Research Article

Length-Based Fishery Status of Indo-Pacific King Mackerel (*Scomberomorus guttatus*) in the Iranian Part of Persian Gulf and Oman Sea Waters

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Abstract | Between the months of August 2020 and February 2023, the exploitation ratio and population dynamics of the king mackerel (*Scomberomorus guttatus*) in the Indo-Pacific region were investigated. The data for this study was collected from three different landing sites: Bushehr, Bandar Abbas, and Chabahar. In all, there were 6,094 fish specimens that were examined in the laboratory over the course of the inquiry. In terms of the link between the total sample weight and length, the equation W=0.015×CL2.89 (n=609, R2=0.85, 95% confidence range of b= 2.81-2.96) is used to represent the relationship. The population dynamics indicators consist of the following: the infinite length (Linf) of 83 centimeters, the natural mortality (M) of 0.58 per year, the growth coefficient (K) of 0.5 per year, the total mortality (Z) of 2.83±0.03 (95% confidence interval = 2.80-2.86), the fishing mortality (F) of 2.25 per year, and the exploitation coefficient (E) of 0.8. A calculation was made to determine the yearly normal standing stock (Bt) was estimated at 4,444 T. The exploitation rate (U) was estimated at 0.75, while the yearly overall stock at the beginning of the year (B0) was 13,333 T. On the other hand, the fishing mortality rate at maximum sustainable yield (FMSY) is 0.75, while the exploitation ratio at maximum sustainable yield (EMSY) is 0.54. In the Iranian section of the Persian Gulf and Oman Sea, the parameters of maximum sustainable yield (MSY 1000 tons), B/BMSY ratio, F/FMSY ratio, and saturation (S) ratio were determined at 11(9-15), 1.37(0.83-1.60), 0.67(0.57-1.11) and 0.67 respectively. According to the calculated parameters, Indo-Pacific king mackerel species is in full fishing status.

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Introduction

Sustainable marine exploitation and development depends critically on the proportion of stocks at (BSLs) to those at BULs. In 1974, BULs were around 10%, rising to approximately 33% by 2016. Conversely, BSLs were 90% in 1974 but declined to about 63% by 2020. The greatest BUL ratios are initiate in the Mediterranean, Black Sea, Southeast Pacific, and Southwest Atlantic oceans. Thus 57% of tuna stocks are regarded as viable, and around 43% are considered as physiologically unsustainable. Approximately 9% of the world's catch comprises tuna and similar species (FAO, 2024). Resource conservation is a widely accepted idea and a crucial requirement for a long-term preservation of all resources connected to water. Fisheries managers assess the appropriate and authorized use of these resources while concentrating on guaranteeing sufficient and safe food from natural sources (Ganga and Pillia, 2000).

The Persian Gulf and Oman Sea, with their unique ecological conditions, harbor a diverse array of aquatic animals that offer sustenance, work, and other economic opportunities for the inhabitants. Iran employs almost 120,000 fishermen, whose primary occupation is fishing. And an important factor in the creation of jobs in coastal communities has been fishing. Eco, as well as commercial endeavors for operations after harvest (Taghavimotlagh *et al.*, 2008). In 2022, the total catch from the Persian Gulf and Oman Sea was approximately 718,000 tons. Of this, large pelagic species contributed 344,677 tons, with tuna and tuna-like species making up around 288,735 tons. The catch mainly consisted of tropical tuna (42.8% or 123,343 tons), neritic tuna (45.2% or 130,576 tons), and billfish species (12% or 34,816 tons) (IFO, 2024). Between 2018 and 2022, Indonesia, India, and Iran accounted for nearly 85% of IOTC (2023).

Tuna is classified under the order Perciformes and the family Scombridae, which includes 52 species across 15 genera. The genus *Scomberomorus* comprises 18 species, with two species inhabiting the Persian Gulf and the Oman Sea (Kaymaram *et al.*, 2009). Tropical and subtropical areas of the western Pacific and Indian seas are home to the epipelagic migratory Indo-Pacific king mackerel. It lives in coastal waters up to 200 meters deep, usually about 90 meters, and occasionally makes its way into murky estuaries. Although it is typically approximately 40 cm long, this species may grow up to 76 cm in length and weigh up to 5 kg. It is often found in small schools. (Collette and Nauen, 1983; Froese and Pauly, 2017). The *S. guttatus* is a significant species in tuna fisheries across tropical and subtropical seas, with global catches nearing 50,000 tons (FAO, 2024) and about 45,000 tons in the Indian Ocean (IOTC, 2022).

In the Indian Ocean, gillnets capture the majority of Indo-Pacific King mackerel (about 66%), with fisheries in Indonesia and India accounting for over two-thirds of the total, with Iran also reporting significant catches (IOTC, 2022). The variations in the distribution of these nomadic species depend on differences in their life history, migration patterns, and habitats affected by unstable environmental conditions such as temperature, patterns of ocean currents and circulations, and food access (Keymaram *et al.*, 2009; Keymaram *et al.*, 2013; Hashemi *et al.*, 2020).

Very little is known about the assessment of this fish, regardless of its economic importance. This study aims to provide fundamental information on the biological traits and population dynamics of the Indo-Pacific king mackerel, as well as to provide suitable management and exploitation guidelines for this species in the Iranian seas of the Persian Gulf and Oman Sea. Additionally, it offers a first-ever preliminary evaluation of *S. guttatus* biomass in this region.

