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Stock assessment of marine catfishes of India

N GOPINATHA MENON[1], M SRINATH[2], Y APPANNA SASTRY[3], S G RAJE[4], P U ZACHARIAH[5] and M FEROZ KHAN[6]

Central Marine Fisheries Research Institute, Cochin, Kerala 682 014

ABSTRACT

The marine catfish fishery of India during 1979–88 laid special emphasis on the stock and exploitation of two major species *Tachysurus thalassinus* and *T. tenuispinis*. These together constituted about 50% of the total catfish landings of the country. Catfish production registered increase in the 1970–89 period, but the high fishing pressure in the mechanized trawl and purse seine sector resulted in non-judicious harvest of spawners or brooders, eggs or embryos and juvenile or sub-adults of catfishes. Because of this, the yield of both the species suffered setback in the late eighties at most of the fishing centres. The exploitation level of *T. thalassinus* was 0.88 at Veraval, 0.85 at Cochin and 0.84 at Visakhapatnam with corresponding E_{max} of 0.72, 0.72 and 0.50. In Gujarat, Kerala and Andhra Pradesh the exploitation of this species exceeded the annual average standing stocks. The exploitation rate of *T. tenuispinis* was 0.61, 0.79 and 0.65 at Veraval, Mangalore and Cochin respectively. The corresponding E_{max} was 0.74, 0.51 and 0.66. The exploitation was higher than the annual average standing stocks in Gujarat, Karnataka and Kerala. The possible management strategies and remedial measures are discussed.

Marine catfishes are widely distributed in the tropical Indo-Pacific region and are dominant in the fish landings along the Indian coast. The estimated potential yield of marine catfishes is 123 000 tonnes and the annual average catch (1980-89) around 54 500 tonnes. They occur all along the coast up to a depth of 80 m, with particular dominance in muddy bottom areas, either in small aggregations or in large shoals. The adult populations ascend vertically and horizontally for feeding and breeding. This group forms a significant seasonal fishery all along the coast since the early days.

In the past three decades, the catfish landings increased steadily from 11 779 tonnes (2% of marine fish catch) in 1950 to 49 794 tonnes (2.1%) in 1989 with annual fluctuations. During 1950–59 and 1960–69 the average annual production was 21 240 tonnes and 21 440 tonnes respectively, which suddenly increased to 52 355 tonnes during 1970–79 and 54 513 tonnes during 1980–89. This steep rise was chiefly due to higher mechanization in the harvesting sector especially by purse seiners. The mechanization was largely confined to small and medium crafts which neither alter or extend the fishing areas nor diversify fishing. This situation led to higher fishing pressure and non-judicious harvest of juveniles or sub-adults and spawners or brooders from the coastal habitats of breeding grounds of different species of catfishes.

Seasonal and bathymetric resource abundance and also pockets of concentration for catfishes along inner and middle shelf waters

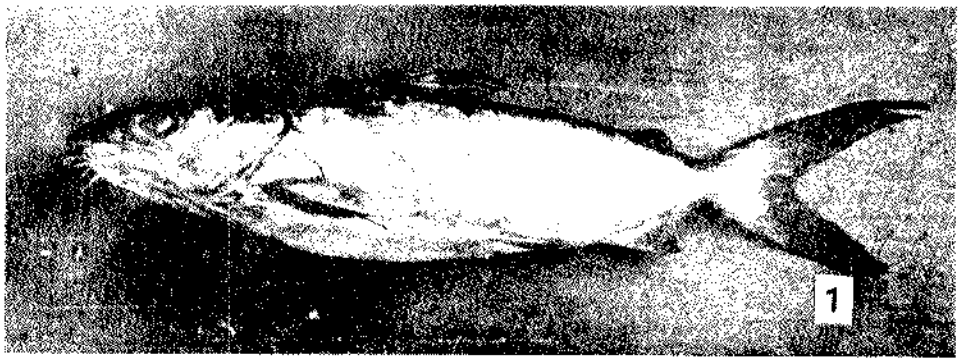
Present address: [1]Senior Scientist, [2]Scientist (Selection Grade).

[3]Scientist (Selection Grade), Visakhapatnam Research Centre of CMFRI, Andhra University P O, Visakhapatnam 530 003.

[4]Scientist (Selection Grade), Bombay Research Centre of CMFRI, 148, Army and Navy Building, 2nd Floor, M G Road, Bombay 400 023.

[5]Scientist, Mangalore Research Centre of CMFRI, P B No 244, Bolar, Mangalore 575 001.

[6]Scientist, Calicut Research Centre of CMFRI, West Hill, Calicut 673 005.



1. *Tachysurus thalassinus*. 2. *T. tenuispinis*. 3. Juveniles of *T. thalassinus* from mechanized trawl catch. 4. Embryos of *T. tenuispinis* caught in purse seine.

of India during monsoon and post-monsoon seasons have been studied (Rao *et al.* 1977, James and Pillai 1990, Philips 1988). A comprehensive study of fishery, biology and resource potential of catfishes from Indian waters have been made by Anonymous (1987) and James *et al.* (1989). Indiscriminate exploitation has necessitated the protection of many species of catfishes. At many fishing centres there are changes in the species diversity of catfishes in terms of quality and abundance (Lakshmi and Rao 1992).

For the formulation of a realistic management policy of this resource it is essential to study the magnitude of the fishery all along the range of distribution and availability, migration pattern, species composition, behaviour and biology of main species, dynamics of the populations fished and the present level of exploitation and its impact on the stocks. To provide information on the standing stock and sustainable yield, two species viz. *Tachysurus tenuispinis* and *T. thalassinus* were selected as they form the bulk of the catfish landings.

MATERIALS AND METHODS

Resources of *Tachysurus thalassinus* and *T. tenuispinis*, were assessed from Veraval, Mangalore, Calicut and Cochin along the west coast and Visakhapatnam in the east coast. In the latter centre biological information on catfishes was also collected. Length frequency data of *T. tenuispinis* and *T. thalassinus* collected during 1984–86 at Veraval from trawl and gill net catches and during 1984–88 at Mangalore from trawl, drift net and purse siene landings, at Calicut from drift net and hooks and line catches, at Cochin from trawl and gill net landings and at Visakhapatnam (*T. thalassinus*) from the trawl net, were considered for this study.

Estimation of growth parameters: Assuming that the growth of catfish is isometric and following von Bertalanffy's growth pattern, namely

$$L_t = L_\infty [1 - e^{-K(t - to)}] \quad \ldots \quad (1)$$

in the usual notation, estimates for L_∞ and K are obtained using ELEFAN-1 (Pauly *et al.* 1981). Since the estimates for each species did not show much variation between centres, estimate (L_∞ and K) for each species was obtained and is presented below along with the corresponding estimate for W_∞.

