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Fishery and Exploitation of Malabar Grouper, *Epinephelus malabaricus* (Bloch & Schneider 1801) from Andaman Islands

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Abstract

The fishery and population dynamics of groupers from Andaman Islands were studied from Jan 2010 to Dec 2011 with a special emphasis on Malabar grouper, *Epinephelus malabaricus* (Bloch & Schneider 1801). The average annual catch of Malabar grouper was 1,296 tonnes contributing to 21.6% of annual grouper landings. Length-weight relationship of Malabar grouper showed that growth was allometric (b=2.96) and relative condition factor (Kn) was 1 and the growth parameters *viz.,* L_∞, K and t_0 were 124.60 cm, 0.80 and -0.05 respectively. The recruitment pattern was unimodal with one major peak during April to July throughout the study period. The natural mortality (M), fishing mortality (F) and total mortality (Z) were 1.05, 1.48 and 2.53 respectively and exploitation rate (E) was 0.58. The M/K ratio (1.31) was found to be well within the normal range of 1to 2.5. Catch per unit effort varied from 4 to16.5 $kg.h^{-1}$. The maximum sustainable yield (MSY) was 1,107 tonnes which was lower than the average annual catch (1,296 tonnes), indicating over exploitation. The current study calls for further research in identifying the grouper fishing and spawning aggregation grounds and introduce measures for reducing fishing efforts with input and output controls to sustain the Malabar grouper fishery in Andaman waters.

Introduction

Epinephelus malabaricus (Bloch & Schneider 1801) is one of the most important groupers in fisheries and aquaculture of the Indo-Pacific; it is also one of the most common for live export trade and caught employing trawls, long-lines, traps, spear and hook-and-line (Heemstra and Randall 1993). Commonly known as Malabar grouper, this species is found in the Red Sea, the Indo-Pacific area (South Africa to Japan, Australia, Palau, Yap and Fiji), Southeast Asia and the Northern Territory to New South Wales of Australia. They are protogynous hermaphrodite and do not change sex from female to male until after approximately 10 years of age (Murata et al. 2010). *Epinephelus malabaricus* is one of the 13 principal species in the live-fish trade which sources wild-caught and maricultured large reef fishes from the Indo-Pacific for export primarily to Hong Kong, China (Sadovy et al. 2003). *Epinephelus malabaricus* is targeted at all life history stages throughout its range, including for the live reef food fish trade and is undoubtedly heavily fished, and probably

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overfished in some countries, resulting in reduction of their population to a significant extent. This could be attributed to their large maximum size, late age of sexual maturity of more than 5 years in males, sex change, and correspondingly low resilience to fishing.

Epinephelus malabaricus, along with other members of the Serranidae and Lutjanidae families constitute a major group of commercially important fishery of Andaman and Nicobar Islands (ANI). Despite their increasing demand for the export market in the Southeast Asian countries, there are no comprehensive studies on fishery and exploitation of groupers from the Andaman waters. Since assessing the stock of the targeted species is very important for better management of fishery resources (Shaklee and Bentzen 1998), the present investigation was carried out to ascertain the fishery and population dynamics of groupers of ANI with a special emphasis on *E. malabaricus* including its recruitment pattern, mortality (natural and fishing mortality) and inherent growth parameters. Fishing is banned for a period of 45 days from April 15 to May 31 annually in ANI considering the monsoon onset and breeding season of marine fishes. The restriction is mainly applicable to mechanised trawlers, gill netters and purse seiners whereas hand-lining using traditional motorised boats are permitted.

