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Fishery status of the longnose parrotfish, *Hipposcarus harid* (Forsskal, 1775) in the southern Red Sea, Shalateen, Egypt.

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ABSTRACT

This is the first analysis for estimating the essential fisheries indices for *Hipposcarus harid* from Shalateen fishing port on the northern Red Sea coast of Egypt. The age was predicted by using scales reading for 179 fish collected through the fishing season from 2014 to 2016. Six age groups were observed for sexes combined. Calculated "b" value was 2.899 showed negative allometric growth. The estimated Von Bertalanffy growth parameters was L_∞ = 55.95 cm, K = 0.22 year^{-1}and t_0 = -0.724year^{1}. The rate of total mortality (Z) was (1 year^{-1}), natural mortality (M) was 0.30 lower than the fishing mortality (F= 0.70). The exploitation ratio (E = 0.70) was high~~er~~ and exceeded the 0.5 optimal values for sustainable yield. The length at first capture (Lc= 20.6cm, 1.3year) was lower than the length at first sexual maturity (Lm= 22.3 and 23.5 cm; 1.6 and 1.8 years) for males and females respectively). In addition, (F=0.70 year^{-1}) was higher than the target biological reference point (F_{opt}=0.15; F_{limi}= 0.2; F_{max} =0.43 and $F_{0.10}$ =0.3). By using the reference points of E_{max}, $E_{0.1,}$ and $E_{0.5}$, current exploitation rates suggest unsustainable stocks for this species in the Shalateen fishing port.

INTRODUCTION

The Egyptian fisheries are based on ancient traditional artisanal fishery, with the highest fishing pressure along the coral reefs in the Red Sea for the relative shallow fishing ground, most fishing ground is only suitable for hook and line or inshore fishing with nets (FAO 2004). Six fisheries centers are present along the Egyptian Red Sea coast. The main landing site in the Red Sea is Ataka, in the Gulf of Suez; Hurghada and El-Tor. Other landing sites include Shalateen, Berenis, and Quseir.

Parrotfish family (Scaridea) are herbivorous reef fishes which use their beaklike fused jaw to remove algae and detritus from the substratum (Bellwood *et al*. 2003).parrotfish are important in maintaining low macro algal cover (Adam, *et al*. 2011). In removing both live and dead corals (Bellwood, *et al*. 2003), in the removal and transport of sediment and help to prevent phase shifts from coral to algal dominant reefs. Parrotfishes are in many parts of the world an important component of reef fisheries (Hawkins and Roberts 2003).This may have immense effects on the dynamics and regeneration of coral reefs (Mumby *et al*. 2007). For the important role they play in promoting coral recovering after disturbance, enhancing coral reef resilience (Golbuu *et al*. 2007). Hence, the highest fishing pressure and size selectiveness of fisheries often leads to consequences larger than changes in biomass and abundance of the targeted stock itself (Hawkins and Roberts.2003) affecting and altering the entire dynamic of reefs (Bellwood *et al*.2003)

Despite the commercial importance of *H. harid* in the Egyptian Red Sea, the studies carried on its life history is very scarce. Thus, Mehanna, *et al*. (2014) recorded the age and growth of the two Scarid species *H. harid* and *Chlorurus sordidus* from Hurghada fishing area, Red Sea, Egypt. While in the eastern coast of the Red Sea, (El-Sayed, *et al*. 2011) estimated the growth and longevity of three parrotfish, *Hipposcarus harid*, *Scarus ferrugineus* and *Chlorurus sordidus*.

The objectives of this study were to assess some biological and dynamic features of the *Hipposcarus harid*. In this, determine the length-weight relationship, age, growth parameters (L_{∞}, K, and t_0) and mortality coefficients (Z, M, and F).In addition, calculated growth index (ø'). The level of an exploitation rate (E) and determine reference points of relative yield and biomass per recruit of *Hipposcarus harid* in the Egyptian Red Sea El- Shalateen site.

MATERIALS AND METHODS

Study area

Shalateen fishing port is sited in the south of the Red Sea. It lies at 454.68 Km south of Hurghada, Egypt (Fig. 1). Shalateen coastal area is very wide and shallow, with a narrow beach composed of sand. The fishing landing site location latitude (N: 23° 09' 07.31") and longitude (E: 35° 36' 51.14"). Coral reefs are found as a seaward parallel to the shoreline. Abo El-Regal, (2009).

