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Application of SPMs and BRPs to Access Overexploitation Risk Faced by *Lutjanus johnii* (Bloch, 1792) in Pakistan: A Sustainable Fishery Management Perspective

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AM: conceptualized the study, administered the project, and wrote the manuscript. MM: planned the methodology, performed data analysis, and wrote results. MAR: constructed tables and figures and edited various parts of the manuscript.

Key words
Overexploitation risk, SPMs, BRPs, Fishery management, *L. johnii*, Bioeconomics

ABSTRACT

Managing fisheries sustainably in Pakistan depends heavily on monitoring industrial fishery operations as many fisheries stocks have been declared overexploited resulting in decreased economic contribution. This study assesses the fishery stock status of *Lutjanus johnii*, estimated for the first time in Sindh, Pakistan. In this regard, surplus production models (SPMs), non-equilibrium, analyzed fishery statistics from 2004 to 2017. ASPIC (A Stock Production Model Incorporating Covariates) and CEDA (Catch and Effort Data Analysis), computer-based and manually operated statistical routines, were used to apply SPMs to the data. Based on the ASPIC output, the maximum sustainable yield (MSY) was computed as 989 tons (t) in the Schaefer Model (S-M) and 873 t in the Fox Model (F-M). In S-M and F-M, the coefficient of variation (CV) and goodness of fit (R^2) remained at 0.107, 0214, and 0.962, 0.978, respectively. Furthermore, ASPIC results highlighted decreased fishing mortality (F) and increased biomass (B). Meanwhile, in CEDA, MSY outputs along with R^2 remained at 1051 t (0.718) for S-M and the Pella-Tomlinson Model (PT-M). S-M and PT-M MSY outputs remained the same at 1051 t (0.718) in CEDA. In contrast, F-M calculated these parameters at 849 t (0.941). Based on the results, it is clear that *L. johnii* is being overexploited in Sindh, Pakistan. To ensure sustainable harvesting of this fishery resource and long-term economic exploitation, current management measures should be strengthened along with further research.

INTRODUCTION

Fisheries resource management science is based on the concept of stock size. Thus, it is crucial to understand fisheries stock size dynamics for effective management (Dudley, 2008). Overexploitation may contribute to a decrease in fish stocks, a concept generally known as stock depletion. Using this concept, scientists have constructed several statistical models to evaluate stock size and predict exploitation status. One of these models is the famous surplus production model (SPM) (Mormede *et al*., 2020). These models are of different types and are reliable tools to assess fishery status around the globe due to their ease of use and simple data requirements (Pedersen and Berg, 2017). Various statistical models such as aggregate biomass dynamics, virtual population analysis, catch-at-length, catch-at-age, and index-based models can be used to access fisheries stock status (NOAA Fisheries, 2024). However, most of these models, except SPMs, have complicated data requirements and difficult to operate. On the other hand, SPMs only utilize catch and effort (CE) data to predict crucial fishery parameters such as growth (r), maximum sustainable yield (MSY), fishing mortality (F), and biomass (B). Considering these advantages SPMs are employed in this study. SPMs Quantitative estimates of these parameters indicate fishery management threshold levels. Therefore, these levels are called biological reference points (BRPs) (Hoggarth *et al*., 2006; Cousido-Rocha *et al*., 2022).

BRPs are generally classified into two types, i.e., target reference points (TRPs) and limiting reference points (LRPs). TRPs represent those harvest levels, which

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are the goal of successful management. On the other hand, LRPs are harvest levels that either cause economic losses or overexploit the fishery resource (Hoggarth *et al*., 2006). Without BRPs, there would be blind management that would not produce the desired results (Caddy, 2004). Suitable fish harvest size is essential to sustain the resilience of fisheries. There are two potential problems associated with it. First, if fishery resources are overharvested, it will lead to diminished catch in the future, affecting fishery resource sustainability. Second, if fishery resources are under-harvested, it will cause economic losses (Kantoussan *et al*., 2018; Perissi *et al*., 2017). Therefore, BRPs are central to sustainable fisheries management. Managers can estimate reliable BRPs by utilizing SPMs to devise effective management plans.

