



Research Article

Volume-06|Issue-02|2026

Stock Assessment and Management of Klunzinger's Mullet, *Planiliza Kluzengeri* in The East Hammar Marsh, IraqEntisar K. Hamed¹, Abdul-Razak M. Mohamed^{2*}, Jassim M. Abed³

Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah, Iraq

Article History

Received: 16.03.2026

Accepted: 21.04.2026

Published: 30.04.2026

Citation

Hamed, E. K., Mohamed, A. R. M., Abed, J. M. (2026). Stock Assessment and Management of Klunzinger's Mullet, *Planiliza Kluzengeri* in The East Hammar Marsh, Iraq. *Indiana Journal of Agriculture and Life Sciences*, 6(2), 38-47.

Abstract: For management of fish stocks, assessing the various parameters of population dynamics, including growth, mortality rates, probability of capture, recruitment pattern, yield per recruit, and virtual population analysis of *Planiliza kluzengeri*, inhabiting the Hammar marsh, was analysed using FiSAT II software. A sampling of *P. kluzengeri* was conducted from November 2022 to October 2023, where 2,337 individuals ranging from 11.0 to 23.0 cm were examined. The length-weight relationship expressed with $W = 0.011 * TL^{3.013}$ exhibited isometric growth. The asymptotic length (L_{∞}), growth constant (K), age at zero length (t_0) and growth performance index (ϕ') were reported to be 27.0 cm, 0.70, -0.12 and 2.708, respectively. Mortality estimates indicated total mortality (Z) at 4.46, natural mortality (M) at 1.37, and fishing mortality (F) at 3.09, resulting in an observed exploitation rate (Eobs) of 0.69. The length at first capture was higher than that at first maturity. Recruitment continued throughout the year, with one major peak in May. The virtual population analysis (VPA) revealed that most catches of the species happened between 15 and 23 cm. The analysis of relative yield per recruit and relative biomass per recruit indicated that the Eobs were below the biological target reference points for the species, E0.1 and Emax. So it is essential to establish management measures to increase the mesh sizes of the fishing nets and protect the feeding grounds in this marsh from illegal fishing.

Keywords: *Planiliza kluzengeri*, Growth and mortality, Recruitment, Yield-per-recruit, Iraq.

Copyright © 2026 The Author(s): This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY-NC 4.0).

INTRODUCTION

The family Mugilidae inhabits the Indo-Pacific region and currently consists of about 24 genera and 75 valid species (Fricke and Fong, 2025). The Klunzinger's mullet *Planiliza klunzingeri* (Day, 1888) belongs to this family, living in the Western Indian Ocean: Arabian Gulf to the western coast of India. It forms schools in shallow coastal waters and enters lagoons, marshes, estuaries, and the lower courses of rivers to feed (Randall, 1995; Çiçek *et al.*, 2023). *P. klunzingeri* is a detritivorous species that feeds on detritus, diatoms, algae, higher plants, zooplankton, and fish (Mohamed *et al.*, 2009; Mohamed and Abood, 2021; Mohamed and Al-Hassani, 2023).

The *P. klunzingeri* was formerly placed in the genus *Liza*, but Durand *et al.* (2012) included it within the genus *Planiliza*. The species is a widely distributed fish in Basrah province, south Iraq, both in marine and inland waters and is known as "Beyah". The species constituted 3.7% of the fish population in the East Hammar marsh (Mohamed *et al.*, 2012), 3.7% of the fish assembly in the Garmat Ali River (Mohamed *et al.*, 2013), 4.2% of the fish assemblage in the Shatt Al-Arab River (Al-Dubake, 2016), and 10.6% of the fish structure in the Shatt Al-Arab River (Mohamed and Abood, 2017). Mohamed and Abood (2024) reported that the total catch of mullet species, mainly *Planiliza subviridis* and *P. klunzingeri*, in 2023 represented about 9.7% of the

overall landings from Iraqi marine waters, the Arabian Gulf.

The population dynamics of *P. klunzingeri* have been described using FiSAT II software (FAO-ICLARM Stock Assessment Tools) by some authors, like Dadzie *et al.* (2005) in the Kuwait Bay, Arabian Gulf; Hakimelahi *et al.* (2010) and (2012) in the Iranian waters of the Arabian Gulf and Oman Sea; Mohamed and Abood (2020) in the Shatt Al-Arab River, Iraq; Al-Hassani and Mohamed (2021) in the Iraqi marine waters, Arabian Gulf and Ali *et al.* (2023) in the Balochistan coast, Pakistan.

Jennings *et al.* (2000) stated that the assessment of species population is essential to meet one of the main objectives of fishery science, involving maximizing yield to fisheries while safeguarding the long-term viability of populations and ecosystems. The present study is the first attempt to assess the stock of *P. klunzingeri* in the East Hammar Marsh, Iraq, so the growth parameters, mortality rates, probability of capture, recruitment pattern, yield per recruit, and virtual population analysis of the species in this marsh from November 2022 to October 2023 were assessed to provide decision-makers with advice on the alternative management to assist in the sustainable fisheries management strategies for the species in this marsh.

MATERIALS AND METHODS

Study site

The East Hammar Marsh is situated in the northern region of Al-Basra Province. It extends south of the Euphrates River and is bordered by the Shatt Al-Arab River to the east and the West Hammar Marsh to the west. The marsh measures approximately 33 km in length, with water depths ranging from 1.2 to 3.0 m, depending on the tides from the Arabian Gulf through the Shatt Al-Arab and Garmat Ali Rivers (Hussain and Sabbar, 2020). The aquatic vegetation in East Hammar Marsh comprises 43 species, distributed across 33 genera and 21 families. The dominant perennial species in the marsh are *Typha domingensis*, *Phragmites australis*, and *Schoenoplectus litoralis* (Sabar and Al-Saadi, 2020). Additionally, Mohamed *et al.* (2017) identified 47 fish species in the marsh, including 24 freshwater and 23 marine species, both native and non-native.

Fish sampling

Fish specimens were collected with the assistance of local fishermen from three locations: Al-Saddah, Al-Sallal, and Al-Nakara within the marsh (Fig. 1). A monthly sampling routine was implemented, during which fish samples were gathered from November 2022 to October 2023. The collection methods employed included drift gill nets, fixed gill nets, trammel nets, cast nets, and an electroshocking device.

