Population dynamic and fisheries management of Eeuropen sea bass, *Dicentrarchus labrax* (f. Moronidae) from Bardawil lagoon, North Sinai, Egypt

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ABSTRACT

Population dynamic of European seabass, *Dicentrarchus labrax* was studied from a small scale fishery of Bardawil lagoon. 1688 specimens ranged between 18.2 and 64.7 cm TL and 62 to 2823 g total weight, were collected from August, 2009 to November, 2010. The relationship between length and weight was estimated as $W = 0.014 L^{2.883}$. Age was determined using scales' reading technique for 586 individuals and the longevity of this species was found to be 6 years. Growth in length and weight at the end of each year was calculated. The growth parameters of the von Bertalanffy equation were calculated as $L_\infty = 70.82$ cm, K = 0.35 yr^{-1} and $t_0 = -0.217$ yr. The observed and predicted extreme lengths were 64.5 and 70.05 cm, respectively. Total, natural and fishing mortality rates were 1.03 yr^{-1}, 0.39 yr^{-1} and 0.64 yr^{-1}, respectively. The current exploitation rate (E = 0.6229) indicated that the stock of seabass in Bardawil lagoon is heavily exploited. The length at first capture L_c was estimated as 20.16 cm. The maximum allowable limit of exploitation (E_{max}) was 0.5, while that at maximum economic yield was 0.42. Based on these results, this important species may be in danger of severe declines in the near future where the stock was over-fished and small fish were unprotected by the current size regulation. Also, the results indicated that an increase of Lc would be associated with an increase in yields at the existing exploitation rate. Thus, for management purpose, the current exploitation rate must be reduced from 0.62 to 0.31 (50%) or the present length at first capture (Lc) should be increased from 20.16 to 32 cm at the current the exploitation rate.

Key words: Population biology, Fisheries regulation, *Dicentrarchus labrax*, Bardawil lagoon, Egypt.

INTROUDACTION

European sea bass, *Dicentrarchus labrax* (L., 1758), is a demersal species found throughout the Mediterranean Sea and Eastern North Atlantic from Southern Morocco to the Norwegian littoral (Frtsch *et al.,* 2006).This species is an important species in the Egyptian coasts of Mediterranean Sea especially in Bardawil lagoon and it the main demersal target of hand lines, long lines and trolling fisheries operating. The sea bass, *D. labrax* is economic species and reaches high prices in the market and are much appreciated nationally. Age determination is essential for studies of growth and population biology of fisheries research. Also, the data on age structure can indicate the health of the population, mortality and survival rate (Nikolsky, 1976; Bagenal, 1978 and Rounseefell and Everhart, 1985).

The previous studies on *D. labrax* in the lagoon indicated that the exploited and fishing effort were above optimum levels (Hegazy & Sabry, 2001; Salem, 2004; Ameran *et al.,* 2008 and Mehanna *et al.,* 2010). This work was carried out to supplement information about biological aspects and exploitation rates of *D. labrax* in Bardawil lagoon that could be useful for management of this important species.

MATERIALS AND METHODS

AREA OF STUDY

The study was carried out in the Bardawil lagoon (Fig. 1). The lagoon is located in an arid area in the northern part of the Sinai Peninsula Egypt and it covers an area of 693 km^2. It separated from the Mediterranean Sea by a long narrow sand-bar measuring 300 m wide. Tow inlets (Boughaz) connect the lagoon to the Sea. The lagoon is extremely shallow and the water depth never exceeds 3 m.