Materials and Methods

Between August 2020 and February 2023, samples of Indo-Pacific king mackerel (*S. guttatus*) were collected from three touchdown sites: Bushehr, Bandar Abbas, and Chabahar, to investigate population trends and exploitation ratios. The ports of Bushehr (50° 82'E, 28° 91'N), Bandar Abbas (56° 28'E, 27° 19'N), and Chabahar (60° 64'E, 25° 29'N) were chosen for sampling based on commercial fishing conditions in the Iranian Persian Gulf and Oman Sea. Gill nets with a mesh size that was roughly 140 mm were used (Figure 1).

Length frequency distribution

Fish arriving monthly at the ports of Bushehr, Bandar Abbas, and Chabahar were sampled. From August 2020 to February 2023, random samples of commercial catches from these harbors were taken. Biometric analysis, including length and weight measurements, was conducted on the specimens. A biometric ruler measured the fork length with 1 cm precision.

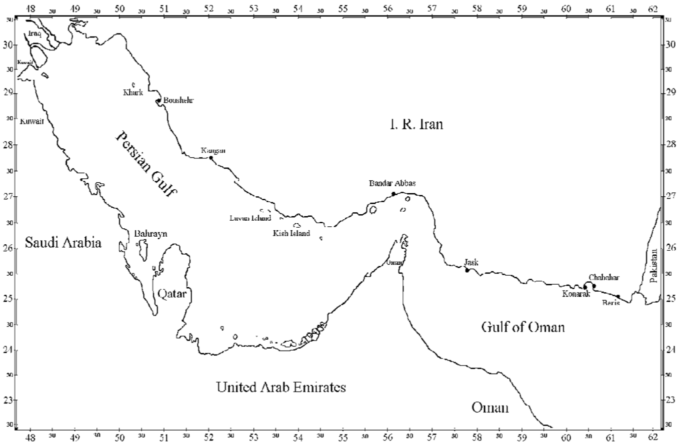

Figure 1: *The map illustrates the locations of S. guttatus sampling sites within the Iranian waters of the Persian Gulf and the Oman Sea.*

Biometry

Biometric information was acquired, such as weight and length. Accurate measurements of fork length to 1 cm and wet weight to 0.1 grams were made using a biometric ruler. Wi is the overall weight, which is measured in grams, Li is the length of the fork, which is measured in centimeters, an is a constant coefficient, and b is the exponent included inside the equation (Wi = a × Li^b). Through the use of the equation, significant disparities were discovered between the estimated value of b derived from the equation and the value of b equal to three for an Indo-Pacific king mackerel that exhibited comparable development. As an example, the letter (b) represents the slope, the letter (s.dx) represents the standard deviation of the natural logarithm of length, the letter (s.dy) represents the standard deviation of the natural logarithm of weight, the letter (r^2) represents the coefficient of determination, and the letter (n) refers to the sample size (Zar, 2010). This is the formula that is employed:

$$t = [(s.dx)/(s.dy)] \times [(lb-3l)/(\sqrt{(l-r^2)}] \times [\sqrt{(n-2)}]$$

Growth studies

Through the utilization of the TropFishR software and the ELEFAN optimization model, Mildenberger *et al.* (2017) conducted an evaluation of the growth rate and the (L∞) value. With the help of the equation (Log (-t0) = - 0.3922 - 0.2752 Log L∞ - 1.038 Log K), which was applied to the empirical Pauly equation (Froese and Binohlan, 2000), the ideal value of (t0) was determined. In order to determine the connection between the growth factor (K) and the infinite length (L∞), the equation T' = Log (K) + 2 Log (L∞) was utilized.

Mortality estimate

The natural mortality rate (M) was calculated using the following formula: M = 4.118 multiplied by K raised to the power of 0.73 multiplied by L∞ raised to the power of -0.33. In this equation, K represents the von Bertalanffy growth rate parameter, while L∞ represents the asymptotic length of the fish, measured in centimeters. A calculation of total mortality (Z) was performed using the catch curve data that had been converted to length. For the purpose of determining fishing mortality (F), the equation F = Z - M was utilized, where M stands for natural mortality. For the purpose of calculating the exploitation rate (E), which is defined as the ratio of fishing mortality to overall mortality (Sparre and Venema, 1998), the equation E = F / Z was utilized. More specifically, the equation tmax = t0 + 3 / K was utilized in order to determine the maximum life expectancy (Froese and Pauly, 2017).

Length-based reference point

According to research, this species' maturity length (Lmat) can reach 40 cm in the northern Oman Sea near Iran (Keymaram *et al.*, 2013). The ideal fishing length (Lopt) is calculated as Lopt = L∞ * (3 / (3 + M/K)), based on Froese and Binohlan's (2000) studies.

Fishery assessment

The exploitation rate (U) was calculated using the formula U = F (1 - e^-z) / z. To determine the total biomass of the stock at the beginning of the year, the formula B0 =Y/U was applied (Nurulamin *et al.*, 2000), where Y represents the annual average catch of approximately 10,000 tons for this species in 2023 (IFO, 2024). Additionally, to evaluate the annual average of the standing stock, the formula Bt = Y / F was utilized (Nurulamin *et al.*, 2000).

