Fishery and population dynamics of *Epinephelus malabaricus* (Bloch & Schneider, 1801) off Tuticorin, southeast coast of India

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Original Article

Abstract

Fishery, population characteristics and stock estimates of grouper with special reference to *Epinephelus malabaricus* from Tuticorin were carried out during 2015-2017. Among the groupers, *E. malabaricus* was the dominant resource contributing 42.2%, with an annual average production of 420t along this region. The asymptotic length (L_∞), growth coefficient (K) and arbitrary origin of growth (t_0) were estimated at 99.75 cm, 0.53 y^{-1} and 0.18 respectively. The mortality parameters, the instantaneous total mortality rate (Z), fishing mortality (F) and natural mortality rates (M) were estimated at 1.14 y^{-1}, 0.62 y^{-1} and 0.52 y^{-1} respectively. The recruitment season was during April to August. The length structured virtual population (VPA) analysis revealed a heavy fishing pressure on length group between 40 and 55cm and there is no sign of recruitment over-fishing in this region. The estimated maximum sustainable yield (MSY) and annual catch were 384 t and 420 t respectively. *E. malabaricus* was optimally exploited as the exploitation ratio (E) was 0.54 but the study infers that further increase in effort may have a detrimental effect on the stock of this species. The results of this study will serve as baseline information for formulating future management measures for the resource along the coast.

Introduction

The family Serranidae is a diverse group of fishes, of which the genus *Epinephelus* commonly known as groupers is the largest one with several species. Groupers are commonly caught in reef areas of tropical and warm-temperate latitudes and are targeted because of their tasty flesh and high value in the live export trade. The Malabar grouper, *Epinephelus malabaricus* (Bloch and Schneider, 1801) is listed in the International Union for the Conservation of Nature (IUCN) as data deficient (Samoilys *et al.*, 2018). It is one of the largest and most common grouper found in the Red Sea, the Indo-Pacific region, Southeast Asia and Australia (Murata *et al.*, 2010). The adults of this species are found in a variety of habitats, including coral and rocky reefs, tide pools, estuaries, mangrove swamps and sandy/muddy bottom from the shore to depths of 150 m, while juveniles are found near shore and also in estuaries (Heemstra and Randall, 1993). *E. malabaricus* primarily feeds on fishes and crustaceans and occasionally on cephalopods and are mainly caught in

trawls, long lines, traps, spear and hook-and-line (Heemstra and Randall, 1993; Kirubasankar *et al.*, 2013).

E. malabaricus has a complex life-history and is a protogynous hermaphrodite. Sexual maturity in males does not occur until they are 114 cm long (Lau and Li, 2000) and do not change sex from female to male until 10 years of age (Murata *et al.*, 2010). Moreover, this species has a very low resilience to fishing, with a minimum population doubling time of more than 14 years (Froese and Pauly, 2018). In Indian waters, stock estimates and studies on different grouper species were done by several authors (Premalatha, 1989; Ameer and Kasim, 1992; Chakraborty, 1994; Rangaswamy *et al.*, 1999; Manojkumar, 2005; Sivakami and Seetha, 2006; Jayasankar *et al.*, 2007; Sujatha *et al.*, 2010; Kirubasankar *et al.*, 2013). Studies on population dynamics and stock characteristics of genus *Epinephelus* were done by very few authors (Manojkumar, 2005; Mehanna *et al.*, 2013; Richu *et al.*, 2018). However, information on the stock assessment more specifically on *E. malabaricus* from Indian waters is scanty with an exception of a publication by Kirubasankar *et al.* (2013) from the Andaman Islands. Growth, mortality and recruitment studies are key parameters for assessment of a fish stock (Manojkumar, 2005). Hence, a study was undertaken to assess the stock status of *E. malabaricus* and the impact of fishing pressure on this important species exploited along this region. This attempt on the fishery and stock assessment of *E. malabaricus* from Gulf of Mannar, southeast coast of India is the first of its kind in the Indian mainland.