SPMs are generally categorized into two types. First, SPMs assume no changes in fish stock. These models are commonly called equilibrium SPMs and are classical SPM versions. On the other hand, SPMs that rely on changing fish stock are generally referred to as non-equilibrium SPMs and are called modern SPMs (Cousido-Rocha *et al*., 2022; Abinaya and Sajeevan, 2022). These SMPs rely on various assumptions. First, there is no competition between fish in the fish stock. Second, CE data employed to calculate fishery parameters represent a single fish stock. Third, the working efficiency of fishing crafts remains consistent over time. Fourth, F occurs with natural mortality. Fifth, CE data represent all age groups of fish stock equally (Chong *et al*., 2022). It is important to note that, by nature, one or several of these assumptions cannot be met. However, the scientific method is not abandoned, as this is the characteristic of every statistical method (Khatun *et al*., 2019). Therefore, calculating BRPs from SPMs is a vital reference for management policies. The management measures based on these BRPs have proved to be very promising in the sustainable development of fisheries around the globe (Haltuch *et al*., 2008).

The majority of literature published online indicates commercial fisheries exploitation beyond their BRPs in Pakistan (Mohsin *et al*., 2017). Therefore, it is imperative to assess commercial fisheries stock status. This study determines BRPs for a very important commercial fishery resource *Lutjanus johnii* (Bloch, 1792) in Sindh, Pakistan. This fish belongs to a group of fish generally known as snappers and is given diverse vernacular names such as Gukur, Mayyo, and Hiro. *L. johnii* belongs to the family Lutjanidae. It is reported that over 32 species of this family exist in Sindh marine waters among which *L. johnii* is of immense commercial importance. *L. johnii* fishery contributes significantly to earning the livelihoods of fishermen and seafood processors. The demand for this fish is high in the international market. Thus, *L. johnii* fishery offers an excellent opportunity for exchange earnings. In addition to providing quality protein and ensuring food security, this fishery offers great opportunities for recreational fisheries and tourism (Abbas *et al*., 2015; Hussain and Zakia, 2000). Despite this, there is a lack of literature on various aspects of the fisheries related to the family "Lutjanidae", mostly focusing on growth performance, hematological analysis, feed efficiency, and other morphological characteristics of fishes (Abbas *et al*., 2015; Ahmed *et al*., 2015). There is no published literature available documenting stock status and providing guidance to determine BRPs for *L. johnii*. This study aims to assess the stock status of *L. johnii* fisheries in Sindh, Pakistan. It will determine MSY by quantifying BRPs and comparing various SPMs based on their R^2 values. It will help managers to determine TRPs and long-term economic exploitation of this fishery resource. Moreover, it is also envisaged that this study will act as a catalyst to initiate such relevant studies to safeguard commercial fisheries in Pakistan.

MATERIALS AND METHODS

Data collection

A comprehensive literature review was conducted to develop sound knowledge and a basis for reliable research. This was done by analyzing published research papers, government reports, and online websites. To access fishery status, published CE data, 2004-2017, of *L. johnii* commercial fisheries reported by the Marine Fisheries Department, Pakistan, was utilized to conduct this study (SBOS, 2024). There are two basic requirements for CE data to be analyzed through SPMs. First, it should better represent commercial fisheries. Second, there should be no data gaps. The data employed in this study meet both requirements and, hence, are statistically suitable for analysis. In addition, it is pertinent to point out that the catch is shown as tons (t). The effort, on the other hand, is represented by trawlers and gillnetters used to catch *L. johnii* fishery resources. It is assumed that all of the catch is through this effort.

Data analysis

Collected data was analyzed through renowned and authentic fishery stock assessment routines. The first software used is ASPIC (a stock production model to incorporate covariates) developed by UK researchers (NOAA, 2015). The second computer application utilized in this study, i.e., CEDA (catch and effort data analysis) was developed by USA scientists (MRAG, 2015). Two statistical routines are used in the same analysis to compare and draw reliable results. By applying these two statistical routines, three production models, i.e., Schaefer (S-M), Pella-Tomlinson (PT-M), and Fox (F-M) models, were used to analyze data. Utilizing multiple approaches at once enables the identification of the best-fitting model for the data. It helps specifically determine BRPs on which reliable management advice can be given. The synchronized use of these three production models is widely documented in fisheries management (Mohsin *et al*., 2017).

