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AGE, GROWTH, MORTALITY AND YIELD PER RECRUIT OF *LIZA RAMADA* IN BARDAWILL LAGOON, NORTH SINAI, EGYPT

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Abstract

Age, growth, and population biology of *Liza ramada* were studied from a small scale fishery of Bardawill lagoon. 3382 specimens (13.5 to 46.6 cm total Length and 12.5 to 794 gm total weight), were collected from April to December, 2009 (one fishing season). The relationship between length and weight was $W = 0.0177^* L^{2.764}$. Age was determined by scales and age groups 0 to 6 years. Growths in length and weight at the end of each year were calculated. The growth parameters of von Bertalanffy equation were calculated as ($L\infty = 49.41$, $K = 0.28$ year-1 and $t_0 = -0.8$ year-1). Growth performance index ($\varphi' = 2.83$). Mortality rates were 1.55 yr^{-1}, 0.61 $yr^{-1}$and 0.94yr^{-1} for total, natural and fishing mortality respectively. The currently exploitation rate E = 0.60. The probability of capture (L_{50} = 25.3). The higher of fishing mortality verses natural mortality observed for *Liza ramada* indicates the stock under the overfishing in Bardawill lagoon.

Keywords: Age, growth, population biology, *Liza ramada*, Bardawill lagoon, Egypt.

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. The fish protein represents about 40% of all the animal protein resources. (El-Ganainy, 1997). The main sectors of fish production in Egypt are Mediterranean Sea, Red Sea and Inland water (Nile, Lakes and fish farms). Mullets (family: Mugilidae), are the most important fish resources in Lake Bardawil where they contributed about 33.5% of the total fish Production in the lagoon (General Authority for Fish Resources Development, 2008). Three species of Mullets are presented at the lake; *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 present work is the first attempt to assess the stock of *L. ramada* 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 Bardawill lagoon. 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 3382 *Liza ramada* were recorded monthly during the fishing season 2009. The scale samples taken were removed from the left side of 971 fish behind the tip of the pectoral fin (Pau1, 1968). The scales were then examined by a projector for age determination with 33 x magnification.

Age and growth

Total length - scale radius relationship

According to Whitney and Calendar, 1956, the best regression to use a describe of fish length and average scale radius as: $L = a + b R$

Where L is total length of fish in cm, R is magnified scale radius in cm and (a and b) is a constant representing the intercept and the slope of the straight line respectively.

The lengths at previous ages were back calculated from scale measurements using Lea's equation "1910 ". $L_n = (S_n/S) L$

Where L_n = is length of fish at age "n "

S_n = is magnified scale radius to "n "annulus

S = is magnified total scale radius

L = is fish length at capture

The back- calculated total weight at the end of each year was estimated by length-weight equation.

The length - weight relationship

The length – weight relationship of most fish can be better described by the general parabola according to Hile, 1956 and Martin, 1949) as $W = a * L^b$

Where W = total weight (g), L = total length (cm) and a & b constants.

Mathematical models of growth

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.

Several mathematical models are used to describe the theoretical growth of fishes are those of Winsor, 1932 and Von Bertalanffy model (1934, 1949).

The most widely used model is that of Von Bertalanffy for theoretical growth in length can be written in the form: $L_t = L_\infty [1 - e^{-k(t-t_0)}]$ 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∞, K and t_0 were estimated by plotting L_t vs L_{t+1} using the Ford, 1933, Walford ,1946 procedure (Jobling, 2002). L_∞ and k are constants of the Von Bertalanffy growth model, in which they can be derived as follows:

K = - Ln(b), L_∞ = a / 1 – b and $t_o = t + 1 / k \, Ln((L_\infty - Lt) / L_\infty)$

The growth performance index (ø) was estimated using Munro and Pauly, 1984 formula as ø = Log K + 2 Log L∞.

Estimation of mortalities and exploitation rate.

The total mortality coefficients were obtained by using Beverton and Holt equation, 1956 based on the relationship between mortality coefficient (Z) and mean length the following Formula:

$Z= (k*(L\infty-\bar{L})/(\bar{L}-L'))$, Where k and L∞ are the parameters of the Von Bertalanffy equation.

