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# PRELIMINARY INVESTIGATIONS ON STOCK ANALYSIS OF TIGERTOOTH CROAKER (*OTOLITHES RUBER*) FROM BALOCHISTAN COAST, PAKISTAN

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## ABSTRACT

Length-weight relationship, growth and mortality rate parameters of Tighertooth croaker (*Otolithes ruber)* were estimated using length-weight and data length frequency distributions, samples gathered from different fish landing sites of Balochistan coast, Pakistan. A total of 278 pairs of length-weight relationship and 4062 samples of length frequency distribution were measured during current study. Length-weight relationship was at a =0.016, $b$ =2.829 ($R^2$= 0.969). ELEFAN method was used to evaluate the growth rate where $L_\infty$= 34.65 cm and $K$ =0.83 $yr^{-1}$ and $t_0$= -0.185, growth performance index was at 2.608 $yr^{-1}$. Length converted catch curve was used to estimate total mortality which was Z =3.18 $yr^{-1}$, whereas, fishing and natural death of fish evaluated at 1.465, 2.171 $yr^{-1}$ respectively, however, exploitation rate (E) was at 0.682 $yr^{-1}$. Pursuant to Gulland (1971, 1979) exploitation rate would be less than 0.5 and Patterson (1992) reported exploitation rate may retained at 0.4 level for sustainable fishery resources. Considering above facts, stock of *O. ruber* from Pakistani waters (Balochistan coast) is in overexploitation state. It may be suggested to government agencies to initiate rules and regulations to sustain the stock of this fishery from Pakistani waters for future.

**Keywords:** Stock analysis, *Otolithes ruber*, fishery resources, Pakistan.

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## INTRODUCTION

Pakistani waters are situated at northern side of Arabian Sea, exclusive Economic Zone (EEZ) consisting upon 250000 km$^2$ including 350 nautical miles (NM). Pakistan coastline consists of 1100 km extended through border of India in southeast to border of Iran at northwest, having coasts at Sindh and Baluchistan province (Figure 1). Pakistani waters are rich in natural resources and fisheries potential from which Pakistan explore and exploit their aquatic assets (Snead, 1967). The Sindh coast consists of 348 km bordering with India and Hub River. In contrast to Baluchistan coast Sindh coast have sandy and sandy muddy bottom. The major areas of shelf expand about 80 miles in to Indus delta. The Sindh coast has many creeks network, having mangroves ecosystem which plays as a nursery ground for shrimps, finfish and shellfish resources (Snead, 1967; FAO, 2009). The Sindh coast have also many major fishing grounds such as Keti Bandar, Hajamro, Patiani, Khobar, Khuddi, Gharo, Phitti, Jhari, Ibrahim Hydri and Korangi. Because of rich mangrove ecosystem the Sonmiani bay in Balochistan creates best nursery grounds for the fishery. Sonmiani bay, Ormara, Pasni and Gwatar bay is also fishing grounds along Balochistan coast (FAO, 2009). In Pakistani waters 250 demersal fish species, 50 species of small pelagic, 15 standard size pelagic fish species and 20 large size pelagic fishes, additionally 15 species of shrimp, 12 species of cephalopods and 5 lobster species are well reported (Bianchi, 1985; FAO, 2009).

Tighertooth croaker (*Otolithes ruber)* is a species under Sciaenidae family. This family is generally distributed in tropical and sub-tropical waters (Trewavas, 1977; Sasaki, 2001), whereas, *O. ruber* mostly distributed in Indo-Pacific Ocean (Brash and Fennessy, 2005). The Sciaenidae fish family is very important demersal fisheries resources of Pakistan. There are several studies on biology and stock assessment available on *O. ruber* around the world. Feeding habits of *O. ruber* is studied by Bandani *et al.* (2007) and primarily are lethargic carnivores (van-der-Elst, 1981). Numerous studies have been conducted on population dynamics of *O. ruber* from Indian waters (Rao *et al.,* 1992; Chakraborty, 1997; Santhosh, 2017), and from Persian Gulf, Iran (Niamaimandi *et al*., 2003; Khodadadi *et al*., 2010; Kamali *et al*., 2006).

