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ASSESSMENT OF INSHORE COMMERCIAL FISHERIES OF HALAIEB / SHALATIEN AREA "RED SEA", EGYPT

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ABSTRACT

The area of Halaieb and Shalatien lies on the south east part of Egypt. It extends from latitude 22^o to 23^o 8' N. The landed catch of the commercial fish families were studied. It comprises about 58 common fish species belonging to 23 fish families. The dominant fish families in the area are Serranidae (39.76%), Lethrinidae (9.78%) and Scaridae (9.67%) relative to the total catch. The present investigation is an endeavor to give information about the catch, effort and fishery biology of the dominant species (*E. areolatus*, *L.nebulosus* and *S.ghobban*) representing the mentioned families in order to develop and manage their fisheries in this area. The length weight relationships were studied and the relationship between the total length and scale radius of the three species under study were estimated to back calculate the lengths by the end of different years of life. Results revealed XI age groups for *E.areolatus* present in the catch, VII age groups for *L. nebulous* and only V age groups for *S. ghobban*. The values of Von Bertalanffy growth constants ($L\infty$, K, t_o) were estimated. The mortalities coefficients of *E.areolatus, L.nebulosus* and *S.ghobban* were studied. The annual average biomass of survivors which is related to the yield per recruit values was computed. The maximum sustainable yield per recruit (MSY/R) values which corresponding to the optimum fishing mortality values of the three species under study were estimated. The optimum F value for *E. areolatus* is 1.31 at a present F value of 0.088. The present F value is 0.092 for *L. nebulosus* and the optimum fishing mortality value is 0.550. In the mean time, the present and optimum F values for *S. ghobban* were 0.06 and 0.46 respectively. This means that, the fishing effort can be increased up to 6 times the present level in order to get close from the values of maximum sustainable yield per recruit. By studying the effect of age at first capture on yield per recruit at different fishing mortalities it was found that, the increase in age at first capture is associated with increase in yield per recruit. Hence, the values of the maximum sustainable yield of the three species under study can be raised to about 3 times the values of the current yield.

1. INTRODUCTION

The fisheries resources in the Egyptian region of the Red Sea have significant contribution to the Egyptian marine landed catch. However some areas there still need further investigations to improve and manage their fisheries. Amongst these areas is Halaieb and Shalatien triangle which include the coastal areas of three main cities namely Shalatien, Abu Ramad and Halaieb. The triangle is situated on the Southern part of Egyptian Red Sea coast extending from latitude 22° near Ras Hedreba to 23° 8' N near Bear Shalatien (Fig. 1).

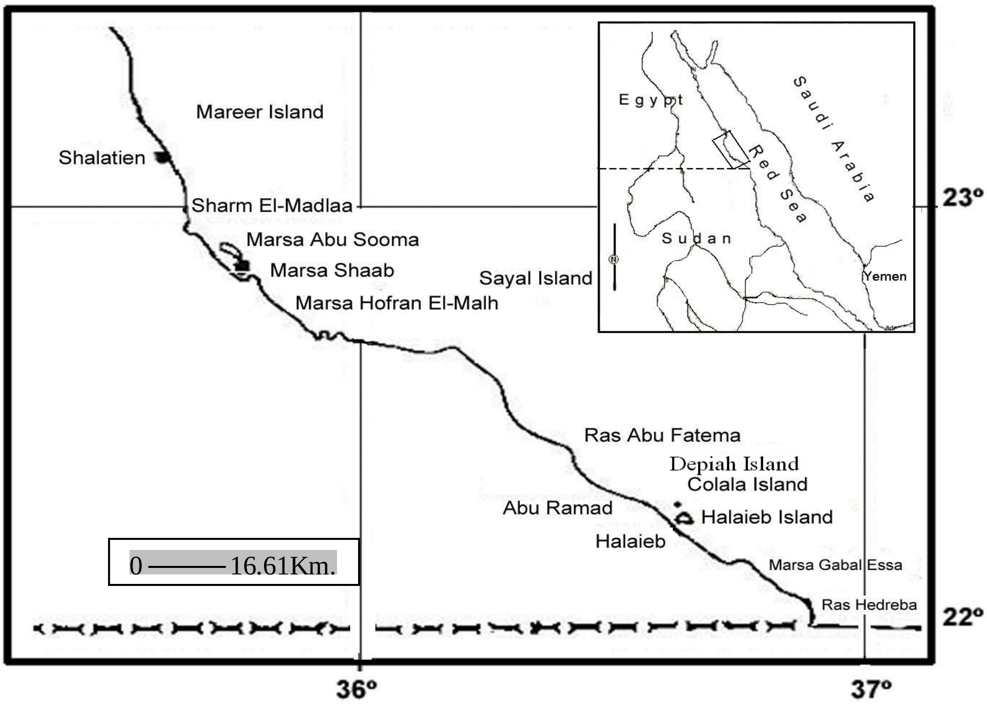


Fig. (1): The study area (Halaieb / Shalatien area).

The coastal area of the triangle is characterized by the presence of the coral reef terraces in many spots. These corals are depressed to about one meter depth to form patches parallel to the coast and disappear in certain places mainly at the downstream of the valleys (Wadies). Further south wards there are some coral islands near the coast and parallel to it.

Fishing activities in the mentioned area is recent where the available rerecords indicate that the dominant fish families in the area are Serranidae which represents an average of about 27% of the total landed catch in the area; Lethrinidae represents about 16%, while Scaridae represents about 11.6% (GAFRD, 1998 and 2000).

The present work aims to concentrate on exploring the fish populations in this area with respect to their present commercial exploitation rate for proposing better fisheries development and management plans.

