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Some Biological Aspects and Stock Status of Goldlined Seabream *Rhabdosargus sarba* (Forsskål, 1775) from the Arabian Gulf of the United Arab Emirates

Elsayed Farrag*, Ahmed Alzaby, Carter Subbiah

Marine Environment Research Department, Ministry of Climate Change and Environment (MOCCaE), Dubai, United Arab Emirates

Email address:

eefarrag@moccae.gov.ae (E. Farrag), amalzabi@moccae.gov.ae (A. Alzaby), csubbaih@moccae.gov.ae (C. Subbiah)

*Corresponding author

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Abstract: Evaluation of *Rhabdosargus sarba* caught from South Arabian Gulf of the United Arab Emirates was investigated using a combination of size frequency and biological data. Forked length ranged between 14.0 and 39.0cm. Length-weight relationship for combined sexes of *R. sarba* was estimated as $W=0.0338*L^{2.7807}$. The spawning season of *R. sarba* was over a limit time period from November to February and the peaks were in January and February for males and females respectively. The overall sex ratio throughout the study period was 1:1.4 males to females, which was not significantly different from 1:1. The size and age at 50% sexual maturity was 22.01cm *FL* and 2.39years. The FiSAT II software was used to perform the estimate of growth, mortality and exploitation rate. Parameter values of asymptotic length L_∞ and growth coefficient *K* were 41.94cm *FL* and $0.25y^{-1}$ respectively. Age at length zero t_o was estimated by substituting the asymptotic length and growth coefficient in Pauly's equation. Instantaneous rate of total and natural mortalities were estimated as 1.09, 0.66 y^{-1} respectively. The length at first capture was obtained as 19.51cm that was smaller than the length at first sexual maturity. The rate of fishing mortality ($F=0.43y^{-1}$) is higher than the optimum level ($F_{opt}=0.33y^{-1}$) and was close to limit ($F_{limit}=0.44yr^{-1}$) biological reference point, indicated that the resource is slightly over-exploited. Results also indicated that the reduction of current level of fishing mortality to optimum level will lead to reduction of exploitation rate by 23.08%.

Keywords: Biological Aspects, Stock Status, *Rhabdosargus Sarba*, Mortality Rate, Arabian Gulf

1. Introduction

Rhabdosargus sarba (Forsskål, 1775) is a fish belonging to family Sparidae, commonly known as seabream that is common in tropical and subtropical inshore waters throughout the Indo-West Pacific including the Red Sea, East Africa, Madagascar, Australia, China and Japan[1, 2]. Fishes of family sparidae are small to medium-sized fishes, diverse in general form, varying in shape from elongate to deep-bodies, with a dorsal profile from very steep to gentle sloping. The species of family sparidae are very important commercially and constitute an important part of the artisanal and industrial fisheries [3, 4]. Sparid fishes are an important component of both small-scale fisheries (gill net, trammel net and hand line) and industrial fisheries (trawlers) in the Omani waters of the Arabian Sea [5], whilst hand lining is the main method used to catch *R. sarba* in the southern Arabian Gulf off the coast of the Emirates of Abu Dhabi in the United Arab Emirates [6]. Most Seabream are excellent food fish and are of notable importance to both commercial and recreational fisheries throughout their range [7, 8]. Despite the importance and widespread occurrence of *R. sarba*, little information about its population biology and stock assessment in the Arabian Gulf and Sea of Oman [5, 6, 9, 10]. In this context, the aim of this study is an attempt to understand various population biology and stock status in order to provide scientific information for management purpose of *R. sarba* in the United Arab Emirates. A comparison of the results with the previous studies is also given.

2. Materials and Methods

2.1. Data Collection

Length frequency data for the present study were collected randomly from five traditional fish-landing sites: Ras Al-Kheima, Umm Alqwain, Ajman, Sharjah and Abu Dhabi (Fig. 1), during the period from January 2014 to December 2015. Lengths were taken using a measuring board and recorded to the nearest centimeter fork length *FL*. Biological data were collected from specimens purchased from commercial catches during the period from January to December 2014. For each fish total, forked and standard lengths were taken to the nearest cm, while total and gutted weights (g) were taken to the nearest gram. The fish were dissected, sexed and maturity status recorded.

