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Resource dynamics of the Indo-Pacific sailfish *Istiophorus platypterus* (Shaw, 1792) from the south-eastern Arabian Sea

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ABSTRACT

The average billfish catch from the Indian EEZ during 2002-2007 was 4561 t which increased to 7856 t during 2008-2010, and nearly 80% of this was caught from the Arabian Sea by drift gillnet cum longline units. In the Indian Ocean region, billfishes (marlins, swordfish and sailfish) are considered as data deficient resource in the IOTC database. The sailfish *Istiophorus platypterus* (Shaw, 1792) was the major component of the billfish catch at Cochin Fisheries Harbour from where a fleet of gillnet cum longline units are regularly operated for oceanic fishes such as yellowfin tuna, seerfishes and pelagic sharks, besides billfishes. Length range of sailfish landed during 2005-2008 was 80-230 cm with inter-year variations in size groups contributing to the fishery. Length-weight relationship was estimated as 0.024 $L^{2.65}$ while growth parameters L_∞ and K (annual) were estimated as 262 cm and 1.0 respectively. Diet preferences of fishes in the size range 180-227 cm indicated percent occurrence of fish as 81% followed by crabs (31%) and molluscs (25%). Trigger fishes (*Balistes* spp.) dominated the gut contents, followed by carangids like *Selar* spp. and *Decapterus* spp. Ova diameter of vitellogenic oocytes in ripe gonad with hydrated eggs ranged from 200 to 1300 µ with a major mode at 700 µ and a minor mode at 1200 µ, indicating hydrated eggs are released in batches at probably close intervals. Absolute fecundity from a ripe stage ovary was estimated as 20,97,481 eggs (1750 eggs per g ovary weight) with hydrated eggs forming about 31% of the total eggs, giving a batch fecundity of about 541 eggs per g ovary weight. Exploitation rate (E) indicated that although billfishes are considered as bycatch in the targeted fisheries for yellowfin tuna and pelagic sharks, the considerable number of fishing units operating for targeted tuna fishing has resulted in heavy fishing pressure (E=>0.6) on the sailfish resource during certain years.

Keywords: Biology, Growth parameters, *Istiophorus platypterus*, Population dynamics, Sailfish

Introduction

Sailfishes, *Istiophorus platypterus* (Shaw, 1792), are widely distributed in tropical and temperate surface waters of the world's oceans (Nakamura, l985) and form important components of commercial as well as recreational fisheries. In the Indian EEZ, this species is taken primarily as incidental bycatch in drift gillnets and hooks and line fisheries. Fishing gear, targeting practices and environmental conditions and interactions with other fisheries are capable of affecting the "apparent abundance" (Marr, 1951) of large pelagics. The lack of data on species-wise gear-wise catch effort indices of billfishes is considered a serious constraint in making estimates of stock abundance in the Indian Ocean (Campbell and Tuck, 1998). In the Indian EEZ, catches of sailfish have steadily increased during the last few years but very little information is available regarding the biology of sailfish caught from the Indian EEZ (Varghese *et al*., 2005; Ganga *et al*., 2008). The study reports information on the growth parameters, length-weight relationship, and diet preferences of sailfish based on sampling from commercial catches.

Materials and methods

The sailfish fishery during the period from 2005 to 2008 was studied by conducting weekly observations of the landings at the Cochin Fisheries Harbour from the mechanised drift gillnet-cum-hook and line fleet. The data collected was used to derive monthly annual length frequency distribution. Length measurements (from tip of lower jaw to caudal fin fork, L_JFL) and weight (g) of 104 nos. of *I. platypterus* (140-218 cm LjFL) at the landing site were used for the estimation of the length-weight relationship ($W = aL^b$) using linear regression after log transformation. Growth parameters were estimated using ELEFAN program in FiSAT (FAO / ICLARM Stock Assessment Tools (Sparre and Venema, 1998) based on the length frequency (n= 1077) data set of years 2005 and 2006. Fishing mortality (F) and exploitation rate (E) was estimated using the length converted catch curve method and natural mortality (M) using Pauly's empirical equation as given in FiSAT.

Diet preferences of sailfishes with full stomachs (n =16), in the size range 180-227 cm, sampled from a fish processing unit close to the landing centre was studied. The Index of Relative Importance (IRI) (Pinkas *et al*., 1971) modified by Labropoulu *et al*. (1997) was calculated and expressed as %IRI as given below:

IRI = ((Cn + Cw) x F_o) where Cn and Cw are the percentage numerical abundance and percentage weight of the various prey items and F_o = percentage frequency of occurrence of the particular food item in the total stomachs examined.

