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Original Article

Optimized exploitation of Pharaoh Cuttlefish (*Sepia pharaonis* Ehrenberg, 1831) stocks in the Iranian part of Persian Gulf and Oman Sea

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Abstract: The purpose of the present study was to investigate the trends in Pharaoh Cuttlefish (*Sepia pharaonis*) capture fisheries and determine the suitable range for optimized exploitation of *S. pharaonis* resources in the Iranian part of Persian Gulf and Oman Sea using catch data. The data on Pharaoh Cuttlefish capture fisheries in Iranian southern waters for the twenty-three years was collected and the suitable range for optimized exploitation of *S. pharaonis* was estimated using the R Software. The average values (95% confidence interval) using the Monte Carlo simulation method for intrinsic population growth rate (r), maximum sustainable yield (MSY), the biomass of maximum sustainable yield (Bmsy) and maximum fishing mortality rate of maximum sustainable yield (Fmsy) were 0.92 (0.73-1.17) per year, 5100 (4200-6200) tons, 1100 (8670-13900) tons, 0.46 (0.36-0.58) per year, respectively. The results showed that the annual catch of *S. pharaonis* exceeded the maximum sustainable yields and measures should be taken to reduce the number of capture fisheries and fishing effort. With results of the prediction model was observed moving average analysis (MAPE=2.85, MAD=0.10, MSD=0.02) and ARIMA (0, 0, 1) (AIC=9.79, BIC=6.38), are better than other models for a period of five years for modeling annual this species landing. It seems that reducing fishing permits and fishing effort will put the *S. pharaonis* stock situation in a more favorable condition in the long term and will further benefit the exploiters and the fishing community.

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Introduction

Global total capture fisheries production was about 91 million tons in 2016, of which 87% were in seawater (79.3 million tons) and 13% from inland waters (11.6 million tons) (FAO, 2018). In recent years, there are remarkable signs of over exploitation of major fish stocks and other aquatic resources. The proportion of stocks fished at Biologically Sustainable Levels (BSLs) to Biologically Unsustainable Levels (BULs) in 1974 was about 90%, whereas this proportion in 2016 was about 67%. Thus, BULs has increased and requires immediate management measures (FAO, 2018). The entire amount of fisheries production in Iran was near 800,000 tons, of which 720,000 tons (more than 90 percent) were fisheries production within the seawaters of southern Iran (Fisheries Statistical Yearbook, Iran area, 2020).

The quantity and quality of knowledge from many of the world's fisheries are inadequate to enable traditional methods of assessment to be applied. The management of "data-rich" stock approaches is usually focused on complex models of stock evaluation and involves variety of knowledge sources. Stock management is currently faced with numerous fish stocks that have little knowledge that do not help these with data-rich approaches (Dick and MacCall, 2011; Ghaitaranpour et al., 2019). Today, Length-based models, like Length Based Spawning Potential Ratio (LBSPR), Length-Based Integrated Mixed Effects (LIME), and Length-Based Bayesian (LBB), and also as catch-based methods, like Catch-Maximum Sustainable Yield (Catch-MSY), Depletion Based Stock Reduction Analysis (DBSRA), Simple Stock Synthesis (SSS), and Catch-MSY (CMSY) in many fishery scenarios and

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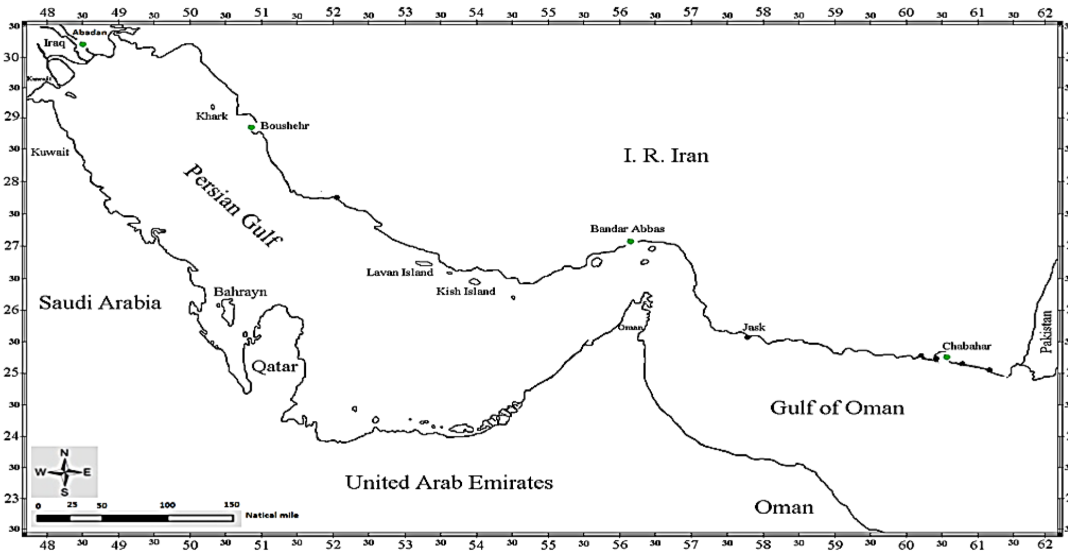

Figure 1. Map of the study area and main Iranian fishing ports (Green color denoted the fishing ports).

in several countries are developed (known as "data-poor" or "data-limited" fisheries) (Wetzel and Punt, 2015).