Fig. 1: The Bardawill lagoon

SAMPLING

Fish samples were collected monthly from commercial hand lines catches between August, 2009 and November, 2010. The boats were equipped with two to four hand line which attached to the boat's side. Each one line is often 5-10 m long and containing one hook. The hooks are often 2-3 cm long containing life bait. One to three fishermen work on each boat. The fishing boats work in night from a static position. The lines laid at depths ranging from 2 – 4 m. The total lengths to the mm using a fish measuring board and total weight was recorded to the nearest 0.1 g were taken for 1688 specimens of *D. labrax* For age determination, the scales were removed from the left side of each fish behind the tip of the pectoral fin for 586 specimens. In the laboratory, the scales were cleaned and stored dry in envelopes for the subsequent study. Later on, scales were soaked overnight in 10% ammonia solution. 5-7 scales were placed between two glass slides, and examined by a projector with 33 x magnifications. On the clearest scale from each batch, the total scales radius as well as the radius of each annulus were measured to the nearest 0.01 cm.

DATA ANALYSIS

The back-calculated total length at the end of each year was determined from scale measurements using Lea's, 1910 equation as $L_x = L_p (S_x/S_P)$, where: L_x equals length of fish at age (x), L_p equals the fish length at capture, S_x equals the scale radius at annulus x and S_p equals total scale radius.

The relationship between length and weight was described by the power equation ($W = a*L^b$, Ricker, 1975), where W is the total weight (g), and L is the total length (cm), a and b are constants. The calculated weight at the end of each year was estimated by applying length-weight equation.

The von Bertalanffy growth equation (VBGE): $L_t = L_\infty (1- e^{-k (t - t_0)})$ was used to describe growth in size, where L_t is the length at age t, L_∞ the asymptotic length, K the body growth coefficient and t_0 the hypothetical age at which a fish would have zero length. The values of $L\infty$ and K were estimated by plotting L_t vs L_{t+1} using the Ford, 1933 – Walford, 1946 plot, while t_0 was estimated by Gulland and Holt plot, 1959. The maximum length (L_{max}) was obtained from extreme value theory (Formacion *et al.,* 1991) using the FiSAT program.

The length-converted catch curve method (Pauly, 1984_a) was used to estimate the instantaneous rate of total mortality (Z) by using the FiSAT program. The instantaneous rate of natural mortality (M) was obtained by two methods: Ursin (1967) formula as $M = W^{-1/3}$ where W is the mean weight of the whole sample and the equations of Pauly, 1980 as $\log M = [- 0.0066 – 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T]$. The fishing mortality (F) was estimated by subtracting the value of natural mortality from the total mortality as F = Z –M, while the exploitation rate E = F/Z.

The probability of capture was estimated from length-converted catch curve, using the running average technique to determine L_c (Pauly, 1984_b).

The model of Beverton and Holt (1966) as modified by Pauly and Soriano (1986) incorporated in FiSAT program (Gayanilo *et al.,* 1997) was used to predict the relative yield-per-recruitment and the relative biomass per recruit as $Y`/R = EU^{M/K} [ 1 - (3U/1+m) + (3U^2/1+2m) – (U^3/1+3m) ]$ where, $U = 1- ( Lc / L\infty )$, $m = (1-E)/ (M/K) = (K/Z)$ : M is the natural mortality, K is the body growth coefficient and E is the exploitation rate. The relative biomass per recruit (B`/R) = (Y`/R)/F where, (Y`/R) is the relative yield-per-recruit and F is the fishing mortality. The optimum exploitation rate which produces maximum yield was found from the yield-per-recruit and biomass-per-recruit model (E_{max}). Also, the exploitation rate at which the marginal increase of Y′/R is 0.1 ($E_{0.1}$), and that which reduces the biomass to 50% of its unexploited level ($E_{0.5}$) were estimated.

RESULTES AND DISSCUTION

Age and growth

The observed total length of the investigated *D. labrax* ranged from 18.2 to 64.7 cm and the observed total weight varied from 62 to 2823 g. Age determination is essential for studies of growth and population biology of fisheries research. Six age groups were identified for *D. labrax*. The growth in length and increment from the back calculated length was shown in table (1) and Figure (2)

Table 1: Back – calculation length (TL, cm) at the end of each life different years of *D. labrax* in Bardawill lagoon.

