

Fishery potential of bullseyes along the west coast of India

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Abstract

Fishery of bullseyes (Family: Priacanthidae), an emerging non-conventional demersal finfish resource, and the stock assessment of the dominant species *Priacanthus hamrur* (Forsskal) along the west coast of India are presented. The resource constituted on an average 16,870t during 2000-2004, and the production showed wide interannual fluctuations. Caught mainly by trawl, the group is represented mainly by *P.hamrur* followed by *P.cruentatus* and *P.tayenus*. The growth parameters of *P.hamrur* along the west coast are L_{∞} = 410 mm and $K = 0.59/\text{yr}$. This fish was found to attain 182.7 mm, 284 mm, 340.2 mm and 371.3 mm during the I-IV th years of its life span. The total mortality coefficient (Z) off northwest and southwest coasts during the period ranged between 4.46 to 6.14 and 3.99 to 5.45 respectively. The natural mortality (M) was 1.14 for the west coast while the fishing mortality (F) ranged between 5 and 3.32 off northwest coast and between 4.31 and 1.13 off southwest coast. The annual average yield from northwest region was 6,293 t while the estimated annual stock, average standing stock and MSY were 8,173 t, 2,069 t, and 6.356 t. respectively. Off southwest coast, it was 10,578 t, 14,692 t, 3,401 t and 10,620 t respectively. The exploitation ratio (E) indicated that the resource is optimally exploited.

Keywords: Fishery of bullseyes, west coast of India, Management brief

Introduction

Exploitation of non-conventional fishery resource is one of the means of augmenting marine fish production in the country. Exploratory surveys carried out along the Indian EEZ have revealed the availability of non-conventional demersal fishery resources such as the bullseyes (*Priacanthus* spp.), greeneyes (*Chlorophthalmus* spp.), Indian drift-fish (*Ariomma indica*) and the black ruff (*Centrolophus niger*). With an estimated potential of 71,200 t, (Sudarsan, 1993), these fishes are considered at par with other conventional fishes for their nutritive value (John and Sudarsan, 1988). Nevertheless, their fishery and stock position are not thoroughly understood probably because of their comparative deep-water habitat which renders them "unexploited" except for a few resources such as bullseyes.

Bullseyes (Family: Priacanthidae) resource of late is increasing in the commercial landings all along the Indian coast. They are exploited along the west coast (80%), Wadge Bank (1%) and east coast (19%) (Sudarsan, 1993). However, their fishery and stock position based on commercial landings have been the subject of few studies (Zacharia *et al.*, 1991; Chakraborty, 1994; Sivakami *et al.*, 2001, 2003) though similar contributions based on exploratory surveys are made both in India (Biradar, 1988; John and Sudarsan, 1988; Vijayakumaran and Naik, 1988; Bande *et al.*, 1989; Sivakami, 1989; Philip, 1994, Philip and Mathew, 1996 and Sivakami *et al.*, 1998) and other South East

Asian countries (Chomjurai, 1970; Nugroho and Rusmadji, 1983; Ingles and Pauly, 1984; Lester and Watson, 1985; Dwiponggo *et al.*, 1986; Joung and Chen, 1992; Liu *et al.*, 1992). This paper is an attempt to elucidate the fishery particulars and stock position of priacanthids along the west coast of India based on commercial landings.

Materials and methods

Gearwise and species-wise data for the fishery of bullseyes were collected from Fishery Resources Assessment Division of CMFRI for different maritime states along the west coast of India for the period 2000 to 2004. Length frequency data of *Priacanthus hamrur*, the most dominant species among the bullseyes landed by trawl, were considered for estimation of population characteristics and stock position. Since the landings of bullseyes are included under "other perches" in the fish landing data base of CMFRI, the data for each zone was extracted from this and then pooled year wise for different gears for states such as Gujarat, Maharashtra, Goa, Karnataka and Kerala.