Yield per recruit and biomass per recruit

For the purpose of computing the relative yield per recruit, which is represented by the variable, the fishing mortality coefficient or the exploitation rate was utilized. As stated by Y'/R. Gayanilo *et al.* (2003), the letters (E) represent the exploitation coefficient, the letters (U) represent the exploitation rate, the letters

(M) represent the natural mortality coefficient, the letters (F) represent the fishing mortality coefficient, and the letters (Lc) refer to the (Lc50) equation. To further elaborate, the accompanying procedure was utilized in order to calculate the relative biomass per recruit, which is denoted by the symbol B'/ Rp.

$$Y'/R = EU^{M/K} (-3\, U/(1+m) + 3\, U^2/(1+2m) + U^3 /(1+3m) \; U = 1 - (LC/L\infty) \; ; \; M = (1-E)/(M/K) = (K/Z) \; ; \; E = F/Z \; B'/R = Y'/R/F$$

Length-based SPR assessment methodology (LB-SPR)
In their 2018 publication, Carruthers and Hordyk present a comprehensive explanation of the fundamental components that make up the length-based SPR (LB-SPR) evaluation approach that has just been deployed and is currently being employed in the Oman Sea. There are five essential input parameters that are required for the LB-SPR framework. Obtaining accurate information about the latter might be difficult in the absence of trustworthy length and age statistics; however, it is commonly assumed to be somewhere around 10%. According to Carruthers and Hordyk (2018), the LB-SPR investigation was carried out with the assistance of the LB-SPR software tool. SPR= Total Egg Production (Fished)/ Total Egg Production (Unfished). The data was analyzed using the TropFishR package, Excel application, R software (R Core Team, 2022), and R studio (2023.03.1-446).

C-MSY (CMSY) method (Monte-Carlo algorithm)
The C-MSY and Graham-Shaefer models share characteristics and both use catch time data to estimate maximum sustainable yield and fisheries reference points. The CMSY requires prior distributions on r and k, as well as biomass at the beginning (Froese *et al.*, 2017). Subsequent biomass is generated using a Schaefer equation (Martell and Froese, 2013).

$$By + 1 = By + rBy\,(1 - By/k)\, es^1 - Ct\, es^2$$

This methodology uses formulas to calculate instantaneous population growth (r) and carrying capacity (K) based on depletion (d) and resource saturation (S). The maximum sustainable yield (MSY) is calculated from MSY= rk/4, and BMSY= K/2. A tentative range for r is set based on the sustainability of stocks, with highly sustainable stocks assigned r values between 0.6 and 1.5. Population growth rates were calculated using the irf formula, which involves the inverse range coefficient and 3/r high– r low (Froese *et al.*, 2018).

To achieve the desired model sampling, the prior process error variance should be 0.2 and the explanatory error must be 0.1 according to Froese *et al.* (2018). Exploit records for the first and last year are used, and the previous preliminary relative biomass ranges from 0.1 to 0.4, while the most recent relative biomass ranges from 0.2 to 0.65. The initial median relative biomass in 2005 was 0.5 to 0.9 over a year. See Martell and Froese (2013) and Froese *et al.* (2018) for CMSY details.

Results

During this research, researchers analyzed a total of 6,094 specimens of Indo-Pacific king mackerel in the laboratory. The fork lengths of these fish varied between 25 cm and 82 cm, with a mean length of 46 ± 17 cm and an average weight of 961±366 grams. The fork length measurements were categorized into intervals of 4 cm each, with the highest occurrence noted in the 41 to 45 cm range, comprising 1,238 specimens, which represents about 20% of the overall sample size (Figure 2).

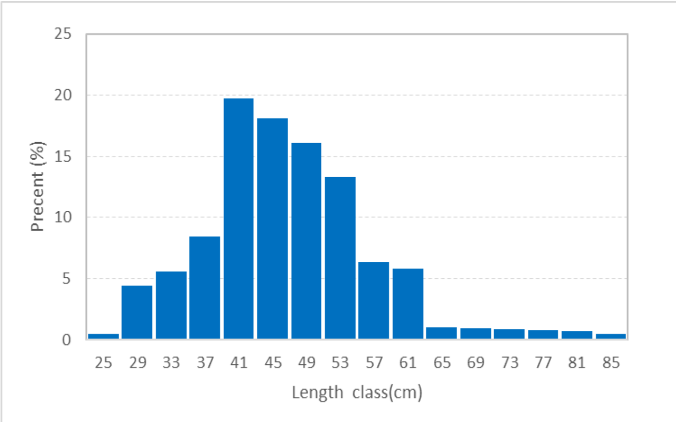

Figure 2: *The percent frequency in various length of S. guttatus in the Iranian part of Persian Gulf and Oman Sea Waters.*

The correlation between length and weight for all samples was represented by the equation W= 0.015 × CL^2.89 (n = 609, R^2 = 0.85, with a 95% confidence interval for b ranging from 2.81 to 2.96) (see Figure 3). Results from the Student's t-test revealed no significant differences between the estimated b value and b = 3 at the 0.05 significance level ($p > 0.05$). This finding indicates an isometric growth pattern for this species in the Iranian segment of the Persian Gulf and the Oman Sea (Figure 3).

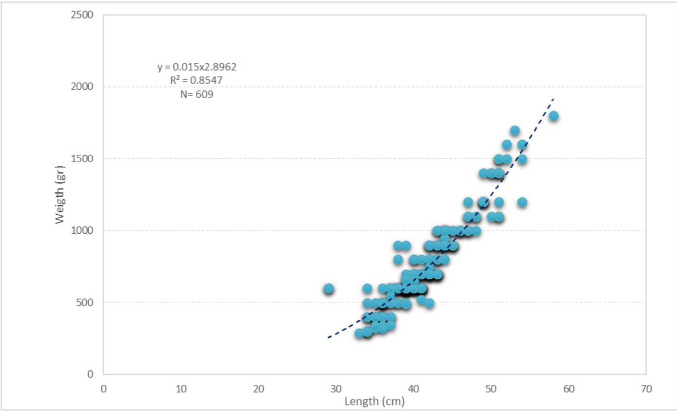

Figure 3: *Length-weight relationship (LWR) of S. guttatus in the Iranian part of Persian Gulf and Oman Sea Waters.*

The population dynamics indicators for *S. guttatus* were determined as follows: the fork length at infinity (Linf) is 83 cm, (K) stands at 0.5 per year, and the growth performance index (Φ) is 3.54. There is a difference between the natural mortality rate (M) of 0.58 per year and the fishing mortality rate (F) of 2.25 per year, resulting in a total mortality rate (Z) of 2.83±0.03 (with a 95% confidence interval of 2.80-2.86). The exploitation coefficient (E) is calculated to be 0.8 (Figure 4). Moreover, the optimal fishing length (Lopt) for this species has been estimated at 60 cm.

