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Growth, Feed, and Food Habits of *Saurida tumbil* (Bloch, 1795) in Jizan Fisheries, Saudi Arabia

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Abstract. The current study provides the latest scientific evaluation on growth and food habits of *Saurida tumbil* in Jizan fisheries. Monthly samples were collected from September 2021 to April 2022, with a total of 343 individuals. Fish scales were used for age determination and back-calculation of fish lengths at different ages to estimate growth rates and von Bertalanffy growth parameters. Several food analyses were carried out to describe the food habits of this species. Results showed that *Saurida tumbil* is categorized as carnivorous fish. Terapon (*Terapon* sp.) and anchovy (*Encrasicholina* sp.) were observed mostly in the stomach followed by sardinella (*Sardinella* sp.), squid (Loliginidae), and berber ponyfish (*Leiognathus berbis*). Vacuity index (VI) analysis showed that *Saurida tumbil* is categorised as middle alimentative regularly regarding the food habits and stomach fullness. The value of GaSI was 3.08 in average. The total Length – gutted weight relationship showed that *Saurida tumbil* is isometric in dimensional growth and can be described based on the power function. $W_{gutted} = 0.0067\ TL^{3.014}$ The average back-calculated lengths at different ages were 18.5, 27.0, 32.4 and 37.4 cm, respectively. The von Bertalanffy growth parameters were found to be: the asymptotic length L_∞ = 50.38 cm, growth constant K= 0.30 per year. The hypothetical age at zero length t_0 = -0.48 year. The growth in length performance index (Φ') was 2.88

Keywords: Asymptotic length; greater lizardfish; red sea; food preferences; compound index.

1. Introduction

In Saudi Arabia, the Red Sea coast of Jizan is an ideal fishing ground for trawling (Fig. 1). It has broad continental shelves with muddy and sandy bottom which is convenient for bottom trawlers. It exists along the eastern Red Sea coastal area with water depths ranging from 20-60 m. Most of catches consist of demersal fishes and penaeid shrimps (Bogorodsky *et al*., 2014).

The greater lizardfish *Saurida tumbil* (Bloch, 1795) is one of the demersal fishes which are commonly utilised there. It is widely distributed in the Indo-West Pacific region from Red Sea to Southeast Asia and Australia (Fischer & Bianchi, 1984; Jaiswar *et al*., 2003). Unfortunately, the exploitation of greater lizardfish may affect its biological activities, such as food habits and fish growth, due to the disturbance on natural condition, such as food availability and population size (Hart & Reynolds, 2002).

The assessment of threat level status on *S. tumbil* has attracted little concern by International Union for Conservation of Nature (IUCN, 2016). It has been categorised as not being a focus of species conservation. It means that the exploitation can be further performed in the future. However, Morgan (2006) and Ye (2011) stated that the fisheries resources in Jizan waters have been fully or already over-exploited. Scientific and continuous evaluation must be conducted to deliver the updated information.

Fisheries biology aspects of *S. tumbil* have been studied by many authors at different localities (Bakhsh, 1996; Jaiswar *et al*., 2003; Fofandi, 2011; Kalhoro *et al*., 2015; Najmudeen *et al*., 2015; Gabr & Mal, 2017). Nevertheless, there are only two studies on greater lizardfish in the Red Sea. The first one followed the reproductive biology of this species in the Jizan Region (Bakhsh, 1996), while the second one investigated the growth and stock assessment of this in Jizan fisheries (Gabr & Mal, 2017). The aim of the current study was to re-evaluate the growth and food habits of *S. tumbil* in Jizan fisheries.

2. Materials and Methods

Samples of *S. tumbil* were collected monthly from September 2021 to April 2022 from Jeddah central fish market where most of the caught fish from Jizan fisheries (Fig. 1) is being sold. The samples were transported in ice boxes directly to the laboratory for subsequent analysis. Fish samples were measured: total length TL (cm) and weight TW (g) by using measuring board to the nearest 0.1 cm and digital balance to nearest 0.1 g. Fish scales were collected and stored in Eppendorf tubes containing water (Gabr, 2015; Mostarda *et al*., 2016). Sea surface temperature data was collected from Aqua-MODIS satellite and extracted on SeaDAS software to describe general waters conditions. There are several methods and data analyses were used to achieve study objectives as follows:

2.1 Fish Growth

A total number of 343 fish specimens of *S. tumbil* (217 females and 126 males) were collected. The length-weight relationship of this species was calculated according to Le Cren (1951) with the following equation:

$$TW = aTL^b$$

Further t-test was performed to find the significant difference between value of b and 3 as described by Pauly (1984).

For age determination in fishes, scales were removed and cleaned in water, dried, and mounted between two microscope glass slides. Zoom Stereomicroscope fitted with digital video camera was used. AmScope software was used to capture and save pictures for further scale measurements, following Gabr & Mal (2017).

The relationship between the body length (TL) and scale radius (S) was calculated using the linear regression form:

$$L = c + dS$$

where c is the intercept and d is the slope. Both of values were used to calculate lengths at ages (back-calculated), based on the Body Proportional Hypothesis (BPH) method (Francis, 1990) as follows:

$$L_i = [(c + dS_i) / (c + dS)]\, TL$$

where L_i is the length at age of annulus i formation, S_i is the radius of the annulus i. The annual growth rates in length and in weight were determined from the average calculated lengths at ages. The growth of *S. tumbil* was measured using the following model (von Bertalanffy, 1938):

$$L_t = L_\infty\left[1 - exp^{-K\,(t-t_0)}\right]$$

The von Bertalanffy growth parameters, asymptotic length (L_∞) and the growth coefficient (K) were estimated according to Ford (1933) and (Walford, 1946), by fitting the method to the average back-calculated lengths-at-ages for males, females and sexes combined. The hypothetical age at zero length (t_0) was estimated using the following empirical equation suggested by (Pauly, (1980):

$$log_{10}(-t_0) = -0.3922 - 0.2752 \times log_{10}(L_\infty) - 1.038 \times log_{10}(K)$$

The growth in length performance index (phi-prime, Φ') for the species in Jizan fisheries was estimated by applying the estimated growth parameters (L_∞) and K in the following formula suggested by Pauly & Munro (1984):

$$\Phi' = log_{10}\,(K) + 2 \times log_{10}\,(L_\infty).$$

The life span (t_{max}) of *S. tumbil* in Jizan fisheries was estimated using the formula suggested by Taylor (1958) as follows:

$$t_{max} = t_0 + 3/K$$

2.2 Food Habits

The stomach contents of the fished were examined under a binocular microscope. The food materials were identified and weighted in an electronic balance, and its volume was estimated using displacement method. Vacuity index (VI), compound indices, and gastrosomatic index ($GaSI$) were determined to describe the food habits (Hynes, 1950; Pillay, 1952). Vacuity index (VI) was used to determine feeding intensity of each sample and the fish appetite for food. The degree of stomach fullness was classified as Full (IV), Three quarters full (III), One-half full (II), and A quarter full or empty (I). Full and Three quarters full stomachs indicate that the fish fed actively. VI was calculated using the equation of Euzen (1987).

$$VI = \frac{The\ number\ of\ empty\ stomachs}{total\ number\ of\ the\ stomachs\ examined} \times 100$$

The obtained value of VI indicated that fish is gluttonous when $0 \le VI < 20$, comparatively gluttonous ($20 \le VI < 40$), middle alimentary ($40 \le VI < 60$), comparatively hypo alimentative ($60 \le VI < 80$), and hypo alimentative ($80 \le VI < 100$).

Occurrence index (O_i), number index (N_i), and volume index (V_i) were further estimated for the assessment of compound indices namely index of preponderance (I_i) and index of relative importance (IRI_i) (Natarajan & Jhingran, 1961; Pinkas, 1971; Chrisafi *et al*., 2007). Chipps & Garvey (2007) explained that the combination two or more indices produced one single index which is more reliable to inform the desirable properties of fish diet measures.

Occurrence index was assessed by the comparison between number of fish with food item i and number of fish with non-empty stomach. According to Euzen (1987), the occurrence index percentage of food item i can be divided into three categories. The prey eaten is dominant and the main diet when $O_i > 50$, secondary prey ($50 > O_i > 10$), eaten accidentally ($O_i < 10$).

