Age and growth of the common sole, *Solea solea* from the Egyptian Mediterranean Coast of Alexandria.

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ABSTRACT

The study of the age and growth of individuals in a population is very important for understanding the general biology of the species and in particular the population dynamics. Age and growth of the common sole, *Solea solea* from Alexandria were studied based on the whole otolith readings using a non-linear back-calculation method during two fishing seasons (2011-2013). A total of 1558 *S. solea* (11.9 – 34.1 cm total length) were aged and the maximum life span was 4 years for both sexes. It was found that the age group one was the most frequent age group in the catch forming 65.8% of the total sampled specimens for male and female. The von Bertalanffy growth parameters obtained by using the back-calculated lengths were $L\infty$ = 34.77 cm; K= 0.55 year^{-1} and t_0 = 0.07 years for males and $L\infty$ = 36.24 cm; K= 0.63 year^{-1} and t_0 = -0.01 years for females. The results showed that the stock of *S. solea* needed to assess in the wise management of this potential fishery. It is also clear that *S. solea* in Alexandria was considered one of the overfished species with a greater need for conservation.

Keywords: Soleidae, *Solea solea,* age and growth, otolith, population dynamics, anagement.

INTRODUCTION

The common sole, *S. solea*, which is locally known as Mousa, is one of the most important commercial fish species in Alexandria coast. The soles assume a very important place in the Egyptian Mediterranean fisheries achieving about 80 million LE annually (2001-2012). Soles in the Egyptian Mediterranean are exploited mainly by trawling and a small part of catch is caught by kannar and trammel nets. About 56 trawlers and 173 fishing boat used kannar and trammel nets are operated in Alexandria region. The age and growth of the common sole were heavily studied around the world, but in Egypt this species was sparsely studied specially in Alexandria region. So, the present paper aims at determining the age and growth of the common sole, *Solea solea* in Alexandria as a guide for its management.

MATERIALS AND METHODS

Fish collection

Sole samples were collected monthly from the commercial landings of trawlers at Alexandria landing sites and local fish market during two fishing seasons (2011-2013). The sole catch was sorted into species and for *S. solea;* each fish was measured to the nearest mm for total length and weighed to the nearest 0.1 gram total weight, and individuals were dissected to determine the sex from visual traits of the gonads.

Age determination

Otoliths were extracted from each specimen, cleaned and stored for age determination. Reading of otolith was done by using an optical system consisting of

Nikon zoom-stereomicroscope focusing block and Heidenhain's electronic bidirectional read out system v r x 182, under transmitted light. Distance between the focus and the successive annuli were measured to the nearest 0.001 mm. The relationship between otolith radius of the otolith (S) and total fish length (TL) was determined by least square method where TL = a + b (S). The value of intercept (a) was used as a correction factor for back-calculated lengths at the end of each year of life from otolith measurements by Lee's equation as follows:

Ln = (Lt – a) Sn/S + a (Lee, 1920)

where a is the intercept of regression line with the Y- axis.

Length-weight relationship

The relationship between total length and body weight of the sole specimens was expressed by the following equation:

$W = a L^b$ (Beckman, 1948 and Le Cren, 1951), where W = total weight, L = length, and (a and b) = constants whose values were estimated by the least square method.

Theoretical growth:

Von Bertalanffy growth model was used to describe the growth of the common sole in Alexandria waters. The growth in length equation of this model can be expressed as follows: $Lt = L\infty [1 - e^{-k (t - to)}]$; where Lt is the predicted length at age t; $L\infty$ is the mean theoretical maximum length; k is a growth rate parameter, and t_0 is the theoretical age at 0 length. The constants of the von Bertalanffy equation (K and $L\infty$) were estimated by applying Ford- Walford method.

Growth Performance Index (Ø'):

Length-based index of growth performance was computed according to the formula of Pauly and Munro (1984) as follows: $Ø' = \text{Log}_{10} K + 2 \text{Log}_{10} L_\infty$, Where: Ø' = Phi-prime, i.e. a length-based index of growth performance.

RESULTS AND DISCUSSION

Age determination

Age of *S. solea* in Alexandria, was determined by counting the growth annuli on sagittal otoliths. From the results it is found that the maximum life span of the common sole in Alexandria fishing area is 4 years for both sexes and age, group one was the most frequent age group in the catch forming 65.8% of the total sampled specimens for male and female. Body length – otolith radius relationship showed a strong correlation between the body length and otolith radius ($r^2 = 0.981$). The obtained life span (4 years) is similar to that estimated by Salman (2014) and Mehanna *et al.* (2013) and different from that given by El-Gammal *et al.* (1994), Turkmen (2003) and Mehanna & Salem (2012). This difference may be due to different values of L_{max} recorded in those studies.