The length frequency data on *P. hamrur* were collected at weekly intervals from the trawl landing at Veraval (Gujarat), New Ferry Wharf (Mumbai in Maharashtra) and Cochin Fisheries Harbour (Kerala) during 2000-2004. A total of 3224 fishes (Total length: 120-339 mm) from Veraval, 3288 (110-358 mm) from Mumbai (NF)

and 1735 specimens (110-368 mm) from Cochin Fisheries Harbour were measured. They were grouped into 10 mm class intervals and raised to the month's catch, pooled for different years and then raised to the total catch of the species in the respective maritime states. Thus, the data from Veraval was raised for Gujarat, from New Ferry Wharf for Maharashtra and from Cochin Fisheries Harbour for Kerala, Karnataka and Goa. The data of Gujarat and Maharashtra were then pooled to represent northwest coast while that from Goa, Karnataka and Kerala were considered for southwest coast. Since the range in total length of the samples measured from northwest and southwest coast were closer, a common VBGF equation was derived for the entire west coast.

The growth parameters were estimated using FiSAT (Gayanilo Jr *et al.*, 1995). Pauly and Munro's (1984) growth performance index (ϕ) was computed for K and L_{∞} for comparison with earlier studies. For tracing the recruitment pattern the percentage of recruitment as derived by FiSAT programme for each month during different years (2000-2004) was pooled and average reckoned. The total mortality rate (Z) was estimated by the length converted catch curve method (Pauly, 1983) based on the pooled data for 5 years. Natural mortality rate (M) was estimated following Pauly's empirical formula. The annual average surface temperature (T) was taken as 27°C (Reuben *et al.*, 1992). Fishing mortality rate (F) was obtained as $Z-M$. The t_0 was considered as 0 (Sparre and Venema, 1992). Exploitation ratio (E) and Exploitation rate (U) were estimated using the formula $E=F/Z$ and $U=F/Z(1-e^{-Z})$ respectively. MSY was estimated using the formula $MSY = (Y * Y/R \text{ of } E_{max}) / Y/R \text{ of } E$, where Y =present yield, Y/R =Yield/recruit and $E=F/Z$.

The total annual stock (Y/U) and average standing stock (Y/F) were estimated by taking the average annual catch of the species during 2000-2004. The yield/recruit in weight (Yw/R) was computed from the equation of Beverton and Holt (1957). The age at first capture (t_c) was

taken as the age corresponding to the lower length of the length group corresponding to the first point in the descending limb of the catch curve. The lower limit of the smallest length class in the length frequency distribution was taken as the length at recruitment (l_c).

Results

Fishery: The average annual production of bullseyes during 2000-'04 was 16871 t along the west coast. The resource contributed to 4% of the total demersal landings in the region. The production indicated a fluctuating trend in all the states. In Gujarat, the production indicated a steep decline from 19371 t to 739 t with an annual average landing of 5,441 t (Table 1). Off Maharashtra, the catch increased from 580 t in 2000 to 2,028 t during 2002 but declined thereafter to 272 t during 2004. In Goa, the landings were high during 2000 (2,373 t) and 2003 (2,182 t) with an annual average landing of 1,187 t. Off Karnataka, the catch indicated an increase from 2,522 t in 2000 to 4,351 t during 2002 but thereafter showed a decrease. The annual average catch off Karnataka was 3,031 t. Off Kerala, a remarkable increase from 3,965 t in the year 2000 to 11,359 t during 2002 could be noticed which later declined to 3,761 t during 2003 and to 4,445 t in 2004.

Gearwise landings : The bullseyes were landed by a variety of gears such as mechanized trawlers, non mechanized gill-netters, outboard gill-netters, mechanized, non mechanized and outboard hooks and line, outboard motorized ring seiners, outboard motorized boat seiners and mechanized purse seiners. However, except off Kerala where about 7% of the landing was brought by gill-netters and 3% by hooks and line, in all the other states about 99% of the landings were by mechanized trawlers.

Species composition: *P. hamrur* was the dominant species landed contributing upto 100% in Goa, Karnataka and Kerala while its contribution ranged between 83% to 100% in Gujarat and Maharashtra. Other species repre-

Table 1. Landings (t) of bullseyes along the west coast of India during 2000-2004

Years/ States	Gujarat	Maharashtra	Goa	Karnataka	Kerala	Total
2000	19,371	580	2,373	2,522	3,965	28,810
2001	4,091	720	19	4,256	8,266	17,353
2002	2,210	2,028	420	4,351	11,359	20,367
2003	797	658	2,182	2,436	3,761	9,834
2004	739	272	943	1,591	4,445	7,989
Av. catch (t)	5,441	852	1,187	3,031	6,359	16,871
% in demersal catch	3.40	0.90	10.20	5.80	6.20	4.00

