first and second major spawning acts	-	92 Days	21 Days
7. Lunar periodicity	No	Spawning takes place around full-moon period	No
8. Spawning season	Jan-Sep	Jan-Aug	Jan-May
Peak spawning	Apr-May	Apr-May	Mid-Mar-May
Weak spawning	Jan-Feb & Jul-Aug	Jan-Feb & Aug	Jan-Mar & Jun-Jul
9. Sex-ratio (males:females)	52.3:43:2	39.5:60.2	40.5:59.5
10.Fecundity (Absolute)	*Y = -2273 +3.5793 X 291.9 million eggs/ton of spawning females	*Y = -1354 +3.4082 X 359.8 million eggs/ton of spawning females	*Y = -4061 +6.5928 X 570 million eggs/ton of spawning females
11.Fecundity increase per 10.mm body length	64,612	34,082	65,998
12.Spawning ground	Inshore and protected coves	Close to shore between 20-60 m depth	Inshore waters upto 25 m
13.Study area	Seas around the Indian penninsula	Palk Bay & Gulf of Mannar	Palk Bay & Gulf of Mannar

*Y = Fecundity in 1000, X = Total length in mm

TL = Total length

Sex ratio

The sex ratio of *S.commerson* of 301-1600 mm, indicated a general dominance of males, the male to female ratio being 52.3: 43.2 with indeterminate of 4.5%. Generally males dominated upto 1201-1300 mm and females beyond 1301 mm. The male to female ratio of *S. guttatus* was 39.5: 60.2 with 0.3% indeterminates in 271-720 mm range. The male to female ratio, in *S.lineolatus* was 40.5: 59.5 in the 361-1000 mm range of fish.

Fecundity

Devaraj (1983a, 1986b and 1987) estimated fecundity and length relationships in different maturity stages of all the three species and also gave a general formula for each species for estimating absolute fecundity. For *S.commerson* the fecundity and length relationship is Y = - 2273 + 3.5793 X, where Y = the total number of ova in 1000s in one spawning season and X = fish length (TL) in mm. He estimated that about 300 million eggs are produced by every ton spawning females in a season. For *S.guttatus* the fecundity and fish length relationship is Y = -1354 + 3.4082 X. The increase in egg number per 10 mm body length is 34,082 and the fecundity per ton of spawning females is 360 millions. The absolute fecundity and fish length relationship for *S.lineolatus* is Y = -4061 + 6.5998 X. Fecundity increases at the rate of 65,998 per 10 mm body length and the fecundity per ton of spawning females is 570 millions (Table 11).

During 1964-81 the percentage composition of the king seer and spotted seer in all-India seerfish landing was 64.5 and 33.30% respectively and at present (1982-94) it is 54 and 44% respectively. The emergence of *S. guttatus* in the seerfish fishery may be attributed partly due to the higher fecundity rate than the king seer in addition to the higher effort put in the northwest coast of India where the spotted seer dominates.

Spawning ground

Devaraj (1983a) reported that the spawning grounds of *S.commerson* are located strictly along inshore and protected coves like Panaikulam on Palk Bay and Pudumadam on the Gulf of Mannar. Chacko *et al.* (1962) had also stated that the species spawns in the coastal waters. Based on the occurrence of spawning ripe females of *S.guttatus* Devaraj (1987) reported that the drift netting grounds in the Gulf of Mannar south of Rameswaram Island

between 20 and 60 m depth lines form the spawning ground. In the Vizhinjam area the species spawns close to the shore as indicated by the occurrence of post larvae during the breeding season (Jones, 1962a). According to Devaraj (1986b) the streaked seer spawns in the inshore waters upto about 25 m depth line in the Gulf of Mannar and Palk Bay area.