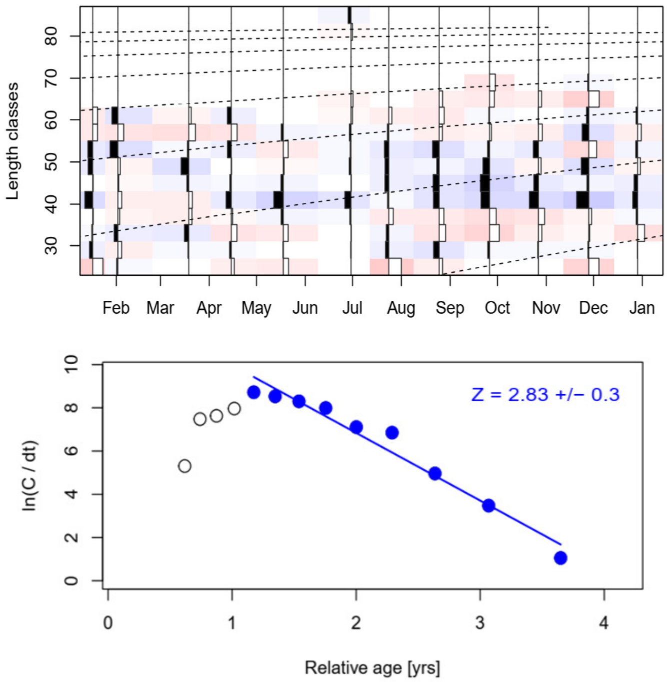

Figure 4: *Growth curve and linear catch curve derived from frequency data of S. guttatus in the Iranian part of Persian Gulf and Oman Sea Waters.*

These values were derived by comparing the ratios of production to recruitment. The maximum sustainable yield (EMSY) was found to have an exploitation ratio of 0.54, according to the findings of the study. Whereas the fishing mortality for the maximum sustainable yield (FMSY) was determined to be 0.75. This indicates that F/Fmsy > 1 (as depicted in Figure 5), which is considered unfavorable. The research results suggest that the maximum lifespan of *S. guttatus* is roughly 6 years.

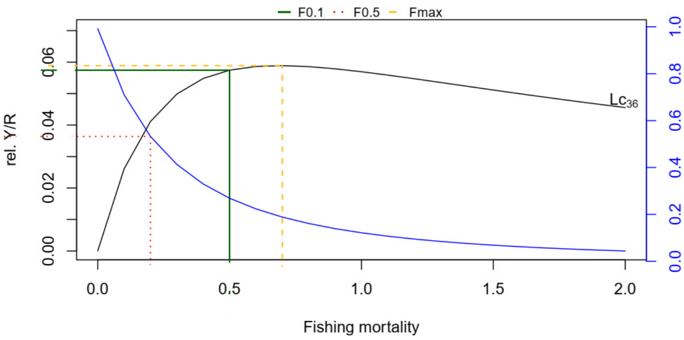

Figure 5: *The Y' / R and B' / R derived from frequency data of S. guttatus in the Iranian part of Persian Gulf and Oman Sea Waters.*

Fishery assessment

At the beginning of the year, the exploitation rate (U) was assessed at 0.7, while the total stock amount, denoted as B0, was recorded at 13,333 tons. Meanwhile, the estimated average standing stock, referred to as Bt, was estimated at 4,444 tons. Additionally, the specific parameter for the Spawning Potential Ratio (SPR) was determined to be 0.21 per year, as demonstrated in Figure 6. The anticipated 95% confidence intervals for evaluations of spawning potential, relative fishing pressure, and selectivity can be found beneath the estimates presented.

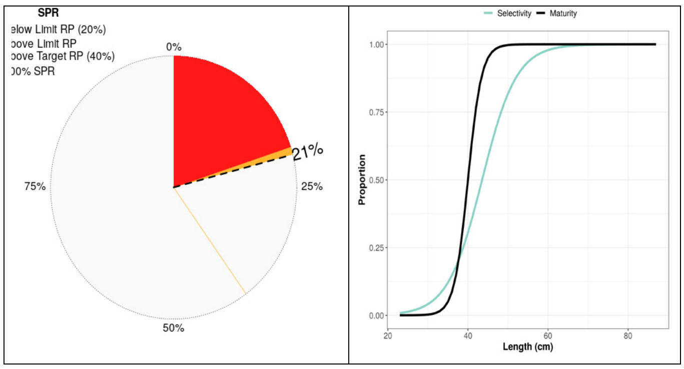

Figure 6: *Graphical representation of the estimated SPR quantities derived from frequency data of S. guttatus in the Iranian waters of the Persian Gulf and Oman Sea.*

C-MSY (CMSY) method

The average values for the instantaneous growth rate of the population (r) and the carrying capacity (K, measured in thousands of tons) were derived using the Catch Maximum Sustainable Yield (CMSY) models, were results of 0.56 (ranging from 0.40 to 0.78) and 147 (with a range of 96 to 225), respectively. For S. guttatus in the Iranian areas of the Persian Gulf and Oman Sea, the following metrics were evaluated: the maximum sustainable yield (MSY, in thousands of tons), the proportion of current plant matter to biomass at MSY (B/BMSY), the ratio of electricity fishing mortality to the fishing mortality rate at MSY (F/FMSY), and a saturation ratio (S = B/K = 0.5 B/BMSY). All of these metrics were evaluated in accordance with the following criteria: As shown in Figure 7, the saturation ratio is 0.67, with 11 (ranging from 9 to 15), 1.37 (ranging from 0.83 to 1.60), 0.67 (ranging from 0.57 and 1.11), and a saturation ratio of 0.67.