Age group	No.	Observed length	Average calculated lengths (cm) at the end of each year (cm)					
			1	2	3	4	5	6
0	135	22.8						
1	383	34.6	24.38					
2	39	45.6	24.00	38.15				
3	10	52.4	23.54	37.55	47.86			
4	8	56.5	23.35	37.14	47.42	53.97		
5	6	60.2	23.30	37.14	47.47	53.85	59.09	
6	5	63.4	23.23	37.13	47.65	54.00	59.03	62.88
	Average		23.63	37.42	47.60	53.94	59.06	62.88
	Increment		23.63	13.79	10.18	6.34	5.12	3.82

It was obvious from Table (1) that, the dominate of age group one (65.35%), while the age grope six the least age group in the catch (0.8 %). The highest annual increment was occurred during the first year of life, while a noticeable decrease was observed in the second year, reaching its minimal value during the six year of life (Fig. 2). The recorded of life groups of bass in Bardawil lagoon were different from study to another as shown in Table (2).

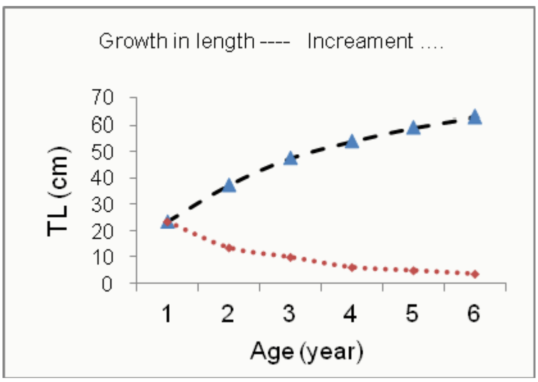

Fig. 2: Growth in length and growth increment of *D. labrax* in Bardawil lagoon.

Table 2: The length at the end of life year of *D. labrax* in Bardawil lagoon given by different authors

Region	Sex	Age	N	Total length at the end of life year 1	2	3	4	5	6	7	8	References
Bardawill lagoon, fishing season 1985/86	M	1--2	136	22.7	27.6							Bebars ,1986
	F	1--6	355	23.7	41.3	54.31	63.6	70.2	74.6			
Bardawill lagoon	M+F	1--7	---	16.1	30.8	42.5	51.7	59.1	64.9	69.6		Hegazy & Sabry, 2001
Bardawill lagoon fishing season 2000	M+F	1--4	1463	22.6	30.6	36.4	41.8					Salem *et al.*, 2004
fishing season 2001	M+F	1--5	1204	22.4	31.3	37.5	43	47.5				
Bardawill lagoon	M+F	1--4	---	22.5	33.4	43.45	49.5					Khalifa, 2005
Bardawill lagoon	M+F	1--8	1419	23.1	34.3	46.6	53.8	59.8	63.9	67.3	69.8	Mehanna *et al.*, 2010
Bardawill lagoon	M+F	1--6	1688	24.38	38.15	47.86	53.97	59.09	62.88			Present study

The length – weight relationship (Fig. 3) was described by the power equation as: $W= 0.014*L^{2.883}$ (R^2 = 0.97). This result agreed with the previous studies. Length-weight relationship is very important for fisheries biologists, where, the differences in length-weight relationship might be interpreted as being due to differences in growth and morphometry between regions (Barnabè, 1976) and it is a practical index of the condition of fish, and varies over the year according to factors such as food availability, feeding rate, gonad development and spawning period (Bagenal and Tech, 1978). In the present study, the length weight relationship was closed to the previous studies.

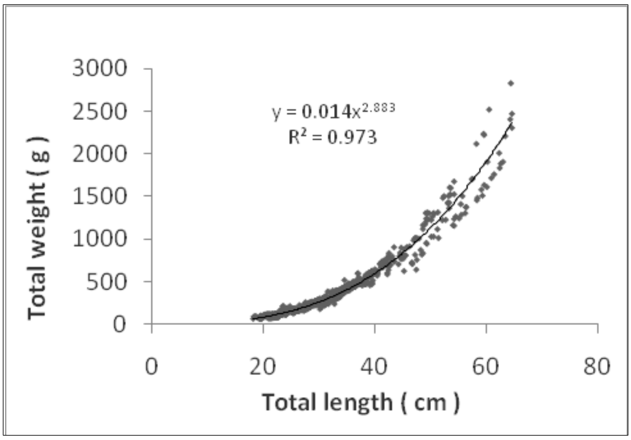

Fig. 3: Length – weight relationship of *D. labrax* in Bardawil lagoon.