Spawning season

S.commerson: Based on the study of monthly distribution of maturity stages, Devaraj (1983a) found that *S.commerson* has a protracted spawning from about January to September resulting in three broods, a weak one during January-February, a strong one during the peak spawning in April-May and another weak brood in July-August. This view has been confirmed by the occurrence of larvae and early juveniles (14.4-91.8 mm length) at Vizhinjam in the southwest coast during January-March (Jones, 1962a) and the capture of oozing males and partly spent females in the trolling grounds off Tuticorin during August (Silas, 1962c). Chacko *et al.* (1962) have reported that the species spawns during May-July in the coastal waters of Madras State. The time taken between the first and second major spawning is about 30 days as reported by Devaraj (1983a). There is no lunar rhythm reported in the spawning activities of the species.

S.guttatus: Devaraj (1987) has shown that *S.guttatus* also has an extended spawning season from January to August releasing a weak brood in January-February, a strong brood in March-July with a peak in April-May and a weak brood in August. This has been further supported by Jones (1962a) who collected large numbers of late post larval and juvenile specimens of the species from Vizhinjam area during February-May. Krishnamoorthi (1958) recorded high percentage of maturing fishes in the Gulf of Mannar and Palk Bay area during March-October and ripe specimens during May-July. Spawning takes place around the fullmoon period and it takes about 112 days from the onset of maturity to spawning and about 92 days between the two major spawnings.

S.lineolatus: Devaraj (1986b) observed that streaked seer in the Gulf of Mannar and Palk Bay spawns during January through May. Broods are released in three batches, a weak one in January to early March, a strong one in mid March to end of May and another weak brood in late June to late July. The time taken from the onset of maturity to the major spawning is 75 days

and between the first and second major spawning about 21 days. As in *S.commerson* there is no lunar periodicity in this species also.

Spawning periodicity

S.commerson: Devaraj (1983a) has reported trimodal distribution of ova in the ripe ovaries of *S.commerson* and concluded that the species spawn in 2.27 batches in the ratios of 1:1:0.27 at an interval of a month or even less in each spawning season (Table 11). Munro (1942) observed three distinct size groups in the ripe ovaries of king seer from north Queensland. Lewis *et al.* (1974) reported two well defined batches of ova and another batch of smaller ova in a ripe ovary of *S.commerson* from New Guinea.

S.guttatus: Based on the multiplicity of modal size groups of ova in the advanced maturing and ripe ovaries of *S.guttatus*, Devaraj (1987) reported that this species also spawns more than once i.e., in 2.23 batches in each season in the ratios of 1:0.23:1 (Table 11). De Jong (1940) observed three modes of maturing ova in the ova diameter frequency polygons for the tennigiri *(S.guttatus)* from Java Seas and presumed that all the three batches might be discharged successively. Krishnamoorthi (1958) observed two groups of ova of immature and mature in the ova diameter frequency of maturing *S.guttatus* from Gulf of Mannar and Palk Bay. In the absence of intermediate groups of ova he concluded that the species spawns in a very short and restricted period. However, the observations made by him are viewed as untenable by Devaraj (1987) as only " measurements of the diameters of eggs in ovaries well advanced toward spawning may give evidence of duration of spawning in a fish (Hickling and Rutenberg, 1936)".

S.lineolatus : According to Devaraj (1986b) the mature and advanced ripe ovaries of *S.lineolatus* showed bimodal distribution of ova and the ova released in two successive batches in each spawning season. Except the studies by Devaraj (1986b) there is virtually no study on the reproductive biology of the species from anywhere in the world. The reason is due to its scarce occurrence in the fishery, though it has a wide distributional range in the Indo-Malaya archipelago (Devaraj, 1986b).

Population dynamics

The earliest study on the population dynamics of seerfishes was by Devaraj (1977a, 1983b). He estimated the stock assessment parameters of all the three species, *S.commerson*, *S.guttatus* and *S.lineolatus*. Later Kasim and

Hamsa (1989) studied the population dynamics of *S.commerson* from the Tuticorin waters, Pillai *et al.* (1994) from Kerala and Karnataka coasts and Yohannan *et al.* (1992) from Tamil Nadu and Kerala waters.