Fish samples were collected monthly from three sites in the marsh (Fig. 1): Al-Saddah, Al-Sallal, and Al-Nakara, from November 2022 to October 2023. The specimens were obtained using drift gill nets, fixed gill nets, trammel nets, cast nets with diameters of 4 to 7 m and a mesh size of 35 mm, and an electroshocking device (230V, 10A). The water temperature was measured using a graduated mercury thermometer (0-100°C). After collection, the specimens were transported on ice in a cooler box to the laboratory for biometric analysis.

Data Analysis

In the laboratory, the total length (TL) of all *P. kluzengeri* specimens was measured to the nearest millimetre (mm) using a standard measuring board. Monthly length-frequency data were used in the FiSAT II software (FAO-ICLARM Stock Assessment Tool) version 1.2.2, outlined by Gayanilo *et al.* (2005), after the division of the length-frequency data into a 1.0 cm class interval.

Subsample from the fish was taken and the total length (TL) and body weight (W) were recorded to the nearest 1 mm and 0.1 g, respectively. The length at 50% maturity (L_{m50}) was designed using the following equation (Binohlan and Froese, 2009): $\log(L_{m50}) = -0.1189 + 0.9157 * \log(L_{max})$, where L_{max} is the largest individual observed in the samples.



Figure 1: Sampling sits of *P. kluzengeri* in the East Hammar Marsh.

The length-weight relationship (LWR) was determined by the least squares method on the logarithmically transformed data using the equation $W = aL^b$, where W is the total weight, L is the total length, and a and b are parameters to be estimated (Le Cren, 1951). A significant deviation of the slope (b) was tested from the value (3) through Student's t -test, with values of $p < 0.05$ considered significant (Froese, 2006). All the calculations were done by using Microsoft Office Excel 2010.

The best growth curve was then fitted based on the initial value for L_{∞} obtained from the formula $L_{max}/0.95$ in the K-Scan analysis. The initial seed value set at $L_{\infty} = 16.60$ cm ($L_{max}/0.95$) in the K-Scan analysis. The ELEFAN-I module in the FiSAT II was used to estimate growth parameters like asymptotic length (L_{∞}) and growth coefficient (K). The initial seed value for L_{∞} ($L_{max}/0.95$) is used as a seed value in the ELEFAN I program (Pauly, 1984) to estimate the best combination of L_{∞} and K . The theoretical age at (t_0) was calculated according to the following relationship (Pauly, 1983):

$$\log_{10}(-t_0) = -0.3922 - 0.275 \log_{10}L_{\infty} - 1.0381 \log_{10}K$$

Based on these parameters (L_{∞} and K) determined, the growth performance index (ϕ') was calculated from the following formula (Pauly and Munro, 1984):

$$\phi' = \log_{10}(K) + 2\log_{10}(L_{\infty})$$

The length-converted catch curve method incorporated in the FiSAT package estimated the instantaneous total mortality (Z), and the natural mortality (M) for the species calculated using the following empirical equation (Pauly, 1980):

$$\log_{10} M = -0.0066 - 0.279 \log_{10} L_{\infty} + 0.6543 \log_{10} K + 0.463 \log_{10} T$$

where K is the growth coefficient, L_{∞} is the asymptotic length and T is the mean temperature of the water body. Fishing mortality (F) was calculated by deducting natural mortality (M) from total mortality (Z). The observed exploitation (E_{obs}) was computed using the formula $E_{cur} = F / Z$ (Sparre and Venema, 1998).

The probability of capture was approximated by backward extrapolation of the regression line of the descending limb of the length-converted catch curve. The inbuilt logits method was used to derive the length values at capture at probabilities of 0.25% (L_{c25}), 0.5% (L_{c50}), and 0.75% (L_{c75}), where L_{c50} represents the length at first capture (Pauly 1984).

Growth parameters (L_{∞} and K) and length-frequency data were used as inputs to estimate the month-wise recruitment pattern incorporated in the FiSAT package. The graph's peaks and troughs reflect the monthly recruitment (Pauly, 1983).

The relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) at various fishing levels were estimated using the FiSAT II package. This was done through the Beverton and Holt model (1966), which was modified by Pauly and Soriano (1986) using knife-edge analysis. The data of L_c/L_{∞} and M/K values were used to estimate the biological reference points, including $E_{0.1}$, $E_{0.5}$, and E_{max} . $E_{0.1}$ represents the exploitation rate at which the marginal increase in relative yield per recruit approaches 10%. $E_{0.5}$ indicates the exploitation rate that reduces the stock to 50% of its unexploited biomass, while E_{max} signifies the maximum sustainable exploitation rate. The observed exploitation rate (E_{obs}) and the biological target reference points ($E_{0.1}$ and E_{max}) were used to indicate the stock status (Cadima, 2003).

The fishing mortality for each length group, the reconstructed population (in numbers), and the mean stock biomass by length class were done using the length-structured virtual population analysis, VPA (Jones and van Zalinge, 1981) incorporated in the FiSAT package. The input parameters in the VPA analysis were L_{∞} , K, M, F and the constants of the length-weight relationship (a and b).

RESULTS

Length-frequency distribution

Figure 2 illustrates the length-frequency distribution of 2,337 *P. kluzengeri* individuals measured with a total length range of 11.0 to 23 cm. The lengths of 16 and 17 cm dominated the population, representing 25.9 and 23.5%, respectively. The length groups from 15-18 cm constituted 80.0% of the total catch.

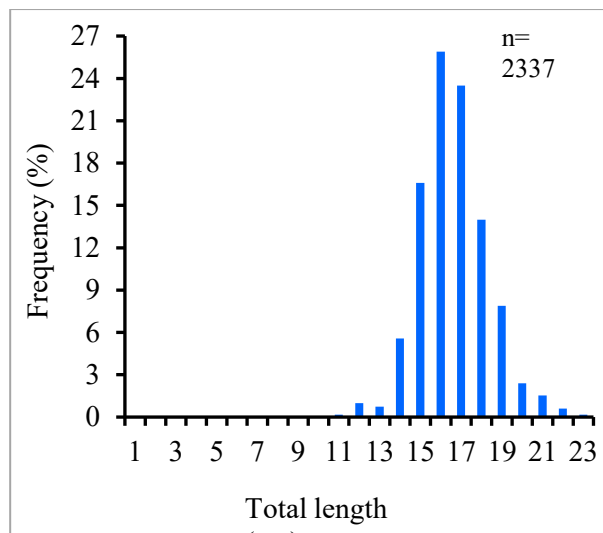


Figure 2: The overall length-frequency distribution of *P. kluzengeri*

Length-weight relationship

A total of 1,268 specimens of *P. kluzengeri* were analyzed to determine the length-weight relationship (Fig. 2). The total length of the species ranged from 11.6 to 23.1 cm, and the weight varied from 20.8 to 132.0 g. The length-weight relationship was described by the equation $W = 0.011TL^{3.013}$. The calculated b-value differed significantly from 3 ($t = 0.519$, $p < 0.05$), indicating that the species exhibits isometric growth.

