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Age, growth, mortality and yield per recruit of the humpnose big-eye bream *Monotaxis grandoculis* (Forsskål, 1775) from Hurghada, Red Sea, Egypt

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ABSTRACT

The humpnose big-eye bream, *Monotaxis grandoculis* is one of the economically important lethrinid species inhabiting the Egyptian Red Sea and has never been studied before in this area. The objective of this study is to estimate the age and growth parameters, mortality, and yield per recruit of *M. grandoculis* to assess its status and give the basic parameters required for its rational exploitation. A total of 438 specimens (135 male and 303 female) were collected monthly from January to December 2020 from the Hurghada landing site, Red Sea, Egypt. Based on otoliths readings, the maximum age recorded for this species was eight years for both sexes. The length-weight equation constants were a = 0.009, b = 3.197 for males; a = 0.0077, b = 3.238 for females and a = 0.0078, b = 3.237 for sexes combined. Based on the von Bertalanffy growth parameters and mortality rates, the exploitation rate (E) was found to be around the optimum one (0.47, 0.50, and 0.47 for males, females, and sexes combined, respectively). From the management point of view, the current E was higher than the $E_{0.5}$ that conserves the spawning stock biomass, and to achieve the rational exploitation of this species, the present level of fishing effort should be reduced through appropriate fishing regulation techniques.

INTRODUCTION

Egyptian Red Sea sector is about 1080 Km producing a yield fluctuated between 44 and 51.5 thousand ton during the period 2010 – 2020. This forming about 46.4% of the total marine fisheries and about 13.7% of the total natural fisheries (**GAFRD, 2020**) in Egypt. The Red Sea contains about 165 species of endemics species, this value is may be the third highest in the world (**Bogorodsky and Randall, 2019**). The family lethrinidae includes five genera and 42 species of which 28 species belong to the most common genus *Lethrinus* (**Froese and Pauly, 2021**). The annual catch of family Lethrinidae from the Egyptian Red Sea in 2020 was around 3000 ton (**GAFRD, 2020**) composed of 17 species (**Mehanna *et al.*, 2022**) and caught mainly by the artisanal fleet (**Mohamed *et al.*, 2022**). Humpnose big-eye bream *Monotaxis grandoculis* (Forsskål, 1775), member of the family Lethrinidae, is widespread in the Indo-West and Central Pacific from the Hawaiian Islands and southeastern Oceania to the east coast of Africa and the Red Sea and Australia northwards to Japan. It is found associated with the coral reefs, often on, the sandy and rubble areas. Generally, the emperors are long-lived species, which reached greater than 20 years.

The fish populations are renewable sources of income if they are exploited in a planned manner, therefore, fisheries are one of the most important sources of revenue to the economy of the country and as an important food sector in human nutrition (**Dwivedi *et al.*, 2009**). The previous studies on the lethrinid species in the Egyptian Red Sea fisheries were focused on the famous species like *L. nebulosus, L. borbonicus, L. mahsena* and *L. lentjan*, and no studies were done on the other species that also have an economic importance in the area. With the reducing trend in the catches of the famous species and increasing their market prices dramatically, the Egyptians start to use the less famous species that are still traded in reasonable prices. Therefore, the present study was undertaken to estimate the key parameters for stock assessment of one of these lethrinid species, *M. grandoculis* in the Egyptian Red Sea for the first time. Such parameters are the asymptotic length, growth coefficient, mortality rates, critical lengths, exploitation level and yield per recruit. This study will help in formulating the fishery management policies of this species in the Red Sea, Egypt.

MATERIALS AND METHODS

Samples collection

A total of 438 random samples of *Monotaxis grandoculis* (Forsskål, 1775) were collected from the commercial landings of artisanal fleet at Hurghada fishing port (Fig. 1) from January to December 2020. The total length for each specimen was measured to the nearest 0.1 mm and the total weight was recorded to the nearest 0.1 g; the sex (male or female) were detected by microscopic observation of the gonad of all specimens.