2. MATERIALS AND METHODS

Samples were collected during the period from March 1997 to March 1999. Field trips to the area of study were carried out on a seasonal basis. Each trip lasted for about 10 days or more to cover the two main landing centers Shalatien and Abu Ramad.

Fishery statistics were recorded from several sources in the area; namely: General authority for fish resources development, the coast guard office in the area, the Egyptian fish marketing company, as well as incentive fishermen working in the area and the wholesalers who collect the fish from the area to be sold in other cities in Egypt. The following data and information were recorded in each trip: Number of crew on each fishing boat, duration of trip in days, number of actual fishing days, the total landed catch in kilograms and Species composition of the landed catch.

Samples were taken directly from commercial fishing boats. Identification of the collected fish samples were carried out using their distinguished external and internal characters. The following data were recorded for each fish sample: Date of capture, total length to the nearest mm, total weight to the nearest gm.

Length weight relationship was estimated using the power equation $W = a\ L^b$ (Le Cren, 1951) Where: W is the total weight in gm, L is the total length in cm and a & b are constants. The condition factor "K" was calculated for the studied species using the equation of Hile (1936). Scales were used to determine fish age. The relationship between the scale radius and the fish total length was determined by the following equation:

L = a + bS where a & b are constants.

The lengths at different ages were back calculated using Lee's method (1920). The back calculated lengths were used to estimate the growth parameters of the Von Bertalanffy growth model (1938) by fitting the Ford (1933) and Walford (1946) plot, while t_o was estimated by inverse Von Bertalanffy growth equation and $W\infty$ was estimated by converting $L\infty$ to the corresponding weight using length weight relationship.

The total mortality coefficient (Z) was estimated by using Beverton and Holt's (1956) equation. Natural mortality coefficient (M) was calculated by using Pauly empirical formula (1980), and the fishing mortality coefficient (F) was computed as F = Z – M. The survival rates (S) was simply estimated according to Ricker (1975) equation, while the exploitation rate (E) was computed from the ratio F / Z (Gulland, 1971).

Length at first capture (L_c), length at recruitment (L_r) and the corresponding age at first capture (t_c) and age at recruitment (t_r) were calculated by the equations of Beverton and Holt (1956). Yield per recruit model was estimated by Beverton and Holt (1957) as written in the form suggested by Gulland (1969) and Biomass per recruit was expressed by Beverton and Holt model.

For maximum sustainable yield (MSY) estimation Cadima modified the version of Gulland's estimator for exploited fish stocks by the form: MSY = 0.5 * Z * B^- Where B^- (Average biomass) = Y (Yield) / F (Troadec, 1977).

3. RESULTS AND DISCUSSION

3.1. The Landed Catch in the Area of Study

Fish samples were obtained from about 404 fish trips landed in Shalatien area throughout the period of study. Hand-line (line and hook) and long line are the most dominant fishing gear in the area due to the presence of coral reefs. Lines take numbers according to their thickness (the most common lines ranged from 0.8mm to 1.2mm). Hooks are numbered too (the most commonly used varies from 6 to 10) depending on size and strength of targeted fish. A lead bullet is fixed also above the hook to help sinking the line into water. One fishing boat uses normally about 10 vertical lines (Each line can have about 2 hooks). In the long line fishery, the mean length of the line is about 100 meter and the number of hooks ranged from 25 to 40 hooks per line. Gill nets are sometimes used to collect small fish which are used as bait depending on depth and size of the targeted fish. Some other fishermen who come from nearby locations could use trammel nets which are not usually used by local fishermen.

Analysis of the landed catch in the area revealed that commercial fish catch is comprised of about 58 common fish species belonging to 23 fish families. All recognized species were cited before by Randall (1983), he gave a detailed description of the most common reef fishes where total of 325 species which belong to 57 families where recorded in the Red Sea. Figure (2) represents the present study landed catch of the commercial fish families and their percentage abundance with respect to the total landed catch during the period of study.

Family Serranidae ranks as number one in terms of contribution to the catch where it represents about (39.76%) of the landed catch, followed by family Lethrinidae (9.78%), family Scaridae (9.67%), family Gerridae (6.89%), family Carangidae (5.68%), family Haemulidae (5.42%), family Lutjanidae (4.93%), family Siganidae (4.64%), family Mugilidae (4.55%) and Belonidae (2.82%). The two families Sphyraennidae and Sparidae are represented by about (1.3%), while the rest of the fish families represent each less than 1% of the landed catch. The most abundant species of the three dominant fish families will be dealt in details in the present study. The most abundant species of family Serranidae was *Epinephelus areolatus* (Forsk-l, 1775). Family Lethrinidae was dominated by *Lethrinus nebulosus* (Forsk-l, 1775), and *Scarus ghobban* (Forsk-l, 1775) was the dominant species of family Scaridae.