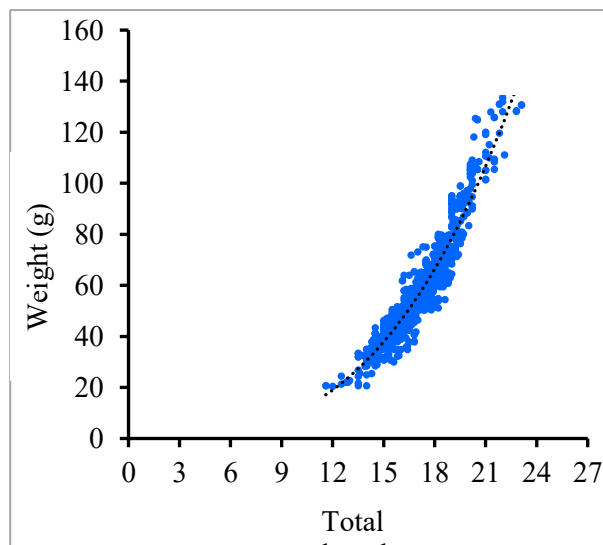


Figure 4: The length-weight relationship of *P. kluzengeri*

Growth model

Samples of 2,336 specimens of *P. kluzengeri* were used to describe the growth parameters: asymptotic length (L_{∞}) and growth coefficient (K) using the ELEFAN I module in the FiSAT software, based on an initial seed value of L_{max} (23.1 cm). The greatest estimate of the R_n value selected from the reconstructed length-frequency curve was 0.383 (Fig. 5). The reconstructed length frequency of the species with superimposed

growth curves is illustrated in Figure 6. The asymptotic length (L_{∞}) was estimated as 27.0 cm and the growth rate (K) was 0.70 per year. The estimated age at zero length (t_0) was -0.12 years and the growth performance index (Φ') was computed to be 2.708. The growth equation of von Bertalanffy of *P. klunzengeri* was derived as follows:

$$L_t = 27.0 [1 - e^{-0.70(t + 0.12)}].$$

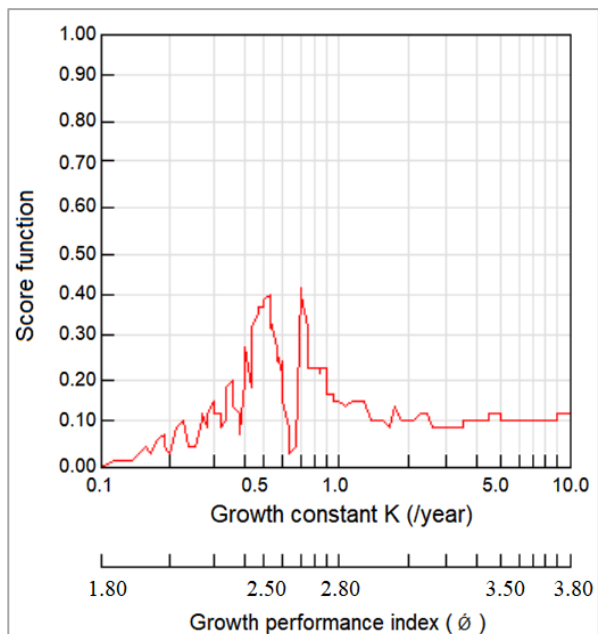


Figure 5: K-scan routines of *P. klunzengeri*

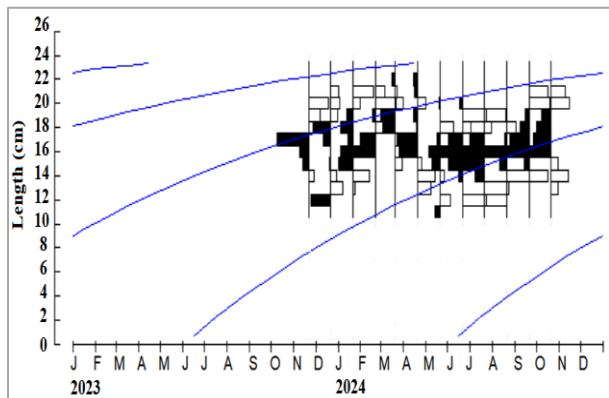


Figure 6: Restructured length-frequency distribution with growth curves superimposed using ELEFAN-1 for *P. klunzengeri*

Mortality parameters

Figure 9 presents the linearized length-converted catch curve used to estimate the instantaneous total mortality rate (Z) of *P. klunzengeri*. The estimated value of Z was 4.46, while the natural mortality rate was 1.37. Consequently, the fishing mortality rate was estimated to be 3.09, and the observed exploitation (E_{obs}) was 0.69.

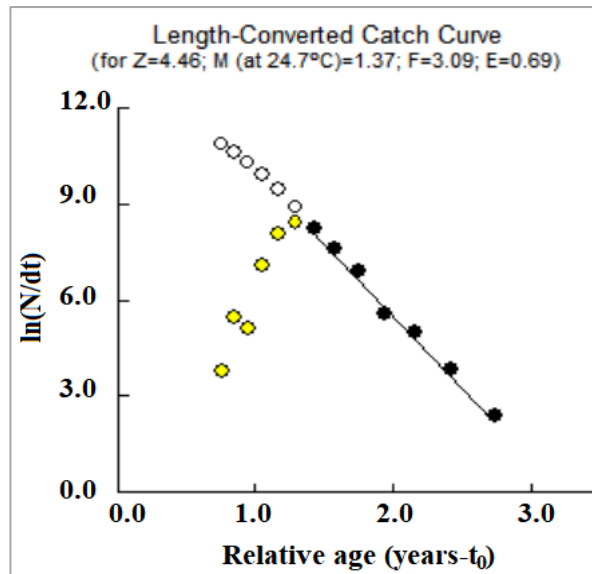


Figure 7: Length converted catch curve for estimation of Z for *P. klunzengeri*

Length at First Capture

Figure 8 shows the probabilities of capturing *P. klunzengeri* at different lengths: L_{25} , L_{50} , and L_{75} were estimated at 15.07, 15.80 and 16.53 cm, respectively (Fig. 5). Consequently, the length at first capture (L_{c50}), which is the length at which 50% of the fish population becomes vulnerable to fishing was determined to be 15.80 cm. In contrast, the total length at which *P. klunzengeri* first reaches sexual maturity (L_{m50}) was 13.5 cm.