S-M is the first biomass dynamic model proposed by Schaefer in 1954. It is based on Graham's work and the concept of logistic fish stock growth. S-M is written below:

$$\frac{dB}{dt} = rB\,(B_\infty - B) \quad \text{(Schaefer, 1954)}$$

Here, B stands for biomass, t stands for time, and B_∞ means carrying capacity. Built on the Gompetz growth concept, PT-M is basically an extension of S-M proposed by Pella-Tomlinson in 1969 (Pella-Tomlinson, 1969). PT-M can estimate some additional parameters like z (natural mortality) to obtain reliable results. Following is a model representation:

$$\frac{dB}{dt} = rB\,(B_\infty^{n-1} - B^{n-1}) \quad \text{(Pella and Tomlinson, 1969)}$$

However, the data fit of this model is not so good and sometimes worse than F-M and S-M (Musick and Bonfil, 2004). In addition to S-M, some other SPMs have also been presented that are more realistic toward fishery stock assessment, such as F-M (1970). This model, like S-M, is not based on population growth via logistic equations, but rather relies on the Gompertz equation of population expansion, and is represented as follows:

$$\frac{dB}{dt} = rB\,({}_{ln}B_\infty - {}_{ln}B) \quad \text{(Fox, 1970)}$$

This model is believed to be more realistic since it implies that it is impossible to wipe out the population. Although this statement seems ideal, however, it might not be true since many fishery populations have been depleted (Musick and Bonfil, 2005).

CEDA statistical routine

It is a windows-based operating system featuring user-friendly options. The bootstrapping combined with 95% confidence limits is an essential feature of its parameter analysis. Therefore, it is widely used for fishery management studies. Before CEDA analysis, the principal initial proportion (IP) was derived from the division of the largest catch by the first one. In this study, the first reported catch was the largest. Therefore, the principal IP value was estimated at 1. IP values between 0.1 and 1 represent the fishery state. An IP value of 0.1 indicates a newly established fishery. Alternatively, 1 describes a situation where excessive harvesting fishery operations occur. To perform the sensitivity analysis, IP values between 0.6 and 1 were chosen. Since the calculated principal IP value was 1, therefore using lower IP value, less than 0.5 was meaningless. Moreover, all SPMs were employed, and each model was used along with three error assumptions: gamma (G), normal (N), and log-normal (LN). These modes represent different model assumptions and their fitting to data. Excel 2013 was employed to generate graphs based on model estimates of parameters such as B, MSY, goodness of fit (R^2), carrying capacity (K), r, and catchability coefficient (q).

ASPIC statistical routine

ASPIC is recognized worldwide for its reliability as an aid to fishery management. This software requires individual IP file preparation for parameter estimates. Two types of files for upload were prepared, namely FIT and BOT. The FIT represents the program mode in which ASPIC employs bootstrapping. Meanwhile, the BOT computes parameters by giving more weight to management aspects. For this reason, BOT files operated longer than FIT files. In total, 600 trials were set to run these files on the software. Data was extracted from the software output files and organized into tables following extraction. ASPIC computed various fishery parameters, including MSY, R^2, K, q, coefficient of variation (CV), fishing mortality at MSY (F_{MSY}), and biomass at MSY (B_{MSY}).

Last but not least, this study applied a set of methods to assess the results produced by different SPMs. Parameter estimates were conducted to evaluate the models. As a first step, MSY estimates with appropriate MSY levels were selected. The second step was to choose models with adequate CV results for concluding. In addition, models with an R^2 above 0.5 were considered valid. Based on these approaches, the models were compared to determine the most appropriate fit.

