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Stock assessment of sciaenid resources of India

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ABSTRACT

The catches of Jew fishes decreased from 1979 to 1980 and later increased in stages from 1981 to 1984, 1985 to 87 and 1988 to 89. Gujarat and Maharashtra together contributed 52% of total sciaenid catches along the west coast. In both the states, the landings during the first few years showed an increasing trend whereas during the remaining period, the catches and percentage contribution varied. Along the east coast also the sciaenid landings showed annual fluctuations. Along the west coast, *Otolithus cuvieri, Johnieops macrorhynus, Protonibea diacanthus, Johnieops vogleri, Johnius glaucus* and *Johnieops sina* dominated whereas along the east coast *Johnius carutta, Pennahia macrophthalmus, Kathala axillaris, Johnieops vogleri* and *Johnius dussumieri* were the dominant species. The seasonal abundance of sciaenids varied in different states at different times. Sciaenids are carnivorous feeding on teleosteans and crustaceans. Spawning season of each species varied from place to place. Other biological aspects like size at first maturity, fecundity, sex ratio, length-weight relationship, age and growth, etc for the common species were also studied. Estimations were made on the yield and biomass at various levels of fishing effort for important species of sciaenids.

Sciaenids contribute 11–12% of total demersal catches. Before the advent of mechanized fishing, sciaenids along with other demersal species were obtained by the artisanal gears such as boat seines, set and drift nets and stake nets. With the introduction of trawlers, the catches improved by several folds. Eventhough information is available on the biology of different species of sciaenids from different regions, the information on the stock position of even common species of sciaenids, that contribute to the fishery, is scanty. The objective of the present study is to present the stock position of important species based on which the future scope for expansion of fishery depends.

Earlier, the work on the fishery and various aspects of biology of different species of sciaenids has been done by Jacob (1948), Chacko (1949), Motwani *et al.* (1954), Kuthalingam (1957, 1971), Bapat and Bal (1962), Annigiri (1963), Rao (1966, 1968, 1970, 1971, 1972), Bhatt *et al.* (1967), Rao (1967, 1978, 1981, 1983, 1985 a, b, c), Rajan (1968), Rao *et al.* (1968, 1972), Sekharan *et al.* (1968), Tholasilingam *et al.* (1968 a,b,c), Rao (1969), Devadoss (1972), Suseelan and Nair (1972), Krishnamoorthi (1974), Nair (1974, 1979, 1981), Radhakrishnan (1974), Bhusari (1975), Dharmaraja and Philipose (1975), Joseph and Radhakrishnan (1976), Muthu *et al.* (1975), Sudarsan (1978), Thomas and Kunju (1981) Bapat *et al.* (1982), Gandhi (1982), Muthiah (1982), James and Baragi (1985), Joseph and John (1985) and Silas *et al* (1986).

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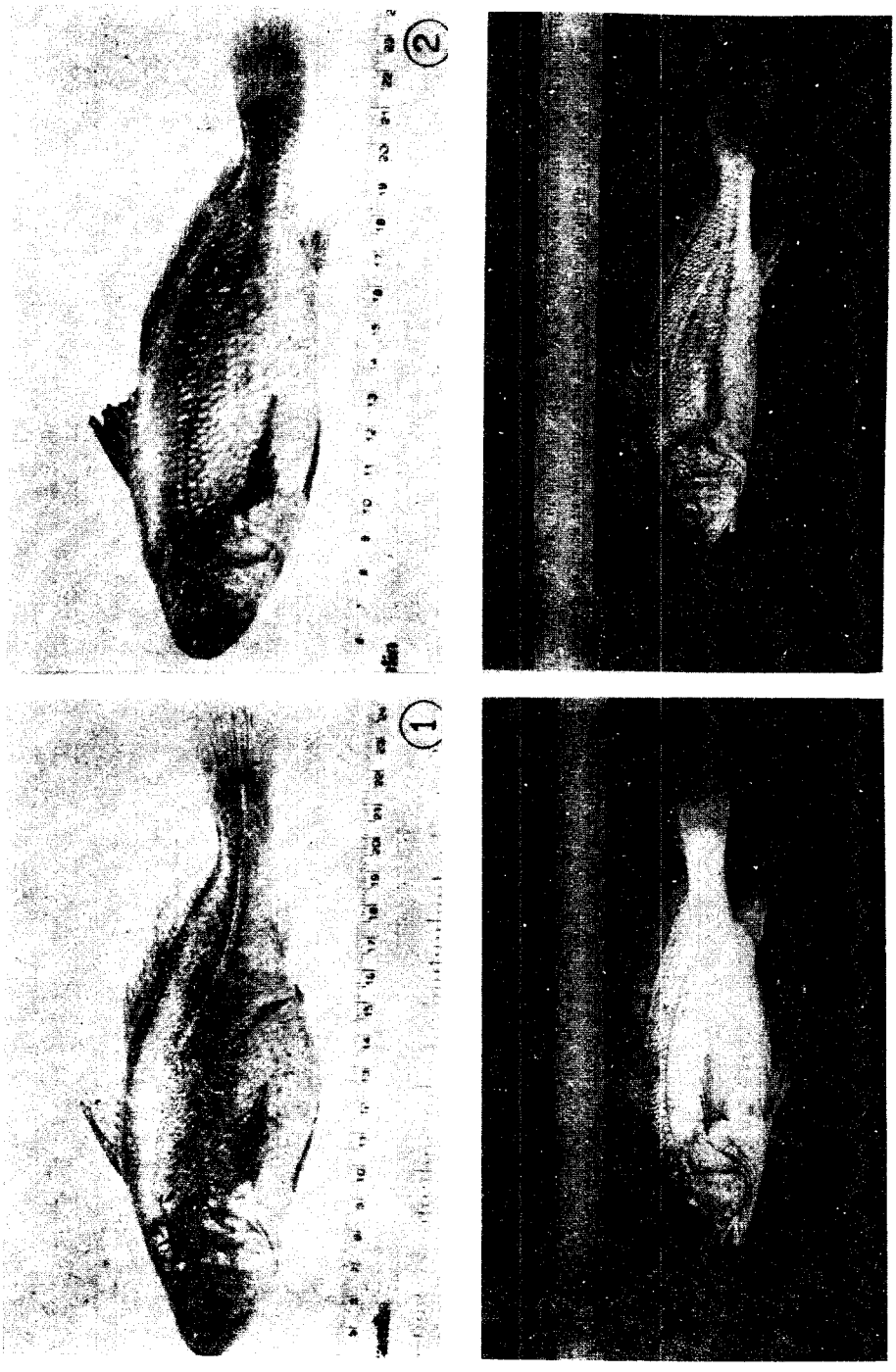

1. *Otolithes cuvieri*. 2. *Johnieops sina*. 3. *J. vogleri*. 4. *Johnius carutta*.