Number index was estimated by the number of food item i divided by the total number of all food items. Meanwhile, volume index was valued by the volume of food item i divided by the total volume of all food items (Chipps & Garvey, 2007; Kuriakose *et al*., 2017). Index of preponderance was estimated by the following equation.

$$I_i = \frac{O_i V_i}{\sum_{i=1}^{Q} O_i V_i} \times 100$$

Index of relative importance was estimated using the following equation.

$$IRI_i = (\%N_i + \%V_i) \times \%O_i$$

Meanwhile the percentage of IRI was expressed by the following equation.

$$\%IRI_i = \frac{IRI_i}{\sum_{i=1}^{Q} IRI_i}$$

Gastrosomatic index ($GaSI$) is a relationship between weight of alimentary canal and weight of fish, which helps in determining the feeding condition in different months and seasons. Total weight of food of individual was divided by its body weight. GaSI were estimated as described by Biswas (1993).

$$GaSI = \frac{Total\ weight\ of\ stomach}{Bodyweight} \times 100$$

3. Results and Discussion

3.1 Water Temperature

The water temperature in Jizan waters (Fig. 2) was high in mid-September for summer and decreasing gradually to reach the lowest value in mid-March for winter. The water temperature in Jizan seems to be suitable for the growth of *S. tumbil*, as it was similar to those of 25-30°C recorded in other areas. According to Froese and Pauly (2022), the preferred temperature of *S. tumbil* is 18.4 - 29.1°C with mean of 27.9 °C.

3.2 Length-Weight Relationship

The total fish length ranged from 17.6 to 41.5 cm for females and from 18.7 to 38 cm for males. The total body weight ranged from 40 to 590 g and from 49 to 425 g for females and males, respectively. The relationship between the total length and total body weight of *S. tumbil* in Jizan fisheries is represented in Fig. 3 and described by the power equations as follows:

$$TW = 0.0053\,TL^{3.114} \quad (R^2 = 0.965, Total = 343)$$
$$TW = 0.0045\,TL^{3.162} \quad (R^2 = 0.956, Females = 217)$$
$$TW = 0.0054\,TL^{3.111} \quad (R^2 = 0.980, Males = 126)$$

T-test revealed that the b values, for females, and males were higher than 3 indicating a positive allometric growth of *S. tumbil* in Jizan fisheries (Table 6). P-value was 0.00043 for total fish, 0.00064 (females), and 0.00722 (males). The relationship between the total length (TL) and gutted weight (GT) could be described by the following power equations:

$$GW = 0.0067\,TL^{3.0144} \quad (R^2 = 0.977, Total = 343)$$
$$GW = 0.0060\,TL^{3.0470} \quad (R^2 = 0.969, Females = 217)$$
$$GW = 0.0078\,TL^{2.9670} \quad (R^2 = 0.982, Males = 126)$$

The b values obtained for the TL-GW relationship, for females, and males were not significantly different from value 3 confirming an isometric growth of *S. tumbil* in Jizan fisheries (Table 1). P-value was 0.581 for total fish, 0.193 for females, and 0.384 for males.

LWR analyses in the present study were compared to other results obtained by different authors at different localities (Table 3). Our results indicated similar somatic growth of *S. tumbil* to some of those observed in other areas, but they appeared different from other records. In the present study, the effect of stomach fullness and gonad weight (included in the total weight) may cause increasing b value (up to 3.114), indicating positive allometric growth, as reported in the same fishery (Gabr & Mal, 2017). By using the gutted fish weight, the value of b (3.014) indicated isometric growth, similar to the results of Bakhsh (1996) in the same fishery.

Isometric growth means the fish grows in height and width proportionally. Allometric positive means the growth of fish in height and width faster than the growth of fish in length. The fish generally has thick body. Meanwhile, the fish with allometric negative is elongated because the length grow faster than the weight or height (King, 2007; Kuriakose *et al.*, 2017).

The variability in the b values for the *S. tumbil* at different localities (Table 2), might be related to some factors like water temperature, sex, and gonad maturity, available food items and stomach fullness degree, length type, and size range (Pitcher & Hart, 1982; Tesch, 1971).

3.3 Age Determination and Back-Calculations

Most previous studies used length frequency to estimate the age of *S. tumbil* (Jaiswar *et al.*, 2003; Kalhoro *et al.*, 2015; Najmudeen *et al.*, 2015; Rao, 1983). Gabr &

Mal (2017) used the whole otoliths for the first time to determine the age of this species in Jizan fisheries. In the present study, the scales were used to determine the age of *S. tumbil* in Jizan fisheries. The opaque and translucent (hyaline) bands of the scales (Fig. 4) were observed using reflected light on dark background. The opaque zones appeared as light zones and the translucent zones appeared as dark zones. Individual ages were estimated using the count of each pair of opaque and translucent bands (annulus) as annual time scale. Similar to Gabr & Mal (2017), the annual time scale was assigned for each pair of alternative opaque and translucent bands (annulus) on the scales of this species. The number of annuli formed on the scales was counted and the age (in years) could be assigned to each specimen. Four age groups (I^+ - IV^+) were determined for both females and males in the current study.

The opaque bands in the current study were thicker than the translucent bands indicating the history of the fish age over time. Green *et al*. (2009) proposed that the opaque band corresponds to fast somatic growth due to high food availability, intense feeding activity, high water temperature, and favorable environmental conditions in spring and early summer. Meanwhile, Carbonara & Follesa (2019) proposed that the translucent band was coincided with slow somatic growth at low food availability, stressful environmental conditions, and spawning season during autumn and winter. Bakhsh (1994) stated that the spawning of *S. tumbil* in Jizan fisheries occurred in winter season, confirming the conclusion reported by Gabr & Mal (2017) that stated the completion for each pair of alternative opaque and translucent bands occurred in the winter or early spring.

The relationship between total fish length (cm) and scale radius (mm) was fitted in linear regression (Fig. 5). It produced intercept (c) and slope (d) which were applied to back-calculation methods. The following equations represent the relationship between total length and scale radius for combined sexes, females, and males, respectively:

$$TL = 4.524S + 2.138 \quad R^2 = 0.976, n = 329$$
$$TL = 4.463S + 2.300 \quad R^2 = 0.974, n = 203$$
$$TL = 4.502S + 2.038 \quad R^2 = 0.967, n = 126$$

The length at the end of each year of life was back-calculated for each specimen using the body proportional hypothesis (BPH) formula for sexes combined as follows:

$$L_i = [(2.138 + 4.524S_i)/(2.138 + 4.524S)] \times TL$$

3.4 Growth in Length

The average back-calculated lengths at ages and the annual increment are given in Table 3 for combined sexes, females, and males, respectively. During the first year of life, the maximum growth in length and annual increment attained were: 18.6, 18.5, and 18.2 cm for combined sexes, females, and males, respectively. During the second year, the growth rate decreased to 8.5, 8.6, and 8.9 cm for both sexes, females, and males, respectively. The rate of length increase reached its minimum during the 4th year of life; 5.0, 5.0 and 5.3 cm for combined sexes, females, and males, respectively.

However, similar characteristic growth pattern and rates have been recorded for *S. tumbil* in other world regions, such as India and Pakistan waters (Rao, 1984; Najmudeen *et al*., 2015; Kalhoro *et al*., 2015). Gabr & Mal (2017) showed that *S. tumbil* reached 20.6 cm in the first year. The fish gained 7.5 cm of increment in the second year, 6.1 cm in the third year, and 4.3 cm in the fourth year. Hart & Reynolds (2002) asserted that growth in length can usually be modelled using an asymptotic curve. The increment of fish length is decreasing with increasing age which is similar to the results of the current study.

3.5 Growth Parameters

The von bertalanffy growth parameters for *S. tumbil* in Jizan fisheries were estimated based on the estimated growth rates, and the following von Bertalanffy Growth Functions (VBGF) were used to estimate the growth curves represented in Fig. 6.

For sexes combined,	$L_t = 50.38\left[1 - e^{-0.30\,(t\,+\,0.48)}\right]$
For females,	$L_t = 51.00\left[1 - e^{-0.30\,(t\,+\,0.48)}\right]$
For males,	$L_t = 49.59\left[1 - e^{-0.31\,(t\,+\,0.46)}\right]$

Table 4 also shows the growth parameters and performance index obtained in the present study compared to the results estimated for the same species by different authors at different localities.

The model illustrated the fish growth in length in accordance with fish ages (Fig. 6). It described the life history of *S. tumbil* in Jizan waters in specific period. However, the growth analysis results were different compared to the previous study by Gabr & Mal (2017). The asymptotic length (L_∞), 50.38 cm, in the present study was lower compared to the previous study with 52.98 cm. Kalhoro, *et al*. (2015) reported the lowest value (48.30 cm) from *S. tumbil* in Pakistan waters. Meanwhile, Najmudeen *et al*. (2015) discovered that the asymptotic length reached 51.70 cm in India waters. The value is the closest one to the current study results. However, the highest value was a long time ago recorded by Rao (1984) with the value of 63.70 cm with samples collected from India waters.

Growth constant (K) with the value of 0.30 per year was higher than the previous value of growth constant with 0.27 per year according to Gabr & Mal (2017). It indicated the rate of growing against time was faster than before. The parameter can also describe the vulnerability of the exploited fish. Musick (1999) and Cochrane & Garcia (2009) stated that the vulnerability is low when growth constant (K) is bigger than 0.3 in value. The results from Pakistan and India waters by Kalhoro, *et al*. (2015) and Najmudeen *et al*. (2015) respectively discovered the constants were also higher than 0.3, namely 0.32 and 0.40. Meanwhile, the lowest one was from study by Rao (1984) with 0.249 in India waters.