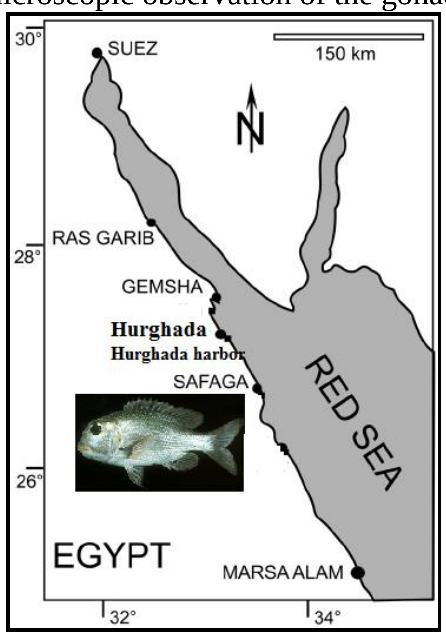

Fig. 1: Hurghada fishing harbor and fish species under study

Otolith preparation and age determination

The age and growth were investigated based on sagittal otolith which were extracted, cleaned in alcohol, dried, weighed to 0.1 mg, and stored in dried envelops for later treatment and investigation. For age estimation, the left otolith was used in the present work, but the right otolith was used when the left otolith was either broken or missing. To increase the transparency of the otoliths for viewing the growth rings, the sagittal otoliths were cleaned with sodium hypochlorite acid for several seconds before investigation. Then the otoliths were cleaned in alcohol 70% and then immersed in few drops of glycerol for clear visible otolith. Otoliths were investigated with stereomicroscope (Carl Zeiss Discovery v20 connects to AxioCam ERc5s camera with software) with reflected light and black background with a magnification of 16x. The growth rings on the otoliths were counted to determine the maximum life span of *M. grandoculis*. The otolith was investigated twice by three readers to minimize the bias and to be sure about the number of annual rings. The coefficient of variation (CV) for the three readings for each otolith was calculated using the method described in **Kimura & Lyons (1991)** and **Campana (2001).** Also, Absolute Percent Error (APE) and Percent Agreement (PA; ±1 y) were used to estimate the reading precision (**Beamish and Fournier, 1981**).

Sex ratio

The sex was identified by examination of the gonads. The sex-ratio (male: females) for the samples was estimated.

Length-weight Relationship

LWR was calculated using the power equation $W = aTL^b$, where the W is the total weight (g), TL is the total length (cm), "a" was the intercept, and "b" was the regression coefficient indicates isometric growth when equal to 3 or allometric growth (negative allometric, b<3 or positive allometric, b>3). Additionally, 95% confidence limits of b were estimated to show if the b-value was significantly different from 3 or not.

Growth modeling

The von Bertalanffy growth model $L_t = L_\infty (1- e^{-k (t- t0)})$ was applied to estimate the growth parameters where L_t is the total length (cm) at time t (year), L_∞ the asymptotic length, K the growth coefficient, and t_0 the theoretical age at length equal zero. The method of **Gulland and Holt (1959)** was fitted to solve the von Bertalanffy growth function (VBGF) and the parameters were estimated separately for males, females, and combined sexes. The growth performance index was estimated from the equation $\varphi' = \log (k) + 2 \log (L_\infty)$ (**Pauly and Munro, 1984**).

Mortality and exploitation rates

The instantaneous rate of total mortality (Z) was estimated by two different methods depending on length-frequency data. The methods are analysis of length converted catch curve (**Pauly, 1983**) and the cumulative catch curve method (**Jones and Van Zalinge, 1981**). The natural mortality (M) was estimated by averaging two methods, the **Rikhter and Efanov's (1976)** empirical model as $M = ((1.52/ t_{mass})^{0.72}) - 0.16$). Where t_{mass} = mean age at massive maturity and the second one was **Pauly's (1980)** empirical equation as:

$$\text{Log } M = -0.0066 – 0.279 \text{ Log } L\infty + 0.6543 \text{ Log } k + 0.4636 \text{ Log } T$$

Where L∞ and K are the VBGF parameters and T is the water temperature inhabited by the fish (25° C). The annual instantaneous rate of fishing mortality (F) was calculated by subtracting the natural mortality rate from the total mortality rate. The calculation was also made for the upper and lower 95% confidence intervals for Z to derive a range of fishing mortality rate estimates. The exploitation rate (E) was calculated as the proportion of fishing mortality relative to total mortality (E = F/Z). Mortality estimates were carried out using the FSA package in R (**Ogle *et al.*, 2018**).

Critical lengths (Lr, Lc and Lm)

The length at recruitment (Lr) was considered as the smallest fish in the catch, while the length at first capture (Lc) was determined by the **Pauly (1984)** method. Length at first sexual maturity (Lm), the length at which 50% of M. grandiculis reach their sexual maturity was estimated by using **Froese & Binohlan (2000)** equation: Log Lm = 0.8979*Log L∞ - 0.0782. The critical ages Tr, Tc and Tm were estimated by conversion the critical lengths to ages using the von Bertalanffy equation.

Relative yield per Recruit (Y/R)'

The model of Beverton and Holt (1966) was applied to analyze the relative yield per recruit (Y/R)' of *M. grandiculis* as follows:

$$(Y/R)' = E*U^{(M/K)} * [1- 3U/(1+m) + 3U^2 / (1+2m)- U^3/ (1+3m)]$$

Where: (Y/R)' = relative yield per recruit.

M = 1-E /(M/K) = K/Z.

U =1– (Lc/L∞).

