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Some biological measurements on the European sea bass in Bardawil Lagoon, Egypt

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ABSTRACT

The length-weight relationship, fish growth, age composition and condition factor of the European sea bass from Bardawil Lagoon, Egypt were addressed in the current study. The exponent b of the length-weight relationship resulted in the isometric mode of growth since the value of b = 3.0287 in the power equation: $W= 0.0081\ L^{3.0287}$. The mean highest values of condition factor (K) of *Dicentrarchus labrax* were recorded in November (where K = 1.38). Scales determined age where age groups ranged from 1 to 6 years. At the end of each year, fish length was calculated as 19.0, 27.2, 34.0, 40.4, 46.4 and 50 cm for 1st, 2nd, 3rd, 4th, 5th and 6th year of life, respectively. Growth parameters (L_∞), (K), (t_0), and t (W_∞) were estimated as L_∞ = 75.6 cm, K = 0.1588 and t_0 = -0.8234. Natural mortality, total mortality and fishing mortality were 0.3779, 0.8434 and 0.4655 $year^{-1}$, respectively. The exploitation rate was 0.552 which indicated that the stock of the European sea bass in the study area is heavily exploited to some extent. The sex ratio of the European sea bass was determined (1M: 1.5F) during the whole period of study. The gonadosomatic index showed the greatest value during November and reached its maximum in December. At the first mature, fish length was determined as 30.0 and 29.9 cm for females and males, respectively. Absolute fecundity was increased with fish size and described by the power equation of $F= 8.5123\ L^{2.9333}$ ($R2$ = 0.9547). At the first capture, the fish length was estimated as 27.3. At the first capture, it is necessary to increase the fish length larger than the length at first sexual maturity to 30.0 cm . This can be achieved by dilating the size of the mesh used to catch *D. labrax* to let the females breed and recruit into the fisheries ground. This work was carried out to supplement information about exploitation rates and biological aspects of *D. labrax* in Bardawil Lagoon, North Sinai that could be helpful for the management of this important fish.

INTRODUCTION

The European sea bass, *Dicentrarchus labrax*, (Linnaeus, 1758) belongs to order Perciformes. The European sea bass is common in the Black Sea, the Eastern Atlantic coasts, the Mediterranean Sea and the Eastern North Atlantic from southern Morocco to the Norwegian littoral. The European sea bass is demersal and found in slightly brackish to marine environments **(Fritsch *et al.*, 2006; Mehanna, 2006)**.

In Bardawil Lagoon, *D. labrax* is one of the remarkable marine fish with a great economic importance **(Abdel-Hakim *et al*., 2010)**.

Reproductive biology studies on fish are important and vital requirement to plan better management strategies of fishery **(Brewer *et al.*, 2008; Grandcourt *et al*., 2009; Muchlisin *et al*., 2010)**. Their significance is remarkable in analyzing the influence of environmental factors on the fish populations dynamics and examining the principal life-history information **(Schlosser, 1990**).

Information on reproduction biology is important to select fish from the wild for diversification of fish species. The reproduction behaviors are radical to be studied to comprehend the spawning seasons of fish and their population dynamic **(Muchlisin, 2014)**. The spawning period knowledge, maturity and fecundity may be very valuable for fisheries management **(Tsikliras *et al*., 2010)**.

In Bardawil Lagoon, the total production of the European sea bass increased to about 124 tons during 2016 fishing season, compared to 26-90 tons during the fishing seasons of 2003-2015 **(GAFRD, 2018)**.

In addition, age determination is important for studies on fish population biology and growth. Whereas, the fish age structure data can indicate the population health, survival rate and mortality **(Nikolsky, 1976; Bagenal & Tesch, 1978; Rounseefell & Everhart, 1985)**. The previous studies on *D. labrax* in Bardawil Lagoon indicated that the exploitation and fishing effort were above the optimum levels **(Hegazy & Sabry, 2001; Salem, 2004; Ameran *et al.*, 2008; Mehanna *et al.*, 2010)**. The relationship of length to weight is very vital in the developmental history of fish population from various regions and in estimating the stock biomass **(Petrakis & Stergiou, 1995)**. It is an important fishery management tool and very beneficial for cultivators and fisheries managers to determine the growth of the species **(Nandikeswari *et al.*, 2014)**.

This work was carried out to supplement information about exploitation rates and biological aspects of *D. labrax* in Bardawil Lagoon, North Sinai that could be helpful for management of this important fish.

MATERIALS AND METHODS

The study area

Bardawil Lagoon is a costal lagoon along the Mediterranean Sea shore of Sinai Peninsula 31°09 N, 33°08 E, Egypt. It extends for about 80km long, with a maximum width of about 21km and a maximum depth of approximately 3m, with an area of ≈ 518.99 km^2 (Fig. 1).

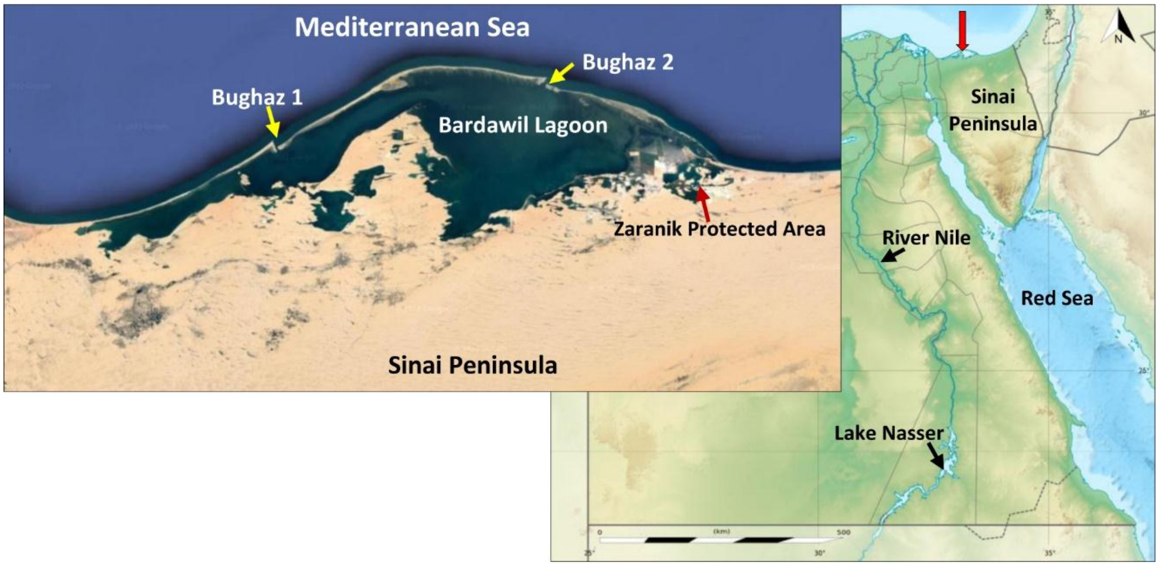

Fig. 1. Map of Egypt showing Bardawil Lagoon of the study area (red arrow at right).

Samples collection

Monthly random samples of the European sea bass, *D. labrax*, were collected from the commercial catch in different sites of the Bardawil Lagoon during 2021 fishing season months from May to December. Total fish weight and length for 482 specimens were measured to the nearest 0.1cm and 0.1g, respectively, in the laboratory. Fish specimens were dissected to determine its sex and maturity stages. The gonads were weighed to the nearest 0.1g, and the ovaries were preserved in 10% formalin for subsequent examinations.

Data analysis

The length-weight relationship was described by the potential equation $W = a L^{b}$ according to **Ricker (1975)**; where, W (g) is the total body weight; L (cm) is the total body length, and b is a constant.The condition factor (K) was calculated monthly using the formula $K = (W \times 100) / L^3$; where, W is the fish weight (g), and L is the fish length (cm) **(Hile, 1936)**.