L′ is the lower limit of corresponding length interval, $\bar{L}$ the mean length from the length at L′ to longer. Natural mortality coefficient was estimated by using the equations of Pauly, 1980. Pauly's empirical formula: Log M = [- 0.0066 – 0.279 log L∞ + 0.6543 log K + 0.4634 log T]

L_∞ 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)

Estimation the yield per recruit

The method of Gulland, 1969 was used to predict the yield per recruit as follows:

$$Y' / R = F^* e^{M(Tc-Tr)} * W_\infty * [(1/Z) - (3S/Z+K) + (3S^2/Z+ZK) - (S^3/Z+3K)]$$

Where $S = e^{-k(Tc-T0)}$

K, t_0 = Von Bertalanfy growth parameter, T_c is age at first capture, T_r 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

The catch of the Bardawill lagoon composed monthly of the high-value saltwater fish such as *Mugil cephalus*, *Liza ramada* and *L. aurata* (family Mugilidae), *Sparus aurata* (Sparidae), *Dicenrachus labrax* and *D. Punctatus* (Moronidae), *Solea vulgars* (Soleidae); *Argvrosonus regius* (Sciaenidae), *Epinephelus spp.* (Serraindae) and *Siganus spp.* (Siganidae) Also, crustacean were represented in the catch by shrimp mainly *Metapenaeus stebbingi* and crabs mainly *portunus pelagicus* (fig. 1.)

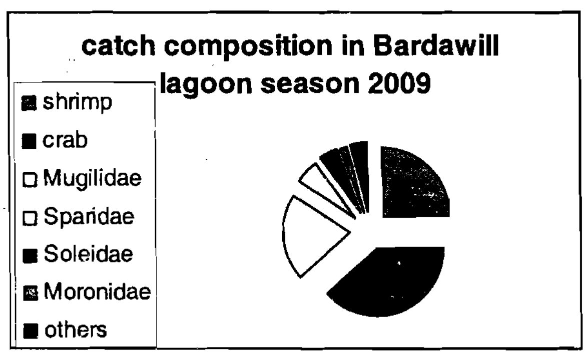

Fig. 1. Catch composition in Bardawill lagoon, 2009

Age and growth

3382 *Liza ramada* caught from Bardawill lagoon between April to December, 2009.The observed total length ranged from 13.5 to 46.6 cm (fig. 2) and total weight ranged from 25 to 794 gm.

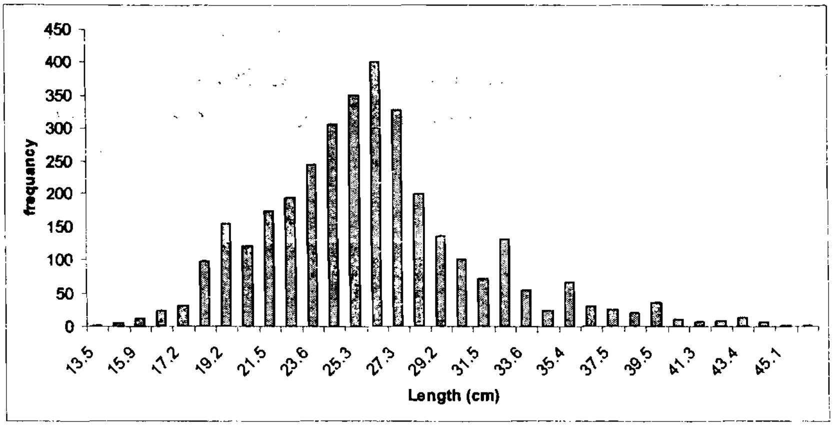

Fig. 2. Length frequency of *L. ramada* in Bardawill lagoon, 2009

Body length – scale radius relationship

In the present work the data for *L. ramada* between fish length and scale radius showed a linear trend on their scatter diagram (fig. 3.) and the straight line respectively as L =- 0.22 + 2.25R

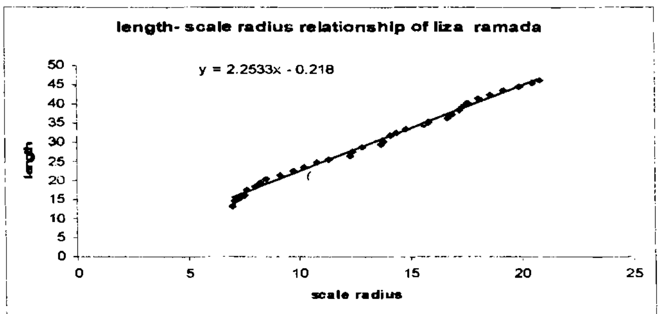

Fig. 3. Length –scale radius relationship of *Liza ramada* in Bardawill lagoon, 2009