Species	L_∞ (mm)	K (annual)	W_∞ (gm)
T. thalassinus	755	0.36	4030
T. tenuispinis	560	0.78	3230

The total instantaneous mortality rate (Z) was estimated from the length converted catch curve based on data from 1984–88. As both the species of catfishes were with high T_{max} and with parental care, the chances of natural mortality (M) was assumed to be very low. Therefore, for the present study, M was considered approximately equal to K value.

The rate of exploitation (μ) was computed from the following formula.

$$\mu = \frac{F}{Z} \quad (1 - e^{-Z})$$

Estimation of yield per recruit and biomass per recruit at various levels of exploitation were made as per the Beverton and Holt (1957).

RESULTS

Fishery

All-India catfish catch during 1979-88: All-India catfish landing fluctuated from 43 745 (1980) to 67 664 tonnes (1982) with a general decline in production during 1984–87. The ten-year average catfish catch was 54 416 tonnes forming 3.55% of total fish production. In the all-India total catfish catch, about 30% was contributed by *Tachysurus thalassinus*

Table 1. Annual catfish production (tonnes) in the maritime states during 1979–88

Year	West Bengal	Orissa	Andhra Pradesh	Tamil Nadu	Pondicherry	Kerala	Karnataka	Goa	Maharashtra	Gujarat	Andaman	LT	Total	Percentage in the total landings
1979	140	1 308	3 799	5 617	51	11 328	9 920	846	10 433	5 320	55		48 817	3.5
1980	723	2 198	2 338	4 047	78	13 936	5 354	1 151	8 653	5 235	32		43 745	3.5
1981	4 449	6 084	4 250	3 792	102	9 562	7 503	2 211	11 045	10 370	22		59 390	4.3
1982	9 075	3 995	3 182	6 048	20	9 532	10 253	1 941	10 919	12 662	37		67 664	4.8
1983	1 501	4 528	3 606	4 620	64	15 344	7 273	1 522	12 008	10 176	34	88	60 764	3.9
1984	2 211	5 993	5 480	4 197	68	11 582	3 722	1 272	13 418	9 313	121	38	57 415	3.5
1985	1 504	5 351	5 230	2 056	39	5 184	1 415	1 715	11 009	10 876	121		44 500	2.9
1986	1 704	4 251	3 615	1 683	1 043	8 589	8 258	393	11 797	11 430	170		52 933	3.1
1987	2 730	4 188	3 370	2 579	31	4 345	2 877	1 378	13 369	9 615	227		44 709	2.7
1988	917	4 968	2 775	2 099	33	9 960	8 818	3 925	21 086	9 497	141		64 219	3.6
Average	2 495	4 286	3 764	3 674	153	9 946	6 539	1 635	12 374	9 449	96		54 416	3.6

LT = Larger Trawlers

and 20% by *T. tenuispinis*. The percentage compositions of the former specie showed a gradual increase, while the latter declined in the ten-year period of 1979–88. The peak landings of 1982 and 1988 were due to heavy purse seine catch in Karnataka and high production from northwest coast respectively.

Statewise catfish catch and species composition: The statewise catfish catch during 1979–89 is given in Table 1. Quite contrary to 1970s, in 1980s the peak contribution of catfish was from Maharashtra and Gujarat together landing more than 40% of the total catfish catch. The fluctuation in landings was high in the west coast compared to that in the east coast.

Less than ten species of catfishes occurred in commercial trawl and gill net landings of Gujarat (Table 2). *Tachysurus dussumieri* was the most abundant species, followed by *T. tenuispinis*, *T. caelatus*, *T. thalassinus*, *Osteogeneiosus militaris* and others.

Although several species appeared in the catches of Maharashtra (Table 3), about 80% of the catfish landing consisted of four species viz *T. dussumieri*, *O. militaris*, *T. thalassinus* and *T. tenuispinis*.

The entire catfish catch of Karnataka during 1979–1988 composed of only four species (Table 4), viz *T. tenuispinis*, *T. dussumieri*, *T. serratus* and *T. thalassinus*.

Kerala also contributed only four species of catfishes with *T. thalassinus* as the chief species followed closely by *T. tenuispinis*. *T. dussumieri* and *T. serratus* accounting for 40%, 30%, 12% and 18% respectively (Table 5).

Only two species *T. thalassinus* and *T. tenuispinis* appeared in trawl catches of Andhra Pradesh during 1979–88 (Table 6).

Annual and seasonal gearwise production and abundance: The annual and monthwise catfish catch, effort and catch rate during 1984–88 at different centres is summarized below.

VERAVAL: Gearwise annual and monthly catfish landing at Veraval (Gujarat) are given in Table 7 and 8 respectively. Production as well as resource abundance showed an increasing trend at Veraval in both the gears.

Table 2. Species composition (kg) of catfish landings in Gujarat during 1979–88

Year	*Tachysurus tenuispinis*	*T. thalassinus*	*T. dussumieri*	*Osteogeneiosus militaris*	*T. caelatus*	Others	Total
1979	835	633	2 411	409	649	383	5 320
1980	822	623	2 371	403	639	377	5 235
1981	1 628	1 235	4 697	799	1 265	746	10 370
1982	1 988	1 507	5 736	945	1 544	912	12 662
1983	1 597	1 211	4 610	783	1 242	733	10 176
1984	1 463	1 108	4 219	717	1 136	670	9 313
1985	1 707	1 294	4 927	837	1 328	783	10 876
1986	1 794	1 361	5 178	880	1 394	823	11 430
1987	1 509	1 144	4 356	740	1 174	692	9 615
1988	1 491	1 130	4 302	731	1 159	684	9 497
Average	1 483	1 125	4 281	727	1 153	680	9 449
Percentage in total catfish	15.69	11.91	45.30	7.69	12.20	7.20	

Table 3. Species composition (kg) of catfish landings in Maharashtra

Year	*Tachysurus tenuispinis*	*T. thalassinus*	*T. dussumieri*	*T. serratus*	*Osteogeneiosus militaris*	*T. caelatus*	*T. sona*	Others	Total
1979	1 408	2 024	2 608	167	2 285	887	449	605	10 433
1980	1 168	1 679	2 163	138	1 895	736	372	502	8 653
1981	1 491	2 143	2 761	177	2 419	939	475	641	11 045
1982	1 474	2 118	2 730	175	2 391	928	470	633	10 919
1983	1 621	2 330	3 002	192	2 630	1 021	516	696	12 008
1984	1 811	2 603	3 355	215	2 938	1 141	577	778	13 418
1985	1 486	2 136	2 752	176	2 411	936	473	639	11 009
1986	1 593	2 289	2 949	189	2 584	1 003	507	684	11 797
1987	1 805	2 594	3 342	214	2 928	1 136	575	775	13 369
1988	2 847	4 091	5 271	337	4 618	1 792	907	1 233	21 086
Average	1 670	2 401	3 093	198	2 710	1 052	532	719	123 744
Percentage in total catfish	13.50	19.40	25.0	1.6	21.9	8.5	4.3	5.8	

Table 8 indicated the better abundance of this resource in the fishing grounds during monsoon months. But the landing in monsoon season was low due to poor fishing pressure. Average seasonal species composition and percentage of catfishes in all gears combined during 1984–88 for Veraval is given in Fig. 1.

