GROWTH, MORTALITY AND YIELD PER RECRUIT OF *MUGIL CEPHALUS* IN BARDAWIL LAGOON, NORTH SINAI, EGYPT

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Abstract

Growth, mortality and yield per recruit of Mugil cephalus were studied from a small scale fishery of Bardawil lagoon. 620 specimens (18.22 to 46.73 cm total length and 103.5 to 1235 g total weight), were collected from April to December, 2010 (one fishing season). The relationship between length and weight was $W= 0.0303*L^{2.6723}$. Age was determined by scales where age groups 0 to 5 years. Growths in length and weight at the end of each year were calculated as 20.24, 29.02, 36.43, 41.46 and 45.65 cm for the 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} year of life respectively. The growth parameters of von Bertalanffy equation were calculated as ($L\infty$= 59.9 cm, K = 0.255 $year^{-1}$ and t_0 = -0.601 year). Growth performance index (φ' = 2.96). Mortality rates were 0.87 yr^{-1}, 0.33 $yr^{-1}$and 0.54yr^{-1} for total, natural and fishing mortality respectively. The currently exploitation rate E = 0.62. The length at first maturity (L_m) was estimated at 32.8 cm (2.58 year) for males and 34.9 cm (2.77 year) for females while the length at first capture (L_c) as 33.4, (2.63 year)). The results of age at first capture and the current exploitation rate indicated that the small fish are caught at higher fishing effort level. The current mesh size should be increased in order to increase the Tc to 3 year which achieve the highest yield at current fishing effort. Thus, the current effort of M. cephalus should be stabilized at increase of Tc to 3 year and if possible should be reduced.

Keywords: Age, growth, yield per recruit, Mugil cephalus, Bardawil lagoon. Egypt.

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INTRODUCTION

In Egypt, marine fisheries provide a valuable supply of animal protein to the continuous expansion in the population and help to solve the problem of protein deficiency. Mullets (family: Mugilidae), are the most important fish resources in Bardawil lagoon where they contributed about 21% of the total fish production in the lagoon (GAFRD, 2009). Three species of mullets are presented at the lagoon; *Mugil cephalus*, *Liza ramada* and *L. aurata*. They are the main constituents of the commercial catch of mullet in the lake. Mullets were exploited by veranda (bouss is a local name) fishing method in the lagoon. The biological information of fish is necessary for stock management. The present work is the first attempt to assess the stock of *Mugil cephalus* in Bardawill lagoon and aims at developing an appropriate management plan to maintain this valuable fish resource.

MATERIALS AND METHODS

The study was carried out in the Bardawil lagoon (Fig. 1). The lagoon is considered as a natural depression with a depth of 0.5-3 m and covers an area of 693 km^2, in an arid area in the northern part of Sinai Peninsula, Egypt. The total length and total weight of 620 combined sexes (372 females and 248 males) of *Mugil cephalus* were recorded monthly during the fishing season 2010. Scales were used to age determination. Scales were examined by a projector for age determination with 33 x magnification.

Scales were removed from the left side behind the pectoral fin for each specimen, cleaned and stored dry (Paul, 1968). Later, Scales were washed with distilled water and mounted dry between two glasses slides then examined. The total radius of each scale and the radius of each annulus were measured. to the nearest 0.001 mm. The lengths at previous ages were back calculated from scale measurements using Lee method (Lagler, 1956). The length–weight relationship described as $W = a * L^b$ where W = total weight (g), L = total length (cm) and a & b constants. Von Bertalanffy, 1934 model was used to describe the theoretical growth as: $L_t = L_\infty [1 - e^{-k(t - t_o)}]$, where: L_t = the length at age t, L_∞ = the asymptotic length at t …∝, K = growth coefficient and t_o = the age at which the length is theoretically nil. The values of $L\infty$, K and t_0 were estimated by Gulland and Holt, 1959 plot, where growth rate is plotted against the mean length during the corresponding year. The growth performance index (ø) was estimated using Munro and Pauly, 1984 formula as ø = Log K + 2 Log $L\propto$.

Total mortality coefficients were obtained by using two methods:

1- Jackson, 1939 as Z = -Ln(S) where $S=(\sum_{N-N0})/(\sum_{N-Nx})$

2- Beverton and Holt, 1956 equation, as based on relationship between mortality coefficient (Z) and mean length from the following formula: $Z=K*((L_{\infty}-\bar{L_C})/(\bar{L_C}-L_C))$, where: Lc : the length at which 50% of the fish is retained by the gear and 50% is escape, $\bar{L_c}$ is average length of fish in catches of 50% even bigger fish in the sample.