The back–calculation weights at the end of each year of life for *D. labrax* were estimated by applying the length – weight relationship and the results are given in Table (3).

Table 3: Back – calculation weight (g) at the end of each life different years of *D. labrax* in Bardawil lagoon

Age group	No.	Observed weight	Average calculated weight (g) at the end of each year					
			1	2	3	4	5	6
o	135	110						
1	383	357	140					
2	39	831	133	508				
3	10	1320	126	485	976			
4	8	1495	123	470	950	1380		
5	6	1720	122	470	953	1371	1792	
6	5	2043	121	470	964	1383	1787	2144
	Average		128	480	961	1378	1790	2144
	Increment		128	353	481	417	412	354

Growth parameters of von Bertalanffy were calculated as L_∞= 70.82 cm, K = 0.35 year^{-1} and t_0 = -0.217 year and the obtained equation was $L_t = 70.82*(1-e^{-0.35(t+0.217)})$. The decrease in $L\infty$ values can be attributed to disappearance of the largest fish sizes from the catch. Parsons (1982) found that, the older year classes were related to the higher $L\infty$ value for the same species. In the present study, the maximum observed length 64.5 cm. Approximately 85% of the investigated fishes were less than 36 cm, (the minimum landing size for *D. labrax*) would satisfy the management objective of reducing growth-overfishing (Pawson *et al.,* 2005). In the same sense, the body growth coefficient (K = 0.35yr^{-1}) was higher than that of most of the previous studies. Lopez-Martinez *et al.* (2003) mentioned that the absence of small size in the samples causes an underestimated value for the growth coefficient. Also, individuals during the first years grow faster (Dominguez-Seoane *et al.,* 2006). Mcllwain *et al.*(2005) mentioned that the differences in growth parameters due to age, sex, maturity and sampling period for the same species. The constant of length-weight relationship and growth parameters for *D. labrax* in Bardawil lagoon were summarized in Table (4).

The predicted extreme lengths (L_{max}) of *D. labrax* were 70.05 cm, respectively (Fig. 4). Maximum length to the asymptotic length (L_{max}/ $L\infty$ = 0.98) is an important parameter of the life history as a recorded by Stergiou (2000) who found that the mean value of L_{max}/L_∞ for marine fish is 0.90. The present value of L_{max}/L_∞ was much closed to the mean value.

Table 4: Constants of length weight relationship and the growth parameters of *D. labrax* in Bardawil lagoon.

Region	Sex	Age (years)	N	length-weight relationship and growth parameters					References
				a	b	L∞	K	t0	
Bardawill lagoon	M+F	5	1688	0.014	2.88	70.82	0.35	-0.22	Present study
Fishing season, 1985/86	M	2	136	0.011	2.96				Bebars, 1986
	F	6	355	0.008	3.03	86.66	0.33	0.04	
	M+F	7	---	0.018	2.82	87.6	0.23	-0.12	Hegazy & Sabry, 2001
Fishing season 2000	M+F	4	1463	0.019	2.8	65.14	0.2	-1.13	Salem, 2004
Fishing season 2001	M+F	5	1204	0.023	2.73	65.15	0.24	-0.73	
Fishing season 2004	M+F	5	1227	0.018	2.83	52.23	0.22	-1.46	Ameran *et al.*, 2008
Fishing season 2008/09	M+F	8	1419	0.014	2.89	76.36	0.29	-19	Mehanna *et al.*, 2010