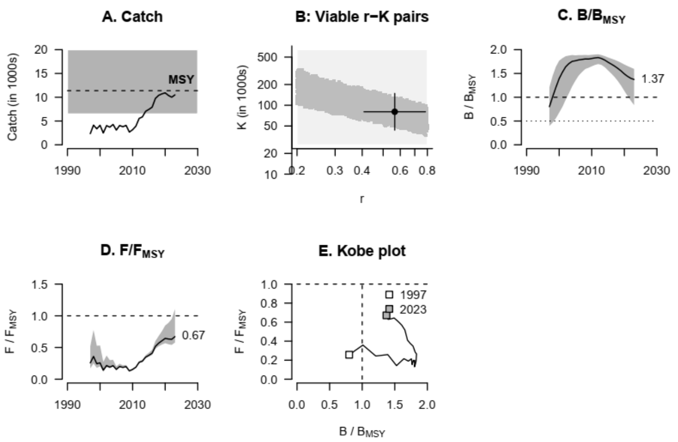

Figure 7: *The range of the maximum sustainable yield (MSY), current biomass to the biomass of MSY (B/B$_{MSY}$), the ratio of the current fishing mortality to fishing mortality rate of MSY (F/F$_{MSY}$) and saturation (S) ratio of S. guttatus in the Iranian part of Persian Gulf and Oman Sea Waters.*

Discussion

The *S. guttatus* a significant large pelagic fish, holds substantial economic value in southern Iran. Its catch has notably risen in recent years in the Iranian waters of the Persian Gulf and Oman Sea, particularly in the Sistan and Baluchistan province. More than 10,000 tons of this fish have been caught in the Southern Waters of Iran (IFO, 2024).

In the field of fisheries biology, establishing length-weight relationships is essential, particularly when precise length measurements are available. These relationships facilitate estimates of fish weight and biomass, serve as metrics for the health of fish populations, and enable comparisons of growth trends among different species in various habitats (Williams, 2000; Bobori *et al*., 2010).

Table 1 compares this species biological indicators with those of previous research conducted globally. The infinite length of *S. guttatus* seems to be greater in the Persian Gulf and Oman Sea regions than it is in Bangladesh, Pakistan, India, and Indonesia. The biological distinctions between each region have an impact on these variations in limitless length and growing rate (King, 2007). Natural selection and biodiversity affect reproductive properties, physical characteristics, population density, and genetic diversity, leading to a variety of adaption techniques during the course of an organism's life. Environmental factors and the quantity and quality of food sources are usually responsible for the differences in size and growth rates between locations (Bartulovic *et al*., 2004). Fish growth is also significantly influenced by other factors such as age, gender, seasonal and annual fluctuations, feeding habits, physiological conditions, food availability, and reproductive cycles (Lalèyè, 2006).

Table 1: *Comparison of the biological traits of S. guttatus with global studies.*

References	Region	L∞ (cm)	K (yr^{-1})	t_o*	Φ'*	M	F	Z	E
Devaraj, 1981	India	127	0.18	-0.63	3.46	-	-	-	-
Ghosh *et al*., 2009	India	61	1.4	-0.09	3.71	1.79	2.92	4.71	0.62
Rashid *et al*., 201	Bangladesh	73	0.6	-0.21	3.50	0.99	0.8	1.79	0.45
Ahmed *et al*., 2016	Pakistan	55	1.08	-0.12	3.51	-	-	-	-
Mahesh *et al*., 2017	India	71	0.23	-0.47	3.14	0.54	0.49	1.03	0.58
Noegroho *et al*., 2018	Indonesia	68	0.37	-0.35	3.23	0.71	1.39	2.1	0.48
Barua and Liu, 2023	Bengal Gulf	117	0.42	-0.26	3.75	0.46	0.72	1.18	0.61
Present study, 2023	Persian Gulf and Oman Sea (Iran)	83	0.5	-0.2	3.54	0.58	2.25	2.83	0.8

*L∞ = asymptotic length, K = growth coefficient, t_0 = hypothetical age at zero length, Φ' = growth performance index, M = natural mortality rate, F = fishing mortality rate, Z = total mortality rate, E = exploitation rate, * = estimated.*

The correlation between growth rate and infinite length leads to the comparison of Φ′ values in the growth curve. A growth curve with fluctuating growth rates over time and across sizes is the result of this relationship. Furthermore, the limitless length and growth rate can be affected by changes in latitude and biological conditions. These variations include different Φ' values, which can also alter over time within the same region due to changing environmental circumstances (King, 2007). In addition, this species' fishing death rate was higher than its natural mortality rate. By having a fishing fatality to maximum sustainable yield ratio (F/FMSY) that was greater than one, Arrizabalaga *et al.* (2012) demonstrated that there was an excessive amount of fishing. In addition, both the exploitation rate and the exploitation coefficient were greater than 0.5, which indicates that the fisheries produced in excess of what would be considered ideal. According to Sparre and Venema (1998) and King (2007), in order to prevent overfishing, the exploitation coefficient and exploitation rate should ideally remain below 0.5, and the mortality rate experienced by fishermen should not exceed the mortality rate experienced by native fish.