%IRI = (IRI/ Σ IRI) X 100

Gonad development pattern as indicated by oocyte size distribution was assessed from several subsamples of a ripe ovary (Clark, 1934) using imaging software (Motic BA 3100). Fecundity was estimated from 9 subsamples of approximately 1 g taken from various locations of a ripe ovary. The subsample estimates were raised to the total weight of the ovary and averaged to arrive at absolute fecundity as follows, assuming that the fish spawned once during the season.

Absolute fecundity (F) was worked out as:

$$\frac{\text{Number of ova in the subsample}}{\text{Weight of the subsample (g)}} \text{ x Weight of ovary (O)}$$

Results and discussion

In present study, the L-W relationship was estimated as 0.024 $L^{2.65}$ with fish attaining weights of about 20-25 kg at about 2 m length (Fig.1). This was comparable to the earlier study where the length-weight relationship, W = 0.0069 $L^{1.559}$ (length in cm, weight in kg) was determined by Varghese *et al*. (2005) using samples of sailfish caught in longlines along the north-west coast of India.

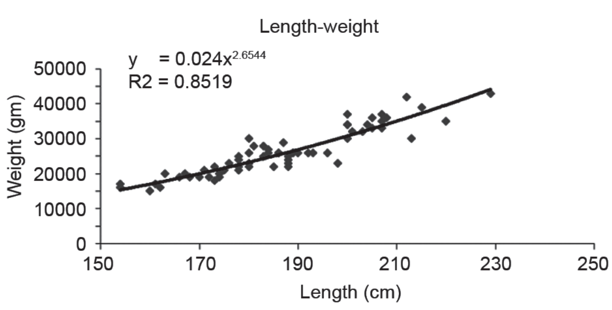

Fig. 1. Length (LjFL)-weight relationship of *I. platypterus* from south-eastern Arabian Sea

The growth parameters were estimated as L_∞=261 cm and K =1.0 yr^{-1} (Fig. 2). The growth rate (K) appears to be higher than 0.39, estimated for the stock off north-west coast, but higher estimates (0.44-0.75) have also been compiled from various publications by Varghese *et al*. (2005). It is reported that growth rate shows a decreasing trend with age and probably this parameter is influenced by the age of fish sampled. The length range of sailfish used for the estimation of growth parameters in this study was 90-280 cm which probably were in the phase of relatively fast growth.

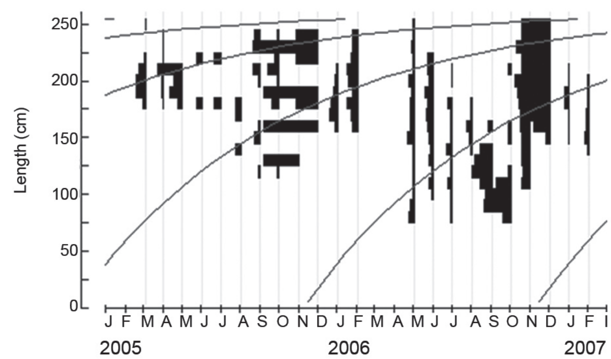

Fig. 2. Growth parameters L_∞ = 261 cm and annual K=1 of *I. platypterus* estimated in ELEFAN

The size range of oocytes in a ripe ovary with hydrated eggs indicated oocyte diameter in the range of 200-1300 µ with a major mode at 700 µ and a minor mode at 1200 µ (Fig. 3). Ova diameter has been correlated to the species in billfishes, with smallest ova seen in sailfish and the largest in blue marlin (de Sylva and Breder, 1997) and appear to be common to the size range described for scombroids in general (Arocha, 2002). The oocyte size distribution of a ripe ovary indicates that nearly 80% of the oocytes are >500 µ which is considered to be the size at which active vitellogenic stage is reached (de Sylva and Breder, 1997; Chiang *et al*., 2006), and is probably ready for spawning in batches at close intervals considering that many modes closely follow the two prominent modes at 1200 and 700 µ. Multiple spawning within a spawning season has been reported in billfishes including sailfish (Merrett, 1970; IUCN, 2011). In the present study, absolute fecundity from a ripe stage ovary was estimated as 20,97,481 eggs

