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Fishery, biology and population characteristics of the Indian mackerel, *Rastrelliger kanagurta* (Cuvier) exploited along the Tuticorin coast

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ABSTRACT

Fishery and population characteristic of mackeral along the Tuticorin coast were studied during 1997-2007. The production of mackeral, exploited mainly by trawls and gillnets varied widely between 411 t and 2,038 t during the period. Fishery occurred round the year with peak abundance in June and August. Spawning as well as recruitment also occurred round the year with peak in January-April. Young ones start entering the fishery at a size of 6 cm in April every year. Growth parameters, L_α and K were estimated as 33.28 cm and 1.634 year^{-1} respectively. Natural mortality (M) estimated was 2.52. Total mortality (Z) varied between 6.04 and 11.85 and fishing mortality (F) between 3.52 and 9.33. The exploitation ratio (E) was in the range 0.582 - 0.787. The value of E max obtained (0.86) was lower than the exploitation rate throughout the period and MSY estimated (1,346 t) was higher than the average production during the period. Stock varied between 666 and 2,650 t and biomass between 99 and 365 t. The results showed that the fishery was largely based on the stock position and was independent of the effort. Since the species mature at an early age and spawn round the year, present fishing pattern appear to have no adverse impact on recruitment. Currently the resource is exploited near the optimum level and there appears to be no immediate threat for the stock.

Keywords: Biomass, Indian mackerel, MSY, Population characteristics, Stock, Tuticorin

Introduction

Mackerel enjoys wide distribution in Indian waters both along the east and west coasts and has good domestic demand as a food fish. Their contribution to the total marine fish production of India varied between 1.8-3.5%. South-west coast is considered as the most productive zone for mackerel. However, their emergence as a major fishery along the east coast in recent years has attracted the attention of researchers.

Several researchers have studied the fishery and biology of mackerel along the west coast (Pradhan, 1956; Sekharan, 1974; Yohannan, 1979; 1982; Udupa and Bhat, 1984; Noble, 1986; Noble *et al.,* 1992; Devaraj *et al*., 1994; Prathibha *et al*., 1998) and from Indian seas as a whole (Yohannan and Nair, 2002; Yohannan *et al.*, 2002). Contribution from the east coast is limited to the occurrence of young ones in the catch (Rao and Basheeruddin, 1953; Appannasastry, 1969), food and feeding (Kuthalingam, 1956; Rao and Rao, 1957), fishery and stock characteristics of Andhra waters (Rao, 1962; Luther, 1995; Abdussamad *et al.*, 2006). During the present investigation, a detailed study was carried out on the fishery and stock characteristics of mackerel along the Tuticorin coast during 1997-2007, to update the knowledge base of the resource.

Materials and methods

Mackerel fishery along the coast by different gears was monitored during 1997-2007. Biology of the Indian mackerel, *Rastrelliger kanagurta* was studied in the laboratory. Monthly length-frequency data for the period 1997-2007 was used to estimate growth parameters, mortality and recruitment pattern. L_α and K were estimated following Ford-Walford plot (Ford, 1933; Walford, 1946) and by ICLARM's FiSAT software (Gayanilo *et al*., 1997). Age at zero length (t_o) was estimated as per Bertalanffy (1934) and size at first capture (Lc) as in Pauly (1984). Natural mortality (M) was estimated using Pauly's empirical formula (Pauly, 1980), by using 29 °C as the mean sea surface temperature. Total mortality (Z) and exploitation rate (E) were estimated from the catch curve as in Pauly (1983) and exploitation rate (U) from the relation; $U = F/Z * (1 e^{Z})$; where, F is the fishing mortality.

Yield per recruit at different levels of exploitation was estimated following Marten (1978) and potential yield per recruit and optimum age of exploitation were estimated as per Krishnankutty and Qasim (1968). Total stock (P) during different years were computed from the relation P = Y/U; where, Y is the yield in tonnes and U the exploitation rate. E max and maximum sustainable yield (MSY) were estimated graphically as per Corten (1974).

Results

Fishery

Mackerel formed by-catch in trawls and small meshed (35-70 mm) drift gillnets. Effort by these gears as well as mackerel catch and catch rate varied over the years (Table 1). About 82.5 % of the catch was realized by gillnets and the rest by trawls. Yield by gillnet varied between 137 (2003) and 1,843 t (2001) with an average catch and catch rate of 1,041 t and 2.6 kg per unit effort respectively. In trawls, yield varied between 92 and 382 t with an average catch of 221 t and a catch rate of 5.7 kg unit effort^{-1} respectively. No direct correlation could be observed between effort, catch and catch rate, probably due to fluctuation in the resource abundance.

Table 1. Effort and mackerel catch by trawls and drift gillnets at Tuticorin during 1997-2007.