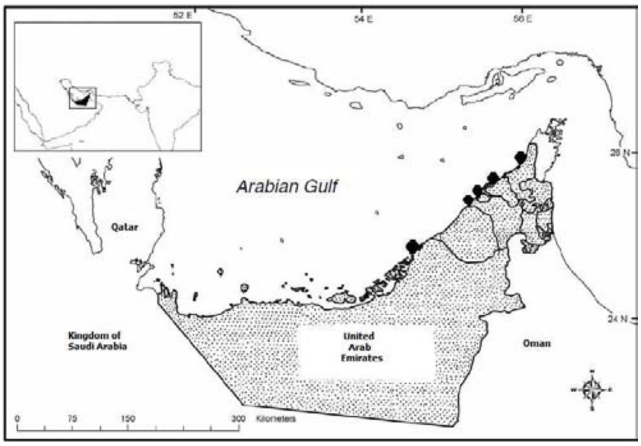

Figure 1. *Location of Five landing areas where R. sarba sampled.*

2.2. Length Weight Relationship

The length weight relationship was estimated with the power equation: $W=aL^b$ [11] where *W* is the weight *g*, *L* is the fish total length *cm*, *a* and *b* are intercept and slope of the relation. The growth type was identified by Student's t-test, which was applied to determine the significance differences between the isometric $b=3$ and allometric $b\neq3$. The linear equation $FL=a+b*TL$ was utilized for total length-fork length relationship where: *FL* is the fork length, *TL* is the total length and *a & b* are constants.

2.3. Reproduction

Sex was checked by the naked eye and gonads were classified to six stages of maturation according to morphological changes that take place during its development to reach spawning [12]. Maturity stages were classified as: immature, resting stage, maturing, mature, ripe and spent. Gonads weight was measured to the nearest 0.01g. Gonado-somatic index *GSI* was calculated monthly for both males and females of *R. sarb*a by the following equation: $GSI=W_G/W_g*100$ [13] where: W_G is the fish gonad weight and W_g is the fish gutted weight. The population sexual structure was examined using Chi-Square X^2 goodness of fit tests. Independent tests were conducted to determine whether sex ratio differed significantly from 1:1. The probability level was set at 0.05. The mean size at first maturity L_{50} was estimated by fitting the logistic function to the proportion of mature fish in 1.0 cm *TL* size categories and determined as the size at which 50% of individuals were mature [14] $P=1/\ (1+exp\ (-r\ (L-Lm)))$ where: *P* is the proportion of sexually mature individuals by length *L* and *r* is the slope of the curve.

2.4. Growth Estimation

Length frequency data were pooled into groups with 10mm length intervals. Growth was investigated by fitting the von Bertalanffy growth function to length frequency data. The von Bertalanffy growth equation is defined as follows: $L_t=L_\infty*1-exp^{-K*(t-t_0)}$ *[15]* Where L_t is the length at time *t*, L_∞ is the asymptotic length, *K* is the growth coefficient and t_0 is the hypothetical time at which length is equal to zero. Estimation of an initial value for asymptotic length L_∞ and *Z/K* (*Z*=total mortality and *K*=growth coefficient) using [16, 17] methods. The electronic length frequency analysis method ELEFAN I [18] was used to fit von Bertalanffy growth function *VBGF* [19]. Whilst the age at length zero t_o was estimated by employing the equation of $Log(-t_0)=-0.3922-0.2752LogL_\infty-1.038LogK$ [20]. Longevity was obtained according to the equation: $t_{max}=3/K$ *[21]* where: t_{max} is the maximum age the fish of a given population would reach and *K* is the curvature parameter. To compare the estimated growth parameters of the present work with the other studies, the growth performance index, ϕ′ [22] was calculated according to the equations: $\phi'=log\ K+2\ log\ L_\infty$ and $\phi=log\ K+2/3logW_\infty$ for length and weight respectively.