In various regions around the globe (see Table 1), reports indicate that natural mortality, fishing mortality, total mortality, and the exploitation coefficient vary within the following yearly ranges: natural mortality from 0.46 to 1.79, fishing mortality between 0.49 and 2.92, total mortality spanning from 1.03 to 4.71, and the exploitation coefficient ranging from 0.45 to 0.80 (Devaraj, 1981; Ghosh *et al.*, 2009; Rashid *et al.*, 2011; Ahmed *et al.*, 2016; Mahesh *et al.*, 2017; Noegroho *et al.*, 2018; Barua and Liu, 2023). This study compared to previous studies in the Persian Gulf and Oman Sea region showed higher fishing mortality, total mortality and exploitation coefficient which indicated an increase in the capture fisheries of this species in recent years (Table 1). The key factors influencing the pressure on fish stocks include (1) the volume of fish caught and harvested, and (2) environmental conditions that impact survival and access to fishery resources (Mateus and Estupinan, 2002). To effectively lower the exploitation rate, it is advisable to decrease fishing activities and limit the issuance of fishing permits, thereby reducing the number of entrants into the fishing community (Jenning *et al.*, 2000). The results reveal that the longest lifespan of *S. guttatus* is around six years, as determined by the formula tmax = t0 + 3 / K (Froese and Pauly, 2017). By applying the standards set by the American Fisheries Society (Cheung *et al.*, 2004) and contrasting the findings of the present study with these criteria, it was concluded that this species faces a medium risk of extinction (see Table 1)

Our findings show that the B/B0 and LBSPR indices are over 0.3 and 0.2, respectively. According to these indicators, fish populations are heading toward overfishing, and the species' stock status is average. A good stock condition is indicated by values that are greater than 0.6 (0.6 = B/B0), while values that are less than 0.2 (0.2 ≈ B/B0) indicate that reserves have been depleted. The LBSPR index is a tool that offers estimations of the SPR. Values that fall between the range of 0.2 to 0.6 are used to indicate an average stock condition (B/B0 = 0.2-0.6) (Froese *et al.*, 2018; Zhai *et al.*, 2020; Hashemi *et al.*, 2020, 2021; Hashemi and Doustdar, 2022). Furthermore, it is of the utmost importance to highlight the 95% confidence limits that are supplied by LBSPR. These bounds demonstrate the extraordinarily low error that is connected with these calculations (Carruthers and Hordyk, 2018).

A 2022 research by Hashemi and Doustdar concluded that the Indo-Pacific king mackerel stock is presently completely exploited, that the ratio of fishing effort to exploitation is at its maximum, and that neither should be increased. The CMSY approach used data collected for this species in the southern seas of Iran from 1997 to 2019 and reported a Maximum Sustainable Yield (MSY) of 1,000 tons. The F/FMSY, B/BMSY, and S ratios, according to Hashemi and Doustdar (2022), were 8.44 (range between 4.65 and 15.30), 0.94 (range between 0.83 and 1.11), 1.36 (range between 0.83 and 1.59), and 0.68 (range between 0.4 and 0.78), respectively.

Another study by Haghi and Ghanbarzadeh's (2022), evaluated the sustainable harvesting levels and reference points for *S. guttatus* in Iran's southern Persian Gulf waters by looking at catch data from 1997 to 2019. According to their findings, the maximum sustainable yield (MSY) was determined to be 7,040 tons using the Bayesian Surplus Model (BSM) and 9,100 tons using the Catch Maximum Sustainable Yield (CMSY) technique. These figures contrast with our own estimate of approximately 11000 tons. The discrepancies in these estimates may stem from differing assumptions regarding the stock's resilience and overall condition. Furthermore, Martell and Froese (2013) have suggested that reliable MSY estimates can often be derived using data- poor methodologies, albeit with a certain degree of error margin. Stock status assessment for Indo-Pacific king mackerel in the Indian Ocean used catch-only methods techniques as Catch-MSY and OCOM in 2018, and the yield target (MSY) which was similar for both models considered (45,022, Catch-MSY and 45,632 OCOM). The FMSY and BMSY (1000 t) for this species in the Indian Ocean was reported 0.52 (0.40–0.69) and 66 (45.9–107), respectively (IOTC, 2022). Ultimately, the authors suggested that if all relevant countries under Regional Fisheries Management Organizations (RFMOs) cooperate in gathering biological data as well as information on catch and fishing effort for shared stocks, the outcomes will yield more accurate and effective management strategies.

ConclusionS and Recommendations

An exploitation coefficient (E) of greater than 0.5, an F/FMSY ratio of less than one, Bt/B0 index greater than 0.3, all suggest that this species is not in favorable stock conditions and that fish populations are trending toward overfishing. According to the calculated parameters (MSY, B/BMSY and S ratio index) Indo-Pacific king mackerel species is full fishing (full exploitation) status. Consequently, targeted actions should not be implemented to increase catch levels and fishing effort.

Acknowledgments

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Novelty Statement

The aim of this research is to provide fundamental insights into the biological parameters and population dynamics of the Indo-Pacific king mackerel, as well as to establish proper management and exploitation guidelines for this species in the Iranian waters of the Persian Gulf and Oman Sea. Additionally, it offers an initial estimate of the biomass of *S. guttatus* in this region, a task not previously undertaken.

Author's Contribution

Seyed Ahmadreza Hashemi: Conceptualization, validation, investigation, analysis, writing original draft.
Mastooreh Doustdar: Conceptualization, validation, analysis, writing review and editing.
Rahimeh Rahmati and Asadullah Ali Muhammad: Validation, investigation, writing review and editing.
Wajiha Shaikh: Edited and finalized the manuscript.

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Ethical approval
Approval of all authors have been obtained. The animal study was reviewed and approved by Iranian Fisheries Science Research Institute.