Back-calculations:

The back-calculated lengths at the end of each year of life for males, females and sexes combined of *S. solea* are given in Table 1 .From the results it is obvious that the mean back-calculated lengths at the end of each year of life for males are 15.5, 23.7, 28.3and 31.1 cm for 1st, 2nd, 3rd and 4th year of life respectively, while those for females are16.8, 25.9, 30.50 and 33.30 cm for1st, 2nd, 3rd and 4th years of life respectively. It is also clear that females are characterized by higher growth rate than males and attained higher lengths at the same age groups. As well as both males and females attain their highest growth in length at the end of the first year of life (15.5cm for males and 16.8cm for females), after which the annual increment in length decreases gradually with further increase in age until reaches its minimum value at the

end of the last year of life (2.8 cm at the end of 4th year of life for males and females). The same findings were reported in the previous studies (El-Gammal *et al.,* 1994; Mehanna, 2007; Mehanna *et al.,* 2011; Mehanna and Salem, 2012; Mehanna *et al.,* 2013; Salman (2014) and Mehanna (2014).

Table 1: Observed (OL) and back calculated lengths (BCL) in cm for *Solea solea* from Alexandria.

Age group year	Male		Female		Sexes combined	
	OL	BCL	OL	BCL	OL	BCL
I	15.79	15.50	17.44	16.80	16.57	16.3
II	23.81	23.70	26.51	25.90	25.61	25.3
III	28.39	28.30	30.92	30.50	29.95	29.8
IV	31.50	31.10	33.47	33.30	33.21	32.9

Length – weight relationship

A total of 570 males varied between 13.4 -31.9 cm for total length and from 23.28 to 282.73g for total weight and a total of 988 females their lengths ranged between 11.9 and 34.1cm and their weights ranged between 11.78 and 371.4g were used for length weight relationship estimation. The estimated length - weight equations for male, female and sexes combined for the investigated species (Fig. 1) are:

Male: $W = 0.0201\ L^{2.7032}$

Female: $W = 0.0125\ L^{2.8883}$

Sexes combined: $W = 0.0131\ L^{2.8615}$

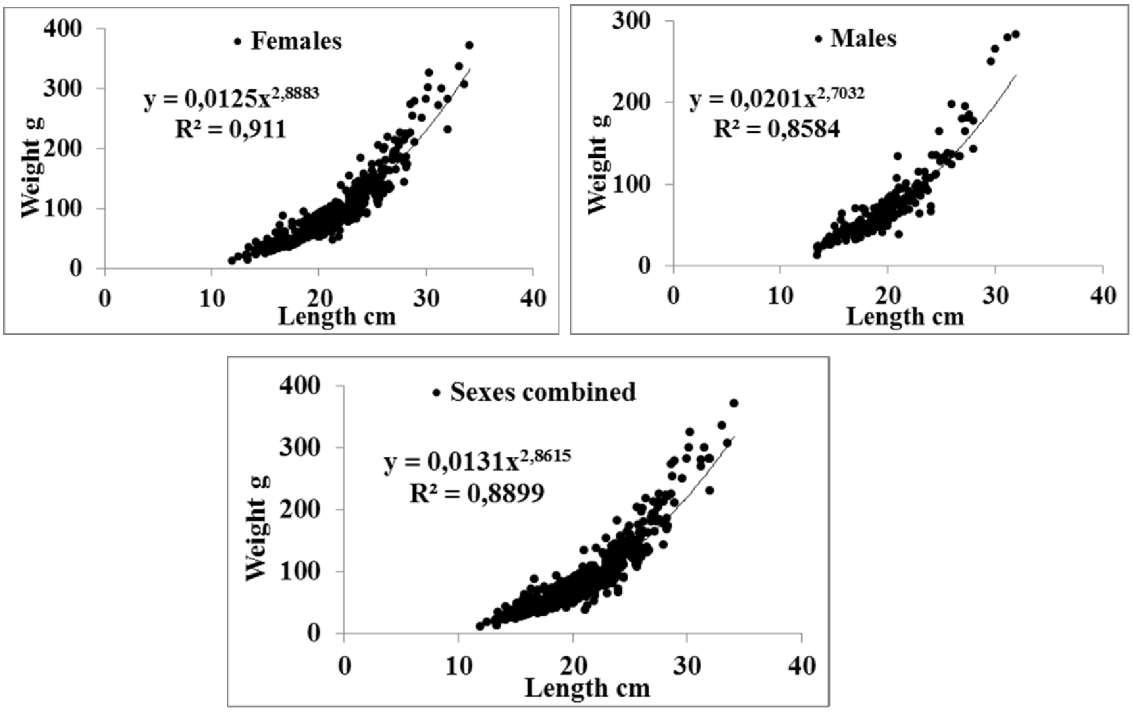

Fig. 1: Length – weight relationship of *Solea solea* (males, females and sexes combined) from Alexandria.

The values of constant "b" in the length-weight relationship of *S. solea* were found to be 2.70, 2.88 and 2.86 for males, females and sexes combined respectively. The value of b is significally difference of 3 so the growth negative allometric growth (b<3).The values of (b) obtained from the present study are more or less similar to (Ezzat *et al.,* 1982; Mosaad, 1990; Mosaad & El-Sayed, 1991; Mehanna & Salem, 2012; Salman, 2013).

