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Age, Growth, Mortality, Yield per Recruit and Stock Assessement of *Carcharhinus sorrah* (Valenciennes, Muller and Henle)

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Abstract

Drift gillnets landed on an average 117.8 t of sharks forming 6.9% of the total catch by drift gillnets and the peak period of abundance is during June - August. *Laxodon macrorhinus* constituted 36.5% followed by *Carcharhinus sorrah* (26.1%), *Scoliodon laticaudus* (15.8%), *Rhizoprionodon acutus*, (10.3%), *Sphyrna zygaena*, (1.8%), *Chiloscyllium griseum*, (1.6%), other *Carcharhinus spp* (2.7%), and other sharks (5.1%). The $L\infty$, K and to the dominant species *Carcharhinus sorrah* have been estimated to be 1459 mm, 0.3993 (annual basis) and 0.0740 yr for males and 1658 mm, 0.3309 (annual basis) and -0.0901 yr for females respectivcly. The total mortality rate (Z) is estimated to be 3.35 and 2.82 during 1991- 92 and 1992-93 respectively for males and 5.82 and 4.01 for females respectively. The natural mortality rate (M) is estimated to be 0.63 for males and 0.54 for females. The exploitation rate indicates that females are exposed to more severely to higher fishing pressure than the males.

Introduction

Studies on the sharks are mostly on the fishery biology, systematics and rare occurrence. A few reports are available on the population dynamics of the dominant species of sharks in India (Prabhakaran Nair, 1981; Krishnamoorthi and Jagdis, 1986; Kasim, 1991) and there is no information on the fishery biology and stock assessment of sharks from the Gulf of Mannar. Present study was initiated in 1991 with an aim to critically analyse the present level of exploitation of sharks and provide the required information for the proper regulation of the fishery. This report embodies the shark fishery, age and growth, mortality rates, yield per recruitment and stock assessment of the dominant species *Carcharhinus sorrah* (Valenciennes, Muller and Henle).

Materials and Methods

Data on catch and effort, species composition were collected per at random once in a week. Sexwise length frequency of the dominant species *C. Sorrah* were also collected every week. These basic data were initially raised to the sampling day and then for month by multiplying with the respective raising factors. Sexwise total length in mm and wet weight in g were collected for *C. sorrah* for obtaining length-weight relationship as per the least square method. The integrated method of Pauly (1980) was used to trace the progression of modes. The average sizes attained in subsequent months were obtained as per George and Banerji (1968). The growth parameters $L\infty$, K and t_0 were estimated as per Bagenal (1955). The natural mortality rate (M) is estimated as per Pauly (1980); the total mortality rate (Z) as per Pauly (1983)and the average size at first capture as per Pauly (1984). The yield per recruitment is estimated as per Beverton and Holt (1957). The optimum age for exploitation (t_y) and potential yield per recruit (y^1) have been estimated as per Krishnankutty and Qasim (1968).

Results and Discussion

Catch statistics: An estimated 74.8 t of sharks were landed at the catch rate of 6.8 kg/unit which formed 5.8% of the total catch in 1990-91. During 1991.92 the shark landing declined to 52.5 t due to decline in the abundance of sharks as indicated by the catch rate (5.0 kg/unit) and reduction in the effort input. In 1992-93, though the shark landing was higher due to better abundance (32.0 kg/unit), the effort input did not high enough to coincide with the higher catch rate to bring in still better yield than that recorded.

The data on the monthwise estimated average effort, catch, CPUE and percentage composition of sharks and all fish catch for 1990-93 indicate that the effort varied from 117 in December to 2142 in August and the all fish catch fluctuated from 4.2 t in December to 630 t in august. The shark landing varied from 02. t in December to 44.1 t in July whereas the catch rate fluctuated from 1.5 kg/unit in April to 23.4 kg/unit in July. The catch rate indicates that the abundance of shark was

Table 1. Estimated monthwise average effort, catch, CPUE and percentage composition of sharks landed by drift gill nets during 1990 - 93 at Tuticorin.

Months	Effort (units)	Allfish catch (t)	Sharks (t)	CPUE (Kg/unit)	%
April	681	48.5	1.0	1.5	2.0
May	673	35.7	1.8	2.6	4.9
June	1284	329.3	26.1	20.4	7.9
July	1883	557.2	44.1	23.4	7.9
August	2142	630.0	37.1	17.3	5.9
September	440	30.8	3.1	7.1	10.1
October	261	13.7	1.1	4.1	7.9
November	182	10.6	0.3	1.9	3.2
December	117	4.2	0.2	2.2	6.0
January	196	8.1	0.6	3.0	7.3
February	140	5.3	0.3	2.4	6.4
March	311	30.4	2.0	6.6	6.7
Total	8310	1703.9	117.8	14.2	6.9

good during June- august. On an average 117.8 t of sharks were landed at the catch rate of 14.2 kg/unit which constituted 6.9% of the total catch by drift gillnet units during 1990-93 at Tuticorin.