2.5. Mortalities

Total instantaneous mortality rate *Z* was calculated using the length converted catch curve developed from length frequency distribution [23, 24]. Natural instantaneous mortality *M* was estimated using the empirical formula of Pauly [20] as follows; $L_n(M)=-0.152-0.279\ L_n(L_\infty)+0.6543\ L_n(K)+0.463Ln(T)$ where L_∞ and *K* are *VBGF* parameters and *T* is the mean annual temperature, which was considered in this study 27.5°C. The annual instantaneous rate of fishing mortality was obtained by subtracting the natural mortality rate *M* from the total mortality rate *Z* derived from length converted catch curve $F=Z-M$. The histogram showing probability of capture for each size class was estimated by backward extrapolation of the straight portion of the right descending part of the catch curve. The existing exploitation rate *E* was estimated as the proportion of the fishing mortality relative to total mortality $E=F/Z$.

Resource status was evaluated by comparing estimates of the fishing mortality rate with target F_{opt} and limit F_{limit}

biological reference points which were defined as: $F_{opt}=0.5M$ and $F_{limit}=2/3M$ [25].

3. Results

3.1. Length-Weight Relationship

The linear regression analysis of the length-weight data allowed the estimation of the constants *a* and *b* of the length–weight relationship represented by the equation $W=0.0338TL^{2.7809}$ or $LogW=-1.4712+2.7807LogL$ with a regression coefficient $R^2=0.96$. The *b* value showed a significant difference in isometric growth ($95\%\ CI_b=2.26-2.36$, *t-test*, $P<0.05$). The t-test result shows that negative allometric growth was observed for *R. sarba*. The total length and fork length relationship was expressed as: $FL=0.8696TL+0.6221$ ($R^2=0.97$). Fig. 2.

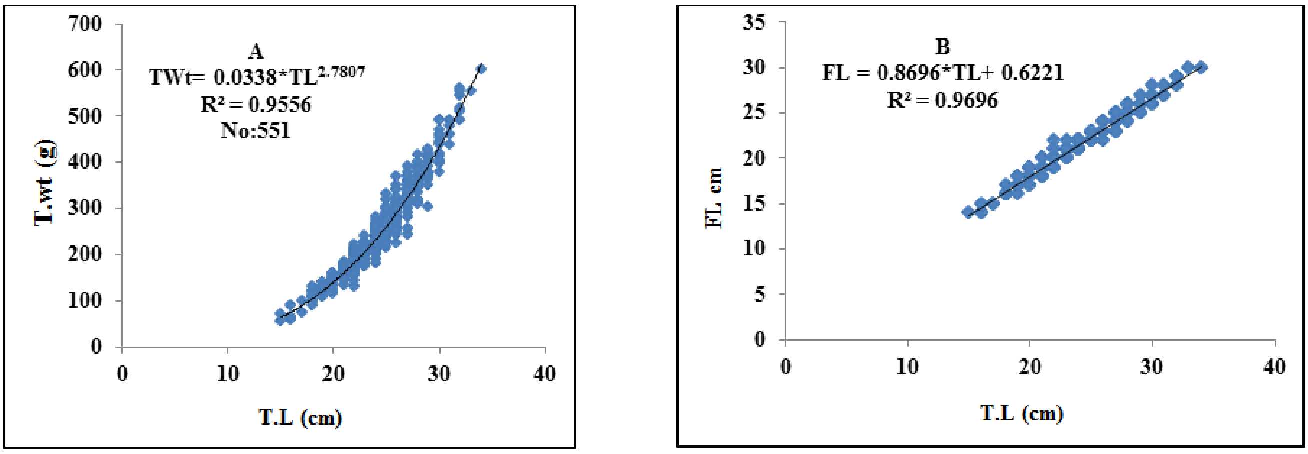

Figure 2. *Length-weight (A) and length-length (B) relationship of R. sarba collected from southern Arabian Gulf of the UAE.*