Some scales of 482 samples were removed, cleaned and stored dry. The annual rings on scales were counted using an optical system consisting of Nikon Zoom-Stereomicroscope focusing block. The distance between the focus of the scales and the successive annuli and the total radius of the scales were measured to the nearest 0.1mm. The measurements of scales were used to describe the total length and the scales radius relationship. Lengths by age were back-calculated using the equation $Ln = (L – a) (Sn / S) + a$ **(Lee, 1920)**. Where, Ln is the fish length at formed of ring; L is the fish length at capture; Sn is the scale radius at fish length; Ln and S are the total radius of scales, and a is a constant. At the end of each year, the calculated weight was estimated by applying the relation between length and weight equation.

The estimation of von Bertalanffy growth parameters were determined by the least squares method for length observed **(Sparre & Venema, 1998)**: $L_t = L_\infty (1- e^{-k (t - t0)})$, where L_t is the length at age t; L_∞ is the asymptotic length; K the body growth coefficient and defines the growth rate towards L_∞ and t_0 the hypothetical age at which a fish would have zero length. The values of L_∞, K and t_0 were estimated by plotting L_t vs L_t+1 **(Ford, 1933; Walford, 1946)**. The growth performance index was calculated by the phi prime test (φ') = log (k) + 2 log (L_∞), which can also be used for comparing growth rates among species **(Pauly & Munro, 1984)**.

Total mortality was obtained by three methods the Powell- Wetherall method **(Powell, 1979)** discussed in **Wetherall *et al*. (1987)**, **Beverton and Holt (1956)** and **Chapman and Robinson (1960)**. Natural mortality coefficient was estimated according to **Pauly (1980)** and **Jensen (1996)**. Fishing mortality was assessed using he following equation: F=Z-M; where, Z is the total mortality and M is the natural mortality. The exploitation rate was denoted using the succeeding equation: E= F/Z according to **Gulland (1971)**.

The method of **Gulland (1969)** was used to predict the yield per recruit as follows: Y / R = F (e -M (tc – tr)) X W_∞ X {1/Z – 3S / (Z + K) + 3 S2/ (Z+2K) - S3/ (Z+3K)}, Where S = e [–k (Tc – T_0)]. As well L_∞, K, and t0 **(Von Bertalanffy, 1934)** growth parameter, Tc is age at first capture, Tris age at recruitment, W_∞ is asymptotic body weight, F is the fishing mortality, M is the natural mortality and the total mortality Z = F+M.

Maturity stages were adopted based on the morphological changes taking place in the gonads during maturity development. Using the equation of **Albertine-Berhaut (1973),** gonadosomatic index (GSI) was calculated as follows: GSI = (gonad weight / body weight) X 100.

At first maturity, for the estimation of the fish length, total body length was plotted against the frequency percentage of mature individuals, and then the length at 50% was considered as the length at first maturity **(Sendecor, 1956)**.

The number of mature eggs in the ovaries during the spawning season is defined as the absolute fecundity (Fabs.). Twenty seven mature ovaries were used to determine fish fecundity. Mature ovaries were taken, washed, dried and weighed. The ovarian tissue was removed and the net eggs weight was obtained. Eggs were well mixed and three subsamples were weighted and counted under a stereo=microscope. Total fecundity was calculated as:

F = [(gonad weight x egg number in the subsample) / weight of subsample] **(Yeldan & Avsar, 2000)**. The relative fecundity (Frel) was calculated as: Frel = Fabs / (body length or body weight).

RESULTS

Length Frequency

The length frequency distribution of the European sea bass, *D. labrax*, from the catch in Bardawil Lagoon was 19.4-66.2 cm, with major length averaging from 20 to 36cm (Fig. 2). These length groups were about 76.3% of the total catch from the European sea bass, *D. labrax,* in Bardawil Lagoon. The length at first capture was 27.3 cm (Fig. 3).

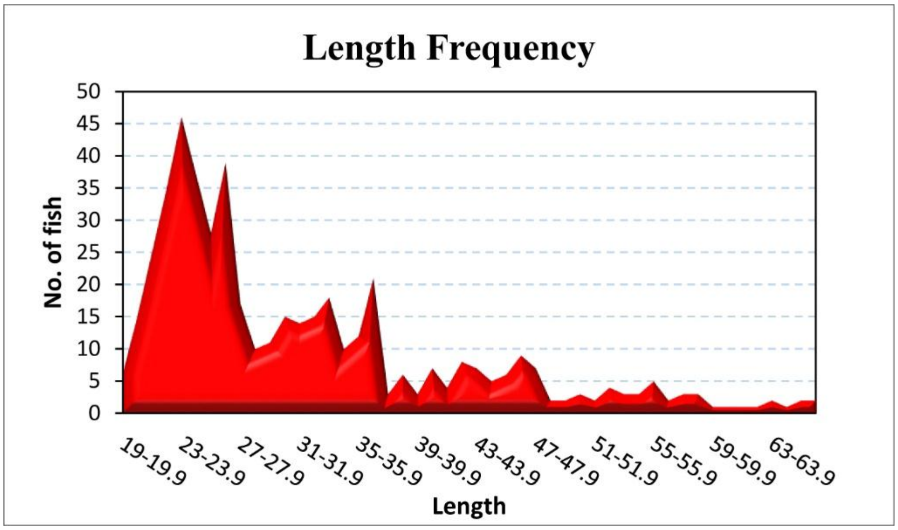

Fig. 2. Length frequency of the European sea bass, *D. labrax,* in Bardawil Lagoon, Egypt

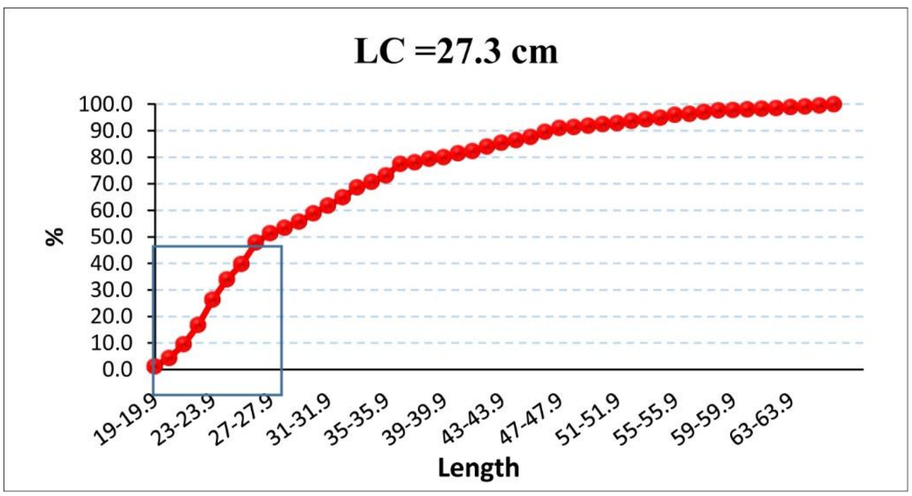

Fig. 3. Length at first capture of the European sea bass, *D. labrax,* in Bardawil Lagoon, Egypt

Relationship between fish length and weight

The length-weight relationship of combined sexes, females and males of the European sea bass, *D. labrax*, in Bardawil Lagoon during fishing season 2021 was estimated as: W=0.0081 $L^{3.0287}$, W=0.0084 $L^{3.0254}$ and W=0.0079 $L^{3.029}$, respectively; Where, W is the total fish weight in g and L is the total length in cm. (Fig. 4). Table (1) shows the monthly average length and weight and the constants of the relationship between length and weight for combined sexes, females and males of the European sea bass in Bardawil Lagoon during 2021fishing season.