Growth

The obtained von Bertalanffy theoretical growth in length equations for *S. solea* was as follows:

Males $L_t = 34.77(1-e^{-0.55\,(t-0.06926)})$

Females $L_t = 36.24\,(1 - e^{-0.62\,(t-0.00955)})$

Sexes combined $L_t = 35.81\,(1 - e^{-0.58\,(t+0.00295)})$

Where L_t is the length at age t

The growth parameters of the present study for males, females and sexes combined of *S. solea* from Alexandria with those reported by other researchers for the same species were given in Table 2. The difference in growth parameters between regions can be attributed to the difference in size composition of the species in each area.

Growth performance Index (Ø')

The computed growth performance index for *S. solea* in Alexandria was 2.82, 2.91 and 2.87 for male, female and sexes combined respectively. It was obvious that females of *S. solea* in Alexandria are characterized by a higher growth rate than males. Also, the growth rate of this species in Alexandria was higher than the other places (Table 2).

Table 2: Population parameters for the common sole from different localities.

Locality	**K (yr^{-1})**	**L_∞ (TL)**	**t_0**	**Ø'**	**Age (y)**	**Author**
North Sea						De Veen, 1976
	0.18	31.2		2.24		(1960)
	0.29	30.1		2.42		(1962)
	0.25	28.2		2.30		(1966)
Spain	0.22	46.4		2.68		Ramos, 1982
France	0.24	48.8		2.76		Vianet *et al.,* 1989
Lake Bardawil	0.33	30.04		2.47*	6	El-Gammal *et al.,* 1994
Hellenic seas	0.38	34.9				Stergiou *et al.,* 1997
Izmir Bay	0.28	34.7		2.53*		Hossucu *et al.,* 1999
Iskenderun Bay					8	Turkmen, 2003
Male	0.22	26.03		2.17*		
Female	0.18	29.95		2.21*		
Bardawil lagoon	0.33	44.36		2.81	6	Mehanna & Salem, 2012
Bardawil lagoon					4	
Male	0.47	32.72	-0.20	2.70		Salman (2013)
Female	0.55	37.23	0.05	2.88		
Alexandria					4	The present study
Male	0.5514	34.77	0.07	2.82		
Female	0.6250	36.24	-0.01	2.91		

* Ø' estimated by the present author

CONCLUSION AND RECOMMENDATIONS

This study provided the basic information on age and growth as well as the von Bertalanffy growth parameters as vital inputs to the study of stock dynamics of the common sole in Alexandria. It will be recommended that an analytical model should be applied to assess and propose some reference points to conserve and develop this valuable fishery in a sustainable manner.

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ARABIC SUMMARY

العمر والنمو لاسمك موسي الشائعة (سوليا سوليا) فى سواحل الاسكندرية بالبحر االمتوسط، مصر.

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تعتبر اسماك موسى من اهم الاسماك الموجودة في البحرالمتوسط في مصر التي يتم صيدها بحرفة الجر. ونظراً للإقبال الشديد على هذا النوع فى السوق المحلى بالإضافة إلى أسعاره العالية فقد لوحظ زيادة فى مجهود الصيد واستخدام حرف غير مطابقة للمواصفات، الآمر الذى أدى إلى نقص حاد فى الإنتاج السمكى وكان العائد المادي من عام ٢٠٠١ الي ٢٠١٢ حوالى ٨٠ مليون جنية .

يوجد على الاقل ٥ انواع من اسماك موسي فى مياه البحر المتوسط بمصر، ويعتبر اهمها اسماك موسي الشائعة (سوليا سوليا) و اسماك موسي المصرية (سوليا ايجيبتياكا) وتسمي اسماك موسي الشائعة (سوليا سوليا) محليا باسماك موسي وتعتبرواحدة من اهم الانواع الموجود في سواحل الاسكندرية. تم تعيين عمر (1558) سمكة من سوليا سوليا حيث كانت تتراوح اطوالهم بين (11.9-34.1) سم وذلك عن طريق قراءة عظمة الأذن (الاوتليس)، وأظهرت النتائج أنه لايوجد فرق فى النمو بين ذكور وإناث الموسى حيث إمتد عمر كل من الذكور والاناث إلى أربعة أعوام وأقصى نمو فى الطول يحدث خلال السنة الأولى من العمر بالنسبة للذكور والإناث ثم بعد ذلك تقل معدلات النمو تدريجيا مع الزيادة فى العمر. وتم حساب معدلات النمو وذلك باستخدام طريقة حساب الاطوال السابقة (لفون برتلانفي) وكان بالنسبة للذكور اقصي عمر يصل اليه هو 34.77 سم و معدل النمو 0.55 لكل عام وبداية عمر للسمكة 0.07 عام، وبالنسبة للاناث كان اقصي عمر يصل اليه هو 36.24 سم و معدل النمو 0.63 لكل عام وبداية عمر للسمكة 0.01- عام. واظهرت النتائج ان مخزون السوليا سوليا في الاسكندرية يحتاج الي تنظيم وادارة لانه يتعرض للصيد بكميات كبيره ويجب تقليل صيده.