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Fishery, biology and dynamics of dogtooth tuna, *Gymnosarda unicolor* (Rüppell, 1838) exploited from Indian seas

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ABSTRACT

The fishery and dynamics of dogtooth tuna *Gymnosarda unicolor* (Rüppell, 1838) exploited along the Indian coast was studied. The species was landed mainly in Kerala, Andaman & Nicobar and Lakshadweep, exploited mainly by hooks and line and the catch showed an increasing trend. The average annual landing by coastal fishery was 130 t (2006-2010) and by Letter of Permit (LOP) vessels was 1,311 t. Size in the catch ranged from 32.5 to 162.0 cm in fork length (FL). The length weight relationship was $W=0.0105\ L^{3.065}$. The von Bertalanffy growth parameters (VBGF) estimated using ELEFAN of FiSAT software were L_∞ = 163.6 cm, K=0.43 yr^{-1}, t_0= -0.12. Estimated total mortality, natural mortality and fishing mortality were 1.06, 0.572 and 0.49 respectively. The estimated t_{max} was 12 years and it reaches 56.6 cm, 94.0 cm, 118.3 cm, 134.1 cm, 158.3 cm, 162.6 cm in 1, 2, 3, 4, 8 and 12 years respectively. The species mature and spawn round the year with peak during August-January. The estimated biological indictors of the species are L_m= 69.0 cm; L_m/L_∞=0.4217; L_{opt} = 75.8 cm, L_{opt}/L_∞ =0.463 and W_∞= 64.0 kg. Fecundity estimated for the species was 3, 15, 244 per kg body weight. Young recruits enter the fishing grounds during most part of the year with peak during February-May. Along the Lakshadweep coast, *G. unicolor* was mainly exploited during September - March. The fishery data suggest that they are available in large numbers along the Andaman and Nicobar area.

Keywords: Fishery, Growth, *Gymnosarda unicolor*, Population dynamics, Spawning

Introduction

Dogtooth tuna, *Gymnosarda unicolor* (Rüppell, 1838) (Fig. 1) is a pelagic tuna preferring waters of temperature between 21 and 26 °C. It is one of the principal species exploited by hook and line (recreational as well as commercial fishery) operated in the oceanic region. Meat of dogtooth tuna is white and so it has great demand and fetch high price (IUCN, 2011). However, occasional ciguatera fish poisoning in humans has been reported on consumption of dogtooth tuna. It is exported in fresh and frozen state and is used for the production of sashimi, canned tuna, and pouch products. Most of the world landings of dogtooth tuna during 1963 -2006 was from the Indian Ocean. Small scale tuna long lines for the species operating in the Indian Ocean belong to Taiwan, Srilanka, Maldives, Japan or Pakistan. Annual catch from the Indian Ocean was 182 t in 1970 and 623 t in 2006 (FAO, 2012). In India, the long line catch was 112 t in 2006 and 165 t in 2010 (present study). Besides this, about 1311 t have been caught by the Letter of Permit (LOP) vessels operating in the Indian Ocean . Longline fishery for dogtooth tuna was developed in Indian Ocean in late 1990. In Lakshadweep, fishery lasts for three months from July to September using hand lines operated from wooden crafts of 5 m OAL (Sivadas and Anasukoya, 2005).

Fig. 1. *Gymnosarda unicolor* (Ruppell, 1838)

Biological information on dogtooth tuna is available in the species synopsis prepared by Silas (1963), describing in detail the distribution, taxonomy, biology and behavior of the species. First record of this species from the Indian mainland was from Calicut coast (Sivadas and Balasubramanian, 1991). However, only limited information on population parameters of dogtooth tuna from Indian Ocean is available (Sivadas and Anasukoya, 2005). The present study provides information on age, growth and population dynamics of dogtooth tuna in the Indian EEZ. Such information is essential for the

management of the fisheries. This is the first attempt made to study the growth rate of dogtooth tuna from Indian waters.

