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STUDY OF SOME BIOLOGICAL AND DYNAMIC CHARACTERISTICS OF THE MEDEIRAN SARDINELLA FISH *SARDINELLA MADERENSIS* OF EASTERN MEDITERRANEAN (NORTH SINAI COAST EGYPT)

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ABSTRACT

Monthly collected samples of *S. maderensis* from January to December 2021 in Mediterranean coast of Sinai for determination the growth and mortality. The lengths raged from 8.5 - 26.3 cm and the weights ranged from 5g to 171g. Value b of the relationship between length-weight was 3.0524 thus, the growth of *S. maderensis* categorized as displaying isometric growth. (VBGP) of L∞, (k) and (t0) were 30.39cm, 0.2937 and -0.6049/year, respectively. The growth performance index (Ø') was 2.334. GSI ranged from 0.11 to 2.6 of males and ranged from 0.19 to 3.4 of females, also the peak spawning periods of *S. maderensis* were the period from April to September. The lengths at first maturity were 15.5 cm (males), 16.7 cm (females) and 16.0 cm for combined sexes. Values of total mortality (Z), natural mortality (M), fishing mortality (F) and exploitation rate (E) of combined sexes of *S. maderensis* were 0.7124 ,0.3229, 0.3895 year-¹ and 0.547, respectively. Length at first capture L50 was 13.5 cm. Should be not increase the fishing effort but should be increasing the size of the nets so that the length at first capture increases from 13.0 cm to 16.0 cm in order to equal the length at first maturity to preserve the stock of these fish.

INTRODUCTION

Sardine fish in the Port of El Arish represents the first product of the Sinai coast. There are several types of sardines, including round sardinella *S. aurita* and maderian sardinella *S. maderensis*, which the maderian sardinella the second part of the production of sardines in North Sinai and there are a little previous studies in this region on *Sardinella maderensis*. Production of sardines on the Mediterranean coast in 1998 was more than 5,000 ton, reaching 11700 ton in 1999, then it decreased to 4,000 in year 2000 **(El-Aiatt, 2004)**, and it decreased further until it reached 210 ton in year 2010 **(Gaber, 2012)**, and this may be due to change in environmental conditions and this is one of the reasons for this study. *S. maderensis* is from the family Clupeidae, and genus sardinella. It is classified as a small ray-finned fish and is usually found in the Eastern Atlantic and southern Mediterranean **(Ba *et al.*, 2016)**. It is a silvery fish like other sardinella species (Fig. 1). The growth parameters of *S. maderensis* were estimated in studies carried out in several regions of the African Atlantic coast, based on scale readings. **Ghéno and Le Guen (1968**) reported that this species can reach six years of age with accelerated growth up to three years of age (**Camarena, 1986**).

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Fig. 1. ***Sardinella maderensis***

Several studies have been carried out in various regions of the West African coast on the determination of the growth of this species, using readings of, scales, and frequency distributions of lengths (**Shcherbich, 1981; Showers, 1996**). These studies indicate that in general *S. aurita* is a fast-growing species, especially in the first two years of life. According to **Ghéno and Le Guen (1968**), longevity in this species is generally 6 to 7 years of life. In Angola, only one study on growth is known, based on the reading of scales carried out by **Shcherbich (1981**). **Konoyima *et al* (2020)** reported that the Mean lengths (18.5 cm) and mean weights (62.4 g) for *S. maderensis* also growth exponent gave negative allometric, the correlation between length and weight (r=0.7282) and the (K) was low (K<1). This research aims to study some of the biological and dynamic characteristics of this important specie to evaluate the status and provide some information to inventory management.

MATERIALS AND METHODS

4047 samples were collected of *S. maderensis* monthly from January to December 2021. Lengths were measured to the nearest 0.1 cm and weights to the nearest 0.1 g. Through simple observation, is determined the development of gonads in fish. Scales were taken from 2333 fish to calculate the age and also the dissection of these fish to know the sex and weight of the gonad to know the development of the gonads (The weights of gonads are rounded to 0.1 grams) and calculate the gonadosomatic index and to know the spawning season for these fish.