With their unique ecological conditions, the Persian Gulf and Oman Sea host a good range of aquatic species that provide settlers with livelihoods, jobs and various economic activities (Rajaei et al., 2014; Taghavimotlagh and Shojaei, 2017; Eagderi et al., 2019). Iran has quite 120,000 fishermen, mainly engaged in fishing, and fishing has played a serious role in generating jobs in coastal areas and in post-harvest economic activities (Taghavimotlagh and Shojaei, 2017). Mollusks are the largest and most diverse group of invertebrates after arthropods with more than 80,000 extant species (Bruska et al., 2016). Among the economically important mollusks, Pharaoh Cuttlefish (*Sepia pharaonis*) is a neritic demersal species inhabiting coastal waters to the depth of 130 meters. It is more likely to be found at the depth of 10 to 40 m (Jereb and Roper, 2005). This species is a predominant species in the Persian Gulf and Oman Sea (Valinasab, 1993, 1997; Roper et al., 1984). In addition, *S. pharaonis* is found in the Indo-Pacific region, the Red Sea, the Arabian Sea to the South China Sea, the East China Sea and the northern Australian waters (Jereb and Roper, 2005). Estimation of optimal fishing based on the time series of various aquatic species fishery has been carried out in some fish species (Martell and Froese, 2013; Froese et al., 2016; Zhou et al., 2017). Hence, the present study aimed to investigated the trends in Pharaoh Cuttlefish capture fisheries in the Iranian part of Persian Gulf and Oman Sea with the aim of determining the suitable range for its optimized exploitation and proper and principled exploitation management.

Materials and Methods

The data on Pharaoh Cuttlefish capture fisheries landings (based on metric ton) in the Iranian part of Persian Gulf and Oman Sea (Fig. 1) for the twenty-three years was collected from the Iran Fisheries Organization (from 1997 to 2019).

Catch-MSY (CMSY): The Catch-MSY model has the same characteristics as the Graham-Shaefer surplus production model**.** These models rely on only a catch time series dataset and prior ranges of r and k and possible ranges of stock sizes in the first and final years of the time series. The CMSY is a method for estimating maximum sustainable yield (MSY) and related fisheries reference points (Bmsy, Fmsy) from catch data and information on resilience (Froese et al., 2017). This model requires a prior distribution on r and K as well as priors on the relative proportion of biomass at the beginning (Martell and Froese, 2013). The biomass in subsequent years was then generated from a Schaefer model according to equation of $B_{y+1}=B_y+rB_y(1-B_y/k)\,es^1-Ct\,es^2$, where By is Biomass in the year y+1, r = population instantaneous growth rate, K = carrying capacity, Cy = catch in the time series. In this method, the values of population instantaneous growth rate and carrying capacity are calculated with depletion formula (d) and storage saturation (S): d=1-S=1-By/Ky. The maximum steady-state mortality rate with the formula of Fmsy=r/2 and the maximum sustainable yield is calculated from MSY=rk/4 and Bmsy=K/2 (Zhou et al., 2017). A prior range was set for *r* based on the resilience of the stock as proposed by Martell and Froese (2013), where stocks with a high resiliency were allocated a *r* value from 0.6–1.5 (Zhou et al., 2017). The intrinsic population growth rate was calculated based on the inverse range factor and the formula of $irf=3/r_{high}-r_{low}$ (Froese et al., 2016). The e^{s1} and e^{s2} remove the bias in the equation and simulation. The e^{s1} is related to the process error, whereas the e^{s2} is related to the observation error. The desired pattern of the model is achieved when the standard deviation of the process error is set to 0.2 and the observation error is set to 0.1 (Froese et al., 2016).

Forecasting Methods:

Univariate time series models: Moving average (MA) method is the arithmetic mean of observations of the full data set and uses the arithmetic mean as the predictor of the future period (Karmaker et al., 2017). Exponential Smoothing (ES) method is a kind of weighted averaging method which estimates the future value based on previous forecast plus a percentage of the forecasted error. Trend Analysis (TD) may be a general model to multiple statistic data having trend pattern and provides idea to traders about what is going to happen within the future supported historical data (Karmaker et al., 2017). Winters Method (WM) is employed to smooth data employing A level component, a trend component, and a seasonal component at each period and provides short to medium range forecasting. Decomposition method (DM) is employed to separate the statistic into linear trend and seasonal components and error (Karmaker et al., 2017).