MATERIALS AND METHODS

Data were collected during 1979–88 on catch, effort and species composition once or twice a week from 5–10% of total units landed. Subsequently, the data were raised to the total number of units operated on the particular day and the total for all the observation days was multiplied by a factor to get the monthly estimates. Catch per trawling hour was taken as an index for the abundance of particular group or species for each season. Besides, observations were made on the food and feeding, maturity, spawning, fecundity, sex ratio, length - weight relationship, growth, age, etc.

RESULTS

Fishery

All India total landings of sciaenids obtained in demersal landings during 1979–88 is given in Fig. 1 and statewise abundance for 1979–88 is given in Fig. 2. During the period, the all-India sciaenid production showed slight increasing trend from 93 018 tonnes in 1979 to 101 201 in 1988 with marginal fluctuations in annual yield between different years. More or less similar trend is also seen in the percentage contribution of sciaenids.

Statewise landings of sciaenids: Statewise sciaenid catches during 1979–88

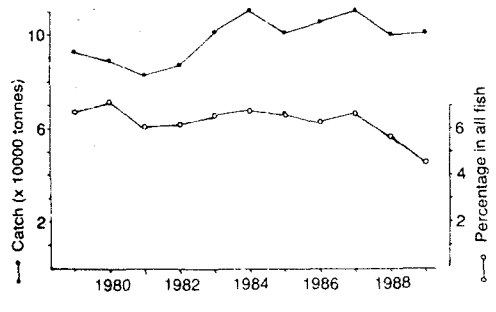

Fig. 1. Total landings of sciaenids in the demersal catches during 1979–88.

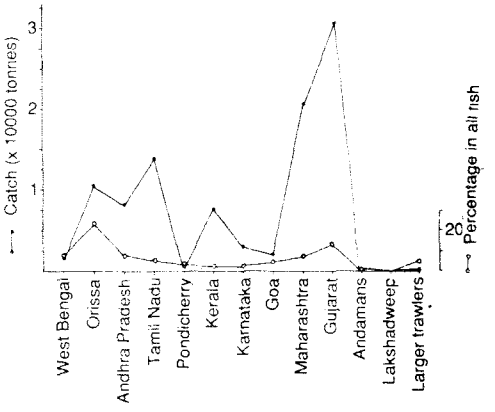

Fig. 2. Statewise average abundance of sciaenids during 1979–88.

are given in Fig. 3 and the statewise percentage contribution of sciaenids in total fish landings is given in Fig. 4.

In West Bengal, during 1979–88, the catches fluctuated from 270 (1981) to 5 765 tonnes (1987). In Orissa, landings varied from 2 133 (1981) to 17 077 tonnes (1988). In Andhra Pradesh, during 1979–85, the catches varied from 6 753 (1985) to 11 554 tonnes (1982), thereafter the values showed a decreasing trend. The percentage contribution of sciaenids during 1979–81 decreased from 9.7% to 6.1% while during the remaining period, the values fluctuated from 5.5% (1988) to 7.8% (1983). In Tamil Nadu, the catches during 1979–82 ranged from 13 140 tonnes (1981) to 22 029 tonnes (1982). The catches then decreased till 1986 (7 176 tonnes). In 1987 and 1988, however, the catches increased again to 11 689 and 11 717 tonnes respectively. The percentage contribution of sciaenids in total catches ranged from 3% (1986) to 9% (1980). In Pondicherry during 1979–82 there was a gradual increase in production from 306 to 561 tonnes while during the remaining period it fluctuated from 414 tonnes (1988) to 741 (1984). The percentage contribution of sciaenids also varied from

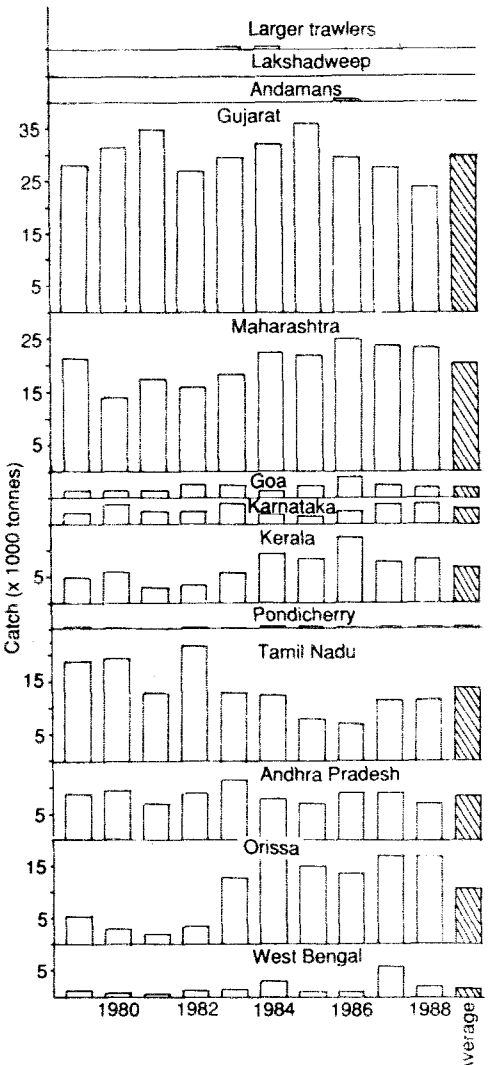

Fig. 3. Yearwise abundance of sciaenids in different states during 1979–88.

a minimum of 2.8% (1985) to a maximum of 5% (1984). In Kerala as well as in Karnataka, the catches increased in stages, first from 1979 to 1980 and second time from 1981 to 1983 while during the remaining period the annual landings fluctuated. The percentage contribution of sciaenids fluctuated during 1979–86. In Goa also the catches during the period 1979–86 increased in stages once from 1979 to 1983 (1 492 to 2 697 tonnes) and again from 1984 to 1986 (1 677 to 3 833 tonnes) whereas from 1987 to 1988 the landings decreased (2 502 to 1 986 tonnes). In Maharashtra, the sciaenid landings varied with a minimum of 13 956 tonnes (1980) and maximum of 25 413 tonnes (1986) whereas the percentage of contribution ranged between 6 and 8.3% in 1980 and 1987 respectively. In Gujarat also the catches increased first from 1979 (28 230 tonnes) to 1981 (35 245 tonnes) and later from 1982 (26 962 tonnes) to 1985 (35 245 tonnes). Subsequently the catches decreased reaching to 24 004 tonnes in 1988. The percentage contribution of sciaenids showed decreasing trend from 15% to 11%. For Andamans, data on the total catches from 1983 only were available, maximum of 324 tonnes was recorded in

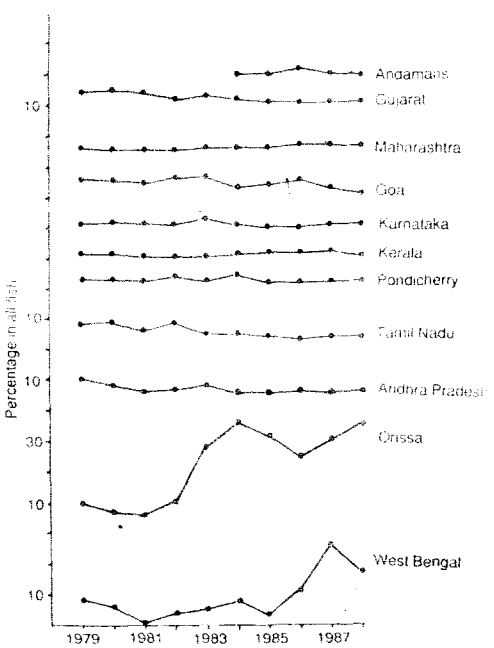

Fig. 4. Percentage contribution of sciaenids in total fish catches in different states during 1979–88.

