Age and growth patterns of the lizard fish, *Saurida undosquamis* (Richardson, 1848), from the Gulf of Suez, Red Sea, Egypt

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ABSTRACT:

The lizardfish, *Saurida undosquamis*, is a species of significant economic importance in the Suez Gulf. This study examined its growth and reproductive characteristics, with age estimation conducted through otolith readings from specimens collected at Attaka Harbor over a one-year period from January to December 2023. A total of 3,183 fish were analyzed to establish the weight- length relationships, yielding the parameters. For males, a = 0.0143, b = 3.0784, while for females, they were a = 0.0077, b = 3.0225. Growth patterns were modeled using the function of growth by Von-Bertalanffy, with parameters, for males as L_∞ = 44.9 cm, K = 0.558 year^{-1} and t_o = - 0.61, and for females as L_∞ = 49.23 cm, K = 0.571 year^{-1}, and t_o = -0.82. These growth parameters facilitated the estimation of total mortality rates through length-transformed catch data, revealing rates of 3.77 per year for male 2.22 per year for female.

Keywords: Saurida undosquamis; Growth patterns; Mortality rate; Otolith readings; Weight-length relationship.

INTRODUCTION

Lizardfish is a demersal species which belongs to the family Synodontidae. Such family include 4 genera and approximately global 57 species (Choi *et al.,* 2024). For instance, it was observed in many in Asian regions such as Pakistan, India, Sri Lanka, Thailand, Philippines, Korea, Japan, and China (Fischer & Bianchi, 1984). Within Pakistani waters, two notable species, *S. tumbil* and *S. undosquamis*, are frequently encountered. *S. undosquamis* predominantly inhabits demersal zones, typically at depths of around 100 metersin While in Africa, it was observed in the eastern African coast, Madagascar, and the Red Sea (Golani *et al.,* 2002). The dietary habit is primarily carnivorous, feeding on fish, shrimp, and mollusks (such as squid and cuttlefish) (Eu *et al.,* 2022; Hinde *et al.,* 2023).

The reproductive activity of *S. undosquamis* in Indian waters spans at final quarter of the year, with a top spawning occurring in month 11th (Hinde *et al.,* 2023). Similarly, studies in Bengal Bay indicated a top-spawning activity during the last two months of the year (Rao, 1943). Three primary fishing zones have been identified, along the Egyptian Red Sea coastline (which extends approximately 1,080 km, stretching from the northern region of *Suez* to the southernmost point near *Mersa-Halayeb*). These zones include Foul Bay, Suez Gulf, and Aqaba Gulf. Historically, amongst previous grounds, from the Egyptian Red Sea, the Suez Gulf has been the most spawning, yielding approximately 64% of all harvest. This is a step by Foul Bay ground, accounting for nearly 33%. While, the last ground (Aqaba Gulf) is mainly underutilized for fishing activities (Khalfallah *et al.,* 2023). The primary fishing methods employed in these areas include trawling, purse-seining, and artisanal techniques like longlines and hand lines (GAFRD, 2021).

Three main fishing methods are operated in the Gulf including trawl, purse-seine, and artisanal fisheries especially long and hand lines (Mehanna, 2021). The family Synodontidae contains 4 genera (Harpadon, Saurida, Trachinocephalus, and Synodus) that contains 77 species (FishBase, 2022). Members of this family are highly prevalent in trawl fisheries and commonly known as lizardfishes. They account for approximately 30% of the total trawl fishery landings in the northern Red Sea, specifically in the Gulf of Suez, and about 26.9% in the southern Red Sea, particularly in Foul Bay (General Authority for Fish Resources Development). Among these species, the brush-tooth lizardfish (*Saurida undosquamis*) stands out as the most abundant and economically significant species in the Egyptian Red Sea.