Materials and methods

The fishery and biology of dogtooth tuna exploited along the Indian coast were monitored. The catch data collected by Fishery Resources Assessment Division (FRAD) of Central Marine Fisheires Research Institute (CMFRI), for the mainland coast and that by concerned fisheries Departments of Lakshadweep and Andman and Nicobar Islands during 2006-'10 were used in the study. Biological samples of dogtooth tuna were obtained at weekly intervals from the commercial longline landings during 2006-2010. Samples were brought to the laboratory and data on total length, weight, sex and stages of maturity were collected and appropriately raised to the monthly catch estimates. The appearance of ovaries in fresh condition, the proportion of area occupied by them in the body cavity and the structure as well as diameter range of the intra-ovarian ova were considered for classification of ovaries into different stages of maturation. For determining the length at first maturity (L_m, taken as the length at which 50% of the fish are mature), specimens with ovaries in stages IV and V of maturation were considered as mature and the proportion of mature fish in each length group was estimated. Length at maturity was determined using logistic curve. To determine length at first maturity, spawning and peak spawning seasons alone were considered as almost all the adult fish during these seasons are expected to be in mature stage. This approach eliminated the possibility of growth influencing the estimate of length at first maturity (Abraham *et al*., 2011).

Estimation of fecundity is based on the mature ovaries as all the ova destined to be spawned during the ensuing season are mature in such ovaries. After separating all the ova from the ovarian tissue, they were transferred to a counting chamber (divided into 100 small squares by transverse and longitudinal lines) and all the mature ova having fully yolked structure, were counted under the microscope.

$$\text{Fecundity} = \frac{\text{Total weight of ovary}}{\text{Weight of the sample}} \times \text{Number of mature ova in the sample}$$

The von Bertalanffy growth parameters were estimated using the ELEFAN programme in FiSAT software (Gayanilo *et al.,* 1988; Sparre and Venema, 1991). A total of 550 fishes in the length range of 32.5 -162.0 cm fork length (FL) were used for the purpose. The total instantaneous mortality rate (Z) and exploitation ratio (E) was estimated from the length converted catch curve of Pauly (1983) using the total annual length frequency distribution of catch. The natural mortality rate (M) was estimated using the equation of Pauly (1980) and for this purpose the temperature in the fishing grounds was taken as 27 ^{o}C following Suseelan and Rajan (1989). The fishing mortality (F) was calculated as F = Z-M.

Exploitation rate (U) was estimated following Beverton and Holt (1957) and Ricker (1975).The annual total stock (Y/U) and standing stock (Y/F) were estimated by taking the average annual catch of the species (Y) during 2006-2010. The value of Y/F thus obtained was taken as the biomass (B) during the exploited phase of the fishes in the trawling grounds. Estimates of yield and biomass at different levels of F and t_c were obtained following Beverton and Holt's (1957) Yield per Recruit analysis. The smallest length in the catch over the two-year period was taken as length at recruitment (L_r). The length at first capture (L_c) was estimated from the length converted catch curve.

Results and discussion

Fishery

Annual average catch of *G. unicolor* in India during 2006-2010 was 1441 t. This includes an average catch of about 1311 t caught by LOP vessels also. The catch was contributed by Kerala, Lakshadweep and Andaman Nicobar Islands (Table 1). The world catch of dogtooth tuna also showed an increasing trend over the years (Fig. 2). Main gears operated are hand lines, long lines and gillnets. The size of dogtooth tuna in the catch ranged from 32.5 to 162.0 cm in FL. Maximum size of fish recorded in the present study was 162 cm FL. Different modes are observed in the annual length frequency distribution of dogtooth tuna (Fig. 3). The maximum size recorded earlier was 126 cm FL from Lakshadweep (Sivadas and Anasukoya, 2005), 110 cm from Western Atlantic Ocean, 150 cm from Pacific Ocean (Collette and Nauen, 1983). The largest dogtooth tuna recorded from recreational fishery is of 248 cm FL (IGFA, 2001) and 131 kg total weight (Collette and Nauen, 1983). The length-weight relationship derived is $W=0.0105L^{3.065}$.

Table 1. Estimated landings (t) of *Gymnosarda unicolor* during 2006-2010

Year	Kerala	Lakshadweep	Andaman and Nicobar	All India
2006	-	16	94	110
2007	-	15	96	111
2008	4	-	106	106
2009	50	6	97	153
2010	56	4	105	165
Average	22	8	100	130