Materials and Methods

Data, with respect to catch and effort and morphometrics of *E. malabaricus* were collected weekly from landing centres of South Andaman for a period of 2 years from January 2010 to December 2011. The monthly and annual estimates of catches were calculated by adopting the methods of Srinath et al. (2005). For observation purpose, a month was divided into three groups, each of 10 days. From the first 5 days of a month, a day was selected at random, and the next 5 consecutive days were automatically selected. From this, three clusters of two consecutive days were formed. For example, for a given zone, in a given month, from the 5 days if the date (day) selected at random is 4, then these clusters are formed, namely, (4, 5); (6, 7) and (8, 9) in the first 10 day group. In the remaining 10 day groups, the clusters were systematically selected with an interval of 10 days. For example, in the above case, the cluster of observation days in the remaining groups were (14, 15), (16, 17), (18, 19) (24, 25), (26, 27) and (28, 29). Normally, in a month there would be nine clusters of 2 days each. Among the total number of landing centres in the given zone, nine centres were selected with replacement and allotted to the nine cluster days as described earlier. Thus in a month, nine landing centre days were observed. The length-weight relationship of *E. malabaricus* was calculated as $W= aL^b$ (Le Cren 1951). For estimating von Bertalanffy growth parameters, L_∞ and K, the month-wise length composition data of 2 years were pooled and analyzed using the ELEFAN I module of FiSAT software version 1.2.0 (Gayanilo et al. 1996). An additional estimate of L_∞ and Z/K values obtained using the Powell-Wetherall plot was compared with the estimates obtained from ELEFAN I before arriving at the final values. The growth performance index Ø was calculated from the final estimates of L_∞ and K (Pauly and Munro 1984). The growth and age were determined using the von Bertalanffy growth equation, $L_t = L_\infty (1-e^{-k(t- t_0)})$. The recruitment pattern was studied from recruitment curves using final estimated values of L_∞, K and t_0.

Longevity was estimated from $t_{max} = 3/K + t_0$, adopting the method of Pauly (1983). Natural mortality (M) was calculated by Pauly's empirical formula (Pauly 1980), taking the mean sea surface temperature to be 29°C (Mohanraj et al. 2009) and total mortality (Z) was calculated from the length converted catch curve (Pauly 1983) using the FiSAT software. Fishing mortality (F) was estimated by F = Z - M. Exploitation ratio was estimated from the equation, E = F/Z and exploitation rate from $U = F/Z \times (1-e^{-z})$; where, F is the fishing mortality rate.

Total stock (P) and biomass or standing stock (B) were estimated from the ratios Y/U and Y/F respectively; where Y is the annual average yield in tonnes. Maximum sustainable yield (MSY) was calculated by the equation (Gulland 1979) for exploited fish stocks, $MSY = Z \times 0.5 \times B$. The relative yield per recruit (Y/R) and biomass per recruit (B/R) at different levels of F were estimated from the Beverton and Holt yield per recruit model.

Results

Species composition

A total of 21 groupers were recorded during the landing centre surveys. *Epinephelus malabaricus, Epinephelus fuscoguttatus* (Forskal 1775), and *Plectropomus* sp were the most targeted species for the export market. Apart from these, *Epinephelus fasciatus* (Forskal 1775), *Epinephelus tauvina* (Forskal 1775), *Epinephelus merra* Bloch 1793, *Cephalopholis argus* Bloch & Schneider 1801, *Cephalopholis miniata* (Forskal 1775), *Variola louti* (Forskal 1775), *Aetheloperga rogaa* (Forskal 1775) were the other most prominent species landed during the study. Details with respect to the mean morphometric parameters of the groupers landed during the study period are summarised in Table 1.

Table 1. Mean morphometric parameters of the groupers landed during the study.

