Pakistan J. Zool., pp 1-10, 2023. DOI: https://dx.doi.org/10.17582/journal.pjz/20221218131229

Population Dynamics and Stock Appraisal of Talang Queenfish (*Scomberoides commersonnianus*) from Balochistan Coast, Pakistan

Zahid Ali[1,2], Muhsan Ali Kalhoro[1]*, Nazeer Ahmed[1,3], Muhammad Shafi[1], Faisal Saeed[1] and Abdul Majeed[1]

[1]*Faculty of Marine Sciences, Lasbela University of Agriculture, Water and Marine Sciences, Uthal, Pakistan*
[2]*Pakistan Agriculture Research Council, Coastal Agriculture Research Institute, Lasbela, Balochistan, Pakistan*
[3]*Pakistan Agriculture Research Council, Agricultural Research Institute, Turbat, Balochistan, Pakistan*

Article Information
Received 18 December 2022
Revised 28 December 2022
Accepted 15 January 2023
Available online 05 May 2023
(early access)

Authors' Contribution
ZA executed the experimental work and paper writing. MAK supervised the study and data analysis. NA, FS and AM helped in sample collection and paper writing. MS helped in writing and review process.

Key words
***S. commersonnianus*, Population dynamics, Exploitation rate, IUU fishing, Pakistan**

ABSTRACT

Scomberoides commersonnianus (Lacepede, 1801) commonly known as Talang queenfish and locally famous as Saram, belongs to the Carangidae family, widely distributed in the Indo-pacific oceans. *S. commersonnianus* is mainly pelagic fish and commercially important fishery resource from Pakistani waters. Study on population dynamics and stock appraisal is an important for the sustainable use of fishery resource. During current study the length-weight relationship, growth, mortality, and exploitation rate was estimated from Balochistan, Pakistan. The length frequency data (n=1635) and length-weight relationship (n=603) of fish was collected from three fish landing sites of Balochistan coast during 2022. The growth, mortality and exploitation of fish was evaluated after analyzing the length frequency distribution in to ELEFAN method. The length-weight relationship slope *b* from Sonmiani Daam, Gaddani and Kundmalir were estimated as 3.287 (R^2=0.827), 3.384 (R^2=0.819) and 3.487 (R^2=0.819) respectively. However, all combined results were calculated as $W = 0.0013\ TL^{3.377}$ (R^2=0.82). The growth parameters were estimated as $L\infty$= 106.05cm (TL), growth curve K= 0.58 and t_0= -1.620 during present study. Though, total mortality was as Z = 1.65 yr^{-1}, natural mortality using sea surface temperature at 26°C at M = 0.848yr^{-1} whereas, fishing (F) was estimated as F=Z-M =0.802yr^{-1} and in continues the exploitation rate (E) was projected as F/Z =0.486 yr^{-1}. Length-weight and growth parameters were also compared with previous studies and found close or similar to current study. However, the exploitation rate was higher at E=0.486yr^{-1} than previous studies especially from Pakistani waters (E=0.45) which shows that the fishing pressure is higher than previous results. Current study also reflects that exploitation rate is greater than the catch limit (E>0.4) suggested by Patterson (1992) which indicates that the fish is in overexploited state. Based on present findings it is recommended that the management steps should be taken for the sustainable use of this commercially important fish species from Balochistan coast, Pakistan.

INTRODUCTION

Pakistan coast is about 1001 km from Iranian to Indian border with an exclusive economic zone (EEZ) of 350 nautical miles (n.m), about 299,000 km^2 (UN, 2015; Pakistan Navy, 2016). The continental shelf was 200 n.m while it was extended up to 350 n.m during 2015 (UN, 2015) from which Pakistan can explore and exploit its marine resources (Fig. 1). Pakistan coast comprises on Balochistan and Sindh provinces and are rich in fishery resources which is one of the backbone of national economy. Sindh coastline starts from Indian border to Hub River in Balochistan about 366.5 km (Pakistan Navy, 2016). Sindh coast has freshwater inflow from Indus River which creates network of small and large channels and creeks that makes rich mangrove ecosystem (FAO, 2009). Mangroves ecosystem provides best breeding, nursery and protecting ground for the fin and shellfish fisheries. Sindh coast bottom is generally sandy and muddy. However, Balochistan coast is extended from Hub River to Iranian border about 734.5 km (Pakistan Navy, 2016), this coast

* Corresponding author: muhsanabbasi@yahoo.com
0030-9923/2023/0001-0001 $ 9.00/0

also has mangroves ecosystem at Sonmiani (Miani Hor), Kalmat and Gawater bay from which Sonmiani (Miani Hor) is the only place where diversity of mangrove species observed (Rasool *et al*., 2002). Balochistan coast bottom is uneven and its continental shelf starts just 10-30 n.m and about 200 m deep. Balochistan coastal waters bottom is generally rocky. Balochistan coast has Charna (border of Sindh and Balochistan) and Astola Islands which have coral reef ecosystem that provides breeding and nursery ground for many shellfish and finfish resources.

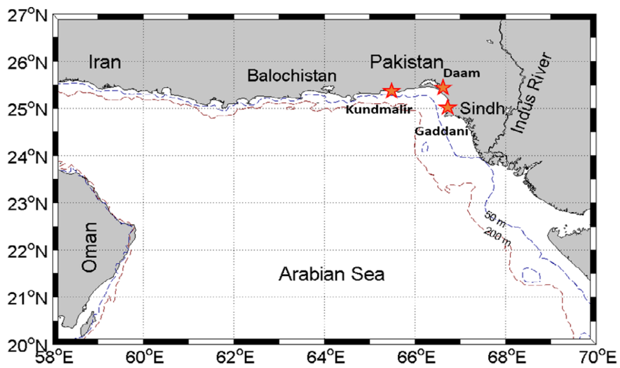

Fig. 1. Pakistan coastline showing Sindh and Balochistan coast, (*) stars indicating sampling sites with exclusive economic zone.

