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RESEARCH ARTICLE

BIOLOGICAL ASPECTS OF THE EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX* L., 1758) FROM BARDAWIL LAGOON, NORTH SINAI, EGYPT

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ABSTRACT

The present study investigated the biological aspects of the European sea bass (*Dicentrarchus labrax*) from Bardawil Lagoon, North Sinai, Egypt. Monthly random samples of *D. labrax* were collected from the commercial catch of different landing sites of lagoon during two fishing seasons from May 2015 to December 2016. The length-weight relationship, condition factor, age composition, and fish growth were studied in the current study. The exponent ‘‘b” of the length-weight relationship resulted in isometric mode of growth, since the value of b = 3.0067 in the power equation: Weight = 0.0093 × length$^{3.0067}$. The mean highest values of condition factor (K) of *D. labrax* were recorded in November (where K = 1.26). Growth parameters such as the asymptotic length (L_∞); growth rate (k); the hypothetical age at which fish would have zero length (t_0), and the asymptotic body weight ($W\infty$) were estimated as 75.31 cm, 0.1221 year^{-1}, −1.8703 year and 4088.99 g, respectively. Total mortality (Z), natural mortality (M), and fishing mortality (F) were 0.8786, 0.3153, and 0.5633 year^{-1}, respectively. Exploitation rate (E) was 0.64, which indicated that the stock of the sea bass in the research area is heavily exploited. However, degree of well-being of *D. labrax* in the lagoon was detected. Overall, the present study concluded that it is essential to maximize the length at the first capture to be larger than that at the first sexual maturity (> 30.0 cm) by widening the mesh size used to catch *D. labrax* to protect this species from extra-exploitation.

INTRODUCTION

Bardawil Lagoon (North Sinai, Egypt) plays an essential role in the fish production in Egypt, where it produces very economically important species of fishes such as sea bass, sea bream, common sole, grey mullet, eel, meager and white grouper[1]. Sea bass (*Dicentrarchus labrax* L., 1758), belongs to family Moronidae. It is a demersal species found throughout the Mediterranean Sea and Eastern North Atlantic from Southern Morocco to the Norwegian littoral[2]. They are one of the important marine fishes in Bardawil Lagoon and have a great economic importance in Egypt. It reaches high prices in the market and is much appreciated nationally as the European sea bass is exported to Europe[1]. It is the main demersal target of hand lines, long lines and trolling fisheries operating. The goal of growth studies of fish is to control the amount of fish that can be produced with contact of time. The annual change in a fishery affects its growth pattern[3]. The previous studies on *D. labrax* in the lagoon indicated that the exploited and fishing effort were above optimum levels[4]. According to the General Authority for Fish Resources Development (GAFRD)[5] the production of sea bass in Lake Bardawil ranged from 26 to 90 tons in the period between 2003 and 2015, and then increased to about 124-134 tons during the fishing season of 2016-2017, which may affect the biological aspects of *D. labrax*. Therefore, the aim of the present study was to supplement information about the biological aspects of *D. labrax* in Bardawil Lagoon during years 2015 and 2016 that could be useful for management of this important species, and considered an important diagnostic system for the management of local fishery wealth, as well as of effective policies for future regional development.

MATERIAL AND METHODS

Area of study

Lake Bardawil (a shallow, hyper-saline lagoon) lies in the north of Sinai, southern east the Mediterranean Sea. It located between 31°03′N to 31°14′N and between 32°40′E to 33°30′E. The lagoon is shallow with a maximum depth of 6.5 m in its western arm, a minimum depth of 0.3 m, and an average depth of 1.21 m[6].

Samples collection

Monthly random samples of sea bass, *D. labrax* (Figure 1) were collected from the commercial catch in different landing sites of Bardawil Lagoon during two fishing seasons extends from May 2015 to December 2016 except February, March and April 2016, because fishing in Bardawil Lagoon is prohibited between January and April, in order to allow fish stocks to recuperate. In the laboratory, total fish length and total weight for 1865 specimens were measured to the nearest 0.1 cm and 0.1 g, respectively. Fish specimens were dissected to determine its sex and maturity stages. Otoliths (oval shape with opaque edge) were obtained (Figure 2) and preserved for age determination by Optka trinocular stereomicroscope (Mode: SZM-2; Poteranica, Italy).