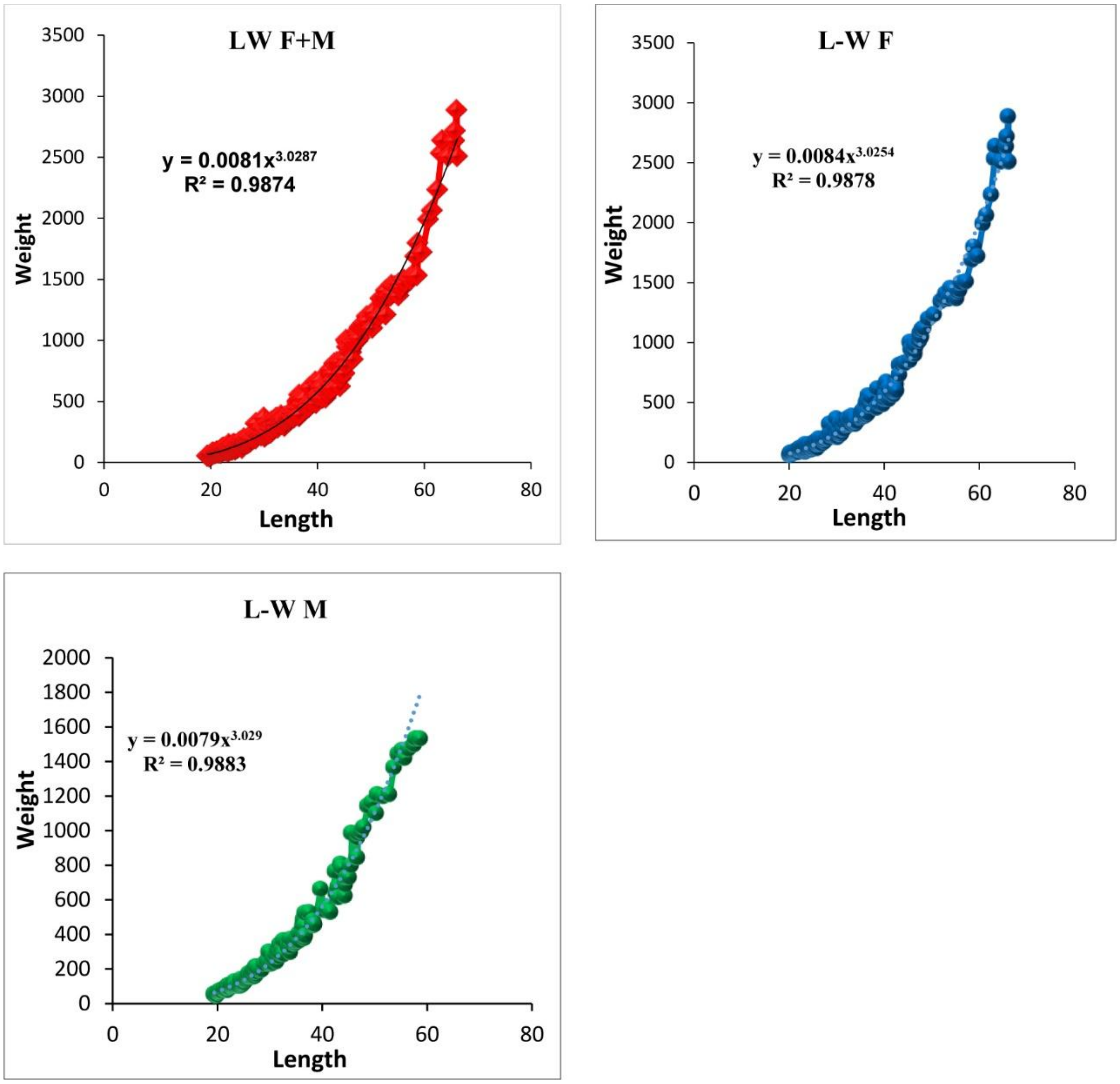

Fig. 4. Length-weight relationship of combined sexes, females and males of the European sea bass, *D. labrax,* in Bardawil Lagoon during 2021 fishing season

Condition Factor

The average values of condition factors for male, female and combined sexes were mainly similar to each other. The lower condition factor values (K) were recorded in June, while the highest values were recorded in November (Fig. 5). Moreover, the study revealed a decline in K value during July in male, but an increase was detected in females during that month.

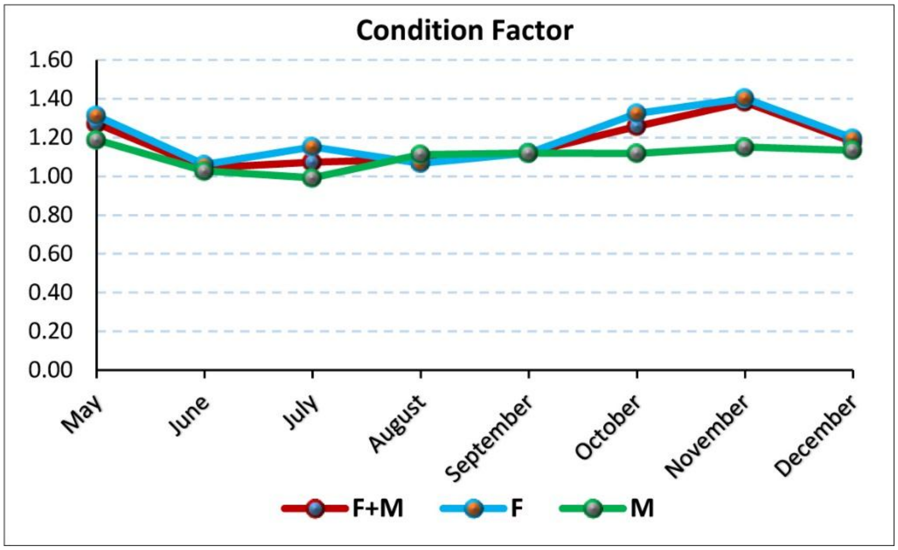

Fig. 5. Monthly changes of condition factor (K) of European sea bass, *D. labrax,* in Bardawil Lagoon during 2021 fishing season

Age Determination

Scales reading of individuals showed ~~a~~ six age classes which were identified as 11, 27.8, 22, 16.6, 13.5, 6.2 and 2.9 %, as a percent for 0, 1^{st}, 2^{nd}, 3^{rd}, 4^{th}, 5^{th} and 6^{th} age groups, respectively.

Back – Calculation Lengths and Weight

The $L_n = (L - 0.7791)\ (S_n / S) + 0.7791$ formula was derived to obtain the back-calculated total length at the end of each year of life.

Average back – calculation lengths and annual increment of the European sea bass are shown in Fig. (6) as 19, 27.2, 34, 40.4, 46.4 and 49.97cm for age 1, 2, 3, 4, 5 and 6 years, respectively. At the end of each year of life, the back–calculation weights were estimated by applying the relationship between fish length and weight, and the results were 60.5,179.6, 352.7, 593.6, 903.2 and 1131 g for age 1, 2, 3, 4, 5 and 6 years, respectively. The annual increase of fish length and weight is displayed in Figs. (6, 7).