Queenfish is a popular name for the Scomberoidae family and found from tropical regions like Indian and Pacific Ocean, generally pelagic species and commonly found in estuaries and reefs commonly close to shore to offshore waters (Griffiths *et al*., 2005). The Talang queenfish (*Scomberoides commersonnianus*), the lesser queenfish (*Scomberoides lysan*), the barred queenfish (*Scomberoides tala*), and the needle skin queenfish (*Scomberoides tol*) commonly exists in *Scomberiodes* group. The Talang queenfish (*S. commersonnianus*), locally known as Saram which is mostly found in reefs and open waters generally in groups. Mostly inhabits at shelf area at water depths ranges 80–200 m, however in some areas juveniles occasionally grown-ups along the coast (Fischer and Bianchi, 1984). Number of studies have been conducted on length-weight relationship, stock assessment and population dynamics of finfish and shellfish using length frequency and fish catch (M.T) and efforts (number of fish boats) data applying different models and methods. The outcomes of those results indicating the stock status and reconmeded management steps to maintain the stock of different fish species from Pakistan (Kalhoro *et al*., 2013, 2014a, b, 2015a, b, 2017a, b, 2018; Memon *et al*., 2015, 2016; Afzaal *et al*., 2016, 2018; Nadeem *et al*., 2017; Razzaq *et al*., 2019; Baloch *et al*., 2020; Majeed *et al*., 2022; Ahmed *et al*., 2022). However, few studies on biological aspects and stock evaluation of Talang queenfish have been conducted from worldwide like Australia (Griffiths *et al*., 2005), Iran (Masoomizadeh *et al*., 2018) and Kenya (Mbaru *et al*., 2010). Though, limited work on length-weight relationship, stock analysis, fecundity and feeding habits have been conducted from Pakistan (Panhwar *et al*., 2013a, b, 2014; Qamer *et al*., 2018; Azam and Naeem, 2021). Study on population dynamics, size composition, growth and mortality parameters are significant parameters for the fisheries management (Asadi *et al*., 2017). Fisheries are living resources and could be utilized for long term if exploited at sustainable way. It is important to evaluate the status of fisheries stock and environmental factors to regulate the fisheries resource. Pakistan maritime and interior fishing resources are abundant which needs to be managed at sustainable way.

Fisheries statistical data of catch and values of different fish groups from Balochistan coast was 555309.098 Matric tons (M.T) while value was Rs. 83233.29 (Million) during 2018 to 2021. However, total quantity (M.T) and value (Rs.) of Talang queenfish was 18067.82 (M.T) and Rs. 2018.28 (Million), respectively (Fig. 2). Fisheries statistically data indicates that there is significant share of Talang queenfish catch and value which specifies the economic important of this species from Balochistan coast, Pakistan (Balochistan Fisheries Department, 2022). Overall fish catch is in species groups while Talang queenfish catch is separately indicated shows the economic importance of this fish species from Balochistan coast, Pakistan (Fig. 2). However, in contrast limited work has been done on the stock status of Talang queenfish from Pakistan, particullay from Balochistan coast, which is about 73% coast of Pakistan (Pakistan Navy, 2016).

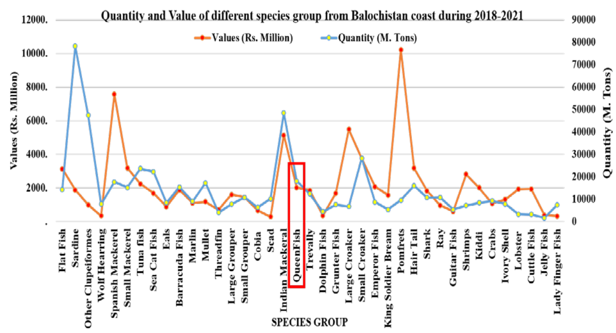

Fig. 2. Fisheries statistical quantity (M.T) and value (Rs. Million) data of different species groups and Talang queenfish catch and values (Red Box) from Balochistan coast, Pakistan during 2018-2021.

In this content present study is focus on to evaluate the status of commercially important Talang queenfish species. Estimation of fish stock and production potential was crucial for better fishery management and important tool for the sustainable use of fishery resources (Pauly and Manuro, 1984; Issac, 1990; Bramick, 2002). Current study is to evaluate the population dynamics i.e. length-weight relationship, growth parameters, growth performance index, exploitation rate and mortality parameters of this species from Balochistan coast, Pakistan. The findings should be applied for better fishery and recommend some management steps to maintain the stock of this commercially important fish species from Balochistan, Pakistan.

MATERIALS AND METHODS

Sample collection and analysis

The fish samples were collected from three landing sites i.e., Gaddani, Sonmiani (Daam) and Kundmalir from April to December, 2022 from Balochistan coast, Pakistan (Fig. 1). Length-weight and length frequency distribution data were gathered, length was measured as total length (TL) in cm and weight were taken in g. Length frequency samples during different months were measured in April 202, May 229, August 250, September 252, October 218, November 233 and in December 251. Total of 1635 length frequencies were collected from Balochistan coast to study the growth, mortality and exploitation rate. However, total of 603 pair of length-weight relationship were measured from which 200 pairs from Sonmiani Daam, 203 Gaddani and 200 from Kundmalir site. Daam, Sonmiani has MianiHor which receives seasonal freshwater from different Rivers that creates mangrove ecosystem which provides shelter and nursery grounds for the fin and shellfish fishery. Bottom of the MianiHor is muddy and sandy. Small and large size of fishing boats are operating from this area and have small jetty for fish landing. While, Gaddani area is located near to Hub River, bottom of this area is sandy and rocky. However, Kundmalir is famous clean beach area from which number of fishing boats operating, and coastal area bottom is generally sandy and rocky.