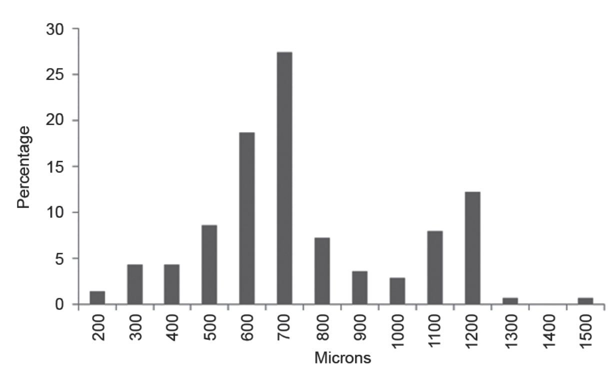

Fig. 3. Oocyte size distribution of a ripe ovary of *I. platypterus*

(1750 eggs per g ovary weight) with hydrated eggs forming about 31% of the total eggs, giving a batch fecundity of about 541 eggs per g ovary weight.

According to Varghese *et al*. (2005) sailfishes are opportunistic feeders with bony fishes as well as squids being the favoured items, which agrees with the observations in this study. Several items of food listed by these authors such as flying fish, scads (*Selar* spp., *Decapterus* spp., *Megalaspis* spp. and squids were observed in the present study indicating a non-selective foraging behavior by sailfish. Crabs were seldom found in the samples collected off the north-west coast as reported by Varghese *et al*. (2005), while they were commonly found (38% Fo) in this study. IRI values indicated that fish was the most preferred item with balistid fishes and carangids like *Selar* spp. common among partially digested food, followed by crab and squids (Table 1). The prey which mainly consisted of coastal varieties of fishes indicated the presence of feeding grounds close to shore rather than offshore oceanic waters, and an opportunistic mode of feeding. Relative abundance of sailfish in the inshore waters in the Pacific Ocean has been related to seasonal prey densities and prey have mainly been broadly classified into two distinct groups of squids and clupeids (Ehrhardt and Fitchett, 2006) similar to the observations of the present study.

Very few studies have been made on billfish biology and stock assessment (Campbell and Tuck, 1998; Chang *et al*., 2006a, b). The present study considered length frequency distribution of the sailfish catches by commercial fishing vessels as an indicator of its availability in the fishing grounds. However, Rouyer *et al*. (2008) observed that doing in stock assessment, climate, trophic interactions and fishing gear effects are important factors while catch or CPUE fluctuations are not directly attributable to changes in species abundance. Compared to exploitation rate of about 0.5 to 0.6 for male and female sailfish respectively in Taiwan waters (Chiang *et al*., 2006b), the present study showed wide inter-annual variations in the size groups landed with the annual exploitation rates, E = 0.1-0.8 (Table 2) probably reflecting the seasonal availability of billfishes in the tuna fishing grounds from where they are mostly caught as bycatch. To refine the natural mortality estimates of this important large pelagic resource as presented in this study and also to facilitate an assessment of the stock of sailfish in Indian seas, further information on the growth pattern validated using hard parts, size specific fecundity estimates and sex ratios are needed.

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Table 1. Forage items of sailfish and Index of Relative Importance (IRI)

Food items	%O	%N	%W	IRI	%IRI
Balistid fish	25.0	7.0	7.5	361.8	6.0
Mackerel	6.3	4.0	0.0	25.0	0.4
Digested fish	43.8	24.0	33.6	2522.2	41.9
Lethrinus spp.	6.3	1.0	1.1	12.8	0.2
Selar spp.	12.5	5.0	12.8	222.7	3.7
Exocoetus spp.	6.3	3.0	7.2	63.6	1.1
D. russelli	6.3	4.0	3.1	44.1	0.7
Crab	37.5	40.0	21.8	2318.6	38.6
Squid	18.8	11.0	11.9	430.3	7.2
Octopus	6.3	1.0	1.0	12.5	0.2

Table 2. Annual mortality rates and exploitation rate estimated for *I. platypterus* with input growth parameters L_∞ = 262 cm, K = 1 yr^{-1} and natural mortality (M) = 0.96

Parameter/year	2005	2006	2007	2008
Total mortality (Z)	5.38	1.41	7.7	1.08
Fishing mortality (F)	4.4	0.45	6.16	0.1
Exploitation rate (E)	0.8	0.3	0.8	0.1
Size range (cm)	120 - 250	90 – 280	110 - 210	100 - 330

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