Population parameters for *S. undosquamis* have been studied extensively, particularly in the Gulf of Suez (Shenouda, 1976; El-Ganainy, 1992, 1997, 2002, 2004; Sanders *et al.,* 1984) and Foul Bay in the southern Red Sea (Mehanna and El-Gammal, 2007). Nowadays, with depleting the aquatic resources in Egypt, the significance of lizardfish species (particularly *S. undosquamis*) has grown. Recently, limited novel biological information is available about this species which could help in managing the fisheries by effective and sustainable aspect.

This study aims to perform novel assessment for the age and growth rates of *S. undosquamis* in the Suez Gulf and to evaluate the recent population parameters that can effectively and sustainably assist in managing such species along Egypt's southern Red Sea coast.

MATERIAL AND METHODS

Study Area

The Gulf of Suez extends approximately 250 kilometers, beginning at its northern boundary near the city of Suez (latitude 29°56' N) and reaching Shadwan Island at its southernmost point (latitude 27°36' N). The gulf varies in width, measuring between 20 and 40 km, while its depth ranges from 5 m in shallower areas to a maximum of 200 m, with an overall average depth of 45 m.

Data collection

Data concerning the monthly and annual catch of *Saurida undosquamis* were based on GAFRD statistics. A total of 3,183 fish were randomly sampled from Attaka Harbor throughout the year 2023. This sample included 1,648 males, with total lengths ranging from 11 to 35.8 cm and weights ranging from 14 to 302 g, and 1,535 females, with lengths between 11.15 and 37.5 cm and weights from 15 to 325 g. For each specimen, the total length was measured to the nearest millimeter, and the total weight was recorded to the nearest 0.1 g. Length frequency distributions were calculated using 1.0 cm intervals. The data were compiled from the annual statistical reports of the General Authority for Fish Resources Development (GAFRD, 2021).

Length-weight relationship (LWR)

The length-weight relationship (LWR) of *Saurida undosquamis* was determined for females and males accordance to Ricker (1975) using the following equation:

$$W = aL^b$$

Where W is the weight, L is the total length, and a and b are constants. If *b* is equal to 3, >3, or <3, this shows isometric, positive allometry, and negative allometry growth type, respectively.

The monthly length frequencies of each sample were grouped into classes of 1 interval and were laid out sequentially over one year to estimate the growth (Froese, 2006).

Growth parameters

Growth curves for all individuals were fitted using the least-squares approach, according to the growth model of Von-Bertalanffy (1938):

$$L_t = L_\infty \times (1 - e^{-K(t-t_0)})$$

L_t represents the whole length at age t, L_∞ refers to the asymptotic length, k denotes the growth coefficient, and t_0 indicates the age at which the length is zero theoretically (Beverton and Holt, 1959).

The solver functions of Microsoft Office Excel 2016 were used to elucidate growth curves.

The growth performance index (Phi Prime, φ) was established using the given equation:

$$\varphi_L = \log(K) + 2 \times \log(L_\infty)$$ (Pauly & Munro, 1984)

Where: K and L_∞ are Von Bertalanffy's growth model parameters.

Mortality parameters

The natural mortality (M) rate (year^{-1}) in Suez was determined using the following equation:

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L_\infty + 0.6543 \log_{10} K + 0.4634 \log_{10} T$$ (Pauly, 1980).

Fishing mortality (F) was determined by subtracting natural mortality (M) from total mortality (Z). The long-term temperature average (T) reported by the Environmental Affairs Agency was used as the water temperature parameter in this context. The exploitation rate was determined using the accompanying formula:

$$E = \frac{F}{Z} \times 100$$

In all statistical analyses, a 95% confidence limit was assigned. We used FiSAT II (v8, 2005) for the statistical methods for analyzing fisheries data, supporting stock assessment, and informing sustainable management strategies.