The Relationship between Length-Scale Radius

The relationship between average length and Scale radius was calculated. **Lee (1920**) reported that the back calculation length of the length is done through the following equation: (Ln = (Sn/S) (L-a) +a). Where Ln = length at the end of year n; Sn = radius of scale to ring n; S = overall radius of the scale; L = total length at capture and a =constant of the relationship between length and Scale radius.

Le Cren (1951) reported that the relationship between length and weight is measured by the following equation: $W= a L^{b}$ where W and L total length and weight a and b are constants the length – weight relationship. Several mathematical models are used to describe the theoretical growth of fishes; the most widely used model is that of **Von Bertalanffy** equation **(1949)** for calculating theoretical growth in length and weight $Lt = L\infty (1 - e^{-k (t- t_0)})$ and $wt = w\infty [(1-e^{-k (t- t_0)})]^{b}$ where lt =length at age t and wt=weight at age t, $L\infty$ = the asymptotic length, $W = aL\infty^{b}$, k= growth coefficient and t_0 =the age at which the length is nil.

Pauly and Munro (1984) reported that the equation Growth performance index (@) is calculated by the following equation (Φ=log k+2 log L∞). Monthly condition factor was calculated by two methods, namely:

1. Condition factor "Kc" Kc=(W×100)/L^3 (**Hile, 1936**) Where: Kc = composite coefficient of condition, W = weight in g , L = length in cm
2. Relative condition "Kn "Kn = W / W* Where: Kn = relative coefficient of condition, W = observed weight in g, W* = calculated weight in g. The gonads removed and weighed to the nearest 0.1 g; calculated (GSI) Gonado somatic index every month by equation of **Bariche *et al.* (2003).** Gonadosomatic Index parameter was calculated using the formula: GSI =[(gonad weight) /(body weight)] x100). The total mortality coefficients were obtained by using the following method: The Powell-Wetherall plot based on data **(Powell, 1979)** discussed in **Wetherall *et al.* (1987**) Z=1-k. Natural mortality coefficient was estimated by using the equations of **(Ursin, 1967)** formula M= $W'^{(-1/3)}$ were W′= Average weight of the total samples. F= Z-M and (E) E= F/ (F+M) Where E: is exploiting rate, F: is fishing mortality, M: is natural mortality.

RESULTS

The lengths of *S. maderensis* ranged from 8.5 to 26.3 (mean 14.63 cm) and the weights ranged from 5.0 to 171 g (mean 29.1g). The relationship between length and weight in Fig. 2 and the length – weight relationship was: W = 0.007 x $L^{3.0524}$.

Determine the Age

From reading the scales of *S. maderensis*, there were five age stages from 0 to age 4, and through this equation (Ln=(L–.7.6046) Sn/S+7.6046) the length was calculated at the end of each year. The percentage of attendance for each age group was as follows 9.82, 42.31, 27.73, 14.1and 6.04% as a percent for 0, 1st, 2nd, 3rd and 4th age groups, respectively and the lengths at the end year were 11.45, 16.1, 20.1, and 22.52 cm for age 1, 2, 3, and 4 years, respectively and the annual increment of length is given in Fig. 3 and the weight at the end year and the annual increment in Fig. 4.

Growth

The growth parameters were L∞=30.39, K=0.2937 and t0=0.3094, respectively. To obtain the theoretical growth of height and weight through the two von Bertalanffy equations for growth in height and weight

Growth of length: $Lt = 30.39\ (1 - e^{-0.2937\ (t + 0.3094))}$

Growth of weight: $Wt = 235.0\ [(1-e^{-0.2937\ (t + 0.3094)})]^{3.0524}$

Growth performance index (φ') for *S. maderensis* in Eastern Mediterranean (North Sinai Coast) were 2.4334 for length and 1.0486 for weight.