Figure 1: Sea bass, *Dicentrarchus labrax*, from Bardawil Lagoon.

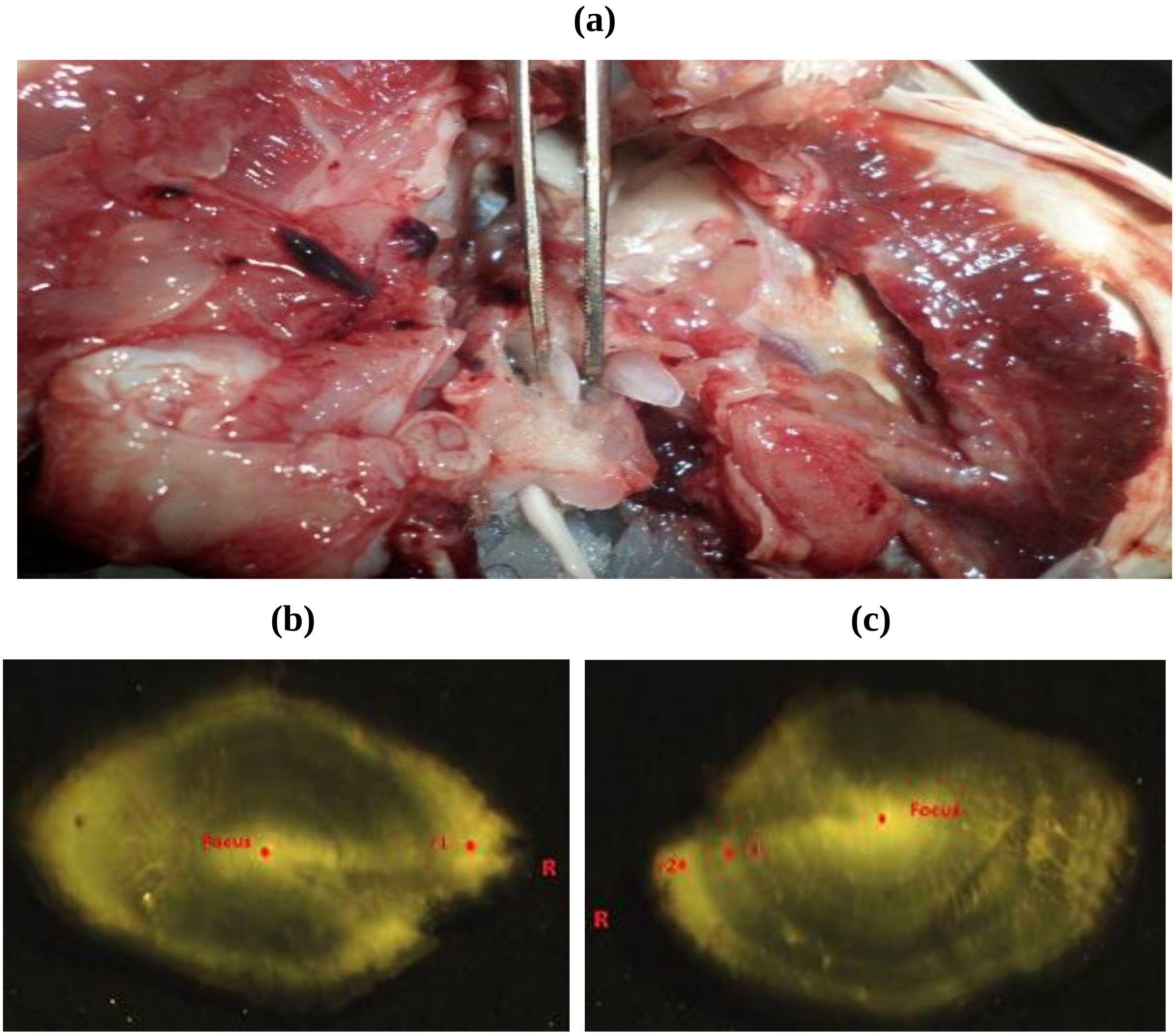

Figure 2: Otolith of sea bass, *Dicentrarchus labrax*, from Bardawil Lagoon (**a**) showed otolith extracting, (**b** and **c**) showed otolith of age groups 1 and 2, respectively, under the light microscope.