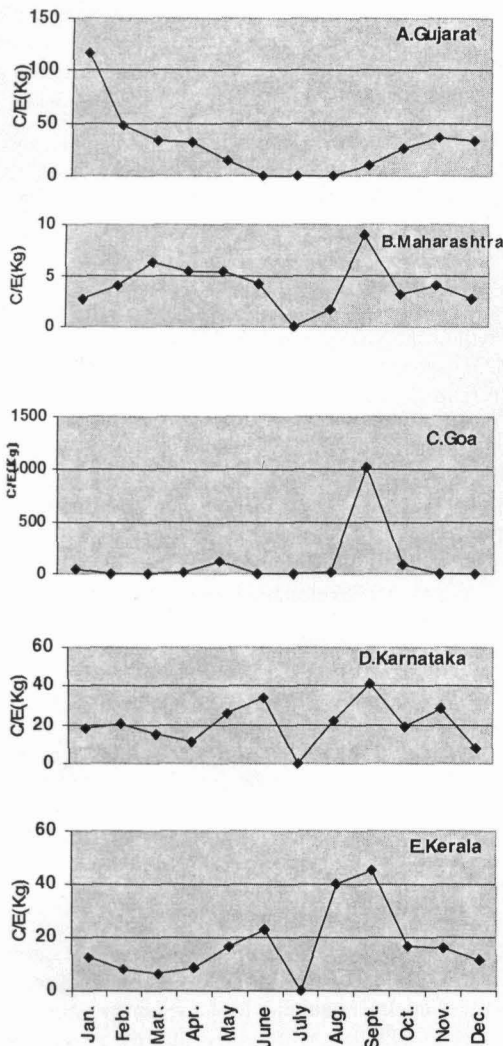


Fig.1A-E. Monthly average C/E(kg) of *P.hamrur* at different maritime states along the west coast of India during 2000-2004.

sented were *P.cruentatus* (15%) in Gujarat and *P.tayenus* (0.1%) in Maharashtra.

Seasonal abundance: Since *P.hamrur* landed by trawl contributed to 83% to 100% of bullseyes landed at different states, the average catch per unit effort (kg) of the species during different months were considered for estimating the seasonal abundance.

In Gujarat, peak landings were obtained during October to February compared to March and during September in Maharashtra. The catch rates of the species off Goa were high during September. Off Karnataka, good catch rates were realized during January-March, June, September and November while along Kerala coast, peak abundance was noticed during May-June and August-September (Fig.1A to E).

Stock assessment

Age and growth: The VBGF for *P.hamrur* along the west coast of India is $L_t = 410\{1 - e^{-0.59(t+1)}\}$. The fish was found to attain a length of 182.7 mm, 284 mm, 340.2 mm and 371.3 mm during I, II, III and IVth years respectively. The maximum size of the species in the fishery off west coast was 368 mm, the age of which is estimated as 3.86 years. The ϕ value obtained was 2.99 (Table 2).

Recruitment: Off Gujarat and Maharashtra, recruitment was rather continuous from February to October with peak during July and March respectively in these areas. Off Kerala, however, peak recruitment was discernible during May/June (Fig.2)

Mortality rates: Annual mortality rates of *P.hamrur* for the period 2000-2004 were estimated for northwest and southwest coasts separately (Table 3). The total mortality co-efficient Z along northwest coast ranged between 6.14 during 2001 to 4.46 during 2004 with an average of 5.08. The natural mortality M was 1.14 and the fishing mortality (F) ranged between 5 and 3.32, the

Table 2. Growth parameters and Phi Prime values of *P.hamrur* estimated along different regions of India

Area of study	L_{max} (mm)	L_{∞} (mm)	K/yr	ϕ Prime	Source
NW coast	341	360	0.7	2.97	Chakraborty, 1994
" "	Not available	345	0.66	2.89	Chakraborty <i>et al.</i> , 1994
" "	Not available	360	0.64	2.91	Chakraborty & Vidyasagar, 1996
West coast	368	410	0.59	2.99	Present study
Upper east coast	262	284	0.37	2.4	Philip & Mathew, 1996