Length – weight relationship

In the present study a total length of 3382 *L. ramada* varied from 13.5 to 46.6 cm with weights ranging between 25 and 794 g was used to estimate the Length – weight relationship (fig. 4). The Length – weight equation was estimated as $W = 0.0177 *L^{2.7642}$

The relationship equation showed the negative allomitric in which b= 2.7642.The power b in this study is lower compared with previous studies in the same lagoon (b=3.134), Mehanna, 2006 and in other regions such as (Croatia, b=3.001) Bartulovic *et al.*, 2007. The relationship between body length and weight can be change with many condition factors as season, sex, food, maturity stage and techniques of sampling (Le Cren, 1951). The negative allometric growth in this study of *L. ramada* from Bardawill lagoon, 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 (Annual Report of General Authority for Fish Resources Development, 2009).

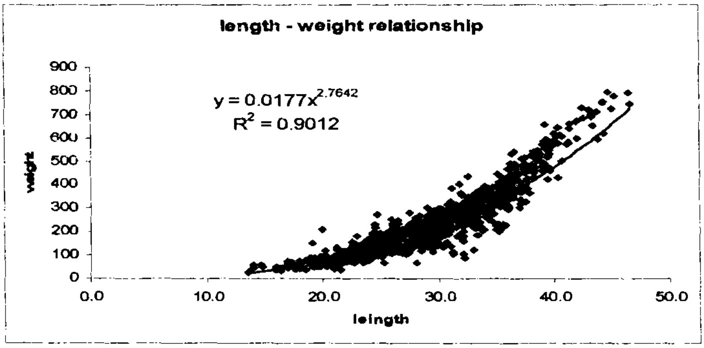

Fig. 4. Length- weight relationship of *L. ramada* in Bardawill lagoon, 2009

Mathematical models of growth

Growth in length (average back – calculation lengths) of *L. ramada* are given in Table (1) as 19.3 , 27, 32.3, 36.1, 39.3 and 42.2 cm in season 2009 for age's 1st, 2nd, 3rd, 4th, 5th and 6th respectively. The highest annual increment occurred during the first year of life, while a noticeable decrease was observed in the second year, reaching its minimal value during the sixth year of life (fig. 5).

Table 1. Back – calculation length at the end of different years of life of L. *ramada* in Bardawill lagoon, 2009.

Age group	No. of fish	Observed length	Average calculated lengths at the end of each year (cm)					
			I	II	III	V	VI	VII
I	**290**	19.2	19.3					
II	**370**	26.4	19.2	27				
III	**163**	32.6	19.5	27	32.3			
IV	**87**	35.5	19	27.1	32.5	36.1		
V	**43**	39.5	19.5	27.3	32.1	36.3	39.3	
V1	**18**	43.2	19.6	27.4	32.5	36	39.4	42.2
Increment			19.3	**7.7**	**5.3**	**3.8**	**3.2**	**2.9**

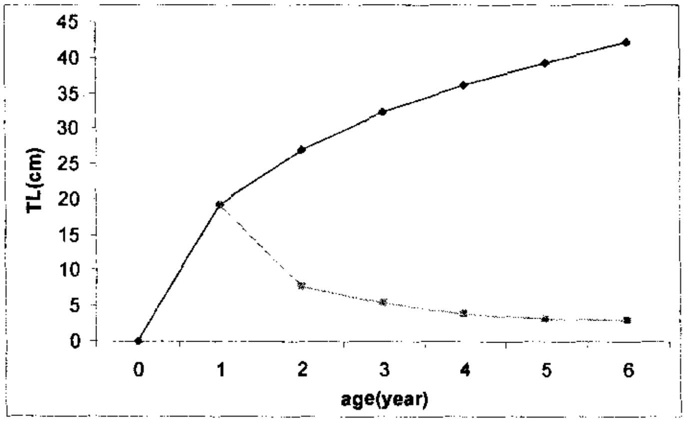

Fig. 5. Growth and annual increment in length of *L. ramada* in Bardawill lagoon in Year 2009.

Age reading indicated that attain their highest growth rate in length was during the first year of life, after which a gradual decreased in growth increment was observed with further increase in age. Table (2) summarized the lengths by age of the *L. ramada* in different Egyptian water.