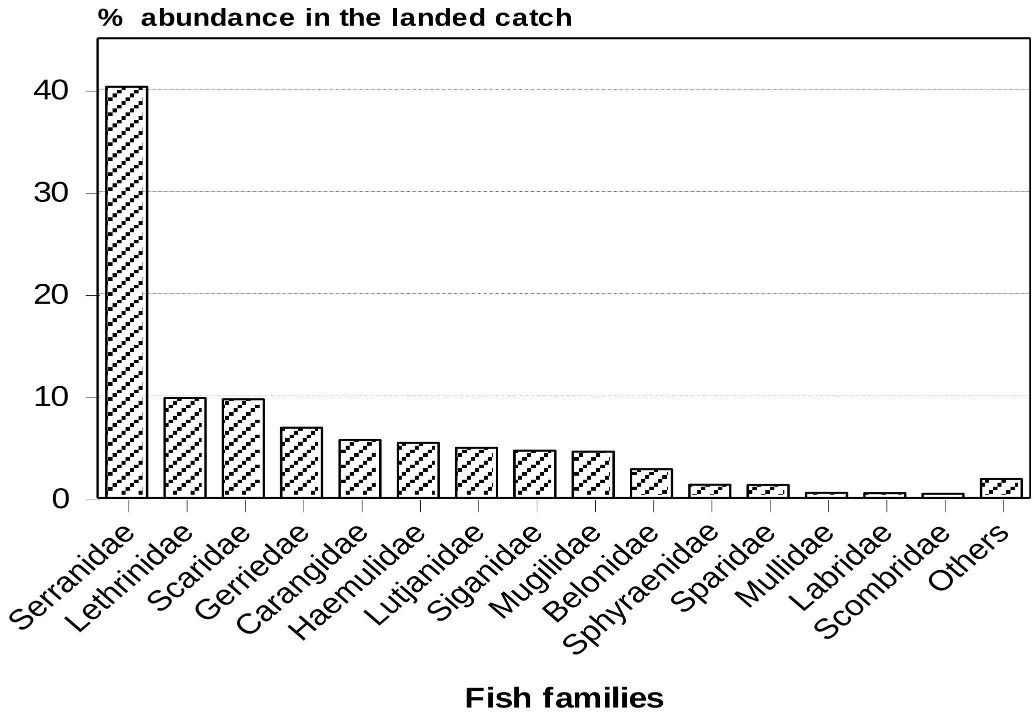


Fig. (2): Percentage abundance of different fish families in the landed catch from Halaieb / Shalatien area.

3.2. Age and Growth

3.2.1. Length weight relationship

The length weight relationships of *E. areolatus*, *L. nebulosus* and *S. ghobban* were found to be represented by the following equations: For *E. areolatus*: $W= 0.0113\ L^{3.0944}$, for *L. nebulosus*: $W= 0.0129\ L^{3.0572}$ while for *S. ghobban*: $W = 0.0146\ L^{3.0346}$ where, W is the total weight in grams and L is the total length in cm. The length weight relationship showed tendency towards positive allometry, These results are in accordance with those given by previous authors as Edwards *et al*. (1985), Mathews and Samuel (1987 & 1991), Letourneur *et al.* (1998) and Al Sakaff and Esseen (1999).

3.2.2. Condition factor

The condition factor (K) is a good indicator of the well being of a fish. By comparing the annual average values of K for the three species, it appears that, the condition factor of *E. areolatus* and *L. nebulosus* were near to each other (1.57 and 1.58), while *S. ghobban* had a slightly higher value (1.64) which indicates that, *S. ghobban* puts on weight at a rate higher than the other two species. Al Dossary (1987) found the annual average value of K of *L. nebulosus* to be 1.27 in Saudi Arabia (Arabian Gulf), while it was 1.58 in the present study; this might show that, this species is doing well in the habitat at Halaieb and Shalatien area.

3.2.3. The body length - scale radius relationship

Ageing of the three species under study was done by scale reading. The body length scale radius relationship according to the present study could be expressed by the following equations:

For *E. areolatus*: $L = 2.29 + 3.79\ S$

For *L. nebulosus*: $L = 2.35 + 2.42\ S$

For *S. ghobban*: $L = 2.50 + 1.36\ S$

3.2.4. Back calculation of length

The back calculation of length at the end of different years of life was calculated for the three species under study as shown in table [1 (a, b & c)] and graphically represented in Fig. (3), it was found that, there are 11 age groups of *E. areolatus* represented in the catch, and for *L. nebulosus* there are VII age groups while for *S. ghobban* there are only V age groups represented in the catch of this species. It appears that, the maximum growth rate occurs by the end of the first year of life and as the fish advances in age linear growth rate decreases gradually for the three species under study. However, *S. ghobban* reached higher lengths by the first year of life than the other two species.

The parameters of Von Bertalanffy growth model were estimated as K = 0.21 $year^{-1}$, $L_\infty = 54.6$ cm and $t_o = -0.31$ year for *E. areolatus*; K = 0.19 $year^{-1}$, $L_\infty = 66.6$ cm and $t_o = -0.45$ year for *L. nebulosus*; K = 0.17 $year^{-1}$, $L_\infty = 71.95$ cm and $t_o = -0.85$ year for *S. ghobban*.

3.2.5. Growth in weight

The equation representing the length weight relationship was used to estimate fish weight by the end of each year of life for *E. areolatus*, *L. nebulosus* and *S. ghobban* as shown in Fig. (4). For *E. areolatus* the increment of the first year for this species was 34.84 gm. Generally, the increment increased with age till it reached the maximum by the sixth year of life 261.35 gm (13.2%) after which a progressive decrease occurred till the end of eleventh year of life 154.45 gm (7.8%). The annual weight increment in the other two species indicates a progressive increase in weight with age. For *L. nebulosus* it was 61.69 gm (3.02%) by the end of the first year whereas; it reached 418.94 gm (20.49%) by the end of VII year of life. For *S. ghobban* the values of this increment was 116.58 gm (7.59%) by the end of the first year where it reached 454.52 gm (29.61%) by the end of the fifth year.