Period	Trawl			Drift gillnets			Total catch (t)	Percentage in total catch
	Effort (units)	Catch (t)	CPUE (kg)	Effort (units)	Catch (t)	CPUE (kg)		
1997	42459	92	2.16	409220	1558	3.81	1650	2.0
1998	37326	245	6.56	565831	738	1.30	983	1.3
1999	39733	364	9.16	468643	1570	3.35	1934	1.3
2000	39826	188	4.73	327639	825	2.52	1013	1.4
2001	40683	196	4.81	358163	1843	5.14	2038	1.1
2002	30194	151	5.00	376967	1568	4.16	1719	4.9
2003	35180	276	7.85	367055	137	0.37	413	1.0
2004	29293	382	13.05	397878	480	1.21	863	2.0
2005	39879	261	6.54	421464	1674	3.97	1935	2.7
2006	37093	96	2.59	416973	315	0.76	411	0.6
2007	56683	183	3.23	383848	746	1.94	929	1.1
Mean	38941	221	5.68	408516	1041	2.55	1263	1.4

Fishery occurred round the year in both gears. In trawls, peak fishery occurred during June-August and in gillnets it was during November-December. About 40% of the annual catch by trawl and 54% by gillnets were realized during the respective peak season. Fishery was supported almost exclusively by the Indian mackerel, *R. kanagurta.*

Population characteristics of the species

Growth and age

Growth parameters, L_α and K were estimated as 33.28 cm and 1.634 year^{-1} respectively and 't_o' as 0.0018 years. Growth of the species can be described by von Bertallanffy growth equation as;

$$L_t = 332.8\ [1- e^{-1.634(t-0.0018)}].$$

This relation showed that species grow relatively faster and attained 105, 176, 223, 254 and 303 mm respectively by the end of 3, 6, 9, 12 and 24 months. Size and age of the species at first capture in small meshed drift gillnet was 187 mm and 6.6 months respectively and in trawls these were 183 mm and 6.3 months. However, optimum age of exploitation was 8.6 months and the corresponding size was 217 mm total length.

Size composition

Small quantities of juveniles and sub-adults were exploited by sardine gillnets of 25 mm mesh during the peak period of recruitment. Catch was supported by 60-145 mm fishes with 101.8 mm as mean size. The catch in small meshed gillnets comprised of relatively larger fishes of 115-310 mm with mean size of 215.7 mm (Table 2). Major share of the catch in sardine net was by juveniles having 95.8% of the catch formed by zero year group, and with only 13.5% represented by juveniles and pre-adults. In trawls, it was 110-314 mm fishes with a mean size of represented 204.1 mm. Ninety nine percentage of the catch in the gear was by zero year groups, where juveniles and pre-adults formed 21.6%. Juveniles enter gillnet fishery at a small size and age of 60 mm and 1.94 months respectively during April and in trawls at 155 mm size and age of 5.1 months during July. Mean size of the fish in different gears varied over the years, but no significant decrease or increase was noticed.

Table 2. Annual size range, mode, and commercial size groups of *R. kanagurta* landed by trawls and drift gillnets during 1997-2007.

Gear	Size range (mm)	Modal class (mm)	Mean size (mm)	Major size group (mm)
Sardine gillnet	60-145	100-105	101.8	85-125
Small meshed gillnet	115-310	210-215	215.7	190-245
Trawl	110-315	200-205	204.1	185-225

Sexual maturity and spawning

Mackerel attained sexual maturity and spawned along the coast during the first year. Size of the fish at first maturity estimated through probability curve was 184 mm for males and 188 mm for females. Their age at these stages was estimated respectively as 6.5 and 6.7 months. However, full gonadal maturity was observed at a much smaller size of 170 mm size onwards.

Mature and spent fishes along with small juveniles were observed round the year in the catch, which indicated that they spawn almost round the year (October-July) with peak spawning and recruitment during January-April (Fig. 1). Since mature fishes with gonads at various stages of development were observed round the year, it is to be assumed that individual fish may breed several times during the year. Fecundity was estimated as 68,500 ova. Estimates showed that, on an average 56.1% of the total stock spawned annually during the period. While considering its high spawning rate and fecundity, a small spawn survival alone was sufficient to maintain the stock at sustainable level.

Mortality and exploitation rate

Total mortality in the population varied between 6.04 and 11.85 with a mean value of 7.86 (Table 3). Natural mortality was 2.52 and mean fishing mortality was 5.34, where the latter varied between 3.52 and 9.33. The mortality values showed that nearly 68% of the stock was succumbed to fishing and 32% to other natural causes.

Exploitation rate fluctuated between 0.582 and 0.787 during 1997-2007 (Table 3). E_{max}, that give maximum yield for the species is 0.865, which is larger than the exploitation rate throughout the period. This indicated that the stock remain under-exploited and have some scope for improving the production.