Table 2. Length (cm) at age of life of *Liza ramada* from some Egyptian water bodies

Regions	Ages (years)								Authors
	1	2	3	4	5	6	7	8	
Medit, Coast	14.7	23.8	31.4	37.7	41.7	42.8			Rafail,1968
Lake Manzala	13.8	20.8	27.5	32.6	35.5				Fayek, 1973
Nozha hydrodrom	18.1	26.8	36.4	44.5					Salem&Mohammed, 1982
Lake Borollus	12.8	17.5	23.1	29	32	34.7			Hosny & Hshem, 1995
Wadi El Raiyan	20.1	28.6	34.6	39.1	42.8	45.8	47.8	48.9	El Gammal & Mehanna, 2004
Lake Timsah	19.9	29.2	35.5	38.9	41.1				Mehanna & Amin 2005
Lake Bardawil	21.1	30.1	36.3	39.3	41.1				Mehanna (2006)
Lake Bardawil	19.3	27	32.3	36.1	39.3	42.2			Present study

Back – calculation weights at the end of each year of life of *L. ramada* from Bardawill lagoon were estimated by applying the length – weight relationship.

Table (3) is giving the calculated weight of *L. ramada* at the end of any year of life, while figure (6) showed the growth and annual weight increment in fishing season 2009

The results in these tables showed that the weight increased successively and reached its maximum at group VII up to 550.4 g.

Our results were disagreement with that results which obtained by Mehanna ,2006 of the same species in the same lagoon where the author found that the back calculated weight were 73.39, 222.6, 403.5, 514.57and 593 gm for ages 1st, 2nd, 3rd, 4th and 5th years respectively. The lower growth in this study may be related to the higher salinity during this work.

Table 3. Calculated and annual increment of *L. ramada* in Bardawill lagoon, 2009

Age group	No. of fish	Observed length	Average calculated weight at the end of each year (gm)					
			I	II	III	V	VI	VII
I	290	65	63.3					
II	370	170	62.4	160.2				
III	163	275	65.1	160.2	262.9			
IV	87	377	60.6	161.8	267.4	357.5		
V	43	535	65.1	165.1	258.4	360.0	452.1	
V1	18	672	66.1	166.8	267.4	354.7	455.2	550.4
Increment			**63.3**	**96.9**	**102.7**	**94.6+**	**94.6**	**98.3**

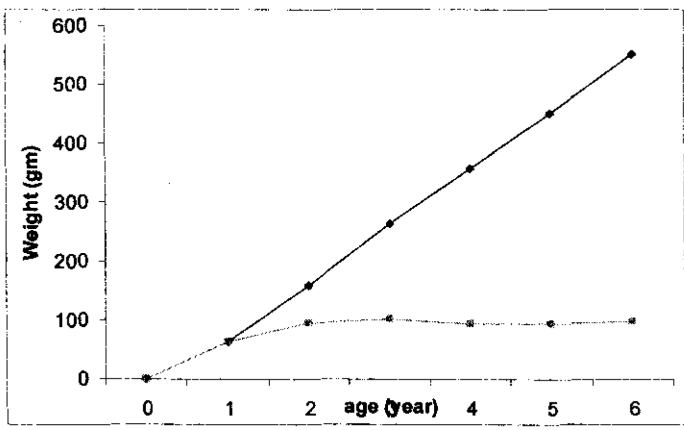

Fig. 6. Growth and annual increment in weight of *Liza ramada* in Bardawill lagoon, 2009.

The contents of the Von Bertalanffy growth models were estimated and the obtained equation was: $L_t = 49.41*(1-e^{(-0.2826*(t+0.8))}$

$W_t = 851.2*\{1-e^{(-0.2826*(t+0.8))}\}^{2.7642}$

Mdlwain *et al.,* 2005 mentioned that the differences in growth parameters due to age, sex, maturity and sampling period for the same species. Table (4) showed the differences of growth parameters between the present study and other studies.

Table 4. Growth parameters of present study comparing with other studies for the same species.

Locality	Samples age	Growth parameters			Authors
		L_∞	K	T_0	
Lake Tunis (Tunisia)	o-4 years	31.8	0.45	-0.21	Farrugio & Quignard,1974
River Krka (Adriatic sea)	0-8 years	52.5	0.25	-0.1	Sinovcic & Alegria,1986
Sibeik Bay (Adriatic sea	o-4 years	40	0.75	0.09	Modrusa *et al*,1988
Aveiro lagoon (Portugal)	0-4 years	65.8	0.08	-0.6	Arruda *et al*,1991
River Rhone (Southern France)	Male 0-8 years	24.8	0.6	-0.1	Quignard & Authern,1981
River Tagus	Female 0-8 years	39.4	0.13	-1.6	Almeida *et al*,1993
River Tagus	0-8 year	45.8	0.12	-1.5	Almeida *et al*,1995
Bardawill lagoon	0-5 year	44.14	0.51	-0.29	Mehanna,2006
Bardawill lagoon	0-6 year	49.41	0.2826	-0.8	Present study