MANGALORE: The annual and monthly catfish production, effort and catch rate by

Table 4. Species composition (kg) of catfish landings in Karnataka

Year	*Tachysurus tenuispinis*	*T. thalassinus*	*T. dussumieri*	*T. serratus*	Total
1979	5 297	585	3 055	983	9 920
1980	2 859	316	1 649	530	5 354
1981	4 006	443	2 311	743	7 503
1982	5 475	605	3 158	1 015	10 253
1983	3 884	429	2 240	720	7 273
1984	1 988	220	1 146	368	3 722
1985	756	83	436	140	1 415
1986	4 410	487	2 543	818	8 258
1987	1 536	170	886	285	2 877
1988	4 709	520	2 716	873	8 818
Average	3 492	386	2 014	647	6 540
Percentage in total catfish	53.39	5.9	30.8	9.9	

Table 5. Species composition (kg) of catfish landings in Kerala

Year	*Tachysurus tenuispinis*	*T. thalassinus*	*T. dussumieri*	*T. serratus*	Total
1979	3 398	4 532	1 359	2 039	11 328
1980	4 181	5 574	1 672	2 509	13 936
1981	2 869	3 825	1 147	1 721	9 562
1982	2 860	2 813	1144	1 715	9 532
1983	4 603	6 138	1 841	2 762	15 344
1984	3 475	4 632	1 390	2 085	11 582
1985	1 555	2 074	622	933	5 184
1986	2 577	3 435	1 031	1 546	8 589
1987	1 304	1 738	521	782	4 345
1988	2 988	3 984	1 195	1 793	9 960
Average	2 981	3 974	1 192	1 788	9 936
Percentage in total catfish	30.0	40.0	12.0	18.0	

purse seine, trawl net and drift gill net from Mangalore are given in Table 9 and 10. The bulk of the catfish catch was landed by purse seine (83.4%) followed by trawl net (14.6%) and drift net (2%). All gear total yield and catch rate of catfishes at Mangalore showed high values in January, February and September–October. All gear total species composition and percentage of catfishes landed at Mangalore in different months during 1984–88 is presented in Fig. 2.

Table 6. Species composition (kg) of catfish landings in Andhra Pradesh

Year	*Tachysurus tenuispinis*	*T. thalassinus*	*T. dussumieri*	Total
1979	270	3 518	11	3 799
1980	166	2 165	7	2 338
1981	302	3 936	13	4 250
1982	226	2 947	9	3 182
1983	256	3 339	11	3 606
1984	389	5 074	16	5 480
1985	371	4 843	16	5 230
1986	257	3 347	11	3 615
1987	239	3 121	10	3 370
1988	197	2 570	8	2 775
Average	267	3 486	11	3 765
Percentage in total catfish	7.7	92.3		

CALICUT: Annual catfish catch, effort and catch rate by different gears at Calicut during 1984–88 are given in Table 11. All gear total catfish yield varied from 300 (1985) to 531 tonnes (1987) during 1984–88 and the catch rate ranged from 46.8 (1987) to 59.5 kg (1986). Average monthly effort, catch and catch per unit effort of various gears are shown in Table 12. More than 79% of the annual total catfish catch of hooks and line had landed during September and October. The monthwise percentage composition of different catfish species landed by all gears during 1984–88 is shown in Fig. 3.

COCHIN: The all-gear annual total catfish catch at Cochin varied from 649 to 1 455 tonnes during 1984–88 with an average of 926 tonnes at a catch rate of 16.1 kg/unit effort (Table 13).

Table 7. Annual catch (tonnes), effort and catch rate (kg) of catfish in various gears at Veraval (Gujarat) during 1984–86

Year	Trawl net			Gill net			Total		
	Effort	Catch (tonne)	Catch rate (kg)	Effort	Catch (tonne)	Catch rate (kg)	Effort	Catch (tonne)	Catch rate (kg)
1984	46 464	514	11.06	30 736	278.4	5.51	77 200	683	8.85
1985	40 254	440	10.93	31 612	324	10.75	71 866	764	10.63
1986	51 089	487	11.49	30 798	413	13.40	81 887	1 000	12.21
Mean	46 639	512.7	11.00	30 021	278.4	9.03	76 660		10.03

Catfish landings by drift net was high during June–October at Cochin (Table 14). The monthly landings varied from 71 kg to 111 009 kg with a corresponding catch rate of 0.08 kg (April)) to 40.5 kg/unit effort (July).

Table 8. Average monthly catch (kg), effort and catch rate (kg) of catfish in various gears at Veraval (Gujarat) during 1984–86

Month	Trawl net			Gill net		
	Effort	Catch (kg)	CPUE (kg)	Effort	Catch (kg)	CPUE (kg)
Jan	6 049	65 096 (13.23)	10.76	3 784	37 022 (12.62)	9.78
Feb	4 795	46 669 (9.48)	9.73	2 810	31 439 (10.72)	11.19
Mar	5 972	63 083 (12.82)	10.56	3 353	33 228 (11.33)	9.91
Apr	7 506	97 702 (19.86)	13.02	3 121	32 853 (11.20)	10.53
May	8 328	25 426 (5.17)	3.05	3 216	30 384 (10.36)	9.45
June	12	5	0.42	444	12 177 (4.15)	27.43
July	–			979	8 391 (2.86)	8.57
Aug	–			2 232	19 544 (16.66)	0.76
Sep	1 699	4 980 (1.01)	2.93	2 527	28 019 (9.55)	11.09
Oct	5 465	59 290 (12.05)	10.85	2 325	5 698 (1.94)	2.45
Nov	5 605	66 196 (13.45)	11.81	3 011	23 117 (7.88)	7.60
Dec	5 446	63 608 (12.93)	11.68	2 715	31 378 (10.7)	11.56

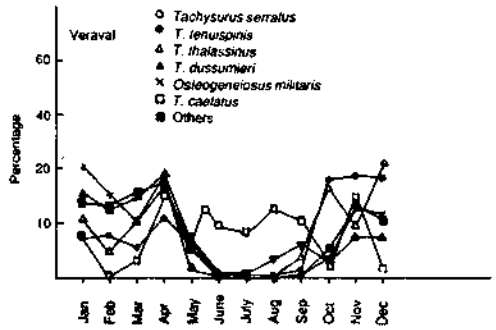


Fig. 1. Average monthly catfish species composition at Veraval (Gujarat) during 1984–88.