Table (1): Back calculated lengths of the three species under study by the end of each year of life.

a. E. areolatus:

Age groups (years)	Back calculated length (cm)										
	L1	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**L9**	**L10**	**L11**
I	13.70										
II	13.61	21.42									
III	13.57	21.37	28.03								
IV	13.51	21.32	27.95	33.24							
V	13.49	21.25	27.77	33.09	37.55						
VI	13.45	21.19	27.71	33.08	37.46	41.00					
VII	13.30	21.07	27.54	33.00	37.43	40.95	43.63				
VIII	13.22	21.00	27.53	32.93	37.20	40.85	43.61	45.62			
IX	13.06	20.95	27.49	32.88	37.11	40.77	43.46	45.58	47.12		
X	13.00	20.94	27.28	32.44	36.80	40.38	43.55	45.53	47.12	48.71	
XI	12.74	20.77	27.20	32.42	36.84	40.46	43.27	45.28	46.88	48.09	49.70
Av.Cal. L.	13.33	21.13	27.61	32.88	37.20	40.73	43.50	45.50	47.04	48.40	49.70
Annual inc.	13.33	7.80	6.48	5.27	4.32	3.53	2.77	2.00	1.54	1.36	1.30
Ann. inc. %	26.82	15.69	13.05	10.61	8.69	7.11	5.58	4.02	3.09	2.73	2.61

b. L. nebulosus

Age groups (years)	Back calculated length (cm)						
	L1	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**
I	16.19						
II	16.06	24.88					
III	16.01	24.81	32.06				
IV	15.95	24.76	32.01	37.89			
V	15.93	24.74	31.98	37.84	42.56		
VI	15.93	24.61	31.94	37.64	42.53	46.60	
VII	15.79	24.47	31.75	37.62	42.38	46.58	50.22
Av.Calculated L.	15.98	24.71	31.95	37.75	42.49	46.59	50.22
Annual increment	15.98	8.73	7.23	5.80	4.74	4.10	3.63
Annual increment %	31.82	17.39	14.41	11.55	9.44	8.16	7.23

c. S. ghobban

Age groups (years)	Back calculated length (cm)				
	L1	**L2**	**L3**	**L4**	**L5**
I	19.48				
II	19.4	27.66			
III	19.28	27.58	34.58		
IV	19.23	27.46	34.31	40.32	
V	19.19	27.37	34.26	40.15	45.17
Av.Calculated L.	19.32	27.52	34.38	40.24	45.17
Annual increment	19.32	8.20	6.87	5.85	4.94
Annual increment %	42.76	18.16	15.20	12.95	10.93

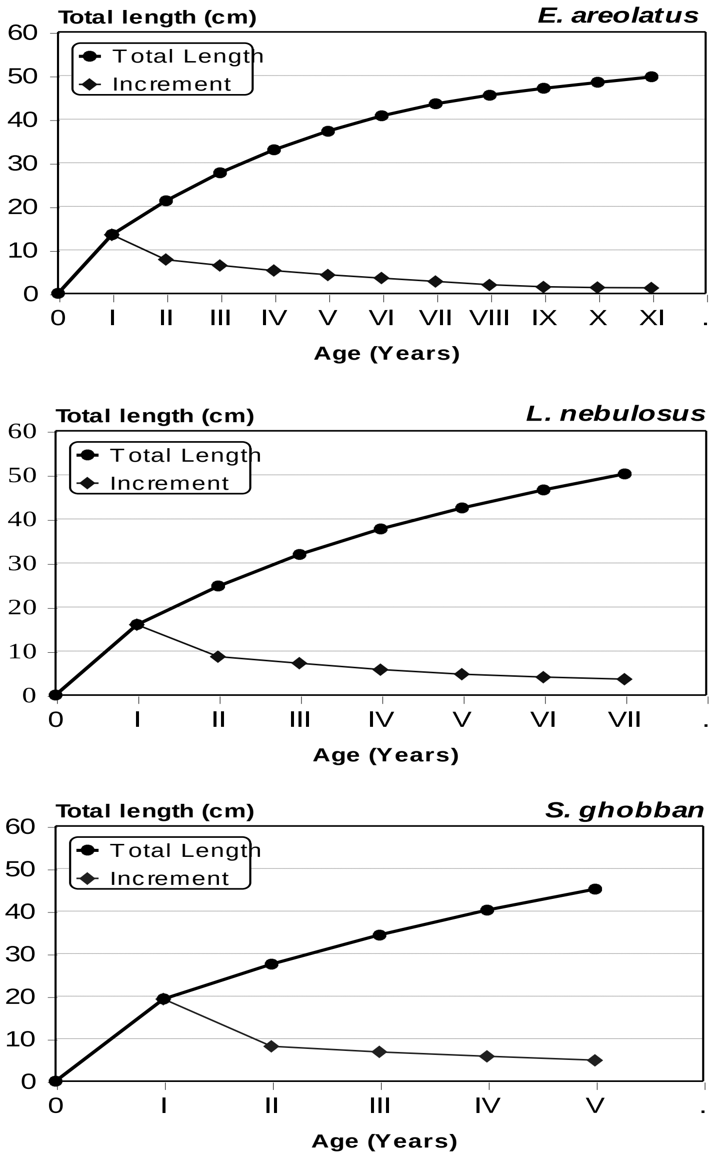


Fig. (3): Growth in length and increments curves of the three Species under study at the end of each year of life.

3.3. Population Structure

3.3.1. Length frequency distribution of age groups

Overlapping in length between the different age groups is more obvious in the small ages. It appears that, in *E. areolatus* age group I could reach up to 23.5 cm while age group II ranges from 22.5 cm to 29.5 cm, for *L. nebulosus* age group I was found to reach 24.5cm and age group II ranged from 22.5cm to 33.5cm, In *S. ghobban* age group I reached 29.5cm and age group II ranged from 26.5cm to 36.5cm.