RESULTS

In order to obtain reliable results, this study utilized the latest available 14 years, 2004-2017, long CE time series data of *L. johnii* commercial fisheries collected from Sindh, Pakistan. CE data showed considerable variation over the study years. This fluctuation is graphically presented in Figure 1. It was observed that catch quantity had declined from 2256 t (2004) to 1247 t (2017), with an average production of 1647 t/year. In the year 2004, the maximum catch was, 2256 t, whereas in 2016, the minimum catch was reported to be 1121 t. On the other hand, effort has also decreased considerably during the study period between 2004 (5350) and 2017 (4661).

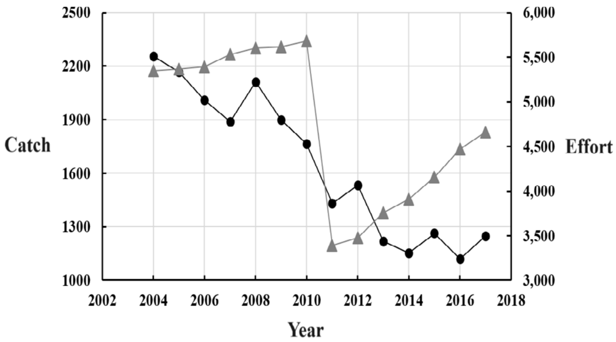

Fig. 1. Reported fishery statistics of *L. johnii* from Sindh, Pakistan (2004-2017).

However, the fluctuations are greater than those in catch statistics. Maximum and minimum effort was observed in 2010 (5680) and 2011 (3389), respectively. The average effort during the study period remained at 4740. Calculated CPUE showed a swift decrease between 2004 (0.422) and 2017 (0.268), correspondingly (Fig. 2). Maximum and minimum CPUE values were observed during 2004 (0.422) and 2016 (0.251), in that order. The value of R^2 (0.649) was estimated using a linear regression method. Trend line slopping downwards represents decreasing catch quantity concerning effort with time.

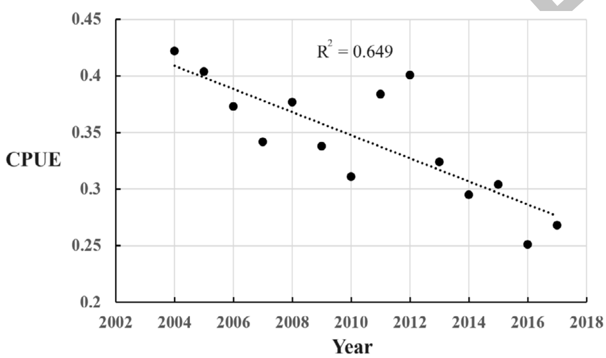

Fig. 2. Computed CPUE of *L. johnii* from Sindh, Pakistan (2004-2017).

CEDA approximations

In total CEDA produced 9 residual graphs demonstrating a comparison between reported catch statistics and estimated catch values for each EA for all models utilized in this study (Fig. 3). Superficially these graphs look alike however in detail they differ. The minute differences between graphs represent parameter estimations based on different assumptions of various models and their subsequent EAs. Table I presents a CEDA software-based sensitivity analysis of *L. johnii* MSY estimates with IP values from 0.6 to 1. For all the models, i.e., S-M, PT-M, and F-M used by CEDA, the G error assumption showed estimation error for most of the IP values. This situation happens when data patterns do not fully comply with model assumptions and statistical procedures. Whereas other error assumptions produced complete results. For lower IP values generally higher values of MSY were obtained whereas for high IP values MSY estimates were lower. For instance, in S-M by using the N error assumption for IP = 1, the MSY was calculated as 1051 t (IP = 1) whereas for IP = 0.6, the MSY was calculated as 1378 t. CV estimates varied with any specific pattern between models and their respective error assumptions.

Table I. CEDA software-based sensitivity analysis of *L. johnii* MSY estimates with IP values from 0.6 to 1.