Species composition: The estimated annual species composition of sharks landed by drift gillnets during 1990-93 at Tuticorin indicate that though many species supported the fishery, the prominent ones are *Laxodon macrorhinus* (36.5%), *Carcharhinus sorrah* (26.1%), *Scoliodon laticaudus* (15.9%),*Rhizoprionodon acutus* (10.3%), *Carcharhinus spp* (2.7%), *Sphyrna zygaena* (1.8%),*Chiloscyllium griseum* (1.6%) and other sharks (5.1%).

Length frequency: The monthwise weighted length frequency of both males and females of *C. sorrah* was obtained at a size interval of 20 mm from drift gillnet landings during 1991-92 and 1992-93. It was observed to be multimodal suggesting the recruitment of different broods into the fishery. The progression of these modes in subsequent months was traced by free hand curves from the scatter diagram of these modes. The time of origin of a few modes available at the lower size ranges have been traced by extrapolating the curves of such modes back to the time axis. *C. sorrah* being viviparous, the time of origin thus obtained may be taken as to include the gestation period also. The average sizes attained by both the sexes of this species in subsequent months were obtained by tabulating the traced modes chronologically and were used for growth estimation.

Age and growth: Initially an empirical growth curve was obtained for both male and female of this species by plotting the average sizes obtained by the above said analysis on an arithmetic graph and fitting a free hand growth curve through these plots. The quarterly sizes attained by this species were obtained from these curves and were used for further analysis to estimate the growth parameters $L\infty$, K and t_0 and the estimates are 1459 mm, 0.3993/year and 0.074 yr respectively for males and for females 1658 mm, 0.3309/year and -0.0901 yr respectively. The growth of both the sexes of this species may be expressed as per von Bertalanffy growth equations as shown below.

Male: $It = 1459 (1 - e^{-0.3993 (t - 0.0704)})$

Female: $It = 1658 (1 - e^{-0.3309 (t + 0.0901)})$

According to these equations, the males of *C. sorrah* attain a size of 451, 783, 1005, 1155, 1285, 1322, and 1367 mm in 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, and 7.0 years respectively and the females attain a length of 502, 828, 1062, 1230, 1350, 1437 and 1499 mm in 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 and 7.0 years respectively.

Length-weight relationship: The sexwise length-weight relationship of this species are described by the following equations:

Male: Log W = -6.3747 + 3.3573 Log L

Female: Log W = -5.9069 + 3.1923 Log L

Based on the length-weight relationship the $W\infty$ is estimated to be 17726 g for males and 23495 g for females respectively.

Mortality rates: The natural mortality coefficient (M) is estimated to be 0.63 for males and 0.54 for females of *C. sorrah* and the annual total mortality rates (Z) is estimated to be 3.35 in 1991-92 and 2.82 in 1992-93 for males and 5.82 in 1991-92 and 4.01 in 1992-93 fro females. The fishing mortality rate (F) is obtained from the relation F = Z - M and the estimates are 2.72 and 2.19 for males and 5.28 and 3.47 for females during 1991-92 and 1992-93 respectively.

Age at first capture and recruitment: The average sizes at first capture are estimated to be 575 mm for males 580 mm for females and the corresponding age at first capture are 1.3288 yr and 1.2109 yr for males and females respectively. The average size and age at recruitment are 540 mm and 1.2316 yr for males and 560 mm and 1.1554 yr for females.

Yield per recruitment: The yield pre recruit estimated for both the sexes separately for 3 different M/K ratios are give in Fig 1 and 2 for males and females respectively. The F_{max} which can produce the highest yield in all the three M/K ratios are lower than the prevailing F for both the sexes indicating higher Fishing pressure exerted by drift gillnets on this species.

Exploitation rate: The exploitation rate U is obtained from the relation $U = F/Z (1 - e^{-Z})$ and the estimates are 0.78 and 0.73 for males and 0.90 and 0.85 for females during 1991-92 and 1992-93 respectively. Annual average U is 0.76 for males and 0.88 for females and it indicates that both the sexes are exposed to higher fishing pressure. Among them the females are exposed to more severe fishing pressure than the males.

Optimum age for exploitation and potential yield per recruit: The optimum age for exploitation (t_y)and potential yield per recruit (y^1) have been estimated to be 2.78 yr and 4016 g for males and 3.19 yr and 7439 g for females.

Table 2. Estimated annual species composition (t) of sharks landed by drift gillnet at Tuticorin during 1990-93.