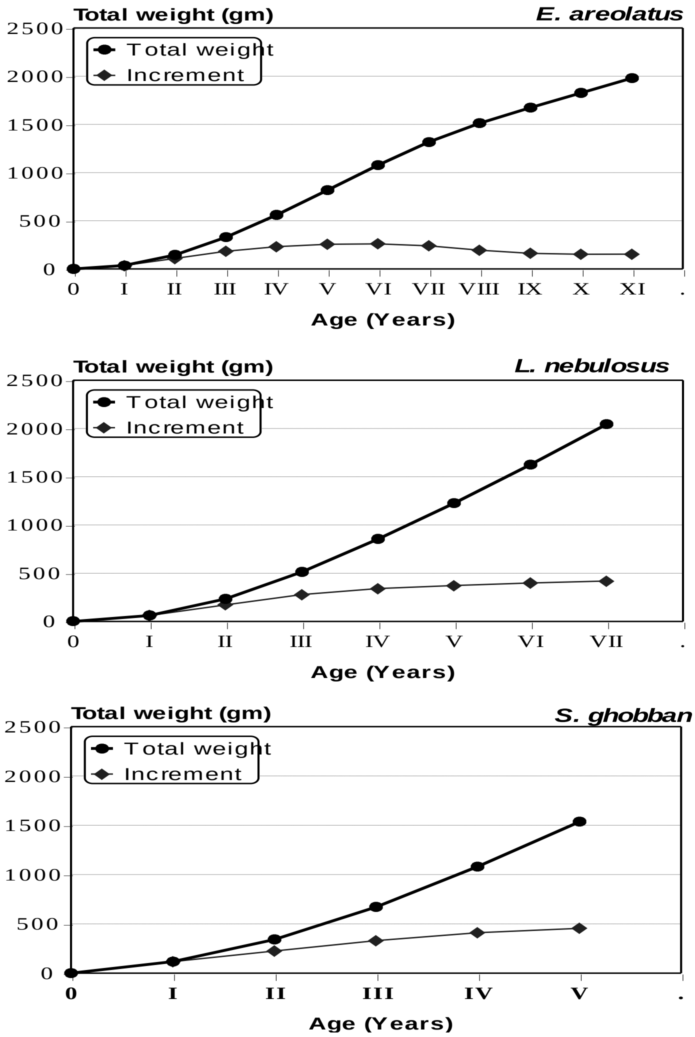


Fig. (4): Ponderal growth and increments curves of the three Species under study at the end of each year of life.

3.3.2. Age composition

Age composition describes the percentage abundance of each age group in all the catch samples of the three species (Fig. 5). The data reveal that age group II (Most dominant 40.5%) for *E. areolatus* is followed by age groups III, IV, I and finally age group V (19.6%, 17.6%, 6.5% and 4.6% respectively). For *L. nebulosus* age group II (Most dominant 44.3%) is followed by age groups III, I, IV then V which are represented by the percentages (23.7%, 14.5%, 11.5% and 4.8% respectively). And for *S. ghobban,* age group II (Also the most dominant 34.1%) is followed by age groups I, III, IV and V which are represented by the percentages (26.1%, 20.5%, 15.9% and 3.4% respectively).The relative numbers of fish belonging to age groups I & II is about 47% of the total landed catch for *E. areolatus*, 59% for *L. nebulosus* and 60% for *S. ghobban*, this means that fishery of the very near shore area is depending mainly on young fish groups.

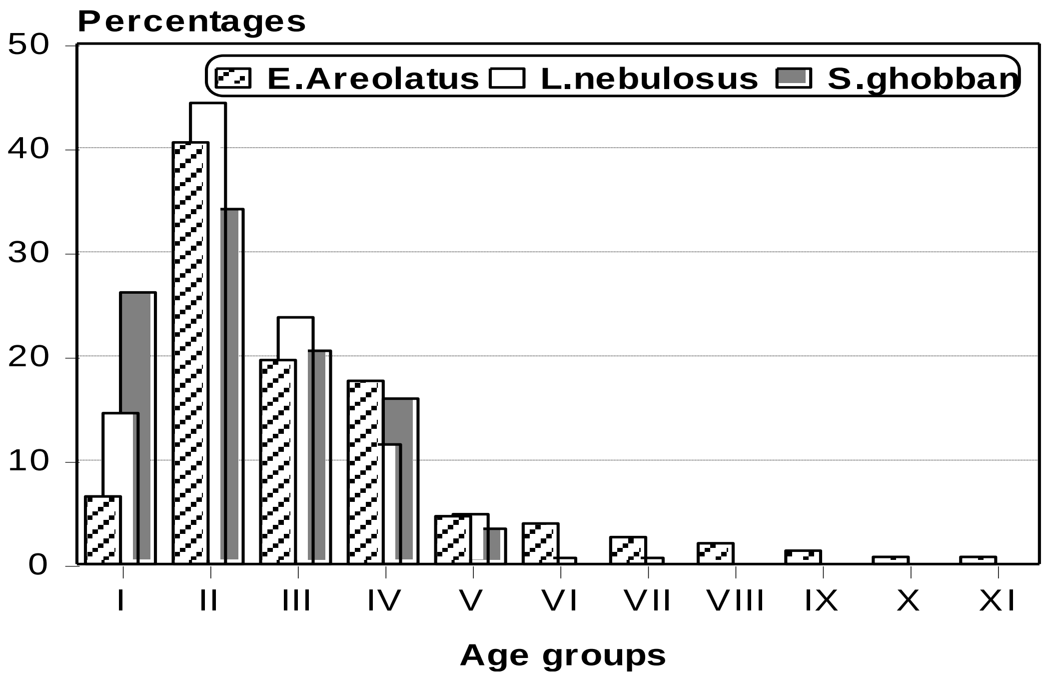


Fig. (5): Age composition of the three species under study in Halaieb and Shalatien area.