Length-weight relationship

The length-weight relationship was calculated by the equation $W = aL^b$, wherever a is the conditional factor, b is the slope, L indicate the TL and W indicate the weight in g (Le-Cren, 1951; Froese, 2006).

Growth parameters

Growth parameter were estimated using length frequency distribution data (n = 1635) in to von Bertalanfy growth function (VBGF) applying in length frequency analysis (ELEFAN) method using equation:

$$L_t = L_\infty(1 - \exp(-k(t - t_0)))$$

Where L_∞ is length infinity, K is growth curve and t is magnitude of age and t_0 is theoretical age at zero (Haddon, 2011) which were determined by Paulys (1983) formula:

$$log_{10}(-t_0) = -0.3922 - 0.275\log_{10} L_\infty - 1.038\log_{10} k$$

Mortality parameters

Length converted catch curve method was used to calculate the total mortality (Z) applying length frequency data (n=1635). Pauly's empirical equations was used to analyze natural mortality (M):

$$\log_{10}(M) = -0.006 - 0.279\log_{10} L_\infty + 0.654\log_{10}(K) + 0.6434\log_{10}(T)$$

L∞ and K was used to estimate the natural fish death (M), where K signifies VBGF growth parameters and T denotes yearly average sea surface temperature (26°C). While, fishing mortality was estimated as F =Z-M. The exploitation rate (E) was assessed through E = F / Z, in this formula F is fishing mortality and Z is total mortality (Pauly, 1983).

Performance index of growth

Pauly and Munro (1984) equation was used to determine the performance growth index (ϕ') of Talang queenfish from Balochistan coast, Pakistan:

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

RESULTS

Length frequency analysis

Total of 1635 length frequency distribution data from April to December 2022 were collected during present study. Length frequency were assembled in 5 cm length class interval ranging from 21 to 105 cm (TL). The length class of 31-60 cm showed the largest number of frequency (Fig. 3).

Length-weight relationship

Overall, 603 pair of length-weight relationships with minimum and maximum length and weight ranging from 19-104±16.84 cm and 0.54-5071±1203 g, respectively. Total of 200 pairs with minimum and maximum length and weight ranging from 19-104±16.72 cm to 0.54-5071±1156.52 g, respectively from Sonmiani Daam, 203 pairs from Gaddani with ranging from 20-89±15.39 cm TL and 0.56-7560±1221.31 g, respectively, and 200 from Kundmalir ranging from 19-103±18.17 cm 5060-0.48±1229.55 g, respectively.

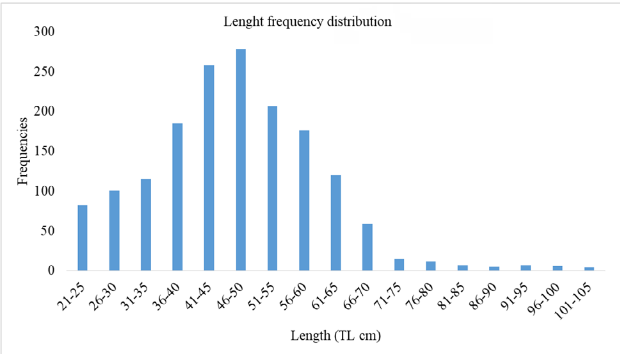

Fig. 3. Length frequency distribution with 5 cm (TL) length interval of Talang queenfish from Balochistan, Pakistan during 2022.

However, length-weight relationship slope '*b*' was calculated from Daam, Sonmiani as W = 0.0018 $TL^{3.287}$ with R^2 = 0.827 (Fig. 4A). Whereas, slope '*b*' values from Gaddani were W = 0.0013 TL $^{3.384}$ (R2=0.819) (Fig. 4B) and slope '*b*' values from Kundmalir was W = 0.0008 $TL^{3.487}$ (R^2=0.819) (Fig. 4C). All combine data results from Balochistan coast were determined as W = 0.0013 $TL^{3.377}$ (R^2=0.82) (Fig. 4D).

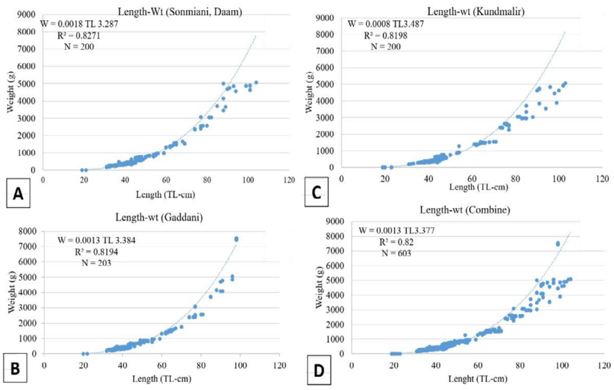

Fig. 4. a, b, c, d. Length-weight relationship from Sonmiani Daam (A); W = 0.0018 $TL^{3.287}$ (R^2 = 0.827) (B); Gaddani was W = 0.0013 $TL^{3.384}$ (R^2=0.819), (C) Kundmalir, W = 0.0008 $TL^{3.487}$ (R^2=0.819), (D); Combine, W = 0.0013 $TL^{3.377}$ (R^2=0.82) from Balochistan during 2022.

Growth parameters

The length frequency distribution data (n=1635) were used into VBGF growth curve applying electronic length frequency analysis (ELEFAN) method to estimate the growth rate parameters. The estimated length infinity (L∞) was 106.05 cm (TL) and growth curve (*K*) was 0.58, the black and white bars showing positive and negative deviation of length ranges (length measured and length predicted) and curves signify the fish length over time (Fig. 5). The theoretical age at zero was estimated as t_0= -1.620, and the growth performance index was estimated as ɸ'= 3.814 during present study.