Natural mortality coefficient was estimated by using three methods:

1- Ursin, 1967 as $M = W^{-1/3}$, where: W is the mean weight of samples.

2- Alverson and Carney, 1975 as $M=3*K/[\exp(t_{max}*0.38*K) - 1]$, where t_{max} is the age of the oldest fish, $t_{max}=3/k$.

3- Pauly, 1980. as Log M = [- 0.0066 – 0.279 log $L\propto$ + 0.6543 log K + 0.4634 log T], $L_{\propto}$ and K (the Von Bertalanffy parameters) and T (average annual surface temperature). Fishing mortality F=Z-M. The exploitation rate (E) by Gulland, 1971: E = F / (F + M)

The length at first sexual maturity L_m (the length at which 50% of fish reach their sexual maturity) was estimated by fitting the maturation curve between the observed points of mid-class interval and the percentage maturity of fish corresponding to each length interval (at the beginning of spawning season). Then L_m was estimated as the point on X-axis corresponding to 50% point on Y-axis. Age at first maturity was estimated by using Bertlanffy, 1934 equation as $T_{(Lm)} = t_o-((1/K)*ln(1-(L_m/L\infty)))$. The length at first capture (Lc) was calculated from the plot of the probability of capture against size.

The method of Gulland, 1969 was used to predict the yield per recruit as follows: Y` / R = F* e M (Tc – Tr)* W∝* [(1/Z) – (3S/Z+K) + (3S2/Z+ZK) – (S3/Z+3K)] Where $S = e^{-k(Tc - T0)}$

K , t_0 = Von Bertalanfy, 1934 growth parameter, Tc is age at first capture, Tr is age at recruitment, W∞ is asymptotic body weight, F is fishing mortality, M is a natural mortality and Z = F+M, is a total mortality.

RESULTS AND DISCUSSION

Catch composition:

The catch of the Bardawil lagoon composed monthly of the high-value saltwater fish such as *Mugil cephalus*, *Liza ramada* and *L. aurata* (family Mugilidae), *Sparus aurata*, *Dicenrachus labrax*, *Solea vulgaris* and *Siganus spp*. Also, crustacean were represented in the catch by shrimp and crabs (Fig. 2.)

Age and growth:

Age was determined using scales for 620 specimens. Five age groups were identified. The average back – calculated lengths of the *M. cephalus* were 20.24, 29.02, 36.43, 41.46 and 45.65 cm for the 1st, 2nd, 3rd, 4th and 5th year of life, respectively. The highest annual increment was occurred during the first year of life, while a noticeable decrease is observed in the second year, reaching its minimal value during the fifth year of life (Fig. 3). Growth in length during the first three years (36.43 cm) was lower than estimated by Bebars, 1986 of *M. cephalus* from Bardawil lagoon as 54.32, cm for females and 42.99 cm for males, respectively. The observed total length ranged from 18.22 to 46.73 cm and the observed total weight varied from 103.5 to 1235 g. The maximum observed total length 46.73 cm is lower than common length, L_{common} = 50 cm (Thomson, 1990). The length – weight relationship (Fig. 4) was described by the power equation as $W = 0.0303*L^{2.6723}$, the negative allometry was established. The length-weight relationship is used for converting weight data to length and vice-versa. Length-weight relationship constant (a and b) are useful in fisheries science in many ways: to estimate weight of individual fish from its length, to calculate condition indices, to compare life history and morphology of populations belonging to different regions (Petrakis and Stergiou, 1995). The relationship equation showed the negative algometric in which b= 2.6723.The power b in this study is lower compared with previous studies in the same lagoon as b=2.817 (Bebars, 1986) and b=2.856 (El Ganainy *et al.,* 2002). In other regions, b=3.232 (Croatia, Dulcic and Glamuzina, 2006) and b=2.99 (Lagos lagoon, Nigeria, Emmanuel *et al*., 2010). The relationship between body length and weight can be change with many factors as season, sex, food, maturity stage and techniques of sampling (Le Cren, 1951). The negative growth in this study of *M. cephalus,* may be related to unavailable food and unsuitable environment where the salinity was higher in fishing season 2009 (51 ppt) compared with lower salinity (47 ppt) during the previous work (GAFRD, 2009).