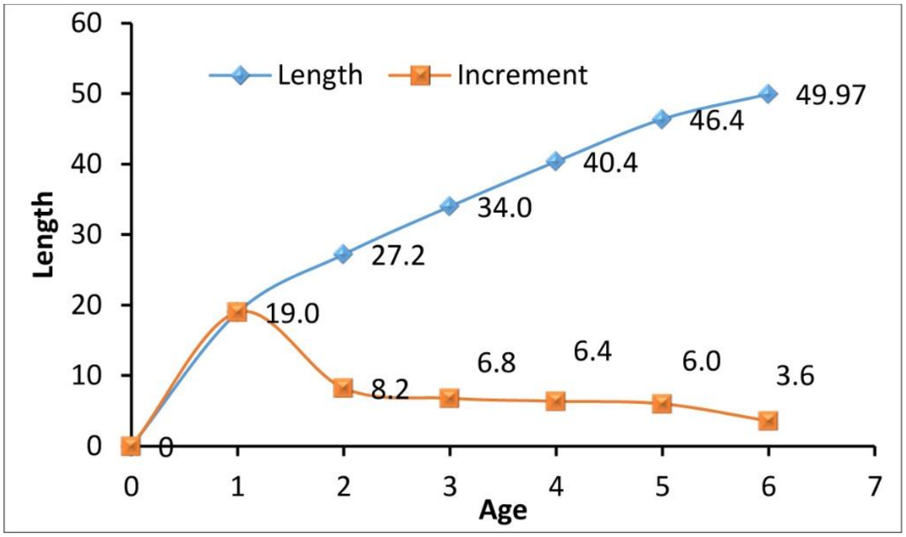

Fig. 6. Back calculation length (TL cm) at the end of life years of the European sea bass in Bardawil Lagoon during 2021 fishing season

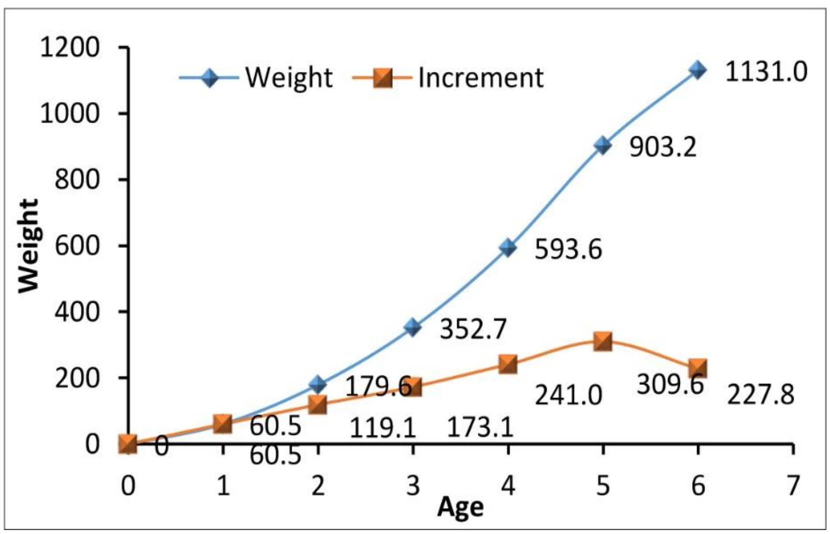

Fig. 7. Back calculation weight (g) at the end of life years of the European sea bass in Bardawil Lagoon during 2021 fishing season

Growth Parameters

The von Bertalanffy growth parameters were estimated as L_∞ = 75.6 cm, K = 0.1588 and t_0 = -0.8234. The von Bertalanffy growth equations recorded were as follows: Length: $L_t = 75.6\ (1 - e^{-0.1588\ (t + 0.8234)})$ and weight: $W_t = 3962.4\ (1 - e^{-0.1588\ (t + 0.8234)})^{3.0287}$

Growth performance index (φ')

The growth performance index (φ and φ') computed for the European sea bass, *D. Labrax*, in Bardawil Lagoon was 2.96 for length and 1.5994 for weight.

Age composition

The sample age distribution ranged from age 0 to VI years for the European sea bass, *D. Labrax*, based on scales reading. The age of group 0 (11.0%), group I was dominant 27.8%, followed by groups П (22.0%), group Ш (16.6%), group IV (13.5%), group V (6.2%) and group VI (2.9%) (Fig. 8).

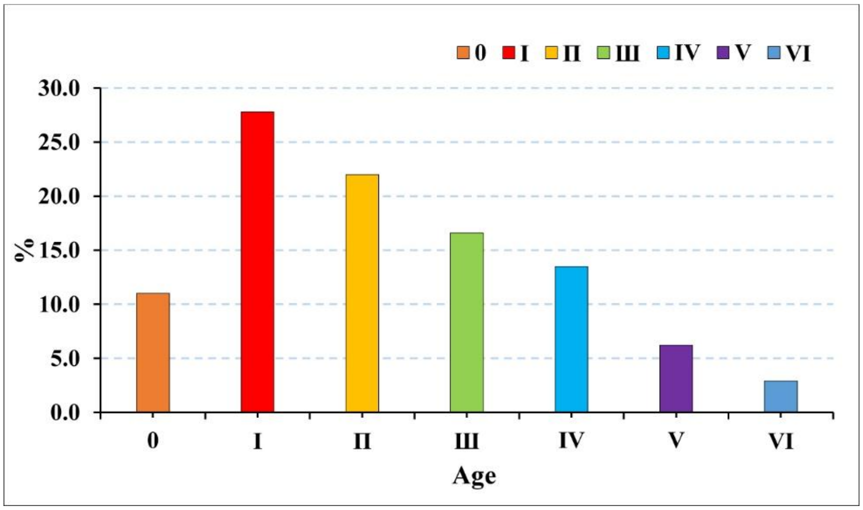

Fig. 8. Age composition of combined sexes of for the European sea bass, *D. labrax*, in Bardawil Lagoon during 2021 fishing season

Mortalities and exploitation rates

The average total mortality (Z), natural mortality (M) and fishing mortality (F) for European sea bass, *D. labrax*, were estimated at 0.8434, 0.3779 and 0.4655 year^{-1}, respectively. Exploitation rates (E) was estimated as E=F/Z =0.552.

Yield per recruit (Y/R) and biomass per recruit (B/R).

The yield per recruit (Y/R) of European sea bass, *D. labrax*, in Bardawil Lagoon during fishing season 2021 were found to be 167.7 g and 169.67 g at the actual fishing mortality of 0.4655 year^{-1} and 0.65 year^{-1}, respectively. Biomass per recruit was decreased with the increase of fishing mortality where it maximized (1465.7 g) at F=0.0 (Fig. 9).

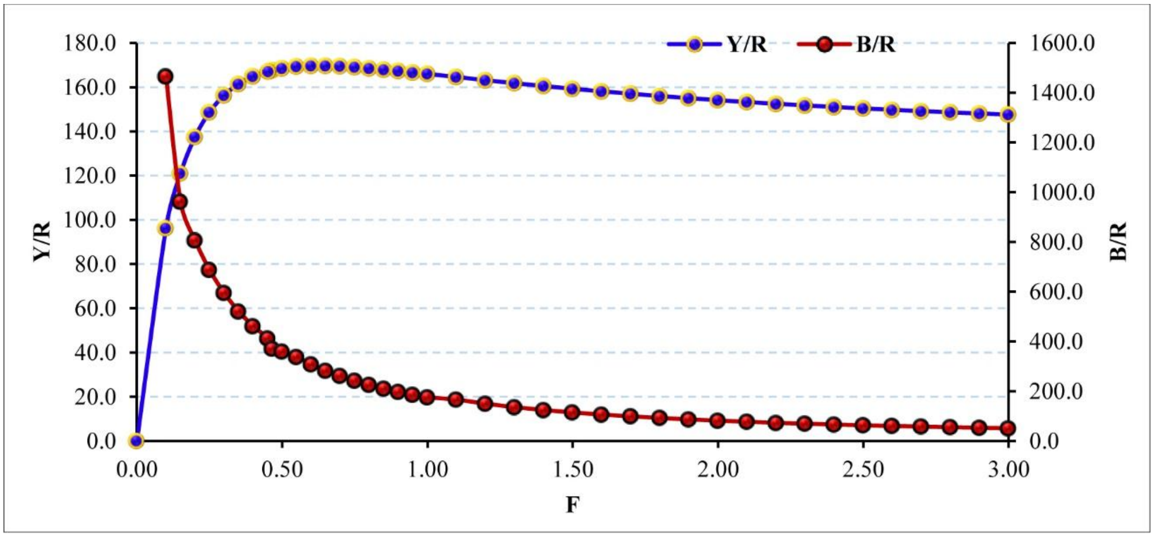

Fig. 9. Yield per recruit (Y/R) and biomass per recruit (B/R) of the European sea bass, *D. labrax*, in Bardawil Lagoon during 2021 fishing season. A function of different fishing mortality