The other parameter of growth is t_{zero} (t_0). The estimated value (-0.48 year) in the present study was different compared to the result of the previous study by Gabr & Mal (2017) with the value of -0.84 year. The difference in fish growth study can occur due to many uncertain factors either biologically or ecologically. It is not the major issue since growth performance index for length (Φ') from current study (2.88) produced similar results with that (2.88) obtained by Gabr & Mal (2017). Pauly and Munro (1984) stated that growth performance index is the value to compare several fish growth performance from any locations in terms of fish length.

Life span estimation determined the longevity of *S. tumbil* in Jizan fisheries. It was estimated to be 9.5 years. According to the VBGF curve, the fish at this age had approximately total length of 47.86 cm which is 95% of the estimated L_∞ for this species. According to Taylor (1958), the fish is affected by temperature changes which determine the life span of the fish. However, fishing activities, waters properties, and food availability may also affect the life span of the fish. Thus, further evaluations regarding these parameters are encouraged to get more comprehensive estimation of fish maximum age and length.

3.6 Food Habits

Fourteen food items were observed in the fish stomach (Fig. 7), namely: (1) anchovy (*Encrasicholina* sp.), (2) herring (*Thryssa* sp.), (3) sardinella (*Sardinella* sp.), (4) terapon

(*Terapon* sp.), (5) Fourlined terapon (*Pelates quadrilineatus*), (6) berber ponyfish (*Leiognathus berbis*), (7) Klunzinger ponyfish (*Equulites klunzingeri*), (8) threadfin bream (*Nemipterus japonicus*), (9) goatfish (*Upeneus* sp.), (10) tounge sole (*Cynoglossus* sp.), (11) cardinalfish (Apogonidae), (12) shrimp (*Penaeus* sp.), (13) squid (Loliginidae), and (14) digested foods.

The frequency of each food item is illustrated in Table 6. The anchovy (*Encrasicholina* sp.) and terapon (*Terapon* sp.) displayed the highest frequency during the whole period of study (34 times each), with a maximum of 9 times for *Encrasicholina* sp. in October and 12 times for *Terapon* sp. in February. In addition, the squid (Loliginidae) was observed with 11 specimens during December. Digested food was observed 98 times.

According to the food items in the stomach of *S. tumbil*, it could be categorized as carnivorous fish. However, it may be also classified as piscivorous due to the dominance of fish items. Although Soofiani *et al*. (2006) reported similar observations, *S. tumbil* was suggested as a cannibal fish in Jizan (Bakhsh, 1996) and in India (Manojkumar & Pavithran, 2016).

The types of food that was found by Bakhsh (1996) be not found in the present study namely *Rastrelliger kanagurta*, *S. tumbil*, *S. undosquamis*, Carangidae, and Gobidae. The similar findings of foods from both studies were sardinella (*Sardinella* sp.), terapon (*Terapon* sp.), threadfin bream (*N. japonicus*), shrimp (*Penaeus* sp.), and squid (Loliginidae).

The possibility of encounter between *S. tumbil* and anchovy is high since the lizardfishes are categorised as demersal fish (Carpenter & Niem, 1999a) and anchovy (*Encrasicholina* sp.) is also found near to reef habitat. Meanwhile, terapon was consumed possibly because both of fishes shared same habitat in the ecosystem. Terapon is marine fish, but it also can reach reef and freshwater area. Meanwhile, *S. tumbil* is also stated as amphidromous fish that can reach freshwater area (Raza *et al*., 2022).

Squid (Loliginidae), berber ponyfish (*L. berbis*), and sardinella (*Sardinella* sp.) were found with moderate frequency. Squid and berber ponyfish are reasonable consumed by *S. tumbil* because both of organisms live in the same water depth range as the lizardfishes (20-60 m) (Froese and Pauly, 2022; Sommer *et al*., 1996). Sardinella as pelagic fish was preyed by *S. tumbil* because they are distributed in the same water characteristic, which is in neritic area where the waters are 10-70 m in depth (Carpenter & Niem, 1999a; Gell & Whittington, 2002). Furthermore, there were several organisms which was preyed by *S. tumbil* in small number. All of organisms live alongside *S. tumbil* in the environment with similar characteristic, such as depth range and ecosystem. However, the high abundance and availability of another type of foods made the probability of these organisms were consumed in small number by *S. tumbil* (Carpenter & Niem, 1998, 1999b, 2001; Kuriakose *et al*., 2017). Another possible reason might be related to the over-exploitation status of Jizan waters as stated by Morgan (2006) and Ye (2011). The low abundance of these organisms decreases the food availability for *S. tumbil*. In addition, the digested food in stomach of *S. tumbil* samples consisted of fish meats, fish bones, and fisheyes which emphasise *S. tumbil* as carnivorous fish.

Vacuity analysis showed the fullness condition of fish stomach. It is observed that there were 188 stomachs filled with foods and the rest (155 stomachs) were empty. Mean of vacuity indexes (VI) was 45.18 which meant the fish was middle alimentative averagely. The fully results are presented in Fig. 8.

Almost half of the total fish samples were observed to have empty stomach. However, the vacuity index fluctuated between comparatively gluttonous during late summer to early autumn and winter, middle alimentative during late autumn to early winter, comparatively hypo alimentative in early spring, and middle alimentative in late spring (Table 7). The relationship between stomach fullness and seasons for *S. tumbil* cannot be fully observed due to the fluctuation and diversity of result in food analysis (Mali *et al*., 2017; Manojkumar & Pavithran, 2016; Soofiani *et al*., 2006). Ecosystem capacity, interspecific interactions between organisms, and human activities impacts toward *S. tumbil* fisheries have crucial role in providing the relative and absolute foods to the species (Cochrane & Garcia, 2009; Kuriakose *et al*., 2017).

The percentage of occurrence index is given in Table 8. Anchovy (*Encrasicholina* sp.), terapon (*Terapon* sp.), squid (Loliginidae), and berber ponyfish (*L. berbis*) were categorised as secondary prey. Nevertheless, anchovy (*Encrasicholina* sp.) and terapon (*Terapon* sp.) might be the main diet as both of fishes produced the highest rank. Squid (Loliginidae) and berber ponyfish (*L. berbis*) furthermore were still considered as secondary prey. Meanwhile, the rest of foods were categorised as eaten accidentally with less than 10 of index value or significantly consumed in small numbers. For more explanation of *S. tumbil* food preference, the results of compound indices methods were shown in Table 9.

Index of preponderance and index of relative importance discovered terapon (*Terapon* sp.) as the most considered and important food consumed by *S. tumbil*. It was followed by anchovy (*Encrasicholina* sp.) and squid (Loliginidae). *Sardinella* sp. and berber ponyfish (*L. berbis*) were ranked in fourth and fifth places respectively. The rest of type food was accounted for less than 2.5% and together they only composed 4.44% for index of preponderance and 3.30% (IRI). The results were different according to Bakhsh (1996) which revealed the most abundant foods found in *S. tumbil* were lizard fish and sardines with 70% and 22% correspondingly. The current study showed that there were significant changes in the diet and prey availability of *S. tumbil* over time.

The means of GaSI was 3.08. The details of GaSI per month of sampling were presented in Fig. 9. Female and male fish tended to have average GaSI in September-October 2021 with 3.07-4.51 in value. GaSI of female fish increased in November 2021 (5.91) until reached the peak in December 2021 (6.24). Meanwhile, male fish was steady in average value in November 2021, but rose in December 2021 (6.92). GaSI of Both sexes were dropped in January 2022 (2.68-4.45) but rose back in February 2022 (6.20-6.81). GaSI of female fish kept rising until reached the second peak in March 2022 (9.38), while male fish was dropped to the average value (4.05). In April 2022, GaSI of both sexes had slightly similar value which was 6.06-6.10.

Female and male fish of *S. tumbil* tended to have high value in GaSI in period of spawning season. Female fish had high value in period of November-December and February-March. Meanwhile, male fish only reached the high value in December and February. Feeding intensity of *S. tumbil* tended to have relationship with the spawning season, but some studies (Metar *et al*., 2005; Norouzi *et al*., 2012) showed no correlations between spawning seasons and feeding intensity.

The present study suggested that *S. tumbil* in Jizan waters still had capability to fulfil its nutrition demands by predation. The vacuity index was high but tolerable. Meanwhile, the decent trend of GaSI value also has a chance to be increased by protecting the ecosystem to support the species and its prey ecologically and biologically to create the sustainability of food webs and food chains (Garcia, 2003; Kuriakose *et al.*, 2017).