Growth parameters of the von Bertalanffy 1934 model were calculated as L∞= 59.9 cm, K = 0.255 $year^{-1}$ and t_0 = -0.601 year and the obtained equation was $Lt = 59.9 *(1-e^{(-0.255(t+0.601)})$. The mathematical models are used to give a general description of fish growth free from sampling errors which may be found in the empirical data. Besides, the mathematical models facilitate the comparison between the rates of growth of different species and between stocks of the same species at different times and localities.

El Ganainy *et al.*, 2002 estimated the von Bertalanffy growth parameter of *M. cephalus* in Bardawil lagoon as L∞ = 74.16 cm, K = 0.246 $year^{-1}$ and t_o = -0.969.

The growth performance index (*φ′*) for *M. cephalus* was about 2.96. Growth performance index (*φ′*) is slightly lower comparing with the *φ′* values obtained by El Ganainy *et al.*, 2002 (*φ′*=3.1) for the same species in Bardawil lagoon. In other regions, it was found that *φ′*=3.11 for Mediterranean, Turkey (Erman, 1959), *φ′*=2.78 at Mediterranean, Tunisia (Farrugio, 1975). In this study, the small sizes of catch and negative allometric growth, reflect the overfishing and may be due to unavailable food and unsuitable environment where the salinity was higher in fishing season 2010 (51 ppt) compared with lower salinity (47 ppt) during the previous work (GAFRD, 2010).

Mortalities and exploitation rate:

The total mortality coefficient Z, the natural mortality M, and fishing mortality F for *M. cephalus* were estimated as 0.87, 0.33 and 0.54, respectively. Exploitation rate (E) was estimated as E=F/Z =0.62. Gulland, 1971 suggested that the optimum exploitation rate for any fish stock is about 0.5 at F=M and more recent, Pauly, 1987 proposed a lower optimum F that equal to 0.4 M, so the values of fishing mortality and exploitation rate were relatively high indicating a high level of exploitation. At this rate, the catch of *M. cephalus* may be not sustained in near future and perhaps the warning signals are already there for this species in the form of decline in CPUE during 2009 and 2010 compared with 2008.

Length at first capture (Lc) and length at first sexual maturity (Lm):

The first sexual maturity (the length at which 50% of fish reach their sexual maturity) for *M .cephalus* in Bardawil lagoon during the study period was determined by examination of gonads to determine the sex and the stage of maturity. The length and age at first sexual maturity for *M .cephalus* was determinad as 32.8 cm (2.58 year) for males and 34.9 cm (2.77 year) for females (Fig. 5). While the length at first capture L_c (at which 50% of the fish are vulnerable to capture) was estimated as 33.4 cm (2.63 year) for combined sexes (Fig. 6).It is clear from the study that most of the fishing is at first sexual maturity. Hence, there is a risk to species in the future years.

Yield per recruit:

To investigate the variation in yield per recruit with changing of age at first capture Tc, this is closely related to the estimation of the optimum mesh size. Yield per recruit of *M. cephalus* was calculated using Tc = 1.5, 2, 2.6 (current age at first capture), 3 and 3.5 years (Fig 7). Results (Fig. 7.) indicated that, the maximum yield per recruit will be achieved at Tc = 3 year with current exploitation rate (F = 0.54) in a long time. In addition, with the increasing of fishing mortality F = 1.0 at T_c = 2.6 year, the maximum yield per recruit will be increase. Increasing of effort (F = 0.5424) to F_{max} (F = 1.0) associated with negligible increase in the yield per recruit (174.15 – 167.84 = 6.31).That means of, the increase in fishing effort by 100% over production as much as 3.6% only, this is unacceptable biologically. Also, higher yields that obtained by increase in effort cannot be maintained, and they will have to be followed by a period of much lower yield. In this study, the value of T_c (whish is a proxy of mesh size) and the current exploitation rate (whish is a proxy of effort) indicated that the small fish are caught at higher effort level.

Conclusion: It may be not easily to balance between the reduction in effort and socio-economic needs of the fishermen, but the application of optimum mesh size may be not difficult where increase of T_c to 3 year achieve the highest yield at current fishing effort.