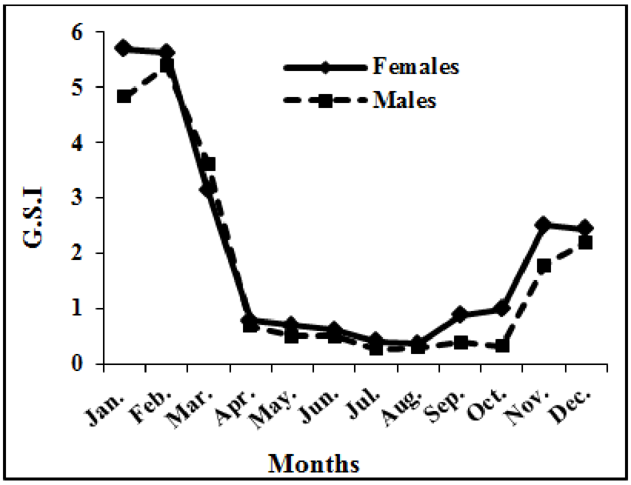

Figure 3. *Monthly variations of GSI for R. sarba from southern Arabian Gulf of the UAE.*

3.2. Reproduction

Out of 551 specimens examined 258 (43.94%) were males and 293 (93.94%) were females, giving a sex ratio of 1: 1.4. The sex ratio not showed a statistically significant deference from the 1:1 ($X^2 = 68.8$; $P > 0.05$). The gonado-somatic index *GSI* ranged in the females from 0.36 to 5.69 with a mean of 2.01±1.93, while in males the values of *GSI* ranged from 0.27 to 5.40 with a mean of 1.74±1.88. Fig. 3 shows the monthly changes in gonado-somatic index by sex. For both sexes, *GSI* started to increase from November (2.51 and 1.79 for females and males respectively), and maintained in high values up to February (5.62 and 5.40 for females and males respectively), then dropped in March. Therefore, the spawning season was considered to be from November to March, with a peak occurring during January and February for females and males respectively. The proportion of fish in aggregated size frequency samples that were below the mean size at first sexual maturity (juvenile retention rate) was 26.13%. The mean length L_m and age T_m at first sexual maturity for *R. sarba* was estimated as 24.6cm TL (22.01cm FL) and 2.95years. Fig. 4.

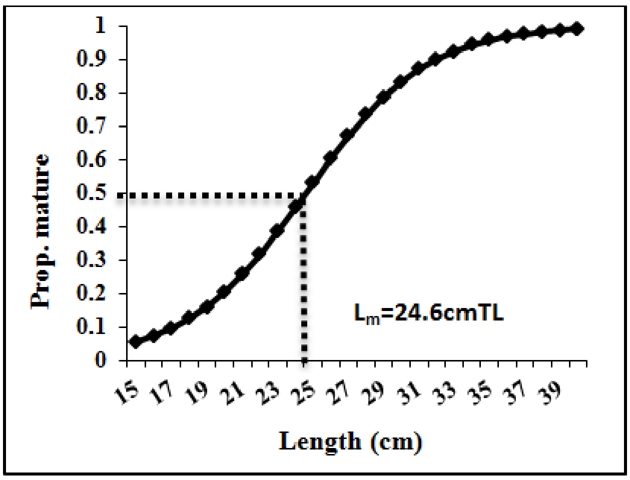

Figure 4. *Estimation of Length at first maturity Lm of R. sarba.*

3.3. Growth Parameters

A total of 5085 specimens were collected from fish ranging in size from 14.0 to 39.0cm *FL* during the period from January 2014 to December 2015. The mean fork length was estimated 26.5±7.65cm (±SD), with the highest frequency in length group 20.0cm (11.66%). On the other hand the terminal length groups 14.0 and 39.0cm were lowest frequency and contributed with 0.12% and 0.02% respectively. Fig. 5