The autoregressive integrated moving average (ARIMA) models demonstrated a good performance in terms of explained variability and predicting power. The autocorrelation (ACF) and partial autocorrelation functions (PACF) were estimated, which led to the identification and construction of ARIMA models (Tsitsika et al., 2007). The ARIMA were implemented on the data and the best model was chosen using the test of Akaike coefficient data autocorrelation functions (Lawer, 2016). The general form of the ARIMA models is referred to as ARIMA *(p, d, q)*, where p is the order of the autoregressive term (AR term), d is the degree of differencing involved to achieve stationarity, and q is the order of the moving average term (MA term).

The best forecasting model: The values of Mean Absolute Percentage Error (MAPE), Mean absolute deviation (MAD) and mean square deviation (MSD) are used to identify the best model (Karmaker et al., 2017).

$$MAPE = \sum \frac{\left|\frac{et}{Dt}\right|}{n} * 100$$

$$\text{MAD}=\sum \frac{|Dt-Ft|}{n}$$

$$\text{MSE}=\sum(Dt-Ft)2/\,n-1$$

Where Dt is actual demand for time period t, Ft is forecast demand for time period t, n is specified number of time periods, and et is forecast error = (Dt – Ft). Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC)) were estimated as follows:

AIC = -2 ln (maximum likelihood) + 2m

BIC = -2 ln (maximum likelihood) + m ln(n)

Where m is that the number of the estimated parameters and n is that the number of the observations. Statistical analyses were performed with R studio (1.1.45), SPSS (22) and Minitab (16) software package and a significance level of 0.05 was adopted.

Results

The average catch (Yi) of the studied period was 3536 tones with 95% confidence intervals of 4284-2919 tones and the average catch was significantly

Table 1. Average values (95% confidence interval) of CMSY model parameters for Pharaoh Cuttlefish in the Persian Gulf and Oman Sea (Iranian coastal waters).

Indices / models	CMSY Average (Maximum-minimum)
Biomass (1000 tonnes)	11.9 (7.1-13.2)
MSY (1000 tonnes)	5.1 (4.2-6.2)
Bmsy (1000 tonnes)	11 (8.67-13.9)
Fmsy	0.46 (0.36-0.58)
F	0.46 (0.41-0.77)
B/Bmsy	1.08 (0.64-1.2)
F/Fmsy	1 (0.93-1.32)
K (1000 tonnes)	22 (17.3-27.9)
r	0.92 (0.73-1.17)
Bt/K	0.54
Bmsy/K	0.50