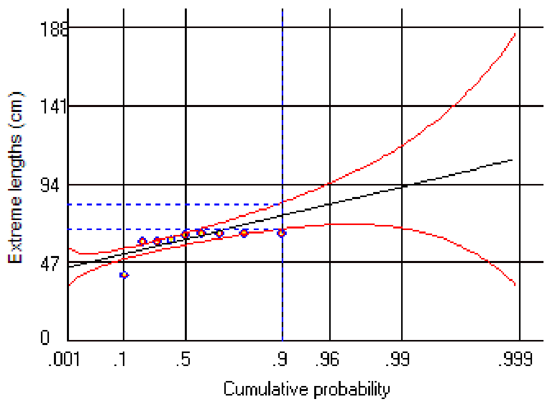

Fig. 4: Observed and prediction of the maximum length of *D. labrax* in Bardawil lagoon (L_{max} = 70.05 cm).

Mortalities and exploitation rate

The total mortality (Z) from length-converted catch curves was estimated as 1.03 yr^{-1} (Fig. 5), while the natural mortality (M) was estimated as 0.39 yr^{-1} and the fishing mortality rate (*F*) was 0.64 $year^{-1}$. From these results, the exploitation rate (E) was 0.623. The current exploitation rate (*E =0. 623*) indicates that the stock of sea bass was heavily exploited according to Gulland (1971) who 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 exploitation.

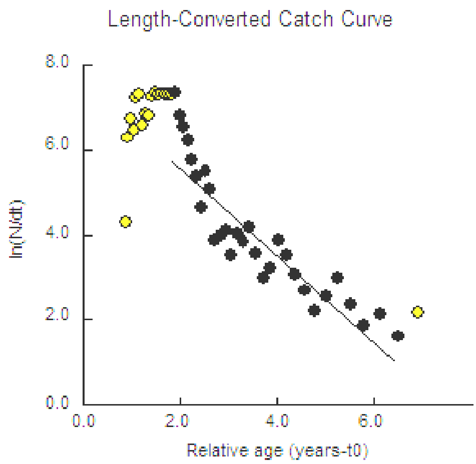

Fig. 5: length-converted catch curve of *D. labrax* in Bardawil lagoon.

The probability of capture is given in Figure (6) using the running average technique, where 25 % of all fish were caught at 18.63 cm TL, 50 % at 20.16 cm TL (the length at first capture, L_c) and 75 % at 21.75 cm TL. The length at first capture is an important input in the computation of the yield per recruit and relative biomass per recruit, where the Knife Edge selection procedure assumes that fishes less than length at first capture are not captured by the fishing gear. The length at first capture in this study was considerably smaller compared with the first sexual maturity of bass (L_m *31.6 cm Lt*) as recorded by Ameran *et al.* (2008).

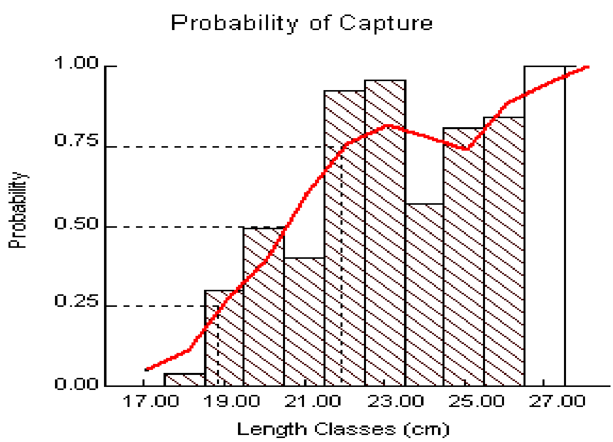

Fig. 6: Analysis of capture probability for *D. labrax* in Bardawil lagoon.

The seasonal recruitment

The structure of recruitment patterns of *D. labrax* in the Bardawil lagoon indicates normal recruitment groups distributed annually. The annual recruitment pattern consists of one cohort produced per year with the highest peak of fish occurring at June, 27.25 % of the observed recruitment (Fig. 7).