The average species composition and percentage of all gear total catfish catch at Cochin during 1984–88 is shown in Fig. 4.

VISAKHAPATNAM: Catfish landings fluctuated from 70 (1985) to 144 tonnes (1987) at Visakhapatnam with an average of 118 tonnes (Table 15) with a mean effort of 2.3 kg/unit. The monthly catch ranged from 2 728 kg (May) to 18 338 kg (September) and the peak landings were during July–September (40%) (Table 16). Average seasonal percentage composition of catfishes in trawl net during 1984–88 is given in Fig. 5.

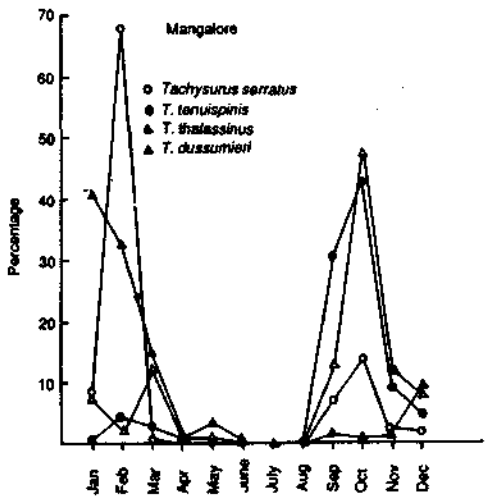


Fig. 2. Average monthly catfish species composition at Mangalore during 1984–88.

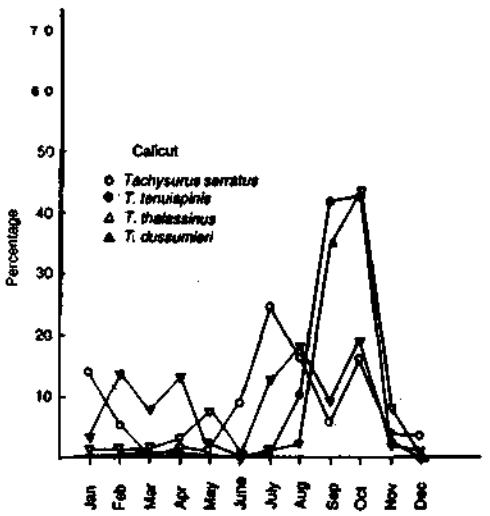


Fig. 3. Average monthly catfish species composition at Calicut during 1984–88.

Gear and mesh size: Catfishes are generally caught in several types of gears; the major ones are trawl net, gill net/drift net, purse seine, and hooks and line with regional variations in the cod end mesh sizes (15–35 mm), gill net (20–70 mm), drift net (70–140 mm) and hook sizes (nos 3–22).

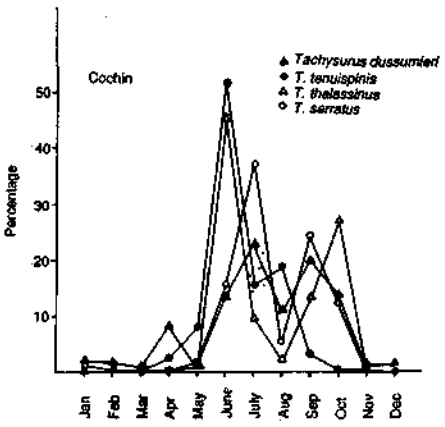


Fig. 4. Average monthly catfish species composition at Cochin during 1984–88.

Table 9. Annual catch (tonnes), effort and CPUE (kg) of catfish in different gears at Mangalore during 1984–88

Year	Purse seine			Trawl			Drift gill net			Total		
	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE
1984	13 404	663	49.47	46 963	460	9.80	4 851	19	3.86	65 218	1 142	17.51
1985	12 604	410	32.50	43 945	87	1.98	2 686	16	5.92	59 235	313	8.65
1986	13 559	3 605	265.85	44 035	101	2.29	4 493	24	5.45	62 087	3 730	60.08
1987	9 743	223	22.92	50 117	60	1.20	5 509	21	3.79	65 369	394	4.66
1988	14 114	830	58.84	39 105	297	7.59	4 154	57	13.71	57 373	1 184	20.64
Mean	12 685	1 146.3	90.36	44 833	201	4.48	3 459	27.4	7.62	61 836	1 374.6	22.22

Table 10. Monthly average gearwise catch (kg), effort and catch rate (kg) of catfish during 1984–88 at Mangalore

	Purse seine			Trawl net			Drift gill net			Total		
	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE
Jan	797	273 338	342.96	7 784	6 841	0.88	335	343	1.02	8 916	280 522	31.46
Feb	635	201 917	317.98	7 092	30 435	4.29	243	1 283	5.28	7 970	233 635	29.31
Mar	886	53 570	60.46	6 668	29 981	4.50	316	694	2.20	8 538	84 245	9.87
Apr	493	–	–	6 583	6 752	1.03	146	106	0.73	7 222	6 858	0.95
May	723	–	–	5 131	25 488	4.97	176	6	0.03	6 030	25 494	4.23
Sep	2 685	229 958	85.65	711	274	0.39	158	2 990	18.92	3 554	233 222	65.62
Oct	2 548	338 240	132.75	875	84	0.10	1 219	14 996	12.30	4 642	353 320	76.11
Nov	2 193	16 376	7.47	3 365	59 637	17.72	1 131	4 678	4.14	6 680	80 691	12.06
Dec	1 724	32 844	19.05	6 566	41 567	6.33	752	2 292	3.05	9 042	76 703	8.48

There was no mechanized fishing in monsoon months (June–Aug)

Table 11. Annual catch (tonnes), effort and catch rate (kg) of catfish in different gears at Calicut during 1984–88

Year	Hooks and line			Drift net			Trawl net			Others (non-mechanized)*			Total		
	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE
1984	1 422	261	183.85	2 733	54	19.62	1 394	–	–	–	–	–	5 549	315	56.78
1985	1 413	206	145.64	3 718	94	25.3	–	–	–	–	–	–	5 131	300	58.44
1986	2 262	278	122.94	5 226	142	27.13	1 271	2	1.23	939	100	106.49	8 759	521	59.53
1987	1 186	356	300.00	6 896	38	5.56	–	–	–	3 265	136	41.80	11 347	531	46.76
1988	780	363	465.00	6 968	42	5.98	–	–	–	–	–	–	7 748	404	52.20
Mean	1 413	293	207.28	5 108	74	14.49	533	0.4	0.75	841	47.2	56.14	7 707	414	53.74