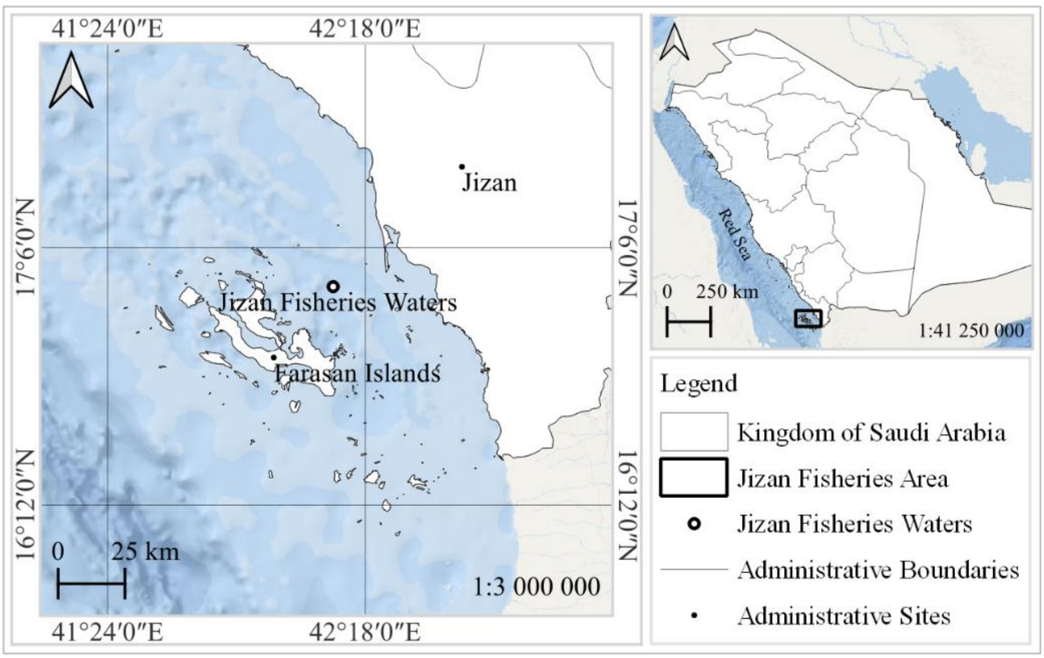

Fig. 1. Jizan fisheries location.

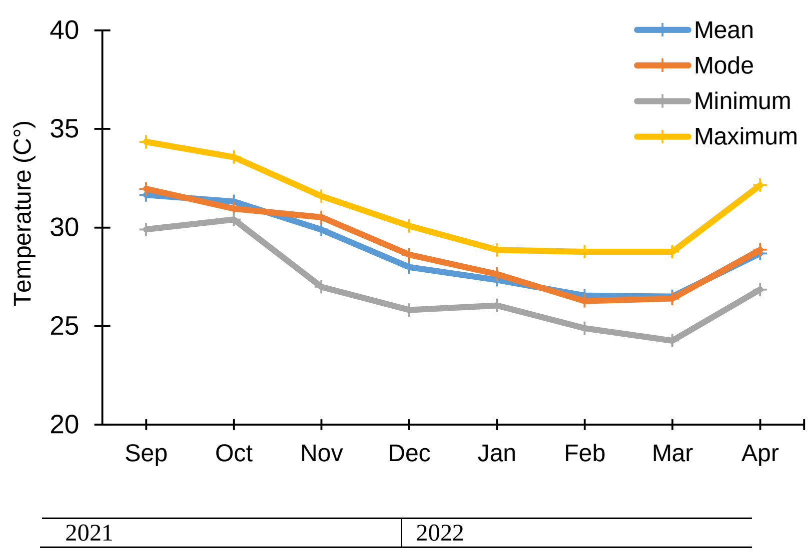

Fig. 2. Trend of temperature values in Jizan waters.

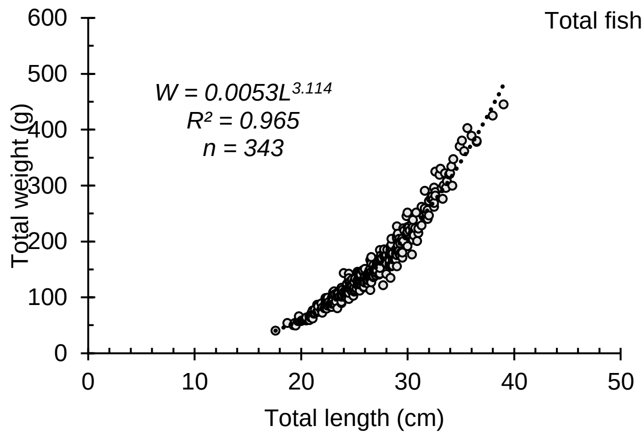

Fig. 3. Total Length-total weight relationship of *S. tumbil* collected from Jizan fisheries.

Table 1. Total length-total weight and total length-gutted weight relationship parameters of S. tumbil in Jizan fisheries.

Weight data	Category	Slope (b)	Intercept (a)	Correlation coefficient (R^2)	Somatic growth
Total weight (TW)	Total fish	3.114	0.0053	0.965	Allometric positive
	Female	3.162	0.0045	0.953	Allometric positive
	Male	3.111	0.0054	0.980	Allometric positive
Gutted fish weight (GW)	Total fish	3.014	0.0067	0.977	Isometric
	Female	3.047	0.0060	0.969	Isometric
	Male	2.967	0.0078	0.982	Isometric

Table 2. Length-weight relationship parameters of S. tumbil at different localities.

References	Location	b	a	R^2	Sex	Somatic growth	Length range	Weight type
Bakhsh (1994)	Jizan, Saudi Arabia	2.96	0.011	-	C	Isometric	12.0 – 33.0 (TL)	GW
Fofandi (2011)	India	3.25	0.0035	0.937	C	Allometric positive	15.2 – 39.9 (TL)	TW
Mohanchander *et al.* (2015)	India	3.066	7×10^{-5}	0.994	F	Allometric positive	13.0 – 43.0 (TL)	TW
		3.025	1.929	0.961	M	Allometric positive		TW
Kalhoro *et al.* (2015)	Pakistan	2.931	0.011	0.976	C	Allometric negative	3.0 – 46.0 (FL)	TW
(Mirzaei *et al.*, 2015)	Iran	3.421	0.002	0.957	F	Allometric positive	16.2 – 55.5 (TL)	TW
		3.402	0.002	0.969	M	Allometric positive	18.1 – 44.0 (TL)	TW
(Wang *et al.*, 2012)	China	3.047	0.975	0.994	C	Isometric	5.5 – 35.0 (SL)	TW
Gabr & Mal (2017)	Jizan, Saudi Arabia	3.150	0.0056	0.98	C	Allometric positive	16.1 – 41.0 (TL)	TW
		3.104	0.0056	0.97	F	Allometric positive	19.6 – 41.0 (TL)	TW
		3.097	0.0048	0.94	M	Allometric positive	16.1 – 31.7 (TL)	TW
Present study (2022), with total weight data	Jizan, Saudi Arabia	3.114	0.0053	0.965	C	Allometric positive	17.6 – 41.5 (TL)	TW
		3.162	0.0045	0.953	F	Allometric positive	17.6 – 41.5 (TL)	TW
		3.111	0.0054	0.980	M	Allometric positive	18.7 – 38 (TL)	TW
Present study (2022), with gutted fish weight data	Jizan, Saudi Arabia	3.014	0.0067	0.977	C	Isometric	17-6 – 41.5 (TL)	GW
		3.047	0.0060	0.969	F	Isometric	17.6 – 41.5 (TL)	GW
		2.967	0.0078	0.982	M	Isometric	18.7 – 38 (TL)	GW

Notes: M = Males, F = Females, C = Combined sexes, TL = Total Length, SL = Standard length, FL = Fork Length.

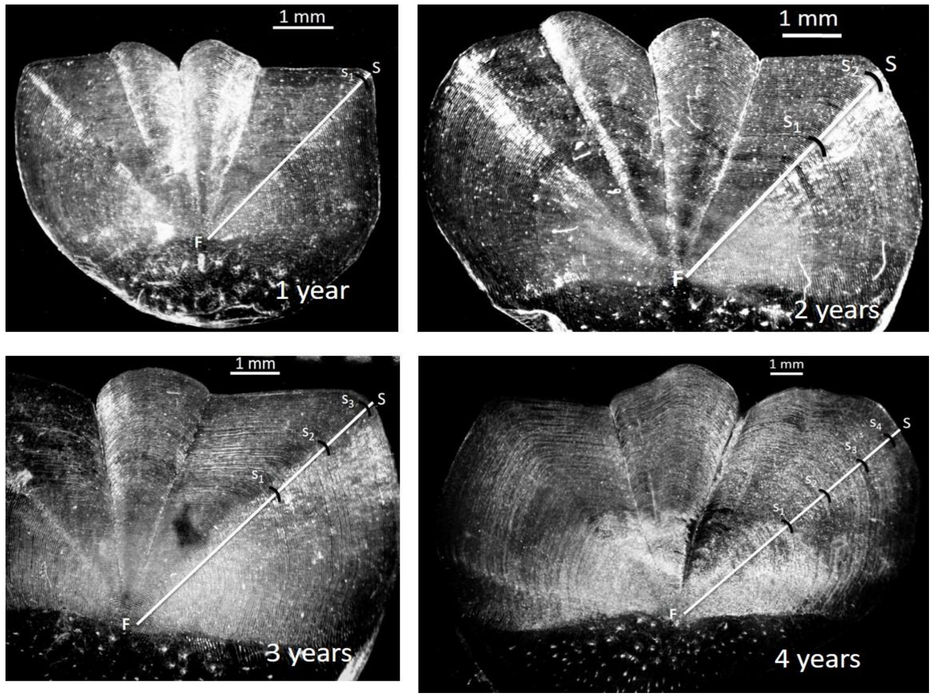

Fig. 4. The illustration of fish age determination based on scale observation of four age groups.