Name of the species	Mean Length	Mean Weight
Cephalopholis argus	43.87 ±3.70	1.32 ± 0.25
Epinepheleus fasciatus	27.66 ± 2.46	0.32 ± 0.07
Epinepheleus caeruleopunctatus	36.72 ± 0.37	1.29 ± 0.05
Epinepheleus fuscoguttatus	80.65 ± 1.17	5.56 ± 0.17
Epinepheleus merra	24.06 ± 0.86	0.29± 0.11
Epinepheleus tauvina	38.51 ± 2.52	1.61 ± 0.37
Epinepheleus bleekeri	40.82 ± 3.00	1.22 ± 0.23
Variola louti	74.00 ± 3.12	4.62 ± 0.53

Fishery

The fishing fleet consisting of artisanal crafts (5 to10 m overall length) with 12 to 25 HP were used for grouper fishing. Line fishing was the major gear used in depths ranging from 10 to100 m. The average annual catch of *E. malabaricus* was 1,296 tonnes which comprised 21.6% of the total grouper catch and 4.3% of annual marine landings. The catch per unit effort (CPUE) for *E. malabaricus* ranged between 4 to16.5 $kg \cdot h^{-1}$ with a mean of 10.25 $kg \cdot h^{-1}$. However the expressed CPUE was collected from fishermen's experience since there was insufficient data to express the CPUE using either $kg \cdot h^{-1} boat^{-1}$ or $kg \cdot h^{-1} fisher^{-1}$.

Growth parameters

Growth parameters *viz*., L_∞ and K (annual) estimated using the ELEFAN I programme were 124.60 cm and 0.80 respectively. The growth performance index Ǿ was found to be 3.717 and t_0 was calculated at -0.0527 years. The M/K ratio (1.31) obtained in the present study was well within the normal range of 1 to 2.5, as suggested by Beverton and Holt (1959). The von Bertalanffy growth equation was: $L_t = 124.60\ [1 - e^{-0.80\ (t + 0.0527)}]$.

Recruitment pattern

The mean ± SD monthly variations in length frequency of *E. malabaricus* are presented in Fig 1. Mean length of *E. malabaricus* ranged from 14 to120 cm (mean 59 ± 24.08 SD; *n* = 1,168) during 2010 and it ranged from 28 to 120 cm (mean 61 ± 24.48; *n* = 1,735) during 2011. Mean length was maximal during April (89.92 cm) and May (90.13 cm) 2010 and it was minimal (50.74 cm) in July 2010 whereas during 2011, maximal mean length was reported in the month of August (74.53 cm). Sexes were pooled during landing data collection. Recruitment was unimodal (Fig. 2) with the major peak occurring during April to July.

Mortality parameters

Total mortality (Z), natural mortality (M) and fishing mortality (F) were found to be 2.53, 1.05, and 1.48 respectively. (Fig. 3 and 4) The exploitation rate (E) calculated using fishing and total mortality was 0.56, indicating overexploitation (E > 0.5).