The length at first capture (Lc) which 50% of fishes retained by the gear of *S. maderensis* in Eastern Mediterranean (North Sinai Coast were estimated at 13.5 cm (Fig. 5). Total mortality, natural mortality, fishing mortality and Exploitation rate for *S. maderensis* were 0.7124; 0.3229; 0.3895 and 0.547, respectively.

Monthly average gonads somatic index (GSI)for both males and females of *S. maderensis* are given in Fig. 6. In females and males, the gonads somatic index increases progressively from April and the top in July these results indicate that the spawning season for these fish is between March to September. The first sexual maturity for of *S. maderensis* season, 2021 was determined by examination of gonads to determine the sex and the stage of maturity. The length at first maturity was estimated at 15.5, 16.7 cm and 16.0 cm for males, females and combined sexes respectively (Fig. 7). The size at first maturity of fish may be important to assess the optimum size of first capture of a fish and the age at first maturity Tm50 = 2.57 years for combined sexes of *S. maderensis* during 2021.

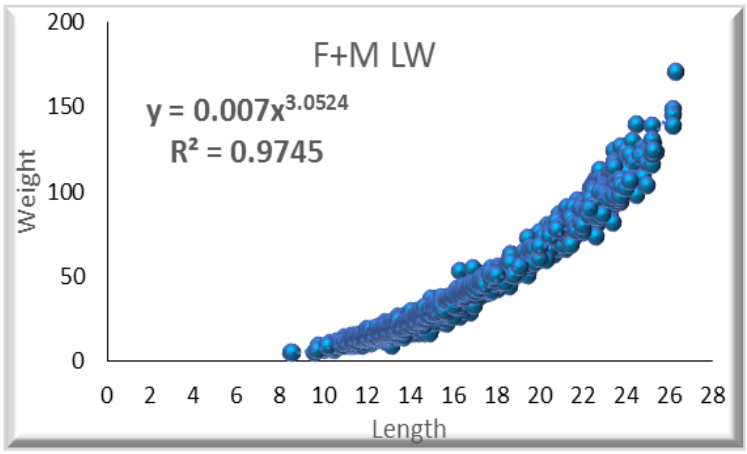

Fig. 2. Length-weight relationship (♀♂) of *S. maderensis* during 2021

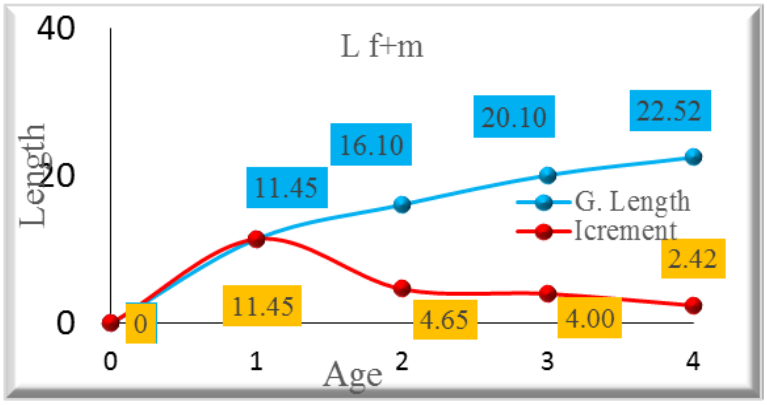

Fig. 3. Growth and annual increment in length (♀♂) of *S. maderensis* 2021

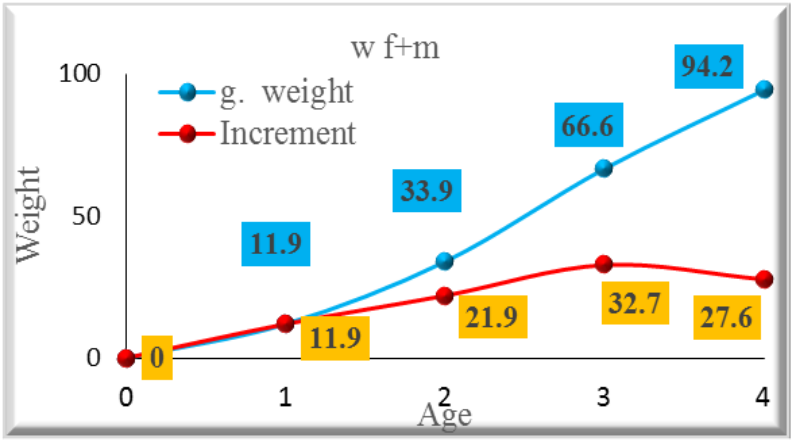

Fig. 4. Back-calculation weight at the end of different years of life (♂♀) of *S. maderensis* during 2021

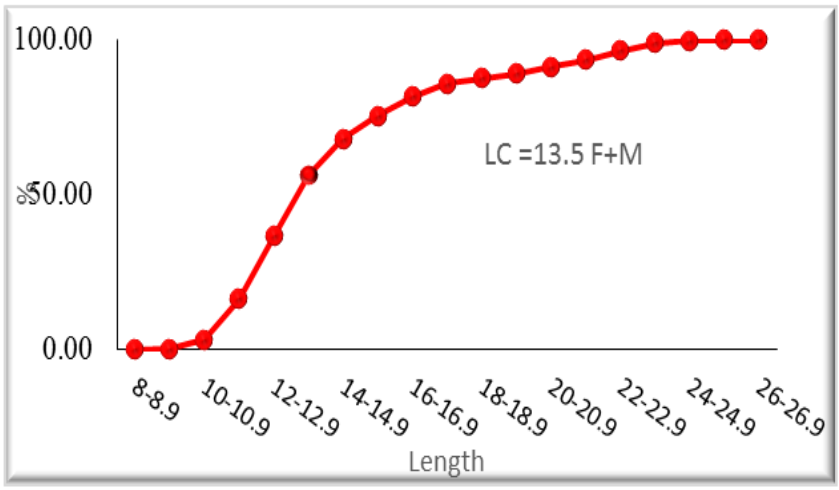

Fig. 5. Length at first capture of combined sexes (♀♂) of *S. maderensis* season, 2021