1986 whereas in other years the catch was negligible with a minimum of 4 tonnes in 1983.

Statewise species composition during 1979–88 showed that in Gujarat 35% of sciaenid catches comprised of *Otolithes cuvieri*, 17% of *Johnius glaucus* and 15% of *Johnieops vogleri* (Fig. 5). In Maharashtra, 25% of the sciaenid landings were accounted by *O. cuvieri* whereas *J. vogleri* and *Johnieops macrorhynus* accounted for 25% and 23% respectively. The pattern of species composition changed in the neighbouring Karnataka. Here *Johnieops aneus*, *J. sina* and *O. cuvieri* contributed equally, 25% each, while the remaining 25% was contributed by *Kathala axillaris*, *Otolithes ruber*, *Johnius belangeri* and *Nibea albida*. In Kerala, *J. sina* was the dominant species which contributed to 45% of the catches followed by *Kathala axillaris* (17%) and *O. ruber* (15%). In Tamil Nadu, *J. carutta* and *O. cuvieri* contributed 26% and 20% respectively. *Atrobucca nibe* (16%), J. carutta (14%) and *J. vogleri* (11%) dominated along the Andhra coast.

The seasonal catch trends of sciaenids during 1979–88 varied not only from west coast to east coast but also from state to state. Along the Orissa and West Bengal coasts, peak landings were recorded from October to December whereas from neighbouring Andhra Pradesh during July–September (Fig. 6). In Tamil Nadu January–March was the period when heavy landings were recorded. Along Pondicherry coast, bulk landings were recorded twice in an year, once during July–September and subsequently from October to December. In Kerala, heavy landings were recorded during July–September. In Karnataka, bumper catches were recorded once during January–March and then from July–September. Similarly along the Goa coast, January–March and October–December were the periods when bumper landings were recorded. Along Maharashtra and Gujarat coasts October–December was the period when heavy landings were recorded.

Biology

Size and age composition: The size of *J. carutta* at Waltair ranged from 40 to 240 mm and juveniles were caught during May–July and the fishery was supported by first and second year age groups.

At Kakinda, *J. carutta* of size 80–235 mm (1–2 year age groups) contributed to the fishery and juveniles of size 80–95 mm were obtained in July. At Madras, the size of the same species ranged from 130 to 150 mm and first and second year age groups contributed to the fishery. *P. macrophthalmus* measuring 120–140 mm mainly contributed to the fishery at Mandapam whereas 40–265 mm size group were landed at Waltair and Kakinada. Juveniles of the size range 40–70 mm were available in February, June, August and October.

Another species of importance was *J. dussumieri*, the size of which varied from 60 to 178 mm with first year age group fishes mainly contributing to the fishery. *J. vogleri* of length range 60–250 mm belonging to first and second year age groups occurred in the commercial catches and juveniles were recorded in April, July and December. Fishes of less than 1-year age mainly contributed to the fishery.

At Kakinada, *Atrobucca nibe* entered the fishery in June and fishes of length range 40–110 mm contributed to the fishery from June to July and in November. Thus, fishes of first year age group measuring less than 150 mm mainly contributed to the catches. At Waltair and also at Kakinada, *K. axillaris* of length range 50–150 mm, *J. maculatus* measuring 70–240 mm and *O. ruber* of length range 100–190 mm contributed to the fishery.