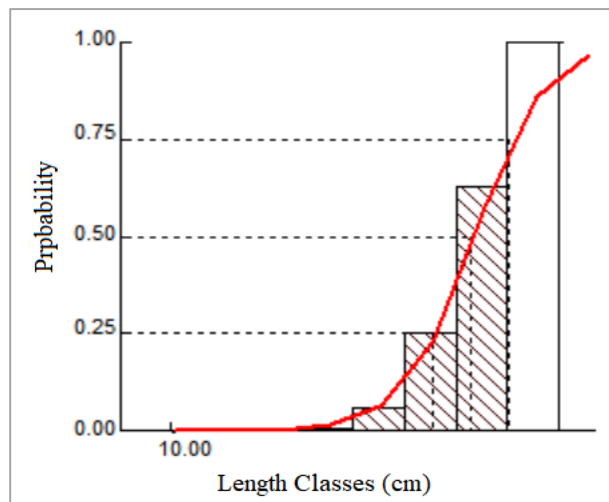


Figure 8: Probability of capture for *P. klunzengeri*

Recruitment pattern

In the present study, the recruitment pattern of *P. klunzengeri* displays only one prominent peak in May (Fig. 7). Recruitment varied from 0.47% in October to 23.61% in May. The most recruitment extended from March to August accounting for 85.24% of the total recruitment.

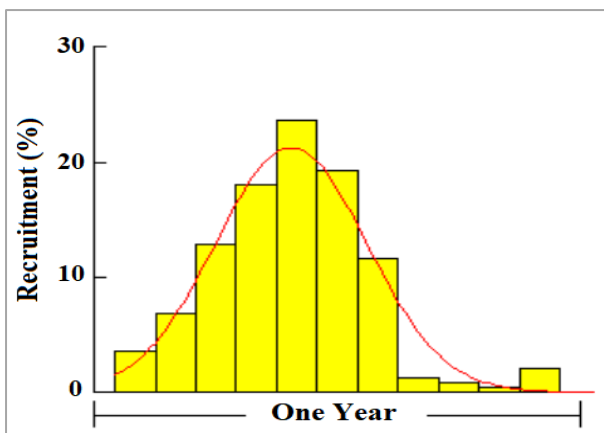


Figure 9: Recruitment pattern of *P. kluzengeri*

Virtual population analysis

Table 1 explains the outputs of the length-structured virtual population analysis (VPA), which includes data on length classes, catch numbers, population size, fishing mortality and steady-state biomass. The highest number of catches for the species occurred at lengths of 15 to 18 cm, while the largest population size was found in individuals measuring 11 cm. Most of the fishing mortality of the individuals occurred at lengths of 17-22 cm, while the greatest biomasses were observed in lengths of 11 to 18 cm.

Table 1: FiSAT II output of virtual population analysis of *P. kluzengeri*

Mid-Length	Catch (in numbers)	Population (N)	Fishing mortality (F)	Steady-state Biomass (tons)
11	4	6350.41	0.0075	0.01
12	23	5615.26	0.046	0.01
13	17	4906.62	0.0364	0.01
14	130	4250.39	0.3046	0.01
15	388	3535.66	1.0611	0.01
16	605	2646.7	2.1981	0.01
17	549	1664.62	3.1272	0.01
18	327	875.11	3.3405	0.01
19	184	414	3.8127	0
20	56	163.89	2.3969	0
21	36	75.88	3.2964	0
22	14	24.91	3.7305	0
23	4	5.77	3.09	0

The virtual population analysis (VPA) revealed a declining trend in the number of surviving fish as their length increased (Fig. 8). Fish groups smaller than 14.0 cm have the highest survival rates, and the primary losses in the fish stock up to this size are attributed to natural causes. However, fishing mortality increased sharply for fish larger than 15 cm, and most catches happened between 15 and 23 cm (Fig. 5).

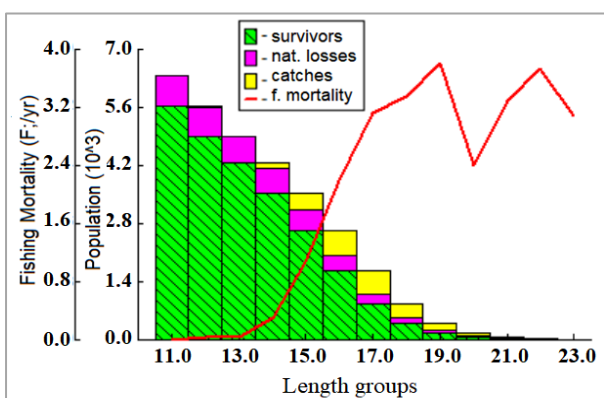


Figure 11: Length-structured virtual population analysis of *P. kluzengeri*

The knife-edge selection routine implemented in the FiSAT software was utilized to calculate the Beverton-Holt relative yield per recruit (Y'/R) and relative biomass per recruit (B'/R) for *P. kluzengeri* (Fig. 8). The calculated Y'/R and B'/R based on the input data which included an M/K ratio of 1.96 and an $LC/L\infty$ ratio of 0.59, were 0.031 and 0.215, respectively. Additionally, the biological target reference points for the species were determined, yielding $E_{0.1}$, $E_{0.5}$ and E_{max} values of 0.808, 0.394, and 0.964, respectively.

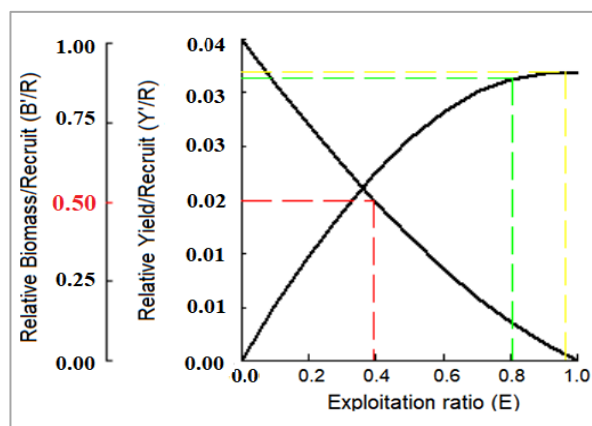


Figure 10: Relative yield per recruit (Y'/R) and biomass per recruit (B'/R) analyses

Yield per Recruit (Y'/R) and Biomass per Recruit (B'/R)