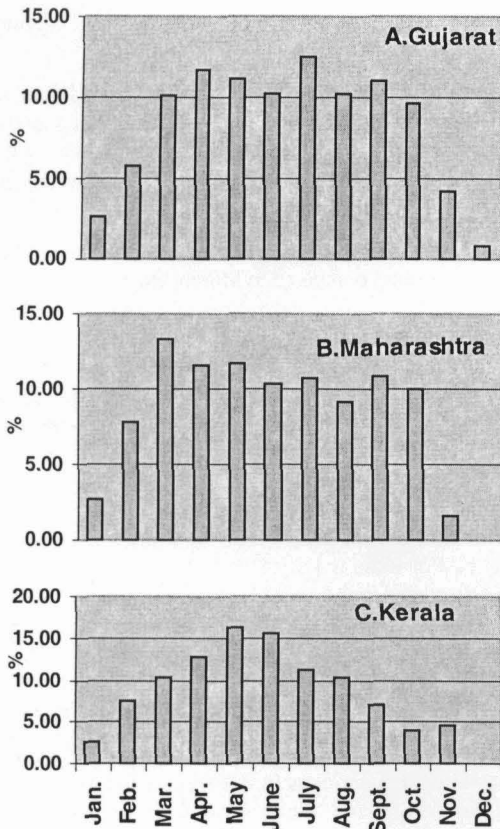


Fig.2. Recruitment pattern of *P.hamrur* during 2000-2004(Average)

average being 3.95. It may be seen that the Z and F showed a decrease over the years. M/K for west coast was 1.93 which lies between 1 and 2.5 (Beverton and Holt, 1959).

Along southwest coast, total mortality Z obtained was high (5.45) during 2000 which however indicated a fluctuating pattern with lesser values realized during 2001

Table 3. Mortality rates of *P.hamrur* off west coast of India

Years	Northwest coast			Southwest coast		
	Z	M	F	Z	M	F
2000	5.15	1.14	4.01	5.45	1.14	4.31
2001	6.14	1.14	5.00	3.99	1.14	2.85
2002	5.08	1.14	3.94	4.77	1.14	3.63
2003	4.60	1.14	3.46	2.27	1.14	1.13
2004	4.46	1.14	3.32	4.79	1.14	3.65
Average	5.09	1.14	3.95	4.25	1.14	3.11

(3.99) and during 2003 (2.27) the average being 4.25. Taking the natural mortality M as 1.14 (common for west coast), the fishing mortality ranged between 4.31 during 2000 to 1.13 during 2003. The average F was 3.11.

Relative yield/recruit: The smallest of *P.hamrur* caught off northwest coast and southwest coast belonged to the size group of 110-119 mm and the corresponding (t_c) was 0.53 years or 6.4 months. However, the length at capture of this species off northwest coast belonged to the size group of 230-239 mm, the corresponding t_c being 1.4 years. Along southwest coast, the length at first capture was within the size group 210-219 mm and the corresponding age (t_c) was estimated as 1.2 years. The exploitation ratio (E) in the present study off northwest coast was 0.78 and E_{max} 0.893. The optimum yield/recruit and the optimum biomass/recruit were 3.6 g and 0.05 g respectively (Fig.3). The exploitation rate (U) was 0.77. Off southwest coast, the Exploitation ratio (E) was 0.73 and the E_{max} 0.802. The optimum yield/recruit and the optimum biomass/recruit were 3.54 g and 0.104 g respectively (Fig.4). The exploitation rate (U) was 0.719.

Annual standing stock and MSY: The annual yield of *P.hamrur* off northwest coast during 2000-2004 was 6,293 t. The estimated annual stock was 8,173 t and the average standing stock 2069t. The MSY based on the E_{max} of 0.893 was 6,356 t. Along the southwest coast, the average annual yield during the period was 10,578 t. The annual stock, average standing stock and MSY were 14,692t, 3,401t and 10,620t respectively (Table 4).