Data analysis

The relationship between length and weight was described by the following equation[7]: $W = aL^b$, where "W" is the total weight (g), "L" is the total length (cm),"a and b" are constants. The condition factor (K) was calculated monthly by the following formula[8]: $K = (W / L^3) \times 100$. The otolith's measurements from 535 specimens were used to describe the relationship between the total length and the otolith radius. Three well-trained readers read growth increments to avoid any errors regarding the stucking zone. The disturbance rings and opaque rings including those located on the edge of the otolith were not counted in the current study; only the hyaline complete rings were counted. Fishing in Bardawil lagoon is prohibited between January and April by the competent authorities in order to allow fish stocks to recuperate, thus it was not possible to determine the season that rings were formed in the current study. Lengths by age were back-calculated using the following equation as cited by Ameran *et al*.[4]: $L_n = (L – a) S_n / S + a$, where "$L_n$" is the length of fish at age "n"; "S_n" is a magnified otolith radius to "n" annulus; "S" is a magnified total otolith radius; "L" is a fish length at capture, "a" is constant derived from the relationship between total otolith radius and fish length at capture. The calculated weight at the end of each year was estimated by applying length-weight equation.

The parameters of the von Bertalanffy growth equation "$L_t = L_\infty [1 - e^{-k(t - t_0)}]$" was used to describe growth in size as described previously[9], where "L_t" is the length at age "t", "L_∞" is the asymptotic length, "K" is the body's growth coefficient, "t_0" is the hypothetical age at which fish would have zero length. L_∞ and K were computed according to Gulland[10] and Ricker[7] by using the Ford-Walford plot. The growth performance index (ø) in length and weight also computed by the following two equations[11]: $ø = \text{Log } K + 2 \text{ Log } L_\infty$ and $ø = \text{Log } K + 2/3 \text{ Log } W_\infty$, respectively. The maximum length with highest biomass (L_{opt}) computed by the following equation[12]: $L_{opt} = L_\infty \times [3 / (3 + (M / K)]$.

Total mortality (Z) was obtained by using the method of Powell-Wetherall plot[13,14], where Z = 1 – K. The coefficient of natural mortality (M) was estimated by using the following equation[15]: $\text{Log } M = [-0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T]$, where "T" is the annual average water temperature. Maximum age of the fish (t_{max}) = 3/K, while fishing mortality (F) = Z – M. The exploitation rate (E) was calculated as follows: E = F / Z. Length at first capture (L_c) was calculated from the plot of the probability of capture against size. The method of Gulland[10] was used to predict the yield per recruit as follows: $Y/R = F \times e^{-M\ (Tc\ - Tr)} \times W\infty \times [(1 / Z) - (3S / Z + K) + (3S^2 / Z + 2K) - (S^3 / Z + 3K)]$, where $S = e^{-k\ (Tc\ -\ t_0)}$, "Tc" is age at first capture, "Tr" is age at recruitment.

RESULTS AND DISCUSSION

GAFRD[5] mentioned that the total production of sea bass in Bardawil Lagoon increased to about 124 tons during the fishing season of 2016, as compared with 26-90 tons during 2003-2015 fishing seasons. This may be connected with the stopping the use of trawl nets in the lake (shrimp cloak), which destroyed large quantities of gilthead sea bream and sea bass. The engines that occupy trawl nets are completely nuisance in the lake, which leads to the escape of fish to areas far from the fishing areas. This also may have occurred due to the great inconvenience caused by trawl nets engines that prevents the entry of fish from the Boughaz. Therefore, the fish entered to the lake during stop of fishing in the lake on Wednesday and Thursday. The evidence for this explanation is an increase in the amount of catch of *D. labrax* at the beginning of the week on Saturday.

The total length of 1865 specimens of sea bass, *D. labrax*, which caught from Bardawil Lagoon during period from May 2015 to December 2016 (except February, March and April 2016), were ranged from 18.4 to 65.3 cm. It should be noted that wide length interval was observed, and the length interval "nearly from 40 to 65 cm" was the lowest percent (Figure 3). The length-weight relationship of all specimens was illustrated in Figure "4". It would appear that this relation indicates an isometric growth as the value of b = 3.0067 in the power equation: $W = 0.0093 \times L^{3.0067}$.