Limited work on Sciaenidae family has been done on growth and mortality parameters of *Otolithes cuvieri* and *Atrobucca alcocki* from Pakistani waters (Memon *et al*., 2015, 2016). While, other research work on stock assessment and maximum sustainable yield has been done on different single species from Pakistani waters (Kalhoro *et al*., 2013, 2014a,b, 2015a,b, 2017a,b, 2018; Nadeem *et al*., 2017; Afzaal *et al*., 2016, 2018; Soomro *et al*., 2015a,b; Razaaq *et al*., 2019). For better fishery management scientists and fishery managers mainly depends on outcomes of population dynamics (Hilborn and Walters, 1992), which is absent for *O. ruber* fishery from Pakistani waters. Based on length frequency distribution, this is first attempt investigation on stock assessment of *O. ruber* from Balochistan coast, Pakistan. The findings of this study will help fishery managers to set fishing efforts particularly for this species from Pakistani water for better fishery management.

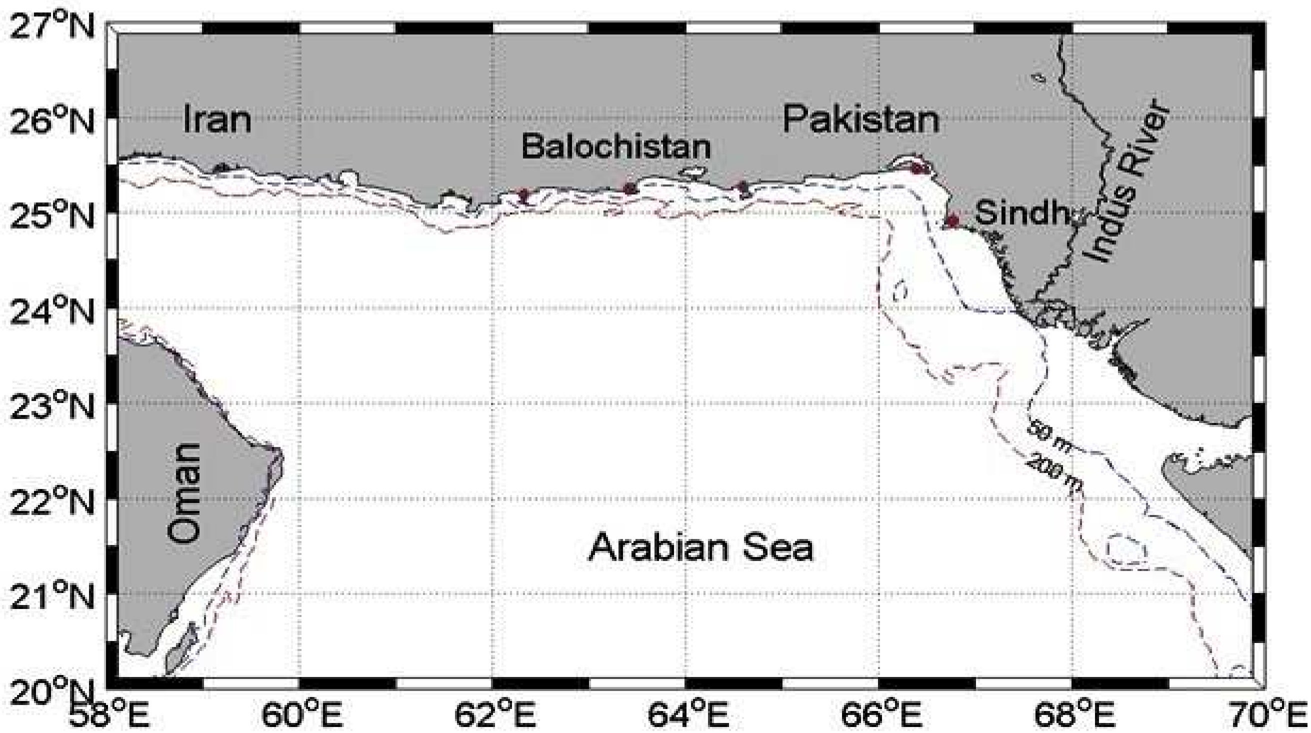


**Fig. 1. Pakistan coast comprises on Sindh and Balochistan circles showing fish landing sites along coast and also showing Indus delta region with rich mangrove ecosystem.**

## MATERIALS AND METHODS

**Collection of data:** Monthly basis samples were collected during February-December 2016 from different fish landing i.e. Sonmiani, Ormara, Pasni and Gwadar sites of Balochistan coast, Pakistan. Length frequency and length-weight relationship data were gathered during present study. Length was taken in centimeters (cm) and weight was measured in grams (g). Total 278 pair of length-weight relationship data of both sexes was examined. Whereas, total 4062 number of length frequency distribution data were gathered to evaluate growth rate, growth performance index, mortality rate and length-structure population analysis.