*In non-mechanized gears chiefly boat seine (*pattankolli vala*) was used

Table 12. Average seasonal catch (kg), effort and catch rate (kg) of catfish during 1984–88 at Calicut

Year	Hooks and line			Drift net			Trawl net			Others			Total		
	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE
Jan	54	2 479	45.91	281	4 425	15.75	93	–	–	–	–	–	428	6 904	16.13
Feb	114	11 503	100.90	364	1 678	4.61	77	–	–	–	–	–	555	13 181	23.75
Mar	93	8 094	87.03	367	659	1.8	306	196	0.64	–	–	–	766	8 949	11.68
Apr	78	6 888	88.31	479	1 720	3.59	–	–	–	39	4 964	127.28	596	13 572	22.77
May	44	1 854	19.94	295	266	0.90	66	115	1.75	–	–	–	405	2 235	5.52
June	7	632	90.00	103	562	5.45	–	–	–	–	–	–	110	1 194	10.85
July	60	5 996	99.93	363	3 714	10.23	–	–	–	365	11 885	31.74	788	21 295	27.02
Aug	35	14 620	417.71	384	10 830	28.20	–	–	–	246	24 508	99.63	665	49 958	75.12
Sep	296	110 544	373.46	593	18 403	31.03	–	–	–	190	6 237	32.83	1 079	135 184	125.29
Oct	394	120 758	306.49	887	28 159	31.75	–	–	–	–	–	–	1 281	148 917	116.25
Nov	41	8 651	211.00	780	2 235	2.87	–	–	–	–	–	–	821	10 886	13.26
Dec	10	758	75.80	700	1 239	1.77	–	–	–	–	–	–	710	1 997	2.81

Table 13. Annual catch (tonnes), effort and catch rate (kg) of catfish in various gears at Cochin during 1984–88

Year	Drift net			Trawl net			Purse seine			Total		
	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE
1984	19 511	346	17.7	40 811	536	13.13	3 693	0.1	–	64 015	882	13.8
1985	19 958	348	17.4	30 347	301	9.9	2 237	–	–	52 652	649	12.3
1986	20 406	619	30.3	48 128	308	6.4	768	–	–	69 302	927	13.4
1987	14 915	150	10.1	52 783	565	10.7	844	2.0	2.4	68 542	717	10.5
1988	16 514	257	15.6	16 477	1 189	72.0	597	9.0	14.6	33 588	1 455	22.8
Mean	18 261	344	18.84	37 731	580	15.37	1 628	2.2	1.08	57 620	926	16.1

Table 14. Average seasonal catch (kg), effort and catch rate (kg) of catfish at Cochin in different gears during 1984–88

Month	Drift net			Trawl net			Purse seine			Total		
	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE	Effort	Catch	CPUE
Jan	561	2 400	4.28	3 975	–	–	138	–	–	4 674	2 400	0.51
Feb	491	804	1.64	4 058	–	–	199	–	–	4 748	804	0.17
Mar	698	380	0.54	4 281	–	–	222	–	–	5 201	380	0.01
Apr	933	71	0.08	4 646	12 175	2.62	210	–	–	5 789	12 885	2.23
May	2 225	1 536	0.69	5 339	35 316	0.61	189	400	2.12	7 753	50 137	6.47
June	1 793	24 265	13.53	5 558	390 351	70.23	–	–	–	7 351	63 300	8.61
July	2 743	111 009	40.47	3 980	41 832	10.51	–	–	–	6 723	52 811	7.86
Aug	2 135	33 668	15.77	2 600	369 364	142.06	–	–	–	4 735	455 873	96.28
Sep	2 480	87 369	35.23	1 951	21 673	11.11	284	20	0.07	4 715	564 935	119.82
Oct	2 314	79 308	34.27	1 776	66 436	37.41	212	1750	8.25	4 302	147 494	34.28
Nov	1 226	2 403	1.96	1 893	2 659	1.40	81	–	–	3 200	5 062	1.58
Dec	472	750	1.59	3 524	–	–	85	–	–	7 281	750	0.10

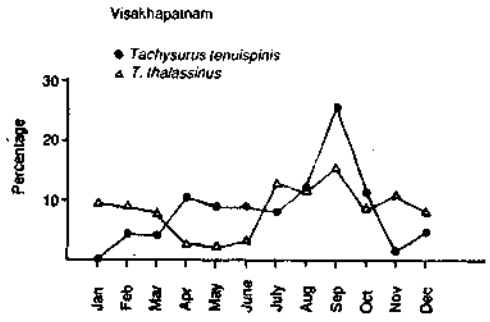


Fig. 5. Average monthly catfish species composition at Visakhapatnam during 1984–88.

Biology

Detailed investigations were carried out on age and growth, length-weight relationship and condition factor, food and feeding habits, and reproductive biology of both *Tachysurus thalassinus* and *T. tenuispinis* by Mojumder (1969, 1971, 1977, 1978), Mojumder and Dan (1981), Dan (1977, 1980), Menon (1979, 1984 a, b, 1986, 1991) and Menon and Muthiah (1987).

Tachysurus thalassinus: Age and growth of the species was studied by Mojumder (1977) from Waltair and Menon (1979, 1986) from Mandapam waters. The growth parameter L_∞ and K and W_∞ estimated by Alagaraja and Srinath (1987) were 755 mm, 0.36 (annual) and 4 030 g respectively.

The length-weight relationship equations for males and females from Mandapam waters (Menon 1979) were:

$$\text{Male} : W = 0.000004855\, L^{3.0995}$$
$$\text{Female} : W = 0.000009873\, L^{3.0093}$$

Mojumder (1978), Menon (1979) and Menon and Muthiah (1987) found the spawning season of the species extending from April to August along the east coast and June to October in the west coast with peaks in July–September. The fecundity was between 25 and 60 ova. The size at first maturity (stage III) was around 28–30 cm and length at first spawning at 36 cm for females.

Table 15. Annual catch (tonnes), effort and CPUE (kg) of catfish in trawl net at Visakhapatnam during 1984–88

Year	Effort	Catch	CPUE
1984	65 047	128	1.97
1985	43 417	70	1.61
1986	49 930	112	2.24
1987	48 185	144	2.99
1988	31 731	136	2.63
Average	51 662	118	2.28

Tachysurus tenuispinis: The age and growth of the species was studied by Dan (1980) based on length frequency data and skeletal hard parts like opercular bone and otoliths form Waltair waters. The estimated growth parameters by Alagaraja and Srinath (1987), based on trawl catch data, were: L_∞, 560 mm; K, 0–78 (annual); and W_∞, 3 230.