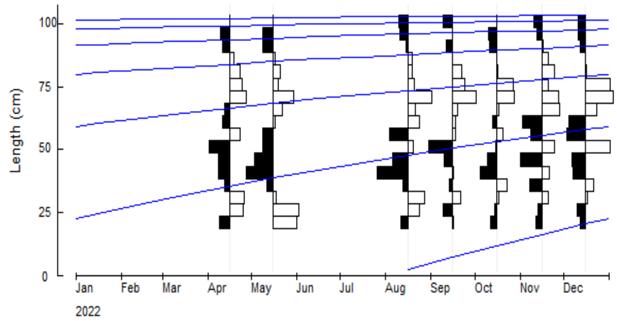

Fig. 5. Growth parameters using electronic length frequency analysis (L∞=106.05 yr^{-1}, K = 0.58 yr^{-1}), the black and white bars showing positive and negative deviation of length ranges (length measured and length predicted by software) and curves signify the fish length over time from Balochistan coast, Pakistan during 2022.

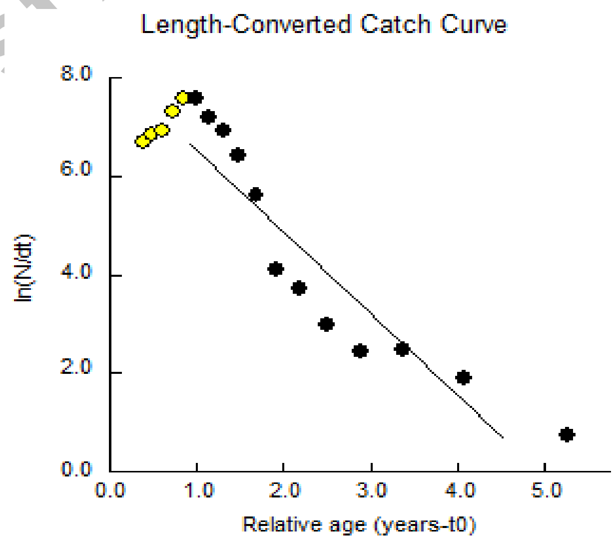

Fig. 6. Length converted catch method used to estimate total mortality (Z=1.65yr^{-1} with confidential interval =1.18 to 2.13), the black dots were selected to calculate mortality though, yellow dots indicating small size fishes and those were excluded from estimation from Balochistan coast, Pakistan during 2022.

Mortality parameters

Length converted catch curve method was used applying length frequency data (n=1635) from Balochistan coast. The total mortality (Z) was evaluated as Z= 1.65 with confidential interval at CI=1.18-2.13. The black dots selected to calculate mortality, yet yellow dots were indicating small size class of fish which were excluded from estimation (Fig. 6). Whereas, natural mortality (M) was calculated using Pauly empirical formula applying average sea surface temperature at 26 °C from Pakistani waters. The natural mortality was estimated as M= 0.848 though, fishing mortality (F) was estimated as F=Z-M =0.802 and in continues the exploitation rate (E) was estimate as F/Z=0.486.

DISCUSSION

Length-weight relationship

Length-weight relationship is the basic information to understand the population structure and stock evaluation of fish (Attia, 2018; Kalhoro *et al*., 2014). Stock assessment is the part of fisheries sciences that studies the stock status as well as possible outcomes for better fishery management. The outcomes indicates that the stock is overexploited or below or above the catch limit. Basic purpose of stock assessment is to provide advice on the optimum exploitation of aquatic living resources (Sparre and Venema, 1992). The overall values from all sites of Balochistan coast indicating the fish has isometric growth rate. The slope *b* values from different locations from Balochistan like Daam was 3.287, Gaddani 3.384, Kundmalir, 3.487 indicating similar pattern of growth and isometric growth, however little change in values maybe catching method or time of sample collection make difference in values. While, the combine slope '*b*' value in the current study was *b*=3.377 (R^2= 0.82), is indicating that fish has isometric growth from Balochistan, Pakistan.

The results of earlier investigations from various parts of the world were compared to the current study (Table I). The value from Pakistan (Azam and Naeem, 2021; Panhwar *et al*., 2014), Australia (Griffiths *et al*., 2005), and from Iran (Masoomizadeh *et al*., 2018) were lower or close to present study. Though, results from Kenya was higher than the current study (Mbaru *et al*., 2010). Although, majority of slope *b* values are comparable to or close to current studies (Table I). During present study the data was gathered from different locations and different time interval from Balochistan coast. Fishermen caught fish by using different fishing methods from inshore and offshore waters which may change in length and weight ranges from Balochistan coast. Based on this phenomena the change in result may be possible, however there is little difference in values to previous findings. However, greater values of slope *b* indicates that Pakistani waters biotic and abiotic factors are more suitable for the growth of this species which may cause of change in values. This slight difference in slope *b* values could be the reason of various factors that impact on the growth rate (length and weight) of fish or collection time and number of samples analyzed (Froese, 2006; Baloch *et al*., 2020; Majeed *et al*., 2022; Kalhoro *et al*., 2014).

Growth parameters

The von Bertalanffy growth function (VBGF) method was introduced by Von Bertalanffy (1938) predict the length and growth of fish. It is simplest method to estimate growth parameters using length frequency data. Estimation of fish stock and production potential was crucial for sustainable use and better fishery management (Bramick, 2002). Knowledge of fish population structure is beneficial for the better fishery resources planning and decision. The productivity of fish stocks in water body was primarily affected by human activities and population growth. Maximum length size, length-weight relationship, growth, mortality and exploitation rate characteristics of population dynamics that simplify the population change (Spare and Venema, 1992).

Table I. Length-weight relationship values compared with earlier findings.