The results of the present study indicate that the maximum yield per recruit is obtained with a fishing mortality coefficient of F = 0.65. This means that the fishing mortality coefficient producing the maximum yield per recruit is higher than the present level of fishing mortality coefficient. It is also evident that the increase of the present fishing mortality coefficient (F = 0.4655) to $F_{\mathbf{max}}$ (F = 0.65) would be associated with negligible increase in the yield per recruit (169.67 – 167.7 = 2.0). This means that the increase of fishing mortality coefficient by about 39.6% from 0.4655 to 0.0.65 = [(0.65 – 0.4655) / 0.4655] X 100 = 39.6% would increase the yield per recruit by only 1.2% [169.7 – 167.7/ 167.7 X 100 = 1.2%].

When the fishing effort is stable at 0.4655, upon increasing the length at first capture (Lc) and the age at first capture (Tc), it appeared that the yield per recruit increased reaching the maximum value of yield per recruit at the length of 34.0 cm and the age of 2.9 years, and after that the yield per recruit decreased (Fig. 10).

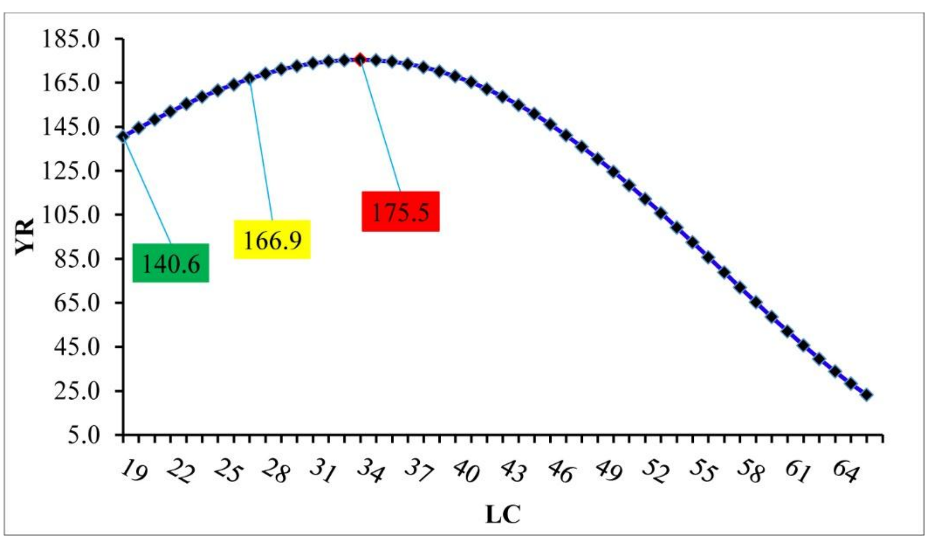

Fig. 10. Y/R of *D. labrax* during 2021 fishing season. A function of different length at first capture in Bardawil Lagoon

Reproduction

Sex ratio

In whole samples, the sex ratio of *D. labrax* was 1:1.5 male:female, where males represented 195 individuals, and females represented by 287 individuals. Fig. (11) shows that during the different months, males and females did not distribute equally. During the period of study, from May to December 2021, females dominated during all months and constituted more than 60 % of the collected samples.

For the length groups, it appeared that females were always dominant, while the males were dominant only once. It was also found that the ratio was equal between males and females in the following length groups 41, 45, 48, 49 and 56.

Ganadosomatic index (GSI)

Fig. (12) shows the monthly changes in males and females GSI of *D. labrax*. GSI values of males were lower than those of the females. In August, the lowest value of GSI of males was 0.1 and started to increase slightly through September, October and November and reached the maximum value in December (7.04). Values of GSI of females showed a similar pattern of the males. It attained the lowest value (0.18) in August and increased slightly to reach the highest value in December (13.5). This means that *D. labrax* in Bardawil Lagoon is a winter spawned fish.

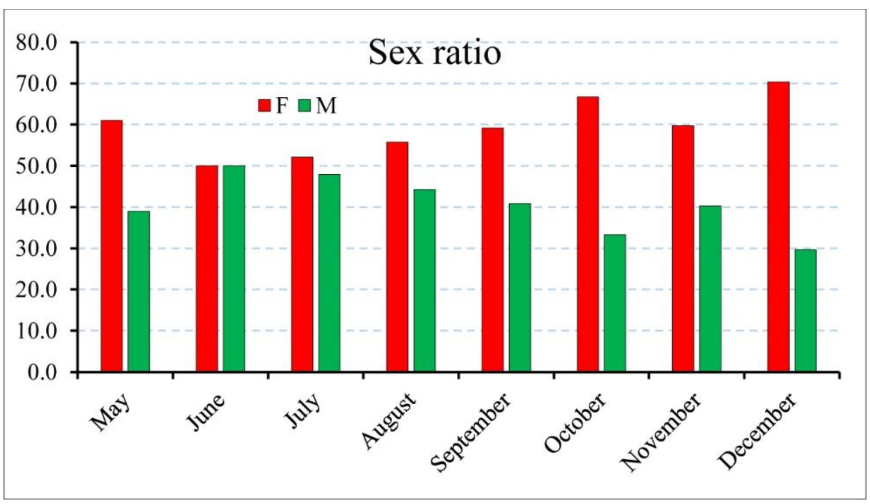

Fig. 11. Monthly sex ratio of *D. Labrax,* in Bardawil Lagoon during 2021 fishing season

Length at first sexual maturity

For each length group, the immature and mature fish was examined to determine the length at first maturation (Lm). All females and males with a total body length above 29cm were considered mature. The body length at first maturity (L_m) was determined as 30.0 and 29.9 cm for females and males, respectively (Fig.13).

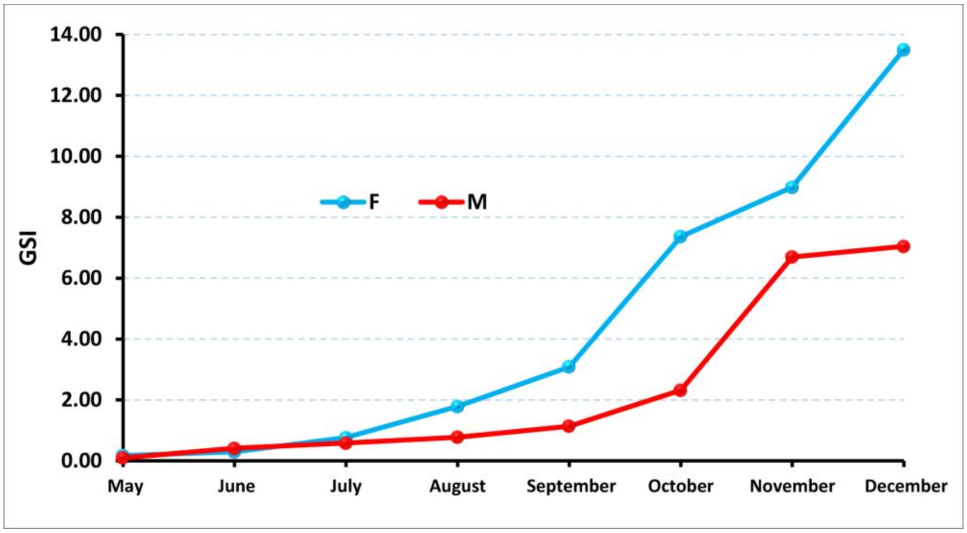

Fig. 12. Gonadosomatic index (GSI) of females (F) and males (M) of *D. Labrax* in Bardawil Lagoon during 2021 fishing season