S.commerson : The total mortality coefficient (Z), the natural mortality coefficient (M), the fishing mortality coefficient (F) and other stock assessment parameters like the exploitation ratio (E), the exploitation rate (U), the length at first capture (lc) and the age at first capture (tc) were estimated by different authors for *S.commerson* from different regions. Most of the estimates on the species were based on drift gillnet fishery.

The estimates of Z for the drift gillnet fishery ranged from 0.81 for west coast to 4.08 for Kerala during different periods. The recent estimates of Z reported by Yohannan *et al.* (1992) and Pillai *et al.* (1994) are higher (3.09-4.08) than the earlier estimates (0.81-1.28) of Devaraj (1983b) and Kasim and Hamsa (1989). Devaraj (1983b) has observed an increasing trend in the values of Z (0.4 for Cape Comorin, 0.53 for Kerala, 0.71 for Karnataka, 1 for Maharashtra and 1.13 for Gujarat) and indicated the possibility of a northerly migration and opined that Z for any locality in the migratory route is the cumulative Z comprising the Z for the locality in question plus for all areas south of it. Kasim and Hamsa (1989) also estimated Z for *S.commerson* exploited by other gears also, hooks & lines, *'podivalai'* and trawl at 0.83, 2.23 and 2.49 respectively.

The M estimates for *S.commerson* ranged from 0.37 (Kasim and Hamsa, 1989) to 0.78 (Yohannan *et al.* 1992 and Pillai *et al.* 1994). Devaraj (1983b) estimated M for the Gulf of Mannar and Palk Bay stock following the regression of effort on Z as 0.4. Kasim and Hamsa (1989) calculated the values at 0.43 in *'paruvalai'*, 0.37 in hooks & line, 0.55 in *'podivalai'* and 0.57 in trawlnet with an average of 0.48 by the above method. They also estimated M independently following Pauly's (1980) method at 0.45. Yohannan *et al.* (1992) and Pillai *et al.* (1994) determined M employing the equation of Pauly. As seen in the total mortality values, the recent estimations by Pillai *et al.* (1994) and Yohannan *et al.* (1992) are higher. Devaraj (1983b) also estimated M values for spotted seer as 0.40, for male streaked seer as 0.42 and for female streaked seer as 0.34.

The fishing mortality coefficient rates in drift gillnet fishery for king

seer varied from 0.67 for Gulf of Mannar during 1967-74 to 3.30 for Kerala during 1984-88 indicating an increasing trend in the fishing mortality rates similar to natural mortality rates during the recent years. The fishing mortality coefficient at Tuticorin among the four gears varied from 0.47 for hooks & line to 1.97 in trawl.

The exploitation ratio for king seer in different fisheries in different regions indicate that the E in gillnet fishery ranged from 0.51 (Devaraj, 1983b) for west coast during 1969-74 to 0.81 (Yohannan *et al.* 1992) for Kerala during 1984-88. It is evident that the exploitation level in recent times has increased along the Tamil Nadu, Kerala and Karnataka coast. Yohannan *et al.* (1992) estimated the present E value as 0.81 and 0.71 as against the Emax of 0.58 and 0.60 at M/K ratio of 1 and 1.5 respectively. Similarly for Tamil Nadu the present E values are 0.75 and 0.62 as against Emax of 0.52 each at M/K 1 and 1.5. Based on this they inferred that the exploitation ratio is above MSY level and advocated for reduction in the expenditure of effort. According to them, for all India level, a 16% reduction in the exploitation rate would be needed to bring the fishery back to MSY level.

At Tuticorin among the four gears for king seer fishery, the E varied from 0.57 in hook & line to 0.84 in *'podivalai'* showing higher fishing pressure by all the three gears except hook & line.