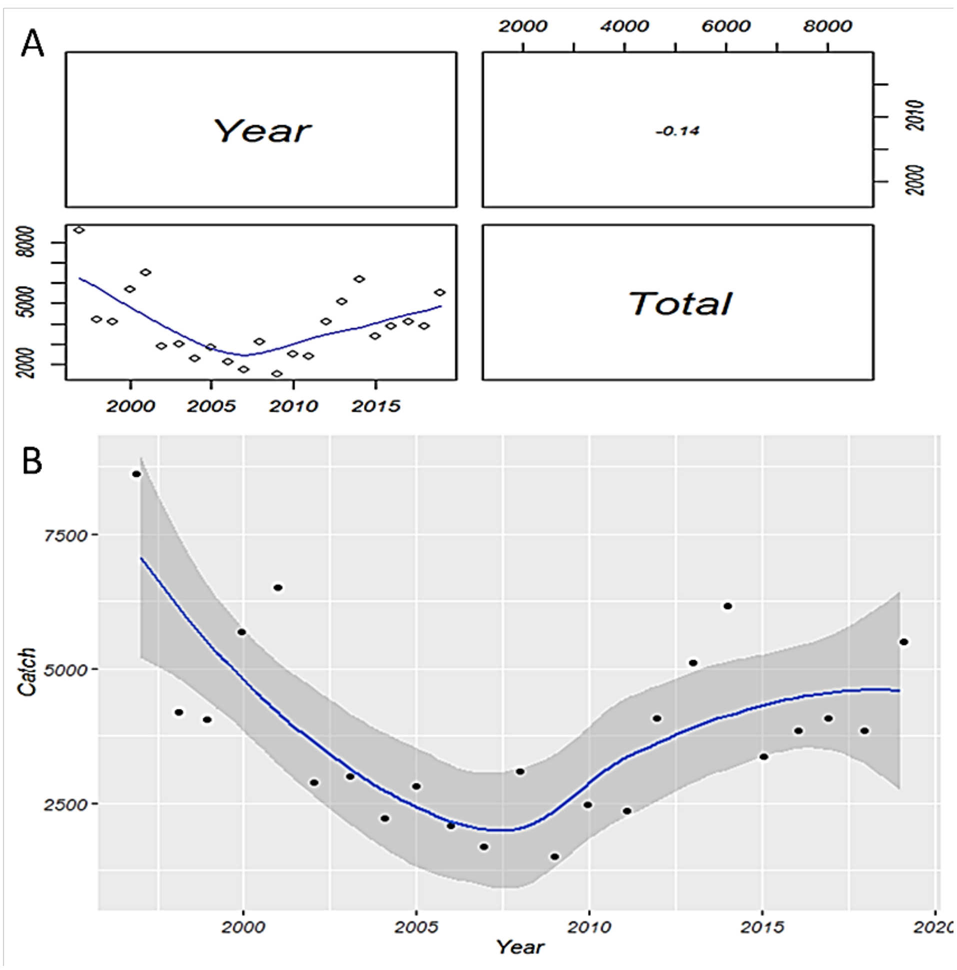

Figure 2. The changes trend in the annual (yr) and catch (total) (A) and trend catch of this period with 95% confidence intervals (B) for *Sepia pharaonis* in the Persian Gulf and Oman Sea (Iranian coastal waters).

decreased for the twenty-three years (R=-0.14, $P<0.05$) (Fig. 2). The amounts of trend catch of this species showed a decreasing trend (Fig. 2).

The CMSY model: Based on the annual catch catches and initial Pharaoh Cuttlefish information (initial growth 0.6-1.5 per year), the software used the initial value to start of modeling based on the CMSY and the Monte Carlo simulation method. The initial relative biomass as 0.5-0.9 and the final relative biomass as 0.2-0.6 were considered. The output values

Table 2. Forecasting and error calculations of different methods (Mean Absolute Percentage Error (MAPE), Mean absolute deviation (MAD), mean square deviation (MSD) for Pharaoh Cuttlefish.

Method	MAPE	MAD	MSD
Multiplicative decomposition (Yt=3.431+0.0375*t)	4.43	0.15	0.035
Additive decomposition (Yt=3.429+0.0377*t)	4.43	0.15	0.035
Moving average	2.85	0.1	0.02
Single exponential smoothing	3.88	0.13	0.025
Double exponential smoothing	3.87	0.13	0.027
Trend analysis (Linear) (Yt=3.56+0.0017*t)	4.43	0.15	0.035
Trend analysis (Exponential) (Yt=3.56*(0.99*t)	4.43	0.15	0.035
Trend analysis (Quadratic) (Yt=3.90-0.083*t+0.0033*t^2)	3.03	0.10	0.016
Winters multiplicative	4.13	0.14	0.036
Winters additive	4.13	0.14	0.036