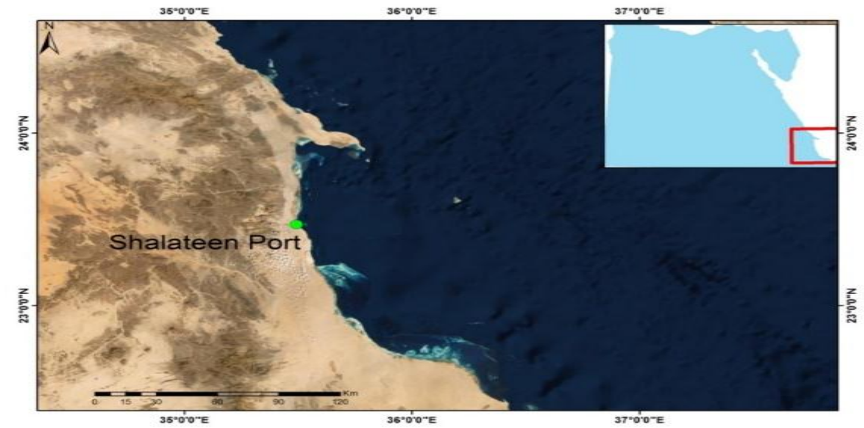

Fig. 1: Shalateen fishing port.

Data collection

179 specimens (19.7- 42.2 cm in TL) of *H. harid* were randomly collected seasonally from 2014 to 2016 from the artisanal commercial boats in El-Shalateen fishing port, southern Red Sea, Egypt. (Fig.1)

Growth parameters

The total length (TL) and body weight (BW) of each specimen was measured to 0.~~0~~1 cm and 0.~~0~~1gm .respectively. This relationship was determined as $W = a\ L^b$. Le Cren (1951) where (W) is the total body weight in g, (L) is a total length in cm. Age was determined by counting the annual rings on the scales. Ford (1933) and Walford (1946) method was applied to estimate L_{∞} and K. The growth performance index (Φ') was estimated following the equation of (Pauly and Munro1984) as (Φ') $= 2 \log L_{\infty} + \log K$. The theoretical age at birth (t_o) be calculated using the empirical formula: $\mathrm{Log10}\ (-t_o) = -0.3922 - 0.275 * \log 10 L_{\infty} - 1.038 * \log 10 K$ (Pauly 1980). The longevity (T_{max}) was estimated as $T_{max} = 3/K + t_o$ (Pauly 1983).

The optimum length (L_{opt}) was estimated empirically from the equation of (Froese and Binohlan, 2000) as, $L_{opt}=3*L_{\infty}/3+M/K$ where L_{opt} denotes the optimum length of exploitation.

The length at the first capture (Lc); the length at which 50% of the parrotfish retained in the gear was estimated by the analysis of the catch curve using the method of Pauly (1984), while the corresponding age at the first capture (T_c) was computed by converting Lc to age using the von Bertalanffy growth equation:

$T_c = t_0 - (1/k * \ln [1- (L_c/L_{\infty})])$.The length at which 50% of parrotfish reach their sexual maturity **(L_m);** was estimated by fitting the percentage maturity against the mid lengths. L_m was estimated as the point on X-axis corresponding to 50% point on Y-axis, while the corresponding age at first sexual maturity (T_m) was computed by converting L_m to age using the von Bertalanffy growth equation:$\mathbf{T_m = t_0 - (1/k * \ln [1- (L_m/L_{\infty})])}$

Mortality parameters: FiSAT II software package (Gayanilo *et al.*, 2005), (Pualy, 1983) method was used to estimate the total mortality Z per year using the length converted catch curve. Djabali *et al*. (1994) assessed natural mortality: Log M = -0.0278 - 0.1172Log (L∞) + 0.5072 Log (K). Fishing mortality (F) was calculated using the relationship: F = Z – M.

Limiting fishing mortality (F_{limit}) and the optimum fishing mortality (F_{opt}) which forms the precautionary target and directly related to the natural mortality was calculated as $F_{opt} = 0.4*M$ (Pauly, 1984) and $F_{limit} = (2/3) * M$ (Patterson, 1992). The rate of exploitation: E =F/Z was calculated.

Relative yield per recruit and relative biomass-per-recruit:

Yield per recruit was estimated using the model of Beverton and Holt (1957): Y/R = F e-M (t_c - t_r) W_{∞} [1/Z - 3S/ Z+K + 3S2 / Z+ 2K - S3/ Z + 3K] Where S = e-K (T_c – t_0) and the other letters as defined above. While the equation for estimating biomass per recruits is: B/R = (Y/R) / F

The extreme values of the fishing level, such as "F_{max}" and "$F_{0.1}$", were defined as biological reference points "BRP" that were estimated. The ratio $F_{cur}/F_{0.1}$ was calculated to show the stock status. The Y/R analysis shows the average level of fishing mortality, the biomass per recruit, and the biological reference points.