Year	*Laxodon macrorhinus*	*C. sorrah*	*C. spp*	*R. acutus*	*Scoliodon laticaudus*	*Spyrna zygaena*	*C. griseum*	Other sharks	Total catch
1990-91	24.9	25.1	2.4	5.7	4.2	1.9	3.8	6.8	74.7
1991-92	17.1	11.8	0.0	5.1	8.9	1.9	1.2	6.4	52.4
1992-93	87.1	55.4	7.1	25.7	43.1	2.4	0.6	4.8	226.2
Average	43.0	30.8	3.2	12.1	18.7	2.1	1.9	6.0	117.8
%	36.5	26.1	2.7	10.3	15.9	7.8	1.6	5.1	-

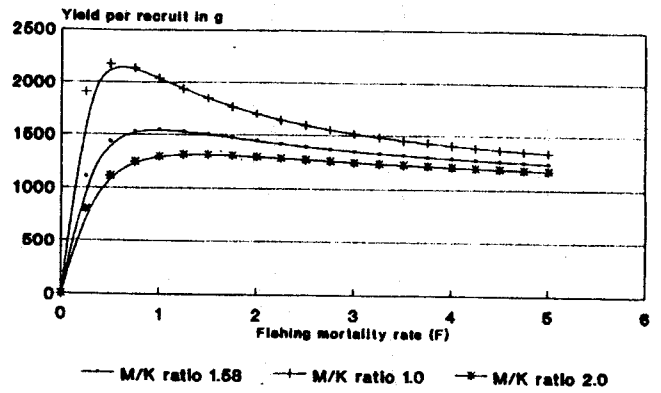

Fig. 1. Yield per recruit of *C. sorrah* (male) obtained at different fishing mortality rates and prevailing age at first capture for three different M/K ratios.

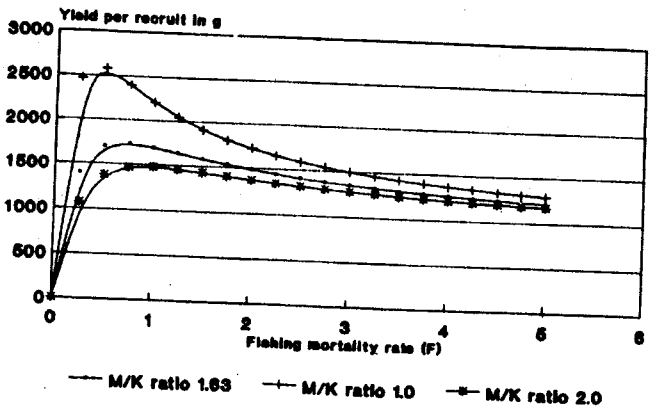

Fig. 2. Yield per recruit of *C. sorrah* (female) obtained at different fishing mortality rates and prevailing age at first capture for three different M/K ratios.

Stock assessment: Tamil Nadu has produced an annual average yield of 3994 t of sharks during 1985-93 and Gulf of Mannar is estimated to contribute 1330 t in a year. Based on the present species composition, the shark landing in the entire Gulf of Mannar is constituted by 485.5 t of *L. macrorhinus,* 347.1 t of *C. sorrah* 211.5 t of *S. laticaudus,* 137.0 t of *R. acutus,* 35.9 t of *Carcharhinus spp,* 23.9 t of *S. zygaena,* 21.3 t of *C. grisem* and 67.8 t of other species. The standing stock (B) of *C. sorrah* in Gulf of Mannar is estimated to be 101.6 t from the relation B = Y/F and the annual average stock (P) is estimated to be 423.3 t form the relation P = Y/U.

The growth rate of shark have been reported to be slow (K is around 0.2) by different workers mostly from temperate waters(Olsen, 1954; Holden and Meadows, 1962; Hensen, 1963; Holden, 1974). Based on this Krishnamoorthi and Jagdis (1986) have taken the K as 0.2 for *R. acutus* in Madras waters and Prabhakaran Nair (1981) has also reported a slow growth rate for *S. laticaudus* in Bombay waters. However, Springer (1960) has observed a faster growth rate 700 mm per annum) in *Eulamia milberti* and Kasim (1991) has also reported a higher K value for *R. acutus* and *S. laticaudus* from Gujarat waters. In the present study also the K of *C. sorrah* is estimated to be very close to and little lower than that of the estimates obtained for *R. acutus* by Kasim (1991). This difference may be due to that *C. sorrah* grows to a larger size than *R. acutus* and hence the smaller K than *R. acutus.*

Generally, low $L\infty$ and higher K value are attributed to higher environmental temperature (Pauly, 1980). As already contended by Kasim (1991) the tropical species including sharks, being poikilotherms, their growth rate is directly correlated to the environmental temperature and it is naturally higher than their counterpart in temperate waters. As stated previously that the present study indicate that both the sexes of *C. sorrah* are exposed to higher fishing pressure and among them the females are exploited more intensively. Factors like the faster growth rate and parental care could not help this species to withstand the higher fishing pressure. Probably the low fecundity rate of this species may be the Achilles' heel to cope with the present fishing intensity.

This situation may be better managed either by increasing the mesh size of the drift gillnet or by reducing the effort input in Gulf of Mannar. Implementation of this suggestion is rendered difficult since the aim of this gear is not only to exploit sharks but also other resources like seerfish and tuna. When most of the component species of these resources also exhibit similar situation of over fishing then the above suggestion may be implemented without any reservations.

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