**Length-weight relationship:** The power equation: $W = aL^b$ was used to compute length-weight relationship of 278 specimens of this species. W denotes weight in g, L denotes length (TL) in cm and *a* represents condition element and b is slope.

**Growth parameters:** Length frequency distribution data used into growth function of von Bertalanffy (VGBF) to evaluate length with age using equation: $L_t = L_\infty (1 - \exp(-k(t - t_0)))$, where $L_t$ was size at age *t*, $L_\infty$ was length infinity, *K* was growth rate, $t_0$ was theoretical age at zero (Haddon 2011) and calculated by using Pauly (1983) empirical formula: $\log_{10}(-t_0) = -0.3922 - 0.2751\log_{10} L_\infty - 1.0381\log_{10} k$

**Mortality parameters:** Total mortality (Z) was calculated by applying length-converted catch curve method (Pauly, 1983). The natural fish death (M) was determined by Pauly's empirical equation. $\log_{10}(M) = -0.006 - 0.279\log_{10} L_\infty + 0.654\log_{10}(K) + 0.6434\log_{10}(T)$ : $L_\infty$ and *K* denotes VBGF growth parameters and T indicates annual sea temperature (26 $^0$C). Exploitation rate (*E*) was calculated using: *E* = *F* / *Z* wherever, *F* is the fishing mortality and is calculated by *F* = *Z* – *M*.

**Growth performance index:** Growth performance index ($\phi$') of *O. ruber* was assessed by Pauly and Munro (1984) equation:

$$\phi' = \log_{10} k + 2\log_{10} L_\infty$$

**Virtual population analysis (VPA):** Length structure VPA of *O. ruber* was calculated by applying length weight, growth, natural and fishing mortality rate values into FiSAT-II from Pakistani waters.

## RESULTS

**Length frequency data:** Total 4062 number of length frequency distribution data was gathered from February – December, 2016. Length frequency was assemble in length classes with 3 cm interval ranges from 3 to 33 cm, foremost length variety was 6 to 15 cm (Figure 2).

**Relation of length and weight:** Total 278 paired length-weight relationship data of combine sexes of *O. ruber* were measured. Total length size and weight range was from 3 to 33 cm and 2 to 406 g, respectively. Length-weight relationship (*a* condition factor and slope *b*) of combined sexes of *O. ruber* were at a=0.016x$b^{2.829}$ ($R^2$ = 0.969) (Figure 3).

**Growth parameters:** Electronic length frequency analysis method was used to evaluate von Bertalanffy growth function (VBGF) parameters of *O. ruber* from Balochistan, Pakistan. The obtained growth parameters were: $L_\infty$= 34.65 cm and *K*= 0.83 $yr^{-1}$ (Figure 4). Goodness-of-fit was at $R_n$= 0.344 indicates that VBGF model is fit for length frequency data analysis, theoretical age at zero was calculated at $t_0$ = -0.185.

**Mortality parameters:** Using length frequency distribution data (n = 4062) length converted catch curve method was used to assess total mortality (Z), where total mortality was Z =3.18 $yr^{-1}$ with 95% confidential interval (CI =2.73-3.63) (Figure 5). However, natural death (M) was determined by Pauly empirical equation with 26 $^{0}$C average sea temperature of Pakistani marine waters and obtained at M = 1.465 $yr^{-1}$, while death of fish due to fishing activities (F) was at Z-M = 2.171 $yr^{-1}$. The exploitation rate (E) was computed from F/Z = 0.682 $yr^{-1}$.