RESULTS

Age and growth

Upon examination of the mounted otolith, the focus appears as a distinct dark point located on the posterior portion. This focus is followed by alternating hyaline (transparent) and opaque (dense) zones. These zones are recognizable on the anterior section and on both lateral sides of the otolith. Each pair of hyaline and opaque zones constitutes an annual ring, which is used to estimate age. Otoliths from larger fish tend to be proportionally larger than those from smaller individuals. The longevity of *Saurida undosquamis* was determined by counting these annual growth rings, with females estimated to reach a maximum age of seven years, while males reach six years (Fig. 2).

Body length- Otolith radius relationship

The body length- Otolith radius relationship of the lizardfish (*Saurida undosquamis*) is graphically represented in Figure (3). The length of samples varied from 11.0 cm to 35.8 cm in total length for male and from 11 cm to 37.5 cm for female. The relationship between the body length – Otolith radius relationships are liner and not pass through the origin. This relationship can be represented by the following equations:

$L = 7.1952 + 6.3614S$ $R^2 = 0.8846$ (male)

$L = 6.4365 + 6.7515S$ $R^2 = 0.8939$ (female)

Length frequency distribution (LFD)

In Fig. (4), LFD of the 3183 sampled individuals results revealed that the largest Length group was 25-25.9 cm for both male and female and smallest length group is 11-11.9 cm but the length group 27-27.9 cm the Second highest group four male.

Age and growth patterns

The age of 625 specimens of lizardfish was estimated, mined through otolith readings. Six and seven age groups were determined for males and females, respectively. The average lengths for the male age groups ranged from 12.6 cm in age group one to 32.2 cm in age group six. For females, the mean lengths ranged from 13.4 cm in age group one to 34.6 cm in age group seven (Fig. 5).

Length-Weight relationship (LWR)

The LWR serves as a crucial tool for assessing various physiological processes, including gonadal development, metamorphosis, and feeding behavior in fish (Le Cren, 1951). In the present study, length and weight data obtained from 390 specimens endemic in the Gulf of Suez were analyzed to characterize the LWR of *S. undosquamis*, as illustrated in Fig. 6. The male specimens exhibited total lengths ranging from 11.0 cm to 35.8 cm, while females varied in length from 11.0 cm to 37.5 cm.

The resulting equation was as follows:

$W = 0.0143\ L^{3.0784}$ $r^2 = 0.9748$ (male)

$W = 0.0077\ L^{3.0225}$ $r^2 = 0.9815$ (female)

Growth Parameters

The von Bertalanffy growth parameters (L_∞ - K and t) were calculated, and the resulting formulas were as follows:

(Male)

Growth in length: $L(t) = 44.9\ [1 - e^{-0.558(t+0.61)}]$

Growth in weight: $W(t) = 493.75\ [1 - e^{-0.559(t+0.61)}]^{3.0784}$

(Female)

Growth in length: $L(t) = 49.23\ [1- e^{-0.571(t+0.82)}]$

Growth in weight: $W(t) = 718.58\ [1 - e^{-0.571(t+0.82)}]^{3.0225}$

Growth Performance Index (φ)

The growth performance index (φ) of *Saurida imdosquamis* males was computed as 3.051 for male and 3.067 for female.

Mortality Rates

As illustrated in Figure 7, the total, natural, and fishing mortality coefficients (Z, M, and F) for males were determined to be 3.77, 1.35, and 2.42 $year^{-1}$, respectively. In contrast, for females, the mortality coefficients Z, M, and F were found to be 2.22, 0.80, and 1.42 $year^{-1}$, respectively. These values resulted in an exploitation rate (E) of 0.64 for both males and females.

DISCUSSION

Lizardfish constitute a vital component of the economically valuable fishery resources in the Gulf of Suez. A comprehensive assessment of trawl landings and the overall annual *S. undosquamis* catch at the Attaka port over the past 10 years showed that, on average, lizardfish catches made up 25.3% of the total trawl catch.