Material and methods

The data pertaining to the catch and effort of groupers including *E. malabaricus* from different gears operating in Tuticorin for eight years from 2010 to 2017 were collected from the Fisheries Resource Assessment Division, ICAR-Central Marine Fisheries Research Institute (CMFRI). The data on the length frequency distribution of *E. malabaricus* comprising 1,675 specimens were collected for a period of three years from 2015 to 2017 through a random sampling technique on a weekly basis following Alagaraja (1984) and for stock assessment studies the samples were collected from the Hook and Lines (H & L) operating along the Tuticorin coast as the bulk of the catch was landed from this gear. Length frequencies were raised to correspond to the weight of the catch assessed for the day and subsequently for the month following Sekharan (1962). The age and growth were assessed using the FiSAT computer software II (Gayanilo *et al.*, 2005). The asymptotic length (L_∞), growth coefficient (K), recruitment pulses and arbitrary origin of growth (t_0) values were analyzed by non-parametric scoring of von Bertalanffy growth function (VBGF) fit using ELEFAN-1. The total mortality rate (Z) was estimated by the length converted catch curve method (Pauly, 1983) using FiSAT. The natural

mortality (M) was estimated by Pauly's equation considering the mean annual temperature (Pauly, 1984). The coefficient of fishing mortality (F) was derived by using the relationship, F = Z-M. The length structured VPA of FiSAT was used to find out the size of each length group of *E. malabaricus*, their natural and fishing mortality. The annual stock, (B=Y/F) was estimated using annual catch where, Y is Yield, and F is fishing mortality. The Maximum Sustainable Yield (MSY) was estimated using the equation described by Gulland (1959) for exploited fish stock, MSY = Z×0.5×B. Yield isopleth diagrams of *E. malabaricus* were derived by FiSAT using L_{50}/L_∞ and F/Z value.

Results and discussion

Craft and Gears

The gears in which *E. malabaricus* landed along the Tuticorin coast are the mechanized trawl fleet consisting of 12-28 m length overall (OAL) fitted mostly with 150 HP engines or even more was operated for single day fishing in this region. The boats are designed for stern trawling with power winches. The gear employed consisted of two or four-seam trawls with the head rope length ranged from 12 to 15 m and the cod end mesh size ranged from 15 to 30 mm. The fishing operation was carried out up to a depth of 120 m or even more. For gill net operation, motorized plank built wooden or FRP boats fitted with inboard or outboard engine with the OAL 8 to 12 m fitted with 9.9 to 110 HP engines are used along Tuticorin coast. The mesh size of gear ranged from 85 to 145 mm. Fishing is either single day or multiday and fishing operation is carried out up to a depth of 60 m. Handlines and longlines were mostly operated by the fishermen of Therespuram, Amali Nagar, Iniconagar and Kombudurai fishing villages. Therespuram fishermen operate longlines seasonally, mainly during November to May; Kombudurai and Iniconagar fishermen operate longlines from January to August whereas the Amalinagar fishermen operates throughout the year. The craft OAL is 8 to 10 m fitted mostly with outboard engines with 9.9 to 15 HP. The main line length was from 2000 to 6000 m with 100 to 150 branch lines for longlines whereas for handline, the main line length was from 50 to 120 m. 'J' type hooks with the hook numbers ranging from 4 to 8 were used.

Fishery

The result of the study conducted showed that from Tuticorin coast, *E. malabaricus* supports an important and a dominant fishery whereas other grouper species occur in small quantities in the catch. The highest landing of grouper was recorded in 2015 (1201 t), thereafter the fishery has shown a declining trend. The annual estimated landings of grouper during 2010-2017 varied from of 725 t (2014) to 1201 t (2015) with an average

contribution of 905 t constituting 10 % of the total catch (Fig. 2). The landing of these resources by hook and line fishing at Tuticorin accounted for nearly 59 % of the exploited total groupers along the coast. The fishery along the coast does not form any pattern and it showed wide fluctuations during the seven-year period. The average annual of *E. malabaricus* contribution to total grouper landings in the trawl net, gill net, H & L and other gears were 22.0%, 27%, 50.0%, and 1.0% respectively.
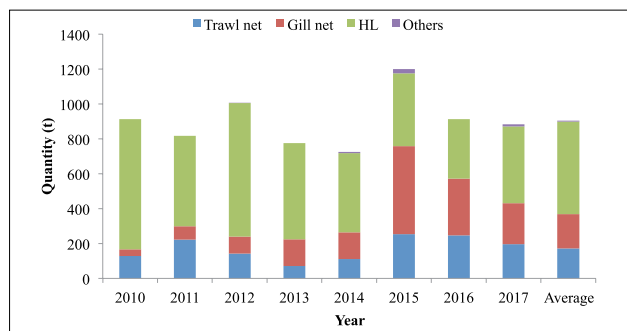