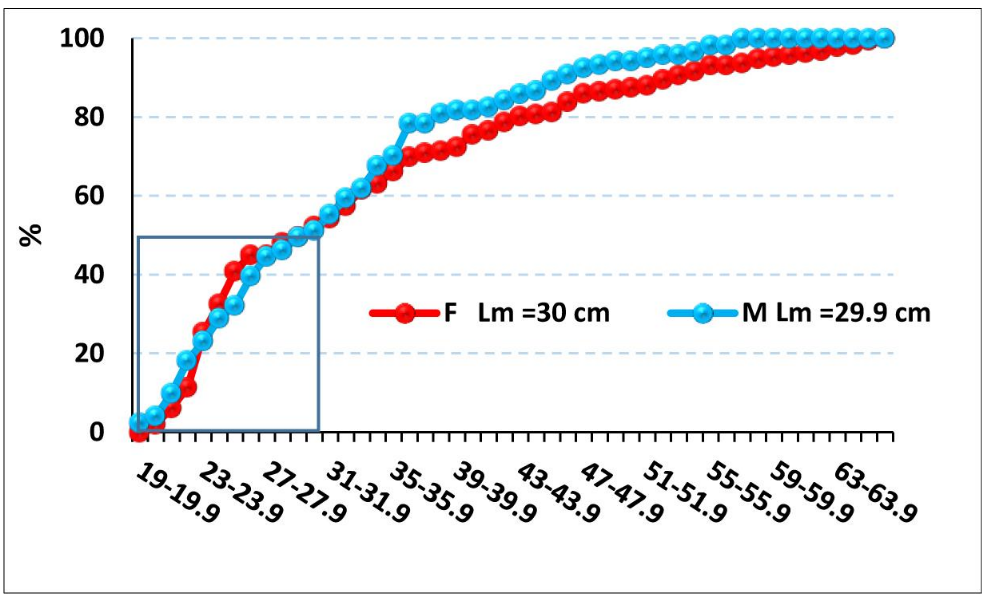

Fig. 13. Length at first sexual maturity (L_m) of males and females of *D. Labrax* in Bardawil Lagoon during 2021 fishing season

Fecundity

The relation between fecundity (absolute), body size (total length) and body weight of the European sea bass, *D. labrax*, was calculated. The egg numbers increased gradually by increasing body length or body weight. The fish has a body length of 32.4cm or a body weight of 355.9 g spawned about 222,500 eggs, and reaching the maximum number of about 1,669,360 eggs for fish with a body length 66.1 cm or body weight of 2889.6 g. The absolute fecundity and total length relationship was represented by power equation: $F= 8.5123\ L^{2.9333}$ (R2 = 0.9547) (Fig. 14).

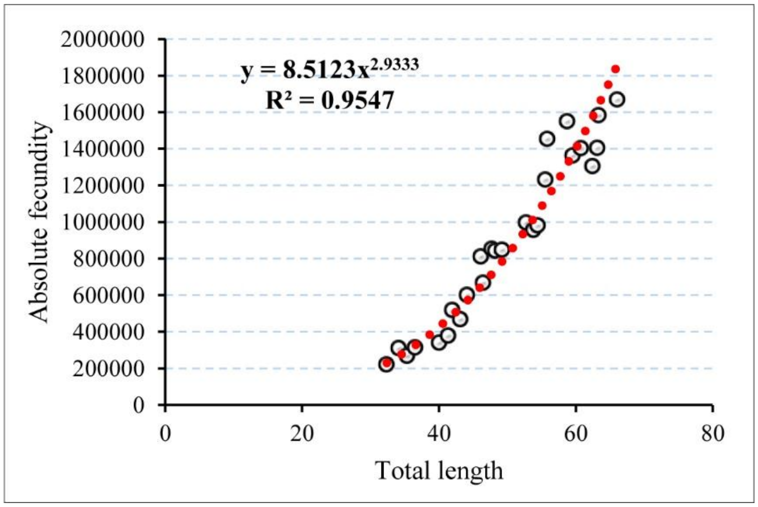

Fig. 14. Absolute fecundity-total length relationship of *D. Labrax* in Bardawil Lagoon during 2021 fishing season

The relative fecundity gradually increased from 6,867 to 25,225 eggs per cm. Although, fish absolute fecundity of *D. Labrax* increased with the increase in the body weight as represented by the following linear regression: F= 141124 + 594.65 W (R2= 0.8731) (Fig. 15), the relative fecundity decreased from about 625 eggs per gram body weight in lighter individuals (355.9 g) to be about 578 per gram in heavier individuals (2889.6 g).

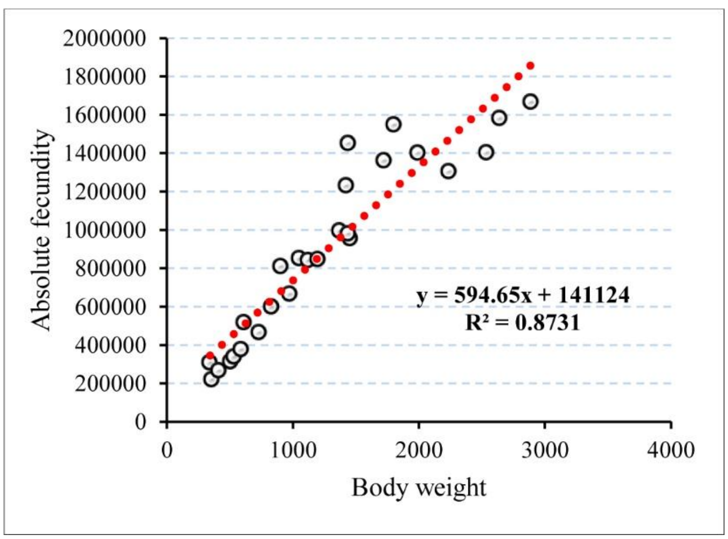

Fig. 15. Relationship between absolute fecundity and body weight (g) of *D. Labrax* in Bardawil Lagoon during 2021 fishing season.

DISCUSSION

Moutopoulos and Stergiou (**2002)** documented that the relationships between length and weight of fish are important for comparative growth studies. These relationships are also fundamental for making comparisons between region of life histories and morphology of certain species. In addition, the body weight of fish, growth rate, age structure and several other aspects of population dynamics are radical for calculating the fish weight of a given individual which the total length or weight are known from the length-frequency distribution of these fish, in a known geographical area. We can estimate the fish indices of condition and can alter the growth-in-weight to growth-in-length equations and vice versa for use in stock assessment models **(Stergiou & Moutopoulos, 2001)**.

Values of b are specific in fish and varies with seasons, sex ratio, age structure, physiological responses, growth rate and feeding status of fish, habitat and impacts of the environmental conditions **(Le Cren, 1951; Bagenal & Tesch, 1978)**.

In the current study, the relationship between fish length and weight was described by the power equation: $W= 0.0081\ L^{3.0287}$, $W=0.0084\ X\ L^{3.0254}$ and $W=0.0079\ X\ L^{3.029}$ for combined sex, females and males, respectively. These results agree and differ with previous results in different regions as listed in Table (1).