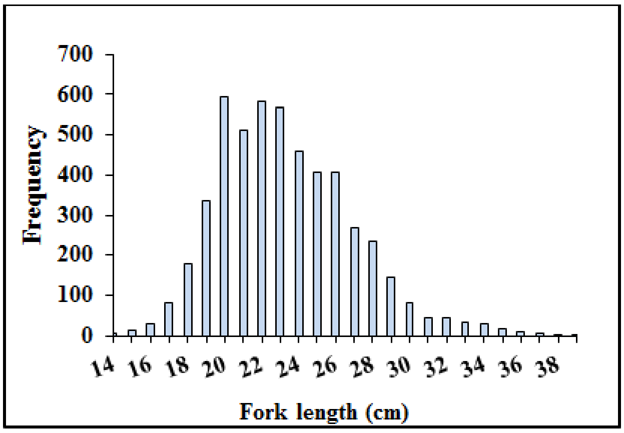

Figure 5. *Length frequency distribution of R. sarba in the Arabian Gulf of the UAE.*

The analysis of length frequency data by the Powell-wetherall method Fig. 6. gave the initial estimate of L_∞ value of 41.94cm and Z/K value of 4.694

The Optimized values of L_∞ and K obtained by ELEFAN II were 41.94cm and $0.25y^{-1}$ respectively. The goodness fit of R_n for the estimated L_∞ and k values was 0.201, and the oscillation parameters C and WP were assumed to be 0 as it is a tropical species. The non seasonalized restricted length frequency histogram with growth curve is shown in Fig. 7. The estimated t_o value was $-0.58y^{-1}$ and the von Bertalanffy growth equation for *R. sarba* can be written as $L_t=41.94*1-\exp^{-0.25*(t+0.58)}$. The values of growth performance index for length and weight were estimated as 2.64 and 1.43 respectively. The life span of *R. sarba* in its natural habitat was computed around 12.0 years.