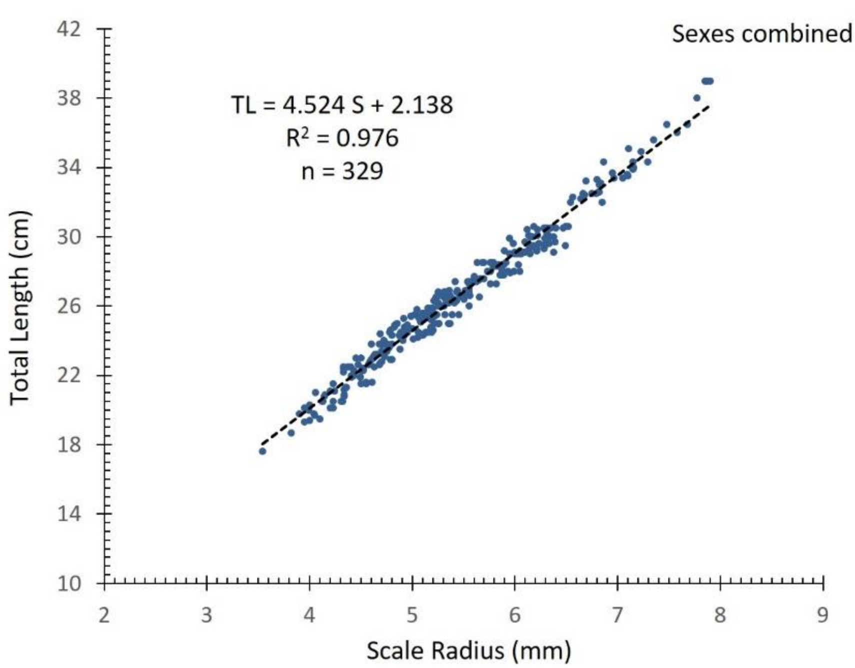

Fig. 5. The relationship between fish length (cm) and scale radius (mm) of total fish.

Table 3. The means of back-calculated total length at the end of year life.

Category	Details	Back-calculated total length at ages (cm)			
		Year I	Year II	Year III	Year IV
Sexes combined	Age group I+	18.6			
	Age group II+	18.4	26.7		
	Age group III+	18.2	26.6	32.3	
	Age group IV+	18.7	27.5	32.5	37.4
	Grand average	18.5	27.0	32.4	37.4
	Annual increment	18.5	8.5	5.4	5.0
Females	Age group I+	18.5			
	Age group II+	18.2	26.5		
	Age group III+	18.3	27.3	32.3	
	Age group IV+	19.0	27.6	32.9	37.6
	Grand average	18.5	27.1	32.6	37.6
	Annual increment	18.5	8.6	5.5	5.0
Males	Age group I+	18.2			
	Age group II+	17.8	26.7		
	Age group III+	17.9	26.9	32.2	
	Age group IV+	17.7	26.8	32.0	37.4
	Grand average	17.9	26.8	32.1	37.4
	Annual increment	17.9	8.9	5.3	5.3

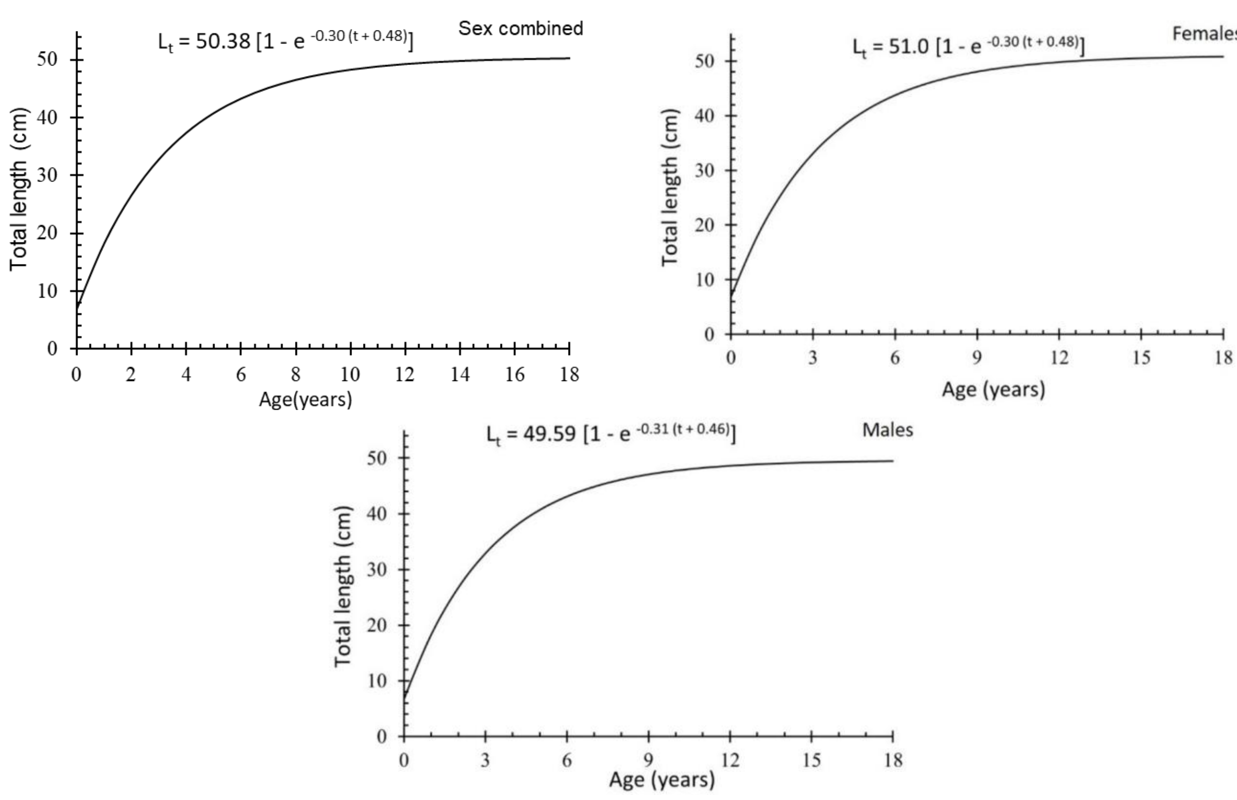

Fig. 6. von Bertalanffy growth curves of S. tumbil in Jizan fisheries.

Table 4. Growth parameters of S. tumbil estimated by different authors at different locations.

Author and Location	Age determination Method	Growth parameters			Growth performance Φ'
		K	L_∞	t_0	
Present study, Jizan, Saudi Arabia	Scale-based (Total Length)	0.30	50.38	-0.48	2.88
Gabr & Mal (2017), Jizan, Saudi Arabia	Otolith-based (Total Length)	0.27	52.98	-0.837	2.88
Kalhoro, *et al*. (2015), Pakistan	Length-based (Fork Length)	0.32	48.30	-0.786	2.87
Najmudeen *et al.* (2015), India, Kerala	Length-based (Total Length)	0.40	51.70	-0.188	3.03
Rao (1984), India, Bay of Bengal	Length-based (Total Length)	0.249	63.70	-0.334	3.00