IP	Model								
	S-M			PT-M			F-M		
	G	N	LN	G	N	LN	G	N	LN
MSY									
0.6	MF	1378	1266	MF	1378	1266	MF	1347	1234
0.7	MF	1257	1286	MF	1257	1286	MF	1091	1126
0.8	MF	1184	1142	MF	1184	1142	MF	911	898
0.9	1145	1165	1130	1145	1165	1130	1087	883	879
1	965	1051	1024	965	1051	1024	831	849	836
CV									
0.6	MF	0.715	0.215	MF	0.154	0.095	MF	0.569	0.154
0.7	MF	0.248	0.178	MF	0.215	0.054	MF	0.025	0.327
0.8	MF	0.413	0.014	MF	0.415	0.007	MF	0.126	0.516
0.9	0.039	0.145	0.003	0.284	0.026	0.121	0.447	0.014	0.097
1	0.514	0.210	0.041	0.542	0.184	0.049	0.059	0.061	0.053

S-M, Schaefer model; PT-M, Pella-Tomlinson model; F-M, Fox model; CV, coefficient of variation; MSY, maximum sustainable yield; IP, initial proportion; G, gamma; N, normal; LN, log-normal; MF, minimization failure.

Since IP = 1 is the principal IP in this study, the results obtained by this IP are presented separately in Table II. In S-M, MSY and R^2 estimates for all error assumptions remain 965 t (0.611), 1051 t (0.718), 1024 t (0.689), in that order. The corresponding CVs were estimated at 0.514, 0.210, and 0.041, respectively. PT-M produced the same results as S-M for MSY and R^2 estimation. However, CV values differed from S-M. In F-M, MSY estimates for all error assumptions were calculated as 831 t, 849 t, and 836 t, correspondingly. Their corresponding R^2 values remained at 0.854, 0.941, and 0.926, in that order. Thus, MSY estimates of F-M were lower than S-M and PT-M whereas R^2 values were higher than other models.

Table II. CEDA results for *L. johnii* fishery parameters with IP = 1.

Model		B	CV	MSY	r	R^2	K
S-M	G	754	0.514	965	0.950	0.611	4823
	N	772	0.210	1051	0.995	0.718	5264
	LN	783	0.041	1024	0.947	0.689	5125
PT-M	G	754	0.542	965	0.950	0.611	4823
	N	772	0.184	1051	0.995	0.718	5264
	LN	783	0.049	1024	0.947	0.689	5125
F-M	G	787	0.059	831	0.547	0.854	4148
	N	791	0.061	849	0.641	0.941	4257
	LN	811	0.053	836	0.634	0.926	4206

B, final biomass; CV, coefficient of variation; MSY, maximum sustainable yield; *r*, intrinsic population growth rate; R^2, coefficient of determination; *K*, carrying capacity.

ASPIC approximations

ASPIC software-based sensitivity analysis of *L. johnii* MSY values with IP values from 0.6 to 1 are given in Table III. In S-M, MSY results varied between 989 t (IP = 1) to 1035 t (IP = 0.6). MSY estimates were higher for lower IP values and vice versa. R^2 and CV values remained in the acceptable range. On the other hand, F-M estimated MSY in the lower range between 873 t (IP = 1) and 978 t (IP = 0.6). Higher estimated R^2 values in F-M represent better fitting of data and more reliable results than S-M. ASPIC results for *L. johnii* fishery parameters with IP = 1 are portrayed in Table IV. For S-M and F-M, MSY and R^2 estimates remained at 989 t (0.962) and 873 t (0.978), respectively. CV estimates for these two models were 0.107 and 0.214, in that order. S-M and F-M calculated B_{MSY} and F_{MSY} as 2016, 0.524 and 3051, 0.291, correspondingly. Figure 4 and 5 represent B and F estimates of *L. johnii* by ASPIC with IP = 1. For S-M, F increased overall between 2004 (0.514) and 2017 (0.878). Likewise, B has decreased from 4637 t (2004) to 1785 t (2017). F/F_{MSY} has shown increasing values during the study period from 2004 (0.895) to 2017 (1.524). This represents increasing fishing mortality as compared to the mortality that should occur at MSY. On the other hand, B/B_{MSY} has decreased from 2.548 (2004) to 0.504 (2017). It is a clear representation of swiftly decreasing biomass that should be present at MSY indicating overexploitation (Table V).