Fig. 1. Gearwise annual landings (t) of groupers in Tuticorin

Species composition

In total, seventeen species of groupers were recorded during the study period (Fig. 2). They were *Epinephelus malabaricus* (42.2%), *E. bleekeri* (11.0%), *E. longispinis* (8.1%), *E. undulosus* (8.0%), *E. fuscoguttatus* (5.0%), *E. coioides* (5.0%), *Cephalopholis urodeta* (4.0%), *C. formosa* (4.0%), *C. miniata* (0.2%), *E. areolatus* (3.0%), *E. merra* (2.0%), *E. faveatus* (2.0%), *E. fasciatus* (2.0%), *E. coerleopunctatus* (0.8%), *E. flavocaeruleus*
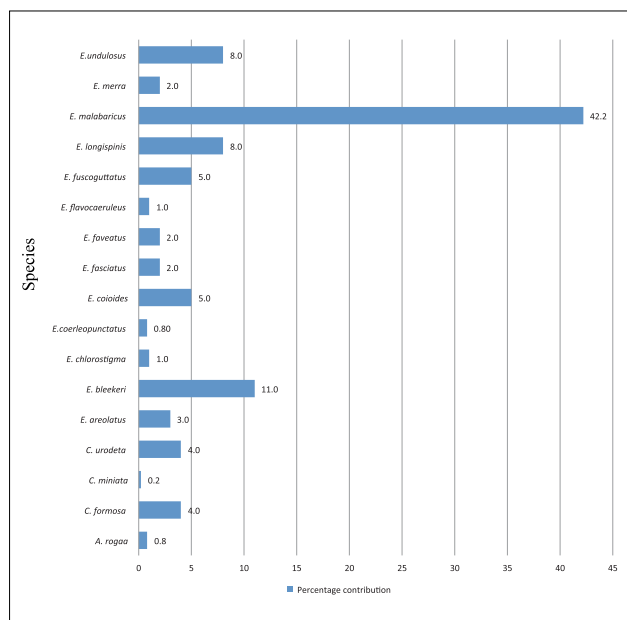
(1.0%), *E. chlorostigma* (1.0%), and *Aethaloperca rogaa* (0.8%). Among all the species of grouper occurring along the Tuticorin coast, *E. malabaricus* was the dominant species. In India, thirty-eight species of groupers have been reported from the seas wherein the *E. malabaricus* is a common species along the west coast of India and in the Gulf of Mannar (James *et al.*, 1996) as observed in the present study.

Catch rate

The annual average catch rate of grouper in trawl net ranged between 0.35 kg per hr (2010) and 0.72 kg per hr (2015) with an average of 0.46 kg per hr. In gill net, the catch rate fluctuated between 0.13 kg per unit (2010) and 2.14 kg per unit (2015) whereas in hook and line the catch rate ranged between 5.07 kg per unit (2014) and 8.90 kg per unit (2010) with an average of 7.07 kg per unit. Overall, the catch rate has shown a declining trend from 2014 to 2015 but showed a slight increase in 2017 (Fig. 3). A comparison of effort, catch and catch rate showed that even though the effort increased there was no such corresponding trend in the catches of groupers during most of the study period. Sujatha *et al.* (2010) reported that *E. malabaricus* were represented both in traditional gear and trawl catches of the north Andhra region, large-size specimens of these species were also caught with hook and line from deeper waters but does not show any trend in the landings.
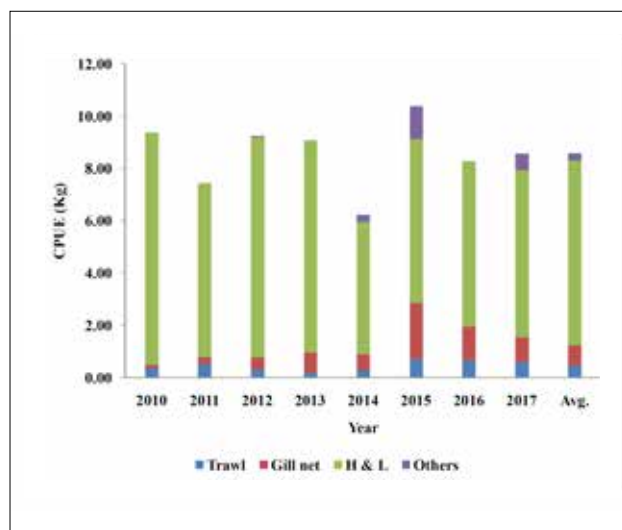