Devaraj (1983b), Kasim and Hamsa (1989) and Yohannan *et al.* (1992) made the yield per recruit studies on *S.commerson*. By the construction of yield isopleth diagram the maximum yield for different values of tc keeping F constant and the MSY for different values of F keeping tc constant have been studied by them. It showed that the optimum age of exploitation (ty) is 4.21 years at a potential yield Y' of 2339 g for king seer in the Indian Seas (Devaraj, 1983b) and 3.88 years and 1749 g for the Tuticorin stocks (Kasim and Hamsa, 1989). Yohannan *et al.* (1992) estimated the optimum size (lc) as 876 mm for Kerala and 803 mm for Tamil Nadu against the present lc of 600 mm and 450 mm respectively. In the king seer fishery at Tuticorin it has been shown that the Fmax which can produce the Ymax has not exceeded 0.5 for any of the four gears but the present Fs are well above 0.5 except hook & line confirming the existence of higher effort input by the other three gears, *'paruvalai'*, *'podivalai'* and trawl.

S.guttatus: The M was estimated at 0.40. The values of Z, F, E, and U were higher, 1.83, 1.43, 0.78 and 0.65 respectively for Gulf of Mannar as compared to east coast excluding Palk Bay and the Gulf of Mannar (0.69, 0.29, 0.42 and 0.21), Palk bay (0.84, 0.44, 0.52 and 0.30) and west coast (0.74, 0.34, 0.46 and 0.24) indicating that the species was over exploited along the Gulf of Mannar coast during the period 1964-74 (Devaraj, 1977a). In the absence of similar studies in the recent years there is a gap in our knowledge on the present exploitation level of the species.

For spotted seer of Gulf of Mannar the optimum age of exploitation is found to be 4.14 years at the optimum yield per recruit of 547 g (Devaraj, 1983b).

S.lineolatus: Stock assessment parameters for males and females of *S.lineolatus* were determined for different regions for 1964-74 period by Devaraj, 1977a. The M was estimated as 0.42 for males and 0.34 for females. The Z and F were high for both sexes (2.61 and 2.19 for males and 2.83 and 2.49 for females) for Palk Bay and lowest (1.08 and 0.66 for males and 1.08 and 0.74 for females) for west coast. The exploitation ratios and the exploitation rates were also high (E= 0.61-0.84, U= 0.40-0.78 for males and E=0.69-0.88, U= 0.46-0.83 for femlaes) for both sexes from all regions indicating that the species was under heavy fishing pressure during the above period. For this species also, there is no study on the stock assessment parameters in the recent years.

Stock assessment

Devaraj (1986a) estimated the all-India maximum sustainable yield (MSY) of seerfishes based on the catch and effort data for 1958-67 at 15,958 t at an annual effort of about 2.2 million drift gillnet boat days. But this estimate is proved to be unrealistic due to the fact that the average annual catch obtained during 1964-81 was 17,852 t at a much less effort of 1.03 million boat days. The current annual catch of 38,394 t (1990-94) also confirms the above estimate as an unrealistic one.

The recent regionwise MSY estimates given by Devaraj (1986a) and the present yield are given in Table 12. It is evident that though the present all-India yield of 38,000 t is nearly close to MSY (40,000 t), the current pro-

duction is much higher in the northwest coast (15,000 t) surpassing the MSY of 5,000 t indicating the unacceptablity of this estimate. Along the southwest coast the yield (9,100 t) is closer to MSY (10,000 t). However, the present yield along the northeast coast (3,500 t) and southeastcoast (10,000 t) is lower than the MSY of 10,000 t and 15,000 t respectively showing the possibility of increasing the catch from these two regions.

Table 12.**All-India maximum sustainable yield (MSY) estimate for seerfishes (Devaraj, 1986a).**

Area	Period	MSY (t)	Present Yield (1990-'94)
All-India	1958-1967	15,958	
Northwest coast (Maharashtra & Gujarat)	Devaraj (1986a)	5,000	15,266
Southwest coast (Goa,Karnataka and Kerala)	"	10,000	9,137
Northeast coast (Orissa & West Bengal)	"	10,000	3,515
Southeast coast (Tamil Nadu & Andhra Pradesh)	"	15,000	9,887
Total for All-India	"	40,000	38,394