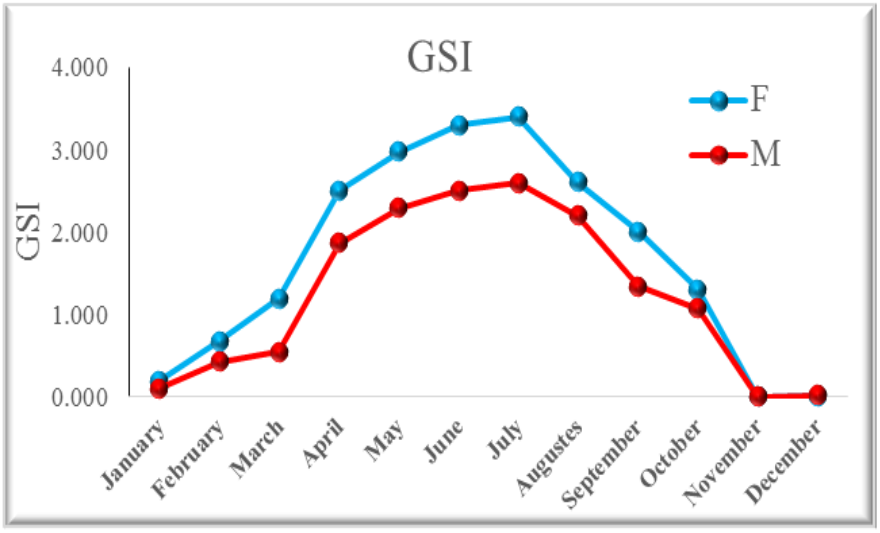

Fig. 6. GSI for males and females of *S. maderensis* during, 2021

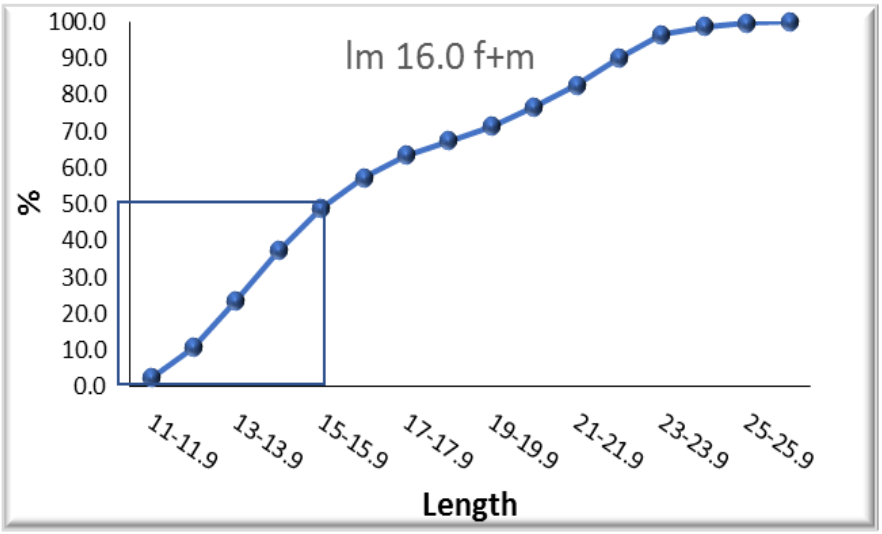

Fig. 7. Length at first maturity of combined sexes(♀♂) of *S. maderensis,* 2021

DISCUSSION

Length weight relationships are important for comparative growth studies (**Moutopoulos and Stergiou, 2002).** Length–weight relationships are very important in order to (i) calculate the weight of a given individual fish of known length or the total weight of a fish from the length and frequency distribution; (ii) estimation of weight growth rate and several other aspects of fish populations; (iii) converting the growth equations in length to the growth equations in weight for use in inventory valuation models; (iv) Estimating the status of fish in a particular geographical area. (5) making interregional comparisons of the life history and morphology of specific species **(Kohler *et al.*, 1995; Stergiou and Moutopoulos, 2001)**.

In this study the percentage of small fish is high. The length –weight relationship values (a and b are constants vary with sex, age, seasons, growth, health, habitat, feeding, and differences in how long a specimen is caught, stage of maturity, and sampling techniques from fishing gear (**Tesch, 1968; Begenal and Tesch, 1978**)

Table 1 shows the differences in the value of b in different regions. **Richter *et al*. (2000)** reported that the growth and the relationship between length and weight very important in fishery management.

In this study, the back-calculated length at the end of life year and the highest annual increment occurred during the first year of life, The increase of length decreased gradually with age. In this study the increment of length in the first year was 50.8% then decreased gradually with age. These results agreement with **Sossoukpe *et al* (2016**) .The increment of *S. maderensis* in the nearshore waters of Benin (West Africa) 42.7%, also with **Mahfoudh *et al* (2018**) 65.7% in Mauritania. In this study, there are four age groups, the first age group dominated hunting (42.31%), followed by the second, third, zero and finally the fourth age group (27.73%), (14.1%), (9.82%). (6.04%) respectively, average length at different ages of *S. maderensis* in different localities (Table 2).

In present study the growth parameters $L\infty$ =30.39cm, $W\infty$ = 234.9g, K = 0.29, T0 = -0.6094 and the growth performance index (φ') for *S. maderensis* was about 2.433. for combined sexes These results are higher, lower or equal to some of the results presented in Table 3 for some scientists in different regions of the world.