3.4. Instantaneous Mortality Coefficients

The study of fish mortality is essential to provide useful information for good management of fish population. The values of the instantaneous natural mortality coefficient (M) were 0.547, 0.475 and 0.433 of *E. areolatus*, *L. nebulosus* and *S. ghobban* respectively, and the instantaneous total mortality coefficient values (Z) were found to be 0.635, 0.567 and 0.495 for the three species under study respectively. While the fishing mortality (F) was found to be 0.088 and 0.092 for both of *E. areolatus* and *L. nebulosus* respectively, and it was 0.062 for *S. ghobban.* The survival rate, the exploitation rates and length & age at first capture and at recruitment of the three under study species were represented in table (2).

4. MANAGEMENT

4.1. Yield per recruit (y/r)

Study of yield per recruit seems to be the method of choice for stock assessment of a fishery (Grifiths 1997). The yield per recruit model (Beverton and Holt 1956, 1957) has been widely applied in the management of reef fisheries (Huntsman *et al*., 1983 and Punt *et al.*, 1993). According to this model the yield per recruit was found to be (57.54 g.) for *E. areolatus* and (80.57 g.) for *L. nebulosus*, while it was (76.22 g.) for *S. ghobban.*

Table (2): Survival and exploitation rates and length & age at first capture and at recruitment of the three under study species.

Parameters	*E. areolatus*	*L. nebulosus*	*S. ghobban*
S	0.53	0.57	0.61
E	0.139	0.163	0.12
Lc	22	18.5	18.5
Tc	2.1	1.28	0.91
Lr	19.23	14.54	13.87
tr	1.72	0.86	0.42

4.2. Biomass per recruit

The average biomass per recruit is defined as the average biomass of the exploited part of the cohort (The biomass of fish of age tc and older). According to the present computations, it was (653.41 g.) for *E. areolatus* and (872.57 g.) for *L. nebulosus*, while it was (1231.18 g.) for *S. ghobban*.

Fig. (6) shows the yield per recruit and the biomass per recruit for the three species under study as a function of fishing mortality by testing various (F) values. It appears that, for *E. areolatus* the maximum sustainable yield per recruit (MSY/R) corresponds to optimum fishing mortality value of 1.31 while the present F value is 0.088. For *L. nebulosus*, the actual F value is 0.092 while the optimum fishing mortality value is 0.55. Finally for *S. ghobban*, the actual and optimum F values were 0.06 and 0.46 respectively. This means that the fishing effort could be raised up to 6 times of the present level in order to get close to the values of maximum sustainable yield per recruit.

Biomass per recruit generally decreases with an increase in fishing mortality at a certain level of natural mortality and age at fishing capture (Beverton and Holt, 1957). This was found to be true for results of the present study for the three species under study as well as those given by other authors (Griffiths, 1997, Rizkalla, 1996, Miranda *et al*., 2000 and Abd El Rahman 2003).

In the case of F = 0, the value of biomass per recruit is considered as the virgin biomass per recruit (The biomass of the unexploited stock). The biomass per recruit can also expressed as a percentage of the virgin biomass. The results show that, the biomass corresponding to the biologically optimum fishing level (F_{MSY}) is only 14.4% of the virgin biomass for *E. areolatus*, 22.07% for *L. nebulosus*, and it was 23.06% for *S. ghobban*.

4.3. The effect of tc on y/r

To represent the effect of age at first capture on yield per recruit at different fishing mortality values, two values of age at first capture were applied namely, 0.5 below and above the present value of each species under study (2.098 for *E. areolatus*, 1.281 for *L. nebulosus* and 0.909 for *S. ghobban*) as shown in Figure (7).

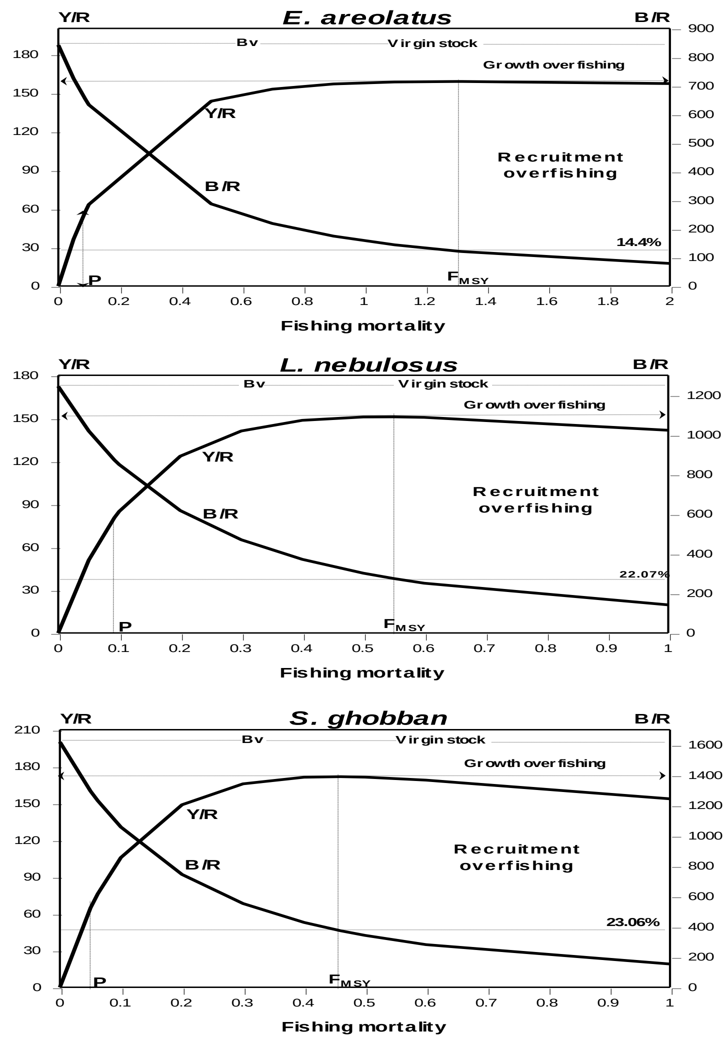


Fig. (6): Yield per recruit and average biomass per recruit curves of the three under study species in Halaieb and Shalatien area.