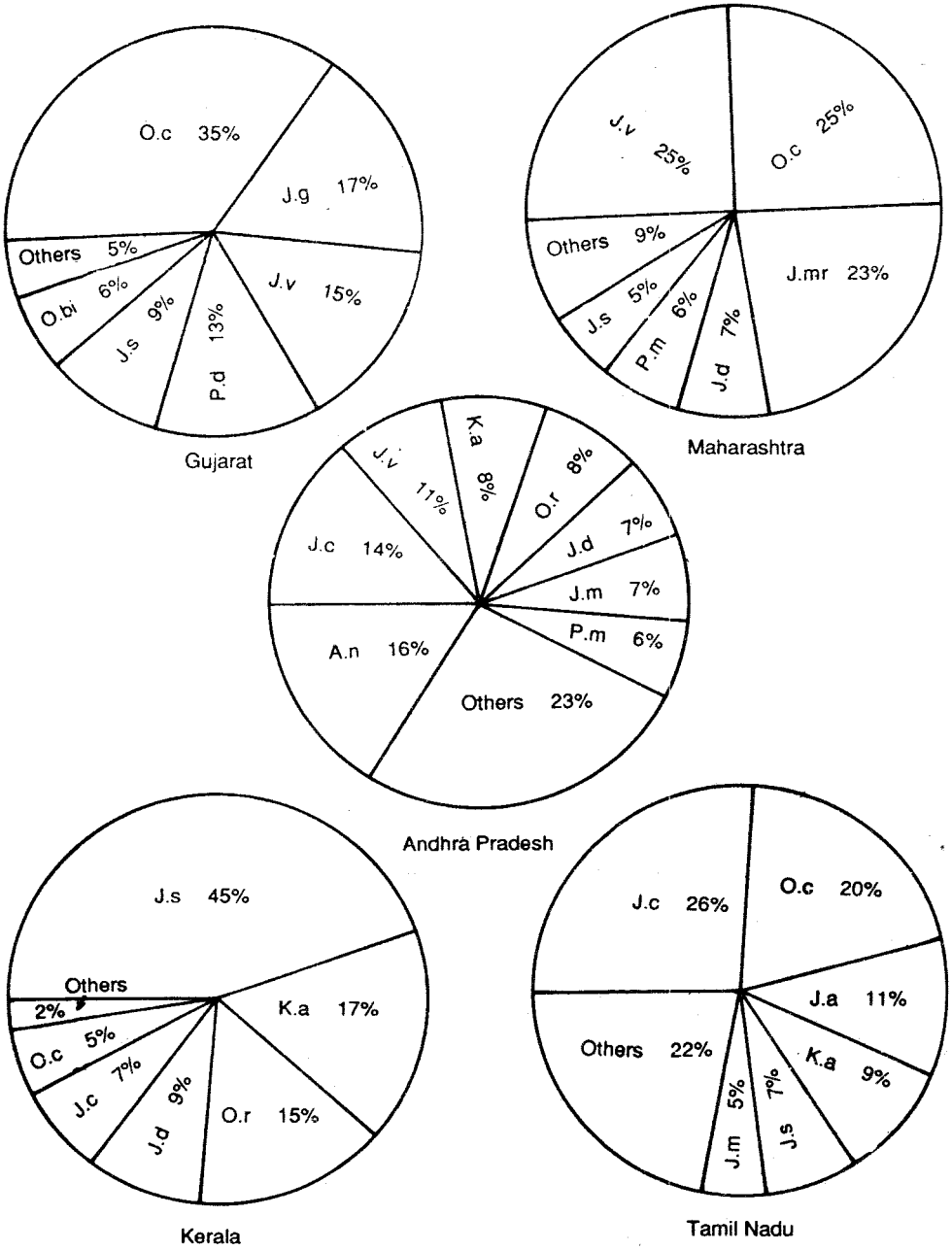

Fig. 5. Statewise species composition of sciaenids during **1979–88. A.n.**, *Atrobucca nibe*; K.a., *Kathala axillaris*; J.a., *Johnieops aneus*; J.c., *Johnius carutta*; J.d., ***Johnius dussumieri***; J.g., *Johnius glaucus*; J.m., ***Johnius macropterus***; J.mr., *Johnieops macrorhynus*; **J.s.**, ***Johnieops sina***; **J.v.**, *Johnieops vogleri*; O.c., *Otolithoides cuvieri*; O.r., *Otolithes ruber*; P.d., *Protonibea* ***diacanthus***; **P.m.**, *Pennahia macrophthalmus*.

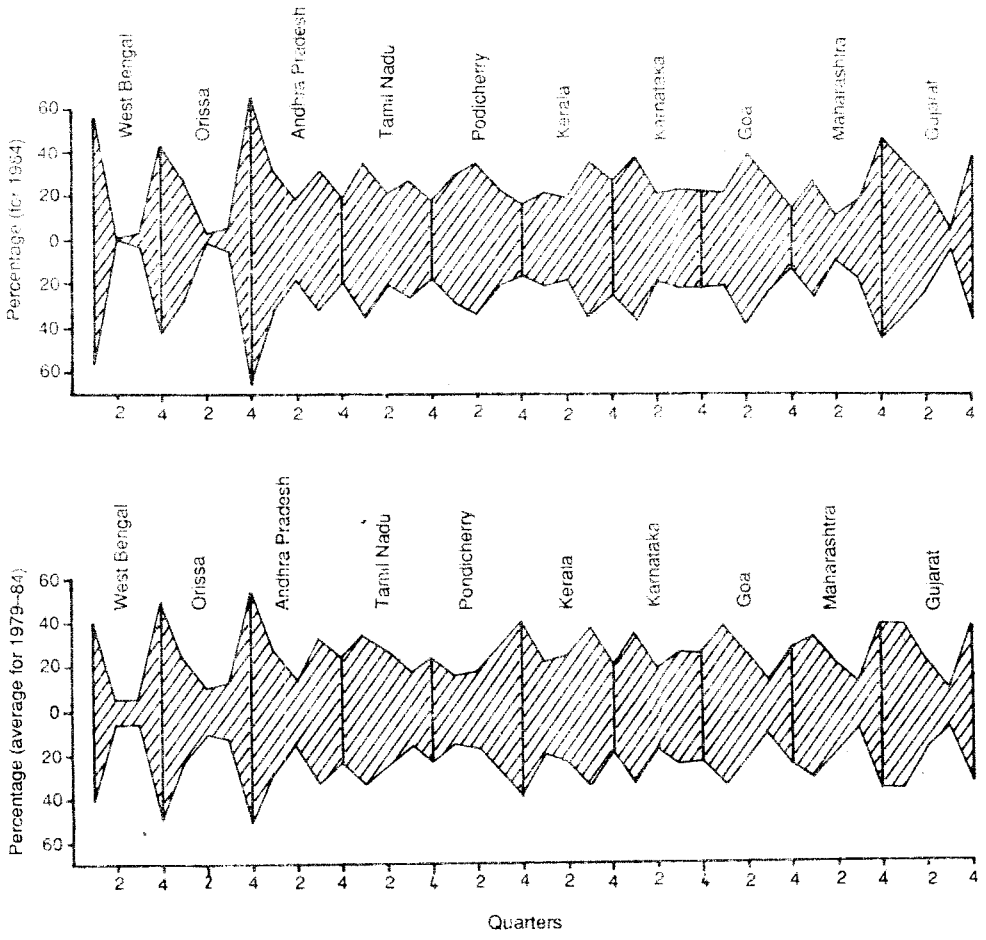

Fig. 6. Statewise seasonal abundance of sciaenids.

Juveniles occurred during the monsoon and post monsoon months and the fishery was supported by less than 1 year age group.

Along the west coast, especially at Calicut, *J. sina*, mainly of 1 year age group, contributed to the fishery. *O. ruber* was another species that contributed significantly to the fishery and fishes of 1 year age group occurred in the commercial catches. *P. diacanthus*, which occurred predominantly along northwest coast of India, contributed to a large extent and fishes of size range 200–1 050 mm (1–4 year age group) were recorded in commercial catches. *O. biauritus* was another species of commercial importance along the Saurastra coast and the fishery was supported by fishes of 1–3 year age group. *O. cuvieri* contributed approximately to 30–40% of sciaenids catches and the fishery was supported by 0–2 year age group. Other smaller sciaenids such as *S. glauca*, *J. dussumieri* and *J. vogleri* contributed to the fishery to a significant extent during the period September–January. Mainly fishes of

less than 2 year age group contributed to the fishery.

From the observations made from different regions along the coasts of India, it was reported that juveniles of different species of sciaenids were found during the monsoon and post-monsoon months. (Rajan 1968, John 1951, Bal and Pradhan 1961, Karamchandani and Motwani 1954).

Size at first maturity: It was observed that both at Waltair and Kakinada, the size at first maturity for *J. carutta* was about 155 mm, at Madras 140 mm, and at the Calicut coast it was 110 mm. *Johnius dussumieri* attained first maturity at 110 mm at Andhra coast and at 160 mm at Bombay. The size at first maturity of *P. macrophthalmus* was 150 mm at Waltair, 147 mm at Kakinada and 135 mm at Palk Bay. *Atrobucca nibe* matured at a length of 145 mm at Kakinada coast. Along the southwest coast, *O. ruber* attained first maturity at 215 mm whereas at Bombay it matured at 195 mm. It was reported that *O. cuvieri* attained first maturity at 120 mm at Calicut, 160 mm at Veraval and 170 mm at Bombay. The size at first maturity for *J. sina* was 115 mm at Calicut. From Chilka lake it was reported that *N. coibor* (*N. albida*) attained its first maturity at the length of 160 mm. *O. biaurites* attained the first maturity at the length of 1 200 mm along Bombay coast and *P. diacanthus* at 850 mm. Chakraborty (1980) reported that the length at first maturity for *J. macrorhynus* and *J. vogleri* was 159 mm and 150 mm respectively, at Bombay.