The length-weight relationship of *T. tenuispinis* showed no significance statistically between sexes, therefore, a common relationship for both the sexes was derived (Dan and Mojumder 1978) as:

$$W = 0.00001842\, L^{2.8860}$$

Table 16. Monthly average trawl catch (kg), effort and catch rate (kg) of catfish during 1984–88 at Visakhapatnam

Month	Effort	Catch	Catch rate	Percentage
Jan	5 150	1 490	2.04	8.89
Feb	3 711	10 009	2.05	8.48
Mar	3 980	8 602	2.16	7.29
Apr	2 925	3 410	1.17	2.89
May	2 167	2 728	1.26	2.31
June	3 566	4 700	1.32	3.98
July	4 263	15 063	3.53	12.76
Aug	5 755	13 414	2.33	11.36
Sep	5 032	18 338	3.64	15.53
Oct	5 272	10 282	1.95	8.75
Nov	4 318	11 577	2.68	9.81
Dec	4 844	9 434	1.95	7.99

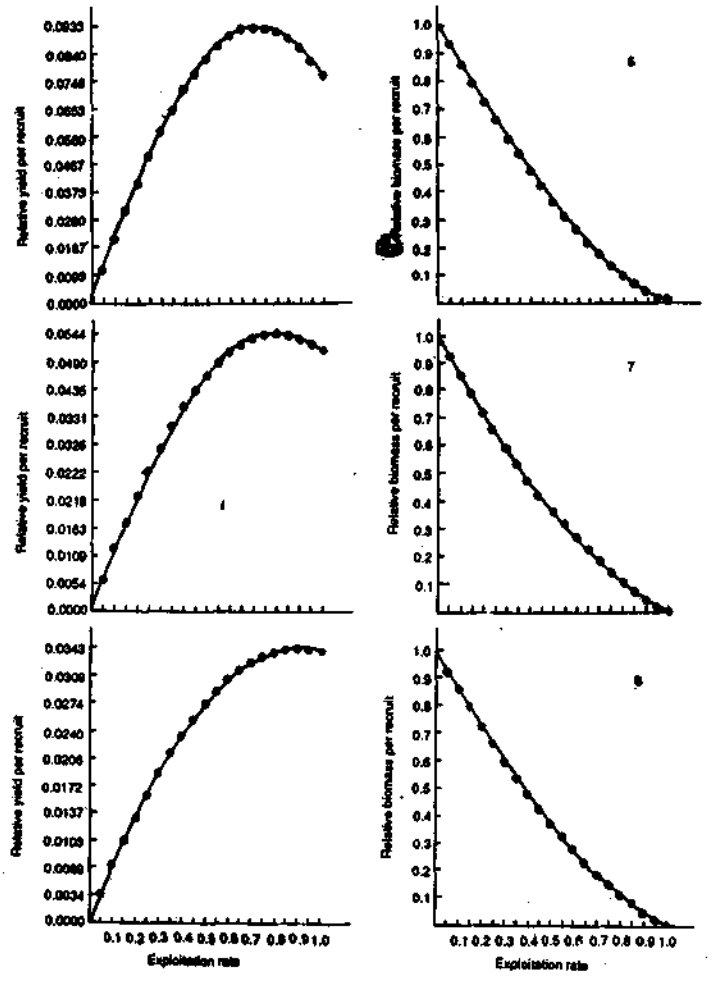
Dan (1977) and Menon and Muthiah (1987) reported that the spawning season of *T. tenuispins* extended from May to September with peak in July–August and it breeds only once a year. The size at first maturity was 275 mm for both males and females. The fecundity of the species varied from 29 to 82 ova in fishes of 285–424 mm.

Stock assessment

Tachysurus thalassinus: The total instantaneous mortality rate (Z), as calculated from the length converted catch curve, was 2.93 at Veraval (Gujarat), 2.36 at Cochin (Kerala) and 2.30 at Visakhapatnam (Andhra Pradesh) for an M/K value of 1 with an M value of 0.36. The fishing mortality (F) value for the above 3 centres was 2.57, 2.0 and 1.94 respectively. The present level of exploitation (E) was 0.88 at Veraval, 0.85 at Cochin and 0.84 at Visakhapatnam whereas the corresponding E_{max} were 0.72, 0.72 and 0.50. In all the three places the existing level of exploitation is close to the maximum allowable limit of the yield per recruit. The estimated maximum sustainable yield (MSY) is 2 056 tonnes and the standing stock is 754 tonnes in Gujarat, whereas the present annual average catch is 1 937 tonnes; in Kerala, the annual average catch is 3 244 tonnes whereas the MSY is estimated at 3 367 tonnes. The annual average landing in Andhra Pradesh is 3 124 tonnes, but the MSY is estimated as 6 280 tonnes. The results of Y/R analysis of *T. thalassinus* for Gujarat, Kerala and Andhra Pradesh are given in Table 17. It shows that in Gujarat with the present fishing mortality of 2.57, the average annual catch is 257% more than the average annual standing stock. Similarly in Kerala with an F of 2.0 the annual average landing is 200% more than the average standing stock whereas in Andhra Pradesh the annual mean catch is 184% more than the annual average standing stock at a fishing mortality of 1.94. The relative yield per recruit for M/K values of 1, 1.5 and 2.0 at Veraval, Cochin and Visakhapatnam are shown in Figs 6–11. All these findings show the high exploitation of the species from the three states.