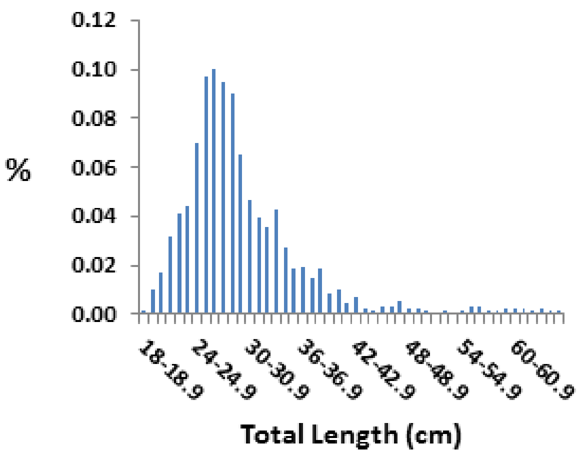

Figure 3: Length frequency distribution of *D. labrax* in Bardawil Lagoon, 2015-2016.

Olurin and Aderibigbe[16] mentioned that fish displaying isometric growth when the length-upswing is in equal proportions with body weight for fixed specific gravity. The regression co-efficient for isometric growth is "3", values greater or lesser than "3" referred allometric growth. Ahmed[17] found that the relationship between length and weight of *D. labrax* in Bardawil Lagoon was estimated as $W = 0.014\ L^{2.883}$. Gonçalves *et al*.[18] found that the length-weight relationship of *D. labrax* in the south and south-west coast of Portugal was $W = 0.0060\ L^{3.039}$. In addition, the length-weight relationship of *D. labrax* in Iskenderun Bay on the northeast end of the Levantine Sea (eastern Mediterranean Sea) was found to be $W = 0.0142\ L^{2.9615}$ as cited by Erguden and Turan[19]. Difference in b values can be due to the combination of various factors such as number of specimens studied, habitat, and status of stomach fullness, gonadal maturity, sex, well-being, and overall fish condition, and the differences in the observed length ranges of the specimens caught[20].

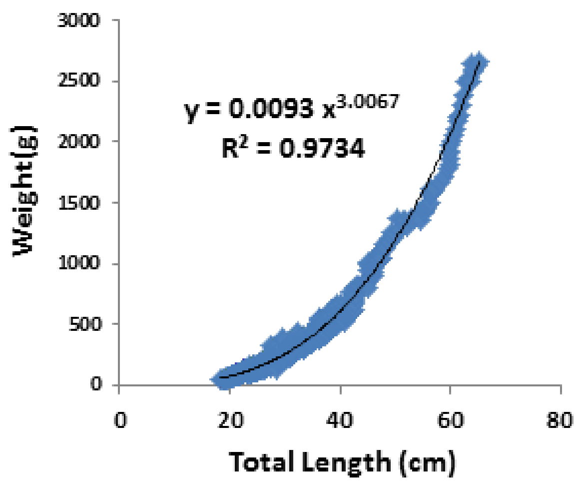

Figure 4: Length-weight relationship of *D. labrax* in Bardawil Lagoon, 2015-2016.

It has been found that the lowest mean values of condition factor (K) of combined sexes (female and male) of *D. labrax* were recorded in June (1.00), while the highest values were recorded in November (1.26). Our results demonstrated that K value of females was better in October and November than the other months, since it composed 1.37 and 1.48, respectively (Figure 5). These findings support the notion that the spawning period of the studied species occur in this period. The K value of sea bass *D. labrax* in Bardawil Lagoon varied from 1.82 and 1.94 with a mean of 1.01 as mentioned by Abdel-Hakim *et al*.[1]. Condition factor recorded for sea bass captured from El-Maadiya region = 1.044, as recorded by Bakhoum *et al*.[21].

