LARGE MARINE ECOSYSTEMS :

EXPLORATION AND EXPLOITATION FOR SUSTAINABLE DEVELOPMENT AND CONSERVATION ON FISH STOCKS

Edited by

Dr.V.S.Somvanshi

February 2004

Fishery Survey of India
Government of India
Ministry of Agriculture
(Deptt. of Animal Husbandry & Dairying)
Mumbai-400 001

MORPHOMETRY AND BIOLOGY OF THE DUSKY SHARK, *CARCHARHINUS OBSCURUS* (LeSueur), FROM THE OCEANIC REGION OFF THE WEST COAST OF INDIA

M. Devaraj * and Deepak Gulati **

ABSTRACT

The correlation co-efficient (r) for the regression of various morphometric characteristics on total length ranged from 0.736 for the second dorsal (D_2) base to 0.997 for the standard length from snout to origin of dorsal lobe of caudal. The length (total) at birth ranges from 69 cm to 102 cm. The lengths at the age of 1, 10, 20 and 30 years were estimated to be 102 cm, 269 cm, 341 cm and 366 cm respectively. The total life span is about 30 years. The length growth parameters were estimated to be $L\infty$ = 383 cm, annual k = 0.1 and t_o = -2.1 year (gestation period) and the weight growth parameters $W\infty$ = 283, 221 g, annual k = 0.0965 and t_o = -2.0384 year (gestation period). There is significant difference between sexes in the exponential value in the length-weight relationship at 5% level. The mean length at recruitment (l_r) and length a maturity (l_m) were found to be 95 cm and 277 cm respectively. Age composition of a single sample studied indicated the total mortality (Z) from the one, year to two year old fish to be 0.0513 which is much less than the independent estimate of natural mortality (M=0.16) for the entire stock. Obviously there is no commercial exploitation of this shark in the oceanic waters off the west coast of India. The potential yield per recruit (y') for the so called optimum age of exploitation (t_y = 8.93 years) is 20.35 kg.

Introduction

During the 62nd cruise of the research vessel M.V. Saraswati (48 meter length) from the 24th February, 1987 to the 28th February 1987 tuna longlining with 180 hooks and handlining from the deck were carried out for a day at the station 16° 20' 50" N Lat. and 71° 17' 23" E Long. Except for one yellowfin

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tuna, the catch was exclusively of the dusky shark, *Carcharhinus obscurus*, observations on the morphometry and biology of which are communicated here.

C. obscurus has wide ranging distribution in the Atlantic, Indian and Pacific oceans. In the Western Indian Ocean, however, it is known to occur only off the coast of South Africa, Madagascar and East Africa (FAO, 1984). The present communication is the first report of the occurrence of this fish in the oceanic waters off the west coast of India, where according to the FAO (1984), it is of doubtful occurrence.

Material and methods

On the evening of the 25th February, 1987 when M.V. Saraswati was stationed at 16° 20' 50" Lat. and 71° 17' 23" Long, where the depth was about 1600 to 2250m, a large number of dusky sharks surrounded the vessel to scavenge on the kitchen refuses thrown overboard. Handlining operations from the deck using about half a dozen tuna longline hooks baited with catfish and squid fillet, yielded 18 sharks from about 6.00 PM to 10.00 PM. Tuna longline of 180 hooks with the same baits set at 12.00 midnight and hauled at 10.00 AM the following day (26th February, 1987) yielded 24 sharks and one yelllowfin tuna. The general oceanographic features prevailing at the station were recorded.

30 different morphometric measurements and weights of all the sharks including 25 males and 17 females were recorded (Fig.1). The regression of each

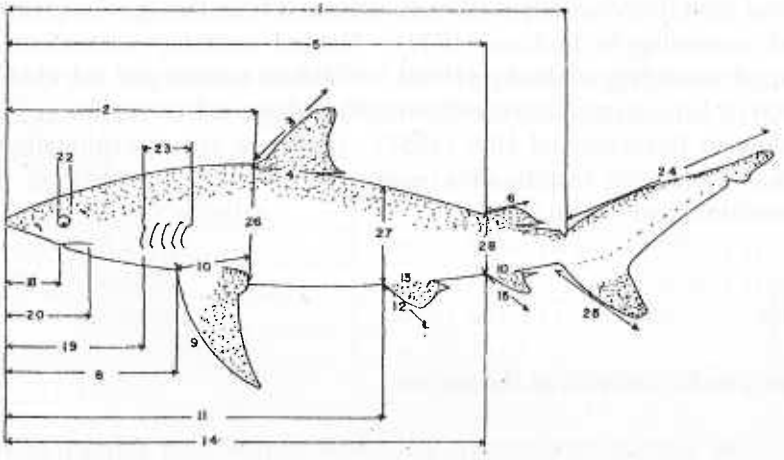

Fig.1 Morphometric measurements. Body parts indicated by numbers here are described in Table 1 by the same number