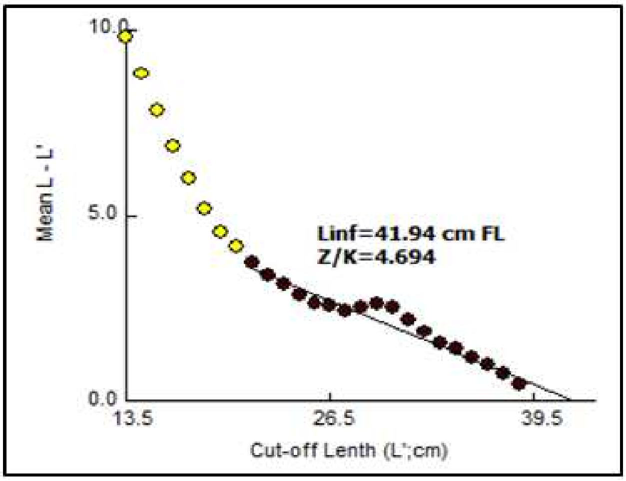

Figure 6. *Powell-Wetherall plot of R. sarba.*

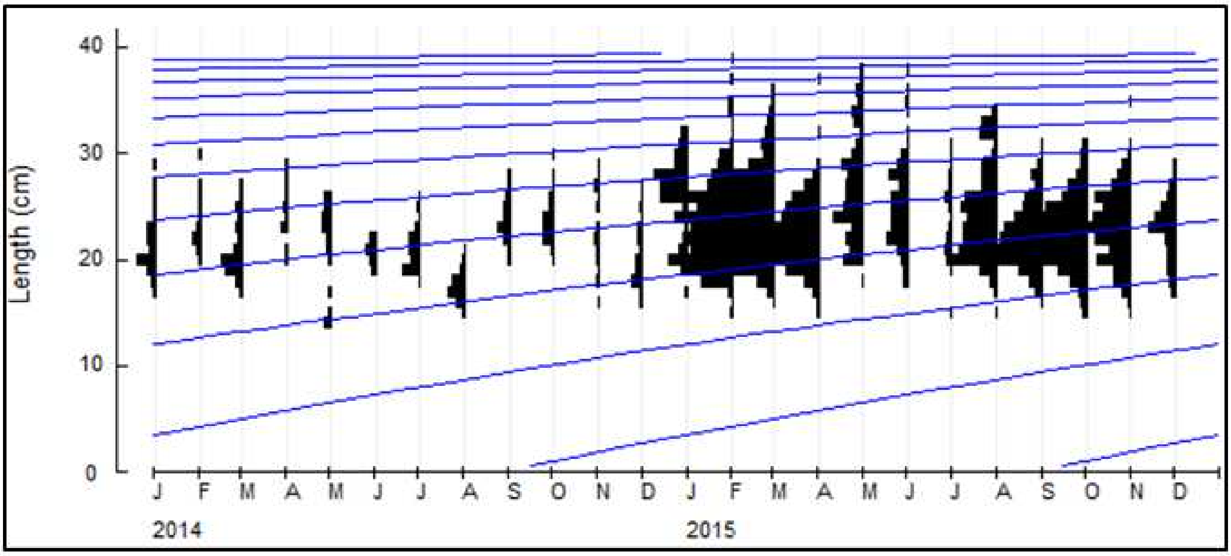

Figure 7. *Monthly length frequency data and growth curve of R. sarba drawn using ELEFAN I.*

3.4. Mortality and Assessment

The annual instantaneous rate of total mortality *Z* derived from length converted catch curve (Fig.8) was $1.09y^{-1}$ (95% confidence interval of Z=-1.15-(-1.03); ±SD of the slope=0.029: r=-0.99. The length at first capture L_c (length at 50% capture) was estimated as 19.51cm FL, which was considerably smaller than the mean size at which first sexual maturity was attained (L_m= *22.01cmFL*). Fig. 9.

The natural mortality coefficient *M* obtained through Pauly empirical formula at 27.5°C temperature was $0.66y^{-1}$. Therefore, the computed instantaneous fishing mortality coefficient ($F=0.43y^{-1}$) was considerably greater than the target ($F_{opt}=0.33y^{-1}$) and close to limit ($F_{limit}=0.44$) biological reference point, indicating that the stock is slightly overexploited. The recruitment pattern graph showed that *R. sarba* have highest recruitment during the period from April to June. The respective current of exploitation ratio *E* was 0.39; the exploitation level which maintains the spawning stock biomass at 50% of the virgin spawning biomass, $E_{0.5}$

was estimated as 0.36. The results indicated that reducing the current fishing effort to the target reference point will lead to reducing in exploitation ratio by 23.08%.