Recommendation: we can recommend that, the current effort of *M. cephalus* should be stabilized and if possible should be reduced. Attempts should be made to increase the age at first capture from 2.6 to 3 year (change of current to optimum mesh size) to help escapement of immature fish that in turn may help recoup the fishery in subsequent years. If this is not carried out immediately, there is a possibility of damage to the *M. cephalus* fishery in near future.

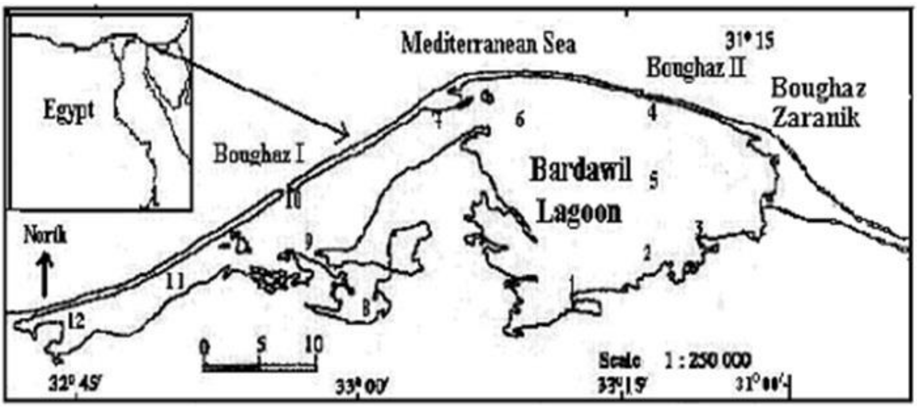

Fig. 1. Bardawil lagoon.

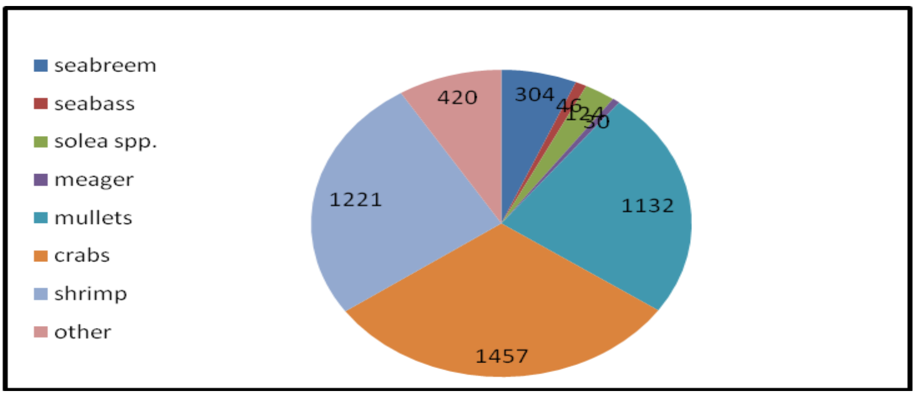

Fig. 2. Showed the catch composition during season 2010 in Bardawil lagoon.

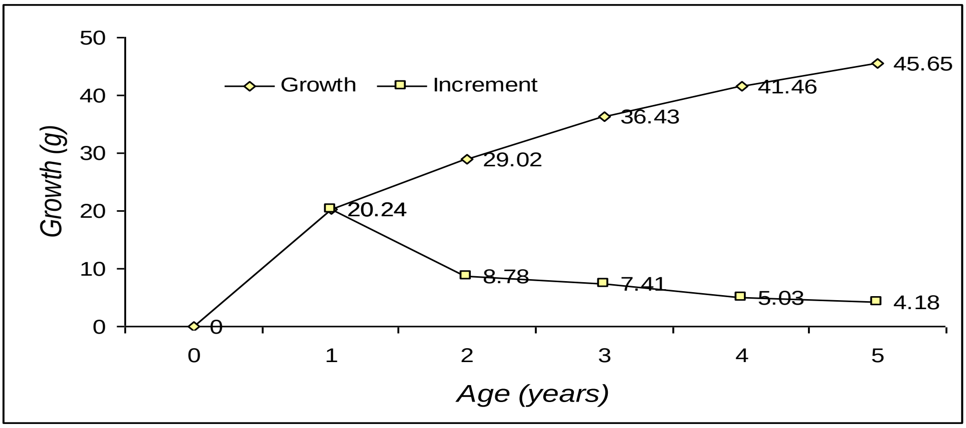

Fig.3. Showed back – calculation and increment of length of *M. cephalus* in Bardawil lagoon, 2010.