Area	Sex	a	b	R^2	References
Pakistan	Both(TL)	0.001	2.53	0.996	Azam and Naeem, 2021
Australia	Both (FL)	0.05	2.791	0.989	Griffiths *et al*., 2005
Australia	Male (FL)	0.05	2.762	0.998	Griffiths *et al*., 2005
Australia	Female (FL)	0.05	2.813	0.99	Griffiths *et al*., 2005
Pakistan	Both (TL)	0.011	2.88	0.952	Panhwar *et al*., 2014
Kenya	Both (TL)	-6.722	3.633	0.918	Mbaru *et al*., 2010
Iran	Both (FL)	0.011	2.88	0.90	Masoomizadeh *et al*., 2018
Pakistan	Both (TL)	0.0013	3.377	0.82	Present work

Table II. Growth rate parameters results also compared with previous studies conducted from different areas of the world.

Area	Sex	Length ($L\infty$ (cm)	Growth (K)	t_0	ϕ'	Ref
Australia	Both (FL)	119.69	0.151	-0.518		Griffiths *et al*., 2005
Australia	Male (FL)	113.60	0.161	-0.577		Griffiths *et al*., 2005
Australia	Female (FL)	128.65	0.136	-0.503		Griffiths *et al*., 2005
Pakistan	Both (TL)	136.5	0.25	-0.139	3.67	Panhwar *et al*., 2014
Iran	Both (FL)	-	1.971	1.984		Masoomizadeh *et al*., 2018
Iran	Male (FL)	-	2.607	1.984		Masoomizadeh *et al*., 2018
Iran	Female (FL)	-	2.159	1.984		Masoomizadeh *et al*., 2018
Pakistan	Both (TL)	106.05	0.58	-1.620	3.814	Present Study

FL, fork length; TL, total length.

During present study the ELEFAN method was used to estimate the growth parameters applying length frequency distribution data and most of the previous studies used the same method (Table II). Present study findings ($L\infty$= 106.05yr^{-1} (TL) and K= 0.58yr^{-1}) were also compared with previous studies from different regions of the world (Table II). Length infinity ($L\infty$) and growth rate parameters (K) are correlated with each other, higher the K values are usually lower the $L\infty$ values and vice versa (Pauly and Morgan, 1987). Which indicates that fish grows faster during the earlier stage of life (Sparre and Venema, 1998). Mostly fish stock assessment is estimated using length frequency distribution data (Sparre and Venema, 1998) because the age-structure method using otoliths and scales are more difficult and laborious to collect reading (annuli) and interpret data (Morales-Nis and Panfili, 2005). Overall, length were measured in TL and FL and in centimeters from the previous studies of different regions compared with present findings. Difference in values may be because of sample size and measurement methods. However, study conducted from Pakistani waters (Panhwar *et al*., 2014) in which length was measured in TL similar to the present study (Table II). The growth parameter values from Australia and Iran (Griffiths *et al*., 2005; Masoomizadeh *et al*., 2018) are higher than current findings or close to the current study. Several ecological, biological factors, sample collection methods, fishing method by fishermen and time for sample collection that may have impact on fish growth. While, growth parameters from Pakistan (Panhwar *et al*., 2014) are smaller to current findings but $L\infty$ value is greater than the present study. This may be due to biotic and abiotic factors or time of sampling effecting on the fish growth. The t_0 values are close to the values from Iranian waters (Masoomizadeh *et al*., 2018). However, the growth performance index during present study was ϕ'= 3.814 which is close to previous study from Pakistan (Panhwar *et al*., 2014) (Table II). Population dynamics have features such as growth rate, mortality rate, maximum length, length-weight connection parameters, and exploitation rate that aid in population development. Fish catches are becoming less varied, which is a sign that stocks are declining (Welcomme, 2001). The difference in values with current study also may be because of collecting methods, sampling time and localities.

Mortality parameters

Mortality defines as the loss of fish from fish populations due to certain reasons in natural waters during definite intervals. The fish mortality composed of natural and fishing mortalities, natural causes could be defined in many ways like predation, ecological biotic and abiotic factors, pollution and diseases while, fishing mortality is defined the fish mortality by the human activities using different catching methods. The calculated mortality parameters were estimated at, the total mortality Z=1.65yr^{-1}, natural as M=0.848 yr^{-1}, and fishing as F=0.802 yr^{-1} were. However, the exploitation rate was E=0.486 yr^{-1} during present study. The obtained results were also compared with previous studies conducted from different areas of the world (Table III).

Table III. Mortality parameters and exploitation rate compared with earlier studies from different regions of the world.

Area	Z	M	F	E	References
Pakistan	1.17	0.4	0.76	0.45	Panhwar *et al*., 2014
Australia	0.484	0.213	-	-	Griffiths *et al*., 2005
Pakistan	1.65	0.848	0.802	0.486	Current Study

Z, total mortality; M, natural mortality; F, fishing mortality.

Mortality rate parameters (Z, M and F) were also compared with previous findings from different regions like from Pakistan were 1.17, 0.4 and 0.76 yr^{-1} respectively (Panhwar *et al*., 2014). While, from Australia were Z= 0.484 and M= 0.213 (Griffiths *et al*., 2005). Current study using length converted catch curve predicted the higher mortality rates in smaller fish size classes during the age of 2–3 years. Overall values from other parts of the world are close and similar with current studies. The exploitation rate values during present study were E=0.486 which is higher than previous study from Pakistan (Panhwar *et al*., 2014). Conferring to Patterson (1992) the exploitation rate must be sustained at 0.4yr^{-1} level. The current values (E=0.486) are higher than the suggested standard values which indicate that the stock of Talang queenfish is in stress condition and high exploitation state. The exploitation rate values conducted from Pakistani waters are lower than the current study indicate that the fishing pressure on this commercially important fish species has increase from 0.45 to 0.486 yr^{-1}. These findings indicates that this species is more overexploited in recent findings compared to previous study (Panhwar *et al*., 2014). Due to this reason the fishing pressure for this commercially important fish species may be reduces, as recommended for sustainable use (Patterson, 1992).