morphometric property (Y variable) on the total length (X variable) was fitted by simple straight line equations. Analysis of covariance as described by Snedecor and Cochran (1967) was employed for test of significance (F test) of the fitted regression lines for the various characteristics between the sexes. Besides regression analysis, the range, mean, standard deviation and standard error for all the 30 characteristics were also computed to facilitate comparison with similar data for other localities, and thereby, to enable stock identity within the total range of distribution.

In India, as elsewhere, elasmobranches are rarely studied for their age and growth mainly because of the difficulties in using any of the conventional methods of age determination. Very little is known about the growth of larger sharks in oceanic waters. Therefore, the simple method of determining the growth of elasmobranches developed by Holden (1974) was adopted in the present study. He described the growth of elasmobranches by substituting the observed values of length at birth (l_o), when time t = 0, the gestation period (treated at to) and maximum reported size (L_{max}, treated as $L\infty$) in von Bertalanffy growth function (VBGF) in order to estimate the growth coefficient.

$$l\infty = L\infty \ (1 - e^{-k(t-to)}) \qquad \ldots\ldots (1)$$

Once *k* is estimated, the length at age in year could be determined from the VBGF.

The VBGF for weight growth was fitted after converting length-at-age into weight-at-age by using the length-weight relationship for the 42 fish studied. The total mortality coefficient (Z) was estimated from the age composition of the 42 fish according to Jackson (1939). Natural mortality coefficient (*M*) was computed according to Pauly (1980). Yield in weight per recruit (Y_w/R) as function of fishing mortality coefficient (F) and age at first capture (t_c) was fitted according to Beverton and Holt (1957). Optimum age of exploitation (t_y) and potential yield per recruit (Y') were estimated by the method given by Krishnankutty and Qasim (1968).

Results

Oceanographic features at the station

The surface temperature, dissolved oxygen and salinity at the study station were found to be 26.5°C, 3.98 ml/l and 36‰ respectively. At the

maximum depth of the station (2250 m) temperature, dissolved oxygen and salinity recorded 4.7°C, 1.60 ml/l and 38‰ respectively.

Diagnostic features of dusky shark

The dusky shark is characterized by rudimentary anterior nasal flaps, broadly triangular upper teeth; relatively low first dorsal fin with a broadly arched anterior margin and a narrowly rounded or pointed apex; origin of first dorsal from about the level of the free rear tip of the pectorals; second dorsal fin rather low and pointed; its posterior margin nearly straight and inner margin nearly or quite twice the fin height; low dermal ridge between dorsal fins; body colour blue grey or lead grey above and white below; tips of pectorals, pelvices, lower lobe of caudal and dorsals dusky in fresh fish (all were young and immature) in the present collection, but reported to be plain in the adults by the FAO (1984).

Morphometry

The regression coefficients for the regression of various body measurements on total length were very similar for males and females, and hence, regression lines were fitted for sexes together. The correlation co-efficients for the regression of morphometric measurements on total length were found to be high ranging from 0.736 for basal length of D_2 to 0.997 for standard length to origin of upper caudal lobe (Table 1). These regression lines and the range and mean statistics (Table 2) are basically meant to facilitate comparison with similar analysis of samples from other localities to establish the degree of homogeneity in the species in the areas of its distribution.