Yield per recruit (Y/R) model

The model of **Beverton and Holt (1957)** was applied using the formula of **Gulland (1969)** as follows:

$$Y/R= F e^{-M(Tc-Tr)}W\infty*[(1/Z)– (3S/ (Z+k))+(3S^2/(Z+2k)- S^3/(Z+3k)]$$

Where Y/R = yield per recruit, S = $e^{-k(Tc - to)}$. Biomass per recruit (B/R) was also considered and hence the effect of mesh size was assessed under the current growth characteristics of *M. grandiculis*.

Virtual population analysis

VPA was applied to estimate the biomass (ton), the catch (ton), fishing mortality (F), and population (ton) using length- frequency data, L∞, k, t_0, a and b parameters.

RESULTS

A total of 438 fish of *M. grandoculis* fishes caught comprise 135 males and 303 females, so the sex ratio of male: female was 1:2.25. The total lengths varied between 19 and 48.1 cm and total weight varied between 110 to 2150 g for male and female. All fishes were examined to determine the age and growth patterns. The maximum life span for both sexes was 8 years and age group III was the dominant group where it contributed 44%, 34%, and 37% for male, female and combined sexes, respectively (Fig. 2).

The length-weight relationship of *M. grandoculis* from Hurghada was determined and the b values were 3.20, 3.24, and 3.24 for male, female, and sexes combined, respectively which were significantly different from 3 (P<0.05) indicating positive allometric growth (Fig. 3).