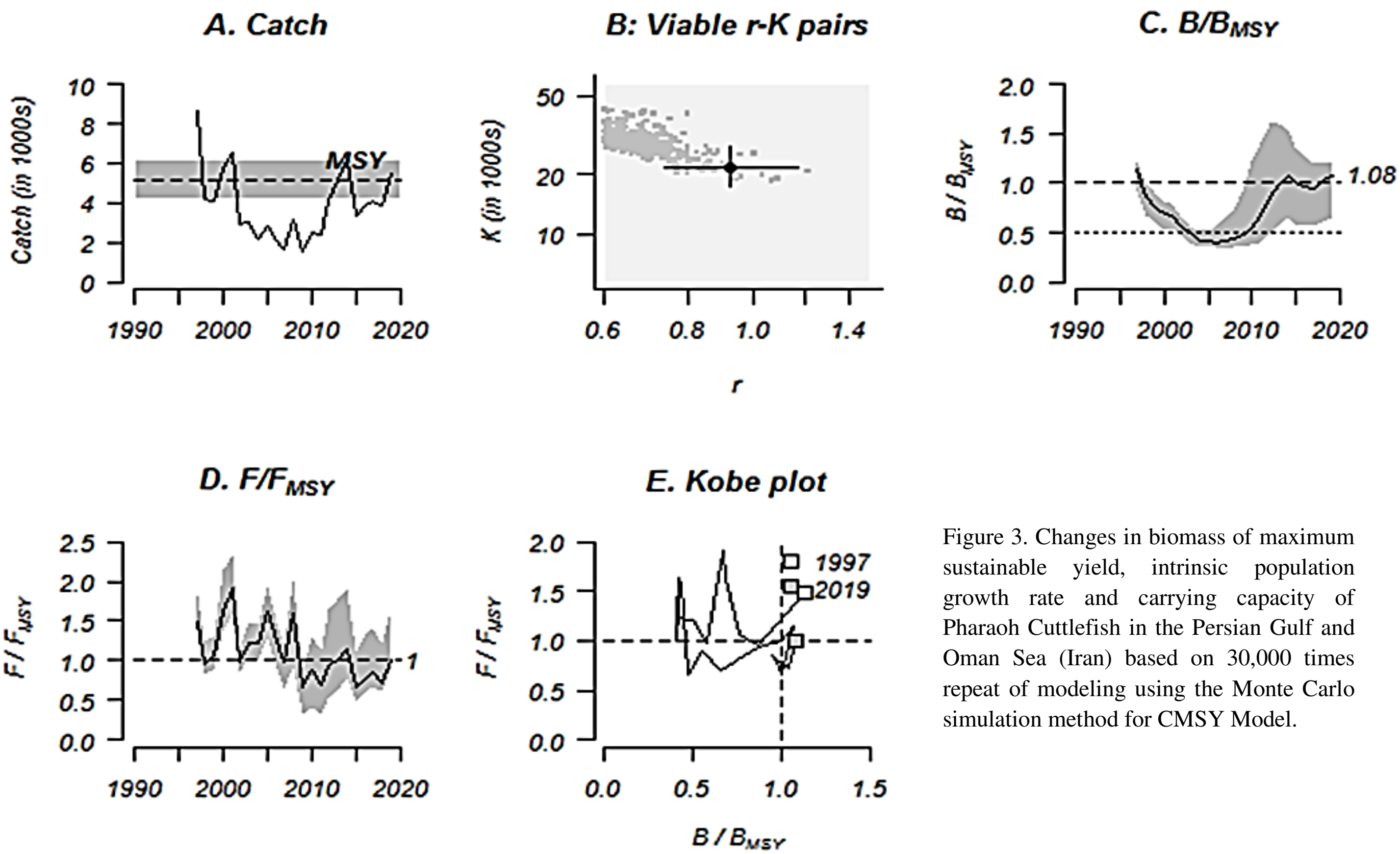

Figure 3. Changes in biomass of maximum sustainable yield, intrinsic population growth rate and carrying capacity of Pharaoh Cuttlefish in the Persian Gulf and Oman Sea (Iran) based on 30,000 times repeat of modeling using the Monte Carlo simulation method for CMSY Model.

of the Monte Carlo simulation method with 30,000 times the modeling repeat result the average values (95% confidence interval) of state-space surplus production model for intrinsic population growth rate (r), carrying capacity (k), maximum sustainable yield (MSY), biomass of maximum sustainable yield (Bmsy), current or existing biomass (B), maximum fishing mortality rate of maximum sustainable yield (Fmsy) and current or existing fishing mortality (F) that are shown in Table 1.

The ratios of the current biomass to the biomass of maximum sustainable yield (B/Bmsy) and the ratio of the current fishing mortality to the maximum fishing mortality rate of maximum sustainable yield (F/Fmsy) were 1.08 (0.64-1.2) and 1 (0.91-1.2), respectively (Fig. 3). According to the kobe plot, which represents the graphic of the values of B/Bmsy and F/Fmsy, it can be concluded that the increase in the fishing

Table 3. Coefficients and summary statistics of multivariate ARIMA modeling for Pharaoh Cuttlefish in the Persian Gulf and Oman Sea (Iran) in the Persian Gulf and Oman Sea (Iran).

Method	*B* (coefficient)		Constant	Standard error of B		Log likelihood	AIC	BIC
	AR1	MA1		AR1	MA1			
ARIMA(1,0,0)	0.58	-	3.58	0.18	-	9.52	13.03	9.62
ARIMA(0,1,0)	-	-	-	-	-	7.07	12.14	11.05
ARIMA(0,0,1)	-	0.37	3.55	-	0.16	7.78	9.79	6.38
ARIMA(1,0,1)	0.77	-0.29	3.59	0.19	0.27	9.95	11.90	7.35
ARIMA(0,1,1)	-0.38	-	-	0.19	-	8.59	13.05	10.86
ARIMA(1,1,1)	-0.16	-0.24	-	0.60	0.59	8.56	11.13	7.85