Table 1 : Regression lines fitted for the various morphometric characteristics (y) as functions of total length (x)

Sl. No.	Morphometric characteristics	Regression lines	r	R^2
1	Standard length	y = -14.86+0.74 x	0.9974	0.9948
2	Pre D_1 length	y = 31.71+0.31 x	0.9799	0.9602
3	Anterior height D_1	y = -41.65+0.15 x	0.9620	0.9254
4	Basal length of D_1	y = -23.63+0.10 x	0.9292	0.8634
5	Pre D_2 length	y = 2.84+0.64 x	0.9949	0.9898
6	Anterior height of D_2	y = -21.49+0.05 x	0.8729	0.7619
7	Basal length of D_2	y = -59.68+0.08 x	0.7355	0.5409
8	Prepectoral length	y = 14.48+0.21 x	0.9473	0.8974
9	Anterior height of P	y = -79.99+0.24 x	0.9818	0.9639

10	Basal length of P	y = -6.56+0.01 x	0.8020	0.6432
11	Prepelvic length	y = -29.93+0.51 x	0.9547	0.9114
12	Anterior height of V	y = -26.84+0.07 x	0.9050	0.8190
13	Basal length of V	y = -31.09+0.07 x	0.9037	0.8166
14	Preanal length	y = 12.65+0.62 x	0.9955	0.9910
15	Anterior height of A	y = 0.11+0.05 x	0.9457	0.8943
16	Basal length of A	y = -3.29+0.03 x	0.8486	0.7201
17	Preanus length	y = -30.26+0.53 x	0.9911	0.9822
18	Snout length	y = 31.77+0.06 x	0.7837	0.6141
19	Prefirst gillslit length	y = 28.01+0.17 x	0.9585	0.9187
20	Premouth cleft length	y = 40.91+0.10 x	0.9225	0.8510
21	Prelower jaw length	y = 19.09+0.07 x	0.9344	0.8731
22	Eye diameter	y = 4.71+0.01 x	0.8661	0.7501
23	Distance from 1st to 5th gill slit	y = 4.99+0.06 x	0.8864	0.7857
24	Length of upper caudal lobe	y = 23.77+0.25 x	0.9552	0.9124
25	Length of lower caudal lobe	y = 45.20+0.09 x	0.7659	0.5866
26	Body depth at D_1 origin	y = -42.20+0.09 x	0.7659	0.5866
27	Body depth at V origin	y = -27.68+0.12 x	0.8035	0.6456
28	Body depth at D_2 origin	y = -21.23+0.07 x	0.9086	0.8256
29	Length of clasper	y = -112.77+0.12x	0.8434	0.7132

Table 2: The range, mean, standard deviation and standard error for 30 characteristics

Sl. No.	Morphometric characteristics	Range	Mean length (mm)	Standard deviation (sample)	Standard error
1	Total length	995-2150	1305.67	217.79	33.61
2	Standard length	734-1590	954.59	162.13	25.02
3	Pre D_1 length	340-691	437.55	69.08	10.66
4	Anterior height D_1	111-306	149.21	33.09	5.11
5	Basal length of D_1	82-228	111.43	24.25	3.74
6	Pre D_2 length	636-1370	836.76	139.81	21.57
7	Anterior height of D_2	30-104	41.79	12.09	1.87
8	Basal length of D_2	22-80	34.48	21.35	3.29
9	Prepectoral length	225-480	285.00	47.58	7.34
10	Anterior height of P	160-456	227.00	57.16	8.82
11	Basal length of P	59-137	82.48	18.52	2.86
12	Prepelvic length	440-1106	636.67	116.46	17.97
13	Anterior height of P	40-144	62.14	16.40	2.53

14	Basal length of P	46-108	62.29	17.23	2.66
15	Preanal length	628-1352	827.02	136.45	21.05
16	Anterior height of A	47-100	61.88	10.89	1.68
17	Basal length of A	28-78	39.90	8.94	1.38
18	Preanus length	503-1148	663.67	116.78	18.02
19	Snout length	80-180	111.60	16.99	2.62
20	Prefirst gillslit length	54-430	255.57	39.60	6.11
21	Prelower jaw length	140-273	173.24	23.74	3.66
22	Length from snout to lower jaw	86-175	104.74	15.29	2.36
23	Eye diameter	17-35	20.79	3.10	0.48
24	Distance from 1st to 5th gill slit	53-130	68.69	13.86	2.14
25	Length of upper caudal lobe	270-555	354.24	57.71	8.90
26	Length of lower caudal lobe	117-291	160.45	33.52	5.17
27	Body depth at D_1 origin	113-285	156.67	34.83	5.37
28	Body depth at V origin	92-192	122.90	31.26	4.82
29	Body depth at D_2 origin	42-120	72.17	17.14	2.65
	Length of clasper	27-200	42.96	32.72	6.42

Length-weight relationship

The length (cm) – weight (g) relationship on 17 females ranging from 101.6 cm (4,000 g) to 164.0 cm (23,000 g) and 25 males ranging from 99.5 cm (4,000 g) to 215.0 cm (58,000 g) was found to be.