RESULTS

A length-weight relationship

The size of *H. harid* ranged from19.7 to 42.2 cm TL (mean 29.8±4.92 cm). The weights ranged from 132.6 to 1010 g (mean 410.3±213.4 gm). Value of exponent *‘b’* was (‘*b*’ =2.89) with a correlation of coefficient of R^2= 0.98 (Fig. 2).

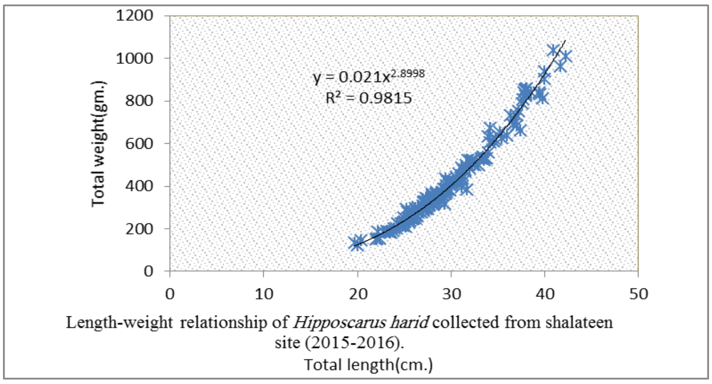

Fig. 2: Length-weight relationship of *H. harid*

Age determination

179 scales were used for age reading and detected six age groups of *H. harid* at 20.03cm, 26.37 cm, 32.1 cm, 37.01, 40.6cm and 42.2cm for the ages from 1 to six respectively.

Age composition

The reading of scales showed six ages with a predominance of age class II (44.69%) followed by age group III (34.64%), IV (16.76%), V (1.68%), I (1.68) and VI (0.56%). Fig. 3.

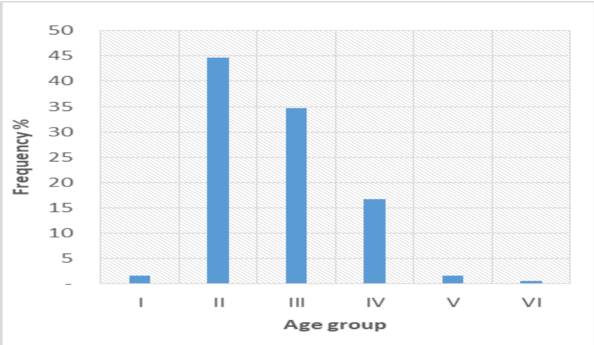

Fig. 3: The age compositions of *H. harid* from, El- Shalateen port, the south Red Sea, Egypt.

The results of growth in length of *H. harid* showed, rapid growth at the end of the first year of life (20.03 cm.), whereas in the following years the rate of a growth slowdown. The annual increment of growth in weight increases with a further increase in age until it reaches its maximum value at age group V (346.6gm.), after which it shows a gradual decrease with a further increase in age.(Figures 4 and 5.).