DISCUSSION

The main objective of fisheries science is to provide recommendations to decision-makers regarding effective management strategies. These recommendations may include predictions on how fish stocks and fishers will respond to varying levels of management (King, 2007). In the current study, the total length of *P. klunzengeri* ranged from 11.0 to 23.0 cm. This range exceeds those previously reported by Dadzie *et al.* (2005) in Kuwait Bay, Arabian Gulf (2.0-21.0 cm), Hakimelahi *et al.* (2010) in the Iranian waters of the Arabian Gulf and Oman Sea (12.1-17.8 cm), and Ali *et al.* (2023) along the Balochistan coast of Pakistan (10.0-21.0 cm). However, it is similar to the range Mohamed and Abood (2020) reported in the Shatt Al-Arab River, Iraq (9.6-23.0 cm). Notably, Al-Hassani and Mohamed (2021) reported *P. klunzengeri* from Iraqi marine waters in the Arabian Gulf, with a total length range of 11 to 27 cm. The size variation in fish may result from differences in climate change, biotic and abiotic factors, population density, food availability, and fishing efforts (Nikolsky, 1963; Takar *et al.*, 2022).

The growth coefficient (b) derived from the LWR provides insight into a fish's growth pattern. An ideal b value is 3, which indicates isometric growth. Values of b less than 3 suggest negative allometric growth, while values greater than 3 indicate positive allometric growth (Riedel *et al.* 2007). In this study, the calculated b value was 3.013, suggesting that the body shape remains constant as the fish grows, signifying isometric growth. Abou-Seedo *et al.* (2002) stated that *P. klunzengeri* collected from Kuwait Bay, Arabian Gulf between 1982

and 1999 showed isometric length-weight relationships in February/March and September/October/November. However, several researchers (e.g. Hakimelahi *et al.* 2010; Al-Hassani and Mohamed, 2021; Mohamed, 2022; Ali *et al.* 2023) have also reported negative allometric growth in *P. klunzengeri* from different waters. The factors affecting the b value in fish include environmental variables, gonadal development, sex, food availability, stomach fullness, health, stress, and sampling techniques (Ricker, 1975; Froese, 2006; Cuadrado *et al.*, 2019).

The growth parameters of *P. klunzengeri* in various studied regions, analysed using FiSAT II software, are presented in Table 2. The asymptotic length (L_{∞}) recorded in this study is comparable to the value reported by Mohamed and Abood (2020). Still, it is higher than those noted by Dadzie *et al.* (2005), Hakimelahi *et al.* (2010), and Ali *et al.* (2023). Additionally, Al-Hassani and Mohamed (2021) reported an even higher L_{∞} value for *P. klunzengeri* in the Iraqi marine waters of the Arabian Gulf. In the present study, the growth coefficient (K) and the growth index (\emptyset') for *P. klunzengeri* were found to be higher than the values reported for this species in other regions (Table 2). The K value, however, was similar to that stated by Ali *et al.* (2023) in the Balochistan coast, Pakistan. The growth of the same species in different waters is significantly influenced by several decisive factors, including habitat type, ecological conditions, food availability, metabolic and reproductive activities, fish sizes, sampling techniques, and fishing pressure (Spare and Venema, 1998; Allen and Hightower, 2010; Wootton, 2011; Panda *et al.*, 2018).

Table 2: The results of the FiSAT analyses for *P. klunzengeri* in different ecosystems.

Author	L_{∞} (cm)	K	\emptyset'	L_{c50}	Z	M	F	E	Location
Dadzie <i>et al.</i> (2005)	24.8	0.46	2.45	4.8	4.64	1.16	3.48	0.75	Kuwait Bay, Arabian Gulf
Hakimelahi <i>et al.</i> (2010)	22.0	0.6	2.39	-	2.31	1.09	1.22	0.52	Iranian waters of the Arabian Gulf and Oman Sea
Mohamed and Abood (2020)	27.0	0.49	2.62	14.0	3.16	1.09	2.07	0.66	Shatt Al-Arab River, Iraq
Al-Hassani and Mohamed (2021)	29.8	0.34	2.48	15.2	1.19	0.84	0.36	0.30	Northwestern Arabian Gulf, Iraq
Ali <i>et al.</i> (2023)	22.05	0.70	2.53	17.3	2.23	1.59	0.73	0.31	Balochistan coast, Pakistan
Present study	27.0	0.70	2.71	15.8	4.46	1.37	3.09	0.69	East Hammar marsh, Iraq

The size at first capture (L_{c50}) for *P. klunzengeri* in this study falls within the range reported for the species in other geographic locations (Table 2). According to Ali *et al.* (2023), the highest L_{c50} value was observed along the Balochistan coast in Pakistan. The L_{c50} value in fish is affected by the types of nets used and their mesh sizes (Beverton and Holt, 1966; Ofori-Danson *et al.*, 2018; Amponsah *et al.*, 2021). The study found that *P.*

klunzengeri reaches sexual maturity, indicated by the length at which 50% of the individuals are mature (L_{m50}), at a size of 13.5 cm. Abou-Seedo and Dadzie (2004) reported that in the waters of Kuwait in the Arabian Gulf, male *P. klunzengeri* reached L_{m50} at a length between 13.1 cm and 17.0 cm, while females reached L_{m50} at lengths ranging from 14.1 cm to 18.0 cm. Additionally, Hashemi *et al.* (2013) determined that the L_{m50} of *P. klunzengeri* in

the coastal waters of Khuzestan in the Arabian Gulf was 15.4 cm. The results show that *P. klunzingeri* is vulnerable to fishing after first sexual maturity, providing opportunities for reproduction and long-term population regeneration (Udoh and Ukpatu, 2017; Panda *et al.*, 2018).

The total mortality (Z), natural mortality (M), fishing mortality, and current exploitation (E_{cur}) rates for *P. klunzingeri* observed in this study fall within the ranges previously reported for this species in various regions (Table 2). The highest rates for total mortality (Z), fishing mortality (F), and observed exploitation (E_{obs}) were recorded in Kuwait Bay, Arabian Gulf (Dadzie *et al.*, 2005). In contrast, the highest rate of natural mortality (M) was noted along the Balochistan coast in Pakistan (Ali *et al.*, 2023). Conversely, the lowest values for all these rates were observed in the Iraqi marine waters of the Arabian Gulf (Al-Hassani and Mohamed, 2021). Mortality rates can vary among species that inhabit different water bodies, influenced by factors such as fishing activity, growth rates, and prey availability. The fishing effort and catchability coefficient may affect the fishing mortality (F) value as a direct result of fishermen's activities (Sparre and Venema, 1998). Additionally, natural mortality is influenced by various environmental and biological factors, including water temperature, salinity, migratory behavior, predation, food availability, and diseases (Allen and Hightower, 2010; Björnsson *et al.*, 2022; Campos *et al.*, 2023, 2024). The optimal exploitation rate for healthy fish stocks is set at 0.5, with values below 0.5 indicating underexploitation and values above 0.5 suggesting overexploitation (Pauly, 1980). In this study, the observed exploitation ratio (E_{obs}) of *P. klunzingeri* was found to be 0.69, which exceeds the threshold of 0.5, indicating that the population is overexploited.