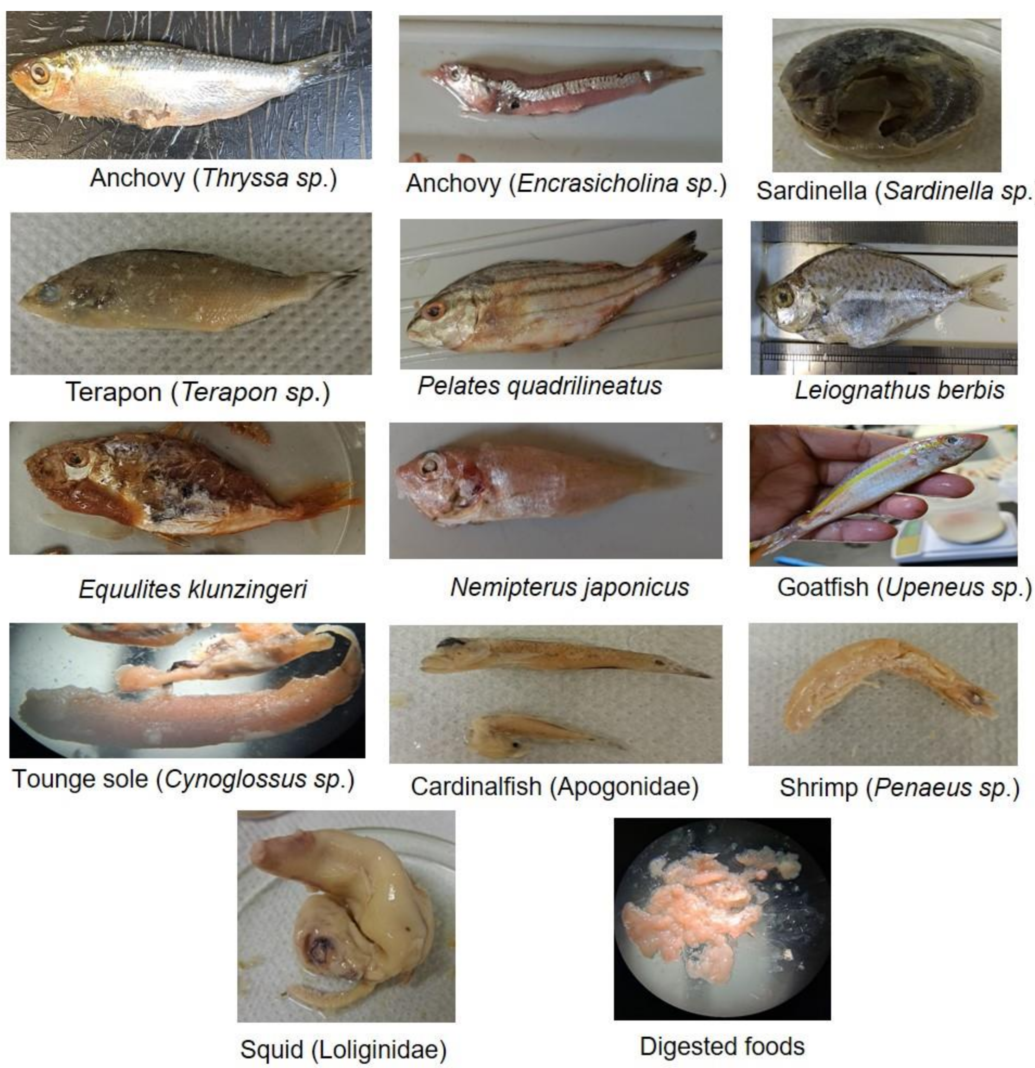

Fig. 7. Stomach contents of Saurida tumbil in Jizan fisheries.

Table 6. Types of foods and its frequency per month.

Type of food	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Freq.
Anchovy (*Encrasicholina* sp.)	3	9	0	7	5	8	1	1	34
Herring (*Thryssa* sp.)	0	0	1	0	0	2	0	0	3
Sardinella (*Sardinella* sp.)	0	0	0	0	1	6	0	2	9
Terapon (*Terapon* sp.)	0	1	4	4	5	12	4	4	34
Fourlined terapon (*P. quadrilineatus*)	0	0	1	0	3	0	1	1	6
Berber ponyfish (*L. berbis*)	2	1	0	0	1	2	4	0	10
Klunzinger ponyfish (*E. klunzingeri*)	0	0	1	0	0	0	1	0	2
Threadfin bream (*N. japonicus*)	0	0	1	0	0	0	1	0	2
Goatfish (*Upeneus* sp.)	0	0	0	1	0	1	0	0	2
Tounge sole (*Cynoglossus* sp.)	0	1	0	0	0	0	0	0	1
Cardinalfish (Apogonidae)	0	0	0	0	0	0	0	2	2
Shrimp (*Penaeus* sp.)	0	1	1	0	0	0	0	0	2
Squid (Loliginidae)	0	0	0	11	1	1	1	0	14
Digested food	17	18	26	14	7	10	3	3	98

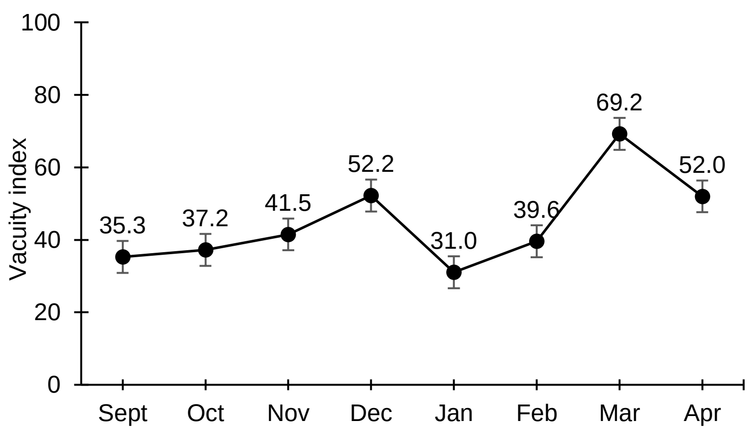

Fig. 8. Vacuity index per month.

Table 7. Stomach fullness description throughout study period regarding the season.

<table>
<tr><td colspan="6">2021</td><td colspan="5">2022</td></tr>
<tr><td colspan="2">Sep</td><td>Oct</td><td>Nov</td><td colspan="2">Dec</td><td>Jan</td><td>Feb</td><td colspan="2">Mar</td><td>Apr</td></tr>
<tr><td>Summer</td><td colspan="4">Autumn</td><td colspan="4">Winter</td><td colspan="2">Spring</td></tr>
<tr><td colspan="3">Comparatively gluttonous</td><td colspan="3">Middle alimentative</td><td colspan="2">Comparatively gluttonous</td><td colspan="2">Hypo alimentative</td><td>Middle alimentative</td></tr>
</table>

Table 8. The percentage of occurrence index of fish food habits analysis.

Type of food	% O_i	Rank	Category
Anchovy (*Encrasicholina* sp.)	34.34	1	Secondary prey
Herring (*Thryssa* sp.)	3.03	6	Eaten accidentally
Sardinella sp.	9.09	4	Eaten accidentally
Terapon (*Terapon* sp.)	34.34	1	Secondary prey
Fourlined terapon (*P. quadrilineatus*)	6.06	5	Eaten accidentally
Berber ponyfish (*L. berbis*)	10.10	3	Secondary prey
Klunzinger ponyfish (*E. klunzingeri*)	2.02	7	Eaten accidentally
Threadfin bream (*N. japonicus*)	2.02	7	Eaten accidentally
Goatfish (*Upeneus* sp.)	2.02	7	Eaten accidentally
Tounge sole (*Cynoglossus* sp.)	1.01	8	Eaten accidentally
Cardinalfish (Apogonidae)	2.02	7	Eaten accidentally
Shrimp (*Penaeus* sp.)	2.02	7	Eaten accidentally
Squid (Loliginidae)	14.14	2	Secondary prey
Digested foods	-	-	-

Table 9. The result of compound indices methods of food habits analysis with ranking in brackets.

Type of food	$\%O_i$	$\%N_i$	$\%V_i$	I_i	IRI_i	$\%IRI_i$
Anchovy (*Encrasicholina* sp.)	34.34	28.10	14.35	27.08 (2)	1457.76	35.39 (2)
Herring (*Thryssa* sp.)	3.03	2.48	10.84	1.81 (7)	40.35	0.98 (7)
Sardinella sp.	9.09	7.44	14.83	7.41 (4)	202.40	4.91 (4)
Terapon (*Terapon* sp.)	34.34	28.10	21.36	40.32 (1)	1698.52	41.23 (1)
Fourlined terapon (*P. quadrilineatus*)	6.06	4.96	6.57	2.19 (6)	69.88	1.70 (6)
Berber ponyfish (*L. berbis*)	10.10	8.26	4.53	2.51 (5)	129.23	3.14 (5)
Klunzinger ponyfish (*E. klunzingeri*)	2.02	1.65	0.38	0.04 (11)	4.11	0.10 (11)
Threadfin bream (*N. japonicus*)	2.02	1.65	0.49	0.05 (10)	4.33	0.11 (10)
Goatfish (*Upeneus* sp.)	2.02	1.65	1.76	0.20 (8)	6.89	0.17 (8)
Tounge sole (*Cynoglossus* sp.)	1.01	0.83	0.16	0.01 (12)	0.99	0.02 (12)
Cardinalfish (Apogonidae)	2.02	1.65	0.87	0.10 (9)	5.09	0.12 (9)
Shrimp (*Penaeus* sp.)	2.02	1.65	0.41	0.05 (10)	4.17	0.10 (11)
Squid (Loliginidae)	14.14	11.57	23.46	18.24 (3)	495.40	12.03 (3)
Total	122.22	100.00	100.00	100.00	4119.14	100.00