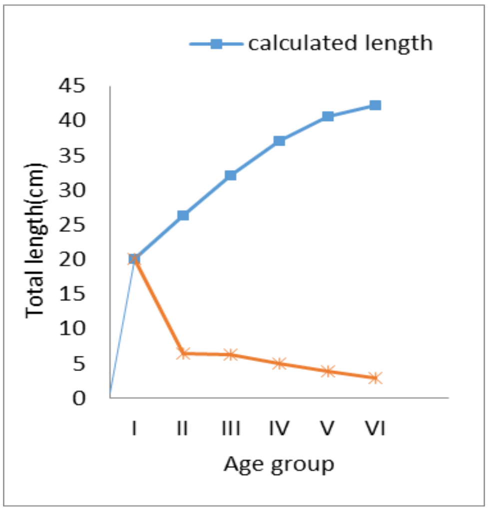

Fig. 4. Growth in length and increment of *H. harid*

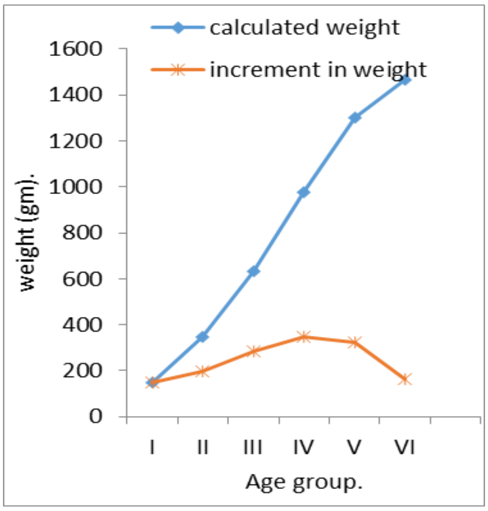

Fig. 5. Growth in weight and increment of *H. harid*

Growth parameters

In the present study, the maximum theoretical length was calculated as ($L\infty$=55.95cm) and the growth constant was (K=0.22 year^{-1}). The growth performance index (Ø = 2.8). Age at zero-length (t_0) was estimated at -0.720 years.

The maximum length is that the largest fish in the sample (L_{max}= 42.2 cm) so the value of L_{max}/L_∞ was (0.87).

The observed and theoretical longevity, the maximum observed age of this study was six years for *H. harid* while theoretical longevity (T_{max}) was estimated by Pauly (1983) at 12.9 years.

The optimum length of exploitation (L_{opt}) estimated was 38.5cm and the value of L_{opt}/L_{∞} calculated was 0.69.

Length at first capture and length at first maturity (Lm_{50})

The length at which (Lc_{50}) of the stock was captured was 20.6 cm. L_c/ L_{inf} ratio at 0.37. The length at first capture (20.6cm) was lower than the size at first maturity (22.3 cm and 23.5 for males and females, respectively, Fig.7).

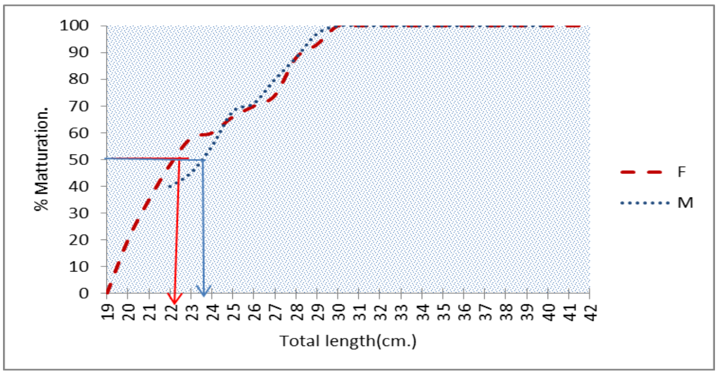

Fig.7. Length at first maturity of *H. harid***.**

Mortalities ~~rates~~

The present study (Z) is estimated at ($1yr^{-1}$). Natural mortality (M) was calculated at 0.30 yr^{-1}. Based on Z, the fishing mortality (F) was 0.70 yr^{-1}. The survival rate was 0.37% and the annual mortality rate was 99.63%. (Fig.8). The ratio (M/K) was obtained in this research as (1.36). The exploitation rate was (E = 0.70).

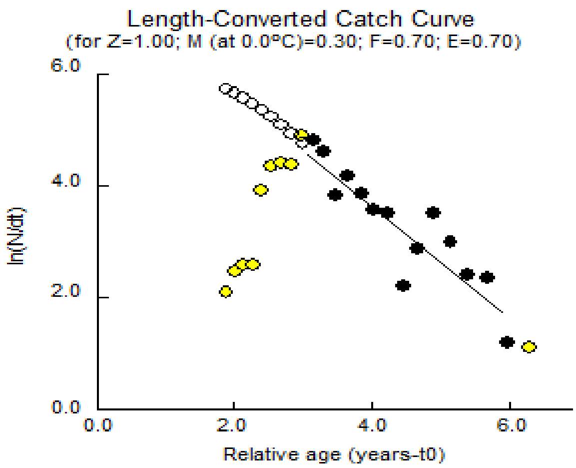

Fig. 8: Length converted catch curve of *H. harid* from Shalateen, Southern Red Sea.