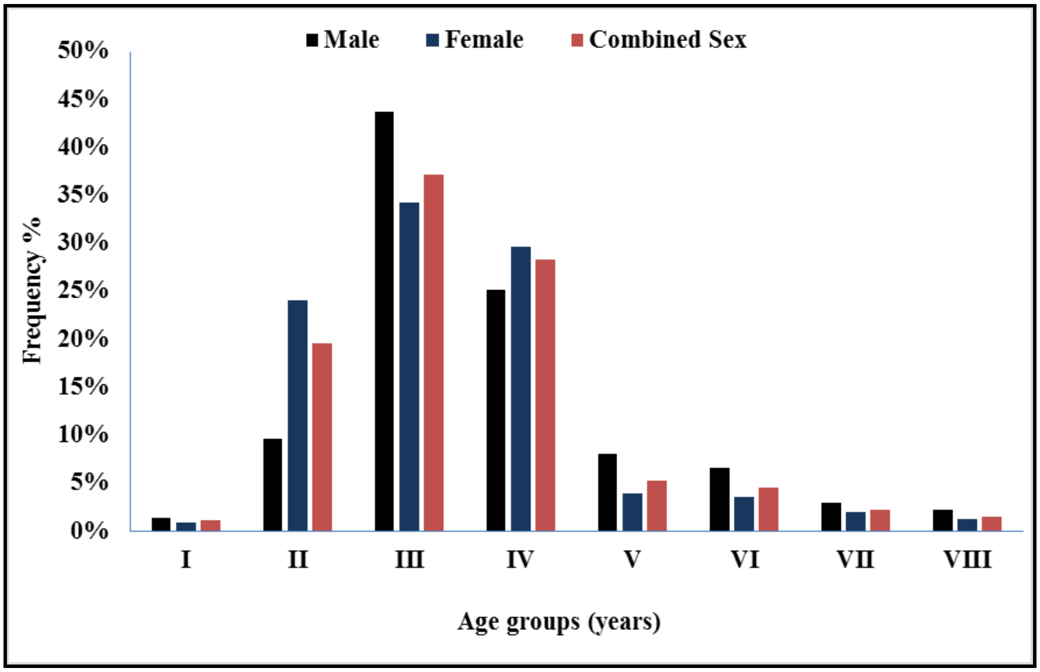

Fig. 2. Age composition for *M. grandoculis* from Hurghada, Red Sea, Egypt

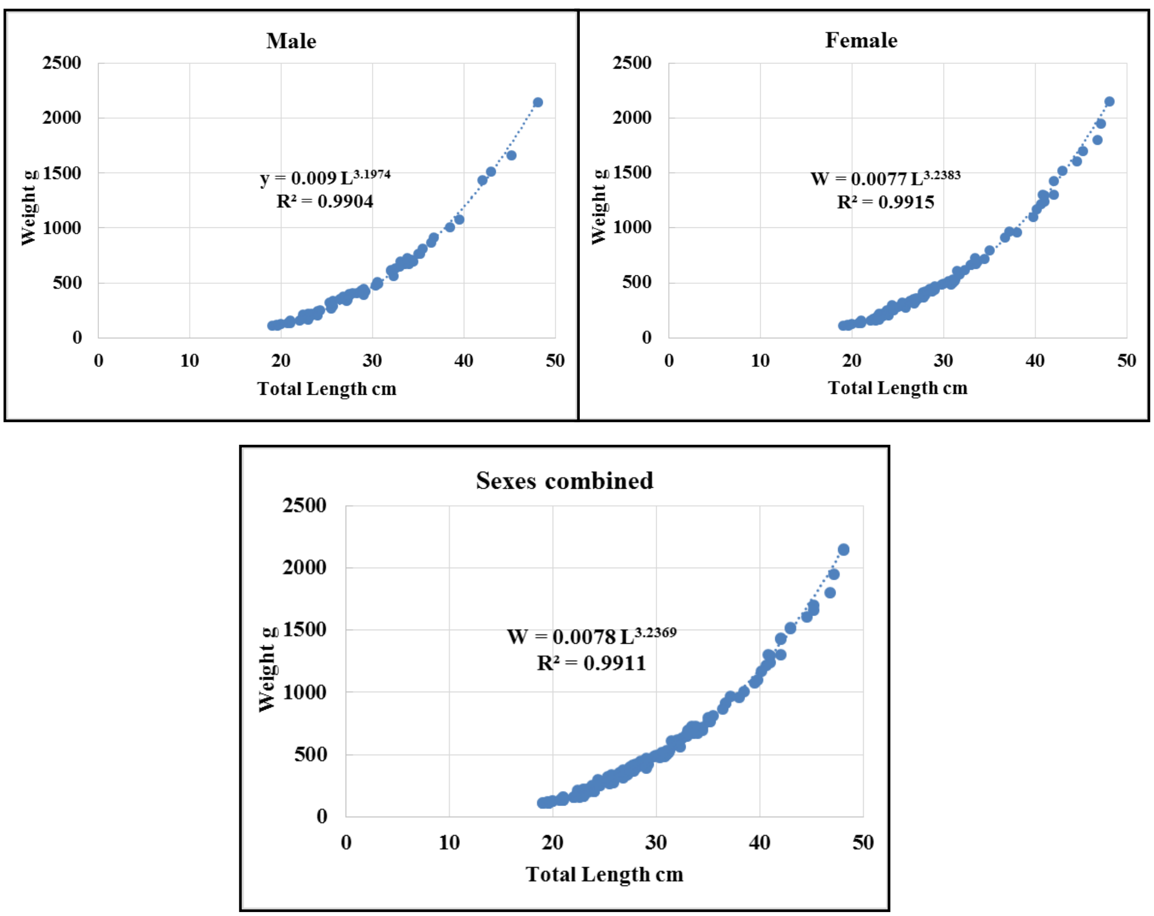

Fig. 3. Length-weight relationship for *M. grandoculis* from Hurghada, Red Sea, Egypt

The growth model of the von Bertalanffy (Fig. 4) yielded the following parameters K, L∞, W∞ and t_0 for *M. grandoculis* in Hurghada fishing area. For males: K= 0.22 y^{-1}, L∞ = 53.3 cm, W∞ = 2982.6 g and t_0 = -0.64 y and for females: K= 0.23 y^{-1}, L∞ = 53.49 cm, W∞ = 3032.83 g and t_0= -0.76 y, while for sexes combined: K = 0.23 y^{-1}, L∞ = 53.87 cm, W∞ = 3134.65 g and t_0 = -0.90 y. Based on the resultant growth parameters, the growth performance index value (Ø') for *M. grandoculis* was 2.80, 2.82 and 2.82 for male, female and combined sexes respectively. There is no significant difference between males and females in respect to the maximum length, longevity and growth parameters.

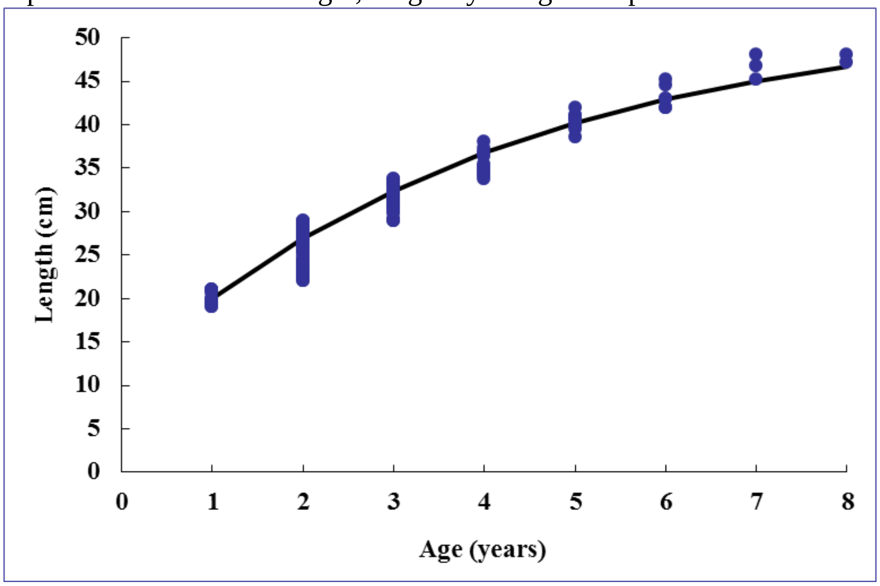

Fig. 4. Growth curve of *M. grandoculis* from Hurghada, Red Sea, Egypt

The smallest fish in the catch is considered as the length at recruitment (Lr) which was 19 cm (≈one year) for both sexes and the estimated Lc (Fig. 5) was 28.25, 25.08, 24.9 cm (2.5, 1.85 and 1.80 y) for male, female and combined sexes respectively. The lengths at first sexual maturity Lm were 27.3, 33.1 & 29.9 cm (2.36, 3.29 and 2.60 y) for male, female and combined sexes respectively.