Table III. ASPIC software-based sensitivity analysis of *L. johnii* MSY estimates with IP values from 0.6 to 1.

Model	IP	B_{MSY}	K	R^2	MSY	q	F_{MSY}	CV
	0.6	2024	3568	0.961	1035	9.6E-07	0.735	0.134
	0.7	1974	3648	0.972	1011	9.6E-07	0.748	0.098
S-M	0.8	1989	3647	0.972	1004	9.6E-07	0.645	0.087
	0.9	2004	3710	0.962	1006	9.5E-07	0.615	0.104
	1.0	2016	3758	0.962	989	9.5E-07	0.524	0.107
	0.6	3096	5799	0.978	978	8.7E-07	0.218	0.147
	0.7	3124	5948	0.978	981	9.2E-07	0.213	0.189
F-M	0.8	3105	5948	0.978	976	9.2E-07	0.214	0.235
	0.9	3051	6487	0.978	974	9.2E-07	0.218	0.205
	1.0	3051	6521	0.978	873	9.2E-07	0.218	0.214

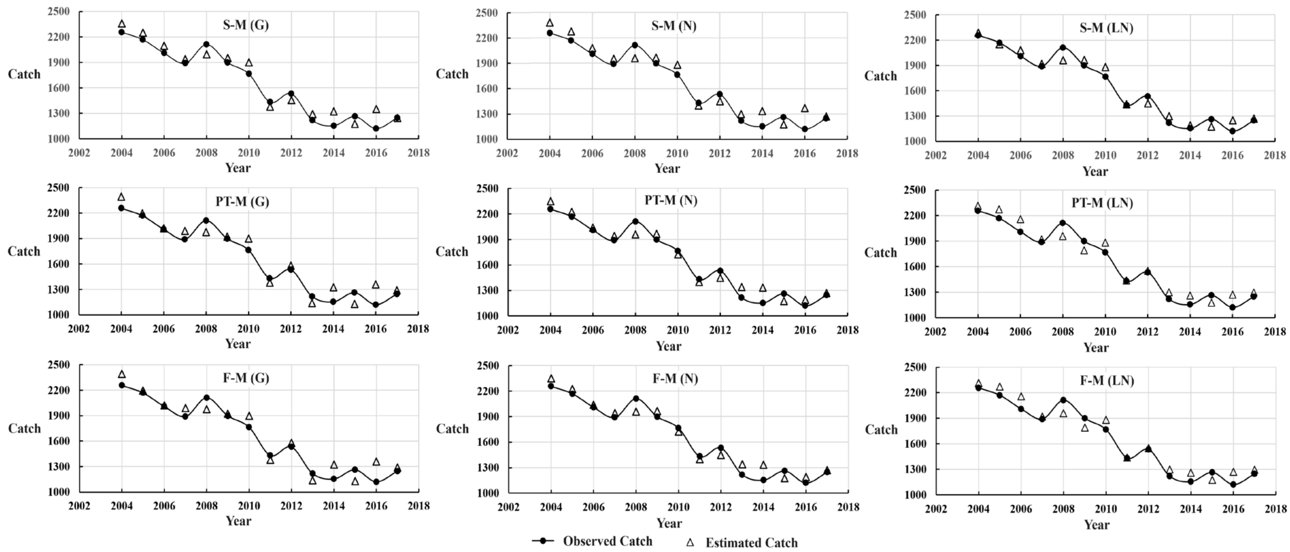

Fig. 3. Comparison between Observed and estimated MSY of *L. johnii* from Sindh, Pakistan (2004-2017).