Fig. 3. CPUE (Kg) of groupers in Tuticorin

Age and Growth

In the present study, multiple modes could be seen in the monthly length frequency data and traceable modes for two consecutive months were used to assess the growth of cohorts from 2015 to 2017 of *E. malabaricus*. The von Bertalanffy's

Fig. 2. Species composition of groupers in Tuticorin

Growth Function (VBGF) plot is given in Fig. 4. The estimated growth parameters, *ie.*, asymptotic lengths (L_∞) and growth coefficient (K), were 99.75 cm and 0.53 y^{-1} respectively. The estimated maximum lifespan was found to be 9 years. Kirubasankar *et al.* (2013) got higher values from Andaman Islands and the estimated growth parameters from length data of *E. malabaricus* landed on Andaman Islands were, L_∞ = 124.60 cm and K = 0.80 y^{-1}. The factors explaining the relationship between the natural mortality coefficient and the growth coefficient (M/K) obtained in the present study were 0.98 and it is well within the normal range of 1 to 2.5, as suggested by Beverton and Holt (1959). The generalized VBGF growth equation is $L_t = 99.75 \{1 - e^{-0.53(t-0.18)}\}$
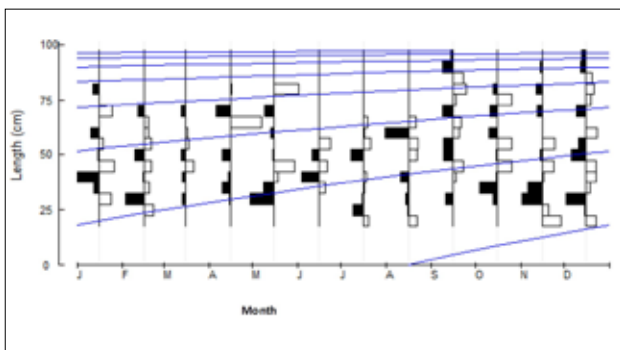

Fig. 4. von Bertalanffy's Growth function (VBGF) plot of *E. malabaricus* exploited off Tuticorin

Mortality, virtual population analysis, and recruitment pattern parameters

The mortality parameters, exploitation ratio and exploitation rate of *E. malabaricus* are given in Table 1. The average natural mortality (M) was found to be 0.52. The average fishing mortality coefficient (F) was 0.62 and the estimated exploitation ratio (E) was 0.54. The estimated Z values of *E. malabaricus* by length converted catch curve method was 1.14. The calculated Z and M were lower when compared to the stock of the same species in Andaman waters. It could be inferred that fishing mortality was higher compared to natural mortality and the same trend was evident in Andaman waters (Kirubasankar *et al.*, 2013).

The recruitment pattern of *E. malabaricus* showed a distinct peak with maximum recruitment during April-August contributing to 75% of total recruitment (Fig. 5). The highest recruitment took place in July (18%) and the lowest in September (5%). In Andaman waters, *E. malabaricus* recruited with a peak during April to July (Kirubasankar *et al.*, 2013). However, in the present study, only one major peak season could be observed from June to July in Tuticorin coast. The major recruitment season coincides after the monsoon ban in the southeast coast of India. The results of the length structured Virtual Population Analysis (VPA) employed to recognize the level of mortality on various length groups are shown in Fig. 6. The fishing pressure on *E. malabaricus* was more in the length group between 40 cm and 55 cm. Higher fishing pressure was recorded in the terminal length group (56.0 cm to 65.0 cm) for *E. malabaricus* in Andaman waters (Kirubasankar *et al.*, 2013).
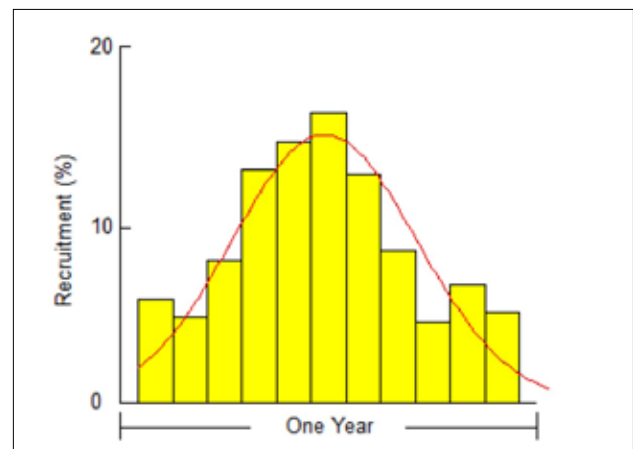