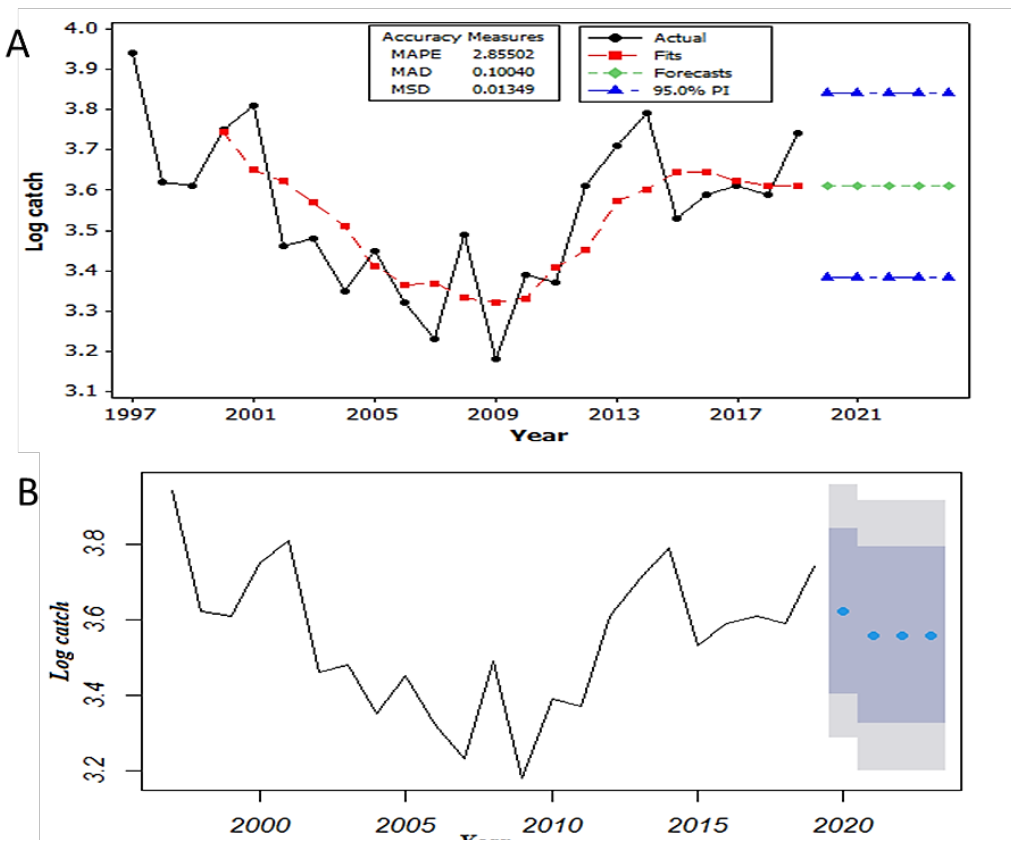

Figure 4. The moving average trend fitted models (A), the ARIMA (0,0,1) trend fitted (B) models (forecast plot is blue line) for of *Sepia pharaonis* in the Persian Gulf and Oman Sea (Iranian coastal waters)

mortality and the reduction of the current biomass has begun and is still ongoing. The mortality fishing (F) to mortality fishing of the maximum sustainable yield (Fmsy) ratio (F/Fmsy), the biomass (B) to biomass of the maximum sustainable yield (Bmsy) ratio (B/Bmsy) in the CMSY model were 1 (0.93-1.32) and 1.08 (0.64-1.20) (in 2019 year), respectively.

Forecasting methods: Performance of sixteen methods was evaluated based on forecasting accuracy. The ten different forecasting techniques, including moving average and using of six methods identified orders of ARIMA (p, d, q) based on the AIC and BIC. With results of the prediction model was observed moving average analysis (MAPE=2.85, MAD=0.10, MSD=0.02) and ARIMA (0, 0, 1) (AIC=9.79, BIC=6.38), are better than other models for a period of five years for modeling annual this species landing (Fig. 4). Various models were then fitted and compared as presented in Tables 2 and 3**,** using identified orders of ARIMA (p, d, q) based on the AIC and BIC. However, ARIMA (0, 0, 1) with drift was suitable for modeling annual *S. pharaonis* landings

(Fig. 4) based on the selection criteria (AIC=9.79, BIC=6.38).

Discussions

In recent years, the catching of Pharaoh Cuttlefish in the waters of southern Iran has been decreased. Over the past two decades, its catch rate in the waters of southern Iran has dropped from about 9,000 tons in 1997 to about 5,000 tons in 2019, indicating a sharp decline (Fisheries Statistical Yearbook, Iran, 2020). In this regard, the Sistan and Baluchestan Province had the highest percentage of Pharaoh Cuttlefish capture fisheries (63%), followed by Bushehr (19%) and Hormozgan (10%) provinces. Khuzestan Province had the smallest percentage of Pharaoh Cuttlefish capture fisheries (8%) and the Hormozgan Province showed the highest reduction.

The intrinsic population growth rate (*r*) value of this species is high flexibility (0.6-1.5) indicating its high potential to stand up to fishing pressure and recovery i.e. it demonstrates the ability to withstand fishing pressure and the recovery of declining fish stocks (Martell and Froese, 2013; Froese et al., 2016; Zhou et al., 2017). The earlier work showed *S. pharaonis* as the most flexible species (Froese and Pauly, 2015). A strong correlation exists between the intrinsic population growth rate (r) and other parameters of life history, especially natural mortality (M). The best model is r=1.73 M for teleosts and r=0.76 M for elasmobranches (Zhou et al., 2017). Froese and Pauly (2015) confirmed that the population intrinsic growth rate (r) is approximate twice the maximum fishing mortality rate of maximum sustainable yield (Fmsy), 2 times the natural mortality (M), 3 times the growth rate coefficient of the von Bertalanffy curve (K), 3 divided by the generation time (tgen) and 9 divided through the most age (tmax) ($r \approx 2FMSY \approx 2\ M \approx 3\ K \approx 3 / tgen \approx 9 / tmax$).