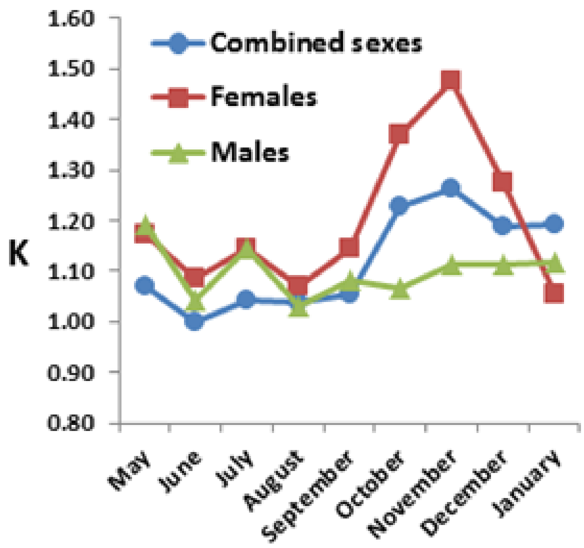

Figure 5: Monthly variation in condition factor (K) of male, female and combined sexes of *D. labrax* in Bardawil Lagoon, 2015-2016.

Age distribution of 535 *D. labrax* samples from Bardawil Lagoon ranged from 0 to 6 years based on results of the otoliths reading (Figure 6). The age group 1 was a dominant group and composed 30.7% of the whole age distribution. The group 1 was followed by the age group 2 (19.6%), group 0 (17.9%), group 3 (16.4%). The age groups 4, 5 and 6 were representing with low percentage in the population (Figure 6). This result is in good agreement with the findings of Ahmed[17] and Erguden and Turan[19], where the age composition of sea bass *D. labrax* lives in Bardawil Lagoon and Iskenderun Bay varied between 0-6 age groups too. In the present study, the low percentages of the age groups 4, 5, and 6 in the population means that there is a catching pressure (fishing effort) on this species, as recorded by Erguden and Turan[19]. They also reported that excessive fishing can cause many morphological changes in growth rate (k), body length and weight, sexual maturation time, sexual maturation age, fecundity and spawning time for this species. Catching pressure of this species in the area of study was indicated also by wide length interval, and the length interval nearly from 40 to 65 cm constituting the lowest percent. Minimum, maximum and mean lengths of different age groups of *D. labrax* in Bardawil lagoon (Table 1) showed overlapping in lengths between all recorded age groups.

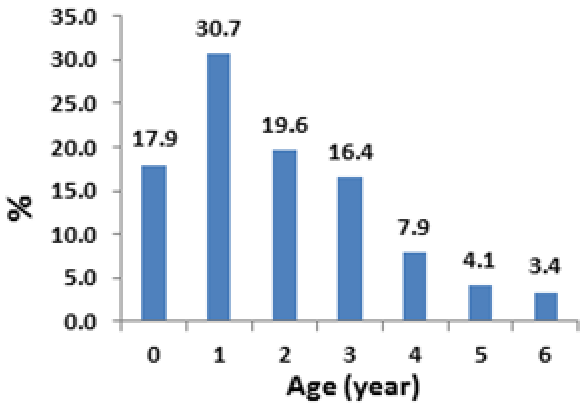

Figure 6: Age distribution of *D. labrax* in Bardawil Lagoon, 2015-2016.

Table 1: Minimum, maximum and mean lengths of different age groups of *D. labrax* in Bardawil lagoon, 2015-2016.

Age	Samples Number	Minimum Length (cm)	Maximum Length (cm)	Mean Length (cm)	Standard Error
0	96	18.8	22.3	20.93	0.0871
1	164	22.0	27.0	24.16	0.1048
2	105	25.1	33.5	29.76	0.2140
3	88	30.8	40.1	35.20	0.1919
4	42	37.9	47	40.70	0.3672
5	22	42.5	48.3	45.59	0.4096
6	18	46.3	65	55.16	1.6223
Total Samples	535				