Spawning season: The spawning season for the species varied from place to place. Along Waltair coast, *J. carutta* spawned during January–April (Rao 1967), at Kakinada during January–June (Murty 1984) and at Madras during June–July (Vivekanandan 1985). At Calicut also it was found to spawn from June–July. Along the Bombay coast, *J. dussumieri* spawned during January–February and June–September whereas at Calicut, the breeding season for the same species was during March–May and September–November. At Kakinada, the species spawned during March–August. At Calicut, *J. sina* spawned from November to February and also in May. In Chilka lake *N. coiber* bred from May–August. *J. belangeri* bred off Calicut coast during monsoon. At Waltair, Mandapam, *J. macrophthalmus* spawned from January to March. At Kakinada, *A. nibe* spawned during February–July.

Off Bombay coast, the spawning season of *P. diacanthus* was during June–September while at Calicut in September. Annigiri (1963) reported that *O. cuvieri* spawned during October–January along the Mangalore coast while at Calicut during April–July. Muthiah (1982) studied the spawning periodicity of *J. vogleri* from Bombay waters and concluded that the species spawned twice in a year and the time interval between the two spawnings was short. From Veraval, Rao (1985 a,c) reported spawning period of *O. cuvieri* from November to April and of *J. vogleri* during June–July and again from October to November. It was also reported (Rao 1985b) that *S. glauca* spawned from December to April. Chakraborty (1980) observed ripe specimens of *J. macrorhynus* from July to August and also from November to December. For *O. cuvieri* ripe specimens were observed during May–July and in December and the spent ones during June–July and in December. Another important species, namely *O. ruber*, was reported to spawn from July to October Off Bombay waters whereas at Calicut from May to August (Jacob 1948) and June–October (Nair 1979). It was also observed that *O. brunneus* bred in August and *O. pama* throughout the year.

Sex ratio: The sex ratio in different species of sciaenids was not uniform but varied from month to month and season to season. From Mandapam, Mohan (1977) reported that in *P. macrophthalmus* the ratio between the sexes was equal during the majority of months in a year. It was observed that the number of males of length 70–124 mm outnumbered the females but in larger fishes of length 125–149 mm, the ratio was equal. Rao (1968) reported that Off Bombay coast males and females of *P. diacanthus* moved in separate shoals during the spawning period thus segregation of sexes was observed. Off Kakinada, in *J. dussumieri*, females dominated during February–July and September–November and studies on sex ratio in different length groups indicated that males outnumbered the females up to 119 mm whereas females were dominant in length of 120–169 mm. In *J. carutta* sex ratio was equal during January–May and July–August whereas males were dominant during September–December and females outnumbered the males during the other months. Further it was also seen that in fishes measuring up to 139 mm, males were predominant whereas in length range 140–219 mm females were dominant. From Kakinada, Murty (1984) reported that males dominated females in all the length groups except 190–209 mm and 220–230 mm groups. Jacob (1948) reported from Calicut that in *O. ruber*, there was significant difference at 5% level between males and females in different size groups. In *J. sina* it was observed that generally there was no difference in sex ratio between males and females except in certain months.

Fecundity: From Veraval, it was reported by Rao (1985b) that fecundity in *S. glauca* ranged from 57 674 to 344 288 (average: 124 477) whereas in *J. vogleri* the values varied from 78 447 to 341 178 with average of 154 202 eggs. In *O. cuvieri*, fecundity ranged from 105 454 to 355 913. At Bombay, fecundity of *J. dussumieri* was between 142 005 and 225 988 with average of 185 523 ova. From the same place Rao (1968) observed the fecundity of *P. diacanthus* from 1743 010 to 6868 368 whereas from Calicut Jacob (1948) found the fecundity in this species as 625 000. The fecundity in *O. ruber* varied from 44 621 to 170 569 with the average of 113 965 eggs. In *O. biauritus* the fecundity was 600 000. From Palk Bay, the fecundity of *P. macrophthalmus* varied from 134 405 to 446 417 with the mean of 302 070 eggs. In *J. sina*, the fecundity varied from 127 744 to 151 697. Rajan (1968) estimated the fecundity of *N. coitor* between 275 000 and 560 040 with average of 135 661 ova.

Food and feeding habits: The observations on the food and feeding habits showed that *J. carutta* fed on decapods, *Lucifer* sp. foraminiferans, radiolarians, crab larvae, *Gammarus* sp. prawns, polychaetes, *Squilla* sp. *Acetes indicus*, amphipods, molluscs and fishes such as *Stolephorus* sp. and *Cynoglossus* spp (Jacob 1948, Suseelan and Nair 1972). *J. belangiri* fed on prawns, bivalve larvae, *Acetes indicus*, crabs, *Gono-dactylus* sp. and Nudibranchs (Mohan 1977; Rao 1967). *J. macrorhynus* fed on larval bivalves, prawns, *Pleurosigma* spp. and *Fragilaria* sp while *J. dussumieri* fed on polynoid worms and molluscs. Juveniles of this species fed on polychaete worms, copepods and crustaceans, (prawns, stomatopods); salps and teleosts (white baits) also contributed to its food (Suseelan and Nair 1972).

Jacob (1948) and Mohan (1977) observed that *J. osseus* fed on prawns, *Acetes* sp. and crabs. *J. sina* fed on prawns, polychaetes, *squilla* spp. amphipods, molluscs, mysids, *Sergestes* spp, Megalopa, Alima larvae and teleosts (Venkataraman 1960, George *et al.*

Table 1. Long-term forecast of yield and mean biomass (tonnes) of *Otolithes cuvieri* in Gujarat and Maharashtra using Thompson and Bell model

F - Factor	Gujarat				Maharashtra			
	M = K		M = 1.5 K		M = K		M = 1.5 K	
	Yield	Mean biomass	Yield	Mean biomass	Yield	Mean biomass	Yield	Mean biomass
0.0000	0.00	46 594.59	0.00	63 828.79	0.00	3642 519.00	0.00	2304 606.25
0.2000	5 325.18	22 854.05	7 106.08	34 786.69	483 141.81	1828 574.75	321 952.53	1516 010.62
0.4000	6 344.98	12 942.54	9 138.41	20 665.57	553 182.56	1136 688.50	428 690.15	1108 562.25
0.6000	6 176.10	8 226.35	9 316.15	13 267.09	540 381.50	785 526.18	467 272.28	856 032.75
0.8000	5 725.58	5 701.66	8 849.50	9 110.66	509 137.40	579 068.75	477 952.09	685 195.87
1.0000	5 257.55	4 212.03	8 203.52	6 617.67	475 920.00	446 627.15	475 920.12	563 302.56
1.2000	4 841.64	3 264.63	7 553.97	5 030.32	445 284.18	356 661.96	467 918.78	475 079.78
1.4000	4 488.51	2 627.24	6 961.71	3 965.14	418 280.00	293 000.37	457 226.50	404 449.53
1.6000	4192.16	2 179.73	6 442.01	3 217.88	394 849.84	246 519.59	445 520.78	351 112.21
1.8000	3 943.15	1 854.76	5 992.80	2 674.13	374 603.09	211 711.23	433 678.78	308 926.03
2.0000	3 732.60	1 612.09	5 606.21	2 266.54	357 084.96	185 078.71	422 157.21	275 060.15
	MSY = 6 359.291 X = 0.4375 Biomass MSY = 11 866.78		MSY = 9 279.104 X = 0.6125 Biomass MSY = 12 366.19		MSY = 553 884.4 X = 0.4375 Biomass MSY = 105 9113		MSY = 478 204.5 X = 0.8375 Biomass MSY = 660 952.3	