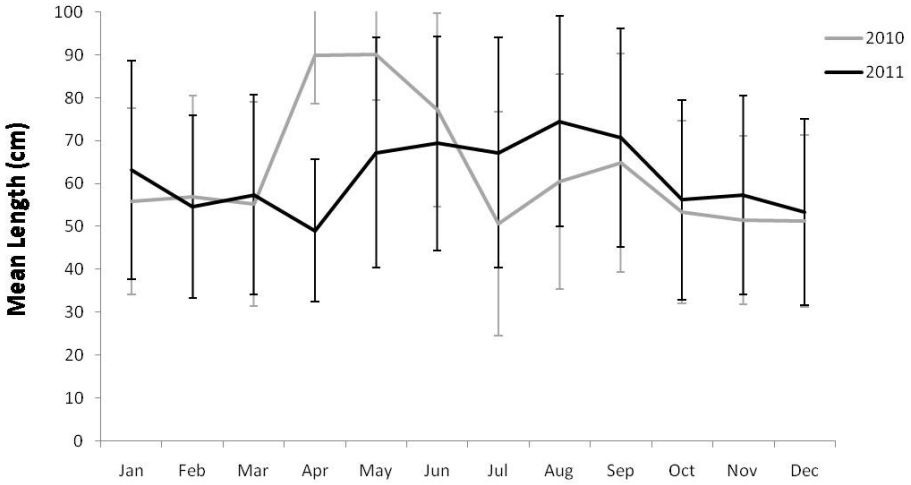

Fig. 1. Mean ± SD monthly length of *Epinephelus malabaricus.*

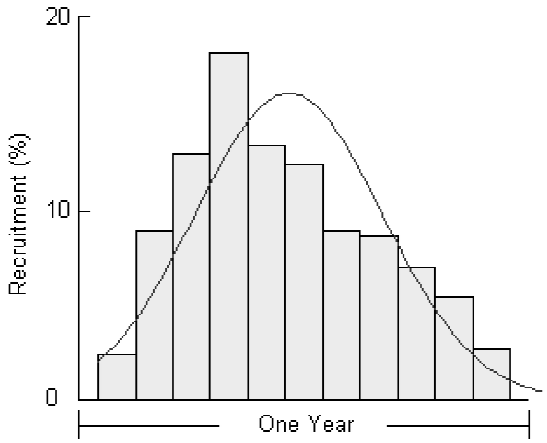

Fig. 2. Recruitment (%) of *Epinephelus malabaricus* in Andaman waters $L\infty = 124.80$ cm, $K = 0.80$ yr^{-1} and $t_0 = -0.0527$ years.

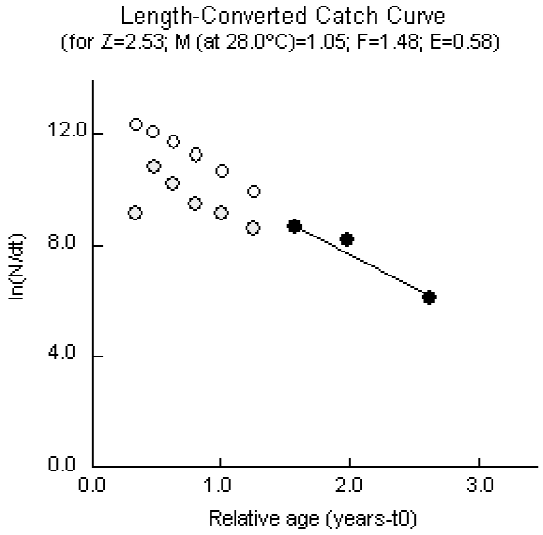

Fig. 3. Length converted catch curve of *Epinephelus malabaricus.*

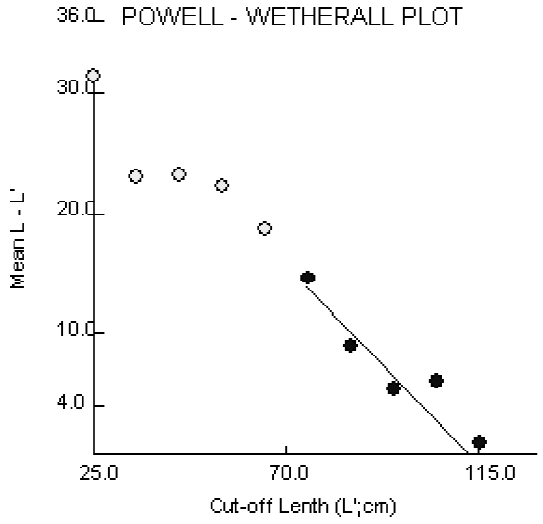

Fig. 4. Power Wetherall plot of *Epinephelus malabaricus.*

Maximum sustainable yield

The maximum sustainable yield was calculated using (MSY= Z×0.5×B) for exploited stocks where Z is total mortality, and B is biomass calculated using B=Y/F where Y is total annual catch and F is fishing mortality. The MSY value corresponded to 1,107 tonnes which was less than 20% of the total annual catch (1,296 tonnes) of *E. malabaricus* indicating over exploitation.