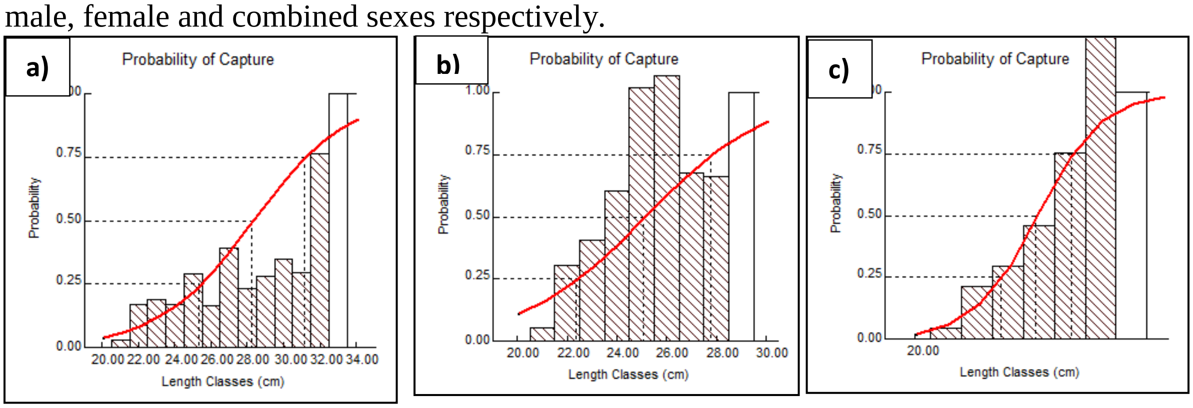

Fig. 5. Probability of capture of *M. grandoculis* (a: male, b: female & c: combined sexes)

The mean values of Z of M. grandoculis which estimated from the two methods used were 1.02, 1.03 & 0.98 y-1 for male, female and combined sexes respectively. The geometric mean of natural mortality coefficient M was 0.54, 0.51 and 0.52 y-1 for male, female and combined sexes respectively. Accordingly, the fishing mortality coefficient was 0.48, 0.52 and 0.46 y-1 and the exploitation ratio was 0.47, 0.5 and 0.47 for male, female and combined sexes respectively. It is obvious that the exploitation rate of this species are running around the optimum values.

The relative and yield per recruit of *M. grandoculis* was calculated for combined sexes as there is no difference in population parameters between males and females as well as any regulatory measures are taken for sexes combined. In the relative yield per recruit model the E_{max} was estimated at 0.76 which is higher than the current one. Also, $E_{0.1}$ and $E_{0.5}$ were estimated at 0.6 and 0.35 respectively (Fig. 6).

The obtained results from the yield per recruit model indicated that the maximum yield per recruit (212.13 g) is achieved at fishing mortality of 1.75 which is greatly higher than the current one (Fig. 7). To show the impact of mesh sizes on the Y/R, a different value of age at the first capture (Lm = 2.6 y) with the present level of age at first capture (1.8 y) was applied (Fig. 7). The yield per recruit increases with the increase of the age at first capture. This means that the increase of age at the first capture can be associated with the increase of the maximum yield per recruit when the fishing mortality also increases.

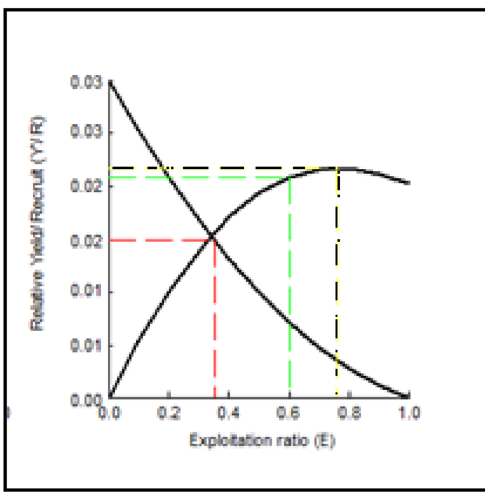

Fig. 6. Relative yield per recruit of *M. grandoculis* Hurghada, from Hurghada, Red Sea, Egypt