Discussion

The annual average landings of bullseyes along the west coast of India was estimated as 16,871 t during 2000-2004. Nearly 63% production was from the southwest coast and the remaining from the northwest region. Bande *et al.*(1989) have reported that the resource is distributed more in the 100-200 m depth zone along the northwest coast while along the southwest coast, the zone up to 100 m yielded a higher catch rate of 319 kg/hr. Vijayakumaran and Naik (1988) have indicated that *Priacanthus* spp. are abundant in the depth zone up to 100 m in latitude 11°-12°N and 100-200 m depth in latitude 13°N along the west coast of India. According to Bhargava *et al.*(1995) about 65% of the shelf area along Gujarat coast (20°-23°N) is within 0-50m depth. However, Sudarsan *et al.*(1990) had indicated the potential of this resource as 25,500 t off the northwest coast and a lesser potential of 18,200 t along the southwest coast. The variations in the commercial landings when compared to the exploratory surveys may be attributed to the difference in the bathymetric distribution of the resource between the zones.

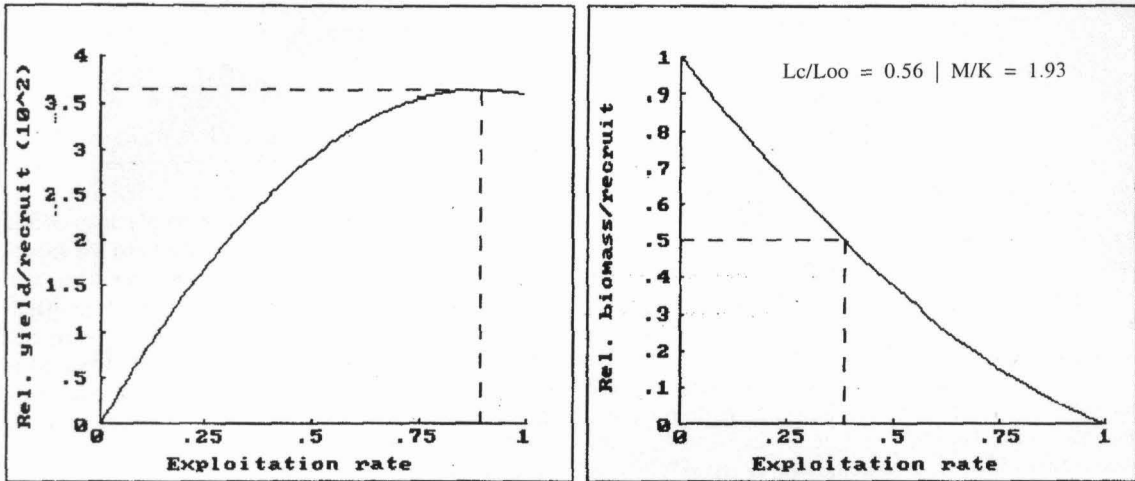


Fig.3. Relative Yield/Recruit of *Phamrur* off northwest coast of India.

As in any other fishery, fluctuations in the production trend was characteristic of this resource as well. Along Gujarat, a steep decline from 19,371 t of 2000 to 739 t during 2004 (96%) was discernible while along the Maharashtra coast the catch fluctuated between 580 t of 2000 to 2,028 t during 2002 but with lesser catch during the subsequent years. Vijayakumaran and Naik (1988) have observed a combined and significant effect of latitude, season and depths of occurrence on the catch rate of *P.hamrur* along the west coast of India. They have found a clear north - south fluctuation in the catch rates at each depth and concluded that this species performs

two types of migrations viz. north-south and east- west. Bande *et al.* (1989) had concluded that bullseyes migrate across the shelf and parallel to the shelf probably depending upon cold water current. The fluctuations in the commercial landings observed over the years in the present study may thus be attributed to their migrations in time and space in addition to the fishery dependent factors.

Investigations on the seasonal abundance of bullseyes based on commercial landings are seldom attempted due to paucity of related data. Biradar (1988) based on exploratory surveys had observed that the stock density of *P.hamrur* was the highest during October-December and