The back-calculated lengths recorded in this study were 22.3, 28.3, 34.0, 38.4, 42.6 and 46.5 cm for age groups 1, 2, 3, 4, 5 and 6 years, respectively (Figure 7). The results showed that the highest increment in length occurred at the first year of life (22.3 cm) and then declined rapidly thereafter till reached 3.9 cm at age of group 6. The increments in weight were 104.7, 111.5, 157.9, 163.6, 199.9 and 221.9 g for age groups 1, 2, 3, 4, 5 and 6 years respectively (Figure 8). The back-calculated weight was 104.7, 216.2, 374.0, 537.7, 737.6 and 959.5 g for age groups 1, 2, 3, 4, 5 and 6 years, respectively. Growth parameters L_∞, K, t_0 and W_∞ were estimated as 75.31 cm, 0.1221 year^{-1}, −1.8703 year, and 4088.99 g, respectively. The equations obtained were as follows: $L_t = 75.31\ [1 - e^{-0.1221\ (t\ +\ 1.8703)}]$ for length, and $W_t = 4088.99\ [1 - e^{-0.1221\ (t\ +\ 1.8703)}]^{3.0067}$ for weight. The growth performance index (Φ and Φ') defined as 2.84 and 1.4943 for length and weight, respectively. Maximum length with the highest biomass (L_{opt}) was 40.5 cm and maximum age (T_{max}) was 24.6 years.

In the present study, Z, M, and F values were 0.8786, 0.3153 and 0.5633 year^{-1}, respectively. E value was recorded as 0.64 year^{-1}. According to Ricker[7], the M value represents deaths from all occasion, except man’s fishing involving predation, senility, epidemics, pollution, etc.

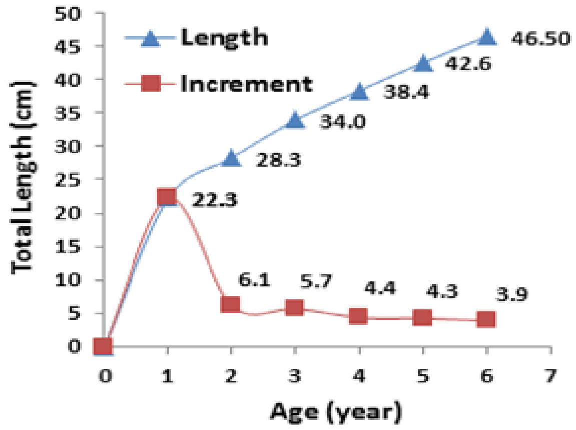

Figure 7: Increment in length of *D. labrax* in Bardawil Lagoon, 2015-2016.

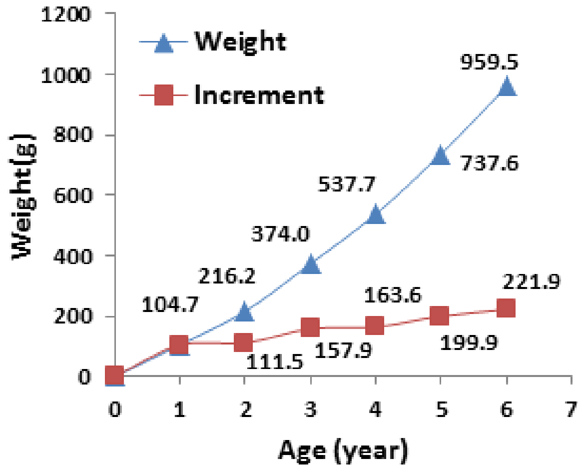

Figure 8: Increment in weight of *D. labrax* in Bardawil Lagoon, 2015-2016.

Bakhoum *et al.*[21] recorded that, the mean value of M coefficient for sea bass captured from El-Maadiya region (Egyptian Mediterranean Sea water) was 0.172. Growth parameters such as L_∞, k and t_0 were calculated as 70.82 cm, 0.35 year^{-1}, and –0.217 year^{-1}, respectively, as mentioned by Ahmed[17]. He also found that Z, M, and F values were 1.03 year^{-1}, 0.39 year^{-1} and 0.64 year^{-1}, respectively, and E value = 0.6229 indicated that the stock of sea bass in Bardawil Lagoon is heavily exploited. The von Bertalanffy growth Parameters of *D. labrax* in Welsh waters (both sexes) were estimated (L_∞ = 78.99, K = 0.103 and t_0 = –0.890)[22]. In the present study, the rate of F (0.5633) and E (0.64) reflect high values, so we attain maximum yield per recruit (Y/R) at F = 0.6. Because we have already high effort, Bardawil Lagoon must be better managed by widening the mesh size of the net to avoid catching small fish, especially fish that is captured by trammel net (El-Dabba).