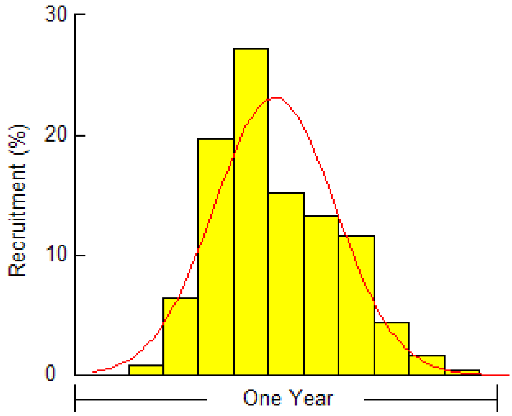

Fig. 7: Recruitment pattern of *D. labrax* in Bardawil lagoon.

3.4. The relative yield–per-recruit (Y'/R) and biomass per-recruit (B/R)

The Knife Edge selection procedure (Fig. 8) showed the relative yield–per-recruit (Y′/R) and biomass per-recruit (B/R) of *D. labrax* vs. the exploitation rate in Bardawil lagoon. The maximum and economic increase of Y′/R at the exploitation rates was 0.5 (E_{max}) and 0.42 ($E_{0.10}$). The exploitation rate which reduces the biomass to 50 % of its unexploited one ($E_{0.5}$) was 0.31. Therefore, the current exploitation rate is higher than the predicted exploitation rates at the maximum economic yield, (*MEY*), the maximum sustainable yield, (*MSY*) and maintains 50% of stock. From that results, the stock of bass in Bardawil lagoon is a heavily exploitated. Therefore the current exploitation rate should be reduced 32% (from 0.62 to 0.42) and 50% (from 0.62 to 0.31) to obtain the maximum economic yield, (*MEY*) and the exploitation rate which reduces the biomass to 50 %, respectively. Also, the results indicated that an increase of L_c to the first sexual maturity (*32 cm as* L_t) would be associated with an increase of Y′/R by 17 % (Fig. 9). Thus, for management purpose, the current exploitation rate must be reduced from 0.62 to 0.31 (50%) or the present length at first capture (L_c) should be increased from 20.16 to 32 cm at the current the exploitation rate.

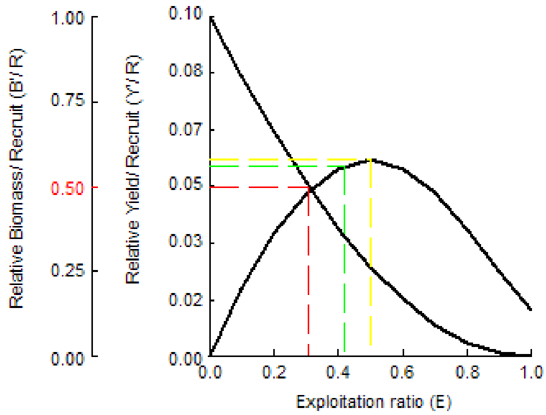

Fig. 8: The relative yield–per-recruit (Y'/R) and biomass per-recruit (B/R) *D. labrax* in Bardawill lagoon with Lc is 20.16 cm as *Lt.*

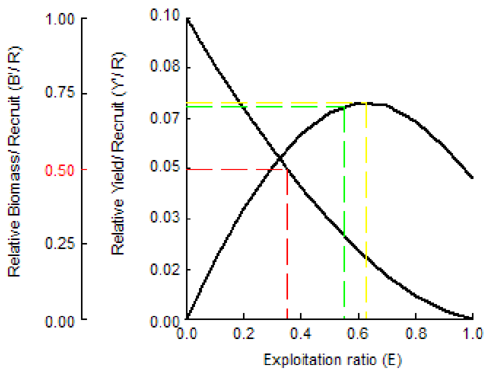

Fig. 9: The relative yield–per-recruit (Y'/R) and biomass per-recruit (B/R) *D. labrax* in Bardawill lagoon with Lc is 32 cm as *Lt.*

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