Females : $W = 0.0070048\ L^{1.947}$; (r = 0.5012) ...... (2)
Male : $W = 0.0000000142\ L^{3.798}$; (r = 0.9921) ....(3)

It is interesting that the exponent for the females is only about 2 while for the males, it is significantly higher than 3 in isometric growth. The difference in the regression coefficient between males and females was found to be significant at 5% level. However, a single relation given below for both the sexes, indicates that growth is generally isometric (the value of b = 3.186 being closed to b =3 for isometric growth).

$$W = 0.00165689\ L^{3.18641};\ (r = 0.81777) \quad \ldots\ldots\ldots (4)$$

Growth parameters

As suggested by Pauly (1984) $L\infty$ was determined as 383 cm by dividing L_{max} = 364 cm (FAO, 1984) by 0.95. The gestation period of 2 years (FAO, 1984) has been considered to be t_o (= - 2.0 year) and $L\infty$ (=383 cm) in Eq. (1), k has been estimated to be 0.099 or 0.1 which falls within the known range of 0.10 to 0.2 for Selachii (Holden, 1974). After converting the age-length relationship into age-weight relationship (using the length-weight relationship in Eq.4), the weight growth parameters have been found to be $W\infty$ = 283.221 g, annual k = 0.09659 and t_o = -2.0384 years. From the VBGF for length and weight growth, the sizes at 1, 10, 20 and 30 years of age were estimated to be 102 cm (4,180 g), 269 cm (91,280 g), 341 cm (194, 805 g) and 366 cm (243,805 g) respectively.

Size at recruitment and first capture

From the length frequency data for the present catch, the length at recruitment (l_r) has been fixed arbitrarily at 97.5 cm and the length at first capture (l_c) at 107.3 cm (midpoint of the 105-110 cm length group). From the VBGF for length growth, t_r and t_c have been computed to be 0.92 year and one year respectively.

Age composition of catch and mortality estimates

On the basis of the age-length key from the VBGF (1st year = 102 cm, 2nd year = 129 cm, 3rd year = 153 cm, 4th year = 175 cm, 5th year = 195 cm and 6th year = 213 cm) the length composition of the 42 fishes in the length groups ranging from 95.0 to 220 cm in the sample has been converted into the following age groups: 1+ (99.5 to 125 cm; the smallest fish in the sample was only slightly smaller than the estimated length at first year, and hence included in = 1 + year group) = 20 fish, 2+ (125 to 155 cm) = 19 fish, 3+ (155 to 175 cm) = only 2 fish as only 155 to 165 cm fish were represented in the sample owing apparently to > 165 cm fish leaving the school of very young fish, and 6+ (215 to 219 cm) = only 1 fish as only 215 cm fish was represented in the sample (Fig.2). Thus only the 1+ and 2+ age groups seem to be fully represented in the sample and Z estimated from these two age groups is found to be 0.0513. Z estimated from the apparently fully represented 2 years groups and the partly represented 3 year group is disproportionately high at 1.8458 relative to Z = 0.0513 for the fully represented younger age groups. Annual Z based on the 3 and 6 age groups is 0.3662. The mean Z for these three values of Z is 0.7544 which cannot be realistic owing to the unrepresentativeness of the 3 and 6 year old fish in the sample.