In the present study, the condition factor (K) value of the European sea bass ranged from 0.70-1.03. Conditions for obesity showed good or to some extent good; according to **Effendie (2002)**, the condition is good or not can be known from the condition factor values of fish. When the condition factor value is less than 1, fish is classified as flat, while if the value ranges from 1 to 3, fish is considered a less flat body- shaped fish. This findings is confirmed by **Ndimele *et al.* (2010)** who stated that, the condition factor of fish is an important index to known the age structure, growth increment and nutritional intensity. The growth increment and nutritional intensity will demonstrate the age groups classification then divided into mature, immature, juvenile or old groups. Additionally, the values of condition factor can be affected by population density, level of gonad maturity, food composition, sex ratio and age structure **(Effendie, 2002)**.

In the current study, a decline in the value of the condition factor (K) was observed during December in females and males; this may possibly be due to some females beginning to spawn in this month. **Murua *et al.* (2003)** stated that the size of fish and its condition factor values are essential key parameters to assess fecundity at the population level. **Anene (2005)** found that the condition factor is highly affected by both abiotic and biotic environmental factors.

In the current study, the age determination of *D. labrax* was made based on scales reading for 482 samples with both sexes. Age structure ranged from 1 to 6 years, 19.4 to 66.2 cm as a total length and 51.4 to 2889.6 g as a total weight.

The growth in length and increment from the back calculated length were 19, 27.2, 34, 40.4, 46.4, and 50.0cm, and increment of length were 19, 8.2, 6.8, 6.4, 6 and 3.6cm for

1st, 2nd, 3rd, 4th, 5th and 6th age groups, respectively. The largest annual increment occurred during the 1st year of life, while an observable decrease was detected in the 2nd year, reaching its lowest value during the six year of life. Also we noticed that the dominate of age group I (27.8%), while the age group VI was the least age group in the catch (2.9 %). The recorded of life groups of the European sea bass in Bardawil Lagoon were different from study to another as shown in Table (2).

Table 1. Summarized values of b of the European sea bass, *D. labrax,* in different studies

Study	b value	Region
The current study	3.03	Bardawil Lagoon
El-Aiatt *et al.* (2022)	2.95	Mediterranean coast
El-Desoki *et al.* (2021)	3.14	Bardawil Lagoon
Shalloof *et al.* (2019)	3.01	Bardawil Lagoon
El-Aiatt *et al.* (2019)	2.84	Bardawil Lagoon
Bakhoum *et al.* (2015)	2.68	Egyptian Mediterranean water
Salem (2011)	2.88	Bardawil Lagoon
Abdel-Hakim *et al.* (2010)	2.82	Bardawil Lagoon
Mehanna *et al.* (2010)	2.89	Bardawil Lagoon
Ameran *et al.* (2008)	2.83	Bardawil Lagoon
Gaber (2007)	3.24	Bardawil Lagoon
Mehanna (2006)	2.94	Bardawil Lagoon
Khalifa (2005)	3.06	Bardawil Lagoon
Haggag (2005)	2.69	Mediterranean
Salem (2004)	2.80	Bardawil Lagoon (2000)
	2.73	Bardawil Lagoon (2001)
Hegazy and Sabry (2001)	2.82	Bardawil Lagoon
Bebars (1986)	2.96	Bardawil Lagoon (1985)
	3.03	Bardawil Lagoon (1986)
Aprahamian and Barr (1985)	3.14	England water
Rafail (1971)	2.82	Mediterranean Coast

Von Bertalanffy growth parameters were calculated as L_∞= 75.6 cm, K = 0.1588 year^{-1} and t0 = -0.8324 year, and the obtained equation was $L_t = 75.6 \text{ X } (1-e^{-0.1588(t+0.8324)})$ for length, and the obtained equation was $W_t = 3926.4 \text{ X } (1-e^{-0.1588(t+0.8324)})^{3.0287}$ for weight. **Mcllwain *et al*. (2005**) mentioned that the differences in growth parameters might be due to sampling period for the same species, maturity rate, age structure and sex ratio. The constant of the growth parameters for *D. labrax* in Bardawil Lagoon are summarized in Table (3). The index of fish growth performance (Φ and Φ') was 2.96 for length and 1.5994 for weight.

Table 2. Total length at the end of life year of *D. labrax* in Bardawil Lagoon reported in different studies

Region	Sex	No.	Total length at the end of life year								Study
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
Bardawil Lagoon	M+F	482	19	27.2	34	40.4	46.4	50	….	…	**The present study**
Bardawil Lagoon	M+F	181	15.5	20.6	24.8	28.6	…..	…..	….	….	**El-Desoki *et al.* (2021)**
Bardawil Lagoon	M+F	535	22.3	28.3	34	38.4	42.6	46.5	…	…	**Shalloof *et al.* (2019)**
Bardawil Lagoon	M+F	586	24.3	38.2	47.9	53.9	59.1	62.8	….	….	**Salem (2011)**
Bardawil Lagoon	M+F	1419	23.1	34.3	46.6	53.8	59.8	63.9	67.3	69.3	**Mehanna *et al.* (2010)**
Bardawil Lagoon	M+F	…..	22.5	33.4	43.5	49.5	….	….	….	….	**Khalifa (2005)**
Bardawil Lagoon (2000)	M+F	1463	22.6	30.6	36.4	41.8	…	…	….	…	**Salem (2004)**
Bardawil Lagoon (2001)	M+F	1204	22.4	31.3	37.5	43	47.5	….	….	…	
Bardawil Lagoon	M+F	…	16.1	30.8	42.5	51.7	59.1	64.9	69.5	…	**Hegazy and Sabry (2001)**
Bardawil Lagoon (1986)	F	355	23.7	41.3	54.3	63.6	70.2	74.6	….	…	**Bebars (1986)**
Bardawil Lagoon (1985)	M	136	22.7	27.6	…	….	…	…	…	…	

Average total mortality (Z) was 0.434 year^{-1}, natural mortality (M) = 0.3779 year^{-1},and fishing mortality rate (F) was 0.4655 year^{-1}. From these results, the exploitation rate (E) was 0.552. The current results show the exploitation rate (E =0. 552) which indicates that the stock of the European sea bass was heavily exploited according to **Gulland (1971**) who stated that, the ideal fish exploitation rate is about 0.5 at F=M. **Pauly (1987)** demonstrated that the lower ideal value of F is equal 0.4 M, thus the values of exploitation rate and fishing mortality were relatively high indicating a high level exploitation.

The increase of the present fishing mortality coefficient (F = 0.4655) to F_{max} (F = 0.65) would be related to negligible increment in the yield/recruit (169.7– 167.7 = 2.0). This means that, the increase of fishing mortality coefficient by about 39.6 % from 0.4655 to 0.65 [(0.65 – 0.4655) / 0.4655] X 100 = 39.6% would increase the yield per recruit by only 0.007% as [(169.7-167.7) / 167.7] X 100 = 1.2%. This shows that we are at the critical point, and any increase in the fishing mortality is not followed by an increase in the yield per recruit.

On the other hand, when the fishing effort is stable at 0.4655, the yield per recruit was 167.7 at the first capture with fish length of 27.3 cm, and at the first fish capture the age was 1.998 years. With the increase in the fish length at the first capture until it was equal to the length at first maturity (34 cm) and the age at first maturity (2.4 years), the yield per recruit reached 172.6 cm.