To analyze the length-weight relationships (LWRs) of *S. undosquamis*, the study employed the log-transformation formula developed by

Le-Cren (1951). This formula models the relationship between fish weight (W, in grams) and total length (L, in centimeters) as: $W = aL^b$. To estimate the parameters a (intercept) and b (slope), the equation was log-transformed to: log(W) = log(a) + b * log(L). To account for potential seasonal variations in the slope parameter b (as suggested by Zargar *et al*. (2012)), the data were categorized into two seasons: warm (spring/summer) and cold (fall/winter). If no significant seasonal differences were detected, the analysis was further refined to investigate finer-scale seasonal variability.

The slope b may differ from the theoretical value of 3, which represents isometric growth, because of environmental influences or variations in fish health (Ricker and Carter, 1958). A slope value of $b < 3$ indicates negative allometric growth, signifying slimmer fish, while $b > 3$ reflects positive allometric growth, characteristic of heavier fish thriving under optimal conditions.

In the present study, the regression coefficient b for the length-weight relationship of *Saurida undosquamis* indicated near-positive allometric growth, with $b = 3.0784$ for males and $b = 3.0225$ for females. These findings align with previous research, as summarized in Table 1, except for the study by Çiçek, and Avşar who reported a negative allometric coefficient for b.

The parameters of the Bertalanffy growth model, alongside growth performance indices, mortality rates, and exploitation rates for *S. undosquamis* in the Gulf of Suez, were calculated, with the detailed findings provided in Table 1. The asymptotic length ($L\infty$) obtained in the present study corresponds closely with values reported in earlier research. Specifically, previous studies documented $L\infty$ values of 40 cm (Aksiray, 1987), 42.11 cm (Bingel, 1987), 50 cm (Bauchot, 1987), 42 cm (Gokce et al., 2007), and 40 cm (CIESM, 2008). In Turkish waters, male *S. undosquamis* reached a $L\infty$ of 41.44 cm, while females exhibited a length of 43.55 cm, resulting in an average $L\infty$ of 41.57 cm (Manaşırl et al., 2011). On a global scale, reported asymptotic lengths for this species range from a minimum of 22.43 cm, as estimated using the otolith method in Turkish waters (Tureli and Erdem, 1997), to a maximum of 51.8 cm in Vietnamese waters (Thuoc et al., 2000).

The growth coefficient (K) demonstrated an inverse relationship with the asymptotic length ($L\infty$), where higher K values were associated with lower $L\infty$ estimates. The exploitation rate (E) serves as a crucial indicator of fishing pressure, with $E < 0.5$ signifying underexploitation and $E > 0.5$ suggesting overexploitation. This framework is grounded in the assumption that optimal exploitation is achieved when $F = 0$ or $E = 0.5$ (Gulland, 1971). The results of this study indicated that both exploitation rates and sex ratios exceeded established biological reference thresholds, providing clear evidence that S. undosquamis stocks in the Suez Gulf are currently experiencing overfishing.

CONCLUSION

The research provides novel insights into the biology and population dynamics of Saurida undosquamis, emphasizing the urgent need for sustainable management strategies to preserve this valuable fishery resource in the Gulf of Suez. Overfishing is currently threatening their populations. With lizardfish constituting an average of 26.9% of the total trawl catch in the Gulf, their economic importance is undeniable. The findings call for immediate action to prevent further depletion and ensure the long-term sustainability of lizardfish stocks.

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Table 1. Growth parameters and Length weight constants for *Saurid undosquamis* collected from different regions compared with the present study.