The variation in results may also be due to the growth pattern, which differs according to sexes, length classes and seasons. It may also be caused by the time of sample collection and sampling sites. During Panhwar *et al*. (2014) study the fish samples were collected from Karachi fish harbor, Pakistan however, current study samples were collected from Balochistan coast may cause in change in mortality and exploitation results. It is well known that sampling time, sampling method and fishing method from different regions may change the values. The findings of higher exploitation rate during current study also indicates the increasing economic importance of this species. Due to that it also increases the fishing pressure on this commercially important fish species from Balochistan coast. In nature, maintaining the growth pattern over an individual lifespan is uncommon. This phenomena is influenced by variables like seasonal shifts, geographic location, sex, species type, rate of eating, and environmental conditions specific to the species (Bagenal, 1978; Kalhoro *et al*., 2014).

CONCLUSION

Present study on population dynamics and stock appraisal of Talang queenfish (*Scomberoides commersonnianus*) was conducted from Balochistan coast, Pakistan. The length-weight relationship values indicate the fish has isometric growth pattern from Pakistani waters. While, present study also compared with previous findings showing the same growth pattern which indicates that Pakistani waters are also very much suitable for the growth of this species. Whereas, growth parameters are different from previous studies it may be because of time and collection method and study area for the sampling change the values. The size may be vary depend on the fishing technology used from different localities directly influences the results of growth parameters. The variation in results may also cause by biotic and abiotic factors effecting on the fish growth. Furthermore, the mortality parameters and exploitation rate is also close and similar to previous studies conducted from other regions. While, exploitation values during present study (E=0.486) is slightly higher then then previous findings conducted from Pakistani waters (E=0.45) indicate that the trend of fishing pressure particularly for this commercially important fish is increasing maybe because of increasing commercial importance in local and international markets. Based on present finding it may also advised that the fishing pressure may be reduced for the sustainable use of this species from Balochistan, Pakistan. It may also be suggested that fishing practices may also be monitored time to time to avoid illegal, unreported and unregulated (IUU) fishing activities in Pakistani waters. Fishing net with larger mesh size maybe used to protect the smaller size of fish species so they grow up to mature stage in order to breed once in their life span. Fishing ban period should be set on the species group according to their breeding season. It may also be suggested that the vessel monitoring system (VMS) should be installed on every vessel to monitor fishing boat activities. Government agencies should allocate the catch quota system for each fishing boat owner and control the registration of new fishing vessels. Based on scientific knowledge marine protected areas (MPAs) must be declared to protect the nursery grounds of fisheries. Further studies should be conducted on maturity stage and spawning season to set the fishing ban season for this species. Government agencies should ban on trawling to reduce the bycatch killing of non-targeted species and save seafloor habitat. It is also recommended that continuous stock monitoring maybe conducted along with other biotic and abiotic factors influence on fish stock. Government should give incentives to the fishermen for better livelihood particularly during fishing ban period. Government should also promote marine aquaculture to reduce the fishing pressure on wild fisheries. All stakeholders and government agencies should work together for well fishery management.

ACKNOWLEDGMENT

The authors are grateful to worthy Vice Chancellor Prof. Dr. Dost Muhammad Baloch, Lasbela University of Agriculture, Water and Marine Sciences, Uthal. Author would like to thank Prof. Dr. Muhammad Aslam, Dean Faculty of Marine Sciences and other laboratory technical staff. First author also likes to thank Pakistan Agriculture Research Council (CARI) Lasbela, Balochistan for providing opportunity for further studies and technical support.

Funding

The present work was supported by Higher Education Commission (HEC) funded project of National Research Program for Universities awarded to Dr. Muhsan Ali Kalhoro. No: 7508/Balochistan/NRPU/R&D/HEC/2017.

IRB approval

All fish samples were collected according to instructions of Animal Ethics Committee of Lasbela University of Agriculture, Water and Marine Sciences (LUAWMS), Faculty of Marine Sciences, Uthal, Pakistan.

Ethical statement

The study was approved from Committee of University of Agriculture, Water and Marine Sciences (LUAWMS), Uthal, Pakistan. Notification. 0135/Notif/REG-ACAD/LUAWMS/339-3403 Dated:09-12-2022.

Statement of conflict of interest

The authors have declared no conflict of interest.

REFERENCES

Afzaal, Z., Kalhoro, M.A., Buzdar, M.A., Nadeem, A., Saeed, F., Haroon, A. and Ahmed, I., 2016. Stock assessment of blue swimming crab *Portunus pelagicus* (Linnaeus, 1758) from Pakistani waters (northern Arabian Sea). *Pakistan J. Zool*., **48**: 1531-1541.

Afzaal, Z., Kalhoro, M.A., Buzdar, M.A., Tariq, S., Shafi, M., Nadeem, A., Imran, S., Saeed, F., Sohail, M., Hassan, R., Haroon, A., Shah, H. and Ahmed, I., 2018. Carapace length-weight and carapace length-width relationship of blue swimming crab from Pakistani waters*. Indian J. Geo-Mar. Sci.*, **47**: 890-896.

Ahmed, F., Balach., Liang, Z., Zhu, L., Liu, C., Kalhoro, M.A. and Shaikh, S., 2022. Length-weight relationship of three commercially important fish species from Balochistan coast, Pakistan. *J. Anim. Pl. Sci*., **32**: 1423-1429. https://doi.org/10.36899/JAPS.2022.5.0549

Asadi, H., Sattari, M., Motalebi, Y., Zamani-Faradonbeh, M. and Gheytasi, A., 2017. Length-weight relationship and condition factor of seven fish species from Shahrbijar River, Southern Caspian Sea basin, Iran. *Iran. J. Fish. Sci.*, **16**: 733-741.

Attia, A.O.A., 2018. Growth, mortality and yield per recruit of the Shrimp Scad (*Alepes djedaba*) From Mediterranean Coast of Sinai Egypt. *Abbassa Int. J. Aquat.,* **11**: 86-108.