Devaraj (1983b) estimated the king seer stock on all-India basis at 40,174 t (1967-76). Yohannan *et al.* (1992) calculated the total annual stock at 24,844 t (M/K=1) and 29,079 t (M/K=1.5) (1984-88) with a MSY of 23,248 t and 19,733 t respectively. The total annual average stock and MSY along the east coast during 1967-74 were estimated at 17,545 t and 9,211 t respectively by

Devaraj (1983b) and during 1984-88 at 8,830-10,776 t and 8,051-6,606 t by Yohannan *et al.* (1992). For west coast the total annual stock and MSY were 22,629 t and 6,408 t respectively during the first period and 16,014-18,303 t and 15,197-13,127 t in the second period. The present yield (1989-94) of 20,533 t and 7,077 t and 13,457 t for all-India, east coast and west coast respectively are closer to the MSY estimates of different periods. The total annual stock for Tamil Nadu was 4,844-5,912 t with MSY of 4,417- 3,624 t (Yohannan *et al.* 1992). The present annual average yield during 1989-94 of 3,804 t is closer to MSY. Along the Kerala coast the total annual stock was 6,136-7,013 t. The current annual average yield (1989-94) of 6,107 is well above the MSY of 5,823-5,030 t. Pillai *et al.* (1994) estimated the MSY during 1989-91 for the Kerala and Karnataka coasts at 7,649 t as against an annual yield of 7,180 t. From the above, it is evident that the present yields of the above regions are closer to the MSY and any further increase should be from outside the present gillnet fishing grounds or by other fishing gears like trawl, hook & lines and shoreseines.

Stock estimates of *S.guttatus* and *S.lineolatus* for different regions of Indian seas for the period were worked out by Devaraj (1977a). For *S.guttatus*, the yields of 271 t, 230 t for east coast and west coast were below the MSY estimates of 358 t and 241 t indicating that there was scope for increasing the yield along both the coasts. The present annual average yield (1982-94) is 5,412 t for east coast and 10,264 t for west coast which shows that the yield has increased many folds than the MSY estimates of 1964-74. In the case of *S.lineolatus* the MSY estimates for the same period was 303 t for east coast and 186 t for west coast against the yield of 255 t and 184 t indicating that the species was exploited at a lower MSY level along the east coast whereas almost closer to MSY level along the west coast. The present annual (1982-94) average yield of 194 t for east coast and 12 t for west coast shows that the species had been over exploited over the years starting from 1964-74 period as revealed by the high fishing mortality rates and the stocks have been almost dwindled from the west coast.

Conservation and management

Though the present seerfish fishery of India is mainly supported by the king seer and the spotted seer in almost equal proportions, adequate stock assessment studies were made only on the king seer, that too only from the

coasts of peninsular India. Hence the conservation and management options suggested here are mainly concerned with the improvement of the king seer fishery. Studies on the exploitation rate of the species show that the stocks are at present heavily exploited by the drift gillnet. In recent years the expansion of trawling grounds to the deeper waters proved that the juveniles of this species are quite vulnerable to this gear also. Exploitation rate by this gear is also found to be on the higher than that of gillnet. Therefore, there is a need to reduce the effort level of both these gears. Reducing the fishing intensity is not a practicable proposition considering their multispecies target, the other larger pelagics in the case of gillnets and shrimps and squids for trawl. The only alternative is to increase the minimum size at first capture by increasing the mesh size. The present gillnets used for seerfish capture varies in mesh size from 65 to 170 mm. The bulk of the king seer catch at present (64% in Kerala, 91% in Tamil Nadu and 78 % in Karnataka) is below the optimum size of 800 mm and the length at first maturity of 750 mm (TL). This show that most of the king seer population at presents is caught before they get a chance to breed atleast once in their life time. If this is left unchecked, it will lead to the depletion of the spawning stocks and further to recruitment overfishing. Hence there is an imperative need to allow the population in sufficient numbers to breed and enhance reproductive success. This can be possible only by increasing the size at first capture from the present 450-600 mm to 800 mm. Therefore, the mesh size of the gillnet being operated in the deeper waters (25-50 m depth line) should be increased to a minimum 130 mm. Studies show that the size at first capture by 130 mm mesh size gillnets is 852 mm which is the optimum size from both biological and economic point of view. This measure would ensure protection of young fish as well as enhance reproductive success. Since such gillnets are employed mainly to catch larger pelagics with higher girth like tunas and sharks, increase in mesh size (above 130 mm) would not have any adverse impact on the fishermen's income.