Relative yield and biomass-per recruit

The value of (E) corresponding to the maximum sustainable level (E_{max}) was (0.580).as well the (E_{cur} = 0.70), the reference point of ($E_{0.5}$=0.32). (Fig. 9)

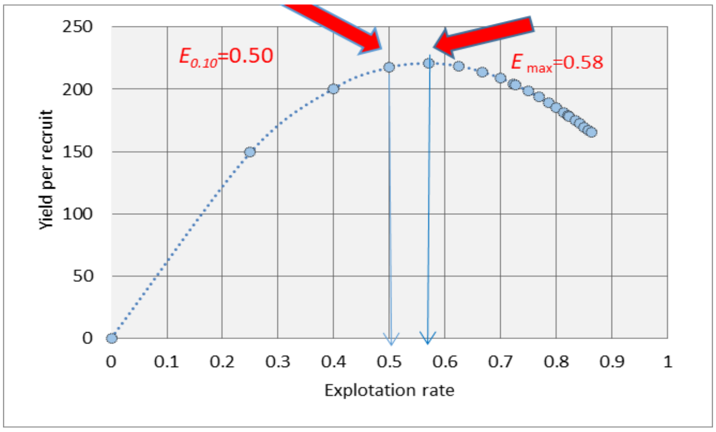

Fig. 9: Relative yield-per-recruit ($E_{0.1}$ = 0.501, $E_{0.5}$=0.32 and E_{max} =0.58).

Estimations of yield per recruit were given for different fishing mortalities 0.1 up to 2 for *H. harid* where the input parameters were: M (0.30), W_∞ (2449.6), K (0.22), t_o (-0.720), t_c (1.4) and t_r (1.25). The level of exploitation of the stock was determined by analyzing the curve of yield per recruit and calculating biological reference points F_{max} and $F_{0.1}$. The value of F_{cur} is equal to 0.70, higher than the estimated F_{max} (0.43) and $F_{0.1}$ (0. 3). In the present work, the ratio F_{cur} /$F_{0.1}$ is 2.33. (B_{cur} / B_{msy}= 0.69).

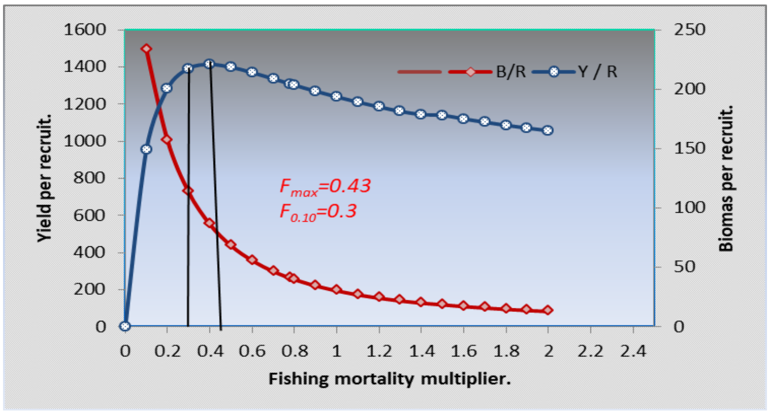

Fig. 10: Effect of fishing mortalities (F) on Yield (Y/R) and biomass (B/R) per recruit for *H.harid* from shalateen site.