Table "2" illustrates comparison of biological items of *D. labrax* in Bardawil Lagoon during different fishing seasons. This table gives an indication of the degree of welfare of *D. labrax* in the lagoon during the present study, since b = 3.0067 (i.e. higher than that recorded in the previous fishing seasons in the lagoon). Also, Table "2" demonstrated that the recorded value of M in the present study was less than that in the previous fishing seasons in the lagoon. This may be due to ban of trawling net (El-Kalssa) by the Egyptian authorities. The yield per recruit (Y/R) was found to be 156.93 g and 156.97 g at the actual F = 0.5633 and 0.6 year^{-1}, respectively. Biomass per recruit was decreased with the increasing of F value, where its maximum value (982.3 g) at F = 0.0 (Figure 9).

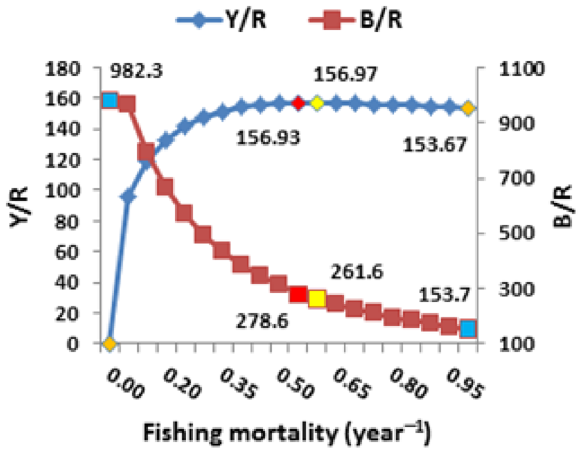

Figure 9: Yield per recruit (Y/R) and biomass-per-recruit (B/R) of *D. labrax* in Bardwil Lagoon, 2015-2016.

The L_c value in the present study was estimated as 27.8 cm (Figure 10) corresponding to an age of 1.904 year. L_c was estimated as 26.8 cm as reported by Ameran *et al.*[4]. The length at first mature (L_{50}) in the same studied fishing season (2015-2016) was determined as 30.8 and 29.2 cm for females and males, respectively[23]. So, it is essential to maximize L_c larger than the length at first sexual maturity (> 30.0 cm) by widening the mesh size used to catch *D. labrax*. Mehanna *et al.*[24] found that the L_c at which 50% of the fish are vulnerable to capture was 31.5 cm, which corresponding to an age of 1.61 year. They also concluded that reducing the E value and increasing the L_c can be achieved through regulating the mesh and hook sizes, proposing the total allowable catch from the lagoon, and protecting the spawning stocks during their spawning migrations from/into the lagoon. Also, the destructive fishing gears such as kalsa and dahbana nets should be banned meanwhile; the technological development and biological effect of several fishing methods operating inside the lagoon should also be taken into account when analyzing the impact of the fishery on the different fish stocks.

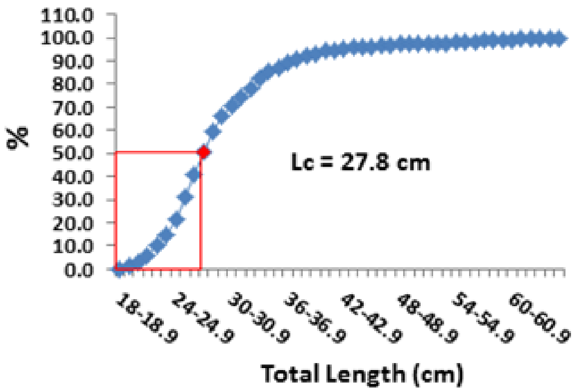

Figure 10: Length at first capture (L_c) of *D. labrax* in Bardwil Lagoon, 2015-2016.

Table 2: Comparison of the biological aspects of *D. labrax* in Bardawil Lagoon during different fishing seasons.