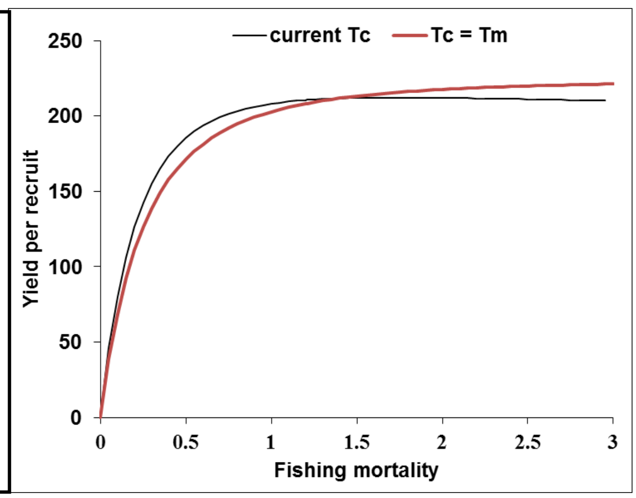

Fig. 7. Yield per recruit (g) of *M. grandoculis* from Red Sea, Egypt

According to the VPA model, Natural loss of *M. grandoculis* was observed at 21 cm to 48 cm, with the highest loss due to natural mortality observed at 21 cm to 33 cm (Fig. 8). Catches for *M. grandoculis* occurred from size 21 cm and peaked at 26 cm. The highest fishing mortality rate was high in the range 24 – 29 cm and 45 - 48 cm. Fishes with length groups from 22-33 cm have higher catches (harvesting rate) than fish with large length groups. The mean fishing mortality for all length groups was 0.16 yr^{-1} which was less than the calculated value (0.48 yr^{-1}). Biomass increase with the increasing length until reach to 32 cm then decrease with increasing length. The high value for biomass was 65503.36 ton and the lower value was 18774.65 ton at length 32 and 48 respectively.

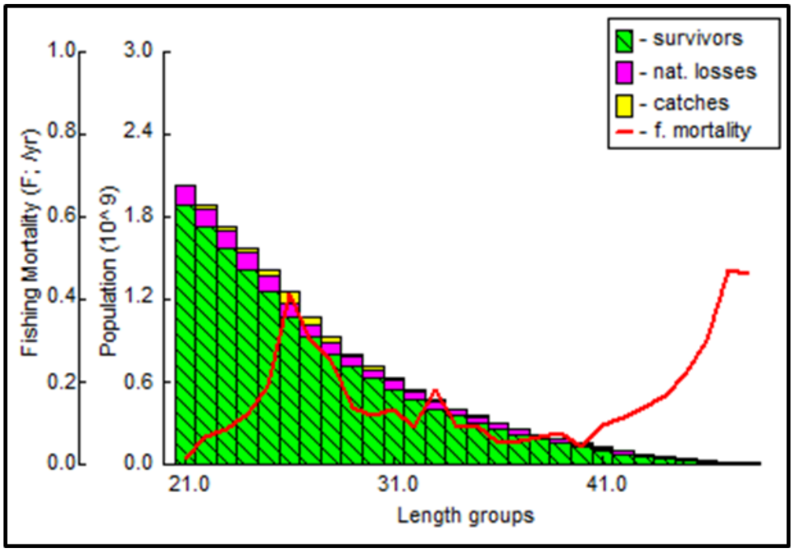

Fig. 8. Virtual Population Analysis of *M. grandoculis* from the Hurghada, Red Sea.

DISCUSSION

The length-weight relationship in fish is affected by several factors including gonad maturity, sex, diet, stomach fullness, differences in the observed length ranges of the caught specimen, and health as well as season and habitat (**Froese, 2006**). In the present study, a positive allometric growth is observed for male and female where the b-values were significantly higher than 3 (Table 1). **Longenecker and Langston (2016)** reported a negative allometric growth for males and females of *M. grandoculis* in Micronesia (b= 2.84 for males and 2.77 for females). **Palla *et al.* (2018)** also observed negative allometric growth for the same species in Philippines (b= 2.8 for whole samples). The variation in the type of growth among different localities is acceptable as b value could be an indicator of the physiological condition of the fish and vary seasonally in response to seasonal variations in environmental condition and changes in the fish wellbeing (**Biswas, 1993**). The length-weight relationship and the b value can also be influenced by fishing pressure that excessively catch the adults. However, the present values were still within the expected range (2.5–3.5).