Growth performance index

Pauly and Munro (1984) have indicated a method to compare the growth performance of various stocks by computing the equation Ø = logk+2logL∞ .The obtained results indicated that the growth performance index of *L. ramada* was 2.84. This results in agreement with the Ø values obtained were consistent with other estimates. It was found that Ø =2.66 for lake Borollus, (Hosny & hashem, 1995), Ø =2.91 at Wadi El- Raiyan lakes (EL Gammal & Mehanna, 2004) , Ø =2.98 at Lake Timsah (Mehanna& EL Gammal,2005) and Ø =3.0 in Bardawill lagoon (Mehanna, 2006).

Mortalities and exploitation rate

The total mortality coefficient Z, the natural mortality M, and fishing mortality F were estimated as 1.55, 0.61 and 0.94 respectively for *L. ramada* .This results disagree with that results which obtained by Mehanna, 2006 (Z=1.22, M=0.16 and F= 1.06 $year^{-1}$) for the same species in the same lagoon. Exploitation rate (E) was estimated as E=F/Z =0.6. 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 exploitation.

Yield per recruit

The formula of Gulland (1969) was used for the calculation of yield per recruit, as follows:

$$Y` / R = F e^{(-M(Tc - Tr))} W\infty \left[(1/Z) - (3S/(Z+K)) + ((3S^2)/(Z+2K)) - ((S^3) /(Z+3K)) \right]$$

The input parameters used in the calculation were as follows in table (5).

Table 5.The input parameters used in the calculation yield per recruit for *L, ramada* in Bardawill lagoon, 2009.

The parameters	Season 2009
Length infinity L∝	49.41
Weight infinity W∝	851.2
Growth constant K	0.2826
Natural mortality M	0.6142
Fishing mortality F	0.9401
Total mortality Z	1.55
Mean age at recruitment Tr	0.33
Mean age at first capture Tc	1.74
Mean length at first capture Lc (cm)	25.3
Mean length at recruitment Lr (cm)	13.5
Theoretical age at length zero t_0	- 0.8
Mean length L`	26.4
$\bar{L}$	29.94

As shown from the figure (7) there were clear that the curves starts at the origin where the yield per recruit was zero when the fishing mortality was zero. Then the yield per recruit increased rapidly as the fishing mortality increased and a maximum value of yield per recruit was reached, after which the yield per recruit decreased with further increasing in fishing mortality.

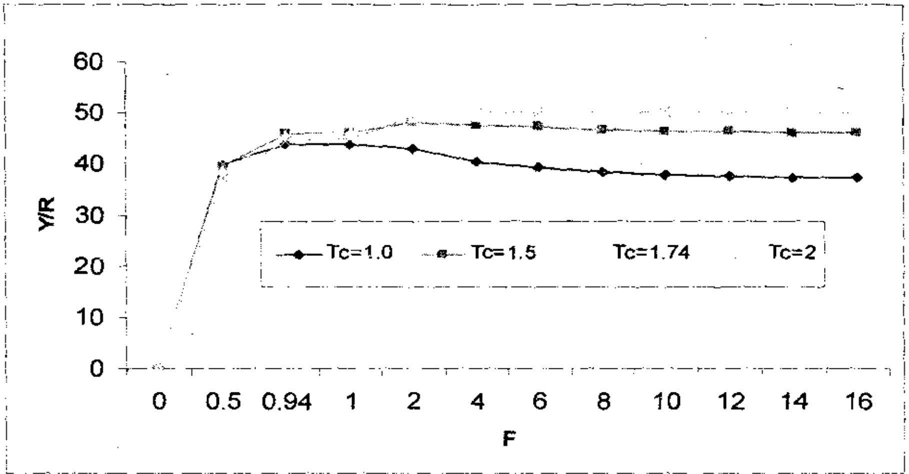

Fig. 7. Yield per recruit (Y / R) as a function of different fishing mortality and age at first capture (Tc) of *L. ramada* during in Bardawill lagoon, 2009.

Table (6) also showed that the present fishing mortality (F = 0.94 and age at first capture (Tc = 1.74) or length at first capture (Lc = 25.3 cm) gave a yield of 45.48 gram per recruit.