	References				
	[4]	[1]	[24]	[17]	The current study
Fishing season	2004	2008	2008	2009/2010	2015-2016
a	0.0175	0.0187	0.0138	0.014	0.0093
b	2.8261	2.824	2.8913	2.883	3.0067
L_c (cm)	26.8	-	-	-	27.8
L_∞ (cm)	52.23	-	76.36	70.82	75.31
k ($year^{-1}$)	0.2165	-	0.29	0.35	0.1221
t_0 (year)	-1.4643	-	-0.19	-0.217	-1.8703
Z ($year^{-1}$)	2.41	-	1.54	1.03	0.8786
M ($year^{-1}$)	0.48	-	0.36	0.39	0.3153
F ($year^{-1}$)	1.93	-	1.18	0.64	0.5633
E	0.8	-	0.766	0.623	0.64

a and b: length-weight relationship parameters, L_c: length at first capture, L_∞: asymptotic length, k: growth rate, $t_{0:}$ the hypothetical age at which fish would have zero length, Z: total mortality, M: natural mortality, F: fishing mortality, E: exploitation rate.

CONCLUSION

Since the b value of dependence of length upon weight exhibits isometric growth, a degree of well-being of *D. labrax* in the lagoon was detected. Also, 6 age groups were detected. The M value in the present study was less than that recorded in the previous fishing seasons in the lagoon.

However, the stock of sea bass in Bardawil Lagoon is heavily exploited since E value was 0.64 $year^{-1}$. This study confirmed that fishing effort and exploitation rate of *D. labrax* was above the optimum level in Bardawil Lagoon. Therefore, the present study recommended that it is essential to maximize the length at the first capture larger than the length at the first sexual maturity (> 30.0 cm) by widening the mesh size used to catch *D. labrax* to protect this species from exploitation.

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الجوانب البيولوجية لأسماك القاروص الأوروبية من بحيرة البردويل، شمال سيناء، مصر

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هدف هذا البحث إلى دراسة الجوانب البيولوجية لأسماك القاروص فى بحيرة البردويل، شمال سيناء، مصر. تم جمع العينات من أسماك القاروص عشوائيا وبصفة شهرية وذلك من المصايد التجارية لمواقع الإنزال المختلفة فى بحيرة البردويل خلال موسمين لصيد الأسماك من مايو 2015 إلى ديسمبر 2016. وتمت دراسة العلاقة بين الطول والوزن، ومعامل الحالة، والتركيب العمري، والنمو. ووجد أن العلاقة بين الطول والوزن هي من النوع الأيزومترى (المتساوي) للنمو. وسجل أعلى متوسط لقيم معامل الحالة "K" للنوع محل الدراسة في نوفمبر "1.26". وقد وجد أن أفضل قيمة لمعامل الحالة للإناث كانت في شهري أكتوبر ونوفمبر مقارنة بالأشهر الأخرى، حيث كانت تلك القيم 1.37 و 1.48، على التوالي. وتراوحت أعمار أسماك القاروص فى منطقة الدراسة بين أقل من عام و 6 سنوات. وتقدر معايير النمو "L_∞ و K و t_0 و W_∞" بالآتي: 75.31 سم و 0.1221 سنة$^{-1}$ و 1.8703– سنة و 4088.99 جم، على التوالي. وكانت قيم إجمالي الوفيات "Z"، والوفيات الطبيعية "M"، ووفيات الصيد "F" تساوي 0.8786 و 0.3153 و 0.5633 سنة$^{-1}$، على التوالي. وقد وجد أن الوفيات الطبيعية فى هذه الدراسة كانت أقل من مثيلتها التى سُجلت فى مواسم الصيد السابقة للدراسة الحالية. بينما كان معدل الاستغلال "E" يساوي 0.64. وأشارت الدراسة إلى أن مخزون أسماك القاروص في بحيرة البردويل يُستغل بشكل كبير. وبشكل عام، توضح نتائج هذه الدراسة أنه من الضروري زيادة الطول عند بداية صيد تلك الأسماك بحيث يكون أكبر من الطول عند النضج الجنسي الأول (أي > 30.0 سم) وذلك من خلال توسيع فتحات الشباك المستخدمة لصيد أسماك القاروص وذلك لحماية هذا النوع من الاستغلال المفرط.