Stock, biomass and sustainable yield

Stock and biomass of mackerel in the present fishing grounds fluctuated widely during the period (Table 3). Average stock for the period was 1,857 t and it fluctuated between 666 and 2,650 t. Biomass varied between 99 and 365 t with 236 t as mean for the period. Mackerel yield at

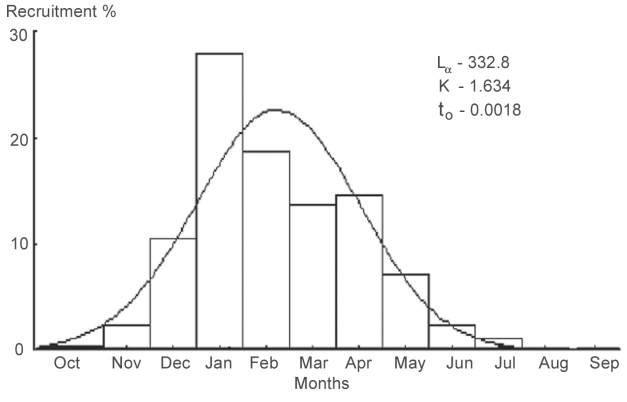

Fig. 1. Recruitment pattern of mackerel, *R. kanagurta* in Tuticorin waters

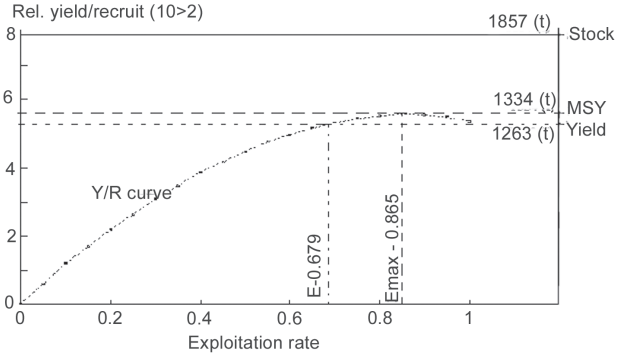

Fig. 2. Relative yield/recruit of *R. kanagurta* at different exploitation levels, super-imposed with stock/yield bar showing MSY.

Table 3. Estimate of mortality rates, exploitation rates, catch stock and biomass of Indian mackerel *R. kanagurta* off Tuticorin coast during 1997-2007 (Natural mortality, M =2.52)

Period	Fishing mortality	Total mortality	Exploitation rate (E)	Exploitation ratio (U)	Stock (t)	Biomass (t)
1997	4.52	7.04	0.634	0.643	2578	365
1998	4.36	6.88	0.739	0.634	1560	225
1999	7.14	9.66	0.616	0.739	2613	271
2000	4.05	6.57	0.787	0.617	1633	250
2001	9.33	11.85	0.709	0.787	2580	218
2002	6.13	8.65	0.624	0.709	2421	280
2003	4.18	6.70	0.635	0.625	666	99
2004	4.38	6.90	0.727	0.635	1348	197
2005	6.71	9.23	0.583	0.727	2650	288
2006	3.52	6.04	0.635	0.584	708	117
2007	4.38	6.90	0.643	0.635	1451	212
Average	5.34	7.86	0.679	0.679	1857	236

the present level of fishing was 28.6 g per recruit and potential yield corresponding to optimum age of exploitation was 86.93 g per recruit. On an average a sustainable production of 1,346 t of mackerel can be expected from the present fishing grounds of Tuticorin region.

Discussion

Catch and catch rate of mackerel from the present fishing ground fluctuated widely during 1997-2007. But, no positive correlation could be established between the yield and fishing effort. However, production and catch rate correlate directly with stock, suggesting that fishery depend entirely on stock abundance. Fishery was supported mainly by zero year group with their size at first capture much smaller than the optimum size of exploitation. However, since species attain full sexual maturity at a small size very close to size at first capture and spawn round the year, part of the stock might have spawned before being caught. Moreover, exploitation rate indicates that, nearly 32% of the stock escapes fishing. Therefore, the estimate shows that the present pattern of exploitation permits more than 56% of the total stock to spawn each year. Such a high spawning rate necessitates only a small spawn survival to maintain the stock at the sustainable level. Moreover, the peak fishing and spawning season of the species is widely separated, limiting the destruction of spawning stock. All these findings suggested only little stress on the spawning stock and recruitment.

Mackerel grow much faster along Tuticorin coast than that was reported by Luther (1995) from Visakhapatnam and Abdussamad *et al*. (2006) from Kakinada along the east coast. This indicated prevalence of a much better living condition for the species along the Tuticorin region.

Exploitation rate over the years indicated that this resource remains under-exploited during the period of study. As indicated by the E_{max} value obtained during the present study, the production can be increased marginally by increasing the effort input, but with close and constant monitoring of the stock. Small meshed gillnets were found most ideal for exploitation of mackerel, as they exploit mainly adults and therefore increased effort input by this gear has to be encouraged. However, further increase in the trawl effort may not be healthy for the stock.

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