Table 17. Results of yield/recruit analysis of *Tachysurus thalassinus*

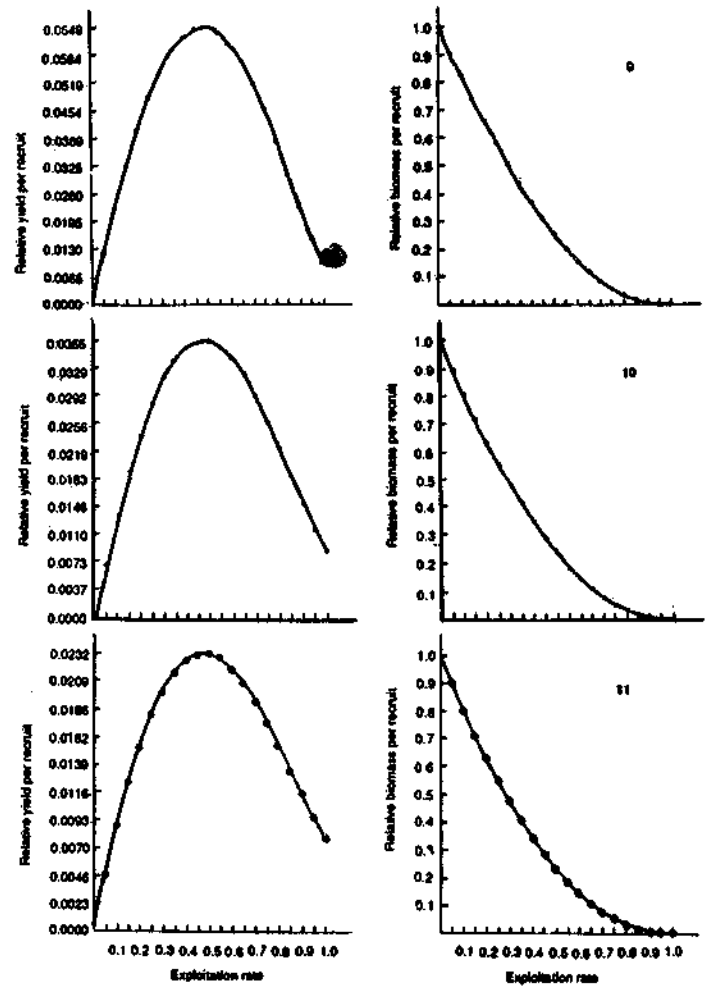
	Gujarat			Kerala			Andhra Pradesh		
	$\frac{M}{K}=1.0$	$\frac{M}{K}=1.5$	$\frac{M}{K}=2.0$	$\frac{M}{K}=1.0$	$\frac{M}{K}=1.5$	$\frac{M}{K}=2.0$	$\frac{M}{K}=1.0$	$\frac{M}{K}=1.5$	$\frac{M}{K}=2.0$
Z	2.93	2.93	2.93	2.36	2.36	2.36	2.30	2.30	2.30
M	0.36	0.54	0.72	0.36	0.54	0.72	0.36	0.54	0.72
K	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
F_P	2.57	2.39	2.21	2.00	1.82	1.64	1.94	1.76	1.58
E_P	0.88	0.82	0.75	0.85	0.77	0.69	0.84	0.77	0.68
Y_P	1 937	1 937	1 937	3 244	3 244	3 244	3 124	3 124	3 124
MSY	2 056	1 940	1 944	3 367	3 253	3 437	6 280	4 606	3 709
F_{max}	2.64	2.46	2.16	2.64	2.46	2.16	2.64	2.46	2.16
E_{max}	0.72	0.80	0.91	0.72	0.80	0.91	0.50	0.49	0.48
$(Y/R)_P$									
Standing stock	754	810	876	1 622	1 782	1 978	1 698	1 775	1 977
Annual stock	2 325	2 495	2 728	4 215	4 653	5 192	4 184	4 510	5 107



Figs 6-8. Relative yield/recruit and biomass/recruit of *Tachysurus thalassinus* at Cochin and Veraval. 6. $\frac{M}{K}=1$. 7. $\frac{M}{K}=1.5$. 8. $\frac{M}{K}=2.0$.

Tachysurus tenuispinis: For analysis, adequate data for yield per recruit estimates were available for Veraval, Mangalore and Cochin only (Table 18), although the fishery for the species exists in other maritime states. The total instantaneous mortality (Z) of *T. tenuispinis* as estimated from the length converted catch curve, is 2.01 in Veraval (Gujarat), 3.70 in Mangalore (Karnataka) and 3.21 in Cochin (Kerala) for an M/K value of 1.

The fishing mortality (F) was 1.23, 2.92 and 1.43 at Veraval, Mangalore and Cochin respectively. The corresponding figure for estimated exploitation rate was 0.61, 0.79 and 0.65. At these places the existing level of exploitation (E) exceeded the maximum required level of MSY/R. In Gujarat the average



Figs 9-11. Relative yield/recruit and biomass/recruit of *Tachysurus thalassinus* at Visakhapatnam. 9. $\frac{M}{K} = 1$.

10. $\frac{M}{K} = 1.5$. 11. $\frac{M}{K} = 2.0$.

annual yield is 12% more than the average standing stock with an F of 1.23. The annual average landing of Karnataka is 252% more than the average standing stock, when the F is 2.92. Similarly the average catch is 143% more than the standing stock in Kerala with an F of 1.43. Thus it is very clear that the exploitation of *T. tenuispinis* is maximum in Karnataka, followed by Kerala and Gujarat and in all the three states the present level of exploitation far exceeded the maximum allowable limit.

DISCUSSION

The biology and behaviour of catfishes are significant from the point of view of ex-

Table 18. Results of yield/recruit analysis of *Tachysurus tenuispinis*

	Gujarat			Karnataka			Kerala		
	$\frac{M}{K}$ = 1.0	$\frac{M}{K}$ = 1.5	$\frac{M}{K}$ = 2.0	$\frac{M}{K}$ = 1.0	$\frac{M}{K}$ = 1.5	$\frac{M}{K}$ = 2.0	$\frac{M}{K}$ = 1.0	$\frac{M}{K}$ = 1.5	$\frac{M}{K}$ = 2.0
Z	2.01	2.01	2.01	3.70	2.70	3.70	3.21	2.21	2.21
M	0.78	1.17	1.56	0.78	1.17	1.56	0.78	1.17	1.56
K	0.78	0.78	1.0	0.78	0.78	0.78	0.78	0.78	0.78
F_P	1.23	0.84	0.45	2.92	2.53	2.14	1.43	1.04	0.65
E_P	0.61	0.42	0.22	0.79	0.68	0.58	0.65	0.47	0.29
Y_P	1 887	1 887	1 887	3 176	3 176	3 176	3 680	3 680	3 680
MSY	1 957	2 541	4 544	4 612	3 578	3 215	3 685	4 256	6 120
F_{max}	2.18	5.34	21.65	0.82	1.20	1.67	1.54	2.97	5.97
E_{max}	0.74	0.82	0.93	0.51	0.51	0.52	0.66	0.72	0.79
MSY/R	219.4048	154.888	118.0682	120.63	72.989	49.66	203.2123	145.09	113.3462
$(Y/R)_P$	211.5	115.031	49.03	83.064	64.787	49.06	202.946	125.44	68.159
Standing stock (Y_P/F_P)	1 534	2 246	4 193	1 088	1 255	1 484	2 573	3 538	5 662
Annual stock size (Y_P/u)	3 573	5 188	9 904	4 123	4 790	5 615	6 360	8 795	14 254

ploitation. At the same time these aspects make the fish vulnerable to over-harvest by all types of modern fishing techniques at all stages of its life. Although the landings on an all-India basis remain more or less steady with annual fluctuations, the general trend at major fishing centres of the southwest coast showed decline, which not only eroded the quantity but also the diversity of species composition.