In the present study, the decreasing trend in the amount of current biomass to biomass of maximum sustainable yield (B/Bmsy) showed that Pharaoh Cuttlefish had been in full exploitation condition for catching fisheries in the Iranian part of Persian Gulf and Oman Sea. In addition, the level of current fishing mortality at the fishing mortality rate to be the maximum sustainable yield (F/Fmsy), is shown with an increasing trend and toward overfishing pattern (Arrizabalaga et al., 2012). The fishery status is usually evaluated based on B/Bmsy and is divided into three general categories: B/Bmsy≥1/5 means stocks under exploited, 0.5<B/Bmsy<1.5 shows stocks fully exploited, 0.2<B/Bmsy<0.5 means stocks overexploited and B/Bmsy<0.2 shows collapsed stocks (Branch et al., 2011; Anderson et al., 2012).

The biomass ratio of maximum sustainable yield to carrying capacity (Bmsy/k) is one of the most relevant indicators for biological reference points. This ratio was 50% for this species in the Persian Gulf and Oman Sea (Iran), suggesting average resource depletion (Palomares and Froese, 2017). The optimum value of this ratio typically varies from species to species and usually ranges 30-60%. There is a small amount of this index for species with high intrinsic population growth rates, while species with low intrinsic population growth rates have a high value. The minimum value for this index is 20-30%, and a sharp decrease in capital is less than this (Gabriel and Mace, 1999).

The rate of exploitation and population biomass undoubtedly affects the rate of population growth and impacts the ratio of maximum sustainable yield biomass to carrying capacity (Zhou et al., 2017). According to the results, the annual catch of Pharaoh Cuttlefish in the Persian Gulf and Oman Sea (Iran), exceeded the maximum sustainable yield of Pharaoh Cuttlefish (approximately 5000 tons in 2019) and steps should be taken to minimize the amount of catch and fishing effort. It seems that reducing fishing permits and fishing effort, especially by fishing vessels, will put the *S. pharaonis* stock situation in a more favorable condition in the long term and will further benefit the exploiters and the fishing community. Restoring fishery stocks that have been overexploited is unlikely to occur in a short time, because the rebuilding of a resource usually requires 2-3 times of its life span (FAO, 2018).

In this study, we illustrate linear forecasting methods that not capable of accurately forecasting the fishery landing time series, due to the fact that the series which is often highly nonstationary, and nonlinearity (Shabri and Samsudin, 2015). Nonlinear forecasting approach better than linear forecasting and the best models of the ARIMA scheme are also ARIMA (0, 0, 1). Time series forecasting using ARIMA models have been widely applied in fisheries and univariate and multivariate ARIMA models are useful tools for predicting the total fish production in different local. The major objective of this work was to develop a composite forecasting model to improve the prediction of this species in the Persian Gulf and Oman Sea (Iranian coastal waters). Despite all the uncertainty of the catch data, we need to use them in their work. Fisheries managers for better and more stable management in the Persian Gulf and Oman Sea should concentrate on the available trends (Rosenberg et al., 2005). Further research can be check to compare the forecast ability of the model with other time series models like SARIMA, PARIMA, etc.

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References

Anderson S.C., Branch T.A., Ricard D., Lotze H.K. (2012). Assessing global marine fishery status with a revised dynamic catch-based method and stock-assessment reference points. Journal of Marine Science, 1(2): 20-26.

Arrizabalaga H., Murua M., Majkowski J. (2012). Global status of tuna stocks: summary sheets. Revista de Investigación Marina, AZTI-Tecnalia, 19(8): 645-676.

Branch T.A., Jensen O.P., Ricard D., Ye Y., Hilborn R. (2011). Contrasting global trends in marine fishery status obtained from catches and from stock assessments. Conservation Biology, 25(1): 777-786.

Bruska R., Moore W., shuster S. (2016). Invertebrates. Thrid edition. Sinauer associates bublisher, 1128 p.

Eagderi S., Fricke R., Esmaeilih R., Jalili P. (2019). Annotated checklist of the fishes of the Persian Gulf: Diversity and conservation status. Iranian Journal of Ichthyology, 6: 1-171.

FAO. (2018). The State of World Fisheries and Aquaculture 2018 - Meeting the sustainable development goals. Rome. Licenses: CC BY-NC-SA 3.0 IGO. 227 p.