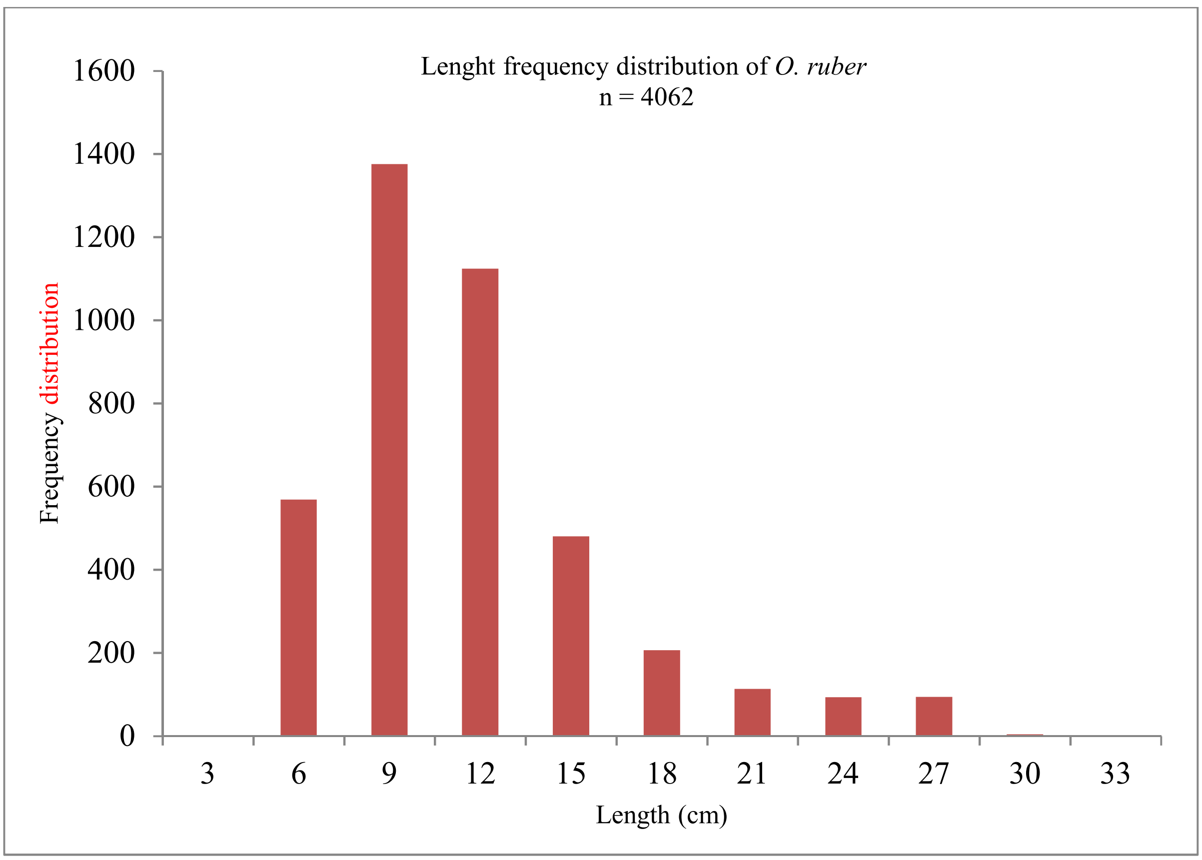


**Fig. 2. Length size class of *O. ruber* from Balochistan coast, Pakistan during 2016.**

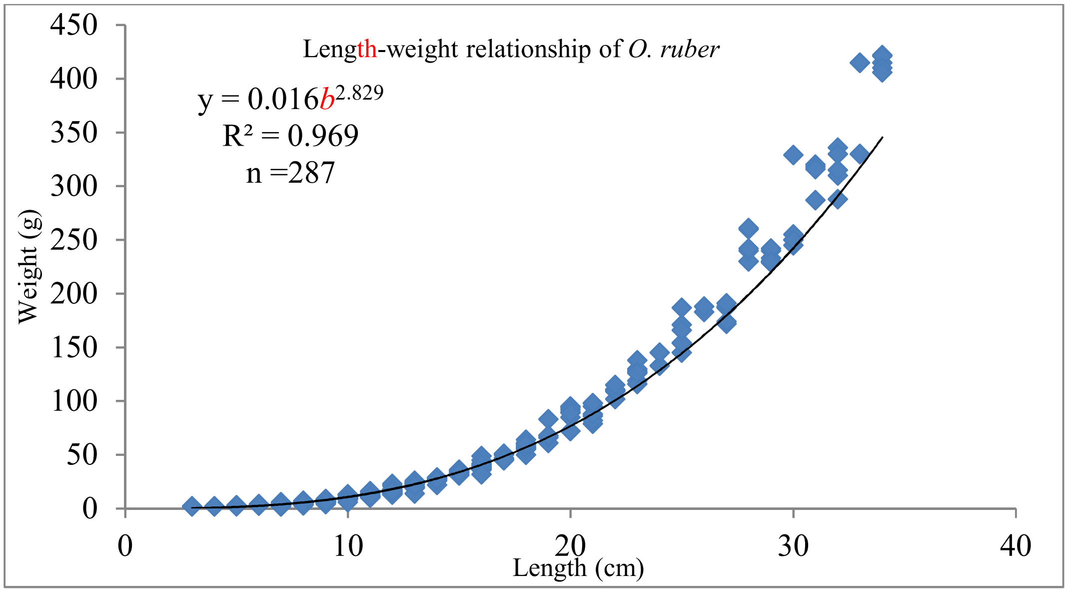


**Fig. 3. Relation of length and weight of *O. ruber* Pakistan (Balochistan coast) during 2016.**

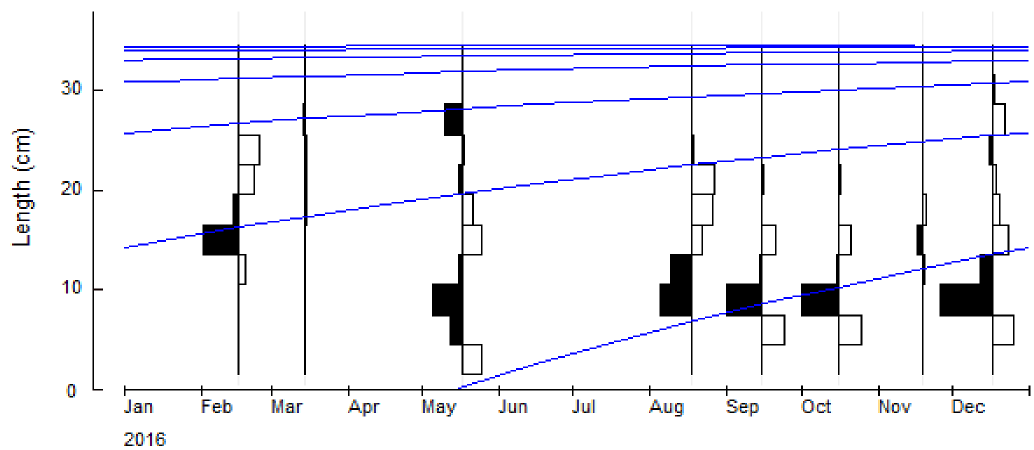


**Fig. 4. The length frequency data (n =4062) of *O. ruber* fit with growth curve from Pakistan (Balochistan) during 2016**

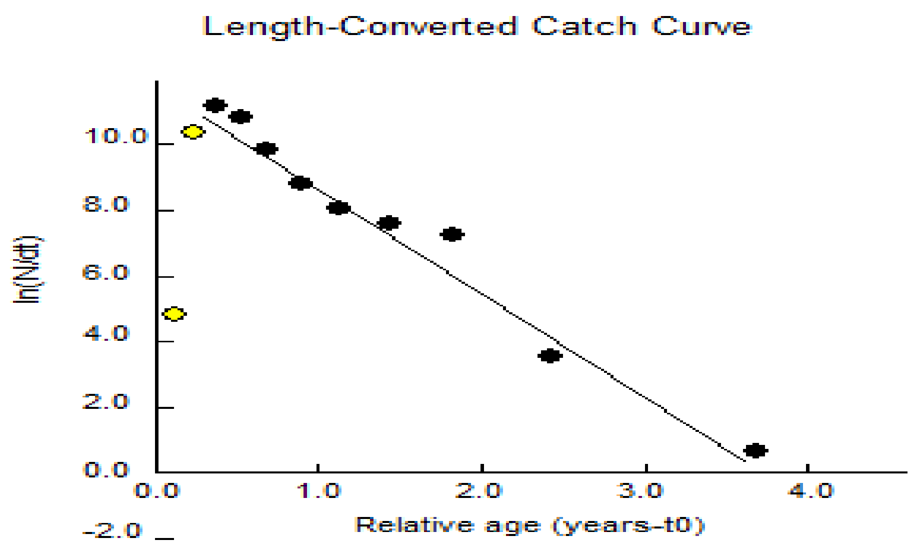


**Fig. 5. Length converted catch curve was applied to calculate total mortality (Z) from Balochistan coast, Pakistan**

**Growth performance index:** The estimated growth rate parameters ($L_\infty$= 34.65 cm and $K$= 0.83 $yr^{-1}$) were used to obtain growth performance value. The assessed value of ($\phi'$) for *O. ruber* in Pakistani waters was 2.608.