It appears that, at these present low levels of fishing mortality values for the three species under study; there is a weak effect of increase or decrease of age at first capture on yield per recruit. While at higher fishing rates it could be seen that, a decrease in age at first capture below the present value would cause a decrease in yield per recruit, on the other hand the increase in age at first capture is associated with increase in yield per recruit.

Figures (8a, 8b & 8c) clarified the nature of the Beverton and Holt model. The series of yield curves are really slices through a three dimensional surface and this is traditionally represented as contours joining points of equal yield per recruit. The yield contours are termed yield isopleth and can be considered analogous to a contour map (Pitcher and Hart, 1982). In these figures, contour lines that express values less than 0.1 fishing mortality are omitted for clarity and tc values were up and down the actual values by about 0.5 year.

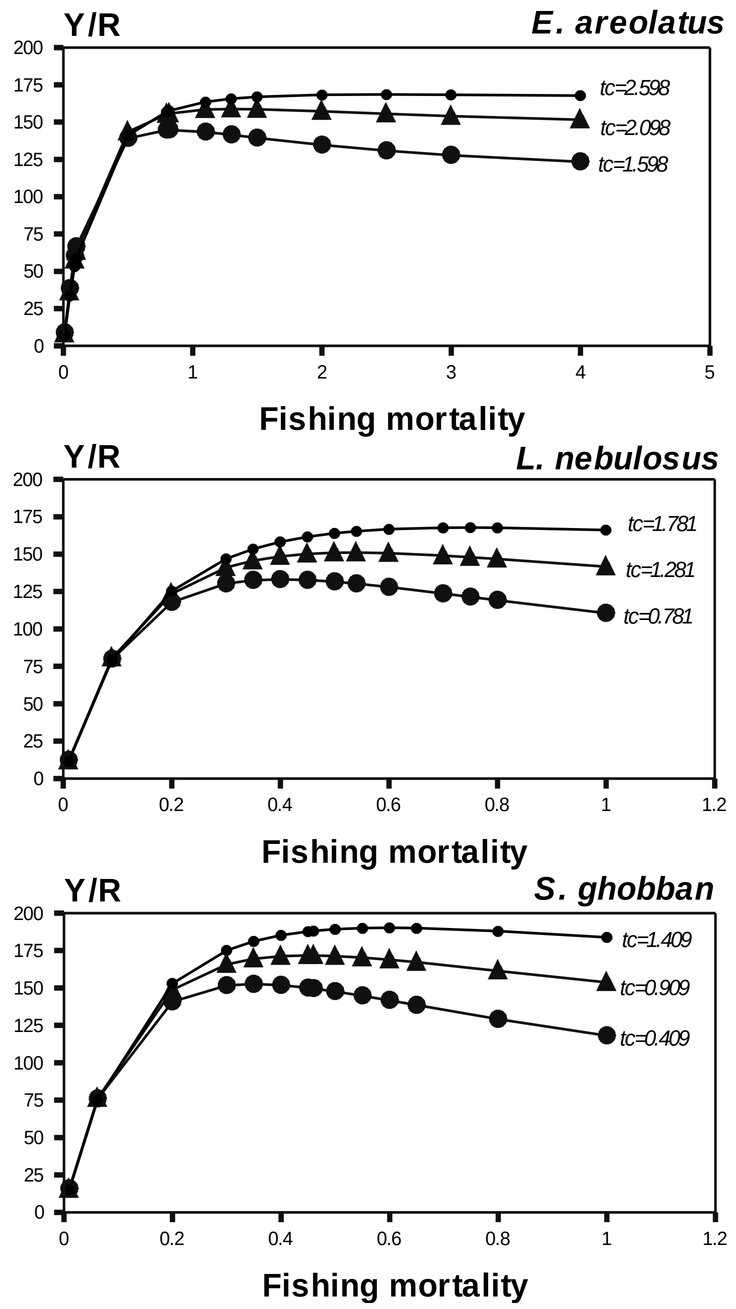


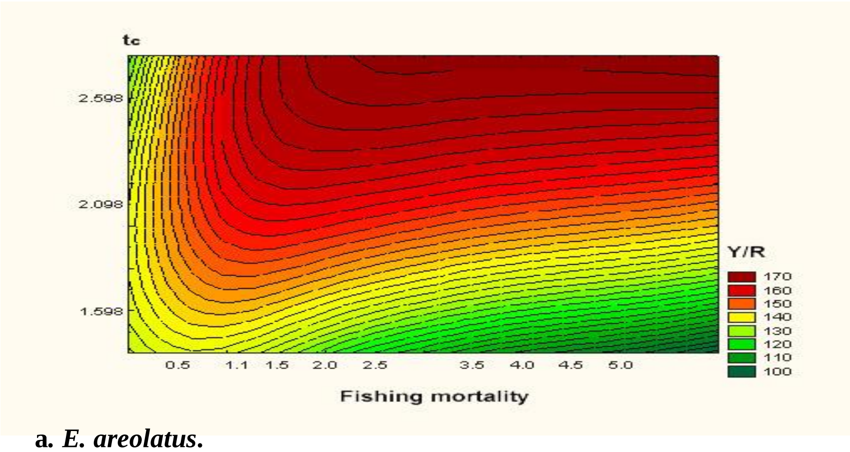
Fig. (7): The relation between yield per recruit and fishing mortality of the three Species under the present study with different values of age at first capture.