Recruitment refers to the number of individuals added to a harvestable fishery stock over a specific period, playing a crucial role in regulating fish populations (Camp *et al.*, 2020). In this study, the recruitment pattern of *P. klunzingeri* was throughout the year, with a notable peak in May. This pattern aligns with findings from Mohamed and Abood (2020) in the Shatt Al-Arab River, Iraq, Al-Hassani and Mohamed (2021) in the Iraqi marine waters of the Arabian Gulf, and Ali *et al.* (2023) along the Balochistan coast in Pakistan. Additionally, Dadzie *et al.* (2005) noted two unequal peaks in the recruitment pattern of *P. klunzingeri* in Kuwait Bay, Arabian Gulf. The main factors influencing fish recruitment include food availability and favourable weather conditions (Gebrekiros, 2016; Nissar *et al.*, 2024).

The Virtual Population Analysis (VPA) is widely used to assess fisheries. It helps reconstruct historical populations of species by age or length, using data on individual deaths that occur each year. These deaths are typically categorized into catches by fisheries

and natural mortality. This information allows us to estimate the population that must have been present in the water to produce the observed catch (Sparre and Venema, 1998; Shepherd and Pope, 2002; Baharti, 2017). In the current study, small groups of less than 13.0 cm had the highest survival rates because they could escape the net's mesh. The primary loss in the fish stock measuring up to 14 cm was attributed to natural causes, whereas the fishing mortality increased sharply for fish larger than 15 cm, and the bulk of catches happened between 15 and 23 cm. Al-Hassani and Mohamed (2021) found that the natural mortality of *P. klunzingeri* was highest among individuals with lengths of 11 to 14 cm in the Iraqi waters, Arabian Gulf, and most of the fish were harvested between 14 cm and 19 cm. Mohamed (2022) reported that the natural losses of *P. klunzingeri* occurred at lengths between 10 and 14 cm, while the most exploited length groups in the fishery were 15-22 cm.

The yield per recruit (Y/R) and biomass per recruit (B/R) analyses were used to establish reference points and assess the exploitation status of the species. Biological reference points act as performance indicators for the exploited stock and consider various stock dynamics parameters, including growth, recruitment, and mortality, and are encapsulated in a single index (Collie and Gislason, 2001; Cadima, 2003). In the current study, the M/K value was found to be within the range suggested by Beverton and Holt (1993), specifically between 1.0 and 2.5. The observed exploitation ratio (E_{obs}) of *P. klunzingeri* was 0.69, which is lower than both the biological reference points: $E_{0.1} = 0.808$ and $E_{max} = 0.964$. This suggests that the fish is underexploited, according to Cadima (2003), even though E_{obs} is higher than the optimal level of exploitation (0.5) as defined by Pauly (1980).

CONCLUSION

The present information on the population status of *P. klunzingeri* may help in the decision-making process for developing conservation plans and sustainable utilization of the fish resources in the marshes. The lengths of individuals were within the lengths for the species recorded from other waters. The species exhibited isometric growth pattern. L_{∞} and K values were comparable to those reported from different regions. The recruitment of the species continued throughout the year, with one major peak. The E_{obs} rate was lower than the $E_{0.1}$ and E_{max} , indicating that the stock of this species is underexploited. Length at first capture L_{c50} was higher than length at first maturity L_{m50} , indicating that they may be vulnerable to capture by the available fishing gear after they mature, which has met the criteria for good management ($L_{c50} < L_{m50}$). Therefore, for management purposes, more yields could be obtained by increasing the fishing activities on this species for a substantial harvest.

ACKNOWLEDGEMENTS

The authors thank the Department of Fisheries and Marine Resources, College of Agriculture, University of Basrah for providing the essential research facilities required for this study.