**Virtual population analysis:** Length structure VPA was estimated using length-weight and growth parameter values it was observed that fish loss are at smaller length size fish while fishing pressure is high from 16 to 33 cm fish species (Figure 6).

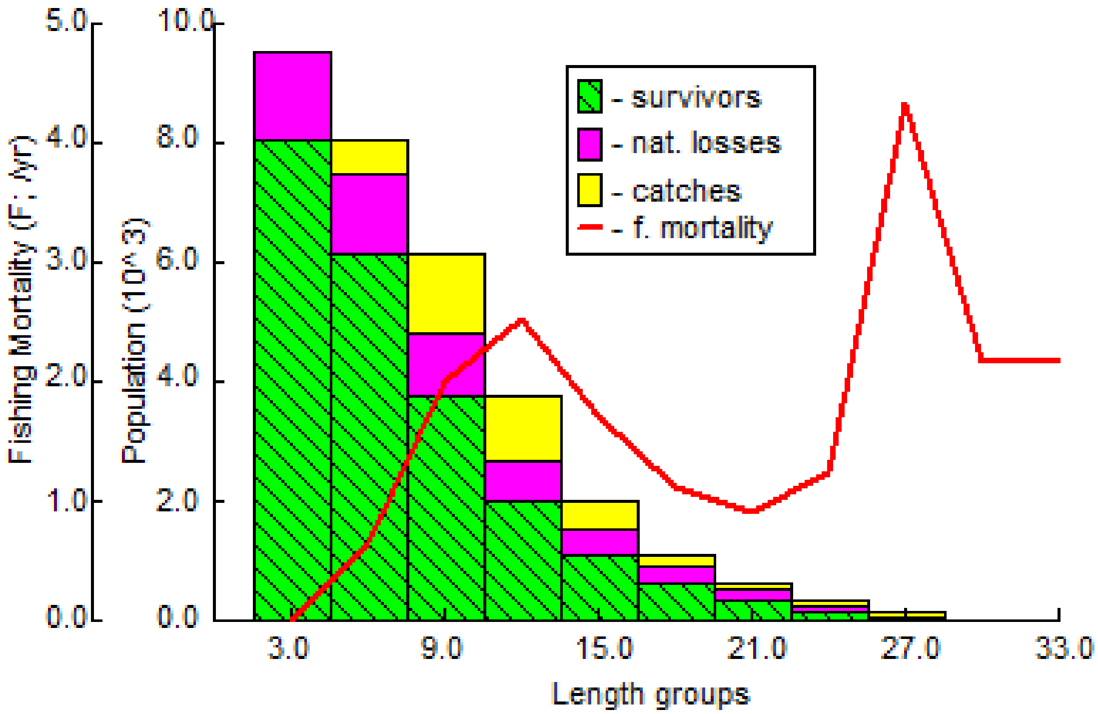


**Fig. 6. Virtual population analysis indicates structure of fish length class caught during present investigations**

## DISCUSSION

**Length-weight relationship:** Relation of length and weight, growth, growth performance index and mortality rate parameters are important aspects to evaluate stock status when species lives in higher food web (Lizama and Ambrosio, 2002). Length-weight relationship is basic parameter to know biology (eg. feed capacity, gonadal development and fish development) and stock assessment for fish species (Le-Cren, 1951, Abdurahiman *et al.,* 2004; Kalhoro *et al.,* 2014a). In general concept if slope *b* value is equal 3 or near to 3 that means fish has isometric growth and it will keep definite shape through life (Wootton, 1998).

However, slope *b* value < 3 defines fish has allometric growth, whereas slope *b* greater than 3 denotes fish has isometric growth (Gayanilo and Pauly, 1997). Froese (2006) clarified that *b*=3 represent that small fish has same form and possibly has same state as large fishes. In present study slope *b* value is 2.829 ($R^2$ = 0.969) is close to value 3, which shows fish has isometric growth of *O. ruber* from Balochistan, Pakistan. Commonly coefficient of determination also describes the goodness of fit ($R^2$) value ranges from 0-1 (1-100%), whereas obtained values close to 1 ($R^2$ = 0.969) indicates percentage of data better fitted in the model.