Region	sex	Growth parameters			Length Weight constant		Method of ageing	Authoress
		L∞	K	to	a	b		
Malaysia	M+F	51.25	0.13	-1.45	0.004	3.107	Otolith	Ambak et al. 1986
Red Sea	M	37.32	0.17	- 2.09	0.0027	3.27	Otolith	El-Ganainy, 1992
	F	55.56	0.11	- 2.13	0.0033	3.196		
Gulf of Suez	M	31.63	0.26	- 1.38	0.0017	3.319	Otolith	El-Ganainy, 2004
	F	41.72	0.17	- 1.53	0.0044	3.109		
Gulf of Suez	M	31.03	0.44	- 1.06	0.0042	3.131	L.F.	Amin et al., 2007
Turkey	M+F	38	0.12	- 1.68	0.0083	2.879	Otolith	Cicek and Avsar (2011)
China	M+F	34	0.52	- 0.3	0.0956	3.043	L.F	Xuphui et al., 2012
Gulf of Suez	M+F	51.25	0.13	- 1.45	0.004	3.107	Otolith	El-Etreby et al., 2013
Gulf of Suez	M+F	49.25	0.25		0.0054	3.2421	L.F.	El-Etreby et al., 2014
Red Sea Foul Bay	M	35.26	0.71	- 0.13	0.006	3.0656	Otolith	Mehanna, 2021
	F	48.81	0.33	- 0.61				
Gulf of Suez	M	44.9	0.55	-0.61	0.0143	3.0484	Otolith	Present study
	F	49.23	0.57	-0.82	0.0077	3.0225		

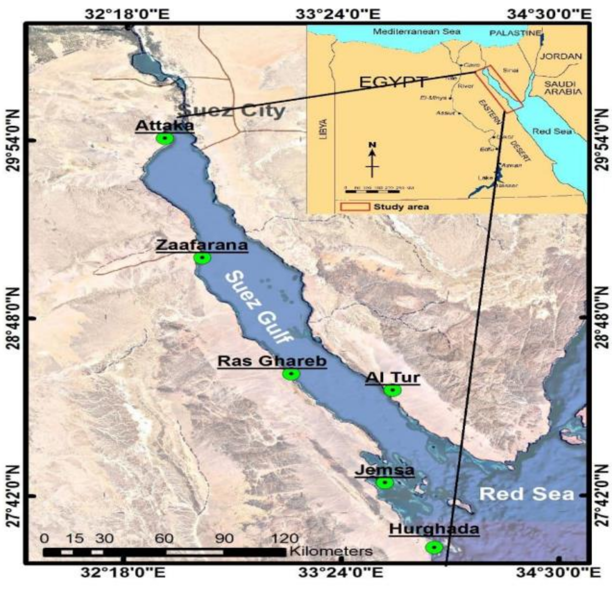


Figure 1. A map of the Gulf of Suez, Red Sea, Egypt.

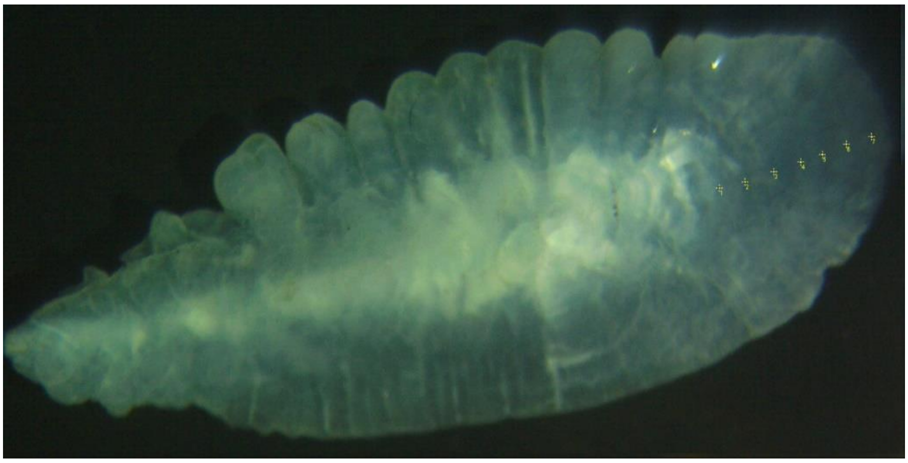
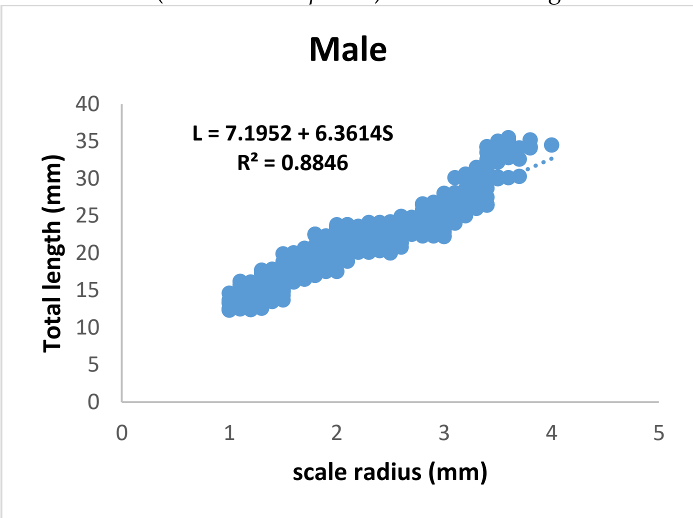