Estimating the mortality factor of fish stocks is an essential step for calculating the potential yield, the optimal yield per recruit, and the optimal fishing effort. In this study, although estimates of the total mortality coefficient (Z) could be affected by the absence of large individuals due to the qualitative selectivity of the size of the small study fish. In the present study the annual rates of total mortality coefficient "Z", the natural mortality "M" and the fishing mortality "F" for combined sexes of *S. maderensis* were estimated to be 0.7124, 0.3229 and 0.3895 respectively. **Olopade, *et al.* (2019)** found that the values of Z, M and F in the Sombreiro River, Nigeria for *S. maderensis* was "Z" =2.74, "M"= 1.32and "F"= 1.42, while **Wehye (2017)** in the Sombreiro River, Nigeria reported that "Z" =1.24, "M"= 0.81 and "F"= 0.43 and **Sossoukpe, *et al*(2016**) in the nearshore waters of Benin found that Z" =3.93, "M"= 1.3 and "F"= 2.63 these results are high compared to our results.

Gulland (1971) reported that the exploitation rate is the fraction of an age class that is caught during the life span of a population exposed to fishing pressure, *i.e.*, the number caught versus the total number of individuals dying due to fishing and other reasons. which allows one to (roughly) assess if a stock is overfished or not, on the assumption that the optimal

Table 1. Constants of relationship between Length and weight in different localities

Area of Study	Author	a	b
Mediterranean Sea, North Sinai	Present study	0.07	3.0524
Nigeria	**Olopade *et al.* (2019)**	0.0225	2.58
Mauritanie (Artisanal fishery)	**Mahfoudh *et al.* (2018)**	0.0071	3.09
Nigeria	**Abdul *et al.* (2016)**	0.011	2.9
Benin	**Sossoukpe *et al.* (2016)**	0.023	2.86
Senegal	**Ba *et al.* (2016)**	0.01560	3.00
Senegal	**Samba (2011)**	0.0006	3.01
Mauritania (industrial fishery)	**Pascual-Alayón *et al*. (2008)**	0.0006	3.12
Gambia	**Ecoutin *et al.* (2005)**	0.00007	3.15

Table 2. Average length at different ages of *S. maderensis* in different localities

Area of Study	Author	Age			
		1	**2**	**3**	**4**
Mediterranean Sea, North Sinai	Present study	11.45	16.1	20.1	22.52
West Africa	**Sossoukpe *et al.* (2016)**	13.01	22.9	28.1	30.68
Mauritania	**Mahfoudh *et al.* (2018)**	23.00	28.5	32.3	35.0

Table 3. Growth parameters of *S. maderensis* in different places

Area of Study	Author	Parameter			
		L∞	**K**	**T0**	**ϕ**
Mediterranean Sea, North Sinai	Present study	30.39	0.29	-0.61	2.433
Nigeria	**Olopade *et al.* (2019)**	23.21	0.54	-0.03	2.464
Ghana	**Arizi (2019)**	32.21	0.58	-0.49	2.776
Ghana	**Samuel *et al.* (2019)**	23.36	0.61	-0.28	2.532
Mauritania	**Mahfoudh *et al.* (2018)**	38.44	0.53	-0.6	2.894
West Africa	**Sossoukpe *et al*. (2016)**	33.6	0.65	-0.24	2.866
Nigerian waters	**Marcus (1989)**	37.5	0.34	-0.25	2.68

value of E is equal to 0.5, the use of E ≈ 0.5 as optimal value for the exploitation ratio itself resting on the assumption that sustainable yield is optimized when F ≈ M.

Pauly (1987) suggested a less optimal E value of 0.4, thus the values of fishing mortality rate and exploitation rate were relatively high indicating a high level of exploitation**.** In present study the exploitation rate was 0.5468 for combined sexes. Sardines are exposed to many predators and to many fish of recreational and commercial importance such as *Scomber japonicus* **(Rizkalla and Faltas, 1997)**. Feeding habits of chub mackerel (*Scomber japonicus*) in Egyptian Mediterranean waters.