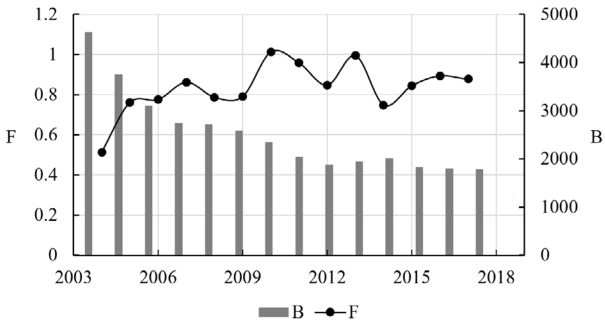

Fig. 4. Estimated trends of F and B utilizing ASPIC for S-M.

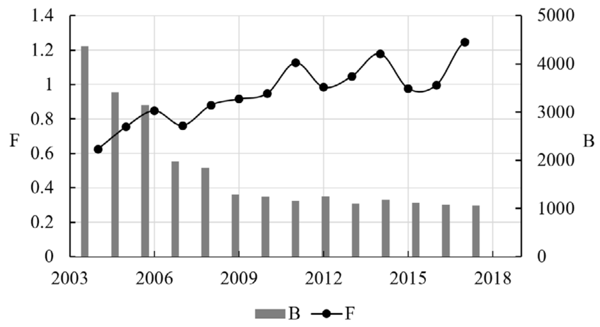

Fig. 5. Estimated trends of F and B employing ASPIC for F-M.

Table IV. ASPIC results for *L. johnii* fishery parameters with IP = 1.

Model	IP	B_{MSY}	R^2	K	MSY	F_{MSY}	q	CV
S-M	1	2016	0.962	3758	989	0.524	9.5E-07	0.107
F-M	1	3051	0.978	6521	873	0.291	9.2E-07	0.214

DISCUSSION

CPUE data can be used to demonstrate fisheries stocks state empirically. A decline in CPUE without an increase in effort suggests overfishing. It is also possible that fishing does not negatively affect fish stocks if CPUE remains the same despite an increase in effort. In the meantime, MSY estimates provide a direct indication of fisheries stocks. It is suspected that overexploitation occurs if their estimates are below recorded catch levels. Fish catches should remain the same if estimations are almost equal to current catch levels. In contrast, when MSY estimations exceed catch expectations, it is possible to increase catch quantity by strategizing (Mohsin *et al*., 2017). According to CPUE and MSY estimates conducted in this study, Sindh's *L. johnii* fisheries stocks are overfished.

Table V. B and F estimates of *L. johnii* by ASPIC with IP = 1.

Year	Model			
	S-M		F-M	
	F/F_{MSY}	B/B_{MSY}	F/F_{MSY}	B/B_{MSY}
2004	0.895	2.548	0.651	3.284
2005	1.154	1.954	1.201	2.941
2006	1.265	1.257	1.352	1.698
2007	1.384	0.105	1.194	1.487
2008	0.993	0.918	1.348	1.596
2009	1.254	0.847	1.591	1.224
2010	1.547	0.831	1.421	1.004
2011	1.321	0.795	1.325	0.947
2012	1.475	0.648	1.486	0.854
2013	1.254	0.609	1.473	0.648
2014	1.547	0.571	1.562	0.516
2015	1.487	0.553	1.248	0.614
2016	1.462	0.562	1.514	0.487
2017	1.524	0.504	1.612	0.478

Overfishing has negative economic consequences (Grafton *et al*., 2007). Increasing fish biomass increases fishermen's revenue. Without quantitative catch control, fishery stocks will degrade and disappear. Therefore, it is, important to regularly assess fish stocks to develop effective management plans. Overexploitation of fisheries resources affects 25% of the worldwide population (FAO, 2007). It is still possible to generate economic benefits from the fishery resources if they are controlled responsibly. Fisheries rebuilding takes time. Because fishermen rely on fishing for their livelihood, they oppose such a strategy. In some studies, it has been suggested that fishermen be compensated for their efforts to restore fisheries resources. SPMs have limitations in addition to their advantages. For example, to estimate K, r, and q properly, fishery statistics must be reliable and accurate. Occasionally, these models cannot predict K and r in declining fish catch biomass (Hilborn and Walters, 1992).