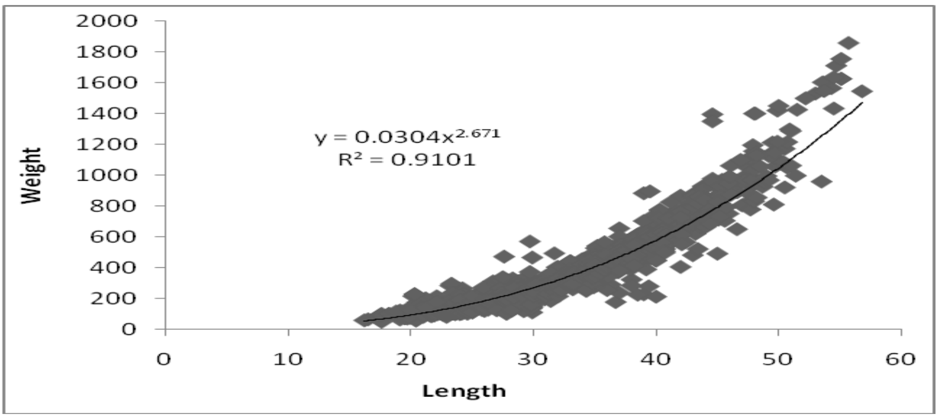

Fig. 4. Showed L-W relationship of *M. cephalus* in Bardawil lagoon, 2010.

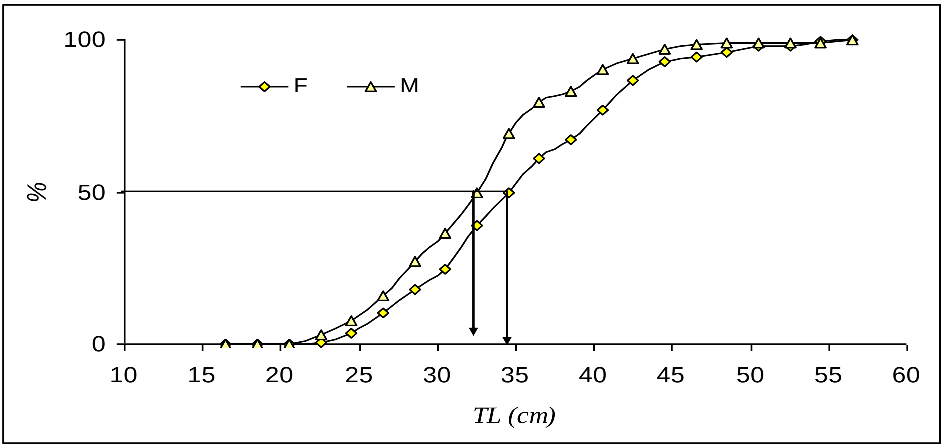

Fig. 5. Showed length at first maturity (***L_m***) of females and males of *M. cephalus* in Bardawil, 2010.

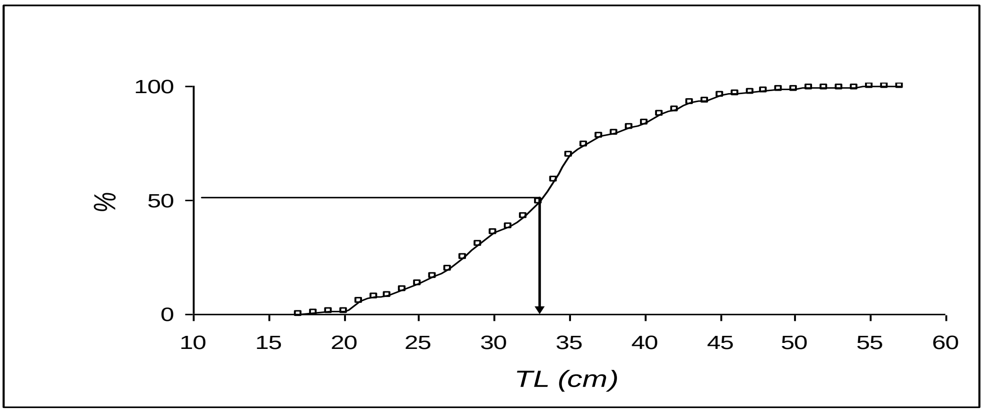

Fig. 6. Showed length at first capture (***L_c***) of combined sexes of *M. cephalus* in Bardawil lagoon, 2010.