Table 3. The growth parameters of *D. labrax* in Bardawil Lagoon obtained by different studies

Region	**Sex**	**No.**	**Growth parameters**			**Study**
			L_∞	**K**	T_0	
Bardawil Lagoon	M+F	482	75.6	0.1588	-0.8234	**The present study**
Bardawil Lagoon	M+F	181	48.7	0.1677	-0.447	**El-Desoki *et al.* (2021)**
Bardawil Lagoon	M+F	535	75.3	0.1221	-1.8703	**Shalloof *et al.* (2019)**
Bardawil Lagoon	M+F	586	70.8	0.35	-0.22	**Salem (2011)**
Bardawil Lagoon	M+F	1419	76.4	0.29	-0.19	**Mehanna *et al.* (2010)**
Bardawil Lagoon	M+F	1227	52.2	0.22	-1.46	**Ameran *et al.* (2008)**
Bardawil Lagoon (2000)	M+F	1463	65.1	0.2	-1.13	**Salem (2004)**
Bardawil Lagoon (2001)	M+F	1204	65.2	0.24	-0.73	
Bardawil Lagoon	M+F	…	87.6	0.23	-0.12	**Hegazy and Sabry (2001)**
Bardawil Lagoon (1986)	F	355	86.7	0.33	0.04	**Bebars (1986)**

Marshall *et al*. (2006) reported that the sex ratio is a significant stock characteristic for the management of fisheries. This might be due to overall population fecundity and the evaluation of spawning stock biomass. **Jakobsen *et al.* (2009)** found that the sex ratio is one of the the factors defining the reproductive potential of a stock.

In the present study, the females dominated over males. The sex ratio of *D. labrax* was 1: 1.5; the males were represented by 195, and females were represented by 287 individuals. The present study disagrees with that of **Bakhoum *et al*. (2015**) who reported that, the sex ratio of females to males of the European sea bass, *D. labrax*, was 1:1.64 from El-Maadiya region.

Values of GSI of females showed a similar pattern of males. It recorded the smallest value (0.18) in May and increased slightly reaching the greatest value in December (13.5) for females. In addition, in males the GSI showed the smallest value (0.10) in May and increased slightly reaching the largest value in December (7.04). This means that the spawning of the European sea bass is in the winter months. These results are in agreement with those of **Bruslé and Roblin (1984**) who reported that, the spawning season of *D. labrax* occurs once a year during 1–2 months in the winter season.

The strategies of spawning duration of fish vary with their geographical location **(ICES, 2005)**. **Tsikliras *et al.* (2010)** reported that, the differences in the values of fish gonadosomatic index among stocks of the same species and sex ratio of the similar body size might be the result of sampling differences and gear selectivity or the changes in reproductive potential to regional conditions that could have come out from increased mortality at fishing and/or other disturbance.

Shankar and Kulkarni (2005) found that in fish biology, the gonadosomatic index is one of the vital items, which gives the deep idea correlated with the reproductive status of fish and assists in the achievement of the breeding period. Moreover, **Shankar and Kulkarni (2005)** found that, the spawning season can be defined by observing the mean monthly variation in the gonad somatic index; whereas during spawning season, GSI reaches its maximum value. In the Mediterranean population, there is only one breeding season per year for bronze featherback, *Notopterus notopterus*, which takes place from December to March.

The length at first mature (L_m) of the European sea bass was determined as 30.0cm for females and 29.9cm for males. The fish maturation occurs at about 35cm for males aging between 3 and 6 years, and the females reach mature stage at about 40 cm. In the present study, the length at first capture (L_C) was 27.3cm. The length at first capture (L_C) is equal to the length at first mature (L_{50}) (30.0 cm). This can be completed by dilating the size of mesh used to catch to allow the females of *D. labrax* to breed in the fisheries areas.

Kapoor and Khanna (2004) stated that, the fecundity is important for studies of life history of fish and their population dynamics. **Bagenal and Tesch (1978**) reported that the fecundity is defined as the number of matured eggs in the female prior to spawning period. The relation between fecundity (absolute and relative), body size (total length) and body weight of *D. labrax* was calculated. The results revealed that the egg number of *D. labrax* was gradually increased by increasing the length or weight of fish. Since the fish has 32.4cm (355.9 g) bears about 222,500 eggs and reaching the largest number of about 1,669,360 eggs for a fish with a body length of 66.1 cm, (2889.6 g).

The absolute fecundity- total length relationship was represented by power equation: $F = 8.5123\ L^{\mathbf{2.9333}}$ (R2 = 0.9547). The relative fecundity of fish gradually increased from 6,867 to 25,255 eggs per cm. *D. labrax* fecundity increased with the body weight and represented by the following linear regression: F = 295.65w+141124 (R2= 0.8731).

Fahim *et al.* (2016) reported that, the absolute fecundity of the European sea bass, *D. labrax*, ranged from 0.2×10^6 to 1.2×10^6 eggs for a total length ranging from 29 to 50 cm; in addition, the absolute fecundity ranged from 0.3×10^6 to 1.02×10^6 eggs for weight ranging from 600 to 1700 g.

CONCLUSION

It could be concluded that, the European sea bass, *D. labrax*, in Bardawil Lagoon has a long spawning season extending from November to December, with a peak during December. The fish sex ratio recorded of males to females was 1:1.5. The fish body length at first mature was determined as 30.0 cm for females and 29.9 cm for males. Using illegal mesh sizes and other destructive fishing methods are not allowed. It is recommended to increase the size of mesh used in Bardawil Lagoon to catch the European sea bass, *D. labrax*, of fish lengths greater than 30.0 cm to protect this fish from exploitation and permit the females to breed, grow and recruit into the fisheries ground.

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Arabic Summary

بعض القياسات البيولوجية للقاروص الأوروبي في بحيرة البردويل، مصر

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في الدراسة الحالية تم دراسة علاقة الطول والوزن ومعامل الحالة والتركيب العمري ونمو الأسماك. ونتج عن دراسة العلاقة بين الطول والوزن وجود نمو متماثل وكانت قيمة b = 3.0287 في معادلة القوة ($W= 0.0081 L^{3.0287}$). كما تم تسجيل أعلى القيم لمعامل الحالة لأسماك القاروص الأوروبي في شهر نوفمبر حيث كانت 1.38. وبعد حساب التركيب العمري للأسماك عن طريق قراءة حلقات القشور وجد أن الفئات العمرية تتكون من ١ إلى ٦ سنوات. كما تم حساب النمو في الطول والوزن في نهاية كل عام فكانت ١٩.٠ و٢٧.٢ و٣٤.٠ و٤٠.٤ و٤٦.٤ و٥٠ سم للسنة الأولى والثانية والثالثة والرابعة والخامسة والسادسة، على التوالي. وسجلت قياسات النمو L_∞ = 75.6 cm, K = 0.1588 t_0 = -0.8234. كما بلغ متوسط النفوق الكلي والنفوق الطبيعي والنفوق عن طريق الصيد ٠.٨٤٣٤ و٠.٣٧٧٩ و٠.٤٦٥٥ لكل سنة، على التوالي. كما بلغ معدل الاستغلال 0.552 ويدل ذلك على أن مخزون أسماك القاروص في بحيرة البردويل يتم استغلاله إلى حد ما بشكل كبير. وسجلت النسبة الجنسية لأسماك القاروص (١ ذكر: ١.٥ أنثى) طوال فترة الدراسة. وكان معدل GSI الأكبر خلال شهر نوفمبر ووصل إلى أعلى قيمة له في شهر ديسمبر. وتم تحديد الطول عند النضج الأول على أنه ٣٠.٠ و٢٩.٩ سم للإناث والذكور، على التوالي. ولوحظ أن هناك زيادة في الخصوبة المطلقة مع زيادة حجم الأسماك التي تم وصفها بمعادلة القوة ($R2 = 0.9547$) $F = 8.5123 L^{2.9333}$. كما تم تقدير الطول عند المصيد الأول للأسماك فكان ٢٧.٣ سم. وتحقق أنه من الضروري زيادة الطول عند بداية المصيد ليزيد عن الطول عند بداية النضج الجنسي ليكون ٣٠ سم، ويمكن تحقيق ذلك عن طريق توسيع حجم الشباك المستخدمة لصيد القاروص الأوروبي للسماح للإناث بالتكاثر والحفاظ على المخزون.