The acoustic surveys and fishes experiments conducted by PFP research vessels in the region Ratnagiri to Gulf of Mannar during 1974–76 showed that the average biomass of catfishes was 84 000 tonnes which was around 4.7 times higher than the average landings from the same region (Rao *et al.* 1977). Their studies also showed that in this region the resource had high abundance during monsoon months with particular dominance off Goa, Karnataka and Kerala at depth range of 50–80 m, which were beyond the reach of traditional fishermen. Similarly surveys conducted by Fishery Survey of India (FSI) during 1973–83 from 11°N to 15°N along the west coast had shown that catfish formed 25% and 21% of the total fish catch in 20–50 and 50–100 m depth belts respectively (Philips 1988). Also, the surveys of FORV *Sagar Sampada* showed higher catfish concentration (CPUE of 1–5 tonnes of trawling) in fishing square 10/75 in June (James and Pillai 1990). All these findings confirmed the fact that the resource had great potentials in the southwest coast particularly during monsoon season. In agreement to the above findings, the landings of catfishes from Karnataka and Kerala increased steeply, chiefly due to purse seine fishing (60% of the all gear total catfish catch) during 1979–83. The major species vulnerable to purse seine were *T. dussumieri* and *T. tenuispinis* and more than 73% of the catfish landing of this gear was realized during September–March, when the resource migrated into the shallow fishing grounds for breeding (James *et al.* 1989). In the total harvest of catfish by purse seines from Karnataka,

about 55% was consisted of gestating males of *T. tenuispinis* (42%) and *T. dussumieri* (13.3%). During 1979–83 an estimated 8.2 million eggs or embryos of *T. tenuispinis* and 1.6 million eggs or embryos of *T. dussumieri* were caught annually accidently by purse seine while exploiting the breeding shoals of the above two species in September–October and January–March respectively. Such a heavy loss of eggs or embryos by fishing is difficult to compensate because of the low fecundity and single spawning of these species (Silas *et al.* 1980, Dhulked *et al.* 1982, Muthiah and Rao 1985, James *et al.* 1989). Such an indiscriminate and irrational exploitation of spawning and breeding population from the shallow fishing grounds, during the eighties, resulted in recruitment overfishing of these two species. These species being migratory (James *et al.* 1989) the impact of the destructive fishing along Karnataka was reflected at other fishing centres all along the course of their migration with poor landings in the latter part of eighties.

The bottom sweeping of nearshore bottom started ever since the mechanized trawler was introduced in early sixties and continued ceaselessly all through the years which ultimately resulted in mass removal of juvenile and subadults of many species of fishes including catfishes. Increase of cod end mesh size of bottom trawl may not help to save catfish young ones because of their barbed spines.

Stock assessment studies on *T. tenuispinis* from Visakhapatnam by Dan (1981) indicated that the high fishing mortality was due to increased fishing pressure by bottom set gill nets and trawl nets in seventies. He found that the Y/R attained maximum at a fishing mortality rate of 0.3 when the actual fishing mortality rate was within 0.58 and 0.96. This indicated that any further attempt to increase production from the stock by increasing the fishing pressure would be detrimental to resource. Similarly the earlier attempt to assess the catfish resources along both the coasts of India by Alagaraja and Srinath (1987) also showed that both, *T. thalassinus* and *T. tenuispinis*, were under heavy fishing pressure. They suggested that either the fishing pressure should be reduced or the size at first capture be increased considerably to achieve the MSY from the available stock. Further, they stated that both at Waltair and Mandapam the effort pressure should be reduced considerably to increase the returns of *T. thalassinus* from the available stock; whereas at Cochin and Veraval the exploitation was not far away from the required levels to obtain MSY and less reduction of effort would improve the landings. But the present assessment showed that the effort should be reduced considerably at Gujarat, Kerala and Andhra Pradesh for a sustained yield.

Alagaraja and Srinath (1987) reported that the level of effort inputs in seventies were not far above the required levels for obtaining MSY of *T. tenuispinis* at Waltair, Cochin and Mangalore, whereas the present study indicated that the species suffered high fishing mortality during the latter part of eighties at Gujarat, Karnataka and Kerala, which even resulted in recruitment overfishing at Karnataka and Kerala. To gain a sustainable yield, the present study showed, the effort should be brought down to at least 75% of the present fishing pressure or the catfish fishing should be closed during September–October and January–March (breeding season) especially along the breeding grounds off Kerala, Karnataka and Goa in depth of 5–30 m.

As catfish is not a target species for all the major gears in which they are usually caught, any suggestion to decrease the fishing effort of those gears, may not be a practicable proposition in the light of the fact that all such

gears are meant to exploit a large array of demersal and column finfishes.

Krishnamoorthy (1987) suggested that to gain an MSY of about 440 g/recruit, the required level of E is 0.70 and C is 0.66, whereas for *T. thalassinus* E varied from 0.79 to 0.83 and C from 0.24 to 0.50 and, therefore, recommended a reduction in effort and an increase in mesh size. But, the recommendation to increase the mesh size (to increase C) may not yield the required results as even smaller catfishes are easily caught in larger meshes of many gears including gill nets. Therefore, a more feasible solution would be to intensify a selective gear, the hooks and line with larger hooks, which spares the young fishes as well as spawners and breeders (Menon *et al.* 1989).

The present species abundance at several fishing centres showed trends of changes when compared to seventies or earlier period. While species like *T. dussumieri* and *T. tenuispinis* dominated the catches of trawl net, purse seine, drift net and hooks and line in 1977–82, they were slowly replaced by *T thalassinus*, *T. serratus*, *T. caelatus* or *O. militaris*. This species replacement has taken place at most of the centres such as Veraval and Bombay (*T. dussumieri* instead of *T. sona*); Cochin and Calicut (*T. thalassinus* instead of *T. dussumieri* and *T. tenuispinis*); Mandapam (*T. caelatus*, *O. militaris* instead of *T. thalassinus*); and Visakhapatnam (*T. thalassinus* instead of *T. tenuispinis*). Although the exploitation of species like *T. thalassinus*, *T. dussumieri* and *T. tenuispinis* either recorded stagnation or crossed the sustainable limit, still the total yield of catfish maintained a progressive trend on all India level which appeared to be due to this species replacement.

Therefore, the following recommendations are made to suitably formulate and implement management measures for rational exploitation and conservation wherever required along the fishing regions: (i) Restrict and control coastal trawling up to a depth of 20 m (ii) Expand the area of purse seine, bottom trawl and mid-water trawl operations to middle shelf regions of already identified areas, depth zones and seasons (iii) Restrict the purse seine fishing during peak breeding seasons of September–October and December–January all along the southwest coast (iv) Intensify the use of hooks and line all along the range of availability of catfishes irrespective of area or season (v) Undertake a detailed study to trace the course and seasons of migration of catfishes and the relation with the monsoon, environment, drift, upwellings, etc.

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