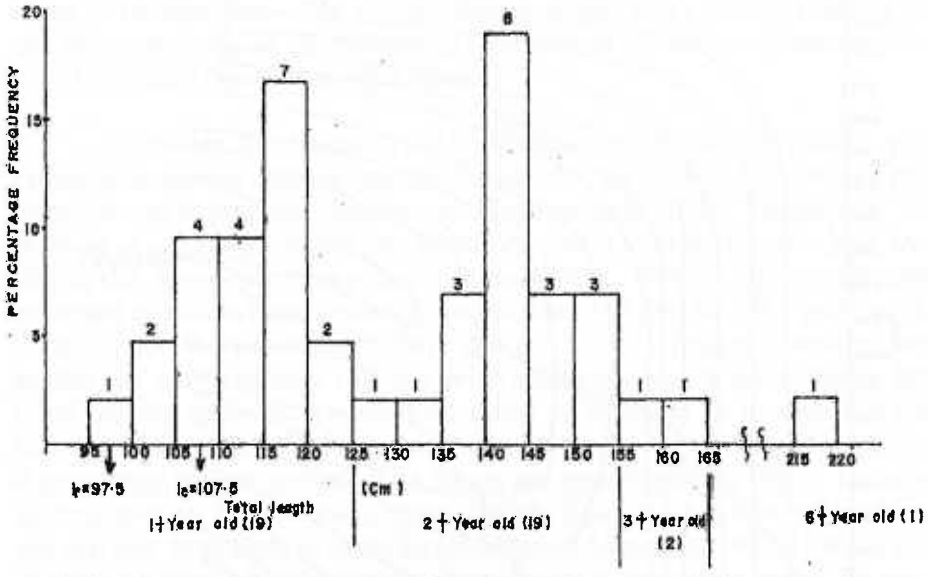

Fig.2 Length frequency of Carcharhinus obscurus caught in handlining and longlining (l_r = length at recruitment; l_c = length at first capture).

Independent estimate of M from the relationship,

$$\log M = 0.1228 - 0.1912 \log L\infty + 0.7485 \log k + 0.2391 \log T \quad \ldots\ldots (5)$$

where $L\infty$ = 383 cm, annual k = 0.1 and T = 26.5°C was found to be 0.1625 which may be considered as the mean M for the entire stock comprising all the age groups. The estimate of Z = 0.0513 based on 1+ and 2+ age group is significantly less than even the M (= 0.1625) and seems to be equivalent to M (=Z=0.0513) for the 1+ and 2+ age groups. Apparently, these young age groups occurring in the present study area are in a virgin state.

Yield curve

Although there is not fishery for the dusky shark in the high seas of the Indian exclusive economic zone, the yield isopleth in Fig.3 could be used as the basis for the optimum age of exploitation (8.93 years) at E = 1 ($F\infty$ = about 3.1), the potential yield per recruit is found to be 20.352 kg (Fig.3).

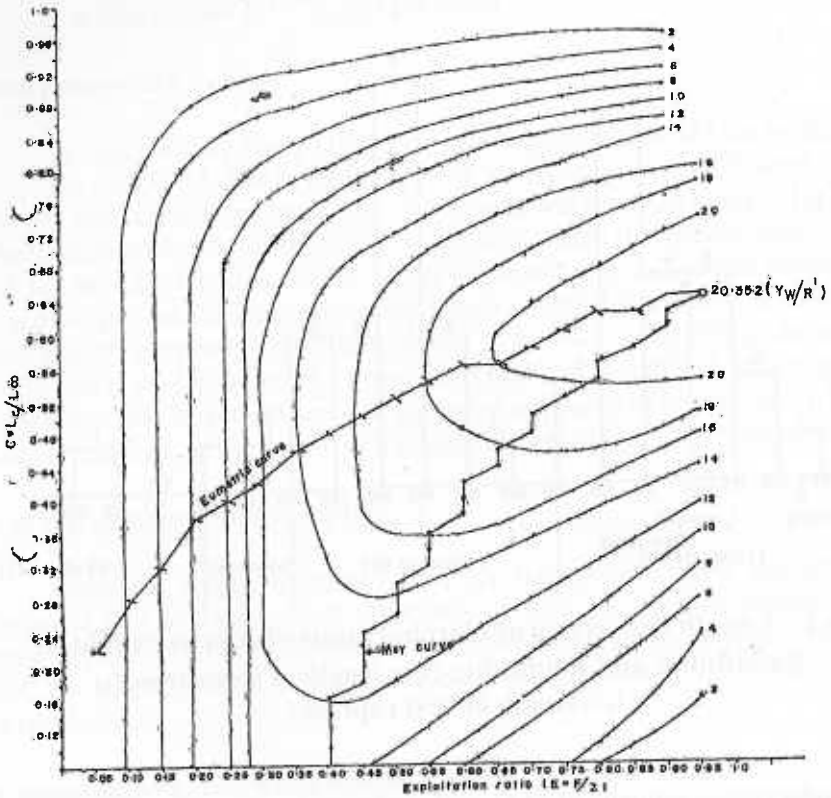

Fig.3 Yield isopleth diagram depicting (Y_w/R as function of age at first capture (t_c) and exploitation ratio (E).

Food

The stomachs of most fish were empty; some contained remains of *Nemipterus, Exocoetus* and cuttlefish and eyeballs of various fishes. The dusky shark is known to feed mainly on fishes including scombrids, clupeids, sciaenids, trichurids, bluefish, anchovies, barracudas, sharks, rays, squids, octopi, gastropods, shrimps and crabs (FAO, 1984).