Figure 2. Otolith of the lizardfish (*Saurida undosquamis*) Otolith showing the annual rings on the Otolith.



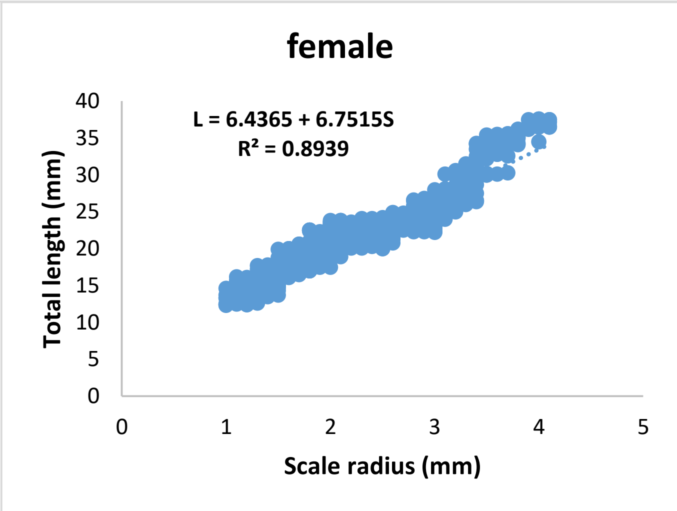
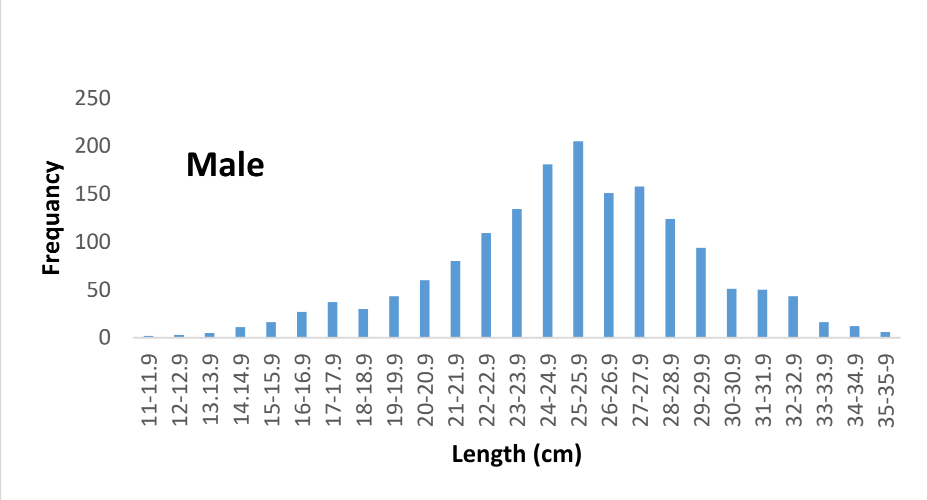


Figure 3. Body length- Otolith radius relationship of the lizardfish (*Saurida undosquamis*) for male and female, collected from the Suez Gulf, Egypt during the fishing seasons, 2023.