Table 1. Length-weight relationship parameters of *M. grandoculis* from Hurghada, Red Sea (a = equation parameter, b = slope of the regression, 95% CI = confidence interval and r^2 = correlation coefficient)

Sex	No.	Length range TL cm	Weight range g	a	b	CI	r^2
Male	135	19 - 48.1	110 - 2142	0.009	3.197	3.106 -3.288	0.99
Female	303	19 - 48.1	112 - 2150	0.0077	3.238	3.174 -3.302	0.99
Combined sexes	438	19 - 48.1	110 - 2150	0.0078	3.237	3.188 -3.286	0.99

The deviation from the expected sex ratio of 1:1 of *M. grandoculis* in Red Sea, Hurghada, Egypt showed a high dominance of females over males during the study period. This could be attributed to partial segregation of mature forms through habitat preferences and migration or behavioral differences between sexes thus rendering one sex to be more easily caught than the other (**Mahmood *et al.*, 2011**).

Many forces like growth, recruitment, fishing, and natural mortality are affect the fish population, as growth and recruitment cause an increase in fish population biomass but fishing and natural mortality caused a decrease in the size of the biomass. The age determination of age and growth is of great importance to both fisheries biology and management as it forms the basic knowledge required for the estimation of mortality, recruitment and yield (**Mehanna, 1997**). A total of 438 otoliths from fish ranging from 19.0- 48.1 cm total length were read and used in the determination of the parameters of the growth. The whole otolith readings indicated good agreement between the different readers (agreement = 92.13%, CV = 3.96% and APE = 2.81%). The maximum observed age was 8 years for the males and females. The results revealed that there is no significant difference in back-calculated lengths between the two sexes.

Growth parameters ($L\infty$, K and t_0) were the main input data into different models used for managing and evaluating the status of the exploited fish stocks. These parameters are usefully used in comparison between the growth of fish belonging to varied species or to the same species at different times and different localities (**Mehanna, 1997**). The present growth parameters were revealed that there is no significant difference between sexes.

One of the important parameters of the life history is the maximum length to the asymptotic length ($L_{max}/L\infty$) ratio where the mean value of $Lmax/L\infty$ for marine fish ranged between 0.56 and 1.34 with a mean value of 0.90 (**Stergiou, 2000**). In this study, the $Lmax/L\infty = 0.9$ for male, female and combined sexes. This value is in the range given by **Stergiou *et al.* (2006).**

Estimation of length at maturation and length at first capture is important for determination the optimum length for catch. The length at first capture Lc (the length at which 50% of the fish at that size are vulnerable to capture) of *M. grandoculis* was estimated at 28.25, 25.08 and 24.9 cm (2.5, 1.85 and 1.80 y) for male, female and combined sexes respectively. On the other hand the length at first sexual maturity (Lm) was estimated at 27.3, 33.1 and 29.9 cm (2.36, 3.29 and 2.60 y) for male, female and combined sexes respectively. It is obvious that the estimated Lc exceeds Lm for males and smaller than Lm for females and whole sample. This means that the exploited *M. grandoculis* especially females must be protected in order to share the spawning activities at least once before being caught.

The results of the relative yield per recruit and yield per recruit models demonstrate that *M. grandoculis* exploited at a lower values of F and E than those achieving the maximum yield, but raising the F and E to that level is not acceptable. The Egyptian Red

Sea fisheries are multifleet and multispecies fisheries and all the commercial and famous fish stocks are overexploited (**Mehanna, 2021**), so any management regulations should consider this fact. By considering $E_{0.5}$ and $F_{0.1}$ as target reference points, the stock of *M. grandoculis* in the Egyptian Red Sea appears to be overexploited. Thus a fishing mortality reduction is necessary to avoid future loss in stock productivity and landings. Fishing effort must be controlled and decreased and the available assessment suggests a target reference point not less than 50% decreasing in fishing effort to maintain their spawning biomass.

REFERENCES

Beamish, R. J. and Fournier, D. A. (1981). A method of comparing the precision of a set of age determinations. Can. J. Fish. Aquat. Sci., **38**: 982-983.

Beverton, R. J. H. and Holt, S. J. (1957). On the dynamics of exploited fish population. U.K. Fish. Invest. Minist. Agr. Fish Food, **19**: 533 pp.

Beverton, R. J. H. and Holt, S. J. (1966). Manual of methods for fish stock assessment. Part 2. Tables of yield functions. FAO Fish. Tech. Pap., (38) Rev. 1: 67 p.

Biswas, S. P. (1993). Manual of methods in fish biology. South Asia, New Delhi, India.

Bogorodsky, S. V. and Randall, J. E. (2019). Endemic Fishes of the Red Sea. In: Oceanographic and Biological Aspects of the Red Sea. Rasul, N.M.A. & Stewart, I. (Eds). pp 239-265. Springer, ISBN 978-3-319-99417-8., https://doi.org/10.1007/978-3-319-99417-8_14

Campana, S. E. (2001). Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. Journal of Fish Biology, **59:** 197–242. doi: 10.1006/jfbi.2001.1668

Carpenter, K. E. (2002). The living marine resources of the Western Central Atlantic. Volume 2: Bony fishes Part 1 (Acipenseridae to Grammatidae) 2002, 601-1373 p.