DISCUSSION

The study of length weight relationship is a method which widely applied in fisheries management as it offers information on stock conditions (Bagenal and Tesch 1978) in this investigation the value of the exponent *'b'* was (2.89) showing negative allometric growth .This different from that reported by Mehanna *et al*. (2014) at Hurghada fishing area, Red Sea, Egypt ('*b*' = 2.93), and El-Sayed *et al*. (2011) in the eastern coast of the Red Sea ('*b*' = 2.99) showing an isometric growth. "b" value be influenced by many factors such as feeding intensity, availability of food, fullness of the gut age, fish size, stage of maturation, season, sex, degree of muscular development, the amount of reserved fat and life history (Gupta and Banerjee, 2015). In our study, a correlation of R^2= 0.98 indications a strong, positive association between the two variables. Age estimation is critical in determining the growth, survival, and mortality of fish and can be linked to different environmental factors that affect this life-history variables. The age was recorded by reading 179 scales. Six age groups were detected for *H. harid* at 20.03cm, 26.37 cm, 32.1 cm, 37.01, 40.6cm and 42.2cm. This is different from Mehanna *et al*. (2014) who recorded, eight age groups with the maximum length (50cm) in the Hurghada fishing area, Red Sea. These differences in the estimations can be regarded for the variation in the maximum recorded length or in the environmental conditions. The predominance age class (II) (44.69%) the result agreement with Mehanna *et al*. (2014) noted the dominant age group (II). The results of growth in length of *H. harid* indicated rapid growth at the end of the first year of life (20.03 cm.), whereas in the following years the rate of a growth slowdown. The annual increment of growth in weight increases with a further increase in age until it reaches its maximum value at age group IV (346.6gm.), after which it shows a gradual decrease with a further increase in age. This result differs with Mehanna *et al*. (2014) who stated that the maximum increment in weight was at age group V. while the results of maximum theoretical length (L_∞=55.95cm)and the growth coefficient (K=0.22) and (t_o) (-0.7) were close to that that estimated by Mehanna *et al*. (2014) as (L_∞=57.16 cm) (k=0.23) and (t_o-0.7). The growth performance index (Ø =2.8) confirms fully to that reported by Mehanna *et al*. (2014). (Pauly 1991) suggested that the growth performance index (ø') remains nearly constant among different populations of the same species In this study the maximum length is that the largest fish in the sample (L_{max}= 42.2 cm) so the value of L_{max}/L_∞ was (0.87) which is close to Stergiou (2000) Who explained that the value of L_{max}/L_∞ for marine fish ranged between (0.56 and 1.34) for 383 marine fish. The length at first capture (20.6cm) was lower than the size at first maturity (22.3 cm. and 23.5) for males and females respectively .This showed stress on spawning stock and could be stopped by enhancing their size and age at exploitation, which meant that an increase in mesh size of gears is required to avoid the young fishes. The instantaneous total mortality rate (Z) of a fish population is one of the important parameters in fisheries stock assessment**.** It is crucial to fish population dynamics analysis, abundance and catch forecast, and fisheries management. The natural mortality coefficient (M) is associated with the growth coefficient (K) and inversely related to the asymptotic length (L_∞). The M/K ratio is almost constant among closely related species and sometimes within the similar taxonomic groups (Bevertonand Holt, 1959; Banerji, 1973). The M/K ratio attained in the present study (1.36) was well within the normal range of 1-2.5, as suggested by Beverton and Holt (1959). The exploitation rate evaluated (E = 0.70), ~~which~~ is higher than the expected optimal exploitation level (E = 0.50). The fishing mortality rate of 0.70 yr^{-1} was also greater than both the optimum target (F_{opt}. = 0.15 $year^{-1}$) and (F_{limit} = 0.2$year^{-1}$) biological reference points shown over-exploitation of *H. harid* stock in the studied area. Principal pressures to marine fishes are exploitation, habitat loss, pollution, invasive species (Reynolds *et al*., 2005) and bad management .The current value of (E) corresponding to the maximum sustainable level (E_{max}) was calculated and used to evaluate the state of the stock: in equilibrium ($E_{cur} \approx E_{max}$), overexploited (growth overfishing) ($E_{cur} > E_{max}$), or underexploited ($E_{cur} < E_{max}$). The results show overexploited (growth overfishing) (E_{cur} =0.70).> E_{max} (~~0.~~0.58)) as well the (E_{cur} = 0.70), is higher than the target reference point of ($E_{0.10}$=0.3). The present results showed that the stock of *H .harid* is to be overexploited. Estimations of yield per recruit were given for different fishing mortalities 0.1 up to 2 for *H. harid* where the input parameters were: M, W_{oo}, K, to, t_c and tr. The level of exploitation of the stock was determined by analyzing the curve of yield per recruit and calculating biological reference points F_{max} and $F_{0.1}$. The value of F_{cur} is equal to 0.70, higher than estimated F_{max} (0.43) and $F_{0.1}$ (0.30) and the ratio F_{cur} /$F_{0.1}$ is 2.33 showing that the *H.harid* stock in the shalateen site is overexploited.

Besides the biomass is lower than the biomass at the maximum sustainable yield (B_{cur} / B_{msy}= 0.69), low biomass showing that the stock is far from safe biological limits.

CONCLUSION

According to the results found, *H .harid* in the shalateen site is overexploited; this research help to understand some information on the life cycle parameters of this species such as growth, mortality and fishery status but a study about the breeding cycles of this species, the time of year that recruitment occurs must be undertaken. This information will help in the development of suitable strategies to attention the protection and conservation of this species in the shalateen site.

The exploitation rate over the years shown that *h.harid* was overexploited at present. As showed by the E_{max} a reduction in fishing effort can increase marginally the production. This may help in restoring the yield to MSY level.

The study has revealed that *H. harid* population within the Egyptian Red Sea Shalateen site is currently overexploited .For resource management purposes, the exploitation rate should be reduced to the optimum exploitation rate.

The mature fishes should be protected by increasing the length at first capture.

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