Azam, S.M. and Naeem, M., 2021. Proximate body composition of talang queenfish (*Scomberoides commersonnianus* Lacépède, 1801) from Pakistan. *Sarhad J. Agric*., **38**: 204-209. https://doi.org/10.17582/journal.sja/2022/38.1.204.209

Bagenal, T.B. and Braum, E., 1978. Eggs and early life history. In: *Methods of assessment of fish production in fresh waters* (ed. T. Bagenal). IBP Handbook 3, Blackwell Scientific, Oxford, pp. 165-201.

Baloch, A., Zhang, K., Kalhoro, M.A., Memon, A.M., Kalhoro, M.T., Buzdar, M.A., Shafi, M., Saeed, F., Sohail, M. and Razaaq, S., 2020. Preliminary investigations on stock analysis of Tigertooth Croaker (*Otolithes ruber*) from Balochistan coast, Pakistan. *J. Anim. Pl. Sci.,* **30**: 1309-1318. https://doi.org/10.36899/JAPS.2020.5.0149

Balochistan Fisheries Department., 2022. *Statistical Data of Balochistan Fisheries Department, 2021*. https://balochistan.gov.pk/departments/fisheries/#1667897037862-e2671c60-6972. Tables for data, https://balochistan.gov.pk/wp-content/uploads/2020/08/FISHERIES.pdf

Bramick, U., 2002. *Estimation of the fish yield potential of lake in north-east Germany* (ed. I.G. Cowx) Blackwell Science, Iowa.

FAO, 2009. *Fishery and aquaculture profile*. FAO's Fisheries Department, Rome, pp. 18.

Fisher, W. and Bianchi, G., 1984. *FAO species identification sheets for fishery purposes, Western Indian Ocean (Fishing Area 51)*, FAO of the United Nations, Rome. (1984) Vol. 1, Clup Sardl. 3.

Froese, R., 2006. Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *J. appl. Ichthyol*., **22**: 241–253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Griffith, Sh, Fry. G. and Van Der Velde, T., 2005. *Age, growth and reproductive dynamics of the Talang queenfish* (Scomberoides commersonnianus) *in Northern Australia.* CSIRO, Cleveland.

Haddon, M., 2011. *Modeling and quantitative methods* *in fisheries*. 2nd edition, Chapman & Hall/CRC, New York, London. pp. 449.

ISSAC, V.J., 1990. The accuracy of some length-based methods for fish population studies. *ICLARM Tech. Rep*., **27**: 81.

Kalhoro, M.A., Liu, Q., Memon, K.H., Chnag, M.S. and Jatt, A.N., 2013. Estimation of maximum sustainable yield of Bombay duck, *Harpodan nehersus* fishery in Pakistan using the CEDA and ASPIC packages. *Pakistan J. Zool*., **45**: 1757-1764.

Kalhoro, M.A., Liu, Q., Memon, K.H., Waryani, B. and Soomro, S.H., 2015a. Maximum sustainable yield of greater lizardfish *Saurida tumbil* fishery in Pakistan using CEDA and ASPIC packages, *Acta Oceanol. Sin*., **34**: 68-73. https://doi.org/10.1007/s13131-014-0463-0

Kalhoro, M.A., Liu, Q., Valinassab, T., Waryani, B., Memon, K.H. and Abbasi, A.R., 2015b. Population dynamics of Greater lizardfish *Saurida tumbil* from Pakistani waters. *Pakistan J. Zool*., **47**: 47-55.

Kalhoro, M.A., Liu, Q., Waryani, B., Memon, K.H., Chang, M.S. and Zhang, K., 2014a. Population dynamics of Japanese threadfin bream *Nemipterus japonicas* from Pakistani waters. *Acta Oceanol. Sin*., **33**: 1-9. https://doi.org/10.1007/s13131-014-0401-1

Kalhoro, M.A., Liu, Q., Waryani, B., Panhwar, S.K. and Memon, K.H., 2014b. Growth and mortality of brushtooth lizardfish *Saurida undosquamis* from Pakistani waters. *Pakistan J. Zool*., **46**: 139-151.

Kalhoro, M.A., Tang, D., Ye, H.J., Morozov, E., Liu, Q., Memon, K.H. and Kalhoro, M.T., 2017a. Population dynamics of Randall's threadfin bream *Nemipterus randalli* from Pakistani waters, northern Arabian Sea. *Indian J. mar. Sci*., **46**: 551-561.

Kalhoro, M.A., Tang, D., Ye, H.J., Morozov, E., Wang, S. and Buzdar, M.A., 2018. Fishery appraisal of family Portunidae *Portunus* spp. using different surplus production models from Pakistani waters, northern Arabian Sea. *Pakistan J. Zool*., **50**: 135-141. https://doi.org/10.17582/journal.pjz/2018.50.1.135.141

Kalhoro, M.T., Yongtong, M., Kalhoro, M.A., Mahmood, M.A., Hassan, S.S.B., Muhammad, M. and Tushar, P.R., 2017b. Stock assessment of Indian Scad, *Decapterus russelli* in Pakistani waters and its impact on national economy. *Fish. Aquacult. J*., **8**: 1-10. https://doi.org/10.4172/2150-3508.1000200

Le-Cren, E.D., 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in Perch (*Perca fluviatilis*). *J. Anim. Ecol*., **20**: 201-219. https://doi.org/10.2307/1540

Majeed, A., Liang, Z., Zhu, L., Liu, C., Kalhoro M.A. and Saeed. F., 2022. Stock analysis of shrimp scad (*Alepes djedaba*) fishery from Northern Arabian Sea, Balochistan coast. Pakistan. *Pakistan J. Zool*. **54**: 2203-2212. https://doi.org/10.17582/journal.pjz/20210329070315

Masoomizadeh, S.Z, Pazooki, J. and Valinassab, T., 2018. Changes in length weight relationship and condition factor of Talang queenfish (*Scomberoides commersonnianus*) in the north-west Persian Gulf. *Iran. J. Fish Sci*., **17**: 118-136.