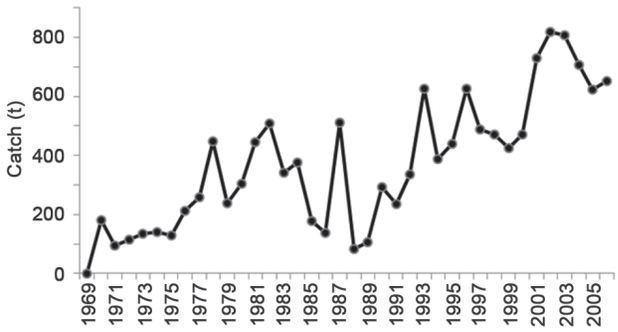

Fig. 2. Global capture production of *G. unicolor* during 1969-2006

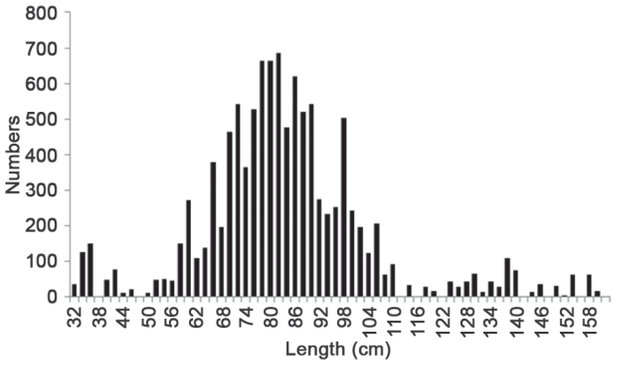

Fig. 3. Length frequency distribution of *G. unicolor* from south-west coast of India

Maturity and spawning season

The species mature and spawn round the year. Ripe and spent fishes (stage IV) were seen almost throughout the year with large proportion during August-March indicating peak spawning period (Fig. 4). Young recruits enter the fishing grounds during most part of the year with peak during February-May. The estimated length at first maturity was 69.0 cm (Fig. 5). Relative fecundity estimated for this species was 3,15,244 per kg body weight.

Earlier studies indicated that peak spawning was during May–June off Ogasawara and Ryuku Islands; during March, August and December along the coast of Samarai, Papua (Dunstan, 1961). As this species is distributed in

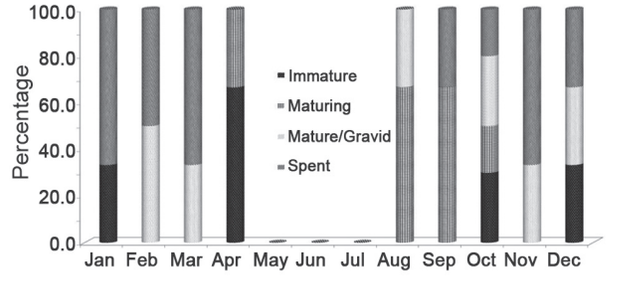

Fig. 4. Distribution of different stages of maturation in *G. unicolor*

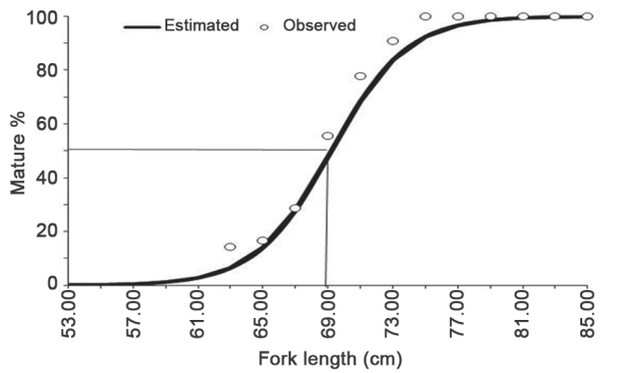

Fig. 5. Length at first maturity of *G. unicolor*

different parts of tropic and subtropic regions of Indian and Pacific oceans, the spawning season also shows variability between regions (Silas, 1963).

Lewis *et al.* (1983) estimated the length at first maturity as 65 cm FL at Fiji and Sivadas and Anasukoya (2005) observed that fishes above 70 cm are mature at Minicoy. Most of the earlier studies indicated that the species has one spawning season per year and shed the eggs as batches (Kishinouye, 1923; Schultz, 1960). There are several spawning grounds like Papua off Samarai, off Mafia Islands, east Africa, Marshall Islands, off Ryukyu Islands, Japan and off Port Blair.