1971, Mohan 1977). *K. axillaris* was found feeding on prawns, *Acetes* sp., stomatopods, isopods, copepods and polychaetes (Suseelan and Nair 1972). Adults of *O. biauritus* were carnivorous feeding mainly on fishes, crustaceans and annelids while juveniles fed on prawns, *Acetes* sp. cephalopods and young fishes (Suseelan and Nair 1972, Jayaprakash 1975).

Length-weight relationship: From Waltair, Rao (1983) found length-weight relationship for *J. carutta* and *P. macrophthalmus* respectively as

$$W = 0.006135\, L^{3.2821}$$
$$W = 0.02336\, L^{2.8459}$$

Murty (1984) estimated the length-weight relationship for *J. dussumieri* and *J. carutta* at Kakinada as

$$\log W = -4.84671 + 2.96347 \log L$$
$$\log W = -5.43389 + 3.23343 \log L$$

From Madras, Vivekanandan (1985) found the relationship in this species as

$$\log W = -4.4063 + 2.7990 \log L$$

From Kakinada the relationship for *A. nibe* was (Murty 1980)

$$\log W = -5.524308 + 3.213476$$

From Bombay, Chakraborty (1980) obtained the following length-weight relationship for *J. macrorhynus*, *J. vogleri* and *O. cuvieri* respectively

$$W = 0.0003409\, L^{2.76874}$$
$$W = 0.000003603\, L^{3.27664}$$
$$W = 0.00000466\, L^{3.127248}$$

Age and growth: Using ELEFAN method the asymptotic length of *Otolithus cuvieri* in Gujarat was estimated as 381 mm and growth co-efficient as 0.55 (r = 0.289). Based on these estimations the length at the end of 1–4 years of its life worked out to be 160, 260, 313 and 342 mm respectively.

In Maharashtra the L_∞ and K values were estimated as 398 and 0.52 respectively (R_n = 0.531) and the lengths at the end of 1–4 years of its life were estimated as 161, 257, 348 and 368 mm respectively.

For *Johnius macrorhynus* the asymptotic length and growth co-efficient were estimated as 350 mm and 0.75 respectively on annual basis. The lengths attained by this species at the end of 1–3 years were 180, 270 and 312 mm respectively. For *Johneiops vogleri* the L_∞ and K were estimated as 345 mm and 0.72 respectively. The lengths attained by this species at the end of 1–3 years were 180, 270 and 312 mm respectively.

In Tamil Nadu the L_∞ and K of *J. carutta* were estimated as 293 mm and 0.51 respectively and the lengths at the end of 1–3 years of its life were estimated as 120, 189 and 231 mm respectively.

In Andhra Pradesh the L_∞ and K for the species was estimated as 281 mm and 0.557 respectively (r = –0.321). The lengths obtained at the end of 1–3 years of its life were 120, 189 and 228 mm respectively.

Stock assessment

The mean exploitation ratio for *O. cuvieri* with length greater than 190 mm in Gujarat, taking M=K, was estimated as 0.6669 and mean F and Z were 1.2946 and 1.8445 respectively. With M = 1.5 K, the mean exploitation ratio and F and Z were estimated as 0.5309 and 1.0574 and 1.8824 respectively whereas with M = 2 K, the mean exploitation rate was 0.4195 and mean F and Z were 0.87782 and 1.97778 respectively. Thompson and Bell study indicated the yield at the present effort (mean effort for 1984–88) level of fishing as 52 575 tonnes. A decline in catches is evident both with M=K or M = 1.5 K and reduction of effort

by 60% in the former and about 20% in the latter case is called for (Table 1).

In Maharashtra, however, for this species, at length greater than 150 mm, mean exploitation ratio, F and Z were calculated as 0.4154, 1.2982 and 3.125 respectively; with M = K and M = 1.5 K the same were 0.5899, 1.2222, 3.1244 respectively. Thompson and Bell analysis for *O. cuvieri* showed that with M = K, 60% reduction in the effort is necessary and with M = 1.5 K effort should be reduced by 20%. At the 1984–88 level of fishing (X = 1), the yield was 475 920 tonnes (Table 1).

In case of *J. macrorhynus* in Maharashtra, taking M = K at length greater than 200 mm, the mean F and Z were calculated as 2.6431 and 3.3931 respectively and with M = 1.5 K the corresponding values were 2.4352 and 3.5602 respectively. The yield at the 1984–88 level of fishing is 51 852 tonnes. The yield declines assuming M = K and 40% reduction in the effort is called for. But with M = 1.5 K no reduction in effort is called for (Table 2).

For *J. vogleri* in Maharashtra, taking M = K at mean length greater than 170 mm the mean F and Z were estimated as 2.6954 and 3.4154 respectively. With M = 1.5 K, the F and Z were 2.517 and 3.587 respectively. Assuming M = K the yield at the present level (mean effort for 1984–88) of fishing comes to 52 332 tonnes. However, at the present level (X = 1), the yield has already shown a decline and reduction of effort by 60% is called for. With M = 1.5 K, the decline and reduction of effort by 60% is called for. With M = 1.5 K, the decline is only after X = 0.81. So here too reduction in effort by 20% is called for (Table 2).

In case of *Johnieops sina* in Kerala assuming M = K, the mean F and Z at the length of 140 mm were estimated as 2.1604 and

Table 2. Long-term forecast of yield and mean biomass (tonnes) of *Johnieops vogleri* and *J. macrorhynus* in Maharashtra using Thompson and Bell model

F - Factor	*Johnieops volgeri*				*Johnieops macrorhynus*			
	M = K		M = 1.5 K		M = K		M = 1.5 K	
	Yield	Mean biomass	Yield	Mean biomass	Yield	Mean biomass	Yield	Mean biomass
0.0000	0.00	2 435.69	0.00	1561.85	0.00	2 161.85	0.00	1382.45
0.2000	530.28	1 082.05	393.80	916.51	455.37	975.03	351.75	807.14
0.4000	592.74	653.92	496.15	646.18	545.44	563.45	468.70	551.28
0.6000	577.85	464.30	524.48	501.17	549.46	392.27	507.31	421.16
0.8000	550.30	361.53	528.40	412.10	535.03	307.62	518.11	346.91
1.0000	523.32	298.14	523.32	352.37	518.52	259.42	518.52	300.46
1.2000	499.48	255.50	514.87	309.77	503.60	228.92	514.99	269.24
1.4000	478.92	225.04	505.37	277.99	490.75	208.06	510.05	247.05
1.6000	461.20	202.27	495.80	253.42	479.76	192.93	504.75	230.52
1.8000	445.85	184.65	486.57	233.90	470.31	181.42	499.52	217.74
2.0000	432.44	170.64	477.86	218.03	462.09	172.33	494.54	207.55
	MSY = 592.7563 X = 0.4125 Biomass MSY = 610.3434		MSY = 528.0964 X = 0.8125 Biomass MSY = 309.9898		MSY = 548.1003 X = 0.6125 Biomass MSY = 373.3236		MSY = 518.2277 X = 1.0125 Biomass MSY = 294.1307	