The results in season 2009 indicated that the maximum yield per recruit was obtained with a fishing mortality coefficient F = 4.0. It was also evident the increase of present fishing mortality coefficient (F = 0.94) to F_{max} (F = 4.0) would be associated with negligible increase in the yield per recruit (49.30 – 45.48 =3.82). This mean that increase of fishing mortality coefficient by about 325.5% from 0.94 to 4.0 [4.0 – 0.94 / 0.94 * 100 = 325.5%] would increase the yield per recruit by only 8.4%. [49.30 – 45.48/ 45.48 * 100 = 8.4%].

To investigate the variation in yield per recruit with changing of age at first capture Tc, which was closely related to the estimation of the optimum mesh size, in season 2009 the yield per recruit of *Liza ramada* was calculated using Tc = 1.0, 1.5, 1.74 and 2.0 with the present age at first capture (T_c = 1.74) and the results are given in table (8) and graphically represented by fig. (7).The results indicated that the maximum yield per recruit increased when the age at first capture increased. The maximum yield per recruit for T_c = 1.0, 1.5, 1.74 and 2.0 can be obtained at fishing mortality 6.0, 6.0, 6.0 and 8.0 respectively. This means that increase of age at first capture can be associated with increase of the maximum yield per recruit in spite of increasing of the fishing mortality (Table. 6).

Table 6. Yield per recruit (Y / R) as a function of different fishing mortality and age at first capture (Tc) of *L. ramada* in Bardawill lagoon, 2009

F	Yield per recruit			
	Tc=1.0	Tc=1.5	Tc=1.74	Tc=2
0.5	39.78	39.52	38.60	37.15
0.9401	43.78	45.73	45.48	44.49
1	43.91	46.11	45.95	45.03
2	43.04	48.06	48.91	48.85
4	40.50	47.61	**49.30**	50.01
6	**39.18**	**47.08**	49.12	50.15
8	38.42	46.73	48.95	**50.15**
10	37.93	46.49	48.82	50.13
12	37.59	46.31	48.72	50.11
14	37.34	46.18	48.64	50.08
16	37.15	46.08	48.58	50.07

*** Present values of Tc and F

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دراسة العمر، النمو، النفوق والانتاج النسبى لأسماك الطوبارة ببحيرة البردويل

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تشكل اسماك العائلة البورية اهمية خاصة من بين الانواع المصيدة من بحيرة البردويل وتحتل اسماك الطوبارة المرتبة الثانية فى الظهور بالمصيد. يهدف هذا البحث الى دراسة العمر، النمو ، النفوق و الانتاج النسبى لاسماك الطوبارة ببحيرة البردويل. تم تجميع ٣٣٨٢ وحدة بأطوال من ١٣,٥ الى ٤٦,٦ سم (طول كلى) ووزن من ١٢,٥ الى ٧٩٤ جم (وزن كلى) من ابريل حتى ديسمبر ٢٠٠٩. تم تحديد العلاقة بين الوزن والطول بالمعادلة التالية: الوزن = ٠,٠١٧٧*الطول^٢,٧٦٤ . تم تحديد اعمار هذا النوع بست مجموعات عمرية كما تم حساب الاطوال والاوزان المقابلة للمجموعات العمرية المختلفة بطريقة الحساب العكسى. حدود معادلة النمو لفونبيرتلانفى كالتالى: الطول عند مالانهاية = ٤٩,٤١ ، معامل النمو = ٠,٢٨ والعمر الصفرى = – ٠,٠٨. وبحساب معامل اداء النمو (٢,٨٢) وجد انة الادنى مقارنة بالدراسات السابقة وارجعت الاسباب لارتفاع الملوحة فى هذة الفترة. معدل الوفيات حسب على النحو التالى: النفوق الكلى = ١,٥٥، النفوق الطبيعى = ٠,٦١ و النفوق بالصيد = ٠,٩٤ /سنة. معدل الاستغلال الحالى ٦٠% وهو اعلى من معدل الاستغلال الامثل. الطول عند بداية الصيد ٢٥,٣ سم وهو مقابل للعمر ١,٧٤ سنة ووجد انة يمكن تحقيق انتاج نسبى اعلى عند زيادة عمر المصيد الى سنتين ولكن مع زيادة جهد الصيد وهى عملية غير اقتصادية. من النتائج السابقة يتضح انة للحفاظ على المخزون السمكى للطوبارة ببحيرة البردويل يجب خفض معدل الاستغلال الحالى والمرتبط بجهد الصيد الى ٥٠% وهو المعدل الامثل للمصيد.