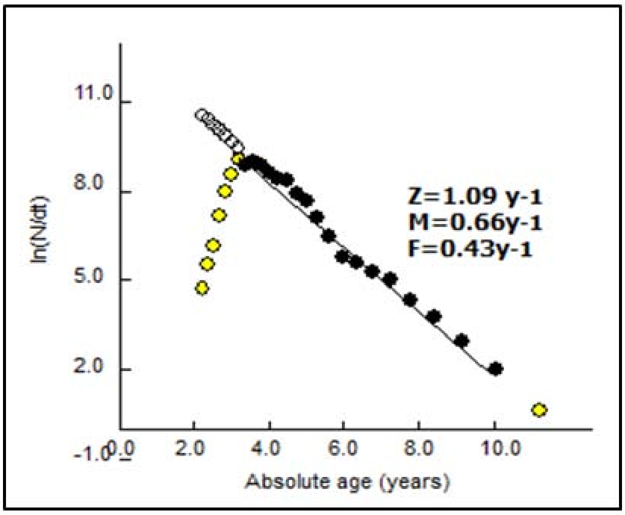

Figure 8. *Length converted catch curve of R. sarba L_∞=41.94cm, K=0.25y^{-1}.*

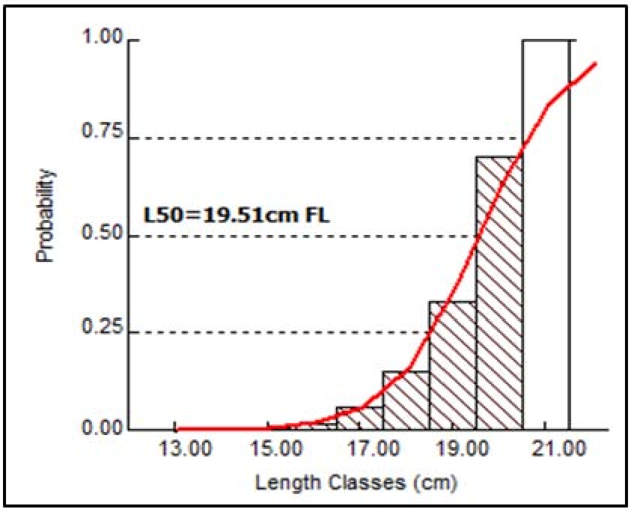

Figure 9. *Probability plot of R. sarba showing the mean size at capture 19.51cm.*

4. Discussion

The length- weight relationship *LWR* is considered as the building blocks of the stock assessment and population structure. The estimated *b* value by the non-linear regression analysis of the length-weight relationship was significantly below 3, which shows that the fish exhibits allometric growth. The *LWR* observed during the present study was $W=0.0338*L^{2.7}$ and The *b* parameter value is less than that the value obtained by [6] from the Coast of Emirate Abu-Dhabi (b=2.94) and [5] from the Oman Coast of the Arabian Sea (b=2.85). The value of *a* and *b* differ not only in different species but in the same species depending on sex, maturity stage, feeding intensity, etc. [26].

Overall males to female's ratio were 1:1.4. This ratio did not differ significantly from 1:1. The results also revealed that, during the periods from April to September males to females' ratio was 1:2.6 and the ratio was statistically differing from 1 to 1 expected ratio at 95% confidence level. The obtained results are compatible with the results obtained by [10] from Omani water of the Arabian Sea. She stated that males to female's ratio were 1:0.91. This ratio did not differ significantly from 1:1 ratio.

Monthly variation in *GSI* of *R. sarba* from the southern part of the Arabian Gulf of the UAE was evaluated. The maximum values of the *GSI* were recorded 5.40 and 5.69 for males and females, respectively. For *R. sarba*, the spawning seasons were identified during the winter season. The results are consistent with the findings of the previous study in Omani waters [27, 10]. They found that the peak of the reproductive season in January and February for males and females respectively. On the other hand the spawning season of *R. sarba* in the Emirates of Abu Dhabi was identified during the winter season [6].

From the maturation curve, the length at first sexual maturity of *R. sarba* was 24.6cm TL which corresponding to 2.95years. The study also revealed that a considerable proportion 26.13% of *R. sarba* catch didn't reach to the first sexual maturity. Therefore, in order to protect this species and to enable it to share at least for one time in reproduction, the mesh sizes must be re-evaluated. The present results are more or less similar to the previous ones. Wallace [28] calculated the length at maturity of *R. sarba* in Lake St. Lucia to be 26.0 cm TL which corresponding to an age of 1.8 years. El-Agamy [9] found that *R. sarba* in the Arabian Gulf mature between their second and third year of life. Age at maturity of *R. sarba* was therefore estimated from the growth curve to be 1.8years in South Africa [29]. Grandcourt [6] declared that the length at first sexual maturity of *R. sarba* was 23.5cm *FL* (2.0years) and 23.7cm *FL* (2.1years) for males and females respectively. On the other hand, in Omani waters of the Arabian Sea the length at first sexual maturity was 29.6 and 28.9 cm TL for males and females, respectively and these lengths lies in age group II [10].