Fisheries Statistical Yearbook, Iranian Area. (2020). Fisheries Administration, Council of Agriculture, Executive Tehran. 20 p.

Froese R., Demirel N., Sampang A. (2015). An overall indicator for the good environmental status of marine waters based on commercially exploited species. Marine Policy, 51(1): 230-237.

Froese R., Demirel N., Gianpaolo C., Kleisner K.M., Winker H. (2016). Estimating fisheries reference points from catch and resilience. Fish and Fisheries, 18(3): 506-526.

Froese R., Pauly D. (2015). FishBase. World Wide Web electronic publication. www.fishbase.org, version. (10/2015), accessed at www.fishbase.org in November /December 2015.

Gabriel W.L., Mace M.M. (1999). A Review of Biological Reference Points in the Context of the Precautionary Approach. 5th NMFS NSAW. NOAA Tech. Memo. NMFS-F/SPO-40. pp: 35-45.

Ghaitaranpour M., Poorbagher H., Eagderi S., Feghhi J. (2019). Modelling the spatial distribution of the yellowfin tuna, *Thunnus Albacares* in the Persian Gulf using a fuzzy rule-based classification. International Journal of Aquatic Biology, 7(6): 351-356.

Jereb P., Roper C.F.E. (2005). Cephalopods of the world. FAO species catalogue for fishery purposes. 262 p.

Karmaker C.L., Halder P.K., Sarker E. (2017). A study of time series model for predicting jute yarn demand: Case study. Journal of Industrial Engineering. Article ID 2061260. 8 p.

Lawer E.A. (2016). Empirical Modeling of Annual Fishery Landings. Natural Resources, 7: 193-204.

Martell S., Froese R. (2013). A simple method for estimating MSY from catch and resilience. Fish and Fisheries, 14(4): 504-514.

Palomares M.L.D., Froese R. (2017). Training on the use of CMSY for the assessment of fish stocks in data-poor environments. Workshop report submitted to the GIZ by Quantitative Aquatics, Inc. Q-quatics Technical Report No. 2. Bay, Laguna, Philippines. 58 p.

Rajaei M., Poorbagher H., Farahmand H., Mortazavi M.S., Eagderi S. (2014). Interpopulation differences in shell forms of the pearl oyster, *Pinctada imbricata radiata* (Bivalvia: Pterioida), in the northern Persian Gulf inferred from principal component analysis and elliptic Fourier analysis. Turkish Journal of Zoology, 38(1): 42-48.

Riede K. (2004). Global register of migratory species - from global to regional scales. Final Report of the R&D-Project 808 05 081. Federal Agency for Nature Conservation, Bonn, Germany. 329 p.

Roper C.F.E., Sweeney M.J., Nauen C.E. (1984). Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. FAO Fisheries Synopsis, 125(1): 277 p.

Rosenberg A.A., Bolster W.J., Alexander K.E., Leavenworth W.B., Cooper A.B., McKenzie M.G. (2005). The history of ocean resources: modeling cod biomass using historical records. Frontiers in Ecology and the Environment, 3(2): 84-90.

Shabri A., Samsudin R. (2015). Fishery landing forecasting using wavelet-based autoregressive integrated moving average models. Hindawi Publishing Corporation Mathematical Problems in Engineering, Article ID 969450, 9 p.

Taghvimotlagh S.A., Akhundi M., Shiraei A.S. (2006). Analysis of fishing process and fishing potential based on statistics and catch data in Gulf and Oman waters. Journal of Fisheries Research, 15(3): 45-35.

Tsitsika E., Maravelias C., Haralabous J. (2007). Modeling and forecasting pelagic fish production using univariate and multivariate ARIMA models. Fisheries Science, 73: 979-988.

Valinasab T. (1993). Pharaoh cuttlefish biology and cephalopods species identification. Iranian Fisheries Science and Research Institute, Tehran. 65 p.

Valinasab T. (1999). Investigating the population diversity of Pharaoh Cuttlefish (*Sepia pharaonis*) in the Persian Gulf and Oman Sea. Dissertation, Islamic Azad University. 173 p.

Wetzel C.R., Punt A.E. (2015). Evaluating the performance of data-moderate and catch-only assessment methods for U.S. west coast groundfish. Fisheries Research, 171: 170-187.

Zhou S., Chen Z., Dichmont C.M., Ellis A.N., Haddon M., Punt A.E., Smith A.D.M., Smith D.C., Ye Y. (2016). Catch-based methods for data-poor fisheries. Report to FAO. CSIRO, Brisbane, Australia. 74 p.

Zhou S., Punt A.E., Smith A.D.M., Ye Y., Haddon M., Dichmont C.M., Smith D.C. (2017). An optimized catch-only assessment method for data poor fisheries. ICES Journal of Marine Science, 1(2): 20-26.