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\textsuperscript{-1} and $t_0 = 0.07$ years for males and $L_\infty = 36.24$ cm; $K= 0.63$ year\textsuperscript{-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:

\[ \text{Ln} = (\text{Lt} - a) \frac{S}{S + a} \quad (\text{Lee, 1920}) \]

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:

\[ W = a L^b \quad (\text{Beckman, 1948 and Le Cren, 1951}), \]

where \( W \) = total weight, \( L \) = length, and \( (a \text{ and } b) = \) 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: \( L_t = L_\infty [1 - e^{-k(t-t_0)}] \); where \( L_t \) 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 (\( \Phi' \)):**

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

### 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 \( L_{\text{max}} \) 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, 28.3 and 31.1 cm for 1st, 2nd, 3rd and 4th year of life respectively, while those for females are 16.8, 25.9, 30.50 and 33.30 cm for 1st, 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 (15.5 cm for males and 16.8 cm 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.

<table>
<thead>
<tr>
<th>Age group year</th>
<th>Male</th>
<th>Female</th>
<th>Sexes combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OL</td>
<td>BCL</td>
<td>OL</td>
</tr>
<tr>
<td>I</td>
<td>15.79</td>
<td>15.50</td>
<td>17.44</td>
</tr>
<tr>
<td>II</td>
<td>23.81</td>
<td>23.70</td>
<td>26.51</td>
</tr>
<tr>
<td>III</td>
<td>28.39</td>
<td>28.30</td>
<td>30.92</td>
</tr>
<tr>
<td>IV</td>
<td>31.50</td>
<td>31.10</td>
<td>33.47</td>
</tr>
</tbody>
</table>

**Length – weight relationship**

A total of 570 males varied between 13.4 - 31.9 cm for total length and from 23.28 to 282.73 g for total weight and a total of 988 females their lengths ranged between 11.9 and 34.1 cm and their weights ranged between 11.78 and 371.4 g 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: \( W = 0.0201 \times L^{2.7032} \)
- Female: \( W = 0.0125 \times L^{2.8883} \)
- Sexes combined: \( W = 0.0131 \times L^{2.8615} \)

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 significantly 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.

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

* 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.
REFERENCES


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ARABIC SUMMARY

العمر والنمو لأسماك موسى الشائعة (سوليا سوليا) في سواحل الإسكندرية بالبحر المتوسط، مصر.

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1 - معهد ديناميكا التجمعات السمكية للمعهد القومي لعلوم البحر والصيد، مصر
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تعتبر أسماك موسى من أهم الأسماك الموجودة في البحر المتوسط في مصر التي يتم صيدها بحيرة الجر. ونظراً للإبداع الشديد على هذا النوع في السوق المحلي بالإضافة إلى أسعاره العالية فقد لوحظ زيادة في مجهد الصيد واستخدام حرف غير مطالبية للمواصفات، الأمر الذي أدى إلى نقص حاد في الإنتاج السمكي وكان العائد المادي من عام 2001 إلى 2012 حوالي 80 مليون جنيه.

يوجد على الأقل 5 أنواع من أسماك موسى في مياه البحر المتوسط بمصر، ويعتبر أهمها أسماك موسى الشائعة (سوليا سوليا) و أسماك موسى المصرية (سوليا ايجيبتياكا) ونسمي أسماك موسى الشائعة (سوليا سوليا) محلية بالاسماك موسى وتعتبر واحدة من أهم الأنواع الموجود في سواحل الإسكندرية. تم تعدين عمر (1558) سمكة من سوليا سوليا حيث كانت تتراوح أطوالهم بين (11.9-34.1) سم وذلك عن طريق قراءة عظمة الأذن (الأوليس)، وأظهرت النتائج أنه لا يوجد فرق في النمو بين الذكور وإناث الأسماك حيث أتم عمر كل من الذكور والإناث إلى أربعة أعوام وأقصى نمو في العسل يحدث خلال السنة الأولى من العمر بالنسبة للذكور والإناث ثم بعد تلك مراحل النمو تدريجيا مع زيادة العمر. وتم حساب معدلات النمو وذلك باستخدام طريقة حساب الامتداد السابقة (فون برولمان) وكان بالنسبة للذكور أقصى عمر يصل إليه 34.77 سم و معدل النمو 0.55 لكل عام وبداية عمر للسمكة 0.07 عام، وبالنسبة للإناث كان أقصى عمر يصل إليه 36.24 سم و معدل النمو 0.63 لكل عام وبداية عمر للسمكة 0.01 عام. وأظهرت النتائج أن مخزون السوليا سوليا في الإسكندرية يحتاج إلى تنظيم وادارة لأنه يتعرض لصيد بكميات كبيرة ويجب تقليل صيده.