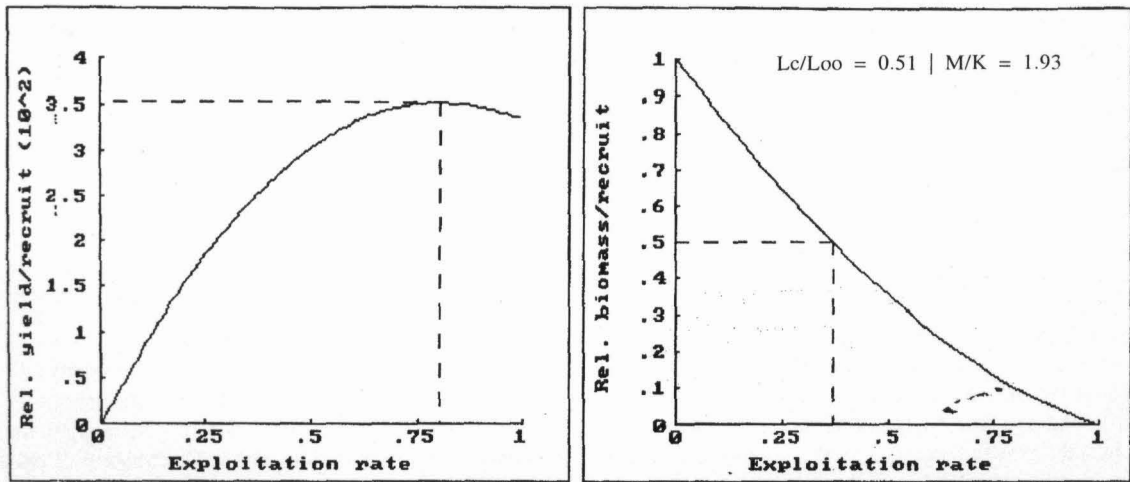


Fig.4. Relative Yield/Recruit of *Phamrur* off southwest coast of India.

Table 4. Yield (t), stock (t) and MSY of *P.hamrur* off west coast of India

Region	E	E_{max}	Yield(Y)	U	Total Stock (Y/U)	Standing Stock (Y/F)	MSY (t)
Northwest	0.78	0.89	6,293	0.77	8,173	2,069	6,356
Southwest	0.73	0.80	10,578	0.719	14,692	3,401	10,620

lowest during July-September between 15°N-22°N latitude (Maharashtra and Gujarat). In the present study, peak landings of bullseyes resource along Gujarat coast were observed during October-February. Likewise, off Maharashtra, peak catch was observed during March and September with less catch obtained during July-August. Even though fishing is suspended during June/July off northwest coast due to ban on trawling, the lesser catch obtained during June-July may be attributed to the monsoon season and its impact on the current pattern, change in oxygen level, etc causing the fish to move away from the fishing grounds. Off Karnataka, peak landing was observed during January-June and during September-November. Vijayakumaran and Naik (1988) have reported good catch off Karnataka during March from 51-100 m and 151-200 m depth while in September, low catch was realized at less than 100m depth suggesting their possible migration towards deeper waters. Off Kerala, two peaks were clearly discernible, during May-June and August-September with low catch realized during July which may be due to the trawling ban during this period. Bande *et al.* (1989) and Sivakami (1989) also had reported peak landings along southwest coast of India during August-October.

Chakraborty (1994), Chakraborty *et al.* (1994) and Chakraborty and Vidyasagar (1996) had estimated an L_{∞} range of 345.5mm to 360mm and K of 0.64 to 0.736 respectively along the northwest coast of India. However, off northeast coast, Philip and Mathew (1996) had estimated an L_{∞} of 284mm and a K of 0.372. The ϕ prime values estimated indicate that growth parameters obtained in the present study are agreeable with the values obtained by earlier workers on *P.hamrur* along the west coast while the L_{∞} , K and ϕ prime value estimated are lower for the species studied off east coast (Table 2). Likewise, the annual growth increments obtained in the present study is 182.7 mm, 101.3 mm, 56.2 mm and 31.1 mm during the I to IV year of the life span of *P.hamrur* along the west coast. Chakraborty (1994) has reported a growth rate of 193 mm, 90 mm and 40 mm during the I-III year off northwest coast. Chakraborty and Vidyasagar (1996) obtained a growth increment of 171 mm, 89 mm, 48 mm and 26 mm respectively off Bombay waters. However, along the east coast, the growth, increment obtained were 96 mm, 59 mm, 40 mm, 27 mm, 20 mm, 13 mm, 9 mm

and 6 mm during the I-VIII year of its life span (Philip and Mathew, 1996). It is therefore evident that the growth rate of *P.hamrur* off upper east coast is slower than their counterpart in the west coast which is further substantiated by the lower L_{max} (262mm) obtained along the east coast (Table 2). The reason for this may be attributed to the narrow continental shelf along the east coast with deeper water inhabitation of *P.hamrur* which tend the species to share some characters of temperate species such as slow growth rate and extended life span (Philip and Mathew, 1996).