El Gammal *et al*. (1994), Mehanna (1996), Gabr (1997), Griffiths (1997) and Abd El Rahman (2003) showed that, any increase in the age at the first capture could be associated with a decrease in the yield per recruit. These results may be due to the state of exploitation of the species under study. So in term of fishery management; age at first capture has to be controlled by changing the mesh size of the fishing gears or changing fishing mortality for example by changing the fishing effort. The contour curves take a plateau shape with a promontory extending down towards fishing mortalities. The peaks of the plateau differ in their position according to the values of fishing mortality (F) and age at first capture (tc) in each species. In *E. areolatus,* at the lower value of tc the yield per recruit peak corresponding to F value of 0.82, at the actual value of tc the yield per recruit peak corresponding to F value of 1.3, while at the higher tc the values of yield per recruit were higher than the yield of the previous values of tc and reach their peak (168.5 g.) with fishing mortality value (2.5). It is clear that, if the actual tc remains steady constant as it is, the fishing effort could be increased to increase the fishing mortality to a rate of 1.3 in order to reach the maximum sustainable yield per recruit (158.82 g.) at the same age at first capture (2.098 year). In *L. nebulosus*, the optimum value of fishing mortality is 0.4 at the lower value of tc, at the actual value of tc the fishing mortality can be increase to reach the optimum value (0.54), while at the higher tc the optimum value of fishing mortality is 0.75. In *S. ghobban* the optimum values of fishing mortality are 0.35, 0.45 and 0.6 for the lower, actual and higher values of age at first capture respectively.

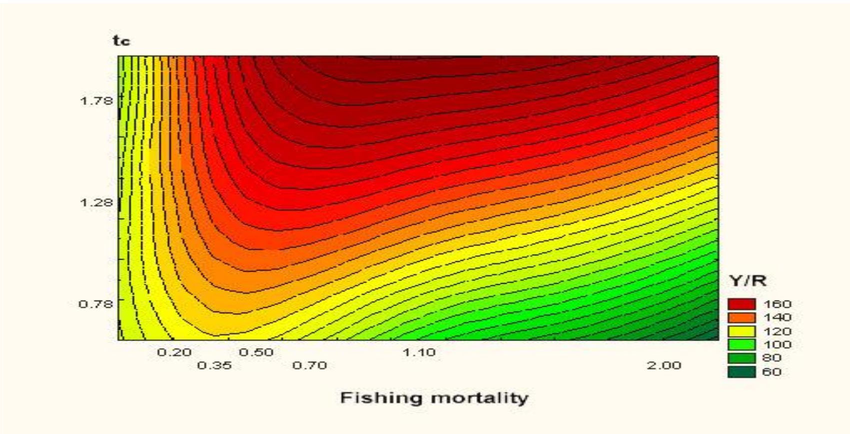
E. MSY estimation based on the surplus production model:

Maximum sustainable yield is the highest theoretical equilibrium yield that can be continuously taken (on the average) from the stock under existing environmental conditions without affecting significantly the reproduction process (Ricker, 1975).

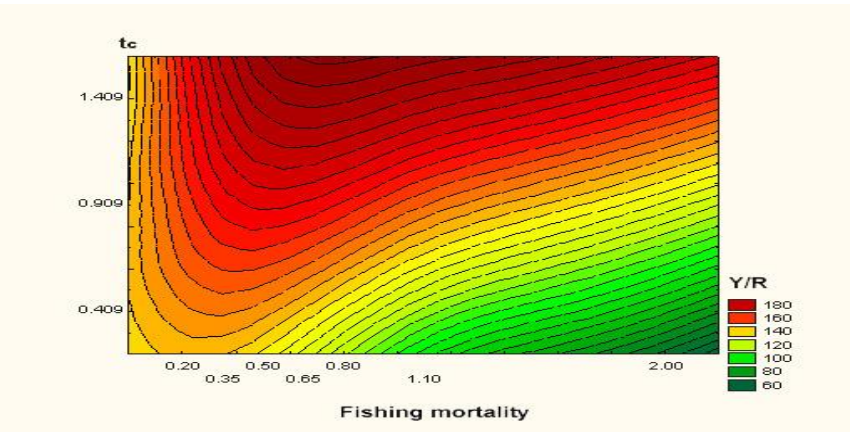
The total catch (Yield) of the three species under study was (12.744, 4.535 and 5.682 tons) for *E. areolatus*, *L. nebulosus* and *S. ghobban* respectively. Then, the maximum sustainable yield of *E. areolatus* is 46.313 tons, 13.998 tons for *L. nebulosus* and it is 22.945 tons for *S. ghobban*. By comparing the yield of the three species under study with those computed values of maximum sustainable yield (Cadima, 1978) it is clear that, the yield values of the three species can be raised at least 3 times the present values of the current yield. These results are in agreement with the results of the optimum fishing mortalities for the three species, which means that the area of Halaieb and Shalatien is still considered as underexploited area from the fisheries point of view and the effort could be increased in this area up to six times the present level as mention before.



a. ***E. areolatus*****.**



b. ***L. nebulosus.***



c. ***S. ghobban.***

Fig. (8): Yield per recruit contours of the three species under study for Beverton and Holt model in Halaieb and Shalatien area.

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