Table 3. Long-term forecast of yield and mean biomass (tonnes) of *Johnieops sina* in Kerala

F-factor	M = K		M = 1.5 K	
	Yield	Mean biomass	Yield	Mean biomass
0.0000	0.00	5 326.95	0.00	4 160.71
0.2000	1 030.14	3 405.40	842.62	3 147.72
0.4000	1 441.53	2 455.17	1 260.32	2 569.01
0.6000	1 603.47	1 937.50	1 480.42	2 207.93
0.8000	1 660.08	1 628.43	1 602.21	1 964.95
1.0000	1 671.01	1 427.50	1 671.16	1 790.72
1.2000	1 661.96	1 286.69	1 712.56	1 659.13
1.4000	1 644.38	1 181.66	1 736.40	1 555.38
1.6000	1 623.43	1 099.37	1 750.14	1 470.73
1.8000	1 601.48	1 032.40	1 757.32	1 399.94
2.0000	1 579.59	976.34	1 760.24	1 339.36
	MSY = 1 670.646 X = 1.0125 Biomass MSY = 1 399.419		MSY = 1 743.33 X = 3.015625 Biomass MSY = 112.1333	

2.9607. The exploitation ratio was 0.7297 which was rather on the higher side. The maximum fishing mortality (F_{max}) was obtained in 160–170 mm groups. The details of Thompson and Bell analysis are presented in Table 3. The MSY was estimated as 1 671 tonnes and the mean biomass was 1 427 tonnes. Taking M = 1.5 K, the F and Z values at the length 140 mm were 2.074 and 3.2734 respectively. The F_{max} 2.6462 was obtained at 160–170 mm length group. Taking M = K the mean F and Z at length greater than 140 mm

Table 4. Long-term forecast of yield and mean biomass (tonnes) of *Johnius carutta* in Tamil Nadu as per Thompsom and Bell model

F-Factor	M = K		M = 1.5 K		M = 2 K	
	Yield	Mean biomass	Yield	Mean biomass	Yield	Mean biomass
0.0000	0.00	571.82	0.00	363.78	0.00	275.72
0.2000	78.94	262.50	69.72	195.61	53.65	179.96
0.4000	96.71	144.45	88.19	126.67	75.92	130.46
0.6000	97.50	94.46	92.17	93.54	85.19	102.72
0.8000	94.02	70.73	91.70	75.50	88.82	85.95
1.0000	89.90	57.99	89.90	64.58	89.90	75.08
1.2000	86.10	50.26	87.79	57.34	89.81	67.56
1.4000	82.79	45.05	85.72	52.17	89.21	62.05
1.6000	79.95	41.24	83.81	48.26	88.37	57.82
1.8000	77.50	38.28	82.06	45.16	87.46	54.44
2.0000	75.36	35.90	80.48	42.62	86.53	51.66
	MSY = 97.18235 X = 0.6125 Biomass MSY = 89.04725		MSY = 97.2587 X = 0.6375 Biomass MSY = 89.61301		MSY = 89.96074 X = 1.0625 Biomass MSY = 71.57375	

were calculated as 2.1607 and 2.9607. Taking M = 1.5 K, F and Z values were 2.074 and 2.734 respectively. In former case there is no decline in the catch at the present level of fishing whereas the effort can be increased even up to three times the present level in latter case. However, the yield in this case increases only by 72 tonnes.

For *J. carutta* in Tamil Nadu taking M = 1.5 K, the mean F and Z values at length greater than 160 mm were 2.1692 and 2.9342 respectively. The exploitation ratio (F/Z) worked out to be 0.7393 which is on the higher side. Taking M = 2 K, the F, Z and E works out to be 1.8173, 2.8376 and 0.6023 respectively. The yield at the present level of fishing was 89.90 tonnes and with M = 1.5 K, there was decline in the catch at the present level of fishing effort. However, at M = 2 K there was no decline in the catch at the present effort (Table 4).

In Andhra Pradesh by taking M = 1.5 K, the E, F and Z values were 0.725, 2.8678 and 3.7033 respectively. With M = 2 K, the values were 0.6641, 2.7009 and 3.8119. Thompson and Bell analysis shows that the yield at the present level of fishing is 534.7 tonnes with M = 1.5 K, the yield shows a decline at the present level of fishing and reduction of effort by 40% is called for. With M = 2 K also there is need to reduce the fishing effort by 20% (Table 5).

DISCUSSION

During 1950–70, total sciaenid catches varied from 20 000 to 40 000 tonnes. After the introduction of trawlers, the production increased to the present level of about 90 000 tonnes but with slight fluctuations in annual landings in different years. In general, it was observed that along the west coast the sciaenid landings during the first few years showed a decreasing trend while during the later period, the catches fluctuated. Along the east coast also an almost identical trend was noticed. Thus the sciaenid fishery showed regional as well as seasonal fluctuations.

Catch analysis of sciaenids along different regions indicated that the northwest

Table 5. Long-term forecast of yield and mean biomass of *Johnius carutta* in Andhra Pradesh as per Thompson and Bell model

F-Factor	M = K		M = 1.5 K		M = 2 K	
	Yield	Mean biomass	Yield	Mean biomass	Yield	Mean biomass
0.0000	0.00	523.53	0.00	523.53	0.00	2 397.46
0.2000	87.67	192.98	87.67	192.98	600.81	1 388.28
0.4000	96.89	100.78	96.89	100.78	774.90	978.43
0.6000	92.70	68.85	92.70	68.85	822.79	780.48
0.8000	87.28	54.60	87.28	54.60	830.99	668.19
1.0000	82.62	46.63	82.62	46.63	826.28	595.66
1.2000	78.84	41.40	78.84	41.40	817.45	544.24
1.4000	75.75	37.64	75.75	37.64	807.56	505.38
1.6000	73.18	34.77	73.18	34.77	797.69	474.72
1.8000	71.01	32.50	71.01	32.50	788.26	449.77
2.0000	69.14	30.65	69.14	30.65	779.37	428.99
	No MSE value found (X > 50)		MSY = 96.65604 X = 0.4125 Biomass MSY = 92.81046		MSY = 830.8394 X = 0.8125 Biomass MSY = 653.3643	

coast of India was rich for sciaenids since some area of Gujarat yielded more than 50 kg/hr particularly during January–March. It was also observed that landings along the southwest coast of India was also more during the period. The sciaenid landings along the southeast coast of India was more during January–March and along northeast coast during October–December. Rao (1972), based on the exploratory trawling operations of Kalyani III–V and Jheenge, observed higher catch rates of sciaenids in deeper water than in shallow areas. Joseph and Radhakrishnan (1976) stated that 'Dhoma' (small sciaenids) formed 25–30% of the total catches from Goa to Porbundar. The results of exploratory surveys conducted during 1976–77 showed that 'Dhoma' catches were more in 20–39 m depth followed by 40–59 m contributing 74.5% and 49.6% of total catches respectively. Muthu *et al.* (1975) found that sciaenids formed 14.8% of total catches in the trawl landings off Kakinada.