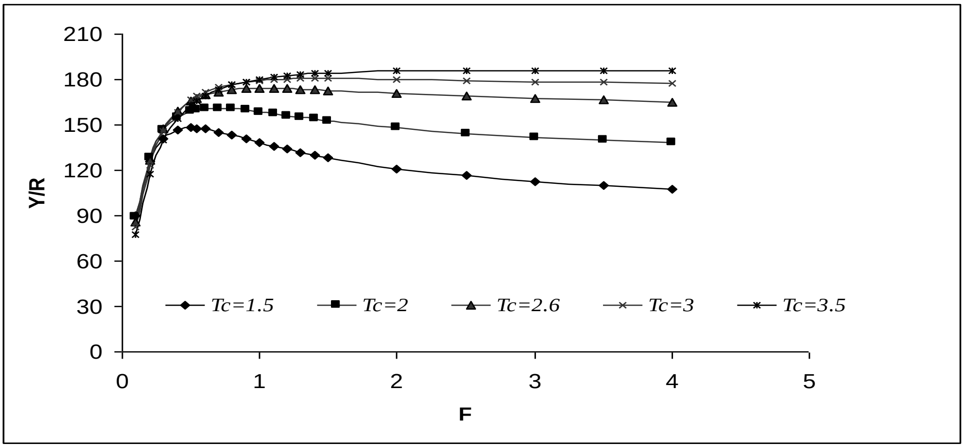

Fig. 7. Showed Y/R of *M. cephalus* a function of different fishing mortality and age at the first capture in Bardawil lagoon, 2010

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النمــو، النفـوق والإنتــاج النسبــي لأســماك البــورى بمنـخفض البـردويل، شـمال سـيناء

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الملخـص العربـى

اجري هذا البحث لوضع خطة علمية عملية لإدارة مصيد اسماك البورى *Mugil cephalus* بمنخفض البردويل. تم تجميع ٦٢٠ عينة فى الفترة من ابريل حتى ديسمبر خلال موسم صيد ٢٠١٠م. قيست أطوال العينات من ١٨.٢٢ الى ٤٦.٧٣ سم مقابل الأوزان من ١٠٣.٥ الى ١٢٣٥ جم. أوضحت الدراسة أن هناك ٥ مجموعات عمرية بالمنخفض تم تحديدها عن طريق قراءة القشور. وحسبت معدلات النمو في الأطوال المقابلة للمجموعات العمرية المختلفة بطريقة الحساب العكسي على النحو التالي ٢٠.٢٤ ، ٢٩.٠٢ ، ٣٦.٤٣ ، ٤١.٤٦ و٤٥.٥٦ سم عند نهاية السنة الأولى، الثانية،........ والخامسة على الترتيب. قيم معاملات النمو لفون بيرتلانفى كانت كالتالي: الطول عند مالا نهاية = ٥٩.٩ سم، معامل النمو = ٠.٢٥٥ /سنة والعمر الصفري = – ٠.٦٠١ سنة. كفاءة النمو = ٢.٩٦. أمكن حساب معدلات النفوق على النحو التالي: النفوق الكلى = ٠.٨٧، النفوق الطبيعي = ٠.٣٣ . النفوق بالصيد = ٠.٥٤ /سنة و معدل الاستغلال = ٠.٦٢ دالا على استغلال مفرط لهذا النوع. حددت الدراسة الطول والعمر المقابل عند بداية النضج الجنسي كالتالي: ٣٢.٨ سم عند عمر ٢.٥٨ سنة و٣٤.٩ سم عند عمر ٢.٧٧ سنة للذكور والإناث على الترتيب. الطول عند أول صيد حوالي ٣٣.٤ سم عند عمر ٢.٦٣ سنة. يتضح من الدراسة ان هناك صيد جائر للأسماك صغيرة الحجم ، ولذلك يجب رفع العمر عند بداية الصيد إلى ٣ سنوات (استخدام فتحات شباك اكبر من الحالية) للاستمرار عند معدل الصيد الحالي وهى التوصية القابلة للتطبيق بدلا من تقليل جهد الصيد ممثلا في تحديد عدد وحدات الصيد او تقليل ساعات العمل وهو المقترح غير المقبول مجتمعيا.