Discussion

The growth of C. *obscurus* is slow. It grows from the minimum size of 69 cm at birth to 102 cm at the age of one year, i.e. an increment of 33 cm. It

takes about 11 years to attain first maturity (l_m = 277 cm, FAO, 1984); all the fish in the present sample ranging from 1 to 6 years of age (99.5 to 215 cm) were found to be immature. The average annual growth from birth to maturity is 19 cm, the range being 11 to 29.5 cm. The growth of *C. obscurus*, however, seems to be faster than that of may other sharks.

According to Holden (1974) all species of elasmobranches studied exhibit slow growth rates, in general, the growth rate of sharks to maturity ranges from 3-8 cm a year for Squalus sp. (Kaganorskaia, 1933; Templeman, 1944; Bonham *et al.*, 1949; Holden and Mendows, 1962) to about 60 cm a year for the subtropical *Negaprion brevirostris* (Moss, 1967). The average annual growth increment of *Galeorhinus australis* ranges from 130 mm for the 1 year old shark to 30mm for the 12 year old shark (Olsen, 1954). Tagged immature female dogfish has grown by only 142 mm in the course of about 8 years (olsen, 1954). From indirect evidence, growth was found to be rapid in the sandbar shark, *Eulamia milberti*, which grew from about 60 cm at birth to 200 cm in two years at an average growth rate of about 70 cm per year (Springer, 1960). Females of the Scotish-Norwegian stock of spiny dogfish, *Squalus acanthias*, grow about 50 mm per year from birth to maturity (Holden and Meadows, 1962; Holden, 1973). *Scomniosus microcephalus*, a large shark, grows at an average rate of 7.5 mm per year (Hansen, 1963). An average annual growth increment of 31-54 mm was observed for tagged juvenile *Carcharhinus albimarginatus* and 41 mm for juvenile *Carcharhinus galapagensis* (Kato and Carvallo, 1967). Length increase of 4 to 6 cm a year was observed for young *Carcharhinus milberti* from tagging data, vertebral ring and tooth replacement rate (Casey and Stillwell, 1970; Wass 1973). The growth increment of *Scoliodon laticaudus* along the Bombay coast was found to be 6 to 18 cm a year (Prabhakaran Nair, 1976). One specimen of the dusky shark 185 cm in total length was landed on the 28th March, 1987 at Veraval in Gujarat state with a ring pierced through the first dorsal fin and the right pectoral fin around the girth of body. The ring, 28.64 cm in diameter and 0.56 cm thick (preserved in the Veraval Research Centre of the CMFRI), had no joint, marking, tag or label, and therefore, the growth between the date of tagging and the date of recapture could not be ascertained (Lipton *et al.*, 1987).

The $L_m/L\infty$ ratio for *C. obscurus* is found to be 0.72. The higher the value of $l_m/L\infty$ the greater the reproductive stress (Cushing, 1968). The mean $L_m/L\infty$ ratio on the basis of 20 species of elasmobranches was found to be 0.77 (Holden, 1974). The mean $Lm/L\infty$ for *Laxodon macrorhinus, Carcharhinus limbatus, Galeocerdo cuvieri, Gymnura poecilura, Pristis cuspidatus and Stegosoma fasciatun* in the Indian seas was found to be of 0.51 (Devaraj, 1983).

Since there seems to be virtually no exploitation of oceanic sharks at present, longlining in the oceanic waters of the Indian EEZ in the Arabian Sea could be very promising. On one occasion in July, 1983 the exploratory fishing vessel M.V. Matsya Sugundhi caught 15 tons of fish comprising 411 sharks and 21 other fish in 259 hours of longlining with 9319 hooks in a three week cruise off Cochin in the 800-2500m isobath. At the rate of one kg processed, shark fin per 30 kg body weight, even a modest catch of 5 tons of sharks over 3 weeks of longlining from vessel like M.V. Matsya Sugundhi would yield about 70 kg shark fins worth Rs. 76,500 at current export price of Rs. 450 a kg. The value of smoked meat for export and liver for the shark liver oil industry will also be substantial.

Acknowledgement

The authors are deeply indebted to the Director, CIFE, Bombay for the facilities provided for this study. The technical assistance given by Mr. R. Palaniswamy is gratefully acknowledged.

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