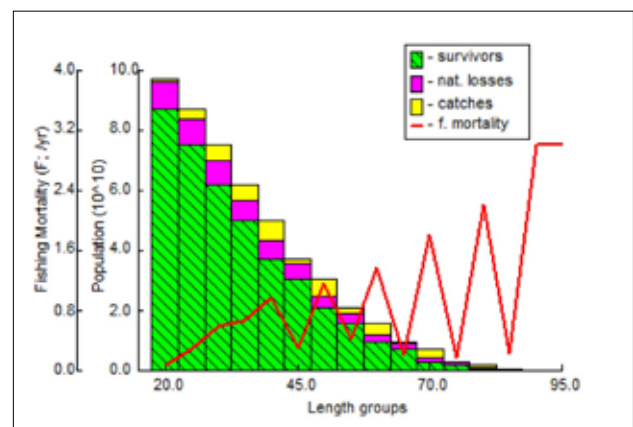Fig. 5. Recruitment pattern of *E. malabaricus* off Tuticorin

Fig. 6. Length structured Virtual Population Analysis of *E. malabaricus* exploited off Tuticorin

Stock assessment

The annual catch, annual stock and MSY estimated for *E. malabaricus* are presented in Table 2. The average estimated

Table 1. Mortality parameters and exploitation ratio of *E. malabaricus* of Tuticorin

Year	Natural Mortality (M)	Fishing mortality (F)	Total instantaneous mortality (Z)	Exploitation ratio (E)
2015	0.52	0.62	1.14	0.54
2016	0.52	0.61	1.13	0.53
2017	0.52	0.65	1.17	0.55
Average	0.52	0.62	1.14	0.54

Table 2. Annual catch, annual stock and MSY of *E. malabaricus* of Tuticorin

Year	Annual catch (Y) (t)	Annual stock B =(Y/F) (t)	MSY (t)	Difference between catch and MSY (t)
2015	504	813	464	40
2016	384	630	356	28
2017	371	571	334	37
Average	420	671	384	36

MSY was 384 t and the annual catch was 36 t in excess of MSY. The MSY was lower compared to the result obtained for Andaman Island (Kirubasankar *et al.*, 2013). The yield per recruit for *E. malabaricus* is shown in Fig. 8. The L_c/L_∞ for the present exploitation ratio is 0.54 and it has been predicted that maximum yield is possible at the present level of exploitation. Yield isopleth is one of the prediction tools in stock assessment studies. The yield isopleths gives an idea about the present level of yield per recruit with the various possible combinations of exploitation rate (Gayanilo *et al.*, 2005). The study suggests that yield of *E. malabaricus* marginally exceeded its MSY level, hence the effort may be maintained at the current level for the exploitation of this resource.
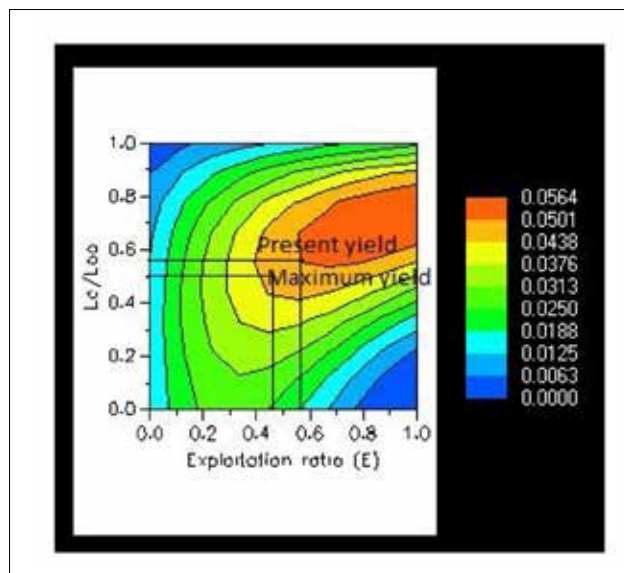
Fig. 7. Yield isopleths of *E. malabaricus* exploited off Tuticorin

Acknowledgements

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