In this study, GSI values differed between males and females, with common values occurring in the period from January to March. The GSI value in this study ranged from 0.11 to 2.6 for males and from 0.19 to 3.4 for females, and the peak spawning season was from April to September. These results differ with studies on *S. maderensis* conducted by **Youmbi *et al*. (1991)** where the peak spawning periods were from April to July. Also **Anonymous (1988**) showed that the spawning periods vary with season in Sardinella species, and this corresponds to the breeding season (August to December) in Ivory Coast and Ghana. **Boely *et al*. (1979**) showed that there is one major spawning period (April to October) for *S. maderensis* with two breeding peaks for *S. aurita,* which are in the dry and cool seasons (February to June). **Longhurst and Pauly (1987)** also noted that reproductive peaking is a feature of commercial fish and invertebrates in tropical waters.

Length at first maturity (L_m) is very important for fisheries management, **Osman *et al*. (2020)** reported that according to length at first maturity we can set a minimum legal size (MLS) for not overfishing. **Woodhead (1978)** found that the length at first maturity is approximately two-thirds of the maximum total length. This assumption is consistent with our results where the maximum length was 26.3 cm and lengths at first maturity were 16.7 cm for *S. maderensis* females. These results show that the *S. maderensis* stock in the Mediterranean is overexploited, with the length at first capture in our results being 13.5 cm, which is significantly less than the length at first maturity.

Double recruitment annually is for tropical fish species and short-lived species (**Pauly 1982**). Recruitment is year-round for tropical fish and shrimp species (**Weber, 1976**). Results obtained by **Diouf *et al.* (2010)** show continuous breeding of *S. maderensis* throughout the year.

Conclusion

The fishing effort during the spawning season should be reduce especially from June to August.and should be not increase the fishing effort but should be increasing the size of the nets so that the length at first capture increases from 13.0 cm to 16.0 cm in order to equal the length at first maturity to preserve the stock of these fish.

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الملخص العربي

دراسة بعض الخصائص البيولوجية والديناميكية لاسماك السردين المفطر (*Sardinella maderensis*) بشرق البحر المتوسط (ساحل شمال سيناء مصر)

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تم جمع عينات شهرية من *S. maderensis* من يناير إلى ديسمبر 2021 في ساحل البحر الأبيض المتوسط في سيناء لتحديد النمو والوفيات. تراوحت الأطوال من 8.5 - 26.3 سم وتراوحت الأوزان من 5 جرام إلى 171 جرام، وبلغت القيمة b للعلاقة بين الطول والوزن 3.0524 وبالتالي فإن نمو *S. maderensis* يصنف على أنه يظهر نمو متساوي القياس. (VBGP) من $L\infty$ و(k) و(t_0) كانت 30.39 سم و0.2937 و-0.6049/سنة على التوالي. بلغ مؤشر أداء النمو 2.334 (Ø'). تراوحت GSI من 0.11 إلى 2.6 للذكور وتراوحت بين 0.19 و3.4 للإناث، كما كانت فترات ذروة التبويض في*S. maderensis* من أبريل إلى سبتمبر. كانت الأطوال عند بداية النضج الجنسى 15.5 سم (ذكور)، 16.7سم (إناث) و16.0 سم للجنس المختلط. تم تقدير قيم الوفيات (Z) و(M) (F) ومعدل الاستغلال (E) للجنسين معا لاسماك السردين المفطر (*S. maderensis*) كانت 0.7124 و0.3229 و0.3895 لكل سنه و0.547 على التوالي. كان الطول عند بداية الصيد 13.5 سم. يجب عدم زيادة جهد الصيد ولكن يجب زيادة حجم الشباك بحيث يزيد الطول عند بداية الصيد من 13.0 سم إلى 16.0 سم لكي يتساوى مع الطول عند بداية النضج للحفاظ على مخزون هذه الأسماك.

الكلمات الاسترشادية: السردين المفطر، دليل المناسل، معايير النمو، النفوق.

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