From the earlier studies on the stock assessment of *S.guttatus* and *S.lineolatus* (1964-74) (Devaraj, 1977a) it was known that while the former species was under heavy fishing pressure along the Gulf of Mannar coast (E=0.78), the latter species was heavily fished along both the coasts of India (E= 0.61-0.88). This over exploitation might be the cause for the present state of low production of the species at 206 t as against the yield of 439 t during the 1964-74 period. Presently the species has become a rare com-

modity along the west coast and the yield has come down to 12 t as compared to 184 t during the above period. This state of situation was the result of absence of proper management measures to safeguard the stocks in the light of the studies conducted during 1964-74 period.

The gillnets of smaller mesh types like *'podivalai'* (70-100 mm) along the Tuticorin coast land exclusively (99.99%) small sized king seer. Studies have shown that the length at first capture by this gear is 325 mm. This indicates that this gear is detrimental to the conservation of seerfish fishery and should be discouraged.

The recent development of trawling in the deeper waters (beyond 50 m depth), no doubt enhanced the seerfish production in the country but the size of individual seerfish caught is causing alarm. The size at first capture is found to be 213 mm along the Tuticorin coast and 284 mm along the Mangalore-Malpe coast. As high as 98% of the king seer population caught by this gear fall below the minimum length at first maturity. But increasing the mesh-size to protect these youngones is least likely to be acceptable to the fishermen, as this is used as a multispecies gear with catches from smallest whitebaits to largest sharks and perches.

The hook & line, being highly selective and targeting mostly larger sized seerfish, is the safest gear for exploiting seerfish resources. This gear is very popular along the east coast. Considering the present low fishing mortality (0.47) by hook & line along the Tuticorin coast, this gear should be encouraged for exploitation of seerfishes in other parts of the country.

Economics and marketing

Seerfishes are the most sought after table fish on par with pomfrets and are in great demand all over the country. They are relished mostly in fresh and to some extent in cured form (salt dried). Because of their high quality meat value, they fetch high unit value. The price at the production centres ranges from Rs.50 to 75 per kg in the peak season and Rs.80-100 per kg in the lean season. They earn still higher price in the metropolitan cities far away from the production centres or in cities where the production is lower than the demand. While smaller fishes are easily handled and sold in the local markets, larger fishes are difficult to sell in small towns and cities.

So merchants prefer to transport them packed in ice to bigger cities where the prices and demands are higher. A sizeable portion of the catch is filleted and frozen for the export market. Because of its higher returns to the fishermen, the success or failure of the gillnet fishery is gauged on the quantity of seerfish, the target species caught in every season.

Future research priorities

1. Estimation of vital biological and population parameters of the species exploited by all gears from different regions of both coasts of India.

2. Stock assessment studies on all species from the entire range of distribution for suggesting optimum exploitation level and suitable management measures.

3. Investigation on the possible migratory pattern concurrent with the northerly flow of the coastal current and the route in relation to environmental parameters through tag-recovery studies.

4. Studies on the age and growth following modern tools.

5. Forecasting model development

Conclusion

In conclusion it can be said that the increasing trend of seerfish catch in the country offers further scope for stepping up production by extending the fishing activities to the deeper waters beyond 50 m depth contour by multiday fishing employing gillnet and hook & line with boats larger than those presently used. Resource characteristic studies on the component species of seerfish taken by all dominant gears from all maritime states, especially from the northern regions of both coasts where good potentials are indicated, should form the future research programmes for better assessment, management and conservation of this much valued resource.

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