Mbaru, E.K., Mlewa, C.M. and Kimani, E.N., 2010. Length–weight relationship of 39 selected reef fishes in the Kenyan coastal artisanal fishery. *Fish. Res*., **106**: 567–569. https://doi.org/10.1016/j.fishres.2010.09.012

Memon, K.H., Liu, Q. Kalhoro, M.A. Baradi, W. and Nabi, A., 2016. Estimation of growth and mortality parameters of croaker *Atrobucca alcocki* from Pakistani water. *J. Agricult. Sci. Tech.*, **18**: 669-679.

Memon, K.H., Liu, Q., Kalhoro, M.A. Mirjat, A.N. Chang, M.S., 2015. Stock assessment of lesser tiger toothed croaker *Otolith cuvieri* from northern Arabian Sea. *Indian J. mar. Sci.* **44**: 63-68.

Morales-Nin, B. and Panfili, J., 2005. Seasonality in the deep sea and tropics revisited: What can otolith tell us? *Mar. Freshw. Res*., **56**: 585-598. https://doi.org/10.1071/MF04150

Nadeem, A., Kalhoro, M.A., Buzdar, M.A., Tariq, S., Shafi, M., Afzaal, Z., Shah, H., Saeed, F., Haroon, A. and Ahmed, I., 2017. Growth, mortality and exploitation rate of *Sardinella longiceps* (Valenciennes, 1847) from Pakistani waters based on length frequency distribution data. *Indian J. Geo-Mar. Sci*., **46**: 1693 -1703.

Pakistan Navy, 2016. *Notification, calculation of Pakistan coastline.* Hydrography Department, Navel Headquarters, 11, Liaquat Barrackers, Karachi. Notification, No. HD/0628/11/938/12 April 2016.

Panhwar, S.K., Qamar, N., Jahangir, S., 2014. Fishery and stock estimates of Talang queenfish, *Scomberoides commersonnianus* (Fam: Carangidae) from the Arabian sea coast of Pakistan. *Pak. J. agric. Sci.,* **51**: 1111-1116.

Panhwar, S.K. and Liu, Q., 2013b. Population statistics of the migratory Hilsa shad, *Tenualosa ilisha* in Sindh Pakistan. *J. appl. Ichthyol*., **29**: 1091-1096. https://doi.org/10.1111/jai.12134

Panhwar, S.K., Siddiqui G. and Ayub. Z., 2013a. Growth, mortality and stock assessment of kelee shad, *Hilsa kelee* (Fam: Clupeidae) in the coastal waters of Pakistan. *J. Ichthyol.,* **53**: 365-371. https://doi.org/10.1134/S0032945213030168

Patterson, K., 1992. Fisheries for small pelagic species: An empirical approach to management targets. *Rev. Fish Biol. Fish*., **2**: 321-338. https://doi.org/10.1007/BF00043521

Pauly, D. and Morgan, G.R., 1987. *Length based methods in fisheries research*. ICLARM Conference Proceeding 13, International Center for Living Aquatic Resources Management, Manila, Philippine.

Pauly, D. and Munro, J.I., 1984. Once more on the comparison of growth in fish and invertebrates. *Fish Byte*, **2**: 21-23.

Pauly, D., 1983. Some simple methods for the assessment of tropical fish stocks. *FAO Fish. Tech. Pap*. *Rome*, **234**: 52.

Pauly, D., 1985. *Quelques méthodes simples pour l'estimation des stocks de poissons tropicaux*. FAO Doc. Tech. Pêches, pp. 5

Pauly, D., 1997. *Small-scale fisheries in the tropics: Marginality, marginalization, and some implications for fisheries management* (eds. E.K. Pikitch, D.D. Huppert and M.P. Sissenwine). American Fisheries Society, Bethesda, MD,

Qamar, N., Panhwar, S.K. and Riede, R., 2018. Feeding patterns of two commercially important fish species *Scomberoides commersonnianus* and *S. tol* in the Northern Arabian Sea. *Pakistan J. Zool*., **50**: 941-949. https://doi.org/10.17582/journal.pjz/2018.50.3.941.949

Rasool, F., Tunio, S., Hasnain, S.A. and Ahmad, E., 2002. Mangrove conservation along the coast of Sonmiani, Balochistan. *Trees*, **16**: 213–217. https://doi.org/10.1007/s00468-001-0151-5

Razaaq, S., Kalhoro, M.A., Memon, A.M., Buzdar, M.A., Shafi, M. and Buzdar, F., 2019. Fishery stock assessment of *Megalaspis cordyla* by using non equilibrium surplus production models in the Arabian Sea coast of Pakistan. *J. Anim. Pl. Sci*., **29**: 132-140.

Spare, P. and Venema, S.C., 1992. Introduction to tropical fish stock assessment. *FAO Fish. Tech. Paper*, Rome, Italy. vol. 306.

Sparre, P. and Venema, S.C., 1998. Introduction to the tropical fish stock assessment. *Manual FAO Fish. Tech. Rep., Rev. 2, Rome*, **306**: 407.

UN., 2015. *United Nations accepts Pakistan's demand for extending sea limit to 350 nautical miles.* March 21, 2015. Case submitted by National Institute of Oceanography, Government of Pakistan. MZN (Maritime Zone Notifications) Released on 08/09/2016. Circular Communications from the Division for Ocean Affairs and The Law of the Sea Office of Legal Affairs. https://niopk.gov.pk/docs/6.pdf

Von Bertalanffy, L., 1938. A quantitative theory of organic growth (Inquiries on growth laws II). *Human Biol.,* **10**: 181 -213.

Welcomme, R.L., 2001. *Inland fisheries: Ecology and management*. Blackwell Publishing Ltd. https://doi.org/10.1002/9780470995693