Rao (1978) based on the results of exploratory surveys made during the year 1975–76 stated that catch rates of sciaenids was 0.6 kg/hr and 0.4 kg/hr from the depth of 20–30 m and 40–59 m respectively from Visakhapatnam. Jayaraman *et al.* (1959) found a north ward increase in the catch rates from 18°N (269 kg/hr) to 22°N latitude zone (364 kg/hr). It was observed by Joseph *et al.* (1976) that the abundance of smaller sciaenids was comparatively higher off Cannanore than off Mangalore and Cochin. Thus, a progressive abundance of sciaenids was noticed from south to north along the west coast. Along the east coast, good sciaenid fishing grounds were observed off West Bengal in the areas 19°86′, 20°86′ and 20°87′ with catch rates of 81 kg/hr, 42.9 kg/hr and 21.3 kg/hr respectively.

Gulland (1973) while summarizing the results of exploratory surveys made between 23°10′ and 15°10′ latitude zones observed that large vessels (300 bhp, 120 GRT) landed between 191 and 387 kg/hr of fishes. In terms of depth, 50–60 m was found productive with 365 kg/hr while still deeper waters of 80–90 m yielded about 100 kg/hr. The studies on the spawning habits of the important species of sciaenids showed that the spawning period in majority of sciaenids is not prolonged but restricted to a brief period at only once in a year particularly during the premonsoon along the east coast. Along the west coast, in majority of the species, the spawning occurred mainly twice in an year particularly during the premonsoon and postmonsoon. But in *O. ruber* spawning occurred only once in an year. Bhusari (1975), based on the ovadiameter studies in species like *K. axillaris*, *J. sina*, *J. aneus* and *J. dussumieri*, stated that there was prolonged spawning from July to October with peak during June–July.

The size of first maturity for smaller sciaenids was observed at the end of one year of age or at the size of 150–170 mm whereas in larger ones, like *O. brunneus* after attaining the size of one metre. Sex ratio in different species of sciaenids was not uniform but varied independently of month and season. Rao (1966) reported that in *P. diacanthus* males and females move in separate shoals. Generally fecundity in sciaenids varied in different species and ranged from few thousands to 2–3 lakhs whereas in larger species such as *P. diacanthus* it might extend up to six lakhs. From Chilka lake, Rajan (1968) reported that even in smaller species, like *N. coibor*, fecundity ranged from 2.7 to 5.6 lakhs.

Studies on the age and growth and stock position of various species were made, the L_∞ and growth co-efficient values varied from species to species. The mean exploitation ratio value depended on the length of fish and on the value of M = K. Thus for *O. cuvieri*, from Gujarat the L and growth co-efficient values

were 381 mm and 0.55 respectively while for fish obtained from Bombay, the corresponding values were 398 mm and 0.52 respectively.

Muthiah (1982) found that *J. vogleri* from Bombay waters attained the length of 158, 240 and 290 mm at the end of 1st, 2nd and 3rd year whereas Chakraborty (1980) estimated the length of this species to be 149, 227 and 277 mm at the end of 1st, 2nd and 3rd year of its life.

At Calicut, Nair (1974) found the length of *J. sina* as 135 mm and 175 mm at the end of 1st and 2nd year of its life. According to Chakraborty (1980), growth of this species from Bombay was 132 and 190 mm at the end of first and second year of its life. The asymptotic length for this species using Bhattacharya's method and ELEFAN method was estimated as 239 and 240 mm respectively and the growth co-efficient was 0.777 and 0.80 respectively. The average Z and E values for 1987–90 were 4.34 and 0.58 respectively. So, the growth parameters estimated by Nair (1974) and Chakraborty (1980) were higher when compared with those from Cochin waters. The higher growth rate and asymptotic length obtained for *J. sina* from Bombay waters could be explained from the fact that, in general, fishes from northwest coast have higher growth rate and higher L_∞. The Z estimated by Chakraborty (1980) was also higher.

Vivekanandan (1985) from Madras stated that *J. carutta* had grown to 105, 185 and 223 mm at the end of 1st, 2nd and 3rd year of its life. The L_∞ estimated by him was 235 mm and the growth co-efficient was 0.725. Murty (1984) working on *J. carutta* from Kakinada estimated L_∞ to be 333 mm, K as 0.44 and M as 1.0.

The assessment of the sciaenid fishery based on length frequencies using the length converted Thomspon and Bell analysis showed that stocks of most of the species of sciaenids are more than fully exploited in almost all the maritime states indicating the need of even reduction of fishing effort for obtaining maximum sustainable yield. In Gujarat a reduction of fishing effort by 60% (M = K) or 20% (M = 1.5 K) is suggested for the exploitation of *O. cuvieri*. In Maharashtra also an almost identical reduction in fishing effort is recommended for the species. The yield of *J. macrorhynus* in Maharashtra is 51 852 tonnes for which a 40% reduction in effort is suggested when M = K but no reduction is needed when M is taken as 1.5 K. For *J. vogleri*, the stock of which has already shown a decline (present production 52 332 tonnes), a reduction of effort by 20% is needed (M = K). For *J. sina* in the state, assuming M=K, the yield does not show any decline at the present level of fishing whereas with M = 1.5 K, by increasing the effort by three times, 5.3% increase in yield can be obtained which is not remunerative. In Kerala for *J. sina*, though effort can be increased by three times, only marginal increase in catch is feasible. In Andhra Pradesh, the rate of exploitation of *J. carutta* appeared to be on the higher side showing a decline in yield which calls for a reduction of effort by 40% and 20% when M is taken as 1.5 K and 2 K respectively. In Tamil Nadu there is no decline in the yield for the species.

This study indicated that the rate of exploitation of the predominant species of sciaenids in Gujarat, Maharashtra and Andhra Pradesh is higher necessitating a reduction in fishing effort for their optimal exploitation. In Kerala and Tamil Nadu, though as yet there is no sign of over exploitation, increase in effort is not suggested since even substantial increase in effort gives only marginal increase in yield which is not an economical proposition. While indicating such management measures, it is fully appreciated that in our multispecies trawl fishery, where prawn and

cephalopods form the target groups, the above measures cannot be initiated unless by-catch resources receive protection and conservation considerations.

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