Carpenter, K. E. and Niem, V. H. (2001). FAO Species Identification Guide for Fishery Purposes. The Living Marine Resources of the Western Central Pacific Volume 5: Bony Fishes Part 3 (Menidae to Pomacentridae). FAO, Rome, 2791-3380.

Carpenter, K. E. and Randall, J. E. (2003). *Lethrinus ravus*, a new species of emperor fish (Perciformes: Lethrinidae) from the western Pacific and eastern Indian oceans. Zootaxa, **240**: 1-8

Dwivedi, A. C.; Singh, K. R.; Khan, S. and Mayank, P. (2009). Dynamics of exploited fish populations and sex ratio of *Cyprinus carpio* var. communis (Linnaeus) in the Yamuna river at Allahabad. Asian J Anim Sci 2:198–202

Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. J. Appl. Ichthyol., **22**: 241–25. doi:10.1111/j.1439-0426.2006.00805.x.

Froese, R. and Pauly, D. (2021) (Eds). FishBase. World Wide Web electronic publication. www.fishbase.org, version (12/2021).

Froese, R. and Binohlan, C. (2000). Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per-recruit in fishes, with a simple method to evaluate length-frequency data. J. Fish Biol., **56:** 758-773.

GAFRD (2020). Publications of the General Authority for Fish Resources Development. Annual fishery statistics report, Ministry of Agriculture. Egypt.

Gulland, J. A. (1969). Manual of methods for fish stock assessment. Part (1). Fish population analysis. FAO Man. Fish. Sci. **4**:154 p.

Gulland, J. A. and Holt, S. J. (1959). Estimation of growth parameters for data at unequal time intervals. Journal of Conservation CIEM **25**: 47-49.

Kimura, D. K. and Lyons, J. J. (1991). Between-reader bias and variability in the age determination process. Fishery Bulletin**, 89:** 53–60.

Longenecker, K. and Langston, R. (2016). Rapid reproductive analysis of four heavily exploited reef fishes from Pohnpei State, Federated States of Micronesia. Bishop Museum Tech, Rep. 68. Bishop Museum Press. 41 p.

Mahmood, K.; Ayub, Z. and Siddiqui, G. (2011). Sex-ratio, maturation and spawning of the Indian Ilisha, *Ilisha melastoma* (clupeiformes: prisigasteridae) in coastal waters of Pakistan (Northern Arabian Sea). Indian Journal of Geo-Marine Sciences, 40(4): 516-521

Mehanna, S. F. (1997). The study of biology and population dynamics of *Lethrinus mahsena* in the Gulf of Suez), PhD Thesis, Faculty of Science, Zagazig University.

Mehanna, S. F. (2021). Egyptian marine fisheries and its sustainability. In: Sustainable fish production and processing, pp. 111-174

Mehanna, S. F.; Mohammad, A. S.; El-Mahdy, S. M. and Osman, Y. A. (2022). An overview on the Lethrinid species inhabiting the Egyptian Red Sea with the first record of three *Gymnocranius* species (*G. satoi*, *G. elongatus* and *G. oblongus*). Egyptian Journal of Aquatic Biology and Fisheries, 26 (3): 687-698.

Nadon, M. O. (2019). Stock Assessment of Guam Coral Reef Fish, 2019. NOAA Technical Memorandum NMFS-PIFSC-82, 107 p. doi: 10.25923/pyd6-7k49.

Ogle, S. E.; Tamsitt, V.; Josey, S. A.; Gille, S. T.; Cerovecki, I.; Talley, L. D. and Weller, R. A. (2018). Data from: Episodic Southern Ocean heat loss and its mixed layer impacts revealed by the furthest south multi-year surface flux mooring. UC San Diego Library Digital Collections. https://doi.org/10.6075/J0T43R83

Palla, H. P.; Pagliawan, H. B.; Rodriguez, E. F.; Cacho, B. S.; Gonzales, B. J.; Bonnell, C. and Fowler, T. (2018). Length-weight relationship of marine fishes from Palawan, Philippines. The Palawan Scientist, **10**:17-28.

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J. Cons. CIEM, **39 (3)**: 175-192.

Pauly, D. (1983). Length-converted catch curves. A powerful tool for fisheries research in the tropics. Part I. ICLARM Fishbase, **1 (2):** 9- 13.

Pauly, D. and Munro, J. L. (1984). Once more on the comparison of growth in fishes and invertebrates. Fishbyte, **2(1):** 21.

Stergiou, K. I. (2000). Life-history patterns of fishes in the Hellenic Seas. Web ecology, **1**: 1-10.

Stergiou, K, I.; Tsikliras, A. C. and Apostolidis, C. (2006). Age and growth of Mediterranean marine fishes.

von Bertalanffy, L. (1938). A quantitative theory of organic growth (inquiries on growth laws. II). Human biol., **10**: 181-213.