REFERENCES

1. Abou-Seedo, F., Otieno, M.J. & Dadzie, S. (2002). Length-weight relationship, condition factor and gonadosomatic index of *Liza klunzingeri* (Day, 1888) in Kuwait Bay: comparison of data from 1980s and 1990s. *Zoology in the Middle East*, 25, 37-47.
2. Abou-Seedo, F.S. & Dadzie, S. (2004). Reproductive cycle in the male and female grey mullet, *Liza klunzingeri* in the Kuwaiti water of the Arabian Gulf. *Cybium*, 28(2), 97-104.
3. Al-Dubakel, A.Y. (2016). Analysis of Natural Food Composition of Fishes in Shatt Al-Arab River, Southern Iraq. *Jordan Journal of Biological Sciences*, 9(2), 89-96.
4. Al-Hassani, A.J. & Mohamed, A.R.M. (2021). Population dynamics of Klunzinger's mullet, *Planiliza klunzingeri* (Day, 1888) from northwest Arabian Gulf, Iraq. *Asian Journal of Fisheries and Aquatic Research*, 13(4), 25-36. DOI: 10.9734/AJFAR/2021/v13i430272.
5. Ali, W., Shafi, M., Saher, N., Muhammad, A.A., Farooq, S., Majeed, S., Eido, M., Hashemi, S.A.R. & Yousuf, B. (2023). Population dynamics parameters in *Planiliza klunzingeri* (Day, 1888) from Balochistan coast, Pakistan. *International Journal of Biology and Biotechnology*, 20(3), 527-534.
6. Allen, M. S. & Hightower, J. E. (2010). Fish population dynamics: mortality, growth, and recruitment, In: *Inland fisheries management in North America*, 3rd ed., (American Fisheries Society), pp. 43-79.
7. Amponsah, S., Amarquaye, N., Alaba, O. O. & Baset, A. (2021). Length-based population dynamics of Lesser African Threadfin (*Galeoides decadactylus*, Bloch, 1795) from the coastal waters of Ghana. *Journal of Wildlife and Biodiversity*, 5(2), 56-68. <https://doi.org/10.22120/jwb.2020.137846.1190>
8. Baharti, V. (2017). Virtual population analysis. In: Gopalakrishnan, A. (Ed), *Advanced Methods for Fish Stock Assessment and Fisheries Management*. Eds. Central Marine Fisheries Research Institute, Kochi, India. Pp. 232-237.
9. Beverton, R.J.H. & Holt, S.J. (1966). *Manual of methods for fish stock assessment. Part II. Tables of yield functions*. FAO Fisheries Biological Technical Paper, No. 38 (Rev. 1), 67p.
10. Beverton, R.J.H. & Holt, S.J. (1993) *On the dynamics of exploited fish populations*, volume 11, Springer, Dordrecht. 538 pp.
11. Binohlan, C. & Froese, R. (2009). Empirical equations for estimating maximum length from length at first maturity. *Journal of Applied Ichthyology*, 25(5), 611-613. <https://doi.org/10.1111/j.1439-0426.2009.01317.x>
12. Björnsson, B., Sólmundsson J. & Woods P.J. (2022). Natural mortality in exploited fish stocks: annual variation estimated with data from trawl surveys. *ICES Journal of Marine Science*, 79, 1569-1582. <https://doi.org/10.1093/icesjms/fsac063>
13. Cadima, E.L. (2003). *Fish stock assessment manual*. FAO Fisheries Technical Paper. No. 393. Rome, FAO. 161p.
14. Camp, E., Collins, A.B., Ahrens, R.N. & Lorenzen, K. (2020) *Fish Population Recruitment: what recruitment means and why it matters*. *EDIS* 2020(2), 1-6.
15. Campos, C.P., Bitar, S.D.B. & Freitas, C. (2023). Uncertainties regarding the natural mortality of fish can increase due global climate change. *PeerJ* 11, e14989 DOI 10.7717/peerj.14989
16. Campos, C.P., Inomatab, D.O., Inomatac, S.O., Bitar, S.D.B. & Freitas, C. (2024). Natural mortality of fish: a review. *Brazilian Journal of Biology*, 84, 1-11.
17. Çiçek, E., Jawad, L., Eagderi, S., Esmacili, H. R., Mouludi-Saleh, A., Sungur, S., & Fricke, R. (2023). *Planiliza klunzingeri* in freshwater fishes of Iraq: a revised and updated annotated checklist- 2023, pp. 1-49 in *Zootaxa* (Vol. 5357, Number 1, p. 32). Zenodo. <https://doi.org/10.5281/zenodo.10019238>
18. Collie, J.S. & Gislason, H. (2001). Biological reference points for fish stocks in a multispecies context. *Canadian Journal of Fisheries and Aquatic Sciences*, 58, 2167-2176. DOI:10.1139/F01-158.
19. Cuadrado, J.T., Lim, D.S., Alcontin, R.M.S., Calang, J.L. & Jumawan, J.C. (2019). Species composition and length-weight relationship of twelve fish species in the two lakes of Esperanza, Agusan del Sur, Philippines. *FishTaxa*, 4(1), 1-8.
20. Dadzie, S., Manyala, J. O. & Abou-Seedo, F. (2005). Aspects of the population dynamics of *Liza klunzingeri* in the Kuwait Bay. *Cybium*, 29(1), 13-20.
21. Durand, J.D., Chen, W.J., Shen, K.N., Fu, C. & Borsa, P. (2012). Genus-level taxonomic changes implied by the mitochondrial phylogeny of grey mullets (Teleostei: Mugilidae). *Comptes Rendus Biologies*, 335, 687-697.
22. Fricke, R. & Fong, J.D. (2025). *Eschmeyer's Catalog of Fishes. Species by family/subfamily*. (<http://researcharchive.calacademy.org/research/ichthyology/catalog/SpeciesByFamily.asp>). Online Version, Updated 14 Mar 2025.
23. Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22(4), 241-253. <https://doi.org/10.1111/J.1439-0426.2006.00805.X>