In fisheries management, fishery data is accessed and analyzed before recommendations are given based on the findings (Jentoft, 2006). A fishery parameter estimate obtained after analysis is used to provide management advice. Fishery managers use these estimates as indicators and benchmarks for managing fisheries (Hoggarth *et al*., 2006). Fisheries management strategies use two types of these points. First, managers strive to achieve harvest levels based on target points. Consequently, these harvest levels must be avoided to maintain an effective fisheries management strategy, as they are hazardous to fish stocks and ruin management efforts.

Excess capacity is believed to be the leading cause of overexploitation (Perissi *et al*., 2017). Fishermen benefit by starting a fishery somewhere. As a result, fishermen become more numerous. Afterward, however, fishery biomass decreases. Fishermen suffer economic losses due to inadequate management practices, while fish stocks become endangered. Furthermore, high catch rates at the beginning of fisheries and local fishing policies also resulted in overfishing globally (Bailey and Jentoft, 1990; Rosenberg, 2003), which also has occurred in Pakistan. Pakistan has put in place numerous measures to safeguard fisheries by limiting catch and effort.

Agribusiness and livestock policies have traditionally addressed issues related to fisheries in Pakistan. A technical cooperation project (TCP/PAK/3005) was requested by the Ministry of Food, Agriculture, and Livestock in 2004 to formulate a fisheries policy. Consequently, the government of Pakistan adopted its first national fisheries policy in 2007 (GoP, 2007). Pakistani fisheries have many overfished resources, as stated in section 2A. However, with knowledge of the conditions of fish resources, management measures are effective. Policy objective 2A.3 suggests promoting sustainable management of marine aquaculture resources and controlling overexploitation of fisheries resources (GoP, 2007). However, the government must pay attention to the practical implementation of the objectives stated in this policy. A recent study conducted by Schmidt (2014) indicates that operational trawlers in Sindh exceed the recommended ones by more than double.

Due to unregulated activity, fishing fleets have become overcapitalized, resulting in open access. Therefore, Pakistani fisheries need revival through concrete measures. This study has observed that the decreased capture production of *L. johnii* is a result of overexploitation, a problem that requires immediate intervention. Nazir *et al*. (2016) highlighted the issue of polluted coastal waters due to industry wastewater discharge. Therefore, in the coming years, *L. johnii* biomass production may decrease significantly through reduced reproduction under pollution conditions. To ensure resource conservation as an economic resource in the long run, fishery policies involving fishery managers must be developed.

It is pertinent to note that the statistical models for data analysis used in this study have some limitations. The use of SPMs has some problems. SPMs sometimes overestimate fishery parameters, such as K and q. Additionally, SPMs are more suitable for analyzing data with good contrast. SPMs may not be able to distinguish between K and r when the catch is decreasing. Therefore, the analysis of effort and the estimation of MSY should be rational in such situations. SPMs cannot always produce reliable results when fishing effort and q are distributed differently (Hilborn and Walters, 1992). Future research can employ other stock assessment models incorporating various ecological factors to produce more reliable results. It is also suggested to do more research to develop species-specific management plans through tailored management policies. Ecosystem-based fisheries should be the focus of future research that is more suitable for the conservation of the entire marine ecosystem. Moreover, exploring innovative monitoring techniques is a good subject for future research.

CONCLUSION

SPMs were employed to access CE statistics of *L. johnii* by using fishing population specialized software, ASPIC, and CEDA. For IP = 1, results clearly indicate fishery resource overexploitation. ASPIC estimates of MSY ranged between 873 t and 989 t. On the other hand, CEDA calculated MSY between 831 t and 1051 t. Considering the precautionary principle and higher R^2 values obtained in ASPIC, MSY estimates from ASPIC are used to predict catch levels. Thus, the catch of *L. johnii* from Sindh, Pakistan, should be between 800 t and 850 t for long-term sustainable exploitation of this commercial fishery resource. This catch range should be considered as TRPs. However, catch lower than 700 t or higher than 1000 t can be considered as LRPs. Further studies are needed to confirm these findings by using longer data series, and other production models and developing better management plans.

Statement of conflict of interest

The authors have declared no conflict of interest.

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