Off northwest coast, recruitment pattern of *P.hamrur* showed interannual variations. Earlier studies have shown that off northwest coast, the gonads of *P.hamrur* encountered were mostly in the immature and maturing stages while the ripe/spent gonads were seldom obtained during October-March off Veraval and April-May off Mumbai (Sivakami *et al.*, 2003). Further, it is also observed that young ones (61 mm onwards) are available off Mumbai during October-March period. (personal communication). Off Kerala, the peak recruitment was during May-June. Sivakami *et al.* (2001) had reported that the species off southwest coast has a protracted spawning season with a major peak during April-July and a minor peak in November-December. Premalatha (1997) had observed that the species breeds during March - April off west coast. In the present study, the smallest specimen to get recruited into the fishery off Cochin during August was 110mm in total length ($t_r = 0.529$ years or 6.35 months) with their probable birth month during February-March. Off northwest coast, no such correlation could be made probably because of the deep water habitat of the species with their breeding ground away from the fishing area. Further, it is also possible that varying recruitment strength results in year to year variations in the reproductive effort and also in variations in survival and settlement of larvae and juveniles.

Ingles and Pauly (1984) had reported a mortality rate of 8.09 for *P.tayenus* from Samar Sea. Chakraborty *et al.* (1994) had estimated the value of M as 1.10 for *P.hamrur* off Maharashtra coast. Chakraborty (1994) giving a M value of 1.52 for the same area suggested that the value estimated by Ingles and Pauly (1984) is an overestimate since it does not give a proper M/K ratio.

Philip and Mathew (1996) had reported the value of M as 0.9 and 0.936 for males and female *P.hamrur* respectively off upper east coast. In the present study, the M value obtained for the west coast was 1.14 which is agreeable with the values obtained by Chakraborty *et al.* (1994).

Gulland (1975) suggested that if the E value is more than 0.5, the stock under study is over exploited. However, Chakraborty *et al.* (1994) comparing the E values for 18 species of fishes off Maharashtra coast had concluded that the concept of E_{opt} may not hold good in tropics. In the present study, *P.hamrur* has an E of 0.78 along northwest coast and 0.73 along southwest coast which are closer to the E_{max} of 0.893 and 0.802 respectively. Since the E value is above the E_{opt} and also because it is closer to E_{max} , it may be concluded that the resource off west coast is optimally exploited. However between the two regions, the fishing mortality is more along the northwest coast (3.95) than the southwest coast (3.11) which is substantiated by the decreasing trend in the landings off northwest coast.

Estimates of standing stock of priacanthids are mainly made based on exploratory surveys. Biradar (1988) had estimated a biomass of 88,560 t and an MSY of 25,000 t up to 200 m depth between 15°N-22°N Latitude off northwest coast of India. Bande *et al.* (1989) estimated a biomass of 86,000t from northwest coast. Chakaraborty *et al.* (1994) based on catch from 40-70m and landed at New Ferry Wharf and Sasoon Dock had estimated a standing stock of 202 t and an MSY of 606 t along Maharashtra coast. The yield was 283 t. Chakraborty (1994) from NFW and Sasoon Dock during 1980-88 had estimated a total stock and standing stock of 1,074 t and 332 t as compared to the current yield of 518 t. In the present study, the annual stock, average standing stock and MSY off northwest coast of India are estimated as 8,173 t., 2,069 t and 6,356 t, the present yield being 6,293 t. Off southwest coast, Sivakami *et al.* (1998) had estimated a potential of 61,445 t and Sudarsan *et al.* (1990) 18,200 t. In the present study, the annual stock and MSY off southwest coast are 14,692 t and 10,620 t respectively, the present yield being 10,578 t. Since the present exploitation rate is closer to MSY along both northwest and southwest coasts, it is reasonable to conclude that the resource is optimally exploited from the inshore waters. Nevertheless, these resource being distributed more in 150-200m depth range (Bande *et al.*, 1989), the production can be further increased by extending fishing to deeper waters.

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