24. Gayanilo, F.C.Jr, Sparre, P. & Pauly, D. (2005). FAO-ICLARM Stock Assessment Tools II (FiSAT II). Revised version. User's guide. FAO Comp. Info. Ser. (Fisheries). 8: 1-168.
25. Gebrekiros S.T. (2016) Factors affecting stream fish community composition and habitat suitability. *Journal of Aquaculture and Marine Biology* 4(2), 00076.
26. Hakimelahi, M., Kamrani, E.1, Taghavi Motlagh, S.A., Ghodrati Shojaei, M. & Vahabnezhad, A. (2010). Growth parameters and mortality rates of *Liza klunzingeri* in the Iranian waters of the Persian (Arabian) Gulf and Oman Sea, using Length Frequency Data. *Iranian Journal of Fisheries Sciences*, 9(1), 87-96.
27. Hakimelahi, M., Taghavi Motlagh, S.A. & Vahabnezhad, A. (2012). Studies on the population dynamic and biology of Klunzinger's mullet (*Liza klunzingeri*) in Persian (Arabian) Gulf and Oman Sea. INOC-CNRS, International Conference on "Land-Sea Interactions in the Coastal Zone" Jounieh, Lebanon, 06-08 November -2012.
28. Hashemi, S.R., Kashi, M. & Safikhani, H. (2013). Study at the reproductive cycle, GSI and maturation of *Liza Klunzingeri* in Khuzestan coastal waters. *Journal of Novel Applied Sciences*, 2(2), 35-39.
29. Hussain, N.A & Sabbar, A.A (2020). Trophic levels of tidal and non-tidal Marshes of Southern Mesopotamia. *Basrah Journal of Agricultural Sciences*, 33(2), 172-181. <https://doi.org/10.37077/25200860.2020.33.2.15>.
30. Jennings, S., Kasier, M. & Reynold, J. (2000). Marine Fisheries Ecology. Blackwell Science, Oxford. 391p.
31. Jones, R. & van Zalinge, N.P. (1981). Estimations of mortality rate and population size for shrimp in Kuwait waters. *Kuwait Bulletin of Marine Sciences*, 2, 273-288.
32. King, M.M. (2007). Fisheries biology, assessment and management. 2nd ed. Blackwell Publishing Ltd.
33. Le Cren, E.D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology*, 20, 201–219.
34. Mohamed, A.R.M. (2022). Stock expectations and virtual population analysis of three mullet species in the Shatt Al-Arab River, Iraq". *Asian Journal of Fisheries and Aquatic Research*, 17(2), 28-41, 2022. <https://doi.org/10.26832/24566632.2021.060205>
35. Mohamed, A.R.M. & Al-Hassani, A.H. (2023). Food habits of two mullets inhabiting Iraqi marine waters, Northwest Arabian Gulf. *World Journal of Advanced Research and Reviews*, 2023, 17(02), 770–779. <https://doi.org/10.30574/wjarr.2023.17.2.0324>.
36. Mohamed, A.R.M. & Abood, A.N. (2024). The current status and recent trends of Iraqi marine fisheries in the northwest Arabian Gulf. *Indiana Journal of Agriculture and Life Sciences*, 4(1), 9-20. <https://doi.org/10.5281/zenodo.10722694>
37. Mohamed, A.R.M, Al-Saboonchi, A.A. & Raadi, F.K. (2017). Ecological assessment of East Hammar marsh, Iraq using a number of ecological guides. *JKAU: Marine Sciences*, 26(2), 11-22. <https://doi.org/10.4197/Mar.26-2.2>
38. Mohamed, A.R.M., Hussain, N.A., Al-Noor, S.S., Coad B.W. & Mutlak F.M. (2009). Status of diadromous fish species in the restored East Hammar marsh in southern Iraq. *American Fisheries Society Symposium*, 69, 577-588. <https://doi.org/10.47886/9781934874080.ch35>
39. Mohamed, A.R.M. & Abood, A.N. (2017). Compositional change in fish assemblage structure in the Shatt Al-Arab River, Iraq. *Asian Journal of Applied Sciences*, 5(5), 944-958.
40. Mohamed, A.R.M. & Abood, A.N. (2020). Population dynamics of three mullets species (Mugilidae) from the Shatt Al-Arab River, Iraq. *Journal of Agriculture and Veterinary Science*, 13(9), 22-31.
41. Mohamed, A.R.M. & Abood, A.N. (2021). Food and trophic relationships of four mullet fish (Mugilidae) in the Shatt Al-Arab River, Iraq. *Asian Journal of Applied Sciences*, 7(1), 19-26.
42. Mohamed, A.R.M., Hussein, S.A. & Mutlak, F.M. (2012). The status of the marine fish in the East Hammar marsh during 2005-2010. The first Scientific National Conference for Women Research, 12-13 December 2012. Ministry of Science and Technology, Baghdad, Iraq. Pp: 133-150.
43. Mohamed, A.R.M., Hussein, S.A. & L. F. Lazem. (2013). Fish assemblage of Garbat Ali River, north of Basrah, Iraq. *Basrah Journal of Agricultural Sciences*, 26(1), 150-166.
44. Nikolsky, G.V. 1963. The ecology of fishes. Academic Press, London and New York, 352 pp.
45. Nissar, S., Bakhtiyar, Y., Yousuf, T., Bhat, A.A. & Zuber, S.M. (2024). Stock assessment of rosy barb, *Pethia conchoni* (Hamilton, 1822) in Dal Lake of Kashmir Himalayas. *Journal of Fisheries*, 12(3), 1-10. <https://doi.org/10.17017/j.fish.572>.
46. Ofori-Danson, G.P.K., Addo, S., Animah, C.A., Abdulhakim A. & Nyarko J.O. (2018). Length at first capture (L_{C50}) of *Sardinella aurita* and *Sardinella maderensis* landed from purse seines at the Tema Fishing Harbour, Ghana. *International Journal of Fisheries and Aquatic Research*, 3(3), 08-13.
47. Panda, D., Mohanty, S.K., Pattnaik, A.K., Das, S. & Karna, S.K. (2018). Growth, mortality and stock status of mullets (Mugilidae) in Chilika Lake, India. *Lakes and Reservoirs: Science, Policy and Management for Sustainable Use*. (2018) 23, no. 1, 4-16, <https://doi.org/10.1111/lre.12205>, 2-s2.0-85044926061.
48. Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*, 39(3), 175-192.

49. Pauly, D. (1984). Fish population dynamics in tropical waters: A manual for use with programmable calculators. ICLARM Studies and Reviews No. 8. International Centre for Living Aquatic Resources Management, Manila, Philippines, 325 pp.
50. Pauly, D. (1983). Some simple methods for assessment of tropical fish stocks. FAO Fishery Technical Paper 234: 52.
51. Pauly, D. & Munro, J.L. (1984). Once more on the comparison of growth in fish and invertebrates. *ICLARM Fishbyte*, 2(1), 21.
52. Pauly, D. & Soriano, M.L. (1986). Some practical extensions to Beverton and Holt's relative yield-per-recruit model. In: J. L. Maclean; Dizon, L. B. and Hosillo, L. V. (Eds.). The First Asian Fisheries Forum. 491-496.
53. Randall, J.E. 1995. Coastal fishes of Oman. University of Hawaii Press, Honolulu, Hawaii. 439 p.
54. Ricker, W.E. (1975). Computation and interpretation of biological statistics of fish populations. *Bull. Fish. Res. Bd. Canada*, 191, 1-382.
55. Riedel, R., Caskey, L.M. & Hurlbert, S.H. (2007). Length-weight relations and growth rates of dominant fishes of the Salton Sea: implications for predation by fish-eating birds. *Lake and Reservoir Management*, 23, 528-535. <https://doi.org/10.1080/07438140709354036>
56. Sabar, A.A. & Al-Saadi, S.A.A. (2020). Biodiversity of aquatic plants in the East Hammar marshes in Iraq. *Plant Archives*, 20, 2299-2305.
57. Shepherd, J. G. & Pope, J.G. (2002). Dynamic pool models I: Interpreting the past using Virtual Population Analysis. In: Hart, P.J.B. & Reynolds, J.D. (Eds.). Handbook of Fish Biology and Fisheries. Vol. 2. Fisheries. Oxford, UK: Blackwell Science. pp. 127-136.
58. Sparre, P. & Venema, S.C. (1998). Introduction to tropical fish stock assessment. Part 1. Manual. FAO fisheries technical paper. No. 306. 1, Rev. 2. FAO, Rome, Italy. 407 p.
59. Takar, S., Jawahar, P., Gurjar, U.R., Kingston, S.D., Neethiselvan, N., Pereira, J.J. & Jagadis, I. (2022). Population dynamics of *Meretrix casta* (Gmelin, 1791) along Thoothukudi, Gulf of Mannar, India. *Indian Journal of Geo Marine Sciences*, 51(07), 618-624. DOI: 10.56042/ijms.v51i07.51654
60. Udoh, J. P. & Ukpatu, J. E. (2017). First estimates of growth, recruitment pattern and length-at-first-capture of *Nematopalaemon hastatus* (Aurivillius, 1898) in Okoro River estuary, southeast Nigeria. *AACL Bioflux*, 10(5), 1074-1084.
61. Wootton, R.J. (2011). Growth: environmental effects. In: Encyclopedia of fish physiology: from genome to environment Elsevier Science Publishing Co (pp 1629-1635). Inc, United States.