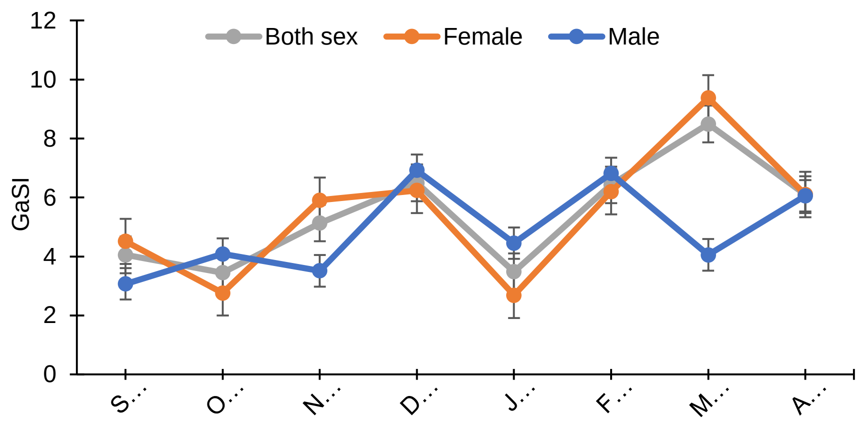

Fig. 9. Gastrosomatic index per month.

4. Conclusions

The present study showed that the growth of *S. tumbil* in Jizan fisheries is isometric. The average back-calculated lengths at age were 18.5, 27.0, 32.4 and 37.4 cm corresponding to the first, second, third and fourth year of life, respectively. The von Bertalanffy growth parameters were found to be: the asymptotic length L_∞ = 50.38 cm, growth constant K= 0.30 per year. The hypothetical age at zero length t_0 = -0.48 year. The growth in length performance index (Φ') was 2.88. The maximum Life span of *S. tumbil* in Jizan fisheries was estimated to be 9.5 years. This species was categorized as carnivorous fish which was indicated by the types of food items found in the stomach namely, fish, mollusc, and crustacean. Terapon (*Terapon* sp.) and anchovy (*Encrasicholina* sp.) were observed mostly in the stomach followed by sardinella (*Sardinella* sp.), squid (Loliginidae), and berber ponyfish (*L. berbis*). Vacuity index (*VI*) analysis showed *S. tumbil* was categorised as middle alimentative regularly regarding the food habit according to stomach fullness. Value of GaSI was 3.08 in average.

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References

Bakhsh, A. A. B. (1996). Reproductive Biology of Lizard Fish, Saurida tumbil (ForskaI) in the Jizan Region of the Red Sea. *J KAU Mar Sci*, **7**(1), 169–178.

Bertalanffy, L. Von. (1938). A quantitative theory of organic growth (inquiries on growth laws. II). *Human Biology*, **10**(2), 181–213.

Biswas, S. P. (1993). Manual of Methods in Fish Biology. New Delhi: South Asian Publisher Pvt. Ltd., pp. 157.

Bloch, M. E., (1795). Naturgeschichte der ausländischen Fische (Vol. 9). Verfasser, pp. 397-429.

Bogorodsky, S. V, Alpermann, T. J., Mal, A. O. and **Gabr, M. H.** (2014). Survey of demersal fishes from southern Saudi Arabia, with five new records for the Red Sea. *Zootaxa*, **3852**(4), 401–437.

Carbonara, P. and **Follesa, M. C.** (ed.), (2019). Handbook on Fish Age Determination: A Mediterranean Experience. Studies and Reviews, Vol. **98**. FAO, pp. 1-179.

Carpenter, K. E. and **Niem, V. H.** (1998). The living marine resources of the Western Central Pacific: Volume **2**. Rome: FAO.

Carpenter, K. E. and **Niem, V. H.** (1999a). The living marine resources of the Western Central Pacific. Volume **3**. Rome: FAO.

Carpenter, K. E. and **Niem, V. H.** (1999b). The living marine resources of the Western Central Pacific. Volume **4**. Rome: FAO.

Carpenter, K. E. and **Niem, V. H.** (2001). The living marine resources of the Western Central Pacific. Volume **5**. Rome: FAO.

Chipps, S. R. and **Garvey, J. E.** (2007). Assessment of Food Habits and Feeding Patterns. In: Guy, C., S. & Brown, M., L. (Eds.), Analysis and Interpretation of Freshwater Fisheries Data. American Fisheries Society, pp. 473–514.

Chrisafi, E., Kaspiris, P. and **Katselis, G.** (2007). Feeding habits of sand smelt (*Atherina boyeri*, Risso 1810) in Trichonis Lake (western Greece). *Journal of Applied Ichthyology*, **23**(3), 209–214.

Cochrane, K. L. and **Garcia, S. M.** (ed.), (2009). A Fishery Manager's Guidebook. Wiley. https://doi.org/10.1002/9781444316315

Euzen, O., 1987. Food habits and diet composition of some fish of Kuwait. *Kuwait Bulletin of Marine Science*, **9**, 65–85.

Fischer, W. and **Bianchi, G.** (1984). FAO species identification sheets for fishery purposes: Western Indian Ocean (Fishing Area 51), IV. Rome: FAO, pp. 513.

Fofandi, M. D. (2011). Investigations on Some Biological Aspects of Lizardfish (*Saurida tumbil*) Landed along Veraval Coast. *J. Fish. Int.*, **6**(3), 62–66.

Ford, E. (1933). An Account of the Herring Investigations Conducted at Plymouth during the Years from 1924 to 1933. *Journal of the Marine Biological Association of the United Kingdom*, **19**(1), 305–384. https://doi.org/10.1017/S0025315400055910

Francis, R. I. C. C. (1990). Back-calculation of fish length: a critical review. *Journal of Fish Biology*, *36*(6), 883–902. https://doi.org/10.1111/j.1095-8649.1990.tb05636.x

Froese, R. and **Pauly, D.** (ed.), (2022). FishBase. World Wide Web electronic publication. Retrieved: January 26, 2022. www.fishbase.org

Gabr, M. H. (2015). Capture production and stock assessment of *Solea aegyptiaca* Chabanaud, 1927 (Soleidae: Pleuronectiformes) in Bardawil Lagoon, Egypt. *The Egyptian Journal of Aquatic Research*, **41**(1), 101–110. https://doi.org/10.1016/j.ejar.2015.01.006

Gabr, M. H. and **Mal, A. O.** (2017). Stock assessment of the lizardfish Saurida tumbil (Bloch, 1795) in Jizan fisheries, Saudi Arabia. *The Egyptian Journal of Aquatic Research*, *43*(2), 147–153. https://doi.org/10.1016/j.ejar.2017.05.001

Garcia, S. M. (2003). The Ecosystem Approach to Fisheries: Issues, Terminology, Principles, Institutional Foundations, Implementation, and Outlook. Rome: FAO.

Gell, F. R. and **Whittington, M. W.** (2002). Diversity of fishes in seagrass beds in the Quirimba Archipelago, northern Mozambique. *Marine and Freshwater Research*, *53*(2). https://doi.org/10.1071/MF01125.

Green, B. S., Mapstone, B. D., Carlos, G. and **Begg, G. A.** (2009). Reviews: Methods and Technologies in Fish Biology and Fisheries, Tropical Fish Otoliths: Information for Assessment, Management, and Ecology. Springer, pp. 148.

Hart, P. J. B. and **Reynolds, J. D.** (ed.) (2002). Handbook of Fish Biology and Fisheries, Volume 1. Blackwell Publishing Ltd. https://doi.org/10.1002/9780470693803

Hynes, H. B. N. (1950). The food of fresh-water sticklebacks (*Gasterosteus aculeatus* and *Pygosteus pungitius*), with a review of methods used in studies of the food of fishes. *The Journal of Animal Ecology*, 36–58.

IUCN (2016). Greater Lizardfish: *Saurida tumbil*, from: https://www.iucnredlist.org. Retrieved: September 2, 2021.

Jaiswar, A. K., Chakraborty, S. K., Prasad, R. R., Palaniswamy, R. and **Bommireddy, S.** (2003). Population dynamics of lizardfish *Saurida tumbil* (Teleostomi /Synodontidae) from Mumbai, West Coast of India. *Indian J. Mar. Sci.*, **32**, 147–150.

Kalhoro, M. A., Liu, Q., Valinassab, T., Waryani, B., Abbasi, A. R. and **Memon, K. H.** (2015). Population dynamics of greater lizardfish, *Saurida tumbil* from Pakistani waters. *Pakistan Journal of Zoology*, **47**(4).

King, M. (2007). Fisheries Biology, Assessment, and Management. United Kingdom: John Wiley & Sons.

Kuriakose, S., Mini, K. G. and **Sathianandan, T. V.** (2017). Course Manual ICAR Funded Summer School on Advanced Methods for Fish Stock Assessment and Fisheries Management. Kerala: CMFRI.