Discussion

Groupers, in recent years have assumed commercial importance in view of their good quality meat and greater consumer demand, in local and export markets (Manojkumar 2005). Since the grouper fishing grounds are mostly located at depths of 10 to 100 m, the potential of such species beyond those depths are largely unknown, attributable to the unorganized deep-sea fishing in Andaman Islands and the bottom with patchy reefs which limits trawler operations.

The length-weight relationship explains that the exponent 'b' in the parabolic equation usually lies between 2.5 and 4.0, and for an ideal fish which maintains constant shape, b=3. In our present investigation, the slope (b=2.97) was slightly lesser than 3 indicating allometric growth. Badhul-Haq et al. (2011) reported that the slope values (b) of males, females and juveniles of *E. malabaricus* from the coastal waters of Mandapam (south east coast of India) centered around 2.05, 2.78 and 2.01 respectively for 2009 and 2.66, 2.80 and 2.35 respectively for 2010, indicating allometric growth. However, Gaspare and Bryceson (2013) from Tanzania reported *E. malabaricus* with 'b' value (3.08), indicating allometric shape. The coefficient of determination was found to be above 90%, which indicated over 90% of variations in weight were explained by length.

Mean length of *E. malabaricus* ranged from 14 to 120 cm (mean 59 ± 24.08 SD; n = 1,168) during 2010 and 28 to 120 cm (mean 61 ± 24.48; n = 1,735) during 2011. Gaspare and Bryceson (2013) reported that in Tanzanian waters the length of *E. malabaricus* females ranged from 25 to 113 cm with mean TL 66.6 ± 15.4 cm; n = 136) and males from 97 to114 cm with mean TL 102.8 ± 4.7 cm; n = 36). Since Malabar groupers are forbidden to handling considering their export market, sex was pooled in this study. Fishing of *E. malabaricus* is banned during April to May in Andaman Islands for gill netters, purse seiners and trawlers but fishing with line nets is allowed and not affected by ban.

Based on the fishing and total mortality, the exploitation rate (E) was found to be 0.60, indicative of the fishing pressure on this species in depths ranging from 50 to100 m. The fishing mortality (1.48) is more than natural mortality (1.05) which indicates biological overfishing is occurring. The maximum sustainable yield (MSY) was found to be 1,107 tonnes based on our present study whereas annual average catch is 1,296 tonnes which indicates this species was being overexploited.. Though deep sea exploitation is not familiar in ANI, exploitation of specific species such as groupers and sharks were in vogue since they fetch good export price compared to other fish landings.

Conclusion

Line-fishing is one of the fishing methods traditionally used for harvesting demersal fisheries. Malabar groupers are targeted with this fishing method considering their high demand for export in Southeast Asian countries. The current fishing ban period for a period of 45 days a year (from April

15 to May 31) may not have significant impact on revival of grouper stock as the ban is largely applicable to the mechanized trawlers only and the artisanal vessels are permitted to exploit the demersal fishery resources employing line-fishing. Groupers like *Plectrpomus areolatus* (Ruppell 1830), *E. fuscoguttatus* (Pet et al. 2005) and *E. striatus* (Smith 1972; Domeier and Colin 1997; Bolden 2000; Sala et al. 2001) are reported to form aggregations for spawning. Studies on *E. malabaricus* spawning aggregations in Andaman Islands will be an interesting area for future research. The study indicates that Malabar grouper are being overexploited in Andaman Islands. Reducing the fishing effort would be an important area to be addressed in order to manage the sustainable fishery of Malabar grouper. Input controls such as number and size of vessels allowed for fishing, vessel usage controls (the amount of time the vessels are allowed for fishing), gear restrictions (hook sizes to be used) and output controls such as catch quotas (restricting the number of fishes that may be landed in a day) are some of the controls that can be applied for grouper fishery management and if the species is heavily fished at grounds where spawning aggregations occur then protection (spatial or seasonal) could be considered. Further research is needed to determine whether the species spawns in aggregations in Andaman waters.

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