Data availability
All of the data that supports the conclusions of this study may be found inside the paper itself as well as the supplementary resources that accompany it.

Consent of publication
The Research Paper has not been published previously nor is being considered for publication.

Conflict of interests
The authors have declared no conflict of interest.

References

Ahmed, Q., S. Bilgin and L. Bat. 2016. Length based growth estimation of most commercially important Scombridae from offshore water of Pakistan coast in the Arabian Sea. Turk. J. Fish. Aquat. Sci., 16: 155-167.

Arrizabalaga, H., M. Murua and J. Majkowski. 2012. Global status of tuna stocks: Summary sheets. Rev. Invest. Mar. AZTI-Tecnalia, 19: 645-676.

Bartulovic, V., B. Glamuzina, A. Conides, J. Dulcic, D. Lucic, J. Njire and V. Kozul. 2004. Age, growth, mortality and sex ratio of sand smelt, *Atherinaboyeri*, Risso, 1810 (Pisces: *Atherinidae*) in the Estuary of the Mala Neretva River (Middle-Eastern Adriatic, Croatia). J. Appl. Icthyol., 20: 427-430. https://doi.org/10.1111/j.1439-0426.2004.00560.x

Barua, S. and Q. Liu. 2023. Population dynamics and biological reference points of Indo-Pacific King Mackerel (*Scomberomorus guttatus*) in the Upper Bay of Benga. pp. 1-15. https://doi.org/10.2139/ssrn.4664468

Biswas, S.P., 1993. Manuel of methods in fish biology, fish biology and Ecology laboratory, Dibruyarh University, Dibrugarh: pp. 1-157.

Bobori, D., D. Moutopoulos, M. Bekri, I. Salvarina and A. Munoz. 2010. Length-weight relationships of freshwater fish species caught in three Greek Lakes. Biol. Res., 14: 219-224.

Carruthers, T.R. and A. Hordyk. 2018. The data-limited methods toolkit (DLM tool): An R package for informing management of data-limited populations. MEE, 9: 2388-2395. https://doi.org/10.1111/2041-210X.13081

Cheung, W., T. Pitcher and D. Pauly. 2004. A fuzzy logic expert system to estimate intrinsic extinction vulnerabilities of marine fishes to fishing. Biol. Conserv., 12: 497-111. https://doi.org/10.1016/j.biocon.2005.01.017

Collette, B.B., C.E. Nauen. 1983. FAO species catalogue. Vol. 2. Scombrids of the world. An annotated and illustrated catalogue of tuna, mackerel's bonitos and related species known to date. FAO Fish. Synop., 125(2): 137.

Devaraj, M., 1981. Age and growth of three species of seer fishes *Scomberomorus commerson, S. guttatus* and *S. lineolatus*. Indian J. Fish., 28(1/2): 104- 127.

FAO, 2024. The state of world fisheries and aquaculture 2018 - Meeting the sustainable development goals. Rome. Licenses: CC BY-NC-SA 3.0 IGO. pp. 227.

Froese, R. and C. Binohlan. 2000. Empirical relationships to estimate asymptotic length, length at first maturity and length at maximum yield per recruit in fishes, with a simple method to evaluate length frequency data. J. Fish. Biol., 56: 758-773. https://doi.org/10.1111/j.1095-8649.2000.tb00870.x

Froese, R. and D. Pauly. 2017. FishBase. World wide web electronic publication. www.fishbase.org, version. (10/2017), accessed at www.fishbase.org in November/December 2017.

Froese, R., H. Winker, G. Coro, N. Demirel, A. Tsikliras and D. Dimarchopoulou. 2018. Status and rebuilding of European fisheries. Mar. Policy, 93: 159–170. https://doi.org/10.1016/j.marpol.2018.04.018

Ganga, U. and N. Pillia. 2000. Field identification of scombroids from Indian sea. Ln. Pillai, N.G.K., Menon, N.G., Pillai, P.P and Ganga, U. (Eds.) management scombroids fisheries. Central Marine Fishery Research Institute, Kochine. pp. 1-13.

Gayanilo, F., P. Sparre and D. Pauly. 2003. FAO-ICLARM stock assessment tools (FiSAT) user's guide. FAO computerised information series (Fisheries). Rome, FAO. 8: 1-266.

Ghosh, S., N.G.K. Pillai and H.K. Dhokia. 2009. Fishery, population characteristics and yield estimates of coastal tunas at Veraval. Indian J. Fish., 57(2): 7-13.

Haghi, A.H. and M. Ghanbarzadeh's. 2022. Estimation of Fisheries Reference Points for (Scomberomorus guttatus Bloch & Schneider, 1801) Using the catch-maximum sustainable yield (CMSY) and the Bayesian Surplus Production (BSM) models in the Southern Waters of Iran (Persian Gulf and Oman Sea). J. Fish. 75(1): 31-47. https://doi.org/10.22059/jfisheries.2021.326498.1268

Hashemi, S. and M. Doustdar. 2022. Stock assessment of Indo-Pacific King Mackerel, *Scomberomorus guttatus* (Bloch and Schneider, 1801) in the Persian Gulf and Oman Sea, southern Iranian waters, using CMSY and DBSRA. Int. J. Aquat. Biol., 10(1): 11-20.

Hashemi, S., M. Doustdar, J. Ghasemzade and A. Gholampor. 2021. Length-based fishery status of skipjack tuna, Katsuwonus pelamis (Linnaeus, 1758) (Teleostei: Scombridae: Scombrinae) in the northern waters of the Oman Sea (Iran). Iran J. Immunol., 8(3) : 160-169.