Le Cren, E. D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *The Journal of Animal Ecology*, 201–219.

Mali, K. S., M, V. K., MK, F. and **AK, B.** (2017). Food And Feeding Habits of Two Major Lizardfishes (Family: Synodontidae) Occurring along North-West Coast of India Between Lat. 18°-23°N. *International Journal of Life-Sciences Scientific Research*, **3**(3). https://doi.org/10.21276/ijlssr.2017.3.3.12

Manojkumar, P. P. and **Pavithran, P. P.** (2016). Diet and feeding habits of Saurida tumbil (Bloch, 1795) from northern Kerala, south-west coast of India. *Indian Journal of Fisheries*, **63**(4). https://doi.org/10.21077/ijf.2016.63.4.60208-07

Metar, S. Y., Chakraborty, S. K., Jaiswar, A. K. and **Telvekar, P. A.,** (2005). Food and feeding habits of Saurida tumbil (Block, 1795) off Mumbai waters. *J. Indian Fish. Assoc.*, **32**: 141-148.

Mirzaei, M. R., Valinasab, T., Khalil, M. and **Mirzaei, S.** (2015). Reproductive cycle and spawning patterns of Lizardfish, Saurida tumbil (Bloch, 1795) in southern water of Iran. *International Journal of Biosciences*, *6*(6), 110–118.

Mohanchander, P., Kadharsha, K., Lyla, P. S. and **Khan, S. A. (**2015). Length-weight relationship and condition factor (Kn) of Saurida tumbil (Bloch, 1795), Southeast coast of India. *An International Journal of Marine Sciences*, **31**(1), 15–22.

Morgan, G. (2006). Subregional review: Northwest Indian Ocean. In: De Young, C. (Eds.), Review of the state of world marine capture fisheries management: Indian Ocean FAO, Rome, pp. 51–66.

Mostarda, E., Japp, D., Heinecken, C., Stiassny, M., Clerkin, P., Ebert, D.A., Xavier, J. and **Tracey, D.** (2016). Marine Species Biological Data Collection Manual. FAO.

Musick, J. A. (1999). Criteria to define extinction risk in marine fishes: the American Fisheries Society initiative. *Fisheries*, **24**(12): 6-14. https://doi.org/10.1577/1548-8446(1999)024%3C0006:CTDERI%3E2.0.CO;2

Najmudeen, T.M., Sivakami, S., Seetha, P.K., Kishore, T.G., Divya, N.D. and **Zacharia, P.U.** (2015). Lizardfish fishery of Kerala with some aspects of the stock characteristics of the greater lizardfish *Saurida tumbil* (Bloch, 1795). *Indian J. Fish*. 62(4): 31– 36.

Natarajan, A.V. and **Jhingran, A.G.** (1961). Index of preponderance-a method of grading the food elements in the stomach analysis of fishes. *Indian Journal of Fisheries*, **8**, 54-59.

Norouzi, H., Valinassab, T., Kamali, A., Kaymaram, F. and **Shamsaei, M.** (2012). Evaluation of some feeding Indices of Saurida tumbil in the Northern Persian Gulf and Oman Sea. *Ecology, Environment and Conservation Journal*, **18**(4), 54–57.

Pauly, D. (1980). A new methodology for rapidly acquiring basic information on tropical fish stocks: growth, mortality, and stock-recruitment relationships. In: Saila, S. B., Roedel, P. M. (Eds.), Stock assessment for tropical small-scale fisheries, International Center for Marine Resource Development, University of Rhode Island, Rhode Island, United States, pp. 154-172.

Pauly, D. (1984). Fish Population Dynamics in Tropical Waters: A Manual for Use with Programmable Calculators (Vol. 8). WorldFish, pp. 289.

Pauly, D. and **Munro, J. L.** (1984). Once more on the comparison of growth in fish and invertebrates. *Fishbyte*, **2**(1), 1–21.

Pillay, T. (1952). A critique of the methods of study of food of fishes. *J. Zool. Soc.*, **4**, 185–200.

Pinkas, L. (1971). Food habits of albacore, bluefin tuna, and bonito in California waters. *Fish. Bull. US*, **152**, 1–139.

Pitcher, T. J. and **Hart, P. J. B.** (1982). Fisheries Ecology. Springer Science & Business Media, pp. 414.

Rao, K. V. (1983). Maturation and spawning of lizard fishes (*Saurida spp.*) From Northwestern part of Bay of Bengal. *Indian Journal of Fisheries*, **30** (1), 27-45.

Raza, H., Liu, Q., Alam, M. S. and **Han, Y.** (2022). Length Based Stock Assessment of Five Fish Species from the Marine Water of Pakistan. *Sustainability*, **14**(3). https://doi.org/10.3390/su14031587

Sommer, C., Schneider W. and **Poutiers, J.M.** (1996). FAO Species Identification Field Guide for Fishery Purposes. The Living Marine Resources of Somalia. Rome: FAO, pp. 376.

Soofiani, N. M., Keivany, Y. and **Shooshtari, A. M. (**2006). Contribution to the biology of the Lizardfish, *Saurida tumbil* (Teleostei: Aulopiformes), from the Persian Gulf. *Zoology in the Middle East*, **38**(1), 49–56. https://doi.org/10.1080/09397140.2006.10638164

Taylor, C. C. (1958). Cod growth and temperature. *ICES Journal of Marine Science*, **23**(3). https://doi.org/10.1093/icesjms/23.3.366

Tesch, F. W. (1971). Age and Growth. In*:* Ricker W., E., *(*Eds.), Methods for Assessment of Fish Production in Freshwaters. Oxford: Blackwell Scientific Publications.

Walford, L. A. (1946). A new graphic method of describing the growth of animals. *The Biological Bulletin*, **90**(2): 141-147. https://doi.org/10.2307/1538217

Wang, X., Qiu, Y., Du, F., Lin, Z., Sun, D. and **Huang, S.** (2012). Population parameters and dynamic pool models of commercial fishes in the Beibu Gulf, northern South China Sea. *Chinese Journal of Oceanology and Limnology*, **30**(1): 105-117. https://doi.org/10.1007/s00343-012-1017-y

Ye, Y. (2011). Global overview of marine fishery resources. In: Ye, Y., and Cochrane, K. (Eds.), Review of the state of world marine fishery resources, FAO, Rome, pp. 121-131.

النمو والعلف والعادات الغذائية لسمكة *Saurida tumbil* (بلوخ، ١٧٩٥) في مصايد جيزان، المملكة العربية السعودية

سوجنج هارتونو، و **ميسر حامد أبو الريش**، و **محمد حسني جبر**

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المستخلص. تقدم الدراسة الحالية أحدث تقييم علمي للنمو والعادات الغذائية لأسماك المكرونة *Saurida tumbil* في مصايد جيزان. تم جمع عينات شهرية من سبتمبر ٢٠٢١ إلى أبريل ٢٠٢٢، بإجمالي ٣٤٣ سمكة. وتم استخدام قشور الأسماك لتحديد العمر والحساب الرجعى لأطوال الأسماك عند الاعمار المختلفة لتقدير معدلات النمو ومعايير نمو فون برتالانفي. تم إجراء العديد من التحليلات الغذائية لوصف العادات الغذائية لهذا النوع. وأظهرت النتائج أن *Saurida tumbil* تصنف على أنها أسماك آكلة اللحوم. ولوحظ أن أسماك التيرابون (*Terapon* sp.) والأنشوجة (*Encrasicholina* sp.) تتواجد في غالبية الأمعاء وتليها أسماك السردين (*Sardinella* sp.) والحبار (Loliginidae) وأسماك نعومة الفكوك (*Leiognathus berbis*). أظهر تحليل مؤشر الفراغ (VI) أن *Saurida tumbil* يصنف على أنه غذائي متوسط بانتظام فيما يتعلق بالعادات الغذائية وامتلاء المعدة. وكانت قيمة مؤشر الاحشاء الجسدي GaSI هى 3.08 في المتوسط. وأظهرت علاقة الطول الكلي – الوزن بدون الاحشاء أن نمو اسماك المكرونة *Saurida tumbil* هو نمو مثالي ويمكن وصفه بناء على معادلة القوة: $W_{gutted} = 0.0067\ TL^{3.014}$، وكان متوسط الأطوال المحسوبة عند الأعمار المختلفة هو ١٨,٥ و٢٧,٠ و٣٢,٤ و٣٧,٤ سم على التوالي. تم حساب معاملات النمو لفون برتالانفي، وكانت: الطول الاقصى $L_\infty = 50.38$ سم، وثابت النمو $K = 0.30$ في السنة. والعمر الافتراضي عند الطول صفر $t_0 = -0.48$ سنة. وكان مؤشر النمو في الطول (Φ') = 2.88.

الكلمات المفتاحية: الطول المقارب سمكة سحلية أكبر، البحر الأحمر، أذواقهم الغذائية، مؤشر مركب.