Present values were compared to findings of previous studies from different areas (Table 1). The value from India (Santhoshkumar *et al.*, 2014), Taiwan (Chu *et al.,* 2011), Iran (Raeisi *et al.,* 2011), South Africa (Torres, 1991) and Philippine (Palla *et al.,* 2018) are close to present outcomes. However, values from Iran (Eskandari, 2012) and South Africa (Fennessy, 2000) are slightly higher than current study, however most of the *b* values are similar or near to present research. This light variation in values may be due to different factors affecting on growth rate (length and weight) of fish. Availability of food, climate change, season of sample collection, different habitat and maturity of fish are most possible factors affecting growth of fishes (Biswas, 1993; Froese, 2006).

**Table 1. Length-weight relationship parameters compared to earlier findings from different waters.**

| Area | *a* | *b* | $R^2$ | Reference |
|---|---|---|---|---|
| Persian Gulf, Iran | 0.005 | 3.19 | - | Eskandari, 2012 |
| Persian Gulf, Iran | - | 2.89 | - | Raeisi *et al.,* 2012 |
| India | 0.018 | 2.834 | 0.885 | Santhoshkumar *et al*., 2014 |
| South Africa | 0.00049 | 3.13 | - | Fennessy, 2000 |
| South Africa | 0.022 | 2.790 | - | Torres, 1991 |
| Taiwan | 0.0300 | 2.630 | 0.830 | Chu *et at*., 2011 |
| Philippines, Palawan | 0.0150 | 2.73 | 0.910 | Palla *et al.,* 2018 |
| Kuwait | 0.020 | 2.916 | 0.980 | Hussain and Abdullah, 1977 |
| Pakistan (Balochistan coast) | 0.016 | 2.829 | 0.969 | Present study |

**Growth parameters:** Length frequency distribution data was used to estimate growth parameters, mostly age-structure data used to evaluate growth parameters. It is well know that age-structure data from otolith and scales reading is very hard and laborious therefore, length frequency data generally used to estimate growth rate (Sparre *et al*., 1992). In present study, VBGF method used to estimate growth parameters. The obtained growth parameter values ($L_\infty$= 34.65 cm and *K*= 0.83 $yr^{-1}$) were compared to previous studies from different areas (Table 2). It shows that most of growth rate values from Iran, Mozambique, South Africa and Kuwait are higher than present findings. However, rare values are similar or close to current study like from India and Philippine. Normally, it was observed that higher $L_\infty$ values have smaller *K* value indicates larger asymptotic length and lower growth curve have lower natural mortality rate (Beverton and Holt, 1957). These both parameters are relatively correlated to each other higher *K* values have lower values $L_\infty$ (Pauly and Morgan, 1987). The compared growth performance index (ø') values from India (2.82) and Philippines (2.60) (Bhuyan *et al.,* 2012; Ingles and Pauly, 1984) are similar to present study (2.608).

The obtained growth parameter values from current study is slightly different from previous studies which illustrates that different factors like availability of food and seasonal variations may affecting growth rate (Adam, 1980; Devaraj, 1981; Sparre *et al.,* 1992; Ciloglu, 2005). Different analysis methods, different data set samples size from different catching method and sampling time may also give variation in results. For the estimated VBGF growth rate is a non-parametric system, which is typically used for length frequency analysis which is basically ad hoc basis and is not depend on calculating cohort distribution parameters directly. However, this method does not draw a strong hypothesis about distribution of sizes in cohorts. Lengths of model of every cohort are fixed to depend upon a curve described by growth models such as VBGF model, thus it makes a strong hypothesis regarding growth (Pitcher, 2002).

**Table 2. Growth rate parameters from present study is compared to previous study from different areas.**

| Area | $L_\infty$ | *K* | $\phi'$ | References |
|---|---|---|---|---|
| Iran | 65.0 | 0.41 | - | Farkhondeh, 2018 |
| Iran | 67.57 | 0.27 | - | Eskandari, 2012 |
| Bushehr, Iran | 50.0 | 1.5 | - | Niamaimandi, 1990 |
| Bushehr, Iran | 56.0 | 1.2 | - | Niamaimandi, 1999 |
| Iran | 58.0 | 0.8 | - | Niamaimandi, 2003 |
| Hormozgan, Iran | 61.5 | 0.32 | - | Niamaimandi, 1999 |
| Khozestan, Iran | 46.6 | 0.43 | - | Niamaimandi, 1999 |
| Bushehr, Iran | 56.0 | 0.8 | - | Niamaimandi, 1999 |
| India | 37.28 | 0.27 | - | Santhosh, 2017 |
| India, Cochin | 31.5 | 0.67 | 2.82 | Bhuyan *et al.,* 2012 |
| India, Maharashtra | 39.8 | 0.52 | - | Chakraborty ,1997 |
| South Africa | 41.9 | 0.31 | - | Jennifer and Fennessy, 2005 |
| Sofala Bank, Mozambique | 45.8 | 0.32 | - | Schultz, 1992 |
| Sofala Bank, Mozambique | 42.9 | 0.14 | - | Gislason, 1985 |
| Philippine, San Miguel Bay | 29.5 | 0.46 | 2.60 | Ingles and Pauly, 1984 |
| Kuwait | 56.0 | 0.38 | - | Almatar, 1993 |
| Pakistan (Balochistan coast) | 34.65 | 0.83 | 2.608 | Present study |