Growth parameters

The estimated VBGF parameters of the species are L_{∞} =163 cm, K= 0.43 yr^{-1}, t_0= -0.12 (Fig. 6). The values obtained in the present study are well within the ranges known for this species. Sainsbury and Whitelaw (1984) derived von Bertalanffy growth curve of dogtooth tuna from Australia and inferred that the growth parameters differ significantly between sexes. The important population values and ratios like $L_{opt,}$ Lm/L_{∞} and L_{opt}/L_{∞} were estimated as 75.8 cm, 0.04217, and 0.463 respectively. The value of W_{∞} was estimated as 64 kg from the length-weight relationship, the values of t_r estimated as 0.513 year taking 32.4 cm as the smallest length at recruitment (L_r) and t_c=2.0 year from L_c=94.4 cm estimated from length converted catch curve for *G. unicolor.*

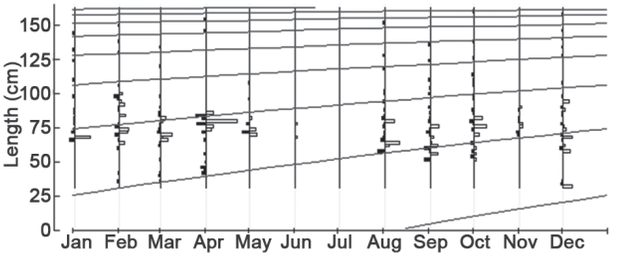

Fig. 6. Restructured growth curve of *G. unicolor*

Age and growth

The estimated t_{max} was 12 years and it reaches 56.6 cm, 94.0 cm, 118.3 cm, 134.1 cm, 158.3 cm and 162.6 cm by the end of 1, 2, 3, 4, 8 and 12 years of life. The growth of *G. unicolor* observed in the present study can be compared with the other oceanic tuna species (Collette and Nauen, 1983; Kuiter and Tonozuka, 2001). The growth curves estimated in the present study are consistent with those estimated by other authors for this species (Collette and Nauen, 1983; Torres, 1991; Kailola *et al.,* 1993). The lower L_{∞} and K values and higher t_0 as compared to those reported from other areas could be attributed to different reasons. The major reason could be the restricted size range in samples particularly lack of large fish. Also the difference in growth patterns can be the results of the difference in habitat temperature, density of food and other habitat conditions (Wood, 1953; Pauly, 1994).

Mortality

The estimated total mortality (Z), natural mortality (M) and fishing mortality (F) of *G. unicolor* for the period 2006-2010 were 1.06, 0.527 and 0.49 (Fig. 7) respectively. The results obtained by catch curve method were taken for the stock assessment studies. The reliability of the estimated M was ascertained using M/K ratio because this ratio has been reported to be within the 1.12 -2.5 range for most fishes (Beverton and Holt, 1957). The value of M/K ratio obtained in the present study was 1.333. Hence the estimated M values can be considered reliable. The recruitment pattern depicted in Fig. 8 indicate, one major and one minor peak.

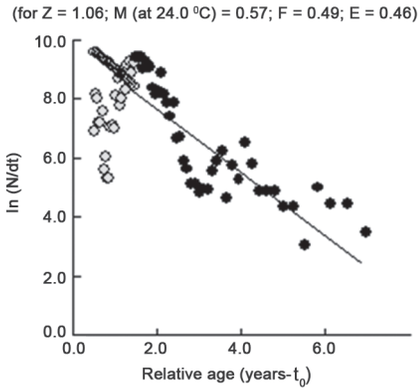

Fig. 7. Length converted catch curve of *G. unicolor*

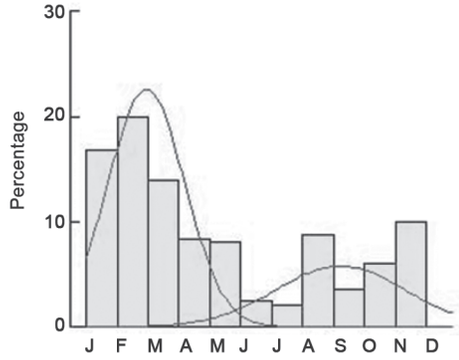

Fig. 8. Recruitment pattern of *G. unicolor*

Stock assessment

Estimated catch of 1,393 t of *G. unicolor* formed about 1.5% of all India tuna catch. The total stock (Y/U) in the fishing ground was about 4,769 t (2006-2010) while the standing stock (Y/F) was 2,940 t. The average estimated fishing mortality (F) was 0.49 with exploitation ratio (U) of 0.3021. Beverton and Holt's Y/R analysis shows that the MSY of 2,400 t can be achieved by increasing the effort up to six times the present level indicating scope for further exploitation of the resource from the Indian coast.

The fishery data indicate their presence in appreciable numbers in the seas around Andaman-Nicobar, Lakshadweep and oceanic ridges and associated seamounts. Fishery is at its initial phase and stock assessment and fishery evaluation indicate considerable scope for increasing their production. Gathered information indicates good potential for recreational fishery along the areas of their abundance.

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