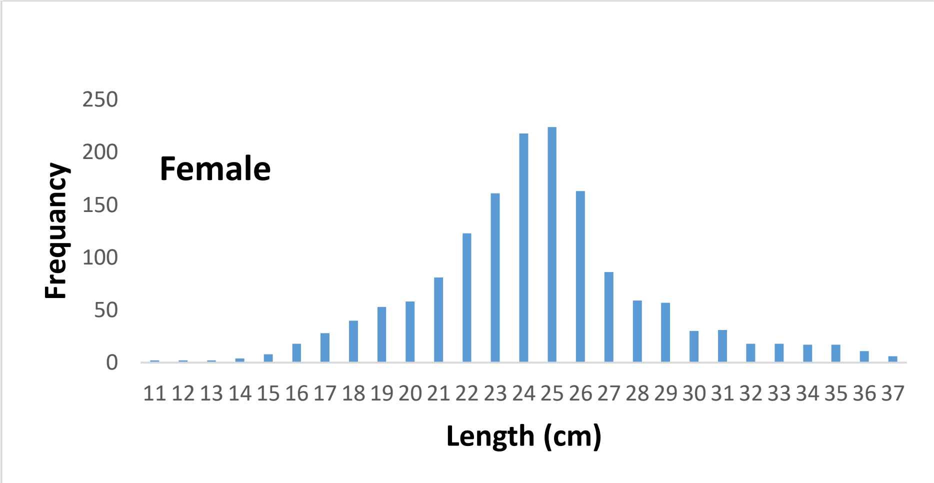


Figure 4. Length frequency distributions of lizardfish (*Saurida undosquamis*) for male and female, collected from the Suez Gulf, Egypt during the fishing seasons, 2023.

أنماط العمر والنمو لسمكة السحلية، Saurida undosquamis (ريتشاردسون، 1848)، من خليج السويس، البحر الأحمر، مصر

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الملخص العربي:

تُعد سمكة السحلية (*Saurida undosquamis*) من أهم الأنواع السمكية التجارية في خليج السويس. هدفت هذه الدراسة إلى تحليل الخصائص البيولوجية للنمو والتكاثر لهذا النوع. تم تحديد أعمار الأسماك من خلال قراءة عظام الأذن الداخلية (الأوتوليث) لعيّنات تم جمعها من ميناء الأتكة خلال الفترة من يناير 2023 إلى ديسمبر 2023. اشتملت البيانات على 3183 زوجًا من قياسات الطول والوزن. تم تحليل العلاقة بين الطول والوزن، حيث أظهرت النتائج معلمات للذكور بقيم a = 0.0143 و b = 3.0784، وللإناث بقيم a = 0.0077 و b = 3.0225. تم حساب معلمات معادلة فون بيرتالانفي للنمو كالتالي: الطول النهائي L∞ = 44.9 سم، ومعامل النمو K = 0.558 سنة$^{-1}$، والعمر عند الطول الصفري t_0 = -0.61 للذكور، بينما كانت القيم للإناث L∞ = 49.23 سم، و K = 0.571 سنة$^{-1}$، و t_0 = -0.82. بالاعتماد على هذه المعطيات، تم تقدير معدل الوفيات الإجمالي باستخدام تحليل منحنى الصيد المحوّل بالطول، حيث بلغ 3.77 سنة-1 للذكور و 2.22 سنة-1 للإناث. تؤكد هذه النتائج أهمية تطبيق إدارة مستدامة للمصايد في خليج السويس لضمان استدامة هذا المورد السمكي الاقتصادي المهم.

الكلمات الاسترشادية: *Saurida undosquamis*، معلمات النمو، معدل الوفيات، قراءات عظام الأذن الداخلية، العلاقة بين الوزن و الطول.