Hashemi, S.A.R., M. Doustdar, A. Gholampour and M. Khanehzaei. 2020. Length-based fishery status of yellowfin tuna (*Thunnus albacares* Bonnaterre, 1788) in the northern waters of the Oman Sea. Iran. J. Fish. Sci., 19(6): 2790-2803.

IFO, 2024. Iran Fisheries Organization (IFO). Bureau of statistics, yearbook of fisheries statistics. pp. 1-25.

IOTC, 2023. Report of the 26th session of the IOTC scientific committee. Online, 4 – 8 December 2023. IOTC–2023–SC26–R[E]: pp. 207. http://www.iotc.org/online

IOTC, 2022. Data and statistics https://iotc.org/data-and-statistics

Jenning, S., M. Kasier and J. Reynold. 2000. Marine Fisheries Ecology. Blackwell Science Ltd., Oxford, United Kingdom. pp. 417.

Keymaram, F., A. Hosseini, M.P. Darwishi and A.T. Zadeh. 2009. Report on the study of population changes of large pelagic fish (yellowfin tuna, skipjack tuna, longtail tuna, Indo-Pacific king mackerel, etc.) for optimal harvesting of resources in the Persian Gulf and Oman Sea. Iranian Fisheries Science and Research Institute in collaboration with Chabahar Offshore Fisheries Research Center and Persian Gulf and Oman Sea Ecological Research Institute, pp. 126.

Keymaram, F., S.H. Gashemi, A. Vahabnezhab and M. Darvishi. 2013. Growth, mortality and exploitation rate of Indo-Pacific king mackerel (*Scomberomorus commerson*) in the Persian Gulf and Oman Sea, Iran, Hormozgan's waters. Third Working Party on neritic tuna in Bali Indonesia, IOTC-2013-WPNT03-29 Rev. 1: 1–7.

King, M., 2007. Fisheries biology and assessment and management. Fishing News Press, pp. 1-340. https://doi.org/10.1002/9781118688038.ch1

Lalèyè, P.A., 2006. Length-weight and length-length relationships of fish from the Ouémé River in Bénin (West Africa). J. Appl. Ichthyol., 22: 502-510. https://doi.org/10.1111/j.1439-0426.2006.00752.x

Mahesh, V.U., S. Ghosh, K. Sreeramulu, M.V.H. Rao and M.K. Satish. 2017. Fishery, biology and stock assessment of spotted seer, *Scomberomorus guttatus* (Bloch and Schneider) off Andhra Pradesh. J. Mar. Biol. Assoc. India, 59(1): 67-72. https://doi.org/10.6024/jmbai.2017.59.1.1934-10

Martell, S. and R. Froese. 2013. A simple method for estimating MSY from catch and resilience. Fish and Fisheries. 14: 504–514. https://doi.org/10.1111/j.1467-2979.2012.00485.x

Mateus, A. and B. Estupina. 2002. Fish stock assessment of piraputanga Brycon microlepis in the Cuiabá River basin, Pantanal of Mato Grosso, Brazil. Braz. J. Biol., 1(1): 165-170. https://doi.org/10.1590/S1519-69842002000100018

Mildenberger, T., M. Taylor and M. Wolff. 2017. Trop Fish R: An R package for fisheries analysis with length-frequency data. Methods Ecol. Evol., 8: 1520–1527. https://doi.org/10.1111/2041-210X.12791

Noegroho, T., M. Boer, Sulistiono and L. Adrianto. 2018. Size structure and population dynamics of Indo-Pacific king mackerel (*Scomberomorus guttatus*) in Kepulauan Riau's water, Indonesia. AACL Bioflux, 11(4): 1081-1088

Nurulamin, S., M. Rahman, G. Hadler, M. Mazid, D. Milton and S. Blaber. 2000. Population dynamics and stock assessment of Hilsa shad, *Tenualosa ilisha* in Bangladesh. Asian Fish. Sci., 15: 123-128. https://doi.org/10.33997/j.afs.2002.15.2.003

R Core Team, 2022. R: A language and environment for statistical computing [online]. R Foundation for Statistical Computing, Vienna. Available from https://www.R-project.org.

Rashid, H., M.G. Mustafa and S. Dewan. 2011. Population dynamics and the management of the Indo-Pacific king mackerel *Scomberomorus guttatus* from the upper Bay of Bengal off Bangladesh coast. Bangladesh Vet., 27(2): 82–90. https://doi.org/10.3329/bvet.v27i2.7558

Sparre, P. and G. Venema. 1998. Introduction to tropical fish stock assessment. Part1- Manual, FAO Rome, Italy: 1-337.

Sparre, P. and S.C. Venema. 1998. Introduction to tropical fish stock assessment, FAO Fisheries technical paper, Roma, pp. 450.

Taghavi, M.S.A., M.G. Shojaei, S.J. Seyfabadi, B. Abtahi and R. Dehghani. 2008. Population dynamics of narrow barred Spanish mackerel (*Scomberomorus commerson*) in coastal waters of Oman Sea (Iran). Iran. J. Fish. Res., 7(2s): 257-270.

Williams, J., 2000. The coefficient of condition of fish. In: Manual of fisheries survey methods II: with periodic updates: Schneider, J.C. ed.). Michigan Department of Natural Resources. Fisheries Special Report 25, Ann Arbor: pp. 1-2.

Zar, J.H., 2010. Biostatistical analysis. 3rd edition. Prentice-Hall Inc., New Jersey, USA. pp. 662.

Zhai, L., C. Liang and D. Pauly. 2020. Assessments of 16 exploited fish stocks in chinese waters using the CMSY and BSM methods. Front. Mar. Sci., 7: 483-993. https://doi.org/10.3389/fmars.2020.483993