$L_\infty$ = length infinity, *K* = growth curve, $\phi'$ = growth performance index.

**Mortality rate:** Mortality shows death rate of fish from population size, the total mortality is estimated as sum of natural and fishing mortality. However, mortality rate may vary from time to time (Gayanilo *et al.,* 2003; Sparre and Venema, 1998). The estimated mortality rate parameters i.e. natural mortality (M =1.465), fishing mortality (F =2.171), total mortality (Z =3.18) and exploitation rate (E =0.682) are compared to previous studies from different regions (Table 3). Overall mortality rate parameters are higher than earlier studies, there is little difference in natural mortality whereas fishing mortality and total mortality is higher than present findings. The exploitation rate is higher than previous studies and greater than exploitation limit (Gulland, 1971; Patterson, 1992).

The overall values are higher than other regions of the world. This is may be this species have higher commercial demand from Pakistani waters and fishermen using their most of efforts to catch this commercial fish. Conferring to the Gulland (1971) exploitation rate should be less than 0.5, if it is higher than prescribed value than stock may be considered at overexploitation state. Referring to Patterson (1992) exploitation rate must be lower than 0.4 level. Based on previous recommendations the obtained results of exploitation rate (E = 0.682) indicates that stock of *O. ruber* fishery from Pakistani waters (Balochistan coast) is in overexploitation state.

**Table 3. Mortality and exploitation rate parameters compared to earlier studies from different areas of the world.**

| Region | M | F | Z | E | References |
|---|---|---|---|---|---|
| Iran | 0.7 | 1.25 | 1.95 | - | Khudadadi *et al.,* 2010 |
| Iran | 1.24 | 1.46 | 2.7 | 0.55 | Niamaimandi, 2003 |
| Bushehr, Iran | 1.95 | 1.72 | 3.67 | 0.47 | Niamaimandi, 1990 |
| Bushehr, Iran | 1.6 | 2 | 3.6 | 0.55 | Niamaimandi, 1999 |
| Hormozgan, Iran | 0.62 | 1.91 | 2.6 | 0.74 | Niamaimandi, 1999 |
| Khozestan, Iran | 0.83 | 1.35 | 2.18 | 0.61 | Niamaimandi, 1999 |
| Bushehr, Iran | 1.24 | 1.46 | 2.7 | 0.55 | Niamaimandi, 1999 |
| Philippines | 1.04 | 0.42 | 1.46 | - | Ingles and Pauly, 1984 |
| Philippines | 0.98 | 0.97 | 1.95 | - | Ingles and Pauly, 1984 |
| Pakistan (Balochistan coast) | 1.465 | 2.171 | 3.18 | 0.682 | Present study |

M = Natural mortality, F = Fishing mortality, Z = Total mortality, E = Exploitation rate.

**Conclusion:** Preliminary investigation on stock assessment of *O. ruber* was conducted from Balochistan coast, Pakistan. The obtained results of length-weight relationship and growth are similar and near to previous studies. Which indicates that samples collected during present study fully represents the sample size of fish species from Pakistani waters (Balochistan coast). Little difference in growth parameters could be because of different localities and sample collecting methodology. However, mortality rate and exploitation rate parameters are higher than earlier studies it may be because of more commercial importance from Pakistani waters. Current study illustrates that stock of Tighertooth croaker (*O. ruber*) was is in overexploitation state. Based on present findings it may be recommended that government agencies related to fisheries resources management must take some strategic steps to sustain stock of this fishery in Pakistani waters particularly from Balochistan coast. The fishery manager should educate local fishermen to not use small mesh size trawl so could save smaller fish to grow at least mature size so they can breed at once. The fishery manager should declare fishing ban period especially during breeding season of this fish. The fishery management departments and fishery research institute and universities should work together to get solution for better fishery management.

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