The values of L_∞ and K for both sexes of *R. sarba* were calculated as 41.94cm and 0.25y^{-1} using *ELEFAN I* and Powell-Wetherall plot. The growth performance index ϕ' was estimated as 2.64. The age and growth of *Sparus sarba* from the Arabian Gulf based on scales readings were estimated by [9]. He evaluated the growth parameters as L_∞ =37.5 cm *TL* and K=0.16 y^{-1}, the K-value suggests that Arabian Gulf population has a lower growth rate but attains a smaller maximum size and larger age. Radebe [29] gave the growth parameters of *R. sarba* in South Africa as: L_∞=71.5cm FL, K=0.16y^{-1} and t_o= –0.996 year. Hughes [30] found that for both sexes of *R. sarba* in south-eastern Australia, the growth parameters were: L_∞ =26.40±0.40 cm *FL*, K =0.39±0.02 y^{-1} and t_o = –0.56 ± 0.09 years. Grandcourt [6] stated the growth parameters of both sexes of *R. sarba* in Emirates Abu-Dhabi as L_∞=25.3cm *FL*, K=1.29 y^{-1} and t_o= -0.03year. On the other hand the growth parameters were estimated by [5] in Omani waters of the Arabian sea as L_∞=46.97cm *TL*, K=0.33y^{-1} and t_o=0.83year. These variations in population parameters can be attributed to different condition e.g sample size, sexes and maturation.

The length at first capture (the length at which 50% of the fish at that size are vulnerable to capture) was estimated as 19.51cm *FL*. This value is equivalent to an age of 1.92 years and it was smaller than the length at first maturity L*m*=22.01cm *FL* i.e., these fishes are captured before their first spawning period. Grandcourt [6] stated the length and age at first capture as 14.0cm *FL* and 0.59years in Emirates of Abu Dhabi. Whilst Mehanna [10] from Omani waters of the Arabian Sea estimated the length and age at first capture as 22.9 cm *TL* and 1.2 years.

Total, natural and fishing mortalities were estimated as: 1.09, 0.66 and $0.43y^{-1}$. The obtained results of mortalities are more or less those results estimated by different authors in different areas. Grandcourt [6] mentioned the total, natural and fishing mortalities are: 1.04, 0.26 and $0.77y^{-1}$. Mehanna [5] estimated the total, natural and fishing mortalities are: 1.80, 0.60 and $1.20y^{-1}$. The specified precautionary target F_{opt}=0.5M and limit F_{limit}=2/3M values are considered to be appropriate biological reference points, in particular given current management objectives which are aimed at stock re-building and resource conservation. The current fishing mortality rate F=$0.43y^{-1}$ was relatively greater than the target (F_{opt}=$0.33y^{-1}$) and almost equal to limit (F_{limit}=$0.43y^{-1}$) biological reference points. The results also revealed that, reducing of the current fishing level $0.43y^{-1}$ to optimum level 0.33 will lead to reducing of exploitation rate by 23.08%.

5. Conclusion

This paper provides information on biology and stock status of one of the key species in the United Arab Emirates *R. sarba* locally called (Gabit). This investigation could strongly helpful to the researcher and policy maker for the preparation of very effective sustainable management plans of fishery resources of the United Arab Emirates. From the present study it is evident that the spawning season of *R. sarba* during the period from November to March and the length at first sexual maturity was 22.01cm. Thus, it is necessary to reduce fishing pressure on this species during the spawning season. The results also revealed that the length at capture is smaller than the length at first maturity, so we can say that the fish must be caught at least at 23.0cm FL to get the chance to spawn even once. The results also concluded that the current fishing mortality is higher than the optimum and the present level of exploitation rate (E=0.39) was higher than the exploitation rate ($E_{0.5}$ = 0.36) which maintains 50% of the stock biomass as spawning stock F_{opt}=0.33.

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